North Lake 2023 Report Executive Summary

December 15, 2023

Kieser & Associates, LLC (K&A) conducted vegetation monitoring on North Lake (Washtenaw County, 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. Results of 2023 show that North Lake met half of its management goals, but fell short on others (Table ES-1).

Table ES-1 – Summary of lake analysis metrics

LakeScan™ Metric	2023 Average	Management Goal
Species Richness	18	n/a
Shannon Biodiversity Index	7.2	> 8.6
Shannon Morphology Index	4.5	> 6.1
Floristic Quality Index	23.5	> 20
Recreational Nuisance Presence	6%	< 10%

The June 2023 early-season survey noted the most common native species included *Chara*, native pondweeds, and white waterlilies. Aquatic Invasive Species (AIS) noted in June included Eurasian watermilfoil and hybrids (EWM), limited sightings of curly-leaf pondweed, and starry stonewort. By August, the most prevalent natives include *Chara*, wild celery, variable pondweed, and broadleaf pondweed. Both starry stonewort and EWM were observed in the late-season survey. EWM was diminished following treatment. While starry stonewort increased in cumulative coverage over the summer, it was mainly documented on the bottom of the lake and did not present a recreational nuisance in 2023. It should be watched closely in subsequent years and may warrant a treatment at a later date if it becomes a nuisance. Water quality samples revealed that North Lake is trending towards mesotrophic conditions.

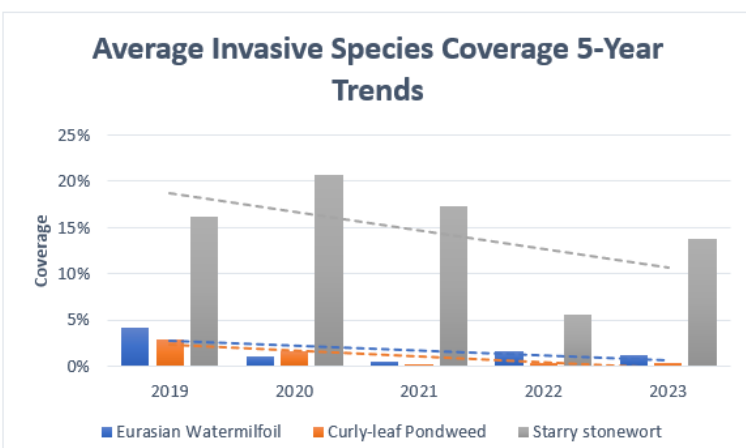

Figure ES-1 – Invasive species coverage 5-year trends.

Looking at the 5-year trend, all three major invasive aquatic species (EWM, starry stonework and curly-leaf pondweed) have shown stable to slightly decreasing trends in coverage. While starry showed increased coverage compared to 2022, it was documented to be intermingled with other species and was not reaching the surface of the lake. Both EWM and curly-leaf pondweed have shown coverages below 5% since 2019 with fairly consistent declines since then. Management in 2024, should be ready to adapt to starry stonewort if nuisance conditions develop for this AIS.

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

North Lake

Washtenaw County

2023 DATA AND ANALYSIS SUMMARY REPORT WITH MANAGEMENT RECOMMENDATIONS

December 15, 2023

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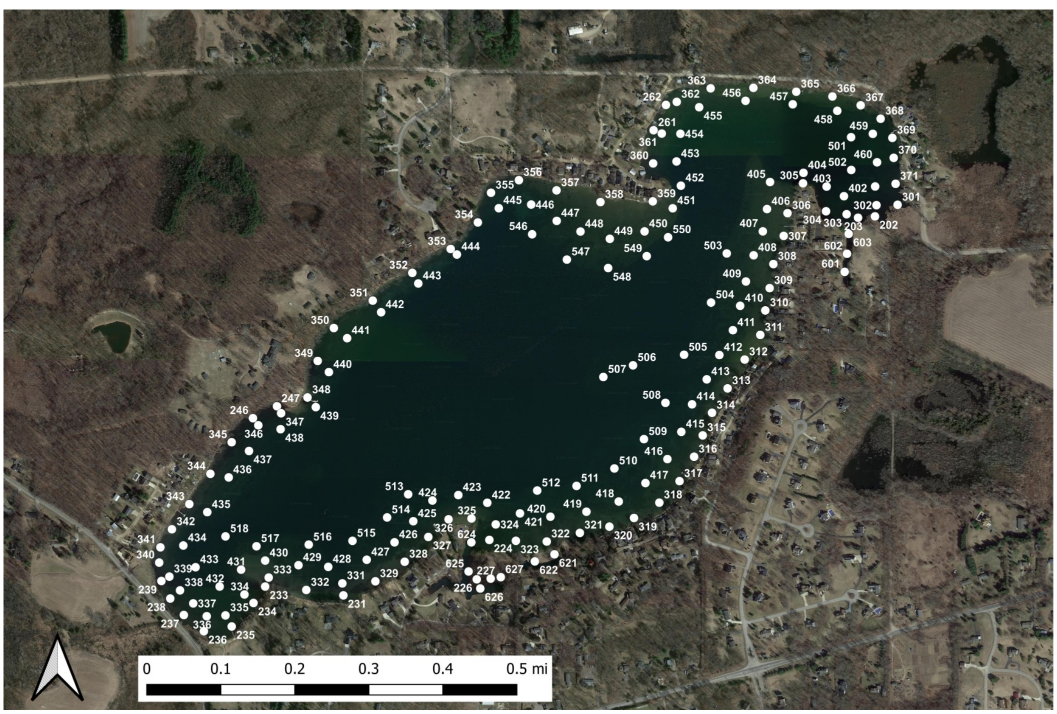

Executive Summary

Kieser & Associates, LLC (K&A) conducted vegetation monitoring on North Lake (Washtenaw County, 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 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.

North Lake annual averaged scores from 2023 LakeScan™ surveys are summarized in Table ES - 1.[1] Yearly average Shannon Biodiversity and Morphology Index scores fell short of management goals. Low scores for these metrics can be indicative of sub-optimal ecological and habitat structural diversity. However, low scores in this case were driven by a very heavy dominance of *Chara* during the early-season survey, and both scores increased for the late-season survey. The Floristic Quality Index score exceeded the management goal of 20, which indicates that native aquatic plant species are competing well with opportunistic and invasive aquatic species. The Recreational Nuisance Presence was low at 6%, beating the management goal of 10%. The Algal Bloom Risk is "moderate" for North Lake.

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Species Richness	18	n/a
Shannon Biodiversity Index	7.2	> 8.6
Shannon Morphology Index	4.5	> 6.1
Floristic Quality Index	23.5	> 20
Recreational Nuisance Presence	6%	< 10%
Algal Bloom Risk	Moderate	Low

The North Lake early-season LakeScan™ survey was conducted on Thursday, June 15, 2023. The most common native species observed during the survey were Chara (*Chara spp.*), native pondweeds (*Potamogeton spp.)*, and white waterlilies (*Nymphaea spp.*). Aquatic invasive species (AIS) observed in North Lake during the 2023 early-season survey included starry stonewort (*Nitellopsis obtuse*), Eurasian watermilfoil hybrids (*Myriophyllum spicatum x sibiricum*; EWM) and curly-leaf pondweed (*Potamogeton crispus*).

The North Lake late-season survey was conducted on August 1, 2023. The most observed native aquatic plants were Chara *(Chara spp.)*, wild celery (*Vallisneria americana*), variable pondweed (*Potamogeton graminius*), and broadleaf pondweed (*Potamogeton amplifolius*). AIS observed during the late-season survey included starry stonewort and Eurasian watermilfoil hybrids.

For this report, K&A also analyzed the past 5 years of LakeScan™ data for invasive species coverage (Figure ES -1). Over the past five years, all three major invasive aquatic species – Eurasian watermilfoil,

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

starry stonewort, and curly leaf pondweed – have shown stable to slightly negative trends in coverage. Over this period starry stonewort has shown to be the most variable, having decreased to nearly 5% coverage in 2022 before increasing to nearly 15% in 2023. However, even though SSW cumulative cover has increased, it is being observed benignly co-mingled with other choroid species and did not present the nuisance conditions in 2023 that were observed in previous years. Both EWM and CLP have shown coverages below 5% since 2019 with continual degression since then.

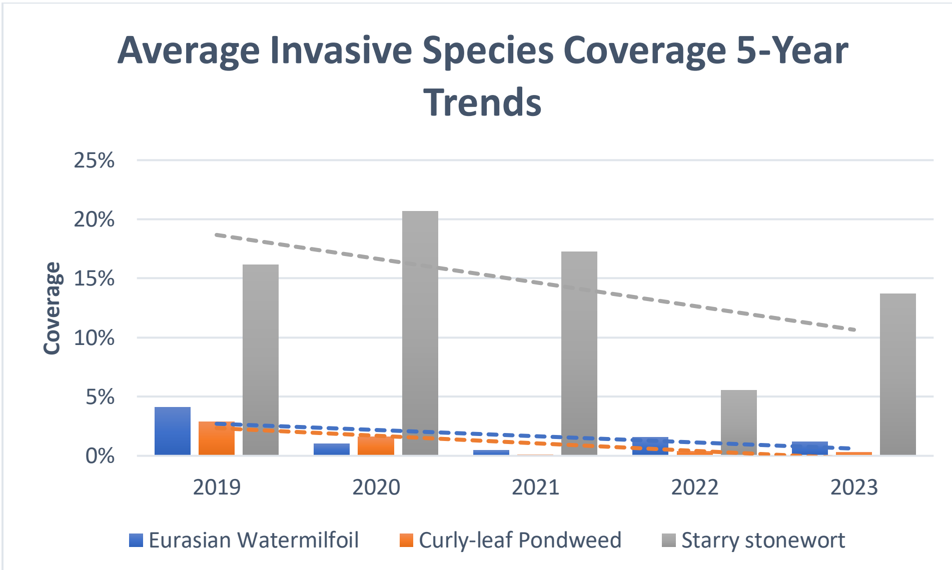

Figure ES-1 – Invasive species coverage 5-year trends.

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

- **Continue herbicide management of Eurasian watermilfoil and curly-leaf pondweed.** Curly-leaf pondweed and Eurasian watermilfoil coverage was low during both surveys, indicating that ongoing chemical treatments appear to be effectively treating and controlling these nuisance species. Management should be continued to suppress growth and address potential recreational nuisance conditions.
- **Continue to monitor Starry stonewort growth conditions.** Starry stonewort, a macroalgae, was observed throughout many of the nearshore AROS zones in North Lake during the 2023 surveys. This species typically increases in density and distribution as the season progresses. Starry stonewort has also been observed coinhabiting nearshore areas with the native macroalgae, *Chara*. It is important to monitor starry stonewort growth conditions; treatment should be considered should this species create nuisance conditions.

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 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 ecological and recreational conditions of a lake.

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 is included with surveys.

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.

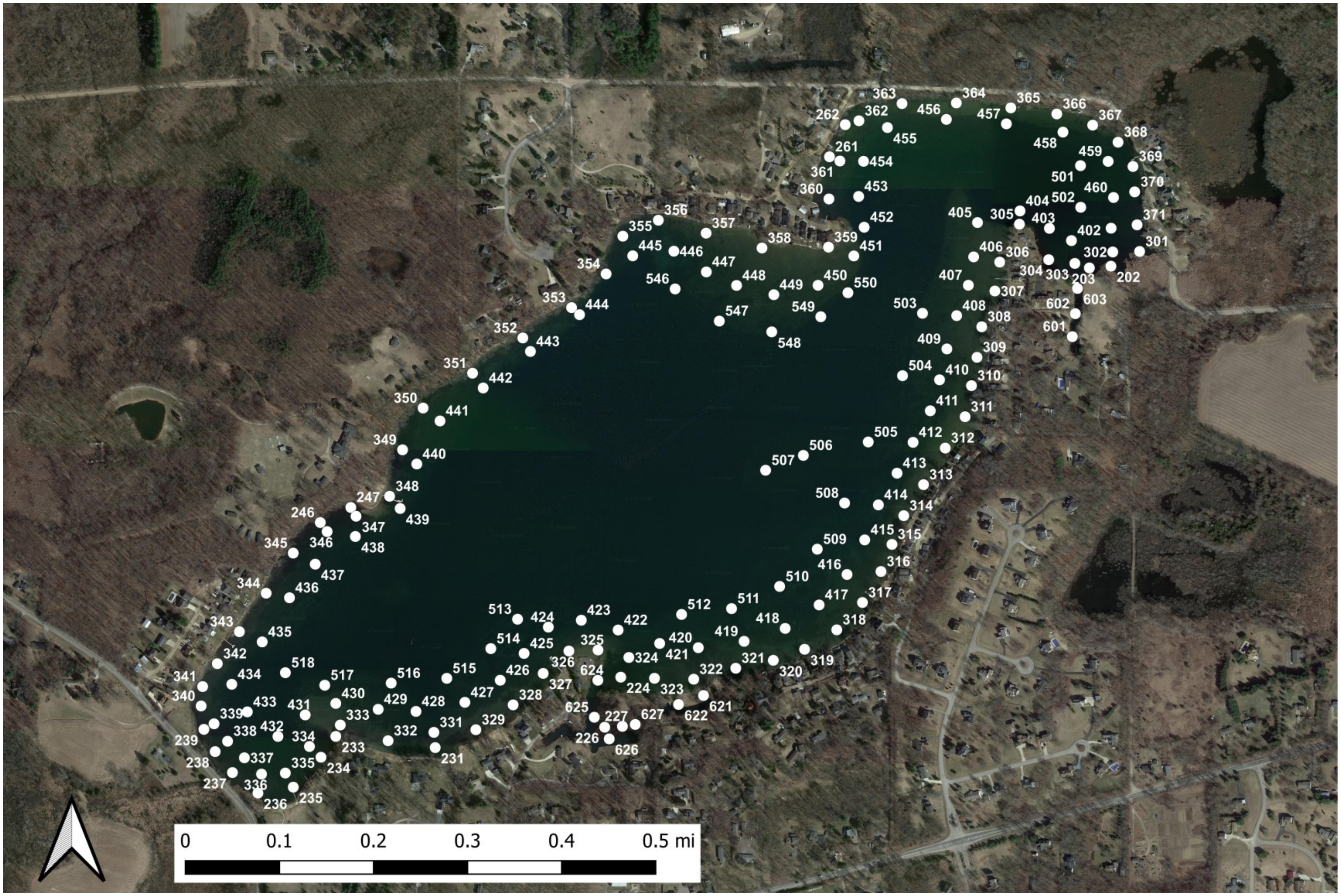

Figure 1 - Map of Aquatic Resource Observation Sites (AROS).

