KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Aquest Corporation

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

Lower Straits Lake

Oakland County

2021 DATA AND ANALYSIS SUMMARY REPORT

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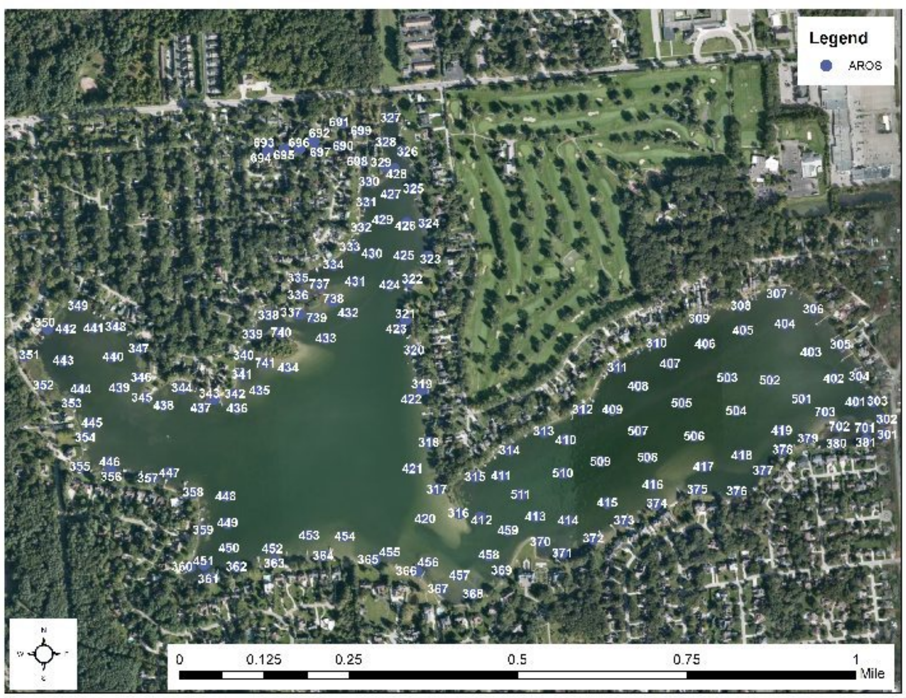

LakeScan™

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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, 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 each year are tailored 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.

Because Lower Straits Lake is shallow, the sediments and large plant communities are the primary determinants of the quality of the lake. Water chemistry measurments done in the past 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.

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 or ways to eradicated ebrid watermilfoil, curly leaf pondweed, or starry stonewort once they have become established in a lake.

Management 2022 Summary

The exotic invasive species, ebrid watermilfoil and curly leaf pondweed are expected to be present in Lower Straits Lake at extreme nuisance levels in 2022. Curly leaf pondweed has emerged much earlier Lower Straits Lake than ebrid watermilfoil in recent 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 extreme nuisance conditions in the lake begin to appear before Memorial Day. Herbicide mediated controls are not as effective when applied to the Lower Straits Lake prior to Memorial Day and the emergence of nuisance conditions, particularly those caused by curly leaf pondweed, in Lower Straits Lake. This growth represents a significant impairment of recreation until the weeds finally succumb to the herbicide applications made in June. Like herbicides, mechanical harvesting is a species selective lake management tool. However, 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. Still, 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. Done properly, mechanical harvesting can be used 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 selectiverly 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. There is extreme volatility in product pricing as a result of supply chain issues in 2022. 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.

The production of nuisance starry stonewort 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 2022. 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.

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 2022.

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.

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 data collected since the inception of the management program in the late 1980's.

Background: LakeScan™ is a monitoring and analytical system that provides an empirical analysis of lake conditions and critical quality measures. This analysis provides definitive metrics and relevant perspectives that serve as the basis of management recommendations. Data is reviewed from multiple lake surveys each year and data and observations garnered over more than two decades. Each survey includes a comprehensive mapping of aquatic vegetation present in the lake. Water clarity, dissolved oxygen profiles, and temperature profiles have also become a part of the standard survey protocol. LakeScan™ 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 the maps generated from by LakeScan™ anaysis 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 Collection Methods: A LakeScan™ analysis involves collecting data over two vegetation surveys. 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 in each AROS, as well as noting any present nuisance conditions. 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

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. Key findings from the June 22 and August 17, 2021 intensive LakeScan™ vegetation surveys of Lower Straits Lake include:

- Overall, combined species biodiversity and structural diversity scoring for Lower Straits Lake has improved but still did not meet management goals for 2021, suggesting inadequate ecosystem health and habitat for fish. Moderate Vegetation Quality Index scoring suggests needed improvements in desirable species, such as native Michigan species coverage throughout the lake. Nuisance conditions were vastly improved relative to 2020 and exceeded management goals. Improved nuisance conditions and ecosystem quality metrics are likely the result of effective herbicide application; however, other factors may influence this improvement.
- The early-season LakeScan™ vegetation survey was conducted on June 22, 2021. The most common native plant species observed in Lower Straits Lake were *Chara* (*Chara sp.*), Hybrid pondweeds (*Potamogeton* hybrid), white-waterlily (*Nymphaea sp.*), and spatterdock (*Nuphar sp.*). Each of these species were observed throughout many of the nearshore AROSs. Invasive species observed included Eurasian watermilfoil hybrid, or Ebrid, (*Myriophyllum spicatum x sibiricum*) and starry stonewort (*Nitellopsis obtusa*).
- The late season LakeScan™ vegetation survey was conducted on August 17, 2021. Native aquatic species observed include *Chara*, naiad (*Najas sp.*), spiny naiad (*Najas marina*), Hybrid pondweed, sago pondweed (*Stuckenia pectinata*), water celery (*Vallisneria americana*), spatterdock, and white-waterlily. Potentially aquatic invasive species observed within Lower Straits Lake included Ebrid watermilfoil and starry stonewort.

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.

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.

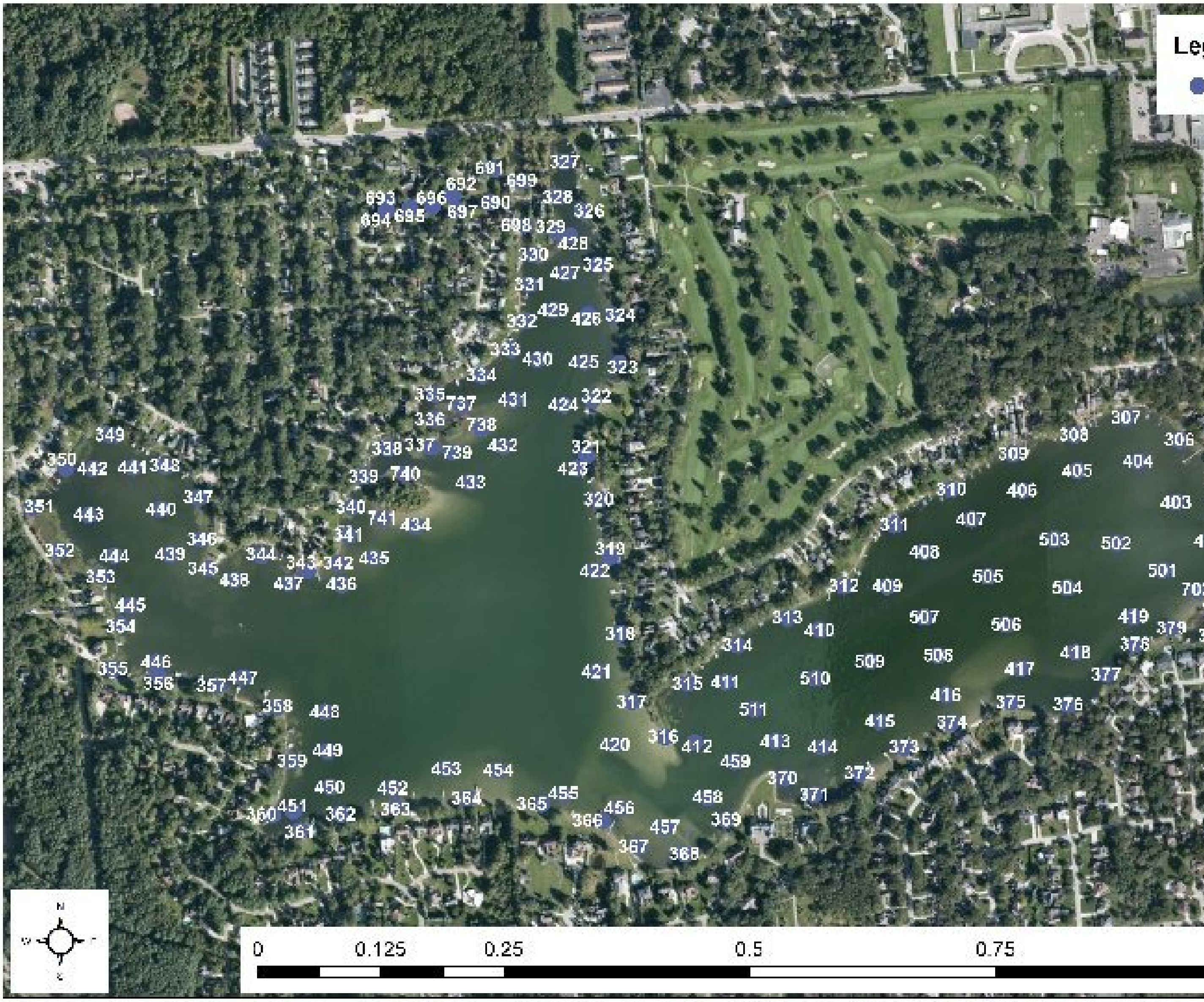

Figure 2 - Map of Aquatic Resource Observation Sites (AROS)

Category 200 – Water Quality

Secchi depth, dissolved oxygen and temperature data were collected at the deepest point in the lake during each vegetation survey (Figures 4 and 5). Secchi disk transparency is the depth at which a Secchi disk (a flat white or black and white platter, approximately 20 centimeters in diameter) suspended into a lake disappears from the investigator's sight. In general, the greater depth at which the Secchi disk can be viewed, the lower the productivity of the water body. Secchi depth readings of greater than 15 feet can be indicative of low productivity or oligotrophic conditions.[1] It is important to note that established populations of zebra mussels in a lake can significantly increase water clarity, thus resulting in greater Secchi disk readings.

