Aquatic Plant Management Plan
Lake Beulah, Walworth County, Wisconsin
January 2022

-Update for Harvesting Permit Renewal

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Lake Beulah Management District

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TABLE OF CONTENTS

Tables:

Figures:

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INTRODUCTION

The purpose of this update is to report the 2021 point-intercept survey results which describes the relative densities and species composition within Lake Beulah during that time and how the lake is progressing since the last aquatic plant management plan update. Review of the past and present aquatic plant community information will be used to formulate a management approach that focuses on providing a diverse lake usage policy while protecting the significant aquatic resources.

This plan will update and revise the preceding plans (RIN Environmental Services 2010, and Lake and Pond Solutions 2017) to assist lake managers and regulatory agencies in directing future aquatic plant management activities. The Lake Beulah Management District (LBMD) intends to use this plan for better management of the lake including their harvesting program, potential chemical treatment and to further educate local residents and lake users alike.

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.

PLANT SURVEY METHODS

The 2021 aquatic plant survey was conducted using some guidelines adopted by the WDNR for point-intercept survey methods. This method utilizes a grid system that takes the size and morphology of the lake into account. For the survey, the WDNR established points were transferred to a Garmin GPSMAP 64st GPS unit before field sampling. There were 996 points although only 906 were sampled due to obstructions, non-navigable or terrestrial designations.

At each established point, a sample was taken with a double-headed rake in areas 15-18 feet deep or less and a double-headed rake-on-a-rope at deeper points. Depths were recorded at each point by using a measuring stick in shallow areas and a *Hummin Bird Helix 7 MSI GPS G3* sonar unit in deeper sections. Data collection included depth, substrate type (when possible), species present, species density, overall rake density and any visuals of species located within the immediate area of the boat. Recording density was based on a number scale. A value of (1) showed that the plant was present but with low density, (2) consisted of moderate density or covering about ½ of the pole rake while (3) showed high density or a rake completely covered with plants. Shoreline vegetation (i.e., cattails, loosestrife, phragmites) was listed as a visual for the points nearest shore. Ultimately, data was used to calculate frequency of occurrence, relative frequency of occurrence, average rake density, total sites with vegetation, maximum depth of plants, average native species per site, average of all species per site, species richness and floristic quality (FQI).

OVERALL SUMMARY

Study Area – Lake Beulah lies in Southeastern Wisconsin in the Kettle Moraine region. The lake is 834 square acres with a mean depth of 23 feet and a maximum depth of 63 feet based on the most recent survey (2021). Survey occurred between August 2nd - 4th, 2021 using the 996 pre-determined WDNR points (Appendix B).

Out of the 996 sampling points 618 were found to have plants (68.21%). No plants were found at a depth greater than 35 feet. 96.11% of the points shallower than the max depth of plants contained vegetation. There were 3.27 species recorded on average at sites shallower than 35 feet. Points that recorded vegetation had an average of 3.65 species, with 3.13 being native. Data described here is also listed in Table 1.

A species richness (total number of species, including visuals) of 35 was found in Lake Beulah with a Simpson diversity index of 0.92. Simpson diversity index is used to quantify the biodiversity of a habitat. It considers the number of species present, as well as the relative abundance of each species. The index assumes a value between 0 and 1, with 1 having complete evenness.

To understand how the plant community in the lake has changed since the original APM plan was written C-values and the FQI are assessed. The C-value is a measure of plant conservatism, which in short, means the value assigned to each plant indicates how sensitive that species is to disturbance. The more disturbed an area is the lower the C-value. C-value can range from 0-10. Per the most recent survey the calculated C-value is 5.71 in 2021. The floristic quality indicator (FQI), which evaluates how close an area is to its undisturbed counterpart [1], is now 30.23 in 2021. High FQI values indicates less disturbance. The overall picture of the lake is that the plant community appears to be maintaining a highly diverse and densely populated plant community for a Wisconsin lake, especially one in South-Eastern Wisconsin's Till Plain.

[1] Nichols, SA. 1999. Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. Journal of Lake and Reservoir Management, 15(2):133-141.

Table 1: Plant Sampling Data Summary

Statistics Summary	2021
Total Number of Sites with Vegetation / All Sites Sampled	618 / 906 (68.21%)
Maximum Depth of Plants (feet)	35.0
Species Richness (Including Visuals)	35
Average Number of all Species per Site (vegetated sites only, including visuals)	3.65
Average Number of Native Species per Site (vegetated sites only, including visuals)	3.13
Simpson Diversity Index	0.92
Average C-Value	5.71
Floristic Quality	30.23

SOURCE: Lake and Pond Solutions Co. (2021)

PLANT SPECIES SUMMARY

The thirty-five different species of plants are listed in Table 2. They are arranged from most to least frequent based on the number of sites where they were found, including visual sightings. Also shown is the overall frequency (percentage plant was found compared to all sites), relative frequency (percentage plant was found compared to vegetated sites) and the average density rating (based on a scale of 1 for least dense and 3 for most dense when sampled). Comparison of this methodology to the WDNR is listed in Appendix D.

The seven most common aquatic plant species in Lake Beulah based on frequency of occurrence within vegetated areas (including visuals) are Muskgrass (72.65%), Sago Pondweed (43.37%), Spiny Naiad (30.74%), Various-Leaved Water-Milfoil (19.74%), White-Water Lily (19.58%), Common Bladderwort (18.45%) and Illinois Pondweed (17.48%). There is a variety of beneficial native plant species, which includes 4 species listed as "high value" by the WDNR and an additional 15 species with a C-Value of 6 or higher.

The depth of plants found in the 2021 survey is listed in Figure 1 below which shows that there is a wide range in depth that plants colonize. *Nitella flexilis* and *Chara* are the primary species to be growing in depths greater than 21 feet. There were nine other species found below 21 feet, but each was only found 1-4 times at that depth. The deep growing plant community is a positive sign of Beulah's health. This deep community is made up of very few species that can exist under those conditions but add greatly to the diversity and range of flora within the lake.

The 10-20 feet of depth range shows a very healthy and diverse plant community. There are 21 different species located within this zone, 11 of which exist in the 10-15-foot range, and 9 species between 16-20 feet of water.

Looking at the shallow region of the lake there are signs of great plant communities that are diverse and dense. At shallower depth light is more abundant making it easier for plants and algal species to photosynthesize, in turn this creates more competition for space. The number of species found in shallow areas are also a positive aspect to the overall plant community health in Lake Beulah.

Figure 1: Plant Depth Graph

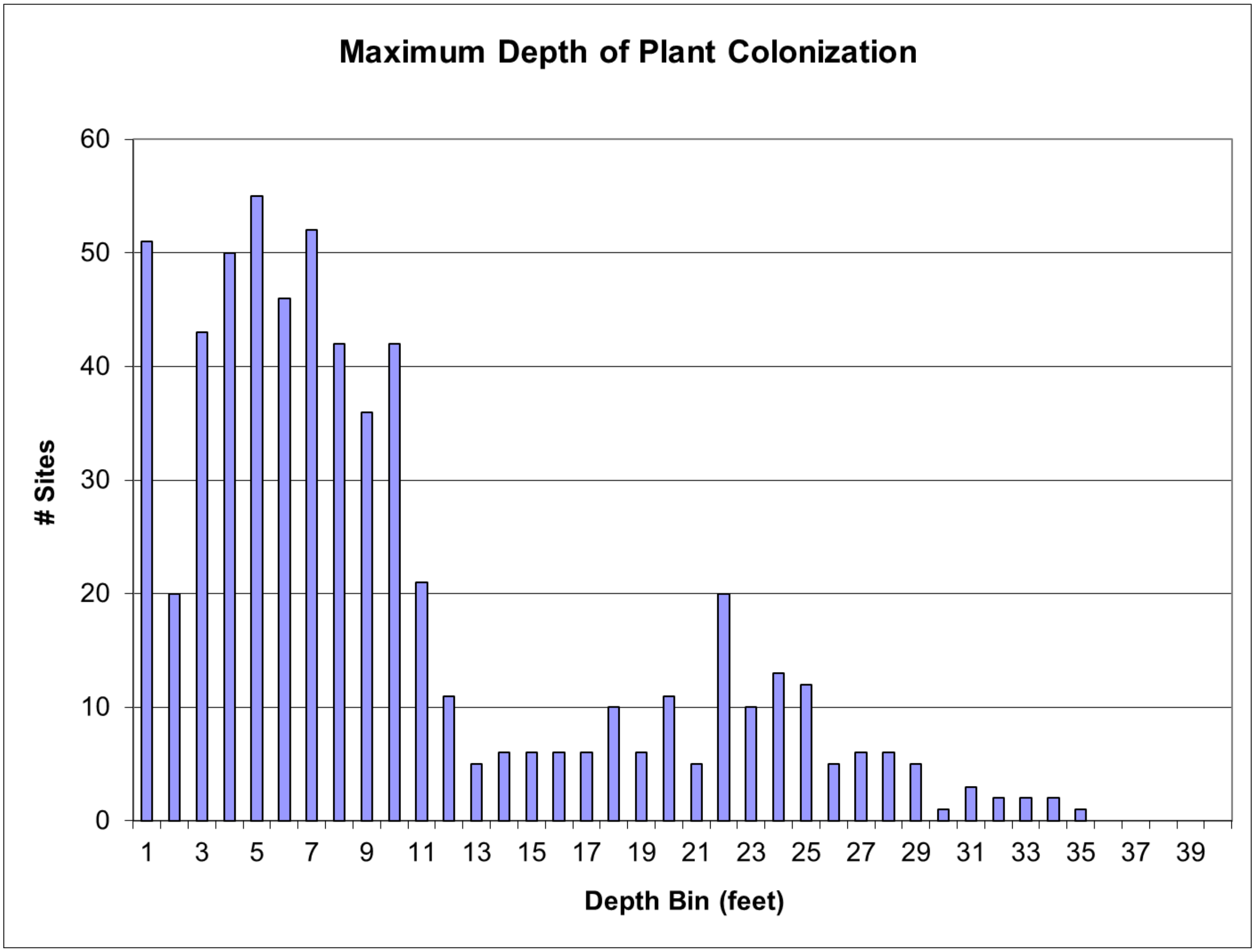

Figure 1: Plant depth graph.

Overall, the native plant community in Lake Beulah has good diversity. Figures 2 –37 shows the distribution and densities of all species in the lake. Invasive species are presented first with the rest listed from most-to-least frequent.

Table 2: Plant Species Summary

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
Muskgrasses *	Chara sp.	449	49.56	72.65	2.36	7
Sago pondweed **	Stuckenia pectinata	268	29.58	43.37	1.22	3
Spiny naiad	Najas marina	190	20.97	30.74	1.28	n/a
Various-leaved water-milfoil*	Myriophyllum heterophyllum	122	13.47	19.74	1.44	7
White water lily *	Nymphaea odorata	121	13.36	19.58	1.22	6
Common bladderwort *	Utricularia vulgaris	114	12.58	18.45	1.14	7
Illinois pondweed **	Potamogeton illinoensis	108	11.92	17.48	1.03	6
Eurasian water-milfoil ***	Myriophyllum spicatum	102	11.26	16.50	1.65	Invasive
Spatterdock *	Nuphar variegata	101	11.15	16.34	1.33	6
Wild celery **	Vallisneria americana	89	9.82	14.40	1.18	6
Swamp loosestrife	Decodon verticillatus	73	8.06	11.81	V	n/a
Variable pondweed *	Potamogeton gramineus	68	7.51	11.00	1.00	7
Nitella *	Nitella sp.	67	7.40	10.84	1.43	7
Small duckweed	Lemna minor	45	4.97	7.28	1.00	4
Coontail	Ceratophyllum demersum	42	4.64	6.80	1.31	3
Floating-leaf pondweed	Potamogeton natans	40	4.42	6.47	1.00	5
Cattail	Typha sp.	40	4.42	6.47	V	1
Arrowhead	Sagittaria sp.	37	4.08	5.99	1.25	3
Orange Jewelweed	Impatiens capensis	37	4.08	5.99	V	
Softstem bulrush	Schoenoplectus tabernaemontani	20	2.21	3.24	V	4
Ditch grass *	Ruppia cirrhosa	17	1.88	2.75	1.67	8
Purple loosestrife ***	Lythrum salicaria	16	1.77	2.59	V	Invasive
Flat-stem pondweed *	Potamogeton zosteriformis	15	1.66	2.43	1.00	6
Slender naiad *	Najas flexilis	13	1.43	2.10	1.00	6
Common watermeal	Wolffia columbiana	9	0.99	1.46	V	5
Common waterweed	Elodea canadensis	8	0.88	1.29	1.00	3
Curly-leaf pondweed ***	Potamogeton crispus	5	0.55	0.81	1.00	Invasive
Narrow-leaved bur-reed *	Sparganium angustifolium	5	0.55	0.81	1.00	9
Aquatic moss		5	0.55	0.81	1.00	n/a
Northern water-milfoil *	Myriophyllum sibiricum	4	0.44	0.65	1.00	6
Whorled water-milfoil	Myriophyllum verticillatum	4	0.44	0.65	1.33	8
Creeping bladderwort *	Utricularia gibba	3	0.33	0.49	1.00	9
Fries' pondweed *	Potamogeton friesii	2	0.22	0.32	1.00	8
Common reed ***	Phragmites australis	1	0.11	0.16	V	Invasive
Clasping-leaf pondweed **	Potamogeton richardsonii	1	0.11	0.16	V	5
Large duckweed	Spirodela polyrhiza	1	0.11	0.16	V	5

SOURCE: Lake and Pond Solutions Co. (2021)

* Species are considered "quality" plant species due to a C-value or 6 or higher

** Species are considered "high value" plant species under Wisconsin Administrative Code NR 107

*** Denotes non-native (exotic) species

% Overall Frequency: The percentage a plant species was found compared to all sites sampled. It is calculated by taking the number of sites a species was found and dividing by the total number of sampled points.

% Relative Frequency: The percentage a plant species was found compared to all sites with vegetation. It is calculated by taking the number of sites a species was found and dividing by the total number of vegetated sites.

Relative Average Density: The average density of each plant species comparative to the number of sites where it was found. It is calculated by dividing the sum of the site densities (for that specific plant species) by the total number of sites where it was found.

FIGURES

Figure 2: Density and Distribution of Eurasian Water-Milfoil (EWM) *Invasive*

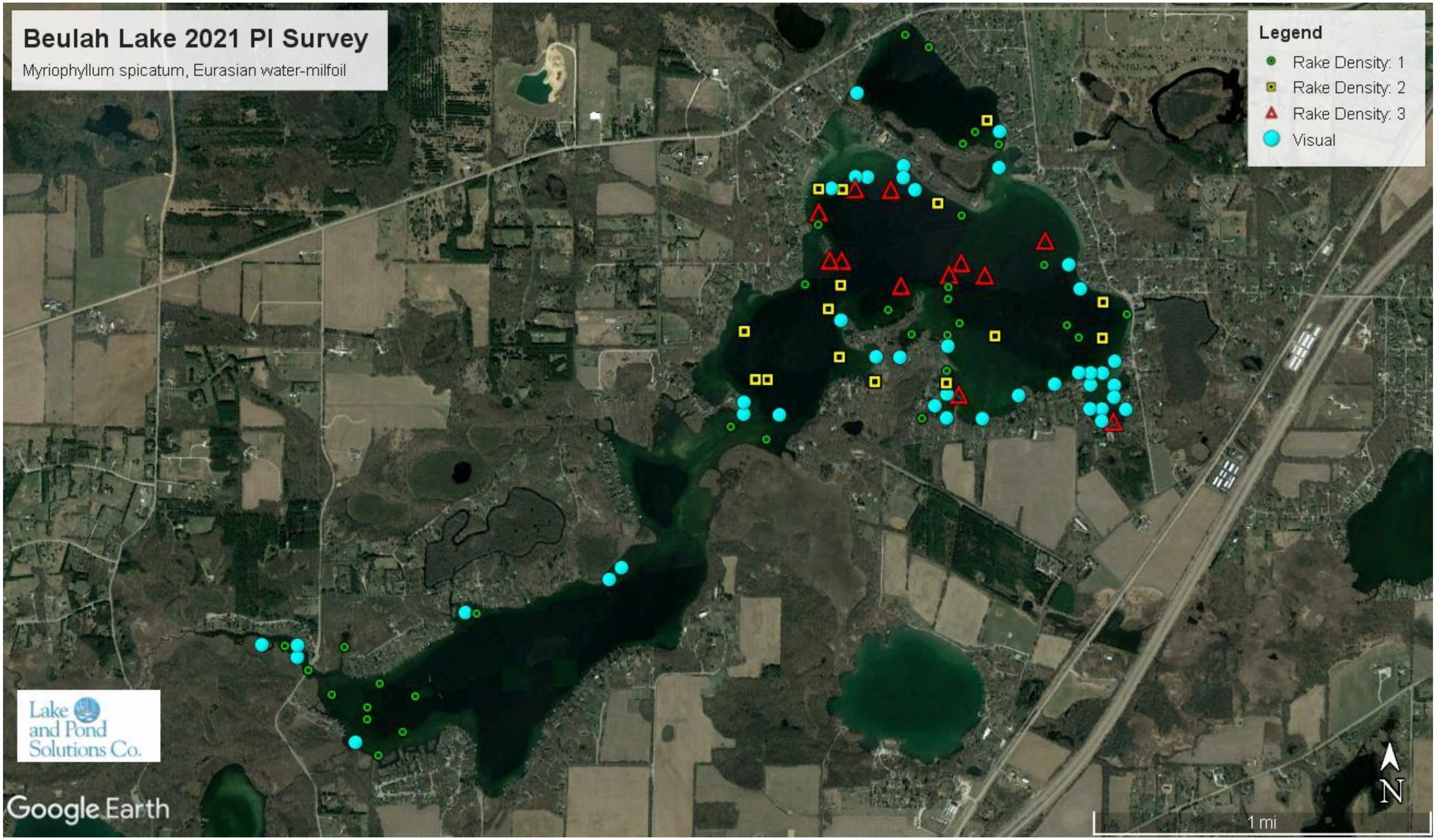

Figure 2: Distribution and density map of EWM.

Figure 3: Density and Distribution of Purple Loosestrife *Invasive*

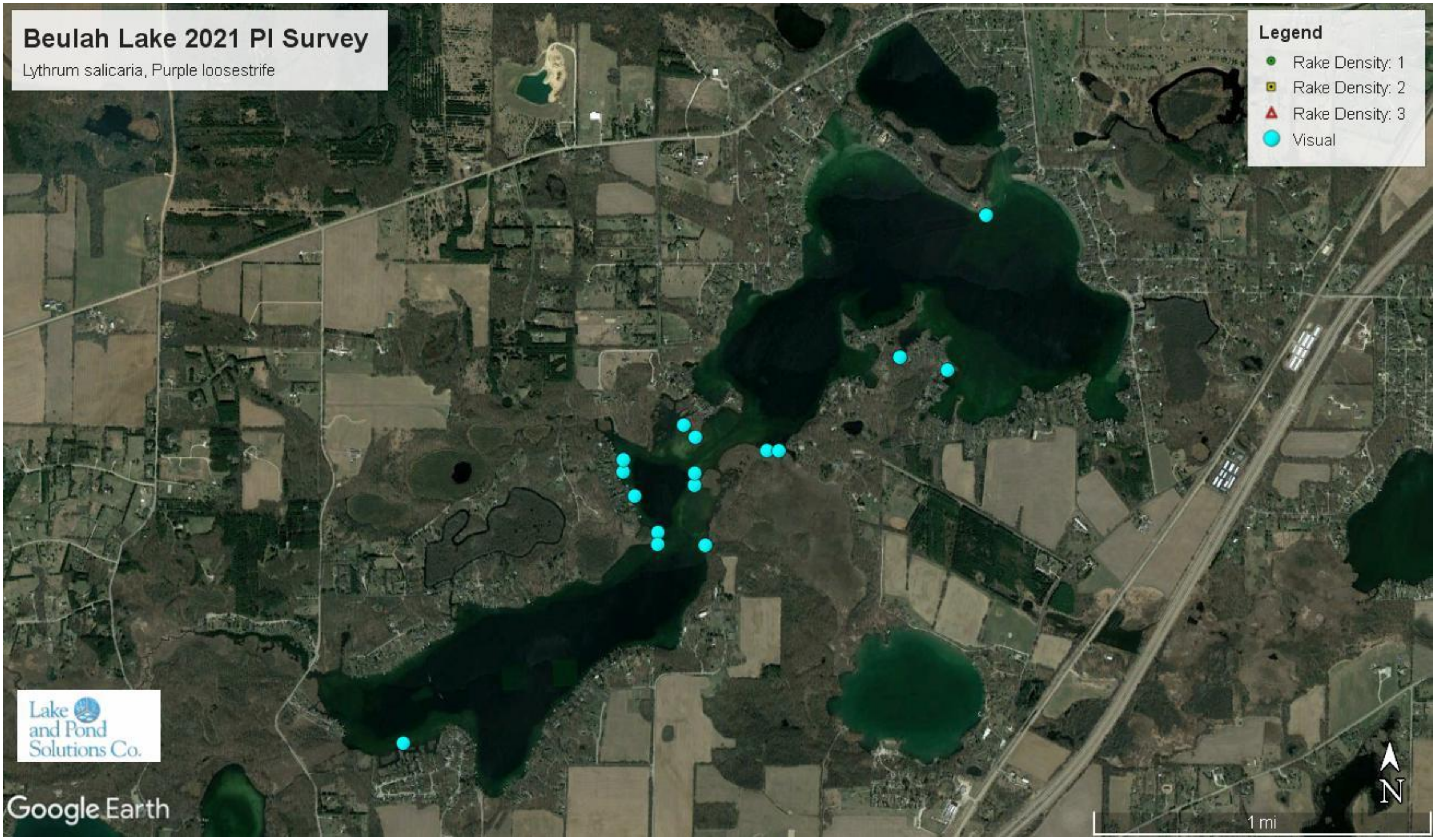

Figure 3: Distribution and density map of Purple Loosestrife.

Figure 4: Density and Distribution of Curly-Leaf Pondweed *Invasive*

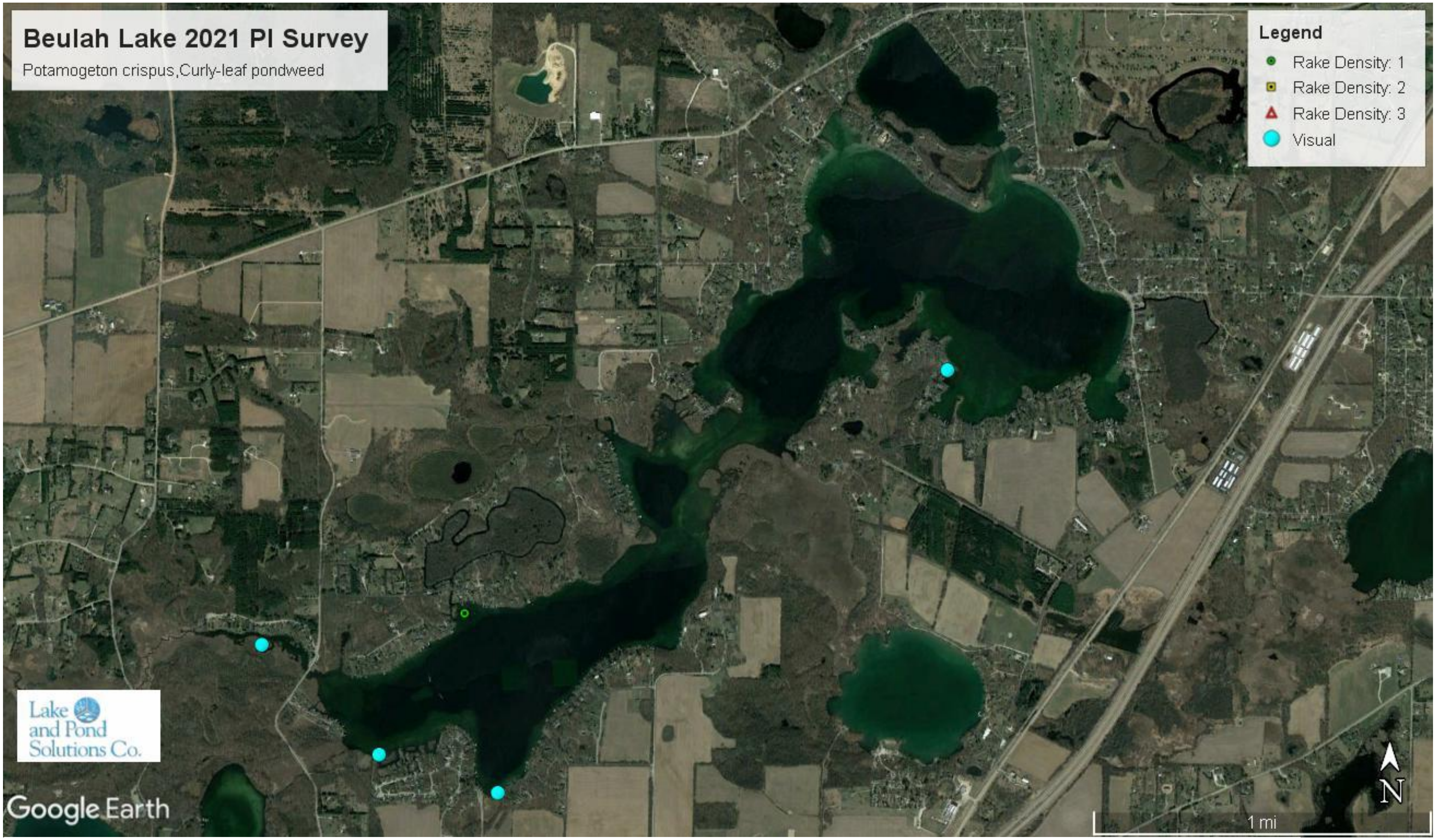

Figure 4: Distribution and density map of Curly-Leaf Pondweed.

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Figure 5: Density and Distribution of Phragmities *Invasive*

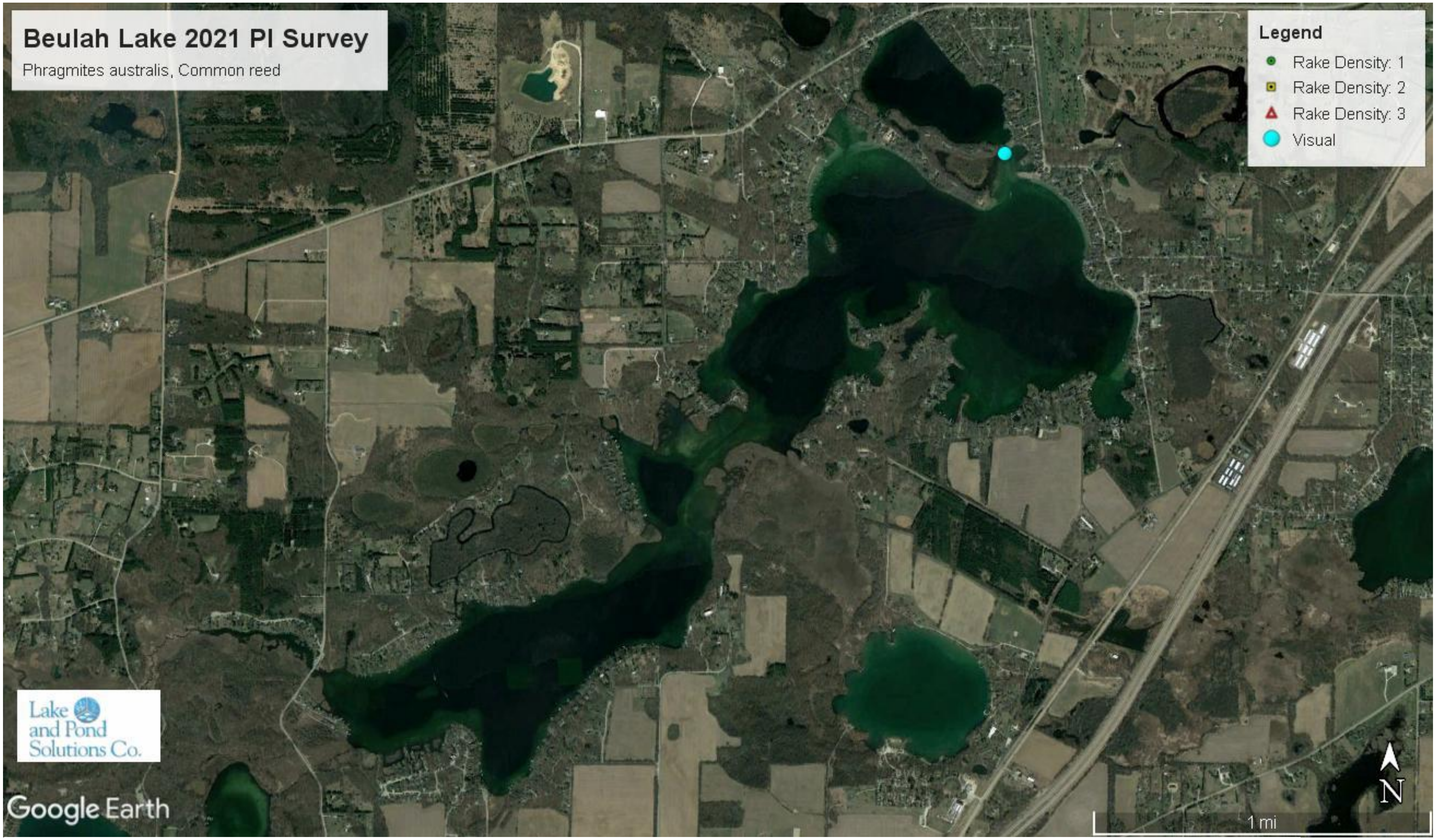

Figure 5: Distribution and density map of Phragmitites.

