Aquest Corporation

A Summary of Findings from a LakeScan™
Survey and Analysis of:

Upper Straits Lake

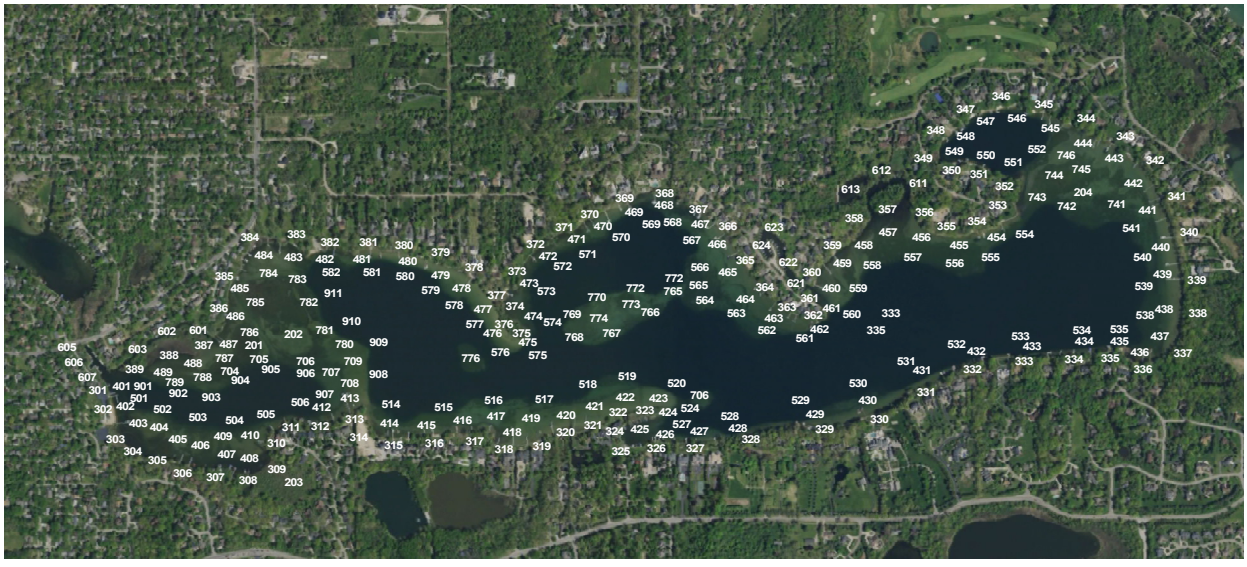
Oakland County, MI

PART 2: DATA AND ANALYSIS EXECUTIVE SUMMARY

Submitted by:

Dr. G. Douglas Pullman

Aquest Corporation



LakeScan™

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 valuable resources. LakeScan™ is a comprehensive system of analysis that is necessary to properly consider conditions in a lake and make reasonable, scientific and empirically based recommendations for management and improvement of aquatic ecosystems. Persons who are already familiar with the LakeScan™ method may wish to skip to Part 2 since the methods and approach sections are primarily "boilerplate". This report is only the "tip of the iceberg". All recommendations are based on the comprehensive record of data that are included in the Upper Straits Lake, LakeScan™ annual review document. That report is available under separate cover.

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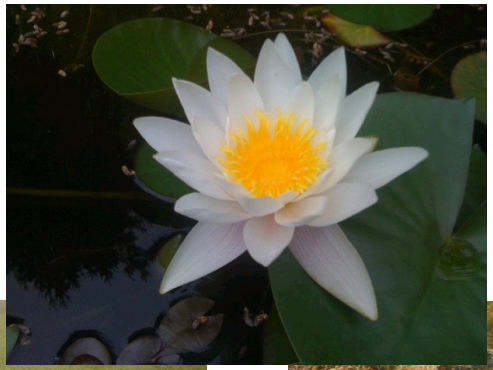
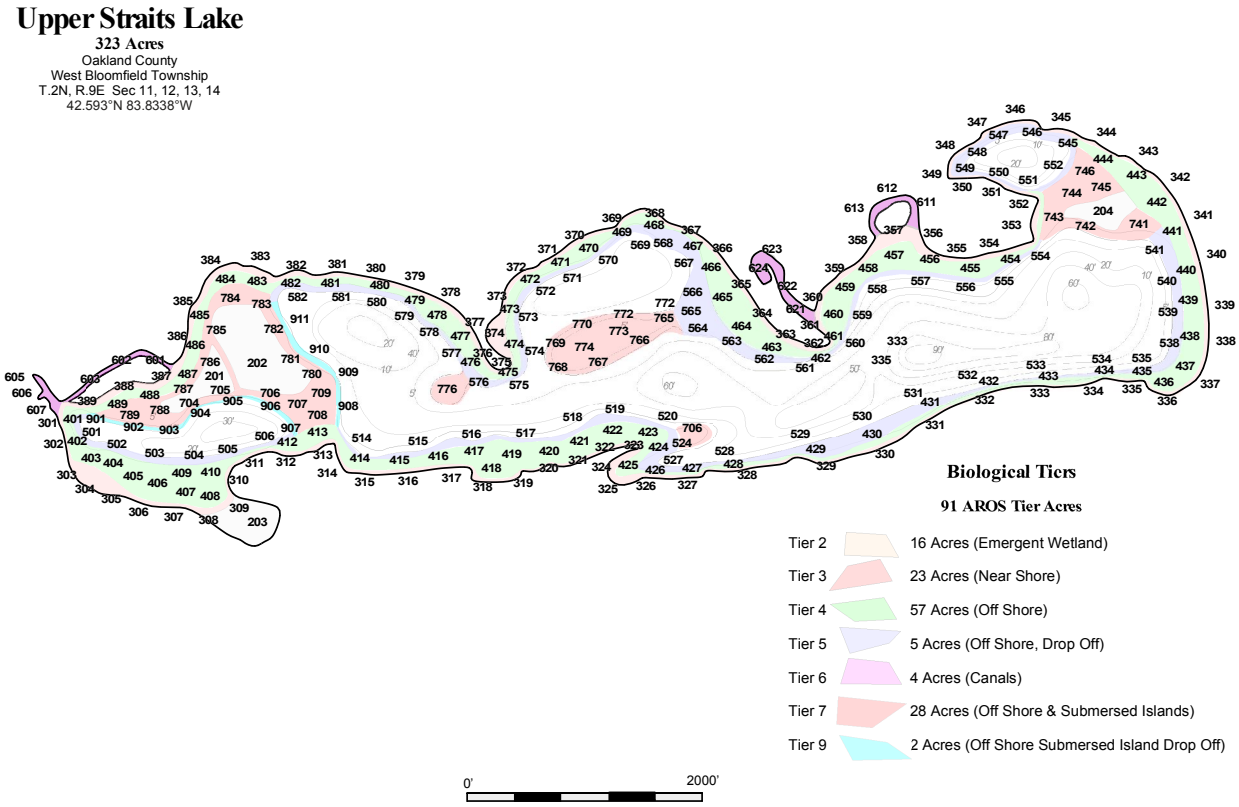




Upper Straits Lake LakeScan™ AROS (Aquatic Resource Observation Site) map. Observation data is collected from each AROS. The colored areas represent distinct biological tiers where distinct biological communities are found.

Category 700: LakeScan™ Analysis Highlights – the 2017 Plant Community.

Background: LakeScan™ is a comprehensive lake analysis system that is designed to consider all of the physical, chemical, and biological systems that contribute to lake condition. These various systems function in a similar way that the vascular, skeletal, nervous, and digestive systems in organisms or humans. Water quality is often the focus of lake assessments; however, such an assessment Upper Straits Lake is not relevant since the submersed plant is the dominant sub-system. Category 700 is far more relevant because it is aimed at plant and weed communities. Upper Straits Lake is currently one of nearly three dozen Michigan inland lakes where LakeScan™ is used to monitor aquatic plant community conditions (Category 700) and evaluate the results of the aquatic vegetation management program.