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

Dissolved oxygen levels and temperature were measured using a YSI ProODO dissolved oxygen meter, calibrated prior to use. Michigan water quality standards for surface waters designated for warm water fish and aquatic life call for a DO of at least 5 mg/L.[2] Temperature and DO concentrations during the early and late-season surveys were relatively uniform from the surface to the lake bottom. Both parameters fell within the range of desirable conditions for fish and aquatic life.

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[1] 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/.

[2] 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.

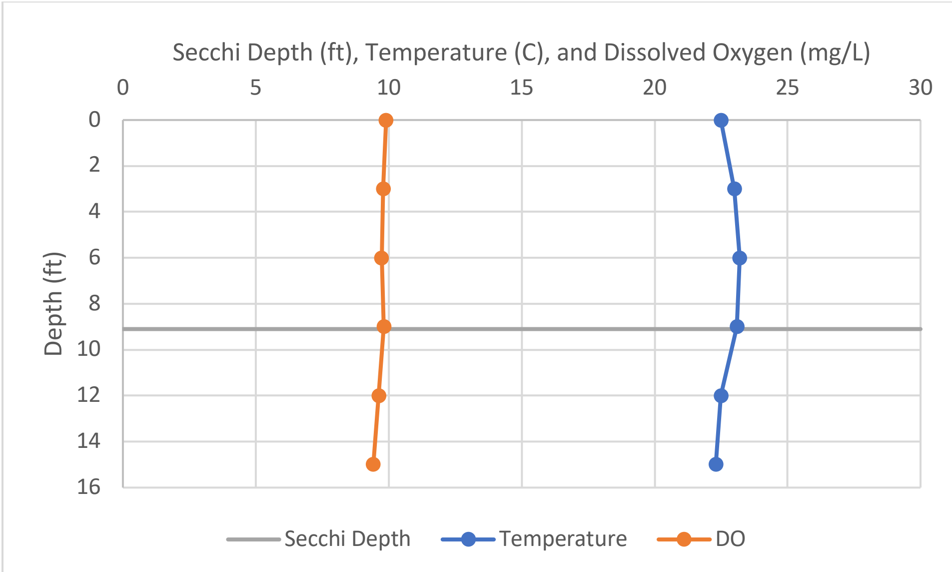


Figure 3 – Early-season survey (June 22, 2021*) dissolved oxygen and temperature profiles with Secchi depth, taken at the deepest point of the lake.*

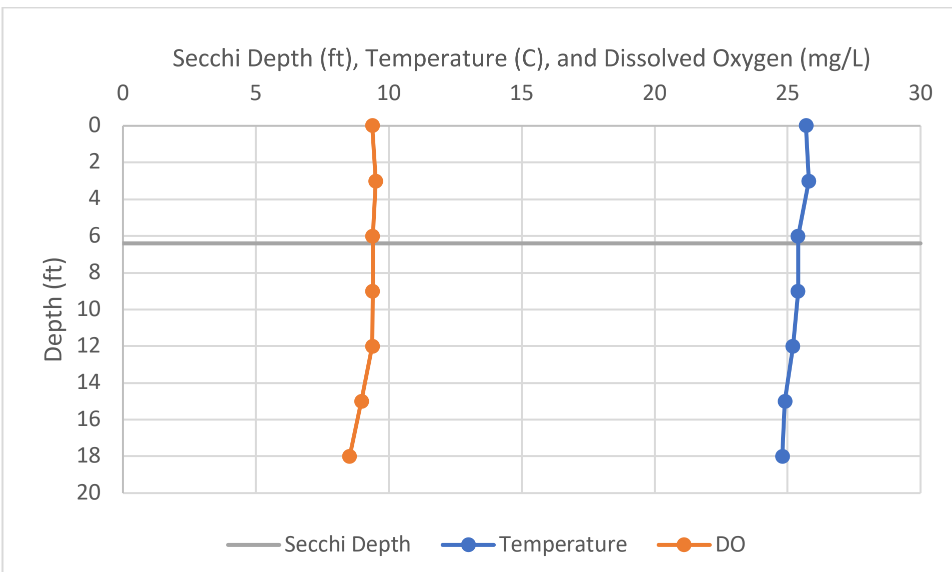


Figure 4 – Late-season survey (August 17, 2021*) dissolved oxygen and temperature profiles with Secchi depth, taken at the deepest point of the lake.*

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 Tables 2-5 and Figures 6-9. Maps in Figures 6 and 7 show results from early and late-season surveys, respectively, combining results for all species. Figures 10-13 show maps of key nuisance plant species.

Early-Season LakeScan™ Survey:

The early-season LakeScan™ vegetation survey for Lower Straits Lake was conducted on June 22, 2021. Weather was 68°F and overcast with 12 mph winds from the north. Overcast and windy conditions reduced visibility. Overall, visibility was moderate with a Secchi disk depth reading of 9.1 feet. Figure 6 depicts data on all combined species using three-dimensional density, which reflects a combination of vegetation density, distribution and height observations of all species observed on Lower Straits Lake during the early-season survey. Color-coding is provided for each AROS and 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 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. Variable pondweed and Illinois pondweed reach high densities in many of the 300 tier AROS as well as AROS 413-415 and 457-459. The high densities of pondweeds in these areas may have caused nuisance conditions.

Invasive species observed during the early-season survey included Ebrid watermilfoil and starry stonewort. Ebrid watermilfoil did exhibit nuisance conditions in the 400 tier AROS. Greater densities of Ebrid were commonly observed at the 4-6ft contour (Figure 10). Starry stonewort was observed at the greatest frequency. Most AROS in Lower Straits Lake had starry stonewort present but was not observed at nuisance conditions and was commonly intermixed with *Chara* in the locations that it was found (Figure 12).

Late-Season LakeScan™ Survey:

The late-season LakeScan™ vegetation survey of Lower Straits Lake was conducted on August 17, 2021. Weather was sunny with temperatures in the low 80°F and calm south winds. Visibility through the water column was low with a Secchi disk depth reading of 6.4 ft. Figure 7 depicts data on all combined species using three-dimensional density, which reflects a combination of vegetation density, distribution and height observations of all species observed on Lower Straits Lake during the late-season survey.

Native aquatic species observed include *Chara*, naiad, spiny naiad, hybrid 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; AROS 403, 402, and 503. 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 found intermixed with *Chara* at low densities and regularly the only species found within the deeper basins, within the 5ft to 9 ft contours, at increased density and distribution.

The maps below depict results of the vegetation surveys. Data on all combined species are represented using three-dimensional density, which reflects a combination of vegetation density, distribution and height observations.

