KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Summary of Findings from LakeScan™
Surveys and Analysis of:

Cedar Lake North

Alcona and Iosco Counties

2023 DATA AND ANALYSIS SUMMARY REPORT WITH MANAGEMENT RECOMMENDATIONS

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Submitted by:

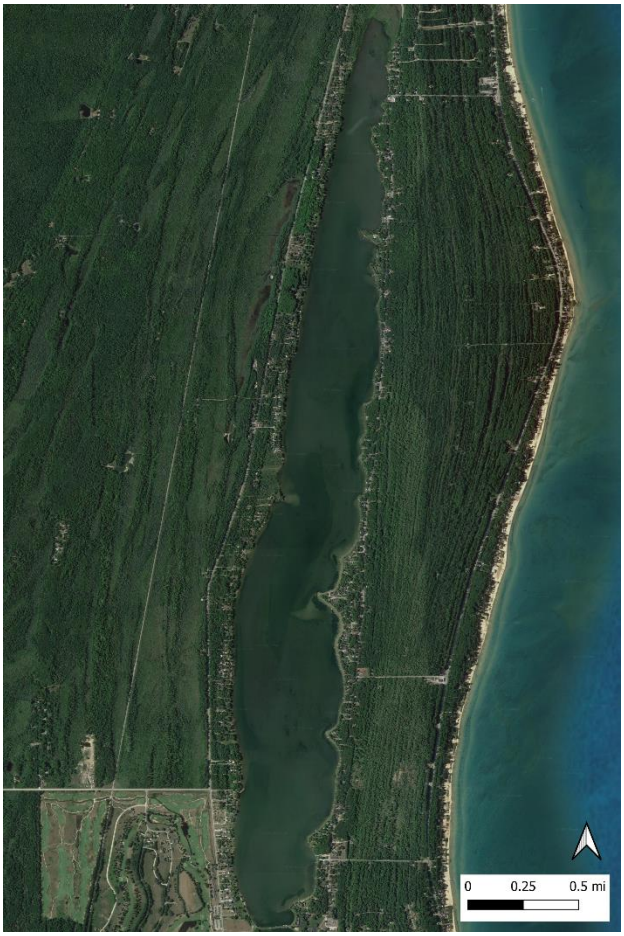
Natalie Howard, Project Scientist

G. Douglas Pullman, PhD, Senior Ecological Adviser

and

Mark S. Kieser, Senior Scientist

Kieser & Associates, LLC



Executive Summary

Kieser & Associates, LLC (K&A) conducted vegetation monitoring on Cedar Lake North (Alcona and Iosco Counties, MI) during the summer of 2023 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 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 for improving the lake's ecological and recreational conditions.

The averaged scores from early and late-season LakeScan™ 2023 surveys for Cedar Lake North are summarized in Table ES - 1.[1] Survey results indicate that the average scores for Shannon Morphology Index, Floristic quality index, and Algal Bloom risk met management goals, while the Shannon Biodiversity Index and Recreational Nuisance Presence were close, but ultimately did not meet the management goals in 2023. The low average Shannon Biodiversity Index indicates that there may be a lower diversity of species present, while the higher Shannon Morphology Index indicates that the species which are present are diverse in structure, contributing to greater habitat suitability. The consistently high average Floristic Quality Index on Cedar Lake North suggests a high distribution of desirable, native plant species and a low distribution of undesirable invasive species. However, several native species created nuisance conditions in 2023, as described below. Average Recreational Nuisance Presence was above the management goal of <10%, which was likely influenced by the presence of hybrid and weedy native pondweeds which were commonly found at the surface during the late-season survey. The shallowness of Cedar Lake North in combination with the tall growth pattern of the native pondweeds could potentially impede boating and swimming activities. The Algal Bloom Risk rating for Cedar Lake North is "low" reflecting the small proportion of agricultural and urban land use draining to the lake.

Table ES-1 – Summary of lake analysis metrics.

LakeScan™ Metric	2023 Average	Management Goal
Species Richness	19	n/a
Shannon Biodiversity Index	8.2	> 8.8
Shannon Morphology Index	7.2	> 6.3
Floristic Quality Index	26.7	> 20
Recreational Nuisance Presence	12%	< 10%
Algal Bloom Risk	Low	Low

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

The Cedar Lake North early-season Lakescan™ vegetation survey was conducted on Monday, July 10, and Tuesday, July 11, 2023. The most common native species observed during the survey included *Chara* (*Chara sp.)*, Richardson's pondweed (*Potamogeton richardsonii)*, broadleaf pondweed (*Potamogeton amplifolius Tuckerman*), naiad (*Najas sp.)*, variable-leaf watermilfoil (*Myriophyllum heterophyllum*), bladderwort (*Utricularia vulgaris*), and sago pondweed (*Stuckenia pectinata*). In addition, emergent plant species, such as white water-lily (Nymphaea odorata) and spadderdock (*Nuphar advena*) were regularly observed nearshore in high densities, especially in the northern bay of the lake. There were no invasive species found in Cedar Lake North during the early-season survey. Potential nuisance conditions were primarily observed within the trenches (Tier 5 AROS) and along the western shoreline.

The late-season LakeScan™ survey on Cedar Lake North took place on Tuesday, August 29, 2023. The most common native species observed throughout the survey included *Chara*, Richardson's pondweed, broadleaf pondweed, naiad, and sago pondweed. In addition, emergent plant species, such as white water-lily and spadderdock were regularly observed nearshore in high densities, although they appeared less dense than the early-season survey. The only observed submerged aquatic invasive species during the time of the survey was hybrid Eurasian watermilfoil (Myriophyllum spicatum x sibiricum; EWM) which was found only in AROS #357.

For this report, K&A also analyzed the past five years of LakeScan™ data for the average percent of nuisance species coverage (Figure ES -1). Over the past 5 years, the average hybrid Eurasian watermilfoil coverage on Cedar Lake North has maintained a minimal presence and exhibited a downward trend. Based on these trends, it appears likely that management activities are successfully controlling nuisance hybrid Eurasian watermilfoil populations and are suppressing any additional population growth. While variable-leaf watermilfoil is not considered an invasive species in Michigan, it does significantly contribute to the nuisance conditions on Cedar Lake. Over the last five years, variable-leaf watermilfoil has exhibited a decrease in coverage, after two relatively high coverage years in 2019 and 2020. This suggests that recent management activities have been effective at suppressing the growth of the species.

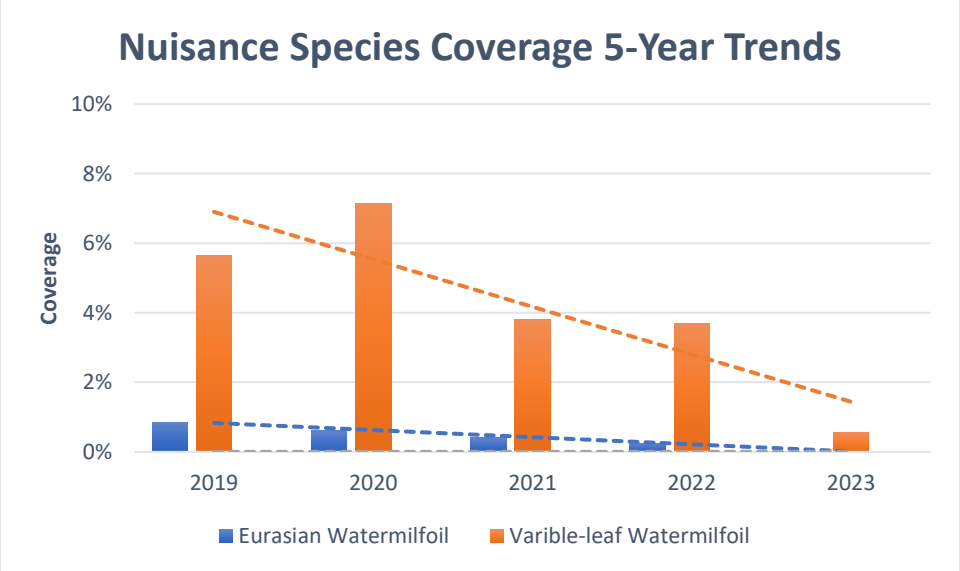


Figure ES-1 – nuisance species average coverage 5-year trends.