The LakeScan™ method uses nine different measures of the plant community to determine the condition of this critical part of the lake ecosystem. These measures or metrics were applied to the whole lake and to individual or distinct areas of the lake including biological tiers, management zones, or treatment zones (where applicable). These data were also used to consider groupings of plant species that differ in quality, invasiveness, and impact on ecosystem stability. For example; plant community biodiversity is calculated “with weed species” and “without weed species”. These data were also used to compare conditions that were surveyed at different times of the year – early and late summer and all of these data can also be compared in year-to-year or lake-to-lake analysis. This analysis is used to formulate the most

appropriate management plan for the submersed plant community and to make certain that any management interventions result in improvements and ensure no further degradation of the lake ecosystem. These data are also necessary to satisfy some of the regulatory conditions imposed by States and Federal agencies. A typical LakeScan™ report is over 100 pages, but is presented in an easy to understand, graphical format. Readers are encouraged to read the entire annual LakeScan™ report for this and other lakes. However, some readers are interested in a summary version of the report and this executive summary has been developed for those readers and stakeholders. It provides only a glimpse of the comprehensive the analysis that is used to evaluate the Upper Straits Lake plant community and inform management decisions but does present many key findings.

Category 700 LakeScan™ analysis include target values for each metric to provide an estimate of scale and specific direction to any management objectives based on the LakeScan™ analysis. Target metric values are determined and derived from observations and analysis made from a very wide range of lakes that differ in size, shape, shoreline development, and chemistry. Some of these lakes are virtually filled with plants because of basin morphometry and sediment fertility and structure. These lakes can support very high metric values and support a stabile ecosystem if they are properly managed. Other lakes support very little rooted plant and bottom dwelling vegetation and metric values tend to trend lower. These considerations are used to establish realistic target metric values for Upper Straits Lake.

Plant production in Upper Straits Lake is relatively low when compared to most other Michigan inland lakes. Sediment fertility and organic content is moderate and would seem to be capable of supporting abundant aquatic plant growth. However, some of the extensive shallow, nearshore areas and very shallow off-shore submersed islands do not support diverse and dense plant communities and this seems to be a result of high energy input from wind and waves. The lake has met or exceeded nearly all LakeScan™ plant community metric targets in 2017 and previous years. Closer inspection of the LakeScan™ plant community metric values suggest that conditions remain fairly stable and the year-to-year data suggest a considerable degree of ecosystem stability.

The common and notoriously invasive, exotic species that are found in most Michigan inland lakes have also become established in Upper Straits Lake. Ebrid watermilfoil is one of these species but nuisance production varies widely from year to year. Starry stonewort is another significant weed in Michigan inland lakes, but it has not produced the amount of biomass or nuisance conditions in Upper Straits Lake that have been observed in most other lake. Flowering rush is another exotic weed species and is listed as an invasive aquatic plant in the State of Michigan. However, it prominent, but not generally considered to be a nuisance in Upper Straits Lake. Hybrid weedy pondweeds could emerge as dominant weeds and are being closely monitored.

Ebrid watermilfoil dominance increased in 2017 in Upper Straits Lake as it did in most other Michigan inland lakes as an apparent response to unusually warm winter of 2017. AROS data suggest that ebrid milfoil is found in different places at different times of the year. In some cases this may be attributed to the management effort expended on the lake but it also seems to be a natural phenomenon that is also observed in parts of the lake where not management interventions have been implemented.

Starry stonewort has been conspicuously present in Upper Straits Lake since LakeScan™ monitoring began in 2012. Starry stonewort is capable of producing high biovolume levels during the course of the growing season. It is also known to bloom and crash, as do several other aquatic weed species. When it crashes, high levels of biomass can produce elevated concentrations of decomposition byproducts that are very toxic to other plants species. Dominance levels have been variable and were highest in 2012 when monitoring was begun. The 2017 starry stonewort dominance level was higher than the 6-year average but was still low

relative to other lakes. It was also recorded as a nuisance in the Tier 6 AROS and was assigned a perceived nuisance index value of 12 on a 100-point scale in 2017.

Year-to-year trends for LakeScan™ metric values varied only slightly in the lake since monitoring began. It is important to note that unusual weather conditions were observed in the winter of 2017 and most LakeScan™ metrics declined in most lakes in Michigan as a consequence of "unusual weather". Metric values were actually higher in 2017 in Upper Straits Lake. Unfortunately, perceived nuisance conditions were higher in 2017 than the previous year. Close monitoring is necessary to evaluate impacts of weather and invasive species on ecosystem stability (lake health) and will help to make best management decisions. This will also help to make better predictions regarding the nuisance potentials of species found in the lake.

The quality of plant species community found in Upper Straits Lake was fair in 2017 and this index value may have declined because of the greater dominance of ebrid watermilfoil. The relative dominance of Target 1 species (T1) was greater than 20% during some surveys conducted during the past five years. These high levels of undesirable species exceeded levels observed other LakeScan™ lakes.

A Graphic Review of Selected LakeScan™ Metrics Used to Evaluate Lake Conditions in Upper Straits Lake

2017 LakeScan™ Metric Targets and Trends

Table ESP2-1.0 Selected LakeScan™ metric values and target values, 2017. Metric target values are based on values collected from a wide range of Michigan inland lakes and may not be totally appropriate for lakes like Upper Straits Lake. However, as the LakeScan™ database continues to grow, it may be possible to establish more realistic target values based on lake groupings. Pink backgrounds are used to highlight metric target values that have not been met or exceeded target values and highlight trends in annual data that are not positive. Blue backgrounds are used to highlight metric values that have exceeded expectations and highlight metric values that trend positively from year to year. Pink is "not good" and blue "is good".

LakeScan™ Metrics and Targets

	Upper Straits Lake		
	2017 Values	Target Values	Trend Analysis
Species Richness	19	16	+
Morphotype	13	12	+
Mean Weighted C	3.8	5	-
Whole Lake BioD	51	40	+
Whole Lake BioD T2+	27	25	+
MorphoD	72	70	+
BioVol	206	206	+
Weediness	3.8	5.0	-
Mean Perceived Nuisance	20	50	-

2017 and Historical LakeScan™ Metric Data

Table ESP2-2.1 Upper Straits Lake LakeScan™ data for the current year and historical comparisons. Historical values are averaged over all of the years of LakeScan™ monitoring. Target values are selected subjectively and may change as the LakeScan™ database expands and different kinds of lakes can be grouped into meaningful assemblages. Metric values where the header is blue, and the footer is pink depict metrics where greater values are better. Lower values are better for the last two metrics, Weediness and PNL Index where the header is pink, and the footer is blue. Blue highlighted trend values are considered good but red highlighted values are bad.

LakeScan Metric Targets, Historical Averages, and Trends

Total Years = 6

	Species Richness	Morpho-types	Weighted Mean C	Whole Lake BioD	Whole Lake BioD T2+	MorphoD	Lake Biovol ft3/acre ft	Weediness	PNL Index
Upper Straits Lake 2017	19	13	3.8	51	27	72	206	3.8	20
Target Values	16	12	5.0	40	25	70	206	5.0	50
Historical Average	18	12	4.9	46	23	65	147	4.9	11
6 Year Trend Analysis	+	+	+	+	+	+	+	+	+
Historical Metric Range	16 to 19	10 to 14	3.8 to 5.3	36 to 51	18 to 27	56 to 72	122 to 206	3.8 to 5.3	2 to 20

Table ESP2-2.2 Historical perspectives on selected LakeScan™ metric data collected during the previous years. Mean metric values represent a sum of all relevant data or a mean value derived from observations collected at several vegetation community surveys that were conducted throughout each summer/growing season. Metric values where the header is blue, and the footer is pink depict metrics where greater values are better. Lower values are better for the last two metrics, Weediness and PNL Index where the header is pink, and the footer is blue.