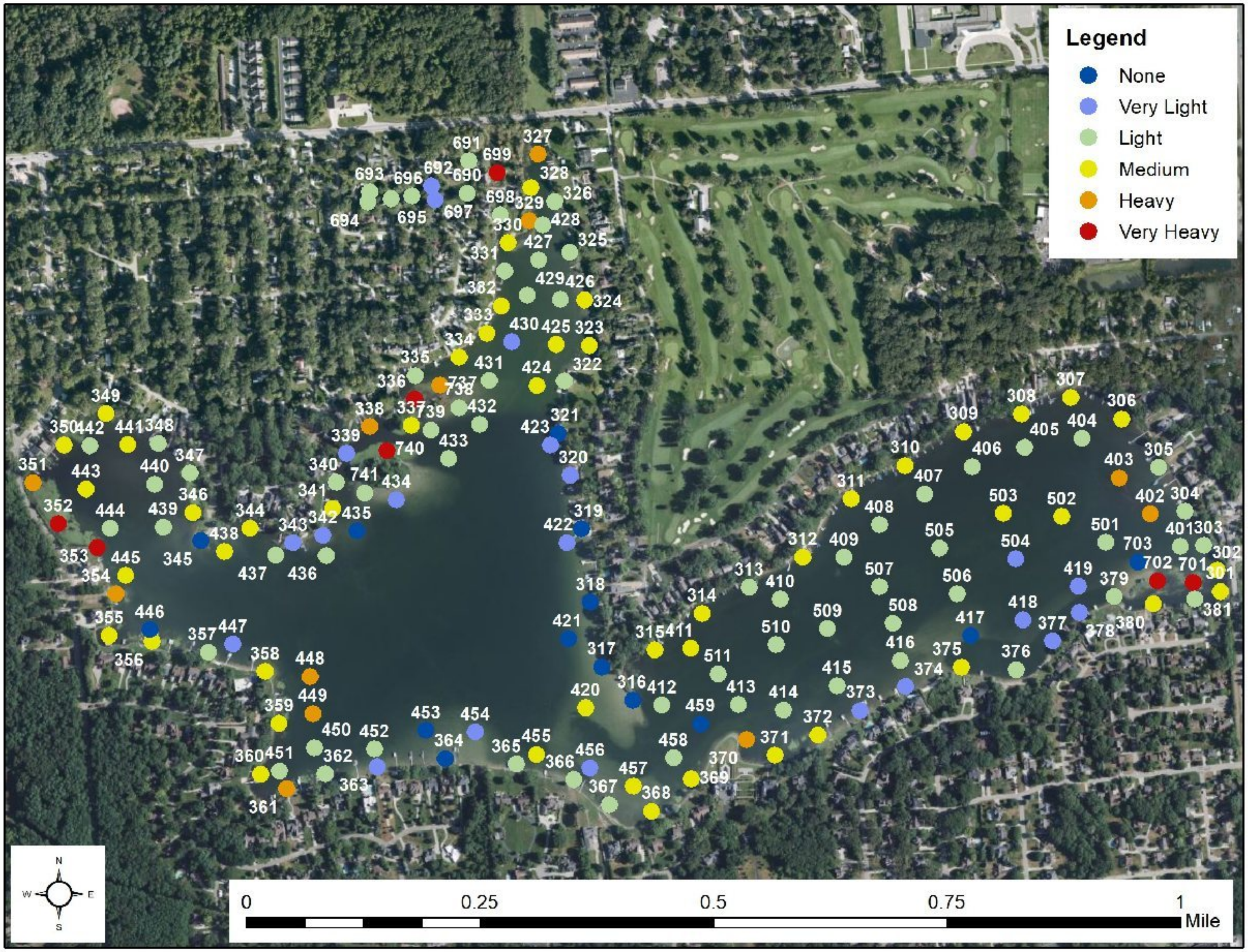


Figure 5 - Early season survey (June 22, 2021) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species)

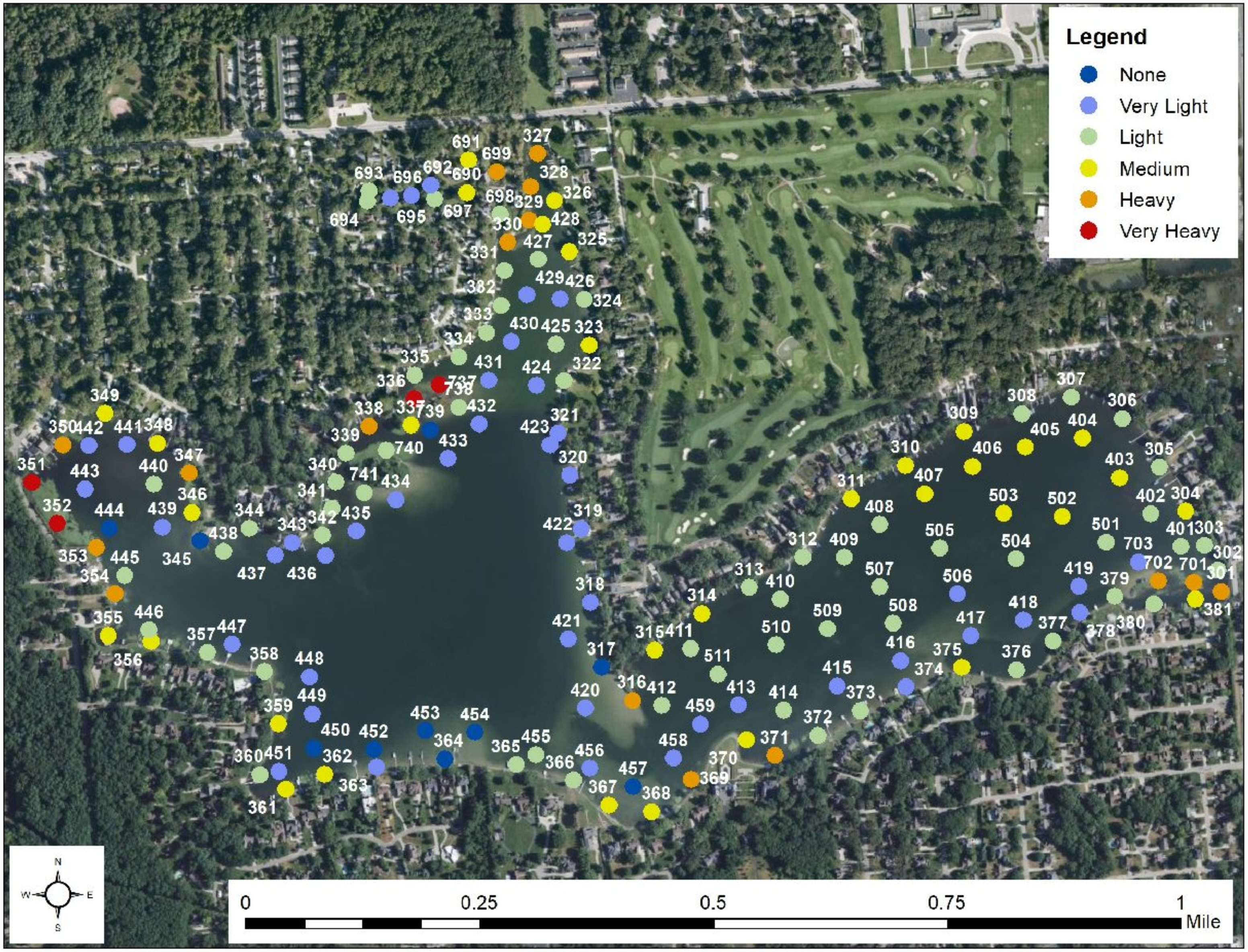


Figure 6 - Late season survey (August 17, 2021) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species)

Six important lake characteristics for defining aquatic plant conditions are presented here for the 2021 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 present in the lake
- BioD60 T2+ Index – a measure of the health of the plant community in your lake
- 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
- Vegetation Quality Index – examines the lake coverage of desirable versus undesirable species
- PNL Index2 – provides a value depicting the density and distribution of nuisance vegetation in your lake

Table 2 – 2021 LakeScan™ Metric Results

LakeScan™ Metric	Score Category	Useful in Describing Conditions For:	2020 Score	2021 Score	Management Goal
Species Richness	Biodiversity	Ecosystem Health	15	16	-
BioD60 T2+ Index	Biodiversity	Ecosystem Health	25	35	50
Morphological Richness	Structural Diversity	Fish Habitat	10	10	-
MorphoD26 Index	Structural Diversity	Fish Habitat	38	35	50
Vegetation Quality Index	Nuisance Condition	Ecosystem Health	43	38	50
PNL Index2	Nuisance Condition	Recreation	3	85	50

Table 3, below, shows how the same six metrics have changed over previous years.

Table 3 – LakeScan™ Metrics Results History

Year	Species Richness	BioD60 T2+	Morpho. Richness	MorphoD26	Veg. Quality Index	PNL Index2
2021	16	35	10	35	38	85
2020	15	25	10	38	43	3
2019	21	42	13	63	39	17
2018	8	12	7	16	36	3
2017	11	18	9	34	43	5
2016	11	19	8	23	44	83

Species present in the lake are shown in the Table 4. 'T Value' is a value ranging from 1 to 4 that is assigned to each species, where 1 represents a species highly likely to require treatment and 4 represents a species highly unlikely to require treatment. 'Morpho. Type' is the category of plant shape describing the species. 'Frequency' represents the percentage of survey sites (AROS) where a given species was found. 'Dominance' represents the degree to which a species is more numerous than its competitors. 'PNL' is a value that ranges from 0 to 3 that incorporates plant species and plant height in the water column with in-field observations of species location within the lake and in-lake structures.

