A Summary of Findings from LakeScan™
Guided Surveys and Analysis of:

Cedar Lake South

Iosco County

2020 DATA AND ANALYSIS SUMMARY REPORT WITH MANAGEMENT RECOMMENDATIONS

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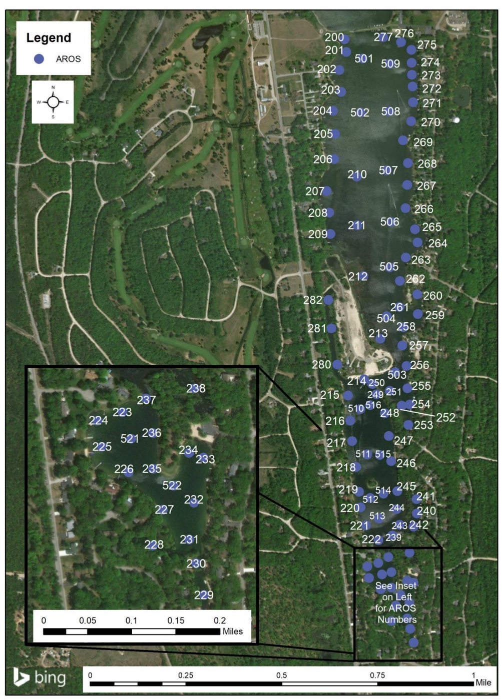

Executive Summary

Kieser & Associates, LLC (K&A), in conjunction with Aquest Corporation, conducted vegetation monitoring on Cedar Lake South (Iosco County) during the summer of 2020 using LakeScan™ assessment methods. The purpose of these efforts was to assess aquatic vegetation during the summer recreational season in the context of nuisance conditions and management needs/outcomes. LakeScan™ methods combine detailed field data collection with mapping capabilities and whole-lake analyses based on established scientific metrics to score various lake conditions. This approach allows lake managers to: readily and consistently identify successful lake management activities; highlight potential issues requiring intervention, and; gather critical planning information necessary to improve the lake's ecological and recreational conditions.

Overall, Cedar Lake South's averaged scores from early-season and late-season LakeScan™ 2020 surveys are summarized in Table ES - 1. These reveal scores meeting optimal management goals set forth in the Shannon Biodiversity Index, Shannon Morphological Index, and Floristic Quality Index.[1] These scores suggest an appropriate and diverse plant community providing good habitat for fish and macroinvertebrates. The high Floristic Quality Index results indicate a higher distribution of desirable, native plant species and a lower distribution of undesirable species. Average Recreational Nuisance Presence scoring is not meeting optimal management goals of less than 10%, indicating that on average, 16% of the sampled areas exhibited vegetation that could impede boating activities due to the location and height of vegetation in the water column. The Algal Bloom Risk rating for Cedar Lake South is "low" reflecting the low proportion of agricultural and urban land use draining to the lake.

Table ES-1 – Summary of lake analysis metrics

LakeScan™ Metric	2020 Average	Management Goal
Shannon Biodiversity Index	10.6	> 6.7
Shannon Morphology Index	8.8	> 5
Floristic Quality Index	27.3	> 20
Recreational Nuisance Presence	16%	< 10%
Algal Bloom Risk	Low	Low

The early-season LakeScan™ vegetation survey of Cedar Lake South was conducted on June 30th. Desirable native aquatic vegetation observed included Chara (*Chara sp.*), variable pondweed (*Potamogeton graminius* L .), clasping leaf pondweed (*Potamogeton richardsonii (Benn.) Tydb*.), sago pondweed (*Stuckenia sp.*), and waterlily (*Nymphaea sp.*). Variable watermilfoil (*Myriophyllum*

[1] See LakeScan™ Metrics section for a more detailed explanation of these management indices.

heterophyllum Michaux) was observed at medium coverage in AROS 206 and exhibited recreational nuisance conditions in AROS 203 and 202. Ecological nuisance species detected include starry stonewort (*Nitellopsis obtusa*) and Ebrid watermilfoil (*Myriophyllum spicatum x sibiricum*).

The late-season LakeScan™ vegetation survey of Cedar Lake South was conducted on August 19th. Ecological nuisance species observed included Ebrid watermilfoil and starry stonewort. Flatstem pondweed (*Potamogeton zosteriformis Fern*.), clasping leaf pondweed, sago pondweed, and variable pondweed were the most common species observed in Cedar Lake South. Chara was also very common, growing at light to medium-heavy coverage, and inhabited the lake bed in shallow and deep areas including abundant growth in the deepest portions of the central lobes. Variable watermilfoil exhibited light coverage in the northern-most main lobe of Cedar Lake South and medium coverage in AROS 261, 258, and 257. This species exhibited recreational nuisance conditions in many of the locations it was found.

For this 2020 report, K&A also analyzed the past five years of LakeScan™ data for coverage of species targeted for management activities. No significant trend has been observed for Ebrid watermilfoil and starry stonewort for the last five years (Figure ES – 1) suggesting that management activities have not been effective at reducing populations. However, management activities could be suppressing any additional invasive species growth. Variable watermilfoil has exhibited an increasing trend over the last five years. This suggests that management activities have not necessarily been effective at reducing population coverage for this species.

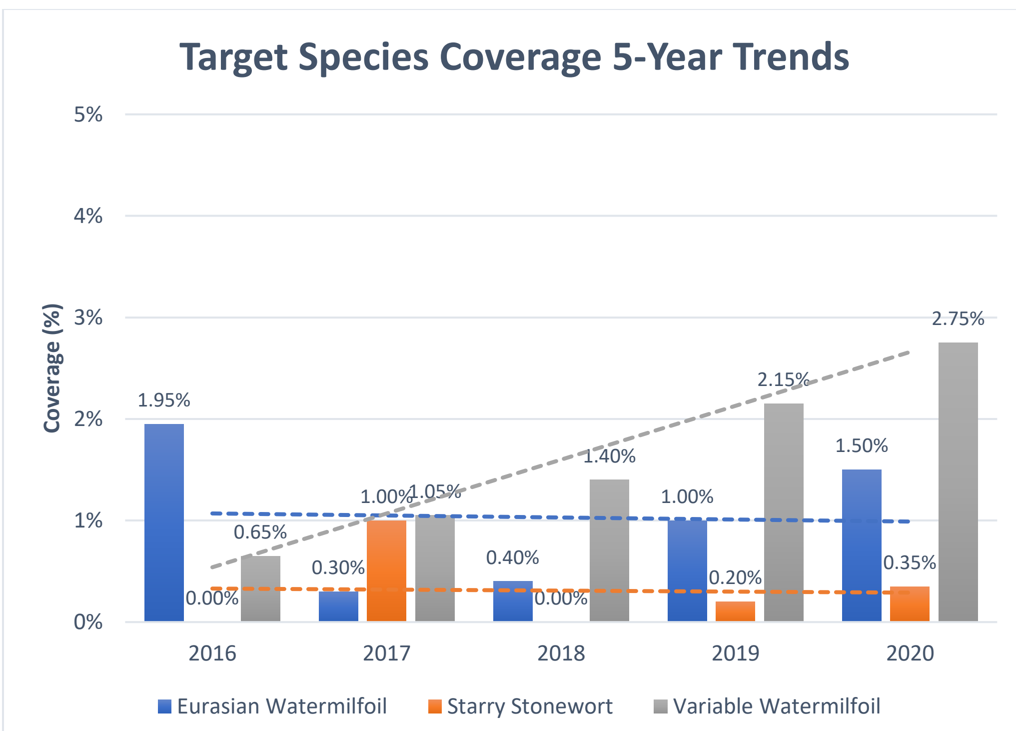

Figure ES-1 – Target species coverage 5-year trends

Based on 2020 findings, K&A recommends the following management considerations for 2021:

- Continue LakeScan™ vegetation monitoring twice a year (once during the spring-early summer and another during the late summer) to assess aquatic vegetation during the growing season. Information collected during these surveys allows lake managers to readily and consistently identify successful lake management activities; highlight potential issues requiring intervention, and; gather critical information necessary to improve the lake's ecological and recreational conditions.
- Continued Ebrid watermilfoil management is recommended. While a slight increase in Ebrid watermilfoil coverage was observed from the early-season to late-season survey in 2020, the trend for the last five years show no change in coverage, suggesting that while management activities do not appear to be signifcantly decreasing Ebrid watermilfoil coverage, Ebrid watermilfoil coverage has not increased. This suggests that management activities may be suppressing the spread and coverage increase of Ebrid watermilfoil.
- Native aquatic plants, such as variable watermilfoil, tend to create recreational nuisances on Cedar Lake South. Variable watermilfoil was observed creating late-season recreational nuisances prompting treatment in September 2020 targeting select areas, which should have lasting effects for up to three years. Locations that received the September treatment will be carefully tracked in the 2021 surveys to determine success for relieving nuisance conditions. These 2021 observations will guide future treatment considerations that balance native plant community diversity as well as recreational and navigational management needs.

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1.0. Introduction

Inland lakes are complex systems, and managing them for both ecological health and recreational enjoyment involves balancing goals that are sometimes at odds with one another. Successful lake management requires a solid understanding of a lake's current ecological and recreational conditions, as well as how those conditions are changing over time. The LakeScan™ program combines a detailed data collection methodology with mapping capabilities and whole-lake analysis metrics backed by scientific literature. This analysis allows lake managers to identify successful lake management activities, as well as highlight potential issues requiring intervention. Appropriately targeted aquatic plant suppression can minimize invasive, weedy, and nuisance species while allowing beneficial species to flourish at ecologically balanced levels supporting healthy lake conditions. This kind of adaptive management system provides a scientifically sound and consistent methodology to better manage a lake's ecological and recreational conditions.

The LakeScan™ analysis involves collecting data over two vegetation surveys during the critical summer recreational season. These surveys are based on a system where the lake is first divided into biological tiers (see Table 1) and then further subdivided into Aquatic Resource Observation Sites (AROS)(see Figure 1). For each survey, field personnel record the density, distribution, and position in the water column of each aquatic plant species in each AROS, as well as noting any present nuisance conditions. Dissolved oxygen profiles and temperature profiles are recorded. Surveys may also collect additional data such as water quality profiles.

Aquatic plant communities change over the course of a year, so the surveys are split into early and late season observations. Early season surveys are scheduled with the goal of taking place within 10 days of early summer treatments to best observe treatment-targeted and non-targeted vegetation. However, this scheduling is subject to weather and times of increased boat activity.

Table 1 - Biological Tier Descriptions.

Tier*	Description
2	Emergent Wetland
3	Near Shore
4	Off Shore
5	Off Shore, Drop-Off
6	Canals
7	Around Islands and Sandbars
9	Off Shore Island Drop-Off

*Tiers 1 and 8 are reserved for future use.

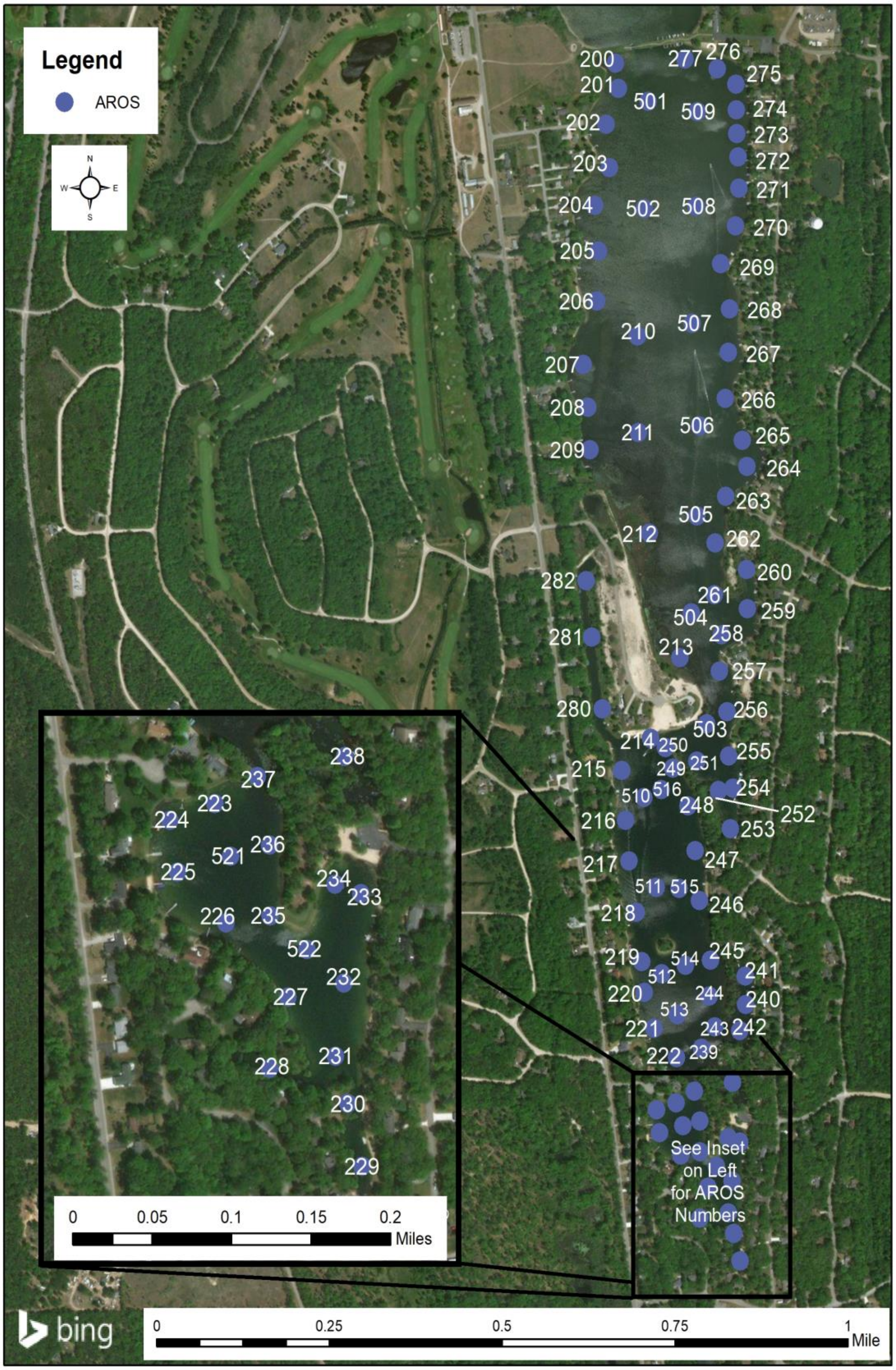

Figure 1 - Map of Aquatic Resource Observation Sites (AROS).

The following sections describe the lake and watershed characteristics, field water quality measurements, results of the aquatic vegetation surveys, and aquatic vegetation management activities and recommendations for Cedar Lake South using LakeScan™ methods.

2.0. Lake and Watershed Characteristics

This section provides a brief overview of physical and geopolitical characteristics of the lake and its watershed.

