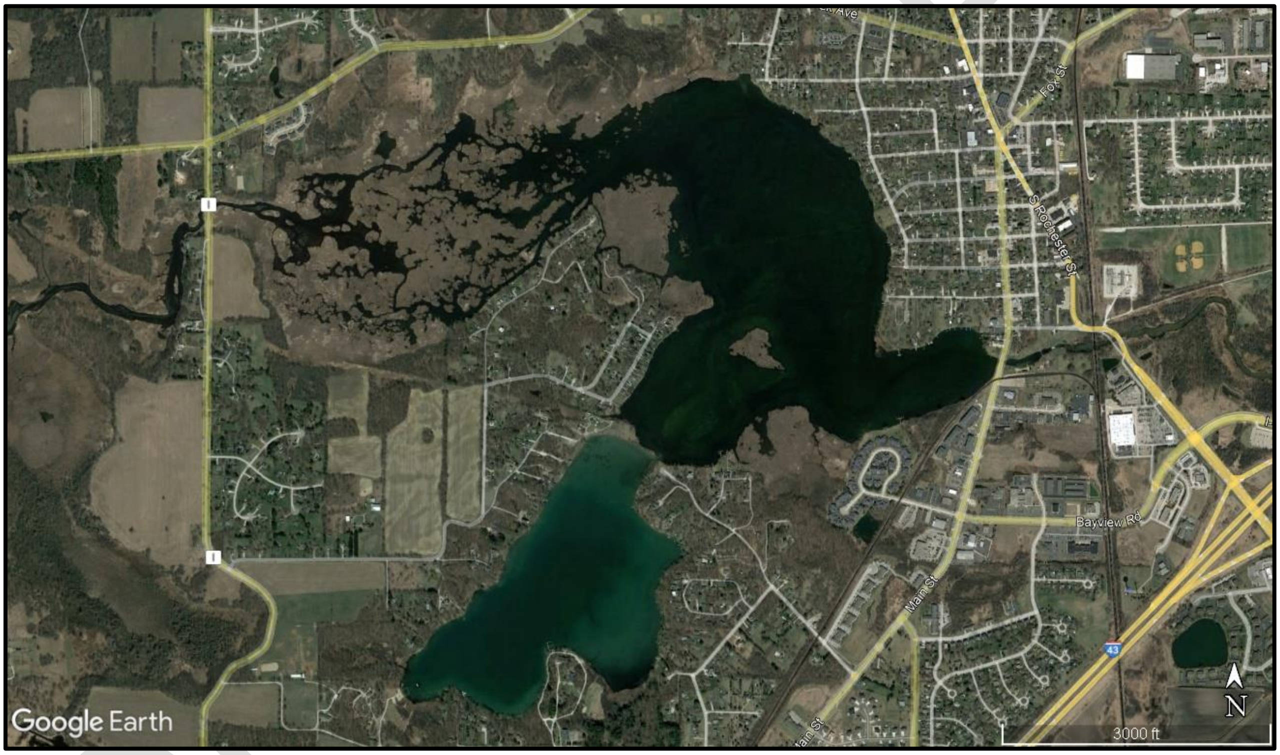
Aquatic Plant Management Plan Update

Phantom Lakes – Lower and Upper



Prepared for:

Phantom Lakes Management District

Content Updated by:

J. Stelzer – Senior Biologist

Lake and Pond Solutions, LLC

TABLE OF CONTENTS

INTRODUCTION 4
Why is Lake Management Important? 4
Goals and Objectives 5
BACKGROUND 6
Waterbody Characteristics 6
Access 7
Water Quality Data 8
Historical Management 9
Harvesting 9
Other Management 12
WDNR Identified Sensitive Areas 12
RESULTS OF THE 2022 POINT INTERCEPT SURVEY 14
Methods 14
Lower Phantom Lake 15
Survey Summary 15
Plant Community 15
Invasive Species 18
High Value and Quality Species 34
Floristic Quality 34
Upper Phantom Lake 35
Survey Summary 35
Plant Community 35
Invasive Species 38
High Value and Quality Species 49
Floristic Quality 49
COMPARISON OF SURVEYS (2017 – 2022) 50
Lower Phantom Lake 50
Upper Phantom Lake 53
PLANT MANAGEMENT ALTERNATIVES 55
No Management 55

Drawdown 56
Nutrient Inactivation 56
Dredging 57
Bottom Screens 57
Biomanipulation 57
Native Species Reintroduction 58
Hand Controls 58
Herbicide and Algaecide Treatment 59
Harvesting 62
DASH 63
Local Ordinances and Use Restrictions 63
RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN 65
Mechanical Harvesting 68
General Requirements and Recommendations 68
Lower Phantom Lake 70
Upper Phantom Lake 74
Plant Offload and Disposal 75
Herbicide Treatment 77
Lower Phantom Lake 77
Upper Phantom Lake 78
DASH 79
Manual Control 80
Public Information and Education 80
RAPID RESPONSE PLAN 81
SUMMARY 81
APPENDIX A 83
REFERENCES 86

Table of Figures

Figure 1: Lower Phantom Lake Bathymetry 7
Figure 2: Upper Phantom Lake Bathymetry 7
Figure 3: Phantom Lakes Public Access 8
Figure 4: Mean Chlorophyll a Trophic Status Index (TSI) for Lower Phantom Lake........ 9
Figure 5: Mean Chlorophyll a Trophic Status Index (TSI) for Upper Phantom Lake........ 9
Figure 6: Lower Phantom Current Harvesting Lanes........ 10
Figure 7: Lower Phantom Current Harvesting Lanes - Small Harvester 10
Figure 8: Upper Phantom Lake Current Harvesting Map........ 11
Figure 9: Volume of Aquatic Plants Harvested from Phantom Lakes (2005 - 2022) 11
Figure 10: Phantom Lakes WDNR Designated Sensitive Areas........ 12
Figure 11: Rake Sampling Criteria 14
Figure 12: PI Survey Points on Lower Phantom Lake 16
Figure 13: Lower Phantom Plant Sampling Data Summary........ 16
Figure 14: Lower Phantom Lake Plant Species - August 2022........ 17
Figure 15: Lower Phantom Lake Plant Depth Distribution 18
Figure 16: Starry Stonewort in Lower Phantom Lake 19
Figure 17: Lower Phantom Lake - Common Bladderwort........ 20
Figure 18: Lower Phantom Lake - Muskgrass 21
Figure 19: Lower Phantom Lake - Spatterdock 22
Figure 20: Lower Phantom Lake - White Water Lily 23
Figure 21: Lower Phantom Lake - Sago Pondweed 24
Figure 22: Lower Phantom Lake - Coontail 25
Figure 23: Lower Phantom Lake - Clasping-leaf Pondweed........ 26
Figure 24: Lower Phantom Lake - Southern Wild Rice 27
Figure 25: Lower Phantom Lake - Purple Loosestrife *(INVASIVE)* 28
Figure 26: Lower Phantom Lake - Starry Stonewort *(INVASIVE)* 29
Figure 27: Lower Phantom Lake - Eurasian Water-milfoil *(INVASIVE)* 30
Figure 28: Lower Phantom Lake - Spiny Naiad *(INVASIVE)*........ 31
Figure 29: Lower Phantom Lake - Phragmites *(INVASIVE)*........ 32
Figure 30: Lower Phantom Lake - Curly-leaf Pondweed *(INVASIVE)*........ 33
Figure 31: Lower Phantom Lake - High Value and Quality Species........ 34
Figure 32: Floristic Quality Index for Lower Phantom Lake, 2017-2022........ 35
Figure 33: PI Survey Points on Upper Phantom Lake 36
Figure 34: Upper Phantom Plant Sampling Data Summary........ 37
Figure 35: Upper Phantom Lake Plant Species - September 2022........ 37
Figure 36: Upper Phantom Lake Plant Depth Distribution 38
Figure 37: Upper Phantom Lake - Sago Pondweed 39
Figure 38: Upper Phantom Lake - Spiny Naiad *(INVASIVE)*........ 40
Figure 39: Upper Phantom Lake - Muskgrass 41
Figure 40: Upper Phantom Lake - Wild Celery 42
Figure 41: Upper Phantom Lake - White Water Lily 43
Figure 42: Upper Phantom Lake - Clasping-leaf Pondweed........ 44

Figure 43: Upper Phantom Lake - Illinois Pondweed....................45
Figure 44: Upper Phantom Lake - Common Bladderwort....................46
Figure 45: Upper Phantom Lake - Purple Loosestrife *(INVASIVE)*....................47
Figure 46: Upper Phantom Lake - Eurasian Water-milfoil *(INVASIVE)*....................48
Figure 47: Upper Phantom Lake - High Value and Quality Species....................49
Figure 48: Floristic Quality Index for Upper Phantom Lake, 2017 – 2022....................50
Figure 49: Lower Phantom Lake PI Survey Statistics Comparison, 2017-2022....................50
Figure 50: Lower Phantom Lake PI Survey Species Comparison, 2017-2022....................51
Figure 51: Lower Phantom Lake – Largest Plant Changes by Percent....................52
Figure 52: Upper Phantom Lake PI Survey Statistics Comparison, 2017-2022....................53
Figure 53: Upper Phantom Lake PI Survey Species Comparison, 2017-2022....................54
Figure 54: Upper Phantom Lake – Largest Plant Changes by Percent....................55
Figure 55: Recommended Aquatic Plant Management Plan for Lower Phantom Lake....................66
Figure 56: Recommended Aquatic Plant Management Plan for Upper Phantom Lake....................67
Figure 57: Lower Phantom Lake Harvesting Comparison....................72
Figure 58: Upper Phantom Lake Harvesting Comparison....................75
Figure 59: Phantom Lakes Harvesting Disposal Routes....................76
Figure 60: Phantom Lakes Harvesting Disposal Site....................76
Figure 61: Lower Phantom Lake Starry Stonewort vs Sensitive Areas....................77
Figure 62: LPS vs WDNR Frequency of Occurrence - Lower Phantom Lake....................84
Figure 63: LPS vs WDNR Statistical Difference - Lower Phantom Lake....................85
Figure 64: LPS vs WDNR Frequency of Occurrence - Upper Phantom Lake....................85
Figure 65: LPS vs WDNR Statistical Difference - Upper Phantom Lake....................85

INTRODUCTION

The purpose of this update is to report the results of the 2022 point-intercept survey to describe the relative densities and species composition of the plant community of Lower and Upper Phantom Lake and compare it to the last Aquatic Plant Management (APM) Plan update, written by SEWRPC and approved in 2019. The Phantom Lakes Management District (PLMD) elected to begin this process a year early to address significant changes in the lakes over the past four years.

This plan outlines a strategy to implement an aquatic plant management program that will provide for recreational lake uses through nuisance and exotic species control. High quality plant communities which help promote water quality and provide fish and wildlife habitat should be protected from unnecessary negative impacts. Through review and comparison of past plant management data, a multi-faceted plant management strategy to optimize both conservation of aquatic resources and recreational value to all lake users can be developed.

It should be noted that this APM plan is an addendum to a previous comprehensive lake management plan and therefore does not address the history of the lake, watershed, recreational uses, robust water quality, land-use, and fish/wildlife.

Why is Lake Management Important?

Lake management plans are an integral part in summarizing available data to aid associations, districts, and local officials in making crucial management decisions. If you asked ten individuals about how to manage a lake, you would most likely get ten different answers. In most cases, the type of use each person is engaged in will heavily dictate their opinion. For example:

- Recreational use impairments due to a nuisance plant condition can lead to social pressures to "do something".
- Anglers who don't catch fish or can't boat through weed masses often push for action. The reverse is also true when a lack of plants influences fishing.
- Excessive algae growth may be aesthetically unpleasing.
- Lake users who can't get their boats out from the pier call for navigational relief.
- If a community wants to obtain grants to manage the nuisance conditions, a plan must be developed to analyze the specific conditions and possible management activities prior to grant approval.

Lake management is important in many other respects.

- There may be significant economic impacts arising from a nuisance aquatic vegetation problem. Lakes that are popular fishing destinations may see businesses suffer as tourists stay away. Residential property values can decline on lakes with severe plant problems. An Army Corps of Engineers study on Lake Guntersville, Alabama revealed that property values declined 17% due to an invasive species infestation (*Hydrilla*).

- It may be necessary to manage the lake to prevent the spread of the exotic species to other lakes. This is particularly important because prevention and public education are the most successful ways to minimize the spread of exotic species.
- Lakes with increased infestations of exotic species lose diversity and density of native species over time. As diversity declines, the entire food chain may be affected.
- Management of the nuisance may be the only way to bring the lake back into "balance".
- Exotic species can completely disrupt the natural processes in the lake. Native plants are low growing while exotic plants tend to form canopies. These canopies greatly influence light penetration into the lake thereby stunting native plants. Another major shift occurs when the exotic plant's canopy prevents the natural cooling effect that takes place in areas with native plant beds. When cooling and mixing cannot occur, the temperature near the surface increases.

Goals and Objectives

The goals and objectives for both Upper and Lower Phantom Lake continue to focus on balancing the various uses and needs while working to improve the long-term quality of the resource. The difficult task facing those who attempt to manage their lake is that user needs often conflict. Fish and wildlife need aquatic plants to thrive. Boaters and swimmers desire relief from nuisance aquatic plants. Those depending on the lake for “aesthetic viewing” desire an undisturbed lake surface.

The management of exotic plants, specifically, Eurasian water-milfoil (*Myriophyllum spicatum*), hybrid water milfoil, curly-leaf pondweed (*Potamogeton crispus*), starry stonewort (*Nitellopsis obtusa*) and excessive amounts of native plants continue to be a great concern to the District. The invasive exotic plants and very dense native plants restrict boating use in some areas of the lakes.

Phantom Lakes and the Mukwonago area in general have experienced tremendous growth and the amount of recreational use is greater than ever (as evidenced by the Town of Mukwonago Police Department in 2020 and 2021 summaries at PLMD Annual meetings). The primary boat launch was recently rebuilt in 2018/2019 and now features two launch lanes as opposed to one in previous years which has increased boat traffic. The tendency for power boats to pass kayaks and fisherman parked in narrow channels to avoid “going the long way around” has created hostility and safety issues, especially with the increasing number of lake users. The PLMD has identified an increasing need to increase transit and harvesting lanes to mitigate these emerging issues. They still acknowledge that controlling exotic plants, preventing new invasions of exotic species, and protecting diversity of the native plant population is crucial to the ecological balance of the resource.

The Phantom Lakes APM plan utilized input from multiple entities including the PLMD, riparian landowners, and the WDNR. The stated goals of the District are to:

- Effectively control the quantity and density of nuisance aquatic plant growth in targeted portions of the Lakes to enhance water-based recreational opportunities, improve community-perceived aesthetic values, and maintain or enhance the Lakes' natural resource value. This first goal is at the core of the early request to update the APM plan.

- Increase transit and harvesting lanes to mitigate increasing hostility and safety issues arising from increased recreational pressures related to the recent growth in the community and the expansion of the boat launch.

- Develop a strategy to monitor and limit the spread of invasive exotic plants by utilizing a multi-faceted approach.

- Manage the Lakes in an environmentally sensitive manner in conformance with requirements under Chapters NR103 (Water Quality Standards for Wetlands), NR107 (Aquatic Plant Management), and NR109 (Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations). Following these rules helps the District preserve and enhance the Lakes' water quality, biotic communities, habitat value, and their essential structure and relative function in relation to adjacent areas.

- Protect and maintain public health and promote public comfort, convenience, and welfare while safeguarding the Lakes' ecological health through environmentally sound management of vegetation, wildlife, fish, and other aquatic organisms in and around the Lakes.

- Promote a high-quality water-based experience for residents and visitors to the Lakes consistent with the policies and practices of the WDNR.

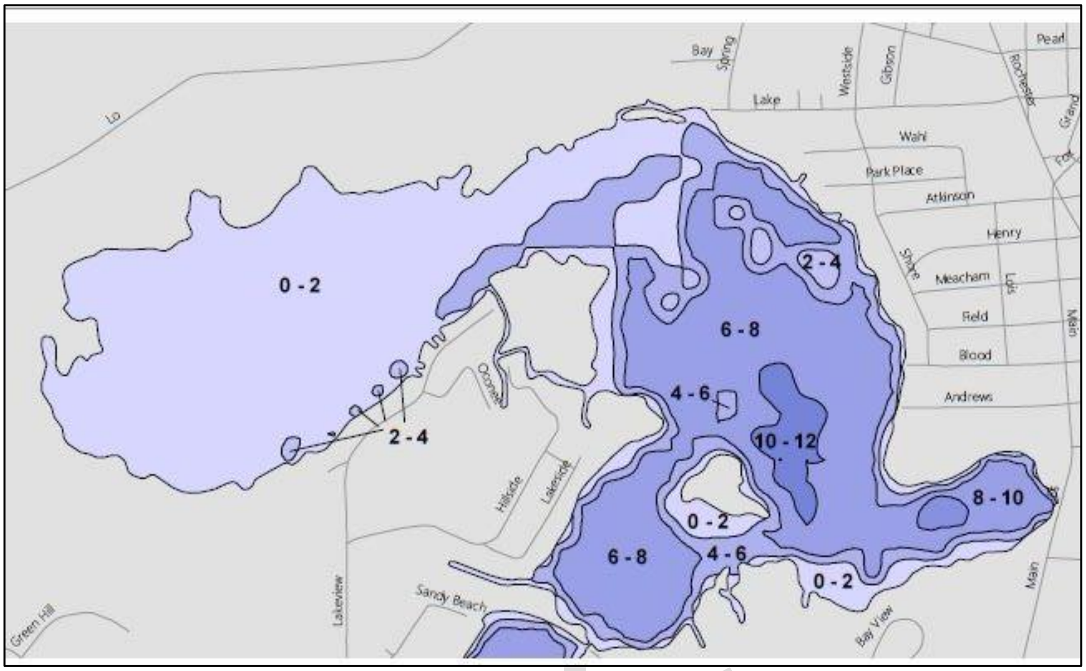
BACKGROUND

Waterbody Characteristics

Lower Phantom Lake is a 373-acre seepage lake locate in Waukesha County that was created by damming the Mukwonago River. It has a 12-foot max depth (located west of the boat launch) and 4-foot average depth. Vast portions (approx. 210-acres) of western Lower Phantom Lake are wetland/marsh areas. Upper Phantom Lake is a 110-acre seepage lake located in Waukesha County with a 29.5-foot max depth (located on the southwest end) and 11-foot average depth. There is a narrow 51-foot opening that connects Upper Phantom Lake to Lower Phantom Lake. Water level of both lakes are controlled by a dam which is located at the southeastern end of Lower Phantom Lake.

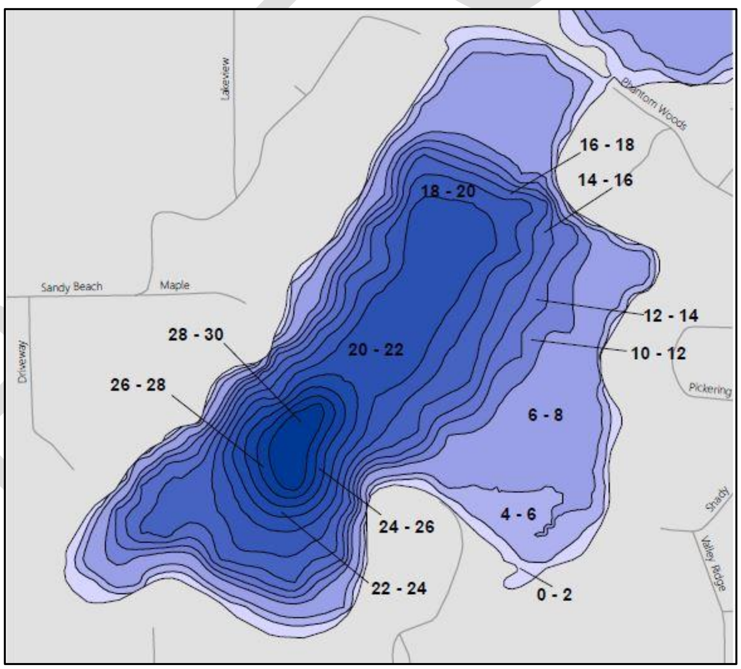
Bathymetry is commonly very old or completely lacking in many area lakes. We chose to present the bathymetry maps presented by SEWRPC in their 2019 APM Plan update since it is the most recent assessment. It should be noted that SEWRPC merged 2017 shallow water measurements with pre-existing bathymetric maps to produce the maps below.

Figure 1: Lower Phantom Lake Bathymetry



SOURCE: SEWRPC (2019)

Figure 2: Upper Phantom Lake Bathymetry



SOURCE: SEWRPC (2019)

Access

There is only one public boat launch between both lakes located on the south side of Andrews Street on the eastern end of Lower Phantom Lake in Phantom Glen Park (Figure 3). The access was recently updated in 2018/2019 with two launch lanes and has parking for thirteen trailered rigs as well as twenty-four spaces for vehicles only. There are also two carry-in sites with one located at the Highway I bridge and the other in the Town of Mukwonago Park at the end of Wahl Avenue. With only one public boat launch on the Lakes, it may provide a simple way to educate boaters via the Clean Boats, Clean Waters program and monitor the potential of aquatic invasive species spread. The PLMD will be participating in the CBCW program in the 2023 season after a 5-year hiatus.

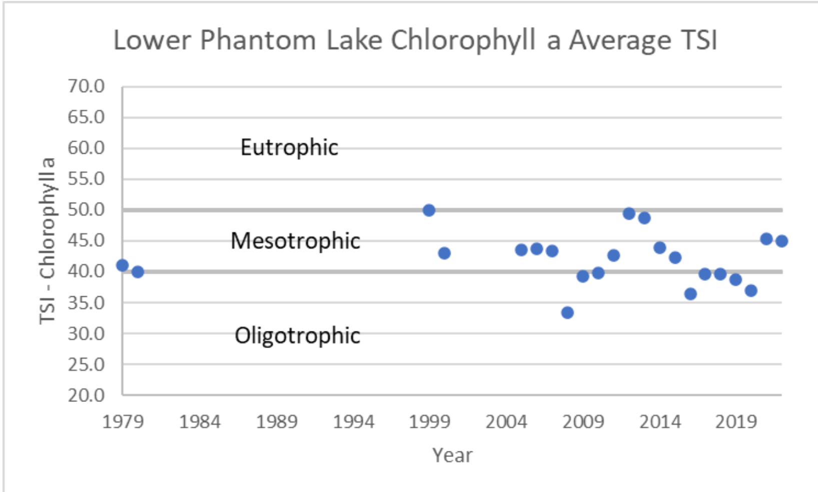
Figure 3: Phantom Lakes Public Access

SOURCE: Lake and Pond Solutions LLC (2023)

Water Quality Data

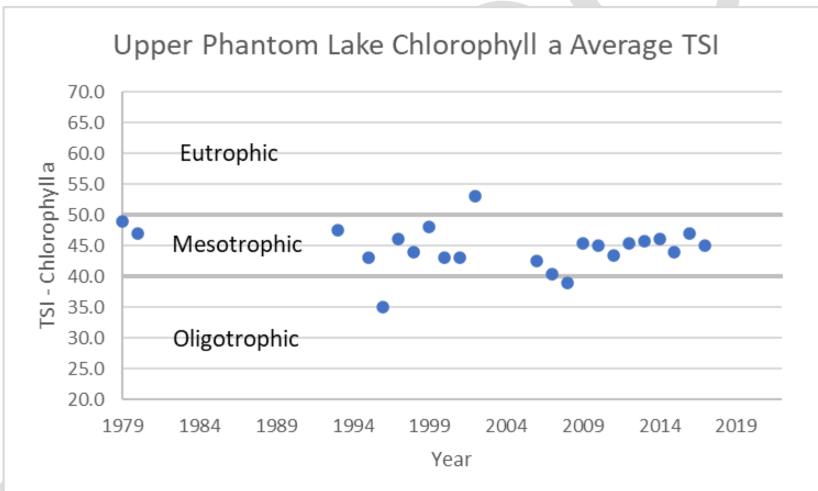
Phantom Lakes has water quality data available through the WDNR citizen lake monitoring program for Secchi Disk, Total Phosphorus, and Chlorophyll-a. These three metrics can each be used to generate a Trophic State Index (TSI) developed by Carlson (1977), which is used to analyze the trophic state of a water body (the quantity of living biomass in a waterbody at a given time). This can determine the likelihood of algal blooms that could cause impaired water clarity and potentially toxic blue-green algae (cyanobacteria). Figure 4 and Figure 5 depict the mean TSI for chlorophyll-a, shown to be a better predictor than the mean of all three. Over the past 43 years, Upper Phantom Lake has generally remained squarely in the mesotrophic category while Lower Phantom Lake has dipped in and out of the oligotrophic and mesotrophic categories. Mesotrophic lakes are characterized by moderately clear water and increasing probability of hypolimnetic anoxia in the summer (limited oxygen in the bottom portions).

Figure 4: Mean Chlorophyll a Trophic Status Index (TSI) for Lower Phantom Lake



SOURCE: Lake and Pond Solutions LLC and Citizen Lake Monitoring Network (2023)

Figure 5: Mean Chlorophyll a Trophic Status Index (TSI) for Upper Phantom Lake



SOURCE: Lake and Pond Solutions LLC and Citizen Lake Monitoring Network (2023)

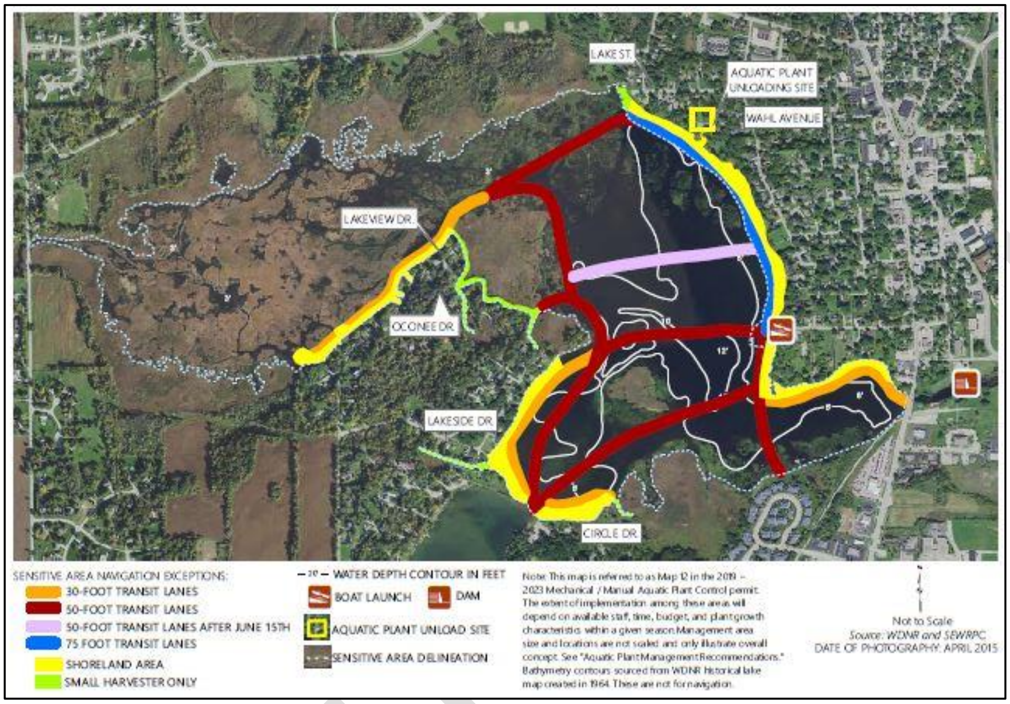
Historical Management

As identified in the 2017 APM Plan written by SEWRPC, aquatic plants have been controlled on Phantom Lakes since at least the 1950's – the earliest date that control program records were kept by State agencies.

Harvesting

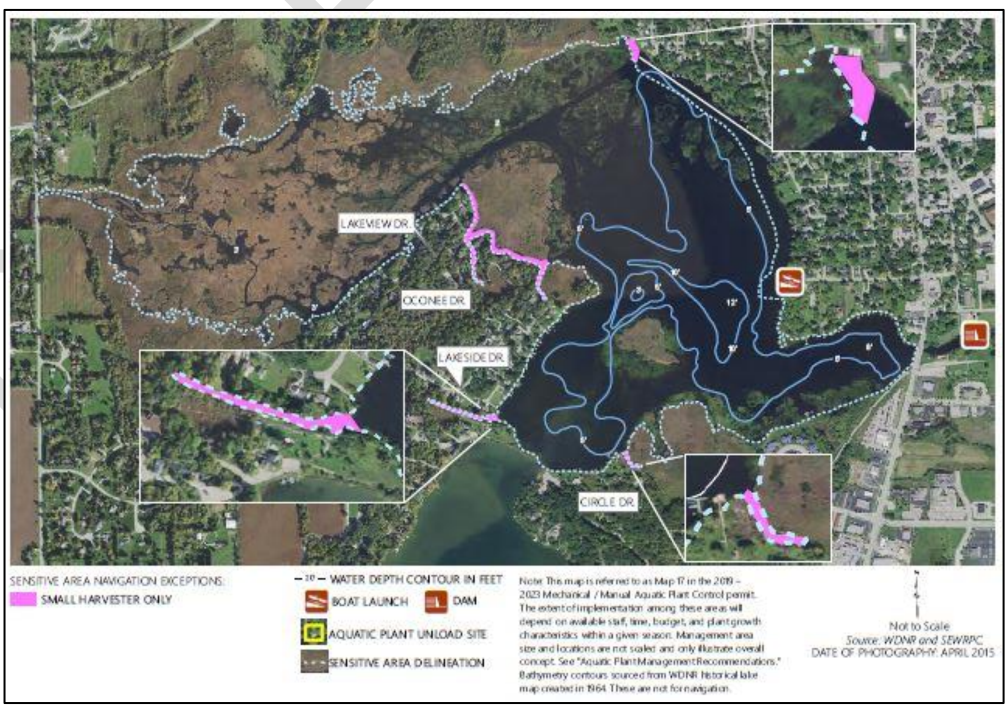
Since the mid-1980's, mechanical aquatic plant harvesting has been the primary control method used on the Lakes. The PLMD owns and operates a 1994 ILH800 (10' wide) harvester and a 2022 ILH7-450 (7' wide) harvester purchased in the summer of 2022. They also contract with Clearwater Plant Harvesters who operate a 5' wide harvester for smaller areas and channels. The harvesters run between 5-7 days per week and follow the current harvesting plan for approved lanes (see Figure 6, Figure 7, and Figure 8). The ILH800 has succumbed to many mechanical breakdowns which has limited the ability to harvest in the past and affected harvesting amounts (see Figure 9). The PLMD is currently in the process of applying for a grant to replace the ILH800.