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 North Lake using LakeScan™ methods.

2.0. 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. For more details, see Appendix A.

The algal bloom risk for North Lake is considered **Moderate**.

3.0. Water Quality

3.1. Water Quality Monitoring Methods

Sampling was conducted during the pre-season survey and during both vegetation surveys. The GPS coordinates, maximum depths, and field and laboratory parameters are compiled in Table 2.

Table 2 - North Lake sampling site locations, depths, and field and laboratory parameters for 2023 K&A water sampling events.

Site ID	GPS Coordinates	Maximum Depth (ft)	Field Parameters	Laboratory Parameters
D1	42.234926, -83.595586	23	Temperature, Dissolved Oxygen, Secchi Disk Depth,	Chlorophyll *a*, Total Phosphorus, Chloride
D2	42.39308, -84.007202	53		

During each sampling event, DO, temperature, and conductivity were measured from the surface to just-above the bottom of the lake to generate depth profiles for these parameters. Dissolved oxygen levels and water temperatures were measured using a YSI Pro-ODO meter during the pre-season and early-season sampling events, and a YSI ProSolo dissolved oxygen meter during the late-season sampling event.

Samples for total phosphorus and chloride analysis were collected from both the surface and bottom waters. Chlorophyll *a* samples were collected using a depth-integrated composite sampler lowered to depths of two-times the measured Secchi disk depth. Laboratory analyses of total phosphorus and chlorophyll *a* were conducted by Great Lakes Environmental Center of Traverse City, MI. Chloride analysis was conducted by Merit Laboratories in Lansing, MI. Lab reports are provided in Appendix B.

Phosphorus, chlorophyll *a*, and Secchi depth are all indicators that can be used to estimate the trophic state of a lake; i.e., the level of primary productivity (algal growth) in an aquatic system. The four trophic states are "oligotrophic," "mesotrophic," "eutrophic," and "hypereutrophic." These correspond to low, medium, high, and extremely high levels of productivity, respectively. Trophic state values for these indicators are presented in Table 3.

Table 3. Lake Trophic State and Classification Ranges Based on Michigan Data (USGS, 2012).

Lake Trophic State	TP (mg/L)	Chlorophyll *a* (µg/L)	Secchi Depth (ft)
Oligotrophic	<0.010	<2.2	>15
Mesotrophic	0.010-0.020	2.2-6	7.5-15
Eutrophic	0.021-0.050	6.1-22	3-7.5
Hypereutrophic	>0.050	>22	<3

3.2. Water Quality Monitoring Results

3.2.1. Phosphorus

Both algae and aquatic plants require a wide range of nutrients for growth. The nutrient in shortest supply relative to the demands of aquatic plant and algal growth is termed the limiting nutrient, which in most freshwater ecosystems is phosphorus. Increases in phosphorus can therefore lead to increases in submersed plant and algae growth as well as increasing the potential for occurrences of harmful blue-green algal blooms. Sources of phosphorus inputs can include soil erosion, septic system leachate, agricultural runoff or tile drainage, decaying plants, and animal waste, among others. TP data for North Lake sampling stations D1 and D2 are presented in Figures 3 and 4. Given field indications of early stratification in May at the time of sampling, water quality samples for surface and bottom depths were collected.

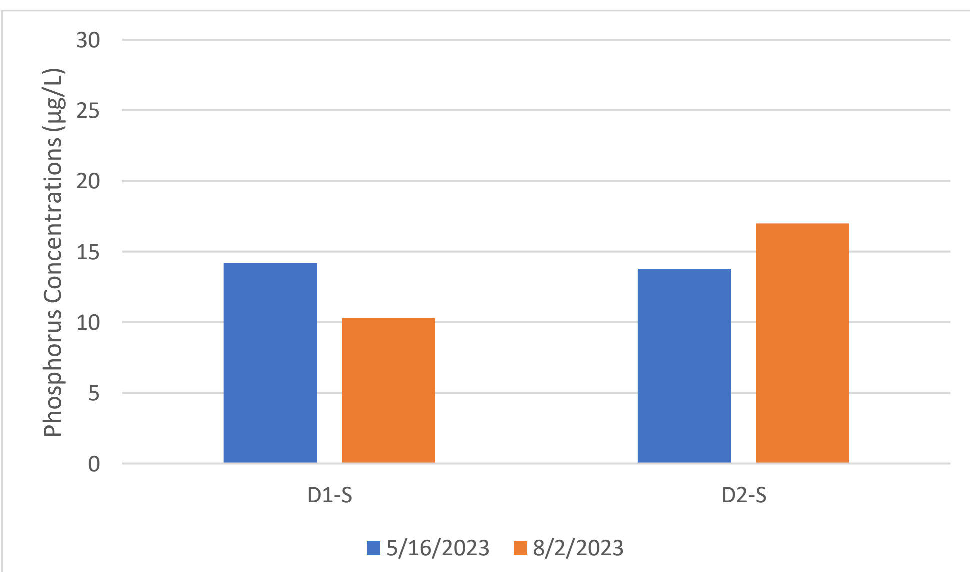

Figure 3 – Total phosphorus concentrations on the surface for Site 1 and Site 2 compared between the pre-treatment and late-season sampling.

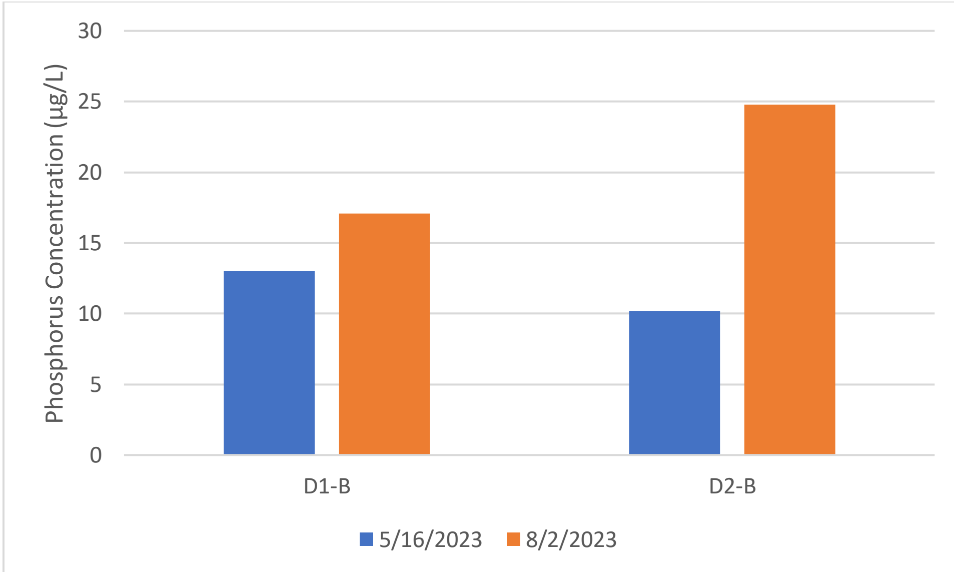

Figure 4 - Total phosphorus concentrations on the bottom for Site 1 and Site 2 compared between the pre-treatment and late-season sampling.

All but one of the phosphorus samples taken for North Lake in 2023 were relatively low, in the range of 10-20 µg/L, reflecting mesotrophic conditions. August bottom water TP at D2-B was measured at 24.8 µg/L. Hypoxic (low dissolved oxygen) conditions induced by stratification can cause the mobilization of phosphorus at or above the sediment surface at the lake bottom, which may have contributed to this higher value. However, consistent with previous monitoring, these slightly higher, late summer bottom water TP levels do not suggest significant internal phosphorus loading to the lake.

3.2.2 Chlorophyll *a*

Chlorophyll *a* is a measure of the active green pigment in algae that allows photosynthesis. Monitoring this pigment is a method to indirectly measure the mass of algae or phytoplankton in a water body. While some algae are necessary for a healthy lake, excess nutrients can stimulate nuisance algal blooms which can potentially be harmful to humans and animals. Chlorophyll *a* concentrations in North Lake for 2023 are provided in Figure 5.

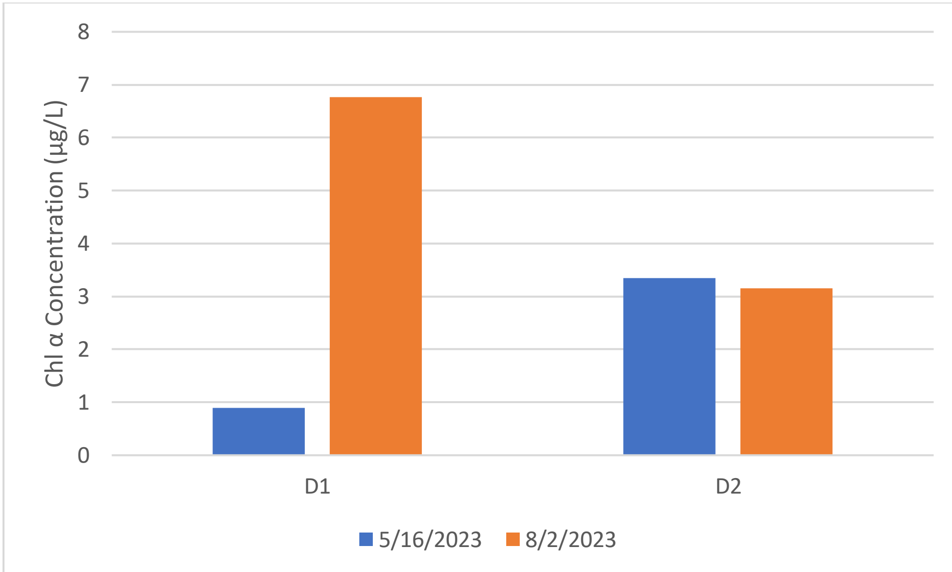

Figure 5 – North Lake 2023 chlorophyll a *concentrations compared between the pre-treatment and late-season sampling.*

Chlorophyll *a* measurements in 2023 showed some seasonal variation. The concentration at sample location D1 was 0.9 mg/L in May, changing to 6.8 mg/L in August. Concentrations at sample location D2 were more consistent, being between 3.2 – 3.4 mg/L across both sample events and indicative of mesotrophic conditions.

3.2.3. Chloride

Chloride is an indicator of anthropogenic impacts in water bodies. Chloride is typically found in surface water at low concentrations but can become elevated from sources such as road salts, agricultural runoff, and wastewater.[2] National standards for chlorides in drinking water have established limits of 250 mg/L.[3] In freshwater ecosystems, high concentrations of chlorides can potentially impact the health of aquatic life such as their mortality rate and reproductive health. Ecological impacts can begin with concentrations of 100 mg/L or greater. Chloride concentration results in North Lake for 2023 are provided in Figures 6 and 7.