Location

County: Iosco

Township: Oscoda

Township/Range/Section(s): T25N, R9E Sections: 3 & 10

GPS Coordinates: N 44°29.79996’ W 83°20.04684

Morphometry

Total Area: 78 acres

Shoreline Length: 20,583 feet

Maximum Depth: 12 feet

Watershed Factors

Tributaries: Residential property runoff

Outlet type: Channel at northern end of lake

Administrative Management

Management Authority: Cedar Lake Improvement Board

Years in LakeScan™ Program: 2003 to Present

2.1. Algal Bloom Risk Level

K&A calculates an algal bloom risk level for each LakeScan™ lake based on the characteristics of its watershed. Agricultural and urban land uses contribute more phosphorus to receiving waters than grasslands or forested land uses; phosphorus being the limiting nutrient that drives algal blooms. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms. Not all algal blooms contain cyanobacteria and their associated toxins (Harmful Algal Blooms or HABs). It is important to note that the risk factor reported here is based on a limited watershed analysis. Lakes at high risk of algal blooms should consider more in-depth studies that can identify possible watershed or in-lake improvements to mitigate the risk of HABs.

The algal bloom risk for Cedar Lake South as assessed by K&A is: **Low**

3.0. Water Quality

Secchi depth, dissolved oxygen and temperature data were collected during each vegetation survey. Data are shown in Figures 2 and 3. Secchi disk transparency is the depth at which a Secchi disk (a flat white or black and white platter, approximately 20 centimeters in diameter) suspended into a lake disappears from the investigator's sight. In general, the greater depth at which the Secchi disk can be viewed, the lower the productivity of the water body. Secchi depth readings of greater than 15 feet can be indicative of low productivity or oligotrophic conditions.[2] It is important to note that established populations of zebra mussels in a lake can significantly increase water clarity, thus resulting in greater Secchi disk readings.

A sufficient supply of dissolved oxygen (DO) in lake water is necessary for most forms of desirable aquatic life. Colder waters contain more dissolved oxygen than warmer waters. Oxygen depletion can occur in deeper, unmixed bottom waters during warmer summer months in highly productive lakes. Increased algal growth associated with additional nutrients in the lake can lead to severe decreases in DO in lake bottom waters. This decrease in oxygen is due in part to dead algae and other organic matter, such as leaves, grass and other plant debris washed in from shoreline lawns and storm drains settling to the bottom of the lake. This organic matter is then consumed along with oxygen by organisms in the sediment. DO depletion is most often observed in lake bottom waters during periods of temperature stratification in warmer summer months and, to a lesser degree, under winter ice cover conditions.

Dissolved oxygen levels and temperature were measured by K&A using a YSI ProODO dissolved oxygen meter, calibrated prior to use. Michigan water quality standards for surface waters designated for warm water fish and aquatic life call for a DO of at least 5 mg/L.[3]

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[2] US Geological Survey. 2012. "Water Quality Characteristics of Michigan's Inland Lakes, 2001-10." Scientific Investigations Report 2011–5233. Available online at: https://pubs.usgs.gov/sir/2011/5233/.

[3] Michigan Department of Environmental Quality. 2006. "Part 4-Water Quality Standards." Water Bureau, Water Resources Protection. Available online at: https://www.michigan.gov/documents/deq/wrd-rules-part4_521508_7.pdf.

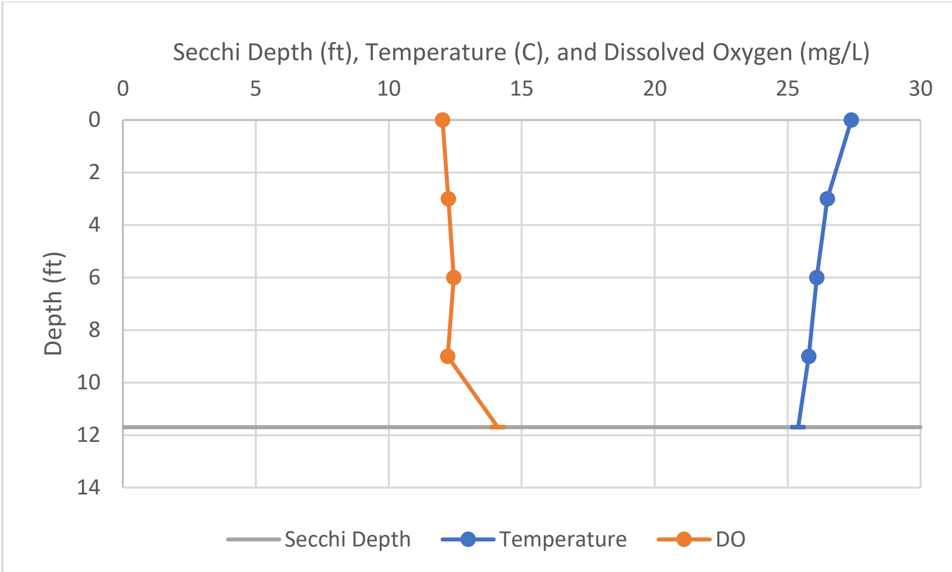

*Figure 2 - Early season survey (June 30th) dissolved oxygen and temperature profiles with Secchi depth, taken at the deepest point in the lake. *Note: last data point is located on the bottom and a bed of Chara was observed on bottom.*

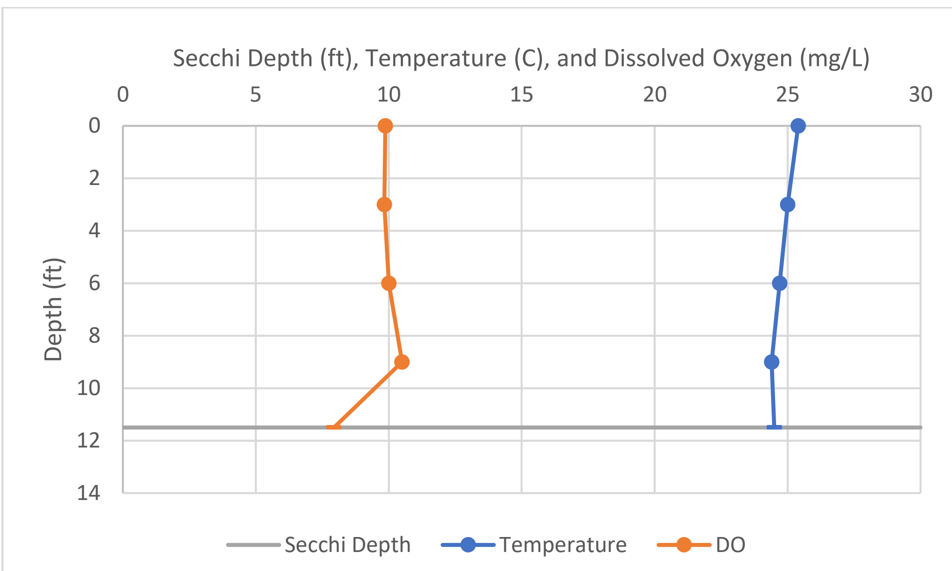

*Figure 3 - Late season survey (August 19th) dissolved oxygen and temperature profiles with Secchi depth, taken at the deepest point in the lake. *Note: last data point is located on the bottom.*

4.0. Aquatic Vegetation

This section details findings from the two vegetation surveys that were conducted on the lake in 2020. This includes observations, aquatic vegetation mapping, and LakeScan™ analysis metrics.

4.1. Early-Season Survey

The early-season LakeScan™ vegetation survey of Cedar Lake South was conducted on June 30th. Weather conditions were 84°F and sunny with a calm wind in the morning and mild wind in the afternoon. Visibility through the water column was good throughout the lake with a Secchi depth of 11.7ft. Figure 4 depicts data on all combined species using three-dimensional density, which reflects a combination of vegetation density, distribution, and height observations of all species observed on Cedar Lake South during the early-season survey. Color-coding is provided for each AROS that helps to spatially depict observed vegetation data. The colors range from dark blue, which depicts no vegetation observed, to yellow, depicting medium density and distribution of plant species, to red, which depicts high density and distribution of vegetation within the AROS.

The ecological nuisance species detected during the early-season survey were Ebrid watermilfoil (*Myriophyllum spicatum x sibiricum*) and starry stonewort (*Nitellopsis obtusa*). Ebrid watermilfoil was found throughout the Tier 3 AROSs as well as AROS 521 with very light to light coverage. Ebrid watermilfoil was also found with moderate density in AROS 225 and 522, but exhibited very light distribution which gives these AROS an overall light coverage rating, and posed no recreational nuisance at the time of the survey (Figure 5). Starry stonewort exhibited light coverage in AROS 256, 251, and 503 (Figure 6) and primarily inhabited the 9-12ft depth contours. The total combined area of starry stonewort found was approximately 1 acre.

Desirable native aquatic vegetation included Chara (*Chara sp*.), variable pondweed (*Potamogeton graminius* L .), clasping leaf pondweed (*Potamogeton richardsonii (Benn.) Tydb*.), sago pondweed (*Stuckenia sp*.), and waterlily (*Nymphaea sp*.). Pondweeds created slight recreational nuisance conditions in AROSs 200-204. Variable watermilfoil (*Myriophyllum heterophyllum* Michaux) was observed at light coverage in a majority of the locations it was found, but exhibited medium coverage in AROS 206 and exhibited recreational nuisance conditions in AROS 203 and 202 (Figure 7).

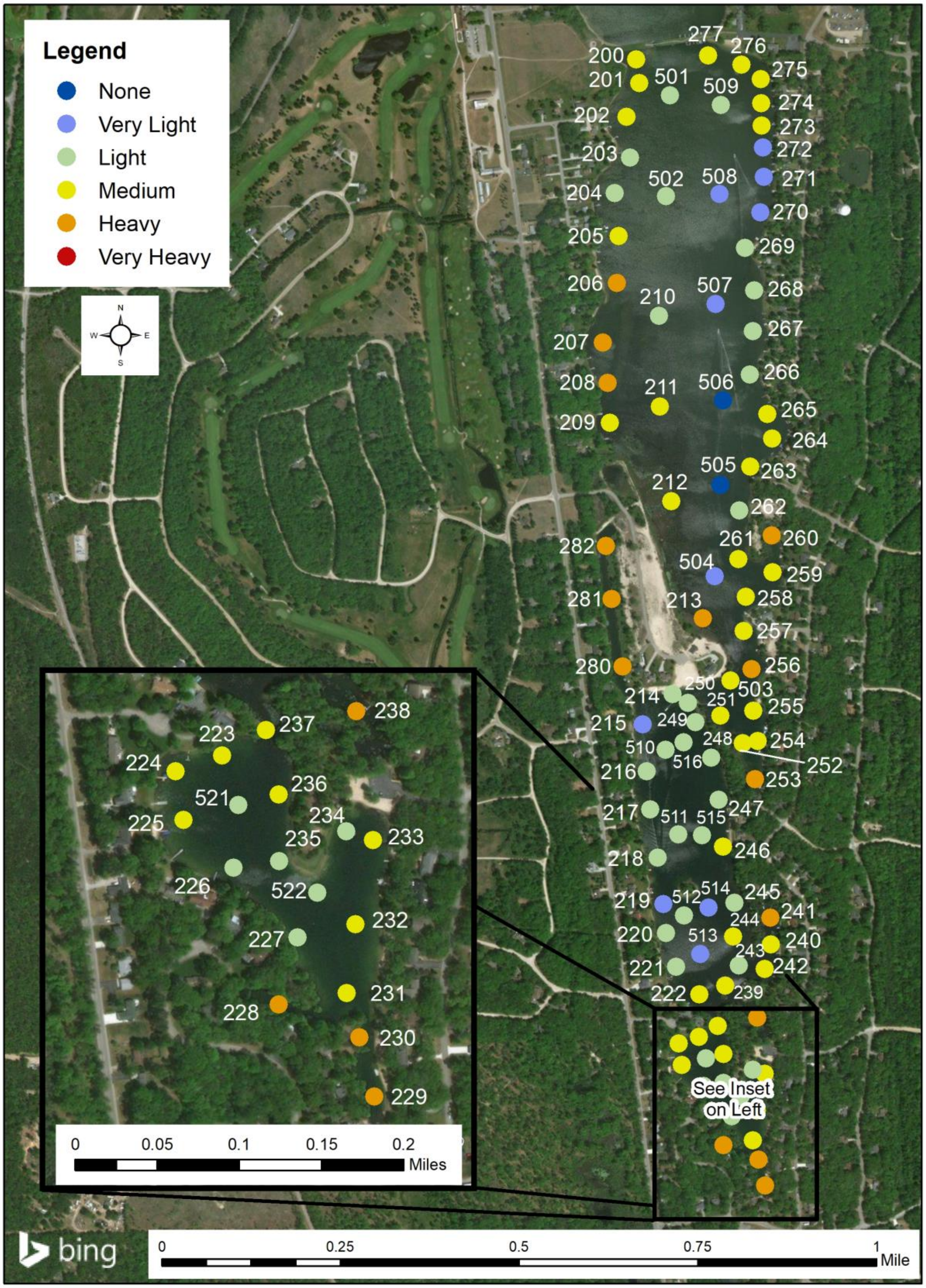

Figure 4 – Early season survey (June 30th) vegetation 3D Density (a function of all species observed vegetation density, distribution and height observations).

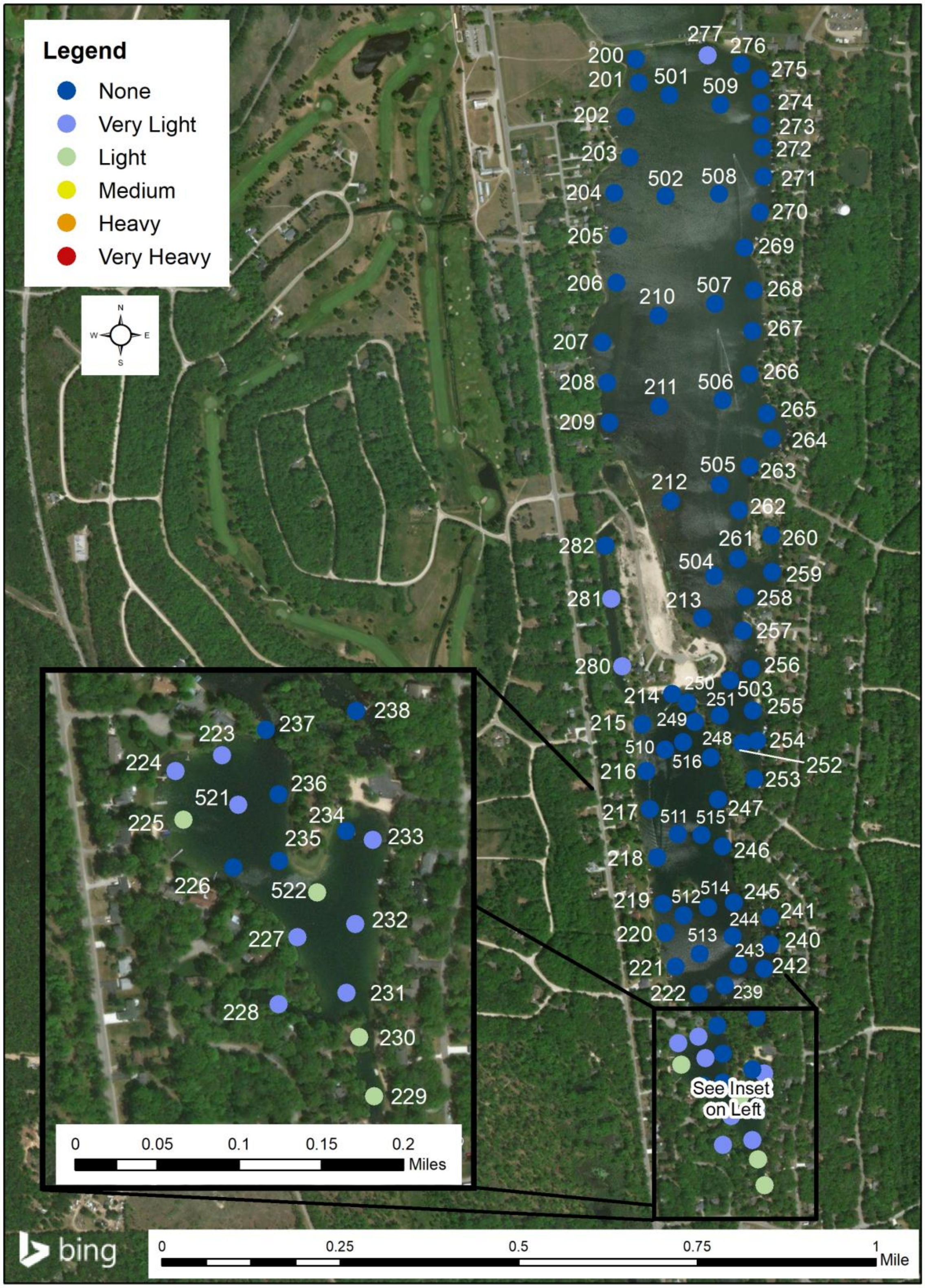

Figure 5 – Early season (June 30th) Eurasian Watermilfoil and Hybrids coverage (a combination of the LakeScanTM density and distribution observations).