Figure 6: Lower Phantom Current Harvesting Lanes



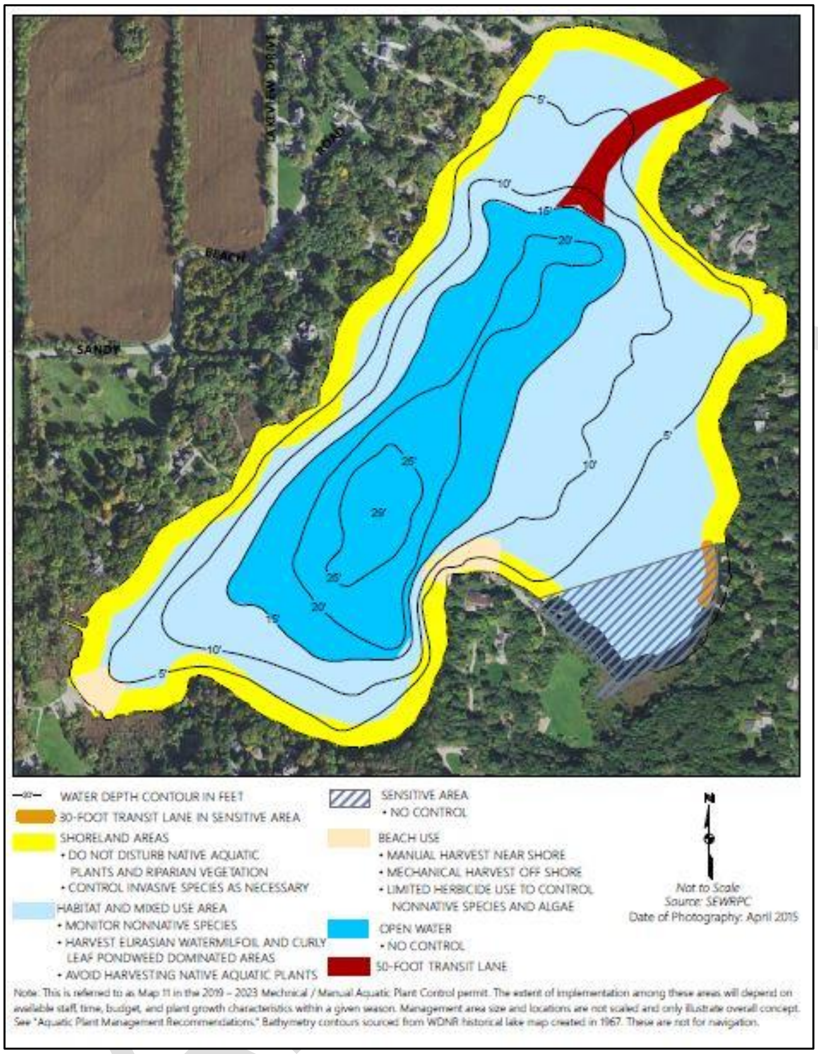
SOURCE: SEWRPC (2019)

Figure 7: Lower Phantom Current Harvesting Lanes - Small Harvester



SOURCE: SEWRPC (2019)

Figure 8: Upper Phantom Lake Current Harvesting Map



SOURCE: SEWRPC (2019)

Figure 9: Volume of Aquatic Plants Harvested from Phantom Lakes (2005 - 2022)

Year	Plant Material Removed (cubic yards)	Year	Plant Material Removed (cubic yards)
2005	1362	2014	Not Available
2006	4572	2015	6820
2007	6730	2016	19655
2008	7260	2017	16387
2009	10764	2018	16629
2010	9481	2019	Not Available
2011	10296	2020	Not Available
2012	10111	2021	2421
2013	9259	2022	8007

SOURCE: SEWRPC (2019). WDNR (2023), PLMD (2023)

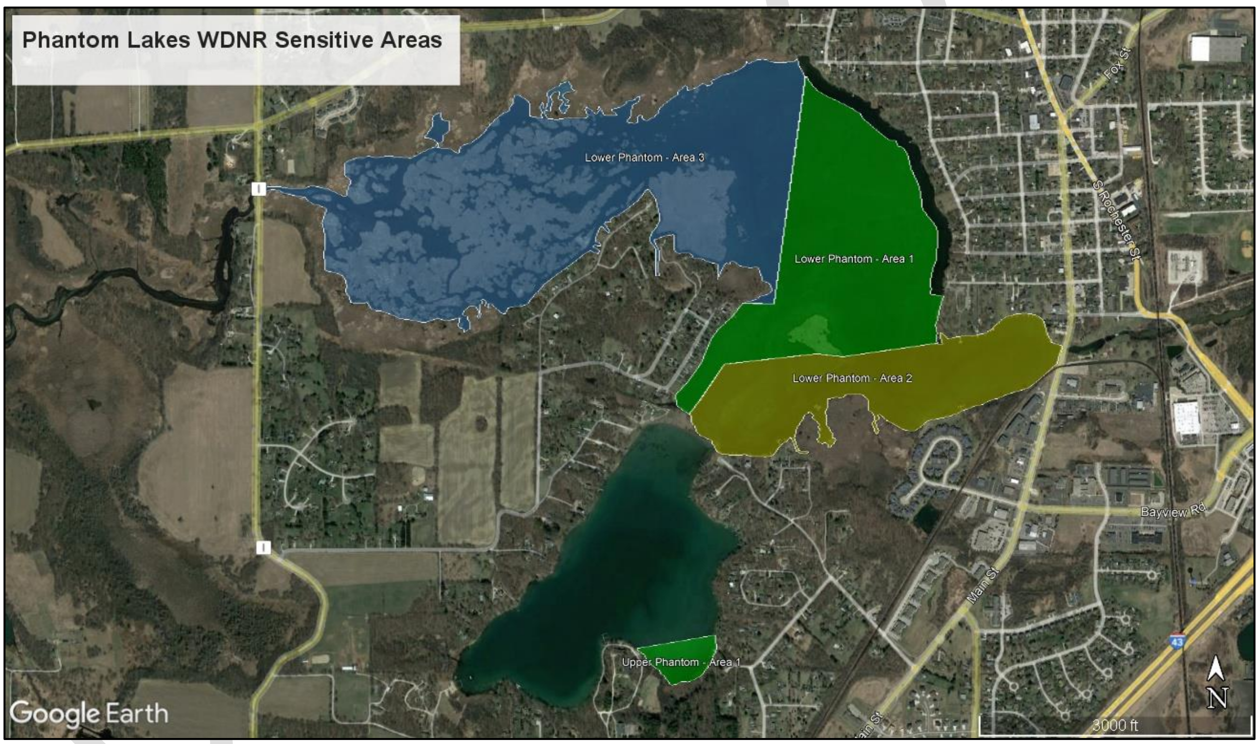
Other Management

No aquatic herbicides or algaecides are known to have been applied to the Lakes since 1975. Additionally, there have been no known Diver Assisted Suction Harvesting (DASH) projects.

WDNR Identified Sensitive Areas

The WDNR has identified one sensitive area in Upper Phantom Lake and three in Lower Phantom Lake (essentially most of this lake is considered sensitive). These designations were completed in 2006 with one modification in 2019, an exclusion of an area on the NE end of Lower Phantom Lake. Abbreviated management recommendations from the WDNR in their Phantom Lakes Integrated Sensitive Area Report are listed below. Lake and Pond Solutions, LLC generally opposes DNR viewpoints on restricting treatments around beach areas on the basis that most products have no swimming restrictions. Also, there is no commentary in the Report about providing fish lanes which we discuss further under Justification For a Harvesting Change.

Figure 10: Phantom Lakes WDNR Designated Sensitive Areas



SOURCE: WDNR. Map by Lake and Pond Solutions LLC

<u>Whole Lake Comments</u>

1. Native aquatic plant beds should be protected and <u>maintained</u>.
2. Prevent the spread of exotic species through sign postings, education, and <u>control exotic species where established</u>.

Upper Phantom Lake – Area 1

1. Selective chemical treatment on case-by-case basis for pioneer stands of non-native species.
2. No mechanical harvesting.
3. New piers allowed for riparian access.
4. Dredging, filling, plant screens, wetland alterations, boardwalks, pea gravel/sand blankets, and rip-rap all not allowed.
5. Littoral zone alteration is only allowed to improve fish habitat and shoreline disturbance is only allowed if there is an actively eroding shoreline.

Lower Phantom Lake – Area 1

1. Selective chemical treatment on case-by-case basis for pioneer stands of non-native species.
2. Mechanical harvesting must follow DNR approved plan and is restricted to navigation channels after fish spawning has concluded.
    a. Minimize native aquatic plant removal and concentrate on monotypic stands of Eurasian water-milfoil.
    b. No alteration of littoral zone except to improve fish habitat.
    c. Do not remove fallen trees along shoreline except where navigation is impaired.
3. New piers allowed for riparian access.
4. Dredging, pea gravel, and rip-rap will be permitted on a case-by-case basis.
5. Wetland filling, aquatic plant screens, wetland alterations, and boardwalks are not allowed.

Lower Phantom Lake – Area 2

1. Chemical treatment not recommended due to close proximities to Mukwonago River and swimming area.
2. Limited mechanical harvesting following management plan. Generally restricted to a navigational channel along the developed shoreline but only after spawning activities have concluded. One channel is allowed to provide ingress and egress to the condo pier off Bay View Circle.
    a. Minimize aquatic plant removal and concentrate on monotypic stands of Eurasian water-milfoil.
    b. No alteration of littoral zone except to improve fish habitat.
    c. Do not remove fallen trees along shoreline except where navigation is impaired.
3. New piers allowed for riparian access.
4. Dredging for navigation access and boardwalks to provide open water access on a case-by-case basis.
5. Pea Gravel and rip-rap are not recommended.
6. Filling of wetlands, aquatic plant screens, cutting large amounts of wetland vegetation, and rip-rap on undeveloped shorelines are not allowed.
7. Minimize swimming/wading area.
8. Implement a “No-Wake Zone” along undeveloped shoreline.

Lower Phantom Lake – Area 3 (Five Subsections)

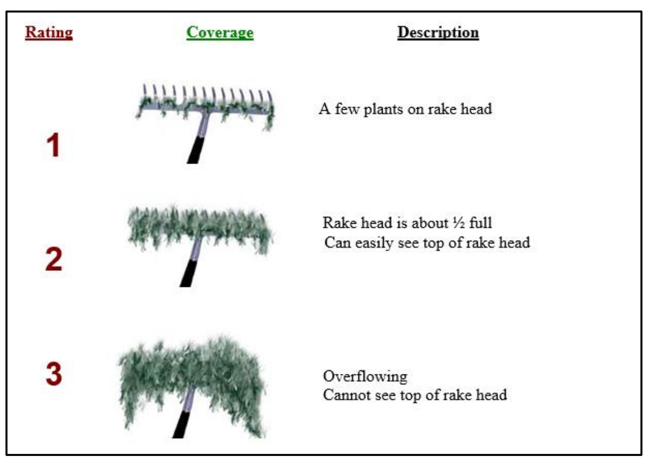
1. No chemical treatment allowed.
2. Mechanical harvesting is limited to one navigational channel along the developed shoreline out towards the main lake.
    a. Do not remove fallen trees along shoreline except where navigation is impaired.
3. Dredging for navigational access, boardwalks for riparian access, and rip-rap along Lakeview Dr only on a case-by-case basis. Dredging is also allowed to maintain the existing navigational channel along Lakeview Drive out to the main lake.
4. Filling of wetlands, aquatic plant screens, cutting large amounts of wetland vegetation, rip-rap on undeveloped shorelines, and pea gravel/sand blankets are not allowed.
5. New piers allowed along the developed shoreline (along Lakeview Dr.) to provide riparian access. New piers along undeveloped shoreline will not be permitted.
6. A "No-Wake" zone should be created.

RESULTS OF THE 2022 POINT INTERCEPT SURVEY

Methods

The 2021 aquatic plant survey was conducted using most of the guidelines adopted by the Wisconsin Department of Natural Resources (WDNR) for point-intercept survey methods. This method utilizes a grid system that accounts for the size and morphology of the lake. The WDNR established points were transferred to a Garmin GPSMAP 64st GPS unit before sampling. At each established point, a plant sample was taken using a double-headed rake on a 15' graduated pole which was rotated twice to gather plants. A double headed rake tied to a rope was used for sites with depths greater than 15' and dragged roughly three feet along the substrate to gather plants. Depths were recorded at each point by using the graduated pole in shallower areas and a Humminbird Helix 7 MSI GPS G3 sonar unit in deeper sections. The rake fullness was rated from one to three when plants were present on the rake (Figure 11). Data collection at each survey point included depth, substrate (when possible), total rake density, species present, species-specific densities, and visuals of species not collected. Shoreline vegetation (i.e. cattails, loosestrife, phragmites) were listed as a visual for the points nearest shore to encompass emergent species that most surveys miss. Frequency of occurrence, average rake fullness, total sites with vegetation, Simpson diversity index, maximum depth of plants, average native species per site, and species richness were calculated using this data.

Figure 11: Rake Sampling Criteria



SOURCE: WDNR

PLEASE NOTE: Although survey methods used by Lake and Pond Solutions, LLC are nearly identical to those of the WDNR, our interpretation of the data does vary. These differences are explained in APPENDIX A.

Lower Phantom Lake

Survey Summary

The 2022 survey conducted by Lake and Pond Solutions, LLC occurred on August 24th and 26th using the 494 pre-determined WDNR points (Figure 12). It should be noted that a significant portion of the points were omitted from the survey due to their location in an unnavigable marshy area in the NW quadrant of the lake. Of the 299 points sampled, 296 were found to have plants (99.0%). There were 42 species of plants identified and an average of 6.03 native species per vegetated site (including visuals). Over 87% of the sampled sites had a muck bottom which isn't surprising given the lake's history as a flooded river basin. The survey statistics can be found in Figure 13.

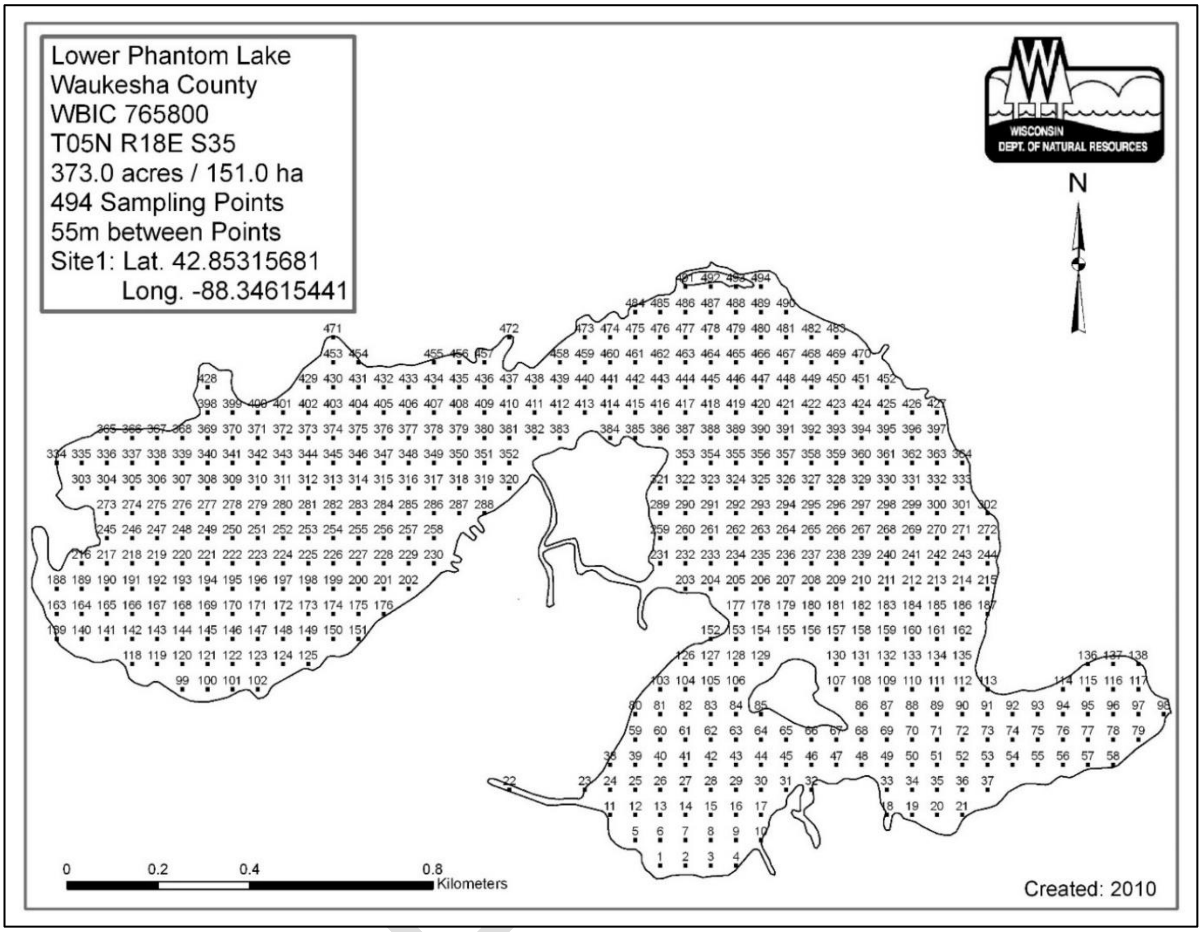
Plant Community

The forty-two different species of plants identified on Lower Phantom Lake are outlined in Figure 14 from highest to lowest frequency. Also shown is the overall frequency (percentage plant was found compared to all sites), relative frequency (percent plant was found compared to vegetated sites), average rake fullness, and C-value. The C-value is the estimated probability that a plant is likely to occur in a landscape that is believed to be relatively unchanged from before development. The C-value ranges from 0 – 10 with 10 being assigned to species most sensitive to disturbance.

The five most common native plant species ranked by relative frequency of occurrence were common bladderwort (*Ultricularia vulgaris*), muskgrass (*Chara sp.*), spatterdock (*Nuphar variegata*), white water lily (*Nymphaea odorata*), and sago pondweed (*Stuckenia pectinata*). The robust plant community really stands out in this survey as there were eleven species, all natives, found at over 20% relative frequency. One major concern for the PLMD and its lake users is the explosive growth of Southern wild rice (*Zizania aquatica*) which is impeding navigation at an alarming rate. Although beneficial, this plant wasn't identified in the previous survey but now can be found in over 35% of vegetated sites, ranking as the eighth most frequent species on the lake.

The depths that plants were found in the 2022 survey are listed in Figure 15. Seventy-four percent of the aquatic plant growth was found in 3' – 5' of water which demonstrates the feasibility and need for mechanical harvesting. Figure 17 - Figure 30 show the distribution of the top eight native species as well as the six invasive species found in Lower Phantom Lake (from most to least frequent).

Figure 12: PI Survey Points on Lower Phantom Lake



SOURCE: WDNR

Figure 13: Lower Phantom Plant Sampling Data Summary

Statistics Summary (including visuals)	August 2022
Total Number of Sites	494
Total number of sites with vegetation / All sites sampled	296/299 (99.0%)
Species Richness	42
Simpson Diversity Index	0.95
Maximum depth of plants (ft)	9.0
Average number of all species per site (veg. sites only) incl visuals	6.26
Average number of native species per site (veg. sites only) incl visuals	6.03
Number of sites with muck (M)	261
Number of sites with sand (S)	35
Number of sites with rock (R)	3
Number of Terrestrial sites	1
Number of Nonnavigable sites	192
Number of Temporary Obstacle sites	2

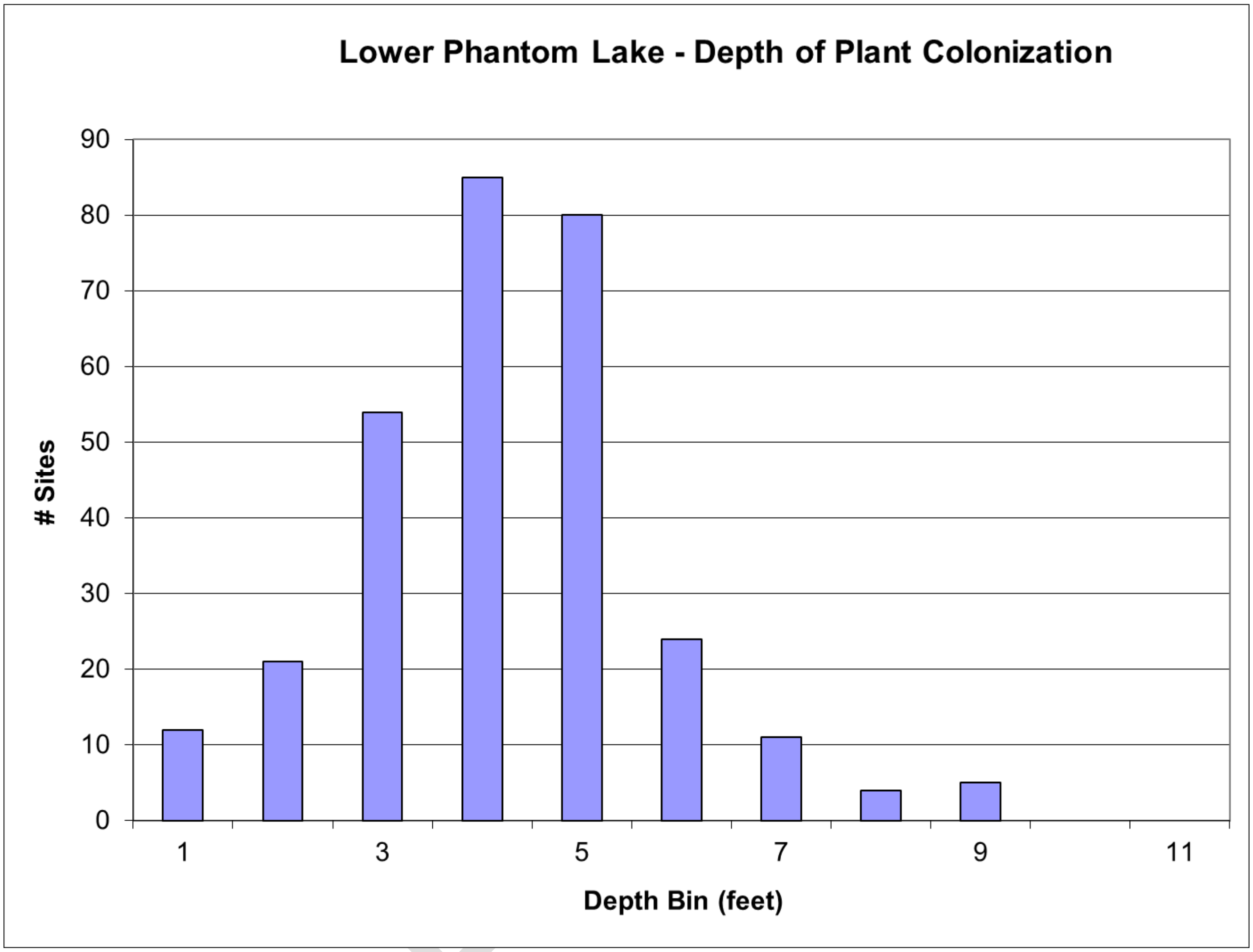
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 14: Lower Phantom Lake Plant Species - August 2022

Common Name	Scientific Name	Total Number of sites found (includes Visuals)	% Overall Frequency of Occurance (Includes Visuals)	% Relative Frequency of Occurance (Includes Visuals)	Average Density Rating	C-value
Common bladderwort	*Utricularia vulgaris*	169	56.52	57.09	1.21	**7**
Muskgrasses	*Chara sp.*	127	42.47	42.91	2.42	**7**
Spatterdock	*Nuphar variegata*	127	42.47	42.91	1.00	**6**
White water lily	*Nymphaea odorata*	120	40.13	40.54	1.00	**6**
Sago pondweed	*Stuckenia pectinata*	116	38.80	39.19	1.08	3
Coontail	*Ceratophyllum demersum*	110	36.79	37.16	1.36	3
Clasping-leaf pondweed	*Potamogeton richardsonii*	105	35.12	35.47	1.12	5
Southern wild rice	*Zizania aquatica*	105	35.12	35.47	1.24	8
Various-leaved water-milfoil	*Myriophyllum heterophyllum*	104	34.78	35.14	1.13	**7**
Wild celery	*Vallisneria americana*	80	26.76	27.03	1.02	6
Cattail	*Typha sp.*	67	22.41	22.64	V	1
Illinois pondweed	*Potamogeton illinoensis*	60	20.07	20.27	1.06	6
Common waterweed	*Elodea canadensis*	46	15.38	15.54	1.08	3
Swamp loosestrife	*Decodon verticillatus*	46	15.38	15.54	V	n/a
Slender naiad	*Najas flexilis*	44	14.72	14.86	1.03	**6**
Purple loosestrife	*Lythrum salicaria*	40	13.38	13.51	V	Invasive
Common watermeal	*Wolffia columbiana*	39	13.04	13.18	1.00	5
Arum-leaved arrowhead	*Sagittaria cuneata*	38	12.71	12.84	1.00	**7**
Flat-stem pondweed	*Potamogeton zosteriformis*	36	12.04	12.16	1.00	**6**
Small duckweed	*Lemna minor*	35	11.71	11.82	1.00	4
Starry Stonewort	*Nitellopsis obtusa*	35	11.71	11.82	1.69	Invasive
Floating-leaf pondweed	*Potamogeton natans*	23	7.69	7.77	1.25	5
Orange Jewelweed	*Impatiens capensis*	20	6.69	6.76	V	n/a
Variable pondweed	*Potamogeton gramineus*	18	6.02	6.08	1.00	**7**
Eurasian water-milfoil	*Myriophyllum spicatum*	15	5.02	5.07	1.00	Invasive
Spiny naiad	*Najas marina*	13	4.35	4.39	1.30	Invasive
Water star-grass	*Heteranthera dubia*	12	4.01	4.05	1.29	**6**
Northern water-milfoil	*Myriophyllum sibiricum*	10	3.34	3.38	1.00	**6**
White-stem pondweed	*Potamogeton praelongus*	9	3.01	3.04	1.00	8
Fries' pondweed	*Potamogeton friesii*	8	2.68	2.70	1.00	**8**
Forked duckweed	*Lemna trisulca*	7	2.34	2.36	1.00	**6**
Common arrowhead	*Sagittaria latifolia*	6	2.01	2.03	V	3
Common reed	*Phragmites australis*	5	1.67	1.69	V	Invasive
Hardstem bulrush	*Schoenoplectus acutus*	5	1.67	1.69	V	**6**
Sessile-fruited arrowhead	*Sagittaria rigida*	5	1.67	1.69	V	**8**
Water smartweed	*Polygonum amphibium*	5	1.67	1.69	V	5
Large-leaf pondweed	*Potamogeton amplifolius*	4	1.34	1.35	V	7
Nitella	*Nitella sp.*	3	1.00	1.01	1.00	**7**
Curly-leaf pondweed	*Potamogeton crispus*	2	0.67	0.68	1.00	Invasive
Large duckweed	*Spirodela polyrhiza*	2	0.67	0.68	V	5
Leafy pondweed	*Potamogeton foliosus*	1	0.33	0.34	V	**6**
Small bladderwort	*Utricularia minor*	1	0.33	0.34	V	**10**

SOURCE: Lake and Pond Solutions LLC (2023)

Figure 15: Lower Phantom Lake Plant Depth Distribution



SOURCE: Lake and Pond Solutions LLC (2023)

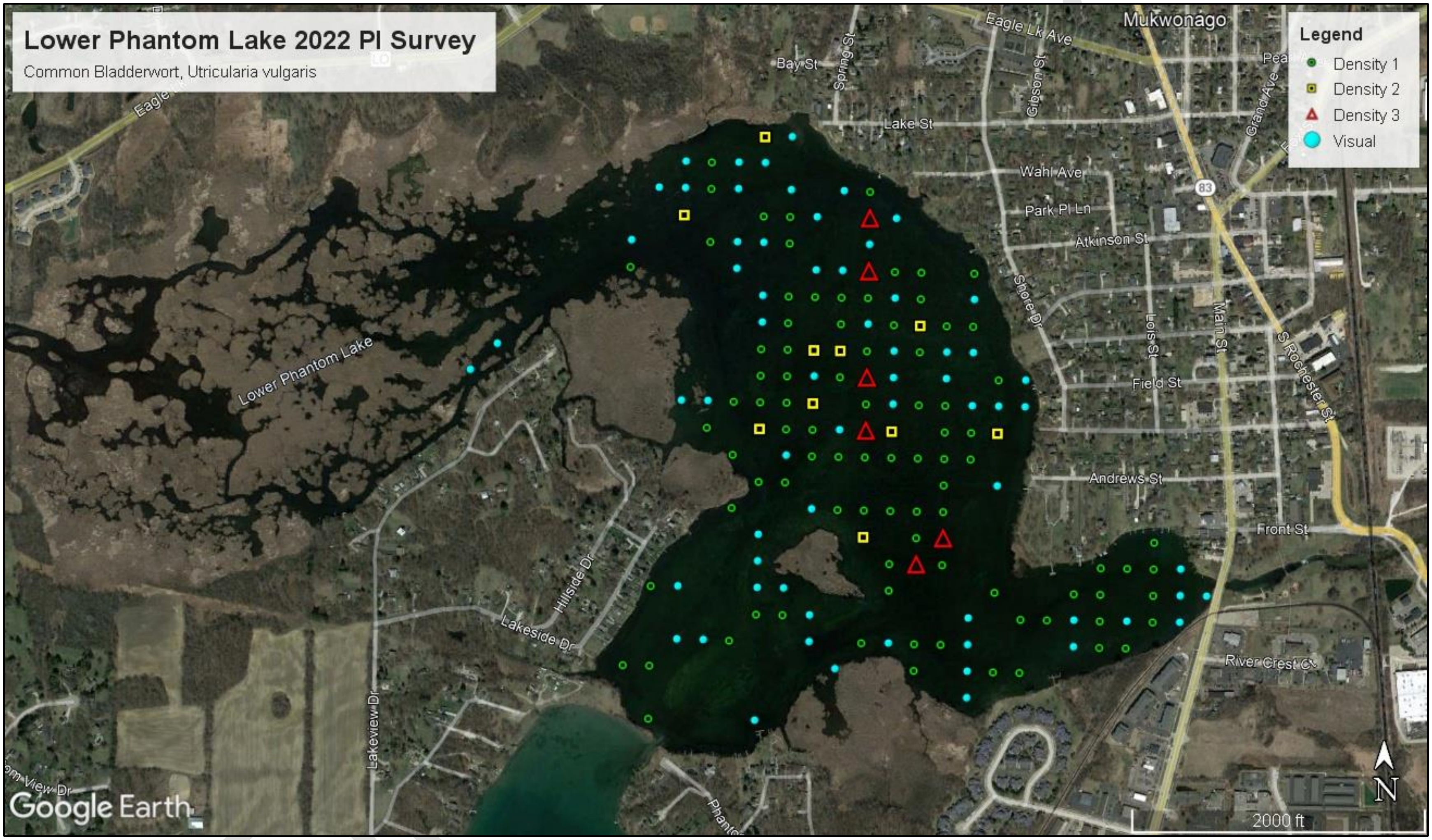
Invasive Species

Six invasive species were identified in the survey including purple loosestrife (*Lythrum salicaria*), starry stonewort (*Nitellopsis obtusa*), Eurasian water-milfoil (*Myriophyllum spicatum*), spiny naiad (*Najas marina*), common reed (*Phragmites australis*), and curly-leaf pondweed (*Potamogeton crispus*). Distribution maps can be found in Figure 25 - Figure 30. The last four species in that list were only found in less than 5% of vegetated sites which might show that native plant communities present in the lake are able to resist aggressive spread. The most concerning element though was the discovery of starry stonewort which is already occupying nearly 12% of all vegetated sites. This invasive alga doesn’t seem to be phased by the robust native plant community and has the potential to significantly increase its range throughout the entire lake. During our survey, we documented the detriments of this plant-like alga firsthand. Figure 16 shows an area where starry stonewort has crowded out a diverse area of native plant species. Notice the monotypic stand of starry stonewort while a rake thrown outside the bed resulted in 12 different species of native plants.

