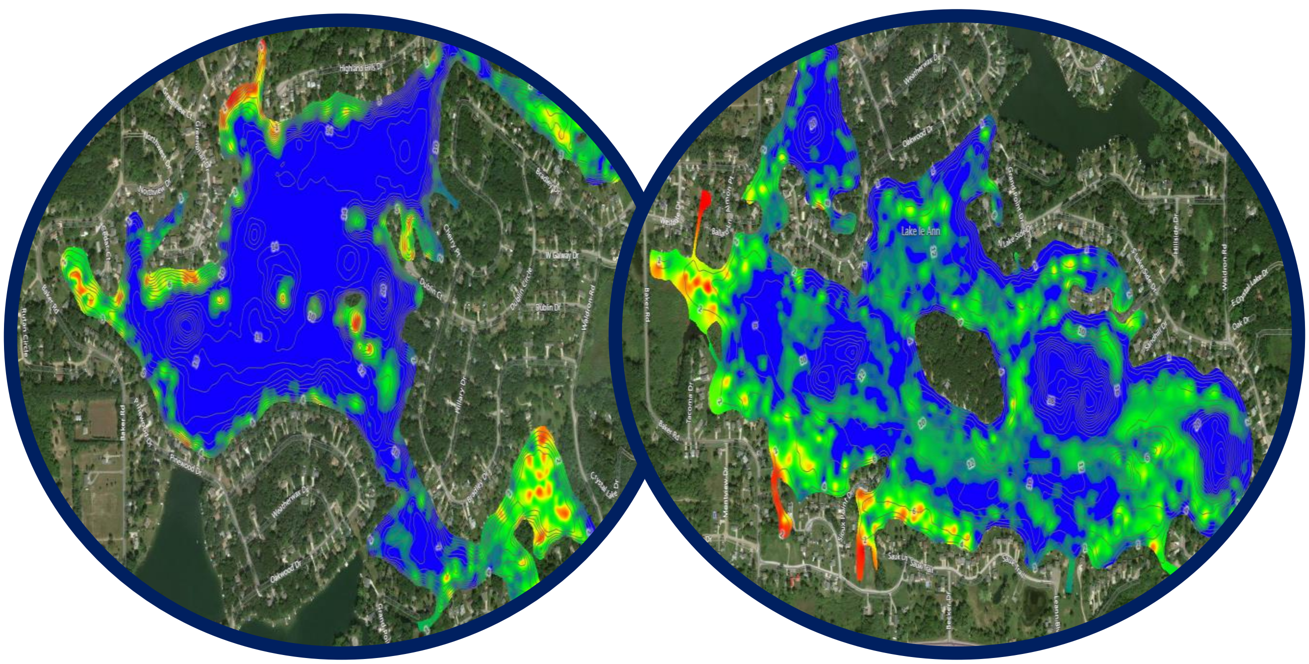
Lake LeAnn 2020 Aquatic Vegetation, Water Quality, & 2021 Management Recommendations Report



November, 2020

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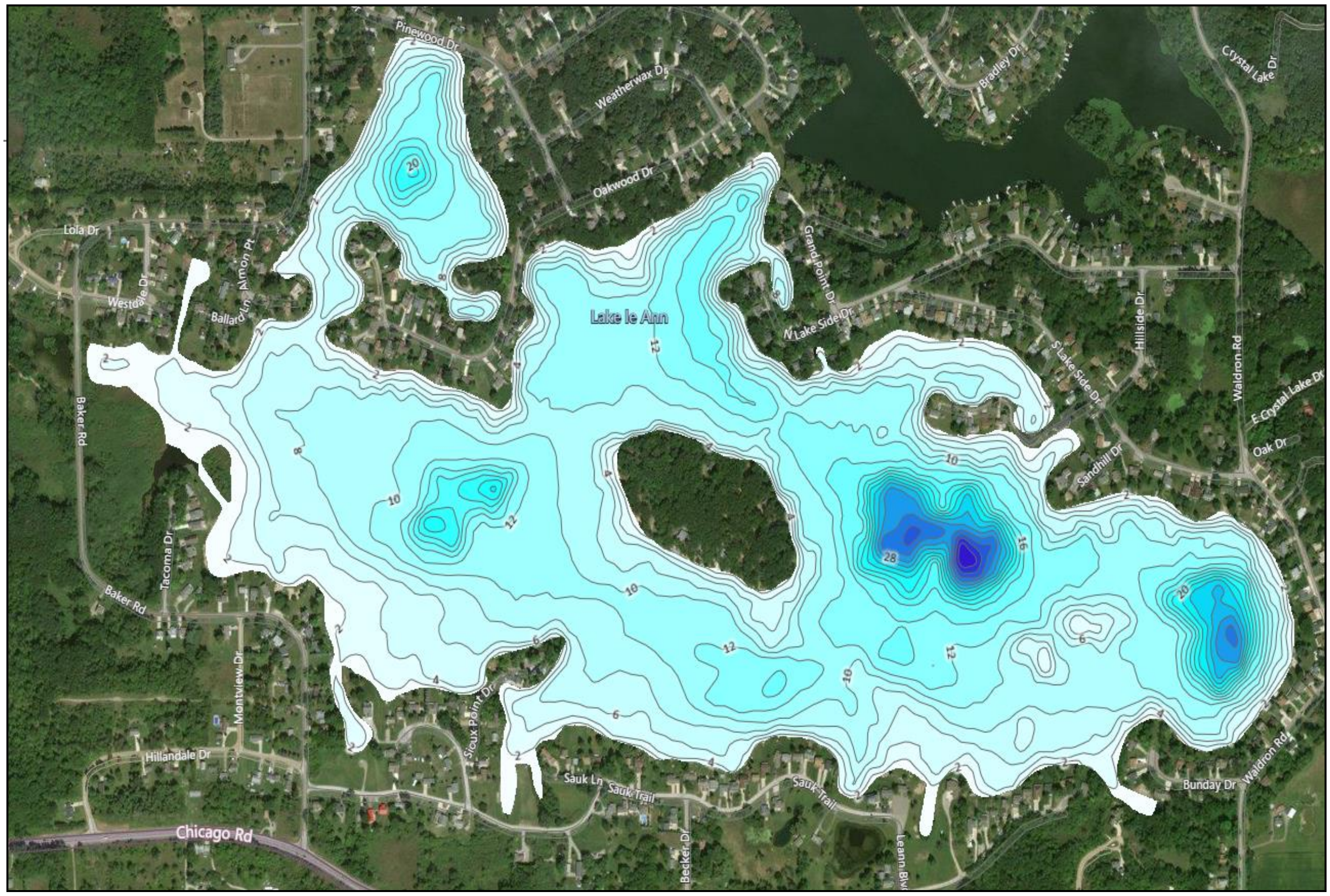

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Section

1

Lake LeAnn 2020 Aquatic Vegetation, Water Quality, & 2021 Management Recommendations Report

The following information is a summary of key lake findings collected during 2020.

