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

Cedar Lake North

Alcona and Iosco Counties

2020 DATA AND ANALYSIS SUMMARY REPORT WITH MANAGEMENT RECOMMENDATIONS

April 9, 2021

Submitted by:

Dr. G Douglas Pullman, President

Aquest Corporation

and

Gabrielle Metzner-Gustafson, Project Scientist

Kieser & Associates, LLC

Executive Summary

Kieser & Associates, LLC (K&A), in conjunction with Aquest Corporation, conducted vegetation monitoring on Cedar Lake North (Alcona and Iosco Counties) during the summer of 2020 using LakeScan^{TM} 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^{TM} 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 North's averaged scores from early-season and late-season LakeScan^{TM} 2020 surveys are summarized in Table ES - 1. These reveal scores meeting management goals set forth in the Shannon Biodiversity Index, Shannon Morphological Index, and Floristic Quality Index[1]. High Shannon Biodiversity Index and Shannon Morphological Index scores indicate a diverse plant community providing good habitat for fish and macroinvertebrates. High Floristic Quality Index scores indicate a high ratio of desirable, native aquatic plant species to undesirable, invasive aquatic plant species. Recreational Nuisance Presence scoring did not meet the management goal of less than 10%. Algal Bloom Risk rating for Cedar Lake North is "low" reflecting the high proportion of wetland and forest land use and low proportion of urban and agricultural land use draining to the lake.

Table ES-1 – Summary of lake analysis metrics

LakeScan^{TM} Metric	2020 Average	Management Goal
Shannon Biodiversity Index	9.0	> 6.7
Shannon Morphology Index	8.1	> 5
Floristic Quality Index	24.4	> 20
Recreational Nuisance Presence	26%	< 10%
Algal Bloom Risk	Low	Low

The early-season LakeScan™ vegetation survey of Cedar Lake North was conducted on June 30th and July 1st. The only ecological nuisance species detected during the early-season survey was Ebrid watermilfoil (*Myriophyllum spicatum x sibiricum*). Desirable native aquatic vegetation observed during the early-season survey included Chara (*Chara sp.*), variable pondweed (*Potamogeton graminius* L.), variable watermilfoil (*Myriophyllum heterophyllum* Michaux), clasping leaf pondweed (*Potamogeton richardsonii*

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

(Benn.) Tydb.), and naiad (*Najas sp*.). Variable watermilfoil exhibited dense growth and medium to heavy coverage creating recreational nuisance conditions in Tier 3, 4, and 5 AROS. Native pondweeds exhibited some recreational nuisance conditions in a few of the Tier 3 and 4 AROS.

The late-season LakeScan™ vegetation survey of Cedar Lake North was conducted on August 19th and 20th. Native aquatic plant species observed include common bladderwort (*Utricularia vulgaris L.),* naiad, Chara, clasping leaf pondweed, and variable pondweed. Wild celery (*Vallisneria americana* Michaux) was also observed. Waterlily (*Nymphaea sp*.) and spadderdock (*Nuphar sp*.) were observed in several Tier-3 shoreline AROS in shallower areas of Cedar Lake North, but did not present obvious recreational nuisance conditions. Variable watermilfoil was observed throughout Cedar Lake North at widely varying densities and distributions, from small single patches to very large groupings. Variable watermilfoil was not observed to be growing at the surface of the water in any AROS, although this may have been influenced in part by the substantial wave action occurring during the survey. Ecological nuisance species detected during the survey include Ebrid watermilfoil and this species was found in several of the Cedar Lake North west-side trenches.

For this 2020 report, K&A also analyzed the past five years of LakeScan™ data for coverage of species primarily targeted for management activities. Cedar Lake North's Ebrid watermilfoil coverage has exhibited no substantial trend for the last five years (Figure ES - 1), suggesting that management activities are not decreasing Ebrid watermilfoil populations. Since no substantial increase has been observed over the last five years, management activities appear to otherwise be successfully suppressing any additional Ebrid watermilfoil spread. Variable watermilfoil, on the other hand, has exhibited a generally increasing cover trend over the last five years, suggesting that periodic herbicide treatments have not necessarily reduced coverage for this particular species.

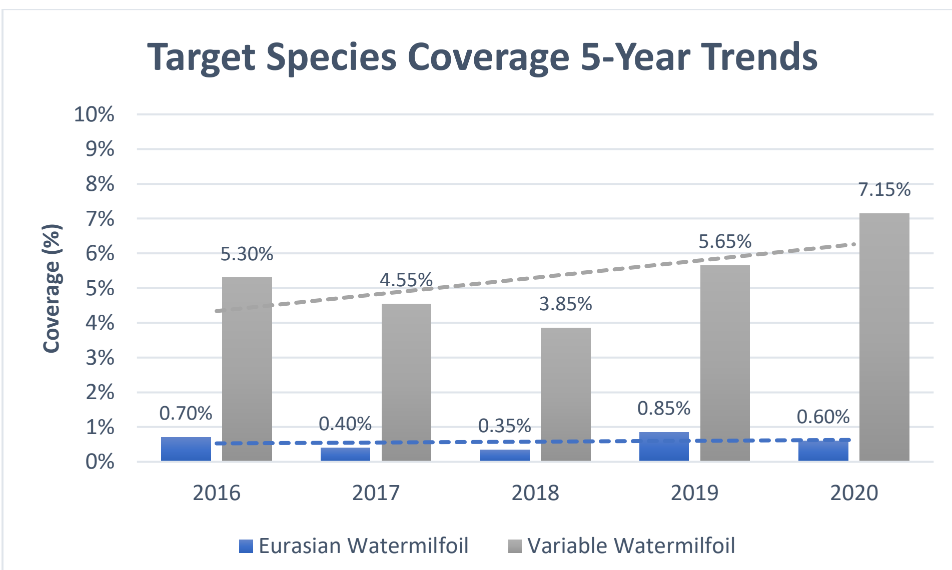


Figure ES-1 - Target species coverage 5-year trends

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

- Continued LakeScan™ vegetation monitoring twice a year (once during the spring-early summer and another during the late summer) is recommended 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.
- Native aquatic plants, such as variable watermilfoil, tend to create recreational nuisances on Cedar Lake North. Variable watermilfoil was observed creating late-season recreational nuisances prompting broad treatment in September 2020, which should have lasting effects for up to three years. Locations that received the September treatment will be carefully monitored in the 2021 LakeScan™ vegetation 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.
- K&A and Aquest are recommending pilot testing up to two select areas in Cedar Lake North to assess the effectiveness of an alternative herbicide on Ebrid residing in the northern trenches. This selective systemic herbicide is ProcellaCOR produced by SePRO Corporation. These pilot applications would slightly increase chemical costs over previous years' treatments of Ebrid watermilfoil, but should also reveal its potential effectiveness. Some spatial restrictions may apply, however, in relation to proximity of treatment areas to water supply wells for any nearby shoreline residences.
- Continued management intervention of Ebrid watermilfoil could also include diver-assisted hand pulling and diver-assisted suction harvesting (DASH) of small Ebrid watermilfoil infestations potentially combined with chemical management to significantly reduce recurrent outcroppings. We recommend a desktop feasibility assessment for 2021 that will look at potential costs and effectiveness of DASH being used in other Michigan and Midwest settings and compare these findings to 2021 ProcellaCOR pilot test results.

Table of Contents

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^{TM} 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^{TM} 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 samples.