Annual LakeScan™ Metric Data Comparisons

	Species Richness	Morpho-types	Weighted Mean C	Whole Lake BioD	BioD T2+	MorphoD	Lake Biovol ft3/acre ft	Weediness	PNL Index
2013	18	14	4.6	46	24	72	123	4.6	
2014	17	12	5.2	46	21	65	126	5.2	
2015	17	11	5.2	47	22	63	135	5.2	
2016	19	12	5.3	49	27	62	122	5.3	2
2017	19	13	3.8	51	27	72	206	3.8	20

Figure ESP2-1.1 Species richness is the total number of species that are present during a LakeScan™ survey. Each of the species are assigned different target values, T-1, T-2, T-3, T-4. These target values are related to the probability that that species would be targeted for control or management in the lake. T-1 species are usually very weedy and create

the greatest nuisance conditions and are therefore most likely to be targeted for control by a variety of means. T-2 species are occasional nuisance species and may be targeted for control in some circumstances. T-3 species are not targeted for control but may sustain some collateral damage if near other species that are targeted for control of suppression. T-4 species are protected from impact from any management activity.

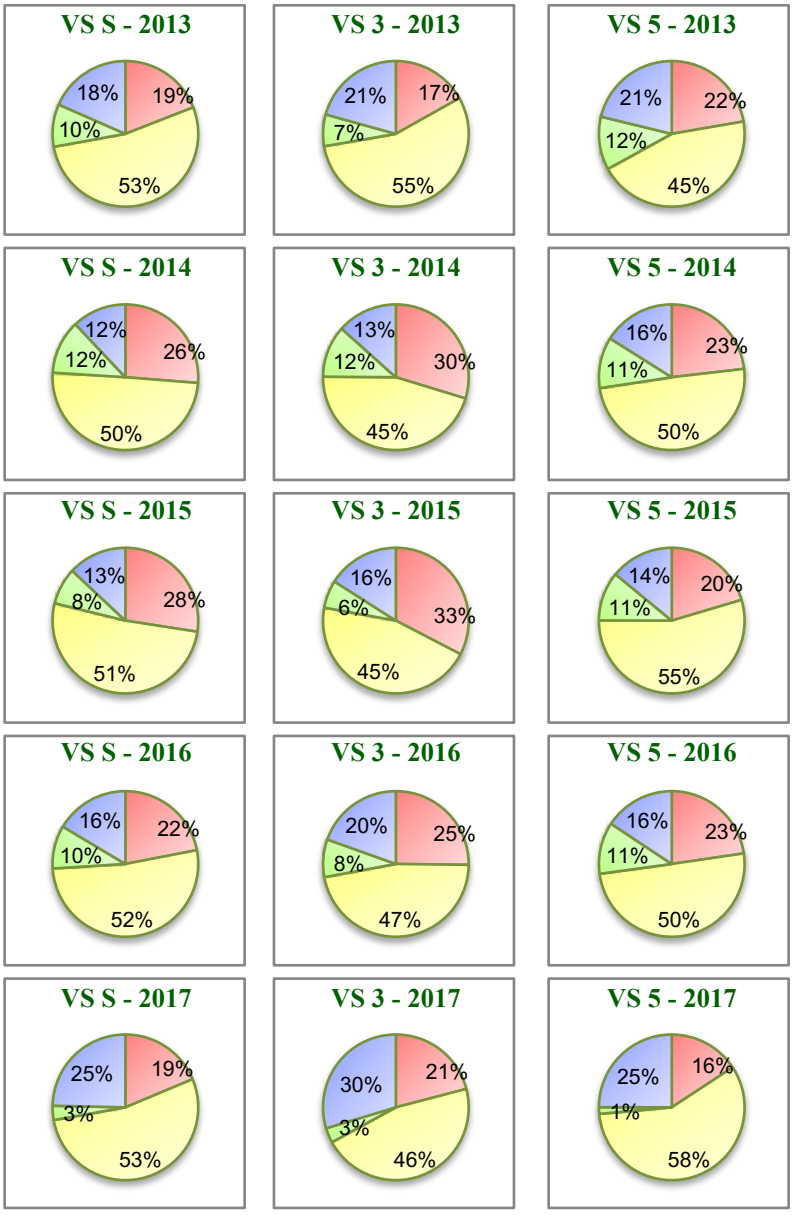


Table ESP2-2.3 A listing of submersed aquatic plants found in Upper Straits Lake in 2017 and various LakeScan™ species qualifiers. The "T" value refers to species that may be targeted for management or suppression. 1 = highly likely and 4 = highly unlikely.

Species highlighted in red are common weed species and are commonly targeted for control. The "i" value or invasive potential scale ranges from 1 to 10 where 1 is highly invasive and 10 is not invasive. The "C" value is an index of conservation that ranges from 1 to 10. Species assigned lower C values are more tolerant of ecological disturbance. Typically, species characterized by low C values are considered to be weedy and undesirable.

2017 PLANT NAME, CODES, AND SELECTED ATTRIBUTES

	CODE #	REFERENCE NAME	TOTAL PHENO-TYPES	COMMON NAME	SCIENTIFIC NAME	T VALUE	i VALUE	c VALUE	MORPH #	LEAF AND STRUCTURAL MORPHOTYPE DESCRIPTION
1	2	EWMx	MANY	Eurasian Watermilfoil & Hybrids	*Myriophyllum spicatum x M. sibiricum*	1	8	3	3	*feathery*
2	33	CNTL	2	Coontail	*Ceratophyllum sp.*	2	7	3	3	*bushy*
3	42	ELD	2	Elodea	*Elodea sp.*	2	6	3	3	*bushy*
4	50	NAID	3	Naiad	*Najas sp.*	2	7	4	4	*bushy*
5	60	CHARA	MANY	Chara	*Chara sp.*	4	3	6	6	*bushy*
6	63	NitT	1	Tufted Nitella	*Tollypella sp.*	4	3	6	6	*bushy*
7	65	StSt	1	Starry Stonewort	*Nitellopsis obtusa (Desv.) J.Groves*	1	9	3	3	*bushy*
8	75	CLP	1	Curly Leaf Pondweed	*Potamogeton crispus L.*	1	9	2	2	*narrow leafy*
9	76	FSP	1	Flat Stem Pondweed	*Potamogeton zosteriformis Fern.*	2	5	6	6	*narrow leafy*
10	90	Rich	1	Richardsons Pondweed	*Potamogeton richardsonii (Benn.) Tydb.*	2	5	5	5	*small leafy*
11	93	AMER	1	American Pondweed	*Potamogeton nodosus Poiret*	3	5	7	7	*broad leafy*
12	109	HPW	MANY	Hybrid Pondweed	*Potamogeton Hybrid*	2	5	5	5	*broad leafy*
13	115	Stuk	3	Sago Pondweed	*Stuckenia sp.*	2	6	3	3	*stringy*
14	117	TLP	7	Thin Leaf Pondweed	*Potamogeton sp.*	4	5	5	5	*stringy*
15	120	ZAN	1	Horned Pondweed	*Zannichellia palustris L.*	3	5	7	7	*stringy*
16	125	VAL	1	Wild Celery	*Vallisneria americana Michaux*	2	7	3	3	*grassy*
17	130	FR	1	Flowering Rush	*Butomus umbellatus L.*	4	2	4	4	*grassy*
18	150	WL	2	Waterlily	*Nymphaea sp.*	2	5	6	6	*floating leaf*
19	153	SPAD	3	Spadderdock	*Nuphar sp.*	2	5	6	6	*floating leaf*

Table ESP2-2.3 A listing of submersed aquatic plants found in Upper Straits Lake in 2017 and historical context. Several LakeScan™ metrics are included in this table for each

species. The species are arranged in each of the metric categories according to the highest to lowest respective values. Only a few species are designated each year as perceived nuisances, so the species listed in that category are usually far fewer than the total found in the lake.