Figure 16: Starry Stonewort in Lower Phantom Lake

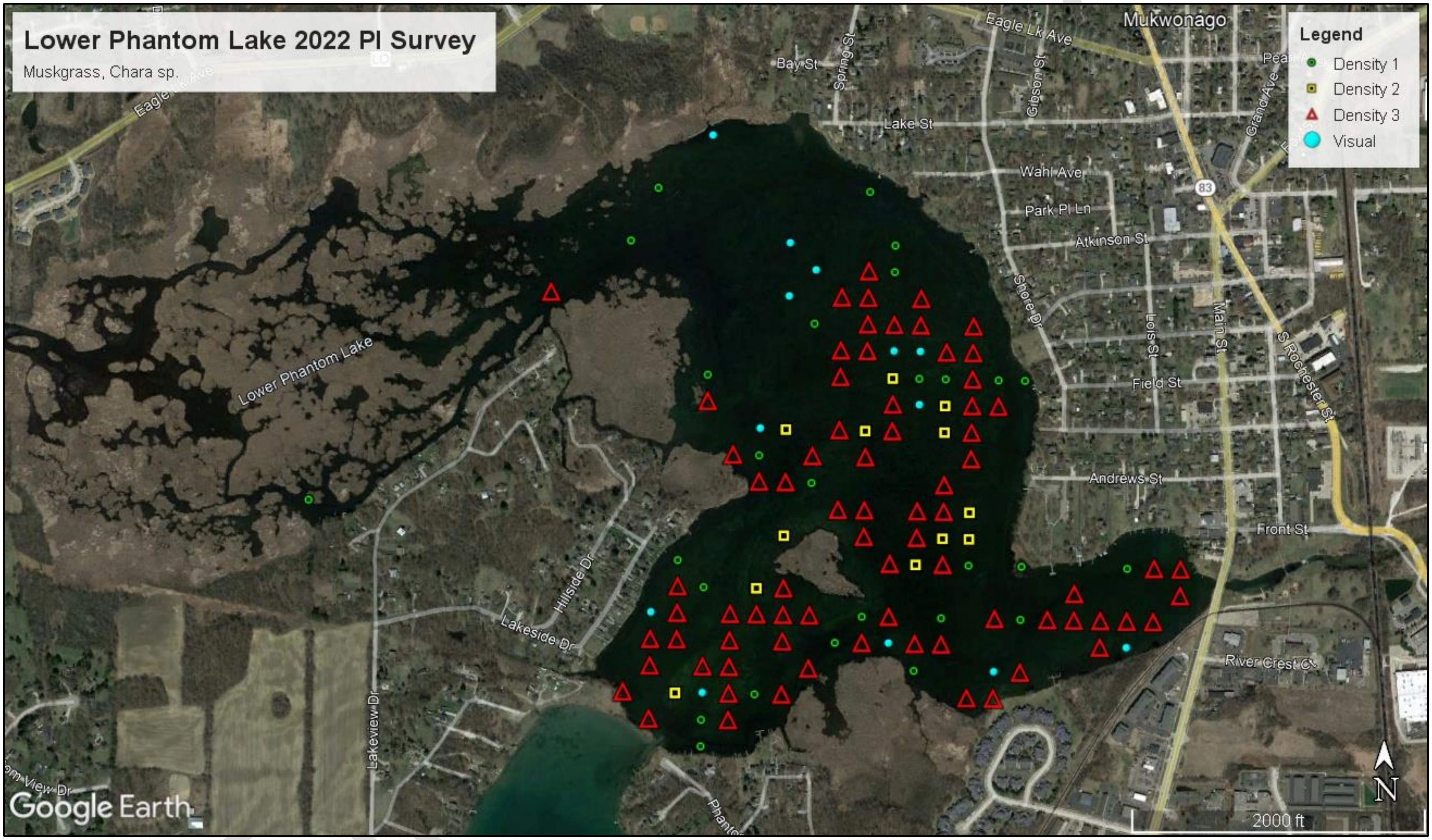
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 17: Lower Phantom Lake - Common Bladderwort



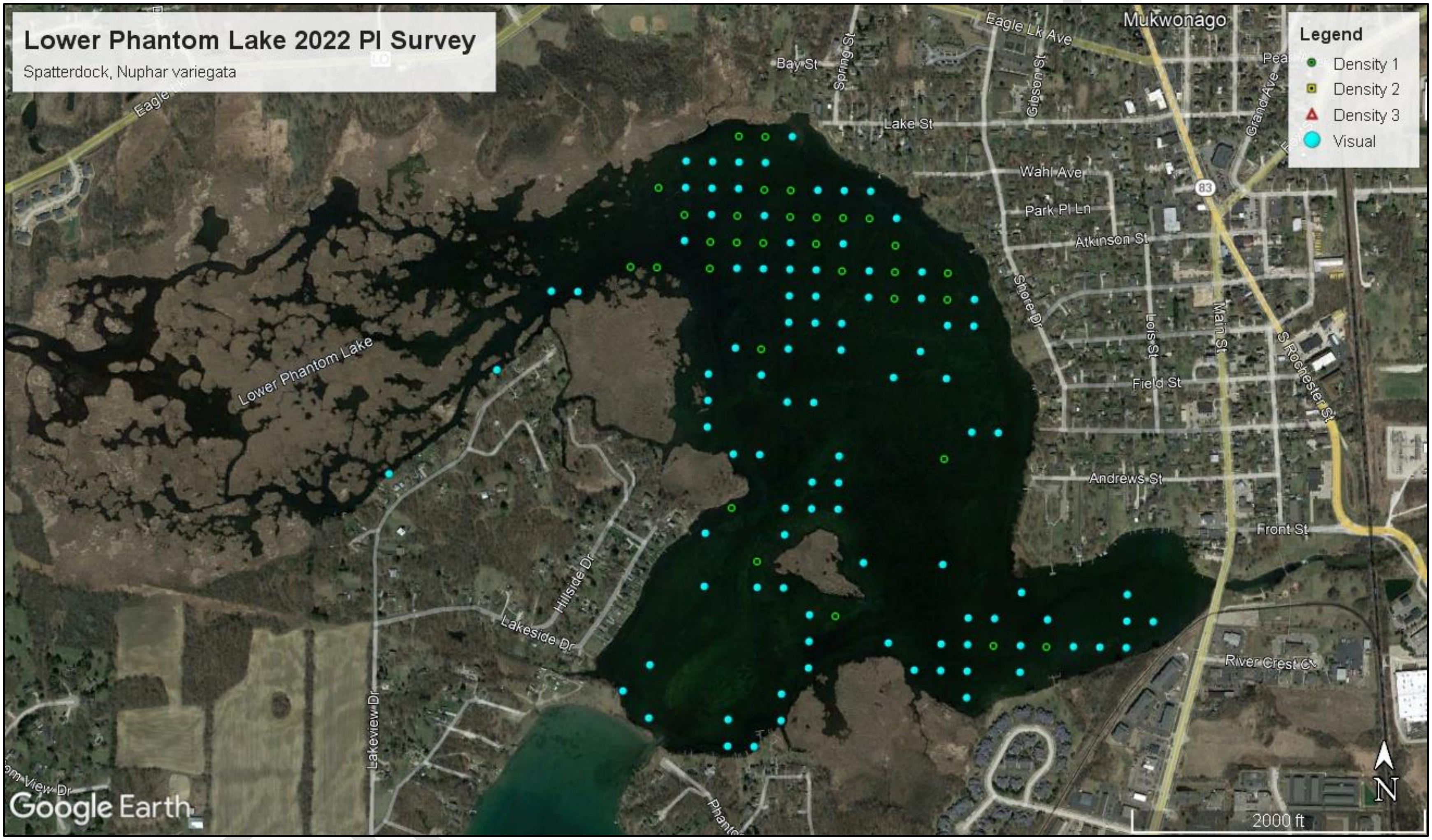
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 18: Lower Phantom Lake - Muskgrass



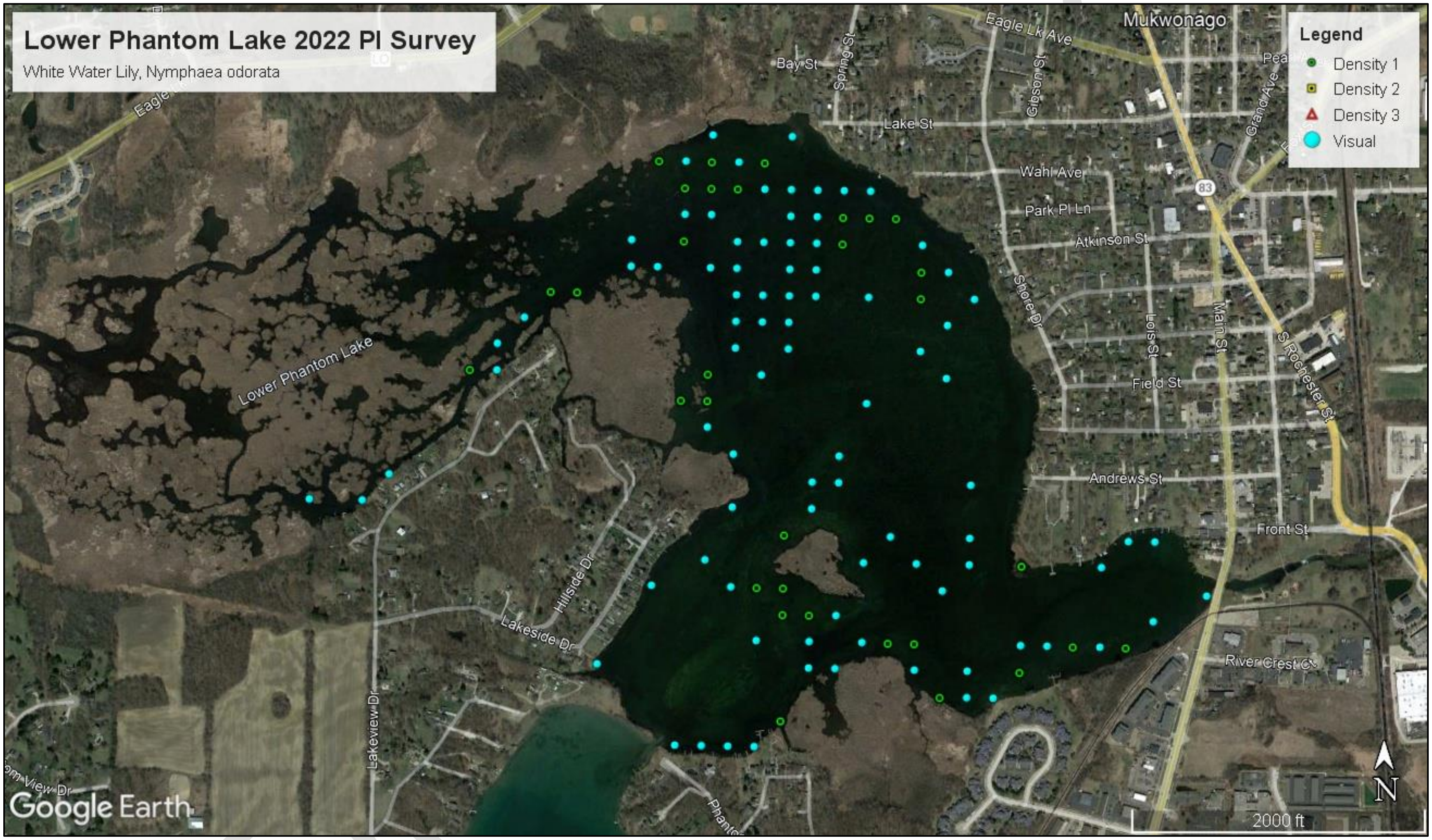
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 19: Lower Phantom Lake - Spatterdock



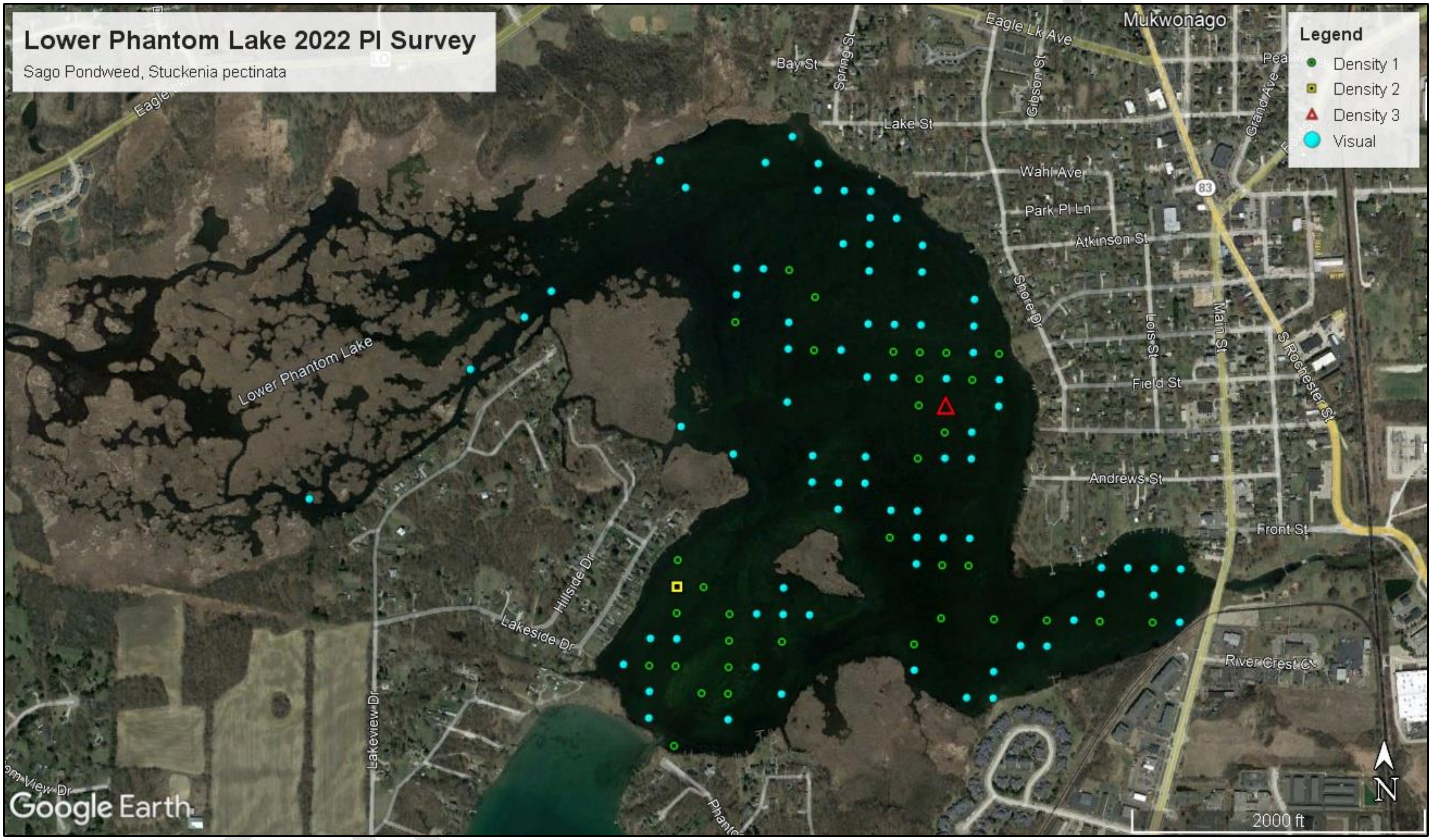
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 20: Lower Phantom Lake - White Water Lily



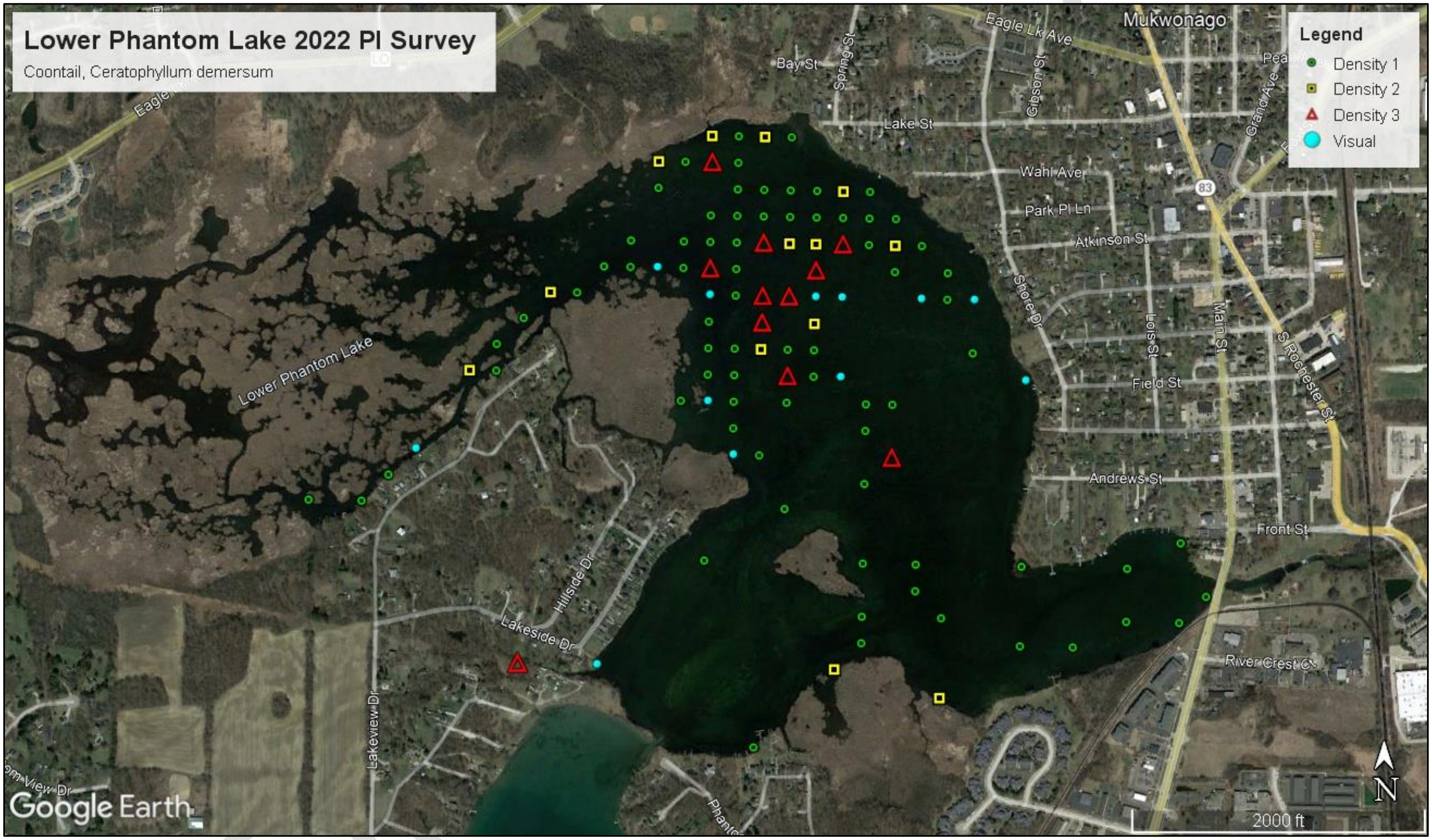
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 21: Lower Phantom Lake - Sago Pondweed



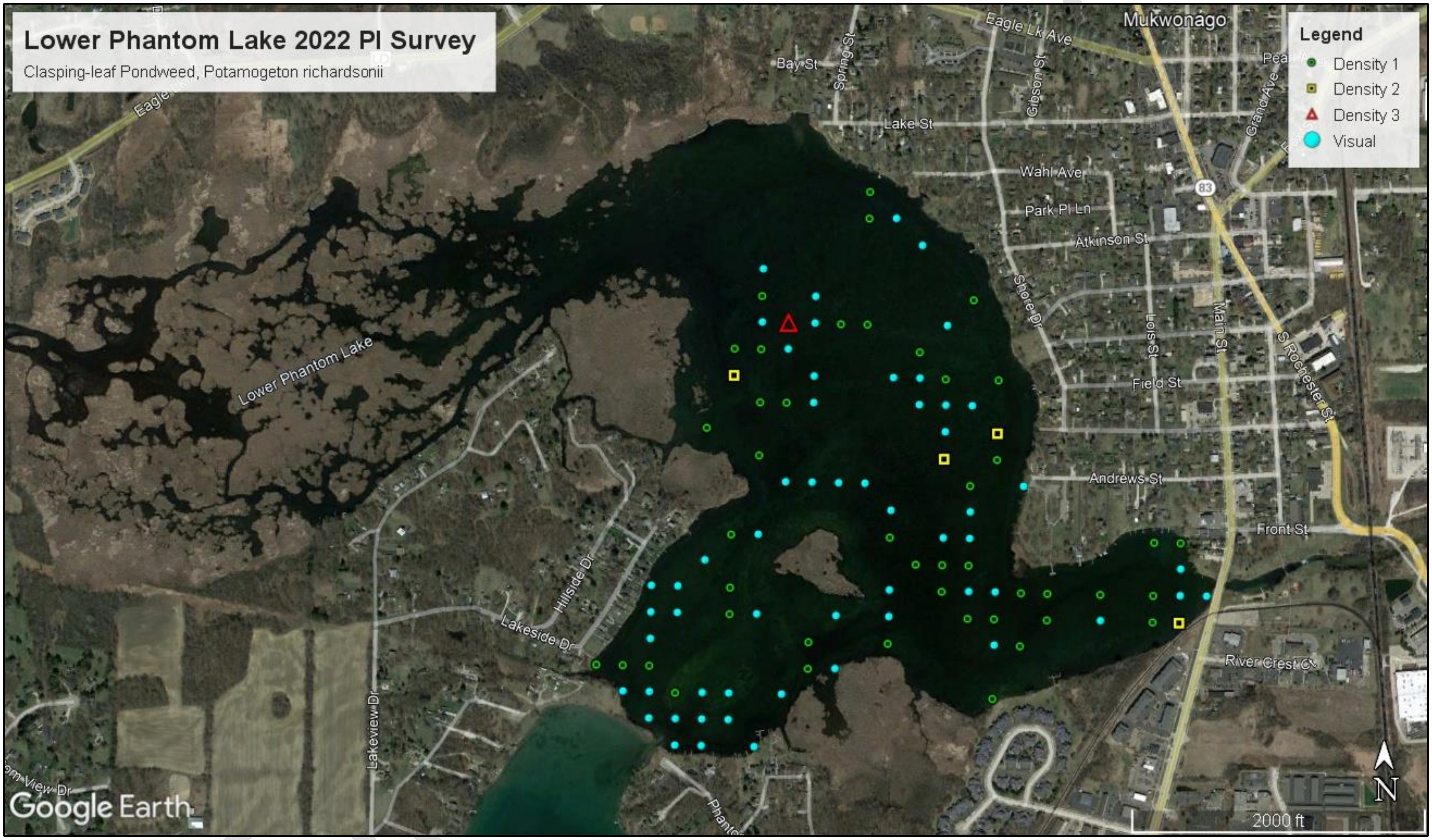
Lake and Pond Solutions LLC (2023)

Figure 22: Lower Phantom Lake - Coontail



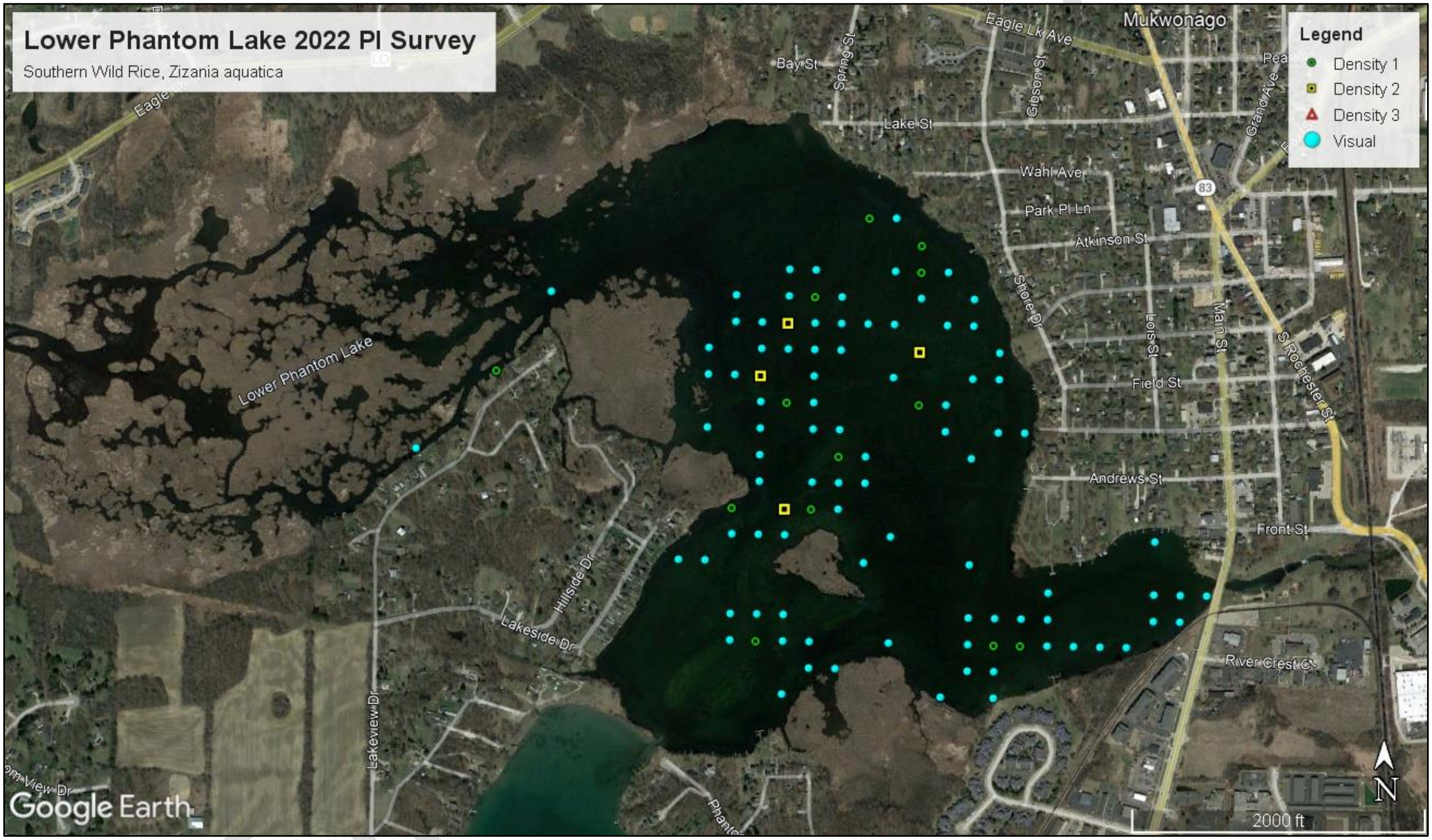
Lake and Pond Solutions LLC (2023)

Figure 23: Lower Phantom Lake - Clasping-leaf Pondweed



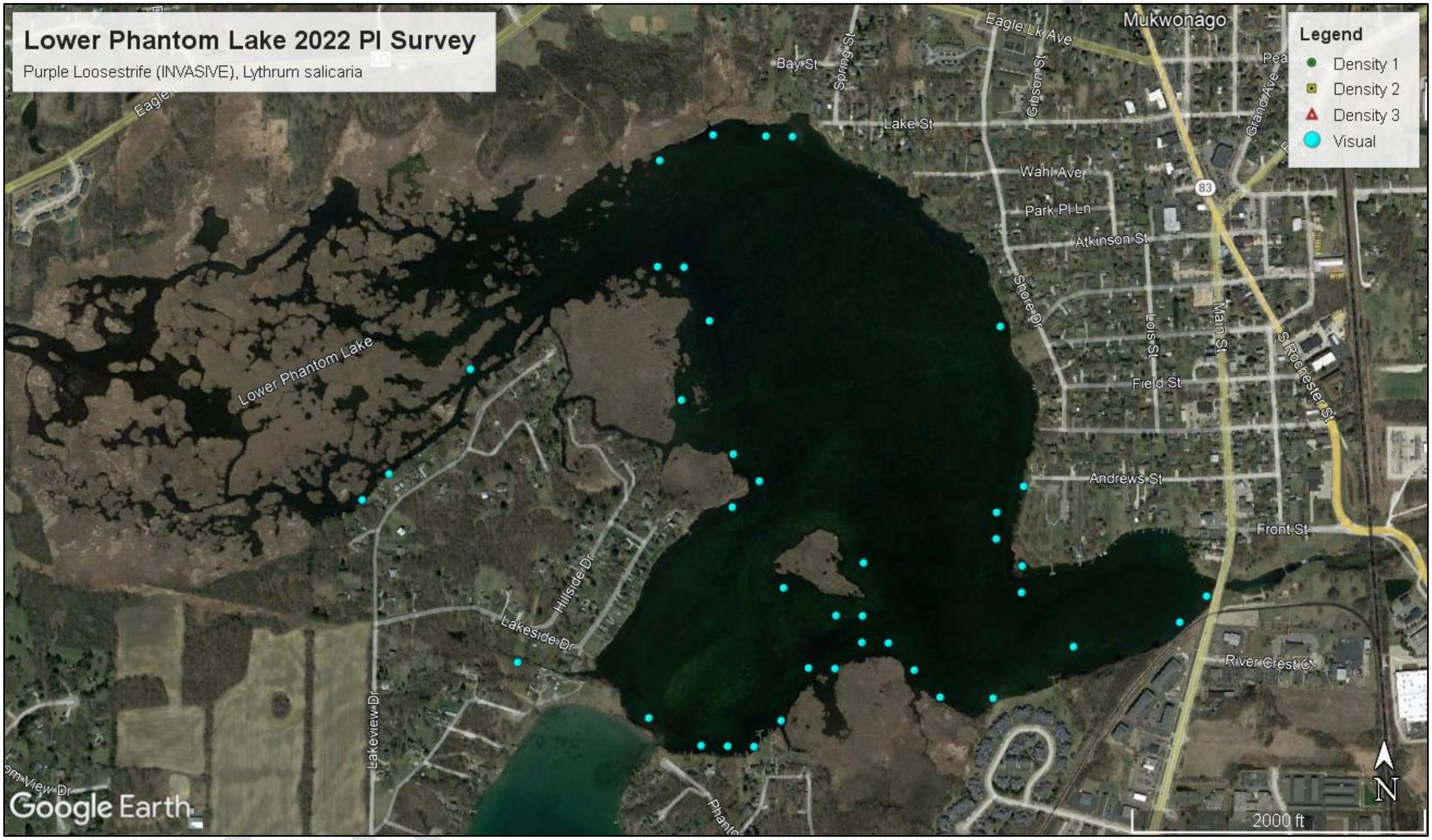
Lake and Pond Solutions LLC (2023)

Figure 24: Lower Phantom Lake - Southern Wild Rice



Lake and Pond Solutions LLC (2023)

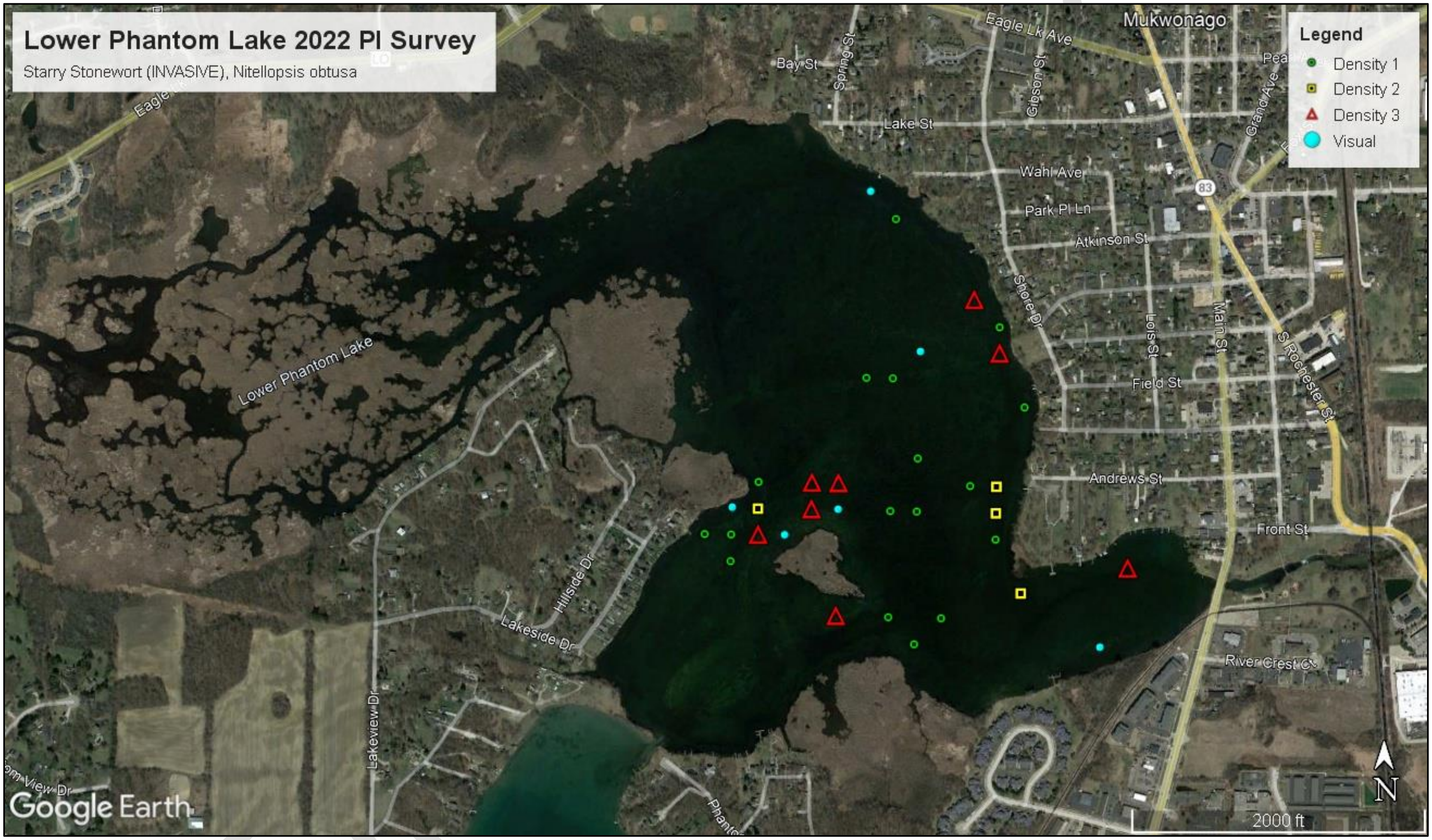
Figure 25: Lower Phantom Lake - Purple Loosestrife ***(INVASIVE)***



