KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Aquest Corporation

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

Lower Straits Lake

Oakland County

2023 DATA AND ANALYSIS SUMMARY REPORT

2024 MANAGEMENT RECOMMENDATIONS

Submitted by:

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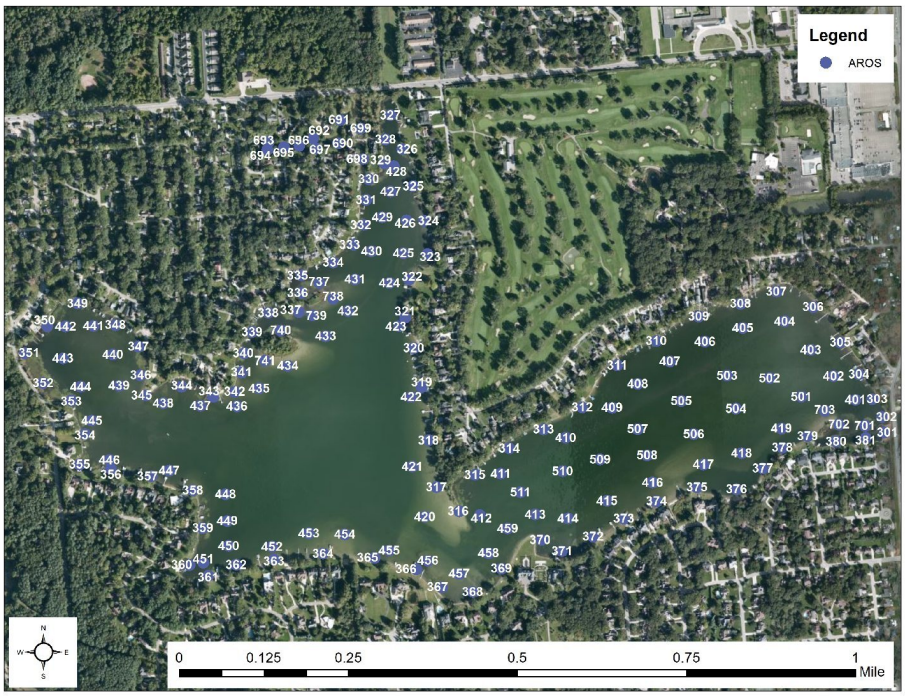

LakeScan™

Table of Contents

At a Glance …

~ *The Lower Straits Lake Management program is outcome based. The development of directives and expectations are focused on creating and supporting a strong and stable ecosystem that supports a variety of recreational activities and aesthetic concerns. LakeScan™ monitoring is used to evaluate lake conditions and management outcomes providing empirical evidence that can be used for numerical and statistical analysis. These data and analysis guide the management team which is comprised of lake resident representatives, lake scientists, township representatives, and intervention contractors (applicators and mechanical device operators).*

~ *Conditions in Lower Straits Lake were generally considered to be good in 2023. LakeScan™ plant community biodiversity estimates met or exceeded expectations. Species numbers were disappointingly low. Plant community composition was good, but improvement is desired. Critical habitat (LakeScan™ Morphodiversity) was acceptable and adequate to support a fishery. Every effort shall be made to improve conditions in the coming years.*

~ *The level of management intervention (herbicides and harvesting) exceeded levels applied to the lake in recent years by a considerable measure. Two herbicide applications provided excellent relief from nuisance conditions. Mechanical harvesting was used for the first time and despite the removal of substantive plant biomass, the results did not meet some lake resident expectations in many areas in the central basin and west bay.*

~ *An aggressive herbicide application approach is once again recommended for the management of exotic and invasive curly leaf pondweed and ebrid watermilfoil in 2023. Harvesting is also, but cautiously recommended to provide relief from nuisance conditions that are present before and immediately after the Memorial Day holiday.*

~ *The canals at AROS 600 are managed on an "as needed" basis requiring coordination between canal area residents and the management team.*

~ *Nuisance water lily growth is managed in the late summer on a rotating basis around the lake perimeter. Approximately 1/3 of waterlily productive areas are treated each year.*

Executive Summary

The overall goal of the Lower Straits Management and Improvement Program is to create stabile ecosystem conditions that provide acceptable and sustainable recreational opportunities, minimize opportunities for hazardous algae blooms, and support a reasonable and rewarding fishery. Extensive LakeScan™ monitoring is conducted each year to provide the empirical data that are used to make certain that the goals of management plan are adequately addressed. The variable nature of lakes and aquatic plant communities demand that the management intervention objectives that are established each year be adaptive and that they address the unique concerns and potential impairments that emerge each summer. Management objectives and decisions are made by consensus agreement of the Lower Straits management contractors (chemical applicators, harvester operators, etc.), lake resident and township representative(s), with the guidance of professional monitoring and management professionals. The Lower Straits improvement program is based on a "no excuses", outcome-based plan, meaning that management tools are selected each year are tailored to achieve the lake management goals and create a more diverse and stabile ecosystem. All options and technologies are considered within the constraints and confines of available monies, relative value, regulatory and safety concerns, and the expressed needs of the Lower Straits Lake resident community.

Because Lower Straits Lake is shallow, the sediments and large plant communities are the primary determinants of the quality of the lake. Water chemistry measurements were done by Aquest in the past and these data have affirmed this assertion. Lower Straits Lake has been afflicted by the presence of both ebrid watermilfoil and curly leaf pondweed since it was first surveyed by Dr. Pullman in 1988. Starry stonewort was first identified in the lake in 2006. Each year, every possible and permitted management approach is considered to improve conditions on the lake and to provide the best value possible using the funds available to improve the lake ecosystem. For example, a 7-acre area of the lake was reserved for the evaluation of a relatively new aquatic herbicide known as ProcellaCOR in 2021. The outcome of the treatment was very positive, but no better than existing approaches that can be implemented at far less cost. Areas were set aside in 2022 as a demonstration of how mechanical aquatic plant harvesting might be used to enhance the management program. The program outcome was generally positive and is still under review.

Despite some of the funding constraints that have existed in many years, the management program has been remarkably successful in suppressing nuisance conditions caused by exotic invasive plant species for most of each summer recreational use season since the late 1980's. Monitoring data show that the quality and habitat value of the Lower Straits submersed plant community has been sustained and generally improved as a consequence of judicious management. The ecosystem has been stabilized by these efforts as the lake has also been improved for recreational pursuits, including fishing. Despite these considerable efforts, there are still no known means, technologies, or ways to eradicate ebrid watermilfoil, curly leaf pondweed, or starry stonewort once they have become established in a lake.

Projected 2024 Management Recommendation Summary

The exotic invasive species, ebrid watermilfoil and curly leaf pondweed are expected to be present in Lower Straits Lake at the extreme nuisance levels, beginning in early May 2024 that have been observed in recent years. Curly leaf pondweed has emerged much earlier Lower Straits Lake than ebrid watermilfoil for the past several years and has been observed at extreme nuisance levels before ebrid watermilfoil becomes highly conspicuous. Starry stonewort had been a serious problem in the lake in previous years but has begun to subside as a major nuisance in recent years.

The typical timing of growth and relative abundance of curly leaf pondweed and ebrid watermilfoil in Lower Straits Lake has resulted in the application of highly species-specific aquatic herbicides in early June of each year. The successional emergence of nuisance conditions caused by these two exotic species mean that significant nuisance conditions in the lake begin to appear before Memorial Day. Herbicide mediated controls have proven not to be effective when applied to the Lower Straits Lake prior to Memorial Day. This is critical because nuisance conditions, particularly those caused by curly leaf pondweed, emerge in early May. In recent years, this early growth represents a significant impairment of recreation until the weeds finally succumb to the herbicide applications made in June. Every submersed aquatic plant management strategy is species selective because individual plant species are more sensitive to the application of a particular strategy or technology and less sensitive to others. This opens the opportunity to selectively manage species within a submersed aquatic plant community and target suppression to the 10% of species that create 90% of the problem. Herbicides are often used because they can precisely target the most notorious weedy species and protect the production of a much larger number of desirable species,. Like herbicides, mechanical harvesting is also a species selective lake management tool because different species respond differently to cutting. Mechanical harvesting can encourage the growth of some of the most weedy species because they are more tolerant of cutting. Cutting tolerant species include ebrid watermilfoil, while those plants that are more sensitive to cutting include desirable native Michigan species that are needed to stabilize lake ecosystems. However, when mechanical harvesting is used in the context of an integrated aquatic plant community management plan it can greatly enhance the outcomes of the management program. Used properly and in context in Lower Straits Lake, mechanical harvesting can be used to improve conditions before Memorial Day and at a time when herbicides are not nearly as effective as a control of nuisance growth. Most of the desirable plant species in Michigan inland lakes do not emerge as early in the growth season as do ebrid watermilfoil and curly leaf pondweed and are too low in the water column to suffer any serious adverse consequences from mechanical harvesting operations when harvesting occurs early in the summer. Mechanical harvesting can be a key component in integrated lake management programs where the objective is to increase the number of weeks of improved recreational conditions. Species targeted and selective strategies, such as herbicide combinations can be used after harvesting operations and when they are most effective to selectively target nuisance ebrid watermilfoil and curly leaf pondweed growth and still protect desirable native plant growth.

There are numerous herbicide and adjuvant combinations that can provide exceptional species selective control of ebrid watermilfoil and curly leaf pondweed. Product pricing has increased significantly in the past two years as a consequence of supply chain issues associated with the global pandemic. The management team will select the most species selective and cost-effective combination of agents for suppression of ebrid watermilfoil and curly leaf pondweed. Early season (May) harvesting may be considered for use in 2024 to extend the recreational season. The selection of agents and timing of the

application will be determined after conditions have been reviewed by the entire lake management team and all options are considered.

The production of nuisance starry stonewort has declined significantly in recent years. Once again, it is not anticipated that starry stonewort control efforts will be required to maintain acceptable recreational and ecological conditions in 2024. However, the first comprehensive LakeScan™ aquatic vegetation survey, conducted in June, will reveal how likely it is that starry stonewort nuisance conditions might form later in the summer.

Water lilies are a critical element in the plant community phyto-architecture that is important for the support of fisheries and ecological stability. MI EGLE policies and regulations constrain the management of waterlilies and limit controls to small areas near boat docks or swimming areas. Selective herbicide treatments are used to manage nuisance waterlily growth in the small areas where controls are permitted. These limited treatments occur in the very late summer and fall when they are most effective and provide treatment for the next summer.

The canals at AROS 600 are very difficult to manage. They have been and will be treated on an "as needed basis" requiring the cooperation of canal residents who communicate with the management team. This is critical since nuisance conditions form unpredictably and quickly in this area of the lake. A newly developed treatment strategy may be available and will be considered in 2024 to reduce ecosystem volatility in this area of the lake.

Thermodynamic conditions are critical considerations for the application of aquatic herbicides and algaecides in the central basin of Lower Straits Lake. This is not normally a primary concern in many lakes but has a dramatic impact on management outcomes in that part of Lower Straits Lake. Experience and guidance from recent scientific literature will be used by the management team in establishing the most effective timing and application methods to provide the best possible management outcomes.