2017 PLANT SPECIES SELECTED METRICS AND BY RANK

	REFERENCE NAME	COMMON NAME	PRESENT IN 2017 √	TOTAL YEARS PRESENT IN LAKE #	SPECIES OCCURRENCE RANKING SPECIES	PERCENT	SPECIES DOMINANCE RANKING SPECIES	VALUE	RELATIVE BIOVOLUME RANKING SPECIES	VALUE	SPECIES PERCEIVED NUISANCE LEVEL FACTOR RANKING SPECIES	VALUE
1	EWMx	Eurasian Watermilfoil & Hybrids	√	6	CHARA	83%	CHARA	48	StSt	38	EWMx	65
2	CNTL	Coontail	√	1	HPW	76%	HPW	36	ELD	34	StSt	12
3	ELD	Elodea	√	1	EWMx	65%	EWMx	35	ZAN	31	VAL	2
4	NAID	Naiad	√	4	VAL	63%	VAL	33	AMER	25	ZAN	2
5	CHARA	Chara	√	1	Stuk	43%	WL	32	TLP	20	CLP	2
6	NitT	Tufted Nitella	√	6	WL	37%	Stuk	22	NAID	17		
7	StSt	Starry Stonewort	√	4	FR	28%	FR	21	EWMx	17		
8	CLP	Curly Leaf Pondweed	√	5	NAID	13%	NAID	13	CNTL	16		
9	FSP	Flat Stem Pondweed	√	6	CLP	12%	StSt	13	CHARA	14		
10	Rich	Richardsons Pondweed	√	1	SPAD	11%	SPAD	13	CLP	12		
11	AMER	American Pondweed	√	1	StSt	10%	CLP	12	WL	11		
12	HPW	Hybrid Pondweed	√	6	Rich	9%	Rich	7	SPAD	11		
13	Stuk	Sago Pondweed	√	6	TLP	4%	ELD	7	HPW	8		
14	TLP	Thin Leaf Pondweed	√	6	ELD	4%	TLP	6	FR	8		
15	ZAN	Horned Pondweed	√	2	CNTL	3%	AMER	6	VAL	6		
16	VAL	Wild Celery	√	2	AMER	2%	CNTL	5	Stuk	6		
17	FR	Flowering Rush	√	1	ZAN	2%	ZAN	4	Rich	4		
18	WL	Waterlily	√	6	NitT	2%	NitT	3	NitT	3		
19	SPAD	Spadderdock	√	5	FSP	0%	FSP	2	FSP	2		

ANTICIPATED ISSUES	ANSWERS

OVERALL LAKE CONDITION *Most Category 700, LakeScan™ aquatic plant community metric values exceeded expectations and target values in 2017. The ecosystem appears to be stable, but it remains threatened by the presence of several notorious weedy species.*	*Plant community conditions in Upper Straits Lake are remarkably stable. The lake has supported ebrid milfoil and starry stonewort for years and these plants have created nuisance conditions in some parts of the lake but not others. Monitoring is required to provide evidence that management interventions are necessary to protect the lake from threat posed by several individual species.*
Ebrid watermilfoil *is a perennial, if not predictable nuisance in Upper Straits Lake. It is typically present as an extreme nuisance in some areas of the lake; however, in others it appears co-mingled with native plant species and does not appear to create nuisance conditions. It is believed that it will return as a significant nuisance to several areas of the lake in 2018.*	*Careful monitoring is required to determine the relative dominance of ebrid milfoil, particularly in context of the emergence of less weedy genotypes. Invasive species growth is inherently unpredictable and annual management objectives must be based on the conditions that are presented in the early summer of each year. Ebrid milfoil is expected to become the dominant nuisance in 2018, although nuisance conditions are not expected in all areas of the lake.*
Starry stonewort *is an alga that looks like a higher plant. It is more aggressive than any other aquatic plant in Michigan and can outcompete all the species currently found in Upper Straits Lake. It has become a very significant nuisance in Tier 6 AROS and has required considerable management attention in past years. Since it continues to plague these areas year after year, it is expected to be present as a nuisance in these same areas in 2018. Starry stonewort can also grow inconspicuously, intermingled with other native charoid algae.*	*Careful monitoring and management are required to prevent the loss of plant community biodiversity and degradation of recreation values in systems that have become infested with starry stonewort. The rapid and unpredictable growth of this plant cannot be understated, and careful monitoring is necessary. It is possible that starry stonewort is far more ubiquitous than is obvious and monitoring will continue to assess the maximum area covered by relatively inconspicuous patches of this plant. Nuisance conditions can form rapidly and careful monitoring is required to anticipate worse case scenarios.*
Flowering Rush *is another exotic and potentially invasive species that is found in Upper Straits Lake. It seems to be particularly obvious in thin "strips" that inhabit the drop off areas (Tier 5) along the southern shore of the east end of the lake. It is not generally considered to be a nuisance and does not seem to exhibit any indication that it will spread more widely throughout the lake.*	*Flowering rush is a significant nuisance in Minnesota and some isolated water resources in Michigan. It is not growing at the expected nuisance levels in Upper Straits Lake, but careful monitoring is required to anticipate any increase in nuisance level production.*
Native pondweed *production has reached nuisance levels in the Upper Straits Lake AROS in recent years. The appearance and growth of weedy hybrid pondweeds is of particular concern in many lakes where these hybrids have emerged as a response to the challenge they face with ebrid milfoil growth. Effective management of these plant species can be difficult.*	*As with all native submersed vegetation, careful monitoring is required to determine if there are biotypes that may be capable of creating serious nuisance conditions in Upper Straits Lake. Should nuisance native plant production occur, management action may be necessary. Unfortunately, selective pondweed management is very difficult, and outcomes can be unpredictable. Caution is always required for native plant control.*

Category 750: LakeScan™ Management Program, 2017

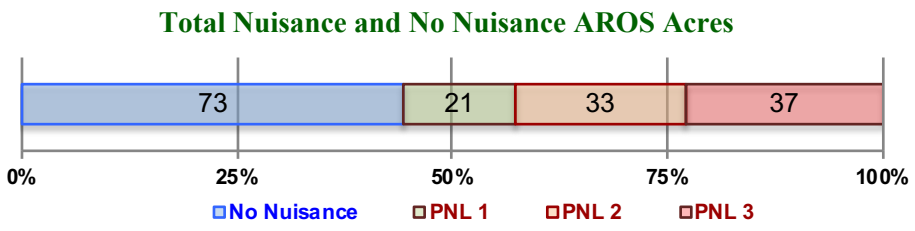
Perceived Nuisance Index, "PNL" Index and Invasive or Nuisance Species.

Background: There are several species that typically become a nuisance in Michigan's inland lakes. 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. The species that are nearly always targeted for control are referred to as T1 species in LakeScan™ parlance.

Upper Straits Lake 2017: Nuisance level aquatic plant conditions were observed in only slightly more than half of lake observation sites (AROS) in 2017. Unequivocal nuisance conditions were largely confined to bays and channels. The main body of the lake remains relatively nuisance free.