SOURCE: Lake and Pond Solutions LLC (2023)

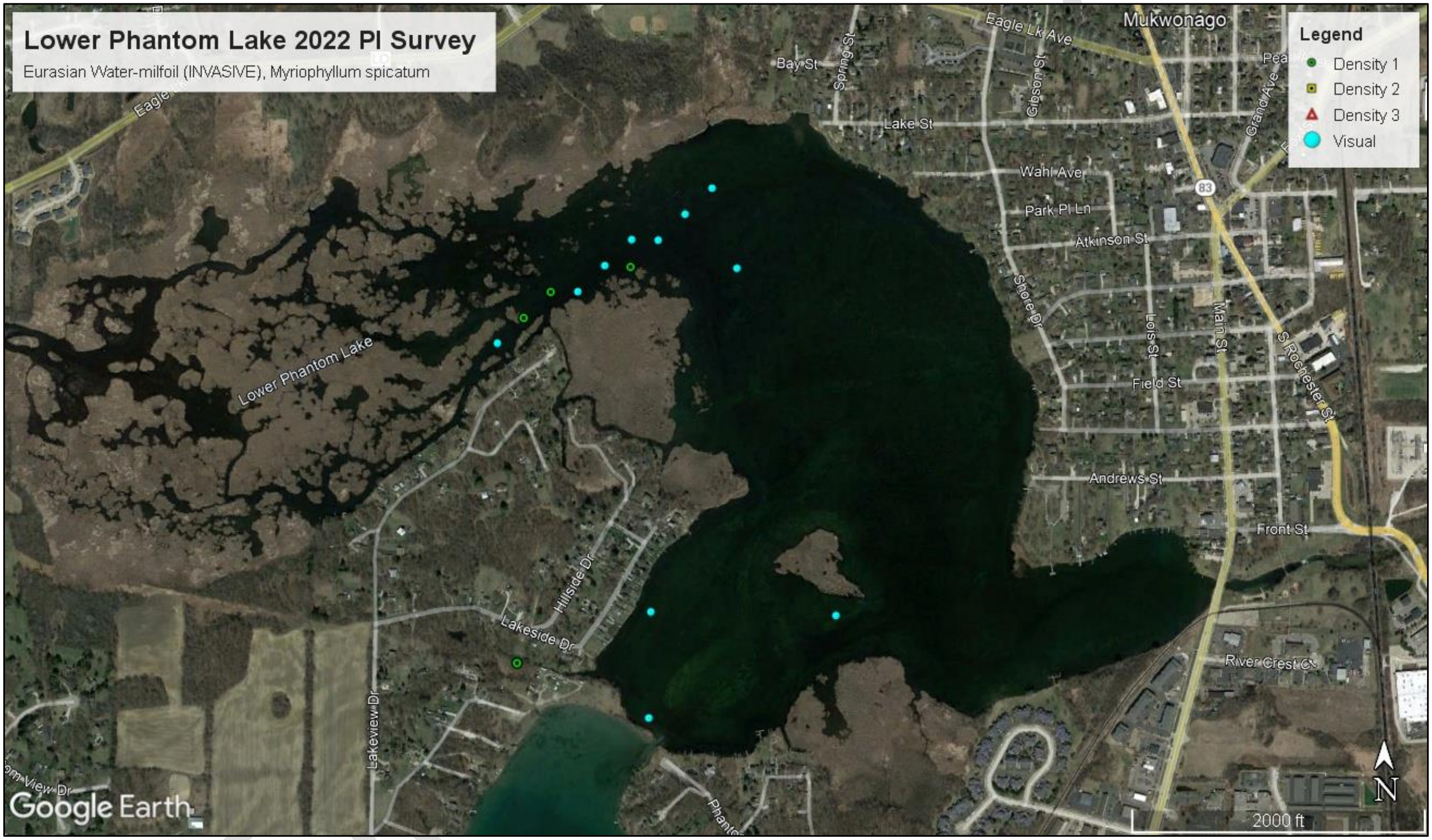
**Points on map do not show the exact location of Purple Loosestrife. Instead, they represent the closest point to an onshore visual sighting.*

Figure 26: Lower Phantom Lake - Starry Stonewort *(INVASIVE)*



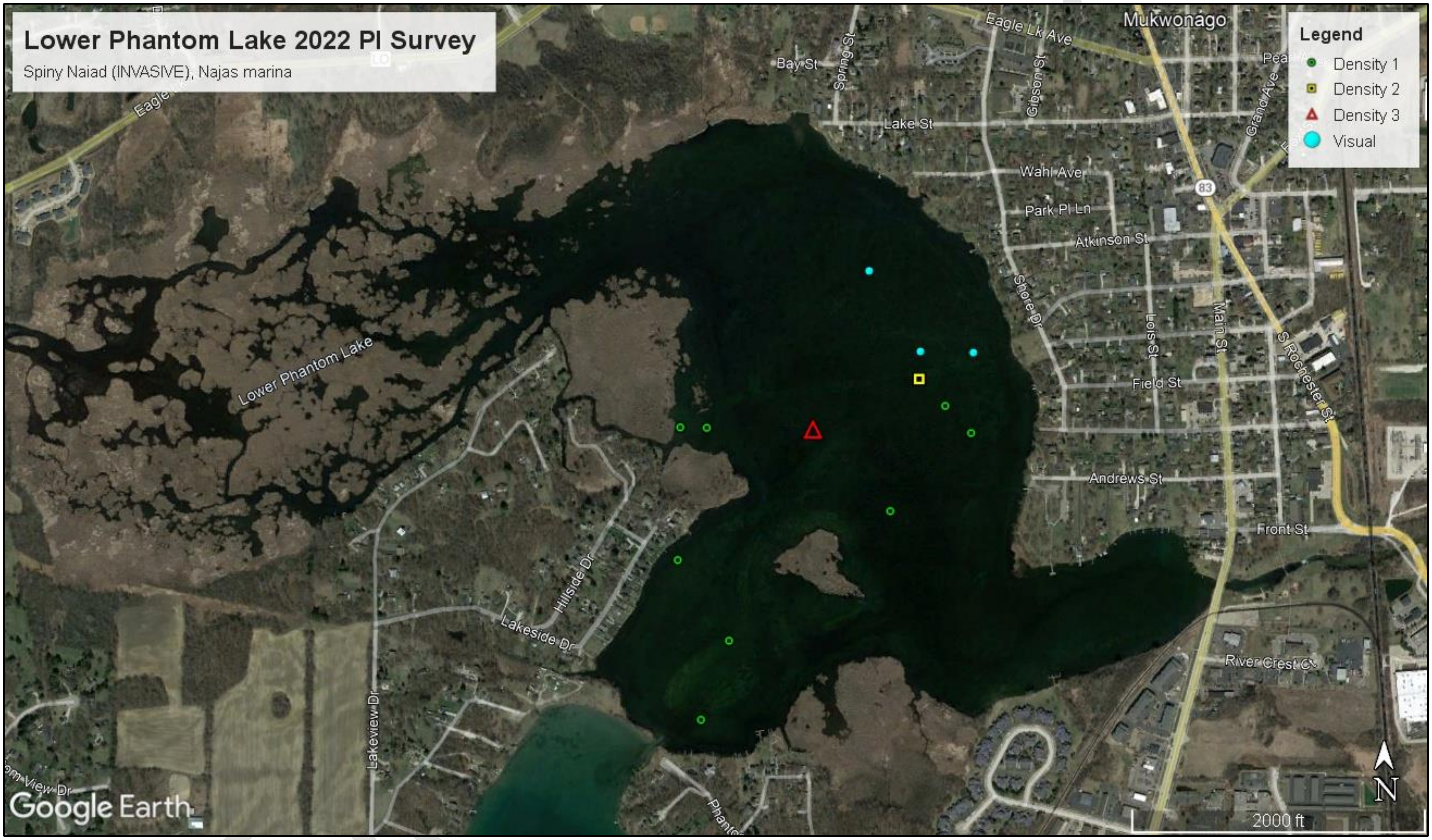
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 27: Lower Phantom Lake - Eurasian Water-milfoil *(INVASIVE)*



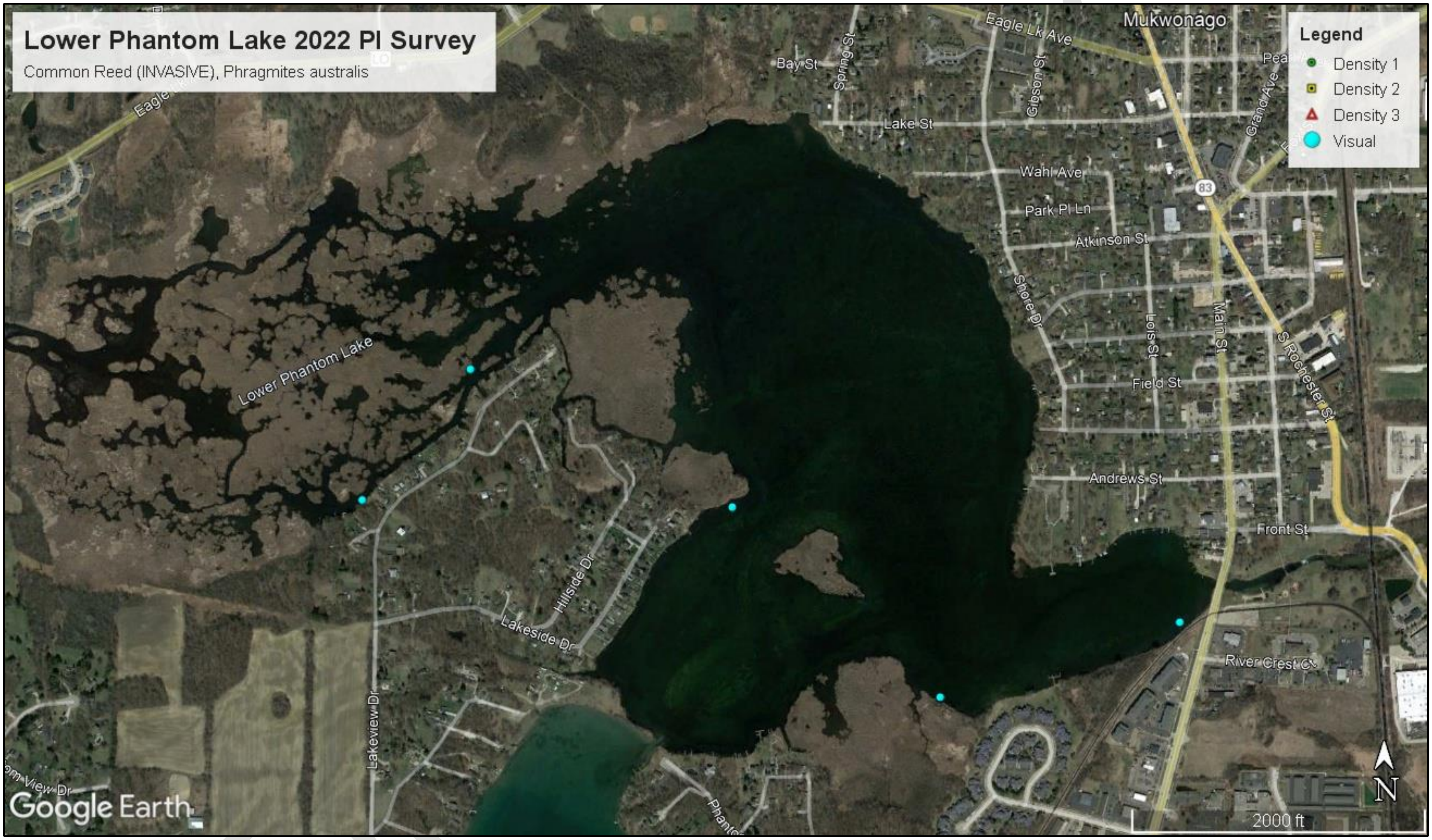
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 28: Lower Phantom Lake - Spiny Naiad *(INVASIVE)*



SOURCE: Lake and Pond Solutions LLC (2023)

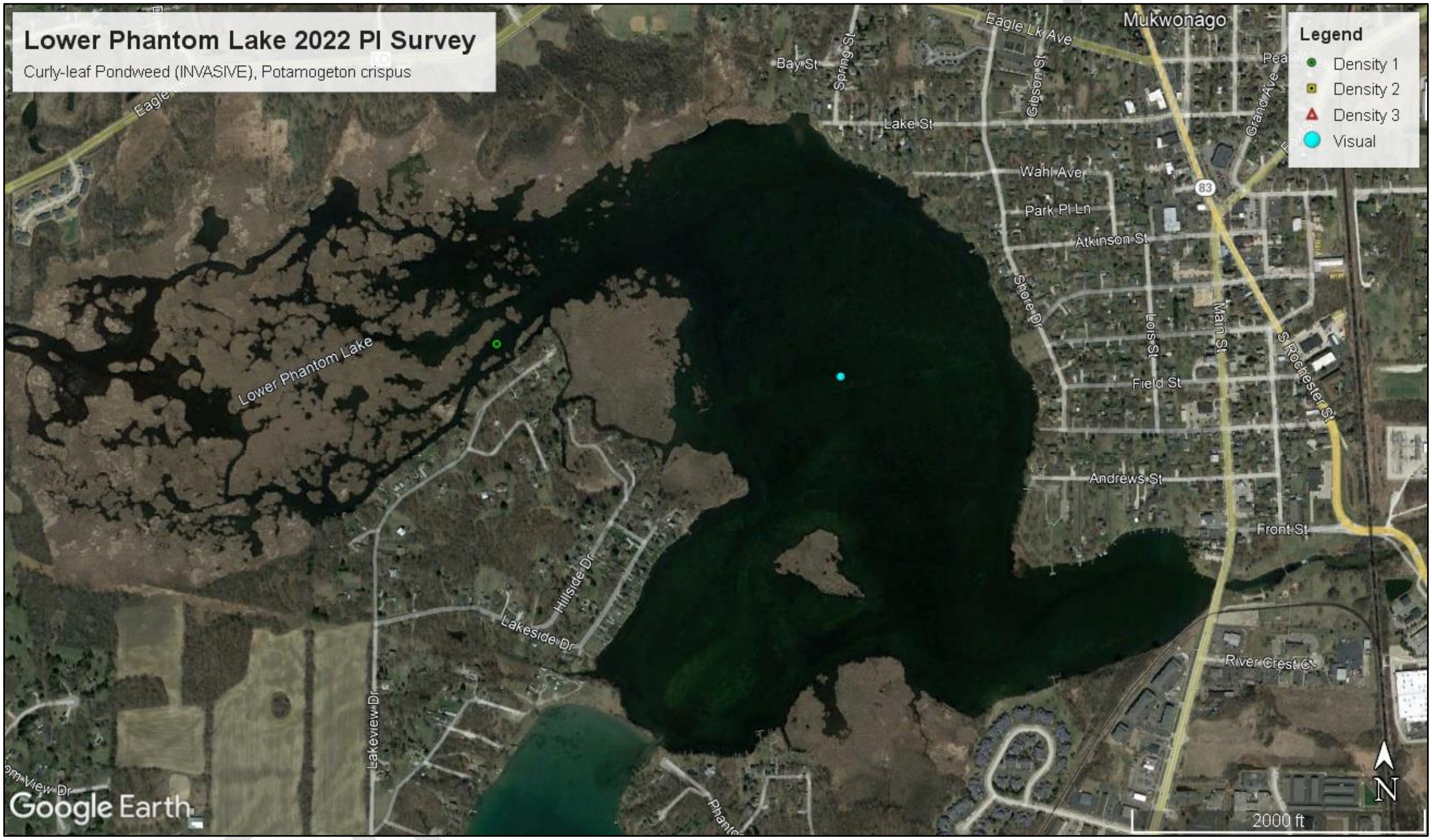
Figure 29: Lower Phantom Lake - Phragmites *(INVASIVE)*



SOURCE: Lake and Pond Solutions LLC (2023)

**Points on map do not show the exact location of Phragmites. Instead, they represent the closest point to an onshore visual sighting.*

Figure 30: Lower Phantom Lake - Curly-leaf Pondweed *(INVASIVE)*

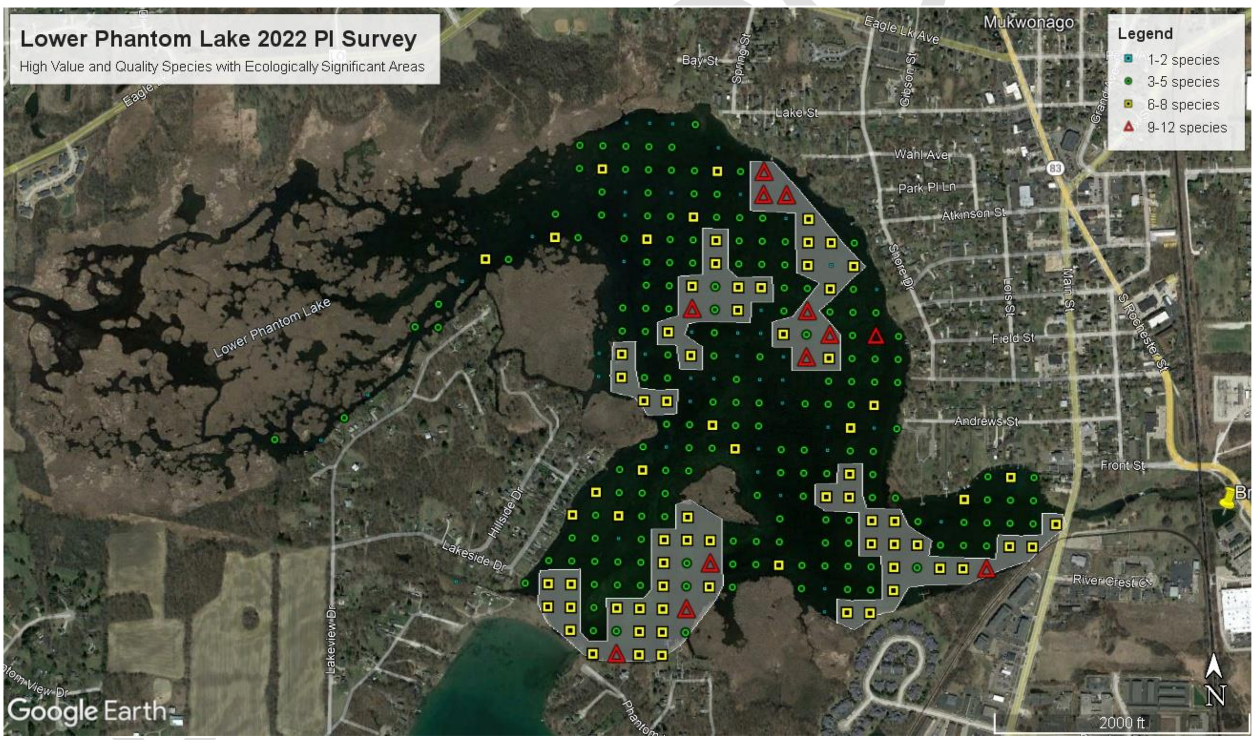


SOURCE: Lake and Pond Solutions LLC (2023)

High Value and Quality Species

High value species are defined in WDNR document NR 109.05(3)(g). For Lower Phantom Lake there were seven species classified as high value including sago pondweed, clasping-leaf pondweed, Southern wild rice, wild celery, Illinois pondweed, white-stem pondweed, and large-leaf pondweed. Additionally, Lake and Pond Solutions LLC uses C-values greater than or equal to six as a metric to also determine "quality species". Aside from the high value species, there were eighteen additional species classified as quality species. Figure 14 above shows the C-value of species present in Lower Phantom Lake. Figure 31 represents the number of both high value and quality species present at each sampled survey point. This can provide a useful image of where on the waterbody the most sensitive and valuable species are present. The number of high value and quality species at each sampled point ranged from zero to twelve with an average of 4.4 species per vegetated site. There are five distinct areas representing some of the larger concentrations of these species that we classify as "Ecological Significant Areas". Three are in the central part of the lake while the other two are in the SW and SE portions of the lake.

Figure 31: Lower Phantom Lake - High Value and Quality Species



SOURCE: Lake and Pond Solutions LLC (2023)

**High value species" are defined in NR 109.05(3)(g) while "quality species" have a C-Value of six or more*

Floristic Quality

Floristic quality (Swink and Wilhelm, 1994) is a rapid assessment metric designed to evaluate the similarity of the flora of a defined area to undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts. For any area (lake in this case), floristic quality (I) equals the average coefficient of conservatism (C-value) times the square root of the number of native species (√N).

The coefficient of conservatism (C-value) was assigned to 128 aquatic plants, compared to regional studies, and reviewed by biologists familiar with Wisconsin lake plants. They range from 0 to 10 with 10 being assigned to species most sensitive to disturbance. These final C-values were used in calculating the Floristic Quality Index for Lower Phantom Lake.

The number of natives and floristic quality have increased significantly since the last survey and are greater than the STP average. Part of this may be due to the survey method which catalogued nine emergent species that were not recorded in 2017. Lower Phantom Lake stacks up nicely with the top 25% of Wisconsin lakes based on number of natives and floristic quality.

Figure 32: Floristic Quality Index for Lower Phantom Lake, 2017-2022

	2017	2022	STP Avg	WI Avg	WI 75th Percentile
Average C-Value	5.88	5.71	5.6	6	6.9
# of Natives (N)	26	35	14	13	20
Floristic Quality	30.01	33.81	20.9	22.2	27.5

SOURCE: Lake and Pond Solutions LLC (2023), SEWRPC (2017)

Upper Phantom Lake

Survey Summary

The 2022 survey conducted by Lake and Pond Solutions, LLC occurred on September 1st using the 276 pre-determined WDNR points (Figure 33). Of the 269 points sampled, 126 were found to have plants (46.8%). There were 28 species of plants identified and an average of 2.55 native species per vegetated site (including visuals). Bottom type was split almost evenly between muck and sand. The survey statistics can be found in Figure 34.

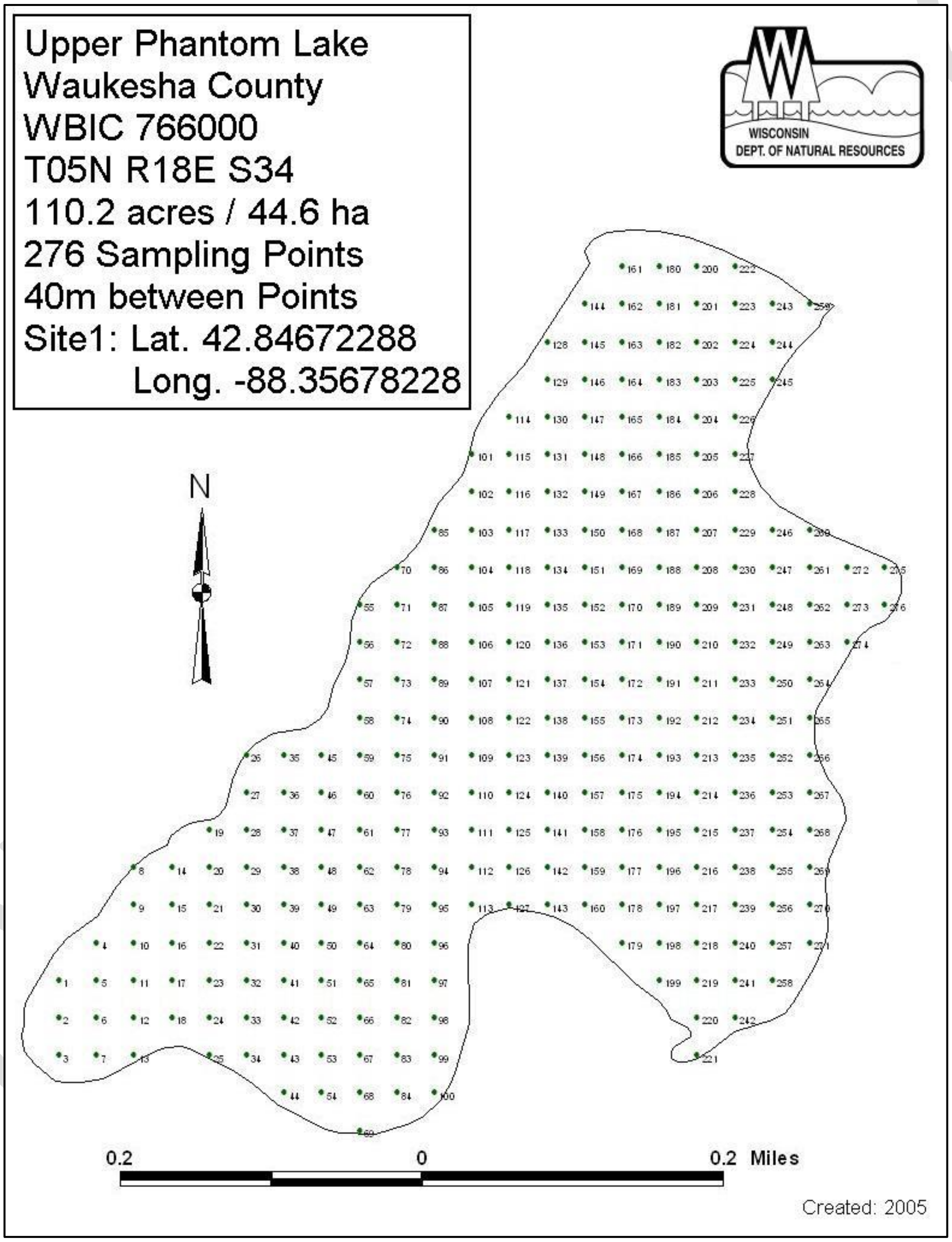
Plant Community

The twenty-eight different species of plants identified on Upper Phantom Lake are outlined in Figure 35 from highest to lowest frequency. Also shown is the overall frequency (percentage plant was found compared to all sites), relative frequency (percent plant was found compared to vegetated sites), average rake fullness, and C-value. The C-value is the estimated probability that a plant is likely to occur in a landscape that is believed to be relatively unchanged from before development. The C-value ranges from 0 – 10 with 10 being assigned to species most sensitive to disturbance.

The five most common native plant species ranked by relative frequency of occurrence were sago pondweed (*Stuckenia pectinata*), muskgrass (*Chara sp.*), wild celery (*Vallisneria americana*), white water lily (*Nymphaea odorata*), and clasping-leaf pondweed (*Potamogeton richardsonii*). Unlike Lower Phantom Lake, there were only three species found at over 20% relative frequency and one was invasive (spiny naiad – *Najas marina*). The concern over southern wild rice expansion on Lower Phantom Lake is not realized here as there were only three sites where it was observed. Generally, plant growth has not impacted recreation on Upper Phantom Lake.

The depths that plants were found in the 2022 survey are listed in Figure 36. Sixty-eight percent of the aquatic plant growth was found in 3' – 7' of water with scattered growth down to eighteen feet. Unlike Lower Phantom which had an average of six species per site, Upper Phantom has less than three species per site. The lower plant density coupled with a deeper lake likely explains the general lack of recreational issues. Figure 37 - Figure 46 show the distribution of the top seven native species as well as the three invasive species found in Upper Phantom Lake (from most to least frequent).