Based on 2023 findings, K&A recommends the following management considerations for 2024:

- **Continued management intervention is recommended for hybrid Eurasian watermilfoil**. Eurasian watermilfoil coverages have trended downward over the last five years with coverage in 2023 being nearly 0%. Thus, current management interventions appear to be effective at suppressing growth and reducing the cumulative coverage of EWM. Therefore, the Cedar Lake Improvement Board should continue exploring management options similar to the ones implemented in 2023 for treating EWM in the following years.
- **Continued ProcelleCOR applications to treat Eurasian watermilfoil in the northern trenches of Cedar Lake North is recommended**. Recent ProcelleCOR applications in Cedar Lake North appear to have been an effective strategy for the management of nuisance hybrid Eurasian watermilfoil. Applications should continue through 2024 to determine if ProcelleCOR continues to be an effective means to control hybrid Eurasian watermilfoil.
- **Continued monitoring of coverage and nuisance conditions of Variable-leaf watermilfoil.** The treatments in 2020 targeting nuisance variable-leaf watermilfoil should have lasting effects for up to three years. Based on 2021 - 2023 LakeScan™ surveys, the 2020 treatments appear to have continually suppressed nuisance conditions. It will be important to closely monitor the treatment areas to see if treatment results persist into 2024.

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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 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 (Table 1) and then further subdivided into Aquatic Resource Observation Sites (AROS) (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 nuisance conditions. Dissolved oxygen profiles and temperature profiles as well as Secchi depth are additionally recorded. Other water quality sampling can be included with surveys when requested.

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 *Chara*cteristics, 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 *Chara*cteristics

This section provides a brief overview of physical and geopolitical *Chara*cteristics of the lake and its watershed.

Location

Counties: Alcona and Iosco

Townships: Greenbush and Oscoda (respectively)

Township/Range/Section(s): T25N & T24N, R9E Sections: 15, 22, 27, 34, and 3

GPS Coordinates: 44.528853, -83.331903

Morphometry

Total Area: 830 acres

Shoreline Length: 47,339 feet

Maximum Depth: 10 feet

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 *Chara*cteristics 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 that is comprised largely of cedar swamp. The algal bloom risk for Cedar Lake North 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) for early and late season surveys, respectively. 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] Some variation in Secchi disk reporting may be a result of cloud cover, time of day, recent rain events, and recreational lake usage.

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. In highly productive lakes, oxygen depletion can occur in deep unmixed bottom waters during the warmer summer months. 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 at a 12 feet deep portion of the lake near AROS 470. These parameters were measured using a YSI ProSolo dissolved oxygen meter, calibrated prior to use. Temperature and DO concentrations during both the early and late-season surveys were relatively uniform from the surface to the lake bottom (Figures 2 and 3). The uniform DO and temperature profiles are to be expected due to the shallow depths of the lake, and the lack of strong stratification. Both DO and temperature parameters fell within the range of desirable conditions for fish and aquatic life.[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.

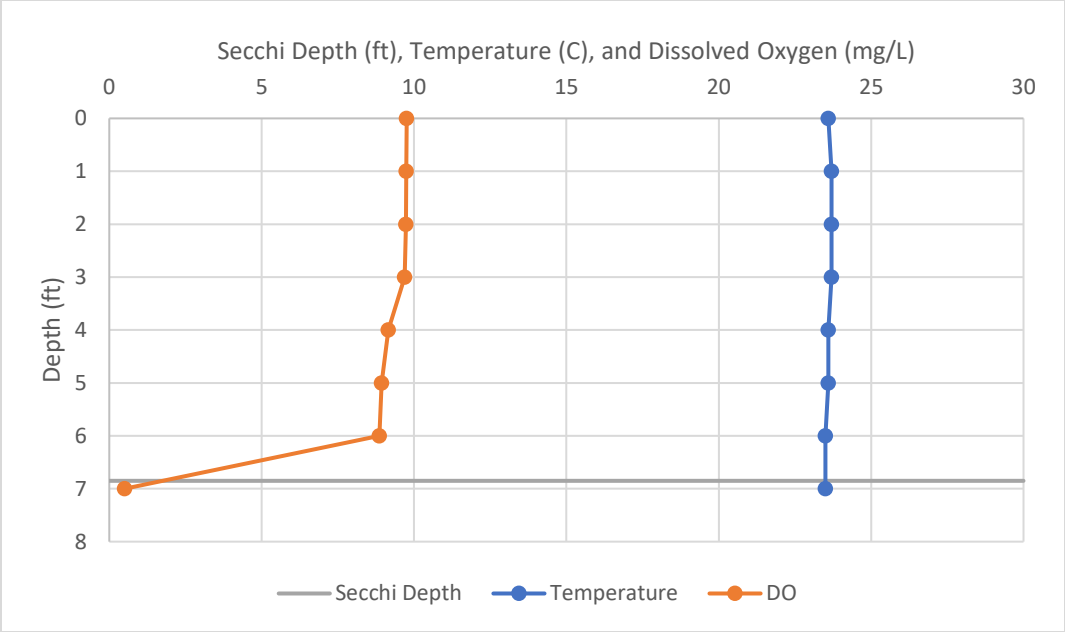

Figure 2 – Early-season survey (July 10, 2023) dissolved oxygen and temperature profiles with Secchi depth, taken near AROS 470.

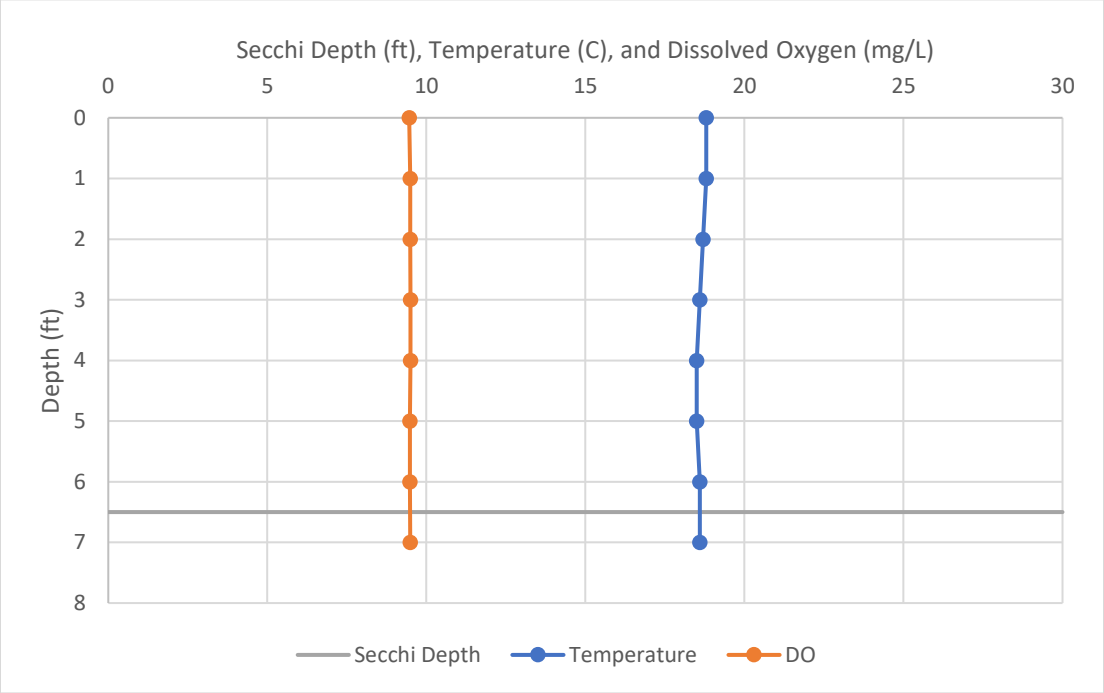

Figure 3 – Late-season survey (August 29, 2023) dissolved oxygen and temperature profiles with Secchi depth, taken near AROS 470.

4.0. Aquatic Vegetation

This section details findings from the two vegetation surveys that were conducted on the lake in 2023. This includes observations, aquatic vegetation mapping, and LakeScan™ analysis metrics.

