Aquatic Plant Survey and Invasive Species Detection Report

Prepared for the Beltrami County AIS Program

Survey by Aquatic Survey Professionals – MN DNR Certified Aquatic Plant Surveyors

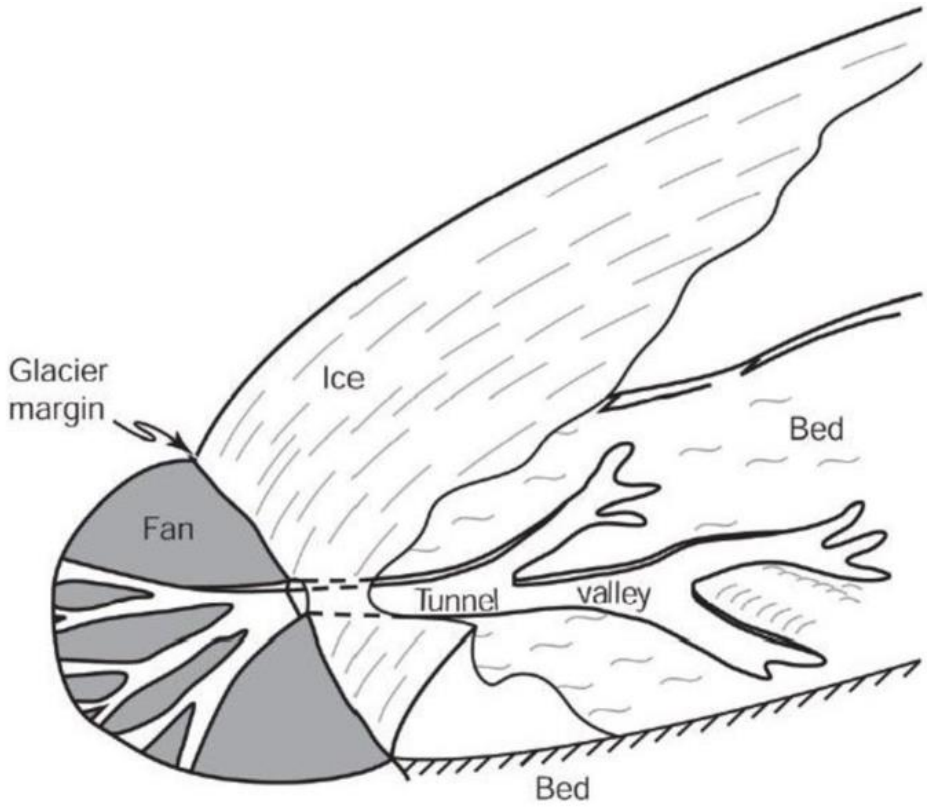
Survey Date June 14th 2026

Report by Aquatic Survey Professionals – Steve Henry

Lake and Watershed Characteristics

Moose Lake is in Beltrami County Minnesota just north of Lake Winnibigoshish and east of Cass Lake. While nestled into the Chippewa National Forest Moose Lake does feature two resorts and numerous private cabins making it a significant local recreational resource. Stretching 2.1 miles in length and 1/2 mile in width the lake covers 601 surface acres. Access to Moose Lake is provided by a MN DNR public water access on the south side immediately off of Timber Wolf Road. This access has an estimated 15 parking spaces available for vehicles with trailers but is mainly grassed.

Moose Lake is in the Chippewa Plains subsection of the Northern Minnesota Drift and Lake Plans ecoregion where mixed Maple, Birch, and Oak Deciduous Woodlands are interspersed with Pine Forests. This area of the State is one of the youngest and the surface drainage network is poorly developed with many wetlands and lakes. Groundwater movement is variable due to the mixture of clayey glacial till where water movement is very slow and sandy outwash where drainage is excessive. Many lakes in this ecoregion occupy shallow depressions left behind when glacial moraines dammed pre-existing drainage channels. Moose Lake likely formed in a tunnel valley that was once an arm of the Pimushe-Kitchi Lakes tunnel valley system. As the Koochiching lobe melted back from the Cass Lake area continued deposition behind the glacial front buried some landforms such as most the tunnel valley system. The glacier may have temporarily advanced back over the tunnel valley system partially burying it.



Sketch of a tunnel valley in relation to glacial margin. (From Hooke and Jennings 2006)

Healthy native aquatic plant communities are present throughout almost all of Moose Lake with pockets of high diversity in some areas. Diversity is lower in some areas due to the presence of invasive Starry Stonewort, limited clarity in areas, and a boggy mucky bottom. One unique plant community present in Moose Lake is a rare carnivorous genus Bladderwort and Greater Bladderwort was observed growing abundantly in many shallow areas of the lake. A second species in the Bladderwort group, Lesser Bladderwort, was also documented in slightly deeper areas of the lake. The Characeae family is widespread in Moose Lake and helps protect the lake's clarity by absorbing and storing any excess nutrients while also oxygenating the deep waters and limiting the internal release of stored nutrients. This family also shows depth preferences with Chara spp being common in the shallow areas and Nitella flexillis common in the deeper waters. Unfortunately Nitellopsis obtusa, Starry Stonewort, is present from the shallowest depths out to 23 feet of water or deeper. The diverse and unique aquatic plants and the high quality fish community have resulted in the lake being ranked as having Outstanding biological significance by the Minnesota DNR.

The water quality in Moose Lake is considered mesotrophic, with moderate fertility and average clarity. The lake has less than average fertility when compared with other lakes in this area. Minnesota Pollution Control notes there is 'evidence that the lake's clarity has been

improving' and there has recently been an improvement over the lower clarity observed in the 1980s.

Moose Lake is fed by a fairly small 2843 acre watershed that drains to the lake via the groundwater system, through wetlands, and through bogs. The lake's watershed has a significant amount of natural cover which provides natural protection to the water quality and lake health. Around 43% of the watershed is forested, 29% is wetlands, and 5% is developed or agricultural. The State of Minnesota has done water quality modeling which indicates that watersheds with over 75% natural land cover can maintain their water quality and Moose Lake could possibly achieve this protection level. The increase in runoff, erosion, nutrient loading, and human traffic associated with higher levels of development disturbs the lake's natural community and is associated with an increased risk of invasive species establishing in a lake. Maintaining the existing natural landscape especially along shorelines and as part of lakeshore development is key to preserving the quality of Moose Lake.

The Beltrami County SWCD and AIS Programs work to preserve the quality of the lake, it's fishery, loon population, and recreational benefits by preventing Aquatic Invasive Species (AIS) infestations and managing existing infestations. This aquatic plant survey was implemented to detect any new invasive species so rapid response efforts can be implemented to control them and evaluate the impacts of Starry Stonewort on Moose Lake. Starry Stonewort was first documented in the lake in 2016 and management has been limited. This survey gives an important glimpse into how this new invader interacts with native species and how spread develops through a lake system.

Lake Area	Area 15' deep or less	Maximum Depth	Shoreline Length	10 yr. Average Water Clarity
600 acres	239 acres	71'	7 miles	14'

Survey Design

The aquatic plant survey used a 65 meter spacing to establish sample sites across the littoral zone, where plants grow, of Moose Lake. This resulted in a total of 247 sample locations. The sample locations created were uploaded to a chart plotter GPS unit on our survey boat. Once on the water the boat was navigated to each sampling site and a double headed weighted garden rake attached to 50 feet of rope was used to collect a sample of the aquatic vegetation. Visual and sonar observations were also used to ensure the plants gathered fully reflected the vegetation present at each site. The plants sampled with the rake were examined and all species sampled were identified and their abundance was ranked using a 1 to 3 scale with 1 being sparse, 2 being common, and 3 being abundant. Species abundance was calculated as the total number of species at each sample site. The frequency of occurrence is the number of sites where a species was observed divided by the total number of sampling sites. Additionally, all samples are extensively examined for the presence of aquatic invasive plants, fish, and

mollusks. This final report was developed that outlines all the plant species encountered, the frequency of each species, and their average growth density. Maps are developed for the report that show the locations where each species that occurred was encountered and that species density at each of those points.

Survey Objectives

This survey examines and physically samples the aquatic plant community of Moose Lake to:
1. Identify any invasive species present in the lake and determine their distribution.
2. Identify the native species present in the lake, their distribution, and growth density.
3. Determine the number of species present in the lake.
4. Determine the percentage of the lake occupied by vegetation.
5. Develop distribution and density maps for the common native species, unique native species, and any invasive plant species encountered.
6. Collect and voucher plant specimens for submission to the Bell Museum.

Survey Results – Full Lake

The weather was good for surveying with moderate winds generally from the northwest which increased throughout the day and got fairly strong by afternoon. Visibility was good with observations of the lake bottom at depths exceeding 7 feet in some areas. The survey day started with temps around 45 degrees while in the afternoon temperatures were in the 60s. Wave activity rarely impacted survey activity and we were able to start on the downwind side in the morning while it was calm and work in the sheltered areas as the wind picked up.

During the survey vegetation was observed at 210 of the 241 sampled points which is 87% of sites. During the survey several sites were not accessible due to Loons with babies, giant floating trampolines, or the point fell on shore. A frequency of 87% represents a very well distributed community and a notable factor in Moose Lake was the Nitella flexilis and Nitellopsis obtusa that we observed in unusually deep water increasing the overall frequency of vegetation. Some lakes are seeing increased density, distribution, and diversity of aquatic vegetation in the past few years but that trend could not be detected in Moose Lake where very little vegetation was growing to nuisance levels or beyond it's expected distribution. Vegetation was found as deep as 27 feet of water which is above average for Minnesota lakes but close to what has been observed in other lakes in this watershed. The average number of species per sample was 3.37 when comparing all sites and the maximum number of species at any one site was 9. These are very good numbers compared to most Minnesota lakes and reflect the diverse and well distributed aquatic plant community of the lake. The most common species observed were **Starry Stonewort** at 37.2% of sites, Coontail at 36.4%, and Flatstem Pondweed at 31.6%. **Starry Stonewort** an invasive aquatic algae/plant was found at 92 of the sample sites, it was very well distributed in the lake and was the most common species encountered.

There was one uncommon species observed during the survey Lesser or Purple Flowered Bladderwort. Bladderwort is unique among aquatic plants in that is captures algae and zooplankton from the lake inside small bladders along the leaflets and digests them for additional nutrients. This species has a very fine leaf pattern almost a mesh and appears as a round tube along the lake bottom. A total of 24 species were observed in the lake with variable distribution see the following pages for more information.



Thin Starry Stonewort found in the deeper waters of Moose Lake.