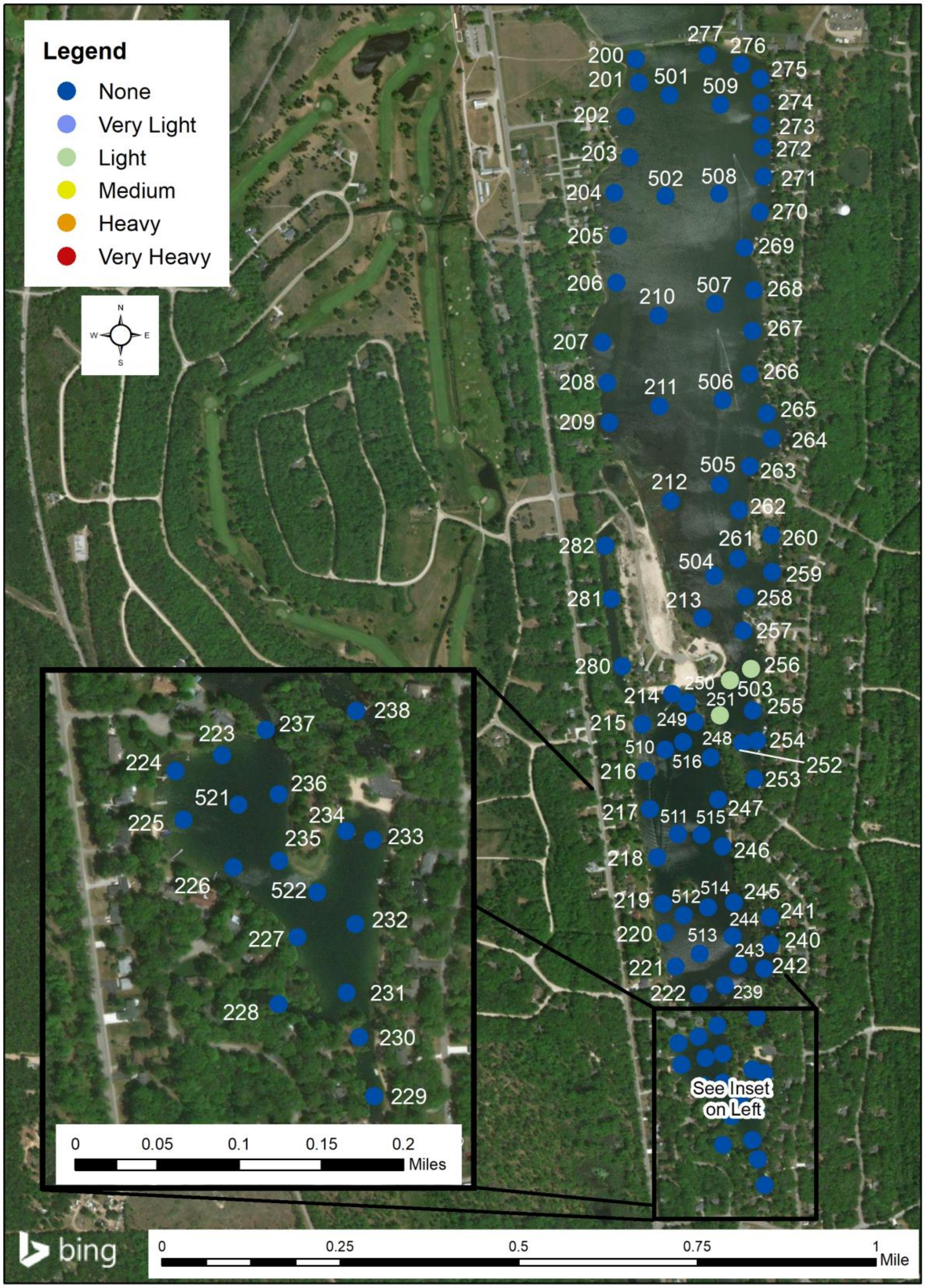

Figure 6 – Early season (June 30th) Starry Stonewort coverage.

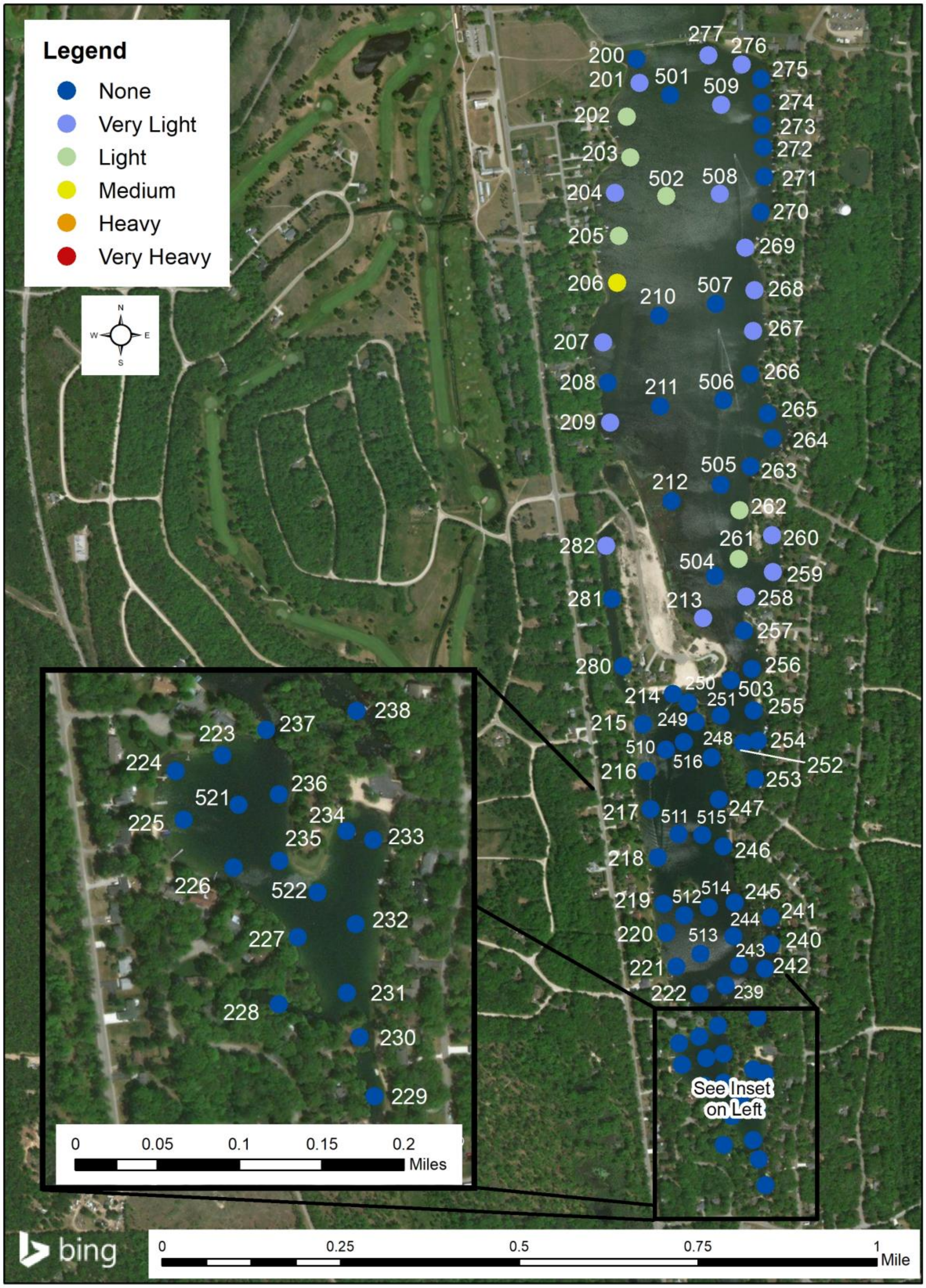

Figure 7 – Early season (June 30th) Variable Watermilfoil coverage.

4.2. Late-Season Survey

The late-season LakeScan™ vegetation survey of Cedar Lake South was conducted on August 19th. Air temperatures were approximately 70°F, with south to east-southeastern winds varying from 3-10mph. Water temperatures ranged from 77.7°F at the surface to 75.9°F at 11.5ft, at the bottom depth. Visibility through the water column was very good, with a Secchi disk depth of 11.5ft. Figure 8 depicts data on all combined species using three-dimensional density, which reflects a combination of vegetation density, distribution and height observations of all species observed on Cedar Lake South during the late-season survey.

Ecological nuisance species observed includes Ebrid watermilfoil and starry stonewort. Ebrid watermilfoil was found at generally light coverage in the Tier-2 AROS within the southern-most lobe of Cedar Lake South. Ebrid watermilfoil was found at higher coverage in AROS 256, 255, and 254, the central-channel portion of Cedar Lake South (Figure 9). Ebrid watermilfoil was not found to be presenting a recreation nuisance at the time of this survey. Starry stonewort (*Nitellopsis obtusa*) was found in AROS 255 and 256, in 9-12ft depths in the center channel section of Cedar Lake South. Starry stonewort was observed at light covergae in these AROS, intermixed with other macrophytes and near dense beds of Chara. This same location and depth are consistent with that observed in the 2020 early-season survey and in both early and late season surveys in 2019 (Figure 10).

Chara was commonly observed, growing at light to medium-high coverage throughout Cedar Lake South, inhabiting the lake bed in shallow and deep areas, including abundant growth in the deepest portions of the central lobes. Naiad (*Najas sp*.) was observed throughout Cedar Lake South growing in shallow to medium-depths, in patches varying from light to medium coverages. Common bladderwort (*Utricularia vulgaris L*.) exhibited very light coverages throughout the northern portion of Cedar Lake South.

Flatstem pondweed (*Potamogeton zosteriformis Fern*.), clasping leaf pondweed, sago pondweed, and variable pondweed were the most commonly observed in Cedar Lake South. Variable pondweed was found growing at a phenotype-3 and potentially a perceived recreational nuisance in many of the Tier-3 AROS. Clasping leaf pondweed tended to be observed in the deeper areas only. Wild celery (*Vallisneria americana* Michaux) was similarly found commonly distributed throughout Cedar Lake South, in some cases causing perceived recreational nuisance in the Tier-3 AROS. Pondweeds and celery tended to be intermixed.

Waterlily (*Nymphaea sp.)* was also distributed throughout the Tier-3 AROS in shallower areas and bays in Cedar Lake South, with some spadderdock (*Nuphar sp*.) and a very small amount of floating leaf pondweed (*Potamogeton natans*) intermixed. Waterlily was generally growing along more naturalized shoreline areas and did not present obvious recreational nuisance conditions.

Variable watermilfoil was observed at very-light to light coverage in the northern-most main lobe of Cedar Lake South. Variable watermilfoil was observed at light coverage, distributed throughout both the western and eastern Tier-3 AROS. Variable watermilfoil was observed at medium coverage in AROS 257, 258, and 261 in Cedar Lake South (Figure 11). Variable watermilfoil was recorded as a phenotype-3 and potential recreational nuisance in AROS 273, 268, 267, 266, 265, and 264.

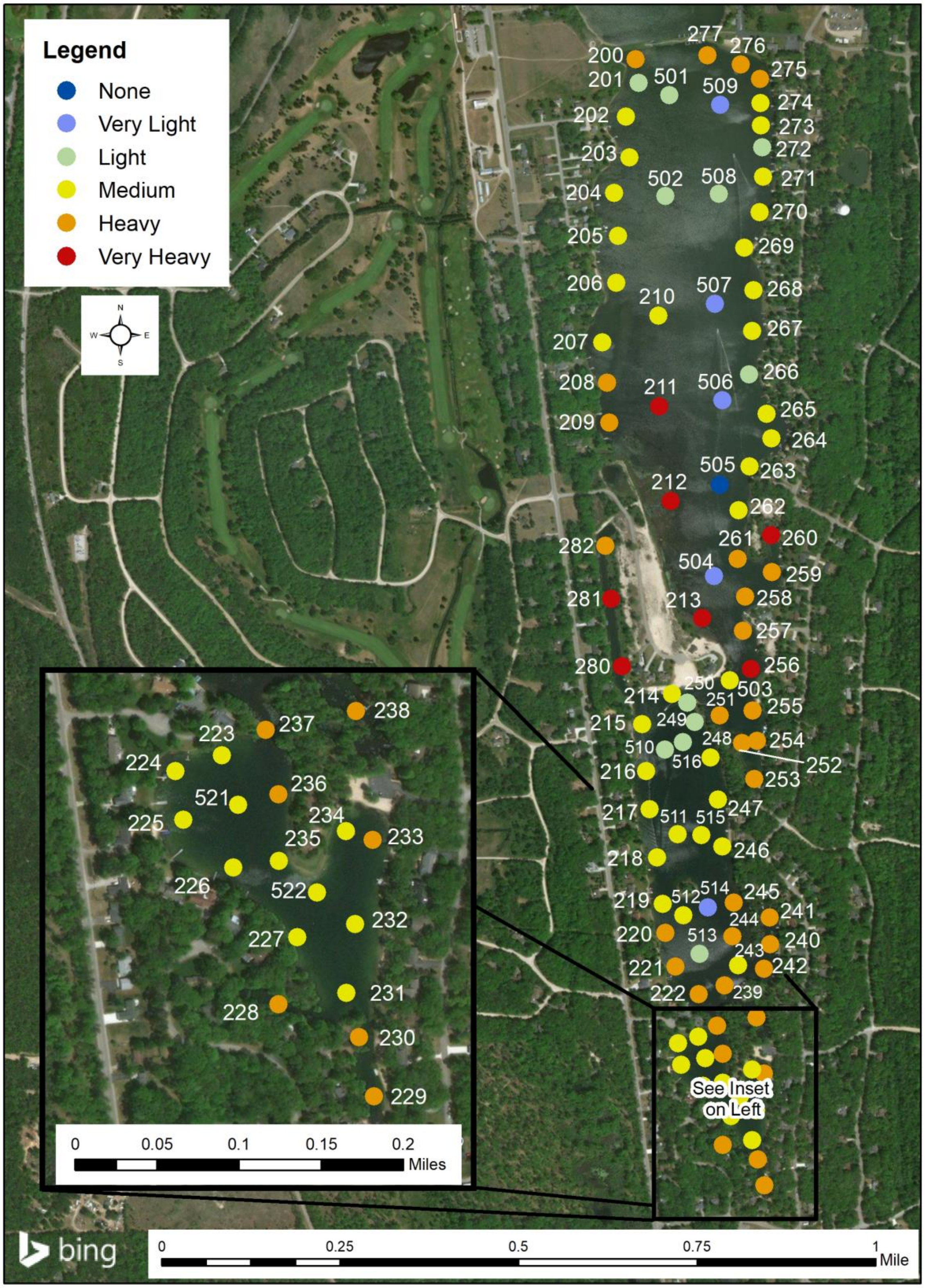

Figure 8 – Late season survey (August 19th) vegetation 3D Density (a function of all species observed vegetation density, distribution and height observations).