Integrated aquatic plant management is usually the best possible approach to protect or improve aquatic plant communities, stabilize aquatic ecosystems, and maintain acceptable conditions for recreation. The combination of mechanical harvesting and species selective chemical agents has been adopted by several lakes in SE Michigan for effective management of the few species that create recreational impairments and threaten critical ecosystem functions. Integrated management approaches are typically more expensive but are justified by being very effective and extending the active recreational use season. This approach is highly recommended for Lower Straits Lake in 2024.

Responsible lake management is measured by results. LakeScan™ monitoring is still the only system available to quantify and enumerate critical ecosystem metrics and conditions in Michigan inland lakes. Limited to the Aquest K&A team, at this time, Lower Straits Lake has been one of the beneficiary lake communities to receive this type of program service. Not only has the LakeScan™ system been available to provide irrefutable evidence that the lake is being monitored in a meaningful way, but the processes and data generated is also used to discover issues such as the emergence of species hybridity and new plant invasions (starry Stonewort) long before these conditions are typically found in other lakes.These studies allow the evaluation of pre- and post- management intervention outcomes, season-to-season comparisons, critical year-to-year comparisons, and lake-to-lake comparisons and assessments. No lake management program should be conducted without the meaningful empirical evidence to provide

meaningful evaluations of the condition of the lake as each management year progresses. Water quality data and mapping are critical components can be a critical component of any lake monitoring plan, but empirical plant community data is foundational for effective plant community management programs. There are only two companies licensed to conduct LakeScan™ programs in MI. Lower Straits Lake has been a long-time beneficiary of this kind of monitoring.

Introduction

Preface: Lakes are complicated systems. There is no simple way to consider all of the interacting systems within a lake and the impact of watersheds and invasive species invasions on these precious resources. LakeScan™ is a comprehensive system of analysis that is used to properly consider conditions in a lake and make reasonable, scientific and empirically based recommendations for management and improvement of lake ecosystems. All recommendations are based not only on the data presented in this brief report, but are also based on the review of volumes of data collected since the inception of the management program in the late 1980's.

Background: LakeScan™ is a multi-faceted monitoring and analytical system that provides an empirical analysis of lake conditions and critical quality measures. The method includes various assessment categories that include water chemistry, plankton and algae community dynamics, plant community characterization, and fishery related assessments. This analysis provides definitive metrics and relevant perspectives that serve as the basis of management recommendations.

The Lower Straits program has focused on the large plant community for over three decades. Occasionally, water quality parameters (water chemistry and plankton community dynamics) have been evaluated, but with limited financial resources, the focus has been aquatic weeds and large plant community improvements. Cost efficiency and values are paramount and the aquatic plant community, Category 700 is key in the development of Lower Straits Management plan. To invoke a human medicine analogy, one would not necessarily seek out a cardiologist when they have a brain tumor. It could be easily argued that some lake management consultants waste resources on analysis of parameters that are only peripherally related to the primary lake impairments. LakeScan™ provides meaningful and relevant information that is needed to properly manage each lake.

The LakeScan™ method used on Lower Straits lake calculates a series of metrics representative of the health of the lake ecosystem, as well as the nuisance threat presented by invasive and weedy species. In addition to providing a measure of lake health, these metrics allow for a comparison of lake conditions on a year-to-year basis as well as a comparison with other lakes. The survey data and analysis generated by the LakeScan™ method are used to provide treatment and intervention recommendations, when necessary. Recommendations are made in the context of these data and it is always intended that interventions and actions always result in improvements and ensure no further degradation of the lake ecosystem.

Data is reviewed from multiple lake surveys each year and data and observations and in the case of Lower Straits Lake, garnered over more than three decades of data collection and LakeScan™ analysis.

Category 700 Data Collection Methods: Because June and August plant communities can be very different, LakeScan™ analysis involves collecting data over two vegetation surveys (see analysis below). These surveys are based on a system where the lake is first divided into biological tiers (Table 1 and Figure 1) and then further subdivided into Aquatic Resource Observation Sites (AROS; Figure 2). For each survey, field personnel record the density, distribution, and position in the water column of each aquatic plant species or species grouping in each AROS, as well as noting any present nuisance conditions. Early-season surveys are scheduled within the context of applied management interventions to provide

additional guidance or assess efficacy. Scheduling is subject to weather and times of increased boat activity. The late season survey is used to assess the impact of earlier management interventions on the late season plant communities and is occasionally used to direct additional management interventions as may seem appropriate.

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

Vegetation Survey Observations: The primary goal of aquatic plant management in Lower Straits Lake, Oakland County, MI, is to preserve, protect, and if possible, improve the biodiversity of the flora and fauna of the lake. Ultimately, conditions should favor critical habitats that support essential ecosystem services and make the lake better for recreation. A valid survey must always include observations collected at each AROS and can be time intensive. Data is collected from boats fitted with specialized equipment and based on observations made visually, with rake-like grapples or hooks (referred to as a Frodis), underwater cameras, and modern side-scan sonar.

Category 100 – Lake and Watershed Characteristics

This section provides an overview of physical and geopolitical characteristics of the lake and its watershed, as well as illustrations of tier layouts (Figure 1) and AROS (Figure 2) used for vegetation surveys. A summary of watershed land-use composition is included in Figure 3. The lake is shallow and all but a few areas are capable of supporting rooted aquatic plant growth.

Location

County: Oakland

Township: Commerce

GPS Coordinates: 42.58356, -83.46297

Morphometry

Total Area: 235 acres

Maximum Depth: 22 feet

Mean Depth 3.8 feet

Watershed Factors

Tributaries: Middle Straits Lake

Outlet type: Dam on northwest corner of the western lobe of the lake

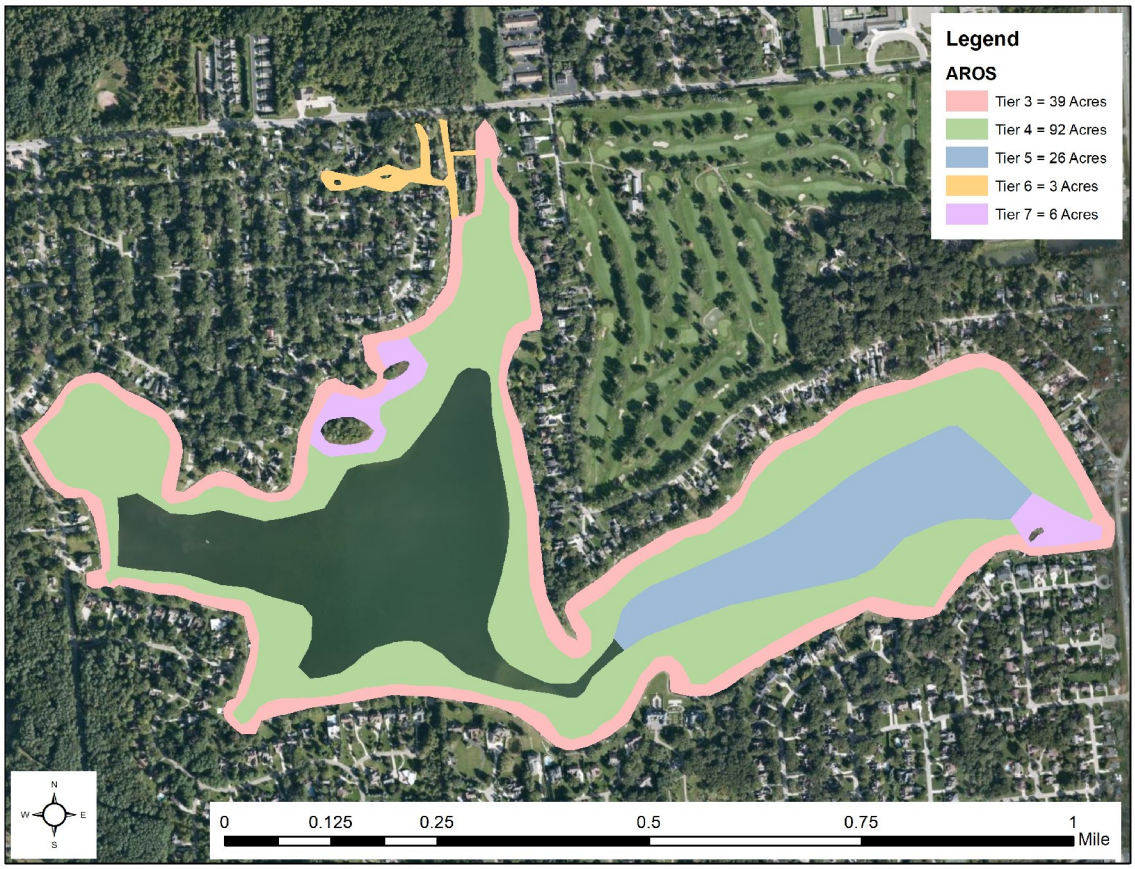

Figure 1. Map of biological Tiers.

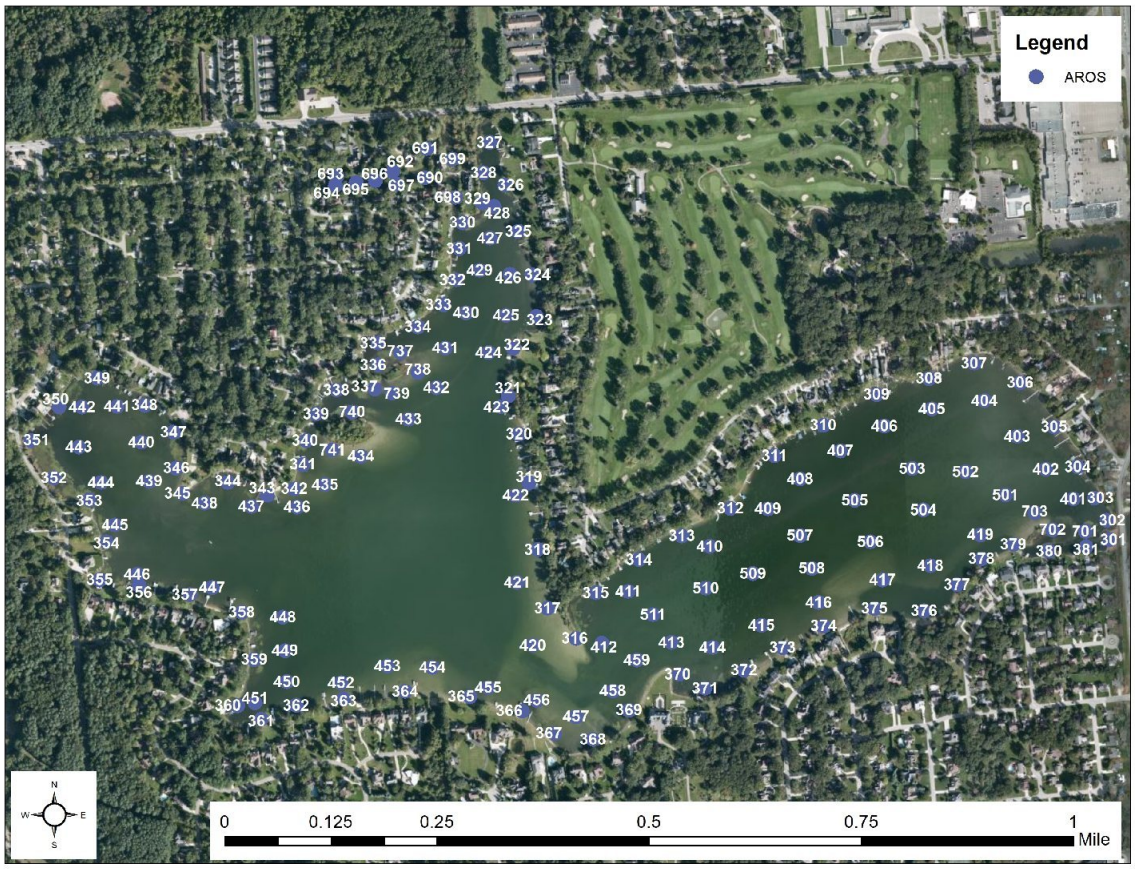

Figure 2. Map of Aquatic Resource Observation Sites (AROS)

Category 200 – Water Quality

Water quality measurements are acquired occasionally and have been added to the historical record for Lower Straits Lake as points of reference. However, the primary impairments of the lake are related to the invasion of the lake by exotic plant species and it would be unwise to expend limited resources on measures that provide little value to the management program, especially when the occasional findings demonstrate the water quality in the lake is actually reasonably good.