4.1. Early-Season Survey

The Cedar Lake North early-season LakeScan™ vegetation survey was conducted on Monday, July 10, 2023, and in the morning on Tuesday, July 11, 2023. The weather on Monday was mostly sunny with strong 9 to 15 mph winds out of the southwest, and temperatures around 80°F. Tuesday was mostly overcast with some scattered showers and temperatures around 70°F with 6 to 10 mph winds out of the north. Visibility through the water column was good with a secchi disk reading of 6.85 ft, however turbidity due to recent rain events combined with overcast skies proved challenging for visibility throughout most of the survey. Figure 4 depicts the 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 to spatially depict observed vegetation data.

The most common native species observed throughout the survey included *Chara*, Richardson's pondweed, broadleaf pondweed, naiad, variable-leaf watermilfoil, bladderwort, and sago pondweed. In addition, emergent plant species, such as white water-lily and spadderdock were regularly observed nearshore in high densities which could cause some navigation concerns, especially in the northern bay of the lake. *Chara*, broadleaf pondweed, and bladderwort were regularly found throughout most of the lake with *Chara* being present in almost all AROS.

Variable-leaf watermilfoil has historically created recreational nuisance conditions within Cedar Lake North and has been a target of previous control efforts. While this species does still create some nuisance conditions, density and coverage has decreased since it was last widely managed in 2020 (Figure 5). Overall, this observed native species did not appear to be causing nuisance conditions during the time of the survey, although some pondweeds were at the surface and flowering in a few AROS. The trenches and excavation zones (Tier 5 AROS) displayed the highest densities of native pondweeds and *Chara*. Trench 1 (AROS zones 567 & 566) was of particular concern with dense sago pondweed near the surface and *Chara* bubbling up from the bottom post-herbicide treatment.

There were no observed aquatic invasive species in Cedar Lake North during the time of the survey, displaying the effectiveness of the herbicide treatment in June. Herbicide damaged hybrid Eurasian watermilfoil was found scattered among some AROS locations, but no standing or living plants were observed during the survey. An early-season herbicide treatment targeting EWM took place on Tuesday, June 27, 2023. This was 13-14 days prior to the early-season vegetation survey. Generally, chemical treatments take about 10 days before full effects are observed, therefore, full treatment efficacy would have been observed during the early-season vegetation survey. Observations made during the survey deemed the herbicide treatments were likely effective at controlling nuisance hybrid Eurasian watermilfoil as each treated location had no active EWM following the herbicide applications.

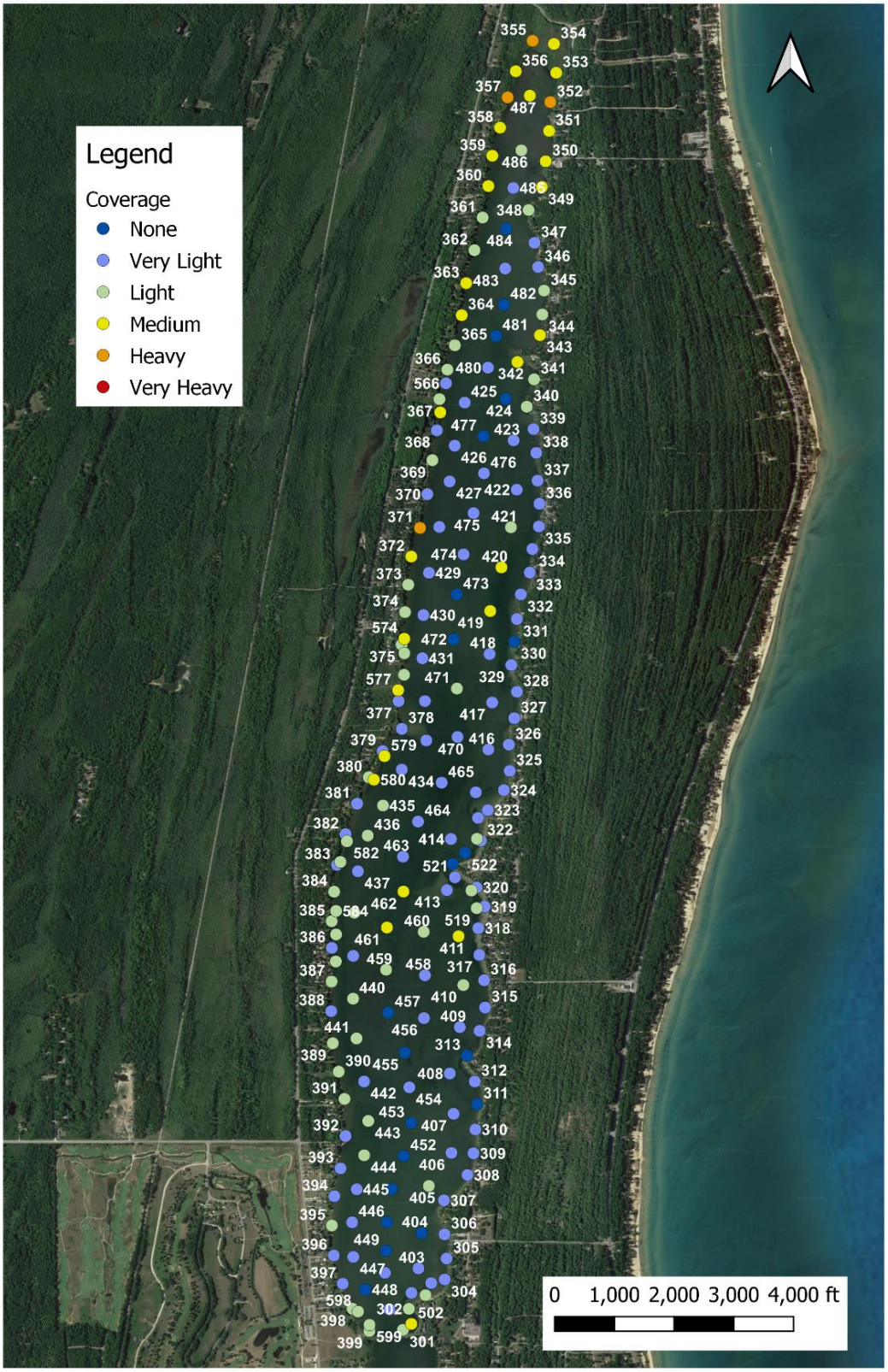

Figure 4 – Early-season survey (July 10-11, 2023) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