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 North 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: Alcona and Iosco

Township: Greenbush and Oscoda (respectively)

Township/Range/Section(s): T25N, R9E Section: 25, 35, 36 and T25N, R9E Section: 3 & 10 (respectively)

GPS Coordinates: 44.528853, -83.331903

Morphometry

Total Area: 830 acres

Shoreline Length: 47,339 feet

Maximum Depth: 10 feet

Watershed Factors

Tributaries: Sherman Creek

Outlet type: Fixed weir at northern end of lake

Other Features: Two wetland shoreline complexes

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 North 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]

---

[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.

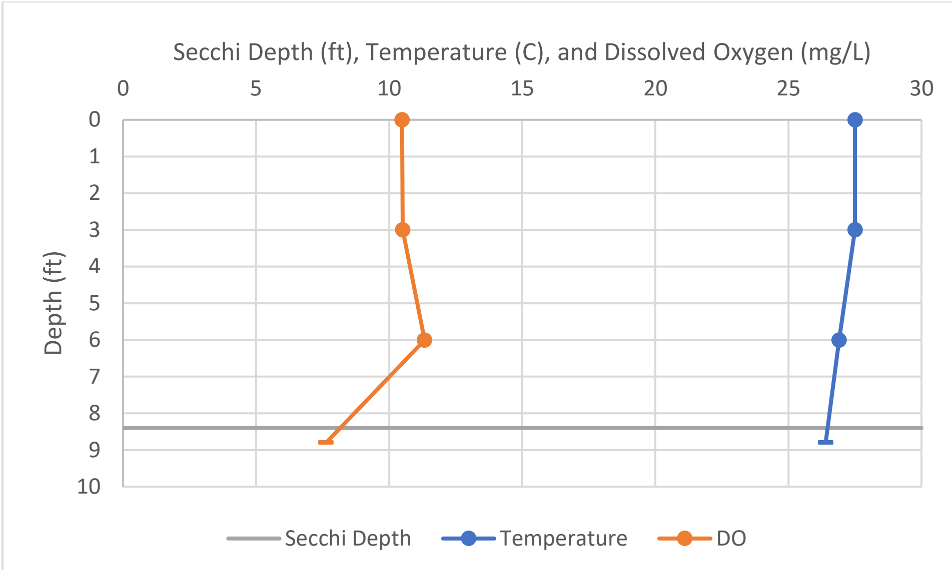


*Figure 2 - Early season survey (June 30th) dissolved oxygen and temperature profiles with Secchi depth, taken at the deepest point in the lake. *Note: last data point is located on the bottom and substantial vegetation was observed on bottom.*

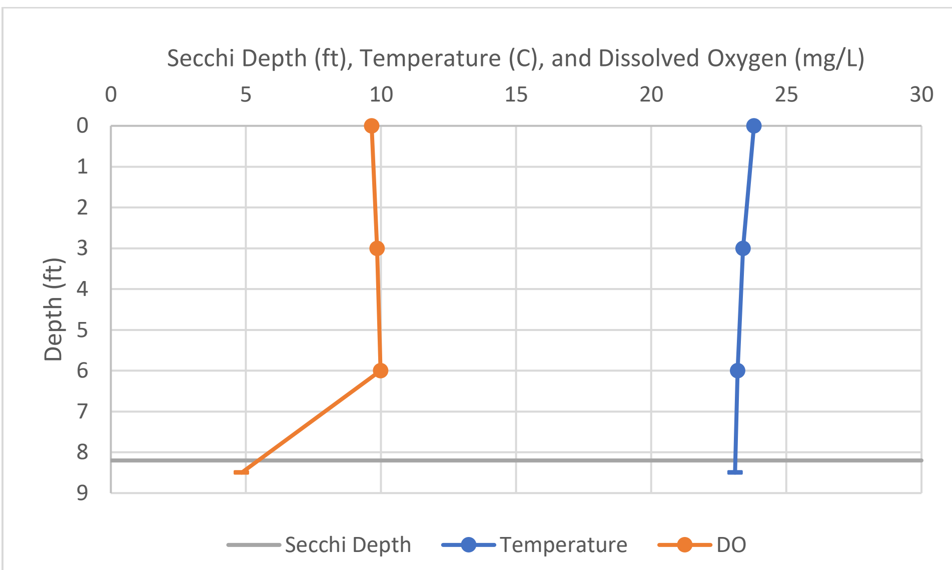


*Figure 3 - Late season survey (August 20th) dissolved oxygen and temperature profiles with Secchi depth, taken at the deepest point in the lake. *Note: last data point is located on the bottom and substantial vegetation was observed on bottom.*

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^{TM} analysis metrics.

4.1. Early-Season Survey

The early-season LakeScan™ vegetation survey of Cedar Lake North was conducted on June 30th and July 1st. Weather conditions were 83°F and sunny with calm winds. Visibility through the water column was good and the bottom of the lake was visible throughout the entire survey. 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 North 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 only ecological nuisance species detected during the early-season survey was Ebrid watermilfoil (*Myriophyllum spicatum x sibiricum*). This species was observed most commonly in the northern portion of Cedar Lake, limited to the deep, west-side trenches. AROS where Ebrid watermilfoil was observed include: 398, 580, 368 and 567, some of which appeared to be dead but upon closer examination, green shoots were visible (Figure 5).

Desirable native aquatic vegetation observed during the early-season survey included Chara (*Chara sp*.), variable pondweed (*Potamogeton graminius* L.), variable watermilfoil (*Myriophyllum heterophyllum* Michaux), clasping leaf pondweed (*Potamogeton richardsonii* (Benn.) Tydb.), and naiad (*Najas sp*.). Variable watermilfoil exhibited dense growth and medium to heavy coverage, creating recreational nuisance conditions in Tier 3, 4, and 5 AROS (Figure 6). Pondweeds exhibited some recreational nuisance conditions in a few of the Tier 3 and 4 AROS.

Figure 4 – Early season survey (June 30th & July 1st) vegetation 3D Density (a function of all species observed vegetation density, distribution and height observations).

Figure 5 – Early season (June 30th & July 1st) Eurasian Watermilfoil and Hybrids coverage (a combination of the LakeScan™ density and distribution observations).

Figure 6 – Early season (June 30th & July 1st) Variable Watermilfoil coverage.

4.2. Late-Season Survey

The late-season LakeScan™ vegetation survey of Cedar Lake North was conducted on August 19th and 20th. Air temperatures were approximately 70°F on August 19th, with south to east-southeastern winds varying from 3-10mph, with good visibility. Air temperatures were approximately 80°F on August 20th, with south-southwestern winds increasing throughout the day to a max of 14mph. Water temperatures ranged from 74.8°F at the surface to 73.6°F at 9 feet bottom depth. Visibility through the water column was fair, becoming poorer in the afternoon, with a recorded Secchi disk depth of 8.2ft. Figure 7 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 North during the late-season survey.