Figure 6: Density and Distribution of Muskgrass (Chara)

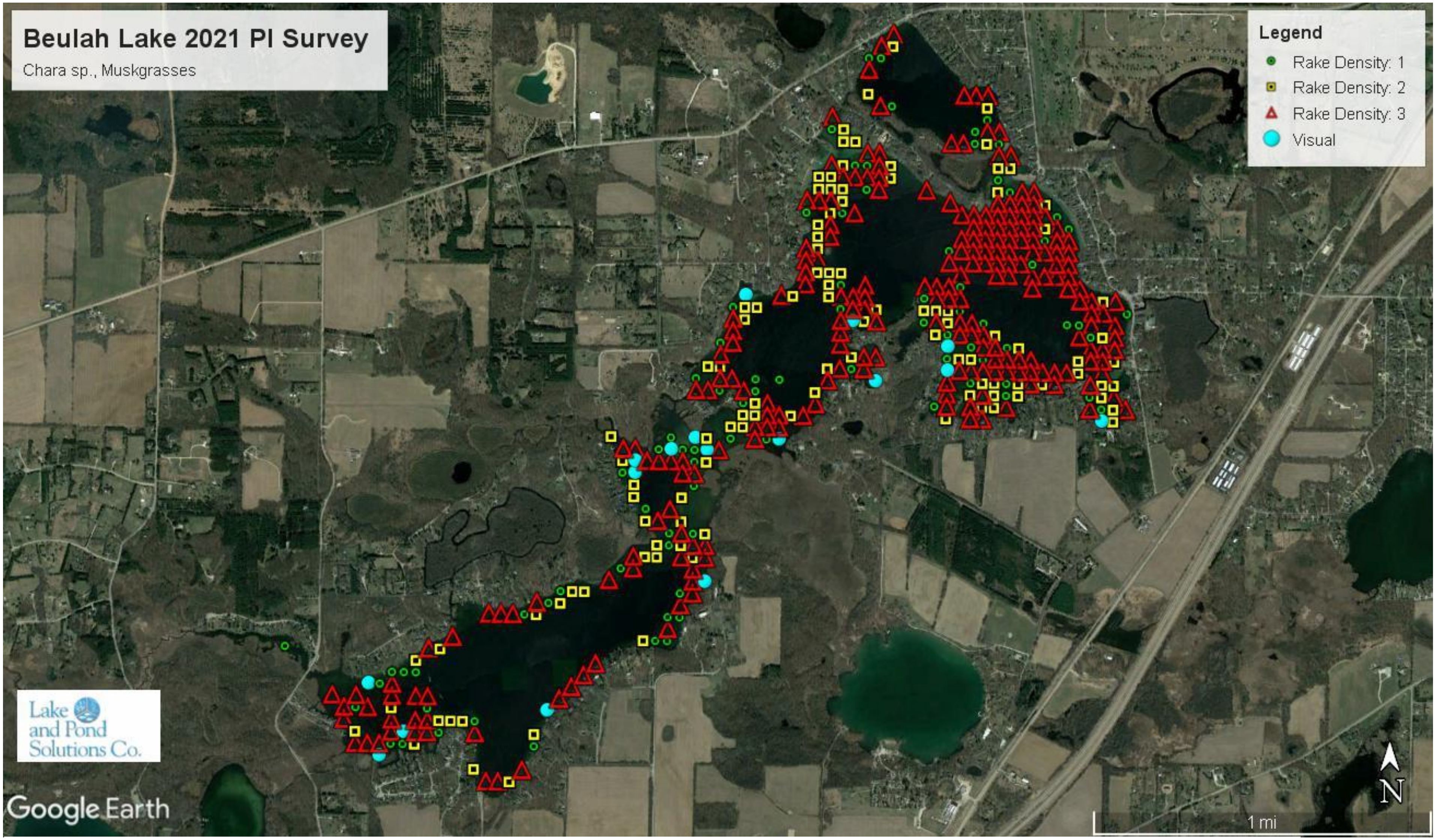

Figure 6: Distribution and density map of Muskgrass (chara).

Figure 7: Density and Distribution of Sago Pondweed

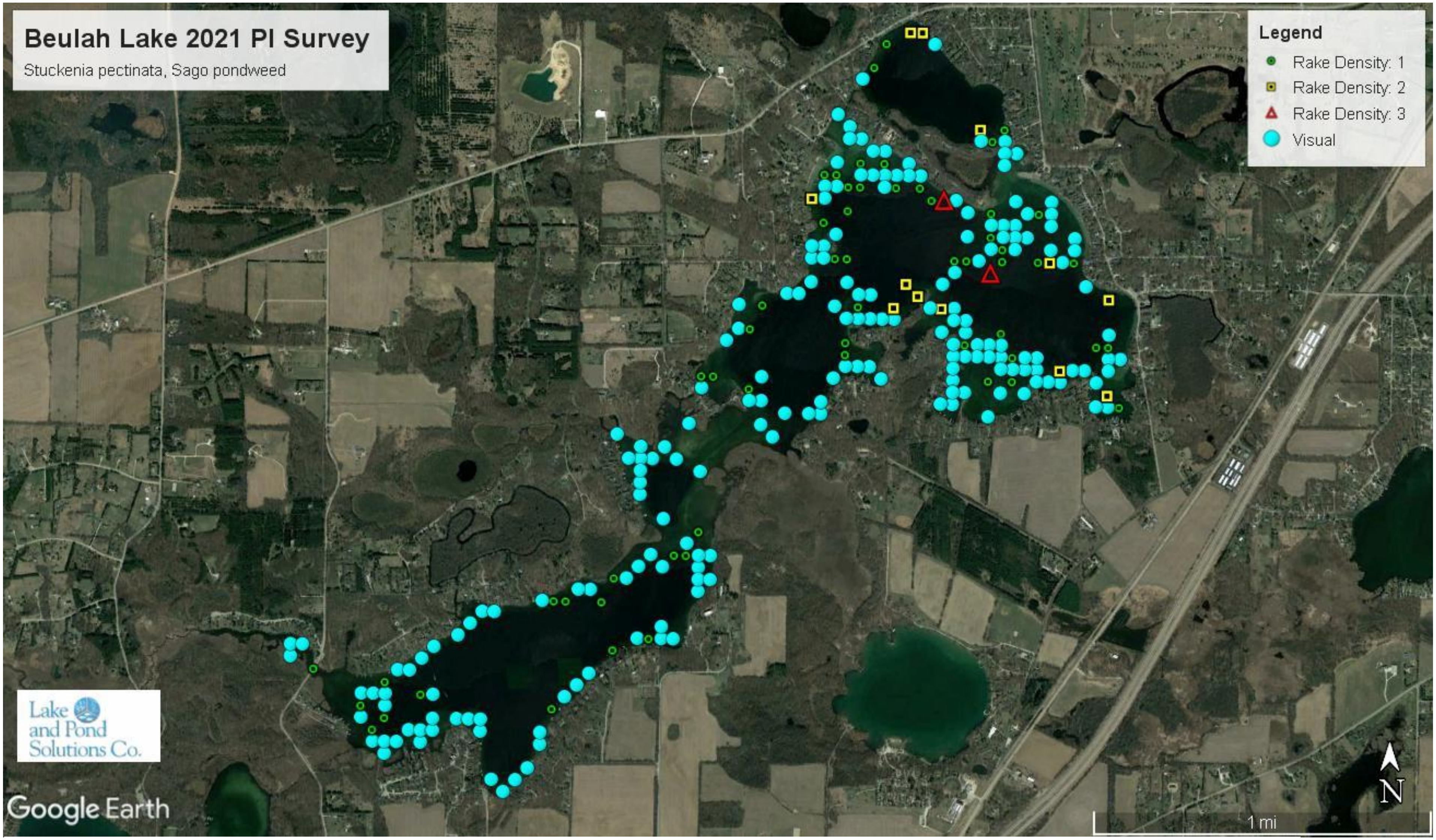

Figure 7: Distribution and density map of Sggo Pondweed.

Figure 8: Density and Distribution of Spiny Naiad

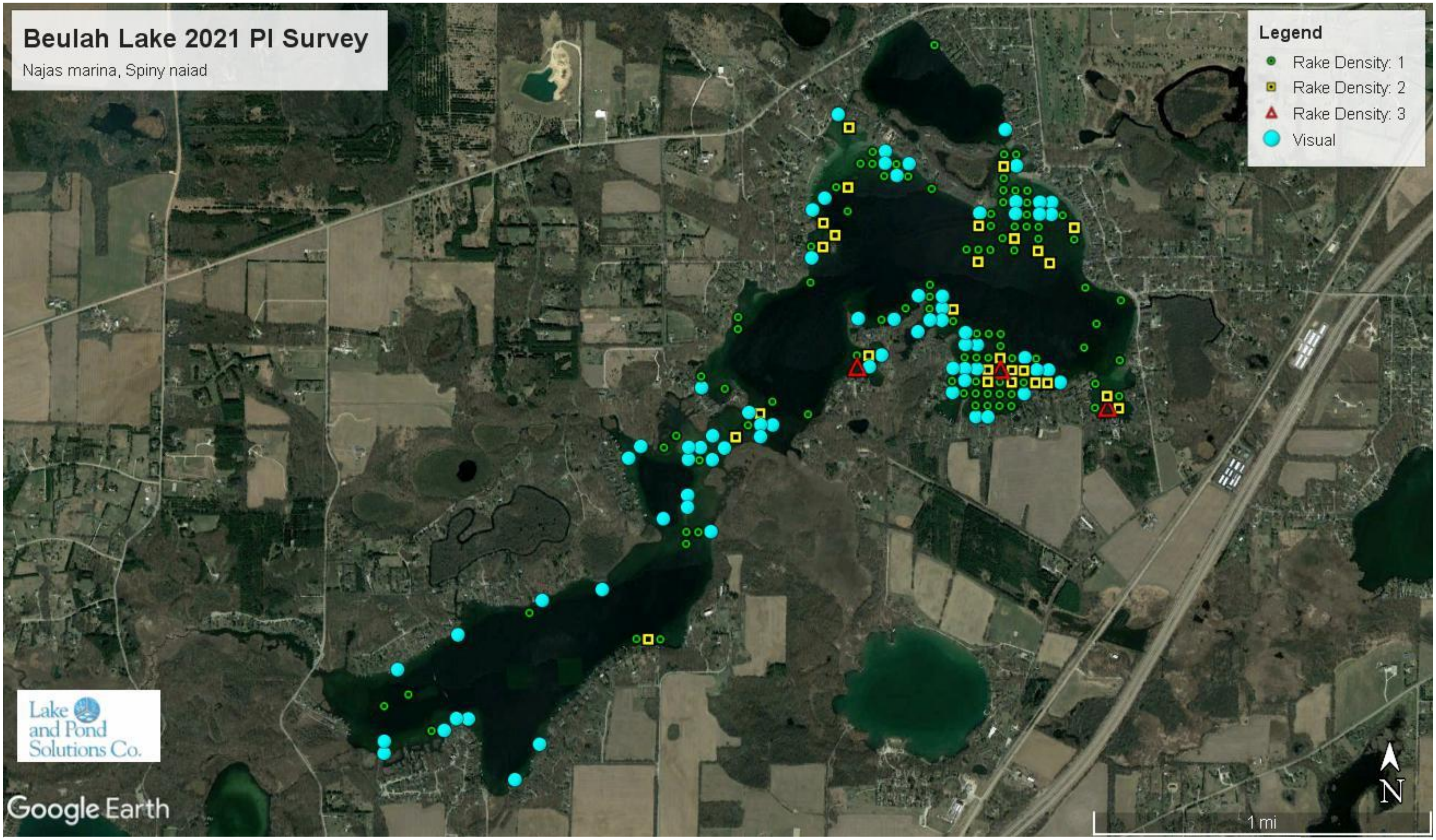

Figure 8: Distribution and density map of Spiny Naiad.

Figure 9: Density and Distribution of Vaious-Leaved Water-Milfoil

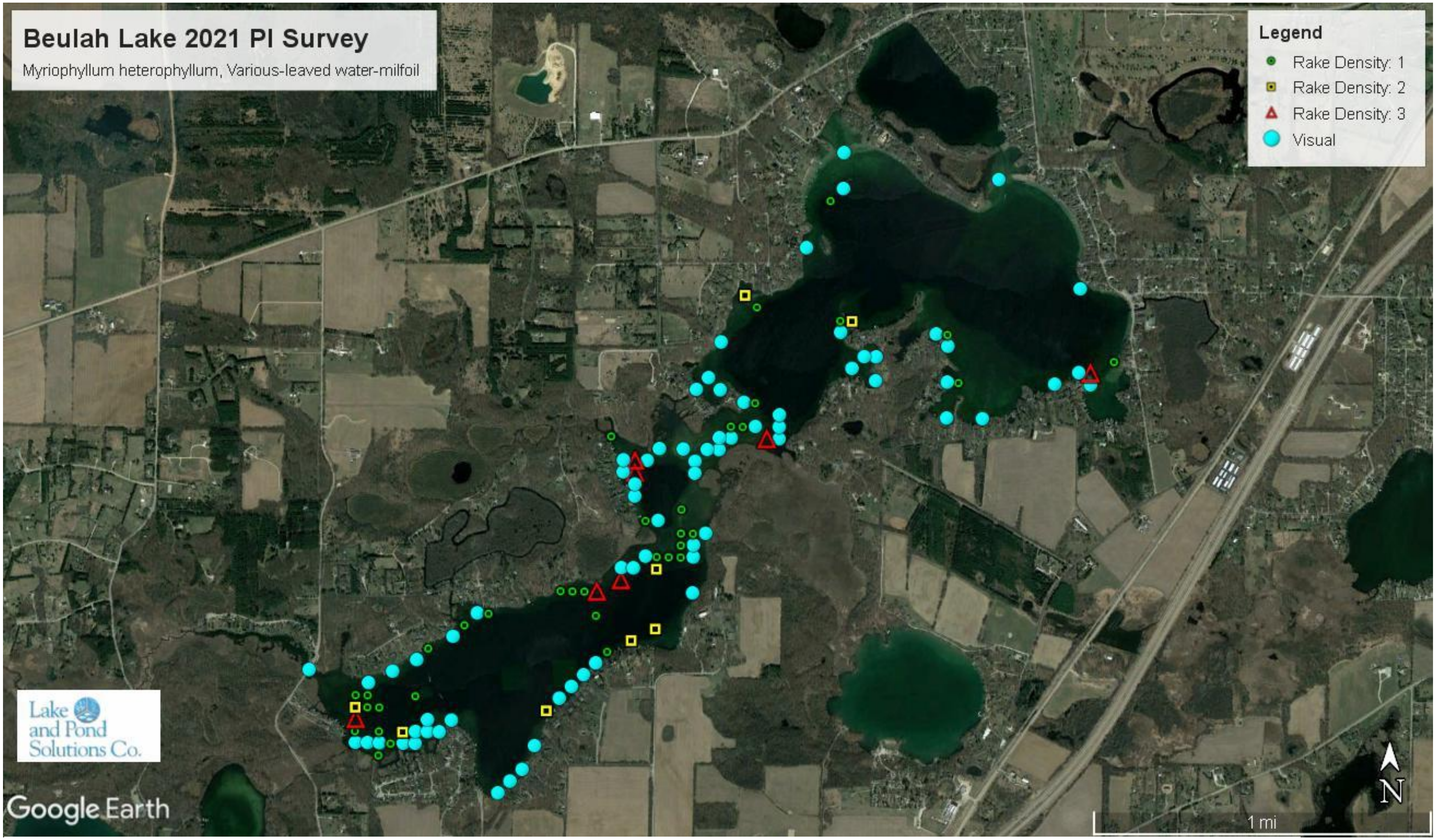

Figure 9: Distribution and density map of Various-Leaved Water-Milfoil.

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Figure 10: Density and Distribution of White Water Lily

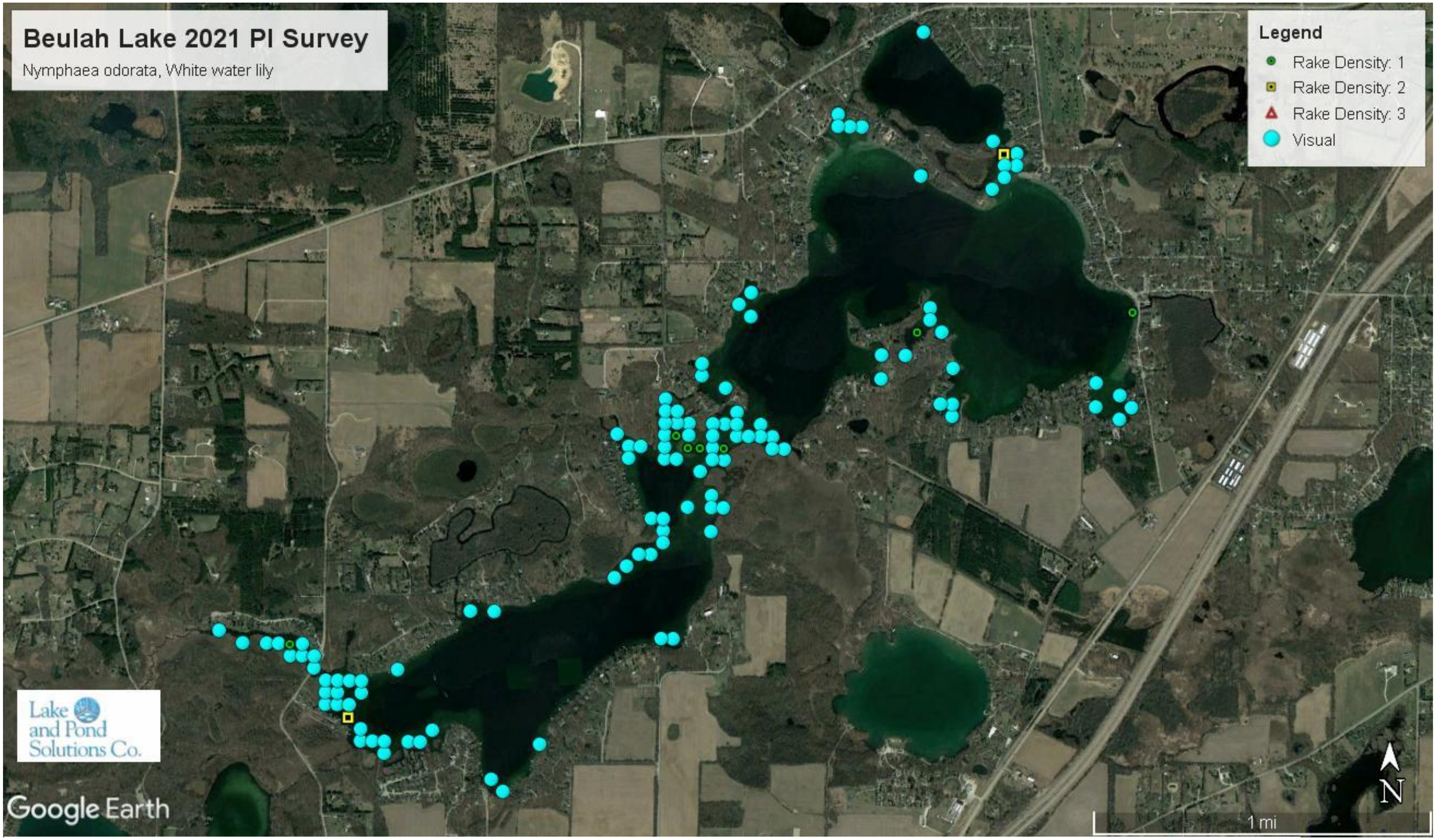

Figure 10: Distribution and density map of White Water Lily.

Figure 11: Density and Distribution of Common Bladderwort

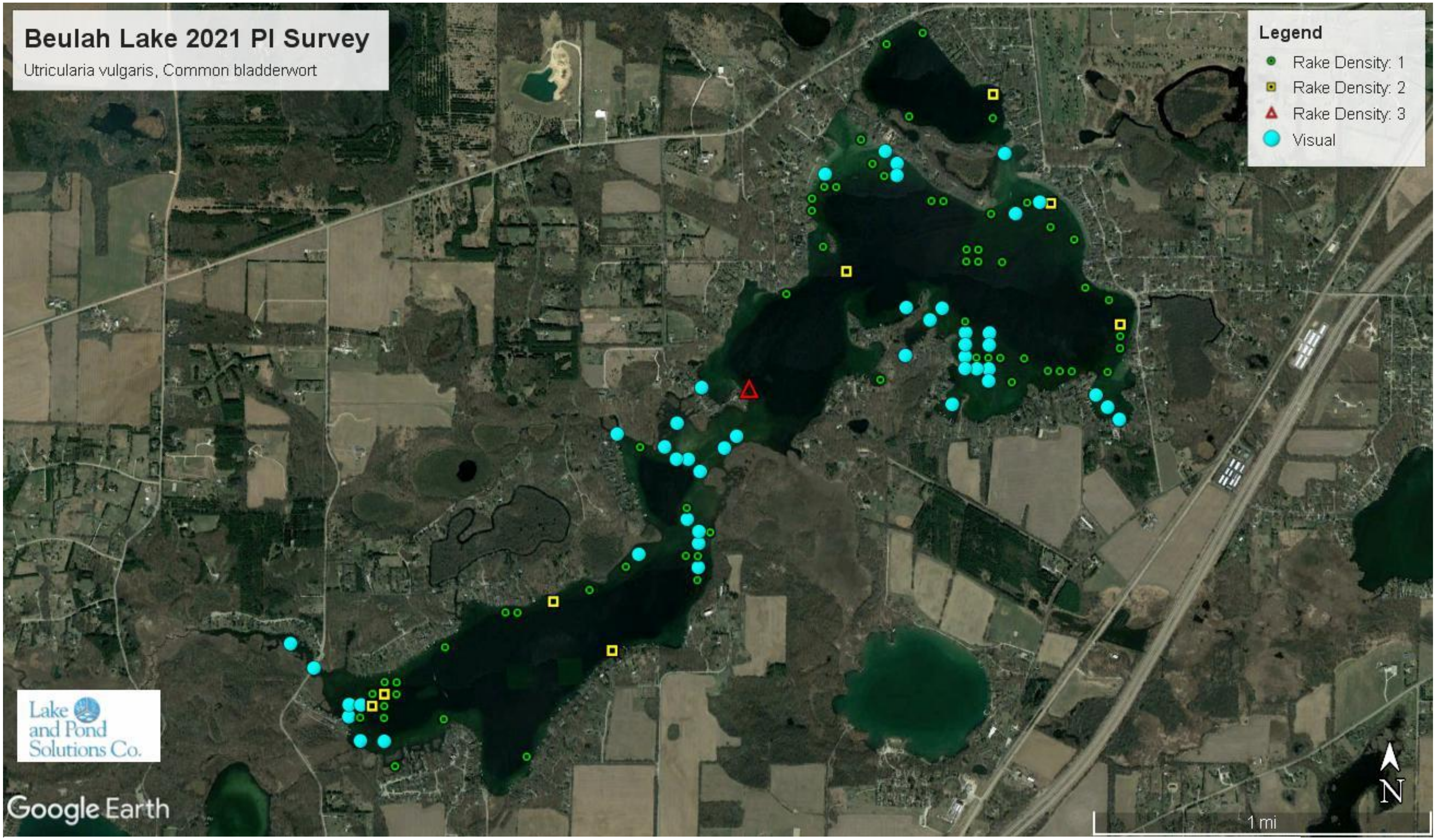

Figure 11: Distribution and density map of Common Bladderwort.

Figure 12: Density and Distribution of Illinois Pondweed

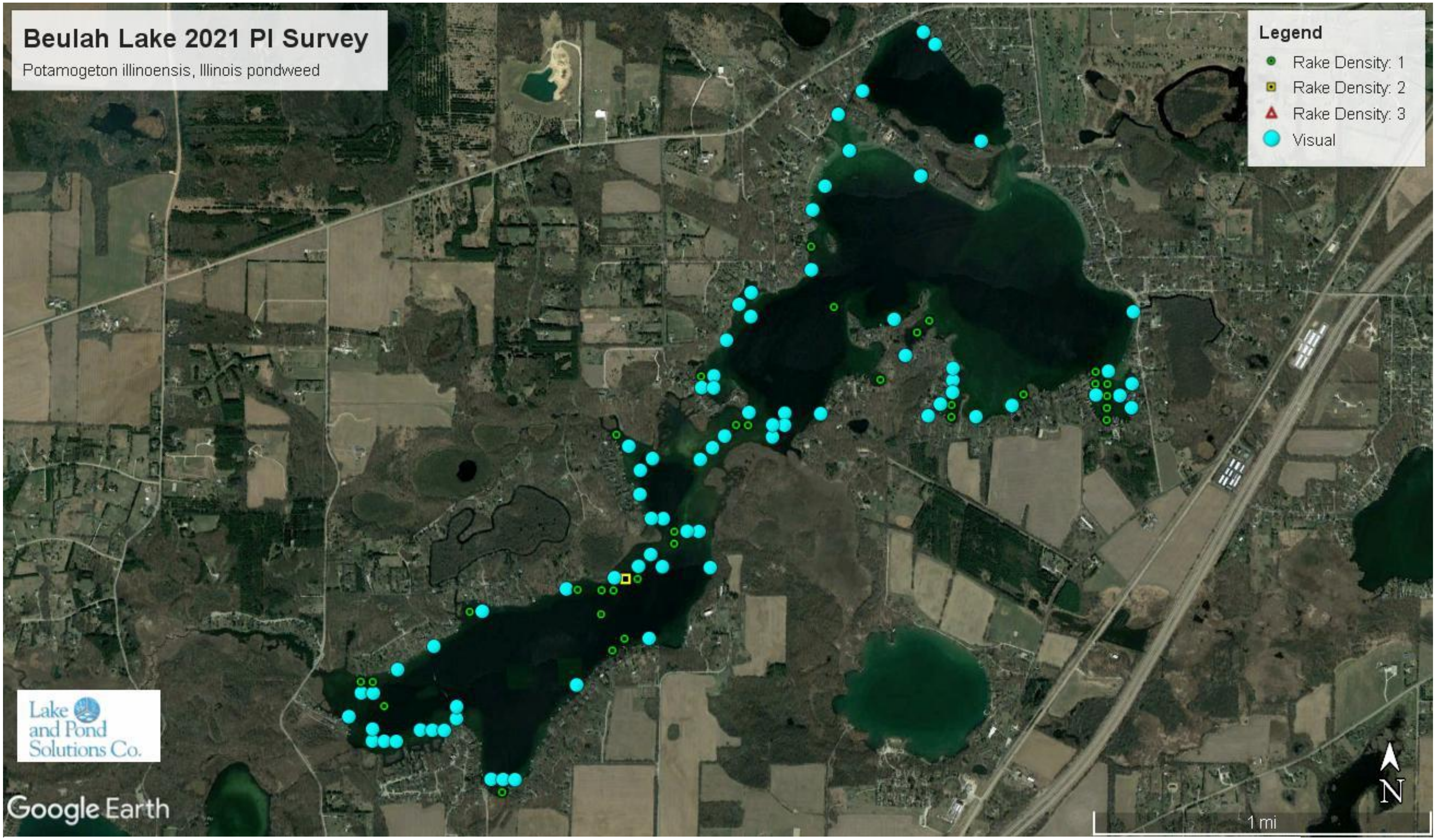

Figure 12: Distribution and density map of Illinois Pondweed.