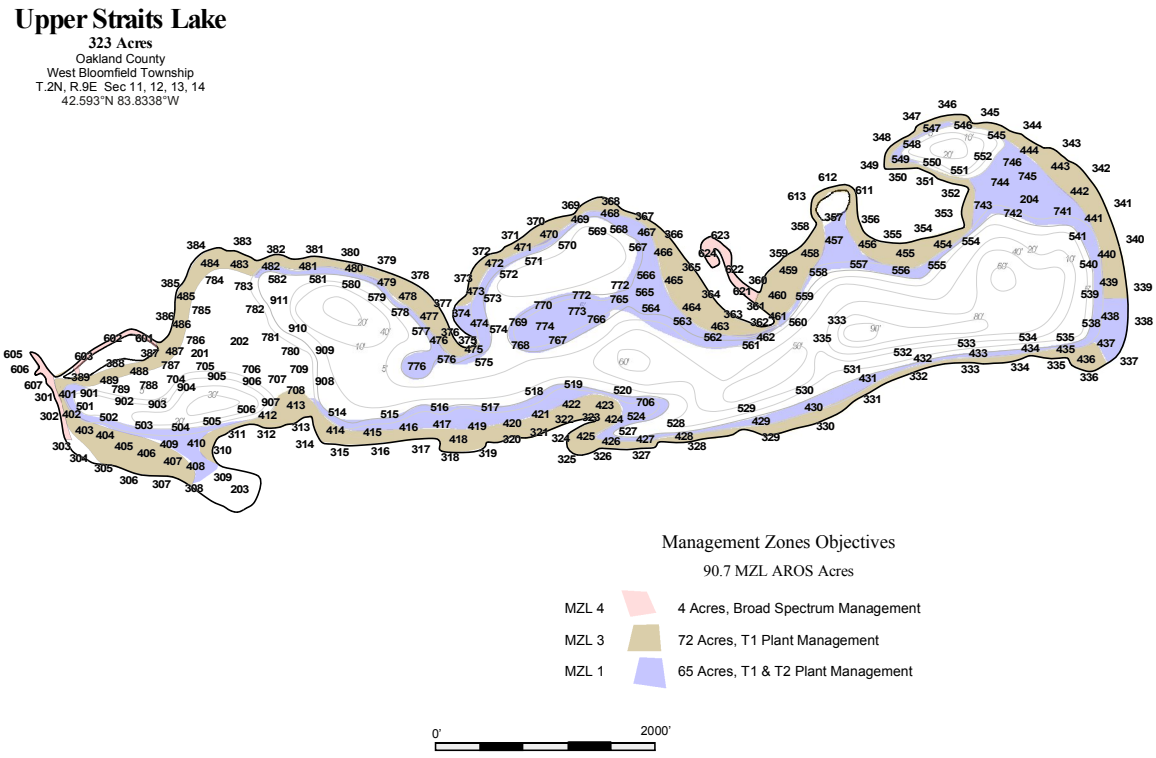
Table ESP2-3.1 The perceived nuisance level (PNL) is determined at each AROS during the LakeScan™ surveys. The AROS acre is the area of each lake Tier (see Tier Map above) divided by the number of AROS that lie inside that tier. The maximum PNL values that are found at each AROS during the seasonal LakeScan™ surveys is used for this analysis. The total number of AROS acres is summed for each of the four PNL levels and the "no nuisance" AROS (PNL 0). The first column is the percentage of the total AROS acres of AROS that are assigned each PNL value.

% Total AROS Acres	PNL Level	Perceived Nuisance Level Description	Total AROS Acres
44%	PNL 0	*"No Nuisance"*	73
13%	PNL 1	*"Ecological Nuisance"*	21
20%	PNL 2	*"Equivocal Nuisance"*	33
23%	PNL 3	*"Obvious Nuisance"*	37



Upper Straits Lake Management Zones (MZL):

MZL's are areas where different management objectives are used that are consistent with the over-all program goal. These objectives range from highly species selective management intervention strategies and technologies (MIST) to fairly broad-spectrum controls that might be considered desirable in a swimming area or marinas. The selection and designation of the areas is based on the ecological significance of the area and State regulatory policy. MZL 4 areas are the most aggressively managed areas in lakes where strategies are non-selective and may be applied frequently throughout the growing season. Again, these areas include swimming areas and marinas. MZL 3 areas are also aggressively managed but the focus is generally to prevent the weediest species from growing at nuisance levels near homes and commercial developments. Lake access is the critical focus in MZL 3 areas and selectivity is a subordinate priority. Only T1 (Target 1) species, such as milfoil, curly leaf pondweed, and starry stonewort are targeted in MZL 2 areas, but there may be some temporary impacts on desirable plants. Only the most highly selective management agents are applied to MZL 1 and the objectives in these areas are to focus on only a single species or two.



Management Interventions Strategies and Technologies (MIST)

The Upper Straits Lake Management Goal

To Preserve, Protect, and if Possible – Improve Big Lake Conditions

To Improve aquatic ecosystem biological diversity and system stability … and thereby improve conditions for recreation, fish and wildlife and the aesthetics.

Ebrid watermilfoil growth is expected to reach nuisance levels after the Memorial Day Holiday in some Upper Straits Lake AROS in 2018. It is also possible that starry stonewort could return at nuisance levels.

The lake is surveyed by one or more members of the lake resident community, the herbicide application contractor, and the lake monitoring and management advisor (Aquest) in May or early June (depending on weather) and specific targets are established during that survey. At that time, species selective herbicide combinations are considered to address observed impairments and then they are applied to various AROS in the lake to target invasive species and encourage the development of a biologically diverse, desirable, native plant community. Different areas of the lake are treated each year and the total number of acres treated will typically vary according to conditions observed that year. Small areas do not respond well to chemical treatment, so it is preferred that larger areas are targeted for control to enhance the efficacy of treatments and preclude the "trap" of numerous, recurring treatments.

LakeScan™ monitoring is used to provide empirical evidence of how the management plan is succeeding in meeting or missing the management goal. It is currently the only system available to provide relevant measures of management outcomes and proof of responsible lake management.

Typical Aquest Weed Control Prescriptives

Plant Species Target	*Management Agents*
Ebrid Water Milfoil	*Diquat Dibromide, Chelated Copper (Cutrine Ultra) and Endothall Salt (most likely)*
	2,4-D and Chelated Copper (Cutrine Ultra)
	Triclopyr and Chelated Copper (Cutrine Ultra)
Starry Stonewort	*Copper Sulfate, Chelated Copper (Cutrine Ultra) and Endothall Amine applied with droplines or by spike injection*
Nuisance Native Species	*Contact Herbicide Combos*
	Mechanical Harvesting

Comments on Individual Plant Species and Management

Eurasian Watermilfoil and Hybrids (Ebrids):

Background: Anecdotal evidence suggests that hybrid milfoil has been found in Michigan inland lakes for decades (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 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.

Upper Straits Lake 2017: Ebrid watermilfoil has been present in Upper Straits Lake for decades. It is characteristically very weedy wherever it is found in Michigan inland lakes; however, nuisance level production is largely confined to bays and channels in Upper Straits Lake. Off shore areas remain relatively unimpaired by nuisance ebrid watermilfoil production. The percent occurrence and relative LakeScan™ dominance levels were considerably higher in 2017 than any previous year. This may be related to unusual weather patterns and the mild winter of 2017 but merits more observations before definitive conclusions may be drawn.

2017

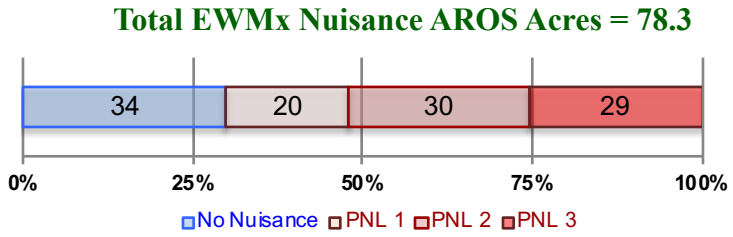


Figure 704. Ebrid milfoil (Eurasian water milfoil + Eurasian and northern watermilfoil hybrids = Ebrid) Perceived Nuisance Levels. These include recreational and aesthetic nuisances, ecological nuisances, and non-nuisance rankings assigned to each AROS and the sum of acres for each PNL designation for data collected throughout the entire summer. Nuisance acres are represented by pinks and reds. PNL-2 = "Equivocal Recreational Nuisance" is pink and PNL-3 = "Unequivocal Nuisance" (everyone would agree that conditions are bad) is represented by the red bars. PNL 1 = "Ecological Nuisance Only" are represented in blue. The green bars represent AROS acres where ebrid milfoil was not detected.