Figure 33: PI Survey Points on Upper Phantom Lake



SOURCE: WDNR

Figure 34: Upper Phantom Plant Sampling Data Summary

Statistics Summary (including visuals)	September 2022
Total Number of Sites	276
Total number of sites with vegetation / All sites sampled	126/269 (46.8%)
Species Richness	28
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	18.75
Average number of all species per site (veg. sites only) incl visuals	2.86
Average number of native species per site (veg. sites only) incl visuals	2.55
Number of sites with muck (M)	92
Number of sites with sand (S)	88
Number of sites with rock (R)	2
Number of Terrestrial sites	6
Number of Dock sites	1
Number of Temporary Obstacle sites	2

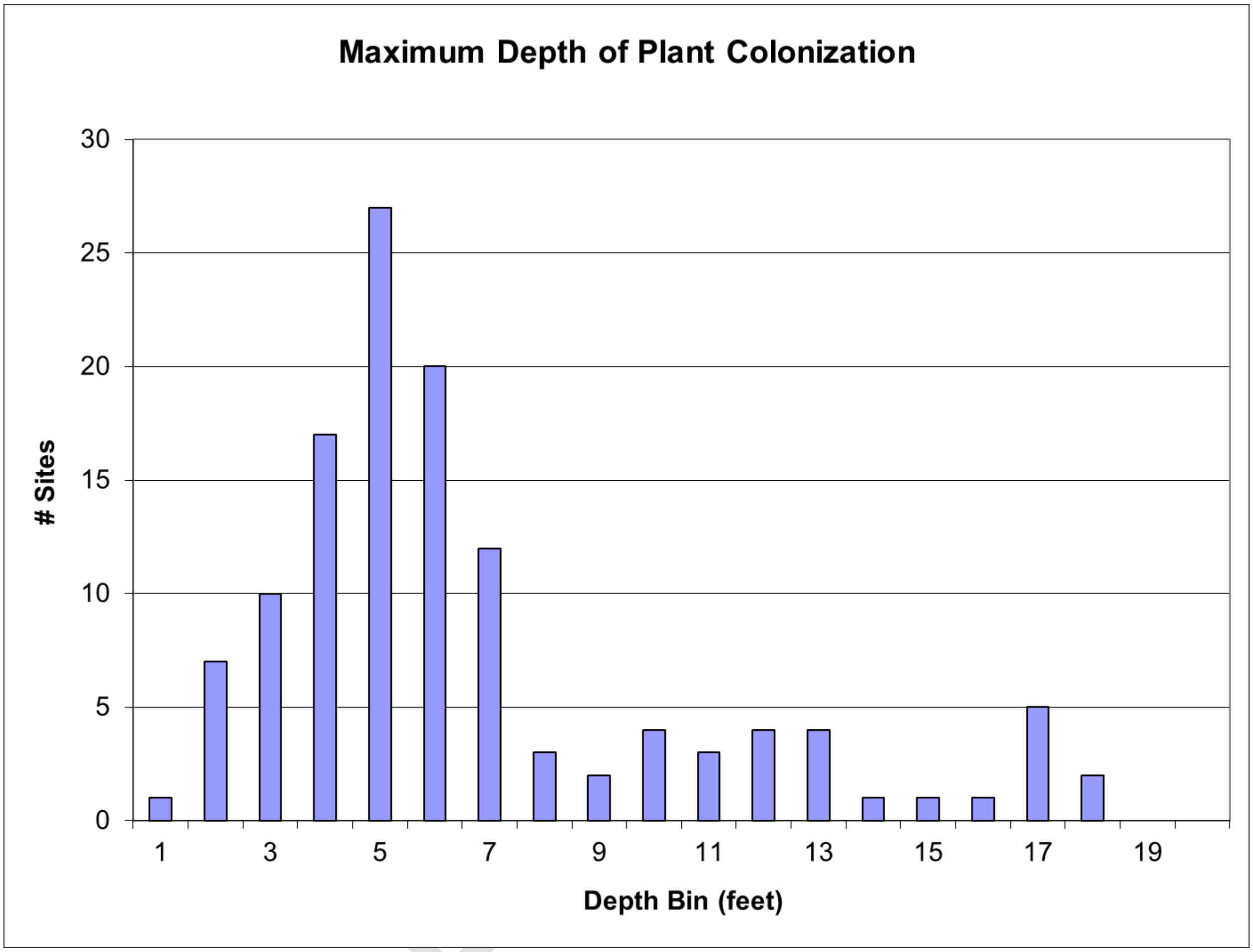
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 35: Upper Phantom Lake Plant Species - September 2022

Common Name	Scientific Name	Total Number of sites found (includes Visuals)	% Overall Frequency of Occurance (Includes Visuals)	% Relative Frequency of Occurance (Includes Visuals)	Average Density Rating	C-value
Sago pondweed	*Stuckenia pectinata*	66	24.54	52.38	1.00	3
Spiny naiad	*Najas marina*	46	17.10	36.51	1.32	Invasive
Muskgrasses	*Chara sp.*	30	11.15	23.81	1.38	7
Wild celery	*Vallisneria americana*	23	8.55	18.25	1.00	6
White water lily	*Nymphaea odorata*	17	6.32	13.49	1.00	6
Clasping-leaf pondweed	*Potamogeton richardsonii*	16	5.95	12.70	1.00	5
Illinois pondweed	*Potamogeton illinoensis*	14	5.20	11.11	1.00	6
Cattail	*Typha sp.*	12	4.46	9.52	V	1
Common bladderwort	*Utricularia vulgaris*	12	4.46	9.52	1.00	7
Swamp loosestrife	*Decodon verticillatus*	12	4.46	9.52	V	n/a
Nitella	*Nitella sp.*	11	4.09	8.73	1.36	7
Orange Jewelweed	*Impatiens capensis*	11	4.09	8.73	V	n/a
Variable pondweed	*Potamogeton gramineus*	11	4.09	8.73	1.00	7
Various-leaved water-milfoil	*Myriophyllum heterophyllum*	10	3.72	7.94	1.25	7
Flat-stem pondweed	*Potamogeton zosteriformis*	7	2.60	5.56	1.00	6
Hardstem bulrush	*Schoenoplectus acutus*	7	2.60	5.56	V	6
Slender naiad	*Najas flexilis*	6	2.23	4.76	1.00	6
Coontail	*Ceratophyllum demersum*	5	1.86	3.97	1.50	3
Southern wild rice	*Zizania aquatica*	3	1.12	2.38	V	8
Water star-grass	*Heteranthera dubia*	3	1.12	2.38	2.00	6
Arum-leaved arrowhead	*Sagittaria cuneata*	2	0.74	1.59	V	7
Purple loosestrife	*Lythrum salicaria*	2	0.74	1.59	V	Invasive
Spatterdock	*Nuphar variegata*	2	0.74	1.59	V	6
Common waterweed	*Elodea canadensis*	1	0.37	0.79	V	3
Eurasian water-milfoil	*Myriophyllum spicatum*	1	0.37	0.79	V	Invasive
Fries' pondweed	*Potamogeton friesii*	1	0.37	0.79	V	8
Northern water-milfoil	*Myriophyllum sibiricum*	1	0.37	0.79	1.00	6
Water horsetail	*Equisetum fluviatile*	1	0.37	0.79	V	7

SOURCE: Lake and Pond Solutions LLC (2023)

Figure 36: Upper Phantom Lake Plant Depth Distribution

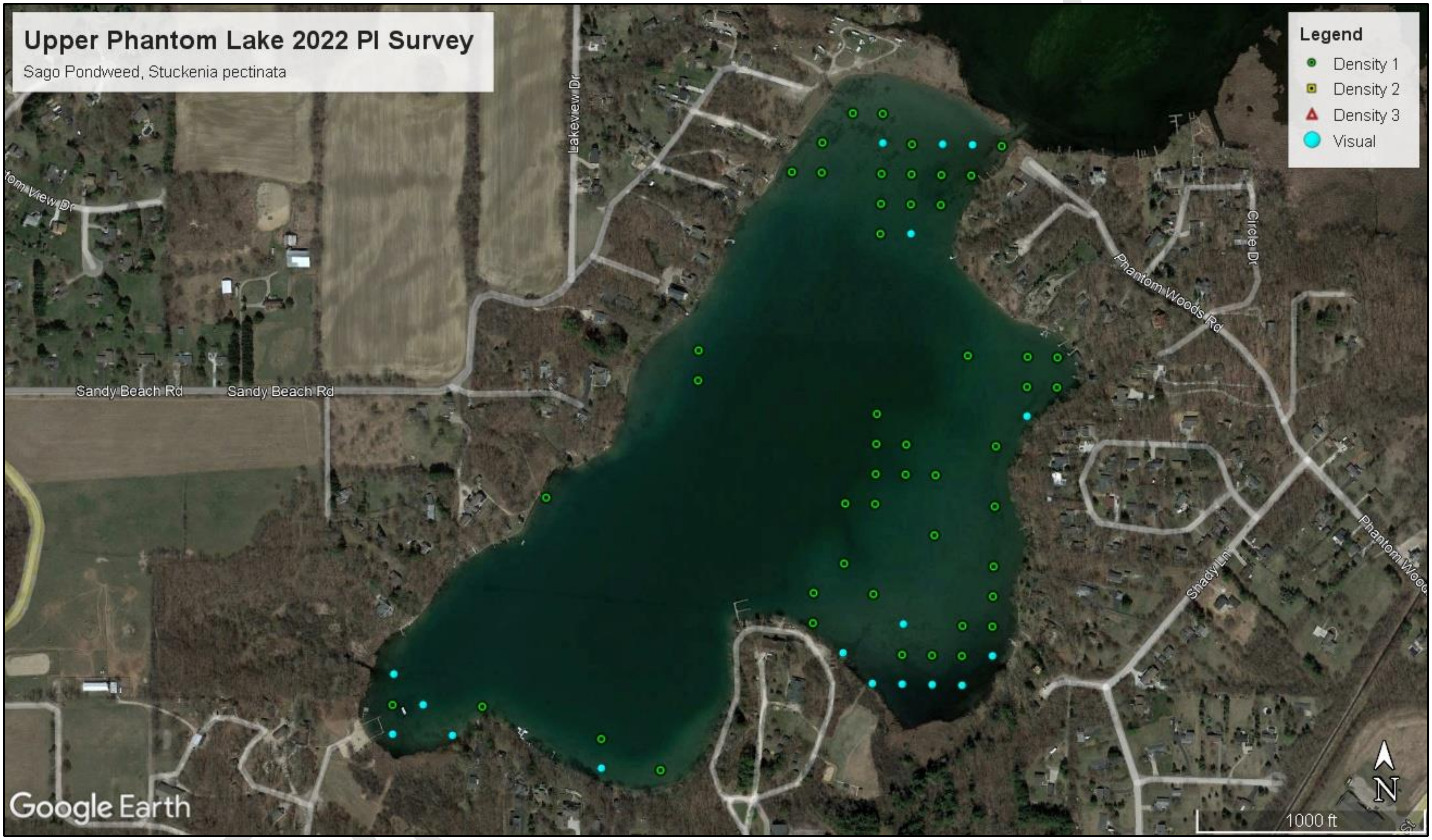


SOURCE: Lake and Pond Solutions LLC (2023)

Invasive Species

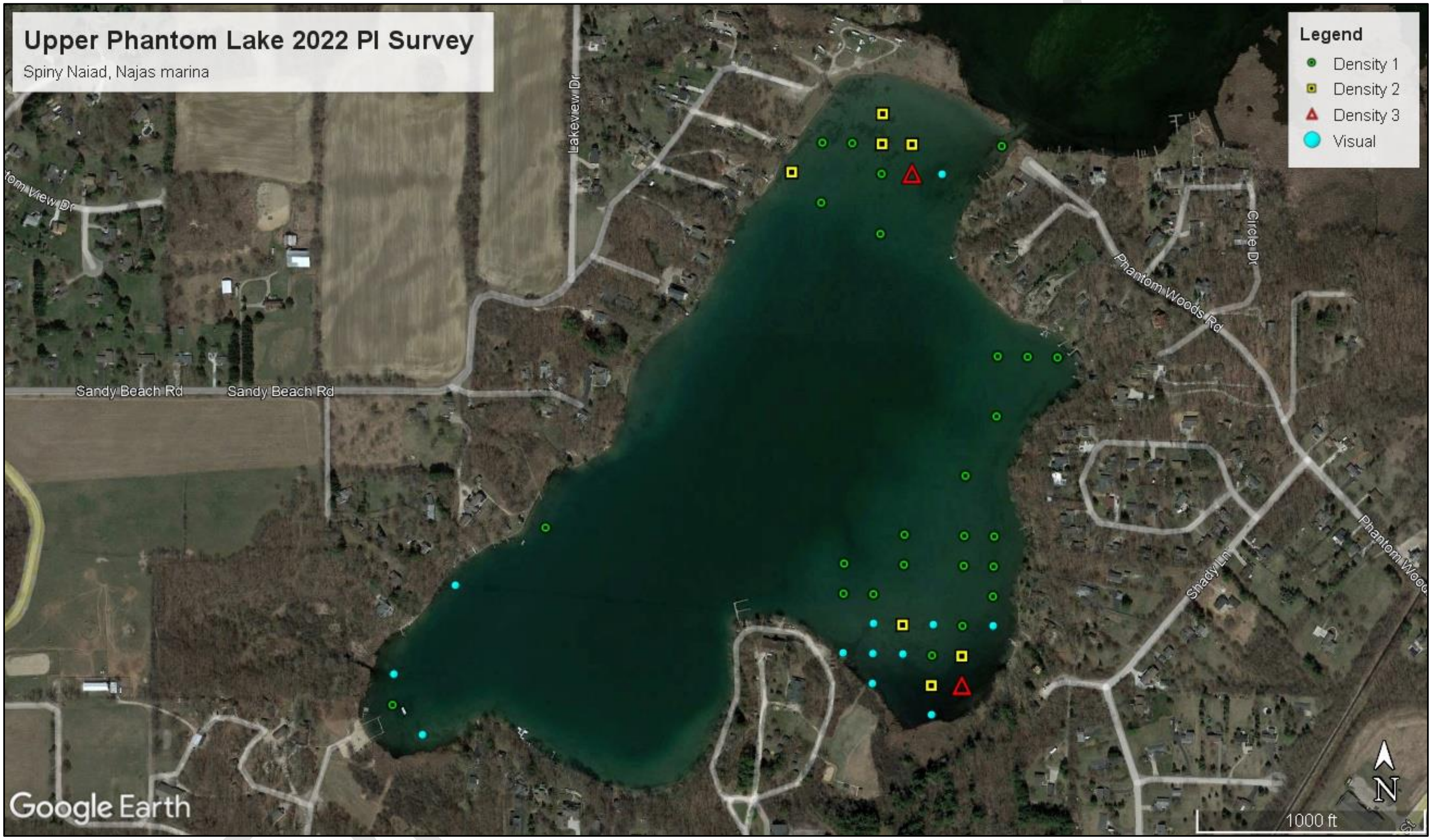
Three invasive species were identified in the survey including spiny naiad (*Najas marina*), purple loosestrife (*Lythrum salicaria*), and Eurasian water-milfoil (*Myriophyllum spicatum*). Distribution maps can be found in Figure 38, Figure 45, and Figure 46. Generally, invasives are not causing an issue for Upper Phantom Lake. Spiny naiad, although native to certain areas of the U.S., is classified as an invasive in Wisconsin. Despite its invasive designation here, it is widely considered naturalized and it typically doesn't have a large impact on native plant populations. Spiny naiad does however spread by fragmentation and has long-lived seed banks so the PLMD should keep a close eye on the North and Southeast ends of the lake. The other two species, purple loosestrife and Eurasian water-milfoil, were only located in a few sites. Despite the burgeoning population of starry stonewort found on Lower Phantom, it has yet to find its way to Upper Phantom. This is also something that should be carefully monitored.

Figure 37: Upper Phantom Lake - Sago Pondweed



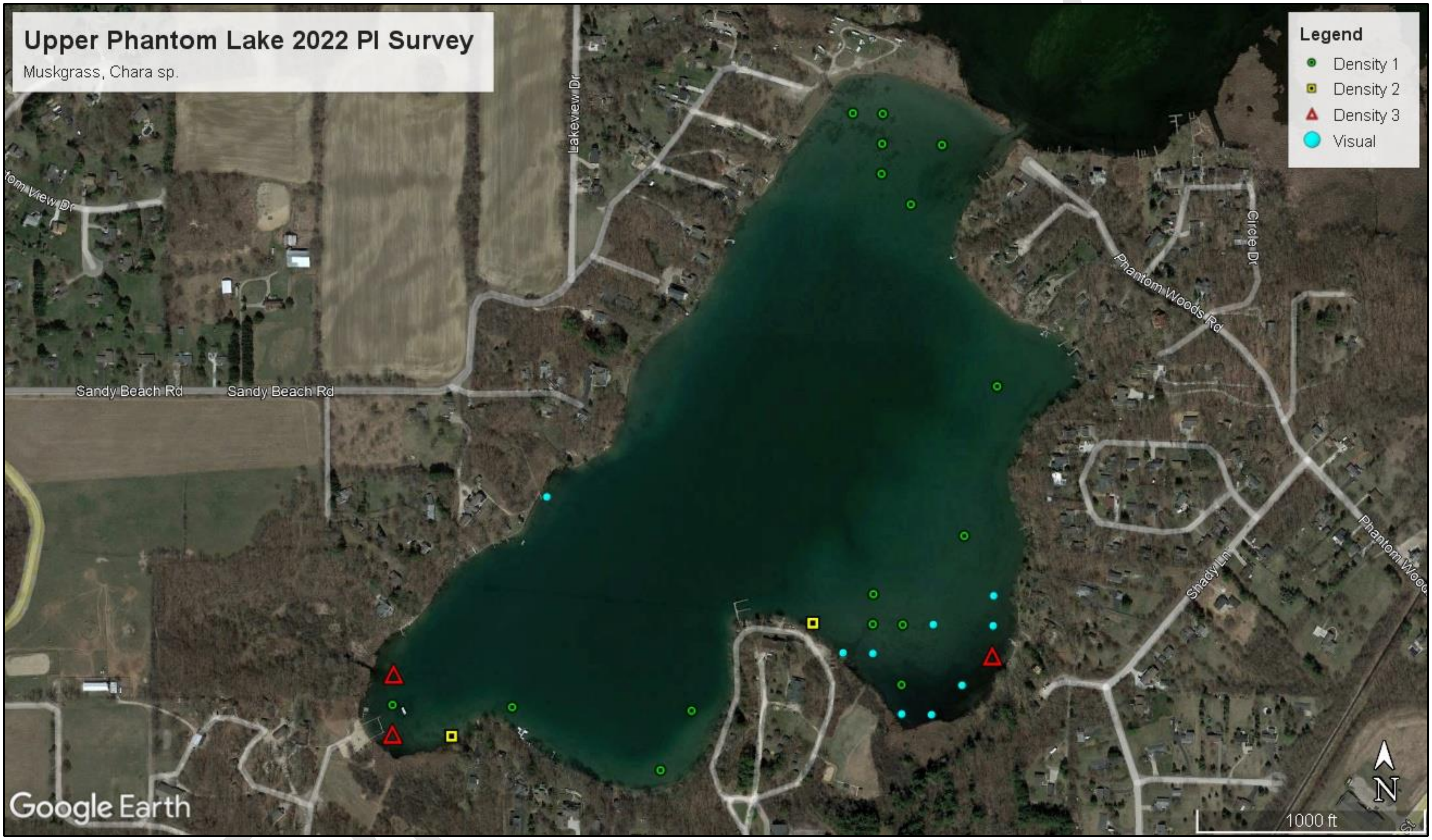
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 38: Upper Phantom Lake - Spiny Naiad ***(INVASIVE)***



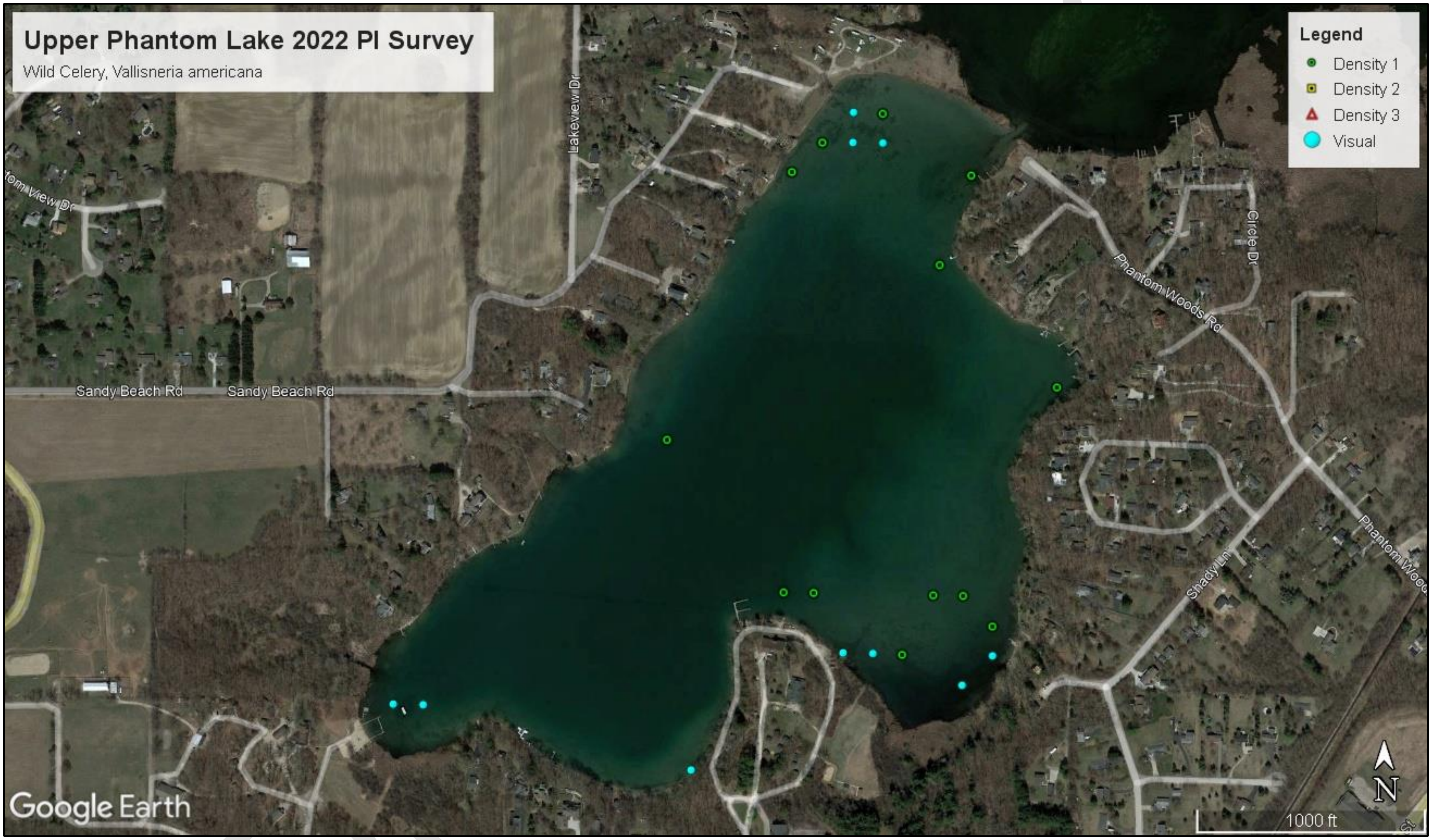
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 39: Upper Phantom Lake - Muskgrass



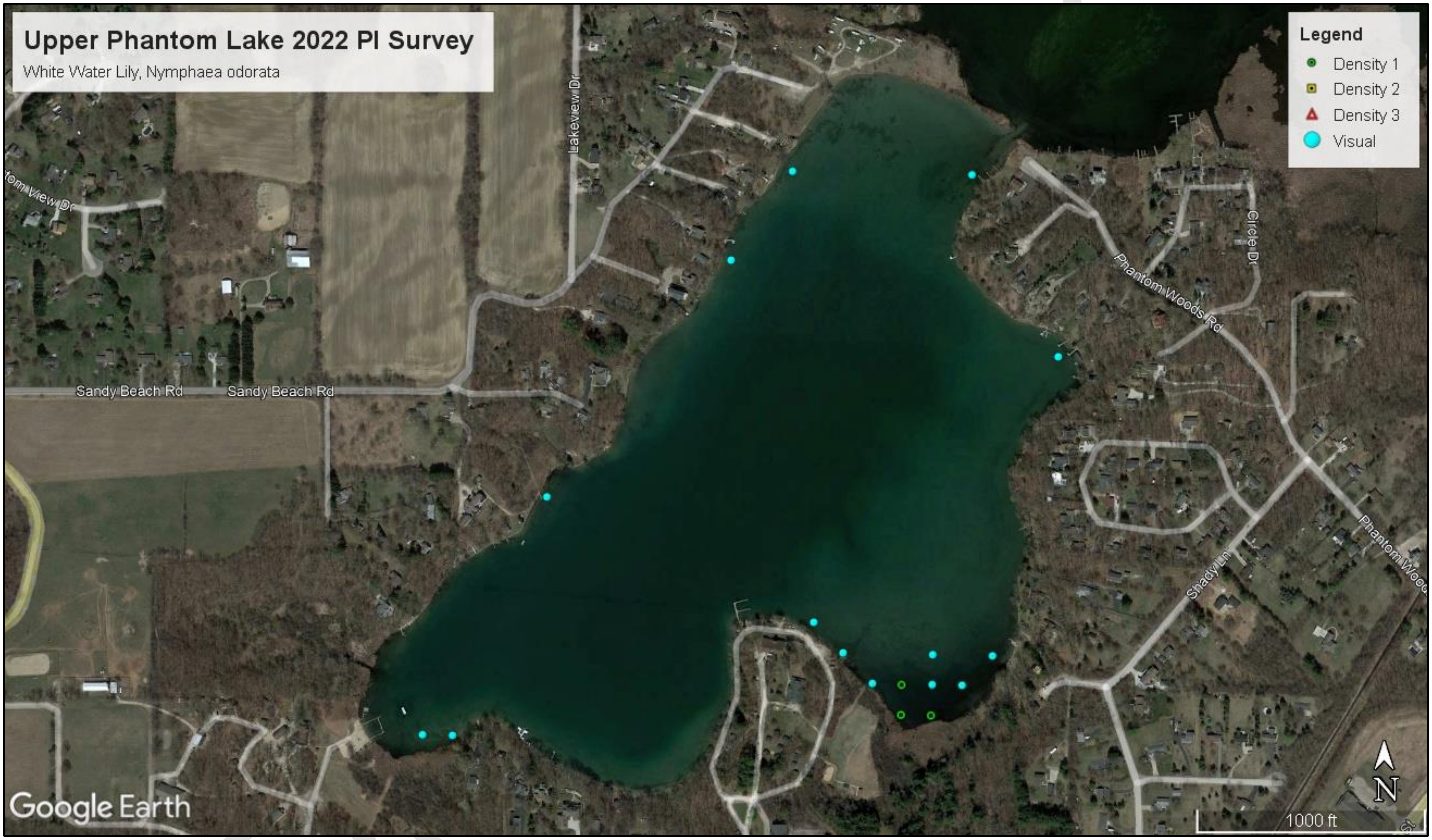
SOURCE: Lake and Pond Solutions LLC (2023)

Figure 40: Upper Phantom Lake - Wild Celery



SOURCE: Lake and Pond Solutions LLC (2023)

Figure 41: Upper Phantom Lake - White Water Lily

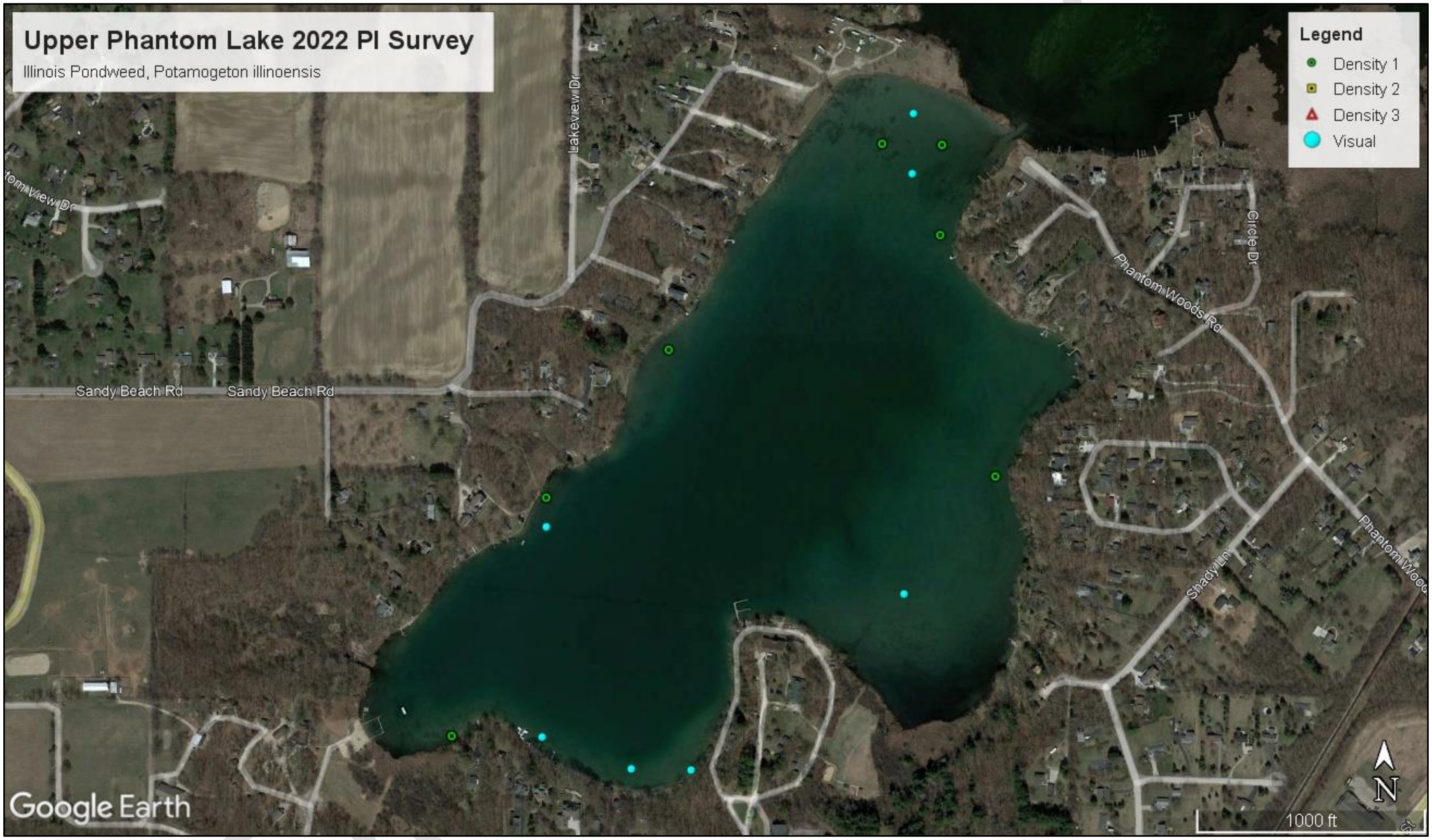


SOURCE: Lake and Pond Solutions LLC (2023)

Figure 42: Upper Phantom Lake - Clasping-leaf Pondweed

SOURCE: Lake and Pond Solutions LLC (2023)

Figure 43: Upper Phantom Lake - Illinois Pondweed



SOURCE: Lake and Pond Solutions LLC (2023)

Figure 44: Upper Phantom Lake - Common Bladderwort

SOURCE: Lake and Pond Solutions LLC (2023)

Figure 45: Upper Phantom Lake - Purple Loosestrife *(INVASIVE)*

SOURCE: Lake and Pond Solutions LLC (2023)

**Points on map do not show the exact location of Purple Loosestrife. Instead, they represent the closest point to an onshore visual sighting.*

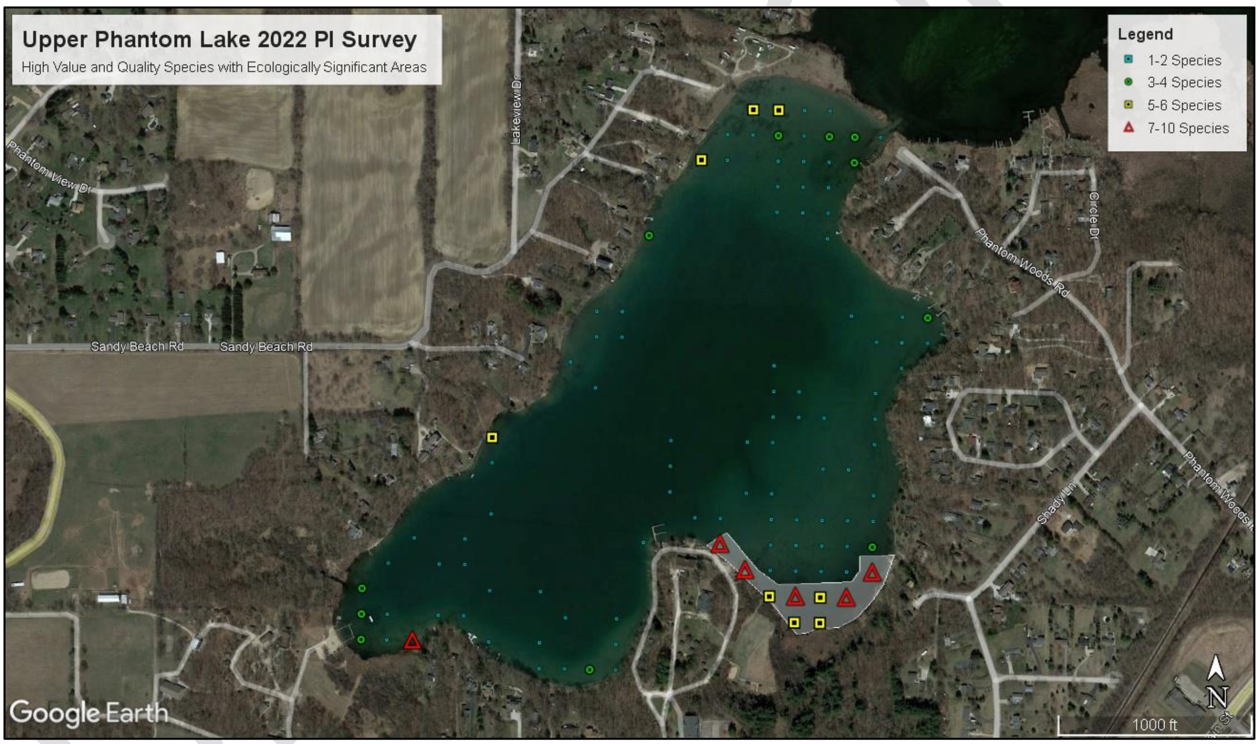
Figure 46: Upper Phantom Lake - Eurasian Water-milfoil *(INVASIVE)*

SOURCE: Lake and Pond Solutions LLC (2023)

High Value and Quality Species

High value species are defined in WDNR document NR 109.05(3)(g). For Upper Phantom Lake there were five species classified as high value including sago pondweed, wild celery, clasping-leaf pondweed, Illinois pondweed, and southern wild rice. Additionally, Lake and Pond Solutions LLC uses C-values greater than or equal to six as a metric to also determine "quality species". Aside from the high value species, there were fifteen additional species classified as quality species. Figure 35 above shows the C-value of species present in Lower Phantom Lake. Figure 47 represents the number of both high value and quality species present at each sampled survey point. This can provide a useful image of where on the waterbody the most sensitive and valuable species are present. The number of high value and quality species at each sampled point ranged from zero to ten with an average of 1.9 species per vegetated site. There was one distinct area representing some of the larger concentrations of these species that we classified as an "Ecological Significant Area".

Figure 47: Upper Phantom Lake - High Value and Quality Species



SOURCE: Lake and Pond Solutions LLC (2023)

Floristic Quality

Floristic quality (Swink and Wilhelm, 1994) is a rapid assessment metric designed to evaluate the similarity of the flora of a defined area to undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts. For any area (lake in this case), floristic quality (I) equals the average coefficient of conservatism (C-value) times the square root of the number of native species ($\sqrt{N}$).

The coefficient of conservatism (C-value) was assigned to 128 aquatic plants, compared to regional studies, and reviewed by biologists familiar with Wisconsin lake plants. They range from 0 to 10 with 10 being assigned to species most sensitive to disturbance. These final C-values were used in calculating the Floristic Quality Index for Lower Phantom Lake.