The overall condition of Lake LeAnn is fair since it has elevated nutrients, excessive aquatic plant and algae growth, and the presence of toxin-producing cyanobacterial (blue-green algae) that are a threat to the lake ecosystem and human and animal health. The water clarity during the September 2020 sampling event averaged around 6.5 feet which is moderately low. Much of this turbidity is created from excessive algae in the water column.

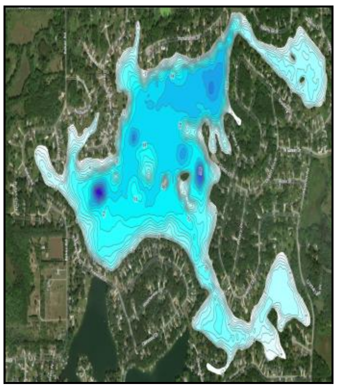
The lake abundant nutrients (phosphorus and nitrogen) to support substantial algae and submersed aquatic plant growth. These nutrient loads must be reduced over time to reduce nuisance weed and algae issues. RLS has recommended a laminar flow aeration system to reduce blue-green algae and nutrients and the system was recently installed during November of 2020. Invasive species such as Eurasian Watermilfoil (EWM), Curly-leaf Pondweed (CLP), and Starry Stonewort (SS) are able to grow in high nutrient waters and thus are a challenge to the Lake LeAnn ecosystem. Protection of the native aquatic plant species is paramount for the health of the lake fishery and these plants should not be managed unless they are a nuisance to lakefront property owners and possess navigational and recreational hazards. Aggressive treatment of EWM, SS, and CLP is recommended to protect biodiversity and enhance lake recreation.

The lake did experience depletion of dissolved oxygen with depth during late-summer which is common for most eutrophic inland lakes. Nutrient concentrations were highest in the north lake. Management recommendations for the 2021 season, which include laminar flow aeration and bioaugmentation are included in the last section of this annual report.

Section 2

Lake LeAnn Water Quality Data (2020)

Water Quality Parameters Measured



There are hundreds of water quality parameters one can measure on an inland lake, but several are the most critical indicators of lake health. In 2020, the measured parameters included water temperature (measured in °C), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), conductivity (measured in micro-Siemens per centimeter-µS/cm), total dissolved and total suspended solids (mg/L), Secchi transparency (feet), total phosphorus, total nitrate nitrogen (both in µg/L), and total Kjeldahl nitrogen (also measured in mg/L), and chlorophyll-*a* (in µg/L). Algal community composition was also measured. Water quality was measured in the deepest basins of Lake LeAnn on September 17, 2020 with a calibrated Eureka Manta II® multi-probe meter. Secchi transparency was measured using a standard secchi disk. Chlorophyll-a was measured in situ with a calibrated Turner Designs® fluorimeter. Table 1 below demonstrates how lakes are classified based on key parameters. Lake LeAnn would be considered eutrophic (very productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth with fair clarity. 2020 water quality data for Lake LeAnn is shown below in Table 2. Water quality data for the lake deepest basins is displayed in Tables 2-3 below. Tables 4-8 display the water quality data for the drains entering the lakes.

Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	*Total Phosphorus ($\mu g\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*Secchi Transparency (feet)*
Oligotrophic	**< 10.0**	**< 2.2**	**> 15.0**
Mesotrophic	**10.0 – 20.0**	**2.2 – 6.0**	**7.5 – 15.0**
Eutrophic	**> 20.0**	**> 6.0**	**< 7.5**

Table 2. Lake LeAnn water quality parameter data collected over the north deep basin on September 17, 2020.

Depth ft.	*Water Temp ºC*	*DO mg/L*	*pH S.U.*	*Total Dissolved Solids mg/L*	*Total Conduct. mS/cm*	*Total Phos. mg/L*	*Total Inorg. N mg/L*	*Total Kjeldahl N mg/L*	*Secchi Trans. ft.*
0	20.8	8.5	8.3	308	481	0.045	0.019	<0.5	--
10	20.7	8.4	8.3	308	481	0.049	0.025	0.7	--
21.5	20.4	5.5	8.3	311	486	0.130	0.330	2.4	5.2

Table 3. Lake LeAnn water quality parameter data collected over the south deep basin on September 17, 2020.

Depth ft.	*Water Temp ºC*	*DO mg/L*	*pH S.U.*	*Total Dissolved Solids mg/L*	*Total Conduct. mS/cm*	*Total Phos. mg/L*	*Total Inorg. N mg/L*	*Total Kjeldahl N mg/L*	*Secchi Trans. ft.*
0	21.0	8.4	8.4	322	503	0.022	0.021	<0.5	--
20	20.5	8.4	8.4	323	504	0.033	0.047	0.9	--
38	11.1	0.2	8.3	414	648	0.054	1.4	3.9	7.7

Table 4. CSA Tributary sampling (2-28-2020)

Tributary	Total P	TIN	NO3	NO2	NH3	TKN	TSS	Flow (ft^3/s)
1a: Baker Rd.	0.013	0.32	0.26	<0.10	0.056	<0.50	<10	0.22
1b: Tacoma Dr.	0.048	1.1	1.1	<0.10	<0.010	<0.50	<10	0.08
2a: Sauk Trail West	0.060	0.46	0.44	<0.10	0.017	1.3	<10	0.24
2b: Sauk Trail East	0.026	0.94	0.93	<0.10	0.011	<0.50	<10	0.46
3: Plaza Ct. (Not Running)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4a: Greenbriar Dr. (Not Running)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4b: Vicary Rd.	0.073	0.42	0.39	<0.10	<0.023	<0.50	<10	0.09
5: Waldron Rd. (Not Running)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 5. CSA Tributary sampling (4-30-2020)