Substantial areas of the Cedar Lake North were unvegetated, as is typical. Common bladderwort (*Utricularia vulgaris L.)* was observed exhibiting very light to light coverage, occasionally spotted in the otherwise unvegetated areas. Naiad and Chara were the most common lake-bed cover, both species tending to grow in small to medium-sized patches intermixed with other macrophytes. Chara and naiad were also occasionally observed at light coverage in the otherwise unvegetated areas. Clasping leaf and variable pondweed were the most abundant pondweeds in Cedar Lake North. Clasping leaf pondweed tended to be observed in the deeper portions, including the trenches, growing at medium to heavy coverage, occasionally nearing the surface but not typically presenting recreational nuisance. Variable pondweed tended to be observed in the shallower areas and along contours, occasionally in the trenches. Wild celery (*Vallisneria americana* Michaux) was also observed growing in areas similar to variable pondweed. Variable pondweed was observed growing at Phenotype 3 (at the surface of the water) in AROS 439, 437, 583, 582, 382, 380, 579, 580, 435, 369, 368, 366, 477, 426, 476, 427, 475, 428, 474, 429, 473, 409, and 410. Wild celery was observed at a Phenotype 3 in AROS 582, 579, 580, 435, 566, and 410. Waterlily (*Nymphaea sp*.) and spadderdock (*Nuphar sp*.) were observed in several Tier-3 shoreline AROS in shallower areas of Cedar Lake North, but did not present obvious recreational nuisance conditions.

Variable watermilfoil was observed throughout Cedar Lake North at widely varying densities and distributions, from small single patches to very large groupings (Figure 8). Variable watermilfoil observed in Tier-3 AROS tended to exhibit light to medium coverage. In the Cedar Lake North trenches, variable watermilfoil was observed at medium-heavy coverage in AROS 503, 585, 586, and 519-521. Outside of the trenches, the highest variable watermilfoil coverage observations were located in AROS 417, 420, 421, 427, 440, and 473. Variable watermilfoil was not observed to be growing at the surface of the water in any AROS, although this was likely influenced in part by the substantial wave action occurring during the survey.

Ecological nuisance species detected during the survey includes Ebrid watermilfoil (Figure 9). Ebrid watermilfoil was found in several of the Cedar Lake North west-side trenches. Ebrid watermilfoil was found at heavy coverage in AROS 566 and 567 (northern-most west-side trench), dominating other species and topped-out, causing a recreational nuisance. Much smaller patches of Ebrid watermilfoil were also observed, intermixed with other species, at very-light to light coverage in AROS 369-370, 575, 579-580, and 582-583.

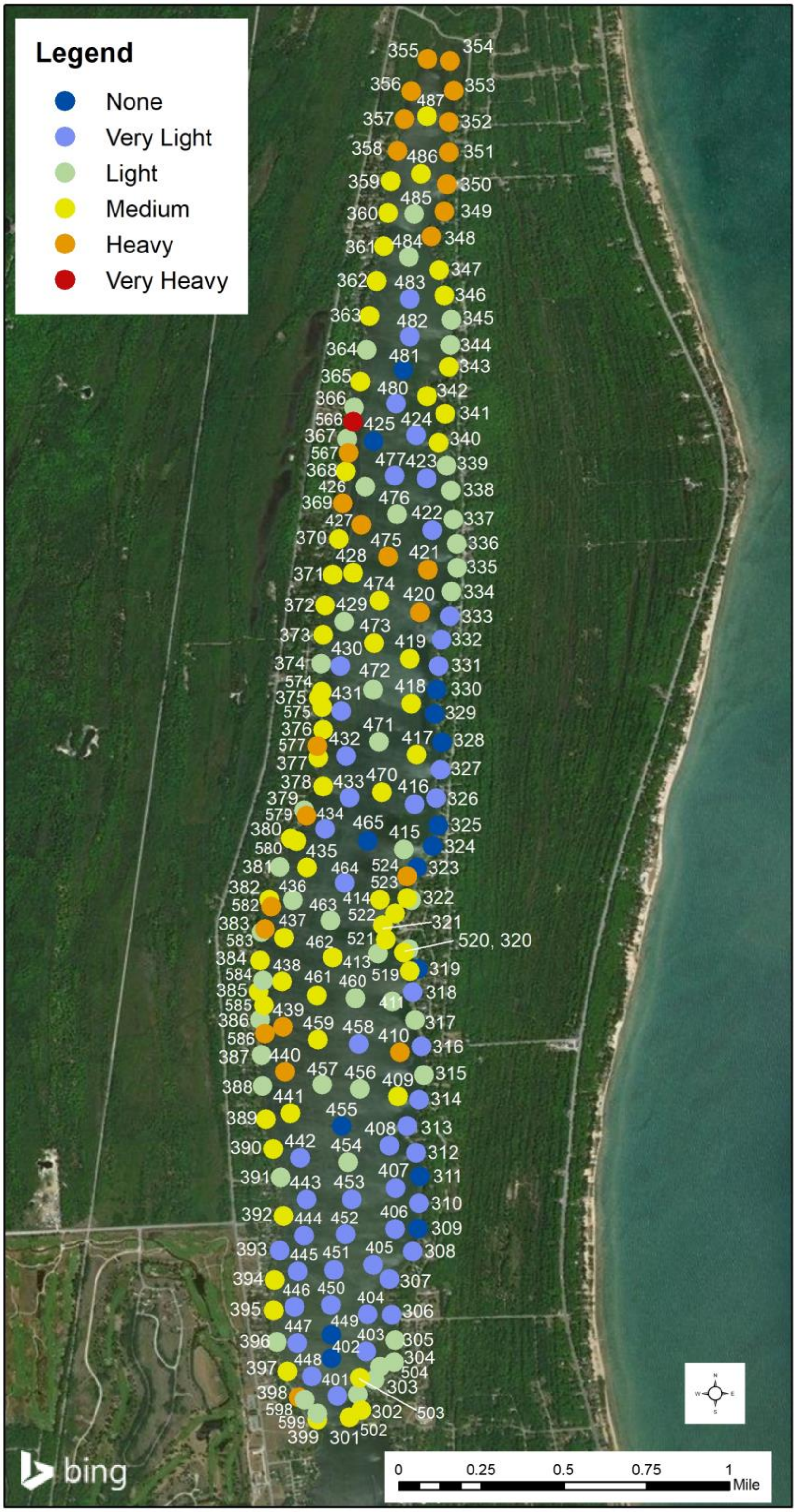


Figure 7 – Late season survey (August 19th & 20th) vegetation 3D Density (a function of all species observed vegetation density, distribution and height observations).

Figure 8 – Late season (August 19th & 20th) Variable Watermilfoil coverage (a combination of the LakeScanTM density and distribution observations).

Figure 9 – Late season (August 19th & 20th) Eurasian Watermilfoil and Hybrids 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 10 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%	1.0%	0.0%	0.1%	0.0%	0.2%
Chara	4	84.2%	85.6%	11.0%	9.3%	24.7%	18.6%
Clasping Leaved Pondweed	3	43.6%	36.1%	6.4%	4.8%	14.5%	9.7%
Common Bladderwort	3	17.8%	21.8%	1.3%	1.5%	2.9%	3.1%
Elodea	2	5.9%	1.0%	0.9%	0.1%	1.9%	0.2%
Eurasian Watermilfoil Hybrid	1	2.0%	6.4%	0.2%	1.0%	0.5%	2.0%
Fries Pondweed	4	0.0%	3.5%	0.0%	0.3%	0.0%	0.6%
Green/Variable Watermilfoil	2	44.6%	40.1%	6.6%	7.7%	14.8%	15.5%
Illinois Pondweed	3	0.0%	0.5%	0.0%	0.0%	0.0%	0.1%
Naiad	2	30.2%	57.4%	2.9%	4.8%	6.5%	9.6%
Purple Loosestrife	3	0.0%	7.4%	0.0%	0.5%	0.0%	0.9%
Rush	4	17.8%	26.2%	1.7%	2.7%	3.8%	5.4%
Sago Pondweed	2	3.0%	2.5%	0.2%	0.2%	0.5%	0.4%
Spadderdock	2	13.4%	15.3%	1.6%	2.1%	3.5%	4.2%
Thin Leaf Pondweed	4	0.0%	1.0%	0.0%	0.1%	0.0%	0.2%
Variable Pondweed	3	79.7%	88.1%	9.3%	8.5%	20.9%	17.0%
Waterlily	2	13.9%	11.4%	1.6%	1.5%	3.7%	3.1%
Wild Celery	2	10.9%	42.6%	0.8%	4.6%	1.9%	9.2%