Table 4 – Aquatic Plant Species Observed in 2021

Common Name	Latin Name	Morpho. Type	T Value	Frequency	Dominance	Coverage	PNL*
Eurasian Watermilfoil Hybrid	*Myriophyllum spicatum x sibiricum*	1	1	87.6%	32.3%	7.1%	1 or 3
Common Bladderwort	*Utricularia vulgaris L.*	3	3	13.0%	0.4%	0.1%	0 or 2
Naiad	*Najas sp.*	7	2	14.2%	0.3%	0.1%	0 or 2
Spiny Naiad	*Najas marina L.*	7	2	1.8%	0.3%	0.1%	1 or 3
Chara	*Chara sp.*	8	4	88.2%	19.3%	4.2%	0 or 2
Starry Stonewort	*Nitellopsis obtusa (Desv.) J.Groves*	8	1	89.9%	16.7%	3.7%	1 or 3
Flat Stem Pondweed	*Potamogeton zosteriformis Fern.*	10	3	0.6%	0.0%	0.0%	0 or 2
Hybrid Pondweed	*Potamogeton Hybrid*	13	2	73.4%	6.9%	1.5%	0 or 2
Sago Pondweed	*Stuckenia pectinatus*	16	2	4.7%	0.1%	0.0%	0 or 2
Thin Leaf Pondweed	*Potamogeton foliosus*	16	4	0.6%	0.0%	0.0%	0 or 2
Wild Celery	*Vallisneria americana Michaux*	17	2	13.6%	0.6%	0.1%	0 or 2
Waterlily	*Nymphaea sp.*	21	2	58.0%	19.4%	4.3%	0 or 2
Waterlily (hybrid)	*Nymphaea sp.*	21	2	10.7%	3.5%	0.8%	1 or 3
Spadderdock	*Nuphar sp.*	21	2	1.8%	0.1%	0.0%	0 or 2
Water Shield	*Brasenia schreberi J.F. Gmel.*	21	3	1.8%	0.0%	0.0%	0 or 2
Smartweed	*Polygonum sp.*	22	3	0.6%	0.0%	0.0%	0 or 2

**PNL can either be one number or the other for each species in each survey site (AROS) and this value depends on plant height in the water column and location within the waterbody*

Figure 8 below shows the distribution of aquatic plant coverage by T Value over different surveys. The Combined Annual (VS S) analysis represents a combination of the seasonal surveys, both the early-season survey (VS 3) and the late season survey (VS 5). T - 1 species are usually very weedy and create the greatest nuisance conditions and are therefore most likely to be targeted for suppression by a variety of means. T - 2 species are occasional nuisance species and may be targeted for control or suppression in some circumstances. T - 3 species are not targeted for control but occasionally require treatment for some growth management. T - 4 species are protected from impact from any management activity.

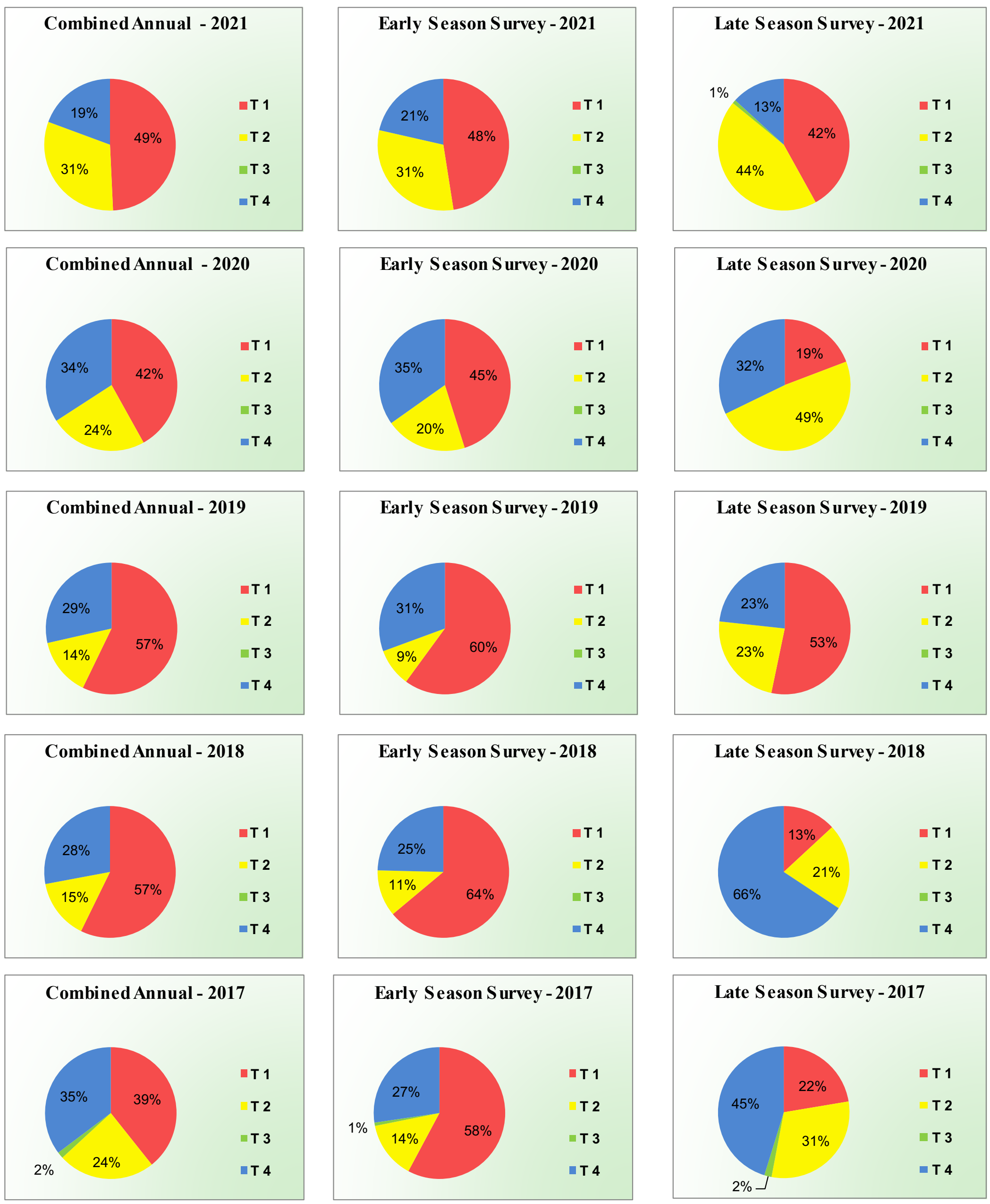


Figure 7 – Distribution of aquatic plant coverage by T Value comparing combined, early-season, and late-season surveys from 2017 – 2021.

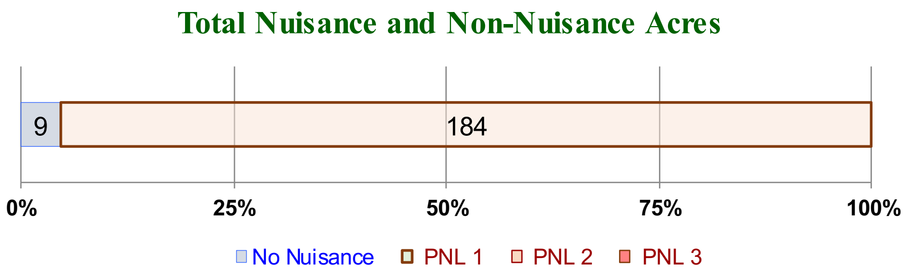
Category 750 – Lake Management

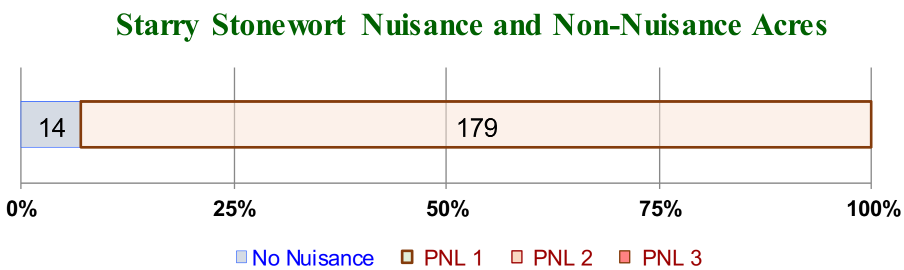
There are several species that typically become a nuisance in Michigan's inland lakes (See Appendix B). These species are usually targeted for very selective control to prevent them from becoming an aesthetic or recreational nuisance and to protect desirable plants that are part of lake floras. This section includes an analysis on nuisance conditions in the lake, as well as a description of any management actions that were taken. Information on the extent and locations of nuisance species are included in Figures 10 – 13.

Perceived nuisance level (PNL) is determined at each AROS during vegetation surveys and is summarized in Table 5 below. PNL is a value that ranges from 0 to 3 that incorporates plant species and plant height in the water column with in-field observations of species location within the lake and in-lake structures (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 is 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 PNL value that is found at each AROS during all seasonal LakeScan™ surveys is used for this analysis. The total number of AROS acres is summed for each of the 3 PNL levels and the "no nuisance" AROS (PNL 0). The first column is the percentage of the total AROS acres that are assigned each PNL value. The total and species-specific PNL summaries are presented in Figure 9 below.

Table 5 – AROS Perceived Nuisance Level Summary

% Total AROS Acres	PNL Level	Perceived Nuisance Level Description	Total AROS Acres
5%	PNL 0	No Nuisance	9
95%	PNL 1	Ecological Nuisance	183
0%	PNL 2	Equivocal Nuisance	0
0%	PNL 3	Obvious Nuisance	0





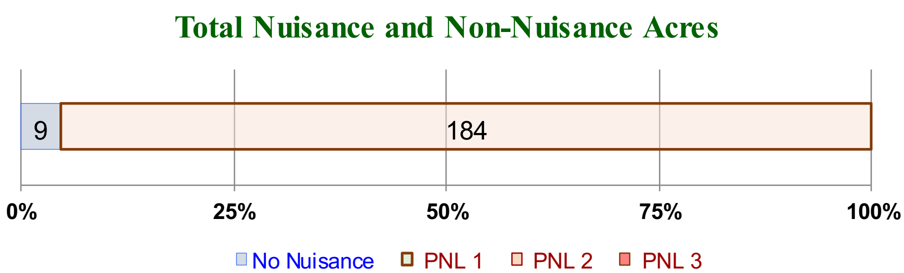


Figure 9 – Total and Species-specific Perceived Nuisance Levels

Mapped data on nuisance species are reported individually below in Figures 10-13 using coverage, a combination of density and distribution observations from the vegetation surveys.