Tributary	Total P	TIN	NO3	NO2	NH3	TKN	TSS	Flow (ft^3/s)
1a: Baker Rd.	0.033	0.042	<0.10	<0.10	0.042	<0.50	<10	0.03
1b: Tacoma Dr.	0.056	0.96	<0.10	<0.10	0.020	<0.50	<10	0.01
2a: Sauk Trail West	0.042	0.28	<0.10	<0.10	0.016	<0.50	14	0.04
2b: Sauk Trail East	0.042	0.64	<0.10	<0.10	0.014	0.64	<10	0.05
3: Plaza Ct. (Not Running)	NA	NA	NA	NA	NA	NA	NA	NA
4a: Greenbriar Dr. (Not Running)	NA	NA	NA	NA	NA	NA	NA	NA
4b: Vicary Rd.	0.082	0.12	<0.10	<0.10	0.031	0.72	<10	0.02
5: Waldron Rd. (Not Running)	NA	NA	NA	NA	NA	NA	NA	NA

Table 6. CSA Tributary sampling (5-19-2020)

Tributary	Total P	TIN	NO3	NO2	NH3	TKN	TSS	SRP	Flow (ft^3/s)
1a: Baker Rd.	0.036	0.044	<0.10	<0.10	0.044	0.66	<10	<0.010	2.92
1b: Tacoma Dr.	0.018	0.94	0.92	<0.10	0.019	<0.50	<10	<0.010	0.03
2a: Sauk Trail West	0.043	0.24	0.22	<0.10	0.019	0.68	10	0.016	1.08
2b: Sauk Trail East	0.036	0.41	0.39	<0.10	0.026	1.2	<10	<0.010	1.57
3: Plaza Ct.	0.037	0.37	0.26	<0.10	0.11	1.2	<10	0.011	0.01
4a: Greenbriar Dr.	0.071	1.3	1.2	<0.10	0.059	1.1	<10	0.027	0.03
4b: Vicary Rd.	0.16	0.036	<0.10	<0.10	0.036	0.99	22	0.025	1.73
5: Waldron Rd.	0.097	0.072	<0.10	<0.10	0.072	0.98	46	<0.010	0.13

Table 7. CSA Tributary sampling (8-4-2020)

Tributary	Total P	TIN	NO3	NO2	NH3	TKN	TSS	SRP	Flow (ft^3/s)
1a: Baker Rd.	0.015	0.038	<0.10	<0.10	0.038	<0.50	<10	<0.010	2.4
1b: Tacoma Dr.	0.058	0.019	<0.10	<0.10	0.019	1.4	100	<0.010	0.1
2a: Sauk Trail West	0.046	1.8	1.8	<0.10	<0.10	0.9	22	<0.010	0.2
2b: Sauk Trail East	0.030	0.50	0.48	<0.10	0.021	0.62	<10	<0.010	0.5
3: Plaza Ct.	0.19	1.1	1.1	<0.10	<0.10	1.3	48	<0.010	0.1
4a: Greenbriar Dr.	0.21	0.28	0.16	<0.10	0.11	0.58	96	<0.010	0.1
4b: Vicary Rd. (Not Running)	NA	NA	NA	NA	NA	NA	NA	NA	NA
5: Waldron Rd.	0.037	2.3	2.2	<0.10	0.064	0.86	<10	<0.010	0.1

Table 8. CSA Tributary sampling (9-17-2020)

Tributary	Total P	TIN	NO3	NO2	NH3	TKN	TSS	Flow (ft^3/s)
1a: Baker Rd.	0.014	0.140	0.110	<0.10	0.030	<0.5	<10	1.3
1b: Tacoma Dr.	<0.010	1.1	1.1	<0.10	0.013	<0.5	<10	0.3
2a: Sauk Trail West	0.017	0.530	0.520	<0.10	0.011	<0.5	<10	1.0
2b: Sauk Trail East	0.010	1.2	1.2	<0.10	0.014	<0.5	<10	1.0
3: Plaza Ct.	0.026	0.150	0.130	<0.10	0.023	<0.5	<10	0.1
4a: Greenbriar Dr. (Not Running)	NA	NA	NA	NA	NA	NA	NA	NA
4b: Vicary Rd. (Not Running)	NA	NA	NA	NA	NA	NA	NA	NA
5: Waldron Rd. (Not Running)	NA	NA	NA	NA	NA	NA	NA	NA

Dissolved Oxygen

Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg/L to sustain a healthy warm-water fishery. Dissolved oxygen concentrations may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration. Dissolved oxygen is generally higher in colder waters. Dissolved oxygen was measured in milligrams per liter (mg/L) with the use of a calibrated Eureka Manta II® dissolved oxygen meter. The dissolved oxygen concentrations in the basins of Lake LeAnn ranged from 8.5-0.2 mg/L with the lowest values recorded at the bottom of the South lake basin.

The bottom of the lake produces a biochemical oxygen demand (BOD) due to microbial activity attempting to break down high quantities of organic plant matter, which reduces dissolved oxygen in the water column at depth. Furthermore, the lake bottom is distant from the atmosphere where the exchange of oxygen occurs. A decline in the dissolved oxygen concentrations to near zero may result in an increase in the release rates of phosphorus (P) from lake bottom sediments.

Conductivity

Specific conductivity is a measure of the number of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases with water temperature and the amount of dissolved minerals and salts in a lake. Specific conductivity was measured in micro Siemens per centimeter (µS/cm) with the use of a calibrated Eureka Manta II® conductivity probe and meter. The conductivity values in Lake LeAnn ranged from 481-648 mS/cm with the highest values recorded in the South lake basin.

Since these values are moderately high for an inland lake, the lake water contains ample dissolved metals and ions such as calcium, potassium, sodium, chlorides, sulfates, and carbonates. Baseline parameter data such as conductivity are important to measure the possible influences of land use activities (i.e. road salt influences) on Lake LeAnn over a long period of time, or to trace the origin of a substance to the lake in an effort to reduce pollutant loading. Elevated conductivity values over 800 mS/cm can negatively impact aquatic life.