The average C-Value, number of natives, and floristic quality have increased significantly since the last survey and are greater than the STP average. Part of this may be due to the survey method which catalogued eight emergent species that were not recorded in 2017. Upper Phantom Lake stacks up nicely with the top 25% of Wisconsin lakes based on number of natives and floristic quality.

Figure 48: Floristic Quality Index for Upper Phantom Lake, 2017 – 2022

	2017	2022	STP Avg	WI Avg	WI 75th Percentile
Average C-Value	5.64	5.83	5.6	6	6.9
# of Natives (N)	14	23	14	13	20
Floristic Quality	21.11	27.94	20.9	22.2	27.5

SOURCE: Lake and Pond Solutions LLC (2023), SEWRPC (2017)

COMPARISON OF SURVEYS (2017 – 2022)

Lower Phantom Lake

Point-intercept plant surveys were conducted on Lower Phantom Lake in 2017 and 2022. Figure 49 - Figure 51 below show a comparison of the plant communities during these surveys. Overall, increases were observed in the species richness (+13 species), average native species per site (+2.26 species), and floristic quality (+3.8). The percentage of sites with vegetation, Simpson Diversity Index, and average C-value remained relatively constant. The maximum depth of plants and average rake fullness declined although the latter is likely due to different survey crew interpretations.

Figure 49: Lower Phantom Lake PI Survey Statistics Comparison, 2017-2022

Statistics Summary (including visuals)	2017	2022
Survey Date	July 31st - August 7th	August 24th - 26th
Total number of sites with vegetation / All sites sampled	256/257 (99.6%)	296/299 (99.0%)
Maximum depth of plants (ft)	11.5	9.0
Species Richness	29	42
Average number of all species per site (veg. sites only) incl visuals	4.15	6.26
Average number of native species per site (veg. sites only) incl visuals	3.77	6.03
Simpson Diversity Index	0.93	0.95
Average C-Value	5.88	5.71
Floristic Quality	30.01	33.81
Average Rake Fullness	1.47	1.14

SOURCE: Lake and Pond Solutions LLC (2023), SEWRPC (2017)

Figure 50: Lower Phantom Lake PI Survey Species Comparison, 2017-2022

Species		% Frequency	
Common Name	Scientific Name	2017	2022
Common bladderwort	*Utricularia vulgaris*	34.38	57.09
Muskgrasses	*Chara sp.*	52.73	42.91
Spatterdock	*Nuphar variegata*	14.84	42.91
White water lily	*Nymphaea odorata*	6.25	40.54
Sago pondweed	*Stuckenia pectinata*	16.41	39.19
Coontail	*Ceratophyllum demersum*	24.22	37.16
Clasping-leaf pondweed	*Potamogeton richardsonii*	45.70	35.47
Southern wild rice	*Zizania aquatica*	-	35.47
Various-leaved water-milfoil	*Myriophyllum heterophyllum*	8.20	35.14
Wild celery	*Vallisneria americana*	41.41	27.03
Cattail	*Typha sp.*	-	22.64
Illinois pondweed	*Potamogeton illinoensis*	12.50	20.27
Common waterweed	*Elodea canadensis*	22.66	15.54
Swamp loosestrife	*Decodon verticillatus*	-	15.54
Slender naiad	*Najas flexilis*	8.59	14.86
Purple loosestrife	*Lythrum salicaria*	-	13.51
Common watermeal	*Wolffia columbiana*	-	13.18
Arum-leaved arrowhead	*Sagittaria cuneata*	20.31	12.84
Flat-stem pondweed	*Potamogeton zosteriformis*	8.20	12.16
Small duckweed	*Lemna minor*	0.39	11.82
Starry Stonewort	*Nitellopsis obtusa*	-	11.82
Floating-leaf pondweed	*Potamogeton natans*	4.30	7.77
Orange Jewelweed	*Impatiens capensis*	-	6.76
Variable pondweed	*Potamogeton gramineus*	6.64	6.08
Eurasian water-milfoil	*Myriophyllum spicatum*	33.59	5.07
Spiny naiad	*Najas marina*	3.91	4.39
Water star-grass	*Heteranthera dubia*	0.39	4.05
Northern water-milfoil	*Myriophyllum sibiricum*	37.89	3.38
White-stem pondweed	*Potamogeton praelongus*	0.39	3.04
Fries' pondweed	*Potamogeton friesii*	1.17	2.70
Forked duckweed	*Lemna trisulca*	0.39	2.36
Common arrowhead	*Sagittaria latifolia*	-	2.03
Common reed	*Phragmites australis*	-	1.69
Hardstem bulrush	*Schoenoplectus acutus*	-	1.69
Sessile-fruited arrowhead	*Sagittaria rigida*	-	1.69
Water smartweed	*Polygonum amphibium*	-	1.69
Large-leaf pondweed	*Potamogeton amplifolius*	2.73	1.35
Nitella	*Nitella sp.*	1.95	1.01
Curly-leaf pondweed	*Potamogeton crispus*	1.95	0.68
Large duckweed	*Spirodela polyrhiza*	0.39	0.68
Leafy pondweed	*Potamogeton foliosus*	1.56	0.34
Small bladderwort	*Utricularia minor*	-	0.34
TOTAL SPECIES EXCLUDING ALGAE		**29**	**42**
TOTAL INVASIVE SPECIES		**3**	**6**
TOTAL EMERGENT SPECIES		**0**	**9**

SOURCE: Lake and Pond Solutions LLC (2023), SEWRPC (2017)

The native plant community in Lower Phantom Lake remains robust but there have been some significant changes since the last survey. There were thirteen new species found although nine were emergent species that were likely not captured with the previous survey techniques. Thirteen species saw 10%+ increases in their frequency of occurrence in vegetated sites (common bladderwort, spatterdock, white water lily, sago pondweed, coontail, southern wild rice, various-leaved water-milfoil, cattails, swamp loosestrife, purple loosestrife, common watermeal, small duckweed, and starry stonewort). Only four species decreased by over 10%+ (clasping-leaf pondweed, wild celery, Eurasian water-milfoil, and northern water-milfoil).

Some of the more dramatic changes (+/-20%) are highlighted in Figure 51 below. At the top of the list is southern wild rice which has become a recreational concern for the District. Northern water-milfoil and Eurasian water-milfoil have been reduced by a large margin despite a lack of herbicide treatment. This may be due to seasonal variations or a shift in the plant community as areas previously inhabited by milfoil now have more white water lily and spatterdock.

Figure 51: Lower Phantom Lake – Largest Plant Changes by Percent

Species		% Change
Common Name	Scientific Name	(2017-2022)
Southern wild rice	*Zizania aquatica*	35.47
Northern water-milfoil	*Myriophyllum sibiricum*	-34.51
White water lily	*Nymphaea odorata*	34.29
Eurasian water-milfoil	*Myriophyllum spicatum*	-28.52
Spatterdock	*Nuphar variegata*	28.07
Various-leaved water-milfoil	*Myriophyllum heterophyllum*	26.94
Sago pondweed	*Stuckenia pectinata*	22.78
Common bladderwort	*Utricularia vulgaris*	22.71
Cattail	*Typha sp.*	22.64

SOURCE: Lake and Pond Solutions LLC (2023)

As mentioned previously, three new invasives were recorded including purple loosestrife, starry stonewort, and phragmites. It is likely that purple loosestrife was present in past surveys but not recorded. The most concerning of the three is starry stonewort which now occupies more than 11% of all vegetated sites. This species looks like a plant but is actually a macro-algae that can form dense mats at the water surface, overtake and outcompete native plants, and results in unsuitable habitat for fish. Our data shows it to be easily spread by boats that drive through dense beds as many new infestations are found at the end of boat lifts.

It appears that the native community on Lower Phantom Lake has not declined over the past five years with the management practices in place. The increase in overall plant growth as well as newly recorded species (like southern wild rice) have created some recreational challenges for the PLMD that may require alterations to future management. New invasive species (like starry stonewort) also threaten native plant diversity and recreational opportunities.

Upper Phantom Lake

Point-intercept plant surveys were conducted on Upper Phantom Lake in 2017 and 2022. Figure 52 - Figure 54 below show a comparison of the plant communities during these surveys. Overall, increases were observed in almost all the metrics including the max depth of plants (3.75 feet), species richness (+12 species), average native species per site (+0.56 species), Simpson Diversity Index (+0.06), average C-Value (+0.19), and floristic quality (+6.83). The only decline was in the average rake fullness (-0.07) which could be related to different survey crew interpretations.

Figure 52: Upper Phantom Lake PI Survey Statistics Comparison, 2017-2022

Statistics Summary (including visuals)	2017	2022
Survey Date	August 7th - 8th	September 1st
Total number of sites with vegetation / All sites sampled	120/270 (44.4%)	126/269 (46.8%)
Maximum depth of plants (ft)	15.0	18.75
Species Richness	16	28
Average number of all species per site (veg. sites only) incl visuals	2.22	2.86
Average number of native species per site (veg. sites only) incl visuals	1.99	2.55
Simpson Diversity Index	0.85	0.91
Average C-Value	5.64	5.83
Floristic Quality	21.11	27.94
Average Rake Fullness	1.31	1.24

SOURCE: Lake and Pond Solutions LLC (2023), SEWRPC (2017)

The native plant community in Upper Phantom Lake remained consistent with a few changes towards the top of the plant list. There were thirteen new species found although seven were emergent species that were likely not captured with the previous survey techniques. Figure 54 shows the three species that saw 10%+ increases in their frequency of occurrence in vegetated sites (sago pondweed, white water lily, and Illinois pondweed) and the two species that decreased by over 10%+ (muskgrass and Eurasian water-milfoil).

Muskgrass saw the biggest decline which may be related to water clarity or the increase in other plant species. Other important plant species additions not found in the previous survey included white water lily, nitella, hardstem bulrush, southern wild rice, and Fries' pondweed. Like Lower Phantom Lake, Upper Phantom Lake saw a reduction in Eurasian water-milfoil despite a lack of herbicide treatment. This is likely due to season variations or a shift in the plant community. Based on the lack of harvesting in Upper Phantom, the milfoil decline observed on both lakes is likely not directly tied to harvesting practices.

We did find an anomaly in the previous reported data on Northern water-milfoil and variable water milfoil. Although the 2017 survey data showed no sites with NWM, the map in the SEWRPC Appendix does show it present. Meanwhile, variable milfoil was found in the 2017 survey and is shown as absent on the SEWRPC map. It is likely that this was a mapping error.

As mentioned previously, purple loosestrife was the sole new invasive recorded during our survey and it was only found at two sites in the lake. Spiny naiad, which can sometimes outcompete native plants, was located at seven less sites so it is not expanding its range. It has however become slightly denser when found with an average rake fullness of 1.32 vs 1.13 in 2017.

Figure 53: Upper Phantom Lake PI Survey Species Comparison, 2017-2022

Species		% Frequency	
Common Name	Scientific Name	2017	2022
Sago pondweed	*Stuckenia pectinata*	37.50	52.38
Spiny naiad	*Najas marina*	44.17	36.51
Muskgrasses	*Chara sp.*	50.83	23.81
Wild celery	*Vallisneria americana*	19.17	18.25
White water lily	*Nymphaea odorata*	-	13.49
Clasping-leaf pondweed	*Potamogeton richardsonii*	4.17	12.70
Illinois pondweed	*Potamogeton illinoensis*	0.83	11.11
Cattail	*Typha sp.*	-	9.52
Common bladderwort	*Utricularia vulgaris*	3.33	9.52
Swamp loosestrife	*Decodon verticillatus*	-	9.52
Nitella	*Nitella sp.*	-	8.73
Orange Jewelweed	*Impatiens capensis*	-	8.73
Variable pondweed	*Potamogeton gramineus*	17.50	8.73
Various-leaved water-milfoil	*Myriophyllum heterophyllum*	15.83	7.94
Flat-stem pondweed	*Potamogeton zosteriformis*	1.67	5.56
Hardstem bulrush	*Schoenoplectus acutus*	-	5.56
Slender naiad	*Najas flexilis*	0.83	4.76
Coontail	*Ceratophyllum demersum*	0.83	3.97
Southern wild rice	*Zizania aquatica*	-	2.38
Water star-grass	*Heteranthera dubia*	1.67	2.38
Arum-leaved arrowhead	*Sagittaria cuneata*	-	1.59
Purple loosestrife	*Lythrum salicaria*	-	1.59
Spatterdock	*Nuphar variegata*	-	1.59
Common waterweed	*Elodea canadensis*	3.33	0.79
Eurasian water-milfoil	*Myriophyllum spicatum*	16.67	0.79
Fries' pondweed	*Potamogeton friesii*	-	0.79
Northern water-milfoil	*Myriophyllum sibiricum*	-	0.79
Water horsetail	*Equisetum fluviatile*	-	0.79
Large-leaf Pondweed	*Potamogeton amplifolius*	0.83	-
TOTAL SPECIES EXCLUDING ALGAE		**16**	**28**
TOTAL INVASIVE SPECIES		**2**	**3**
TOTAL EMERGENT SPECIES		**0**	**7**

SOURCE: Lake and Pond Solutions LLC (2023), SEWRPC (2017)

It appears that the native community on Upper Phantom Lake has improved over the past five years with the management practices in place. New invasive species found in Lower Phantom Lake (like starry stonewort and phragmites) also threaten to invade Upper Phantom Lake and must be closely observed.

Figure 54: Upper Phantom Lake – Largest Plant Changes by Percent

Species		% Change
Common Name	**Scientific Name**	**(2017-2022)**
Muskgrasses	*Chara sp.*	-27.02
Eurasian water-milfoil	*Myriophyllum spicatum*	-15.88
Sago pondweed	*Stuckenia pectinata*	14.88
White water lily	*Nymphaea odorata*	13.49
Illinois pondweed	*Potamogeton illinoensis*	10.28

SOURCE: Lake and Pond Solutions LLC (2023)

PLANT MANAGEMENT ALTERNATIVES

Control of exotic or nuisance plant species is an uphill battle in many lakes. Realistic expectations are important in aquatic plant management, and it is unlikely that exotic plants species can ever be completely removed from a lake system. A combination of lake management techniques and public education are most effective in minimizing the long- term impact of exotic plant species in a lake. Dr. John Madsen (formerly a research biologist with the US Army Engineer Research and Development Center) sums up management alternatives best:

"Despite the views of some, there is no single cure-all solution to aquatic plant problems, no single "best choice". For that matter, several of these techniques can be made to work for most aquatic plant problems, given enough time and money. None of these techniques are evil or inherently unacceptable; likewise, none of these techniques are without flaws or potential environmental impacts. Rather, it is up to each management group to select the most appropriate techniques for their situation given a set of social, political, economic and environmental conditions."

The concept of Integrated Pest Management (IPM) involves consideration of biological, chemical, and physical means to control a nuisance species. A rotation of different methods can provide a thorough management strategy for nuisance plant control. Rotating different chemical products used to treat nuisance or invasive species can achieve greater efficacy and reduce chemical resistance. No management, drawdown, nutrient inactivation, dredging, bottom screens, biomanipulation, native species reintroduction, hand controls, herbicide treatment, harvesting, DASH, and lake use ordinances were all evaluated as management options for both Lower and Upper Phantom Lake.

No Management

Under this alternative, aquatic plants would be left to occur naturally with no active management and continue to expand or reduce their ranges. The downside of not managing the plant community is that it allows invasive species to flourish because of their completive nature. Phantom Lake's plant communities already consist of 3-6 invasive species: purple loosestrife, starry stonewort, Eurasian water-milfoil, spiny naiad, phragmites, and curly-leaf pondweed. Each of these invasives has a unique ability to outcompete native species. Some gain a competitive advantage by growing first and aggressively in the spring, some spread by fragmentation, while others have the ability to produce prolific or long-lasting seed structures.

Expanded areas of submerged invasive species may also impact the fishery by increasing the areas for panfish to hide from predators, leading to overpopulation and stunted growth. In the case of starry stonewort, it can even make large expanses unsuitable for fish spawning.

While the short-term monetary cost of "No Management" is nothing, the long-term ecosystem cost is much higher. Unmanaged, invasive species can have severe negative effects on water quality, native plant distribution, abundance and diversity, and the abundance and diversity of aquatic insects and fish (Madsen, 2000).

Conclusion – Although "no management" is technically feasible for Lower and Upper Phantom Lake, it should not be considered for the best, long-term interest of the water resource.

Drawdown

Drawdown can be used to control some plant growth by dropping the lakes water level for a period of time and exposing the plants to extreme temperatures, drying and freezing. Some plants respond very favorably to drawdown, while other plants react negatively or unpredictably. Some lakes have had good success with extended drawdowns that thoroughly freeze the lakebed, especially those areas with soft sediments in shallow shoreline areas. Besides the effects to the plant community, drawdown can have a negative impact on animal communities. Spawning areas are no longer accessible to fish and shoreline areas become unsuitable for amphibian hibernation.

Costs associated with drawdowns depend on many variables. Lowering and raising the lake by pumps requires equipment, electricity, and staff while the ability to open a gate to lower the lake and close the gate to raise the water level can help minimize cost.

Conclusion - Drawdown for the purpose of aquatic plant control on Lower and Upper Phantom Lake is not recommended at this time due to the impacts on recreation and wildlife communities along with the limitations due to a connection with the Mukwonago River.

Nutrient Inactivation

Nutrient inactivation is used to bind soluble nutrients, primarily phosphorus, into an insoluble/unusable form thereby reducing growth. One of the most common substances used is aluminum sulfate (alum) although there are other options now available including Phoslock and Eutrosorb WC. These treatments bind the phosphorus which precipitates out of the water column creating a floc formation covering the bottom sediments. Nutrient inactivation is commonly done for algal or phytoplankton control. Nutrient inactivation typically improves water clarity and if careful consideration is not taken toward reducing additional nonpoint source phosphorus pollution, an increase in aquatic plant growth may occur. Additionally, lakes with a large population of rough fish (carp and bullhead) may see little effect from an alum application as the floc can be agitated releasing nutrients back into the water body.

Nutrient inactivation is typically done in large expanses with water depths greater than five feet. This allows the largest amount of phosphorus to be bonded as the product descends in the water column. Because of the large-scale treatment methods, these treatments need to be performed by certified pesticide applicators under a WDNR approved permit. The treatment would likely cost hundreds of thousands of dollars for either Lower or Upper Phantom Lake.

Conclusion – Due to limited algae growth, large shallow expanses, high cost, and a connection with the Mukwonago River, nutrient inactivation is not currently recommended for Lower or Upper Phantom Lake.

Dredging

Dredging is most often used to increase depths for navigation in shallow waters, like channels, rivers and harbors. To be considered for aquatic plant control, dredging would need to bring the lakebed to depths past the littoral zone of the lake. Dredging is the costliest form of plant management control with costs ranging from $5.00 per cubic yard up to $20.00 or more per cubic yard depending on site conditions, methods used and disposal costs. The WDNR highly regulates dredging and if considered would need permit approval. Dredging can lead to a decrease in plant species diversity and cause a shift toward disturbance tolerant species such as Eurasian Water-milfoil (Nichols, 1984).

Conclusion – Due to cost and scale, widespread dredging is not recommended or allowed by the WDNR for aquatic plant management on Lower and Upper Phantom Lake. It may be an option to consider on a local scale for some of the shallow channels on Lower Phantom Lake if depths continue to decrease over time.

Bottom Screens

Bottom screens are similar to window screens that are placed on the lake bottom to control plant growth. Screens come in rolls that are spread out along the bottom and anchored by stakes, rods, or other weights. Screens create little environmental disturbance if confined to small areas that are not important fish or wildlife habitat. Although they are relatively easy to install over small areas, installation in deep water may require SCUBA gear. Care must be taken to use screens where sufficient water depth exists, reducing the opportunity for damage by outboard motors. Bottom screens cost more than $350 for a 500 sq. ft. roll and must be removed in fall and reinstalled in spring. Because of the high cost, most bottom screen applications are best used in small scale scenarios including swim beaches or confined navigational lanes. Large scale applications are not recommended or typically allowed by the WDNR because of the negative impact on native plants.

Conclusion - Bottom/plant screens are not allowed in any designated sensitive areas so they would not be a viable alternative in Lower Phantom Lake. Although they may be allowed outside the sensitive area on Upper Phantom Lake, they are not recommended due to the broad control and labor-intensive install/removal.

Biomanipulation

The use of biological controls for aquatic plant management purposes is currently very limited. Most of these controls are theoretically possible, however they have limited applications. Careful consideration should be used when picking a bio-manipulation technique because there are several instances where the use of biological controls caused new problems when a non-target organism was preferred. Biological controls also produce slower, less reliable results compared to mechanical control activities or herbicide applications.

Conclusion – There are currently no viable biomanipulation options for Phantom Lakes.

Native Species Reintroduction

Native plants are being re-introduced into lakes to try to diminish the spread of exotics and to reduce the need for more costly plant management tools. Native plants are usually less of a management problem because they tend to grow in less dense populations, are more often low-growing and have natural predation to keep them in balance. Encouraging landowners with developed shorelines to incorporate planting of native emergent plant species such as bulrushes, pickerelweed, smartweed, iris, sedges and associated upland plantings should be considered. The emergent plant species would provide a buffer zone between the water and shoreline thereby reducing the effects of wave action erosion and reduce some nutrient runoff into the lake. The emergent plants would also provide important habitat for fish, reptiles, amphibians, macro invertebrates and may increase the aesthetic value of the lake in general.

Costs to conduct plantings vary with the number and type of plants and whether volunteers or paid staff does the work. Successful plantings can be affected by many factors, including health of the new plants, weather, timing, bottom substrate, water clarity and waterfowl grazing. The WDNR should be consulted before conducting any planting activities to ensure the protection of the lakes' water resources, the necessity of a permit and the likelihood of success.

Conclusion - Shoreline plantings can be considered. Individual landowners are encouraged to allow the upland shoreline edge to re-vegetate into a stable buffer zone. This can be accomplished through a "no mow zone" which tends to work well on lakes with marsh fringes. These buffer zones would provide habitat for birds, turtles, frogs and other wildlife while also helping to filter out nutrients and sediments from manicured lawns that contribute to an increase of in-lake nuisance aquatic plant growth. Although an established buffer will require less work than a developed shoreline, there will be maintenance required. This may include cutting, mowing, or elimination of undesirable or exotic species such as sandbar willow, phragmites and purple loosestrife. Landowners should consult with a professional to determine specific maintenance requirements for their shoreline buffers. A permit issued by the WDNR will be needed for aquatic plantings.

Hand Controls

Hand controls are a method of aquatic plant control on a small scale which consists of hand pulling or raking plants. Rakes with ropes attached are thrown out into the water and dragged back into shore. Skimmers or nets can be used to scrape filamentous algae or duckweed off the lake surface. These methods are more labor intensive and should be used by individuals to deal with localized plant problems such as those found around piers or swimming areas. Hand controls are inexpensive when compared to other techniques with various rakes and cutters available for under $150. Although labor intensive, hand controls, especially using rakes, is an effective way to remove plants from a small near shore area.

Current NR 109 allows riparian landowners to manually remove aquatic vegetation including native species and invasives like Eurasian water-milfoil and Curly-leaf pondweed within their "riparian zone" without permits as long as the resident's riparian zone is considered a single area that is no more than 30 feet wide as measured parallel to the shoreline. The area must have piers, boatlifts, swim rafts or other recreational and water use devices located in the zone and cannot be in addition to an area where plants are controlled by another method. Hand controls are not allowed in listed WDNR Sensitive Areas. The 30-foot area must remain the same each year. It is illegal to remove native plants outside the 30-foot wide area without a permit.

Conclusion – Hand controls are not allowed in any Sensitive Areas. On Lower Phantom Lake, this would limit hand control to the NE shoreline while most of the Upper Phantom Lake riparian owners could use this technique to clear swimming or pier areas. Landowners should be encouraged to be selective in their clearing, again focusing on Eurasian water-milfoil, Curly-leaf pondweed, and Purple Loosestrife. A natural area of native vegetation is recommended both on the shoreline and in the water because leaving a void will allow exotic invasive species to re-establish. Before conducting any large-scale hand control management, refer to Wisc. Admin Code NR 109 and consult with the local WDNR lakes biologist regarding any permits needed for removal of plants.

Herbicide and Algaecide Treatment

Herbicide and algaecide treatments of aquatic plants and algae in lakes are governed by WDNR under Wisc. Admin Code NR107 and each product is registered by the EPA. Herbicide treatment for the control of aquatic plants is one of the more controversial methods of aquatic plant control with debates over the toxicity and long-term effects of these products. Currently, no product can be labeled for aquatic use if it poses more than a one in one million chance of causing significant damage to human health, the environment or wildlife resources (Madsen, 2000). In addition, the product must not show evidence of biomagnification, bioavailability, or persistence in the environment (Joyce, 1991). Modern herbicides have been tested extensively and it can take $20 - $40 million and 8 – 12 years to successfully navigate the registration process and its accompanying series of laboratory and field testing (Getsinger, 1991). The EPA requires between 84 and 124 different studies prior to registration to examine potential harm to people and the environment (Stubbs and Layne, 2021).

Prior to any treatment, a permit is required from the WDNR. Only Wisconsin approved and EPA registered herbicides may be used, following all label directions, use applications, application rates and use restrictions. In most situations, herbicides may only be applied by licensed applicators certified in aquatic application by the Wisconsin Department of Agriculture, Trade, and Consumer Protection. Proper handling and application techniques must be followed, including those to protect the applicators. All applications must comply with current laws in the State of Wisconsin.

Although individuals may apply for permits to apply aquatic herbicides, residents are strongly encouraged to work with the PLMD on any questions or concerns about aquatic plants prior to undertaking any plant management activities. It is recommended that individuals do not purchase and apply aquatic herbicides themselves because the products may be completely ineffective if they are used to treat the wrong plant species. Also, unregulated, uneducated use may result in overuse and cause damage to the beneficial plant species, fish, wildlife and humans.

Aquatic herbicide usage can provide excellent plant control when properly applied but it is important to remember that native aquatic plants are an integral part of a lake ecosystem. For instance, a public swimming beach might use a non-selective herbicide to control aquatic plants in a relatively small area. Early season treatments targeting only invasive species such as Eurasian water-milfoil or Curly-leaf pondweed have been very effective in limiting the impact to native species while providing season long control.

Identification of the target species is critical because product selection and treatment timing will affect results. Herbicides labeled for aquatic use are either classified as contact or systemic. Contact herbicides do not translocate throughout the plant but kill the exposed portions of the plant that they come into contact with. Typically, these herbicides are faster acting but do not have a sustained effect, meaning they do not kill root crowns, roots or rhizomes. Contact herbicides are frequently used to provide short-term nuisance relief. In contrast, systemic herbicides are translocated throughout the plant. They are slower acting but often result in the mortality of the entire plant.

There are many different types of products that can be considered based on the target species, acceptable non-target impacts, length of desired control, and use restrictions. These include chelated copper, glyphosate, imazapyr, 2,4-D, diquat, endothall, flumioxazin, carfentrazone, fluridone, and florpyrauxifen-benzyl. Defining expectations and choosing the right product will make the difference between a perceived success or failure. The average cost of commercial aquatic herbicide treatments can range from $250 - $1,000 per acre and vary greatly depending on the target plant(s) and herbicide(s) uses. Permits are needed from the WDNR including approved products, quantities, and application area, and timing.

Misinformation is plentiful surrounding pesticide treatment, including generalizations made in the last APM Plan. These statements have been examined below.

<u>GENERALIZATION #1: Pesticide products have unknown and/or conflicting evidence about the effects of long-term chemical exposure on fish, fish food sources, and humans.</u>

In 1962 Rachel Carson published “Silent Spring”, which drew widespread public attention to the indiscriminate use of pesticides with unknown human health and environmental effects. Many of the pesticides from this era were persistent in the environment and were transferred from one animal to the next (bioaccumulation). Very little was known at the time about the fate of pesticides in the environment and the potential effects of their residues on man and wildlife. Thus, the EPA was created in 1970 and in 1972 Congress passed the Federal Environmental Pesticide Control Act which gave the EPA greater authority over pesticide manufacturing, distribution, shipment, registration, and use.

Pesticide regulations are continuously under review and revision as scientific methods and knowledge increase. As mentioned above, it now costs $30 - $60 million or more, and 8 to 10 years, to introduce a new pesticide to the market. The EPA requires 84 to 124 different studies to ensure a pesticide will not cause unreasonable adverse effects on man and the environment. These studies include toxicity (acute, chronic, oncogenicity, developmental, and reproductive), chemistry, exposure, environmental fate, and ecological toxicity. There is a laboratory audit program which includes strict guidelines on how studies are conducted and documented. Ultimately the EPA reviews the information for corrective action including label changes, use deletions, or product cancellation).

**Much of the above text was taken from the book Biology and Control of Aquatic Plants, specifically Section 3.7 about Requirements for Registration of Aquatic Herbicides. That section was written by Don Stubbs and Carlton Layne who are both retired US EPA regulators.*

<u>GENERALIZATION #2: Pesticide treatment increases organic sediment deposition.</u>

Although it is true that dead and decomposing plant material from treatment can add to organic sediment in the lake, one must also realize the same thing will happen naturally in the fall and winter. Typically, invasive treatments are performed early in the season when biomass is low which lowers the potential organic accumulation. If growth is allowed to expand to its full potential throughout the season, the organic deposition is theoretically higher than invasives treated early on with pesticides. The natural die off of plants in the fall and winter can also lead to more drastic oxygen reduction and winterkill scenarios.

<u>GENERALIZATION #3: Pesticide treatment can cause a need for repeated treatments due to existing seed banks and/or plant fragments left behind.</u>

It is true that there is no “silver bullet” when looking at lake management and more specifically, aquatic plant management. The argument here is that plants are not removed from the system when treating which increases the possibility for seeds/fragments to remain in the lake, thereby causing a resurgence the next year. If this was the benchmark, then no lake should allow harvesting or boating either since these activities inherently cause fragmentation. Treatments do leave the plant behind, but in a decomposing form that would not allow viable growth. When looking at an invasive plant like curly-leaf pondweed, turions (vegetative seeds) are produced once the plant has reached maturity. By not addressing this plant through some form of management, you are allowing the turion bank to grow exponentially each year.

<u>GENERALIZATION #4: Effectiveness of small-scale treatments.</u>

Small-scale treatments can absolutely be more challenging than larger treatments based on wind, waves, and dilution potential. The study referenced in the previous plan looked at 2,4-D which requires much more contact time than other types of herbicides, and it broadly applied it to all small-scale treatments. None of the studied treatments used a weighting agent to reduce drift and dilution. This demonstrates how important it is to have an experienced professional management company analyze all available products, additives, and application techniques since they are constantly improving.

Conclusion - Herbicide treatments are a viable management tool on Phantom Lakes (except in Lower Phantom Lake Sensitive Area #3). These treatments should focus on targeting exotic species like Eurasian water-milfoil (EWM), curly-leaf pondweed (CLP), starry stonewort, purple loosestrife, and phragmites. If CLP becomes a widespread problem, then treatments should be planned early in the season to try to prevent the production of turions, an important method of reproduction for the plant. Also, for large expanses of EWM, early season treatments are encouraged before plant biomass increases and while native plant growth is minimal. Starry stonewort is best assessed early in the summer when growth becomes more active. Native aquatic plant beds should only be treated for nuisance conditions that may be affecting navigation. Destruction of any large native plant populations will increase potential problems from exotic species. Management of purple loosestrife and phragmites should be conducted in early to mid-August to control these invasive species before they increase their current ranges.

Harvesting

Harvesting is another lake management tool that is frequently used to control aquatic plants and is governed by WDNR under Wisc. Admin Code NR109. In the past, the presumption was that eventually plant growth in a lake with harvesting practices would cease to be a problem when nutrients have been removed. However, a lack of plant growth after harvesting will not normally be seen because incoming nutrients from the watershed will usually offset any nutrients removed during harvesting (Engel, 1990).