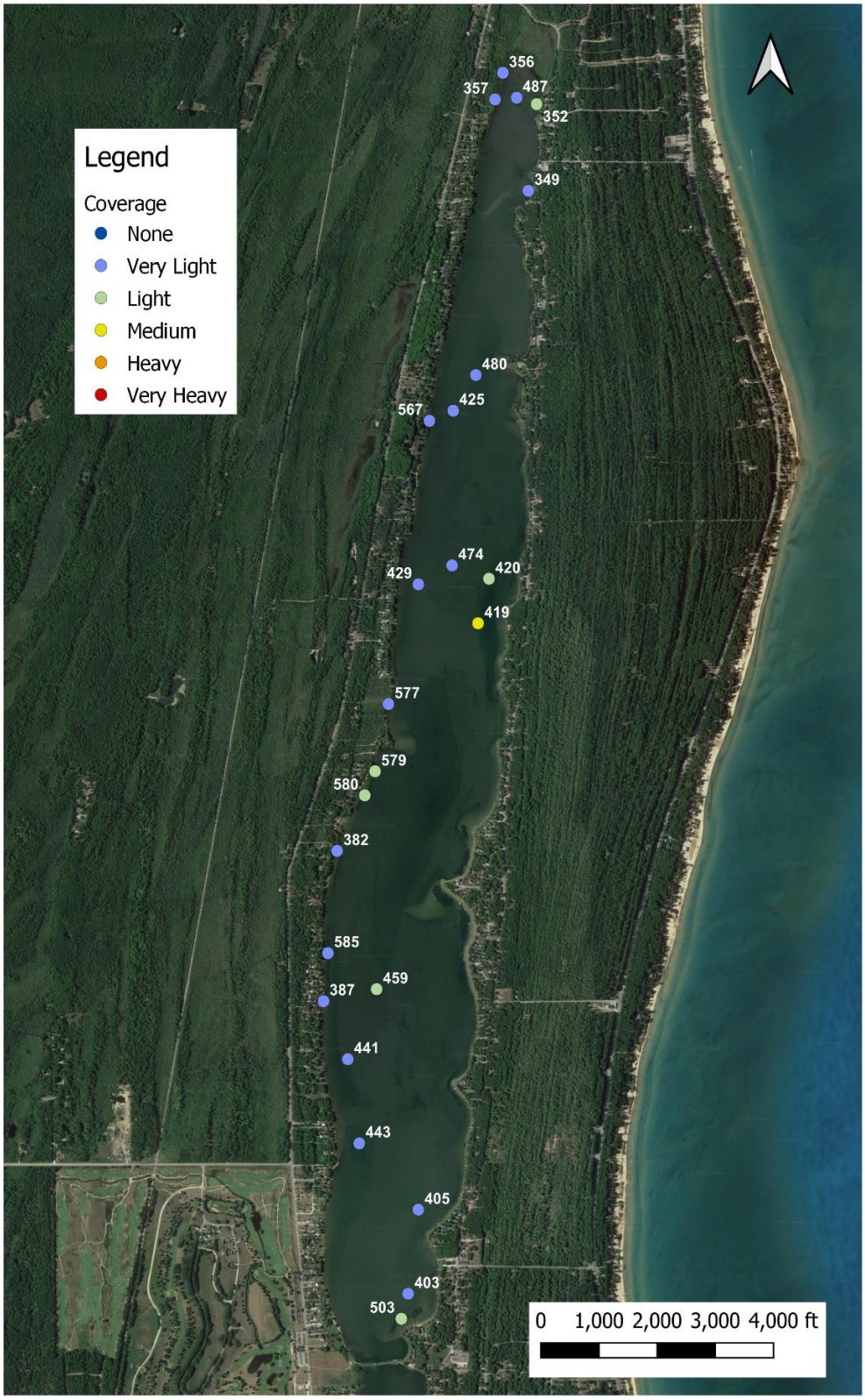

Figure 5 – Early-season (July 10-11, 2023) Variable-leaf Watermilfoil and Hybrids coverage.

4.2. Late-Season Survey

The Cedar Lake North late-season LakeScan™ vegetation survey was conducted on Wednesday, August 30, 2023. The weather was mostly sunny with strong 10 to 15 mph winds out of the northwest, and temperatures around 55-65°F. Visibility through the water column was good with a secchi disk reading of 7.5 ft. Figure 6 depicts data on all combined species using three-dimensional density observed on Cedar Lake North during the late-season survey.

The most common native species observed throughout the survey included *Chara*, Richardson's pondweed, broadleaf pondweed, naiad, and sago pondweed. In addition, emergent plant species, such as white water-lily and spadderdock were regularly observed nearshore in high densities which could cause some navigation concerns, especially in the northern bay of the lake, although the lilies appeared less dense than they were in the early-season survey. *Chara*, broadleaf pondweed, and Richardson's pondweed were regularly found throughout most of the lake with *Chara* being present in almost all AROS zones. The observed native species did not cause many nuisance conditions, however, the pondweeds, mainly broadleaf but occasionally sago and Richardson's, were at the surface and flowering in some locations, creating recreational nuisance concerns around swimming areas and docks. The trenches and excavation zones (Tier 5 AROS) displayed the highest densities of native pondweeds and *Chara*, creating some recreational nuisance concerns. Trench 1 and Trench 2 (AROS 567-566 & 574-575) were of particular concern with dense sago pondweed near the surface. Variable-leaf watermilfoil was sparsely distributed and only observed at low densities in AROS zones 356 and 357 (Figure 7). These observations suggest that variable-leaf watermilfoil treatments have successfully controlled nuisance growth over multiple years.

The only observed submerged aquatic invasive species during the time of the survey was Eurasian watermilfoil hybrid (*Myriophyllum spicatum x sibiricum*; EWM) which was only found in AROS 357 and was not part of the early-season treatment in June. The small patch of EWM did not appear dense or continuous enough to warrant treatment at the time of the survey (Figure 8). The terrestrial invasive species purple loosestrife (*Lythrum salicaria L.*) and phragmites (*phragmities sp*.) were observed during the late-season survey at very light coverages. Exotic phragmites was found in the same single AROS in both 2022 and 2023 indicating that the species has persisted, but not expanded its population over the past year. Purple loosestrife was more common, and was observed in isolated patches in 17% of shoreline AROS. The trends in purple loosestrife coverage closely mirror those observed in 2020 suggesting that the year-to-year spread of the species is minimal.

Large amounts of lake foam were additionally observed during the late-season survey on Cedar Lake north. Pictures were taken in AROS where heavy presence of lake foam was noted. Appendix C details the history of foam on Cedar Lake and includes pictures taken during the survey.

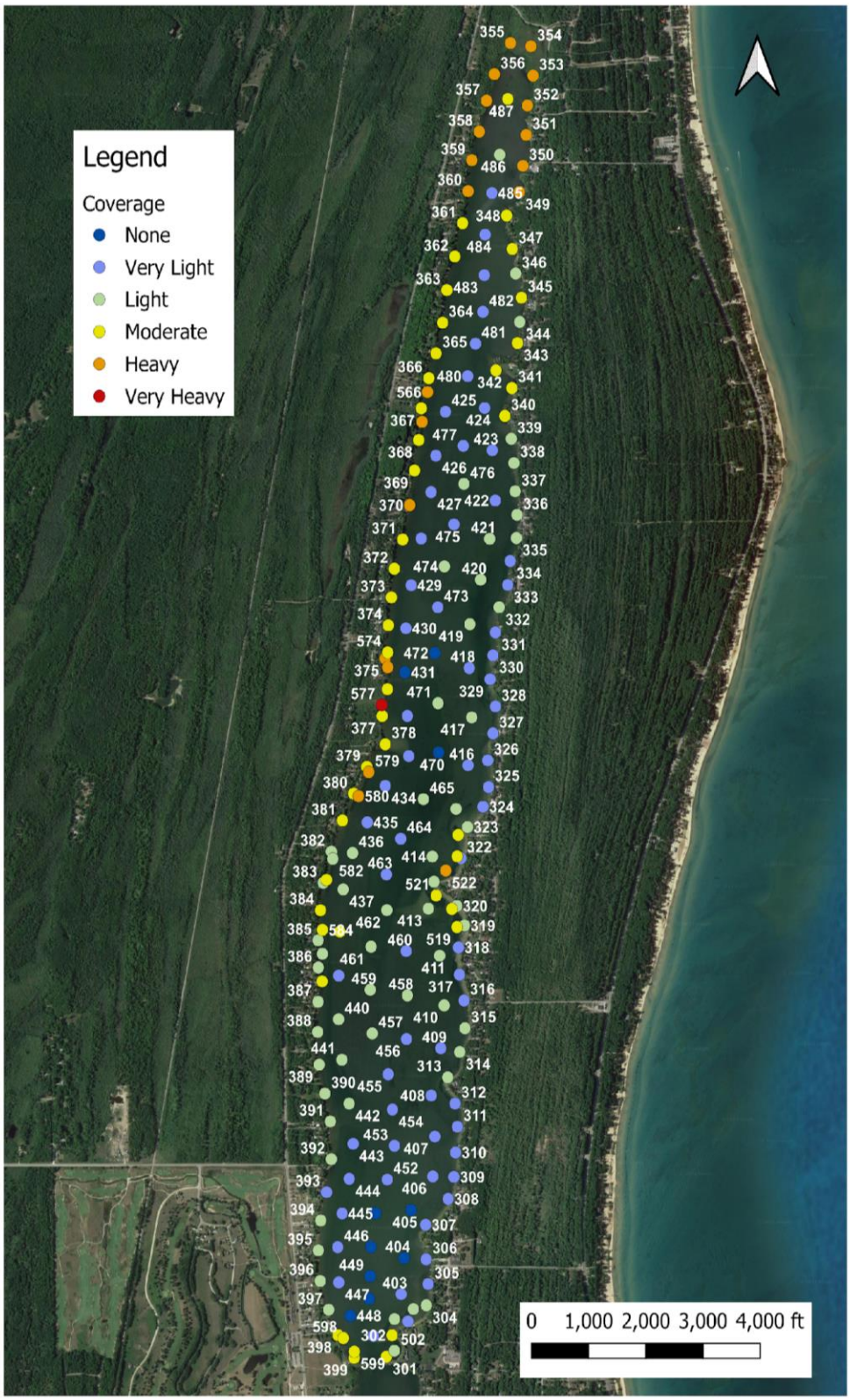

Figure 6 – Late-season survey (August 30, 2023) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

Figure 7 – Late-season (August 30, 2023) Variable-leaf Watermilfoil coverage.