Water Clarity (Transparency) Data

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Lake LeAnn in mid-September was moderately low and averaged 6.5 feet. This is still adequate enough to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake. Secchi transparency is variable and depends on the number of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement. It is not uncommon for the clarity to increase during periods of low lake use and cooler water temps that reduce water column algae.

Total Phosphorus

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. The dissolved oxygen levels are low enough at the bottom of the south lake to cause release of phosphorus from the bottom and are marginal in the north lake. TP concentrations ranged from 0.022-0.130 mg L^{-1} from the surface to the bottom during the September 2020 sampling event. The highest concentration was measured at the bottom of the north basin. Most of the other concentrations are at or above the eutrophic threshold and indicate a productive lake. The TP was higher in the drains for spring and summer months.

Total Inorganic and Organic Nitrogen

Total Kjeldahl Nitrogen (TKN) is the sum of nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_4^+), and organic nitrogen forms in freshwater systems. TKN was measured with Method EPA 351.2 (Rev. 2.0) and Total Inorganic Nitrogen (TIN) was calculated based on the aforementioned three different forms of nitrogen. Much nitrogen (amino acids and proteins) also comprises the bulk of living organisms in an aquatic ecosystem. Nitrogen originates from atmospheric inputs (i.e. burning of fossil fuels), wastewater sources from developed areas (i.e. runoff from fertilized lawns), agricultural lands, septic systems, and from waterfowl droppings. It also enters lakes through groundwater or surface drainage, drainage from marshes and wetlands, or from precipitation (Wetzel, 2001). In lakes with an abundance of nitrogen (N: P > 15), phosphorus may be the limiting nutrient for phytoplankton and aquatic macrophyte growth. Alternatively, in lakes with low nitrogen concentrations (and relatively high phosphorus), the blue-green algae populations may increase due to the ability to fix nitrogen gas from atmospheric inputs. Lakes with a mean TKN value of 0.66 mg/L may be classified as oligotrophic, those with a mean TKN value of 0.75 mg /L may be classified as mesotrophic, and those with a mean TKN value greater than 1.88 mg/L may be classified as eutrophic. The TKN concentrations in Lake LeAnn during the mid-September sampling event ranged from <0.5-3.9 mg/L with the highest concentrations in the South lake basin and near the lake bottom.

The total inorganic nitrogen (TIN) consists of nitrate (NO3), nitrite (NO2), and ammonia (NH3) forms of nitrogen without the organic forms of nitrogen. The mean TIN concentrations in Lake LeAnn during the mid-September sampling event ranged from 0.019-1.4 mg/L with the highest concentrations noted in the South deep basin.

Total Dissolved and Suspended Solids

Total dissolved solids (TDS) are the measure of the amount of dissolved organic and inorganic particles in the water column. Particles dissolved in the water column absorb heat from the sun and raise the water temperature and increase conductivity. Total dissolved solids were measured with the use of a calibrated Eureka Manta II® meter in mg/L. Spring values are usually higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The mean TDS concentrations in Lake Leann in mid-September ranged from 308-414 mg/L. These values are high for an inland lake and correlates with the measured moderately high conductivity.

Total suspended solids are the measure of the number of suspended particles in the water column. Particles suspended in the water column absorb heat from the sun and raise the water temperature. Total suspended solids were measured in mg/L and analyzed in the laboratory with Method SM 2540 D-11. The lake bottom contains many fine sediment particles that are easily perturbed from winds and wave turbulence. Spring values would likely be higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The TSS concentrations were measured for the drains only. Ideally values should be < 10 mg/L.

pH

Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH < 7) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). Lake LeAnn is considered "slightly basic" on the pH scale. The pH of Lake LeAnn during the September 2020 sampling event ranged from 8.3-8.4 S.U. which is ideal for an inland lake.

Chlorophyll-*a* and Algal Species Composition

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6 $\mu g\ L^{-1}$ are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 μg/L are found in nutrient-poor or oligotrophic lakes. The chlorophyll-*a* concentration during the September 2020 sampling event was 9.0 μg/L which is quite high for an inland Michigan lake and indicates high productivity.

The algal genera were determined from composite water samples collected over the deep basins of Lake LeAnn in September of 2020 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae; Figure 1): *Rhizoclonium* sp., *Ulothrix* sp., *Spirogyra* sp., *Chlorella* sp., *Scenedesmus* sp., *Mougeotia* sp., *Pandorina* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae; Figure 2): *Microcystis* sp., and *Oscillatoria* sp., the Bascillariophyta (diatoms; Figure 3): *Synedra* sp., *Navicula* sp., *Fragilaria* sp., and *Cymbella* sp. The aforementioned species indicate a diverse algal flora, but the blue-green algae were the most abundant next to filamentous green algae.

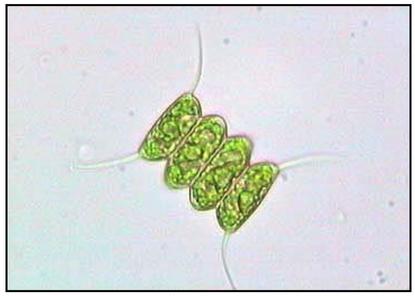


Figure 1. A Green Alga

Figure 2. A Blue-Green Alga

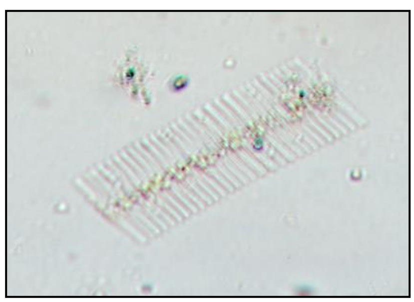


Figure 3. A Diatom

Section

3

Aquatic Vegetation Data (2020)

Status of Native Aquatic Vegetation in Lake LeAnn

The native aquatic vegetation present in Lake LeAnn is essential for the overall health of the lake and the support of the lake fishery. There were two full aquatic plant inventory surveys on May 13, 2020 and again on July 29, 2020. These surveys determined that there were a total of 10-14 native aquatic plant species in Lake LeAnn during those summer months. This indicates a moderate biodiversity of aquatic vegetation in Lake LeAnn that is threatened by the EWM growth.