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Figure 13: Density and Distribution of Spatterdock

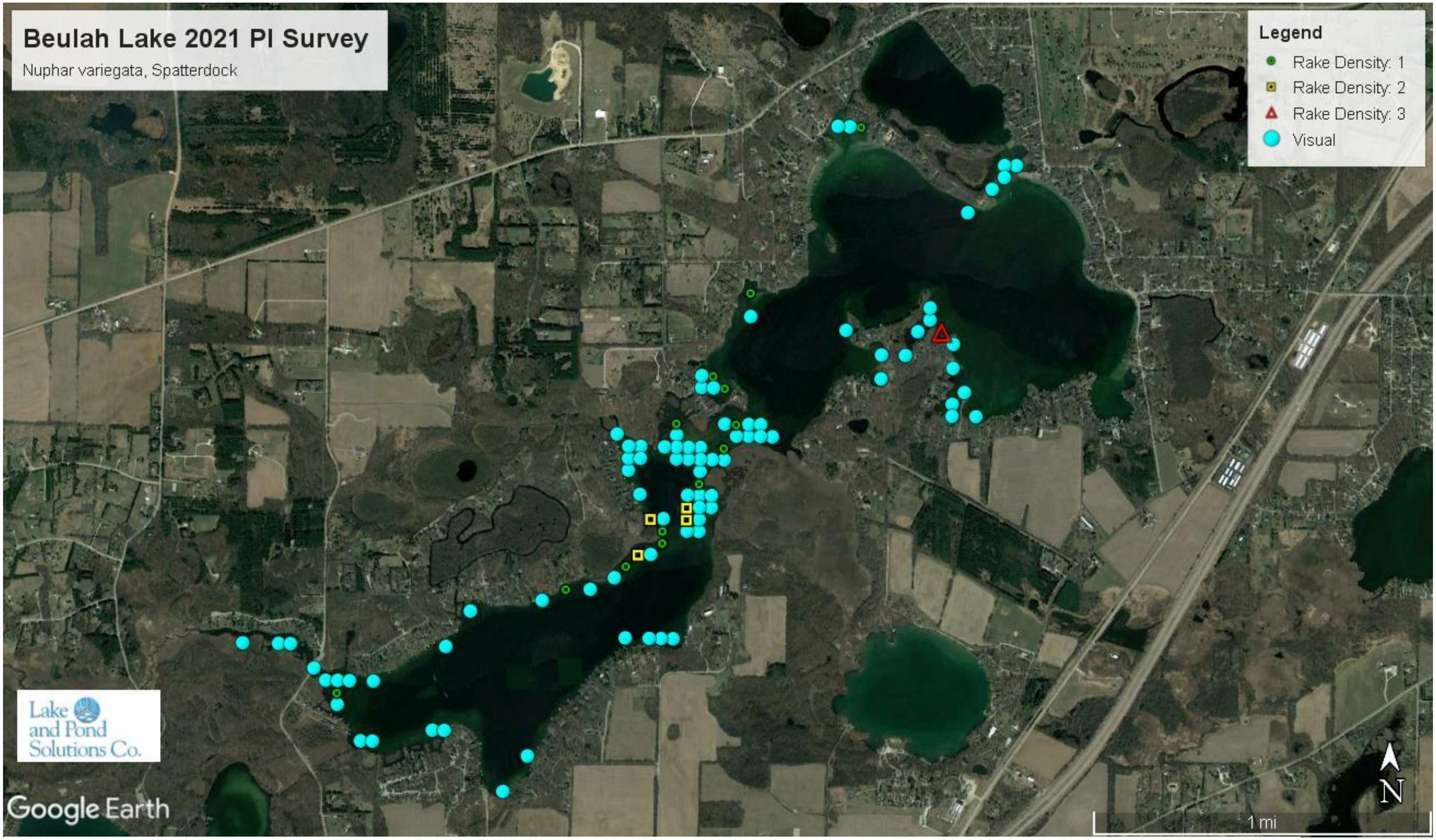

Figure 13: Distribution and density map of Spatterdock.

Figure 14: Density and Distribution of Wild Celery

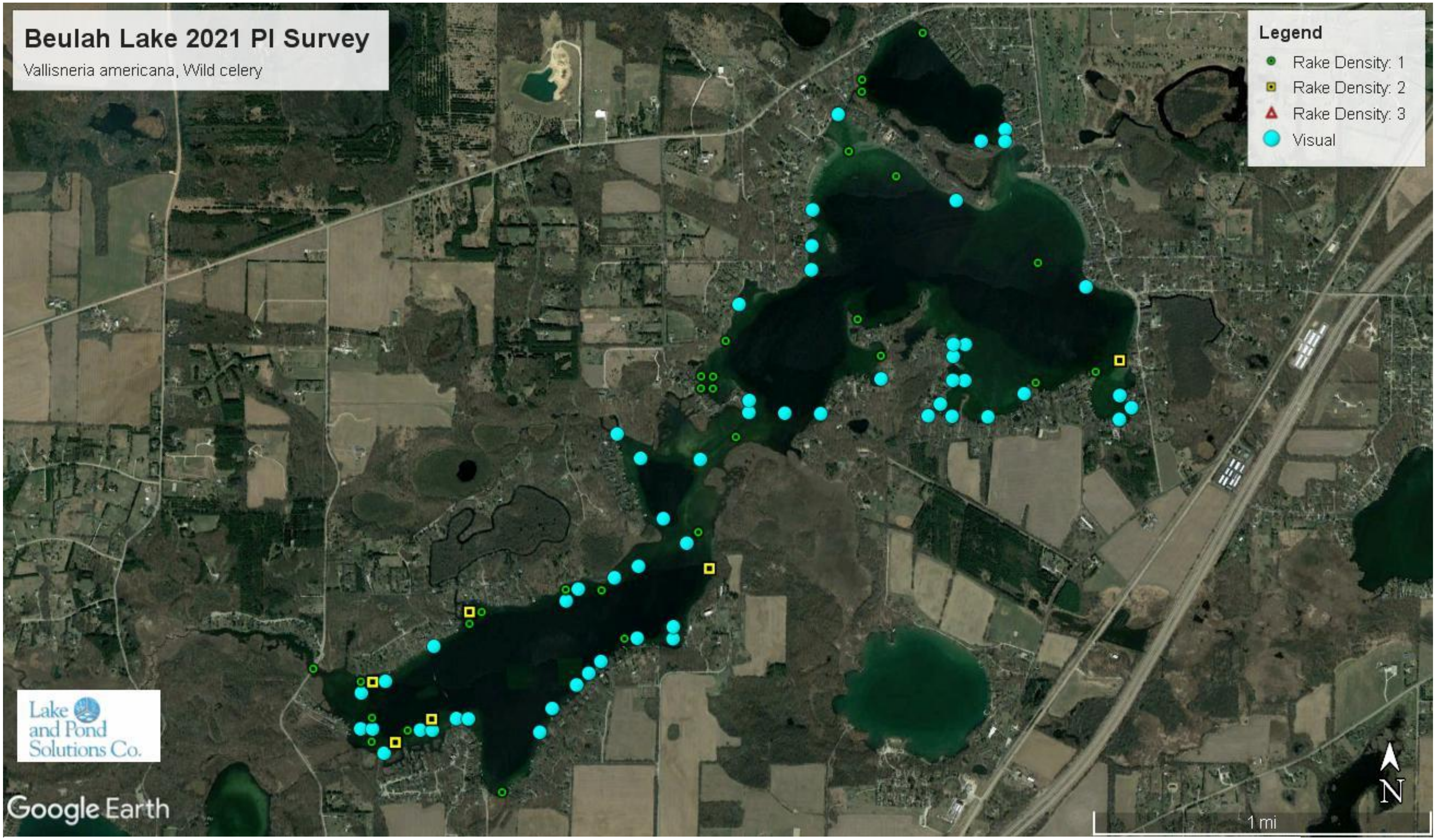

Figure 14: Distribution and density map of Wild Celery.

Figure 15: Density and Distribution of Swamp Loosestrife

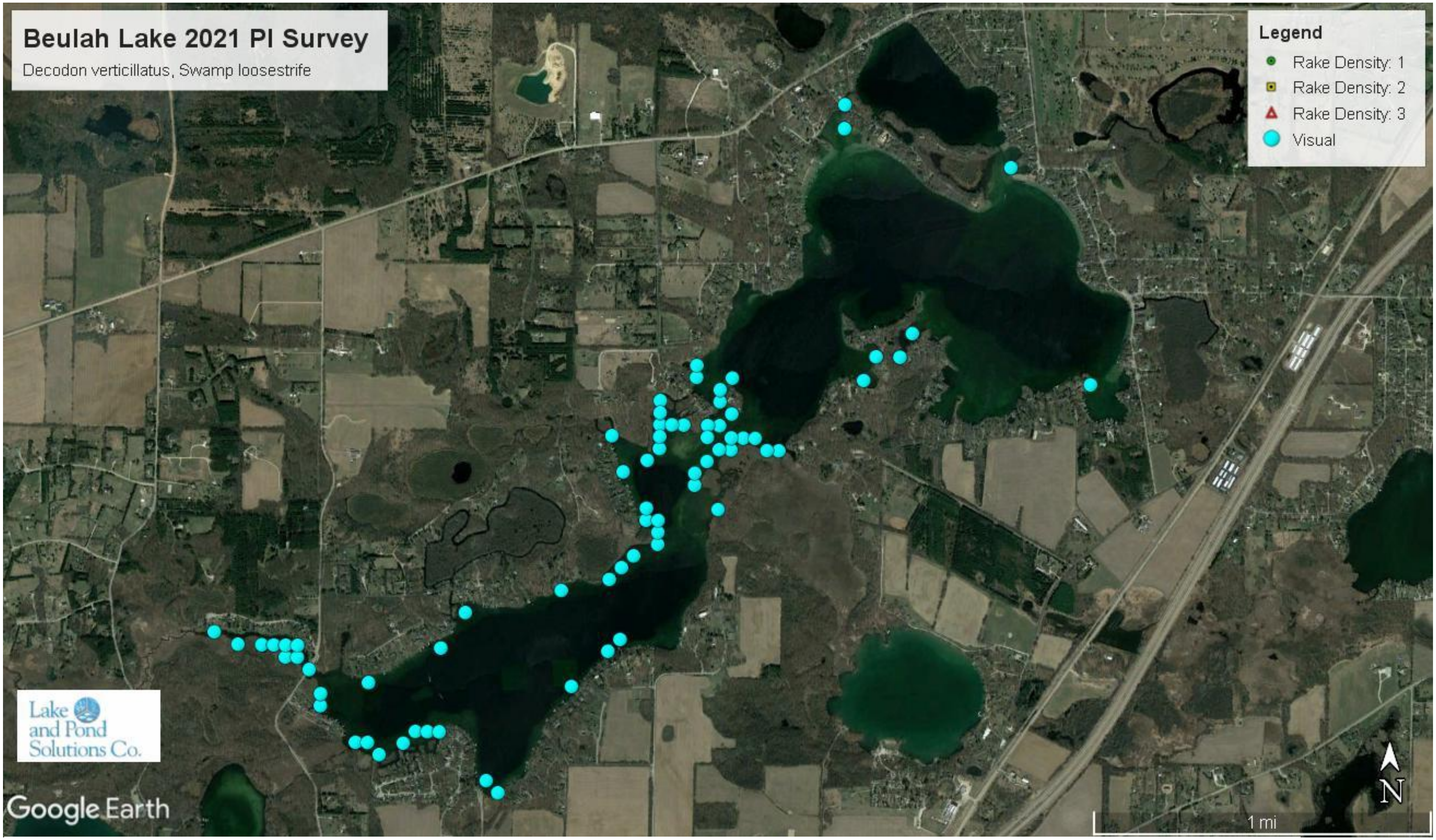

Figure 15: Distribution and density map of Swamp Loosestrife.

Figure 16: Density and Distribution of Variable Pondweed

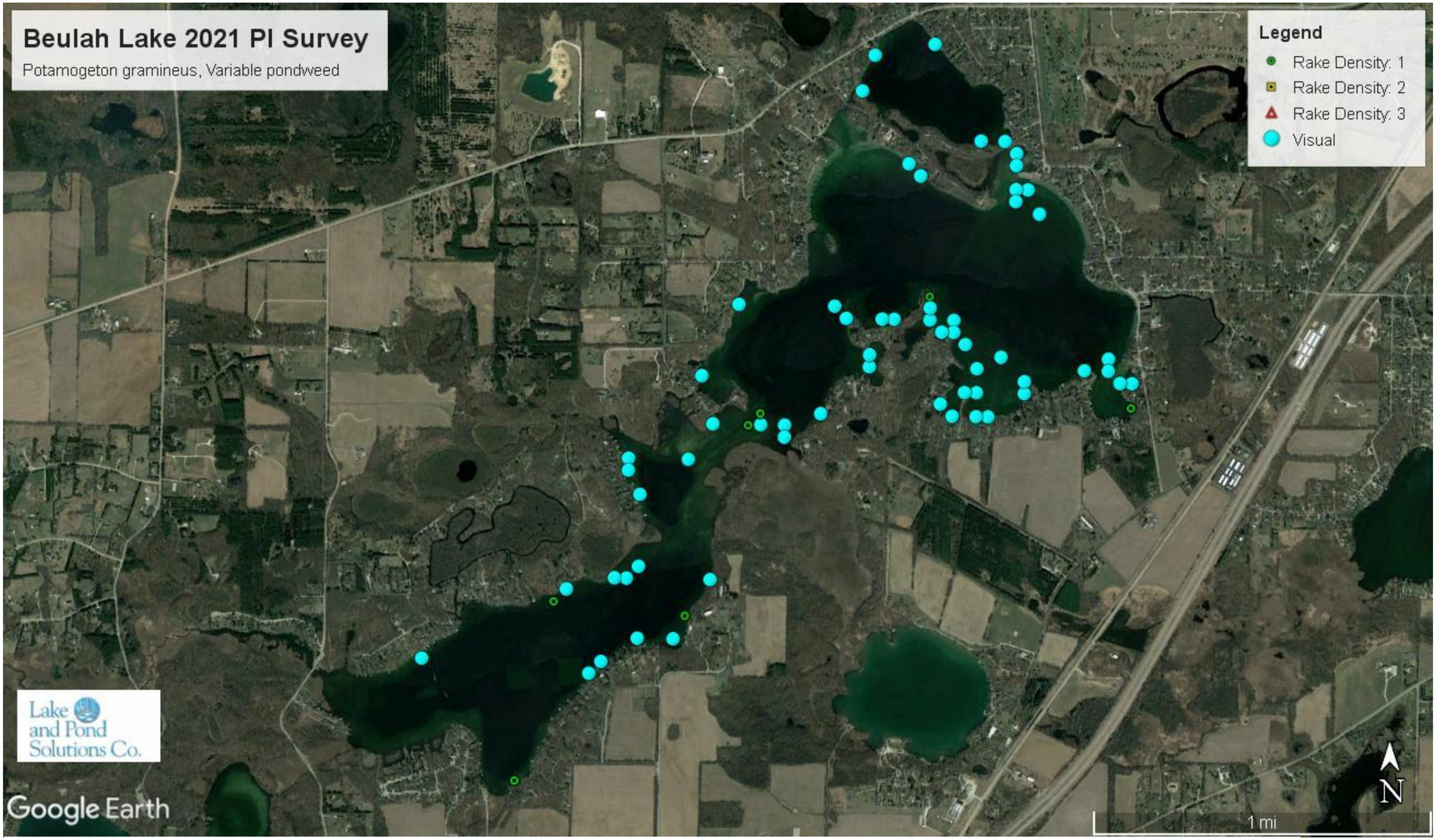

Figure 16: Distribution and density map of Variable Pondweed.

Figure 17: Density and Distribution of Nitella

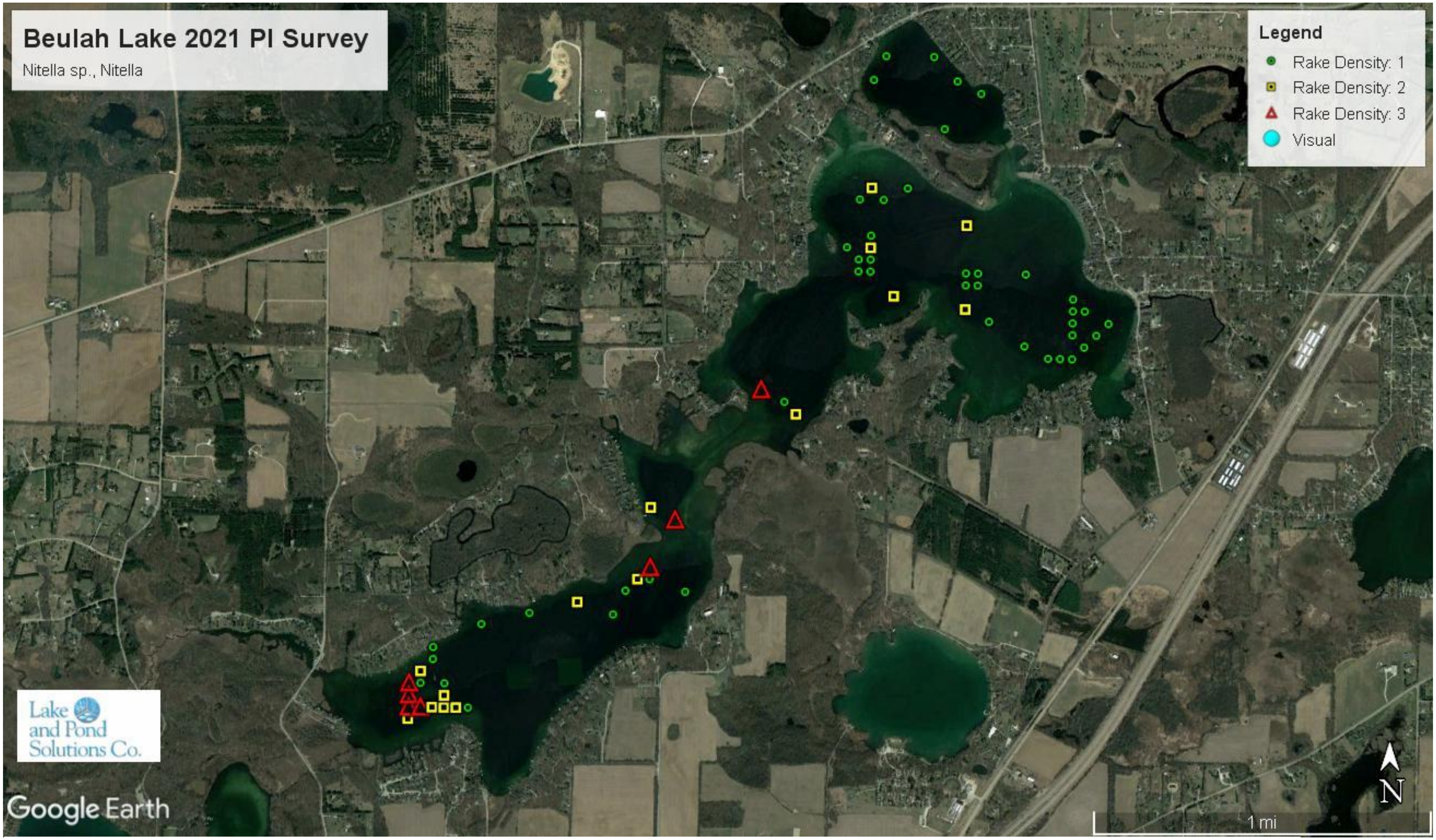

Figure 17: Distribution and density map of Nitella.

Figure 18: Density and Distribution of Small Duckweed

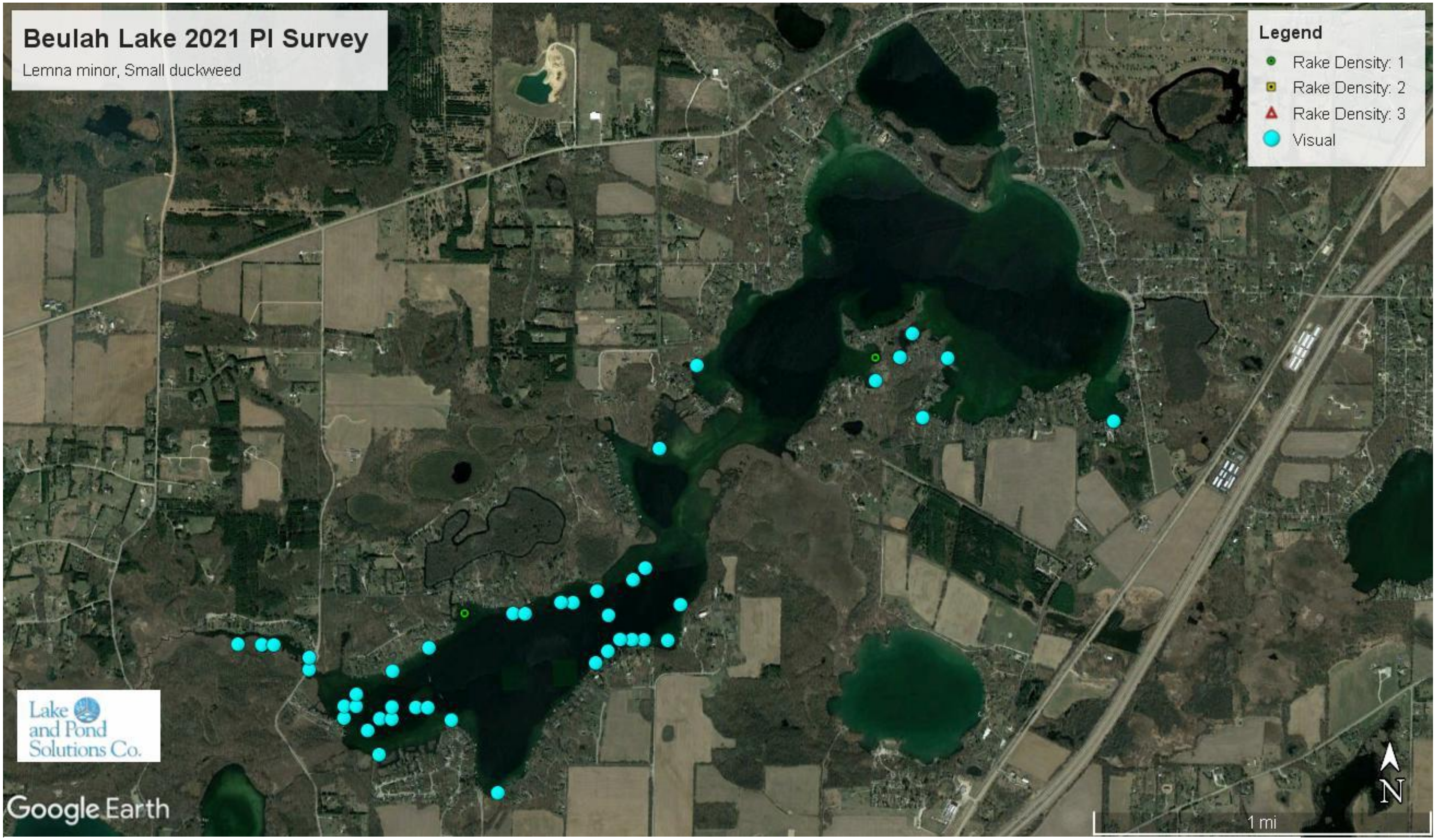

Figure 18: Distribution and density map of Small Duckweed.

Figure 19: Density and Distribution of Coontail

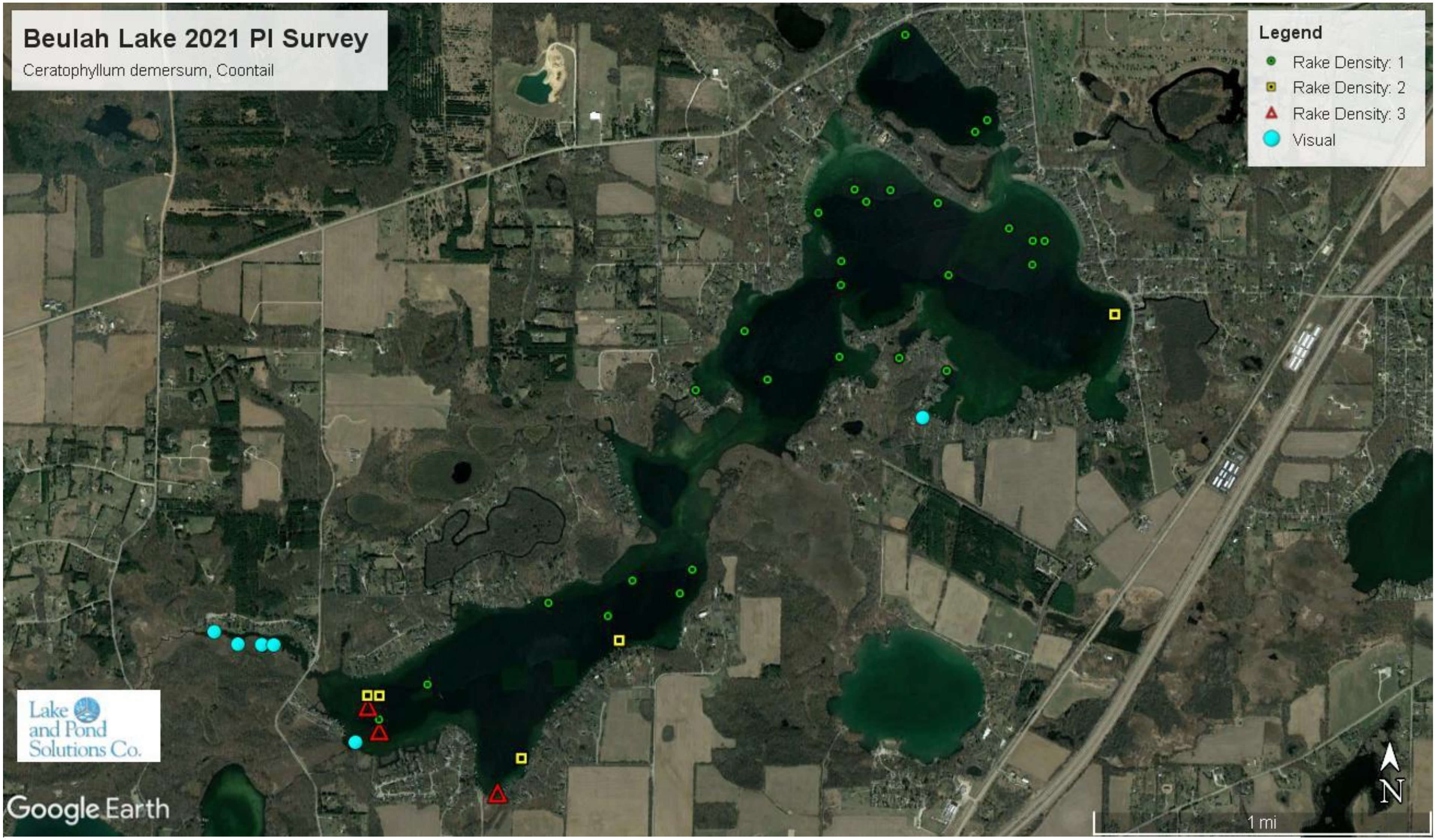

Figure 19: Distribution and density map of Coontail.