Species Observed, Frequency, and Distribution

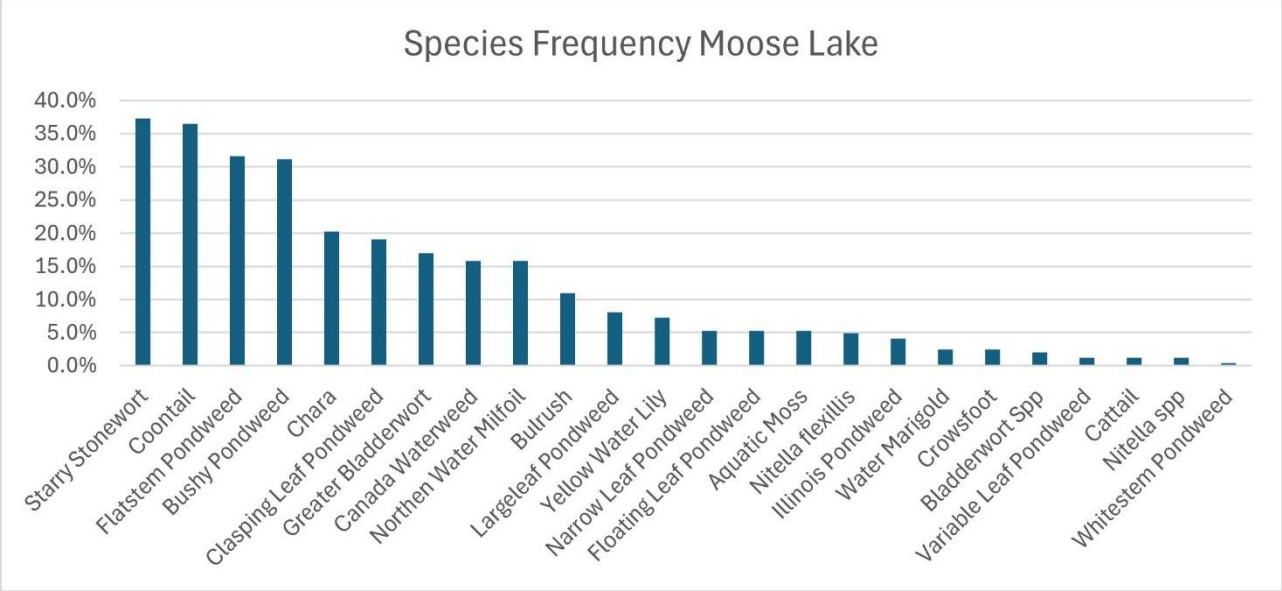
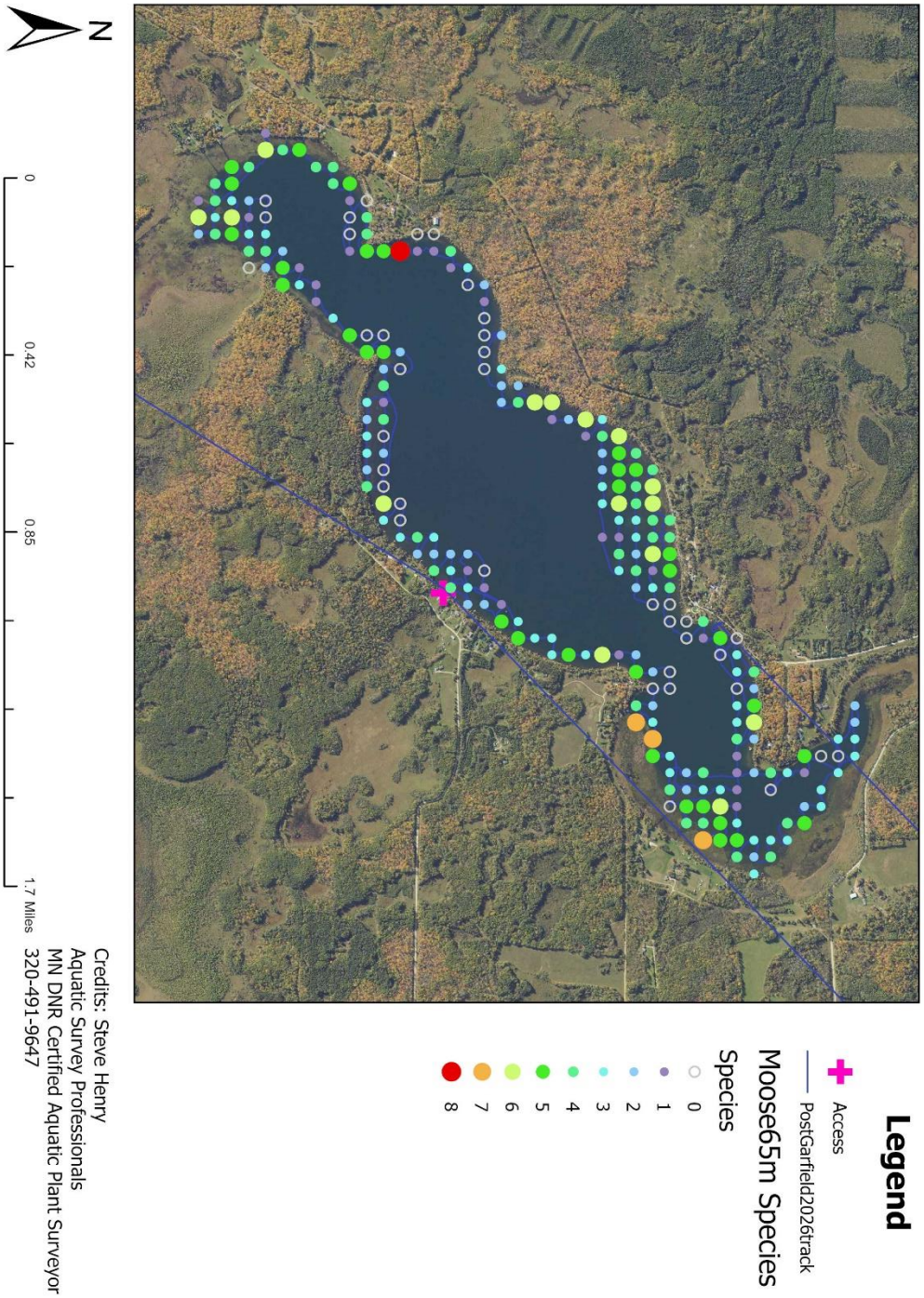


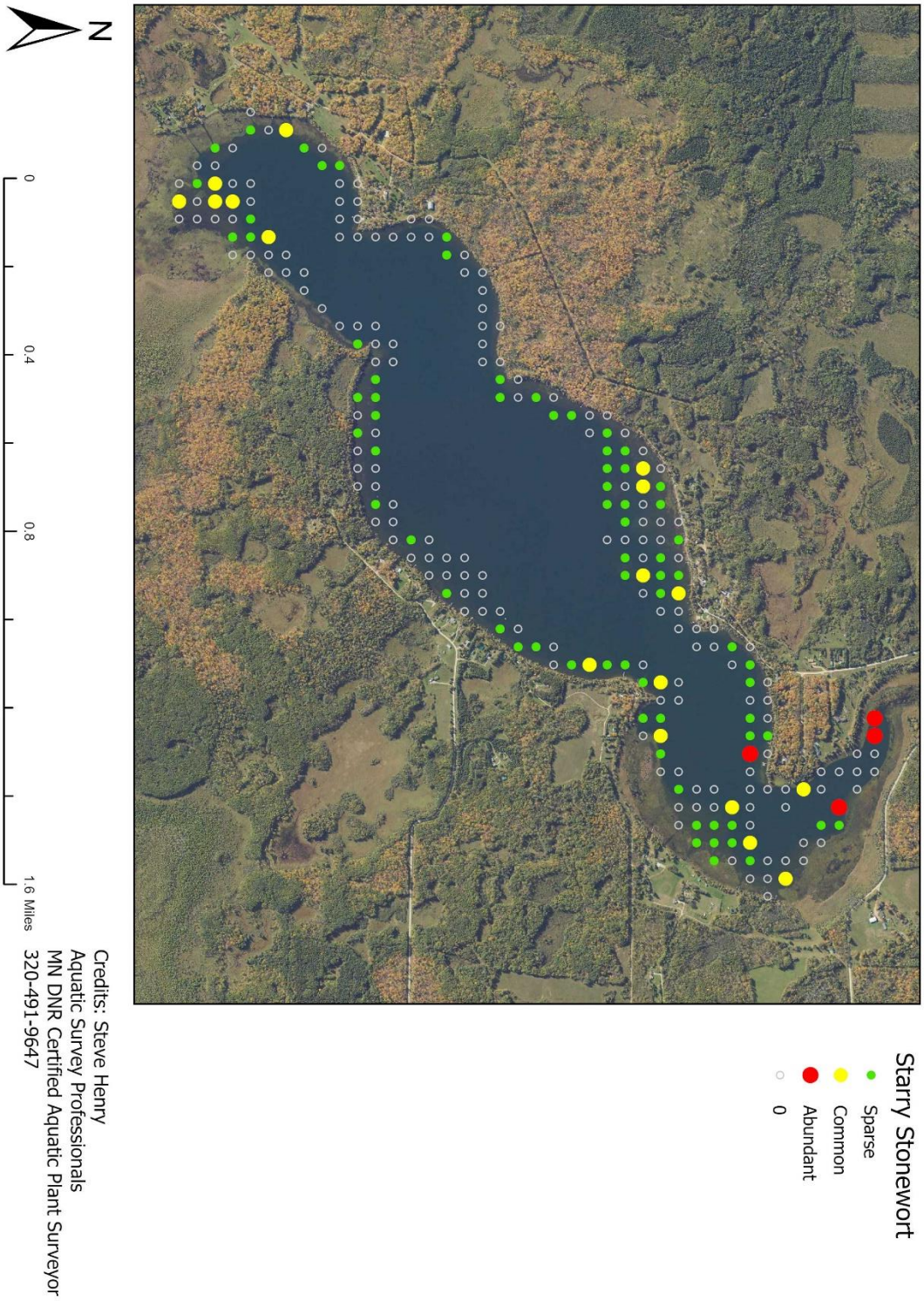
Table of Species and Occurrence

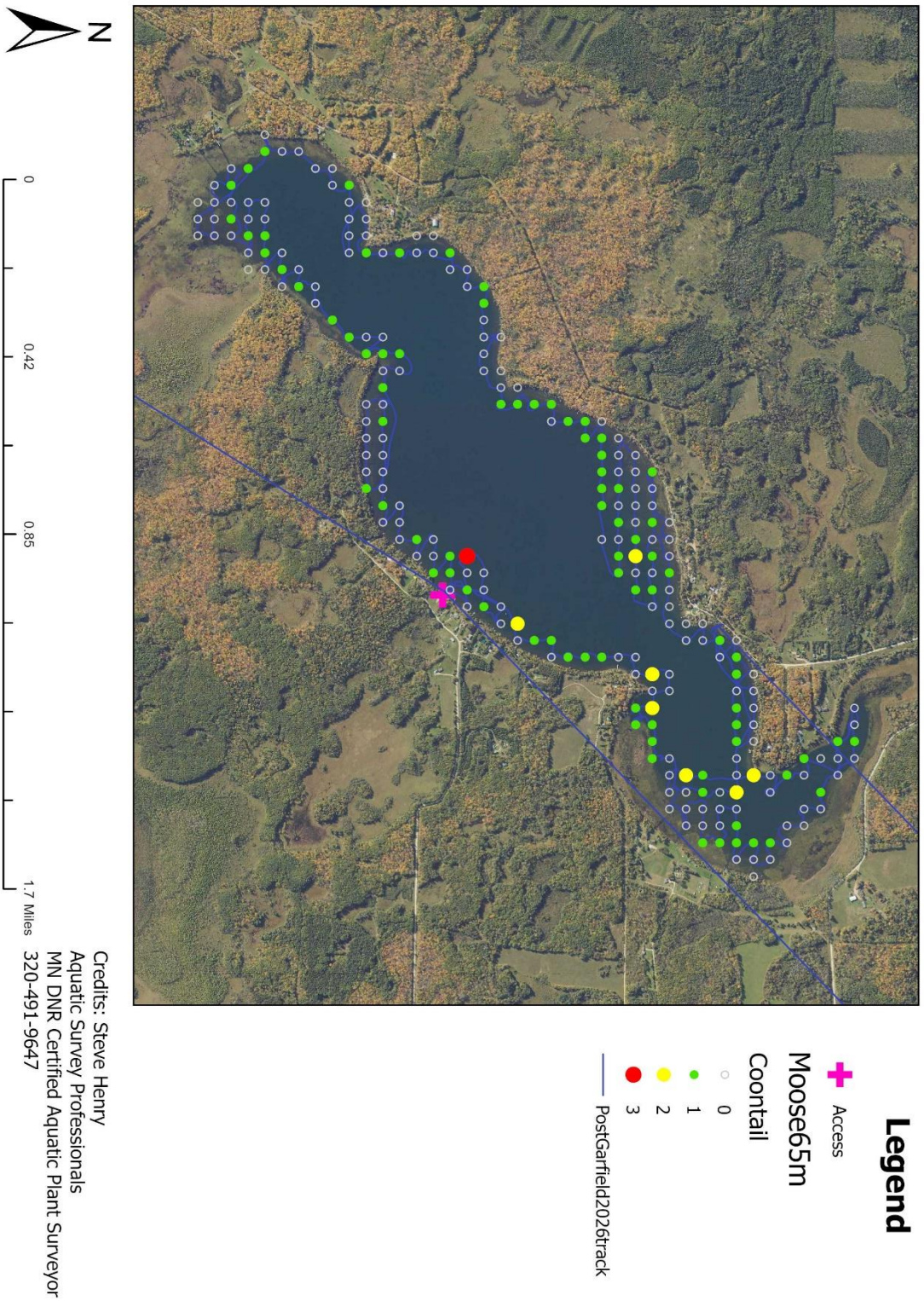
Emergent Species	% Occurrence	Count of Occurrence	Density When Present
Bulrush	10.9%	27	1.1
Cattail	1.2%	3	1
Floating Leaf Species	**% Occurrence**	**Count of Occurrence**	**Density When Present**
Yellow Water Lily	7.3%	18	1.2
Floating Leaf Pondweed	5.3%	14	1.2
Submerged Species	**% Occurrence**	**Count of Occurrence**	**Density When Present**
Starry Stonewort	37.2%	92	1.3
Coontail	36.4%	90	1.1
Flatstem Pondweed	31.6%	78	1.1
Bushy Pondweed	31.2%	77	1.2
Chara	20.2%	50	1.3
Clasping Leaf Pondweed	19.0%	47	1.2
Common Bladderwort	17.0%	42	1.0
Canada Waterweed	15.8%	39	1.0
Northen Water Milfoil	15.8%	39	1.1
Largeleaf Pondweed	8.1%	20	1.0
Narrow Leaf Pondweed	5.3%	13	1.0