The most dominant native aquatic plants included aquatic plants such as the macro alga Chara, Thin-leaf Pondweed, Illinois Pondweed, Large-leaf Pondweed, and White Waterlily. It is important to protect these native plants as they offer different growth forms and plant architecture that are favorable for a variety of fish forage habitat and associated food.

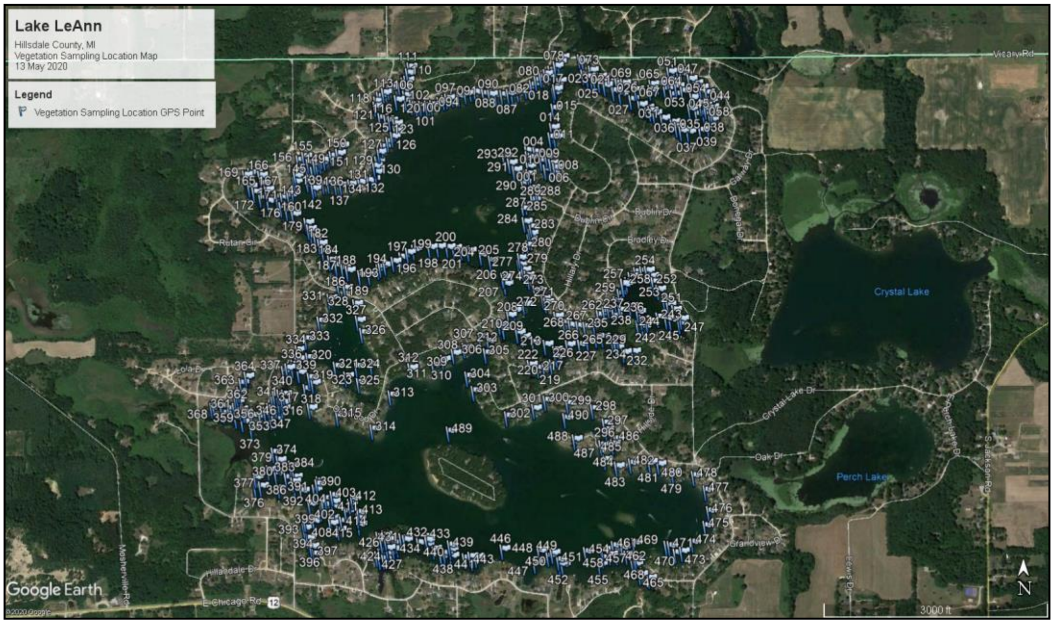


Figure 4. Aquatic Vegetation sampling locations in Lake LeAnn (May 13, 2020).

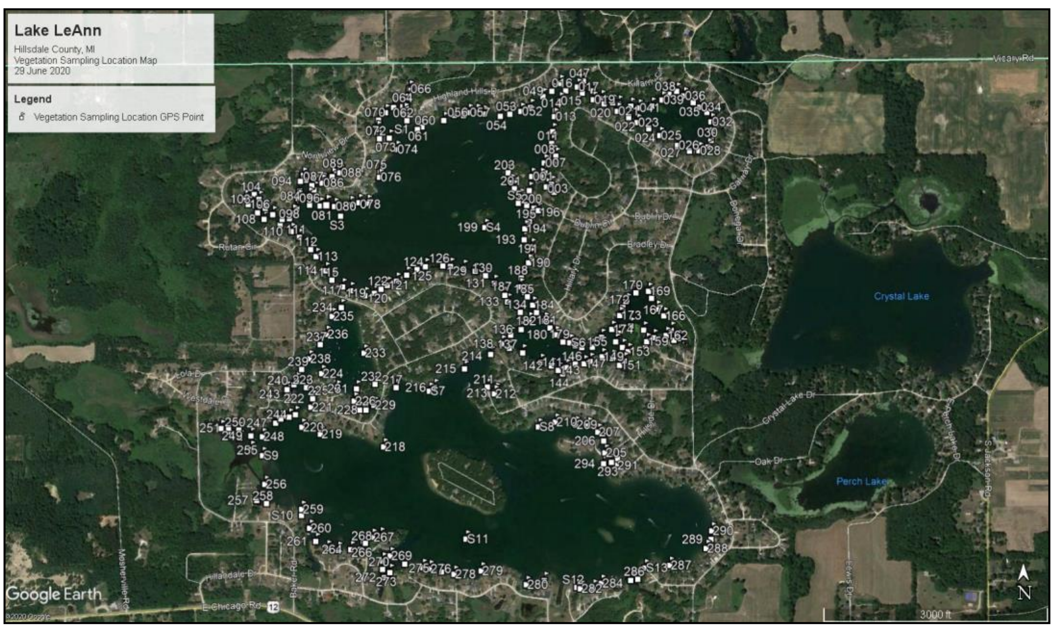


Figure 5. Aquatic Vegetation sampling locations in Lake LeAnn (June 29, 2020).

Table 9. Lake LeAnn North Basin AVAS survey data (May 13, 2020).

LAKE NAME: **Lake LeAnn North** SURVEY DATE: **13-May-2020**
COUNTY: **Hillsdale** SURVEY BY: **GJ, KJ**