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[2] Iowa Department of Natural Resources. (2009). "Water Quality Standards Review: Chloride, Sulfate, and Total Dissolved Solids." [Microsoft Word - TDS Chloride Sulfate Consultation Pkg Final 2-9-09.doc (iowadnr.gov)]

[3] UD Environmental Protection Agency. (2023). "Drinking Water Regulations and Contaminants". [Drinking Water Regulations and Contaminants | US EPA]

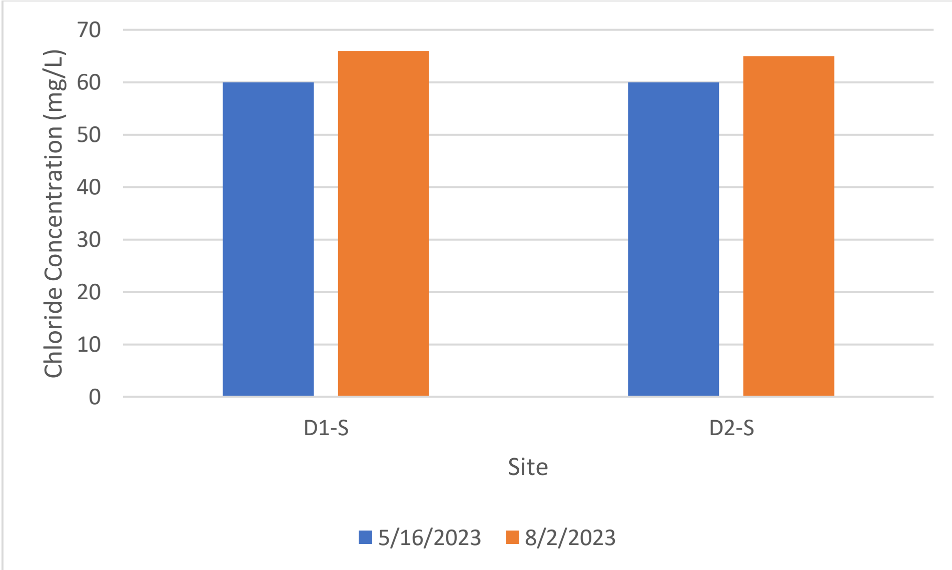

Figure 6 – Surface chloride concentration for Site 1 and Site 2 measured pre-treatment and late-season.

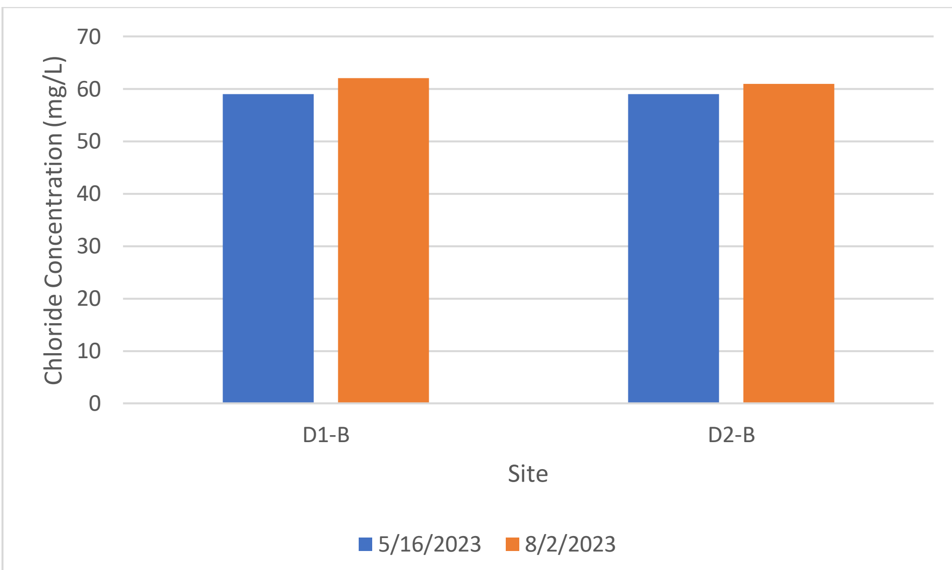

Figure 7 – Bottom chloride concentration for Site 1 and Site 2 measured pre-treatment and late-season.

Chloride concentrations found in North Lake in 2023 were fairly consistent (59 – 66 mg/L for all 8 samples) and well below drinking water concentration guidelines as well as below levels of ecological harm. These concentrations are similar to those typically found for other Midwest lakes of this size.[4]

[4] Dugan, H. A., Summers, J. C., Skaff, N. K., Krivak-Tetley, F. E., Doubek, J. P., Burke, S. M., ... & Weathers, K. C. (2017). Long-term chloride concentrations in North American and European freshwater lakes. Scientific data, 4(1), 1-11.

3.2.4 Temperature and Dissolved Oxygen

Secchi depth, dissolved oxygen and temperature data were collected during every site visit. Data are shown in (Figures 9-13) for the pre-season, early-season and late-season surveys, respectively. 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.[5]

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.

Temperature and dissolved oxygen profiles for North Lake in 2023 are provided in Figures 8-12. Oxygen depletion in bottom waters and temperature stratification were observed during May, June and August. May profiles showed shallow (< 10 feet) stratification with oxygen remaining above 5 mg/L until 20+ feet in depth. June profiles showed stratification beginning around 18 feet with oxygen remaining above 5 mg/L until 18-21 feet of depth. These values decreased slightly in August, with stratification around 12 feet and oxygen decreasing below 5 mg/L at 15-18 feet in depth.

[5] 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.

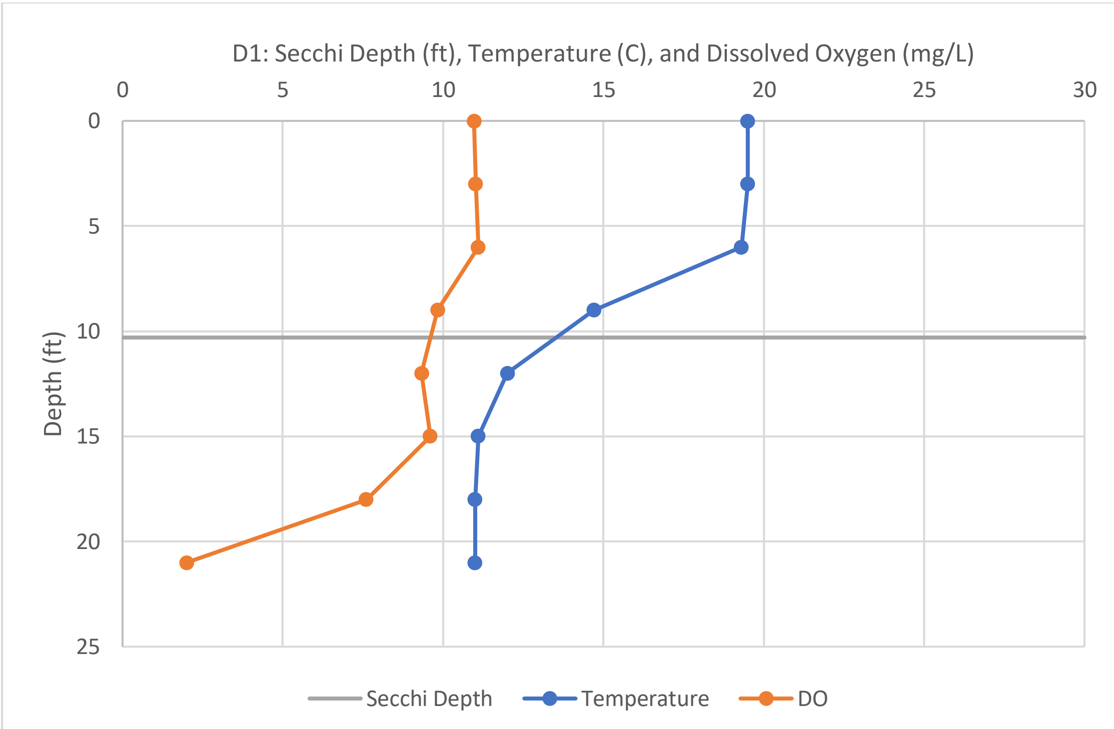

Figure 8 – Pre-season survey (May 16, 2023) dissolved oxygen and temperature profiles with Secchi depth, at station D1.

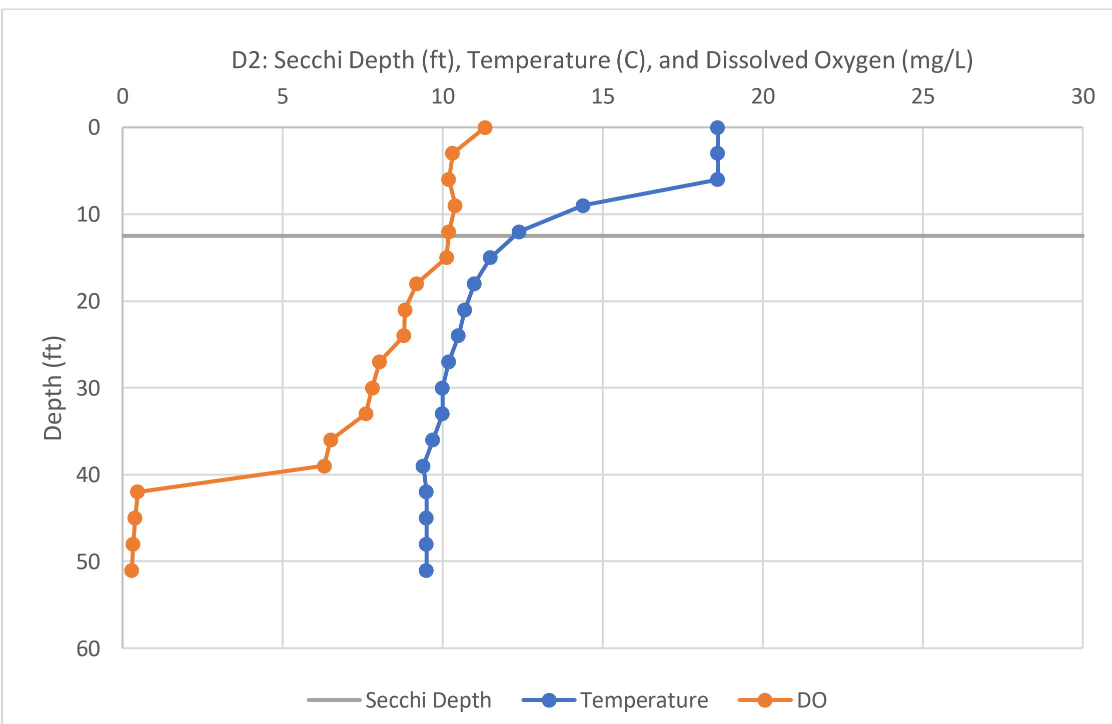

Figure 9 – Pre-season survey (May 16, 2023) dissolved oxygen and temperature profiles with Secchi depth, at station D2.

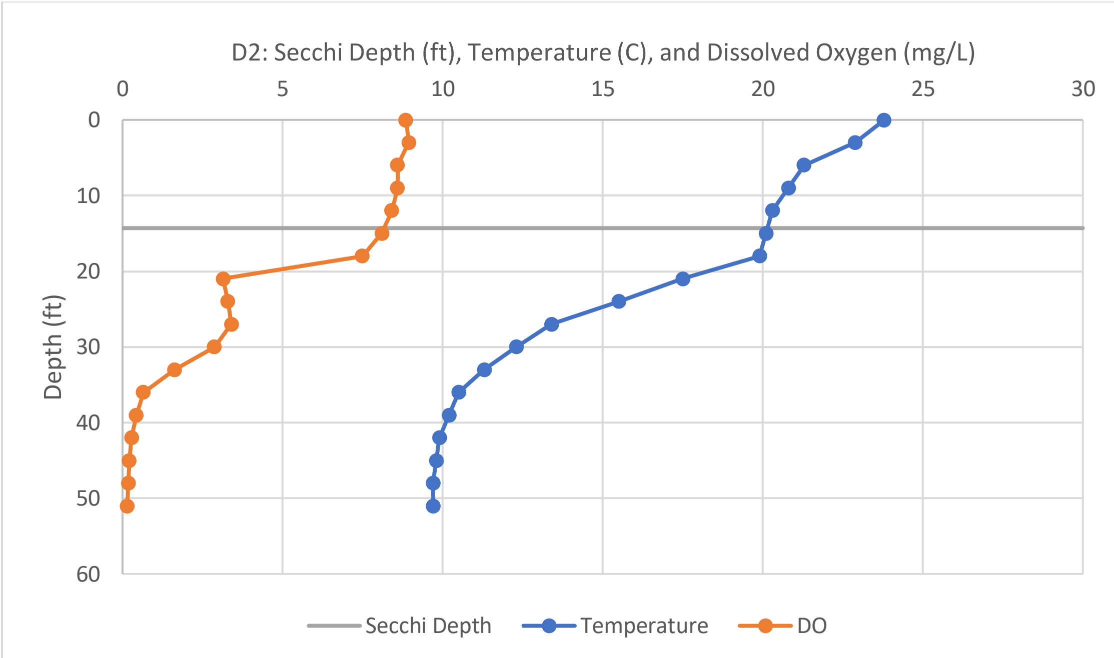

Figure 10 - Early-season survey (June 15, 2023) dissolved oxygen and temperature profiles with Secchi depth, taken at station D2.