Figure 20: Density and Distribution of Floating-Leaf Pondweed

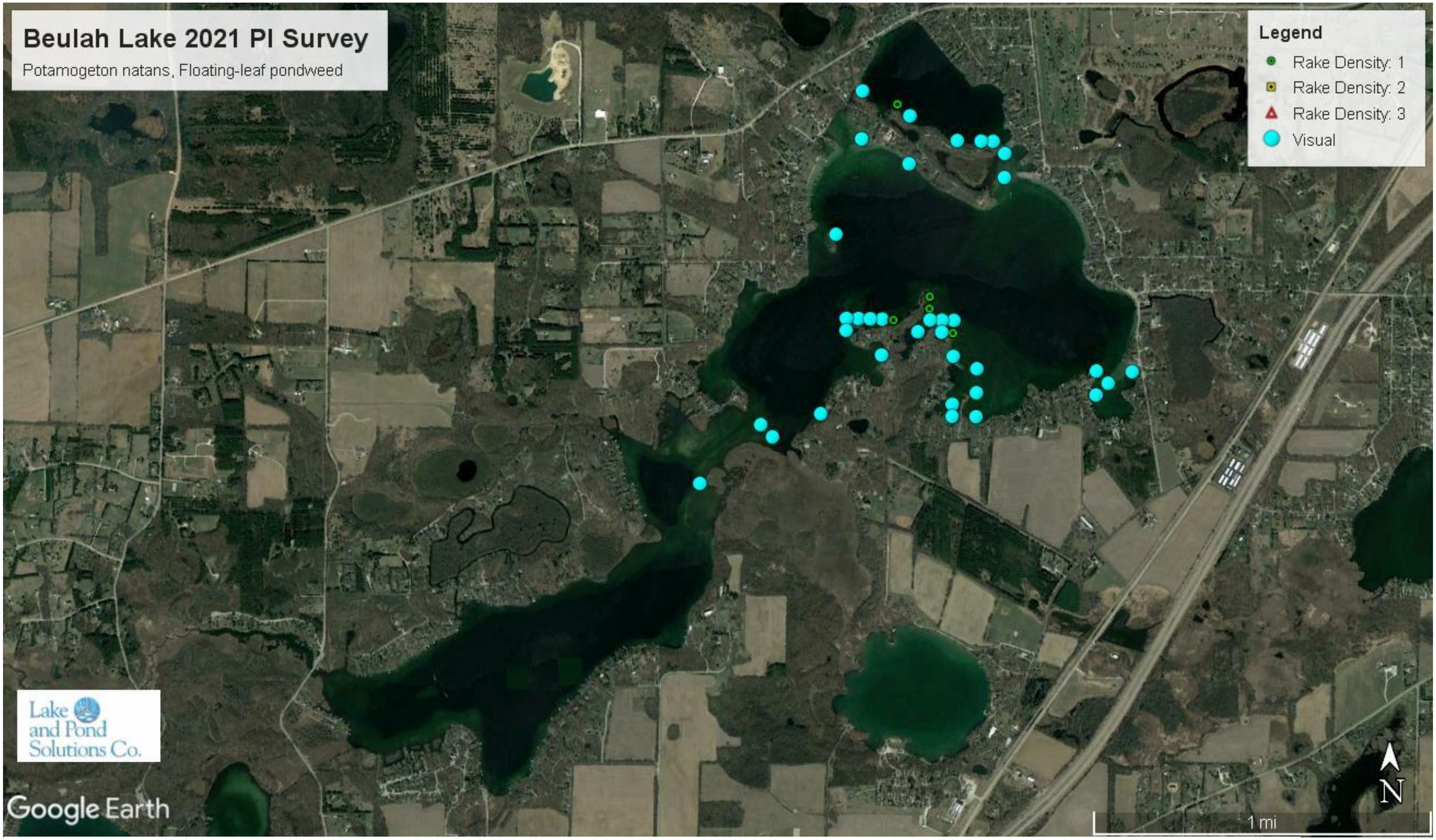

Figure 20: Distribution and density map of Floating-Leaf Pondweed.

Figure 21: Density and Distribution of Cattail

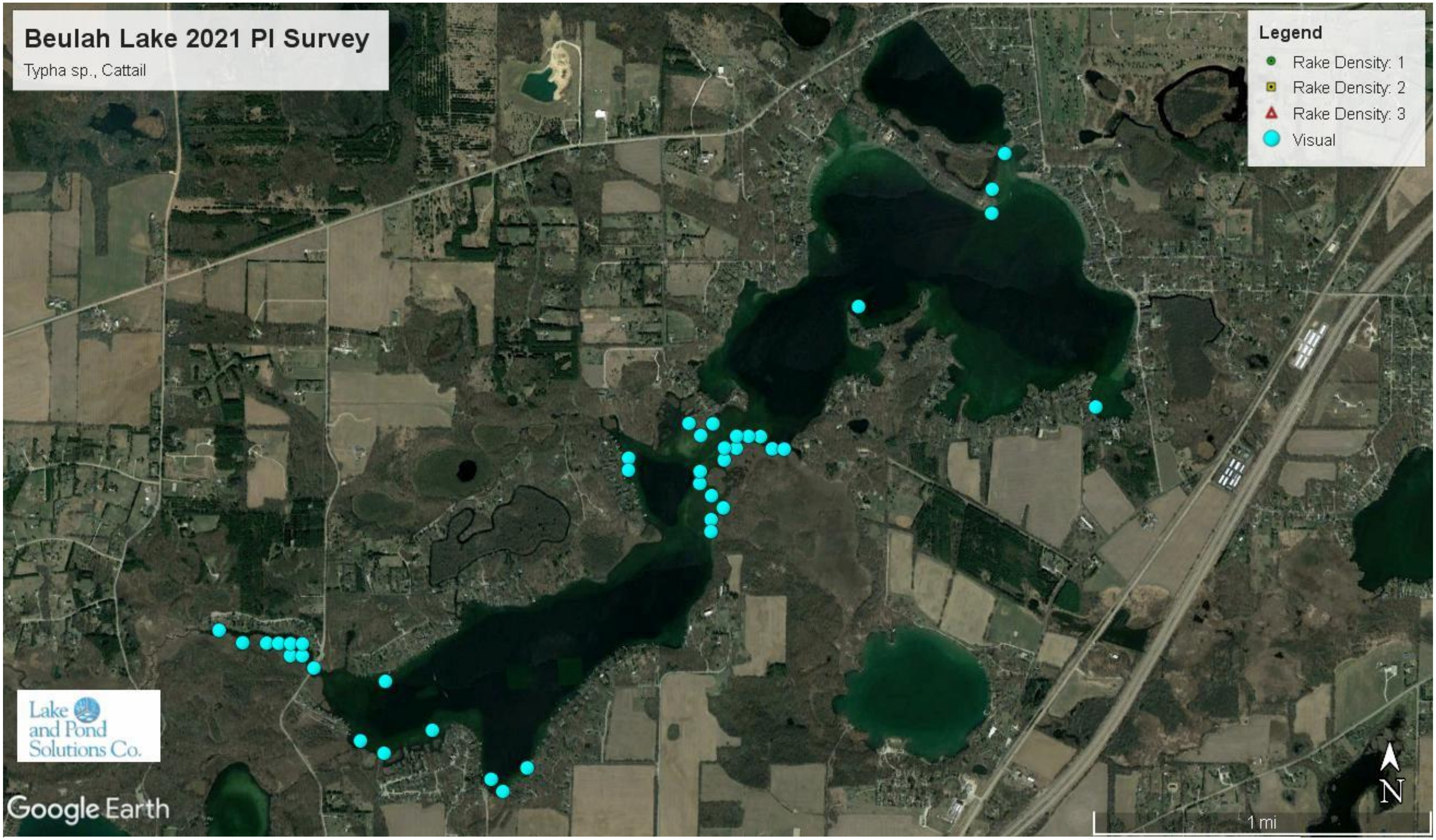

Figure 21: Distribution and density map of Cattail.

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Figure 22: Density and Distribution of Arrowhead

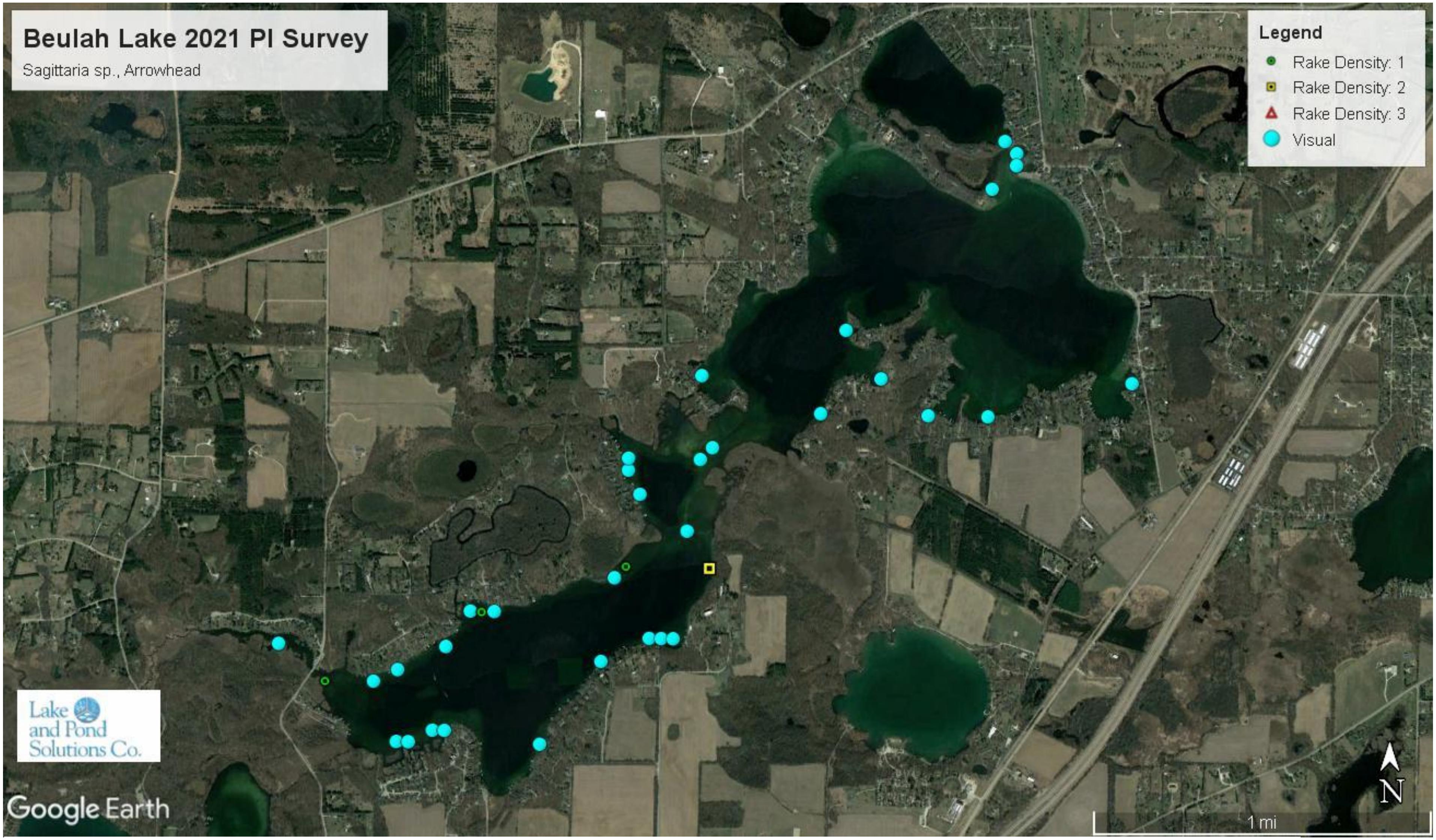

Figure 22: Distribution and density map of Arrowhead.

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Figure 23: Density and Distribution of Orange Jewelweed

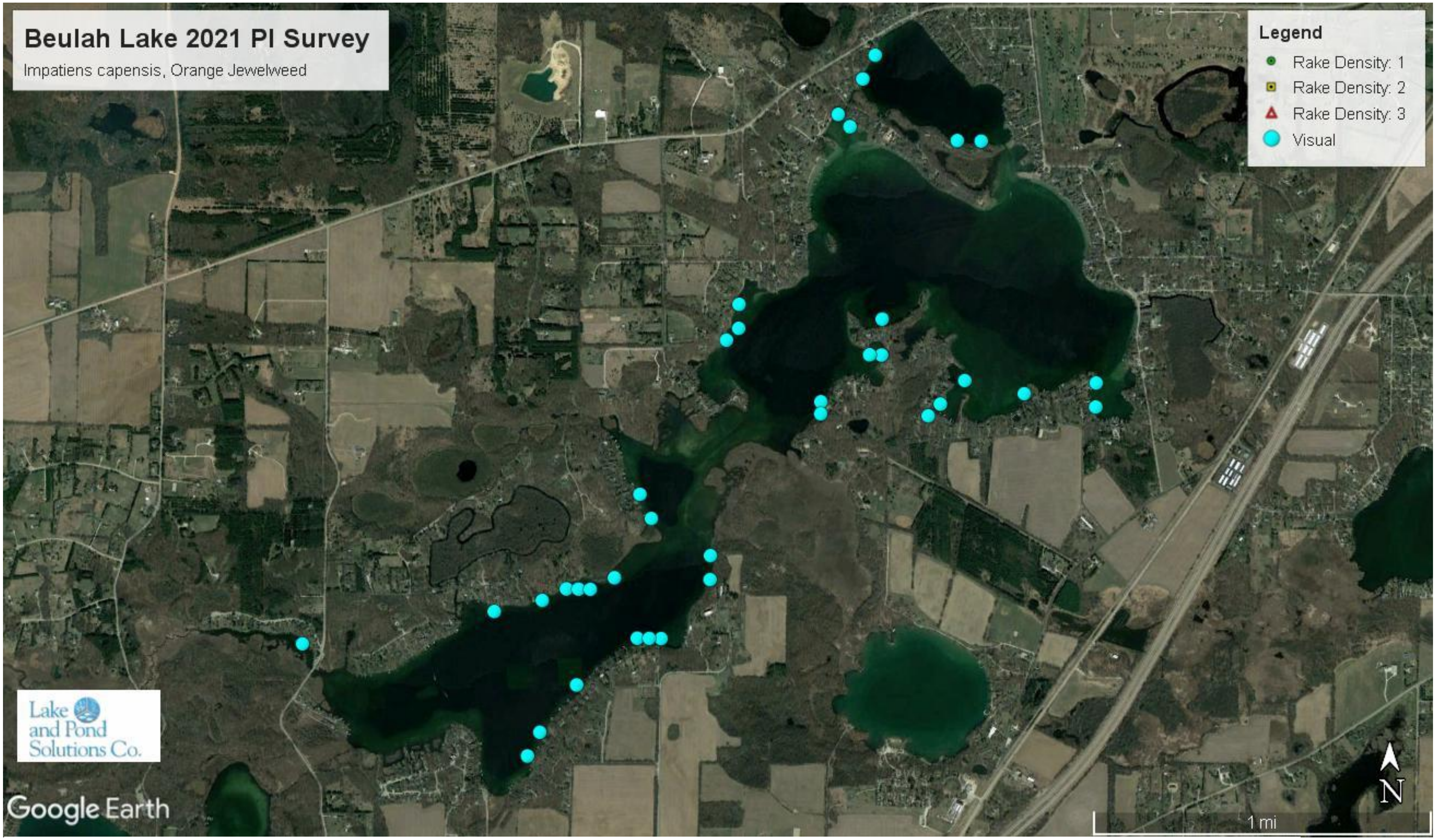

Figure 23: Distribution and density map of Orange Jewelweed.

Figure 24: Density and Distribution of Softstem Bulrush

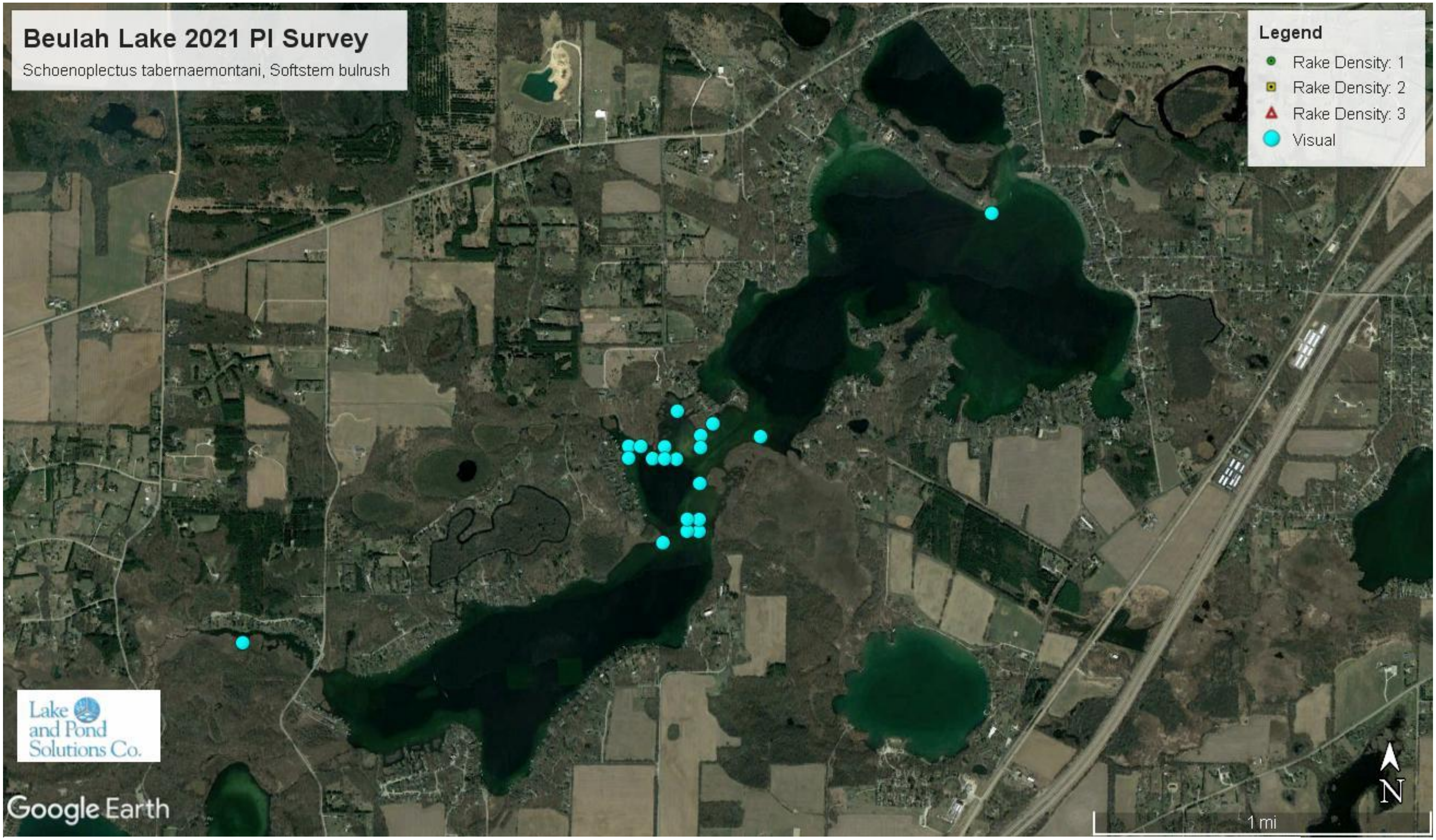

Figure 24: Distribution and density map of Softstem Bulrush.

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Figure 25: Density and Distribution of Ditch Grass

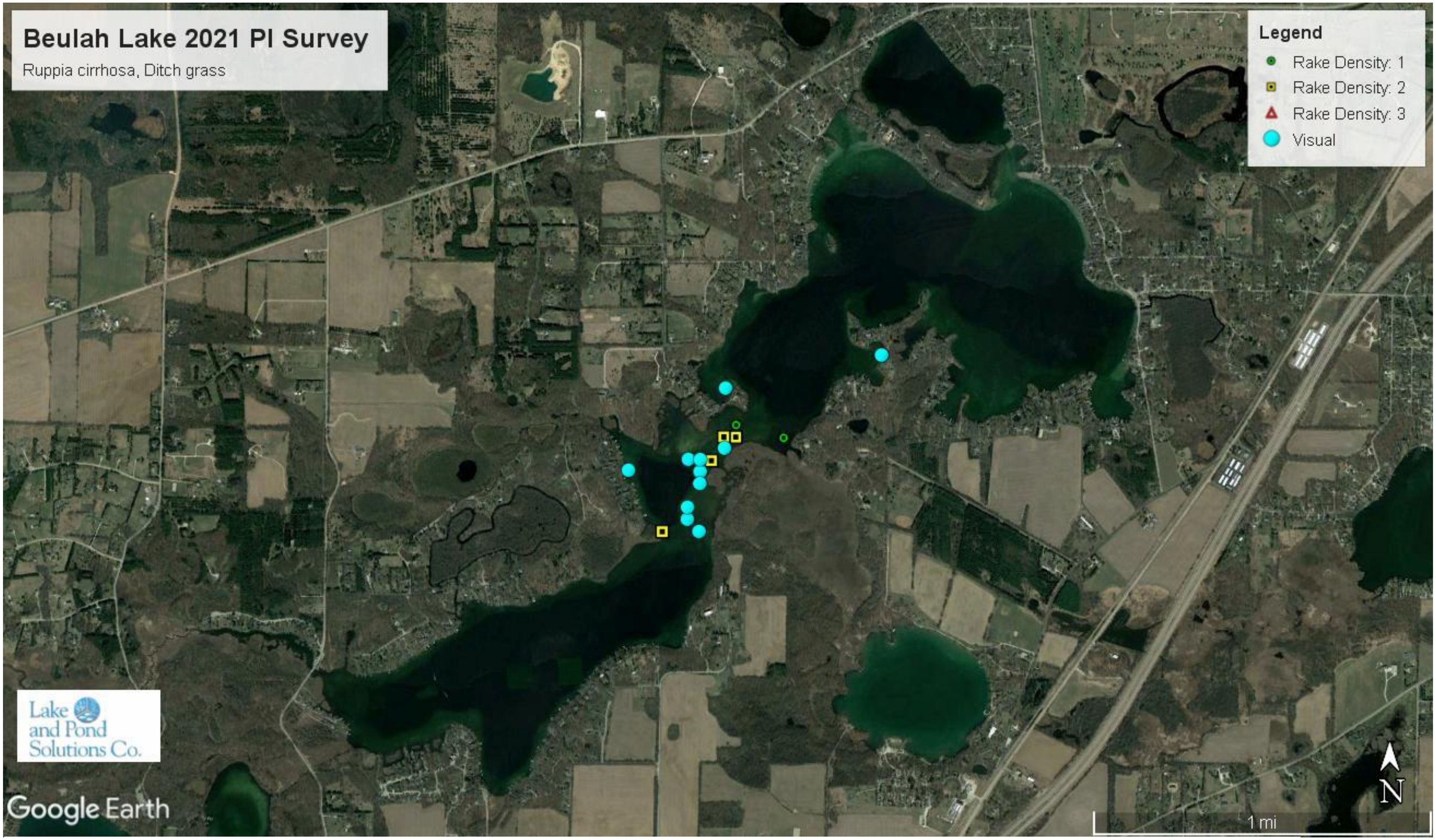

Figure 25: Distribution and density map of Ditch Grass.

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Figure 26: Density and Distribution of Flat-Stem Pondweed

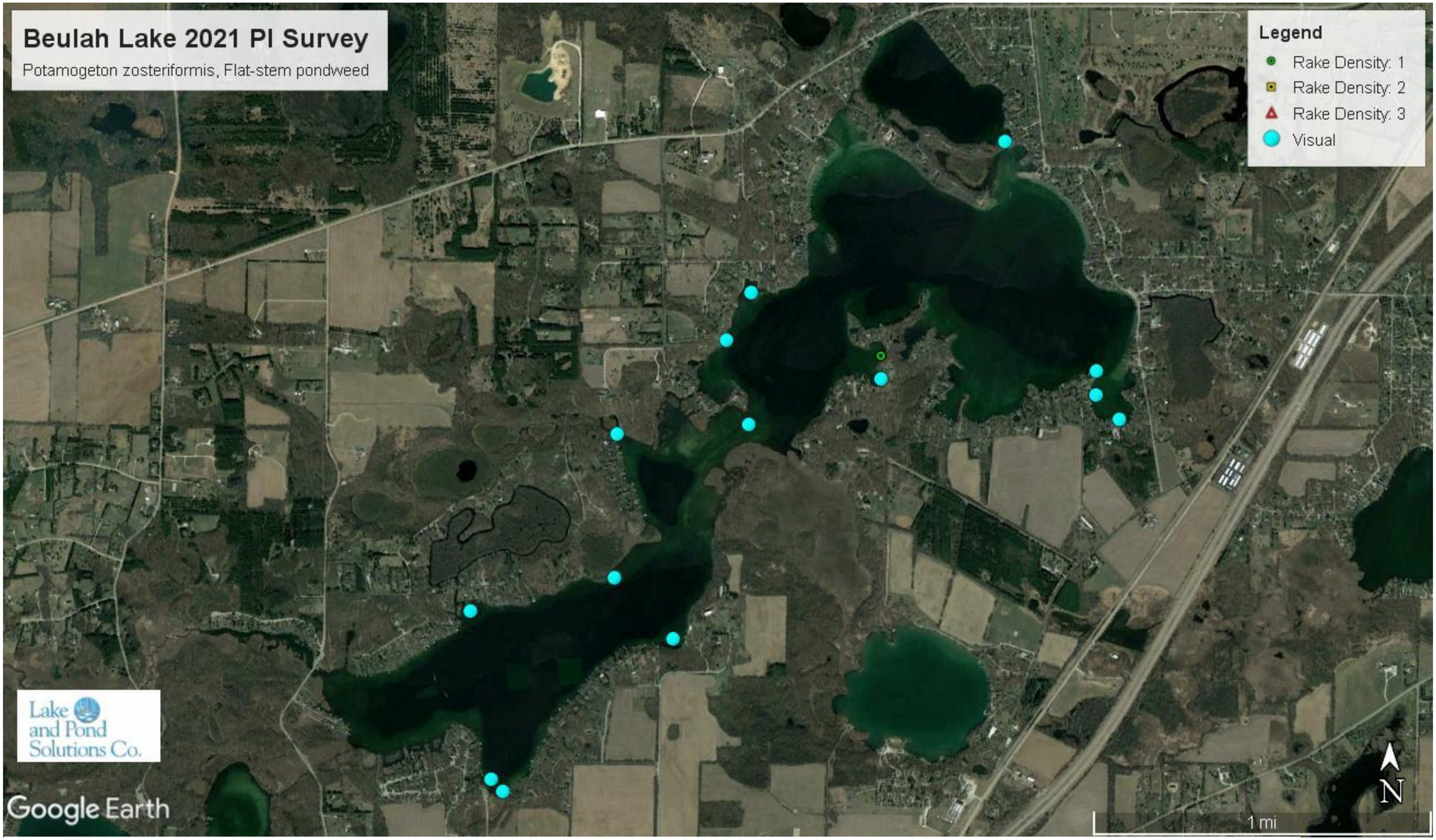

Figure 26: Distribution and density map of Flat-Stem Pondweed.