Extensive water quality monitoring was conducted from 1992 to 1993. A wide range of parameters were measured to establish baseline conditions on the lake and to determine key determinants of water quality in Lower Straits Lake. Unsurprisingly, these data revealed water quality conditions in the lake are largely determined by water sediment interactions mediated to a significant degree by vegetation cover and recreational boating activity. It is commonly observed that water transparency and other critical water quality parameter values are influenced and in some cases, diminished by the suspension of bottom sediments that occurs as a consequence of recreational motor boating activity. These conditions are particularly obvious after weekends. Despite these high levels of cultural and recreational disturbance, nutrient concentrations in the lake do not exceed reasonable levels for a lake in Southeastern Michigan. Based on open water chemistry, the lake would be considered to be mesotrophic to eutrophic depending on recreational activity and the timing of sampling.

Category 700 – Aquatic Vegetation

This section details findings from the two vegetation surveys that were conducted on the lake. This includes observations, aquatic vegetation mapping, and LakeScan™ analysis metrics as discussed below and presented in various tables and figures.

Preseason LakeScan™ Survey:

The annual pre-season review of lake conditions was conducted on 26 May 2023. It was attended by Aquest and representatives of the resident communities. The township and application and harvesting contractors declined to attend. Treatment and harvesting maps were generated during this assessment and forwarded to the respective contractors. Curly leaf pondweed had reached maximum production levels by this date and was beginning to show signs of natural decline. Ebrid watermilfoil had established an understory of dense vegetation that would ultimately supplant curly leaf pondweed and grow to a considerable nuisance level throughout the lake. Harvesting operations were in process during the survey and a prodigious quantity of curly leaf pondweed was being removed from the lake by multiple machines. Plans were made to continue the harvesting operations and for a very large-scale herbicide treatment program to be applied in the middle of June. It was agreed that the canal at AROS 600's would be treated upon request and as often as needed to respond to unpredictable and recurrent algae problems that form in that area of the lake.

Early-Season LakeScan™ Survey:

The early-season LakeScan™ vegetation survey for Lower Straits Lake was conducted on June 05, 2023. The most common native plant species observed in Lower Straits Lake were *Chara*, Hybrid pondweeds, water lily, and spatterdock. Each of these species were observed throughout many of the nearshore AROSs. Due to hybridization, variable pondweed and Illinois pondweed have been "lumped together" and are represented as medium leaf pondweeds. These "native" pondweeds had reached nuisance levels in many AROS in 2020 and some prior years; however, they were not present at significant nuisance levels in 2021 or 2022. The nuisance production of these probably hybrids is a matter of concern and will be watched closely in 2023.

Notoriously invasive and exotic species observed during the early-season survey included Ebrid watermilfoil and starry stonewort. Curly leaf pondweed was very abundant and dominant prior to the Memorial Day holiday but declines naturally before the Fourth of July Holiday. It had completed its cycle of production and collapse in Lower Straits Lake, much earlier than other nearby lakes. It was not present during the late June survey as it had already declined. Ebrid watermilfoil did exhibit nuisance conditions in numerous Tier 3 and 4 AROS. Greater densities of Ebrid were commonly observed at the 4-6ft contour. Starry stonewort was observed at the greatest frequency of all of the exotic potentially invasive and nuisance species. However, it was present at typical nuisance levels during most of 2023 conditions and was commonly intermixed with *Chara* in the locations that it was found.

Late-Season LakeScan™ Survey:

The late-season LakeScan™ vegetation survey of Lower Straits Lake was conducted on August 01, 2023. Native aquatic species observed include *Chara*, naiad, hybrid medium leaf pondweed, sago pondweed, water celery, spatterdock, and white-waterlily. Overall, these species were observed at much lower densities throughout the lake compared with observations made during the early-season survey.

Chara and hybrid pondweed were the most abundant native submerged aquatic species within Lower Straits Lake. Both species were commonly observed together, nearshore, with wild celery appearing intermittently. Hybrid pondweed and wild celery were occasionally observed growing at or slightly below the water's surface but did not appear to hinder recreational activities on the lake.

Additionally, white-waterlily and spatterdock were widely distributed throughout Lower Straits Lake at varying densities. Occasionally, these species were observed at high densities in front of and around residents' docks which may hamper boat access to the lake. Most instances of this occurred on the southern and eastern shorelines.

Aquatic invasive species observed within Lower Straits Lake included Ebrid watermilfoil and starry stonewort. Ebrid watermilfoil was widely distributed throughout the nearshore but was generally observed at low densities. Ebrid was only observed causing recreational nuisances within the eastern basin. Starry stonewort was the most abundant and widely distributed aquatic invasive species observed within Lower Straits Lake. Starry stonewort was observed within most AROSs but was not creating any recreational nuisance conditions at the time of this survey. Nearshore, starry stonewort was typically or occasionally found intermixed with *Chara* at low densities and found regularly as the only species found within the deeper basins, within the 5ft to 9 ft contours.

2023 Data and Analysis

Six important lake characteristics for defining aquatic plant conditions are presented here for the 2022 annual findings on lake health (Table 2). 'Richness' metrics are counts of either species or morphology (plant structure) types that were observed in the lake. 'Index' metrics are scores indicative of different aspects of lake health. The range of possible index scores is 1 to 100 with a higher score indicating better conditions in relation to management goals assigned for your lake. Annual metrics are also compared here to last year's metrics and include:

- Species Richness – the number of species or species groups present in the lake.
- BioD60 Index – a measure of the health of the plant community based on the number of species or species groups and the distribution of each across all lake AROS.
- Morphological Richness – the number of morphology types present in the lake.
- MorphoD26 Index – reflects the habitat value of vegetation for fish and other aquatic animals and is based on the total number of morphotypes observed at all AROS and how those are distributed throughout the lake.
- MorphoD26 Index – reflects the habitat value of vegetation for fish and other aquatic animals and is based on the total number of morphotypes observed at all AROS and how those are distributed throughout the lake.
- Critical Habitat 60 Index – reflects the habitat value of vegetation for fish and other aquatic animals but is based on the total number of species or species groups observed at all AROS and how those are distributed throughout the lake within the context of a literature review and identification of critical habitat elements for the support of fisheries.

Plant Community Composition, Distribution, and Biomass Production

Conditions in Lower Straits Lake were considered to be good in 2023. The has lake always supported fewer species and less growth than most other lakes in the region. However, the percentage AROS occupied by plant growth has steadily increased throughout the decades. Levels observed in 2023 were very high and exceeded optimal levels considered good for fisheries production according to the literature. The average density and distribution weight of all species and species groups at all AROS were relatively high suggesting that plant productivity in Lower Straits Lake is similar to other nearby weedy lakes.

*Table 2. Aquatic plant community characteristics related to lake quality, 2023. **

PLANT COMMUNITY COMPLEXITY AND D/D PRODUCTION		
	VS 3	**VS 5**
% Vegetated AROS	100%	89%
Total Distinct Communities	25	61
Total Recorded Communities	142	290
Species Average AROS D/D Weight	3.06	2.27
Average AROS D/D Weight	2.94	2.30

** D/D weights are the weighted values of density and distribution recorded for each species at each AROS during LakeScan™ vegetation surveys.*

Species and Morphotype Richness and Seasonality

Historically, the species richness of Lower Straits Lake has been lower than other nearby lakes, but levels observed in 2023 place it on par with other regional lakes. Sixteen species are typically considered to be an acceptable number for southern Michigan inland lakes and the total number of species observed in Lower Straits Lake in 2023 exceed that threshold value. The lake supports two relatively dissimilar aquatic plant communities in the early and then late summer season. Some of this variation can be attributed to targeted invasive species management. However, continued application of these efforts has resulted in the development of a more robust, diverse, and healthy lake flora. Conditions were good in 2023.

Table 3. Aquatic plant community characteristics related to the number of species present in the lake, average number observed in all AROS (richness), and the total number of distinct morophotypes observed in the lake, 2023.

SPECIES, MORPHOTYPE AND QUALITY DATA		
	VS 3	VS 5
Species Richness (Total Number Present)	11	14
Average Species Richness at AROS's	2.9	3.0
Total Morphotypes	6	6

Table 4. Aquatic plant community characteristics related to the number of species observed in the lake during LakeScan™ vegetation surveys conducted in June (VS3) and August (VS5), 2023.

SPECIES RICHNESS BY SURVEY EVENT	Total	%
Species Observed During Combined Surveys	17	
Species Observed at Both Survey Events	8	47%
Species Observed Exclusively VS3	3	18%
Species Observed Exclusively VS5	6	35%

Biodiversity, Morphological Diversity and Habitat Quality

Like humans, lakes are a reflection of various interdependent but clearly different systems. Hence, there is no single metric value that can meaningfully and accurately describe the quality and health of surface water resources from every perspective. The BioD 60 metric value is built upon observations of cumulative cover of all plant species and species groups at all lake AROS's. It is a good descriptor of plant community ecosystem heath and resilience. The current index provides values ranging from 1 to 100 and higher levels are better. The MorphoD 26 Index value is similar but is based on differing plant morphology rather than plant names. Since aquatic organisms are probably more aware of plant shape, size, and height than what humans have named them, this may be a better index value to consider from an ecological perspective. The Habitat 60 value is based on literature reviews of what level of plant cover and type is most supportive of fisheries and recreation. Imagine a bell shaped curve where the highest values appropriate the best level of plant cover and quality. Higher levels are better.

A BioD 60 value of 50 is the target value for Lower Straits Lake and others in the region. Lower Straits Lake narrowly missed this target in 2023. The MorphoD 26 target level for this lake is 60 and the lake nearly met expectations during the first LakeScan™ survey of 2023 but exceeded the target value by the time of the late summer survey. The Habitat 60 value is still too new to merit serious discussion but is provided for the interest of the reader.