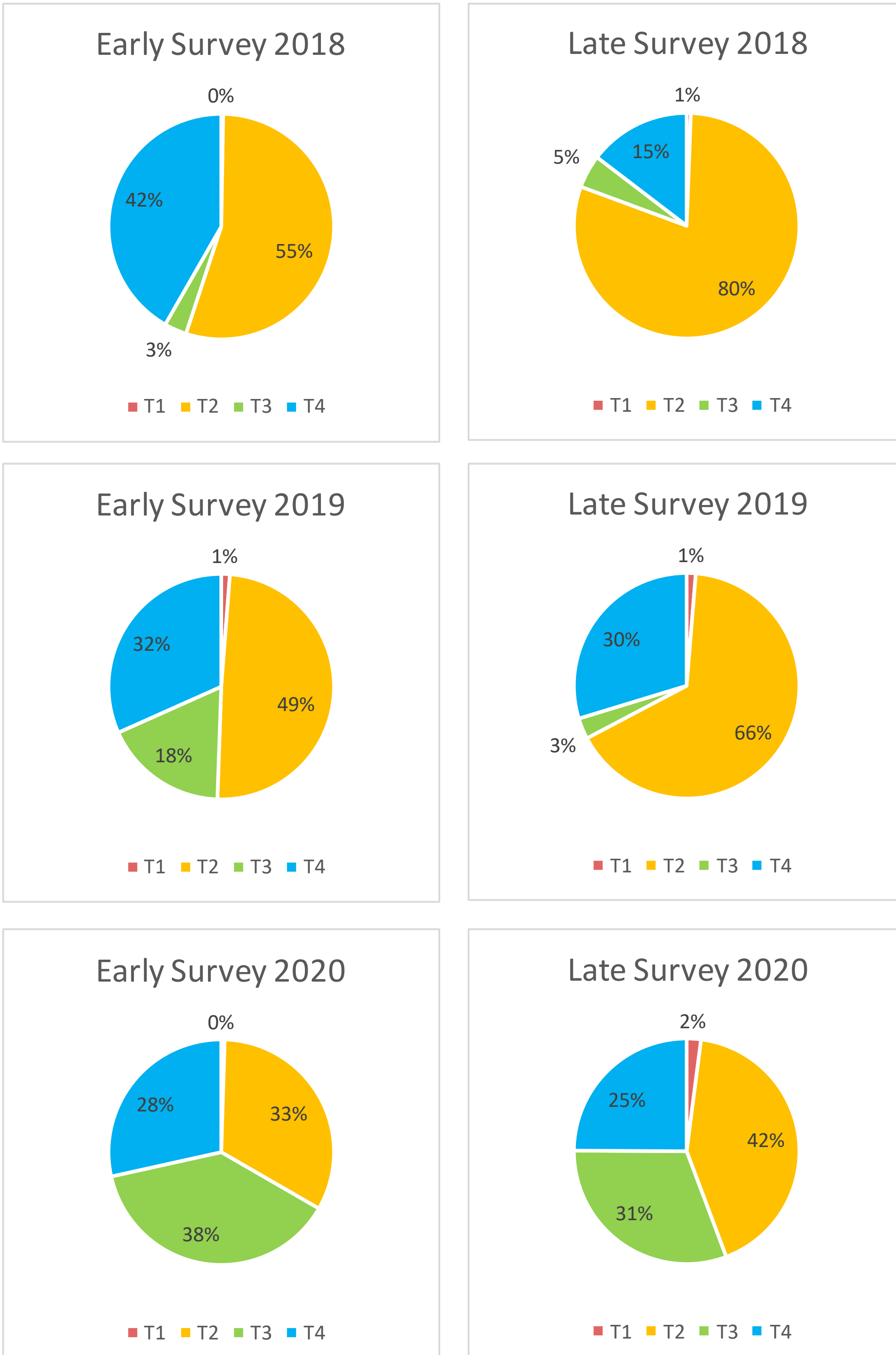


Figure 10 – Distribution of aquatic plant coverage by T Value comparing early-season and late-season surveys from 2018 – 2020.

4.4. LakeScan™ 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.

---

[4] Metrics used in past LakeScan™ 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	13	18	15.5	n/a
Shannon Biodiversity Index	1 -15	8.0	9.9	9.0	> 6.7
Shannon Morphology Index	1 - 10	7.5	8.7	8.1	> 5
Floristic Quality Index	1 - 40	23.4	25.3	24.4	> 20
Recreational Nuisance Presence	0 - 100%	21%	32%	26%	< 10%
Algal Bloom Risk	Low - High	n/a	n/a	Low	Low
Total Lake Score	1 - 10	n/a	n/a	8.5	n/a

*n/a = not applicable

Overall, Cedar Lake North scores met optimal management goals set forth in the Shannon Biodiversity Index, Shannon Morphological Index, and Floristic Quality Index. High Shannon Biodiversity Index and Shannon Morphological Index scores indicate a diverse plant community providing good habitat for fish and macroinvertebrates. High Floristic Quality Index scores indicate a high ratio of desirable, native aquatic plant species to undesirable, invasive aquatic plant species. Recreational Nuisance Presence scoring did not meet the less than 10% management goal in the early-season survey and nuisance conditions increased in the late-season survey. The Algal Bloom Risk rating for Cedar Lake North is "low" reflecting the high proportion of wetland and forest land use and low proportion of urban and agricultural land use draining to the lake.

The five-year historical trends for Floristic Quality Index (FQI) scores and target species coverage values are presented in Figures 11 and 12, 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 North has exhibited a positive trend, which indicates an increase in desirable, native plant species and a decrease in undesirable, non-native plant species (Figure 11). For the last two years, Cedar Lake North's FQI score exceeded the management goal of 20. Furthermore, Cedar Lake North's Ebrid watermilfoil coverage has exhibited no significant trend for the last five years (Figure 12), suggesting that management activities are not decreasing Ebrid watermilfoil populations, but do appear to be suppressing any additional Ebrid watermilfoil population expansion. Variable watermilfoil, on the other hand, has exhibited a substantial increase over the last five years (Figure 12), suggesting that periodic management activities have not kept in check nuisance coverage for this particular species.