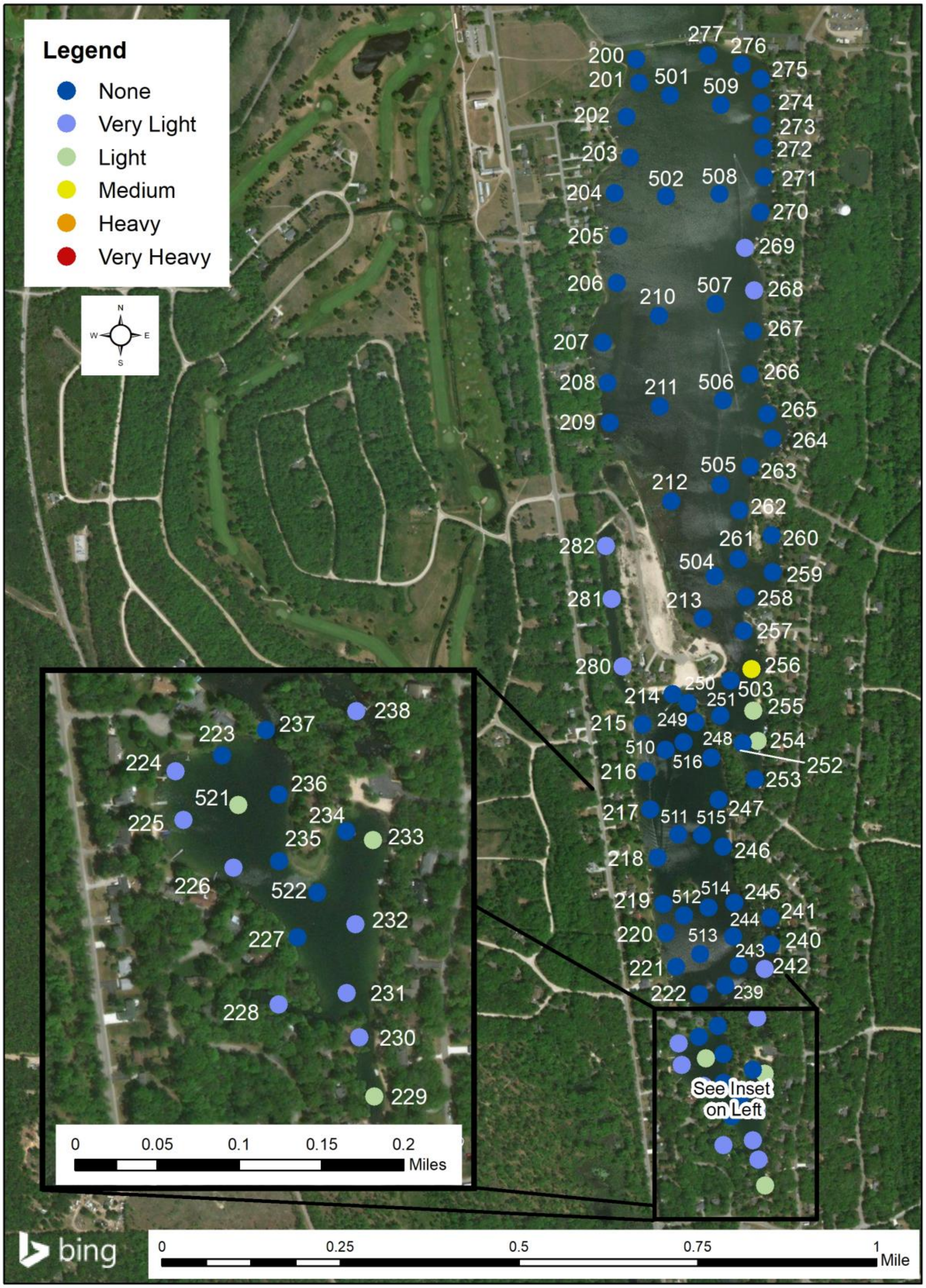

Figure 9 – Late season (August 19th) Eurasian Watermilfoil and Hybrids coverage (a combination of the LakeScanTM density and distribution observations).

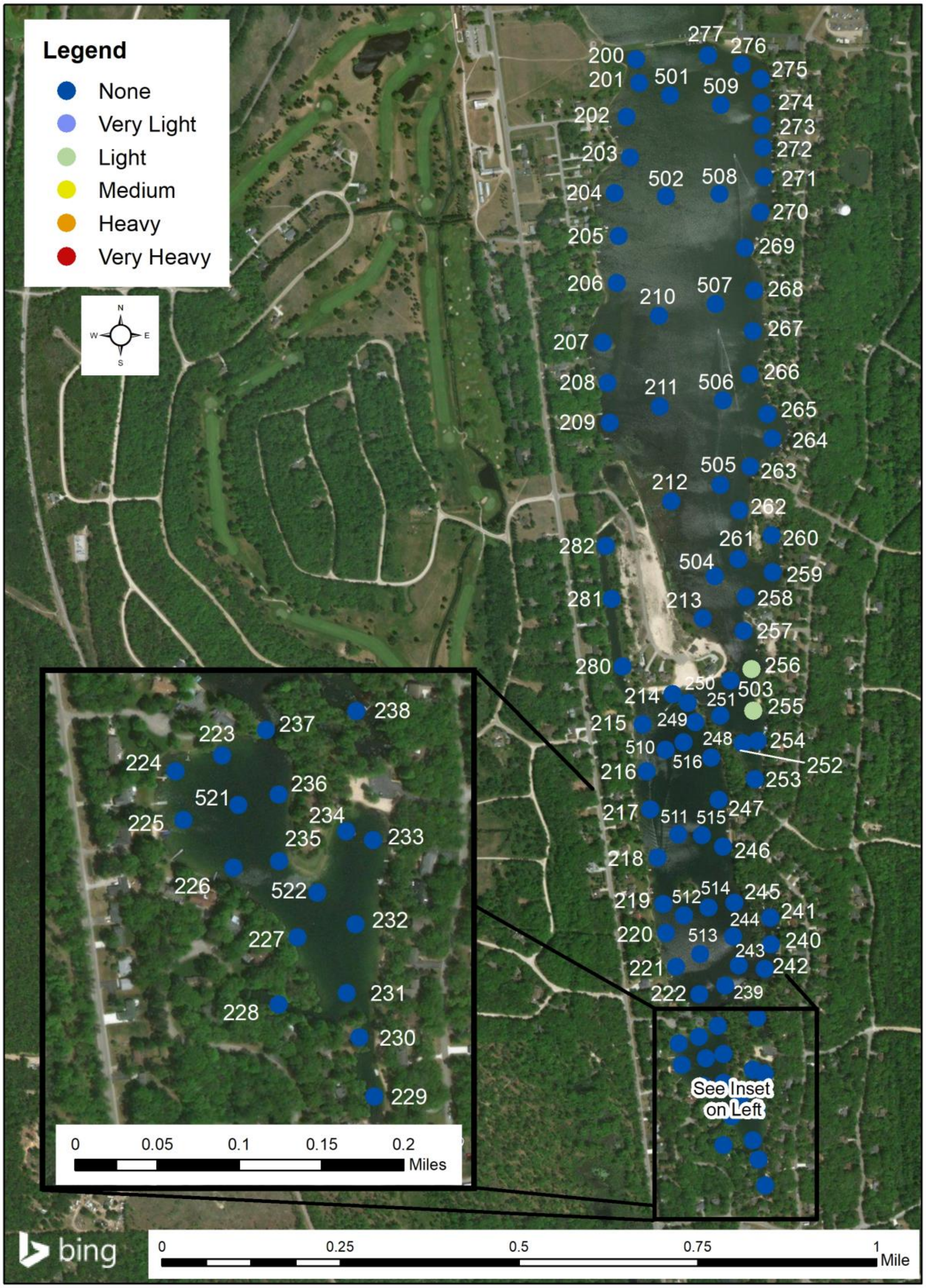

Figure 10 – Late season (August 19th) Starry Stonewort coverage.

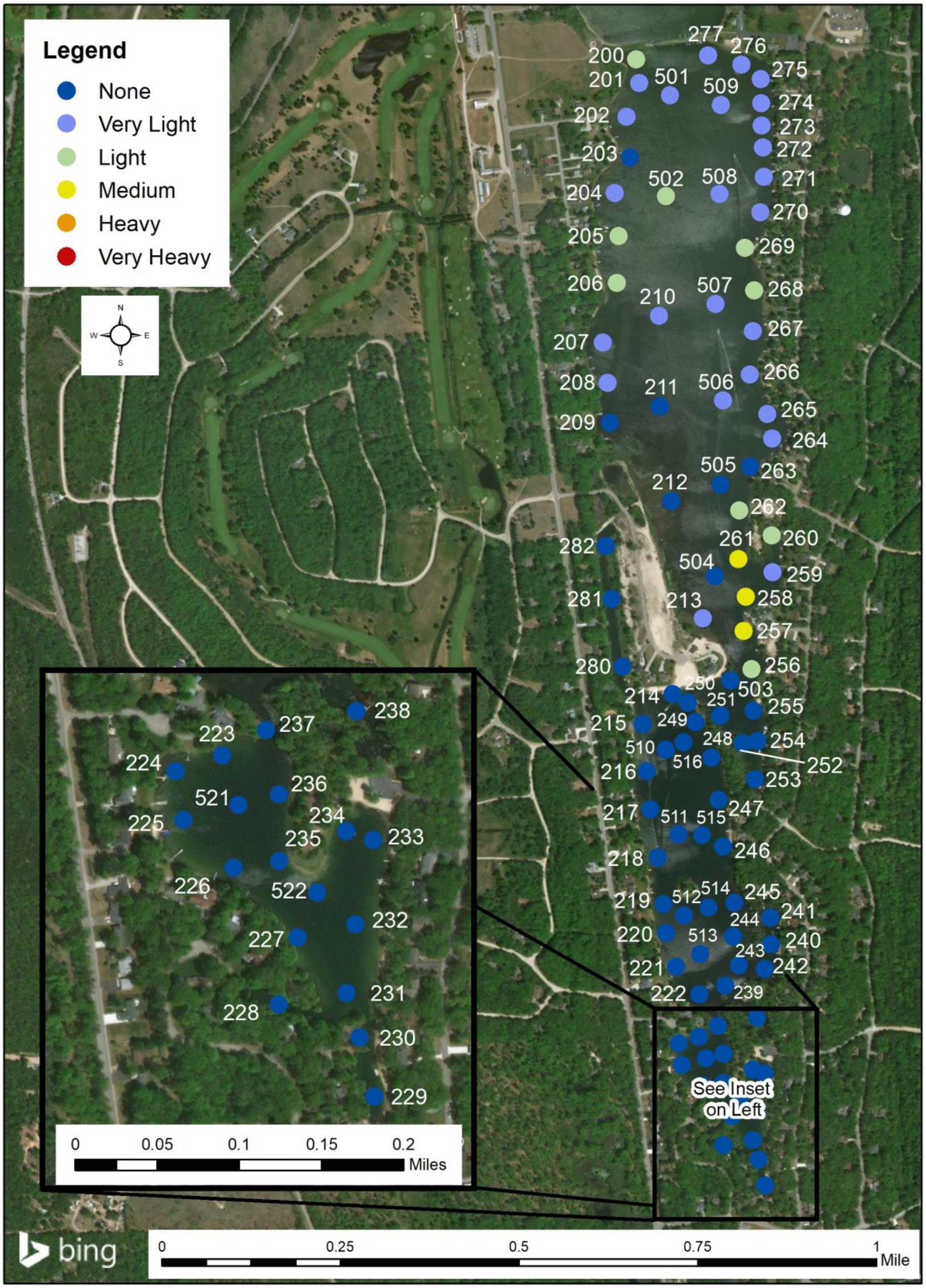

Figure 11 – Late season (August 19th) Variable Watermilfoil coverage.

4.3. Summary Observations for Early & Late Season Surveys

Aquatic plant species observed during the 2020 vegetation surveys are identified in Table 2. The 'T Value' in this table is a qualitative value ranging from 1 to 4 that is assigned to each species, where 1 represents an undesirable species highly likely to require treatment and 4 represents a desirable species highly unlikely to require treatment (thus, 1 is 'bad'; 4 is 'good'). 'Frequency' represents the percentage of survey sites (AROS) where a given species was found. 'Coverage' represents the lake bottom spatial cover observed for each species, represented as a percentage of available area. 'Dominance' represents the degree to which a species is more numerous than its competitors. Figure 12 illustrates dominance by T Value categories for early and late season surveys over the last few years.

Table 2- Aquatic Plant Species Observed in 2020.