Table 5. A primary measure of overall lake health is related to the richness and distribution of aquatic plant species and morphotypes throughout the lake. Species BioD 60 and MorphoD 26 values are computed from observations during LakeScan™ vegetation surveys conducted in June (VS3) and August (VS5), 2023. The Habitat 60 value is a new LakeScan™ index value where the density and distribution values are weighted differently from the BioD60 metric to account for optimal conditions described in the scientific fisheries literature.

COMMUNITY DIVERSITY DATA		
	VS 3	VS 5
Species BioD 60	42.09	48.33
Morpho BioD 26	58.15	78.41
Habitat 60	66.13	62.09

Nuisance Conditions

Perceived nuisance levels (PNL) are determined for each species at each AROS during vegetation surveys. PNL is a subjective value that ranges from 0 to 3 and is based on known plant species characteristic, plant height in the water column coupled to in-field observations of species location within the context of localized lake uses (i.e., surrounds a dock, within the ski lane, in front of the boat launch). Before a PNL is assigned, a species is determined to be either an ecological nuisance, a recreational nuisance, or both. An ecological nuisance is identified as a species that is invasive or non-native to Michigan that seriously threatens the biodiversity of the plant community, ecosystem functions, and overall stability of the lake ecosystem. Recreational nuisance scores are assigned to species that may impair or inhibit boat traffic or swimming ability at the time of the survey. Recreational nuisance can be assigned to both native and invasive/non-native species. PNL 0 is assigned to plant species that are native and do not create a recreational nuisance. PNL 1 indicates ecological nuisance species that do not pose a recreational nuisance. PNL 2 describes native plant species that are a recreational nuisance. PNL 3 indicates ecological nuisance species that also create a recreational nuisance. The maximum species PNL value that is found at each AROS during all seasonal LakeScan™ surveys is used for this analysis.

Nuisance levels in Lower Straits Lake in 2023 were higher than desired and higher than recorded for other regional lakes. Management efforts are required to maintain acceptable ecological and stability levels and recreational values in the lake.

Table 6. The number of AROS where various species nuisance levels were observed in the lake during LakeScan™ vegetation surveys conducted in June (VS3) and August (VS5), 2023. Level 1 nuisance levels are where invasive species threaten ecological stability but do not present an ecological nuisance. AROS where the Nuisance level exceeds 1.5 may be considered to harbor recreational nuisance conditions while AROS where the nuisance average exceeds 2.5 unequivocally harbor impediments to common recreation.

AROS Average Nuisance Levels			
		VS3	VS5
Total AROS	<1.5	8	46
Total AROS	1.5 to 2.5	46	123
Total AROS	>2.5	2	14

Historical Data and Analysis

Species and Morphotype Richness and Seasonality

The species richness of the Lower Straits Lake flora has steadily increased in the lake since the late 1980's. Approximately 5 species were common in the lake until 2010 when the number began to increase annually. Sixteen species is a reasonable target for most regional lakes and 2023 marked the first year that Lower Straits Lake met or exceeded that target level. Only two of these species create nuisance conditions while the remainder help to stabilize and improve ecological resiliency. Despite the increasing number of species and species groups the mean productivity of the species present in the lake as a function of weighted density and distribution values has actually decreased. Given the high nuisance levels observed in the lake, it is a positive sign that even though there are more species covering more of the habitable areas in the lake, the overall production of biomass is trending downward.

The MorphD 26 metric analysis has run concurrently in a positive direction with species richness. This would suggest that conditions are good and improving for the fishery.

At least 25 different species or species groups have inhabited Lower Straits Lake since 1988 (when surveys were first conducted by the author of this document). This is fewer than most regional lakes but is considered to be good never-the-less.

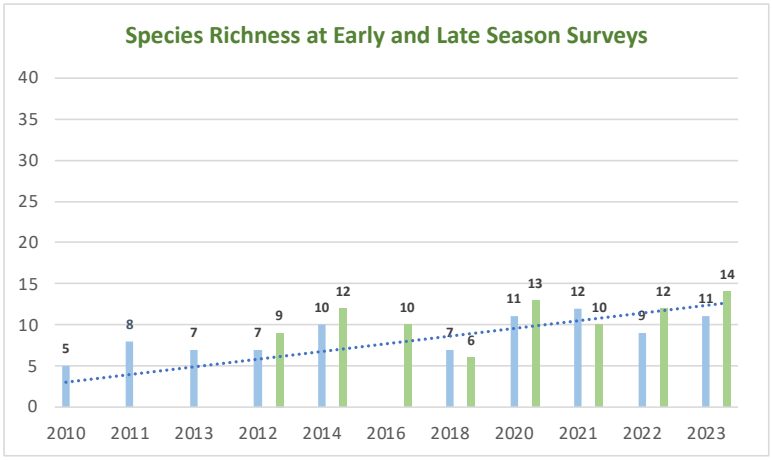

Figure 3. The total number of species or species groups observed in the lake during early (June) and late (August) season LakeScan™ surveys for selected years since 2010. Early and late season survey data are paired for each year. Early season survey data are represented by blue bars and late season survey data is represented by green bars.

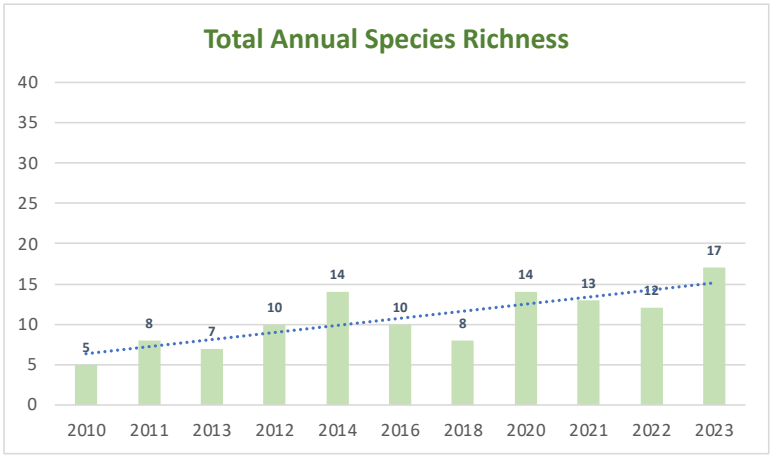

Figure 4. The combined total number of species or species groups observed in the lake from early (June) and late (August) season LakeScan™ surveys for selected years from 2010.

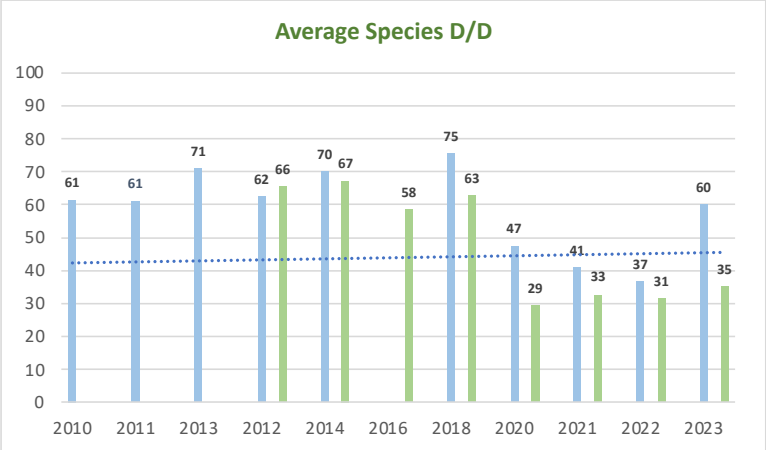

Figure 5. The average species D/D value for the species and species groups obsevered during Early and late season LakeScan™ vegetation surveys for selected years since 2010. Data are paired for each year. Early season survey data are represented by blue bars and late season survey data is represented by green bars. D/D weights are the weighted values of density and distribution recorded for each species at each AROS during LakeScan™ vegetation surveys.

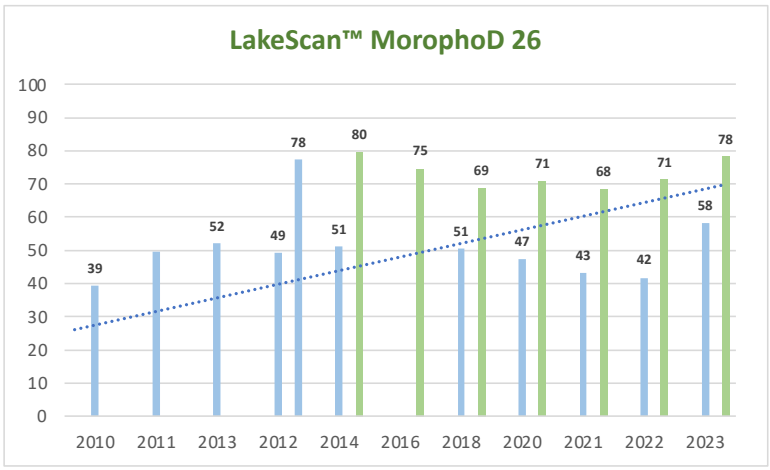

Figure 6. The average species MorphoD 26 values calculated from observations made during early and late season LakeScan™ vegetation surveys from select years since 2010. Early and late season survey data are paired for each year. Early season survey data are represented by blue bars and late season survey data is represented by green bars.

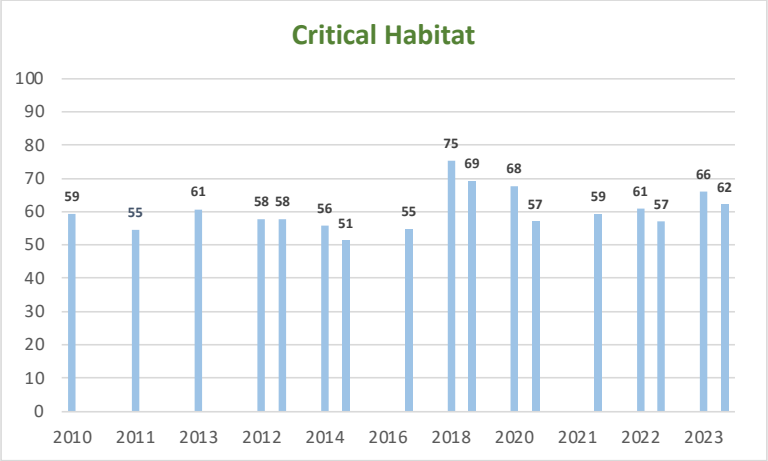

Figure 7. Critical vegetation community habitat data from early (June) and late (August) LakeScan™ surveys performed during selected years since 2010. Data from early and late season surveys are paired by year.

Table 7. The percentage of all AROS where individual aquatic plant species or species groups were observed during early and late season surveys conducted during select years since 2010. The species list includes all species or species groups observed since LakeScan™ monitoring was initiated. There are no data entered for species if they were not present during the years selected for this table but were present during other survey years.