Figure 8 – Late-season (August 30, 2023) Eurasian Watermilfoil and hybrids coverage.

4.3. Summary Observations for Early & Late Surveys

Aquatic plant species observed during the 2023 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 9 illustrates dominance by T Value categories for early and late season surveys over the last few years.

Table 2- Aquatic Plant Species Observed in 2023.

Common Name	T Value	Frequency		Coverage		Dominance	
		Early '23	Late '23	Early '23	Late '23	Early '23	Late '23
Eurasian Watermilfoil Hybrid	1	0.0%	0.5%	0.0%	0.1%	0.0%	0.1%
Green/Variable Watermilfoil	2	11.9%	1.0%	1.0%	0.1%	3.6%	0.3%
Common Bladderwort	3	12.9%	5.9%	1.3%	0.4%	4.6%	1.0%
Elodea	3	3.5%	0.5%	0.4%	0.1%	1.4%	0.1%
Naiad	2	25.2%	12.9%	2.8%	1.5%	9.7%	3.4%
Chara	4	83.7%	80.2%	11.4%	13.1%	39.6%	31.0%
Nitella	4	1.5%	0.0%	0.2%	0.0%	0.5%	0.0%
Flat Stem Pondweed	3	0.5%	0.5%	0.0%	0.0%	0.1%	0.1%
Purple Loosestrife	1	0.0%	8.4%	0.0%	0.5%	0.0%	1.2%
Swamp Loosestrife	4	0.0%	2.5%	0.0%	0.2%	0.0%	0.4%
Richardson's Pondweed	2	15.8%	46.0%	1.8%	6.2%	6.2%	14.6%
White Stem Pondweed	3	1.5%	0.0%	0.1%	0.0%	0.3%	0.0%
Broadleaf Pondweed	3	22.3%	78.7%	2.0%	8.5%	7.0%	20.2%
Hybrid Pondweed	2	29.2%	0.0%	3.2%	0.0%	11.0%	0.0%
Sago Pondweed	2	5.0%	12.9%	0.7%	2.2%	2.4%	5.3%
Horned Pondweed	3	3.0%	0.0%	0.2%	0.0%	0.8%	0.0%
Wild Celery	2	4.0%	20.8%	0.3%	2.4%	1.0%	5.6%
Rush	4	0.0%	30.2%	0.0%	2.2%	0.0%	5.2%
Waterlily	2	14.9%	14.9%	1.8%	2.2%	6.2%	5.1%
Spadderdock	2	11.9%	8.9%	1.5%	1.1%	5.3%	2.6%
Water Shield	3	0.5%	0.0%	0.1%	0.0%	0.2%	0.0%
Arrow Arum	3	0.0%	4.5%	0.0%	0.5%	0.0%	1.2%
Cattail	3	0.0%	11.9%	0.0%	1.0%	0.0%	2.3%
Phragmites	1	0.0%	0.5%	0.0%	0.0%	0.0%	0.1%

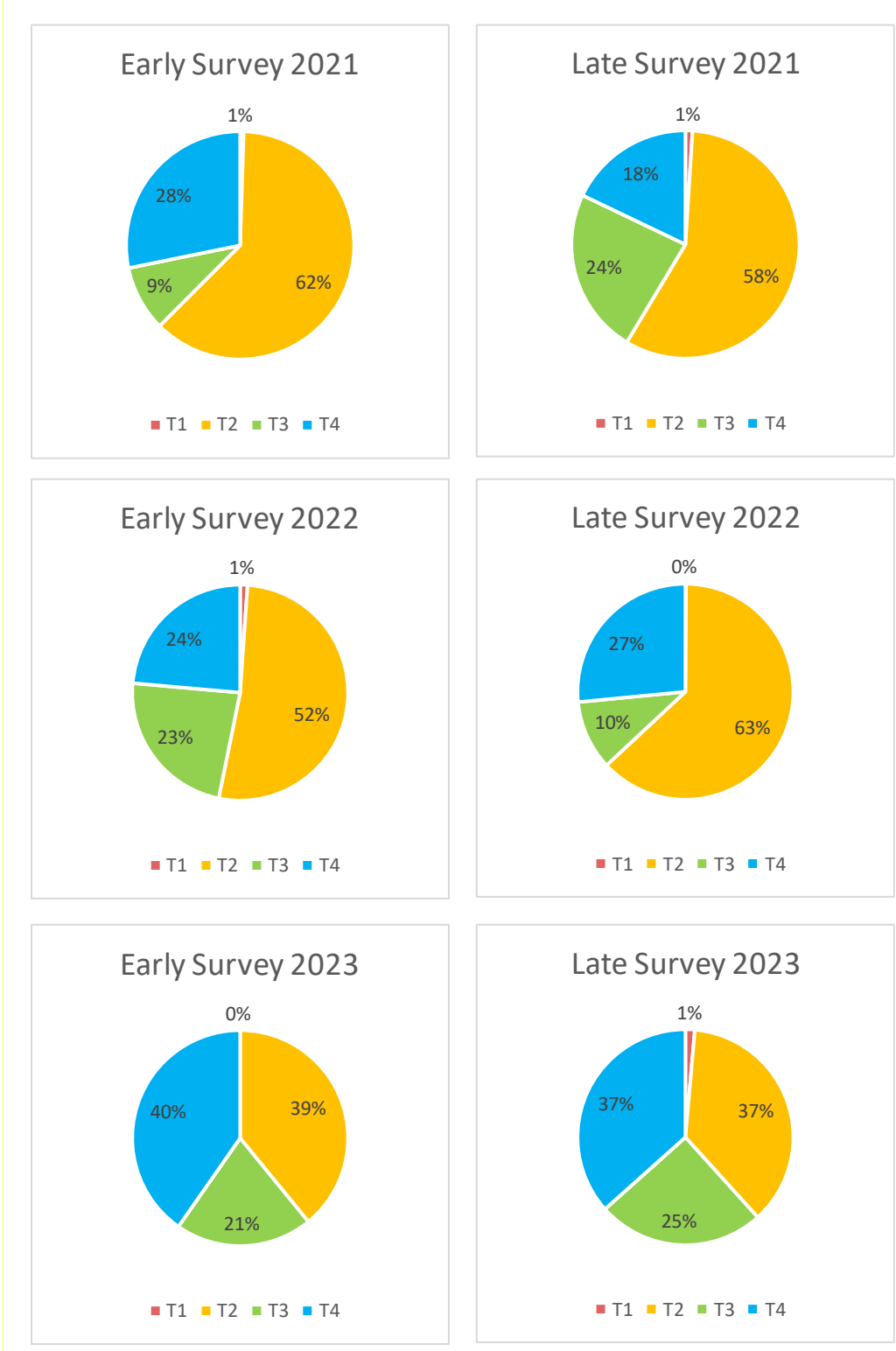

Figure 9 – Distribution of aquatic plant coverage by T Value comparing early-season and late-season surveys from 2021 – 2023.

4.4. LakeScan™ Metrics

Six important metrics for defining lake conditions are presented here for the 2023 vegetation surveys (Table 3). 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[4] is presented with 1 being poor and 10 being excellent. Descriptions of each metric are as follows:

- **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. (Areas where any vegetation is growing densely enough to inhibit boating and/or swimming).
- **Algal Bloom Risk** – a calculated algal bloom risk level based on the *Chara*cteristics 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] A total lake score is a summary of the category scores where: "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.

[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.

The LakeScan™ metric scores from early and late-season 2023 surveys for Cedar Lake North are summarized in (Table 3). Survey results indicate that the LakeScan™ metrics remained generally consistent between the early and the late-season surveys. The Shannon Morphology Index and Floristic quality index met the management goals across both surveys, while the Shannon Biodiversity Index and Recreational Nuisance Presence were close, but ultimately did not meet the management goals for Cedar Lake North. The low Shannon Biodiversity Index scores across both surveys indicates that there may be a low diversity of species present, while the high Shannon Morphology Index suggests that the species which are present are diverse in structure, contributing to improved fish and wildlife habitat suitability. The consistently high Floristic Quality Index averages on Cedar Lake North indicate a high distribution of desirable, native plant species and a low distribution of undesirable invasive species.