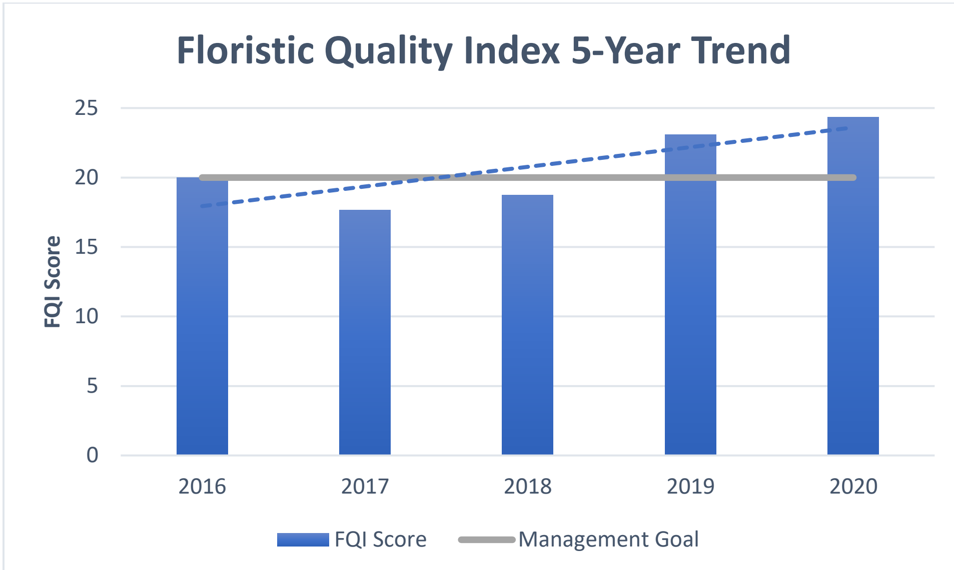


Figure 11 – Floristic Quality Index 5-Year Trend.

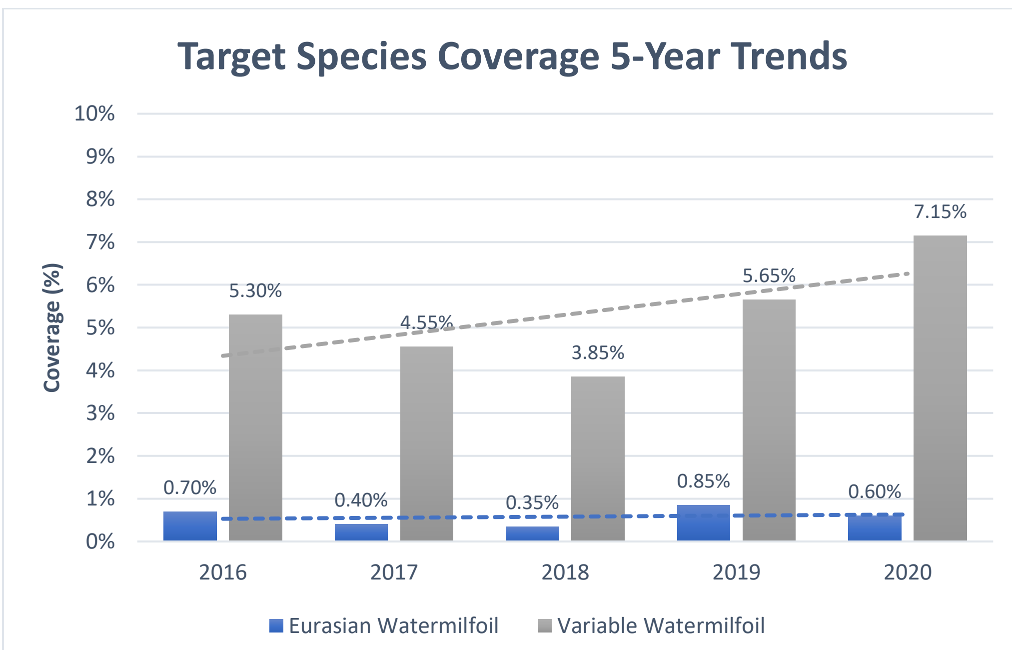


Figure 12 – Target Species Coverage 5-Year Trends.

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 13 shows the coverage changes of targeted species over both surveys. Simplified herbicide treatment maps are included in Figures 14 and 15, showing all treatments conducted on Cedar Lake North in 2020. Information for Figures 14 and 15 was obtained through the herbicide applicator. Copies of the herbicide applicator treatment maps are included in Appendix D.

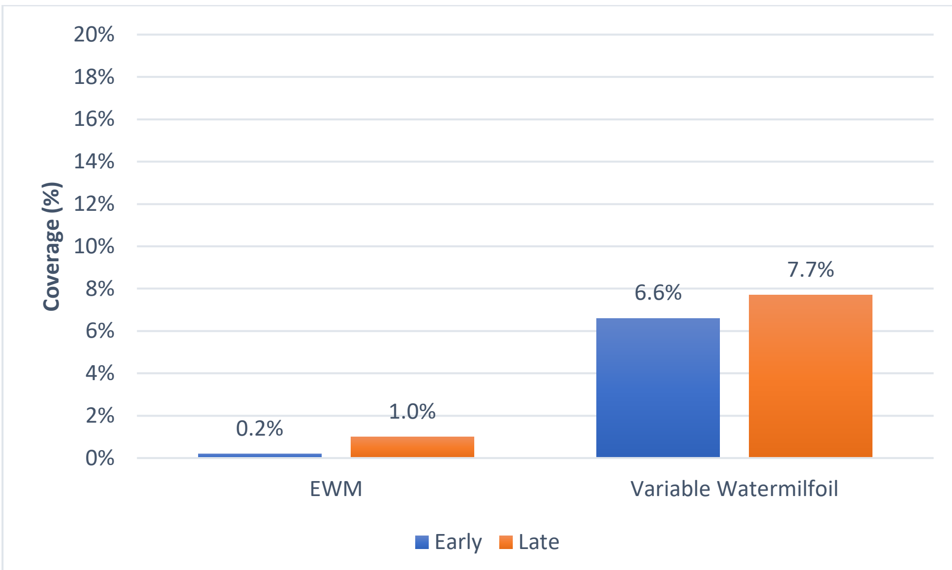


Figure 13 – Changes in coverage across both 2020 surveys for targeted species.

Figure 14 – June 15th, 2020 Herbicide Application Map.