Plant Code	Plant Name	Total number of AVAS's for each Density Category A	B	C	D	Category Calculations A x 1	B x10	C x 40	D x 80	Sum of Previous Four Columns	Total Number of AVAS's	Quotient of Sum / # of AVAS sites
1	Eurasian milfoil	14	158	52	9	14	1580	2080	720	4394	295	**14.9**
2	Curly leaf pondweed	51	129	7	0	51	1290	280	0	1621	295	**5.5**
3	Chara	1	47	2	0	1	470	80	0	551	295	**1.9**
4	Thinleaf pondweed	3	0	0	0	3	0	0	0	3	295	**0.0**
5	Flatstem pondweed	1	0	0	0	1	0	0	0	1	295	**0.0**
6	Robbins pondweed	0	0	0	0	0	0	0	0	0	295	**0.0**
7	Variable pondweed	0	0	0	0	0	0	0	0	0	295	**0.0**
8	Whitestem pondweed	1	0	0	0	1	0	0	0	1	295	**0.0**
9	Richardsons pondweed	0	0	0	0	0	0	0	0	0	295	**0.0**
10	Illinois pondweed	6	5	0	0	6	50	0	0	56	295	**0.2**
11	Large leaf pondweed	1	1	0	0	1	10	0	0	11	295	**0.0**
12	American pondweed	0	0	0	0	0	0	0	0	0	295	**0.0**
13	Floating leaf pondweed	0	0	0	0	0	0	0	0	0	295	**0.0**
14	Water stargrass	0	0	0	0	0	0	0	0	0	295	**0.0**
15	Wild Celery	0	0	0	0	0	0	0	0	0	295	**0.0**
16		0	0	0	0	0	0	0	0	0	295	**0.0**
17	Northern milfoil	0	0	0	0	0	0	0	0	0	295	**0.0**
18	M. verticillatum	3	0	0	0	3	0	0	0	3	295	**0.0**
19	M. herterophyllum	0	0	0	0	0	0	0	0	0	295	**0.0**
20	Coontail	0	0	0	0	0	0	0	0	0	295	**0.0**
21	Elodea	0	0	0	0	0	0	0	0	0	295	**0.0**
22	Utricularia spp.	0	0	0	0	0	0	0	0	0	295	**0.0**
23	Bladderwort-mini	0	0	0	0	0	0	0	0	0	295	**0.0**
24	White water crowfoot	0	0	0	0	0	0	0	0	0	295	**0.0**
25	Najas spp.	0	0	0	0	0	0	0	0	0	295	**0.0**
26	Brittle naiad	0	0	0	0	0	0	0	0	0	295	**0.0**
27	Sago pondweed	0	0	0	0	0	0	0	0	0	295	**0.0**
28	Starry stonewort	0	3	0	0	0	30	0	0	30	295	**0.1**
29	European Water Clover	0	0	0	0	0	0	0	0	0	295	**0.0**
30	Nymphaea	8	4	0	0	8	40	0	0	48	295	**0.2**
31	Nuphar	0	1	0	0	0	10	0	0	10	295	**0.0**
32	Brasenia	0	0	0	0	0	0	0	0	0	295	**0.0**
33	Lemna minor	0	0	0	0	0	0	0	0	0	295	**0.0**
34	Spirodella	0	0	0	0	0	0	0	0	0	295	**0.0**
35	Watermeal	0	0	0	0	0	0	0	0	0	295	**0.0**
36	Arrowhead	0	0	0	0	0	0	0	0	0	295	**0.0**
37	Pickerelweed	0	0	0	0	0	0	0	0	0	295	**0.0**
38	Arrow Arum	0	0	0	0	0	0	0	0	0	295	**0.0**
39	Cattails	2	2	0	0	2	20	0	0	22	295	**0.1**
40	Bulrushes	0	0	0	0	0	0	0	0	0	295	**0.0**
41	Iris	0	0	0	0	0	0	0	0	0	295	**0.0**
42	Swamp Loosestrife	0	0	0	0	0	0	0	0	0	295	**0.0**
43	Purple Loosestrife	0	0	0	0	0	0	0	0	0	295	**0.0**
44	nitella	0	0	0	0	0	0	0	0	0	295	**0.0**
45	Phragmites	0	0	0	0	0	0	0	0	0	295	**0.0**
46	Flowering Rush	0	0	0	0	0	0	0	0	0	295	**0.0**
47	Wild Rice	0	0	0	0	0	0	0	0	0	295	**0.0**
48	Button Bush	0	0	0	0	0	0	0	0	0	295	**0.0**
49	Spike Rush	0	0	0	0	0	0	0	0	0	295	**0.0**
50	Beak Rush	0	0	0	0	0	0	0	0	0	295	**0.0**
51	Burr Reed	0	0	0	0	0	0	0	0	0	295	**0.0**
52	Water Pennywort	0	0	0	0	0	0	0	0	0	295	**0.0**
53	Twig Rush	0	0	0	0	0	0	0	0	0	295	**0.0**
54		0	0	0	0	0	0	0	0	0	295	**0.0**
55		0	0	0	0	0	0	0	0	0	295	**0.0**
												22.9

Table 10. Lake Leann South AVAS survey data (May 13, 2020).

LAKE NAME: **Lake LeAnn South** SURVEY DATE: **13-May-2020**
COUNTY: **Hillsdale** SURVEY BY: **GJ, KJ**