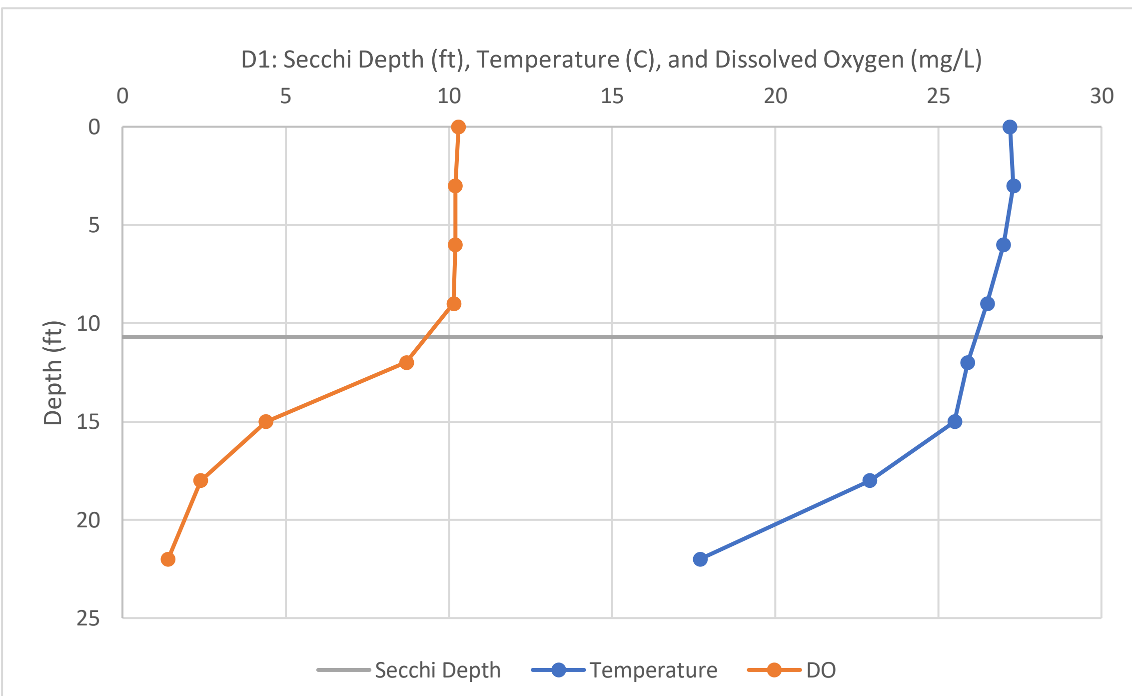

Figure 11 - Late-season survey (August 1, 2023) dissolved oxygen and temperature profiles with Secchi depth, taken at Station D1.

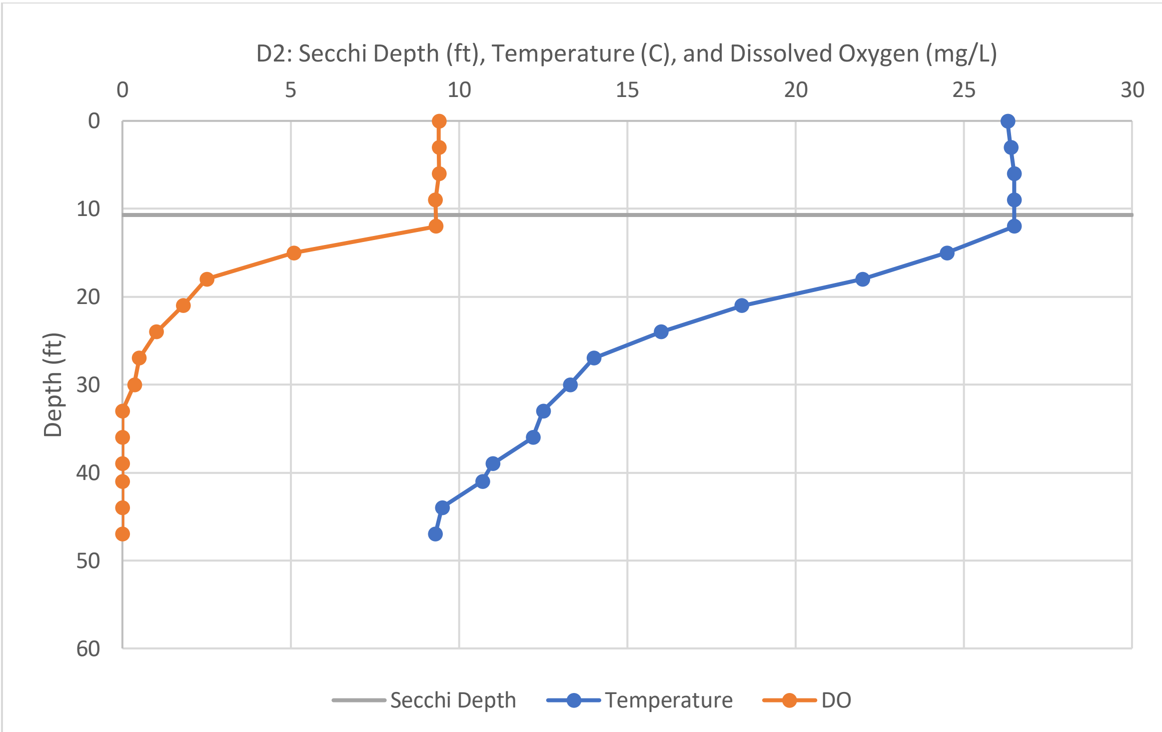

Figure 12 - Late-season survey (August 1, 2023) dissolved oxygen and temperature profiles with Secchi depth, taken at station D2.

4.0. Aquatic Vegetation

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

4.1. Early-season Survey

The North Lake early-season LakeScan™ survey was conducted on Thursday, June 15, 2023. The survey occurred 15 days after scheduled herbicide treatments on Wednesday, May 31, 2023. The weather was mostly cloudy early, but sunny later in the day with a high of 71 °F and light winds. There was some precipitation in the late morning that dissipated in the early afternoon. Visibility in the water column was good with a Secchi disk reading of 14.3 feet.

North Lake three-dimensional density during the early-season survey is illustrated in Figure 13. Three-dimensional density reflects a combination of vegetation density, distribution and height observations of all species observed. 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 most common native species observed during the early-season survey were Chara (*Chara spp.*), pondweed species (*Potamogeton spp.*), and white waterlilies (*Nymphaea spp.*). Chara was one of the most dominant species and was found in moderate to high densities around the lake from the shoreline to the lake drop-off. Pondweed species were observed at moderate densities and were commonly seen growing with Chara. White waterlilies, spadderdock (*Nuphar spp.*), and watershields (*Brasenia schreberi*) were so dense in some AROS that the survey boat was unable to enter and navigate those areas. Observations were made visually, at a distance, and then extrapolated for the impassible zones. Benthic filamentous algae were exceptionally dense in some areas making it difficult to observe other higher vegetation in the lake.

Aquatic invasive species (AIS) observed in North Lake during the 2023 early-season survey included starry stonewort (*Nitellopsis obtuse*) and curly-leaf pondweed (*Potamogeton crispus*; CLP). Eurasian watermilfoil hybrid (*Myriophyllum spicatum x sibericum*; EWM) was observed in moderate densities but was concentrated in only four AROS (Figure 14). Starry stonewort was found in moderate to low densities around the entire lake but was most densely concentrated near the boat launch on the northeast side of the lake (Figure 15). Curly-leaf pondweed was observed at a much lower density than starry stonewort and was only found in the northeast end of the lake (Figure 16).

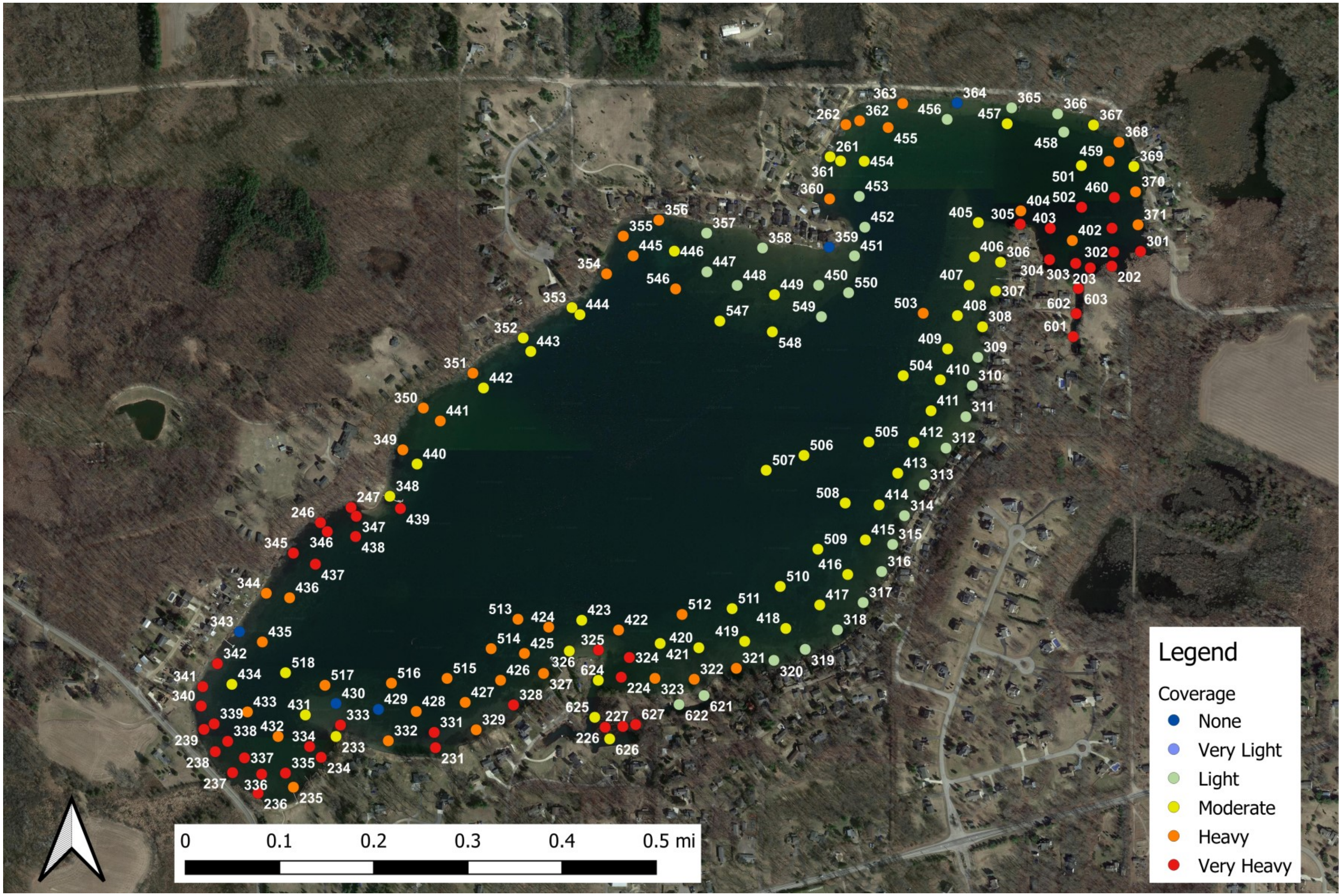

Figure 13 - Early-season survey (June 15, 2023) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

Figure 14 - Early-season (June 15, 2023) Eurasian watermilfoil and hybrids coverage.

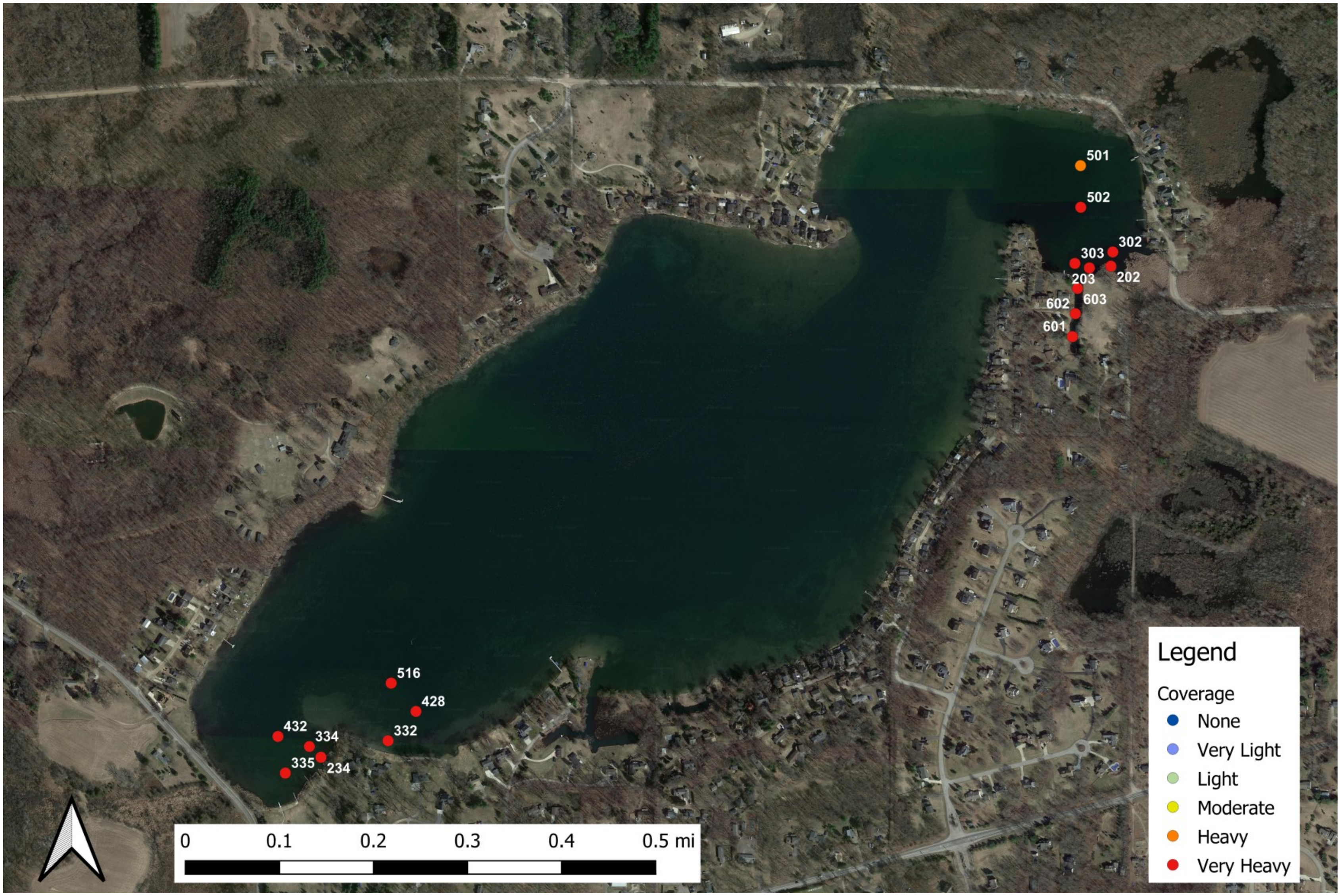

Figure 15 - Early-season (June 15, 2023) Starry stonewort coverage.