Common Name	T Value	Frequency		Coverage		Dominance	
		Early '20	Late '20	Early '20	Late '20	Early '20	Late '20
Bull Rush	4	0.0%	2.0%	0.0%	0.2%	0.0%	0.2%
Chara	4	90.9%	91.9%	16.4%	15.1%	28.0%	18.0%
Clasping Leaved Pondweed	3	55.6%	64.6%	5.6%	7.1%	9.6%	8.5%
Common Bladderwort	3	26.3%	30.3%	2.0%	1.9%	3.3%	2.3%
Elodea	2	4.0%	1.0%	0.5%	0.1%	0.9%	0.1%
Eurasian Watermilfoil Hybrid	1	15.2%	20.2%	1.2%	1.8%	2.0%	2.1%
Flat Stem Pondweed	2	15.2%	24.2%	1.8%	1.8%	3.0%	2.1%
Floating Leaf Pondweed	3	5.1%	3.0%	0.4%	0.2%	0.8%	0.2%
Fries Pondweed	4	2.0%	4.0%	0.1%	0.3%	0.2%	0.3%
Green/Variable Watermilfoil	2	23.2%	37.4%	2.0%	3.5%	3.4%	4.1%
Illinois Pondweed	3	0.0%	1.0%	0.0%	0.1%	0.0%	0.1%
Naiad	2	10.1%	85.9%	1.2%	10.5%	2.0%	12.5%
Purple Loosestrife (sub)	3	0.0%	17.2%	0.0%	1.1%	0.0%	1.3%
Rush	4	24.2%	36.4%	2.0%	3.6%	3.3%	4.3%
Sagittaria	4	1.0%	1.0%	0.1%	0.1%	0.1%	0.1%
Sago Pondweed	2	38.4%	43.4%	3.2%	3.9%	5.4%	4.6%
Spadderdock	2	6.1%	23.2%	0.8%	3.3%	1.3%	3.9%
Starry Stonewort	1	3.0%	2.0%	0.4%	0.3%	0.6%	0.3%
Thin Leaf Pondweed	4	0.0%	4.0%	0.0%	0.4%	0.0%	0.5%
Variable Pondweed	3	90.9%	93.9%	10.5%	11.0%	17.8%	13.2%
Water Shield	3	1.0%	0.0%	0.1%	0.0%	0.1%	0.0%
Waterlily	2	57.6%	76.8%	8.2%	12.6%	14.0%	15.0%
Wild Celery	2	24.2%	50.5%	2.4%	5.3%	4.1%	6.3%

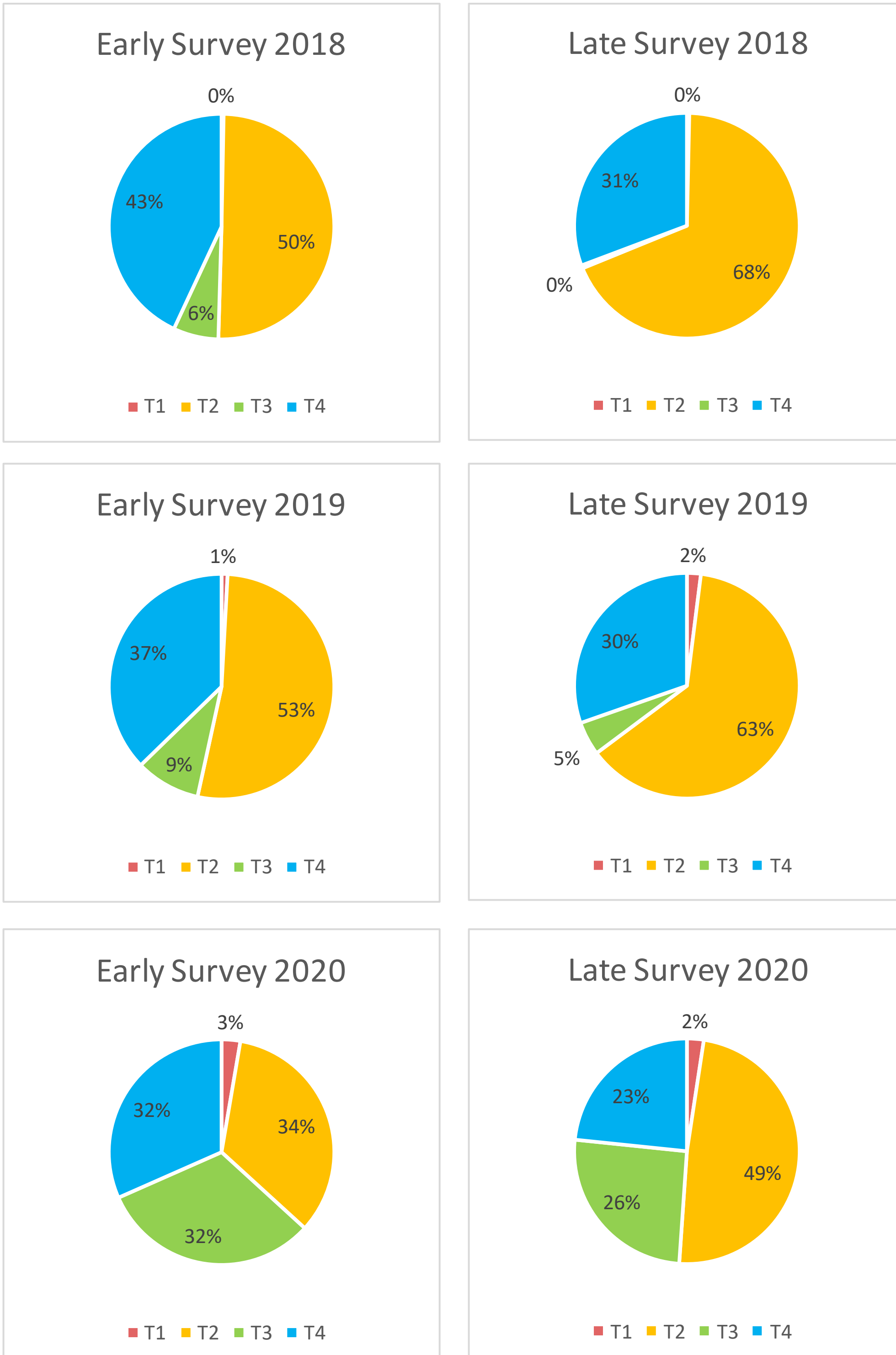

Figure 12– Distribution of aquatic plant coverage by T Value comparing early-season and late-season surveys from 2018 – 2020.

4.4. LakeScan^{TM} Metrics

Six important metrics for defining lake conditions are presented here for the 2020 vegetation surveys (Table 3).[4] Early and late season scores are averaged for a yearly score and compared against a management goal for each metric. Management goals are based on median Michigan lake values (Shannon Biodiversity Index and Shannon Morphology Index), scientific literature (Floristic Quality Index), and professional judgement (Recreational Nuisance Presence and Algal Bloom Risk). Green shading in Table 3 highlights scores meeting management goals, while yellow and red highlights represent scores needing improvement. A total lake score is presented as a summary of the provided category scores: "red" scores receive 0 points, "yellow" scores receive 1 point, and "green" scores receive 2 points. The Floristic Quality Index is double weighted, and the total is then refit to a 1 to 10 scale for more simplified scaling and interpretation of the overall lake condition (1 being poor; 10 being excellent). Descriptions of each metric follow below:

- Species Richness – the number of aquatic plant species present in the lake. More species are generally indicative of a healthier ecosystem, but not all species are desirable.
- Shannon Biodiversity Index – a measure of aquatic plant species diversity and distribution evenness, indicative of the plant community's stability and diversity. Also known as the Shannon Expected Number of Species.[5]
- Shannon Morphology Index – a measure of aquatic plant morphology type diversity and distribution evenness, indicative of fish and macroinvertebrate habitat quality. This is calculated using morphology types instead of species.
- Floristic Quality Index[6] – a measure of the distribution of desirable aquatic plants. This index is used by Midwestern states for aquatic habitats, with higher scores indicative of increased biodiversity and a positive ratio of desirable versus undesirable aquatic plant species.
- Recreational Nuisance Presence – the percentage of survey sites that identified aquatic plants inhibiting recreational activities.
- Algal Bloom Risk – a calculated algal bloom risk level based on the characteristics of the lake's watershed. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms because these land uses contribute more phosphorus to receiving waters than grasslands or forests.

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[4] Metrics used in past LakeScan^{TM} reports are included in Appendix A.

[5] Hill, M. O. (1973). Diversity and evenness: a unifying notation and its consequences. *Ecology*, 54(2), 427-432.

[6] Nichols, S. A. (1999). Floristic quality assessment of Wisconsin lake plant communities with example applications. *Lake and Reservoir Management*, 15(2), 133-141.

Table 3 – 2020 LakeScan™ Metric Results.

LakeScan™ Metric	Score Range	2020 Early Season	2020 Late Season	2020 Average	Management Goal
Species Richness	5 - 30	19	22	20.5	n/a
Shannon Biodiversity Index	1 -15	9.5	11.6	10.6	> 6.7
Shannon Morphology Index	1 - 10	8.3	9.3	8.8	> 5
Floristic Quality Index	1 - 40	27.9	26.6	27.3	> 20
Recreational Nuisance Presence	0 - 100%	5%	27%	16%	< 10%
Algal Bloom Risk	Low - High	n/a	n/a	Low	Low
Total Lake Score	1 - 10	n/a	n/a	9.3	n/a

*n/a = not applicable

Overall, Cedar Lake South exhibited scores meeting management goals set for the Shannon Biodiversity Index, Shannon Morphological Index, and Floristic Quality Index. These scores indicate a diverse plant community harboring good habitat for fish and macroinvertebrates. The consistently high Floristic Quality Index results indicate a higher distribution of desirable, native plant species and a lower distribution of undesirable species, such as Eurasian watermilfoil. Recreational Nuisance Presence met optimal management goals of less than 10% in the early-season survey (5%) but did not meet management goals in the late-season survey (27%). Variable watermilfoil and variable pondweed created many of the nuisance conditions observed during the late-season survey. These species exhibited growth that could impede boating activities due to the location and height in the water column. The Algal Bloom Risk rating for Cedar Lake South is “low” reflecting the low proportion of agricultural and urban land use draining to the lake.

The 5-year historical trends for Floristic Quality Index (FQI) scores and target species coverage values are presented in Figures 13 and 14, respectively. Trendlines shown are calculated using Microsoft Excel’s linear trendline function. Positive trends for the FQI scores indicate increases in desirable plant species and/or decreases in undesirable plant species. Negative trends for the target species coverage values indicate that herbicide treatment and other lake management activities are showing success.

Over the last five years, the FQI score for Cedar Lake South has exhibited a positive trend, which indicates an increase in desirable, native plant species and a decrease in undesirable, non-native plant species (Figure 13). For the last five years, Cedar Lake South’s FQI score exceeded the management goal of 20. Furthermore, Cedar Lake South’s invasive species coverage of Ebrid watermilfoil and starry stonewort has exhibited no significant trend for the last five years (Figure 14), suggesting that management activities are not reducing invasive species population but could be suppressing any additional invasive species population expansion, since no significant increase has been observed. However, variable watermilfoil coverage has exhibited an increasing trend over the last five years (Figure 14) suggesting that management activities targeting this species has not effectively managed population expansion.

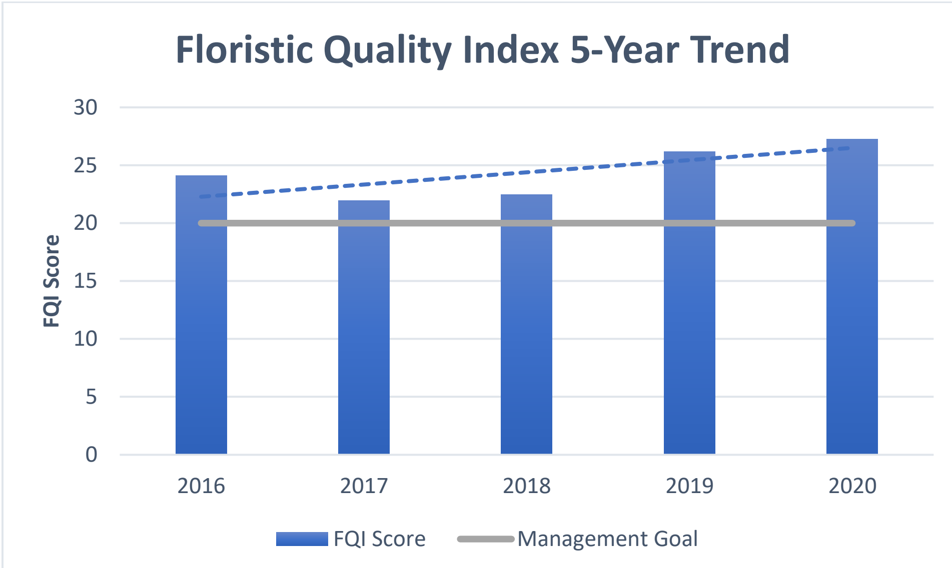

Figure 13 – Floristic Quality Index 5-Year Trend.

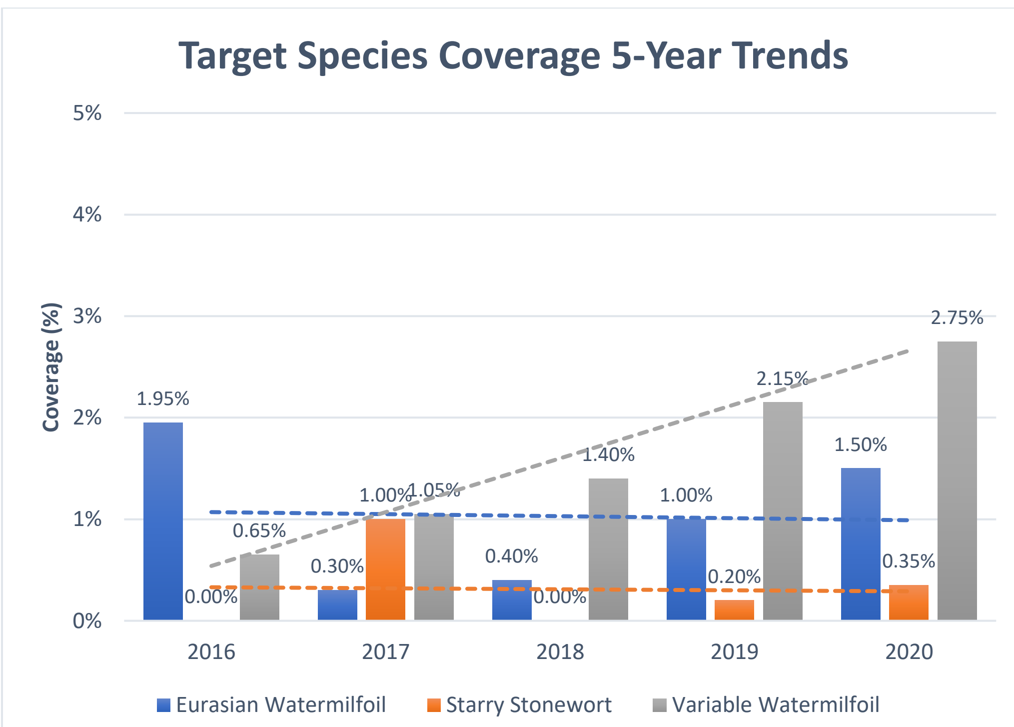

Figure 14 – Target Species Coverage 5-Year Trends.

5.0. Lake Management

There are several species that typically become a nuisance in Michigan's inland lakes (see Appendix B). These species are usually targeted for very selective control to prevent them from becoming an aesthetic or recreational nuisance and to protect desirable plants that are part of healthy lake ecosystems. This section includes an analysis on nuisance conditions in the lake, as well as a description of any management actions that were taken in 2020. Figure 15 shows the coverage changes of targeted species over both surveys. Simplified herbicide treatment maps are included in Figures 16-18, showing all treatments conducted on Cedar Lake South in 2020. Information for Figures 16-18 was obtained through the herbicide applicator. Copies of the herbicide applicator treatment maps are included in Appendix D.