	2010		2011		2012		2013		2014		2016		2018		2020		2021		2022		2023	
	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE
Eurasian Watermilfoil Hybrid	18%		46%		29%	34%	45%		52%	33%		41%	64%	22%	74%	22%	72%	49%	70%	26%	6%	56%
Northern Watermilfoil					0%																	
Common Bladderwort					0%	4%			25%	3%		4%			2%	4%	2%	9%	2%	0%	5%	5%
Coontail																1%						
Naiad						2%				3%		8%		2%		5%		13%		7%		0%
Spiny Naiad																0%						
Chara	35%				31%	21%	38%		56%	33%		39%	62%	69%	73%	77%	68%	65%	70%	55%	73%	65%
Tufted Nitella												1%										
Starry Stonewort	36%		52%		34%	22%	37%		56%	31%		26%	60%	5%	59%	45%	73%	64%	65%	51%	68%	52%
Native Moss																				2%		
Curly Leaf Pondweed			4%				1%								16%	0%						
Flat Stem Pondweed																	1%				2%	
Richardsons Pondweed																						18%
Medium Leaf Hybrid Pondweed	18%		45%		19%	38%	19%		7%	20%		30%	60%	35%	66%	56%	60%	30%	43%	28%	61%	3%
Broad Leaf Hybrid Pondweed			0%																		3%	3%
Sago Pondweed			5%			1%	17%		1%	1%			17%		2%	0%	4%	3%	3%	1%	19%	6%
Thin Leaf Pondweed															5%		1%			0%	8%	
Horned Pondweed									11%													
Wild Celery						1%				1%		3%	2%		18%	9%	4%	9%	7%	4%	1%	1%
Sagittaria										1%												
Waterlily	24%		41%		27%	39%	29%		34%	31%		31%	37%	43%	46%	53%	44%	50%	43%	38%	25%	57%
Spadderdock			1%						0%	0%		2%			7%	4%	10%	2%	10%	1%	9%	
Water Shield									0%								1%				9%	
Floating Leaf Pondweed																					6%	
Thin and Floating Leaf Pdwd																					4%	

Table 7. The mean weighted density and distribution of all aquatic plant species or species groups at all AROS observed during early and late season surveys conducted during select years since 2010. The species list includes all species or species groups observed since LakeScan™ monitoring was initiated. There are no data entered for species if they were not present during the years selected for this table but were present during other survey years. The D/D values reported are the weighted density and distribution values assigned to each species or species group observed in each AROS.

	2010		2011		2012		2013		2014		2016		2018		2020		2021		2022		2023	
	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE	EARLY	LATE
Eurasian Watermilfoil Hybrid	60		51		67	81	64		65	71		58	68	48	58	25	45	30	44	38	78	36
Northern Watermilfoil					75																	
Common Bladderwort					30	50			82	42		50			35	25	35	32	35	25	54	38
Coontail																27						
Naiad						80				53		42		80		26		27		29		20
Spiny Naiad																25						
Chara	73				54	57	82		73	87		66	99	70	70	36	52	36	41	40	49	56
Tufted Nitella												20										
Starry Stonewort	69		49		51	95	35		51	84		71	100	80	60	32	48	43	43	43	51	57
Native Moss																				25		
Curly Leaf Pondweed			69				100								47	20						
Flat Stem Pondweed																	35				45	
Richardsons Pondweed																						30
Medium Leaf Hybrid Pondweed	30		30		65	39	58		68	46		50	48	36	47	29	39	32	32	34	56	24
Broad Leaf Hybrid Pondweed			60																		60	27
Sago Pondweed			56			50	75		60	55			74		33	20	37	25	27	23	56	30
Thin Leaf Pondweed															30		35			25	48	
Horned Pondweed									74													
Wild Celery						55				80		80	75		44	31	33	29	21	29	73	25
Sagittaria										80												
Waterlily	74		74		94	82	85		68	76		81	64	62	52	44	47	44	39	44	85	42
Spadderdock			100						100	80		66			48	42	50	29	49	23	67	
Water Shield									60								35				88	
Floating Leaf Pondweed																					62	
Thin and Floating Leaf Pdwd																					48	
Smartweed										55												
Star Duckweed																						

Category 750 – Lake Management

There are several species that typically become a nuisance in Michigan's inland lakes (See Appendix B). These species are usually targeted for very selective control to prevent them from becoming an aesthetic or recreational nuisance and to protect desirable plants that are a necessary part of lake floras. Of the 17 species or species groups observed in Lower Straits Lake in 2023, only two were present at nuisance levels. This section includes an analysis on nuisance conditions in the lake, as well as a description of any management actions that were taken.

Eurasian watermilfoil and its hybrids have been the primary nuisance in Lower Straits Lake since the late 1980's. It would seem that it does not create the same level of nuisance conditions that it did prior to the early 1990's, but still remains a significant in lakes afflicted by its presence. It has hybridized with a native milfoil and Lower Straits Lake was among a select few where hybrids were identified through molecular testing in 2003 by Aquest and researchers at the University of Connecticut. Since it is very difficult to distinguish between Eurasian watermilfoil and its hybrids and because the consequences of nuisance production do not differ significantly in many cases, Eurasian watermilfoil and hybrids are referred to collectively as ebrid watermilfoil. It is important to note; however, that nuisance conditions caused by ebrids range from non-nuisance to conditions that nearly rival those created by Eurasian watermilfoil and observed in the late 1980's. Eurasian watermilfoil management has been and continues to be the primary annual objective of the plant management program for Lower Straits Lake. More can be found about this species in the appendix attached to this document.

Curly leaf pondweed and starry stonewort are like ebrid watermilfoil because they are non-native or exotic species that were introduced to North America from other continents. Curly leaf pondweed nuisance levels and production vary considerably from year to year. It can create the same level of nuisance conditions that are common with ebrid watermilfoil. It is nearly always found associated with ebrid watermilfoils. It is very sensitive to nearly all EPA registered aquatic herbicides and this makes selective management easy for the protection of desirable plant species and improvement of submersed plant communities. The selective control agents applied to lakes for the management of ebrid watermilfoil simultaneously suppress nuisance production of curly leaf pondweed. Curly leaf pondweed is an early season plant and completes most of its life cycle prior to the Fourth of July holiday and is rarely a nuisance after that holiday. Starry stonewort was also an exotic nuisance plant in Lower Straits Lake, but like so many invasive species, its impact on lake floras has diminished over time to a level where it is not generally considered a nuisance in most AROS. It has not required significant management attention in Lower Straits Lake for several years.

Ebrid Watermilfoil Percent Cover and Weighted D/D Data

Ebrid watermilfoil percent cover, weighted D/D values have varied considerably since the mid-1990's. It is arguable that the variation is a function of weed control efforts since this variability seems to be an inherent trait. Despite these wide variations in production and recurring nuisance levels, management efforts have been largely successful in the maintenance of acceptable conditions from both recreational and ecosystem sustenance perspectives. It remains impossible to eradicated ebrid watermilfoil from afflicted lakes, but maintenance efforts can be employed to dramatically improve lake conditions. A

very wide range of control agents have been used through the decades and the management team continues to entertain new approaches that are affordable, provide good value, result in rapid "knock-down", and season-long control.

The percent occurrence of ebrid watermilfoil in the AROS of Lower Straits Lake has varied during the years but has generally trended higher during the early season surveys. The survey conducted in 2023 was performed after the nuisance milfoil had dropped from the water column after treatment with harvesting followed by herbicides. Recollections from the early season lake condition survey suggest that the level was near that observed in the previous year. The most disturbing statistic is that ebrid watermilfoil was found in over half of the AROS during the late season survey. This would suggest that nuisance conditions could be extreme in the early part of 2024.

The weighted density and distribution values roughly correlate with the accumulation of vegetal biomass. Despite ebrid watermilfoil being present at more and more AROS in most recent years, the total amount of biomass production seems to be easing. The 2023 levels were greater than have been observed in recent years and this is disturbing because harvesting was added to the management approach in 2022. Data will also be collected in 2024 and will be reviewed to see what impacts may be associated with harvesting the milfoil prior to chemical treatment.

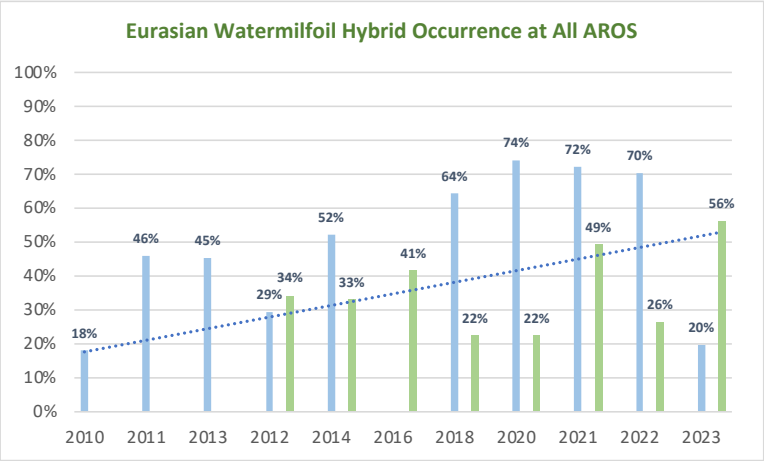

Figure 8. The percentage of all AROS where ebrid watermilfoil was observed during early (June) and late (August) LakeScan™ surveys performed during selected years since 2010. Data from early and late season surveys are paired by year.

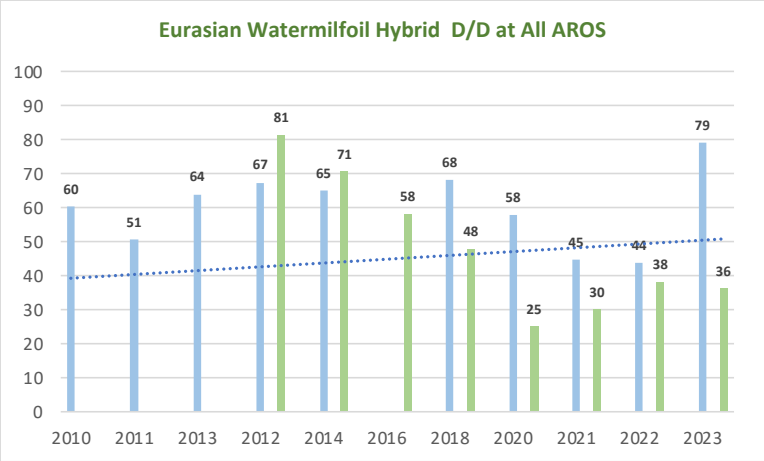

Figure 8. The combined, mean, weighted density and distribution values observed at all AROS for ebrid watermilfoil observed during early (June) and late (August) LakeScan™ surveys performed during selected years since 2010. Data from early and late season surveys are paired by year where early season surveys are depicted in blue and late season survey data is depicted in green.

Desirable Aquatic Plant Species Percent Cover and Weighted D/D Data

There is an abundance of desirable species that are a part of the Lower Straits submersed, floating leaf, and floating aquatic plant flora. These species help to stabilize the ecosystem and prevent radical surges in the production and formation of nuisance conditions and help to hold invasive species production at lower levels than might be observed in their absence. They also can help to mitigate conditions that could lead to the production of toxic algae blooms.