Figure 16 - Early-season (June 15, 2023) Curly-leaf pondweed coverage.

4.2. Late-season Survey

The North Lake late-season survey was conducted on August 1, 2023. Skies were partially cloudy with winds up to 8 mph and a high of 85 °F. Visibility was good with a Secchi disk reading of 11.2 feet despite some turbidity due to wind.

The most observed native aquatic plants were Chara, wild celery (*Vallisneria americana*), variable pondweed (*Potamogeton graminius*), and broadleaf pondweed (*Potamogeton amplifolius*). Three-dimensional density for the late-season survey is illustrated in Figure 17. Native vegetation was the densest in the 200 and 300 tier AROS zones in the west, north, and east portions of the lake with dense Chara extending into the 400 and 500 tiers throughout the lake. White waterlilies (*Nymphaea spp*.) and watershields (*Brasenia schreberi*) were particularly dense in the west and north parts of North Lake. Due to navigational issues, some of the zones were not able to be properly surveyed given the density of the vegetation. Additionally, in the very near shore zones (200 and 600 AROS), there was visible vegetal biomass on the lakebed from the early-season chemical treatment.

Aquatic invasive species observed during the late-season survey included starry stonewort and EWM. Eurasian watermilfoil was found in low to moderate densities in the entire lake but was most dense nearshore around watershields and lilies (Figure 18). In the 400 and 500 AROS zones throughout the lake, starry stonewort was exceptionally dense especially in the northeast zones of the lake but did not pose a nuisance threat (Figure 19).

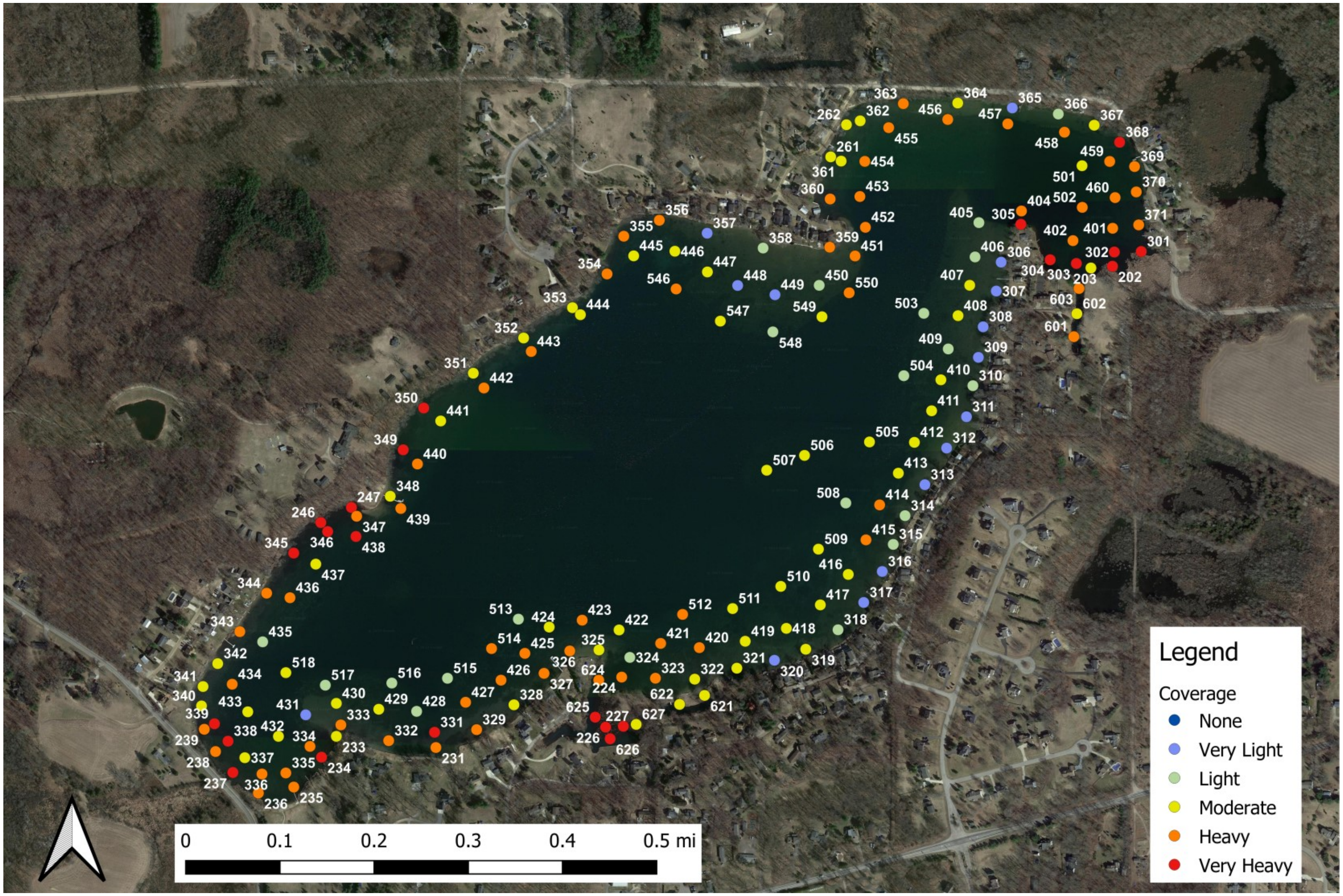

Figure 17 - Late-season survey (August 1, 2023) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

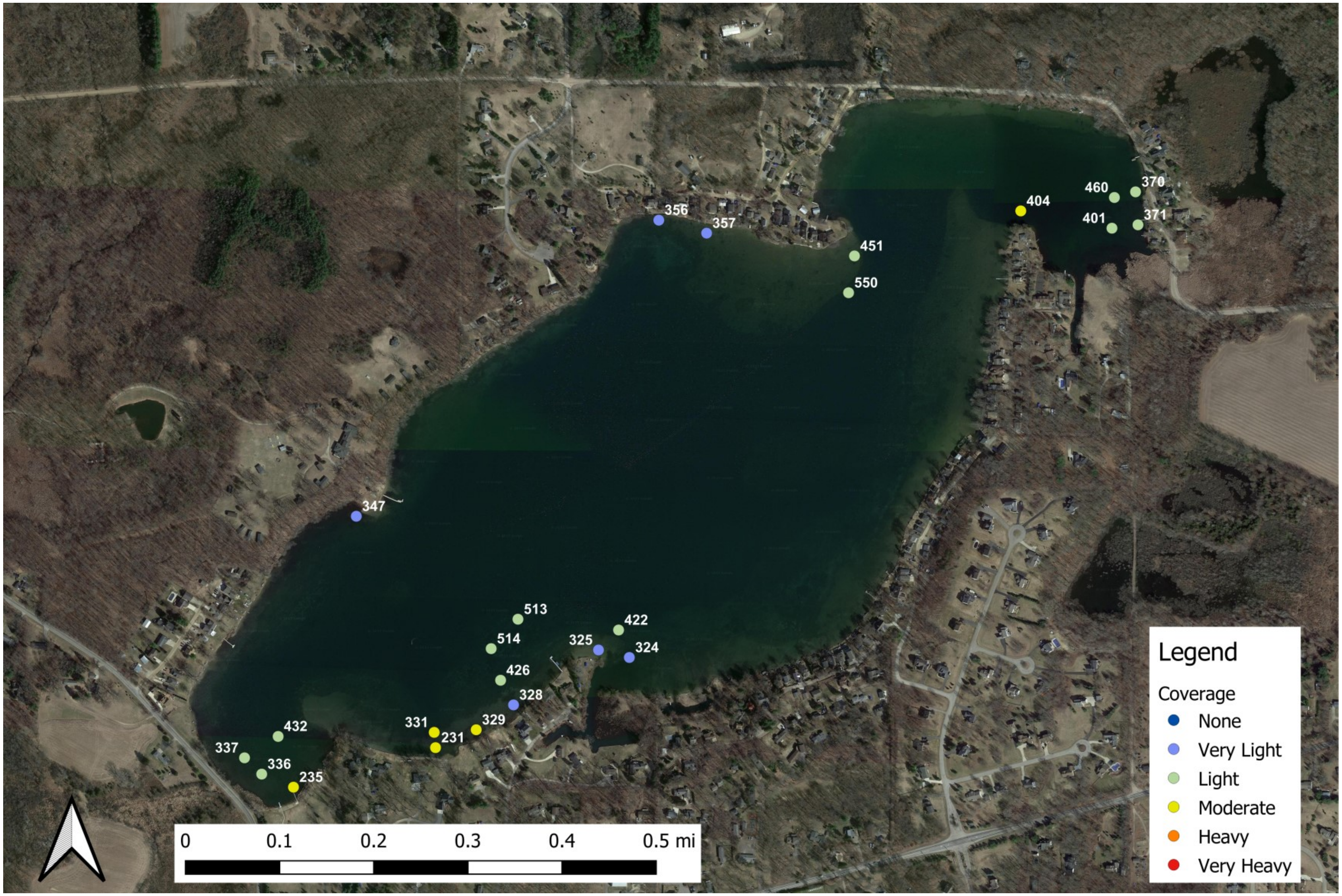

Figure 18 - Late-season (August 1, 2023) Eurasian watermilfoil and hybrids coverage.

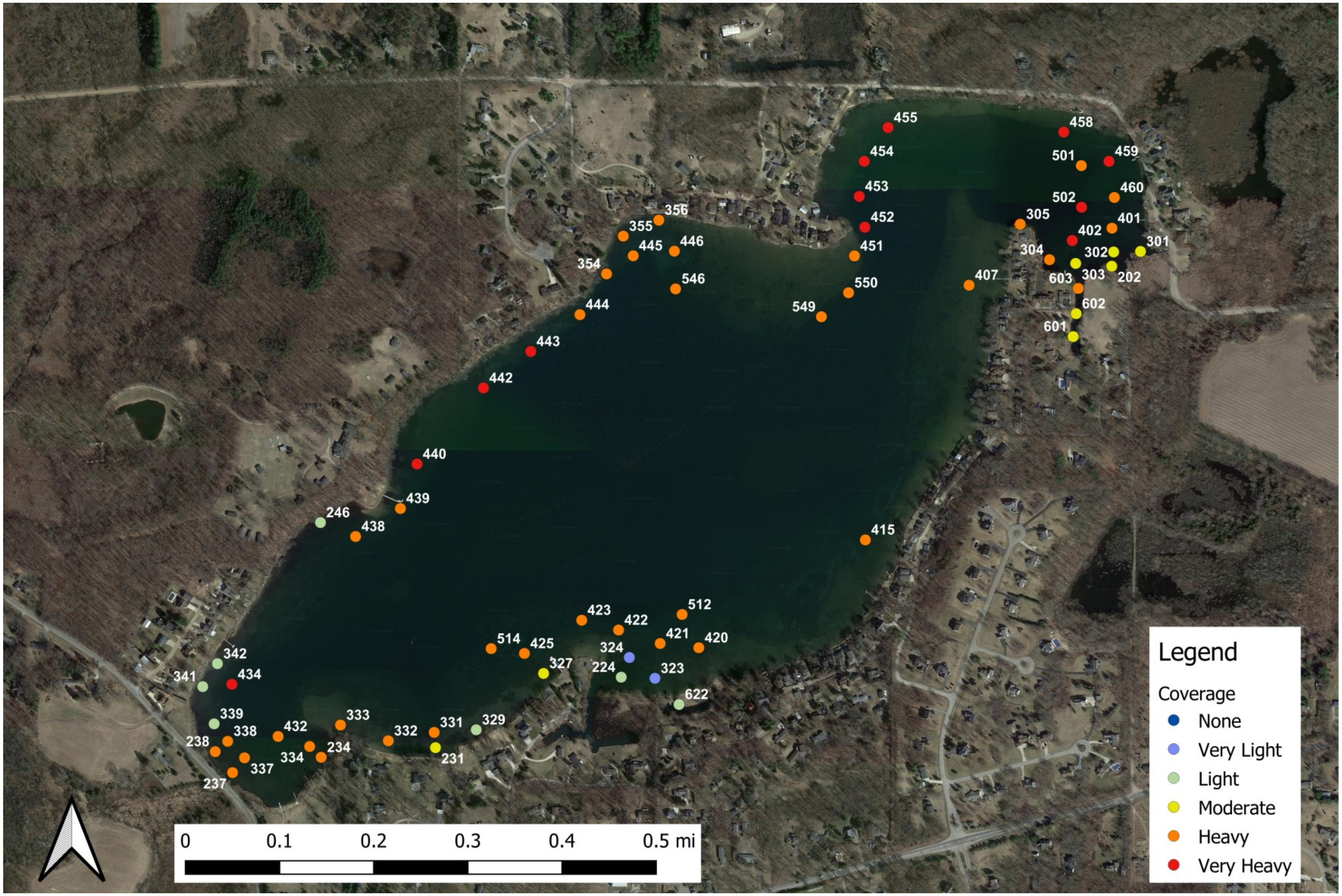

Figure 19 - Late-season (August 1, 2023) Starry stonewort coverage.