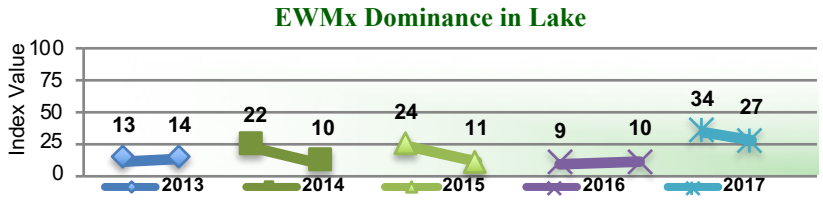


Figure 705. Ebrid milfoil (Eurasian water milfoil + Eurasian and northern watermilfoil hybrids = Ebrid) dominance recorded in the AROS of Upper Straits Lake. AROS are assigned to all of the plant productive and potentially plant productive parts of the lake.

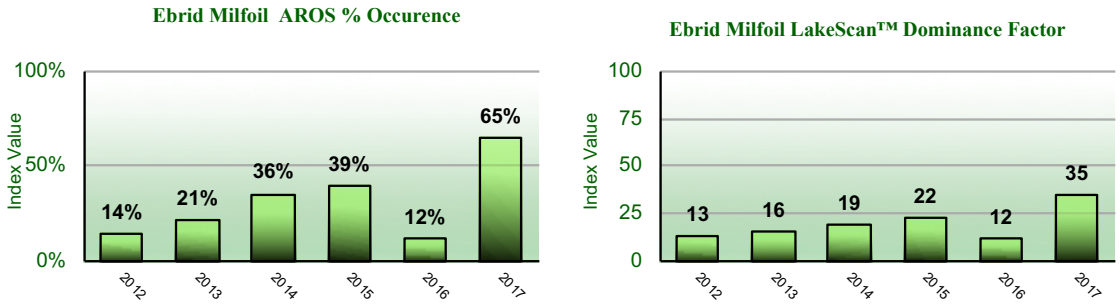


Figure 706. Ebrid milfoil (Eurasian water milfoil + Eurasian and northern watermilfoil hybrids = Ebrid) seasonal maximum AROS percent occurrence and LakeScan™ dominance factors in Upper Straits Lake. AROS are assigned to all of the plant productive and potentially plant productive parts of the lake.

Prescriptives: Ebrid watermilfoil was a significant nuisance in the bays and channels of Upper Straits Lake in 2017. Even though Ebrid milfoil production did not reach typical nuisance levels in Upper Straits Lake in off-shore and exposed areas of the lake, it can still grow to significant nuisance levels and is an ever-present threat to the biological diversity and stability of the ecosystem. Species selective herbicides are often used to successfully suppress the nuisance production ebrid milfoil and support the production of a more desirable flora.

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. It is plausible that milfoil dominance will not be significant in Upper Straits Lake in 2018, but this cannot be guaranteed. Should MIST applications be warranted, it is important to note that some of the milfoil genotypes may be more herbicide resistant than others and treatment strategies must be adjusted to remain effective.

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 Lobdell Lake, Genesee County, MI. Since then, it has been discovered in lakes all over Michigan. The most important characteristic of this species is that it is predictably unpredictable. It is truly an opportunistic species and 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. Some years it 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.

Upper Straits Lake, 2017: Starry stonewort never dominated the Upper Straits Lake ecosystem as it has in other lakes. Several of the Tier 6 areas have experienced extreme nuisance conditions, but generally the plant is found scattered around the lake at non-nuisance levels. It is likely to return as a serious nuisance in Tier 6 and may or may not be present as a serious nuisance elsewhere in the lake. The most predictable characteristic of starry stonewort is that it is inherently unpredictable. It is conceivable that it could grow to nuisance levels In parts of the lake where it has not previously grown to nuisance levels. Hence, careful monitoring is required. Starry stonewort percent AROS occurrence increased; however, dominance levels declined in Upper Straits in Upper Straits Lake in 2017. This was also observed in many other lakes during the same year.

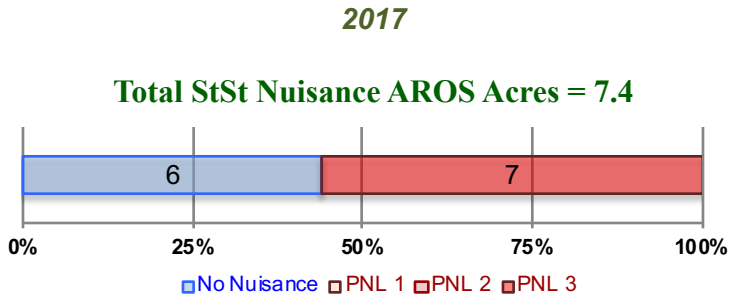


Figure 707. Starry Perceived Nuisance Levels. These include recreational and aesthetic nuisances, ecological nuisances, and non-nuisance rankings assigned to each AROS and the sum of acres for each PNL designation for data collected throughout the entire summer. Nuisance acres are represented by pinks and reds. PNL-2 = "Equivocal Recreational Nuisance" is pink and PNL-3 = "Unequivocal Nuisance" (everyone would agree that conditions are bad) is represented by the red bars. PNL 1 = "Ecological Nuisance Only" are represented in blue. The green bars represent AROS acres where starry stonewort was not detected.

2017

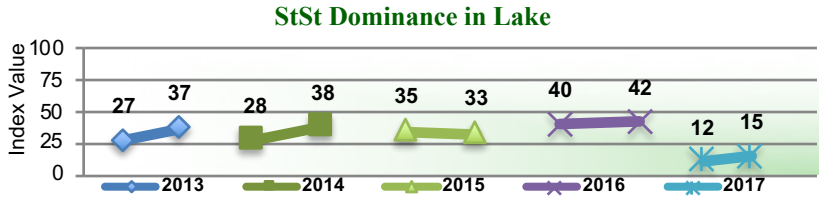


Figure 708. Starry stonewort LakeScan™ dominance factors recorded in the early summer and late summer in the AROS of Upper Straits Lake. AROS are assigned to all of the plant productive and potentially plant productive parts of the lake.