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 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.

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. 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.

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 is not likely to be chosen by the Lower Straits management team in 2022.

Table 6 – Efforts expended in recent years to ameliorate the impact of invasive species on Lower Straits Lake.

YEAR	Total Tmtz	Target Plants and Algae	Total Treated AROS Acres
2016	2	Ebrid Watermilfoil and Curly Leaf Pondweed Algae and Starry Stonewort	27 83
2017	2	Ebrid Watermilfoil and Curly Leaf Pondweed Algae and Starry Stonewort	34 13
2018	2	Ebrid Watermilfoil and Curly Leaf Pondweed Algae and Starry Stonewort	28 93
2019	1	Ebrid Watermilfoil and Curly Leaf Pondweed Algae	72 2
2020	1	Ebrid Watermilfoil and Curly Leaf Pondweed Algae and Starry Stonewort	98 21
2021	1	Ebrid Watermilfoil and Curly Leaf Pondweed	85

Management 2022

The exotic invasive species, ebrid watermilfoil and curly leaf pondweed are expected to be present in Lower Straits Lake at extreme nuisance levels in 2022. 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. However, 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 2022. 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 2022. 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.

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 2022.

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.

Table 7 – Estimated cost of aquatic weed management in Lower Straits Lake, 2022.

Month	Treatment Tool	Target Plants and Algae or Purpose	Total AROS Acres	Cost USD ($)
MANAGEMENT INTERVENTIONS				
May	Harvesting	Ebrid Watermilfoil and Curly Leaf Pondweed	30	$15,000
June	Herbicides	Ebrid Watermilfoil and Curly Leaf Pondweed Algae and Starry Stonewort	85	$38,000
August	Herbicides	Ebrid Watermilfoil and Starry Stonewort	20	$7,000
MONITORING & MANAGEMENT GUIDANCE				
June/August	Monitoring Management Guidance	Lake Health and Use Support	retainer	$7,272
			TOTAL	$67,272

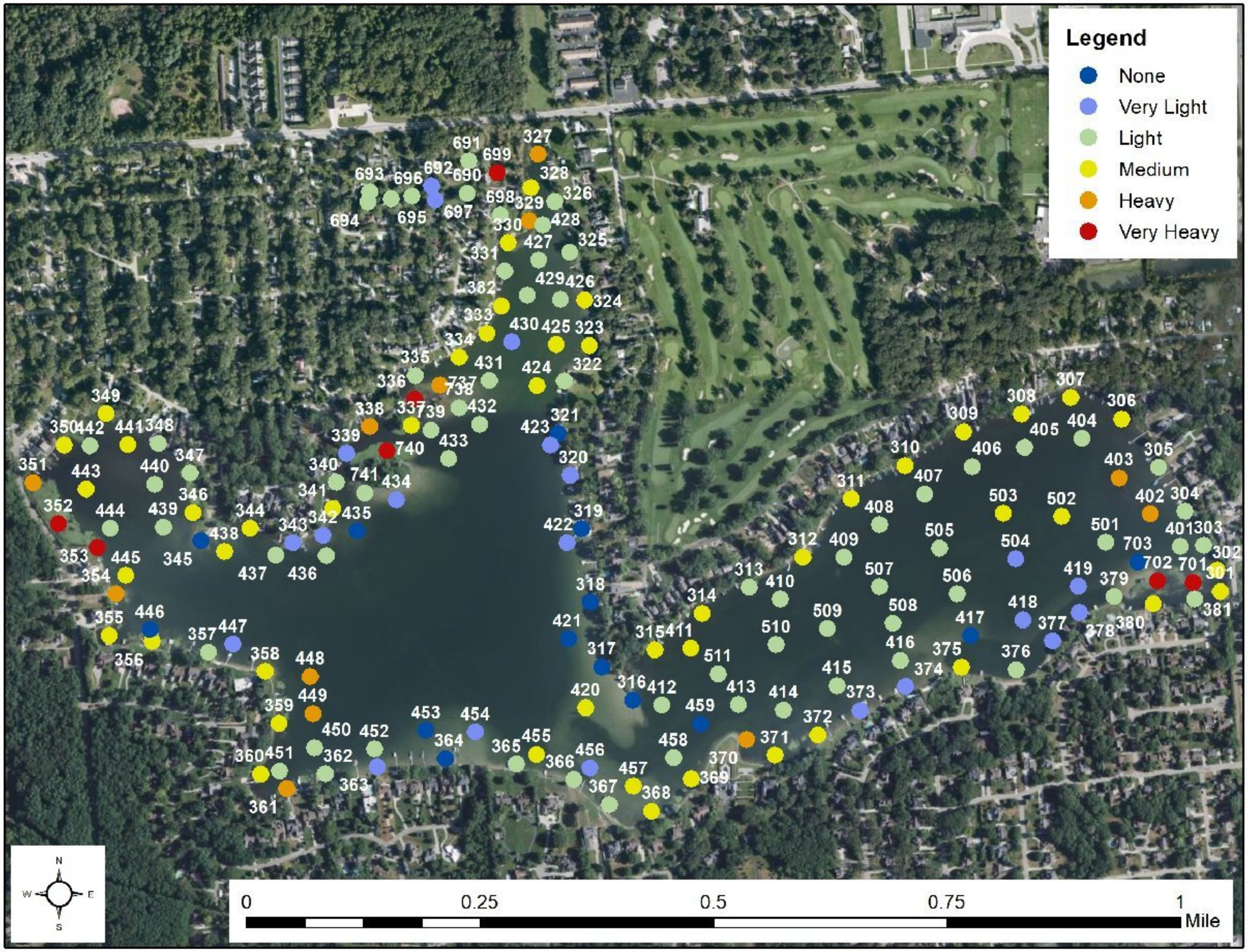


Figure 10 – Early-season (June 22, 2021) Eurasian Watermilfoil and Hybrids coverage (a combination of the LakeScan™ density and distribution observations)

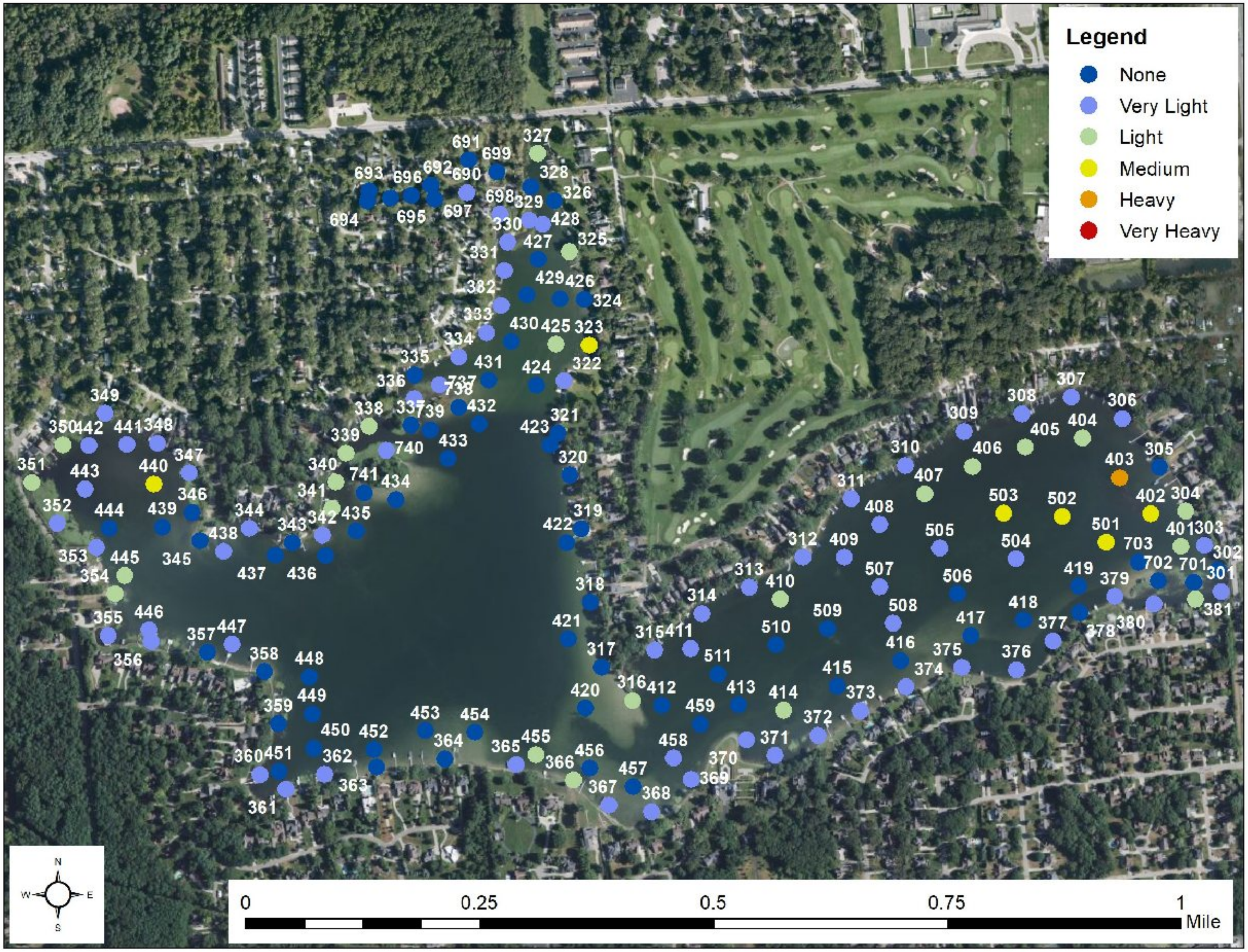


Figure 11 – Late-season (August 17, 2021) Eurasian Watermilfoil and Hybrids coverage