4.3. Summary Observations for Early & Late Surveys

Aquatic plant species observed during the 2023 vegetation surveys are identified in Table 4. 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 20 illustrates dominance by T Value categories for early and late-season surveys over the last few years.

Table 4 - 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	2.2	13.4	0.6	1.8	0.4	1.5
Coontail	3	3.9	2.8	1.1	0.3	0.7	0.3
Elodea	3	4.5	5.6	1.5	0.7	1.0	0.6
Chara	4	91.6	93.9	73.0	45.1	48.3	37.4
Starry Stonewort	1	8.9	36.9	8.7	18.7	5.7	15.5
Curly Leaf Pondweed	1	1.7	0.0	0.3	0.0	0.2	0.0
Flat Stem Pondweed	3	6.1	5.6	1.7	0.8	1.1	0.7
Robbins Pondweed	3	2.8	0.0	0.3	0.0	0.2	0.0
Purple Loosestrife (sub)	1	1.7	17.3	1.7	1.9	1.1	1.6
Swamp Loosestrife	4	0.0	1.1	0.0	0.3	0.0	0.3
Richardsons Pondweed	2	0.0	15.6	0.0	2.0	0.0	1.6
Variable Pondweed	2	37.4	36.3	6.1	5.5	4.1	4.5
Broadleaf Pondweed	3	47.5	39.7	16.8	13.0	11.1	10.7
Sago Pondweed	2	0.0	9.5	0.0	1.2	0.0	1.0
Wild Celery	2	12.3	34.6	2.5	6.6	1.7	5.5
Rush	4	0.0	5.0	0.0	0.5	0.0	0.4
Waterlily	2	36.9	40.2	16.9	10.6	11.2	8.8
Spadderdock	2	19.0	10.6	9.1	1.2	6.0	1.0
Water Shield	3	18.4	16.8	9.6	6.8	6.4	5.7
Star Duckweed	3	3.9	2.2	1.2	0.4	0.8	0.3
Arrow Arum	3	0.0	8.4	0.0	0.9	0.0	0.8
Cattail	3	0.0	11.7	0.0	2.2	0.0	1.8

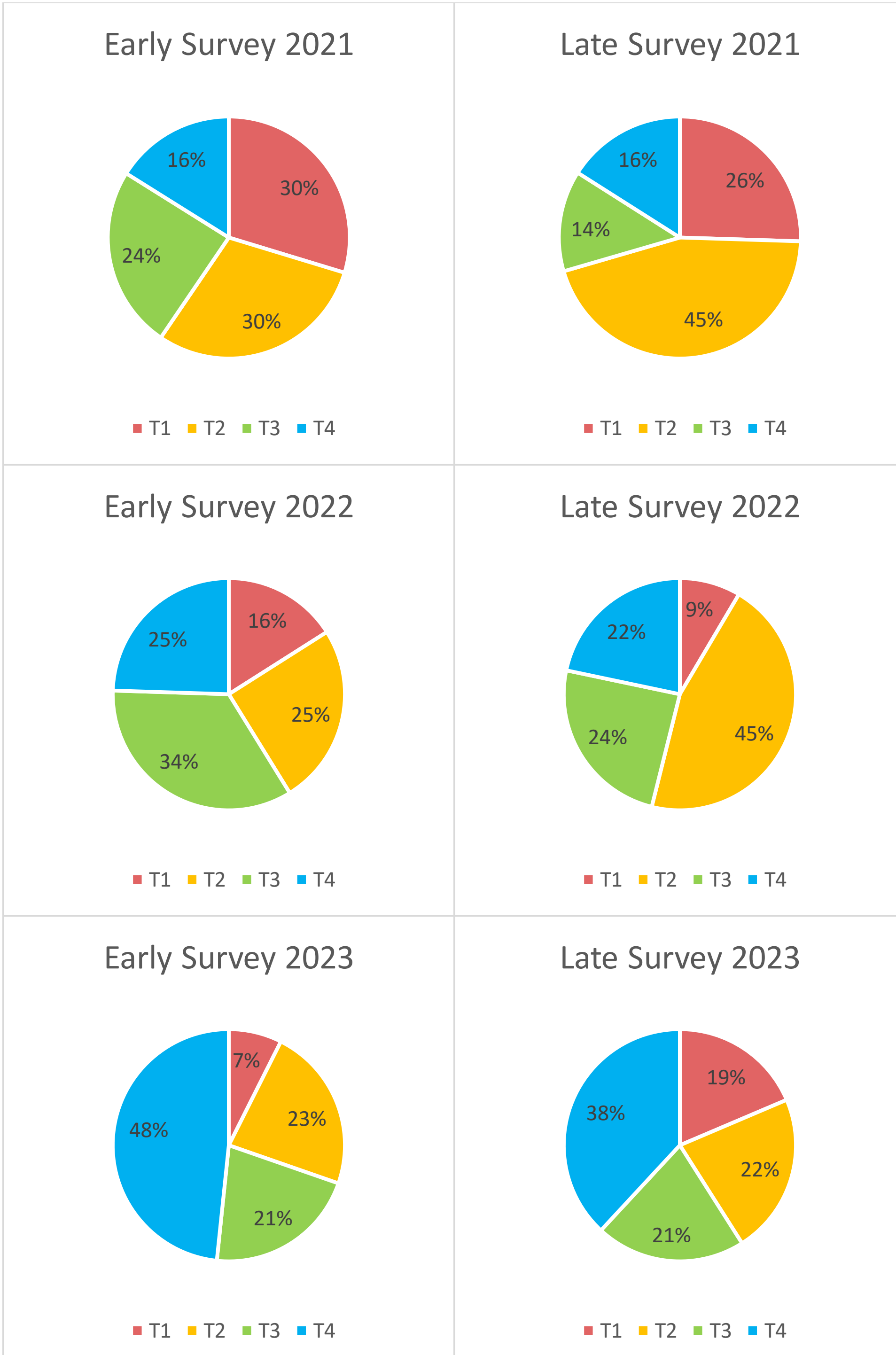

Figure 20 - Distribution of aquatic plant coverage by T Value comparing early-season and late-season surveys from 2021-2023 (reference Table 3).

4.4. LakeScan^{TM} Metrics

Six important metrics for defining lake conditions are presented here for the 2023 vegetation surveys (Table 5). 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 5) highlights scores meeting management goals, while yellow and red highlights represent scores needing improvement. 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[6].
- 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[7] – 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.

Table 5 – 2023 LakeScan^{TM} Metric Results.

LakeScan^{TM} Metric	Score Range	2023 Early Season	2023 Late Season	2023 Average	Management Goal
Species Richness	5 - 30	16	20	18	n/a
Shannon Biodiversity Index	1 -15	6.1	8.2	7.2	> 8.6
Shannon Morphology Index	1 - 10	3.9	5.1	4.5	> 6.1
Floristic Quality Index	1 - 40	24.0	22.9	23.5	> 20
Recreational Nuisance Presence	0 - 100%	1%	12%	6%	< 10%
Algal Bloom Risk	Low - High	n/a	n/a	Moderate	Low

*n/a = not applicable

[6] Hill, M. O. (1973). Diversity and evenness: a unifying notation and its consequences. *Ecology*, 54(2), 427-432.
[7] Nichols, S. A. (1999). Floristic quality assessment of Wisconsin lake plant communities with example applications. *Lake and Reservoir Management*, 15(2), 133-141.

The Floristic Quality Index (FQI) score exceeded the management goal for both surveys. This indicates that native and niche species are successfully competing against opportunistic and invasive species. For the early-season survey, both the Shannon Biodiversity and Morphology Index scores fell short of the management goal, indicating that ecological and structural diversity of aquatic plants may not be optimal for supporting diverse fish populations in North Lake.

Over the course of both vegetation surveys, North Lake did show improvement in their Shannon Biodiversity and Shannon Morphology Index scores, but still fell short of management objectives. This is suspected to be largely due to growth of pondweeds and other species catching up to Chara, which dominated the early-season survey. Ideally these scores would be above the management goal, but consistently good FQI scores for this lake indicate that it has the potential to provide better ecological and habitat structures for fish communities in the future given continued management activities.

The Recreational Nuisance presence increased from 1% to 12% between surveys. The low early-season percentage is indicative of the herbicide application being effective in controlling the targeted nuisance populations of aquatic plants. However, the late-season survey revealed that the majority of recreational nuisance was stemming from native pondweed populations blooming at the surface of the lake. Late-season management may be required to combat late-season nuisance conditions using mechanical harvesting or other strategies if this situation continues in future years.

FQI and invasive species coverage 5-year historical trends are presented in Figures 21 and 22, respectively. Trendlines shown are calculated using Microsoft Excel's linear trendline function. Positive trends for FQI scores indicate increases in desirable plant species and/or decreases in undesirable plant species. Negative or stable trends for invasive species coverage values indicate that herbicide treatment and other lake management activities appear to be effective.

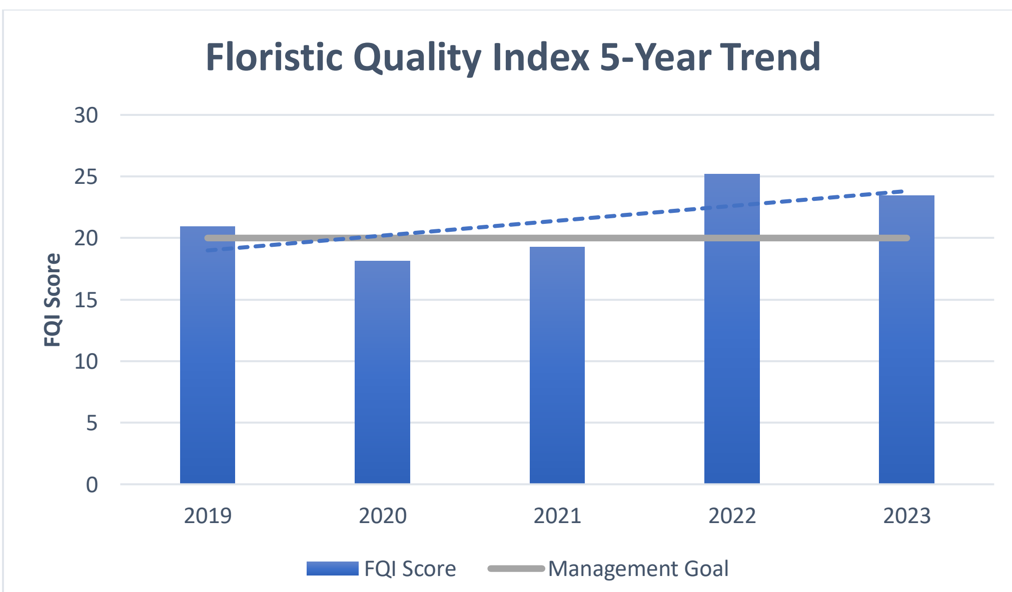

Figure 21 – Floristic Quality Index 5-Year Trend.