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Figure 27: Density and Distribution of Slender Naiad

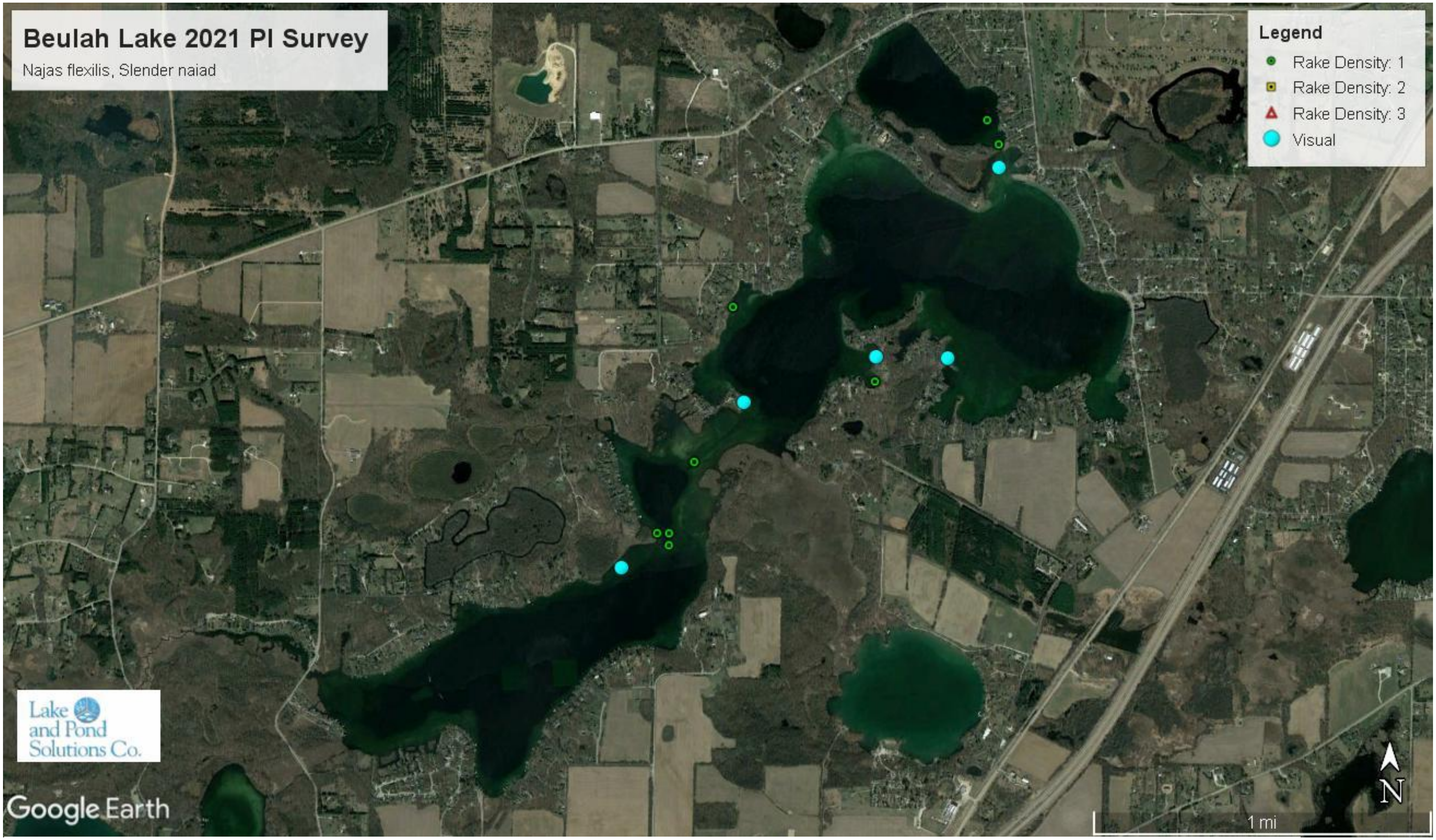

Figure 27: Distribution and density map of Slender Naiad.

Figure 28: Density and Distribution of Common watermeal

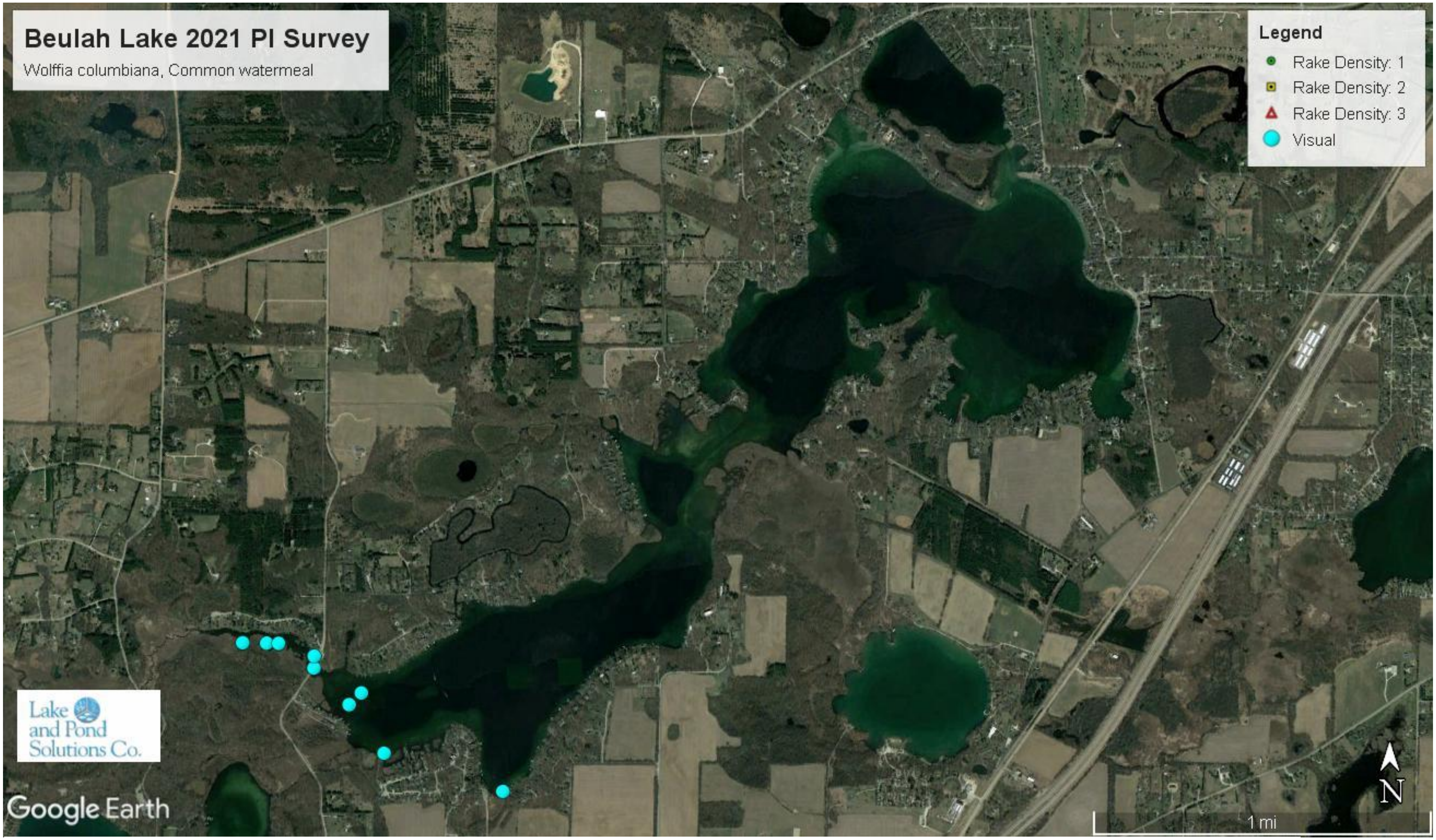

Figure 28: Distribution and density map of Common Watermeal.

Figure 29: Density and Distribution of Common Waterweed

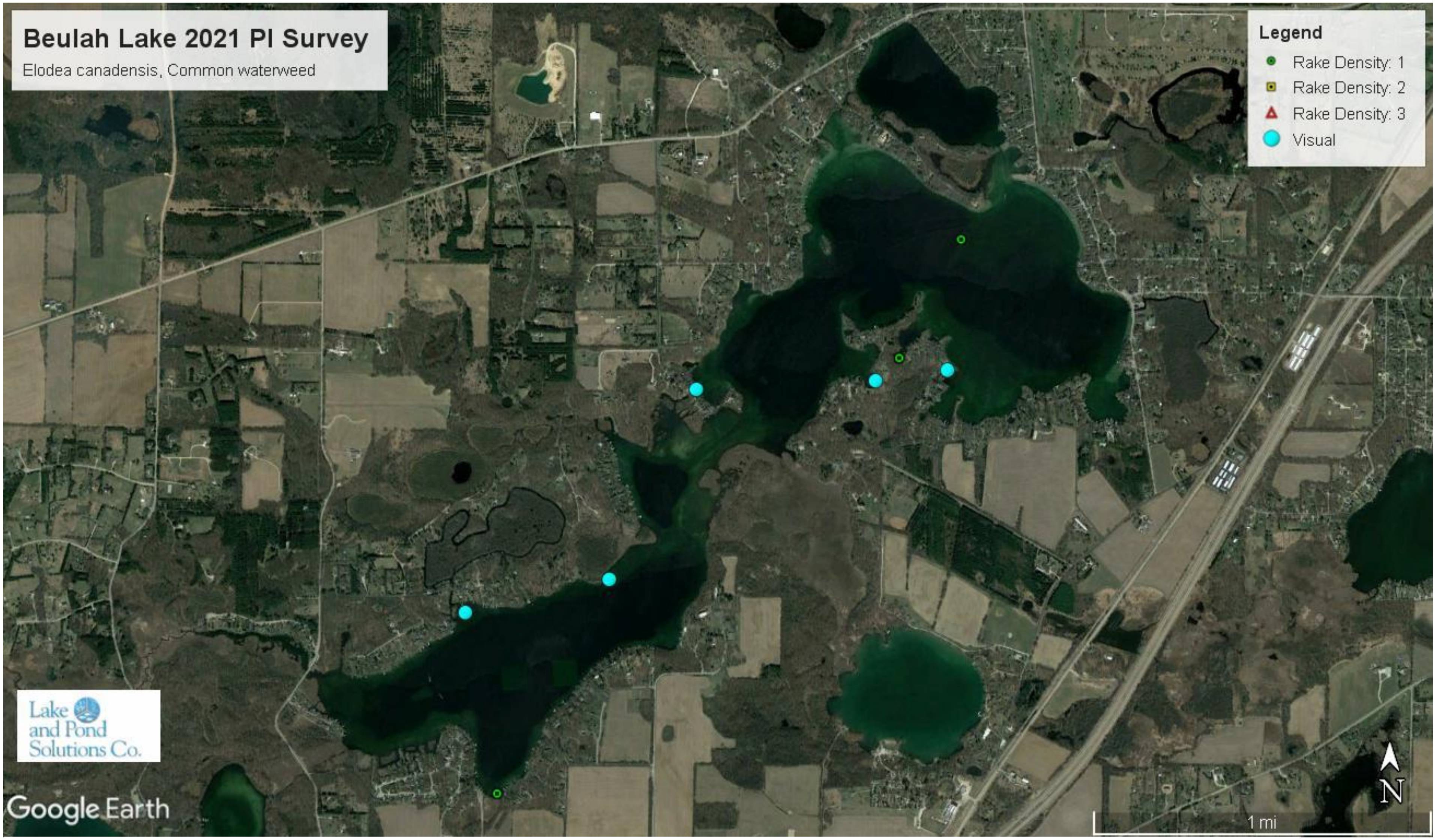

Figure 29: Distribution and density map of Common Waterweed.

Figure 30: Density and Distribution of Narrow-Leaved Bur-Reed

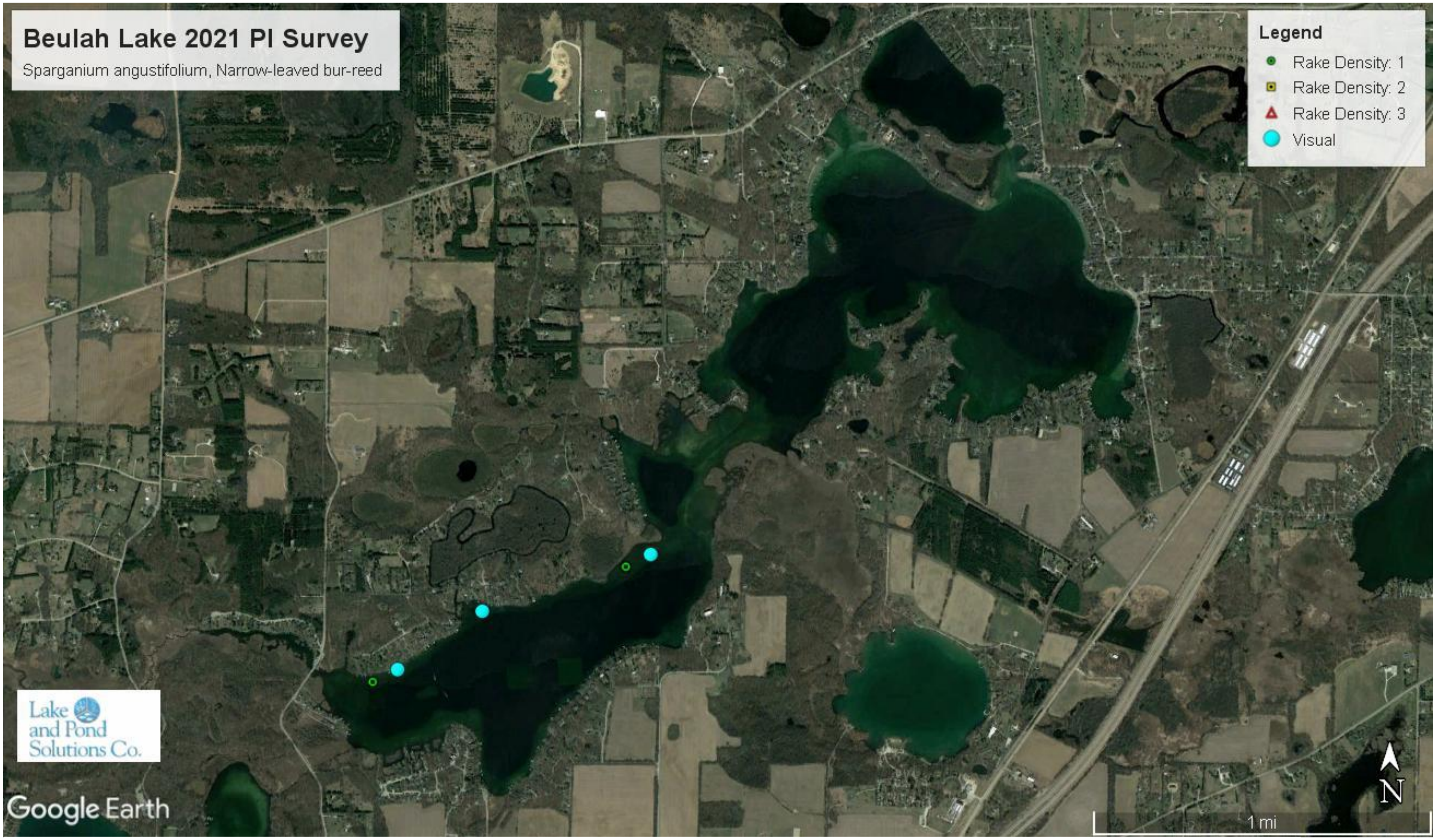

Figure 30: Distribution and density map of Narrow-Leaved Bur-Reed.

Figure 31: Density and Distribution of Aquatic Moss

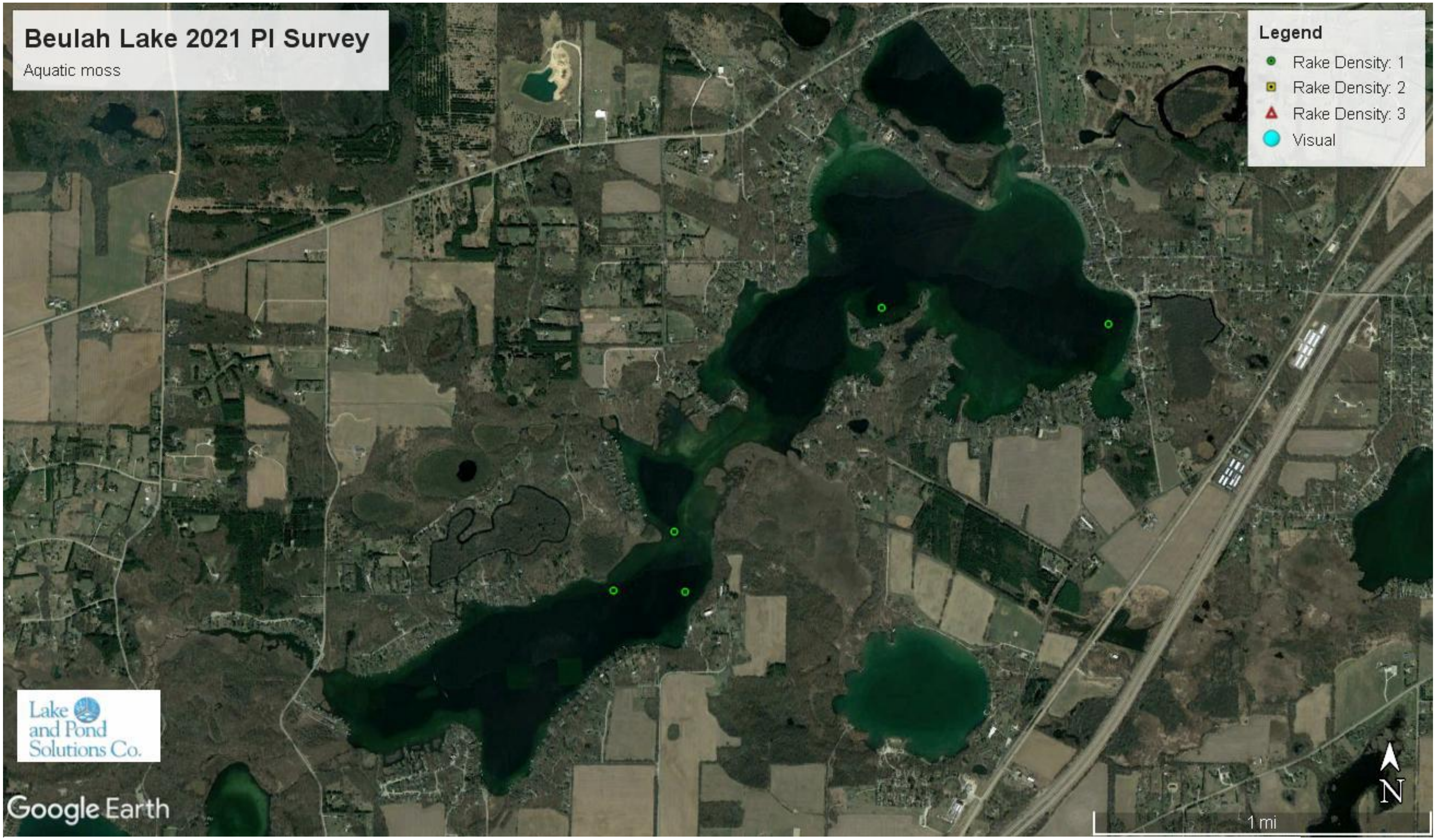

Figure 31: Distribution and density map of Aquatic Moss.

Figure 32: Density and Distribution of Northern Water-Milfoil

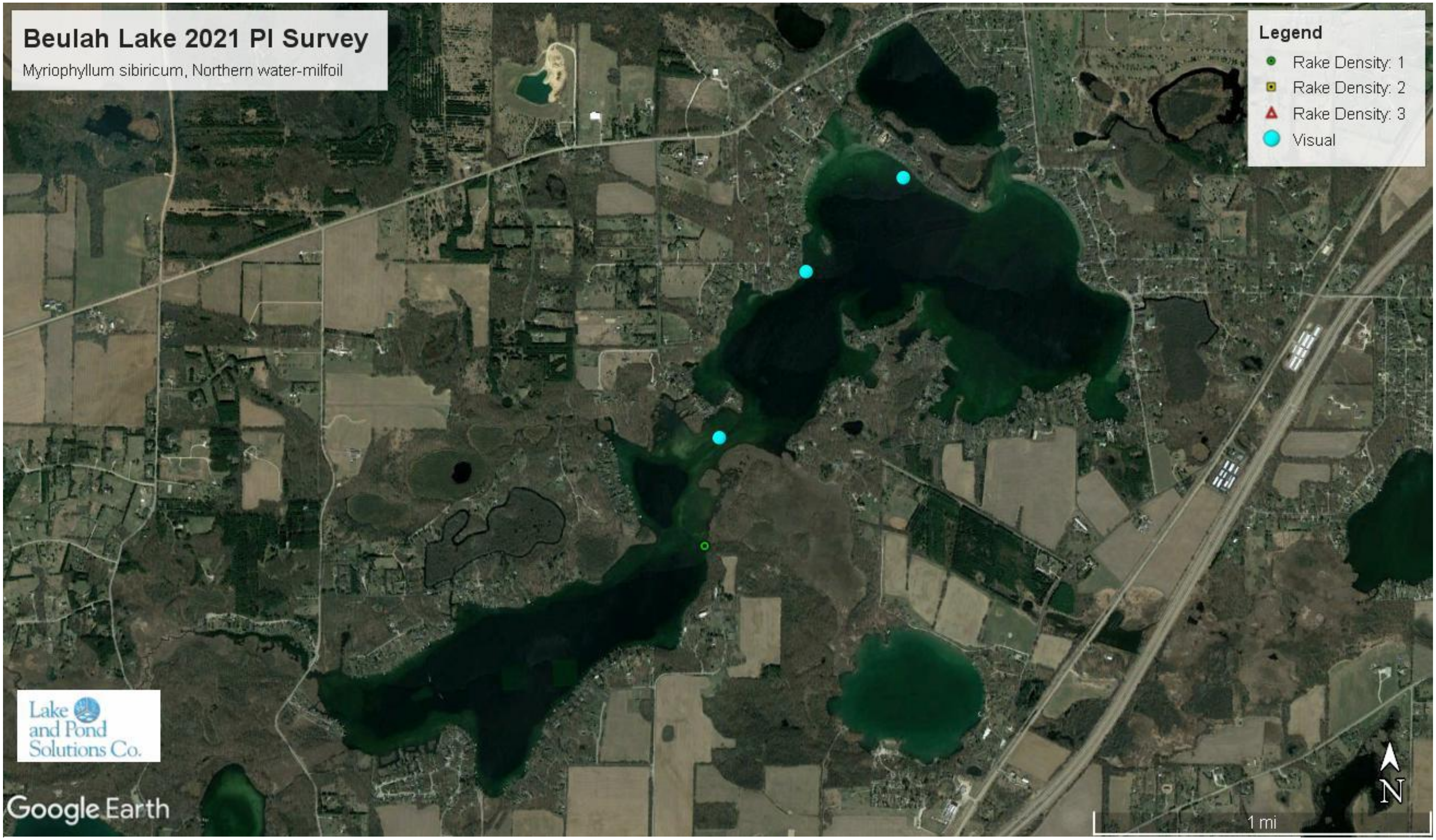

Figure 32: Distribution and density map of Northern Water-Milfoil.

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Figure 33: Density and Distribution of Whorled Water-Milfoil

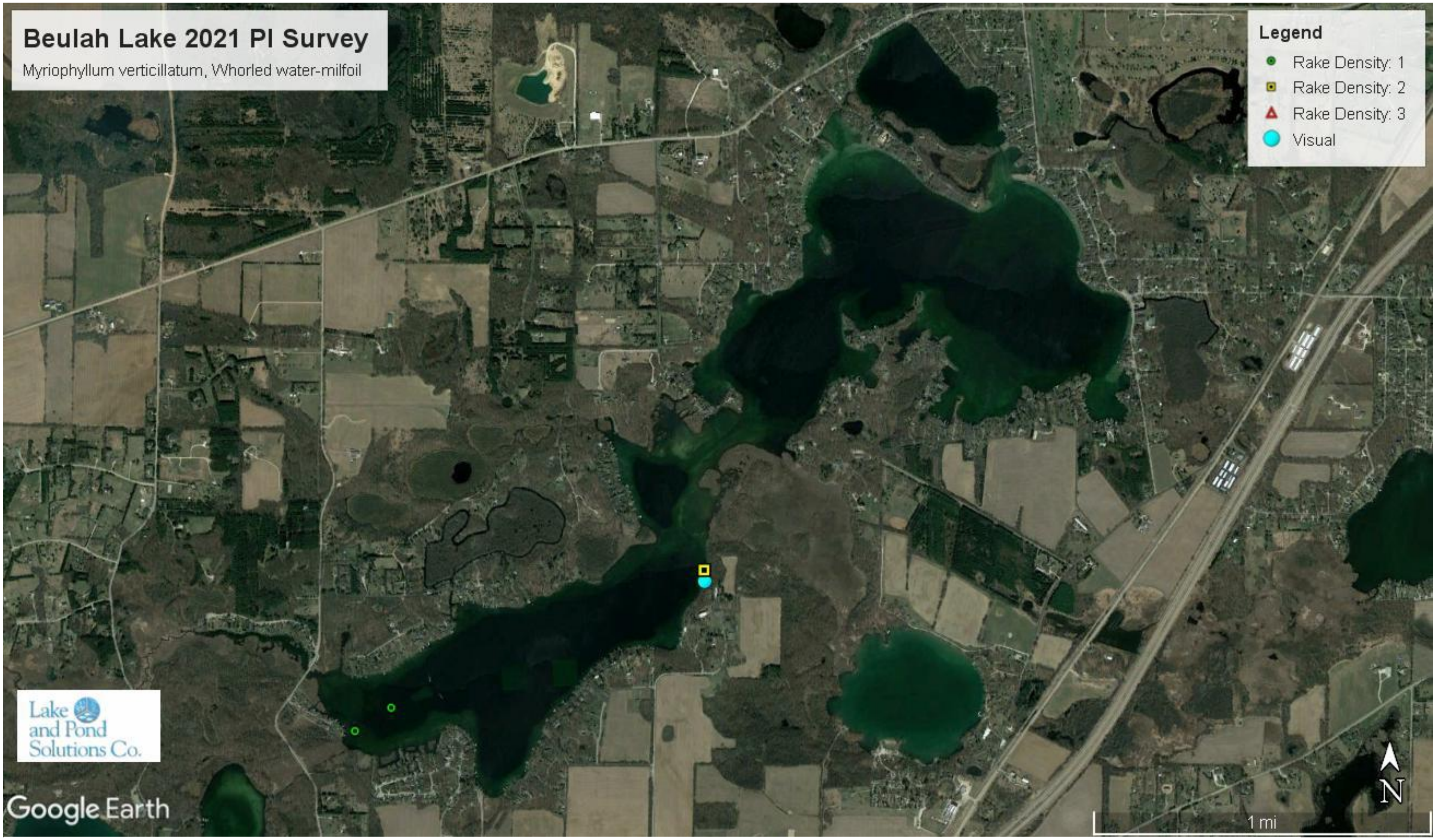


Figure 33: Distribution and density map of Whorled Water-Milfoil.