Aquatic Moss	5.3%	13	1.0
Nitella flexillis	4.9%	12	1.2
Illinois Pondweed	4.0%	10	1.0
Water Marigold	2.4%	6	1.0
Crowsfoot	2.4%	6	1.0
Bladderwort Spp	2.0%	5	1.0
Variable Leaf Pondweed	1.2%	3	1.0
Nitella spp	1.2%	3	1.0
Robbins	0.4%	1	1.0
	Total Occurrences	707	

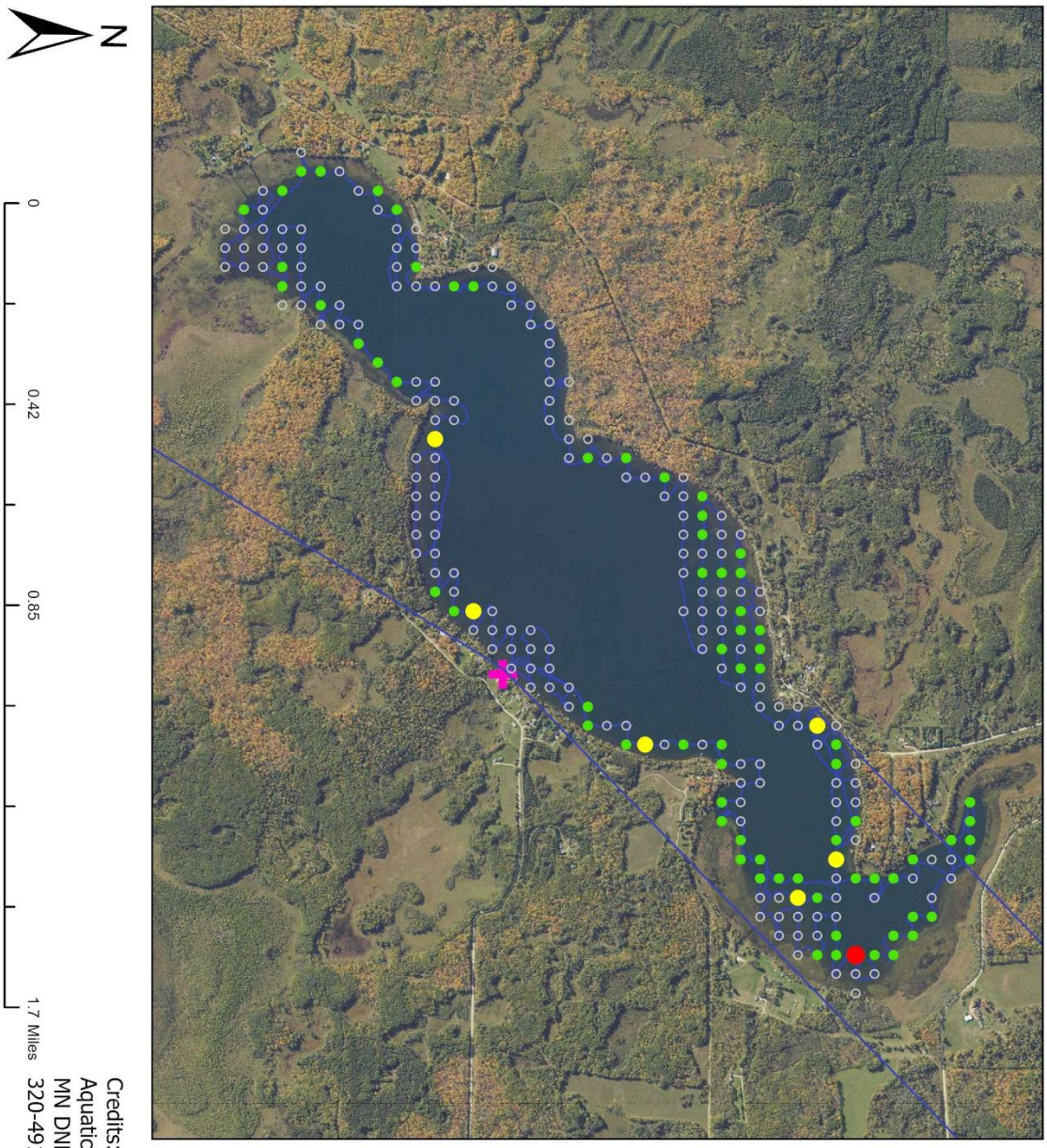
Abundance of Species – Whole Lake




Moose Lake Starry Stonewort
Legend
Starry Stonewort
Sparse
Common
Abundant
0
N
0
0.4
0.8
1.6 Miles
Credits: Steve Henry
Aquatic Survey Professionals
MN DNR Certified Aquatic Plant Surveyor
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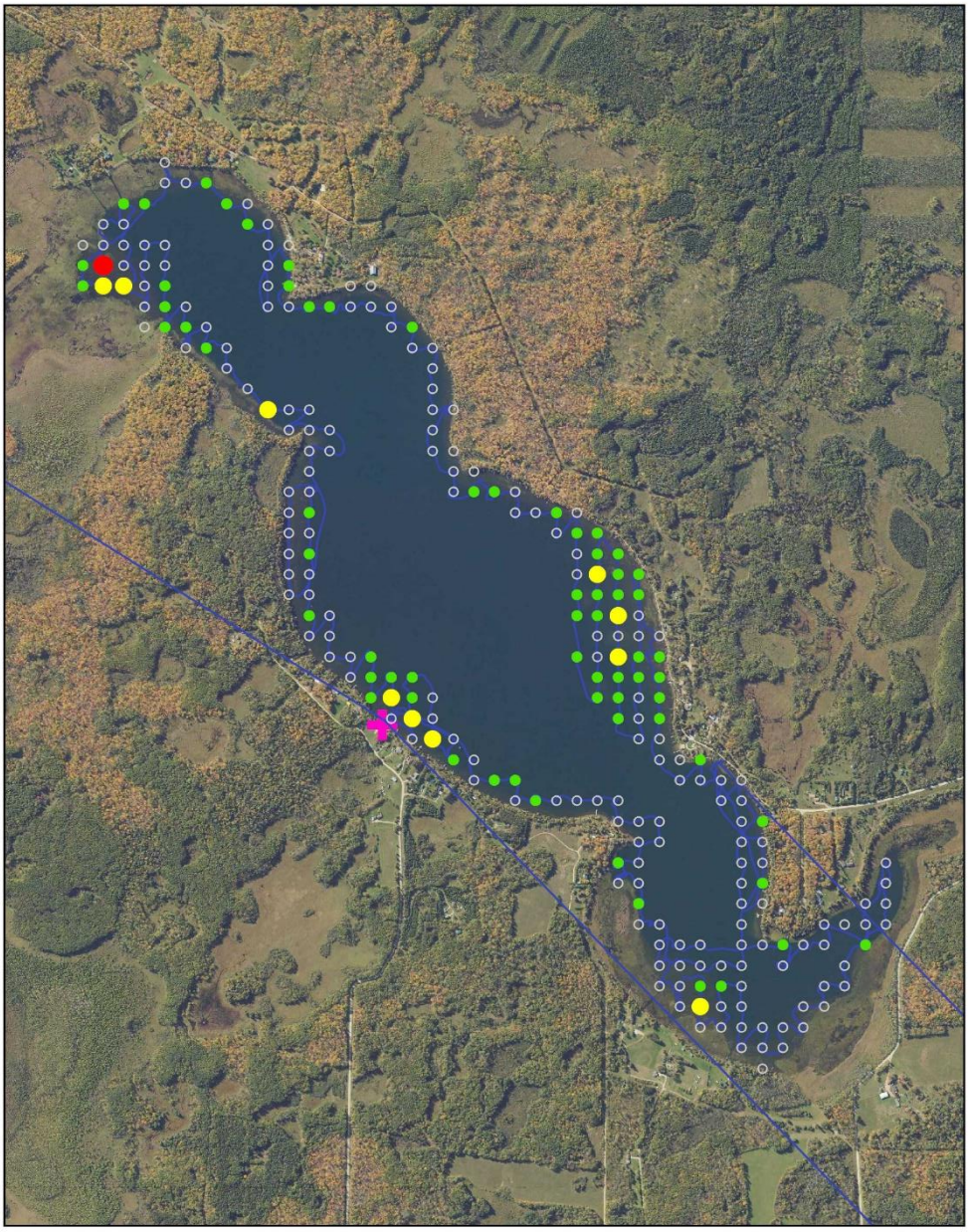

Moose Lake - Coontail
Legend
Access
Moose65m
Coontail
0
1
2
3
PostGarfield2026track
N
0
0.42
0.85
1.7 Miles
Credits: Steve Henry
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Moose Lake - Flatstem Pondweed