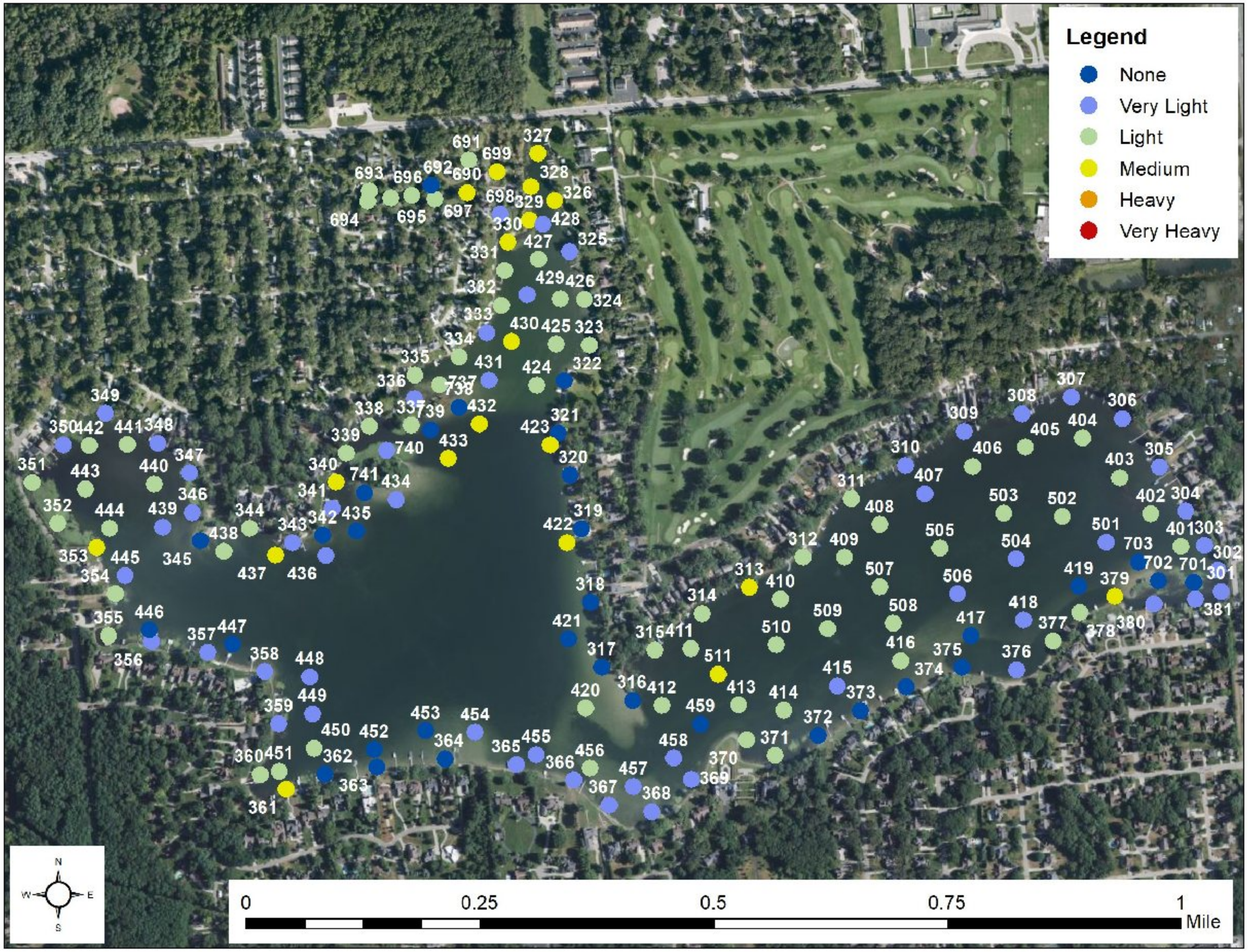


Figure 12 – Early-season (June 22, 2021) Starry Stonewort coverage

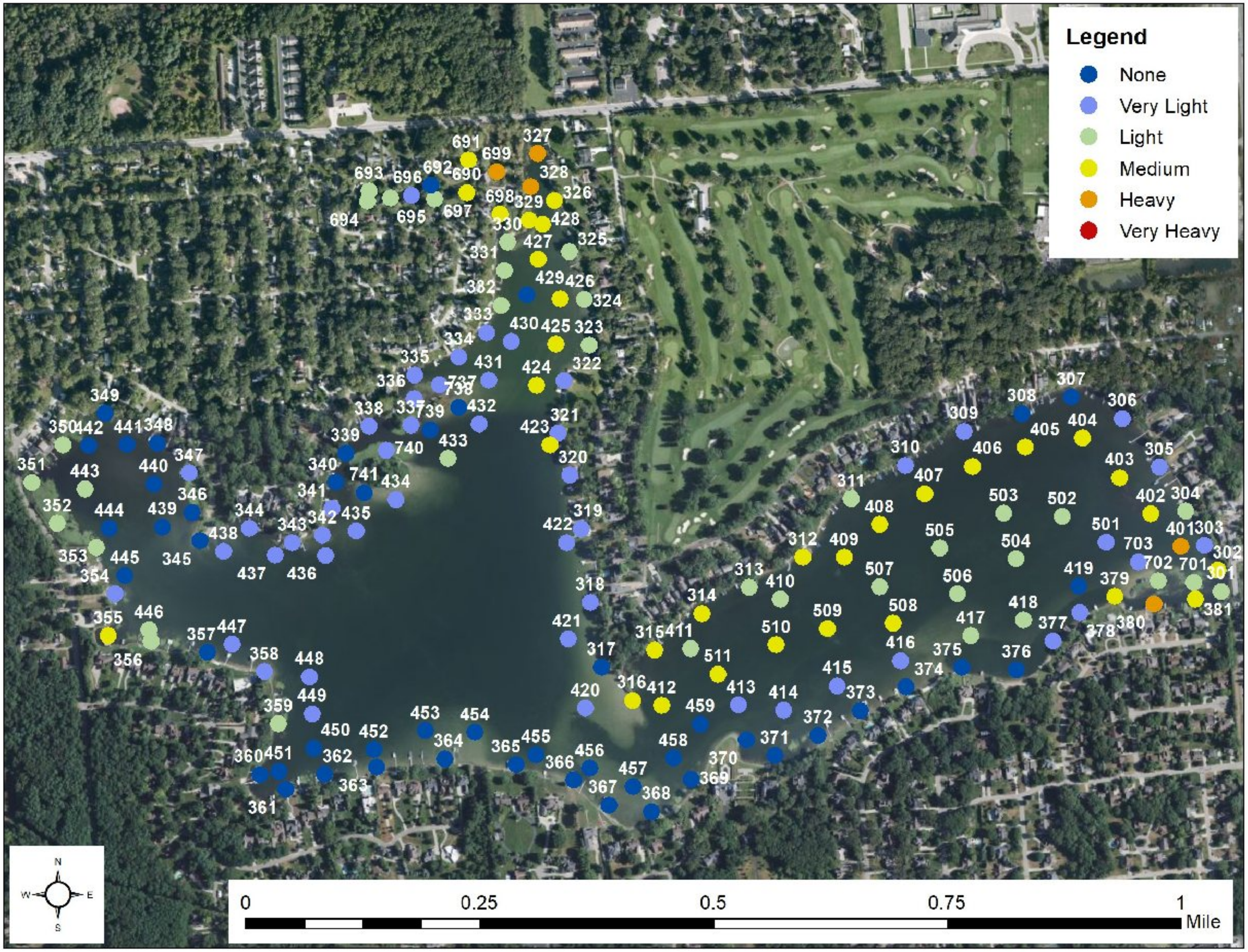


Figure 13 – Late-season (August 17, 2021) Starry Stonewort coverage

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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.