Figure 34: Density and Distribution of Creeping Bladderwort

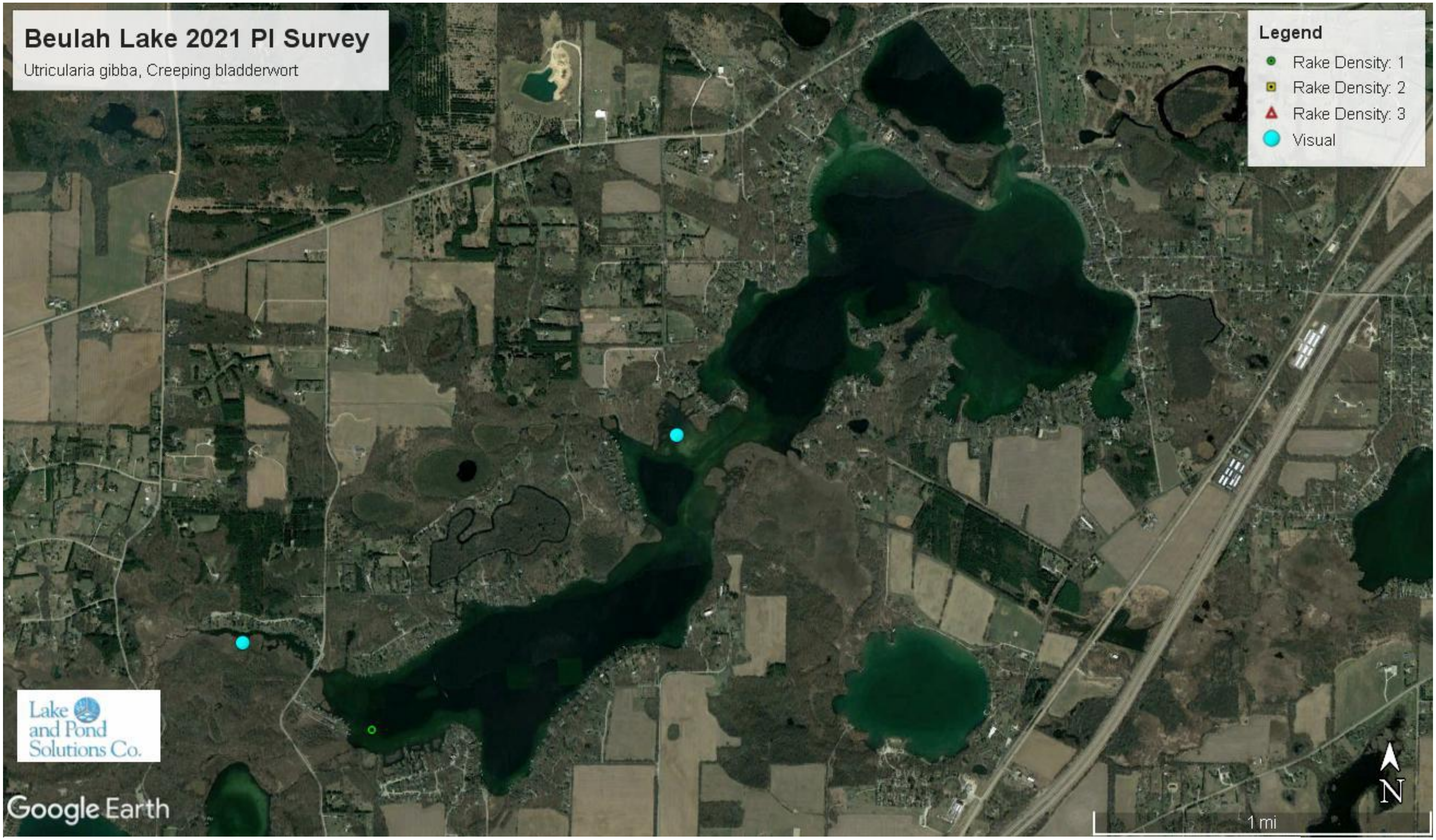


Figure 34: Distribution and density map of Creeping Bladderwort.

Figure 35: Density and Distribution of Fries' Pondweed

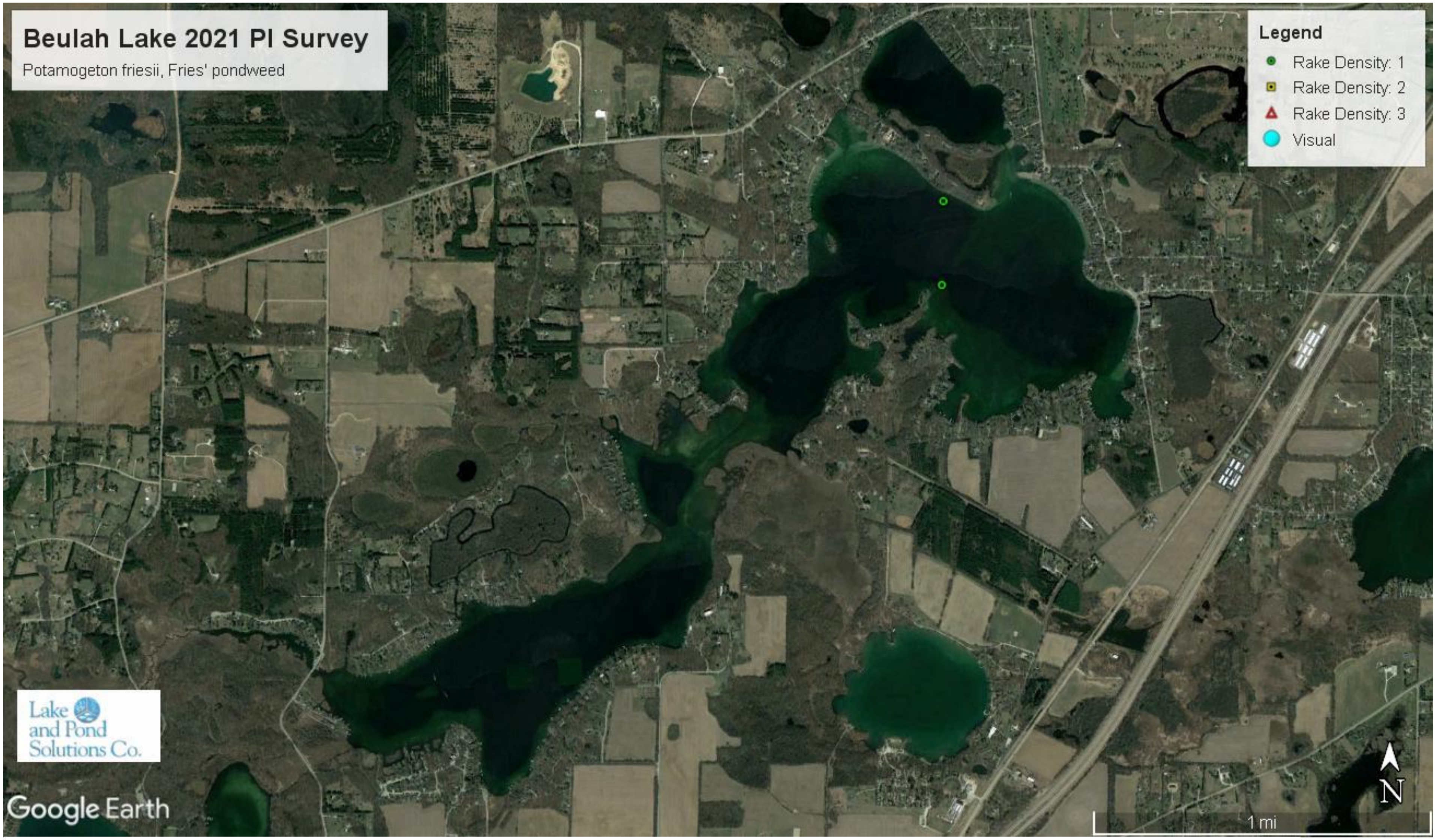


Figure 35: Distribution and density map of Fries' Pondweed.

Lake and Pond Solutions Co.

Figure 36: Density and Distribution of Clasping-Leaf Pondweed

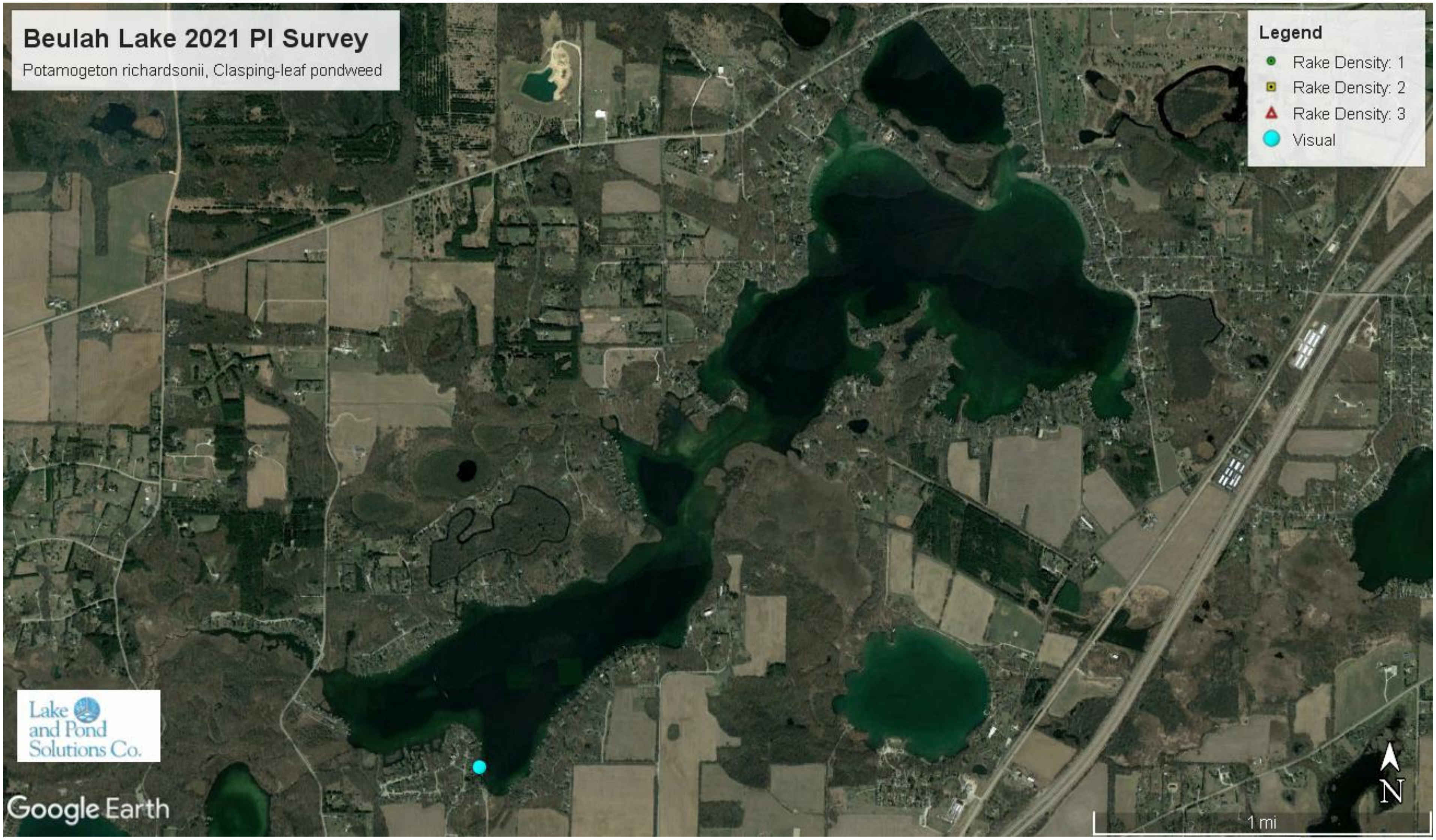


Figure 36: Distribution and density map of Clasping-Leaf Pondweed.

Figure 37: Density and Distribution of Large Duckweed

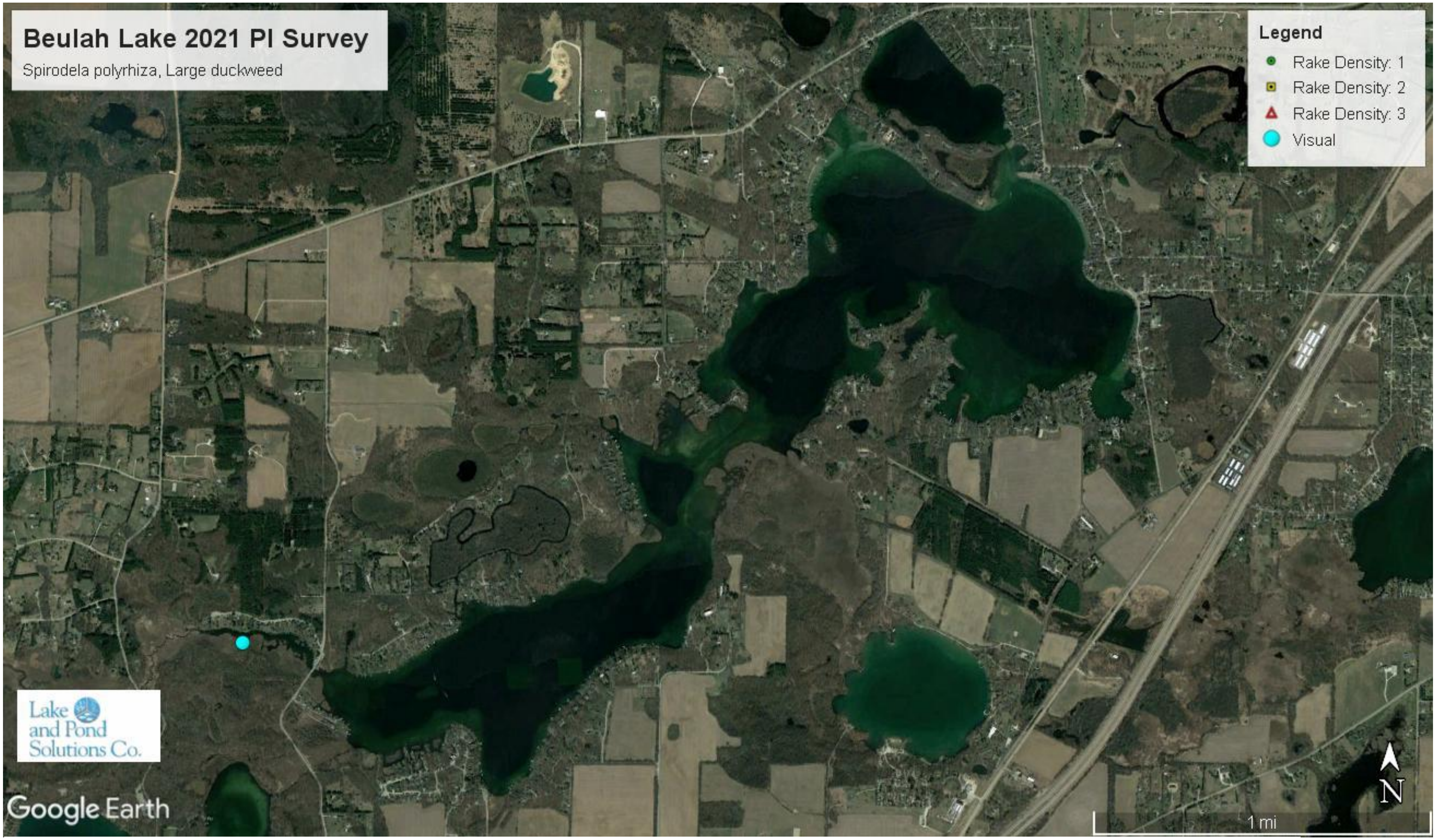


Figure 37: Distribution and density map of Large Duckweed.

HIGH VALUE AND QUALITY SPECIES

There are 19 species of plants which should be considered "quality" based on a C-Value of 6-10 or deemed "High Value" in the WDNR NR109.05(g) document. Those species include Chara, Clasping-Leaf Pondweed, Common Bladderwort, Creeping Bladderwort, Flat-Stem Pondweed, Fries' Pondweed, Illinois Pondweed, Narrow-Leaved Burr Reed, Nitellla Sp., Northern Water-Milfoil, Sago Pondweed, Slender Naiad, Spatterdock, Variable Pondweed, Various-Leaved Milfoil, White Water Lily, Whorled Milfoil, Widgeon Grass and Wild Celery.

The C-value is the estimated probability that a plant is likely to occur in a landscape that is believed to be relatively unaltered from pre-settlement conditions. The figure below shows the sites that reported a "high value" species, "quality" species or both and how many were found at that location.

Figure 38: High Value and Quality Species Distribution

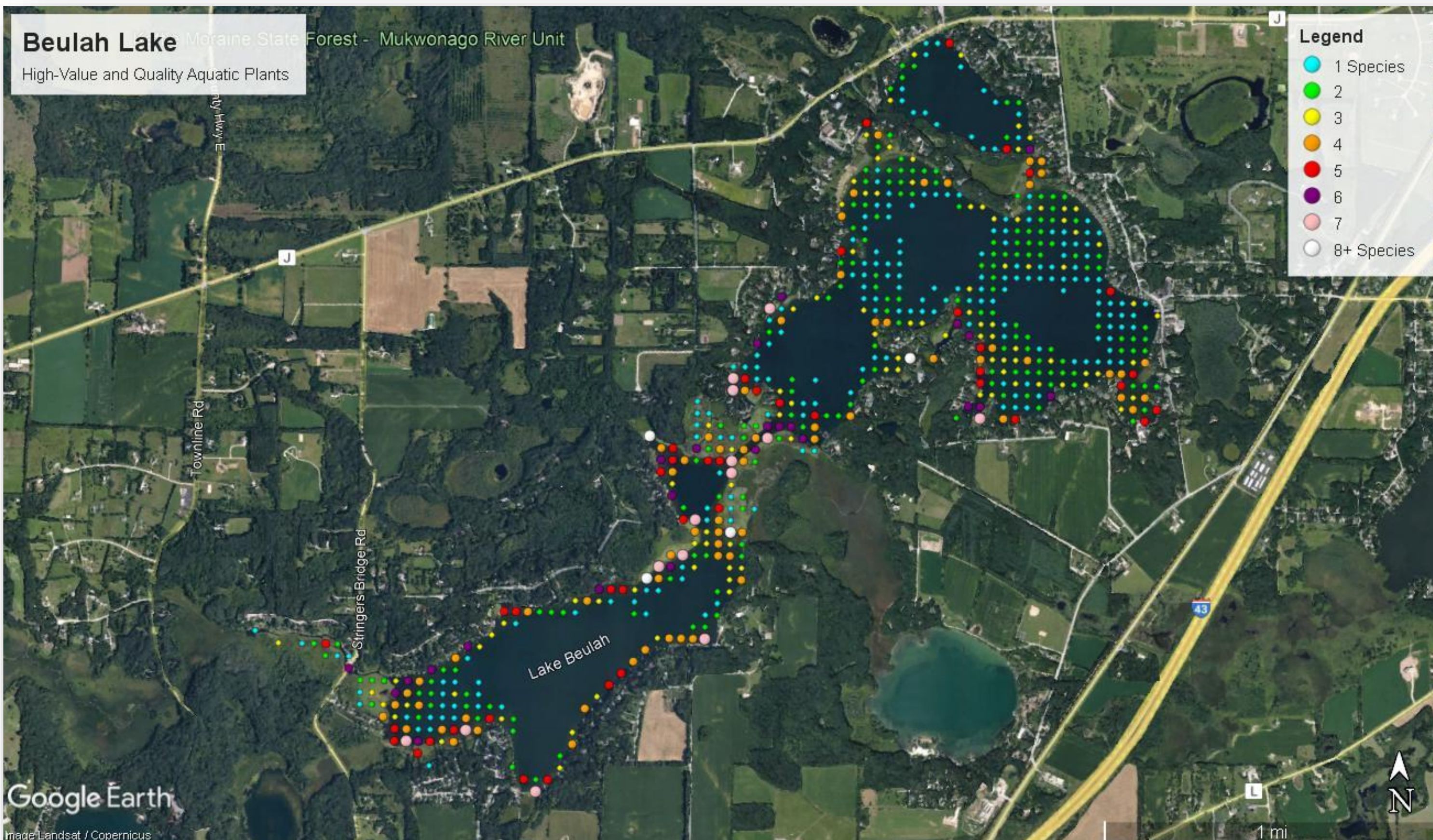


Figure 38: Distribution of High value and quality species found during the August 2021 Point-Intercept Survey.

Exotic Species Summary

Three exotic species, Eurasian Water-milfoil, Curly-Leaf Pondweed and Purple Loosestrife, were identified during the survey and their distribution and densities can be found above in Figures 1-4. Phragmites and Purple Loosestrife are found in relatively few numbers. Treatment for these species would likely be more selective at this point, before they continue to expand their range. Curly-Leaf Pondweed (CLP) was found 5 times. It is likely that CLP encompasses a broader distribution area, but timing of the survey has likely missed when that species is commonly present. Eurasian Water-Milfoil (EWM) was found throughout the lake, with a higher concentration found in several select bays and areas within the Eastern Lobe. EWM was found also in the Westernmost section of the lake near the area of shallow water and ample lily-pad growth.

Floristic Quality

Since each lake possesses unique ecological characteristics, comparing lake biological health can be difficult. The Floristic Quality Index (FQI) created by Swink and Wilhelm (1994) attempts to identify natural conditions within the system, monitor long-term floristic trends, and monitor restoration efforts.

For any area (a 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 ($\sqrt{N}$). A C-value was assigned to 128 aquatic plants, compared to regional studies and reviewed by a number of 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 for Lake Beulah. Table 2 on page 9 shows each individual plant species found in the lake along with its assigned C-value. Table 3 summarizes the values compared to the Southeast Till Plain (STP) average, Wisconsin average and 75th percentile numbers. The STP average categorizes the lakes in the southeast corner of the state.

Table 3: Floristic Quality Comparison

	Lake Beulah	STP Average	W I Average	WI 75th Percentile
Average C-Value	5.71	5.6	6.0	6.9
# of Natives (N)	31	14	13	20
Floristic Quality	30.23	20.9	22.2	27.5

SOURCE: Lake and Pond Solutions Co. (2021), STP= Southeastern Till Plain.

The plant community within Lake Beulah ranks among the best, most diverse and undisturbed lakes in Wisconsin in terms of number of native species and overall floristic quality. The average C-Value for this lake is lower than expected. the lakes in this region for number of native species but falls short when it comes to average C-value. The way these numbers are calculated are dependent on the sampled rake density. Visuals are not typically included in these calculations. However, emergent shoreline aquatic plants are an important aspect of any waterbody so we have included visuals. Because many of these emergent species have a low C-value associated with them they tend to lower the average. If they were not included the C-Value would be 6.22. The FQI considers the importance of diversity while balancing the importance of a species resistance to disturbance. Without the inclusion of emergent visuals, the FQI would be 29.20. When taking all these numbers into consideration it points to an excellent waterbody. The diversity and abundance of native vegetation is above the average Wisconsin lake. Good water clarity allows plants to grow to great depths here and the natives encompass the entire range of maximum depth of plants, meaning there are few areas where invasive species can take hold.

COMPARISON OF AQUATIC PLANT SURVEYS (1995-2021)

A comparison of past plant surveys can serve as a valuable resource indicating how the lake may be changing from a variety of factors. Line transects were developed to extend out into the center of the lake. Aquatic plants were sampled at points along each transect by recording the density of each species found on the rake. The limiting factor of this type of survey is the lower number of points sampled and higher probability to omit pertinent vegetation. There is also the potential of skewed percent frequency numbers if sampling took place in a large bed of one plant species. Surveys in 1995 and 1999 were, in fact, transect based and these surveys are not entirely comparable to the surveys that followed. Point-Intercept Surveys use a modified grid sampling method determined by the size and morphology of the lake. Instead of developing transects, the WDNR generate grids to include points throughout the entire lake. Sampling takes place at each point, a rake is used, and individual plant densities are recorded. These surveys are much more comprehensive and the same GPS points can be used year after year.

Comparison between the most current survey and the preceding surveys show that many of the species that were found at significant rates continued to thrive and became more abundant at the time of this survey except for Common Bladderwort and Nitella. Since 2016 shoreline vegetation was recorded at the point closest to shore. It is important to note that visuals were included in the frequency of occurrence because they provide a more complete picture of the plant community at the time of the survey. Wetland species such as cattail, loosestrife and bulrush, among others, are typically overlooked during PI surveys because they exist very close to shore or in non-navigable areas.

Table 4: Plant Survey Comparison (1995 – 2021) [2]

Species	Overall Frequency (%)	Relative Frequency (%)			
	Transect 1995	Transect 1999	2009	2016	2021
Muskgrasses	0.588	20.5	35.23	64.48	72.65
Sago pondweed	-	-	-	18.56	43.37
Spiny naiad	0.083	2.9	0.37	19.04	30.74
Various-leaved water-milfoil	-	-	-	1.44	19.74
White water lily	0.073	2.5	4.57	8.64	19.58
Common bladderwort	0.146	0.5	10.42	30.24	18.45
Illinois pondweed	-	-	-	9.12	17.48
Eurasian water-milfoil	0.203	7.1	13.42	18.24	16.50
Spatterdock	-	-	1.12	5.6	16.34
Wild celery	0.0193	6.7	3.00	11.2	14.40
Swamp loosestrife	-	-	-	0.8	11.81
Variable pondweed	-	-	-	4.8	11.00
Nitella	-	-	-	21.92	10.84
Small duckweed	0.016	0.5	0.15	1.92	7.28
Coontail	0.016	0.5	4.87	10.08	6.80
Floating-leaf pondweed	0.125	4.4	0.45	8.16	6.47
Cattail	0.094	3.3	-	0.48	6.47
Arrowhead	-	-	-	0.16	5.99
Orange Jewelweed	-	-	-	-	5.99
Softstem bulrush	0.026	0.9	1.12	0.96	3.24
Ditch grass	-	-	4.57	-	2.75
Purple loosestrife	-	-	-	-	2.59
Flat-stem pondweed	-	-	0.37	1.76	2.43
Slender naiad	-	-	0.07	5.28	2.10
Common watermeal	-	-	-	0.32	1.46
Common waterweed	-	-	0.22	0.96	1.29
Curly-leaf pondweed	-	-	0.22	-	0.81
Narrow-leaved bur-reed	-	-	-	0.16	0.81
Aquatic moss	-	-	-	-	0.81
Northern water-milfoil	0.245	8.5	5.40	3.04	0.65
Whorled water-milfoil	-	-	-	12.48	0.65
Creeping bladderwort	-	-	-	-	0.49
Fries' pondweed	-	-	-	4	0.32
Common reed	-	-	-	-	0.16
Clasping-leaf pondweed	-	-	0.52	1.12	0.16
Large duckweed	-	-	-	-	0.16
Small pondweed	-	-	2.92	1.28	-
Large-leaf pondweed	0.109	3.8	6.67	0.96	-
Filamentous algae	0.036	1.3	0.15	0.8	-
White-stem pondweed	-	-	-	0.8	-
Alternate-flowered water-milfoil	-	-	-	0.64	-
Water star-grass	-	-	-	0.64	-
Aquatic moss	-	-	-	0.32	-
White water crowfoot	-	-	-	0.32	-
Blunt-leaf pondweed	-	-	-	0.16	-
Leafy pondweed	-	-	-	0.16	-
Small bladderwort	-	-	-	0.16	-
unknown pondweed	-	-	-	0.16	-
Watershield	-	-	-	0.16	-
Yellow pond lilly	-	-	4.12	-	-
Wild Rice	0.026	0.9	-	-	-

[2] frequency of occurrence during the 2016 and 2021 surveys included visuals

Table 4 shows the individual species found during all surveys since 1995. In 2021, six species were added (Orange Jewelweed, Purple Loosestrife, Aquatic Moss, Creeping Bladderwort, Phragmites, and Large Duckweed). Fifteen Species were not observed again since past surveys. These species were very sparse even when sampled and may still be present in the lake but at the similar low densities. Newly identified species had low relative frequencies, except for Orange Jewelweed (5.99%).

The change in plant community from the 2016 PI survey primarily focuses on species that have increased, decreased, or have stayed the same. Most plants have seen a positive increase in distribution since 2016; they include: Chara (+8.17%), Sago Pondweed (+24.81%), Spiny Naiad (+11.70%), Various-Leaved Water-Milfoil (+18.30%), White Water Lily (+10.94%), Illinois Pondweed (+8.36%), Spatterdock (+10.74%), Swamp Loosestrife (+11.01%), Variable Pondweed (+6.20%), Cattail (+5.99%), and Arrowhead (+5.83%) and Small Duckweed (+5.36%). Decreases were seen in Common Bladderwort (-11.79%) and Nitella (-11.08%).