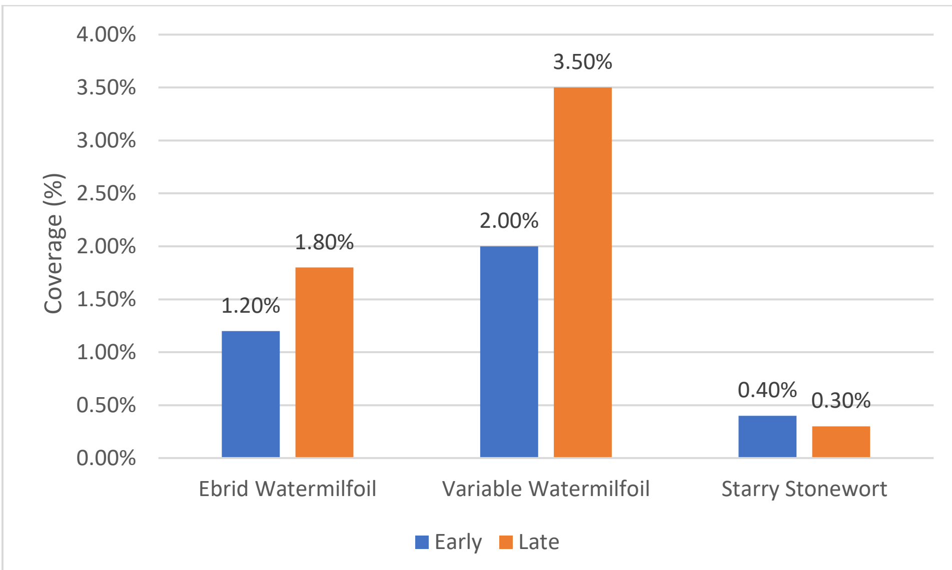

Figure 15 – Changes in coverage across both 2020 surveys for targeted species

Ebrid watermilfoil coverage slightly increased from early to late-season surveys, while starry stonewort coverage did not change substantially.

It's important to note that Michigan's Department of Environment, Great Lakes, and Energy (EGLE) restricts the timing of herbicide applications of copper products on Cedar Lake South to after June 10th to limit impacts on fish spawning. Also, treatments cannot be conducted on areas of the lake where water temperatures meet or exceed 75°F. Historic mussel surveys conducted between 1900 and 1973 indicated the presence of an endangered mussel species, the Eastern Pondmussel (*Ligumia nastua*), in the southern portion of Cedar Lake South in 1953. However, during recent surveys conducted between 1998 and 2015, no presence of this species was found[7]. Since there is historical presence of this endangered mussel species, EGLE may include an exclusion zone for copper and Hydrothol based products for the southern half of Cedar Lake South within the permit restrictions, concurrent with 2020

[7] Badra, P. J. (2017). Status Assessment of Unionid Mussel Species in the Huron-Manistee National Forest. *Michigan Natural Features Inventory.*

restrictions. It might be necessary to submit a permit amendment in 2021, similar to the one submitted in 2020, to allow for starry stonewort treatment within this exclusion zone.

EGLE restrictions limit native emergent and floating leaf aquatic plant control to a 40-foot x 40-foot area for swimming and boat launching, and a 20-foot-wide boat lane to reach open water per residentially developed parcel. EGLE also limits treatment of native algae and native submersed aquatic plants to 100 feet of frontage out to the 5-foot depth contour or 100 feet (whichever is closer to shore) per residential property. However, treatments of non-native floating or emerging aquatic plant species in excess of 40-foot x 40-foot area and treatments of non-native submersed algae and aquatic plants exceeding 100 feet of frontage (also along undeveloped shoreline and in offshore areas) is approved using selective application methods and timing to prevent impacts to non-target native species. This means that offshore treatments greater than 100-feet from shore are limited to only those non-native (invasive) species which includes Ebrid watermilfoil, curly-leaf pondweed and starry stonewort.

It might be necessary to submit permit amendments to allow for selective treatment of variable watermilfoil (considered a native species in Michigan), however, there is no assurance that these efforts will be successful as treatment restrictions tighten. Because of the treatment restrictions on variable watermilfoil and the considerable nuisance conditions this species poses for Cedar Lake South, it may be feasible to explore harvesting options to allow for boat passage in critical areas of the lake. Harvesting can be very expensive and may not provide long-term control due to issues such as plant fragmentation.

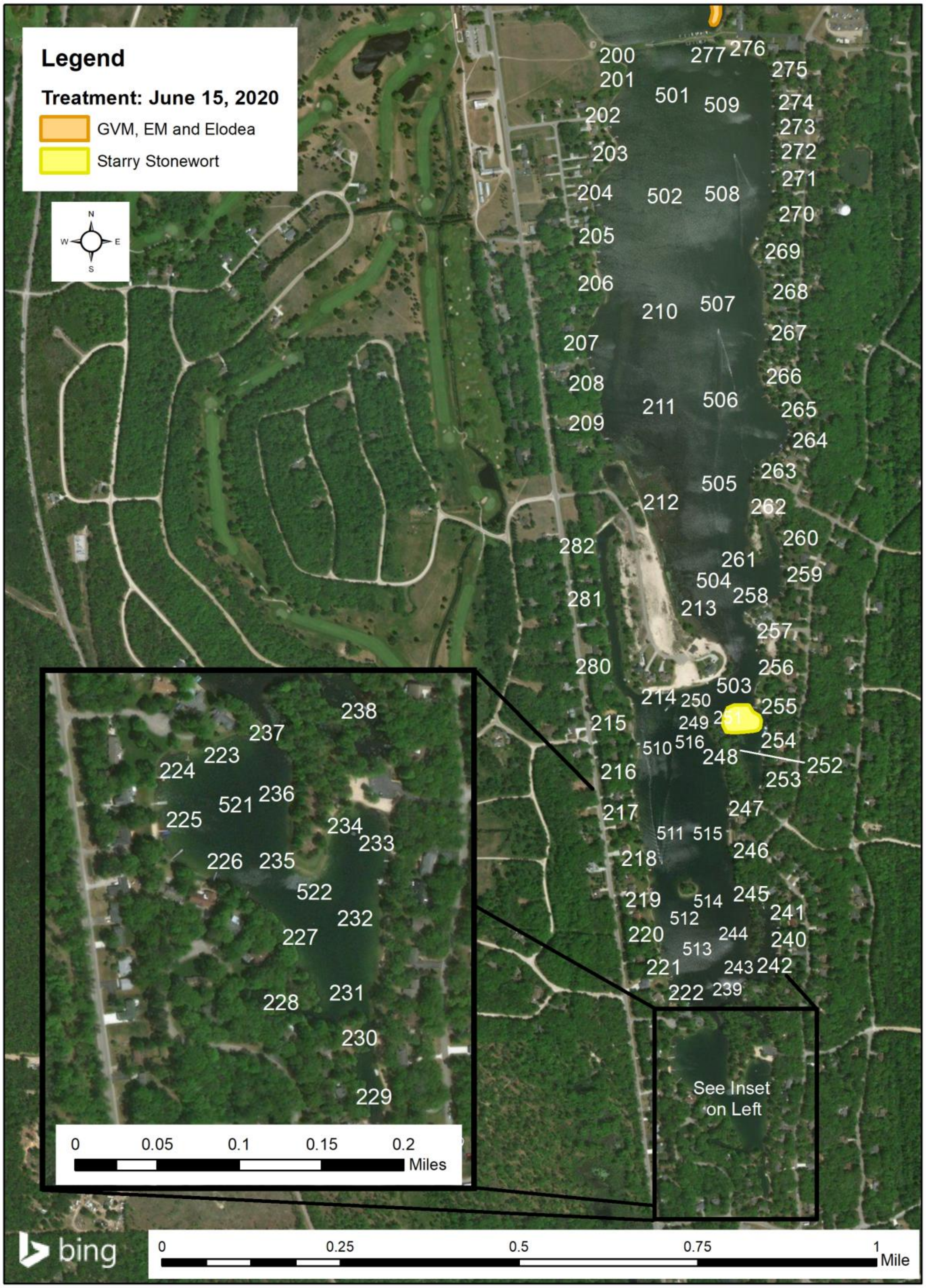

Figure 16 – June 15th, 2020 Herbicide Application Map.

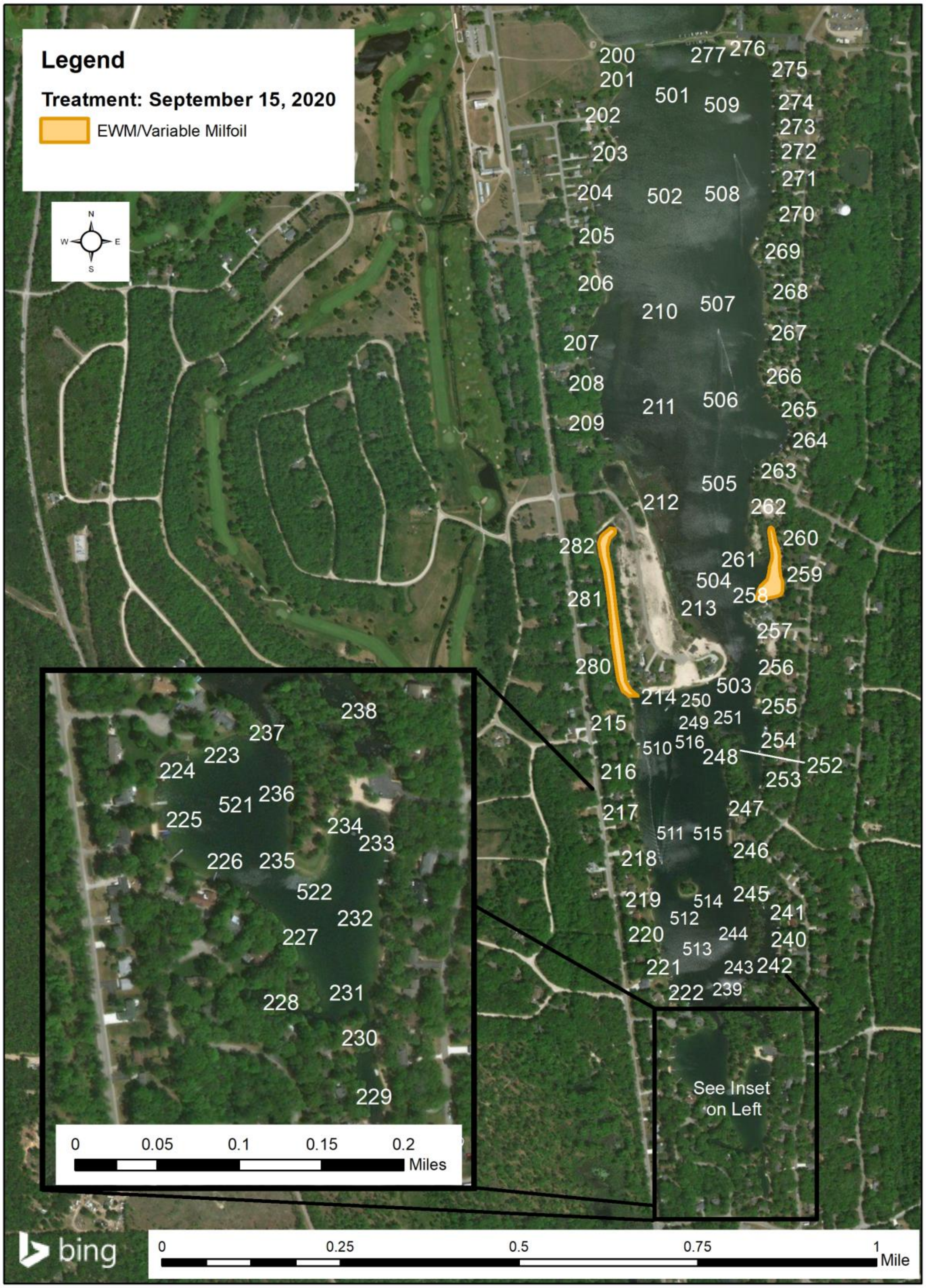

Figure 17 – September 15th, 2020 Herbicide Application Map

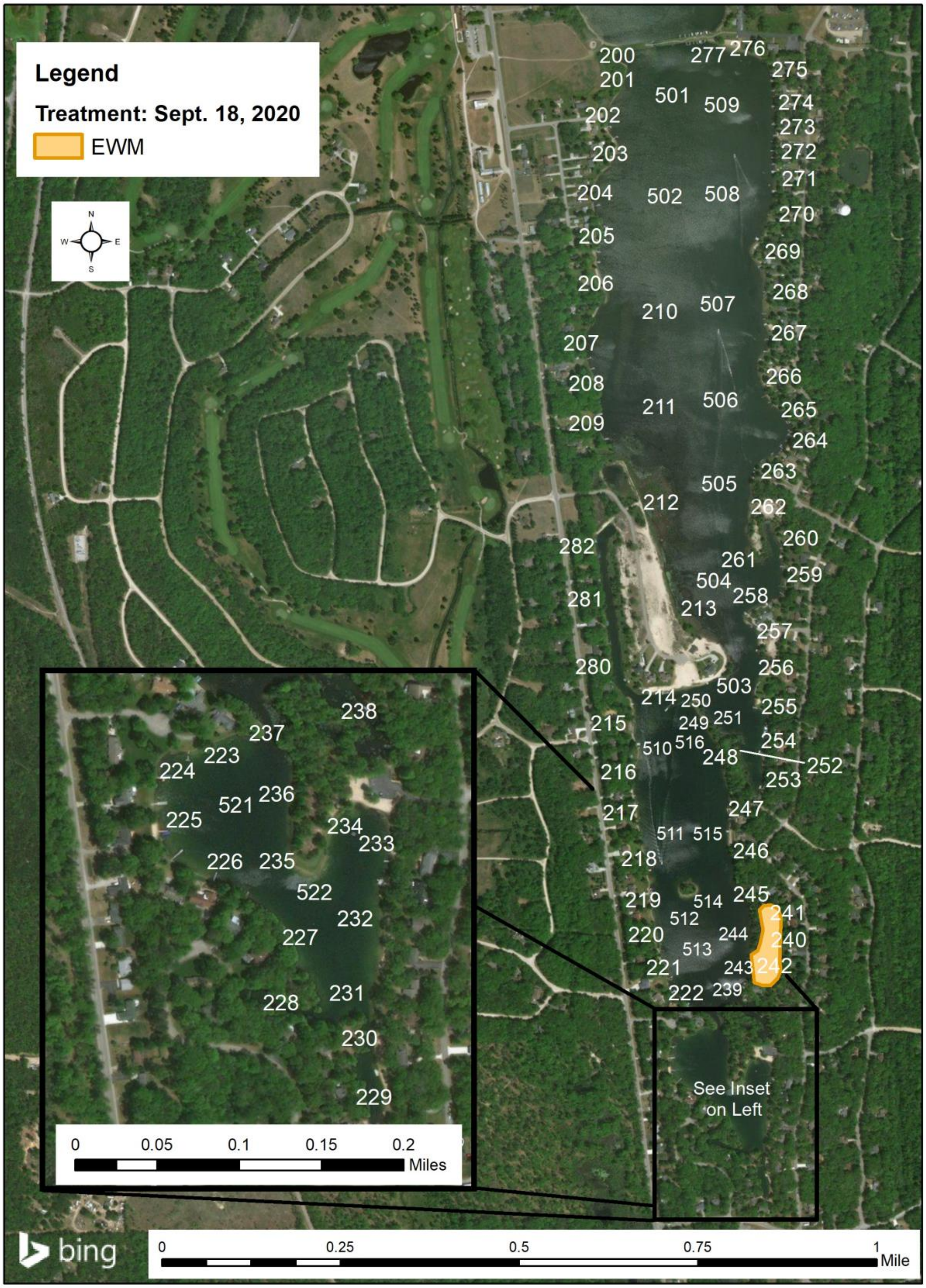

Figure 18 – September 18th, 2020 Herbicide Application Map

5.1. Future Management Recommendations

Continued LakeScan™ vegetation monitoring twice a year (once during the spring-early summer and another during the late summer) to assess aquatic vegetation during the growing season is recommended. Information collected during these surveys allows lake managers to readily and consistently identify successful lake management activities, highlight potential issues requiring intervention, and gather critical information necessary to improve the lake's ecological and recreational conditions.