The highly invasive and exotic plant (an alga), starry stonewort was first observed in the lake in 2006. For the next decade it contributed to the constitution of considerable nuisance conditions. It is currently found in a high percentage of AROS; however, the nuisance production of starry stonewort has subsided. It is currently found as an inconspicuous part of the low-growing bottom flora of the lake where it is observed intermingled with a close taxonomic relative, chara. It is often a little more conspicuous during the late season surveys than the early season surveys. This trend of increasing percent cover but transition from nuisance to non-nuisance production levels has been observed in numerous other lakes. Together starry stonewort and chara assemblages provide substantial ecosystem benefits to the lake. The trending spread of chara to an increasing number of AROS over the past several years is a positive indication that the weed maintenance program is achieving its goals.

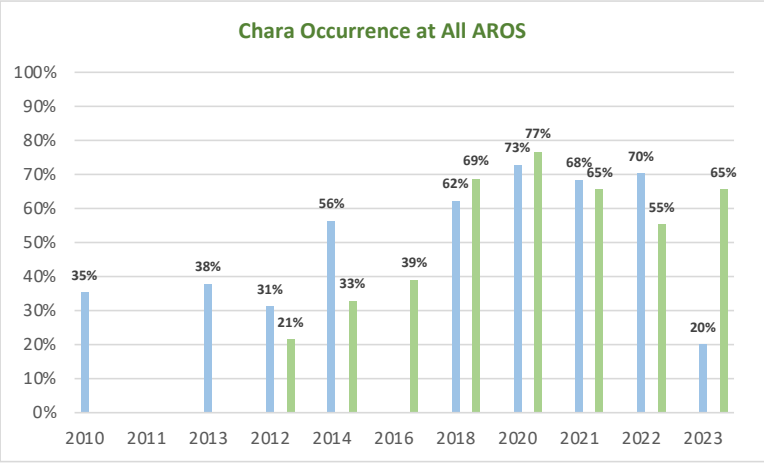

Figure 9. The percent occurrence of Chara at all AROS observed during LakeScan™ surveys conducted during selected years since 2010. Early and late season surveys are paired by year where early season survey data are depicted in blue and late season survey data is depicted in green.

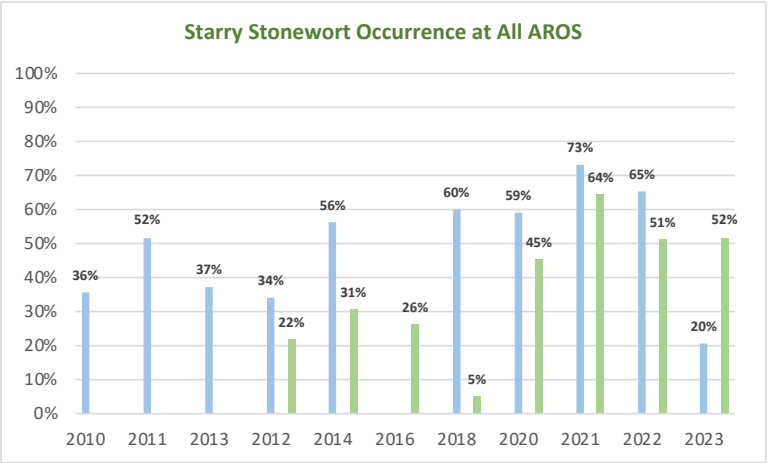

Figure 9. The percent occurrence of Starry Stonewort at all AROS observed during LakeScan™ surveys conducted during selected years since 2010. Early and late season surveys are paired by year where early season survey data are depicted in blue and late season survey data is depicted in green.

Native pondweeds are no longer be considered to be the pondweeds that were observed in previous decades. The European literature has provided convincing evidence that hybridization of pondweeds is common and that naming conventions may be difficult to applied during field surveys. Furthermore, some of the emerging hybrids may be present at significant nuisance levels. Consequently, many of the pondweeds have been lumped into functional groupings based on leaf size for the purpose of field surveys. Further molecular analysis is needed to justify this move, but practicality and cost demand that the groupings be made. The production of medium leaf pondweeds has surged since the late 2010's but has declined since the early 2020's. This could be a result of competition with ebrid watermilfoil. The

pondweeds can create nuisance conditions but are generally considered to provide significant ecosystem benefits. The decline in medium leaf pondweed production is a matter of concern for ecosystem health and stability.

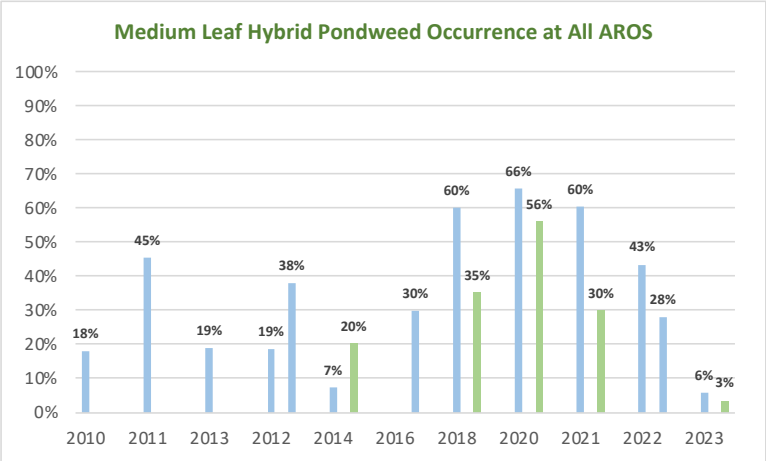

Figure 9. The percent occurrence of Starry Stonewort at all AROS observed during LakeScan™ surveys conducted during selected years since 2010. Early and late season surveys are paired by year where early season survey data are depicted in blue and late season survey data is depicted in green.

A Historical Review of LakeScan™ Metric Data.

All of the AROS that were harvested in 2023 were also treated with herbicides. Lake residents reported high levels of satisfaction with the 2023 treatment program, even though survey data portended significant nuisance conditions may be found in early 2024.

Herbicide efficacy is compromised by drift in TmtZ that are less than 5 acres. A very small number of areas that were smaller than 5 acres were treated in 2023 and some of those TmtZ were found in the canal at the north end of the lake.

Herbicide costs have been increasing in recent years as a consequence of industry consolidations. The cost of treatment in 2023 was high, but not as high as the previous two hears. This was achieved by the judicious selection of control agents.

Table 8. The number of times that AROS were treated in 2023, total acres treated, and cost of treatment. Treatment 1 was harvesting while Treatment 2 was herbicides.

Annual Treatment Summary					
Total AROS Treated:	55	**Acres Treated**	126	**Cost**	$46,105
1 Time:	30	**TmtZ AROS < 5 acres**	15	**Treatment 1**	$17,930
2 Times:	25	**TmtZ AROS > 5 acres**	112	**Treatment 2**	$28,175

Table 9. A historical review of the number of AROS that were treated once or more times during the management year and the cost of treatment.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Total AROS Treated:	156	227	220	220	169	156	137	181	127	118	55
1 Time:	94	102	77	77	124	94	137	73	127	112	30
2 Times:	62	125	143	143	34	62		108		6	25
3 Times:					11						
Total Lake Acres Treated										300	35.86
TmtZ < 5 acres											6.1
TmtZ > 5 acres										300	29.76
Annual Cost of Treatment	$33,750	$43,405	$38,250	$53,463	$45,510	$0	$30,200	$26,650	$64,875	$86,910	$46,105

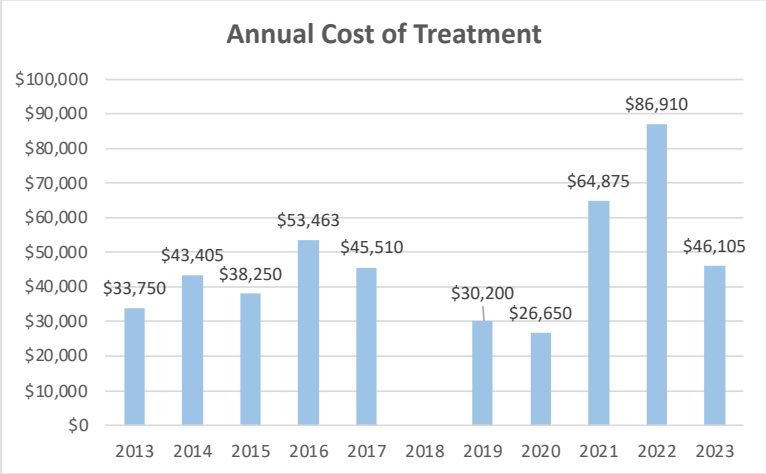

Figure 10. The annual const of weed management (maintenance) for the past decade.

Table 10. A compilation of the total acres to which control agents have been applied, percent of the total lake acres towhich they have been applied and the total volume or weight of products used since 2013..

Acres and Quantities of Herbicides and Algaecides Applied Select Years Since 2013

Corrective Agent	Applied to Acres	% Total Treated Acres	Total Unit Vol/Wt Appied
Copper Chelate +Adjv (L)	90	27%	90
Diquat Dibromide (L)	1,604	478%	1,784
Endothall Salt (L)	934	278%	934
Triclopyr Amine (L)	50	15%	50
2,4-D BEE (G)	8	2%	8
Flumioxazin (F/WP)	338	101%	338

Lower Straits Lake Management History

The overall goal of the Lower Straits Management and Improvement Program is to create stabile and sustainable ecosystem conditions that are necessary to provide acceptable and sustainable recreational opportunities, including fishing. Extensive LakeScan™ monitoring is conducted each year to make certain that the goals of management plan are adequately addressed. The variable nature of lakes and aquatic plant communities demand that the management intervention objectives that are established each year be adaptive. Management objectives and decisions are made by consensus agreement of the Lower Straits management contractors (chemical applicators, harvester operators, aeration installers, etc.), lake resident and township representative(s), with the guidance of professional monitoring and management professionals. The Lower Straits improvement program is outcome-based, meaning that management tools are selected to achieve the lake management goals and create a more diverse and stabile ecosystem. All options are considered within the constraints and confines of available monies, relative value, regulatory and safety concerns, and the expressed needs of the Lower Straits Lake resident community.

Lower Straits Lake has been afflicted by the presence of both ebrid watermilfoil and curly leaf pondweed since it was first surveyed by Dr. Pullman in 1988. Hybrid watermilfoil was suspected to be present in the lake in 1991 and confirmed by the pioneering work done by the researchers at the University of Connecticut, Les and Moody, in 2003. Starry stonewort was first identified in the lake in 2006. Each year, every conceivable management approach has been considered to improve conditions on the lake and to provide the best value possible using the funds available to improve the lake ecosystem. Despite some of the funding constraints that have existed in some years, the management program has been remarkably successful in suppressing nuisance conditions caused by these three invasive species for most of each summer recreational use season since the late 1980's. Monitoring data show that the quality and habitat value of the Lower Straits submersed plant community has been sustained and generally improved as a consequence of judicious management. The ecosystem has been stabilized by these efforts as the lake has also been improved for recreational pursuits, including fishing.