Harvesting is non-selective, that is, it harvests all plants in its path. “Top cutting” of plant beds has become an important strategy to apply. In an area with a mix of plant species including Eurasian Watermilfoil (EWM), “top cutting” the plant bed will remove the canopy of the exotic plant. With the canopy gone, native species can again begin to flourish. Sometimes, native plant beds can reach nuisance levels and impede navigation. “Top cutting” these areas leaves enough beneficial growth behind while opening otherwise impassible areas for navigation. Harvesting can also be used to create openings and edges in dense vegetation allowing predatory fish to more effectively seek out panfish that may otherwise become stunted. It is typically only allowed in waters deeper than three feet, leaving at least one foot of plant material. This decreases damage done to the equipment by bottom sediments or debris, minimize bottom sediment disruption reducing the chances of re-entry by exotic plant species and reduce disruption toward fish spawning and nursery areas. There are also small harvesters that are suited to working around obstacles and in shallow nearshore areas and channels.

Another aspect of harvesting operations is shoreline pickup programs. These programs help control floating plant material and plant debris that is washed up on shore by wind, wave, recreational use and harvesting operations. Many lakes with high amounts of invasive species like Eurasian Water-Milfoil benefit from shoreline pickup programs, by reducing the amount of floating plant material that would have otherwise started to re-colonize in the near shore areas. When a shoreline pickup program is used, plant debris should be placed on the ends of piers for retrieval. This will remove the need for harvesters to go near shore minimizing the disruption toward sediment and rooted plants.

Harvesting is a very costly management alternative with high initial equipment costs as well as long-term operational expenses. A harvesting program requires a variety of equipment and includes, but not limited to, a harvester, trailer, truck to haul cut plants, and a conveyor to move plants from the harvester to the truck. Along with equipment, a location to dump cut vegetation is needed. Another major component is staffing the program which usually depends on the size of the harvesting operation and/or lake. Smaller lakes typically have 1 to 2 harvesters which are run by volunteers or part time paid staff. Larger lake harvesting operations tend to have 2 or more harvesters and have full-time paid staff to conduct daily and seasonal maintenance, as well as repairs. Some local lakes even employ college students due to their availability during the summer.

Conclusion – Harvesting is currently being utilized and continues to be a viable management strategy for aquatic plant management on Phantom Lakes.

DASH

Diver Assisted Suction Harvesting (DASH) is a management option where a certified diver maintains control of a hydraulic pump and pulls selected plants by the root, feeding them into the intake hose. The plant is transferred to a collection station that can range from a mesh onion-sack to large on-shore drainage bags. The advantage of DASH includes the ability to select the target plant for removal. The disadvantage is the slow nature of the process and high cost (up to $12K per acre) due to specialty trained staff and equipment. Also, as operations begin in a DASH location, underwater visibility rapidly diminishes, further reducing the speed of removal. Low visibility and human error also contribute to missed plants or improper removal (not removing the roots). It is also common to do relative damage to non-target species through the tangled nature of aquatic plants and the hydraulic hose flattening areas as the diver(s) are searching for target plants. Mollusks, crustaceans, insects and other species that live in and around the lake bottom, on or within the plants are also inevitable bycatch. DASH should be used in instances of very small and relatively dense patches of invasive plant species that are ideally located on solid substrate. Deeper patches of target plants on a sand or gravel substrate with few native species is also ideal.

Conclusion - As a management strategy for invasive plants, DASH is most likely a limited option for the Lakes in isolated shoreline sites. With the broad plant distribution especially on Lower Phantom Lake, DASH is not a viable option for mitigation of invasive plants on a larger scale than individual sites.

Local Ordinances and Use Restrictions

Local lake ordinances have long been used to control activities on lakes. Local communities may adopt ordinances to protect public health, safety, and welfare. Any proposed ordinances are sent to the WDNR for review to be sure they comply with State Statutes. Once approved by WDNR, communities may then finalize and enforce the ordinances. Costs associated with ordinance development depend upon the problem, potential solutions, municipal cooperation, and municipal legal reviews. Grants are available through the WDNR to assist with the cost of developing ordinances.

Historically, public health, safety and welfare were interpreted to mean peoples' physical issues associated with using the lake. Speeding and reckless uses endanger lives and are usually controlled through local ordinances. Recently there has been a growing realization that the lake's health has a bearing on public welfare. Lake use activities conducted in inappropriate areas of lakes can be very damaging to the lake ecosystem. Spawning habitat can be destroyed along with disrupting aquatic plant communities, shifting the plant communities to become less beneficial. With the state's acceptance of the environmental health premise, communities are looking at lake use zoning. Some have shoreline zones that are no slow wake, while others have restricted some or all of the lake to no-motors. Protection of specific species or valuable areas can be achieved by developing an ordinance to minimize intrusions.

It is important to keep in mind the following in the development of ordinances:

- Any proposed ordinance must have prior review by the WDNR.
- An ordinance must not discriminate on a particular craft
- An ordinance must be clearly understood and posted. Buoys (which must also be approved by the WDNR) should warn boaters of areas to avoid.
- Any ordinance should address a specific problem. If boating damages a sensitive area of the lake, allowing boats in the area on alternating days does not achieve the protection sought.
- An ordinance must be reasonable and realistic. An ordinance that creates a slow no wake zone that affects all of the lake area less than three feet deep may not be enforceable. The general public could not know the extent of that area. A more reasonable approach would be to review the desired area and develop a plan based on a specific distance from shore. Buoys could then be used to identify that area.
- Any proposed ordinance should be studied to ensure that it does not aggravate a different problem. For example, many communities have shoreline slow no wake zones that exceed that of state law. On a small lake, enlarging that shoreline zone may provide more resource protection. It may also further concentrate other lake use activities such as skiing into an area too small to be safe.

Any attempts to restrict lake use should be weighed along with the social and economic impacts. It is well documented that those most involved with lakes and lake protection are those same people who spend the most time on or around lakes. They either live on or have easy access to a lake. It is very difficult to convince outsiders that lake quality is a concern or that funds should be spent because they do not have a personal involvement. Reducing public use of a lake will have a direct effect on their involvement and possibly their social and economic concern about a lake. Lake ordinances should be developed to protect health or safety, not to restrict a specific user group.

Conclusion – The Town of Mukwonago has generally adopted State boating and water safety laws. Additionally, they have created ordinances related to swimming in the channel, slow-no-wake areas and times, waterskiing, speed, littering, and motor vehicle speed during ice cover. Creating more ordinances and restrictions may be a viable option for Upper and Lower Phantom Lakes, however, they should be carefully developed and studied to ensure that they address the problems without undue restrictions. The restrictions on stopping aquatic hitchhikers are particularly important and should continue to be well documented with signage at the boat launch and within the CBCW program.

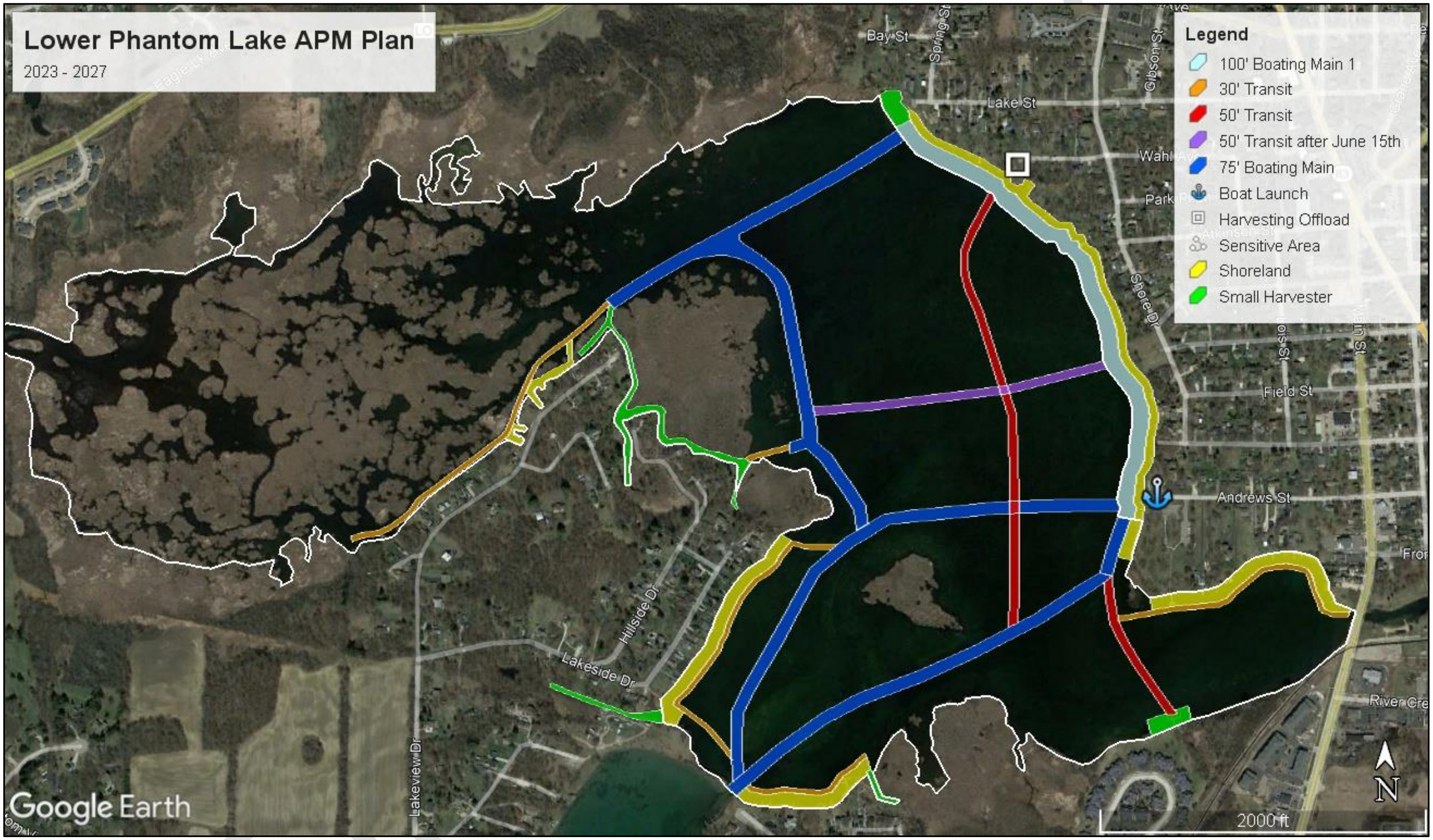
RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

Control of exotic or nuisance plant species is an uphill battle in many lakes. Realistic expectations are important in aquatic plant management, and it is unlikely that exotic plants species can ever be completely removed from a lake system. There is no single cure-all solution, so utilizing Integrated Pest Management (IPM) is important. The concept of IPM involves consideration of biological, chemical, and physical means to control an invasive or nuisance species. Based on our analysis of currently available techniques, we've provided our recommendations for Phantom Lakes below.

For the purpose of these recommendations, nuisance species shall be defined as those native species which produce excessive biomass that hinder realistic lake uses and may include multiple species in navigational lanes. Invasive species include Eurasian Water-milfoil, Curly-leaf pondweed, Starry Stonewort, Spiny Naiad, Phragmites, and Purple loosestrife. Limiting disruption of non-nuisance, native aquatic plant beds should be a priority to meet long-term management goals. The protection of the desirable species will provide natural "seedbanks" or "plantbanks" for re-establishment into other areas of the lake. ***Selection of management areas and techniques should always be based on present conditions.***

The new Aquatic Plant Management (APM) Plan maps for each lake are presented in Figure 55 and Figure 56 along with lake specific strategies. These maps will be referenced for each component of the Plan which includes mechanical harvesting, herbicide treatment, hand controls, DASH, and public education. Each strategy has its own set of benefits and drawbacks. It is up to the District to select the most appropriate technique(s) for their situation after examination of social, political, economic, and environmental conditions.

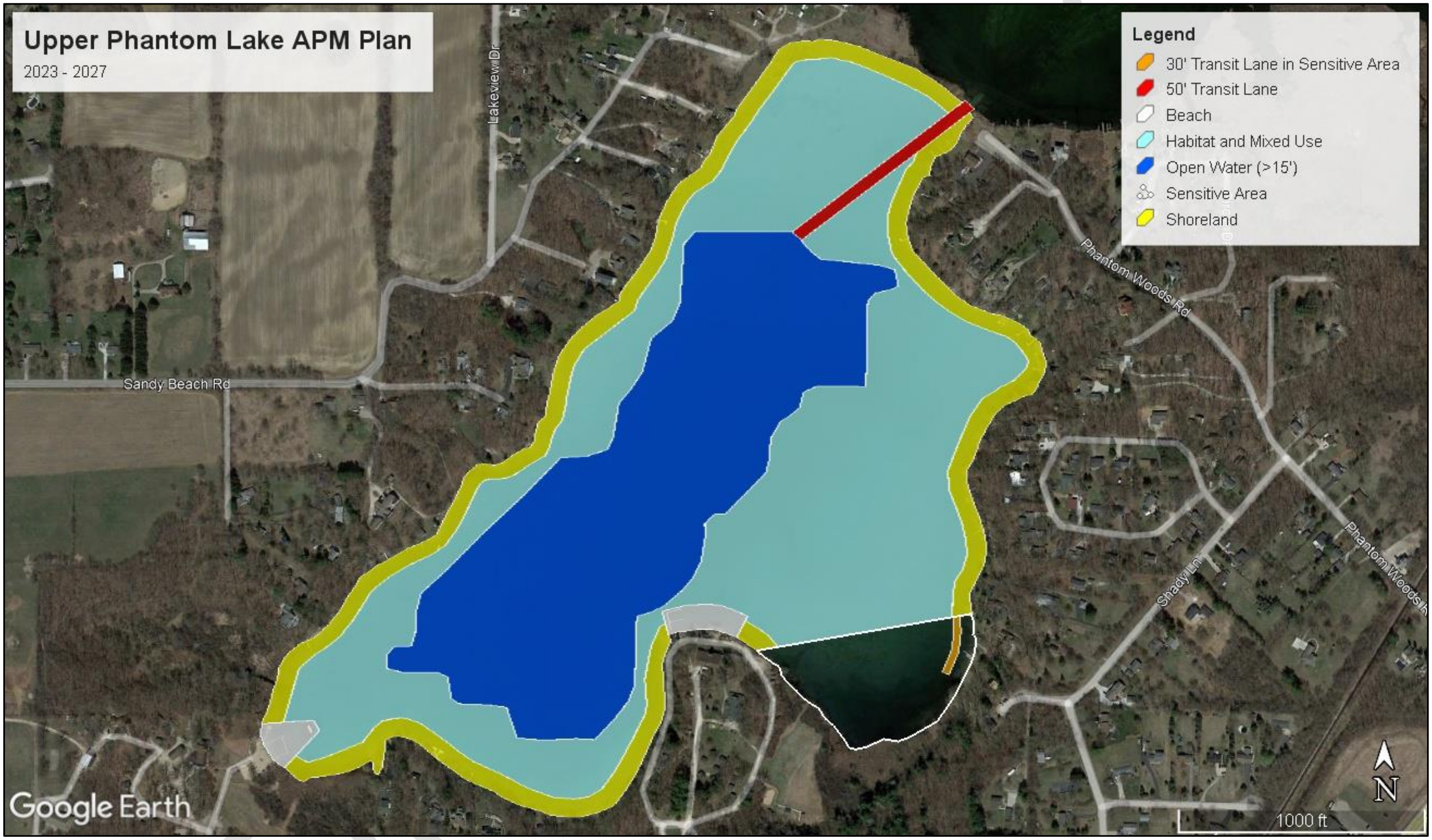
Figure 55: Recommended Aquatic Plant Management Plan for Lower Phantom Lake



SOURCE: Lake and Pond Solutions LLC (2023)

**The extent of implementation among these areas will depend on available staff, time, budget, and plant growth each season. Management area sizes and locations have been scaled appropriately. Refer to Page 68 for specific descriptions of the management areas as they relate to harvesting and Page 77 for herbicide treatments.*

Figure 56: Recommended Aquatic Plant Management Plan for Upper Phantom Lake



SOURCE: Lake and Pond Solutions, LLC (2023)

**The extent of implementation among these areas will depend on available staff, time, budget, and plant growth each season. Management area sizes and locations have been scaled appropriately. Refer to Page 68 for specific descriptions of the management areas as they relate to harvesting and Page 78 for herbicide treatments.*

Mechanical Harvesting

Mechanical harvesting is the main aquatic plant control method used in Phantom Lakes. The Phantom Lake Management District (PLMD) owns and operates a 1994 ILH800 (10' wide) harvester and a 2022 ILH7-450 (7' wide) harvester purchased in the summer of 2022. They also contract with Clearwater Plant Harvesters who operate a 5' wide harvester for smaller areas and channels. Harvesting has historically been conducted predominately on Lower Phantom Lake with the goal of opening lanes in dense invasive and nuisance vegetation to allow easier access for recreational opportunities. The District harvests 5-7 days per week depending on needs and harvested a total of 8,007 cubic yards of plant material in 2022.

The key goal of the harvesting program must be the adequate control of aquatic plants in the common use areas of the lakes, while protecting the integrity of the native species lake wide. During the growing season it would be highly desirable to dispatch a "weed scout" to determine area specific management strategies for that harvesting period. The weed scout could be any reasonably trained person familiar with overall aquatic plant management strategies and basic plant identification. By executing spot monitoring of the aquatic plant communities, priority harvesting areas and lanes can be formulated throughout the season. Since the two lakes have very different characteristics, we've presented specific details regarding both lakes below that reference the maps in Figure 55 and Figure 56 .

General Requirements and Recommendations

General harvesting requirements for both Upper and Lower Phantom Lake include:

- **Harvesting could begin as early as May 15th and may extend as late as October 15th.**
    - Except for central West to East path on Lower Phantom Lake which starts June 15th (marked in purple)
    - Harvesting schedules, cutting patterns, and overall intensity will need to be modified to protect spawning fish and target invasive and nuisance plant growth.

- **Harvesting shall not occur in water depths less than 3'.**
    - The ILH7-450 (or smaller) may perform navigation pier harvesting and cleanup in shoreland areas < 3' deep (marked in yellow) or beach areas < 3' deep (marked in grey). No harvesting shall take place in less than 1.5' deep in these two areas.
    - A small harvester (5' or less cutting width) may be used in small channels that are <3' deep (marked in green).
    - Use slower speed and extreme care when harvesting areas less than 4 feet deep to prevent incidental damage with other crafts and avoid cutter head contact with the bottom.

- **In all areas, no more than 3' of plant material should be cut AND at least 1' of living plant material must remain attached to the lake bottom after cutting.**
    - This will reduce the resuspension of lake sediments and help to maintain desirable plant communities.

- **Collect and properly dispose of harvested plants and collect plant fragments.**
    - Plant cuttings and fragments should be immediately collected upon cutting to the extent practicable.
    - Fragments collected by landowners can be used as garden mulch or compost.
    - Harvested plant material to be offloaded at Wahl Avenue to be brought to the disposal site (see Figure 59 and Figure 60).

- **Stick to designated harvesting lanes.**
    - Final harvested lanes shall remain fixed throughout the year to avoid unintentional disturbance to adjacent areas or harvesting of larger than intended lanes.
    - With the discovery of starry stonewort, it is important to stay within the designated harvesting lanes to reduce the potential spread throughout the lake.
    - No mechanical harvesters should be operated in the marshy northwestern reaches of Lower Phantom Lake or the designated sensitive area on Upper Phantom Lake except to maintain the defined access channels and boating transit areas described below.

- **Provide all harvesting operators with copies of the approved harvesting plan and maps to be kept on board at all times.**

- **Immediately return incidentally captured living fish and animals to the water.**
    - Turtles, fish, and amphibians commonly become entangled within harvested plants. Live species must be returned to the lake during harvest or offload to the extent practical.

- **Provide annual reports summarizing harvesting activities to WDNR by November 1st.**
    - Report should include information such as a map showing the areas harvested, the total acres harvested, and the total amount of plant material removed from the body of water.

- **Harvesting operators must successfully complete appropriate training.**
    - Understanding the harvesting components to this Plan including which harvester to use, types of cuts, lanes, and sensitive area restrictions.
    - General equipment function, capabilities, limitations, and general maintenance
    - General plant identification of native and invasive plants present in the Lakes
    - Safety, courtesy, and etiquette.
    - Understand legal obligation to accurately track and record harvesting for inclusion in WDNR required annual reports.

Additional general recommendations for the harvesting program include:

- Implement a regularly scheduled aquatic plant pickup program.
    - Due to the sheer amount of vegetation in Lower Phantom Lake, aquatic plant harvesting and boating will result in a higher-than-normal amount of plant fragments (“floaters”).
    - Residents could place floaters in a pile at the end of pier to be picked up by the harvester during a regular pickup schedule.

- Establish a supplemental plant offload site.
    - Having a potential offload site on the southern side of the lake could reduce transit times, lake traffic, use conflicts, and lower operation costs all while increasing harvesting efficiency.
    - If a new suitable site is identified, this plan would encourage its use.

Lower Phantom Lake

The approximate orientation and extent of the proposed harvesting lanes have been altered since the last APM Plan published in 2019. The justification for these changes is provided at the end of this section. Although the map is drawn to scale, the actual locations of the lanes may differ slightly in the field based on conditions. It is important that the final harvested lanes remain fixed throughout the year to avoid unintentional disturbance to adjacent areas or harvesting of larger than intended lanes. Lane choice should consider water depth, plant species, recreational uses, and boating habits. General Requirements and Recommendations listed above apply.

Specific harvesting requirements for Lower Phantom Lake include (refer to Figure 55):

- Boating Mains: These channels are either 75 feet or 100 feet wide and are intended to be the main travel corridors for recreational watercraft and harvesting equipment.
    - 75-foot boating mains (**dark blue**) should generally follow already established travel lanes. EQUIPMENT: Any harvester but ILH800 is ideal.
    - The 100-foot wide boating main (**light blue**) on the east side of the lake may be started wherever water is 3’ deep. The map shows an example of this lane from 50-150’ out. EQUIPMENT: Any harvester but ILH800 is ideal.

- Transit Lanes – These lanes are either 30 feet or 50 feet wide and are intended to provide secondary travel thoroughfares for recreational watercraft and harvesting equipment.
    - The three 30-foot wide transit lanes (**orange**) on the south end of the lake may be started wherever water is 3’ deep. The map shows an example of this lane from 75-105’ out. The other two 30-foot wide lanes

on the NE end of the lake should generally follow already established travel lanes. EQUIPMENT: Any harvester but ILH7-450 is ideal.
    - The 50-foot wide transit lanes (**red**) should be established as shown in Figure 55. EQUIPMENT: Any harvester
    - The 50-foot wide transit lane (**purple**) should be established as shown in Figure 55 but only after June 15th. EQUIPMENT: Any harvester

- Shoreland Areas – These areas (**yellow**) are immediately adjacent to developed shorelines and are intended to provide limited access from piers and docks to transit lanes or boating mains. To the extent practical, aquatic and riparian vegetation should be maintained.
    - These areas on the south end of the lake start at the shore and extend 75' out or up to the start of the 30' transit lanes. On the east shoreline, this area starts at the shore and extends 50' out into the lake or up to the start of the 100' boating lane. In the NW channel, there are two areas that encompass resident access to the main transit lane.
    - Harvesting may occur locally around piers or docks for navigational purposes and general cleanup and would be allowed in depths less than 3' (but no less than 1.5'). EQUIPMENT: ILH7-450 or smaller

- Small Harvester – These areas (**green**) are located around the lake in channels and/or shallow areas and are intended to provide access to transit lanes.
    - Due to the shallow and sensitive nature of these areas, only a small harvester approved by the WDNR may be used. EQUIPMENT: Harvester with width ≤ 5 feet.

Justification For a Harvesting Change

To summarize the harvesting change for Lower Phantom Lake, Figure 57 has been provided to show the difference in previous harvesting acreage versus newly proposed harvesting acreage. The main alterations surround a widening of the main transit lanes, now called "boating mains" and the reinstatement of a north to south transit lane to ease recreational pressure.

Recreational pressure has increased tremendously since the last Plan with the improvement of the boat launch (two launch lanes) and a surge in lake use during the Covid-19 pandemic. According to the National Marine Manufacturers Association, retail unit sales of new powerboats in the U.S. reached a 13-year high in 2020 which was led by 415,000 first-time boat buyers. Additionally, The Water Sports Foundation in 2022 reported that according to data from the Outdoor Foundation, a record 37.9 million people participated in such activities as kayaking, canoeing, and stand-up paddleboarding during the Covid-19 pandemic. The data, from late 2020, also showed 2.5 million new paddlers. This surge brought an increase in accidents as new paddlers accounted for 26 percent of all boating accidents.

Phantom Lakes has observed the same increase in recreational which has led to use conflicts, hostility, and potential safety issues as more lake users vie for the same navigational space. This increase is anecdotally evidenced by the Town of Mukwonago Police Department in 2020 and 2021 patrol summaries provided at PLMD Annual meetings. The PLMD has identified an increasing need to increase transit and harvesting lanes to mitigate these emerging issues.

Figure 57: Lower Phantom Lake Harvesting Comparison

Category	Previous acreage	Proposed acreage	To Permit
100' Boating Main (Light Blue)	0.00	7.00	7.00
75' Boating Main (Dark Blue)	5.25	18.54	18.54
50' Transit (Red)	13.86	4.48	4.48
50' Transit after 6/15 (Purple)	2.14	2.14	2.14
30' Transit (Orange)	4.65	4.86	4.86
Small Harvester (Green)	3.33	4.18	4.18
Shoreland (Yellow)*	14.79	11.79	7.00
TOTAL ACREAGE	**44.02**	**52.99**	**48.20**
PERCENT OF LAKE	**11.80%**	**14.21%**	**12.92%**

SOURCE: Lake and Pond Solutions LLC (2023)

The 2011 Plan had the main navigational lanes at 120 feet wide as opposed to the 50 and 75 feet present in the 2019 Plan. This Plan has proposed to increase the eastern boating main back to 100 feet wide (from 75 feet) while also increasing the other boating mains to 75 feet wide (from 50 feet) to provide larger travel lanes for passing watercraft. A 50-foot wide transit path down the center of the lake was also added back to the plan. This should help ease congestion at the boat launch as users will have another north to south travel option. Even with the increase in boating main widths and the addition of a new 50-foot transit path down the center of the lake, total proposed acreage will only increase 8.97 acres (2.41% more of the lake). The actual acreage to permit would be less (48.20 acres) since the Shoreland areas are not 100% harvested.

During the last harvesting permit renewal, the District's request to increase harvesting on the lakes was partially denied. There were a few underlying reasons for these denials that we would like to address in this Plan.

1. There is the potential of "fragmenting habitat significantly" which ultimately would affect fish's ability to feed, rear, and take cover.
    a. RESPONSE: There are a number of white papers (see below) that highlight the benefits of creating fishing lanes, especially in a lake like Lower Phantom which is 99 percent vegetated.
2. Native plants provide a competitive advantage for native panfish and gamefish species, resulting in improved water quality and increased angling opportunities.
    a. RESPONSE: Overly excessive plant growth can have a detrimental effect on water quality by way of reduced dissolved oxygen levels and increased temperature (see below). Fishing success is also reduced.
3. Further fragmentation of the main water body is likely to increase EWM.
    a. Although EWM has declined over the past two surveys on Lower Phantom with a reduced harvesting footprint, the same is true for Upper Phantom which is generally unmanaged. This indicates that harvesting alone may not be the

mechanism driving the change. Additionally, current harvesting patterns have not spread milfoil down the transit lanes on Lower Phantom Lake. If fragmentation (transit lanes) truly did increase EWM, then we would expect to have seen it spread throughout all the transit lanes on this survey (which wasn't the case). The proposed harvesting plan only amounts to a total of 8.97 acres more, most of which is in the form of widened channels.

An October 1993 paper by the US Army Corps of Engineers entitled "Relationships Between Fish and Aquatic Plants: A Plan of Study" by Killgore, Dibble, and Hoover examined literature available regarding fish and aquatic plants. They found that:

- *Too much structure or too many plants can reduce interactions between fish and prey, leading to a reduction of fish production (Dunst et al. 1974, Smith and Crumption 1977, Diehl 1988). An intermediate level of plant density and structure appears optimal (Killgore, Morgan, and Rybicki 1989, Glass 1971), Savino and Stein 1982, Crowder and Cooper 1979, Colle and Shireman 1980). Vegetation in aquatic systems impacts growth and condition in fish. Based on a survey of 300 systems, growth of largemouth bass decreased as vegetation increased (Engel 1985). Others have reported similar results in the relationship of increased plant abundance and the growth rates of largemouth bass (Colle and Shireman 1980, Noble 1986, Maceina et al. 1991). The opposite appears to be true in the growth and condition of smaller centrarchids. Since bluegill and other small centrarchids use vegetation as a food source (Gerking 1962, Engel 1988), the increase in vegetation tends to increase growth rates and conditions in bluegill, crappie, and redear sunfish populations (DiCostanzo 1957, Bailey 1978, Colle and Shireman 1980, Wiley et al. 1984, Maceina and Shireman 1985, Savino, Marschall, and Stein 1992). However, too much vegetation can actually decrease growth rates in these fish (Colle and Shireman 1980, Shireman et al. 1984, Colle et al. 1986), but control of plant densities can maintain optimal growth and condition (Cope et al. 1970).*

- *Colle and Shireman (1980) predicted that the condition of largemouth bass would significantly decrease in systems with 40 percent or greater coverage of aquatic plants. The creation and maintenance of edges also may increase the availability of important forage and refuge habitat (Werner et al. 1977, Werner, Hall, and Werner 1978, Engel 1984). Based on these predicted benefits, moderate plant densities and plant edges, if maintained, should increase the growth and condition of harvestable fish and supply enough food and cover for the strong recruitment and survival of younger fish.*

There is no debate about the importance of aquatic plants and fish. In the fourth edition book *Biology and Control of Aquatic Plants* edited by Gettys, Haller, and Petty (2021), Section 1.2 regarding the Impact of Invasive Aquatic Plants on Fish written by Eric Dibble from Mississippi State University states that:

- *Sites with vegetation generally have higher numbers of fish compared to non-vegetated areas. However, excessive growth of aquatic plants promotes high populations of small fish in contrast to more diverse and balanced plant populations. The ability of fish to* *forage declines as vegetated habitats become more complex. Visual barriers created by leaves and stems may make it more difficult for fish to find and capture prey. Aquatic plants can also change water temperatures and available oxygen in habitats, thus indirectly influencing growth and survival of fish. Plant beds that are managed for fish habitats should include open areas such as patches and/or lanes to improve the water circulation and oxygen exchange that are important to fish health.*

A 1997 study in large Georgia reservoir looked at population characteristics of largemouth bass including growth, body condition (relative weight), size structure, and fecundity in relation to abundance of submersed aquatic vegetation (SAV) coverage (Brown and Maceina, 2002).

- *Relative weight, fecundity, and growth of largemouth bass in the Spring Creek embayment with 76% SAV coverage was considerably less than measured in the Chattahoochee and Flint arms that contained lower SAV coverages (26% and 32%). It also took fish 1.8 years longer to reach 16 inches in Spring Creek and fish produced 47% less eggs.*

Upper Phantom Lake

The approximate orientation and extent of the proposed harvesting lanes **have not** been altered since the last APM Plan published in 2019. Although the map is drawn to scale, the actual locations of the lanes may differ slightly in the field based on conditions. It is important that the final harvested lanes remain fixed throughout the year to avoid unintentional disturbance to adjacent areas or harvesting of larger than intended lanes. Lane choice should consider water depth, plant species, recreational uses, and boating habits. General Requirements and Recommendations listed above apply.

Specific harvesting requirements for Upper Phantom Lake include (refer to Figure 56):

- Transit Lanes – These lanes are either 30 feet or 50 feet wide and are intended to provide access for recreational watercraft to reach deeper portions of the lake.
  - The 30-foot wide transit lane (**orange**) on the southeast end of the lake is located in the Sensitive Area and was allowed on the last harvesting permit. It may be started wherever water is 3' deep. The map shows an example of this lane from 60-90' out. EQUIPMENT: Any harvester but ILH7-450 is ideal.
  - The 50-foot wide transit lane (**red**) should be established as shown in Figure 56. Although the lane extends to 15' of water, harvesting should only be as needed to provide for navigation. EQUIPMENT: Any harvester

- Shoreland Areas – These areas (**yellow**) are immediately adjacent to developed shorelines and are intended to provide limited access from piers and docks to deeper water. To the extent practical, aquatic and riparian vegetation should be maintained.
  - These areas around the lake perimeter start at the shore and extend 75' out. Harvesting may occur locally around piers or docks for navigational

purposes and general cleanup, extending as much as 75’ from shore. Harvesting would be allowed in depths less than 3’ (but no less than 1.5’). EQUIPMENT: ILH7-450 or smaller

- Beach – These areas (**grey**) are similar to shoreland areas except most aquatic and riparian vegetation can be removed. Both locations on the lake remain the same and were selected for more intensive management due to the camps that utilize the area.
  - Harvesting may occur locally but shall not occur in depths less than 1.5’. EQUIPMENT: ILH7-450 or smaller.