Appendix C. Herbicide Treatment Maps

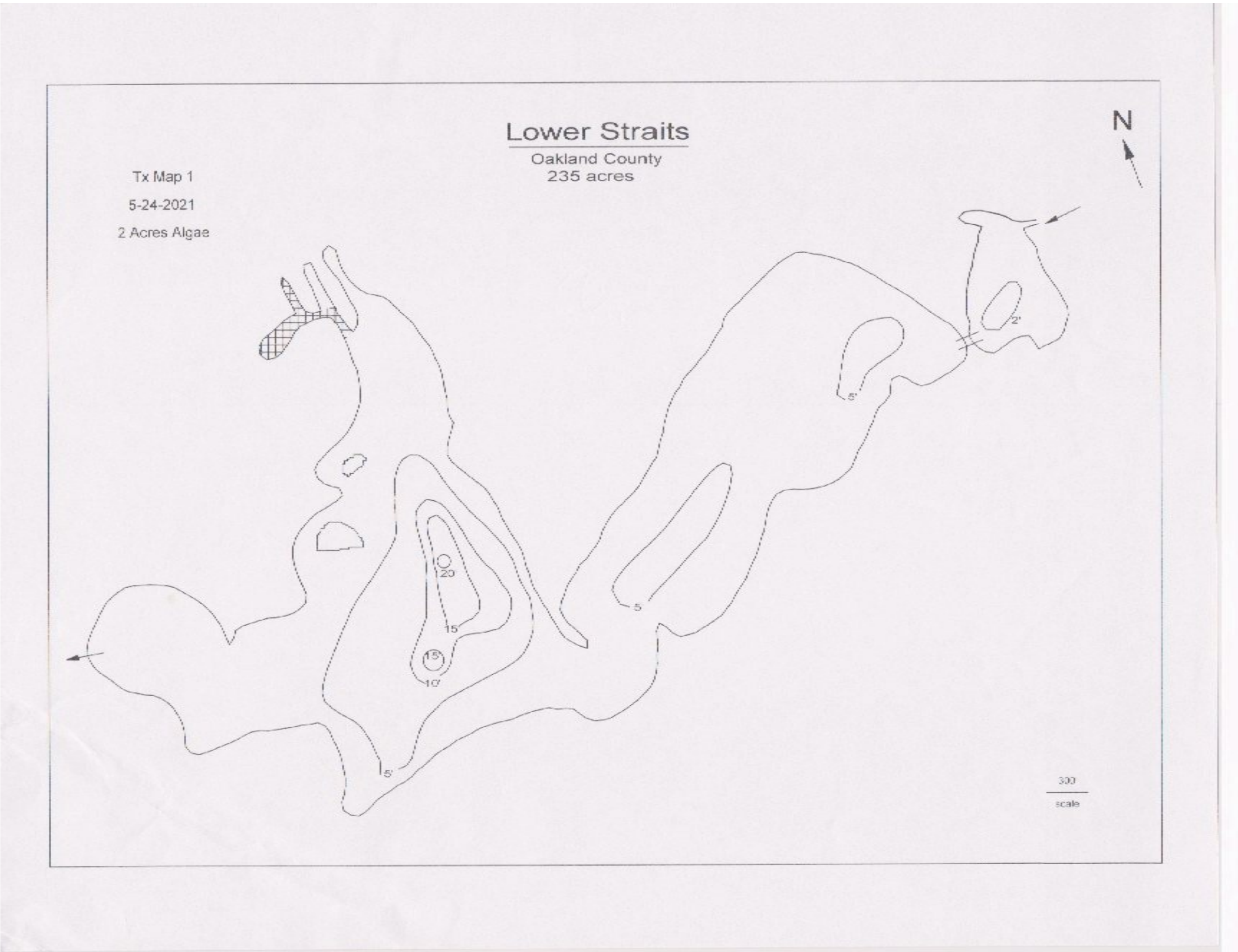

Figure C1: May 24, 2021 Herbicide Application Map

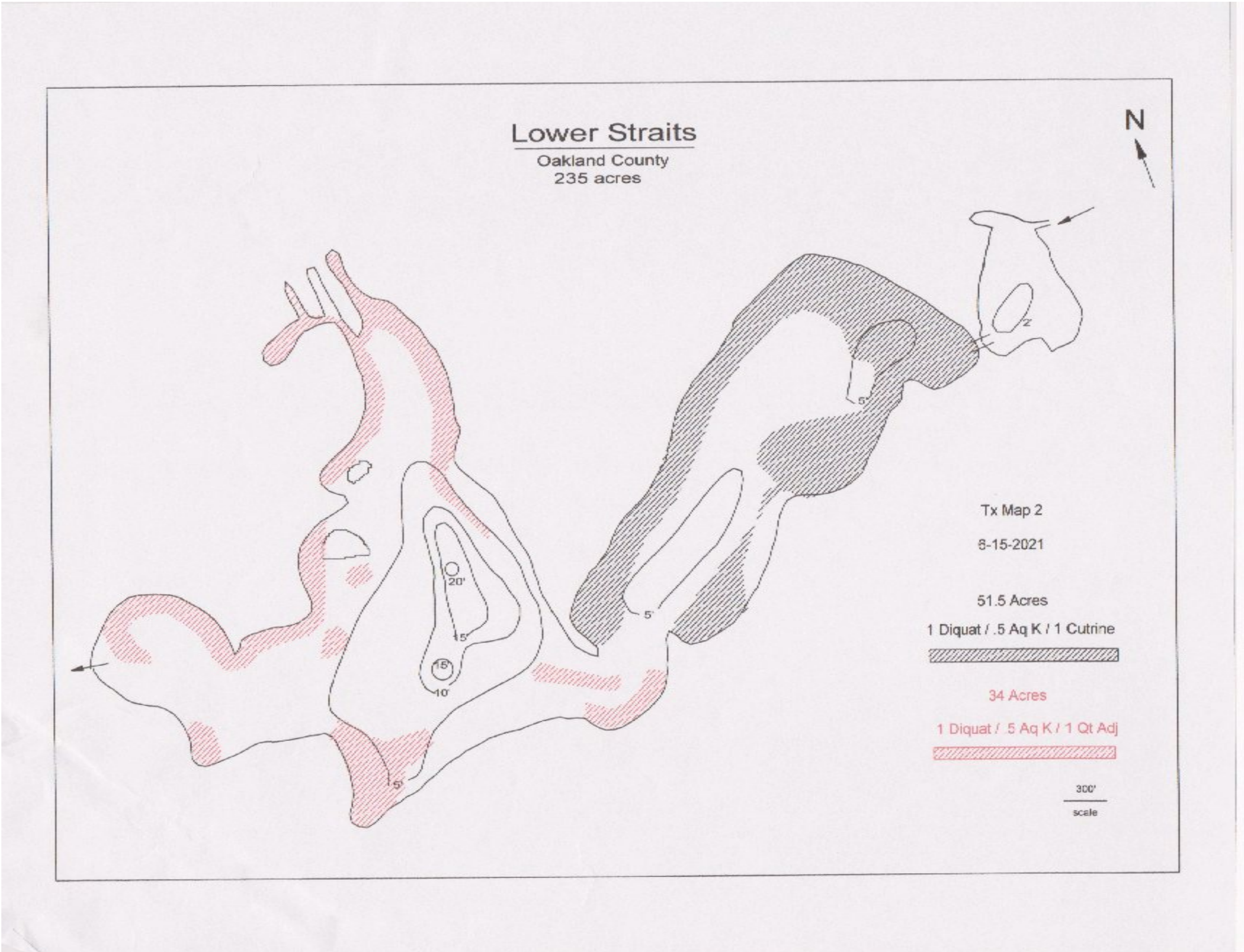

Figure C2: June 15, 2021 Herbicide Application Map

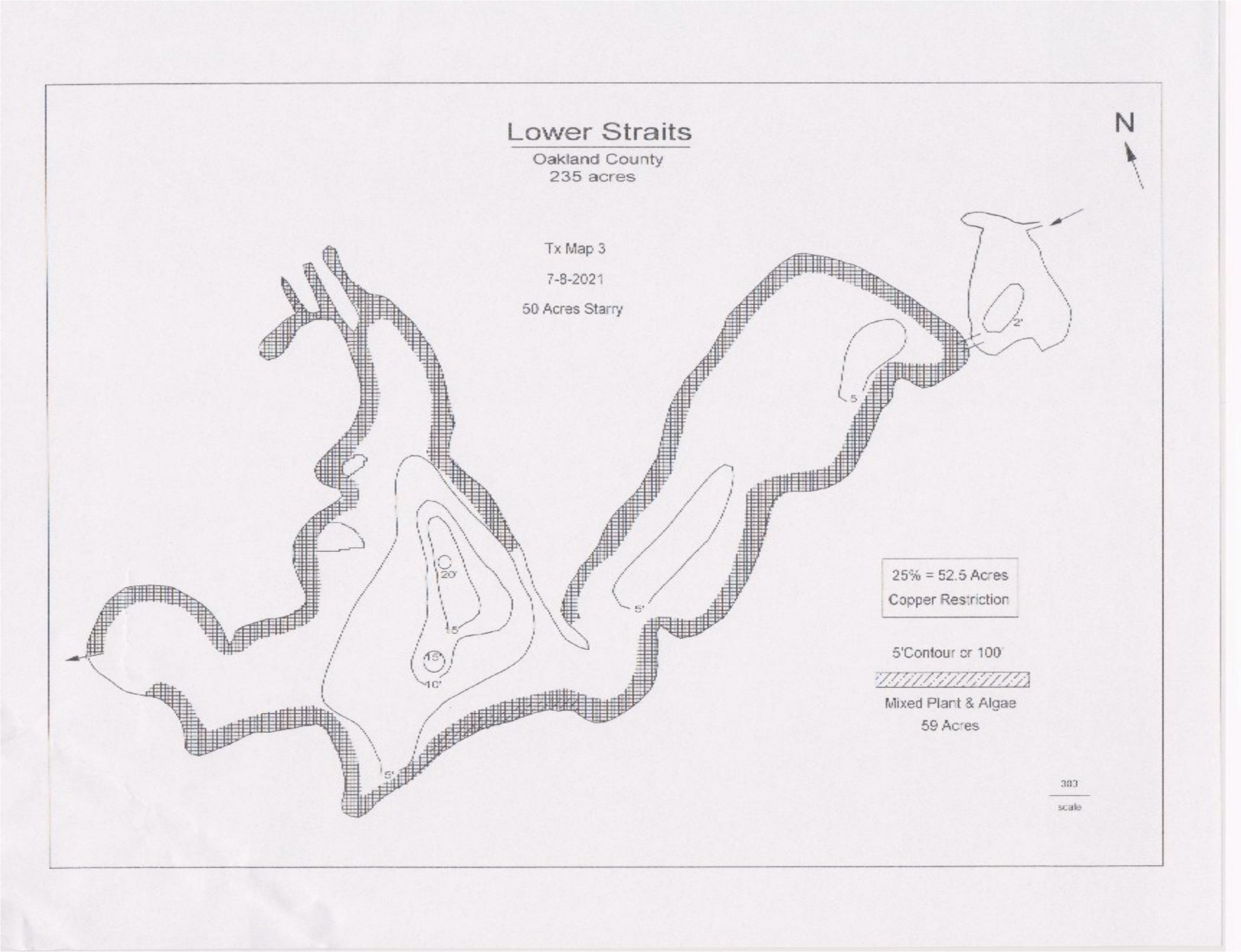