Recreational Nuisance scoring met the management goal of less than 10% in the early-season survey (0%), but nuisance conditions increased by the late-season survey (24%). Weedy native species such as sago pondweed, broadleaf pondweed, and Richardson's pondweed flowering at the surface, caused many of the nuisance conditions observed during the late-season survey. While the flowering species caused aesthetic and recreational concerns, flowering is a natural stage in the late lifecycle of many native pondweeds, therefore nuisance conditions are typically more common in the late-season, but may not persist for extended periods as the pondweeds typically recede after flowering. 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 overall total lake score for Cedar Lake North is 8.5 out of 10.

Table 3 – 2022 LakeScan™ Metric results.

LakeScan Metric	Score Range	2023 Early Season	2023 Late Season	2023 Average	Management Goal
Species Richness	5 - 30	18	20	19	n/a
Shannon Biodiversity Index	1 -15	8.1	8.3	8.2	> 8.8
Shannon Morphology Index	1 - 10	6.9	7.4	7.2	> 6.3
Floristic Quality Index	1 - 40	26.5	26.8	26.7	> 20
Recreational Nuisance Presence	0 - 100%	0%	24%	12%	< 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

The 5-year historical trends for Floristic Quality Index (FQI) scores and nuisance species coverage values are presented in (Figures 10 and 11), respectively. Trendlines were 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. Slight negative trends for the invasive 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 the dominance of desirable, native plant species and a decrease in undesirable, non-native plant species (Figure 10). For the last five years, Cedar Lake North's FQI score has exceeded the management goal of 20. Furthermore, Cedar Lake North's Eurasian watermilfoil coverage has exhibited a slight declining trend over the last five years, indicating that management activities appear to be effective at controlling and suppressing any additional Eurasian watermilfoil population expansion (Figure 11). Variable-leaf watermilfoil, dominance has also decreased over the last five years (Figure 11). In 2023 Variable-leaf watermilfoil has exhibited a lower average coverage than the four years prior. These trends suggest that management actions which target variable-leaf watermilfoil might have successfully acted as a multi-year control for the species.

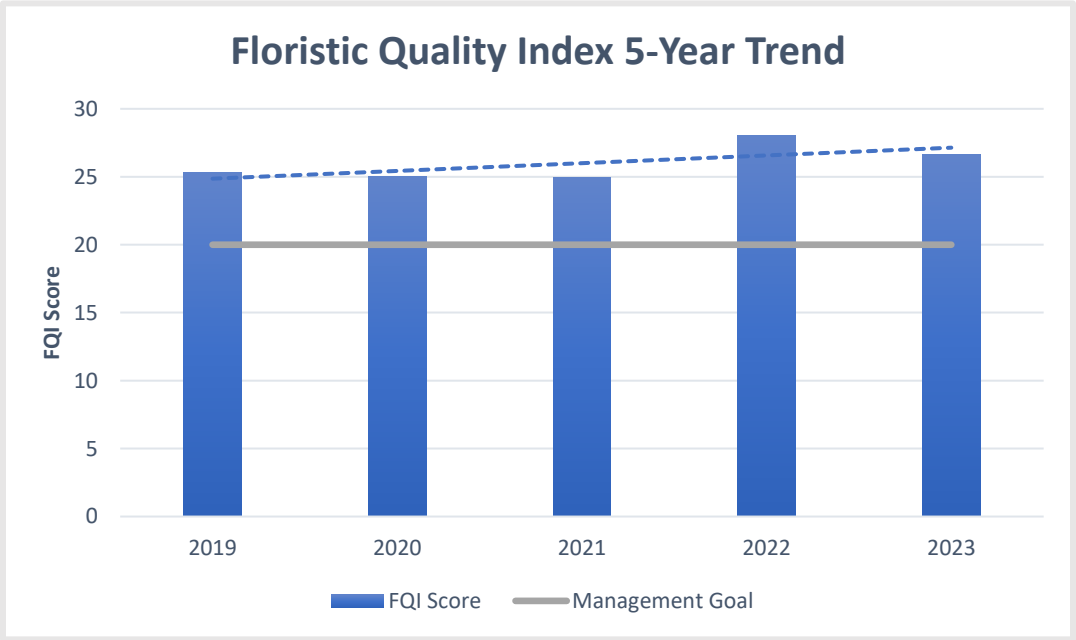

Figure 10 – Floristic Quality Index 5-Year Trends.

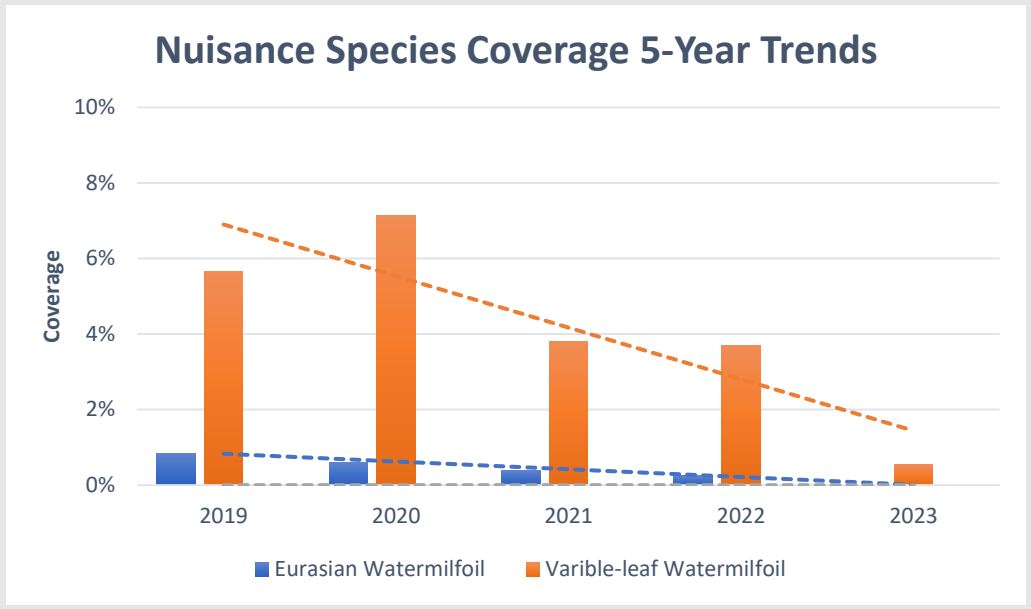

Figure 11 –Nuisance Species Coverage 5-Year Trends.

5.0. Lake Management

There are several species that typically become a nuisance in Michigan's inland lakes (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 2023. Figure 12 shows the coverage change of targeted species over both surveys. Copies of the herbicide applicator treatment maps are included in Appendix D.

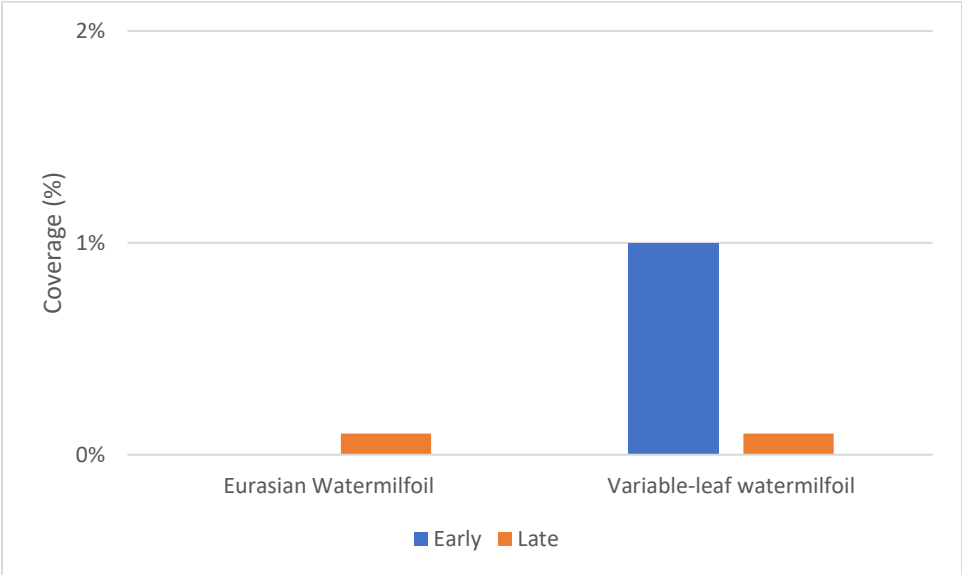

Figure 12 – Changes in coverage across both surveys for targeted species.