Plant Code	Plant Name	Total number of AVAS's for each Density Category				Category Calculations				Sum of Previous Four Columns	Total Number of AVAS's	Quotient of Sum / # of AVAS sites
		A	B	C	D	A x 1	B x10	C x 40	D x 80			
1	Eurasian milfoil	9	19	2	0	9	190	80	0	279	195	**1.4**
2	Curly leaf pondweed	26	62	14	2	26	620	560	160	1366	195	**7.0**
3	Chara	52	59	2	0	52	590	80	0	722	195	**3.7**
4	Thinleaf pondweed	1	0	0	0	1	0	0	0	1	195	**0.0**
5	Flatstem pondweed	1	0	0	0	1	0	0	0	1	195	**0.0**
6	Robbins pondweed	0	0	0	0	0	0	0	0	0	195	**0.0**
7	Variable pondweed	0	0	0	0	0	0	0	0	0	195	**0.0**
8	Whitestem pondweed	0	0	0	0	0	0	0	0	0	195	**0.0**
9	Richardsons pondweed	0	0	0	0	0	0	0	0	0	195	**0.0**
10	Illinois pondweed	9	1	0	0	9	10	0	0	19	195	**0.1**
11	Large leaf pondweed	3	0	0	0	3	0	0	0	3	195	**0.0**
12	American pondweed	0	0	0	0	0	0	0	0	0	195	**0.0**
13	Floating leaf pondweed	0	0	0	0	0	0	0	0	0	195	**0.0**
14	Water stargrass	0	0	0	0	0	0	0	0	0	195	**0.0**
15	Wild Celery	0	0	0	0	0	0	0	0	0	195	**0.0**
16		0	0	0	0	0	0	0	0	0	195	**0.0**
17	Northern milfoil	0	0	0	0	0	0	0	0	0	195	**0.0**
18	M. verticillatum	3	3	0	0	3	30	0	0	33	195	**0.2**
19	M. herterophyllum	0	0	0	0	0	0	0	0	0	195	**0.0**
20	Coontail	0	0	0	0	0	0	0	0	0	195	**0.0**
21	Elodea	0	0	0	0	0	0	0	0	0	195	**0.0**
22	Utricularia spp.	0	0	0	0	0	0	0	0	0	195	**0.0**
23	Bladderwort-mini	0	0	0	0	0	0	0	0	0	195	**0.0**
24	White water crowfoot	0	0	0	0	0	0	0	0	0	195	**0.0**
25	Najas spp.	0	0	0	0	0	0	0	0	0	195	**0.0**
26	Brittle naiad	0	0	0	0	0	0	0	0	0	195	**0.0**
27	Sago pondweed	0	0	0	0	0	0	0	0	0	195	**0.0**
28	Starry stonewort	1	1	0	0	1	10	0	0	11	195	**0.1**
29	European Water Clover	0	0	0	0	0	0	0	0	0	195	**0.0**
30	Nymphaea	1	0	0	0	1	0	0	0	1	195	**0.0**
31	Nuphar	1	2	0	0	1	20	0	0	21	195	**0.1**
32	Brasenia	0	0	0	0	0	0	0	0	0	195	**0.0**
33	Lemna minor	0	0	0	0	0	0	0	0	0	195	**0.0**
34	Spirodella	0	0	0	0	0	0	0	0	0	195	**0.0**
35	Watermeal	0	0	0	0	0	0	0	0	0	195	**0.0**
36	Arrowhead	0	0	0	0	0	0	0	0	0	195	**0.0**
37	Pickerelweed	0	0	0	0	0	0	0	0	0	195	**0.0**
38	Arrow Arum	0	0	0	0	0	0	0	0	0	195	**0.0**
39	Cattails	2	2	0	0	2	20	0	0	22	195	**0.1**
40	Bulrushes	0	0	0	0	0	0	0	0	0	195	**0.0**
41	Iris	0	0	0	0	0	0	0	0	0	195	**0.0**
42	Swamp Loosestrife	0	0	0	0	0	0	0	0	0	195	**0.0**
43	Purple Loosestrife	0	0	0	0	0	0	0	0	0	195	**0.0**
44	nitella	0	0	0	0	0	0	0	0	0	195	**0.0**
45	Phragmites	1	0	0	0	1	0	0	0	1	195	**0.0**
46	Flowering Rush	0	0	0	0	0	0	0	0	0	195	**0.0**
47	Wild Rice	0	0	0	0	0	0	0	0	0	195	**0.0**
48	Button Bush	0	0	0	0	0	0	0	0	0	195	**0.0**
49	Spike Rush	0	0	0	0	0	0	0	0	0	195	**0.0**
50	Beak Rush	0	0	0	0	0	0	0	0	0	195	**0.0**
51	Burr Reed	0	0	0	0	0	0	0	0	0	195	**0.0**
52	Water Pennywort	0	0	0	0	0	0	0	0	0	195	**0.0**
53	Twig Rush	0	0	0	0	0	0	0	0	0	195	**0.0**
54		0	0	0	0	0	0	0	0	0	195	**0.0**
55		0	0	0	0	0	0	0	0	0	195	**0.0**
												12.7

Table 11. Lake LeAnn North AVAS survey data (July 29, 2020).

LAKE NAME: **Lake LeAnn North** SURVEY DATE: **29-Jul-2020**
COUNTY: **Hillsdale** SURVEY BY: **GJ, KJ**

Plant Code	Plant Name	Total number of AVAS's for each Density Category				Category Calculations				Sum of Previous Four Columns	Total Number of AVAS's	Quotient of Sum / # of AVAS sites
		A	B	C	D	A x 1	B x10	C x 40	D x 80			
1	Eurasian milfoil	26	78	18	2	26	780	720	160	1686	204	**8.3**
2	Curly leaf pondweed	47	26	1	0	47	260	40	0	347	204	**1.7**
3	Chara	2	1	0	0	2	10	0	0	12	204	**0.1**
4	Thinleaf pondweed	10	107	16	1	10	1070	640	80	1800	204	**8.8**
5	Flatstem pondweed	4	4	0	0	4	40	0	0	44	204	**0.2**
6	Robbins pondweed	0	0	0	0	0	0	0	0	0	204	**0.0**
7	Variable pondweed	0	0	0	0	0	0	0	0	0	204	**0.0**
8	Whitestem pondweed	0	0	0	0	0	0	0	0	0	204	**0.0**
9	Richardsons pondweed	0	0	0	0	0	0	0	0	0	204	**0.0**
10	Illinois pondweed	8	1	0	0	8	10	0	0	18	204	**0.1**
11	Large leaf pondweed	0	1	0	0	0	10	0	0	10	204	**0.0**
12	American pondweed	0	0	0	0	0	0	0	0	0	204	**0.0**
13	Floating leaf pondweed	7	3	0	0	7	30	0	0	37	204	**0.2**
14	Water stargrass	0	0	0	0	0	0	0	0	0	204	**0.0**
15	Wild Celery	5	1	0	0	5	10	0	0	15	204	**0.1**
16		0	0	0	0	0	0	0	0	0	204	**0.0**
17	Northern milfoil	0	0	0	0	0	0	0	0	0	204	**0.0**
18	M. verticillatum	0	0	0	0	0	0	0	0	0	204	**0.0**
19	M. herterophyllum	0	0	0	0	0	0	0	0	0	204	**0.0**
20	Coontail	2	2	0	0	2	20	0	0	22	204	**0.1**
21	Elodea	0	0	0	0	0	0	0	0	0	204	**0.0**
22	Utricularia spp.	0	0	0	0	0	0	0	0	0	204	**0.0**
23	Bladderwort-mini	0	0	0	0	0	0	0	0	0	204	**0.0**
24	White water crowfoot	0	0	0	0	0	0	0	0	0	204	**0.0**
25	Najas spp.	0	0	0	0	0	0	0	0	0	204	**0.0**
26	Brittle naiad	0	0	0	0	0	0	0	0	0	204	**0.0**
27	Sago pondweed	0	0	0	0	0	0	0	0	0	204	**0.0**
28	Starry stonewort	0	24	13	0	0	240	520	0	760	204	**3.7**
29	European Water Clover	0	0	0	0	0	0	0	0	0	204	**0.0**
30	Nymphaea	13	38	3	0	13	380	120	0	513	204	**2.5**
31	Nuphar	2	0	0	0	2	0	0	0	2	204	**0.0**
32	Brasenia	0	0	0	0	0	0	0	0	0	204	**0.0**
33	Lemna minor	0	0	0	0	0	0	0	0	0	204	**0.0**
34	Spirodella	0	0	0	0	0	0	0	0	0	204	**0.0**
35	Watermeal	0	0	0	0	0	0	0	0	0	204	**0.0**
36	Arrowhead	0	0	0	0	0	0	0	0	0	204	**0.0**
37	Pickerelweed	0	0	0	0	0	0	0	0	0	204	**0.0**
38	Arrow Arum	0	0	0	0	0	0	0	0	0	204	**0.0**
39	Cattails	2	1	0	0	2	10	0	0	12	204	**0.1**
40	Bulrushes	0	1	0	0	0	10	0	0	10	204	**0.0**
41	Iris	0	0	0	0	0	0	0	0	0	204	**0.0**
42	Swamp Loosestrife	0	0	0	0	0	0	0	0	0	204	**0.0**
43	Purple Loosestrife	0	0	0	0	0	0	0	0	0	204	**0.0**
44	nitella	0	0	0	0	0	0	0	0	0	204	**0.0**
45	Phragmites	0	0	0	0	0	0	0	0	0	204	**0.0**
46	Flowering Rush	0	0	0	0	0	0	0	0	0	204	**0.0**
47	Wild Rice	0	0	0	0	0	0	0	0	0	204	**0.0**
48	Button Bush	0	0	0	0	0	0	0	0	0	204	**0.0**
49	Spike Rush	0	0	0	0	0	0	0	0	0	204	**0.0**
50	Beak Rush	0	0	0	0	0	0	0	0	0	204	**0.0**
51	Burr Reed	0	0	0	0	0	0	0	0	0	204	**0.0**
52	Water Pennywort	0	0	0	0	0	0	0	0	0	204	**0.0**
53	Twig Rush	0	0	0	0	0	0	0	0	0	204	**0.0**
54		0	0	0	0	0	0	0	0	0	204	**0.0**
55		0	0	0	0	0	0	0	0	0	204	**0.0**
												25.9