- Habitat and Mixed Use – These areas (**light blue**) are located in the intermediate depths of the lake starting 75’ out from shore and extending to a water depth of 15’.
  - Harvesting should mainly occur when areas are dominated by invasive species or when necessary to reduce the canopy of native plants to allow reasonable recreational use of the lake. Areas dominated by native plants and not required for reasonable Lake access and use should be left unaltered. EQUIPMENT: Any harvester.

- Open Water – This area (**dark blue**) is located in an area of the lake that is over 15’ deep. No plant control should be necessary in this zone.

Figure 58 shows the harvesting comparison for Upper Phantom Lake and suggests the appropriate acreage to permit.

Figure 58: Upper Phantom Lake Harvesting Comparison

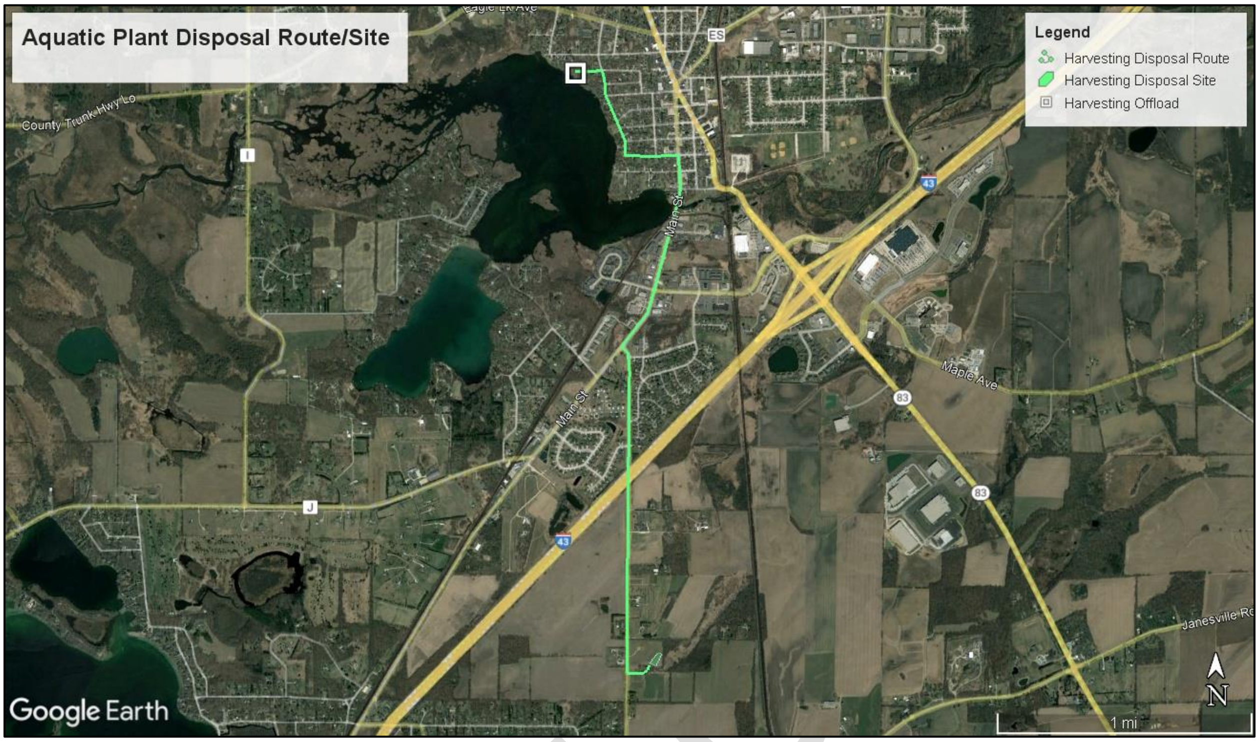
Category	Previous acreage	Proposed acreage	To Permit
50' Transit (Red)	1.00	1.00	1.00
30' Transit in Sensitive Area (Orange)	0.17	0.17	0.17
Habitat and Mixed Use (Light Blue)*	52.80	52.80	7.00
Beach (White)	1.40	1.40	1.40
Shoreland (Yellow)*	15.59	15.59	7.00
TOTAL ACREAGE	**70.96**	**70.96**	**16.57**
PERCENT OF LAKE	**64.51%**	**64.51%**	**15.06%**

SOURCE: Lake and Pond Solutions LLC (2023)

Plant Offload and Disposal

Harvested plant material is off-loaded at the Northeast end of Lower Phantom Lake at Wahl Avenue. A conveyor moves plant material into a dump truck that transports it to the disposal site located South of 1616 Honeywell Road. The PLMD currently uses only one disposal site for vegetation from the harvesting operation. The route taken to this site as well as a site map with nearby wetlands are presented in Figure 59 and Figure 60. Plant material should be collected and disposed daily to reduce undesirable odors and pests, avoid nutrients leaching back to the lake, and minimize aesthetic issues related to offloaded material.

Figure 59: Phantom Lakes Harvesting Disposal Routes



SOURCE: Lake and Pond Solutions LLC (2023)

Figure 60: Phantom Lakes Harvesting Disposal Site

SOURCE: Lake and Pond Solutions LLC (2023)

Herbicide Treatment

The use of approved aquatic herbicides should be assessed on an annual basis in coordination with a certified and licensed professional applicator, the PLMD, and the WDNR. Permits must be obtained through the WDNR before undertaking any kind of treatment. All recommendations are based on the 2022 PI survey; ***conditions are subject to change and recommendations should be reanalyzed each year based on current information.***

Lower Phantom Lake

Lower Phantom Lake is a complex system with higher-than-average densities of beneficial native plant species and sensitive area designations that span most of the lake. There are two main forms of treatments to consider: Invasive Treatments and Navigational Treatments.

<u>Invasive Treatments</u>

The invasive species found in Lower Phantom Lake include starry stonewort, Eurasian water-milfoil, spiny naiad, curly-leaf pondweed, purple loosestrife, and phragmites. Based on the 2022 PI survey, no herbicide treatment is currently necessary for **spiny naiad** or **curly-leaf pondweed** but the need should be reevaluated annually

Starry stonewort (SSW) was the most commonly found invasive and some of the denser beds are represented by red triangles and yellow squares. These areas are candidates for treatment although there likely will be impacts to surrounding native vegetation. It could be argued that leaving starry stonewort to expand will also have detrimental impacts to surrounding native vegetation (see Figure 16). Careful planning must consider these potential impacts, associated navigational issues, and sensitive area designations. Currently the WDNR lists that Sensitive Area 1 may receive selective treatment for non-native species while in Sensitive Area 2, treatments are listed as “not recommended”. Vegetation in the lake has changed since those criteria were written so it’s worth reevaluating. We’ve found that the most successful treatment for SSW is a combination of flumioxazin and chelated copper at maximum label rates.

Figure 61: Lower Phantom Lake Starry Stonewort vs Sensitive Areas

SOURCE: Lake and Pond Solutions LLC (2023)

Eurasian water-milfoil (EWM) was an issue for the Lower Phantom Lake in previous PI surveys but it did not show up in significant numbers during our 2022 survey. Currently, whole lake treatment is not an option to consider but it could be evaluated if new conditions warrant the discussion. Outside of a few points on the south end of the lake, most of the EWM points are located in the navigational channel that is part of Sensitive Area 3. This area is listed as "no chemical treatment allowed". For these reasons, EWM treatments are not recommended at this time but should be reevaluated annually. Fluridone is the recommended active ingredient for whole lake treatments while florpyrauxifen-benzyl is preferred for spot treatments.

Purple loosestrife and **phragmites** were found scattered throughout the shoreline of Lower Phantom Lake. Both of these species are aggressive wet-footed emergent plant invaders that should be managed. There are multiple strategies to accomplish that goal including herbicide treatment which is one viable option for Lower Phantom Lake. The preferred treatment for purple loosestrife is glyphosate with a surfactant while the treatment for phragmites is a combination of glyphosate, imazapyr, and surfactant. Since these spot treatments can be very selective based on the method of application, Sensitive Area restrictions may be altered (although this determination would come from the WDNR).

<u>Navigation Treatments</u>

Due to the harvesting program in place for Lower Phantom Lake, the need for navigational treatments for nuisance plant species will likely be limited. However, treatments along shorelines, channels, and piers may be a viable alternative especially when shallower water limits harvesting activities. The area that navigational treatments may be considered is represented in yellow (Shoreland) on Figure 55. These areas predominately cover 75 feet out from shore except for the East shore (50 feet). Boating mains and transit lanes on this map may also be considered for treatment if the harvesting operation ceases or cannot effectively maintain the designated lanes due to loss of equipment or lack of hired labor. The WDNR will have final approval of any proposed navigational treatments.

Upper Phantom Lake

Upper Phantom Lake is a normal system with average densities of beneficial native plant species and a single sensitive area designation on the Southeast end of the lake. There are two main forms of treatments to consider: Invasive Treatments and Navigational Treatments.

<u>Invasive Treatments</u>

The invasive species found in Upper Phantom Lake include spiny naiad, purple loosestrife, and Eurasian water-milfoil.

Spiny naiad was the most commonly found invasive but is generally thought of as a naturalized invasive. We normally don't see many issues with this species, but it can expand to densities large enough to impact native species. It has established a sizeable footprint in the Sensitive area and the North end of the lake which should be monitored. These areas may be candidates for treatment along with any area listed as "Shoreland", "Beach", or "Habitat and Mixed Use" although planning should consider potential impacts, associated navigational issues, and any sensitive area designation. Currently the WDNR lists that the Sensitive Area "may receive selective treatment for pioneer stands of non-native species", although that could change if the integrity of the Sensitive area is threatened. We've found that the most successful treatment for spiny naiad is a combination of diquat, endothall, and chelated copper.

Eurasian water-milfoil (EWM) was an emerging issue for the Upper Phantom Lake in previous PI surveys but it did not show up in significant numbers during our 2022 survey. The only survey point with EWM was located in the Sensitive area. Currently, treatments are not an option to consider but they could be evaluated if new conditions warrant the discussion. Any areas listed as "Shoreland", "Beach", or "Habitat and Mixed Use" may be candidates for treatment although planning should consider potential impacts, associated navigational issues, and any sensitive area designation. Fluridone is the recommended active ingredient for whole lake treatments while florpyrauxifen-benzyl is preferred for spot treatments.

Purple loosestrife was only found in two shoreline locations of Upper Phantom Lake, one of which was the Sensitive area. This is an aggressive invasive wet-footed emergent plant that should be managed. Although herbicide treatment may be a viable option in the future, the limited range of this species now might lend itself to other management strategies like manual removal.

<u>Navigation Treatments</u>

Generally, the plant community in Lower Phantom Lake has remained largely unchanged. There has been very little need for active management, including herbicide treatments which we don't expect will change. However, treatments along shorelines, piers, and camp beaches may be a viable alternative especially when shallower water limits harvesting activities. The area that navigational treatments may be considered is represented in yellow (Shoreland), grey (Beaches), and light blue (Habitat and Mixed Use) on Figure 56. The "Shoreland" area predominately covers 75 feet out from shore except in the Sensitive area. The "Beach" areas cover a variable distance out to the edge of piers and swim rafts. The "Habitat and Mixed Use" area should be deep enough to limit most navigational issues, but treatments may be considered if needed to promote reasonable recreational use of the lake. Transit lanes on this map may also be considered for treatment if the harvesting operation ceases or cannot effectively maintain the designated lanes due to loss of equipment or lack of hired labor. The WDNR will have final approval of any proposed navigational treatments.

DASH

Although time consuming and expensive, Diver Assisted Suction Harvesting (DASH) could be used by private individuals as a small-scale management strategy to provide navigation areas around piers and other congested areas. For Lower Phantom Lake, DASH would be suitable in the areas marked "Shoreland" and the single "Small Harvester" area on the SE end of the lake (see Figure 55). For Upper Phantom Lake, suitable locations are marked "Shoreland" and "Beach" (see Figure 56). Additionally, it may be an appropriate strategy outside of these areas on both lakes to combat small-scale pioneer infestations of invasive species. WDNR NR109 permits are required, and it is important to have realistic expectations for DASH and ensure that permit conditions are being adhered to.

Manual Control

NR 109 allows riparian landowners to manually remove aquatic vegetation including native species and invasives like Eurasian water-milfoil and Curly-leaf pondweed within their "riparian zone" without permits as long as the resident's riparian zone is considered a single area that is no more than 30 feet wide as measured parallel to the shoreline. The area must include piers, boatlifts, swimrafts, or other recreational and water use devices. It may not be located in a listed WDNR Sensitive Area. The 30-foot area must remain the same each year and it is illegal to remove native plants outside the 30-foot wide area without a permit.

For Lower Phantom Lake, hand controls may only be used by individual landowners on the East shoreline to clear swimming areas or pier areas without a permit since the rest of the lake is a Sensitive Area (see Figure 10). For Upper Phantom Lake, hand controls may be used by any individual landowners not located in the Sensitive Area on the SE end of the lake. Residents on either lake who are in a Sensitive Area would need to secure a NR109 permit for manual removal.

Landowners should be encouraged to be selective in their clearing, again focusing on Eurasian watermilfoil, curly-leaf pondweed, starry stonewort, purple loosestrife, and phragmites. A natural area of native vegetation is recommended both on the shoreline and in the water because leaving a void will allow invasive species to re-establish.

Public Information and Education

It is extremely important to provide information to lake property owners and lake users on the benefits of a healthy aquatic plant community including the management issues involved in controlling nuisance and invasive aquatic plants. Annual meetings, newsletters, and informational materials provided by the University of Wisconsin-Extension, Aquatic Ecosystem Restoration Foundation (AERF), and the Wisconsin Department of Natural Resources can assist lake users in understanding the many areas of aquatic plant management and ways to protect lakes from other invasive species. Currently, annual meetings and newsletters are the main form of communication between the District and lake residents.

Currently the WDNR is collecting water quality data on Lower Phantom Lake annually but there has been no information collected on Upper Phantom Lake since 2017. It is recommended that the PLMD consider the WDNR – Citizen Lake Monitoring Program, which assists in monitoring overall health of the lakes. Volunteer data collection could provide secchi disk, chlorophyll a, and total phosphorus data. An outside consultant could collect this data as well. Historical information can be found at:

Lower Phantom Lake
https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=765800&page=waterquality

Upper Phantom Lake
https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=766000&page=waterquality

The PLMD is initiating the Clean Boats, Clean Waters Program this season in coordination with Waukesha County after a 5-year hiatus. It will provide valuable contact with recreational boaters at the launch site. Boat inspectors help perform boat and trailer checks, hand out informational brochures, and educate boaters on how to prevent the spread of aquatic invasive species.

RAPID RESPONSE PLAN

Rapid response to a new aquatic invasive is imperative. The first step is ensuring that it is, in fact, an invasive species not previously found on the waterbody.

If a suspected invasive species is found:

- Take a digital photo of the plant in the setting where it was found and mark with a GPS (if possible). Then collect 5 – 10 intact specimens. Try to get the root system, all leaves as well as seed heads and flowers when present. Place in a Ziploc bag with no water. Place on ice and transport to refrigerator.

- Fill out form http://dnr.wi.gov/lakes/forms/3200-125-plantincident.pdf.

- Contact the WDNR Aquatic Invasive Program Coordinator (currently Amy Kretlow) and deliver the specimens, report, digital photo, and coordinates (if available). Do this as soon as possible; but no later than 4 days after the plant is discovered. A PLMD board member and current lake consultant should also be notified.

Upon determination of species, a coordinated response plan should be developed in consultation with the DNR, the County, and lake consultant as needed.

*The Rapid Response Plan language was developed in coordination with Craig Helker (WNDR)

SUMMARY

The purpose of this update was to report the results of the 2022 point-intercept survey on Lower and Upper Phantom Lake and compare it to the last Aquatic Plant Management (APM) Plan update, written by SEWRPC and approved in 2019. The Phantom Lakes Management District (PLMD) elected to begin this process a year early to address significant changes in the lakes over the past four years.

The goals and objectives for both Upper and Lower Phantom Lake continue to focus on balancing the various uses and needs while working to improve the long-term quality of the resource. The management of exotic plants, specifically, Eurasian water-milfoil (*Myriophyllum spicatum*), hybrid water milfoil, curly-leaf pondweed (*Potamogeton crispus*), starry stonewort (*Nitellopsis obtusa*) and excessive amounts of native plants continue to be a great concern to the District.

Phantom Lakes and the Mukwonago area in general have experienced tremendous growth and the amount of recreational use is greater than ever. The invasive exotic plants and very dense native plants restrict boating use and have caused some hostility and safety issues among users competing for limited recreational space. The PLMD identified an increasing need to increase transit and harvesting lanes to mitigate these emerging issues which has been supported by the data in this Plan. They still acknowledge that controlling exotic plants, preventing new invasions of exotic species, and protecting diversity of the native plant population is crucial to the ecological balance of the resource.

In Lower Phantom Lake, the native community has not declined over the past five years with management practices in place. The increase in overall plant growth as well as newly recorded species (like southern wild rice) have created some recreational challenges that may require alterations to future management. New invasive species (like starry stonewort) also threaten native plant diversity and recreational opportunities. The native community on Upper Phantom Lake has also improved over the past five years with the management practices in place. New invasive species found in Lower Phantom Lake (like starry stonewort and phragmites) threaten to invade Upper Phantom Lake and must be closely observed.

The PLMD should continue to utilize mechanical harvesting as its primary form of plant management. Herbicide treatment, DASH, and manual controls **should be assessed annually** to determine the feasibility of adding them as supplemental controls. The changes provided in this Plan, particularly for Lower Phantom Lake, should help to ease some of the recreational issues while still preserving the integrity of the native plant community.

APPENDIX A

The table below compares the Wisconsin Department of Natural Resources (WDNR) interpretation of the data collected via Point-Intercept (PI) Survey with how Lake and Pond Solutions LLC (LPS) views the same data set. During a PI survey and according to WDNR protocol, any plant species not found on a rake within 6' of the boat is recorded as a visual. LPS takes this a step further to include emergent species when that sample point is the closest point to the shoreline. LPS includes these visuals in frequency of occurrence calculations to give a more representative analysis of the plant community within the lake. The WDNR chooses to view a plants frequency based on only plants that were physically removed by the sample rake which eliminates logging many emergent species.

The formula used to calculate Frequency of Occurrence is viewed differently as well. LPS calculates the relative frequency of occurrence (FOO), meaning a species frequency is based off of how many sample points the plant was found divided by the number of all the sites that contained any vegetation, including visuals. The WDNR calculation of FOO focuses on the number of sites a plant was found divided by the number of sites that are shallower than the maximum depth of plants. Not all sites that are shallower than the max depth of plants contain vegetation, and for many different reasons. Ultimately, WDNR tables show lower plant species frequency due to the exclusion of visuals and inclusion of additional points without plants.

LPS Frequency of Occurrence Calculation

Relative FOO = # of sites a species was found *including* visuals / # of sites with plants

DNR Frequency of Occurrence Calculation

FOO = # of site a species was found *excluding* visuals / # of sites less than the max depth of plants

The combination of whether or not to include visuals and how to represent frequency of occurrence (i.e. % of sites with vegetation versus % of sites less than the max depth of plants) can lead to some significant differences (Figure 62 and Figure 64). By excluding visuals, 12 plant species on Lower Phantom Lake and 10 species on Upper Phantom Lake are excluded from the WDNR frequency of occurrence.

Besides differing species frequencies, representation of the top 5 species, # of sites with vegetation, Simpson Diversity Index, average natives per site, and floristic quality indices are altered using the WDNR method (

Figure 63 and Figure 65). This can have a significant impact on how future management is to be viewed and addressed.

Lake and Pond Solutions, LLC has chosen to stand behind the method of analysis and interpretation in this Plan and all references to past PI survey data and statistics were corrected to match our method of reporting. This Appendix was provided as an alternative way to represent the data as requested by WDNR.

Figure 62: LPS vs WDNR Frequency of Occurrence - Lower Phantom Lake

Common Name	Scientific Name	Number of Sites Species Was Found on Rake	Number of Sites Where Species Was Visually Observed	LPS % Relative Frequency of Occurance (Includes Visuals)	WDNR % Relative Frequency of Occurance (w/o Visuals)
Common bladderwort	*Utricularia vulgaris*	104	65	57.09	34.90
Muskgrasses	*Chara sp.*	114	13	42.91	39.72
Spatterdock	*Nuphar variegata*	31	96	42.91	10.40
White water lily	*Nymphaea odorata*	32	88	40.54	10.74
Sago pondweed	*Stuckenia pectinata*	36	80	39.19	12.08
Coontail	*Ceratophyllum demersum*	98	12	37.16	32.89
Clasping-leaf pondweed	*Potamogeton richardsonii*	49	56	35.47	16.44
Southern wild rice	*Zizania aquatica*	17	88	35.47	5.70
Various-leaved water-milfoil	*Myriophyllum heterophyllum*	68	36	35.14	22.82
Wild celery	*Vallisneria americana*	60	20	27.03	20.13
Cattail	*Typha sp.*	0	67	22.64	0.00
Illinois pondweed	*Potamogeton illinoensis*	18	42	20.27	6.04
Swamp loosestrife	*Decodon verticillatus*	0	46	15.54	0.00
Common waterweed	*Elodea canadensis*	38	8	15.54	12.75
Slender naiad	*Najas flexilis*	32	12	14.86	10.74
Purple loosestrife	*Lythrum salicaria*	0	40	13.51	0.00
Common watermeal	*Wolffia columbiana*	2	37	13.18	0.67
Arum-leaved arrowhead	*Sagittaria cuneata*	2	36	12.84	0.67
Flat-stem pondweed	*Potamogeton zosteriformis*	20	16	12.16	6.71
Small duckweed	*Lemna minor*	4	31	11.82	1.34
Starry Stonewort	*Nitellopsis obtusa*	29	6	11.82	9.73
Floating-leaf pondweed	*Potamogeton natans*	8	15	7.77	2.68
Orange Jewelweed	*Impatiens capensis*	0	20	6.76	0.00
Variable pondweed	*Potamogeton gramineus*	2	16	6.08	0.67
Eurasian water-milfoil	*Myriophyllum spicatum*	4	11	5.07	1.34
Spiny naiad	*Najas marina*	10	3	4.39	3.36
Water star-grass	*Heteranthera dubia*	7	5	4.05	2.35
Northern water-milfoil	*Myriophyllum sibiricum*	5	5	3.38	1.68
White-stem pondweed	*Potamogeton praelongus*	4	5	3.04	1.34
Fries' pondweed	*Potamogeton friesii*	2	6	2.70	0.67
Forked duckweed	*Lemna trisulca*	1	6	2.36	0.34
Common arrowhead	*Sagittaria latifolia*	0	6	2.03	0.00
Common reed	*Phragmites australis*	0	5	1.69	0.00
Water smartweed	*Polygonum amphibium*	0	5	1.69	0.00
Sessile-fruited arrowhead	*Sagittaria rigida*	0	5	1.69	0.00
Hardstem bulrush	*Schoenoplectus acutus*	0	5	1.69	0.00
Large-leaf pondweed	*Potamogeton amplifolius*	0	4	1.35	0.00
Nitella	*Nitella sp.*	3	0	1.01	1.01
Curly-leaf pondweed	*Potamogeton crispus*	1	1	0.68	0.34
Large duckweed	*Spirodela polyrhiza*	0	2	0.68	0.00
Leafy pondweed	*Potamogeton foliosus*	0	1	0.34	0.00
Small bladderwort	*Utricularia minor*	0	1	0.34	0.00
TOTAL NUMBER OF SPECIES FOUND BY METHOD		**29**	**41**		

SOURCE: Lake and Pond Solutions LLC (2023)

Figure 63: LPS vs WDNR Statistical Difference - Lower Phantom Lake

REPORTING	# of Sites w/ Vegetation	Simpson Diversity Index	Avg Native Species Per Site (Veg Sites)	Avg C-Value	# of Native Species Used for FQI	Floristic Quality (FQI)
LPS Method	296	0.95	6.03	5.71	35	33.81
WDNR Method	287	0.92	2.75	5.92	25	29.60

SOURCE: Lake and Pond Solutions LLC (2023)

Figure 64: LPS vs WDNR Frequency of Occurrence - Upper Phantom Lake

Common Name	Scientific Name	Number of Sites Species Was Found on Rake	Number of Sites Where Species Was Visually Observed	LPS % Relative Frequency of Occurance (Includes Visuals)	WDNR % Relative Frequency of Occurance (w/o Visuals)
Coontail	*Ceratophyllum demersum*	4	1	3.97	1.90
Muskgrasses	*Chara sp.*	21	9	23.81	10.00
Swamp loosestrife	*Decodon verticillatus*	0	12	9.52	0.00
Common waterweed	*Elodea canadensis*	0	1	0.79	0.00
Water horsetail	*Equisetum fluviatile*	0	1	0.79	0.00
Water star-grass	*Heteranthera dubia*	1	2	2.38	0.48
Orange Jewelweed	*Impatiens capensis*	0	11	8.73	0.00
Purple loosestrife	*Lythrum salicaria*	0	2	1.59	0.00
Various-leaved water-milfoil	*Myriophyllum heterophyllum*	4	6	7.94	1.90
Northern water-milfoil	*Myriophyllum sibiricum*	1	0	0.79	0.48
Eurasian water-milfoil	*Myriophyllum spicatum*	0	1	0.79	0.00
Slender naiad	*Najas flexilis*	5	1	4.76	2.38
Spiny naiad	*Najas marina*	34	12	36.51	16.19
Nitella	*Nitella sp.*	11	0	8.73	5.24
Spatterdock	*Nuphar variegata*	0	2	1.59	0.00
White water lily	*Nymphaea odorata*	3	14	13.49	1.43
Fries' pondweed	*Potamogeton friesii*	0	1	0.79	0.00
Variable pondweed	*Potamogeton gramineus*	3	8	8.73	1.43
Illinois pondweed	*Potamogeton illinoensis*	7	7	11.11	3.33
Clasping-leaf pondweed	*Potamogeton richardsonii*	1	15	12.70	0.48
Flat-stem pondweed	*Potamogeton zosteriformis*	2	5	5.56	0.95
Arum-leaved arrowhead	*Sagittaria cuneata*	0	2	1.59	0.00
Hardstem bulrush	*Schoenoplectus acutus*	0	7	5.56	0.00
Sago pondweed	*Stuckenia pectinata*	49	17	52.38	23.33
Cattail	*Typha sp.*	0	12	9.52	0.00
Common bladderwort	*Utricularia vulgaris*	4	8	9.52	1.90
Wild celery	*Vallisneria americana*	13	10	18.25	6.19
Southern wild rice	*Zizania aquatica*	0	3	2.38	0.00
TOTAL NUMBER OF SPECIES FOUND BY METHOD		**16**	**26**		

SOURCE: Lake and Pond Solutions LLC (2023)

Figure 65: LPS vs WDNR Statistical Difference - Upper Phantom Lake

REPORTING	# of Sites w/ Vegetation	Simpson Diversity Index	Avg Native Species Per Site (Veg Sites)	Avg C-Value	# of Native Species Used for FQI	Floristic Quality (FQI)
LPS Method	126	0.91	2.55	5.83	23	27.94
WDNR Method	104	0.83	1.42	5.87	15	22.72

SOURCE: Lake and Pond Solutions LLC (2023)

REFERENCES

Borman, S., R. Korth, and J. Temte. 1997. Through the Looking Glass…A Field Guide to Aquatic Plants. Second Printing. Wisconsin Lakes Partnership. Wisconsin Department of Natural Resources Publication FH-207-97. 248pp.

Brown, S.J and M.J. Maceina. 2002. The Influence of Disparate Levels of Submersed Aquatic Vegetation on Largemouth Bass Population Characteristics in a Georgia Reservoir. Journal of Aquatic Plant Management. 40: 28-35.

Deppe, E. and R.C. Lathrop. 1992. A comparison of two rake sampling techniques for sampling aquatic macrophytes. Wisconsin Department of Natural Resources. Res. Manage. Find. No. 32. 4 pp.

Dibble, E.. 2021. Impact of Invasive Aquatic Plants on Fish. Biology and Control of Aquatic Plants: A Best Management Practices Handbook (4th ed.). 7-14.

Dresen, Michael and Korth, Robert. Life on the Edge….Owning Waterfront Property. University of Wisconsin Extension, Lakes Management Program. 1994.

Dunst, R.C. et al. 1974. Survey of lake rehabilitation techniques and experiences. Technical Bulletin No. 75 Wisconsin Department of Natural Resources, Madison, Wisconsin. 179 pp.

Engel, S. 1985. Aquatic community interactions of submerged macrophytes. Tech. Bull. No. 156. Department of Natural Resources, Madison, WI. 81 pp.

Engel, S. 1987. Concepts in Lake Management: Restructuring littoral zones. Research/Management Findings No. 2. Wisconsin Department of Natural Resources, Madison, Wisconsin. 3 pp.

Engel, S. 1990. Ecosystem response to growth and control of submerged macrophytes: a literature review. Technical Bulletin No. 170. Wisconsin Department of Natural Resources, Madison, WI. 22 pp.

Fassett, N.C. 1969. A manual of aquatic plants. University of Wisconsin Press, Madison. 405 pp.

Jessen, R. and R. Lound. 1962. An evaluation of a survey technique for submerged aquatic plants. Minnesota Department of Conservation. Game Investigational Report No. 6. 12 pp.

Killgore, J., D. Dibble, and J Hoover. 1993. Relationships Between Fish and Aquatic Plants: A Plan of Study. US Army Corps of Engineers Environmental Laboratory Miscellaneous Paper A-93-1. 64pp,

Korth, R. and Dudiak, T. 2002. How's the Water? Planning for Recreational Use on Wisconsin Lakes & Rivers. University of Wisconsin-Stevens Point. Wisconsin Department of Natural Resources Publication FH-397-2002.

Lind, O.T. 1979. Handbook of common methods in limnology. Second Edition. C.V. Mosby Company. St. Louis, MO. 199 pp.

McComas S. Lakesmarts: The First Lake Maintenance Handbook. Terrene Institute. Washington, D.C. 215 pp.

Nichols, S.A. 1991. The interaction between biology and the management of aquatic macrophytes. Aquatic Botany. 41: 225-252.

Nichols, S.A., S. Engel and T. McNabb. 1988. Developing a plan to manage lake vegetation. Aquatics 10(3):10, 14-19.

Nichols, S.A. and R. Martin. 1990. Wisconsin Lake Plant Database. Information Circular 69. University of Wisconsin-Extension, Geological and Natural History Survey. 29 pp.

Nichols, S.A. and J.G. Vennie. 1991. Summary Sheets: Attributes of Wisconsin Lake Plants. Open-file Report 91-4. University of Wisconsin-Extension, Geological and Natural History Survey. 117 pp.

Nichols, S.A. 1998. Floristic quality assessment of Wisconsin lake plant communities with example applications. Lake and Reservoir Management. 15(2):133-141.

Nichols, S.A. 1999. Distribution and habitat descriptions of Wisconsin lake plants. Bulletin 96. University of Wisconsin-Extension, Geological and Natural History Survey. 266 pp.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the upper Midwest states. U.S. Environmental Protection Agency. EPA/600/3-88/037.

Shaw, B.H., C. Mechenich, and L. Klessig. 1996. Understanding Lake Data. University of Wisconsin-Extension publication G3582. 20 pp.

Stubbs, D. and C. Layne. 2021. Requirements for Registration of Aquatic Herbicides. Biology and Control of Aquatic Plants: A Best Management Practices Handbook (4th ed.). 155-162.

University of Wisconsin Extension, Lakes Management Program. 1988. Machine Harvesting of Aquatic Plants. PUBL-WR-201 88.

Wisconsin Department of Natural Resources. 1983. Limnological characteristics of Wisconsin lakes. Tech. Bull. No. 138. Department of Natural Resources, Madison, WI. 116 pp.