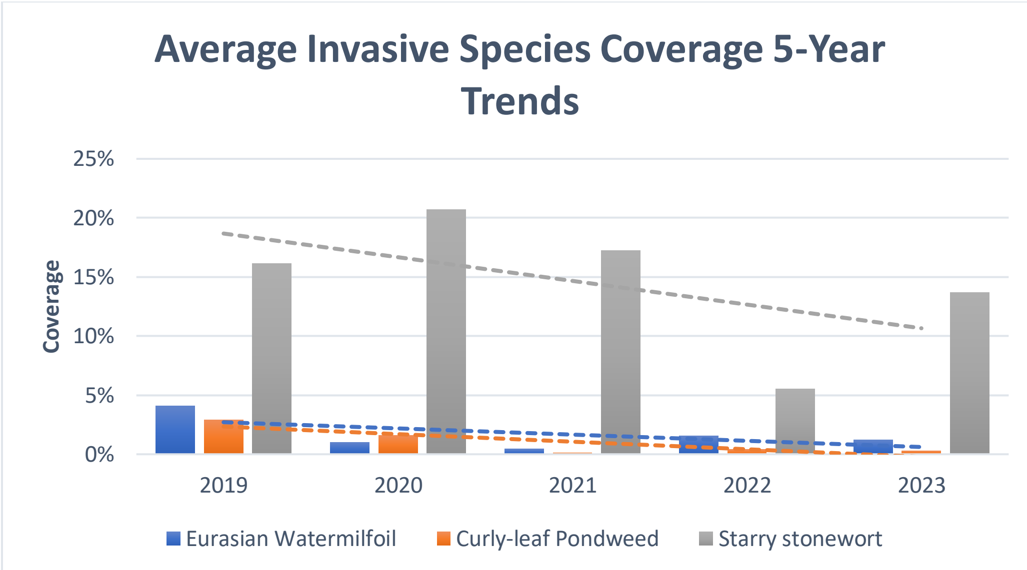

Figure 22 – Invasive Species Coverage 5-Year Trends.

Over the past five years, FQI has exceeded the management score three times, with a slightly increasing trend over this time period. Eurasian watermilfoil and curly-leaf pondweed coverage levels have remained low with a slightly decreasing trend, indicating that management has successfully been suppressing these species. Starry stonewort coverage levels are higher than what is desirable, but coverage levels in 2022 and 2023 were lower than they were for the previous 3 years. This species should be closely monitored to see whether this downward trend continues.

The Eurasian watermilfoil observed in North Lake over nearly a decade has been uncharacteristically non-aggressive.[8] This could be a consequence of the adaptation of this species in this lake and elsewhere in southern Michigan. It has been observed at non-nuisance levels in some AROS over the course of the entire growing season and has not needed treatment to maintain acceptable conditions. Alternately, some of the pondweeds in North Lake have been uncharacteristically aggressive and have been observed growing at nuisance levels.

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[8] Personal Communication, Dr. Douglas Pullman, Kieser & Associates, LLC, formerly of Aquest Corporation, 2023.

5.0. Lake Management

There are several plant species that typically become a nuisance in Michigan's inland lakes (see Appendix C). 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. Coverage changes of targeted AIS over both surveys are illustrated in Figure 23.

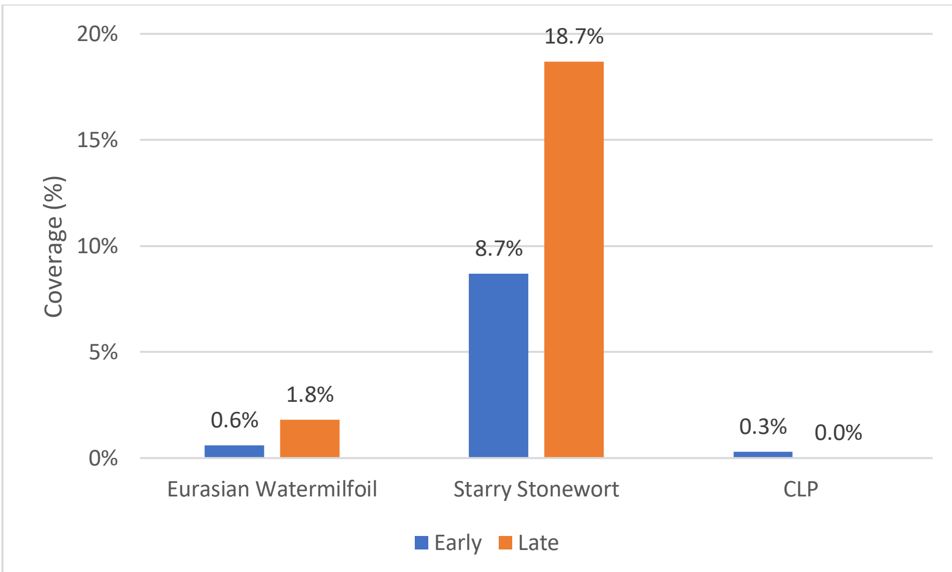

Figure 23 – Changes in coverage across both surveys for targeted species.

Nuisance level production of Eurasian watermilfoil was slightly greater in 2023 than in recent years, and a treatment was prescribed and agreed on by the lake's management team. Chemical treatment for North Lake occurred on May 31, 2023, 15 days prior to the early-season vegetation survey. (The 2023 herbicide applicator map is provided in Appendix D.) This treatment targeted curly-leaf pondweed, EWM, and nuisance algae. Typically, the effects of chemical treatment are seen approximately 10 days after the application. During the early-season survey, EWM and curly-leaf pondweed were observed at a lower coverage than what had been seen during the pre-season survey. Additionally, visible signs of treatment efficacy could be seen including plant deterioration and biomass accumulation on the bottom of the lake.

The late-season survey showed a slight increase in EWM, as well as an increase starry stonewort. Treatment for EWM was unavailable in waterlily floats during the early-season application due to permit restrictions, so a slight increase in coverage in these untreated niches is likely unavoidable as waterlily begins to senesce in later summer periods. There was a 10% increase in starry stonewort coverage from the early-season survey to the late-season survey. However, it remained benthic in nature and did not encroach into the water column or to the surface and therefore did not pose a recreational nuisance.

5.1. Future Management Recommendations

Curly-leaf pondweed production and nuisance growth is unpredictable. However, the continued chemical treatment of curly-leaf pondweed is recommended, with a focus in the northeastern lobe of the lake. The May 31, 2023 treatment appeared to be effective in controlling growth of this species. Curly-leaf pondweed should continue to be closely monitored and treated annually.

Continued chemical treatment of hybrid Eurasian watermilfoil is recommended. The 2023 chemical treatment was effective short-term. However, as noted in the early-season survey summary, stands of emergent vegetation may have been harboring watermilfoil in the southwest and northeast portions of the lake, which was unable to be treated due to ANC permit requirements. As the emergent vegetation retreated toward the shoreline in the late summer, some of this watermilfoil could have been exposed. Regardless of the decreasing yearly trend in coverage, Eurasian watermilfoil growth should be monitored closely in 2024, particularly near the southwest and northeast shoreline.

Starry stonewort, an AIS macroalgae, was observed throughout the lake in both the nearshore zones and the deeper contours of the lake during the early-season survey in much higher densities than the previous year. Coverage increased from the early-season survey to the late-season survey, but growth was low in the water column and did not constitute a recreational nuisance. Starry stonewort should be monitored closely to prevent any growth from reaching recreational nuisance levels at the end of the growing season, particularly nearshore.

6.0. Appendices

6.1. Appendix A: 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.

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

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

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

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

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

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

Biotic Factors: Zebra mussels and zooplankton (microscopic, free-floating animals) are filter feeding organisms that strain algae and other substances out of the lake water for food. Studies have shown that filter-feeding organisms often reject blue green algae and feed selectively on more desirable algae. Over time, and given enough filter feeding organisms, a lake will experience a net loss in “good” algae and a gain in “bad” blue green algae as the “good” algae are consumed and the “bad” algae are rejected back into the water column. This is one of the most disturbing factors associated with the invasion and proliferation of zebra mussels. Lakes that are full of zebra mussels 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.

6.2. Appendix B: Lab Reports

Great Lakes Environmental Center

Project Number: 2592-B09

June 6, 2023

Kieser & Associates-North Lake
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: John Hart

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests were performed within the maximum holding times and have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-North Lake

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
2K05160033	D1-S	5/16/2023	0.0142	mg/L	0.003	0.0014		6/2/2023		BSC
2K05160034	D1-B	5/16/2023	0.0130	mg/L	0.003	0.0014		6/2/2023		BSC
2K05160036	D2-S	5/16/2023	0.0138	mg/L	0.003	0.0014		6/2/2023		BSC
2K05160037	D2-B	5/16/2023	0.0102	mg/L	0.003	0.0014		6/2/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Tuesday, June 06, 2023

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-North Lake

REPORT OF ANALYSIS

chla

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
2K05160035	D1	5/16/2023	0.00089	mg/L	2.473E-05	0.000000294		6/2/2023		BSC
2K05160038	D2	5/16/2023	0.00335	mg/L	2.473E-05	0.000000294		6/2/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: EPA Method 445.0

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates

Report Results To: John Hart

Address: 536 E. Michigan Ave. Kalamazoo, MI 49007

Phone: 269-344-7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name: North Lake

Project Number:

P.O.#:

Sampled by: (initials) ☐ GLEC ______ ☒ Client JH

Section III. **Sample Information at Collection**

Section IV. Requested Analysis

#	GLEC No.	Sample Identification	Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Type	Size	No.	TP	Chl a							pH of Sample Upon Receipt
1		D1-S	5/16/23	3:20	SW	grab	Y (TP)	~~N~~ N	glass	250	1	X								<2
2		D1-B	↓	3:25	↓	grab	Y (TP)	N	glass	250	1	X								<2
3		D1	↓	3:30	↓	Comp	N	Y	filter	NA	1		X							
4		D2-S	↓	2:35	↓	grab	Y (TP)	N	glass	250	1	X								<2
5		D2-B	↓	2:40	↓	grab	Y (TP	N	glass	250	1	X								<2
6		D2	↓	2:45	↓	Comp	N	Y	filter	NA	1		X							
7																				
8																				

Sample Containers: Type / Size / No.

Client Notes: Chl a 150 mL filtered for all samples

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Julie Kieser Kieser & Associates			Print Name & Organization		
Signature [signature]			Signature BA	5-30-23	12:30
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 4.9 °C Initials: R Bottle ID #, if applicable D2-S ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies: ______

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT SW = SURFACE WATER E = EFFLUENT GW = GROUNDWATER SL = SLUDGE AO = AQUATIC ORGANISM

Great Lakes Environmental Center

Project Number: 2592-B09

August 28, 2023

Kieser & Associates-North Lake
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: John Hart

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests were performed within the maximum holding times and have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

NELAP ACCREDITED TNI LABORATORY

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-North Lake

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
2K08020039	NWQ1 Surface	8/2/2023	0.0103	mg/L	0.003	0.0014		8/22/2023		BSC
2K08020040	NWQ1 17 ft	8/2/2023	0.0171	mg/L	0.003	0.0014		8/22/2023		BSC
2K08020041	NWQ2 Surface	8/2/2023	0.0170	mg/L	0.003	0.0014		8/22/2023		BSC
2K08020042	NWQ2 37 ft	8/2/2023	0.0248	mg/L	0.003	0.0014		8/22/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-North Lake

REPORT OF ANALYSIS

chla

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
2K08020043	NWQ Site 1	8/2/2023	0.00676	mg/L	2.47333E-05	0.000000294		8/14/2023		BSC
2K08020044	NWQ Site 2	8/2/2023	0.00315	mg/L	2.47333E-05	0.000000294		8/14/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: EPA Method 445.0

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.
Submitting Company: Kieser & Associates, LLC
Report Results To: John Hart
Address: 536 E Michigan Ave, Suite 300 Kalamazoo 49007
Phone: (269) 344-7117 E-mail: jhart@kieser-associates.com

Section II.
Project Name: North Lake
Project Number:
P.O.#: 300
Sampled by: (initials) RM JH
☐ GLEC ____ ☒ Client ____

Section IV. Requested Analysis

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Container Type	Container Size	Container No.	Total Phosphorus	Chlorophyll a							pH of Sample Upon Receipt
1		NWQ1 Surface	8-2-23	6:44	SW	Grab	H2SO4	N	glass	250	1	X								LL
2		NWQ1 17 ft	↓	6:48	SW	Grab	H2SO4	N	↓	↓	1	X								LL
3		NWQ2 Surface	↓	7:00	SW	Grab	H2SO4	N	↓	↓	1	X								LL
4		NWQ2 37 ft	↓	7:05	SW	Grab	H2SO4	N	↓	↓	1	X								LL
5		NWQ Site 1	↓	6:49	SW	Grab	–	Y	Plastic	↓	1		X							
6		NWQ Site 2	↓	7:00	SW	Grab	–	Y	Plastic	↓	1		X							
7																				
8																				

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark S. Kieser K&A	8/10/23	16:25	Print Name & Organization		
Signature [signature]			Signature [signature]	8-10-23	16:25
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY
Temperature of Samples: 2.1 °C Initials: [initials] Bottle ID #, if applicable SWQIM ☒ Received on Wet Ice
Notes/Anomalies/Discrepancies:
GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

Merit Laboratories, Inc.