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Moose Lake - Bushy Pondweed



Legend

Access

PostGarfield2026track

Moose65m

Bushy

0

1

2

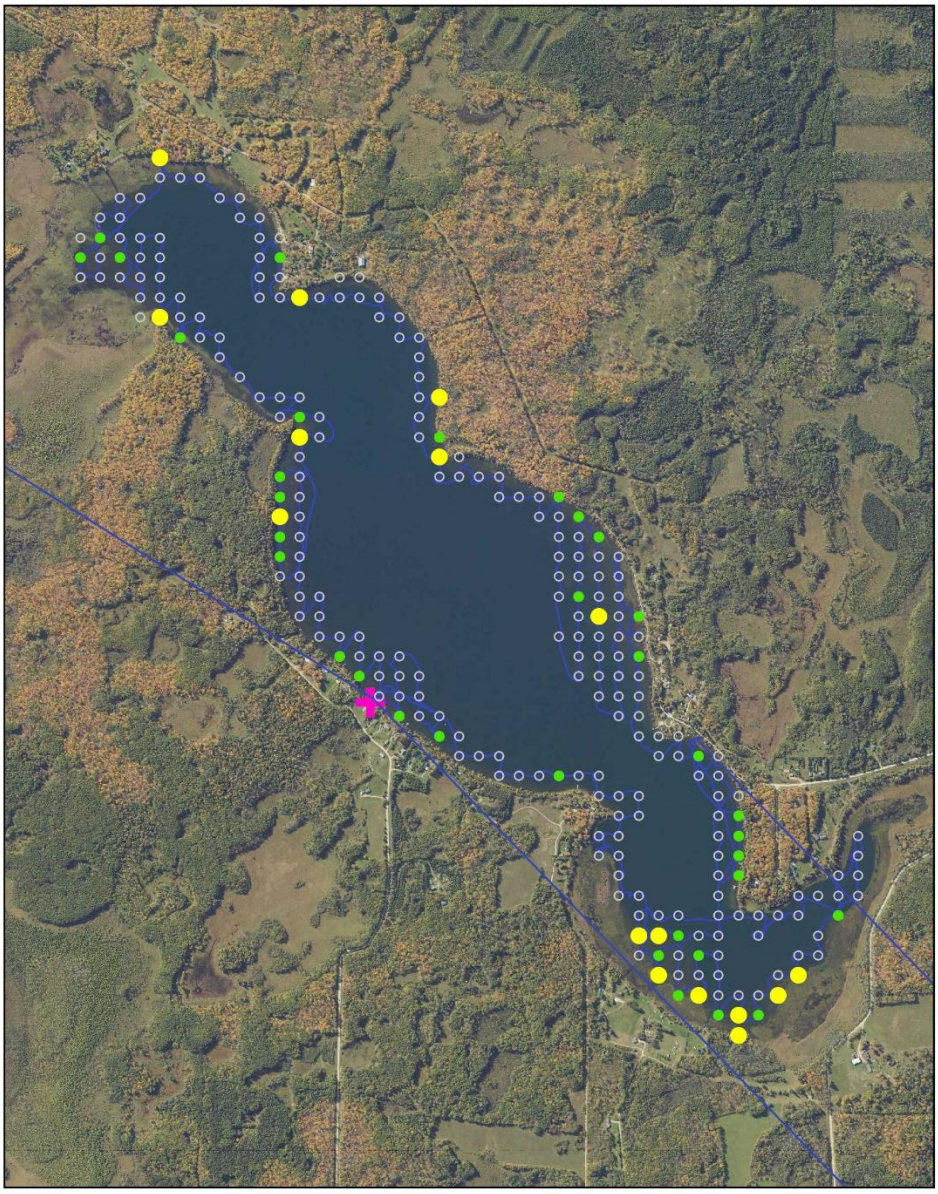
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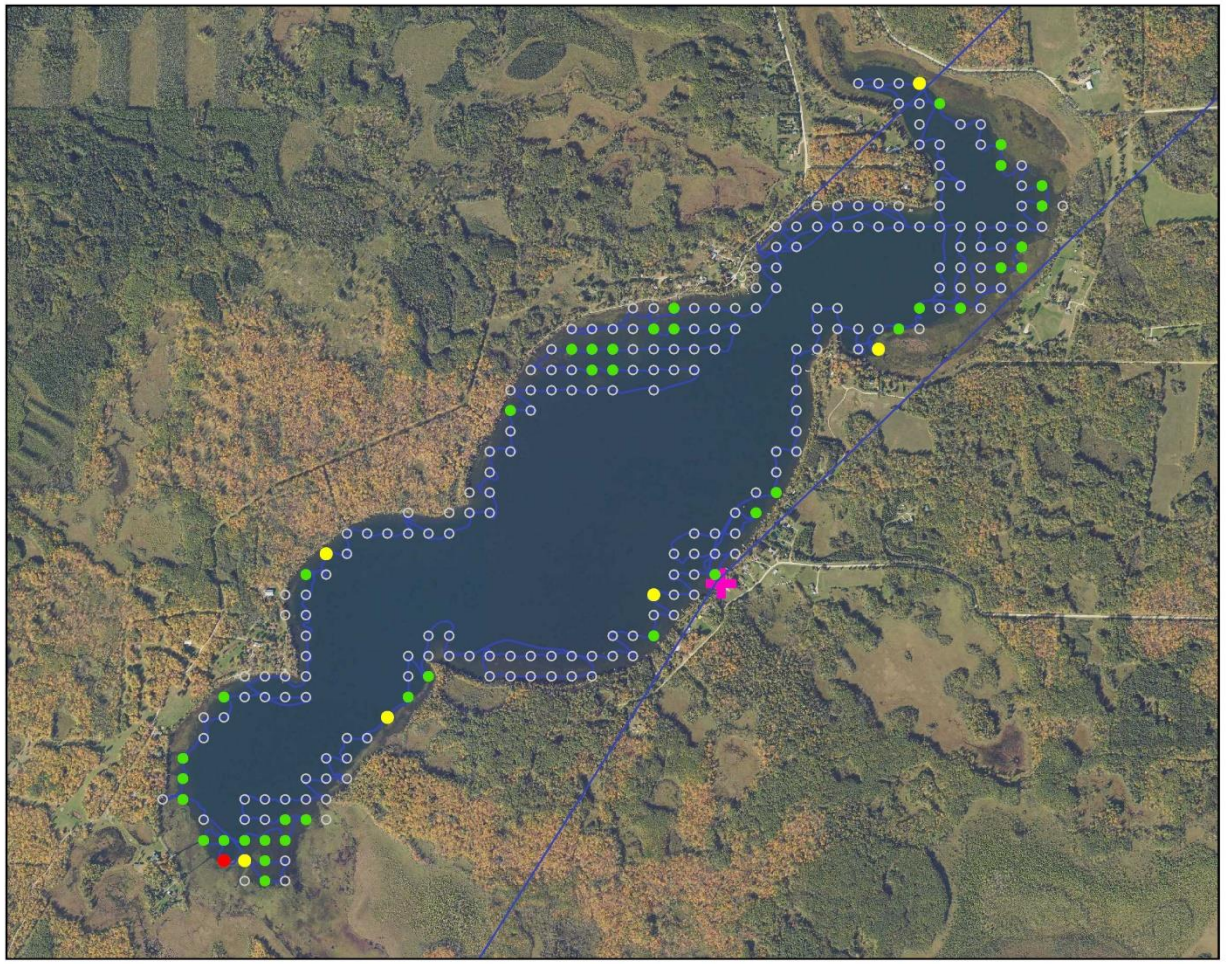
0 0.42 0.85 1.7 Miles

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Moose Lake - Chara spp



Moose Lake - Clasping Leaf Pondweed



Legend

- Access
- PostGarfield2026track

Moose65m

Clasping

- 0
- 1
- 2
- 3

N

0 0.42 0.85 1.7 Miles

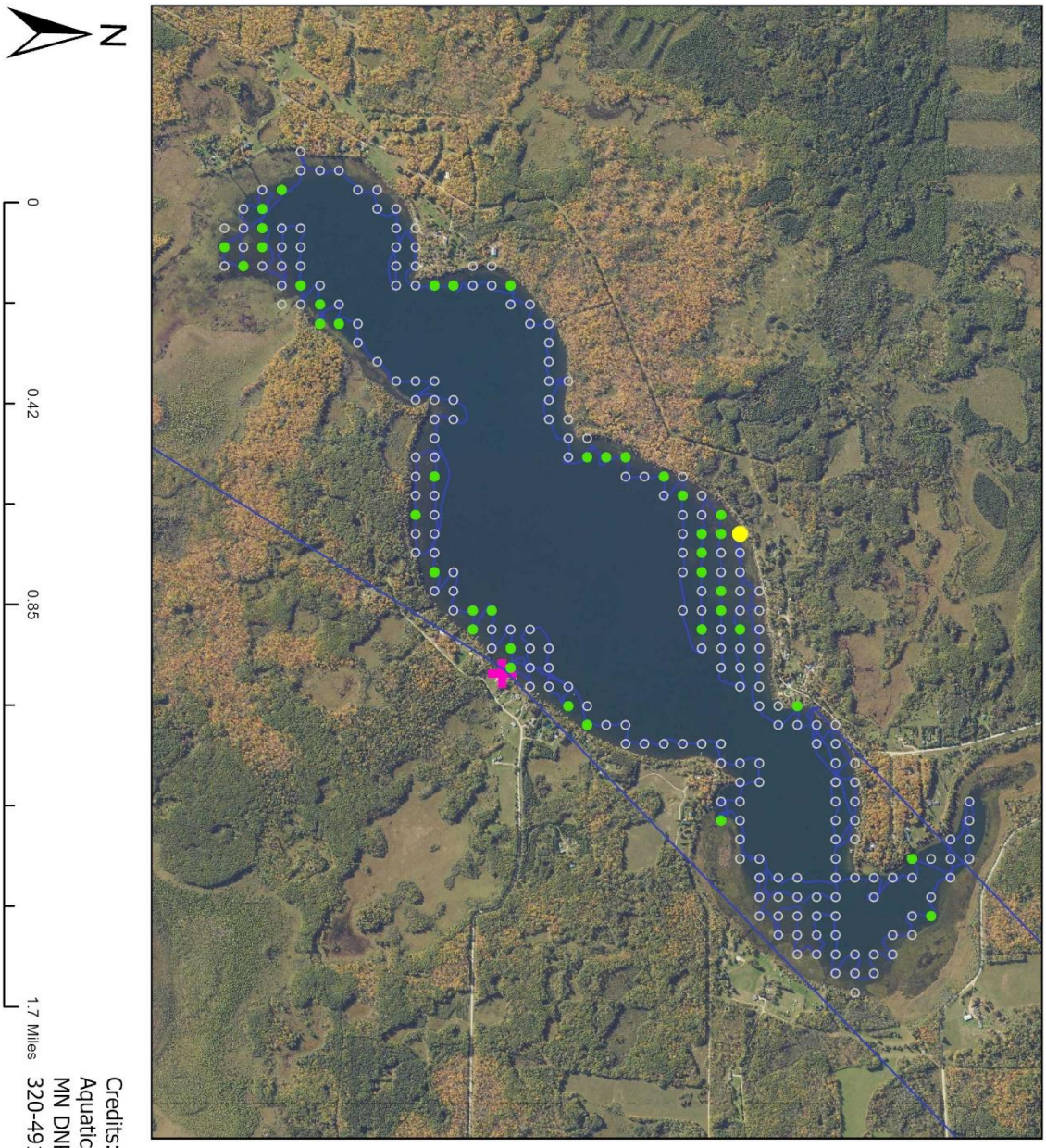
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Moose Lake– Beltrami County