Continued Ebrid watermilfoil management is recommended. While a slight increase in Ebrid watermilfoil coverage was observed from the early-season to late-season survey in 2020, the trend for the last five years show no change in coverage, suggesting that while management activities do not appear to be signifcantly decreasing Ebrid watermilfoil coverage, Ebrid watermilfoil coverage has not increased. This suggests that management activities may be suppressing the spread and coverage increase of Ebrid watermilfoil.

Native aquatic plants, such as variable watermilfoil, tend to create recreational nuisances on Cedar Lake South. Variable watermilfoil was observed creating late-season recreational nuisances prompting treatment in September 2020 targeting select areas. Locations that received the September treatment will be carefully tracked in the 2021 surveys to determine success for relieving nuisance conditions. These 2021 observations will guide future treatment considerations that balance native plant community diversity as well as recreational and navigational management needs. Because of EGLE restrictions on chemical treatment for native aquatic plant nuisance conditions, it may be feasible to explore other options, such as harvesting, to alleviate nuisance variable watermilfoil conditions in the future, which could require additional EGLE permitting.

6.0. Appendices

6.1. Appendix A: Past LakeScan™ Metrics

Past LakeScan™ metrics are included in Table A1 below for reference. Lake characteristics for defining aquatic plant conditions are presented here for the 2020 annual findings on the lake health. 'Index' metrics are scores indicative of different aspects of lake health. The range of possible index scores is 1 to 100 with a higher score indicating better conditions in relation to management goals assigned for your lake. Annual metrics are also compared here to previous years' metrics and include:

- BioD60 T2+ Index – a measure of the health of the plant community in the lake
- MorphoD26 Index – reflects the habitat value of vegetation for fish and other aquatic animals
- PNL Index2 – provides a value depicting the density and distribution of nuisance vegetation in the lake

Table A1 – Past LakeScan™ Metrics.

Year	BioD60 T2+	MorphoD26	PNL Index2
2020	79	83	64
2019	82	83	91
2018	53	78	86
2017	43	52	88
2016	43	54	71

Using the Shannon Biodiversity Index in place of BioD60 as a biodiversity metric:

K&A has a few concerns with the BioD60 index that led to us introducing a Shannon Biodiversity Index. Our primary concern lies with scientific justification. Any claims or methods K&A uses in its reports must have a solid scientific basis, and the best way to prove that this basis is in place for a given claim or method is to cite peer-reviewed work. The Shannon index has been used as a biodiversity metric in thousands of papers over the last few decades, and is a well-established tool in the field of ecology. To our knowledge, the BioD60 metric has not gone through a peer review process. Even if it proved to be an excellent metric for analyzing biodiversity, it is not used outside of reports produced by Dr. Pullman. In order for K&A to feel comfortable with its use, the onus would first be on Dr. Pullman to introduce it to the scientific world.

Our secondary concern with the BioD60 index lies with its functionality. Biodiversity indices are typically a combination of species richness (the number of different species present in an ecosystem) and species evenness (how evenly these species are distributed throughout the ecosystem). For example, an ecosystem with 20 species would have a very low evenness if one species accounted for 99% of the individuals in the ecosystem. Expanding on this point, it would be difficult to claim that a lake had good biodiversity if 99% of its plants were milfoil, no matter how many other species comprised the remaining 1%. Dr. Pullman created the BioD60 metric in part because he felt that the commonly used Shannon index weighed evenness too heavily. However, in K&A's opinion, BioD60 has skewed things back too far towards species richness, to the point where species richness is almost entirely responsible for the BioD60 score (see Figure A1 below).

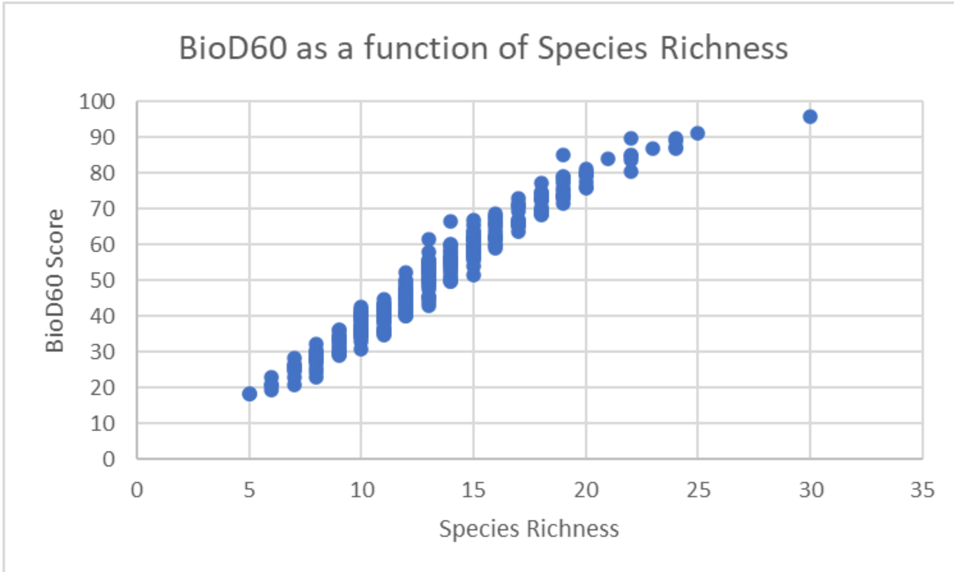

Figure A1 – BioD60 graphed as a function of Species Richness.

6.2. Appendix B: Common Aquatic Invasive Species

Eurasian Watermilfoil and Hybrids (Ebrids):

Background: Anecdotal evidence suggests that hybrid milfoil has been found in Michigan inland lakes for a long time (since the late 1980's). University of Connecticut professor Dr. Don Les was the first to determine that there were indeed, Eurasian watermilfoil and northern watermilfoil hybrids in Michigan based on samples sent to his Connecticut lab by Dr. Douglas Pullman, Aquest Corp. in 2003. Experience has proven that it is usually not possible to determine whether the milfoil observed is either Eurasian or hybrid genotype. However, because they play such similar roles in lake ecology, they are simply "lumped together" and referred to collectively as Ebrid watermilfoil. Ebrid watermilfoil is a very common nuisance in many Michigan inland lakes.

Management: Lake disturbance, such as weed control, unusual weather, and heavy lake use can destabilize the lake ecosystem and encourage the sudden nuisance bloom of weeds, like ebrid watermilfoil. Ebrid watermilfoil is an ever-present threat to the stable biological diversity of the lake ecosystem. Species selective, systemic herbicide combinations have been used to suppress the nuisance production of ebrid watermilfoil and support the production of a more desirable flora. However, it is becoming much more resistant to herbicidal treatment and herbicide resistant Eurasian watermilfoil and hybrid watermilfoil has been observed in many lakes throughout the Midwest.[8,9] Continued chemical

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[8] Berger, S. T., Netherland, M. D., & MacDonald, G. E. (2015). Laboratory documentation of multiple-herbicide tolerance to fluridone, norflurazon, and topramazone in a hybrid watermilfoil (*Myriophyllum spicatum× M. sibiricum)* population. Weed Science, 63(1), 235-241.

[9] Netherland, M. D., & Willey, L. (2017). Mesocosm evaluation of three herbicides on Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid watermilfoil (*Myriophyllum spicatum x Myriophyllum sibiricum*): Developing a predictive assay. J. Aquat. Plant Manage, 55, 39-41.

applications can select for herbicide resistant plants, resulting in hybrid watermilfoil.[10] Some research suggests this resistance can be defeated with the use of microbiological system treatments. Milfoil community genetics are dynamic and careful monitoring is needed to adapt to the expected changes in the dominance of distinct milfoil genotypes. Some of these genotypes may be more herbicide resistant than others and treatment strategies must be adjusted to remain effective in different parts of the lake.

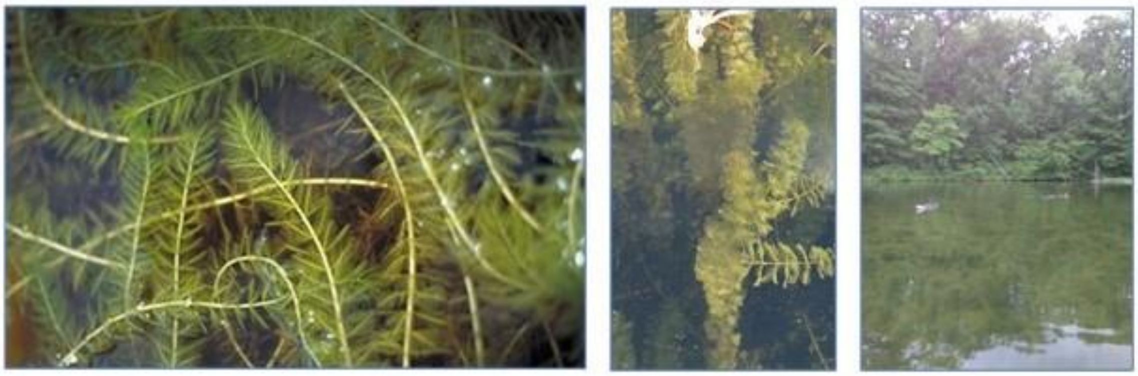

Figure B1: Example Eurasian Watermilfoil and Hybrids images from the 2019 LakeScanTM field crew.

Starry Stonewort

Background: Starry stonewort, a macroalgae native to northern Eurasia, invaded North American inland lakes after becoming established in the St. Lawrence Seaway/Great Lakes system. Though not positively identified in a Michigan inland lake until 2006, by Aquest Corporation in Lobdell Lake, Genesee County, starry stonewort has likely been present in Michigan's inland lakes since the late 1990's. Since then, this invasive species has spread throughout Michigan. Able to spread by both fragmentation and asexual reproduction, starry stonewort has thrived in Michigan's high-quality oligotrophic and mesotrophic lakes, particularly those with marl sediments. Once established, this opportunistic species will bloom and crash and impose a very significant and deleterious impact on many ecosystem functions. Bloom and crash events are unpredictable and can happen at any time of the year. In some years starry stonewort can become a horrendous nuisance while it can be inconspicuous in others. It can comingle with other similar species and be very difficult to find when it is not blooming.

Management: Starry stonewort is capable of growing to extreme nuisance levels and can significantly impact important ecosystem functions. This species is difficult to control due to its asexual reproductive structures (bulbils) which embed in lake sediments.[11] While many strategies have been employed to manage starry stonewort, no single strategy has emerged as a panacea for controlling infestations.

Diver-assisted suction harvesting (DASH) or diver-assisted hand-pulling of small starry stonewort infestations could reduce populations over time.[12] While these methods can be effective and have high

[10] Netherland and Willey, 2017
[11] Glisson, W. J., Wagner, C. K., McComas, S. R., Farnum, K., Verhoeven, M. R., Muthukrishnan, R., & Larkin, D. J. (2018). Response of the invasive alga starry stonewort (*Nitellopsis obtusa*) to control efforts in a Minnesota lake. Lake and Reservoir Management, 34(3), 283-295.
[12] Glisson et al., 2018.

specificity, they are expensive, labor-intensive strategies that require long-term commitment.[13] These strategies may not be viable for large-scale infestations, however, due to their labor-intensive nature and their potential for increasing distribution of the target plant species through fragmentation during removal.

Starry stonewort chemical treatments using copper-, diquat- and endothall-based algaecides have produced mixed results and long-term management has yet to be achieved using chemical biocides alone.[14] While starry stonewort is susceptible to most selective algaecides, the dense mats of vegetation are very difficult to penetrate and provide reasonable biocide exposure. Consequently, multiple algaecide applications may be required to "whittle down" dense starry stonewort growth if the mats reach sufficient height.

Figure B2: Example starry stonewort images from the 2019 LakeScan™ field crew.

6.3. Appendix C: Blue Green Algae

Blue green algae blooms are becoming increasingly common in Michigan. Blooms can appear as though green latex paint has been spilled on the water, or resemble an oil slick in enclosed bays or along leeward shores. Blue green algae blooms are usually temporal events and may disappear as rapidly as they appear. Blue green algae blooms are becoming more common for a variety of reasons; however, the spread and impact of zebra mussels has been closely associated with blooms of blue green algae.

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[13] Larkin, D.J., Monfils, A.K., Boissezon, A., Sleithd, R.S., Skawinski, P.M., Welling, C.H., Cahill, B.C., and Karold, K.G. 2018. Biology, ecology, and management of starry stonewort (*Nitellopsis obtusa*; Characeae): A Red-listed Eurasian green alga invasive in North America. https://doi.org/10.1016/j.aquabot.2018.04.003

[14] Pokrzywinski, K. L., Getsinger, K. D., Steckart, B., & Midwood, J. D. (2020). Aligning research and management priorities for *Nitellopsis obtusa* (starry stonewort).

Figure A1: Example blue green algae images from the 2019 LakeScan™ field crew.

Blue green algae are really a form of bacteria known as cyanobacteria. They are becoming an important issue for lake managers, riparian property owners and lake users because studies have revealed that substances made and released into the water by some of these nuisance algae can be toxic or carcinogenic. They are known to have negative impacts on aquatic ecosystems and can potentially poison and sicken pets, livestock, and wildlife. Blue green algae can have both direct and indirect negative impacts on fisheries. Persons can be exposed to the phytotoxins by ingestion or dermal absorption (through the skin). They can also be exposed to toxins by inhalation of aerosols created by overhead irrigation, strong winds, and boating activity.