Overall, there seems to be a trend towards a much more robust and healthy lake since the mid 1990's. Water clarity according to routine secchi disk data shows there is little change from year to year, with the average reading of 8 feet being recorded.

Plant Management Alternatives

Control of exotic or nuisance plant species is an uphill battle especially 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."

No Management

Under this alternative, aquatic plants would be left to occur naturally with no active management and continue to expand their ranges. The downside of not managing the plant community is that it allows exotic species to flourish because of their completive nature. Lake Beulah's plant community already consists of four invasive species, Eurasian water-milfoil (EWM), Curly-Leaf Pondweed (CLP), Purple Loosestrife and Phragmites. EWM has the ability to outcompete native species in two ways. EWM is one of the first plant species to start growing in the spring, which blocks the space needed for native plant growth. Once established, it forms dense surface mats that block sunlight further reducing native plants. Expanded areas of Eurasian water-milfoil may also impact the fishery by increasing the areas for panfish to hide from predators, leading to over population and stunted growth. Purple Loosestrife and phragmites will outcompete native shoreline / wetland vegetation and will continue t expand its range if left alone.

While the short-term cost of "No Management" is nothing, the long-term ecosystem cost may be much higher. Unmanaged, exotic 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 Lake Beulah, 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/close a gate or dam to raise or lower water level can help minimize cost.

Conclusion – Drawdown for the purpose of aquatic plant control on Lake Beulah is not recommended due to the recreational demands on the lake, limited exotic species in shallow water and the abundance of beneficial natives in shallow water.

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). The alum treatment binds the phosphorus which precipitates out of the water column creating a floc formation that covers bottom sediments. Nutrient inactivation is commonly done for algal or phytoplankton control. Alum treatments typically improve 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, thus releasing nutrients back into the water body.

Alum treatments are typically done in large expanses with water depths greater than five feet. This allows the largest amount of phosphorus to be bonded as the alum descends in the water column. Because of the large-scale treatment methods, alum treatments need to be performed by certified pesticide applicators under a WDNR approved permit.

Conclusion – Due to limited algae growth and already robust plant population and good water quality along with cost, nutrient inactivation is not recommended for Lake Beulah.

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 – Lake Beulah is a lake with lots of underwater elevation changes. There is ample aquatic plant growth occurring past 10 feet. Dredging for aquatic plant control would only be considered for navigational channels or outflow due to the extremely high costs and considerable disruption of the aquatic environment.

Aeraion

Aeration is the process of artificially pumping air into the lake to allow deep, oxygen reduced water to mix with surface. The goal of artificially aerating is to allow oxygen depleted water to be replenished via contact with the atmosphere. In the winter, aeration will allow gases like hydrogen sulfide (toxic to fish) to be released instead of building up under the ice. The amount of oxygen depletion depends on a couple of factors. Waters with excessive nutrients tend to have higher amounts of aquatic plant growth that take up oxygen during the decomposition process. Lakes that have more organic material (muck) also demand more oxygen. As the muck tries to break down through decomposition, oxygen is depleted. This process can be more pronounced over the winter when ice cover prevents oxygen from mixing with the lake. These factors can inevitably lead to fish kills if not managed.

Summer aeration is an expensive lake management technique that is not typically feasible. A high initial capital cost along with annual maintenance and operational costs would need to be considered. DNR permitting and approval is required for any permanent structure (diffusers and airline) to be placed on the lakebed. Problems frequently result with improperly sized aeration systems making initial planning and engineering imperative to ensure that the installed system will provide the desired effects. Winter aeration is smaller scale and more affordable with costs ranging from $20,000 to $50,000 in total. Winter systems provide oxygen during a critical time when ice cover prevents mixing although the liability of open water during the winter is a major drawback. It is important to note that aerators must be well marked for recreators like snowmobilers and ice fisherman for instance, but they remain a safety concern. Typically, 3-5% of the lake area should be kept open to prevent winterkill, depending on the morphology of the lake.

Conclusion – Unless Lake Beulah shows depleted oxygen levels to be a problem, summer aeration should not be considered. Installed equipment such as air lines and bottom diffusers could be damaged by recreational activities. Also, wind, wave and boat activity all contribute to oxygenation of the water. If winterkill becomes more prevalent, a winter aeration system may be appropriate.

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 used in small scale in swim beaches and in confined navigational lanes. Large scale applications are not recommended or typically allowed by the WDNR because of the negative impact on native plants.

Conclusion – Lake Beulah would likely not benefit from this management strategy due to its overall size shape and depth. Large scale costs would be prohibitive, and the non-selective nature would be detrimental. Bottom screens would only be a viable alternative for limited applications by individual property owners to improve conditions in swimming areas or in select navigational channels. A WDNR permit would be required.

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 a number of 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.

<u>Grass carp</u> (*Ctenopharyngodon idella* Val.) are an exotic species originally imported from Malaysia. They are voracious eaters of aquatic plants and can reduce or even eliminate vegetation completely from an ecosystem. Grass carp generally will graze on more beneficial plants before turning to Eurasian Water-milfoil, thereby compounding nuisance problems. In the United States, only a few states allow the use of a sterile form of Grass carp. In Wisconsin, the WDNR lists Grass carp as a prohibited invasive species. Grass carp are not an option for Lake Beulah plant control.

A <u>weevil</u> (*Eurhychiopsis lecontel*) native to North America has been found to help control Eurasian Water-milfoil in some lakes in Wisconsin and Illinois but may no longer be commercially available. The weevil does major damage to the milfoil plant as it is closely associated with it during its entire life cycle. The adult female lays eggs on the tips of the milfoil. When the larvae hatch, they feed in the growing tips and then burrow into the stem. Pupation (when the larvae changes to an adult) occurs in the stem. In fall, adult weevils burrow into the shoreline litter and remain until spring. Weevils mature from egg to adult within 30 days and reproduce from May through September.

Efforts to introduce the weevil into new lakes has not been successful and in many cases unfeasible due to cost ($1 per weevil – per two stems). Also, most lakes use intensive harvesting or herbicidal management practices, which disturb vegetated sites making them less likely to support good populations of the weevils. Lastly, lake systems with high amount of native milfoil species would not benefit from weevil management because this native weevil predates on native milfoils along with invasive milfoils. Because of the abundance of native Milfoil species and since the weevil is no longer commercially available, weevils are not an option for Lake Beulah.

Another beetle, Cella Chow (*Galerucella calmariensis*), is being used around Wisconsin to combat the spread of purple loosestrife. Purple loosestrife is a wetland invasive species that is a prolific seed producer. Plants produce over two million seeds per season and can quickly take over a wetland, displacing native plants. The Cella beetle is used in areas of high infestation, especially those too large for manual control. Volunteers obtain incubator populations of the beetle, raise them through the beetles' four life-stages and then release the new beetles into established purple loosestrife areas. Effective control may take from one to several years. The WDNR website (http://dnr.wi.gov/topic/invasives/loosestrife.html) has specific information on purple loosestrife including manual, herbicidal and biological control.

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. Lake Beulah has a robust native plant composition and would benefit from the repopulating areas of intense management with available plants within the lake. 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 a number of 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 and upland restoration 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 lead 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. The Healthy Lakes Program is a great resource for additional guidance on this topic and there is information on their website regarding available grants for districts to apply on behalf of interested landowners. Permits will be needed for aquatic plantings and the County should be consulted for upland restoration permits. The web-links below provide additional assistance to this topic.

- https://healthylakeswi.com/
- https://dnr.wi.gov/Aid/documents/SurfaceWater/WIHealthyLakesImplementationPlan.pdf
- https://erc.cals.wisc.edu/healthylakesgrants/files/2020/06/NativePlantCompanionGuide.pdf
- https://healthylakeswi.com/best-practices/#350

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, duckweed or floating dead vegetation 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. There are a variety of rakes and cutters available for under $130. 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. This includes 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. It can include swimming and pier areas as long as it is not a listed within a WDNR designated Sensitive Area. 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 may be used by individual landowners to clear swimming areas or pier areas in areas not designated as "Sensitive" (please refer to Figure *43* below). If located within one of these areas an NR 109 permit is required. Landowners should be encouraged to be selective in their clearing, again focusing on Eurasian water-milfoil or

Curly-leaf pondweed. 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 ALGICIDE APPLICATION

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).

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 LBMD 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/or 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 using products that are more specific to 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 very important 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 - $800 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 defined application area.

Conclusion - Herbicide treatments should be considered as a viable management tool on Lake Beulah. These treatments should focus on targeting exotic species like Eurasian water-milfoil (EWM), Curly-leaf pondweed (CLP), 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 approved treatments should also be focused early in the season before plant biomass increases and while native plant growth is minimal. Native aquatic plant beds should only be treated for nuisance conditions that may be affecting navigation. Destruction of any native plant populations will increase potential problems from exotic species. Yearly management of Purple loosestrife and Phragmites should be conducted in early or mid-August to control invasive before they increase their current range. These species often form monotypic stands and drive down native diversity. Using a scout to identify and locate areas of visible plants to create a treatment map depicting areas requiring application can be submitted to the DNR for approval, and along with an approved permit, a treatment can be performed to reduce the population before it produces and drops its seeds.

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" invasive plant beds has become an important strategy to employ. In an area with a mix of plant species including Eurasian Water-milfoil (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. This method can also be used to create openings and edges in dense vegetation to allow predatory fish to more effectively seek out panfish that may otherwise become stunted. Harvesting should only be done in waters deeper than three feet and must leave at least one foot of plant material. This will decrease damage done to equipment by bottom sediments or debris, minimize bottom sediment disruption, reduces the chance of re-entry of exotic plant species and decrease disruption of fish spawning within nursery areas.

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 plant growth, especially Wild Celery and EWM, benefit from shoreline pickup programs by reducing the amount of floating plant material. EWM can spread via fragmentation, meaning that even small pieces of the plant can settle out and grow into a new plant in turn begin to re-colonize in the near shore, disturbed 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 cost as well as long term operational expenses. A harvesting program requires a variety of equipment and includes, but not limited to, a harvester, trailer, dump-truck and conveyer to move and haul cut plants from the lake. 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 - Landowners should be encouraged to remove floaters from their shorelines as part of a shoreline pick-up plan. Harvesting is a viable option to provide navigational relief from dense vegetation on Lake Beulah. Mechanical harvesting is currently the only management technique being used to manage aquatic plants on Lake Beulah.

DASH

Dash is a process 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 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 ideal.

Conclusion – EWM is currently not confined or concentrated in any specific areas within Lake Beulah. DASH operations would be ineffective at reducing the EWM infestation. This method is not considered to be a viable option for reducing native growth for navigational situations.

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, specifically the Recreation Safety Warden, 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. For example, an ordinance that creates a slow no wake zone that affects the entire lake area that is 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 - Lake use ordinances may be considered for Lake Beulah, however, they should be carefully developed and studied to ensure that they address the problems without undue restrictions. A copy of the current boating ordinances for Lake Beulah can be found in Appendix C.

GOALS & OBJECTIVES

The difficult task facing those who manage lakes often confront conflict because of a potentially wide range of usage priorities sought by the users of these areas. Fish and wildlife need aquatic plants to thrive. Boaters and swimmers desire relief from nuisance aquatic plants while fishermen look to find the perfect balance. Those depending on the lake for "aesthetic viewing" desire an undisturbed lake surface.

The ultimate goal should be to work toward the preservation of the aquatic system that includes water quality, fisheries and wildlife. It is important to minimize the conditions resulting from aquatic invasive and nuisance species while also preserving and maintaining the multitude of recreational uses on Lake Beulah. Listed below are the stated goals and subsequent objectives that should be considered to achieve them.

The district desires to:

1. Minimize fragments of aquatic plants that are caused by the high volume of boating traffic and natural processes.
2. Control exotic and nuisance plant species and maintain recreation access for lake users by:
    a. Harvesting
    b. Use of selective chemical treatments
    c. Encouraging landowners to protect native species.
3. Preserve and enhance the natural lake environment by:
    a. Educating landowners and lake users in lake ecology.
    b. Work with the Town, County and State governments to review existing ordinances, and if necessary, develop and enforce ordinances to protect Lake

Beulah.

    c. Continue efforts to improve the watershed and protect Lake Beulah.

4. Identify and expand local educational efforts that the District may undertake to improve the public's understanding of lake issues by:
    a. Distributing at least 2 pamphlets per year.
    b. Encouraging community participation in lake management activities.
5. Conduct in-lake management activities with the long-range goal of minimizing the management as much as possible by:
    a. Conduct year-end evaluations as to the success of plant management activities and the community reaction to the activities.
    b. Track the annual progress of lake management activities.
    c. Conduct water quality monitoring efforts to assist in the documentation of results.
    d. Develop a plan for quick response to invasive species.
6. Maintain navigational access:
    a. Maintain navigational access by controlling plants as necessary.
    b. Control floating plant debris
    c. Control vegetative mats that collect on the surface.

Historical Steps to Address Goals and Objectives

1. Mechanical harvesting focuses on the minimization of plant fragments within Lake Beulah.
2. Controlling exotic and nuisance plants
    a. Harvesting: Removal of nuisance plants and algae via the harvesting program.
3. Watershed management
    a. Ongoing efforts to track and monitor disruption caused by a high capacity well near Lake Beulah.
4. Local Education
    a. Local education efforts are encouraged by the Lake Beulah Protective and Improvement Association (LBPIA) and their two annual newsletters. These informational documents are aimed at public involvement of activities that pertain to Lake Beulah and encourages future public participation.
5. Water Quality Monitoring
    a. Annual Citizen Lake Monitoring program implemented to take data that important to the Trophic State Index calculations.

Recommendations

For the purpose of these recommendations, nuisance species shall be defined as those native species which produce excessive biomass as to hinder realistic lake uses and may include multiple species in navigational lanes. Exotic species include Eurasian Water-Milfoil, Curly-leaf pondweed, 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.

Harvesting

Specific areas of the lake will continue to need harvesting repeatedly each year, concentrating on removing nuisance levels of aquatic plants to provide navigation and to allow recreational boating and fishing activities. The key goal of the harvesting program must be the adequate control of aquatic plants in common use areas of the lake, while protecting ecologically important areas. 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 (i.e. harvesting coordinator, lake volunteer, town consultant, etc.). By executing spot monitoring of the aquatic plant communities within specific areas, priority harvesting zones, cutting depths and intensities can be formulated.

The harvesting guidance map is provided in Figure 39. Important features of mechanical harvesting guidance include:

1. WDNR permit is required.
2. Harvesting operations shall not operate in waters less than three feet (3') deep and should not disturb plants that are at or below one foot (1') above the lake bottom.
3. Harvesting lanes are designated at 30 feet wide but growth each year may dictate a shift in lanes and harvesting priorities.
4. WDNR must be notified with any deviation from NR109 harvesting permits. Harvesting should not occur in the early spring to prevent physical disturbance of fish spawning sites.
5. Figure 41 states that there is to be no removed plant material placed within a WDNR listed wetland (which is highlighted).
6. Steps should be taken to reduce floaters from the harvesting operation.
7. Harvesting crew should return captured fish and other wildlife to the water immediately to prevent wasteful bycatch.

Plant Material Off-Load

Harvested plant material will be off-loaded at a single location, the Seminary, on Seminary Road. Any fish or turtles among other wildlife will be removed and returned to the lake.

Harvesting Crew Training

Proper staff training is an important step in the harvesting program. Front-line workers have a direct impact on the management of the lake during daily operations. Annual training for personnel should occur at least annually. Plant identification, permit compliance and safety are important items to consider. Additional support may be found by requesting assistance from your local DNR Lakes Biologist and other WDNR staff.

Cutting Procedures

All harvesting operations will be limited to depths that are greater than three feet. Disturbance of the bottom sediment can disrupt spawning activity and beneficial benthic organisms. Furthurmore, the suspension of solids reduces visibility of sight-feeding predators, as well as, the posibility of increasing available nutrients throughout the water column.

By targeting and removing EWM only, it is the operator's intent to promote native species. Top-cutting is a preferred method where native plants are present while still reducing the canopy of the target species.

In stands where the target species dominates, deep harvesting may be implemented. Bottom sediment must remain undisturbed with a minimum buffer of one foot between blades and top of sediment. It's understood that the district has been harvesting to a depth of 4 feet while staying one foot above the sediment in all shallow areas.

The following map indicates areas available for harvesting operations. There are three categories for harvesting, green, yellow and blue. Each harvesting zone will fall into one of these groups. All zones are allowed 30-foot navigational cutting lanes. Green areas are approved for harvesting, yellow sections are restricted to EWM and navigational cutting ONLY. Blue is approved for harvesting after June 15^{th}, to allow for young-of -the-year fish species to thrive.

Shoreline Pick-Up

Currently, there is a pier pickup program in place to collect homeowners raked weeds from their piers. Riparian Owners must call the hotline at (262) 363-5359 to inform staff when they are ready for pick-up.

Harvesting Equipment

Equipment currently used for the harvesting of aquatic plants on Beulah are listed below: one aquatic plant harvester: Aquarius HM-420, with the associated trailer: Aquarius T-23, one aquatic plant transport barge: Aquarius T-12S, with the associated trailer: AquariusTR-12, and one aquatic conveyor that is made by Aquarius. Transport Truck is a Ford F350 Superduty dump truck.

Harvested Plants

The Lake Beulah Management District's Harvesting Program offers an estimate of 120 loads, on average, per season. Each load is assumed to weight 6,000 – 10,000 pounds.

Disposal Route

As seen in Figure 40 below there is a single route to the off-load point and that is as follows:

From Seminary road head south, turn right on St.Peters road heading west, turn left on Division street heading south, take a left on hwy ES heading west, then take a left on Bowers road heading south. Arrive at disposal site 7517 Bowers road East Troy WI 53120

Disposal Sites

A visual representation is below in Figure 41, The disposal sight for the aquatic plants removed via harvester are transported to and deposited at 7517 Bowers Road, East Troy, WI 53120. Plant material are not allowed to be deposited on WDNR designated wetlands or floodplains located at the disposal site. If circumstances change where the current disposal site is no longer available, communication with the WNDR is needed and an addendum to the current Harvesting Permit is required immediately, before harvesting operations can resume.

TIMING

Harvesting operations typically begin in late May. Harvesting during this period is typical due to the emergence of the target species that hinders lake usage. Listed below is a table that depicts the previous start dates.

Historical Harvesting Start Dates

2012	Monday, May 14th
2013	Monday, May 27th
2014	Saturday, May 24th
2015	Thursday, May 28th
2016	Sunday, June 12th
2017	Thursday, June 1st
2018	Friday, June 1st
2019	Saturday, June 1st
2020	Monday, June 1st
2021	Tuesday, June 1st

Table 5: Historical Harvesting Start Dates for past 10 years.

CONCERNS

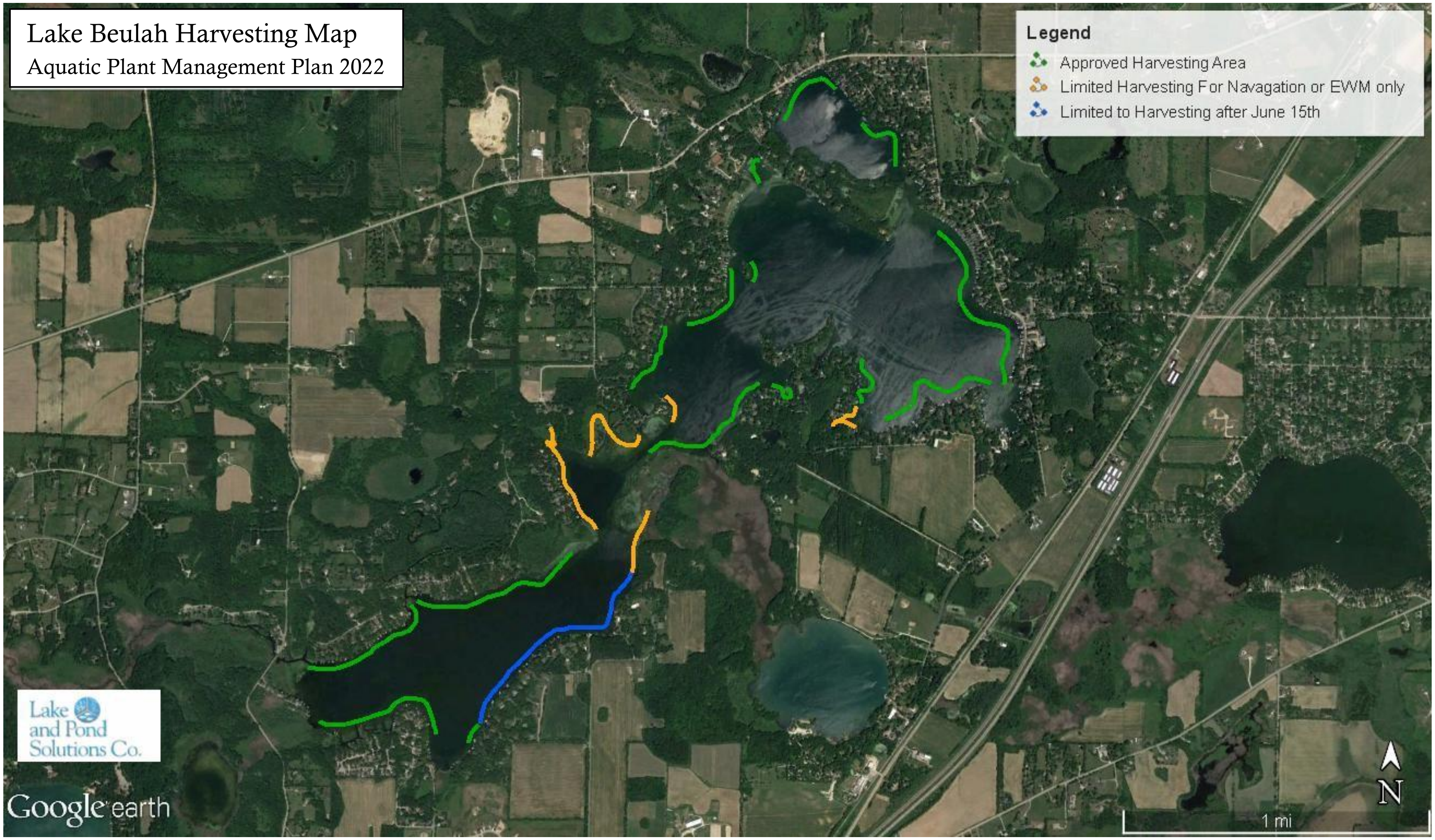
Care should be taken to eliminate damage to spawning habitat and the conveyer must be monitored for the removal of young-of-the-year fish. All harvester operators must be proficient in basic aquatic plant identification. The harvester supervisor must train all seasonal employees prior to operation.

Please note that harvesting areas have remained per the following statement from 2016.

"During our spring 2016 survey, we found the large majority of walleye in the lake congregated for spawning activities in the southern portion of the lake near the seminary (roughly along the shoreline from points 190 through 375). After hatching, larval walleye can be expected to reside in nearby plant beds for shelter and feeding. Restricting the initiation of plant harvest in this area until June 15th would give young walleye time to acclimate to their surroundings and possibly migrate out of the immediate spawning area, thereby likely reducing incidental take during harvest activities. If possible, I would also like to see navigation channels restricted to a 30' width in areas where the plant community is particularly diverse or valuable. Beulah seems to have an excellent plant community that serves the resident fish species very well, providing anglers with a great range of opportunities. These two restrictions should help take advantage of the diversity found in the macrophyte community and further enhance habitat conditions within the lake."

-Luke Roffler, Senior Fisheries Biologist – Racine, Kenosha and Walworth Counties. Wisconsin Department of Natural Resources

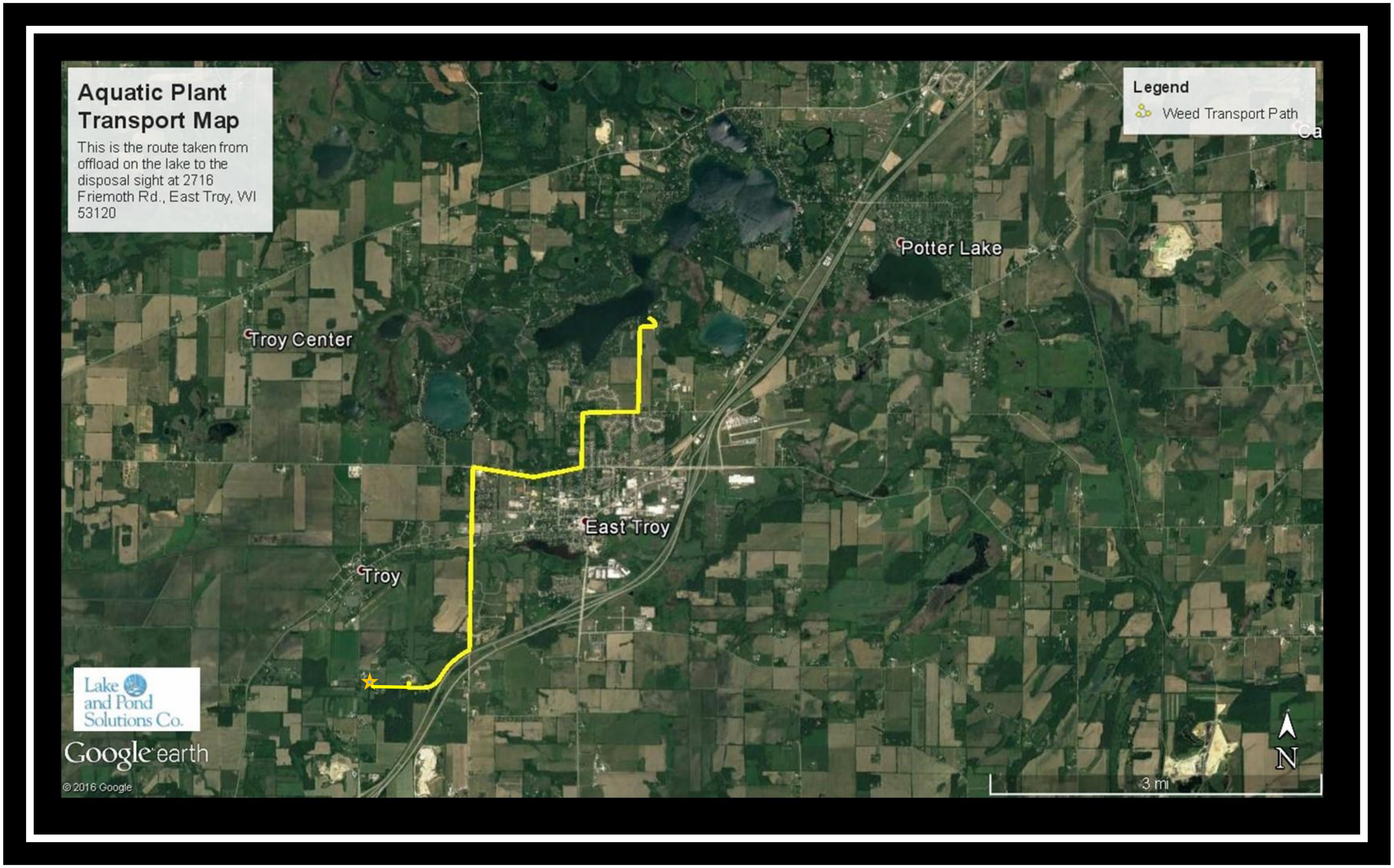
Figure 39: Mechanical Harvesting Map



SOURCE: Lake and Pond Solutions Co. (2021)

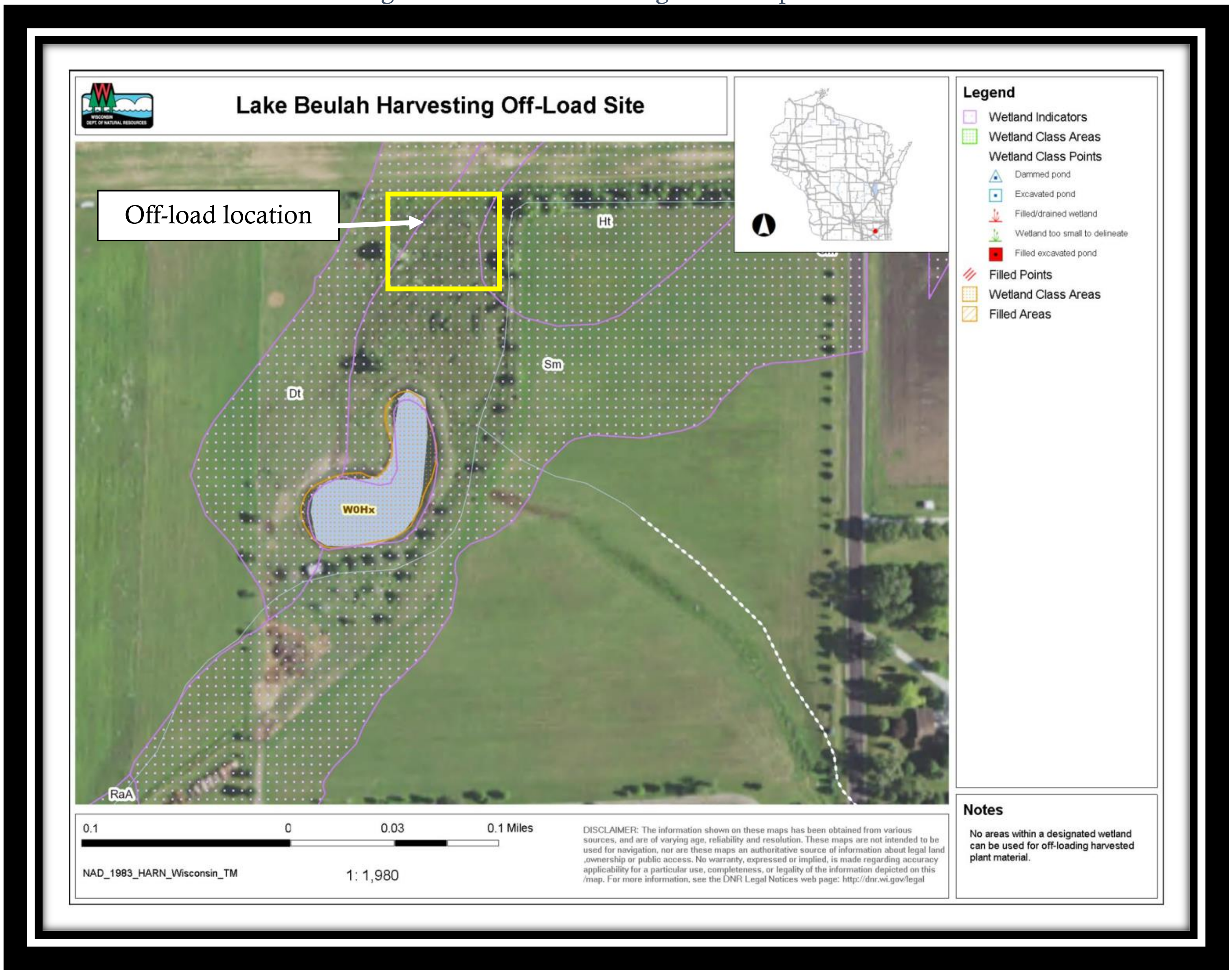
*Important: The map above serves as a reference to suggested harvesting lanes of <u>ONLY</u> dense native vegetation or EWM when present. Actual harvesting lanes are predicated on current conditions of native and invasive plant densities

Figure 40: Weed Harvesting Disposal Routes



SOURCE: Lake and Pond Solutions Co. (2021)

Figure 41: Weed Harvesting Plant Disposal Site



SOURCE: WDNR Surface Water Data Viewer accessed on 10-15-2021.