Figure C3: July 8, 2021 Herbicide Application Map

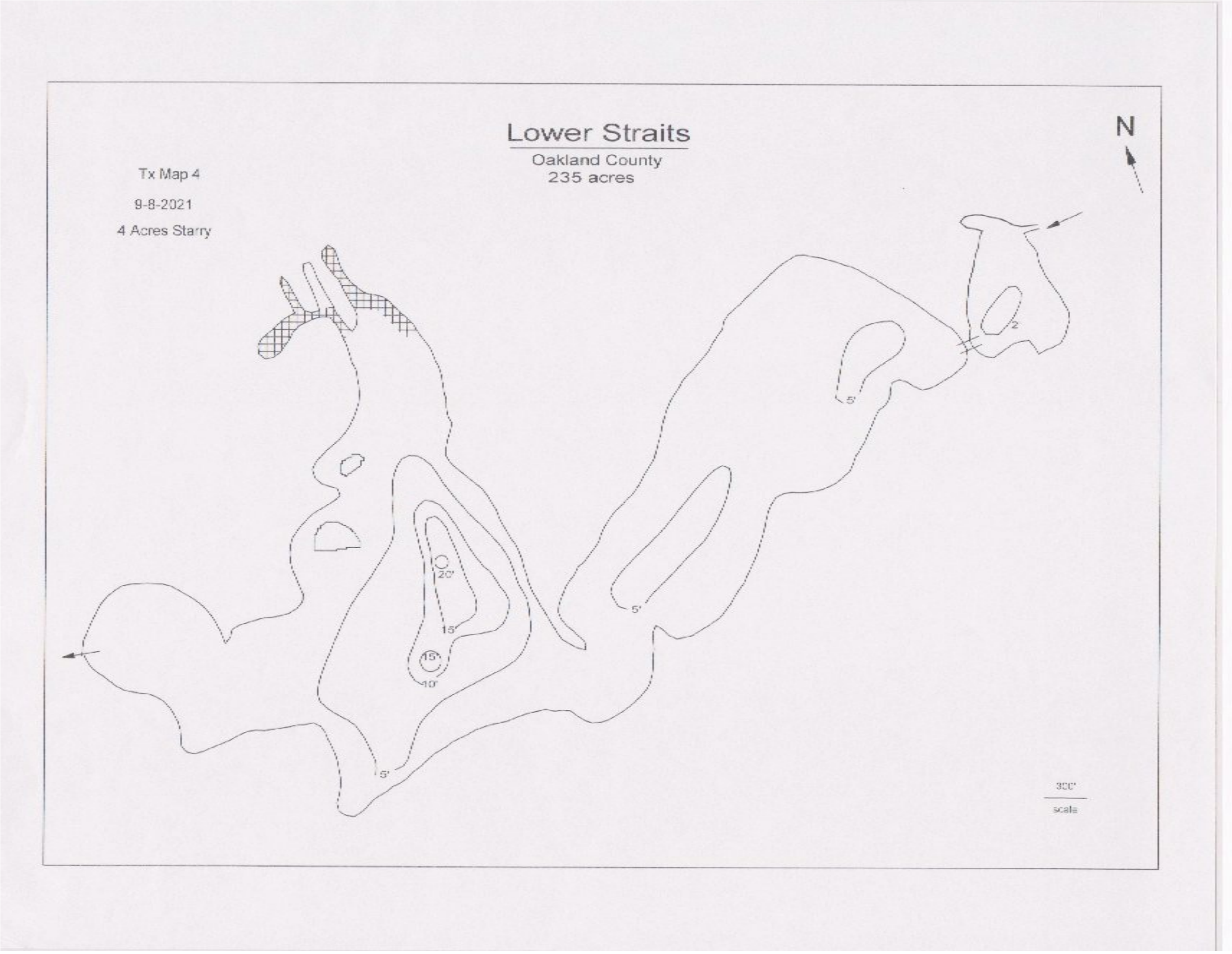

Figure C4: September 8, 2021 Herbicide Application Map

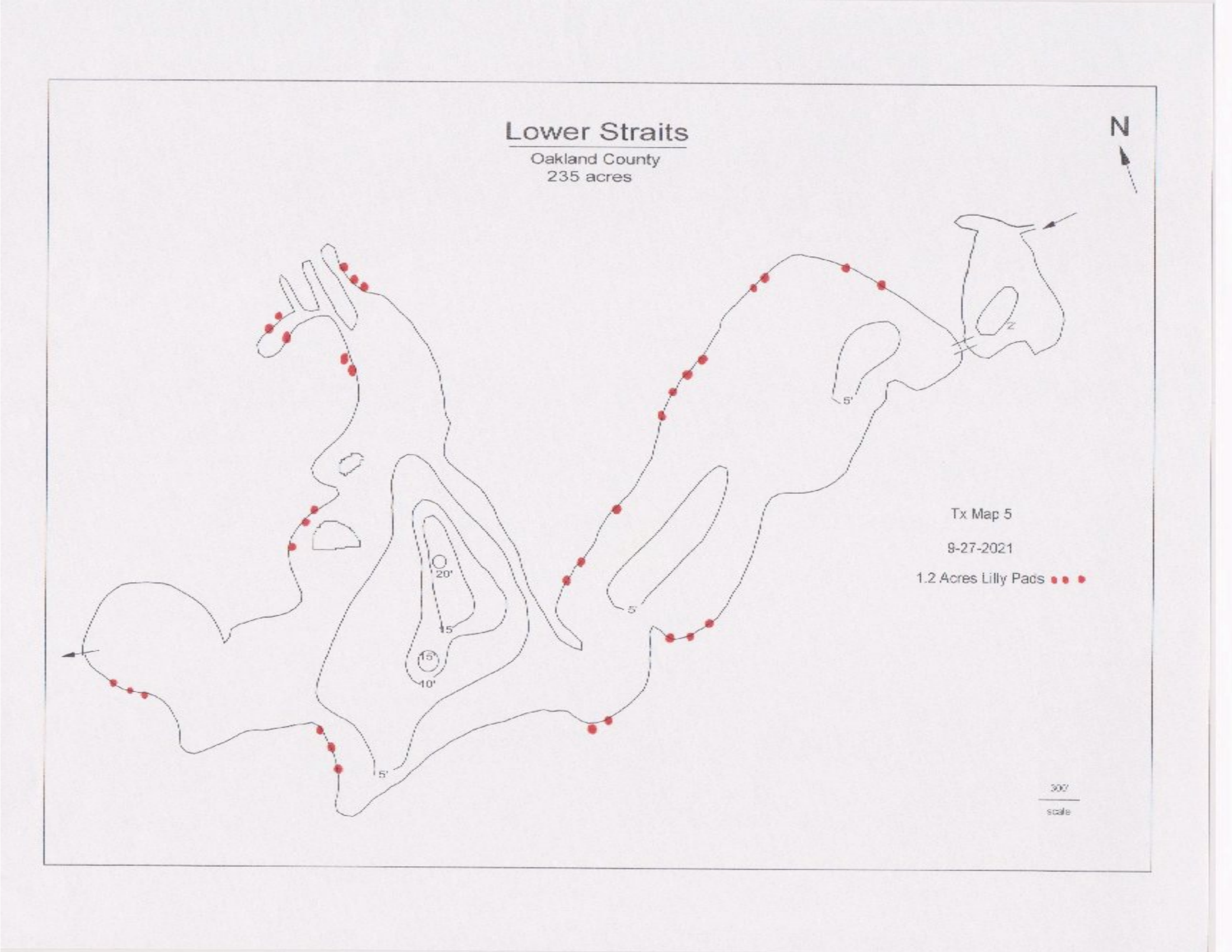

Figure C5: September 27, 2021 Herbicide Application Map