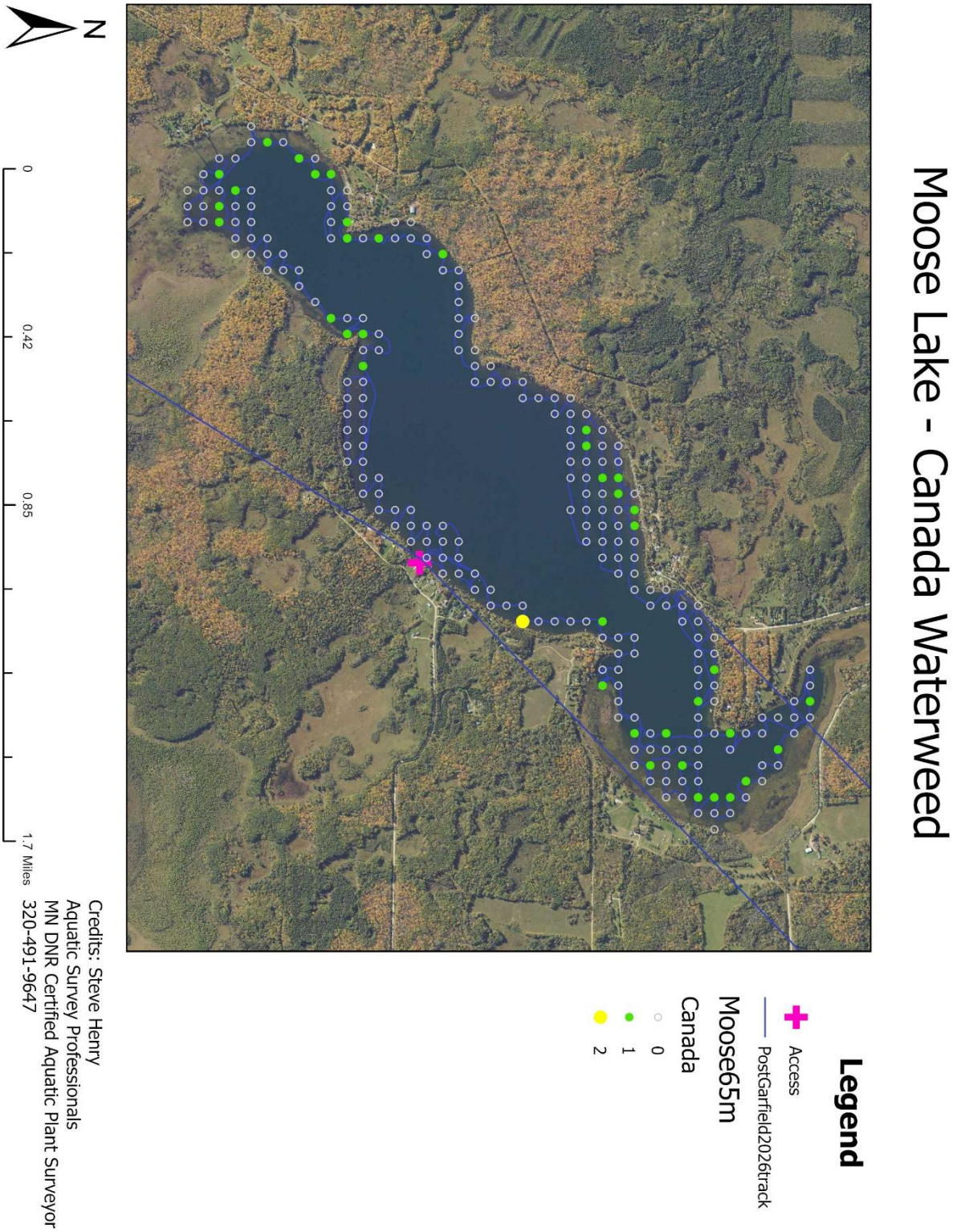
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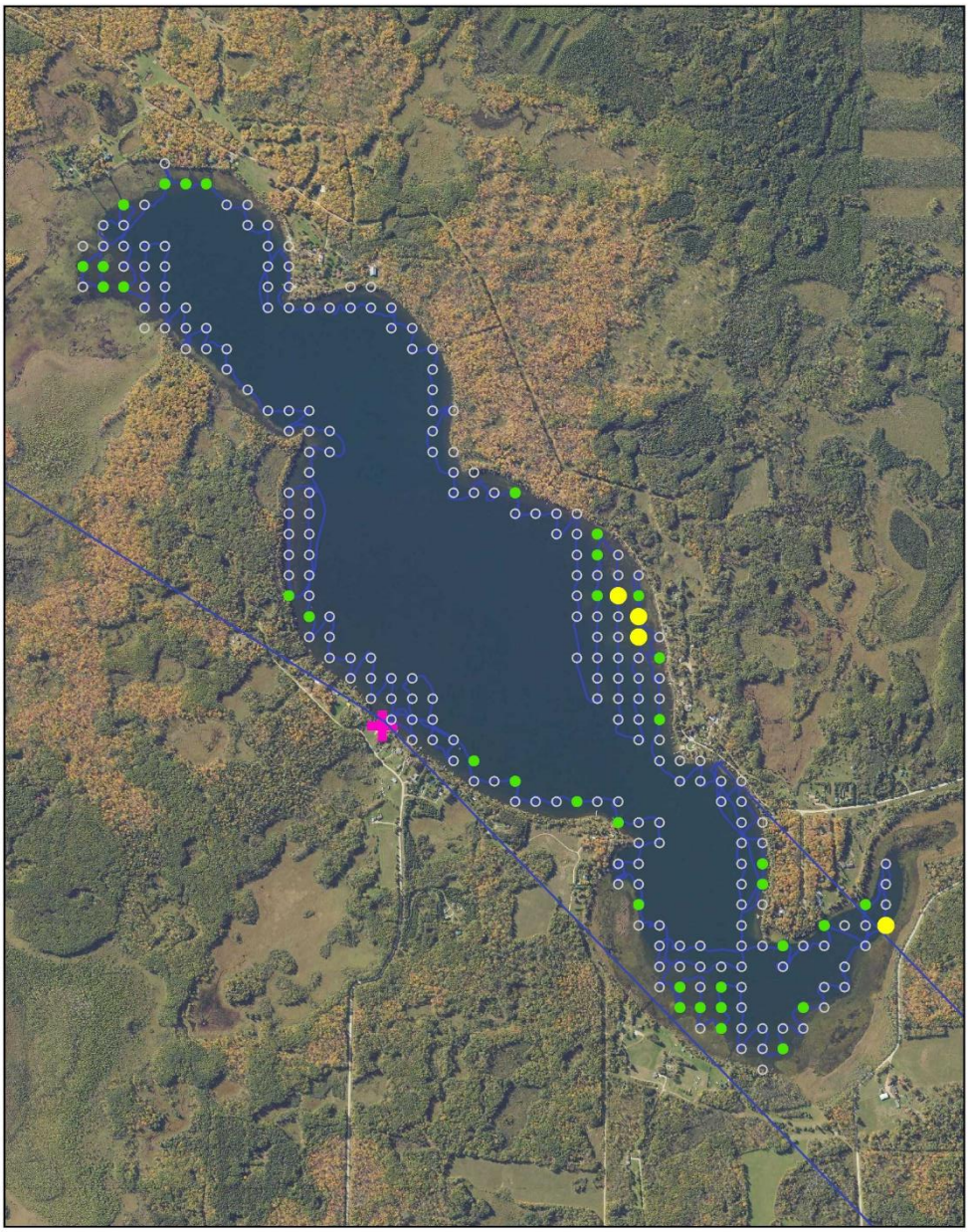
Moose Lake - Greater Bladderwort



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Moose Lake - Canada Waterweed
Legend
Access
PostGarfield2026track
Moose65m
Canada
0
1
2
N
0
0.42
0.85
1.7 Miles
Credits: Steve Henry
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Moose Lake - Northern Water Milfoil



Legend

Access

PostGarfield2026track

Moose65m

Northen Water Milfoil

0

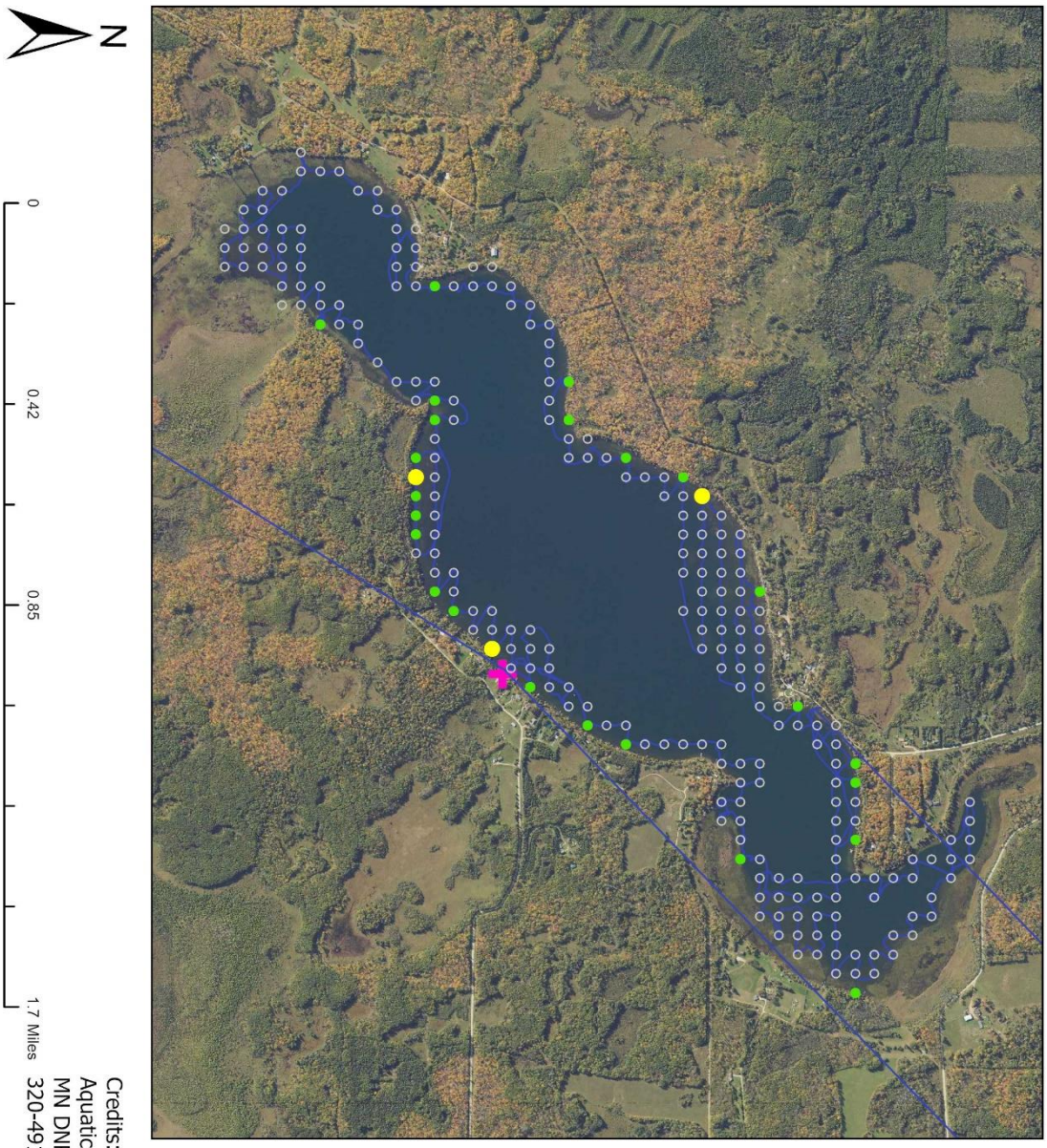
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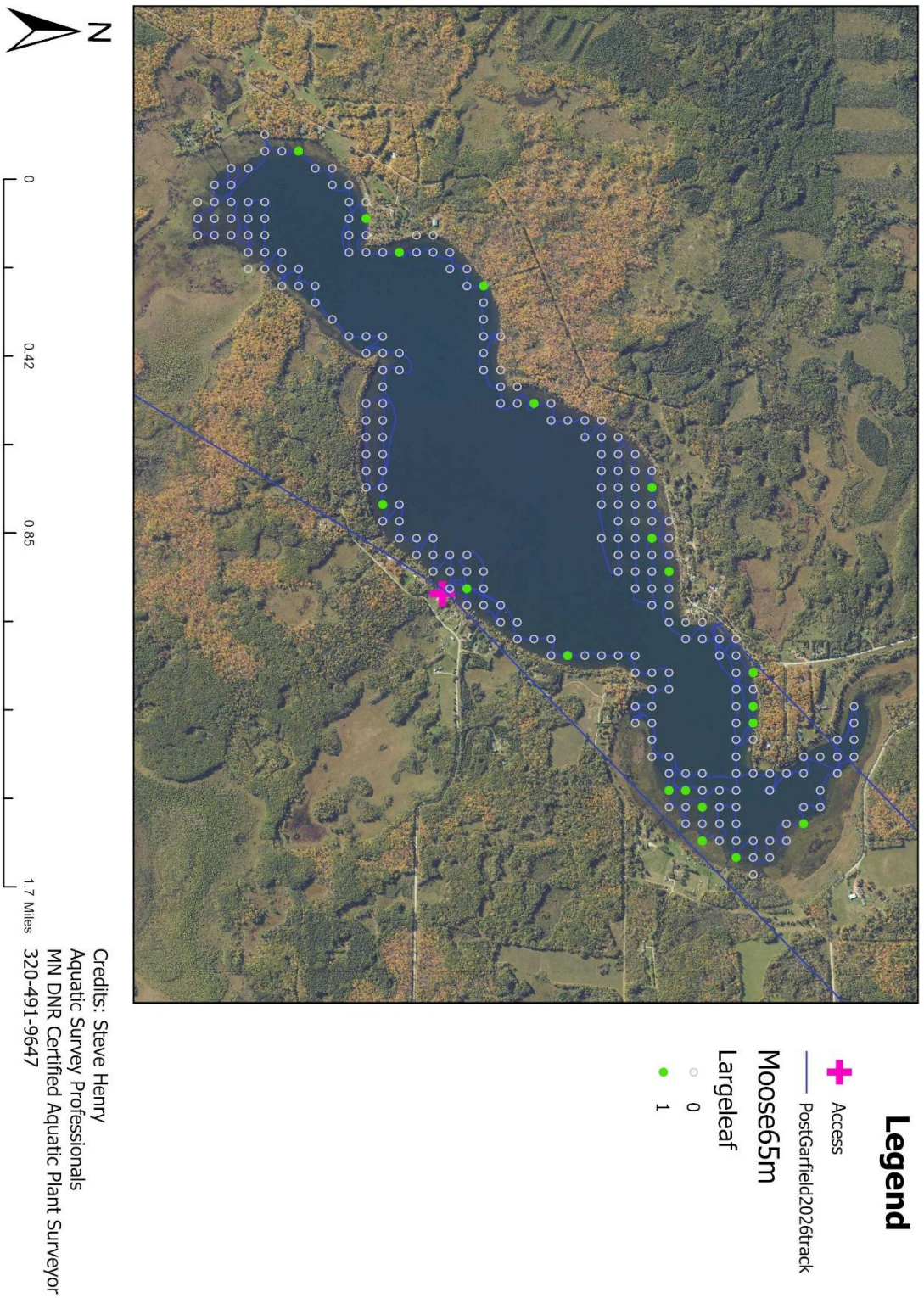
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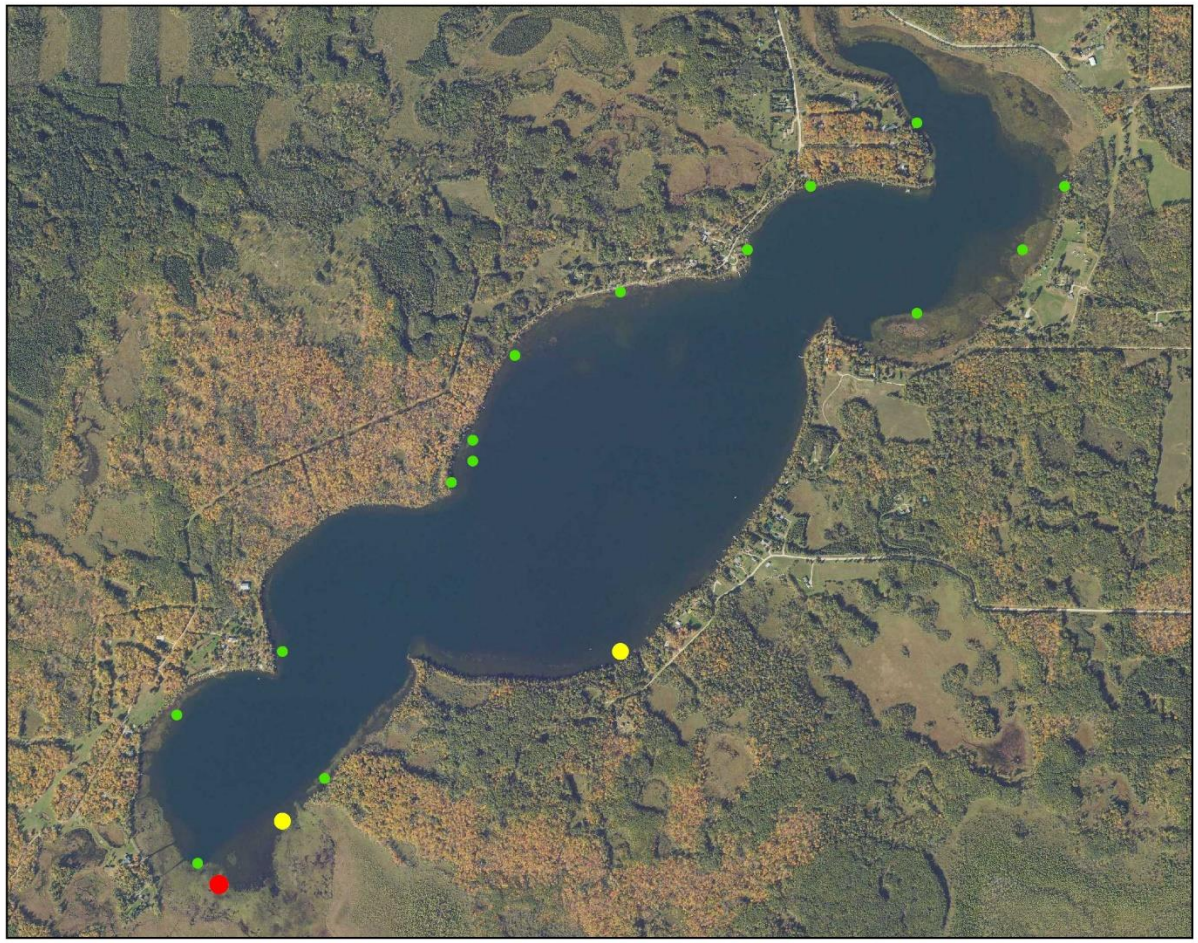
0 0.42 0.85 1.7 Miles