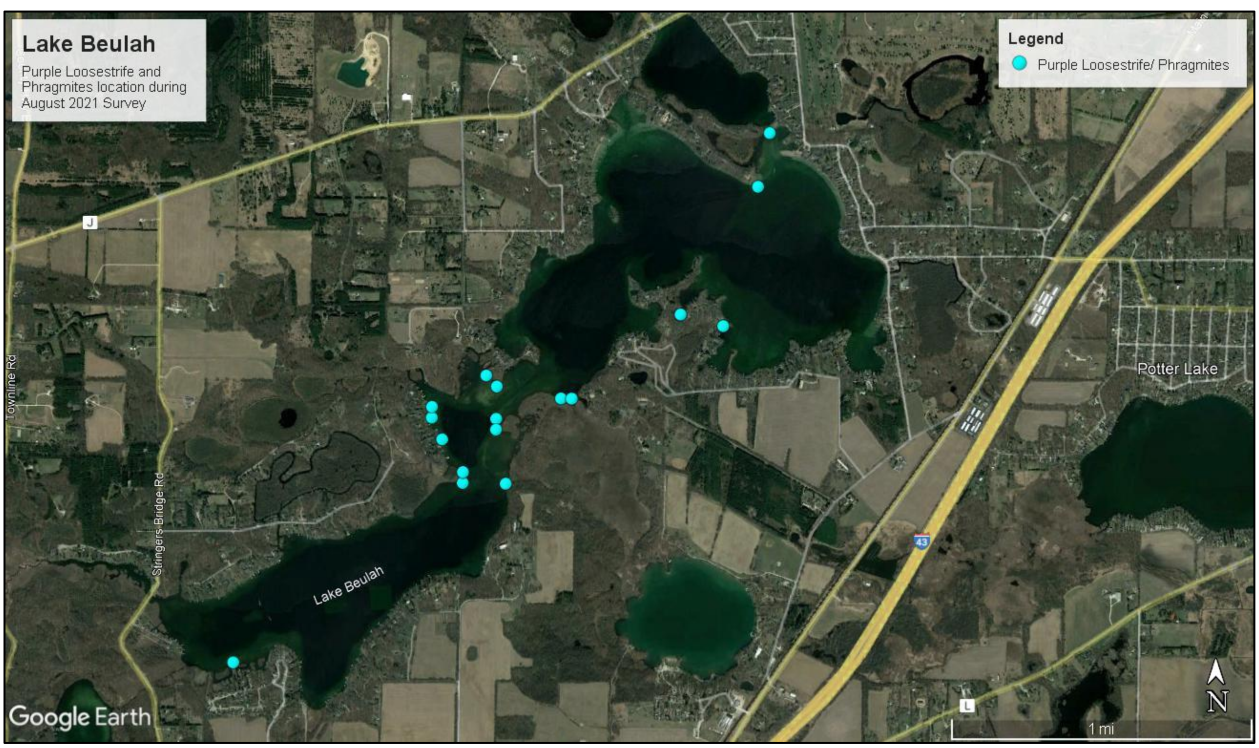
Herbicide Treatment

The use of approved aquatic herbicides should be assessed on an annual basis in coordination with a certified and licensed professional applicator, the LBMD and the WDNR. Permits must be obtained through the WDNR before undertaking any type of treatment.

Chemical Management

1. Perform selective august treatments for Purple Loosestrife and Phragmites.
    a. WDNR permit would be required.
    b. Since locations and densities can change, a pre-treatment survey should be performed each prior to application to accurately target current growth (see Figure 3 and 5 for 2021 locations).
    c. Treatment should ideally occur in late July or August when invasive species is identifiable via flowers or tassels and is distinguishable from native growth. ***Product selection and areas should be based on present conditions.***
    d. Spot treatment
        i. Current Recommendation: 1.5% solution of glyphosate (4 pints per acre) applied with hand-held equipment. A non-ionic surfactant or Methylated Seed Oil (MSO) should also be added to aid in product penetration and uptake.
        ii. Follow product labels for specific rates and use restrictions.

Figure 42: Lake Beulah Recommended Purple Loosestrife and Phragmites Treatment Locations



SOURCE: Lake and Pond Solutions Co. (2021)

Shoreland Buffers

Near-shore vegetation provides habitat for many wildlife species. Creating a shoreland buffer can be as basic as leaving a strip of un-mowed grass along the shoreline. According to the WDNR, having at least 35-50 feet of natural vegetation between the water's edge and mowed lawn will accommodate the needs of some shoreline wildlife. Dense ground cover buffers help to slow yard runoff, while proper use of pesticides and fertilizers will prevent excess pollutants and nutrients from reaching the lake. While 35-50 feet is an ideal buffer there are still benefits to having at least some unmanicured area that extends 5+ feet from the shoreline.

High profile (taller) plantings also help deter Canadian geese from visiting buffered lawns which is a problem facing many lakes in Southeast Wisconsin. Non-migratory Canadian Geese are different than migratory geese and typically cause significant problems, both for residents and for the water quality of the lake. These non-migratory geese remain in an area year-round, preferring manicured lawns and open water, making open lakeshores prime targets. People often enjoy watching a few of these geese, but the problems arise as their numbers become excessive. Geese can introduce a large source of nutrients into a lake if the population is too great for the lakes' ecosystem. Numerous studies have shown that on average, an adult goose can eat three pounds of turf and leave behind one and a half pounds of droppings per day!

Sensitive Areas

WDNR designated Sensitive Areas are designated based on being an important area to the water resource that they are apart of. As of May 1994, eight areas within Lake Beulah earned this designation. They are key areas of the lake due to the diverse plant community they support, which leads to nutrient/ sediment stabilization and are also important in supporting the food web and habitat for fish. More information can be found within the Appendix A in the 2010 Aquatic Plant Management Plan by RJN Environmental Services LLC. The figure below depicts these areas on an updated aerial map.

Figure 43: Lake Beulah WDNR Designated Sensitive Areas 1-8

SOURCE: Lake and Pond Solutions Co. (2021)

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 exotic aquatic plants. Annual meetings, newsletters and informational materials provided by the Department of Natural Resources and the University of Wisconsin-Extension can assist lake users in understanding the many areas of aquatic plant management and ways to protect lakes from other invasive species. The Lake Beulah Protective and Improvement Association is involved with multiple programs to involve the community including Citizen Lake Monitoring through a Healthy Lakes Grant from the DNR, Nature Classroom, Fish Stocking, plant surveys of sensitive areas, they also produce 2 newsletters a year, and hold at least 2 meetings annually. Continuation of the WDNR-Citizen Lake Monitoring Program is recommended. This program is set up to monitor the overall health of the lake including water clarity, total phosphorus and chlorophyll *a*. Additionally, Wisconsin Lakes (www.wisconsinlakes.org) provides some valuable resources including workshops and conferences geared towards lake owners and users. Another program, Clean Boats Clean Waters, aims to reduce to spread of invasive species through boat trailering. Invasive species can hitch a ride from lake to lake if not removed from the underside of boats and trailers. Preventing new invasive species such as Starry Stonewort which may spread rapidly in local lakes. A link to the WDNR Clean Boats Clean Waters page can be found here (www.dnr.wi.gov/lakes/CBCW/).

Rapid Response Plan

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

<u>If a suspected invasive species is found:</u>

- 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 local WDNR Aquatic Invasive Species Coordinator (currently Patrick Siwula, WDNR Aquatic Invasive Species Specialist) 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. The LBMD and current lake consultant should also be notified.

Upon determination of species, a coordinated response plan should be developed in consultation with the WDNR, Lake Beulah Management District, and lake consultant(s) as needed.

SUMMARY

Since the 2017 APM plan, the overall plant community has seen some positive shifts towards native species increasing their ranges. Chara and Nitella continue to be an important deep growing species in much of the lake, due to its topography. These species are known to be a low-growing macrophytic algaes that is capable of sequestering nutrients and limiting sediment transportation by covering large areas. Sensitive areas 1,4,6,7 all continue to show great diversity and include some plants that are very sensitive to disturbance. Areas 2,3,5, and 8 show less diversity but play an important role to the overall ecology of the lake for other reasons such as fish/ wildlife habitat or low-lying areas associated with bogs, fens or marshes which are important for primary production.

Existing PI data shows a shift to increased native species abundances with EWM population expanding its range and density within the eastern lobe. Continued eradication of these invasives is recommended to allow native populations to thrive. Current management efforts have been successful at minimizing impacts of EWM and providing navigational access for recreation while balancing environmental impact. Seasonal treatments for Purple Loosestrife and Phragmites are encouraged as this appears to be a relatively new infestation and eradication is a possibility. Future management strategies should focus on reducing any and all invasive species in density and range along with creating navigational lanes for recreational activities.

With the increasing demand for recreational opportunities by lake users, the LBMD along with the other lake groups have demonstrated an ongoing effort to manage the aquatic resources while providing for multiple use recreation. The District is currently involved in Integrated Pest Management (IPM) by their multi-faceted approach using Mechanical Harvesting and implementing shoreline floating-weed pick-up crews. Moving forward, it is important to consider reducing invasive shoreline vegetation. The education of landowners and lake users about the benefits of native plants and the detriments posed by exotics also remains a priority. This can be accomplished through cooperation between the WDNR, LBMD, LBPIA, local businesses, riparian owners and the general public.

Prior to the next aquatic plant management plan update for 2027, it is suggested that the LBMD work with local groups to develop and send a Lake Users Survey to riparian owners. The survey results can assist the management district in evaluating past accomplishments and future lake management goals that can be addressed in future plans.

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.

Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

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.

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. 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.

Getsinger, K.D., E.G. Turner, J.D. Madsen, and M.D. Netherland. 1997. Restoring native vegetation in a Eurasian water milfoil-dominated plant communit4y using the herbicide triclopyr. Regulated Rivers: Research and Management 13:357-375.

Getsinger, K.D., M.D. Netherland, C.C. Grue, T.J. Koschnick. 2008. Improvements in the Use of Aquatic Herbicides and Establishment of Future Research Directions. Journal of Aquatic Plant Management. 46: 32-41.

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.

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.

Madsen, J.D. 1997. Methods for management of nonindigenous aquatic plants. IN: J.O. Luken and J.W. Thieret, eds. Assessment and Management of Plant Invasions. Spring, NY. Pp. 145-171.

Madsen, John D. *Advantages and Disadvantages of Aquatic Plant Management Techniques*. LakeLine, v.20, no.1, pp22-34. Spring 2000.

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.

Shaw, B., C. Sparacio, J. Stelzer. 2001. Assessment of Shallow Groundwater Flow and Chemistry and Interstitial Water, Sediment, Aquatic Macrophyte Chemistry for Tri Lakes. University of Wisconsin-Stevens Point Final Report to the WDNR. 76 pp.

Swink, F. and G. Wilhelm. 1994. *Plants of the Chicago region*. 4th Edition. The Morton Arboretum. Lisle, IL. 921 pp.

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.

APPENDIX A

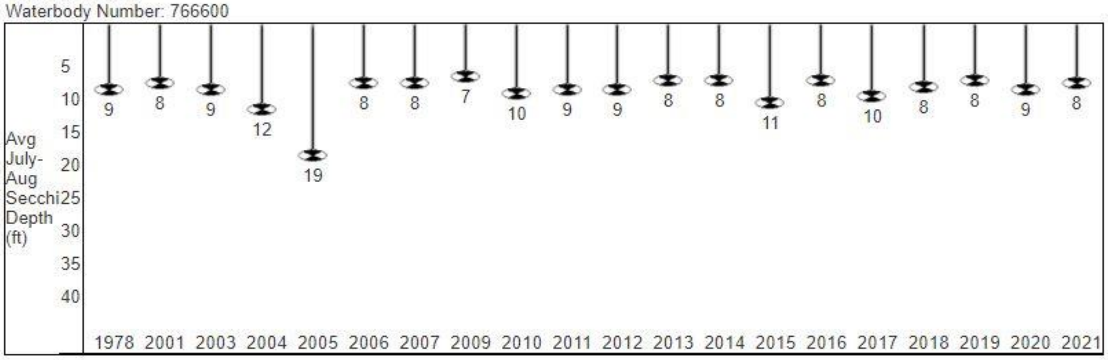
Table 6: Historical Secchi Disk Data Lake Beulah - Deep Hole

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1978	9	8	10	2
2001	8	8	8	1
2003	9	8	10	2
2004	12	9	15	2
2005	19	19	19	1
2006	8	8	8	1
2007	8	7	9	2
2009	7	7	7	1
2010	9.5	9.5	9.5	1
2011	8.9	6.5	11.3	2
2012	9	8	10	2
2013	7.5	7	8	2
2014	7.5	7	8	2
2015	11	11	11	2
2016	7.5	7	8	2
2017	10	10	10	1
2018	8.5	8	9	2
2019	7.5	6	9	2
2020	9	9	9	1
2021	8	8	8	1

Report Generated: 09/27/2021

Lake Beulah
Walworth County
Waterbody Number: 766600

Lake Type: DRAINAGE
DNR Region: SE
GEO Region:SE



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

Figure 44: Historical secchi disk data, Lake Beulah- deep hole.

APPENDIX B

Figure 45: Point Intercept Sampling Map

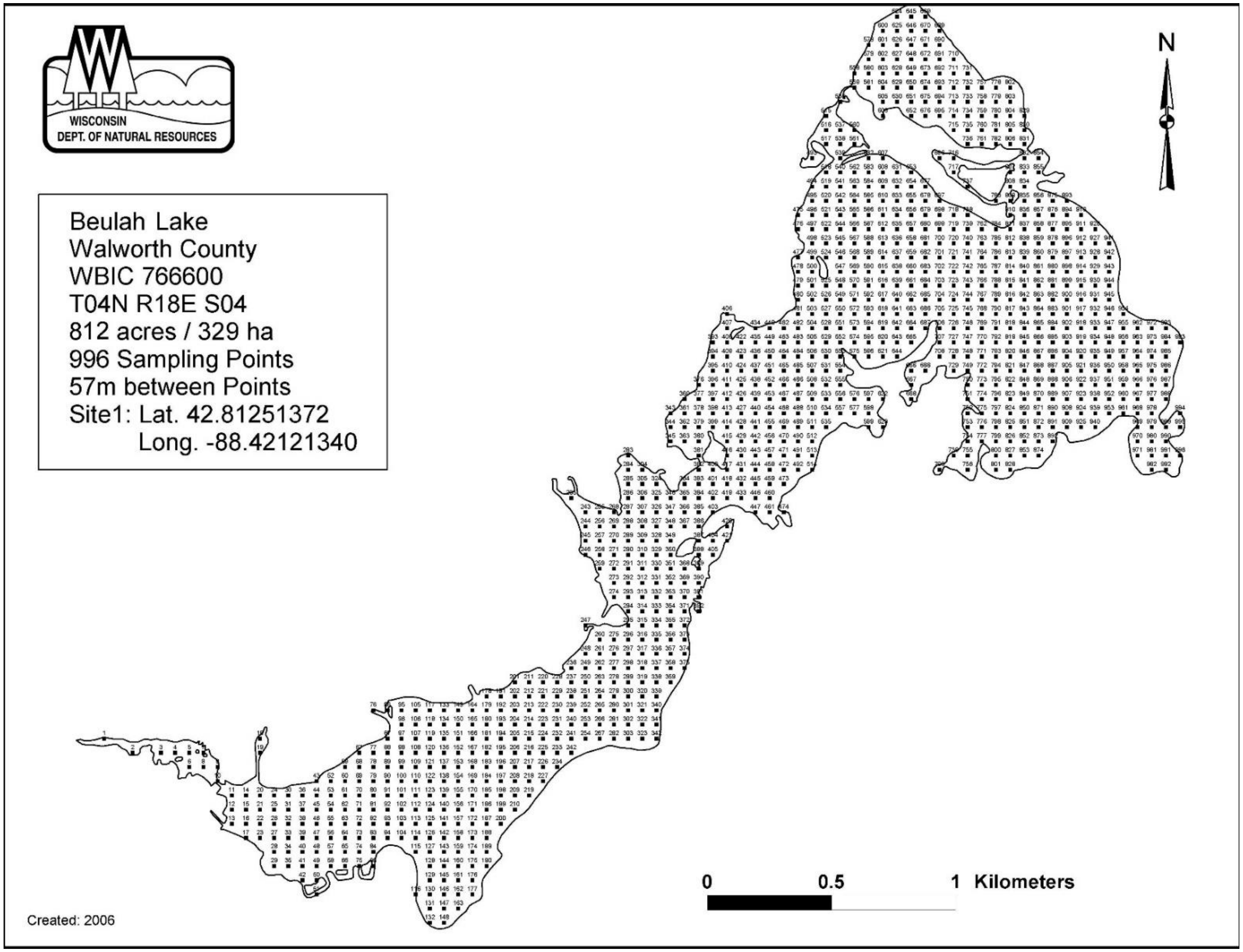


Figure 45: Lake Beulah Point-Intercept Map.

APPENDIX C

LAKE BEULAH BOATING ORDINANCE REMINDERS

See all Boating Ordinances at the townofeasttroy.com website. Also, see WI DRN Boating Laws.

SLOW NO WAKE

- 200' from shore.
- 100' from any pier, raft, structure, anchored boat, skin diver's flag, swimmer, etc.
- While traversing any channel on Lake Beulah.

SPEED RESTRICTIONS

- Saturdays, Sundays and Holidays: Slow no wake only from 6:00pm to 10:00am.
- A boater must travel no faster than is reasonable and prudent under existing conditions.

SKIING, WAKEBOARDING & TUBING

- Skiing, wakeboarding & tubing are allowed from 10:00am until sunset, Monday thru Friday, between 10:00am until 6:00pm on Saturdays, Sundays and holidays.
- **Skiing, wakeboarding & tubing on Mill Lake must be in the counterclockwise direction** (**see map**).
- Weekends and holidays: one tow rope allowed behind a boat at a time.
- Skier / wakeboarder / tuber and boat must stay clear of areas requiring no wake. Pulling skiers from shore and / or dropping them off is prohibited.
- Each boat towing a skier must have one competent observer in the boat, in addition to the driver, or the driver must have a wide-angle rearview mirror.

PERSONAL WATER CRAFT (PWCS)

- All boating laws apply to PWCs.
- PWCs must maintain slow no wake when closer than 100' to any other craft.
- It is illegal to operate a PWC while facing backwards.
- Towing a skier: the PWC msut be designed for at least three people: driver, competent observer plus vacant seat in case skier needs transport.

IN ADDITION

- Sailboats have the right of way.
- All boats must have a Coast Guard Approved PFD for each person on board.
- Front and rear lights required after sunset.
- Operating a boat while under the influence of alcohol or other drugs is illegal.

TOWN OF EAST TROY POLICE EMERGENCY - CALL 911

Non-emergency 262-642-3700

Police Marine Unit Monitors VHF Channel 72

Figure 46: Lake Beulah's Current Boating Ordinances. Source: Lake Beulah Protective and Improvement Association.

Appendix D

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 (LPS) views the same data set. During a PI survey and according to WDNR protocol, any plant species within 5' 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 calculations to give a more representative analysis of the plant community within the lake. The WDNR chooses to view a lake's plant community based on only plants that were physically removed by the sample rake.

The 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 this 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.

The combination of including visuals and different FOO calculations lead to drastic differences between what is represented as the top seven native species and what invasive/exotic species are included. This has a significant impact to how future management is to be viewed and addressed.

For Lake Beulah these differences amount to nine species not being recorded in the WDNR format. Two invasives were also not recorded in that format: Phragmites and Purple Loosestrife.

Table 7: Comparison of Frequency of Occurrence Table

Wisconsin Department of Nautral Resources Data Model		
Common Name	**Scientific Name**	**% FOO Shallower than Max Depth of Plants (No Visuals)**
Muskgrasses	*Chara sp.*	67.19
Spiny naiad	*Najas marina*	18.66
Sago pondweed	*Stuckenia pectinata*	11.20
Common bladderwort	*Utricularia vulgaris*	10.73
Nitella	*Nitella sp.*	10.42
Eurasian water-milfoil	*Myriophyllum spicatum*	9.33
Various-leaved water-milfoil	*Myriophyllum heterophyllum*	7.78
Coontail	*Ceratophyllum demersum*	5.60
Wild celery	*Vallisneria americana*	5.29
Illinois pondweed	*Potamogeton illinoensis*	5.13
Spatterdock	*Nuphar variegata*	2.80
White water lily	*Nymphaea odorata*	1.40
Slender naiad	*Najas flexilis*	1.24
Variable pondweed	*Potamogeton gramineus*	1.09
Ditch grass	*Ruppia cirrhosa*	0.93
Floating-leaf pondweed	*Potamogeton natans*	0.78
Aquatic moss		0.78
Arrowhead	*Sagittaria sp.*	0.62
Common waterweed	*Elodea canadensis*	0.47
Whorled water-milfoil	*Myriophyllum verticillatum*	0.47
Small duckweed	*Lemna minor*	0.31
Fries' pondweed	*Potamogeton friesii*	0.31
Narrow-leaved bur-reed	*Sparganium angustifolium*	0.31
Filamentous Algae		0.31
Northern water-milfoil	*Myriophyllum sibiricum*	0.16
Curly-leaf pondweed	*Potamogeton crispus*	0.16
Flat-stem pondweed	*Potamogeton zosteriformis*	0.16
Creeping bladderwort	*Utricularia gibba*	0.16
Swamp loosestrife	*Decodon verticillatus*	-
Orange Jewelweed	*Impatiens capensis*	-
Purple loosestrife	*Lythrum salicaria*	-
Common reed	Phragmites australis	-
Clasping-leaf pondweed	Potamogeton richardsonii	-
Softstem bulrush	*Schoenoplectus tabernaemontani*	-
Large duckweed	Spirodela polyrhiza	-
Cattail	*Typha sp.*	-
Common watermeal	*Wolffia columbiana*	-

Lake and Pond Solutions LLC Data Model		
Common Name	**Scientific Name**	**% Relative FOO (Includes Visuals)**
Muskgrasses	*Chara sp.*	72.65
Sago pondweed	*Stuckenia pectinata*	43.37
Spiny naiad	*Najas marina*	30.74
Various-leaved water-milf	*Myriophyllum heterophyllum*	19.74
White water lily	*Nymphaea odorata*	19.58
Common bladderwort	*Utricularia vulgaris*	18.45
Illinois pondweed	*Potamogeton illinoensis*	17.48
Eurasian water-milfoil	*Myriophyllum spicatum*	16.50
Spatterdock	*Nuphar variegata*	16.34
Wild celery	*Vallisneria americana*	14.40
Swamp loosestrife	*Decodon verticillatus*	11.81
Variable pondweed	*Potamogeton gramineus*	11.00
Nitella	*Nitella sp.*	10.84
Small duckweed	*Lemna minor*	7.28
Coontail	*Ceratophyllum demersum*	6.80
Cattail	*Typha sp.*	6.47
Floating-leaf pondweed	*Potamogeton natans*	6.47
Arrowhead	*Sagittaria sp.*	5.99
Orange Jewelweed	*Impatiens capensis*	5.99
Softstem bulrush	*Schoenoplectus tabernaemontani*	3.24
Ditch grass	*Ruppia cirrhosa*	2.75
Purple loosestrife	*Lythrum salicaria*	2.59
Filamentous Algae		2.43
Flat-stem pondweed	*Potamogeton zosteriformis*	2.43
Slender naiad	*Najas flexilis*	2.10
Common watermeal	*Wolffia columbiana*	1.46
Common waterweed	*Elodea canadensis*	1.29
Aquatic moss		0.81
Curly-leaf pondweed	*Potamogeton crispus*	0.81
Narrow-leaved bur-reed	*Sparganium angustifolium*	0.81
Northern water-milfoil	*Myriophyllum sibiricum*	0.65
Whorled water-milfoil	*Myriophyllum verticillatum*	0.65
Creeping bladderwort	*Utricularia gibba*	0.49
Fries' pondweed	*Potamogeton friesii*	0.32
Clasping-leaf pondweed	*Potamogeton richardsonii*	0.16
Common reed	*Phragmites australis*	0.16
Large duckweed	*Spirodela polyrhiza*	0.16