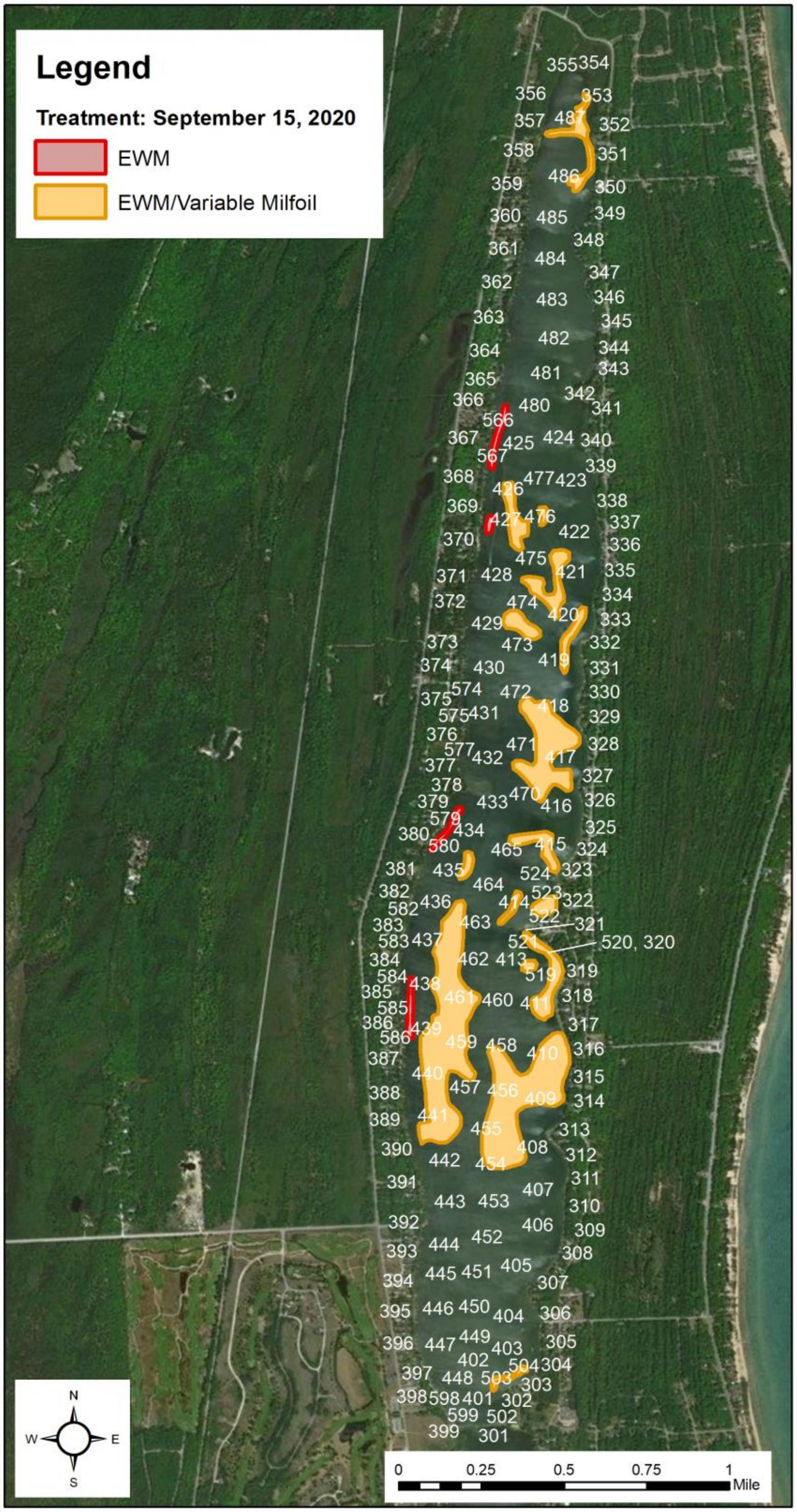


Figure 15 – September 15th, 2020 Herbicide Application Map.

Overall plant growth on Cedar Lake North is minimal when compared to most other inland lakes in Michigan. Variable watermilfoil and native pondweeds have been some of the most dominant species observed on the lake. Variable watermilfoil frequently grows in dense patches throughout the body of the lake and can create recreational nuisance conditions in many of the areas it is observed. Aquatic plant growth is very dense within the deeper “trenches” of Cedar Lake. Ebrid watermilfoil, variable watermilfoil, elodea, and some native pondweeds grow to extreme nuisance levels in these trenches forming dense bands of nuisance conditions that can cause navigational hazards.

Low coverage percentages and no observed increase of Ebrid watermilfoil coverage over the last five years suggest that lake management activities have been suppressing Ebrid watermilfoil expansion. It is also possible that conditions are not conducive for substantial Ebrid watermilfoil growth outside of the deep trenches on Cedar Lake North. K&A suggests considering a combination of management strategies, such as diver assisted suction harvesting (DASH), with targeted herbicide applications to reach even lower populations of target species. Some studies suggest that combining mechanical and chemical methods, such as DASH with targeted herbicide applications, could help to significantly reduce populations of Ebrid watermilfoil.[7] While DASH or diver assisted hand pulling methods can be effective and have high specificity, they are labor-intensive, expensive, and require long-term commitment. It is important to note that invasive species such as Ebrid Milfoil, once established on a lake, are almost impossible to eradicate. Removing Ebrid watermilfoil may allow room for other invasive or native species to take its place, potentially species that could also cause recreational nuisance conditions.

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 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.

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 North, it may be

[7] Kelting, D. L., & Laxson, C. L. (2010). Cost and effectiveness of hand harvesting to control the Eurasian watermilfoil population in Upper Saranac Lake, New York. *Journal of Aquatic Plant Management (JAPM)*, *48*, 1.

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.

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 management intervention is recommended for Ebrid watermilfoil. 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 essentially no change in coverage. Thus, while management interventions do not appear to be signifcantly decreasing Ebrid watermilfoil coverage, these activities may be suppressing possible spread and coverage increases of Ebrid watermilfoil. Cedar Lake Improvement Board should explore the pilot use of new chemical technologies, such as ProcellaCOR, to treat Ebrid residing in the northern trenches. This method could have slightly higher costs associated than previous years' treatment costs of Ebrid watermilfoil, but should be tested in up to two selected locations to assess its effectiveness at targeting Ebrid watermilfoil.

Diver-assisted hand pulling and diver-assisted suction harvesting (DASH) of small Ebrid watermilfoil infestations are alternative control options that could be combined with chemical management to reduce invasive species populations. We recommend a desktop feasibility assessment for 2021 that will look at potential costs and effectiveness of DASH being used in other Michigan and Midwest settings and will compare these findings to 2021 ProcellaCOR pilot test results.

Native aquatic plants, such as variable watermilfoil, tend to create recreational nuisances on Cedar Lake North. Variable watermilfoil was observed creating late-season recreational nuisances prompting broad 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 monitored in the 2021 LakeScan™ vegetation 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	57	64	63
2019	59	63	90
2018	34	51	83
2017	30	41	89
2016	36	47	55

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).

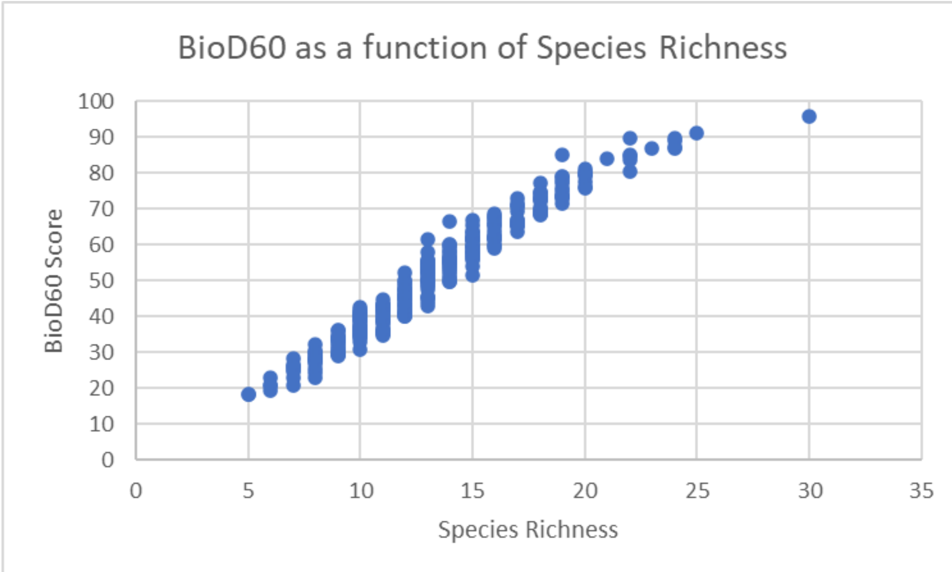


Figure A1 – BioD60 graphed as a function of Species Richness.

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

[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.