Credits: Steve Henry
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Moose Lake - Bulrush
Legend
Access
PostGarfield2026track
Moose65m
Bulrush
0
1
2
N
0
0.42
0.85
1.7 Miles
Credits: Steve Henry
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Moose Lake - Large Leaf Pondweed
Legend
Access
PostGarfield2026track
Moose65m
Largeleaf
0
1
N
0
0.42
0.85
1.7 Miles
Credits: Steve Henry
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Moose Lake Yellow Water Lily



Legend

Moose65m

Yellow Water Lily

- Sparse
- Common
- Abundant

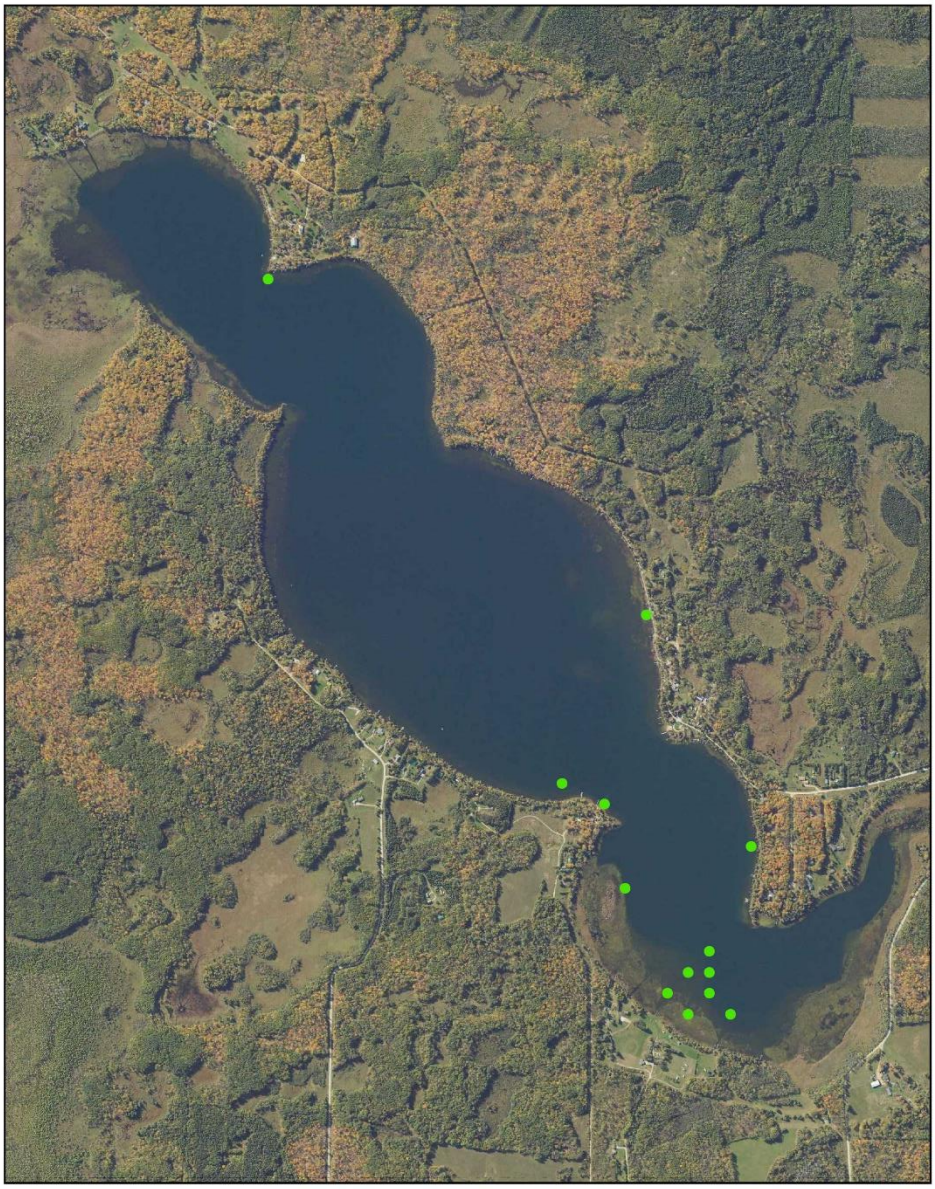
N

0 0.4 0.8 1.6 Miles

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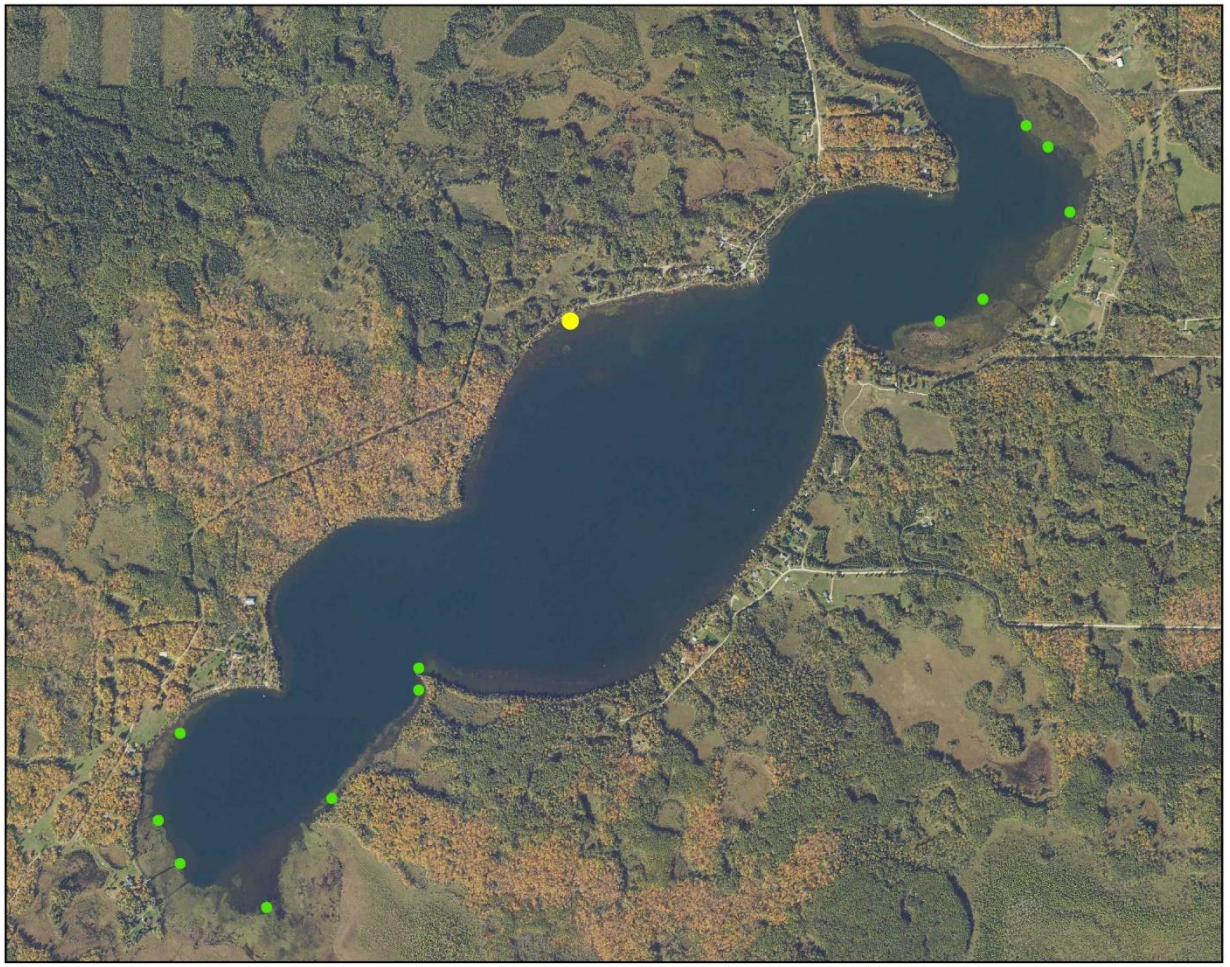
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Moose Lake Narrow Leaf Pondweed