Variable-leaf watermilfoil and native pondweeds have been some of the most dominant species observed on Cedar Lake North. Historically, variable-leaf watermilfoil has grown in dense patches throughout the main body of the lake creating navigation hazards and recreational nuisance conditions. Within the deeper trenches and excavation zones of Cedar Lake, aquatic plant growth is typically very dense and often grows to the surface. Eurasian watermilfoil, variable-leaf watermilfoil, elodea, wild celery, Richardson's pondweed, and other native pondweeds grow to nuisance levels in these trenches forming dense bands of vegetation that can cause navigational hazards.

During the 2020 late-season survey, variable-leaf watermilfoil was observed creating recreational nuisance conditions throughout the center of the lake. The year-over-year increases and excessive nuisance conditions exhibited by variable-leaf watermilfoil prompted a treatment in September of 2020. According to survey results, locations that received the September 2020 treatment appeared to have suppressed variable-leaf watermilfoil growth during 2021 - 2023. These observations suggest that the treatment in 2020 and continued treatment of variable-leaf watermilfoil in the trenches and nearshore areas have been successful at limiting growth and suppressing the recreational nuisance conditions caused by the species.

It is important to monitor the growth of variable-leaf watermilfoil since this species has been known to cause nuisance conditions on Cedar Lake North. In the future, it might be necessary to submit permit amendments to allow for selective treatment of variable-leaf 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-leaf watermilfoil and the considerable nuisance conditions this species poses for Cedar Lake North, it may be wise to explore harvesting options to allow for boat passage in critical areas of the lake. However, harvesting can be costly and may not provide long-term control due to issues such as plant fragmentation.

Low coverage of hybrid Eurasian watermilfoil in 2023 and a slight decrease in coverage trends over the last five years suggest that lake management activities have successfully been suppressing hybrid Eurasian watermilfoil growth and expansion. It is also possible that current conditions are not conducive for substantial Eurasian watermilfoil growth outside of the deep trenches and excavation zones on Cedar Lake North. The bump of observed Eurasian water milfoil coverage in the late season is most likely attributed to the area being excluded from the early-season treatment plan.

ProcellaCOR was applied to the northern trenches as a pilot test to treat the persistent Eurasian watermilfoil population on June 16, 2021. This pilot test was done to test how effective PrecellaCOR is for treating Eurasian watermilfoil. Initial results in 2021 suggested that treatment of EWM with this herbicide have generally been successful, with the exception of the northernmost portion of Trench 1 which still exhibited a significant amount of EWM following treatment (likely due to application error). To remedy this, a late-season treatment was applied in 2021 to ensure this area received treatment. On June 27th, 2023 ProcellaCOR was again applied to areas of the lake displaying nuisance conditions of EWM and variable-leaf watermilfoil. EWM was absent from Trench 1 during the 2022 and 2023 vegetation surveys, indicating that control of EWM in the trenches of Cedar Lake North using ProcelleCOR is promising.

5.1. Future Management Recommendations

LakeScan™ vegetation monitoring will continue with two surveys per growing season under the current K&A contract (once during the spring-early summer and another during the late summer). 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 hybrid Eurasian watermilfoil. EWM coverage substantially decreased between the early and late-season surveys. Furthermore, Eurasian watermilfoil coverages have trended downward over the last five years. Thus, current management interventions appear to be effective at suppressing the possible spread and reducing the cumulative coverage of watermilfoil. It is also possible that the ebrid watermilfoil strain that dominates Cedar Lake North is becoming less aggressive.

Continued ProcelleCOR applications to treat nuisance Eurasian watermilfoil in the northern trenches of Cedar Lake North is recommended. Recent ProcelleCOR applications in Cedar Lake where an effort was made to inject the herbicide below the water surface appear to have been an effective strategy for controlling nuisance Eurasian watermilfoil populations. Applications and testing should continue through 2024 to determine if ProcelleCOR continues to be an effective means to treat Eurasian watermilfoil.

Continued monitoring of coverage and nuisance conditions of variable-leaf watermilfoil is additionally recommended. Variable-leaf watermilfoil, tends to create recreational nuisances on Cedar Lake North and was targeted for treatment in September 2020, which should have lasting effects for up to three years. Based on 2021 - 2023 LakeScan™ surveys, the 2020 treatments appear to have suppressed nuisance conditions. It will be important to closely monitor these areas again in 2024 to see if treatment results achieved multi-year suppression or if the efficacy of the treatment is beginning to wear off.

K&A recommends exploring alternative management strategies to control native aquatic plant nuisance conditions. Because EGLE restricts chemical treatments for native aquatic plant nuisance conditions, it may be feasible to explore other options, such as harvesting to alleviate nuisance variable-leaf watermilfoil conditions in the future, which would not require additional EGLE permitting.

6.0. Appendices

Appendix A: Blue-green Algae

Blue-green algal 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 algal blooms are usually temporal events and may disappear as rapidly as they appear. Such blooms have become more common for a variety of potential reasons; however, the spread and impact of zebra mussels has been closely associated with blooms of blue-green algae.

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. 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 algal 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 algal 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 typically bloom and become a nuisance when resources are limiting to other plant and algae or when biotic conditions reach certain extremes, particularly warm water conditions. 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). Very small amounts of phosphorus may

result in large algal 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.

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 cyanobacteria and feed selectively on other 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.

Management: Treatment methods for blue-green algae are generally preventative rather than reactionary. One of the most common forms of algae treatment is limiting nutrients, namely phosphorus, from entering the lake ecosystem through several sources. Phosphorus mainly enters lake systems through surface water inputs such as rivers, creeks, or overland runoff. In some inland lakes that experience late-summer stratification, sediment-bound phosphorus at the lake bottom becomes mobilized due to low-oxygen conditions which, under high sustained wind conditions, can mix surface and bottom waters. This is particularly problematic in the late summer. Phosphorus-reducing practices include: implementing Best Management Practices (BMPs) in upstream agricultural and urban areas, limiting nutrient (fertilizer) applications on lawns, planting vegetative buffer strips between nutrient-producing areas and surface water, reducing septic system leaching (if riparian homes are not sewered), binding lake-bottom phosphorus using alum or other adsorbent materials (e.g., Phoslock®), and treating/infiltrating stormwater prior discharge into upstream surface waters of the lake. Some blue green algae blooms are caused by species/communities that depend on luxuriant sediment nutrient pools. The restriction of nutrient inputs to these lakes cannot be realistically expected to resolve nuisance bloom conditions in any reasonable amount of time, if at all. K&A is investigating the use of products that can serve as barriers to the mobilization of sediment nutrients for use by bottom associated noxious algae blooms.

When nuisance conditions occur, contact algaecides or hydrogen peroxide may be used as a reactionary treatment to destroy algae present in the water column. However, chemicals should be applied with caution due to concerns of bioaccumulation and toxicity to other forms of aquatic life. Sometimes, algaecide applications are made to surface blooms. However, the effectiveness of such treatments is compromised because the surface blooms can be pushed to different areas of the lake with prevailing winds.

Appendix B: Common Aquatic Invasive Species

Eurasian Watermilfoil and Hybrids:

Background: Anecdotal evidence suggests that hybrid watermilfoil 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 watermilfoil 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 Eurasian watermilfoil hybrids. Eurasian watermilfoil hybrids are 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 Eurasian watermilfoil. Eurasian 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 Eurasian watermilfoil and support the production of a more desirable flora. However, it is becoming much more resistant to herbicidal treatments. Herbicide resistant Eurasian watermilfoil and hybrid watermilfoil have been observed in many lakes throughout the Midwest.[7,8] Continued and misguided chemical application strategies can select for herbicide resistant plants, resulting in the dominance of resistant hybrid watermilfoil strains. Herbicide treatment strategies must be monitored and adjusted to accommodate for this possibility.[9] Research and field experience suggest that herbicide resistance can be linked to ecosystem microbial functions and factors and can overcome with the use of microbiological system treatments.