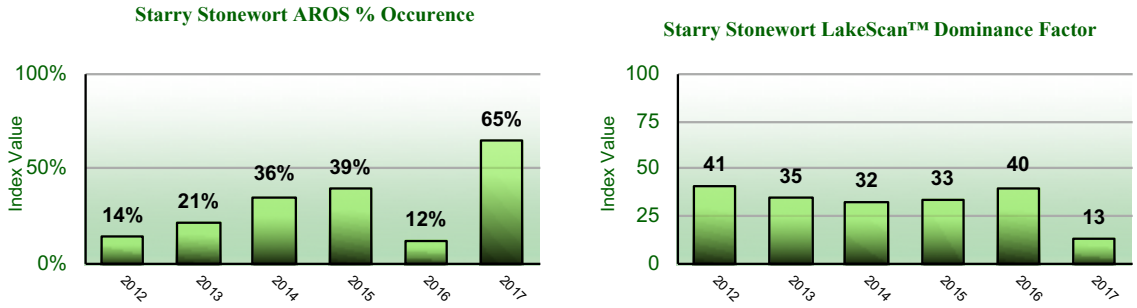


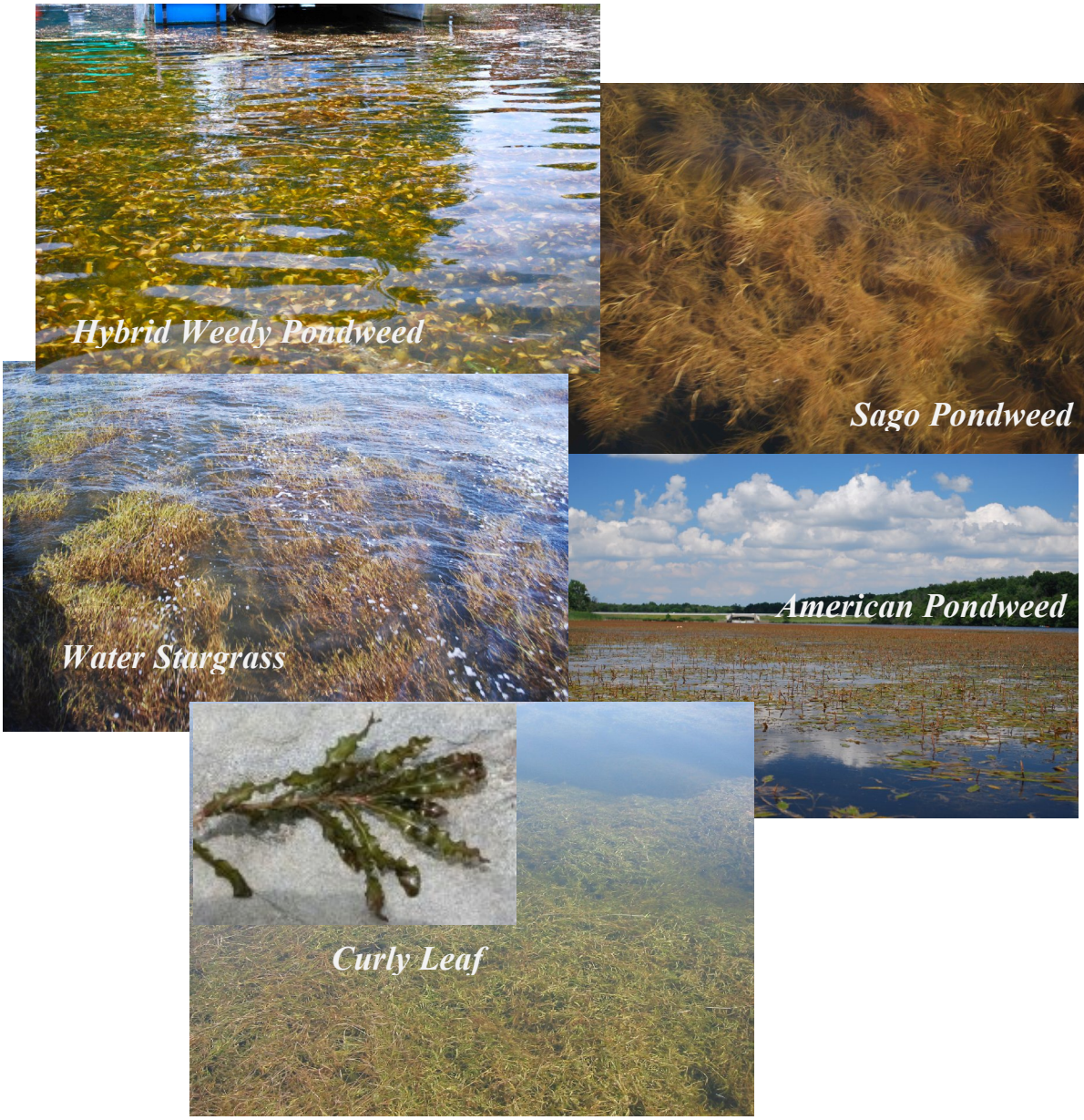
Figure 706. Ebrid milfoil (Eurasian water milfoil + Eurasian and northern watermilfoil hybrids = Ebrid) seasonal maximum AROS percent occurrence and LakeScan™ dominance factors in Upper Straits Lake. AROS are assigned to all of the plant productive and potentially plant productive parts of the lake.

Prescriptives: An evaluation treatment strategy was applied to ARO 611, 612, and 613 in 2017 where starry stonewort was mechanically harvested just prior to treatment with species selective agents (algaecides). Regrowth was so rapid after mechanical removal that the starry stonewort had returned to levels that were very similar to those observed before mechanical harvesting was applied to these AROS. The additional cost of this treatment strategy cannot be justified so species selective algaecide treatments will be applied to starry stonewort afflicted areas in 2018.

Pondweeds

Background: The pondweeds are possibly the most common plant found in Michigan inland lakes. They are a very large and diverse group of aquatic plants. All but one of the common Michigan Pondweeds are native or endemic. Curly leaf pondweed is the only exception and is native to Europe and Asia and is thought to have arrived in North America near the turn of the 20th century. It can become an extreme nuisance in the early spring but generally declines on its own prior to the important Fourth of July holiday. It seems to have been a more common nuisance in previous decades and has been less aggressive in recent years. However, it can still bloom near Memorial Day and become a terrible nuisance in some lakes – in some years.

The leaves of the native pondweeds range from thin stringy to broad and almost "cabbage-like". This kind of morphological diversity contributes to the structural diversity of the submersed flora of lakes they inhabit and is believed to be an important component of constitutes critical habitat. More often than not, pondweeds are thought to be desirable because of the support they provide for a wide range of aquatic animals, including fish. Many of the most common species are considered to be promiscuous and hybrids, resulting from a variety of species crosses, abound in Michigan inland lakes. Although the native pondweeds are generally considered to be desirable and rarely grow to nuisance levels, they have been observed to grow to increasingly nuisance levels during the past decade. American pondweed can grow to extreme nuisance levels in slow moving water. Sago pondweed has been observed at extreme nuisance levels in lakes where there has been excessive weed control pressure. There is a broad leaf pondweed/hybrid that forms a dense cover on the sediment in the late fall that over-winters and provides a strong competitive advantage to this biotype in the spring. The first reports that Richardson's pondweed could grow to nuisance levels came from western Michigan more than ten years ago; however, it has been observed to grow to nuisance level throughout Michigan in the past 5 years. And finally, hybrids of Illinois, variable, white-stem, and broad leaf pondweed are becoming an increasing nuisance. There is no definitive answer or reason why the native pondweeds are emerging as increasingly weedy and problematic plants in inland lakes. However, it is not difficult to imagine that the pondweeds have evolved to become more aggressive after 40 years of competition with aggressive ebrid milfoils, curly leaf pondweed, and starry stonewort - and steadily increasing cultural disturbance in Michigan. Today, pondweed production must be carefully monitored. Management action may be required when particular pondweed biotype becomes invasive and threatens the diversity of large plant communities.


Hybrid Weedy Pondweed
Sago Pondweed
Water Stargrass
American Pondweed
Curly Leaf

Upper Straits Lake, 2017. Weedy hybrid pondweeds are common in Upper Straits Lake but have not been considered to be present at nuisance levels. Pondweed production as reported by the LakeScan™ dominance factor was higher in 2017 than any previous year. Monitoring is required to determine if this is a trend, or if it is merely a response to the unusually warm weather in 2017.

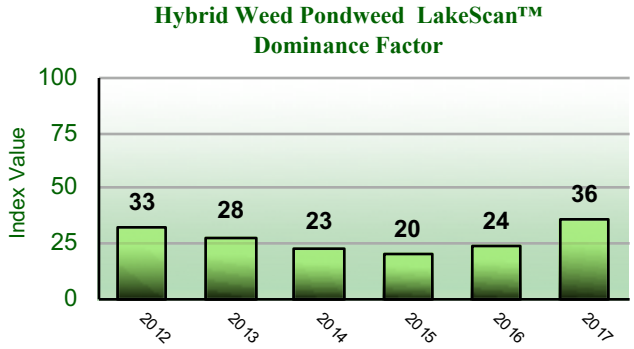


Figure 706. Hybrid weedy pondweed Perceived Nuisance Levels. These include recreational and aesthetic nuisances, ecological nuisances, and non-nuisance rankings assigned to each AROS and the sum of acres for each PNL designation for data collected throughout the entire summer. Nuisance acres are represented by pinks and reds. PNL-2 = "Equivocal Recreational Nuisance" is pink and PNL-3 = "Unequivocal Nuisance" (everyone would agree that conditions are bad) is represented by the red bars. PNL 1 = "Ecological Nuisance Only" are represented in blue. The green bars represent AROS acres where ebrid milfoil was not detected.

Prescriptives: Nuisance pondweed growth is very difficult to manage. However, it can become necessary to manage these native species when they interfere with reasonable navigation and compromise ecosystem stability. It is recommended that the production of various pondweeds be closely monitored before any specific management intervention strategy or technology (MIST) be considered for management. Most native pondweeds are much more resistant to herbicides than other plant species. Mechanical harvesting is generally recommended for nuisance pondweed management, despite the lack of selectivity. There are contact herbicides that can be used to suppress nuisance native pondweeds, but the use of these agents must be precisely prescribed and executed or worse problems can emerge.