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Moose Lake Floating Leaf Pondweed



Legend

Moose65m

Floating Leaf Pondweed

- Sparse
- Common
- Abundant

N

0 0.4 0.8 1.6 Miles

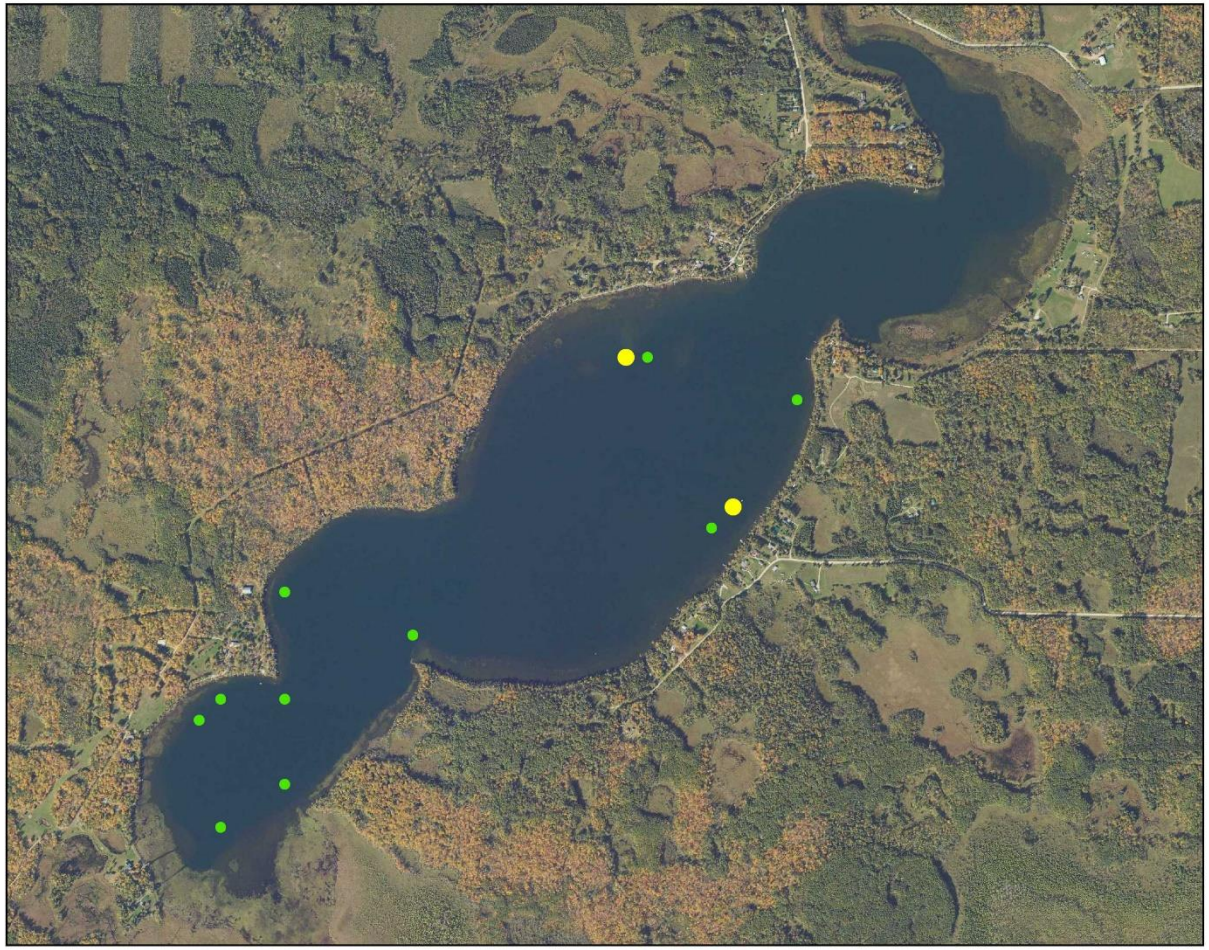
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Moose Lake– Beltrami County

04-0011-00

Moose Lake Nitella flexilis



Legend

Moose65m

Nitella flexillis

- Sparse
- Common
- Abundant

N

0 0.4 0.8 1.6 Miles

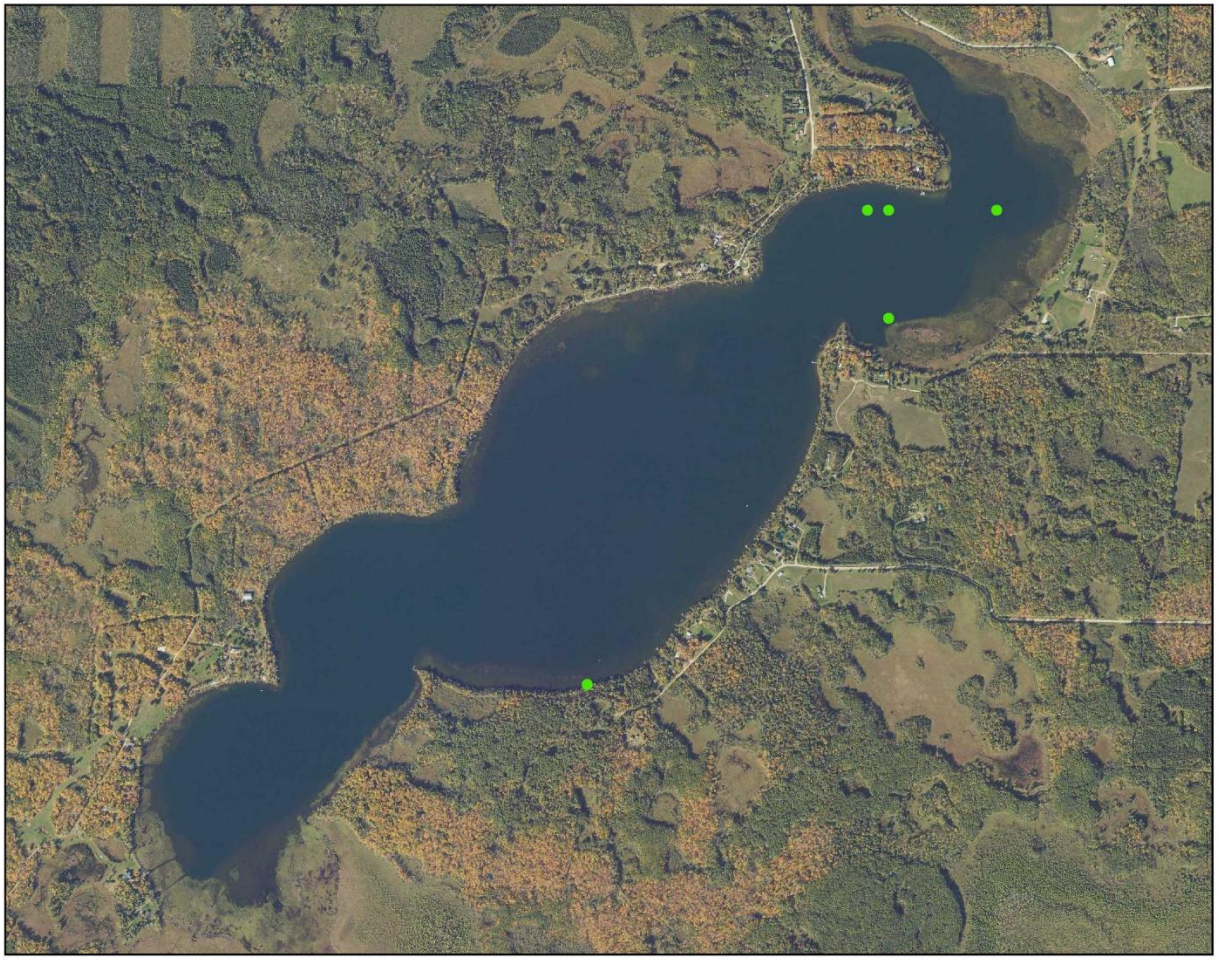
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Moose Lake– Beltrami County

04-0011-00

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Moose Lake Bladderwort spp



Legend

Moose65m

Bladderwort spp

- Sparse
- Common
- Abundant

N

0 0.4 0.8 1.6 Miles

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Moose Lake– Beltrami County

Down and Side Scanning Sonar for Aquatic Invasive Species Detection

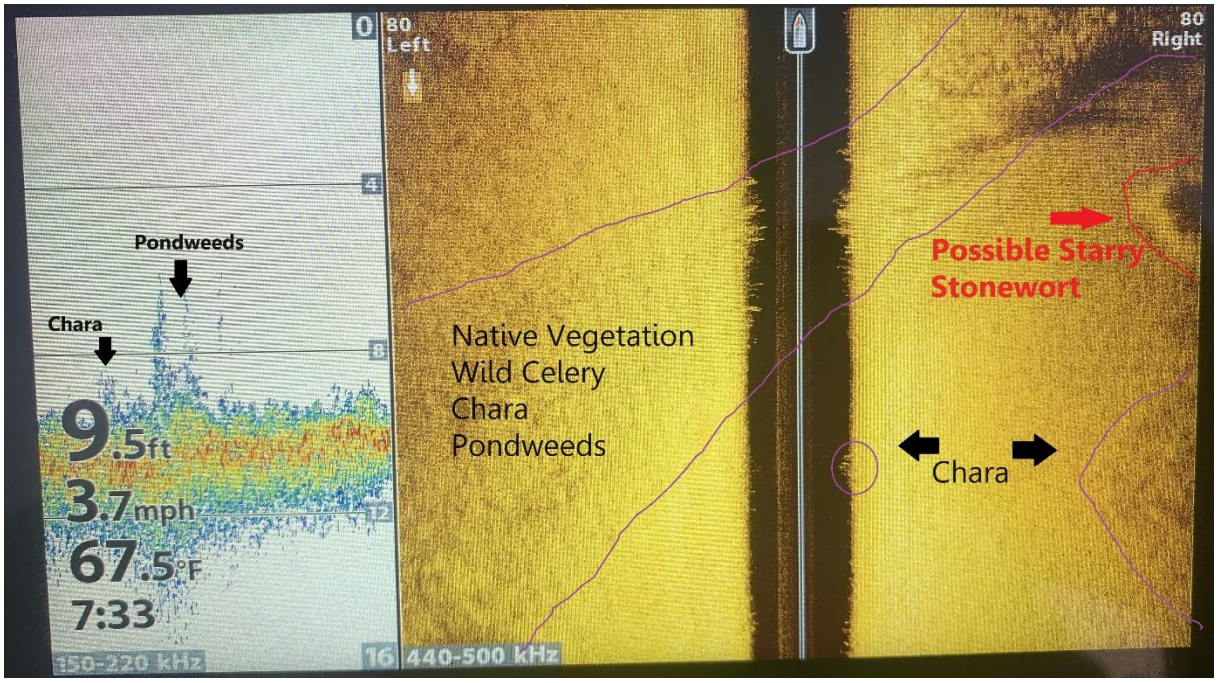
As technology has improved aquatic plant survey techniques have adjusted to incorporate those improvements. Until recently aquatic plant surveys were based solely on using a sample rake to document the plants at pre-established survey points. Those survey points were spaced 200 feet or further apart in an even grid across the lake providing only a limited snapshot of the plant community. In 2020 Minnesota DNR approved a new Standard Operating Procedure for Invasive Species Delineations that utilizes sonar and visual observations to continuously document the lake's plant community as the surveyor navigates around the lake. Aquatic Survey Professionals combines these two survey techniques to provide our clients with a data set comparable to their previous surveys while also continuously examining the lake bottom to detect any newly introduced invasive species.