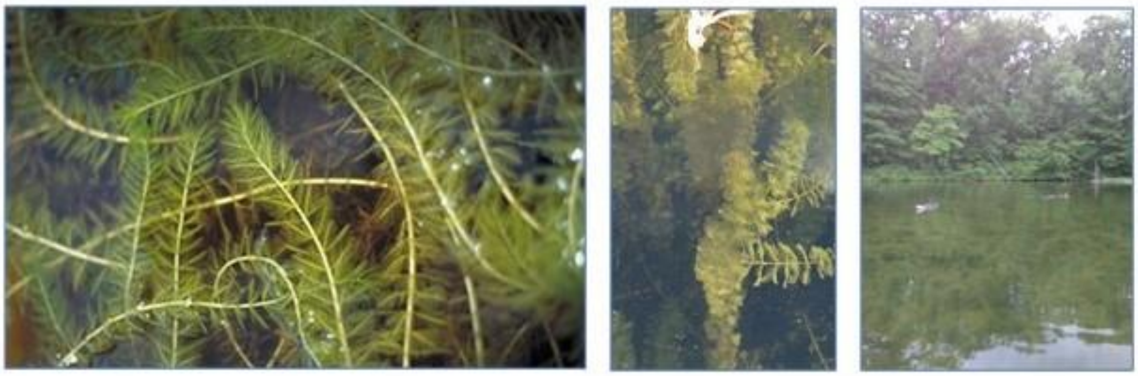


Figure B1: Example Eurasian Watermilfoil and Hybrids images from the 2019 LakeScan™ field crew.

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 LakeScanTM 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.

---

[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 C1: 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:

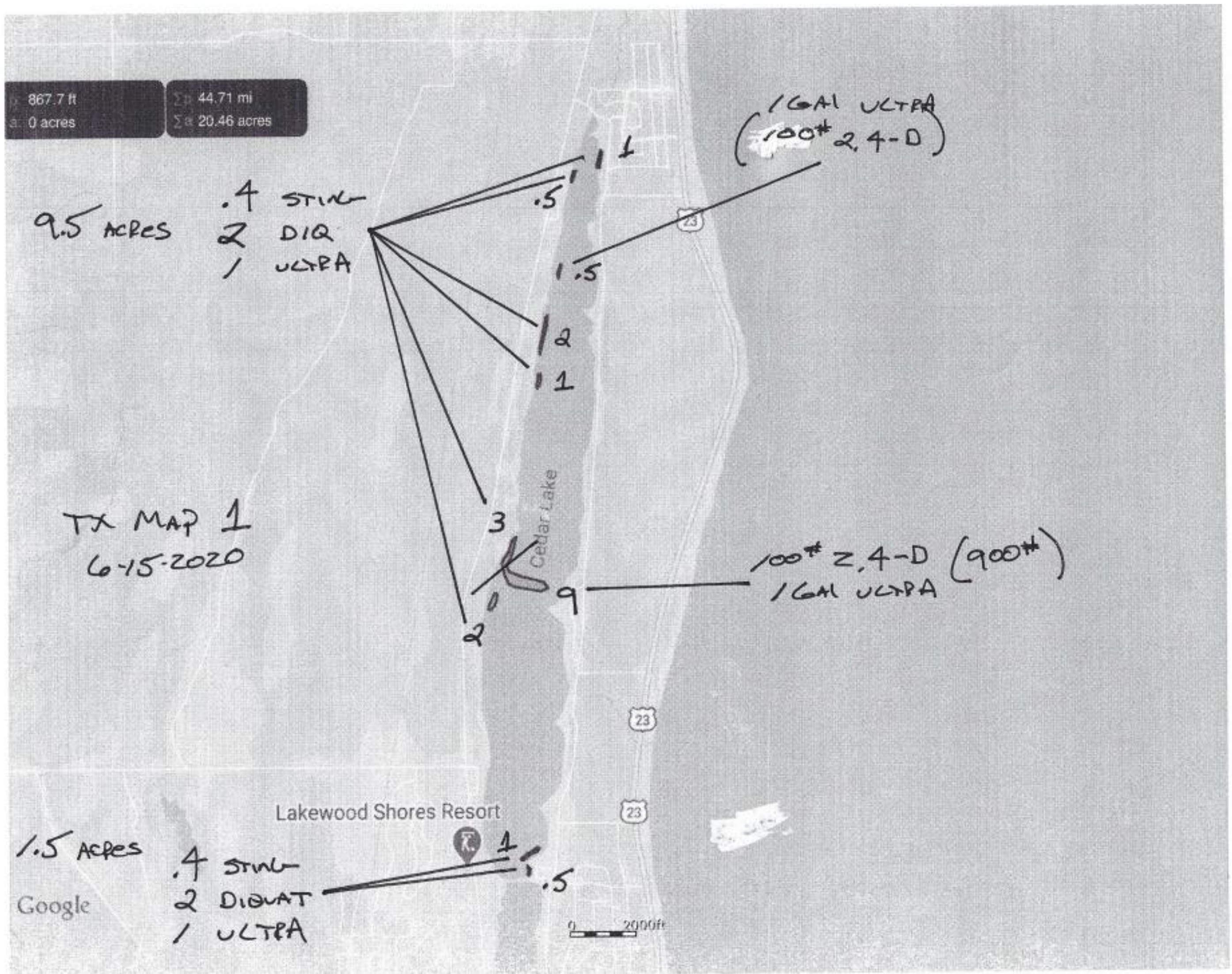
TP and TN: The total phosphorus (TP) concentration in a water resource is usually positively correlated with the production of suspended algae (but not rooted plants, i.e. seaweed). Very small amounts of phosphorus may result in large algae blooms. If the ratio of total nitrogen (TN) to total phosphorus 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.

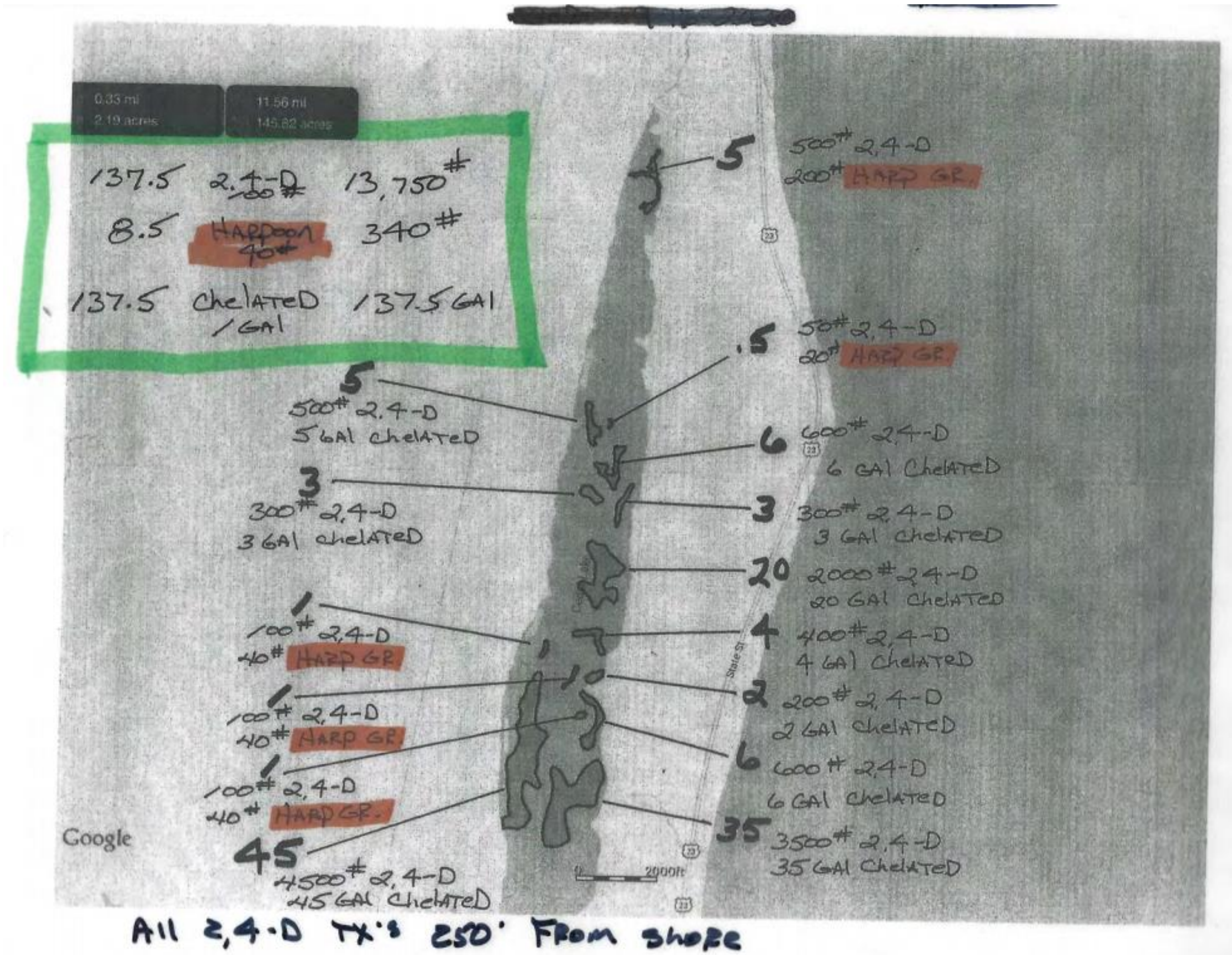
Free Carbon Dioxide: All plants, including algae, use carbon dioxide in photosynthesis. Alkalinity, pH, temperature, and the availability of free carbon dioxide are all closely related and inter-regulated in what can be referred to as a lake water buffering system. Concentrations of these key water constituents 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.