Eurasian watermilfoil community genetics are dynamic and careful monitoring is needed to adapt to the expected changes in the dominance of distinct Eurasian watermilfoil 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.

Watermilfoil community genetics are dynamic and constantly evolving. There nuisance levels caused by watermilfoil have been in decline in many Michigan inland lakes for decades. There is some evidence that some watermilfoil strains do not grow to nuisance levels and may not require treatment to protect ecosystem functions. The milfoil community must be closely monitored to avoid unnecessary management interventions if the milfoil present is not growing to noxious levels or presents a threat to more desirable vegetation.

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[7] 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.

[8] 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.

[9] Netherland and Wiley, 2017.

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 can 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.

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

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.[10] 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.[11] While these methods can be effective and have high specificity, they are expensive, labor-intensive strategies that require long-term commitment.[12] 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.

Properly conducted starry stonewort algaecide treatments using copper-, diquat-, flumioxazin and endothall-based algaecides have produced outstanding short-term results but have been largely ineffective for long-term management. 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" vegetation mats or the biocides must be injected into the dense starry stonewort growth to achieve adequate control in some cases.

Curly-leaf Pondweed:

Background: Curly-leaf pondweed (CLP) is one of the world's most widespread aquatic plant species. Although it is found worldwide, CLP is native to only Eurasia. The earliest verifiable records of the plant are from Pennsylvania in the 1840s, and has been found in Michigan since 1910. Curly-leaf pondweed is currently found in inland lakes of 34 counties in Michigan, distributed both in the upper and lower peninsulas.[13] Scientific literature suggests that curly-leaf pondweed is an aggressively growing species that often expands to nuisance levels when native plants are damaged.

Curly-leaf pondweed can create problems such as recreational nuisances, ecological nuisances (by outcompeting native species and reducing light availability to other plants), and degraded fish spawning habitat. Curly-leaf pondweed is easily detectable in early spring as it will be one of the few plants readily growing and the first submersed plant to reach the surface. This gives it a competitive advantage and can grow 4 to 5 feet tall before other plants begin germinating from the bottom sediments. As water

[10] 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.

[11] Glisson et al., 2018.

[12] 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

[13] MDEQ. (2018). "State of Michigan's Status and Strategy for Curly-leafed Pondweed (*Potamogeton crispus L.*)." Accessed online: <https://www.michigan.gov/documents/invasives/egle-ais-potamogeton-crispus_708948_7.pdf>.

temperatures rise in late June and early July, curly-leaf pondweed stems begin to die, break down, and can be completely gone by mid-July.[14]

Figure B3: Example curly-leaf pondweed image from the 2021 LakeScan™ field crew.

Management: Like other invasive species, CLP is easy to control, but once established it is for all practical purposes seemingly impossible to eradicate. It is considered widespread in Michigan. Therefore, prevention of new populations in uninfected waters is the most economical management approach. Several herbicides have been shown to be effective at achieving season-long, species selective control of CLP. Bottom barriers have shown effectiveness at combating CLP in small areas, and mechanical harvesting of CLP can be effective if timed and managed correctly.[15]

The most viable ways to control CLP is through chemical and physical means after developing an integrated pest management plan. Early infestations may best be controlled by manual removal, diver-assisted suction harvesting (DASH), or benthic barrier use during spring before turions are produced. Aquatic herbicides including endothall, diquat, and flumioxazin are the most effective for general applications. Chemical treatments are a part of a long-term integrated management plan as the turions are viable for at least 5 years and only diquat, fluoridone, and some hormone treatments have shown a reduction of turion development in the laboratory.[16]

[14] Hart, Steven, M. Klepinger, H. Wandell, D. Garling, L. Wolfson. (2000). "Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes." Accessed online: <https://www.michigan.gov/documents/invasives/egle-great-lakes-aquatics-IPM-manual_708904_7.pdf>.

[15] MDEQ, 2018

[16] MDEQ, 2018.

Appendix C: Lake Foam

Background: During the late-season LakeScan™ vegetation survey on August 30, 2023, large amounts of foam was observed along the shoreline (Figures C1 & C2). Lake foam is often naturally occurring due to chemical changes in the lake and from decomposing plant material or, in rarer instances, lake foam can be caused by pollutants such as per- and polyfluoroalkyl substances (PFAS & PFOS).[17]

The abundance of the foam observed during the survey, and the presence of the foam in years past suggests that the foam found on Cedar Lake North during the August survey could be caused by PFAS pollutants.[18] Between 2018 and early 2020, EGLE sampled foam at Cedar Lake as part of a broader study. Results from samples found PFOS in foam from Cedar Lake at 7,260 ppt while a previous test, done in December 2018, found PFOS at 158 ppt[19].

Management: There are no EGLE standards for PFAS in foam, so no regulatory actions can be taken based on the results collected at Cedar Lake. All results from EGLE are shared with the Michigan Department of Health and Human Services (MDHHS) to determine if a foam advisory is needed**.** The variability in reported PFOS levels in Cedar Lake North has influenced the Iosco County district health department to recommend that residents avoid contact with foam around on the lake. EGLE has also posted informational signs at the Cedar Lake boat launch warning against coming into contact with the foam (Figure C3).

Figure C1. Foam found along Cedar Lake North shoreline, August 30, 2023.

[17] Foam: A naturally occurring phenomenon - state of Michigan. (n.d.). https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/Inland-Lakes-and-Streams/Naturally-Occurring-Phenomenon-foam.pdf?rev=758d5181dc50402e9a679d0dd45caebb

[18] Ewg. (n.d.-b). *Interactive map: Pfas contamination crisis: New data show 3,186 sites in 50 States*. Interactive Map: PFAS Contamination Crisis: New Data Show 3,186 Sites in 50 States. https://www.ewg.org/interactive-maps/pfas_contamination/map/

[19] *Residents should avoid foam on Cedar Lake due to PFAS and reminded to continue avoiding foam on Van Etten Lake*. DISTRICT HEALTH DEPARTMENT NO. 2. (n.d.). http://www.dhd2.org/wp-content/uploads/2020/06/2020-6-30-VEL-and-Cedar-Lake-foam.pdf

Figure C2. Close up example of foam found at the boat launch on Cedar Lake North, August 30, 2023.

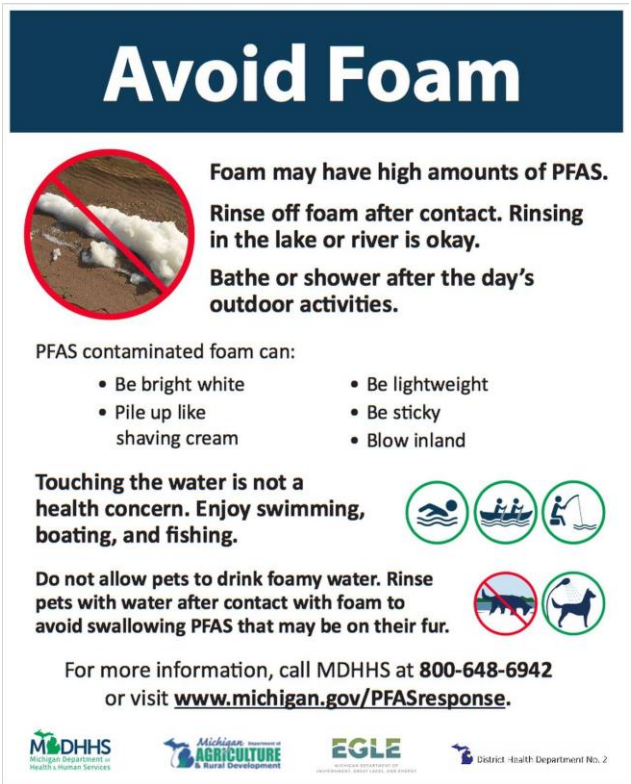

Figure C3. Example of EGLE infographic regarding lake foam found at the Cedar Lake North boat launch.

Appendix D: Herbicide Applicator Map