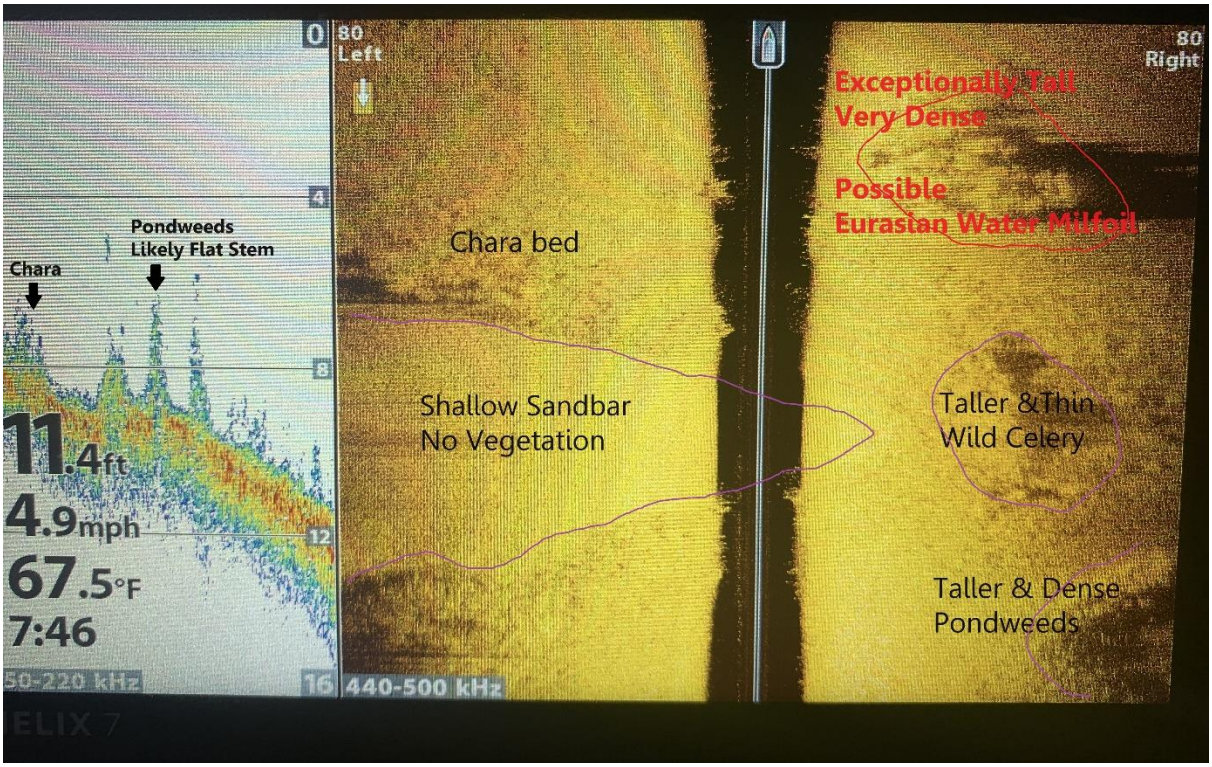
Sonar images can appear grainy and coarse, seemingly of limited value in documenting a lake's plant community. Aquatic surveyors gain hundreds of hours of experience monitoring these sonar images alongside thousands of rake obtained plant samples. Over time surveyors learn that each species has a distinctive appearance that changes over the season. Eurasian Water Milfoil is taller and denser than most native species in spring returning images with a different color pattern. By mid-summer Eurasian Water Milfoil develops a dense head over moderate stems often in tall patches that are slightly open near the bottom with a unique appearance on the sonar images. Starry Stonewort is referred to as 'Super Chara' by researchers which matches it's sonar appearance. Starry Stonewort is taller and denser than Chara but generally shorter than other native species. Starry Stonewort grows very dense and usually in well-defined patches with no natives intermixed, it's appearance on sonar is distinctive. Eventually surveyors learn how to 'calibrate' each lake's plant community to the sonar images within 30 minutes of starting their survey on that lake. This allows surveyors to detect unusual sonar images, drop a new waypoint on top of that location, and carefully examine that unusual growth with multiple rake tosses and visually.

Side scanning sonar covers both sides of the boat track and has an adjustable scan width. Up to 200 feet in each direction can be displayed on the sonar unit which covers a track width of 400 feet. Normally the side scanning is set closer to 100 feet to keep the image clarity high, this increases the survey coverage from one small point every 200 feet to a continuous swath of observations 200 feet wide tracking back and forth across the lake. Combined with visual observations made continuously as the boat tracks the lake the 'density' of observations sky rockets compared with traditional point surveys. See the example images on the next page.

These images were produced with side scan set to 80 feet allowing the surveyor to see that far to each side of the boat track. The black area represents the water below the boat, the black area is equal to the water depth. Sample waypoints can be dropped on this screen to mark

suspicious sites. Those waypoints are correctly offset to the side and behind the boat exactly on top of the suspicious growth allowing the surveyor to navigate back for additional sampling.





Lake Health Stats – From MN DNR

Explore Watershed Lakes: Minnesota Department of Natural Resources

Minnesota DNR has developed a new lake health evaluation framework that draws together the results from numerous programs implemented through their various divisions. This framework is meant to be more comprehensive and informative while still stimulating the interest of lake residents in how each evaluation is performed and ranked. Following the link above will lead you to information on each evaluation and descriptions of the ranking system.

Informative Ranking added by Aquatic Survey Professionals Excellent Good Fair Poor

Lake Health Score	65
Lake Health Grade	B
Major Watershed Lake Health Mean Score	68
Major Watershed Lake Health Minimum Score	50
Major Watershed Lake Health Maximum Score	100
Water Quality Score	52
Major Watershed Water Quality Mean Score	48
Major Watershed Water Quality Minimum Score	17
Major Watershed Water Quality Maximum Score	100
Phosphorus Score	64
Major Watershed Phosphorus Mean Score	64
Major Watershed Phosphorus Minimum Score	25
Major Watershed Phosphorus Maximum Score	100
Total Phosphorus (µg/l)	19
Total Phosphorus Regional Goal (µg/l)	30
Total Phosphorus Percent Deviation from Goal	13
Total Phosphorus Goal Status	At or Above Goal
TP Sensitivity Index (inches)	21
TP Sensitivity Significance Priority Class	Highest
Water Clarity Score	39
Major Watershed Water Clarity Mean Score	30
Major Watershed Water Clarity Minimum Score	3
Major Watershed Water Clarity Maximum Score	100
Five-year mean Water Clarity Meters	4
Water Clarity Regional Goal	2
Water Clarity Percent Deviation from Goal	83
Water Clarity Goal Status	At or Above Goal
Water Clarity ID for Lake Browser	04001100

Impairments	Mercury in fish
Biology Score	56
Major Watershed Biology Mean Score	57
Major Watershed Biology Minimum Score	35
Major Watershed Biology Maximum Score	100
Fish Community Quality	68
Major Watershed Fish Community Quality Mean Score	75
Major Watershed Fish Community Quality Minimum Score	41
Major Watershed Fish Community Quality Maximum Score	100
Fish IBI Score	59 ★
Fish IBI Threshold	45
Fish IBI Lake Type	Deep lakes with complex shorelines
Fish IBI % Deviation From Threshold	31
Fish IBI Status	At or Above Threshold
Fish IBI Aquatic Life Use Judgement	Full Support
Lake Plant Community Quality	45
Major Watershed Lake Plant Community Quality Mean Score	50
Major Watershed Lake Plant Community Quality Minimum Score	0
Major Watershed Lake Plant Community Quality Maximum Score	79
Plant FQI Score	30 ★
Plant FQI Threshold	20
Plant FQI Ecoregion	3Bw
Plant FQI % Deviation From Threshold	53
Plant FQI Status	At or Above Threshold
Biological Significance Class	Outstanding ★
Hydrology Score	89
Major Watershed Hydrology Mean Score	95
Major Watershed Hydrology Minimum Score	75
Major Watershed Hydrology Maximum Score	100
Lake Watershed Health Index	98 ★
Major Watershed Lake Watershed Health Index Mean	96
Major Watershed Lake Watershed Health Index Minimum	76
Major Watershed Lake Watershed Health Index Maximum	100
Lake Watershed Transport Capacity Class	1
Percent Disturbed	5 ★
Watershed to Lake Area Ratio	4.7

Watershed to Lake Area Class	Less than 5
Score the Shore	81 ★
Major Watershed Score the Shore Mean	81
Major Watershed Score the Shore Minimum	58
Major Watershed Score the Shore Maximum	96
Shoreland Zone Score	27
Shoreline Zone Score	28
Aquatic Zone Score	25
Score the Shore Rating	Moderate
Stewardship	Not Scored
Benefit to Cost Assessment Class	Higher
Percent Forested	43 ★
Percent Grass and Shrub	2
Percent Wetland	29
Percent Pasture and Hay	2
Predicted Total Phosphorus Load (pounds/year)	260
Phosphorus Load Reduction Goal (pounds/year)	10 ★

Status of the Fishery

Moose Lake is a 601-acre lake with a maximum depth of 71 feet. The lake is located north of the town of Pennington in eastern Beltrami County. Public access is located on the east shore of the lake off of Timberwolf Road Northeast. Moose Lake is managed primarily for Walleye, Bluegill, Black Crappie, and Largemouth Bass with Northern Pike managed as a secondary species.

Moose Lake is a popular fishing lake with the local populace and resort guests. The Walleye population is maintained through annual fingerling stocking. The 2021 survey showed an increase in the Walleye gill-net catch rate (5.9 per net) which meets management goals. Walleye captured in 2021 had an average size of more than 18 inches in length. The largest Walleye captured in the survey measured just over 26 inches.

The 2021 Northern Pike catch rate of 10.2 fish per net was slightly lower than findings in the previous survey. Few pike over 30 inches in length were measured and only nine percent exceeded 26 inches. . There is currently an abundance of fish directly below the 22-26 inch protected slot limit which are vulnerable to the north-central zone's expanded 10

fish bag limit. Moose would be a good choice for anglers interested in taking advantage of this liberal harvest regulation.

Black Crappie were found in strong numbers and 60% of those fish exceeded 10 inches in length. The largest crappie captured in the survey was 13.3 inches.

Bluegills are abundant in Moose Lake but lack the larger sizes commonly desired by anglers. The largest captured was 7.8 inches and overall average length was 5.5 inches.

For More Information

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