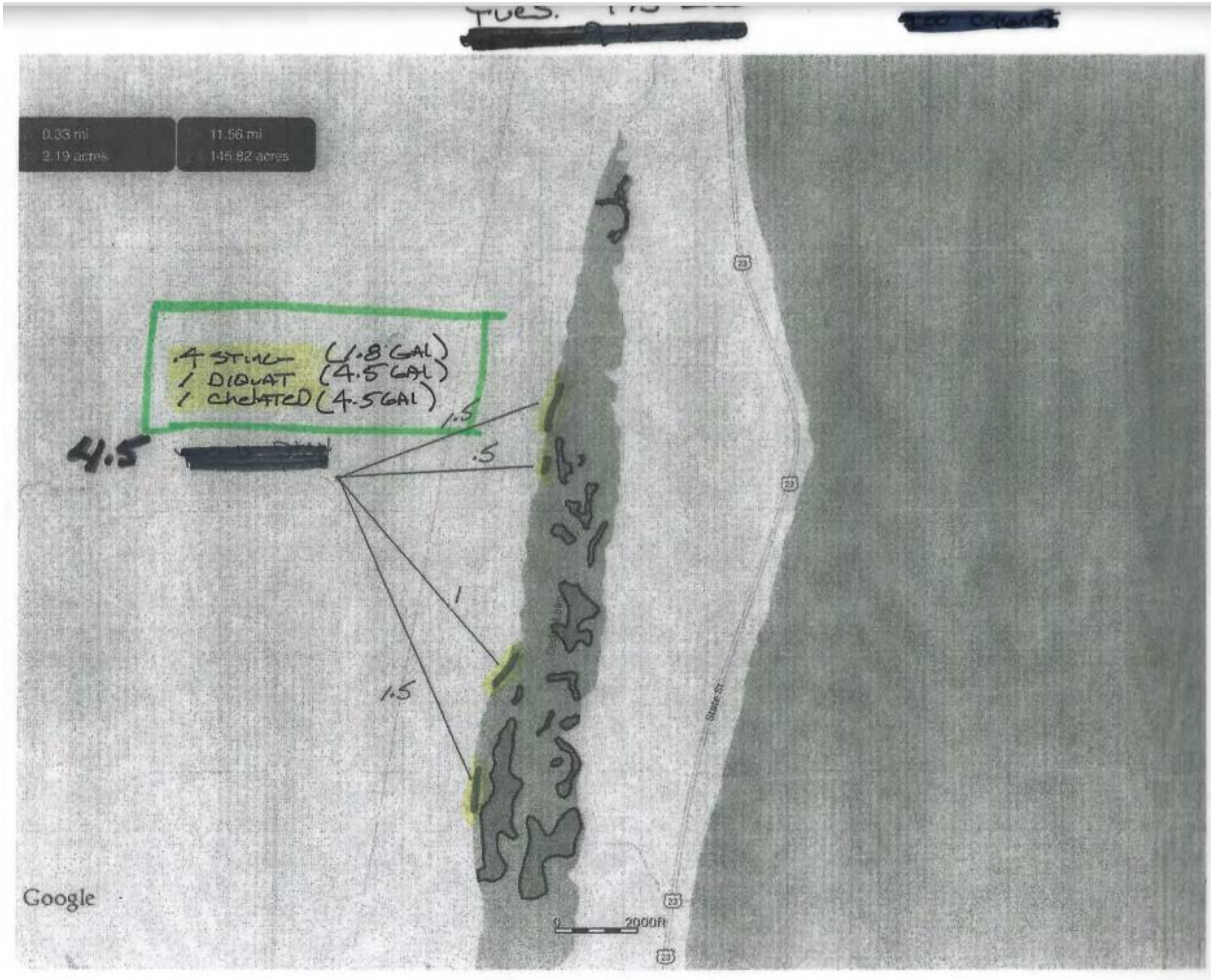
Biotic Factors: Zebra mussels and zooplankton (microscopic, free-floating animals) are filter feeding organisms that strain algae and other substances out of the lake water for food. Studies have shown that filter-feeding organisms often reject blue green algae and feed selectively on more desirable 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.




[redacted]
0.33 mi
2.19 acres
11.56 mi
145.82 acres
137.5 2,4-D /100# 13,750#
8.5 HARPOON 40# 340#
137.5 ChelATeD /GAl 137.5 GAl
5 500# 2,4-D 200# HARP GR.
.5 50# 2,4-D 20# HARP GR.
5 500# 2,4-D 5 GAl ChelATeD
6 600# 2,4-D 6 GAl ChelATeD
3 300# 2,4-D 3 GAl chelATeD
3 300# 2,4-D 3 GAl ChelATeD
20 2000# 2,4-D 20 GAl ChelATeD
1 100# 2,4-D 40# HARP GR.
4 400# 2,4-D 4 GAl ChelATeD
1 100# 2,4-D 40# HARP GR.
2 200# 2,4-D 2 GAl ChelATeD
1 100# 2,4-D 40# HARP GR.
6 600# 2,4-D 6 GAl ChelATeD
45 4500# 2,4-D 45 GAl ChelATeD
35 3500# 2,4-D 35 GAl ChelATeD
Google
All 2,4-D TX's 250' FROM SHORE



TUES. [redacted]
0.33 mi
2.19 acres
11.56 mi
145.82 acres
/ DIQUAT (4.5 GAL)
/ chelATED (4.5 GAL)
4.5 [redacted]
1.5
.5
1
1.5
State St
Google
0
2000ft