Flowering Rush (Butomus umbellatus L.)

Background: Flowering rush is an attractive wetland plant species that produces a very attractive flower. It is a common water garden plant, but it has escaped to grow to nuisance levels in some lakes. It has a submersed form that can significantly impede most boat motors. It has been present in Michigan inland lakes for decades but does not grow to the nuisance levels that are typical of ebrid milfoil, starry stonewort and curly leaf pondweed. It can be controlled with selective herbicide treatments.

Upper Straits Lake: Flowering rush grows in a relatively narrow strip that is particularly conspicuous along the southern shore of the east side of the lake. Both the submersed and emergent plant forms are present in the lake. It is usually an equivocal nuisance in Michigan Lakes because it grows in narrow strips that are relatively easy for boats to avoid and this was true in Upper Straits Lake. These strips also create a unique habitat feature for fisheries.

Prescriptives: It is recommended that the production of flowering rush be closely monitored before any specific MIST be considered for management. Experience has shown that growth may diminish over time in some lakes, where it has become virtually inconspicuous. There are viable and selective MIST available for flowering rush, should it become an unequivocal nuisance.

Appendix

FIELD NOTES

Lake: **Upper Straits Lake, Oakland County, MI**

Date of Observation: **23 May 2017**

Activity: **LakeScan™ Category 700 Pre-Treatment Review**

Key Points

- **Ebrid milfoil was conspicuous in many parts of the lake. Percent occurrence appears to be greater than what has been observed at this time of the year in previous years (see attached maps). It was not observed at nuisance levels; however, it is expected that it will reach nuisance levels in the next several weeks.**
- **Curly leaf pondweed was much more conspicuous than it has been in recent years. It was observed as co-dominant with milfoil.**
- **Starry stonewort was not conspicuously present and it would appear that it will not interfere with fish spawning in the lake this year. However, it is expected to grow to nuisance levels later in the summer, particularly in the canals and marina area.**
- **Waterlilies were only beginning to appear in the lake and this are considered to be later than normal.**

Narrative

The day was overcast with a steady wind near 12 mph. The water clarity was fair for Upper Straits Lake. The water was coated in pollen and there was sign of an algae bloom. The water temperature near the water surface was in the low 60's°F.

It appears that ebrid milfoil will be the dominant nuisance in Upper Straits Lake in early 2017. Curly leaf pondweed was also conspicuous. Treatment with selective herbicide combinations will be necessary to ameliorate nuisance conditions. Mechanical harvesting is expected to provide at least temporary relief from nuisance pondweed conditions in off-shore areas later in the season. If starry stonewort grows to significant levels in AROS 211 & 212 and 221 & 222 it may offer an opportunity to evaluate a new treatment theory where harvesting is used to reduce biomass and the remaining biomass would be treated with algaecide. This could only occur if conditions develop that would lend themselves to such a treatment strategy in the mid-summer.

Management Prescriptives

No herbicide treatment is recommended until the week of June 5th. Treatment areas are delineated on the accompanying map. A herbicide combination that is suitable for the control of ebrid milfoil and curly leaf pondweed and that is selective for these species is recommended for TmtZ's 11.1 to 11.11. A broad spectrum control herbicide combination is recommended for TmtZ's 12.1 to 12.3. These areas are infested with a broader range of species that will interfere with nearshore navigation and recreation. There are nearly 40 acres that required management intervention at this time. The cost of treatment for TmtZ areas 11.* are approximately $295 per acre [~ 35 acres x $295 = $10,325]. The broad spectrum treatment areas, 12.* can be treated for approximately $325 per acre [~ 5 acres x $325 = $1,625]. The total cost of treatment for the early summer is estimated to be near $11,950.

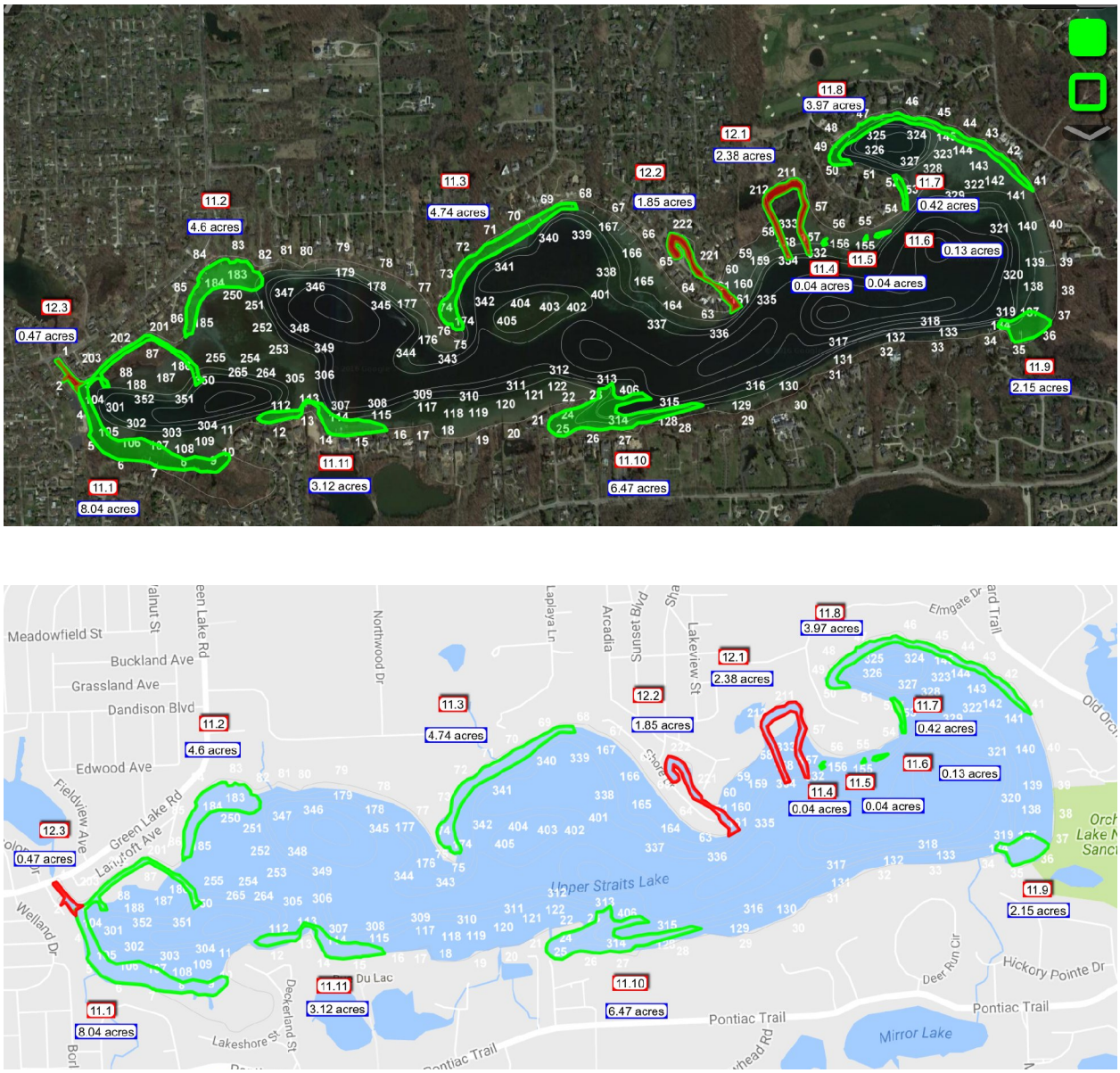


Figure 1. Upper Straits Lake AROS/TmtZ Map, 2017 – 2 views. The green areas 11.* require milfoil treatment. The blue areas 12.* required broad spectrum treatment for pondweeds, curly leaf pondweed, and milfoil.