Table 8. Notable submersed aquatic vegetation events since the beginning of LakeScan™ monitoring.

1988	Vegetation Community Monitoring for Lake Health Begins
1991	First Autumnal Fluridone (Sonar) Appication Made to any Lake for Milfoil Control
1992	Recognition of Possible Watermilfoil Hybridity by MI DNR and Aquest
2003	Confirmation of Watermilfoil Hybridity (first of 3 MI lakes)
2006	Discovery of Starry Stonewort (part of only a dozen lakes)
2008	Development of Enhanced Methods for Starry Stonewort Control
2010	Development of Enhanced Methods to Control Increasingly Management Resistant Ebrid Watermilfoil (Aquest and U of M Researchers)
2021	Limited trial of a New Herbicide, ProcellaCOR, for Ebrid Watermilfoil Control
2022	Mechanical Harvesting Trial for Ebrid Watermilfoil and Curly Leaf Pondweed Management to Extend Recreation Season

Each year, nuisance conditions caused by the relative abundance of noxious and invasive species have varied so the final management strategy decisions are not made until a pre-management season inspection is made around the Memorial Day Holiday. The 2022 pre-season survey was conducted on 24 May. Conditions are also monitored throughout the recreational use season and adjustments are made to include late-season interventions when they have been necessary to sustain ecosystem integrity and recreational values. The selective suppression or eradication of exotic invasive species has always been an objective of the management program. Late season applications of nuisance species selective phenoxy herbicides and fluridone have been used to suppress or eradicate ebrid water milfoil in Lower Straits Lake in previous years. Various combinations of State and Federal approved and registered herbicides and algaecides have also been used each year to ameliorate the adverse impacts of unrestrained invasive species growth. Despite these considerable efforts, there are still no known means or ways to eradicated ebrid watermilfoil, curly leaf pondweed, or starry stonewort once they have become established in a lake.

Lower Straits Lake has always been at the forefront of lakes in the U.S. where new management strategies are tested. Recently, and consistent with the adaptive approach taken to the management of Lower Straits Lake plant communities, a 7-acre area of the lake was reserved for the evaluation of a relatively new aquatic herbicide known as ProcellaCOR in 2021. The outcome of the treatment was very positive, but no better than existing approaches that can be implemented at far less cost. The treatment outcome was consistent with the outcome of treatments made on several other regional lakes and it was chosen as a management option by the Lower Straits management team in 2022.

Management Review 2023

Harvesting: Mechanical aquatic plant harvesting was facilitated on a trial basis in 2022. It was repeated in 2023. Harvesting events were conducted during in late May with the intent was to remove curly leaf pondweed biomass and ameliorate nuisance conditions around the important Memorial Day Holiday. This was done to expand the recreational "use" season in the lake around this key holiday. Expectations were that conditions would be improved for boating for several weeks in the early summer, but that there would be substantial regrowth of cut plants that would require subsequent, herbicide mediated species selective control efforts. It should be noted that curly leaf pondweed was present at higher-than-normal production levels during the initial harvesting events in both 2022 and 2023.

Lake resident responses have been mixed. Many correctly believed that the cutting depth was not sufficient to provide good extended control and nuisance relief in 2022, but this complaint was not as common in 2023. Other residents complained that broken plant parts (flotsam) were creating nuisance conditions on shorelines. However, the amount of flotsam was no greater than that associated with typical mechanical plant harvesting operations and seemed to be well within reasonable expectations. Overall, resident response to the trial harvesting program could be described as "tepid". Operational improvements are possible, but the cost to provide marginally better recreational conditions near the Memorial Day Holiday needs to be reconsidered. Harvesting is recommended for 2024 and LakeScan™ data collected in 2024 will help to make decisions about future harvesting deployments.

Herbicides: Warm winters have encouraged earlier curly leaf pondweed production than normal in Lower Straits and other SE Michigan inland lakes. Ebrid water milfoil appeared to lag behind curly leaf pondweed production, and it appears that this may be a characteristic of warm winters. It is unreasonable to believe that harvesting can provide season-long control of ebrid watermilfoil since it is able to rebound quickly from harvesting/cutting. A species selective herbicide treatment is stridently recommended as a "follow-up" to the harvesting operation to provide reasonable expectations of season-long control. Should ebrid water milfoil resurge in August, am additional species selective herbicide treatment may be required to maintain acceptable conditions.

Herbicides and Harvesting Summary: As stated previously, curly leaf pondweed grew to prodigious levels in May 2022 and 2023 and harvesting removed substantial curly leaf pondweed biomass. However, ebrid watermilfoil was present just below the curly leaf pondweed and was released from competition by the removal of the curly leaf pondweed surface vegetation canopy in both years. Ebrid watermilfoil growth "exploded" and rapidly grew to create significant nuisance levels. The species selective herbicide combination of control agents deployed in 2023 successfully suppressed the nuisance growth of ebrid watermilfoil in most AROS throughout the growing season.

The pattern of harvesting followed by species selective herbicide applications is recommended for 2024. LakeScan™ surveys are critical to monitor the impact of the application of this integrated strategy.

The Canals: Ebrid watermilfoil, curly leaf pondweed, wild celery, starry stonewort and unsightly filamentous algae blooms all afflict the canals (AROS 600's) at completely unpredictable times during the course of the submersed plant growing season. Hence, residents report conditions to the management team and appropriate responses are implemented, depending on the timing and nature of the nuisance condition. Given the nature and rapid development of nuisance conditions that typically form in the canals, extraordinary efforts may be applied to these AROS to ameliorate these impairments. New technologies will be applied in the ensuing years. Concerns for low oxygen conditions that occur in the warmest months has precluded treatment of the canals with herbicides in some years because of the threat of fish kills. These can occur as a consequence of oxygen depression that can follow herbicide treatments as the treated vegetation decays. Late summer treatment must be approached cautiously.

Waterlilies: Waterlilies normally wax and wane from year to year because of the presence of a wide range of herbivores and possibly pathogens. However, they have continued to grow at increasing nuisance levels in Lower Straits Lake in recent years. Each year, nuisance waterlilies are treated in the late summer to provide good conditions for the subsequent years. Approximately 1/3 of areas afflicted by nuisance waterlily growth are treated each year. The areas treated cycle around the lake from year to year, and again at around 1/3 of the total waterlily nuisance area.

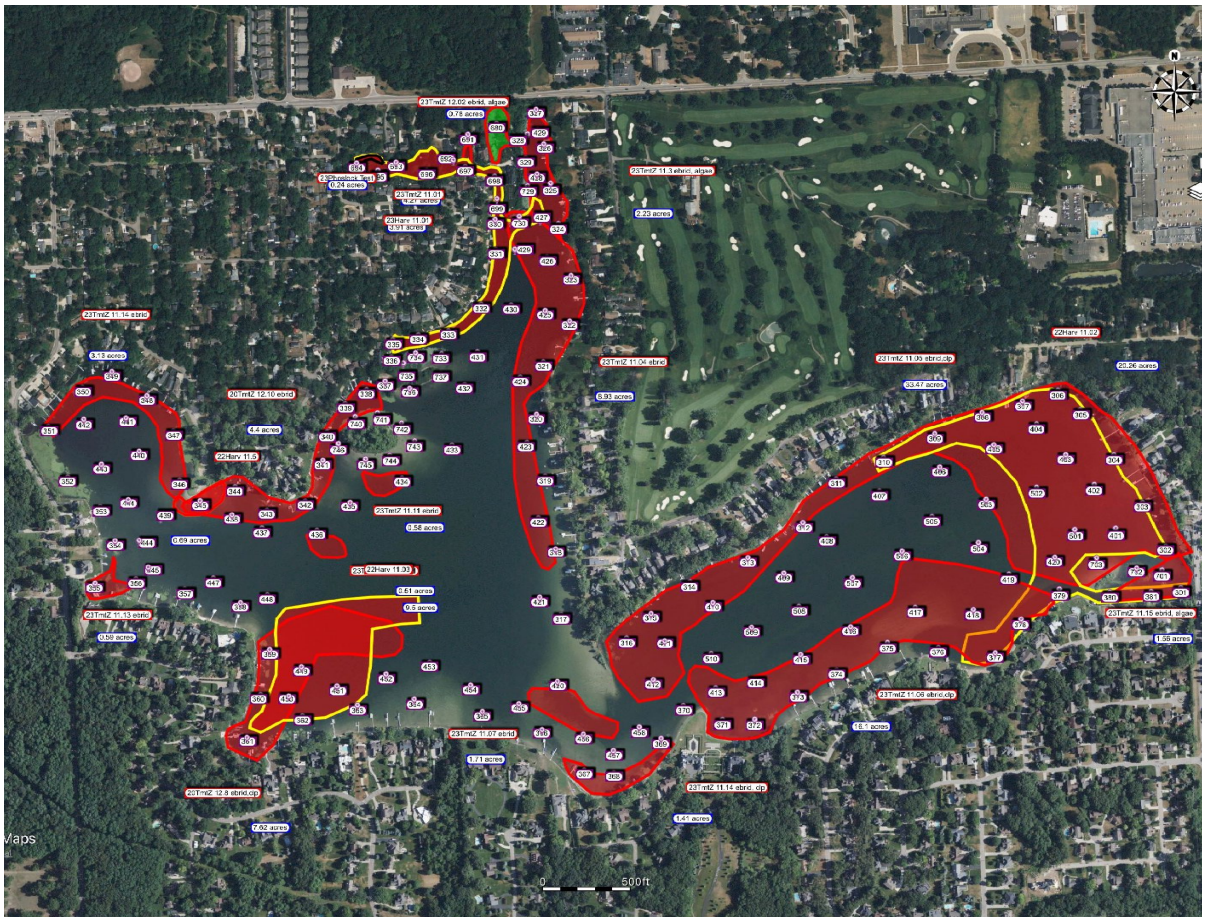

Figure 11. Mechanical harvesting overlay on herbicide applications Zones (HarvZ & TmtZ), 2023.