Approximately one half of blue green algae blooms contain phytotoxins, and this is determined through lab testing. It is recommended that persons not swim in waters where blue green algae blooms are conspicuously present. Specifically, persons should avoid contact with water where blooms appear as though green latex paint has been spilled on the water, or where the water in enclosed bays appears to be covered by an "oil slick". Pets should be prevented from drinking from tainted water. Since blue green algae toxins can enter the human body through the lungs as aerosols, it is suggested that water containing obvious blue green algae blooms not be used for irrigation in areas where persons may be exposed to it.

Blue green algae are not very good competitors with other, more desirable forms of algae. They typically bloom and become a nuisance when resources are limiting or when biotic conditions reach certain extremes. Some of the reasons that blue green algae can bloom and become noxious are listed below:

TP and TN: The total phosphorus (TP) concentration in a water resource is usually positively correlated with the production of suspended algae (but not rooted plants, i.e. seaweed). Very small amounts of phosphorus may result in large algae blooms. If the ratio of total nitrogen (TN) to total phosphorus is low (<20), suspended algae production may become nitrogen limited and noxious blue green algae may dominate a system because they are able to "fix" their own nitrogen from atmospheric sources. Other common and desirable algae are not able to do this.

Free Carbon Dioxide: All plants, including algae, use carbon dioxide in photosynthesis. Alkalinity, pH, temperature, and the availability of free carbon dioxide are all closely related and inter-regulated in what can be referred to as a lake water buffering system. Concentrations of these key water constituents will shift to keep pH relatively constant. Carbon dioxide is not very soluble (think about the bubbles of carbon dioxide that escape soda pop). The availability of this essential substance can be in short supply in lake water. Many blue green algae contain gas “bubbles” that allow them to float upward in the water column toward the water surface where they can access carbon dioxide from the atmosphere. Consequently, blue green algae that can float have a competitive advantage in lakes where carbon dioxide is in low supply in the water. This is also why blooms form near the surface of the water.

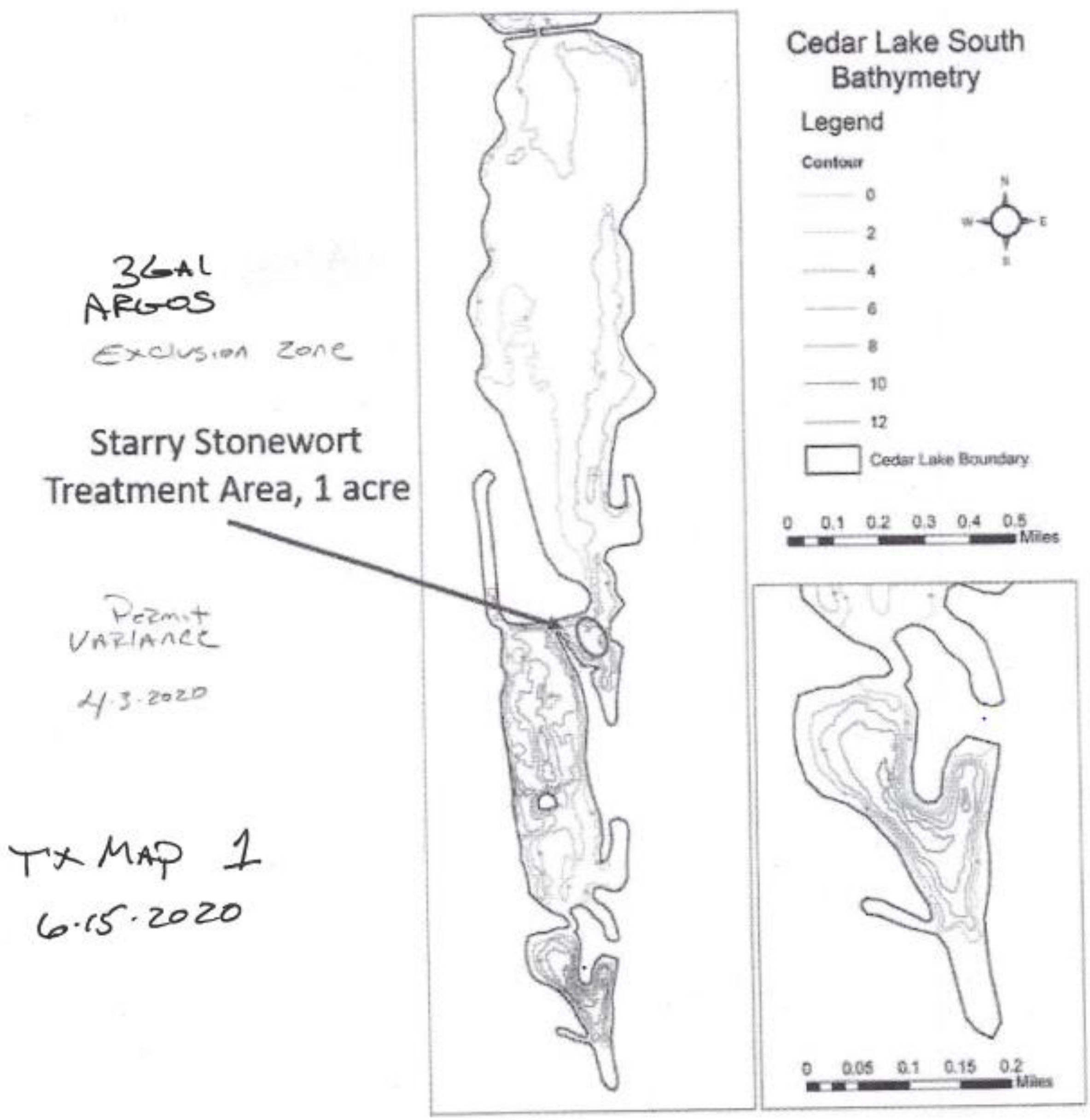
Biotic Factors: Zebra mussels and zooplankton (microscopic, free-floating animals) are filter feeding organisms that strain algae and other substances out of the lake water for food. Studies have shown that filter-feeding organisms often reject blue green algae and feed selectively on more desirable algae. Over time, and given enough filter feeding organisms, a lake will experience a net loss in “good” algae and a gain in “bad” blue green algae as the “good” algae are consumed and the “bad” algae are rejected back into the water column. This is one of the most disturbing factors associated with the invasion and proliferation of zebra mussel. Lakes that are full of zebra mussel may not support the production of “good” algae and experience a partial collapse of the system of “good” algae that are necessary to support the fishery.

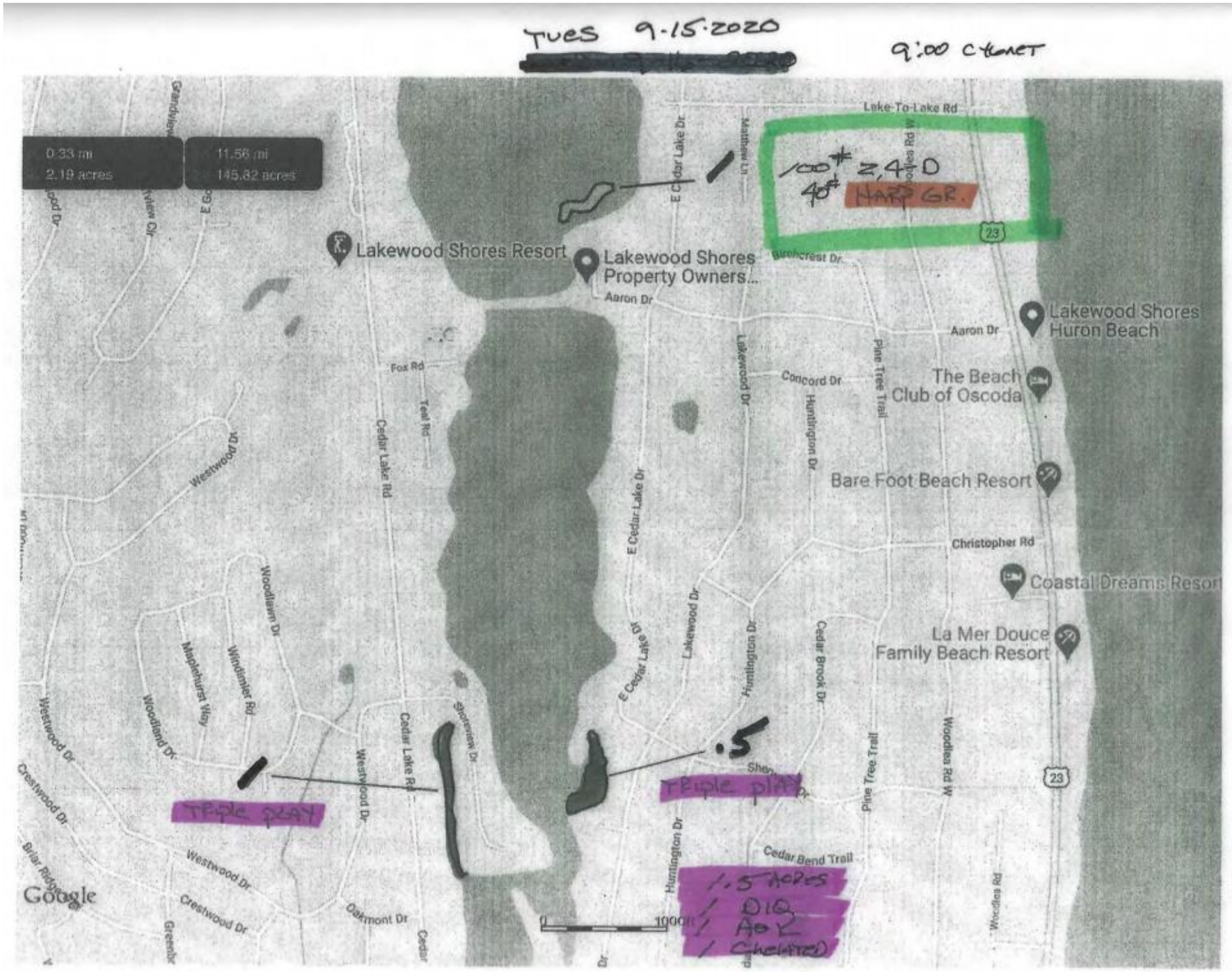
6.4. Appendix D: Herbicide Applicator Maps

Copies of the herbicide treatment maps obtained by the herbicide applicators are included below.

ANC9805707 Amendment 1

EGLE Approved Amendment 1 Treatment Map
Map 1 of 1




Tues 9.15.2020
[redacted]
0.33 mi
2.19 acres
11.56 mi
145.82 acres
Lake-To-Lake Rd
Lakewood Shores Resort
Lakewood Shores Property Owners...
Aaron Dr
Lakewood Shores Huron Beach
The Beach Club of Oscoda
Bare Foot Beach Resort
Christopher Rd
Coastal Dreams Resort
La Mer Douce Family Beach Resort
Concord Dr
Fox Rd
Cedar Lake Rd
E Cedar Lake Dr
Lakewood Dr
Huntington Dr
Pine Tree Trail
Cedar Brook Dr
Woodlea Rd W
Westwood Dr
Woodlawn Dr
Maplehurst Way
Windimier Rd
Woodland Dr
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Shoreview Dr
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Triple Play
Triple Play
1.5 Acres
Chelated
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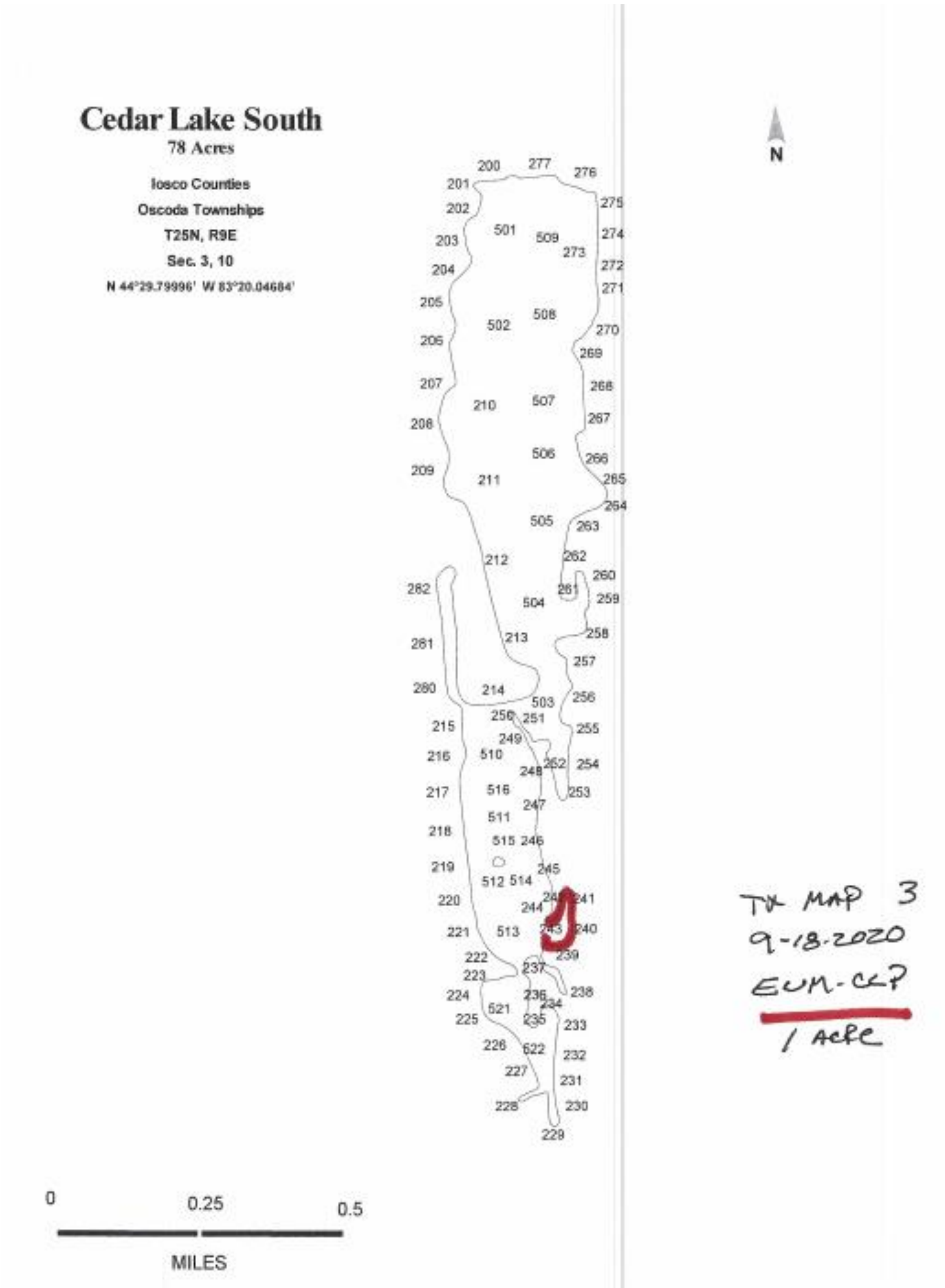
Cedar Lake South
78 Acres
Iosco Counties
Oscoda Townships
T25N, R9E
Sec. 3, 10
N 44°29.79996' W 83°20.04684'
N
0
0.25
0.5
MILES
TX MAP 3
9-18-2020
EWM-CLP
1 Acre