Analytical Laboratory Report

Report ID: S48678.01(01)
Generated on 05/24/2023

Report to

Attention: John Hart
Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: jhart@kieser-associates.com

Addtional Contacts: Doug Ervin

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S48678.01-S48678.04
Project: North Lake
Collected Date(s): 05/16/2023
Submitted Date/Time: 05/17/2023 12:30
Sampled by: John J Hart
P.O. #:

Table of Contents

Maya Murshak
Technical Director

Analytical Laboratory Report

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Full accreditation certificates are available upon request. Starred (*) analytes are not NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.
Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.
Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.
Wisconsin PFAs analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.

Report Narrative

There is no additional narrative for this analytical report

Analytical Laboratory Report

Laboratory Certifications

Authority	Certification ID
Michigan DEQ	#9956
DOD ELAP/ISO 17025	#69699
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Alaska CSLAP	#17-001
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
SM4500-Cl- E	Standard Method 4500-Cl- E 2011

Analytical Laboratory Report

Sample Summary (4 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S48678.01	D1-S	Liquid	05/16/23 15:20
S48678.02	D1-B	Liquid	05/16/23 16:00
S48678.03	D2-S	Liquid	05/16/23 14:35
S48678.04	D2-B	Liquid	05/16/23 14:45

Analytical Laboratory Report

Lab Sample ID: S48678.01
Sample Tag: D1-S
Collected Date/Time: 05/16/2023 15:20
Matrix: Liquid
COC Reference: 140058

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	4.7	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/22/23 15:06, Analyst: PJH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	60	1		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S48678.02

Sample Tag: D1-B

Collected Date/Time: 05/16/2023 16:00

Matrix: Liquid

COC Reference: 140058

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	4.7	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/22/23 15:06, Analyst: PJH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	59	1		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S48678.03
Sample Tag: D2-S
Collected Date/Time: 05/16/2023 14:35
Matrix: Liquid
COC Reference: 140058

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	4.7	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/22/23 15:06, Analyst: PJH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	60	1		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S48678.04
Sample Tag: D2-B
Collected Date/Time: 05/16/2023 14:45
Matrix: Liquid
COC Reference: 140058

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	4.7	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/22/23 15:07, Analyst: PJH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	59	1		mg/L	1	16887-00-6	

Merit Laboratories Login Checklist

Lab Set ID: S48678
Client: KIESER (Kieser & Associates)
Project: North Lake
Submitted: 05/17/2023 12:30   Login User: BJB

Attention: John Hart
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117   FAX:
Email: jhart@kieser-associates.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 4.7
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[ ] No	[X] N/A	Do water VOC or TOX bottles contain headspace	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: ______________________________   Date: ______________

Merit Laboratories, Inc.
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Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # 1 OF 1

140058

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME	John Hart
COMPANY	Kieser & Associates
ADDRESS	536 E. Michigan Ave.
CITY	Kalamazoo
STATE	MI
ZIP CODE	49007
PHONE NO.	269-344-7117
FAX NO.	
P.O. NO.	
E-MAIL ADDRESS	jhart@kieser-associates.com
QUOTE NO.	

INVOICE TO

CONTACT NAME	Becky Hough
☐ SAME	
COMPANY	
ADDRESS	
CITY	
STATE	
ZIP CODE	
PHONE NO.	
E-MAIL ADDRESS	bhough@kieser-associates.com

PROJECT NO./NAME: [redacted] North Lake

SAMPLER(S) - PLEASE PRINT/SIGN NAME: John J Hart John J Hart

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER

DELIVERABLES REQUIRED ☒ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER

MATRIX CODE: GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR W=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Containers & Preservatives

MERIT LAB NO. (FOR LAB USE ONLY)	YEAR DATE	TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Chloride
48678.01	5/16/23	3:20	D1-S		1								X
.02	↓	4:00	D1-B		1								X
.03	↓	2:35	D2-S		1								X
.04	↓	2:45	D2-B		1								X

Certifications
☐ OHIO VAP ☐ Drinking Water
☐ DoD ☐ NPDES

Project Locations
☐ Detroit ☐ New York
☐ Other

Special Instructions

ICE

		DATE	TIME
RELINQUISHED BY: SIGNATURE/ORGANIZATION	SAMPLE FRIDGE ☐ Sampler	5/17/23	9:40
RECEIVED BY: SIGNATURE/ORGANIZATION	[signature]	5/17/23	9:40
RELINQUISHED BY: SIGNATURE/ORGANIZATION	[signature]	5/17/23	12:30
RECEIVED BY: SIGNATURE/ORGANIZATION			

		DATE	TIME
RELINQUISHED BY: SIGNATURE/ORGANIZATION			
RECEIVED BY: SIGNATURE/ORGANIZATION	Babre Ball	5/17/2023	1230

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

NOTES: TEMP. ON ARRIVAL 4.7

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 5.18.12

Merit Laboratories, Inc.

Analytical Laboratory Report

Report ID: S51827.01(01)
Generated on 08/08/2023

Report to

Attention: John Hart
Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: jhart@kieser-associates.com

Addtional Contacts: Doug Ervin

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S51827.01-S51827.04
Project: North Lake
Collected Date(s): 08/02/2023
Submitted Date/Time: 08/04/2023 14:30
Sampled by: John J Hart
P.O. #:

Table of Contents

Maya Murshak
Technical Director

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Full accreditation certificates are available upon request. Starred (*) analytes are not NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.
Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.
Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.
Wisconsin PFAs analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.

Report Narrative

There is no additional narrative for this analytical report

Laboratory Certifications

Authority	Certification ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
SM4500-Cl- E	Standard Method 4500-Cl- E 2011

Sample Summary (4 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S51827.01	NWQ1 Surface	Liquid	08/02/23 06:49
S51827.02	NWQ1 17ft	Liquid	08/02/23 06:48
S51827.03	NWQ2 Surface	Liquid	08/02/23 07:10
S51827.04	NWQ2 37ft	Liquid	08/02/23 07:15

Analytical Laboratory Report

Lab Sample ID: S51827.01
Sample Tag: NWQ1 Surface
Collected Date/Time: 08/02/2023 06:49
Matrix: Liquid
COC Reference: 140076

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	4.2	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 08/08/23 12:25, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	66	20		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S51827.02
Sample Tag: NWQ1 17ft
Collected Date/Time: 08/02/2023 06:48
Matrix: Liquid
COC Reference: 140076

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	4.2	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 08/08/23 12:25, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	62	20		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S51827.03
Sample Tag: NWQ2 Surface
Collected Date/Time: 08/02/2023 07:10
Matrix: Liquid
COC Reference: 140076

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	4.2	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 08/08/23 12:25, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	65	20		mg/L	1	16887-00-6	

Lab Sample ID: S51827.04

Sample Tag: NWQ2 37ft

Collected Date/Time: 08/02/2023 07:15

Matrix: Liquid

COC Reference: 140076

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	4.2	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 08/08/23 12:26, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	61	20		mg/L	1	16887-00-6	

Merit Laboratories Login Checklist

Lab Set ID: S51827
Client: KIESER (Kieser & Associates)
Project: North Lake
Submitted: 08/04/2023 14:30   Login User: MMC

Attention: John Hart
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117   FAX:
Email: jhart@kieser-associates.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 4.2
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[ ] No	[X] N/A	Do water VOC or TOX bottles contain headspace	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: ______________________________   Date:______________

Merit Laboratories, Inc.

2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # 1 OF 1

140076

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: John Hart
COMPANY: Kieser and associates
ADDRESS: 536 E. Michigan AVE
CITY: Kalamazoo STATE: MI ZIP CODE: 49007
PHONE NO.: 269-344-7117 FAX NO.: P.O. NO.:
E-MAIL ADDRESS: jhart@kieser-associates.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Becky Hough ☐ SAME
COMPANY:
ADDRESS:
CITY: STATE: ZIP CODE:
PHONE NO.: E-MAIL ADDRESS: bhough@kieser-associates.com

PROJECT NO./NAME: North Lake
SAMPLER(S) - PLEASE PRINT/SIGN NAME: John J Hart [signature]

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER

DELIVERABLES REQUIRED ☐ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER

MATRIX CODE: GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR W=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications: ☐ OHIO VAP ☐ Drinking Water ☐ DoD ☐ NPDES

Project Locations: ☐ Detroit ☐ New York ☐ Other

Special Instructions

MERIT LAB NO. (FOR LAB USE ONLY)	DATE	TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Chloride
51827.01	8/2/23	6:49	NWQ1 Surface	L	1	1							X
.02	↓	6:48	NWQ1 17ft	↓	↓	1							X
.03	↓	7:10	NWQ2 Surface	↓	↓	1							X
.04	↓	7:15	NWQ2 37ft	↓	↓	1							X

JLC

RELINQUISHED BY: SIGNATURE/ORGANIZATION	Sample Fridge ☐ Sampler	DATE 8/4/23	TIME 10:30	RELINQUISHED BY: SIGNATURE/ORGANIZATION	DATE TIME
RECEIVED BY: SIGNATURE/ORGANIZATION	[signature]	DATE 8/4/23	TIME 10:30	RECEIVED BY: SIGNATURE/ORGANIZATION	DATE TIME
RELINQUISHED BY: SIGNATURE/ORGANIZATION	[signature]	DATE 8/4/23	TIME 2:30	SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS	NOTES: TEMP. ON ARRIVAL 4.2
RECEIVED BY: SIGNATURE/ORGANIZATION	M Chilcote	DATE 8/4/23	TIME 1430	SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS	

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 5.18

6.3. Appendix C: Common Aquatic Invasive Species

Eurasian Watermilfoil and Hybrids (EWM):

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 EWM. EWM 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 EWM. EWM 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 EWM and support the production of a more desirable flora. Resistance to herbicidal treatment has been observed.[1,2] Continued chemical applications can select for herbicide resistant plants, resulting in hybrid watermilfoil.[3] 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.

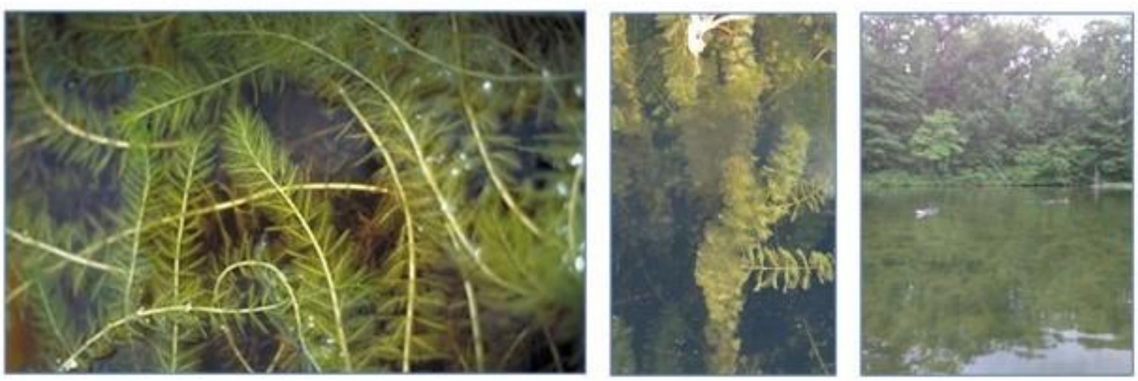

Figure C1: Example Eurasian Watermilfoil and Hybrids images from the 2019 LakeScan™ field crew.

Starry Stonewort

[1] 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.

[2] 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.

[3] Netherland and Willey, 2017

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 due to its asexual reproductive structures (bulbils) which embed in lake sediments.[4] 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.[5] While these methods can be effective and have high specificity, they are expensive, labor-intensive strategies that require long-term commitment.[6] 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-, flumioxazin and endothall-based algaecides have produced mixed results and long-term management has yet to be achieved using chemical biocides alone.[7] 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.

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[4] 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.
[5] Glisson et al., 2018.
[6] 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
[7] Pokrzywinski, K. L., Getsinger, K. D., Steckart, B., & Midwood, J. D. (2020). Aligning research and management priorities for *Nitellopsis obtusa* (starry stonewort).

Figure C2: Example starry stonewort images from the 2019 LakeScan™ field crew.

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. [8] 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 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.[9]

Management: Like other invasive species, CLP is difficult to control once established and 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 long-term control of CLP, but eradication is difficult after establishment. Bottom barriers have shown effectiveness at combating CLP in small areas, and mechanical harvesting of CLP can be effective if timed and managed correctly.[10]

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-

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[8] 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>.

[9] 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>.

[10] MDEQ, 2018.

assisted suction harvesting (DASH), or benthic barrier use during spring before turions are produced. Aquatic herbicides including endothall, diquat, and imazamox are the most effective for general applications. Aquatic herbicides including flumioxazin and imazamox are effective for specific types of application and in specific environments. 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, fluridone, and some hormone treatments have shown a reduction of turion development in the laboratory.[11] (false hopes)

Figure C3: Example curly leaf pondweed image from the 2021 LakeScan™ field crew.

[11] MDEQ, 2018.

6.4. Appendix D: Herbicide Applicator Maps

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

Figure D1 – Herbicide applicator maps from May 31, 2023, chemical applications to treat Eurasian watermilfoil, curly-leaf pondweed, and algae.