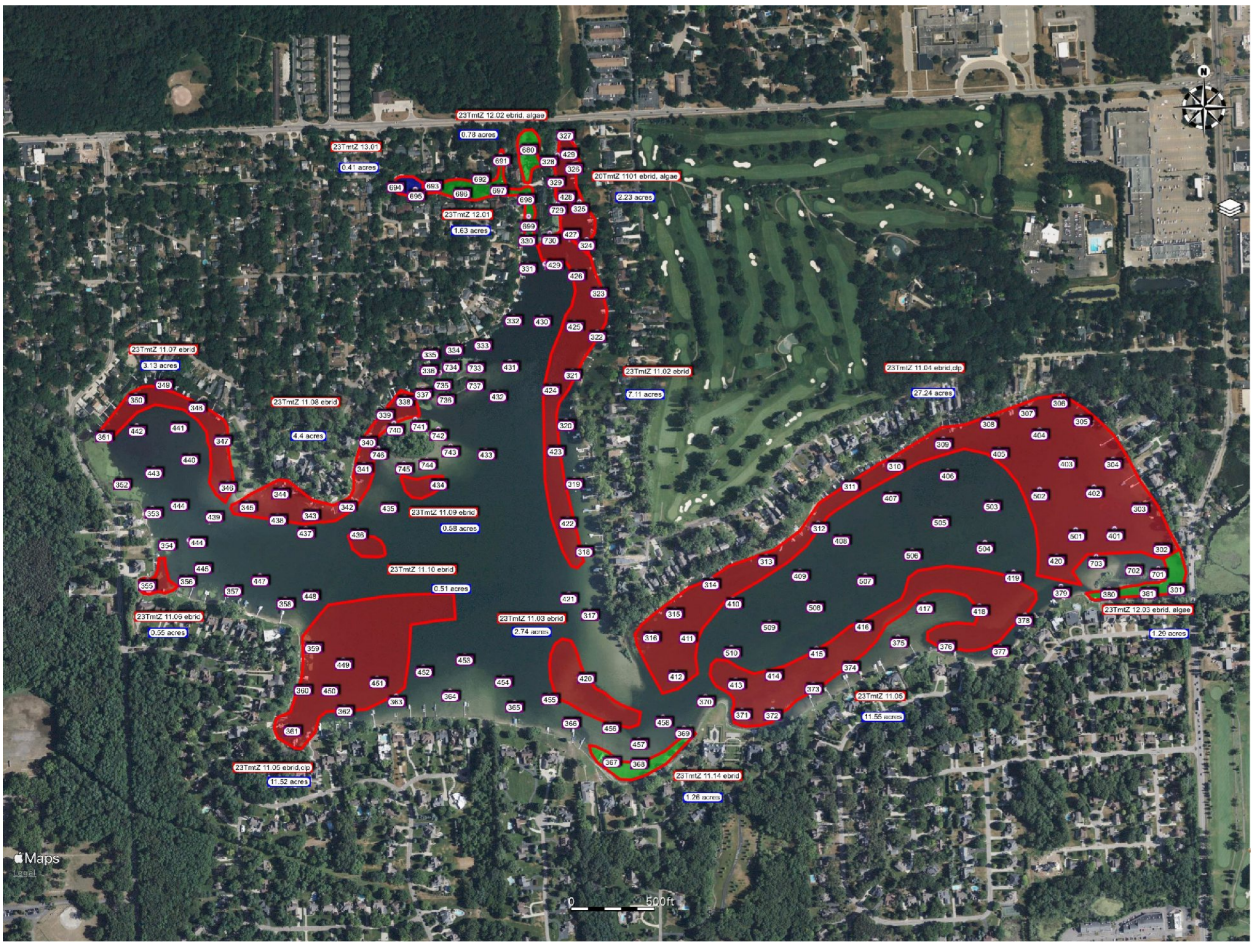

Figure 12. Herbicide application map 2023.

Management 2024

[Repeated in part from earlier in this report]. Ebrid The exotic invasive species, ebrid watermilfoil and curly leaf pondweed are expected to be present in Lower Straits Lake at extreme nuisance levels in 2024. Curly leaf pondweed has emerged much earlier Lower Straits Lake than ebrid watermilfoil in recent years. It has been observed at extreme nuisance levels before ebrid watermilfoil becomes highly conspicuous. Starry stonewort had been a serious problem in the lake in previous years but has begun to subside as a major nuisance in recent years.

The typical timing of growth and relative abundance of curly leaf pondweed and ebrid watermilfoil in Lower Straits Lake has resulted in the application of highly species-specific aquatic herbicides in early June of each year. Ebrid watermilfoil production has lagged behind curly leaf pondweed in recent years and this has delayed the application of control agents that simultaneously and selectively act upon both exotic species. These agents are used because they can pin-point the growth of nuisance species and preserve and enhance the production of desirable plant species production in Lower Straits Lake which

is necessary to stabilize critical ecosystem functions. Unfortunately, the successional emergence of nuisance conditions caused by these two exotic species mean that extreme nuisance conditions in the lake begin to appear before Memorial Day. Herbicide controls are not as effective when applied to the Lower Straits Lake prior to Memorial Day and the emergence of nuisance conditions, particularly curly leaf pondweed, in Lower Straits Lake. Recreation is hampered by these exotic species until they finally succumb to the herbicide applications made in June. Mechanical harvesting is also a species selective lake management tool but it will typically encourage the growth of weedy species that are more tolerant of cutting, such as ebrid watermilfoil, over the more desirable native Michigan species that are needed to stabilize lake ecosystems. However, mechanical harvesting can be used to improve conditions before Memorial Day and at a time when herbicides are not nearly as effective as a control of nuisance growth. Furthermore, many of the desirable plant species in Michigan inland lakes do not emerge as early in the growth season as do ebrid watermilfoil and curly leaf pondweed and are too low in the water column to suffer any adverse consequences of mechanical harvesting operations when harvesting occurs early in the summer. Consequently, harvesting can be used responsibly as part of integrated management programs where the objective is to increase the number of weeks of improved recreational conditions. Species targeted and selective strategies, such as herbicide combinations can be used after harvesting operations and when they are most effective to suppress nuisance ebrid watermilfoil and curly leaf pondweed growth and still protect desirable native plant growth.

There are numerous herbicide and adjuvant combinations that can provide exceptional species selective control of ebrid watermilfoil and curly leaf pondweed. There is extreme volatility in product pricing as a result of supply chain issues in 2023. The management team will select the most species selective and cost-effective combination of agents for suppression of ebrid watermilfoil and curly leaf pondweed in areas of the lake that are not harvested and those areas of the lake where harvesting has occurred, but the exotic species are observed to be recovering. The selection of agents and timing of the application will be determined after conditions have been reviewed.

Starry stonewort nuisance production has declined significantly in recent years. It is not anticipated that starry stonewort control efforts will be required to maintain acceptable recreational and ecological conditions in 2023. However, the first comprehensive aquatic vegetation survey, conducted in June, will reveal how likely it is that starry stonewort nuisance conditions might form later in the summer.

Water lilies are a critical element in the plant community phyto-architecture that is important for the support of fisheries and ecological stability. MI EGLE policies and regulations constrain the management of waterlilies and limit controls to small areas near boat docks or swimming areas. Selective herbicide treatments are used to managed nuisance waterlily growth in the small areas where controls are permitted. These limited treatments occur in the very late summer and fall when they are most effective and provide treatment for the next summer.

The canals near AROS 600 continue to be problematic. Nuisance conditions form rapidly and unpredictably. Because nuisance conditions arise so quickly in this area, it is incumbent upon canal residents to notify the management team when nuisance conditions arise. The management team can then implement appropriate responses based on this input. A new strategy for stabilizing the canal ecosystem may be considered in 2024.

Integrated aquatic plant management is usually the best possible approach to protect or improve aquatic plant communities, stabilize aquatic ecosystems, and maintain acceptable conditions for

recreation. The combination of mechanical harvesting and species selective chemical agents has been adopted by several lakes in SE Michigan for effective management of the few species that create recreational impairments and threaten critical ecosystem functions. Integrated management approaches are typically more expensive but are justified by being very effective and extending the active recreational use season. This approach is highly recommended for Lower Straits Lake in 2024.

Responsible lake management is measured by results. LakeScan™ monitoring is still the only system available to quantify and enumerate critical ecosystem metrics and conditions in Lower Straits Lake. These studies allow the evaluation of pre- and post- management intervention outcomes, season-to-season comparisons, critical year-to-year comparisons, and lake-to-lake comparisons and assessments. No lake management program should be conducted without the empirical evidence to provide meaningful evaluations of the condition of the lake as each management year progresses. There are only two companies licensed to conduct LakeScan™ programs in MI. Lower Straits Lake has been a long-time beneficiary of this kind of monitoring.

References

Michigan Department of Environmental Quality. 2006. "Part 4-Water Quality Standards." Water Bureau, Water Resources Protection. Available online at: http://dmbinternet.state.mi.us/DMB/ORRDocs/AdminCode/302_10280_AdminCode.pdf.

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/.

Appendices

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 2020 LakeScan™ field crew.

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

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

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

TP and TN: The total phosphorus (TP) concentration in a water resource is usually positively correlated with the production of suspended algae (but not rooted plants, i.e. seaweed). Very small amounts of phosphorus may result in large algae blooms. If the ratio of total nitrogen (TN) to total phosphorus is low (<20), suspended algae production may become nitrogen limited and noxious blue green algae may

dominate a system because they are able to “fix” their own nitrogen from atmospheric sources. Other common and desirable algae are not able to do this.

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

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

Appendix B: Common Aquatic Invasive Species

Eurasian Watermilfoil and Hybrids (Ebrids):

Background: Anecdotal evidence suggests that hybrid milfoil has been found in Michigan inland lakes for a long time (since the late 1980's). University of Connecticut professor Dr. Don Les was the first to determine that there were indeed, Eurasian watermilfoil and northern watermilfoil hybrids in Michigan based on samples sent to his Connecticut lab by Dr. Douglas Pullman, Aquest Corp. in 2003. Experience has proven that it is usually not possible to determine whether the milfoil observed is either Eurasian or hybrid genotype. However, because they play such similar roles in lake ecology, they are simply "lumped together" and referred to collectively as ebrid milfoil. Ebrid milfoil 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 ebriid milfoil. Ebrid milfoil is an ever-present threat to the stable biological diversity of the lake ecosystem. Species selective, systemic herbicide combinations have been used to successfully suppress the nuisance production of ebrid milfoil and support the production of a more desirable flora. However, it is becoming much more resistant to all herbicidal treatment. This resistance can be easily defeated with the use of microbiological system treatments. This is done with only a minor increase in cost. Milfoil community genetics are dynamic, not static, and careful monitoring is needed to adapt to the expected changes in the dominance of distinct milfoil genotypes. Some of these genotypes may be more herbicide resistant than others and treatment strategies must be adjusted to remain effective in different parts of the lake.

Figure B1: Example Eurasian Watermilfoil and Hybrids images from the 2020 LakeScan™ field crew.

Starry Stonewort

Background: Starry stonewort invaded North American inland lakes after becoming established in the St. Lawrence Seaway/Great Lakes system. It has probably been present in Michigan's inland lakes since the late 1990's but was not positively identified until 2006 by Aquest Corporation in Lobdell Lake, Genesee County, MI. Since then, it has been discovered in lakes all over Michigan. It is truly an opportunistic species that 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. It is easy to kill, but very difficult to treat. It grows so rapidly that mechanical methods of control are strongly discouraged. First, starry stonewort can regrow so rapidly after cutting that it can be nearly impossible to keep up with the nuisance production of this fast-growing plant. Mechanical controls can also help to disperse and spread starry stonewort throughout inland lakes when the plant is fragmented. It is even more disturbing that desirable plant species are more susceptible to mechanical control strategies than starry stonewort and mechanical controls can thereby select for the dominance of starry stonewort over a much more desirable flora. Starry stonewort is susceptible to most selective algaecides, but the dense mats of vegetation are very difficult to penetrate and provide reasonable biocide exposure. Consequently, multiple algaecide applications may be required to "whittle down" dense starry stonewort growth if the mats reach sufficient height.

Figure B2: Example starry stonewort images from the 2020 LakeScan™ field crew.