Table 12. Lake LeAnn South AVAS Survey data (July 29, 2020).

LAKE NAME: **Lake LeAnn South** SURVEY DATE: **29-Jul-2020**
COUNTY: **Hillsdale** SURVEY BY: **GJ, KJ**

Plant Code	Plant Name	Total number of AVAS's for each Density Category				Category Calculations				Sum of Previous Four Columns	Total Number of AVAS's	Quotient of Sum / # of AVAS sites
		A	B	C	D	A x 1	B x10	C x 40	D x 80			
1	Eurasian milfoil	2	16	2	0	2	160	80	0	242	89	**2.7**
2	Curly leaf pondweed	11	6	1	0	11	60	40	0	111	89	**1.2**
3	Chara	9	19	1	0	9	190	40	0	239	89	**2.7**
4	Thinleaf pondweed	1	29	2	0	1	290	80	0	371	89	**4.2**
5	Flatstem pondweed	1	5	0	0	1	50	0	0	51	89	**0.6**
6	Robbins pondweed	0	0	0	0	0	0	0	0	0	89	**0.0**
7	Variable pondweed	0	0	0	0	0	0	0	0	0	89	**0.0**
8	Whitestem pondweed	0	0	0	0	0	0	0	0	0	89	**0.0**
9	Richardsons pondweed	0	0	0	0	0	0	0	0	0	89	**0.0**
10	Illinois pondweed	8	19	2	0	8	190	80	0	278	89	**3.1**
11	Large leaf pondweed	5	10	1	0	5	100	40	0	145	89	**1.6**
12	American pondweed	0	0	0	0	0	0	0	0	0	89	**0.0**
13	Floating leaf pondweed	2	0	0	0	2	0	0	0	2	89	**0.0**
14	Water stargrass	0	0	0	0	0	0	0	0	0	89	**0.0**
15	Wild Celery	4	0	0	0	4	0	0	0	4	89	**0.0**
16		0	0	0	0	0	0	0	0	0	89	**0.0**
17	Northern milfoil	0	0	0	0	0	0	0	0	0	89	**0.0**
18	M. verticillatum	4	1	0	0	4	10	0	0	14	89	**0.2**
19	M. herterophyllum	0	0	0	0	0	0	0	0	0	89	**0.0**
20	Coontail	4	0	0	0	4	0	0	0	4	89	**0.0**
21	Elodea	0	0	0	0	0	0	0	0	0	89	**0.0**
22	Utricularia spp.	0	0	0	0	0	0	0	0	0	89	**0.0**
23	Bladderwort-mini	0	0	0	0	0	0	0	0	0	89	**0.0**
24	White water crowfoot	0	0	0	0	0	0	0	0	0	89	**0.0**
25	Najas spp.	0	0	0	0	0	0	0	0	0	89	**0.0**
26	Brittle naiad	0	0	0	0	0	0	0	0	0	89	**0.0**
27	Sago pondweed	0	0	0	0	0	0	0	0	0	89	**0.0**
28	Starry stonewort	1	11	1	2	1	110	40	160	311	89	**3.5**
29	European Water Clover	0	0	0	0	0	0	0	0	0	89	**0.0**
30	Nymphaea	6	4	0	0	6	40	0	0	46	89	**0.5**
31	Nuphar	1	1	0	0	1	10	0	0	11	89	**0.1**
32	Brasenia	0	0	0	0	0	0	0	0	0	89	**0.0**
33	Lemna minor	0	0	0	0	0	0	0	0	0	89	**0.0**
34	Spirodella	0	0	0	0	0	0	0	0	0	89	**0.0**
35	Watermeal	0	0	0	0	0	0	0	0	0	89	**0.0**
36	Arrowhead	0	0	0	0	0	0	0	0	0	89	**0.0**
37	Pickerelweed	0	0	0	0	0	0	0	0	0	89	**0.0**
38	Arrow Arum	0	0	0	0	0	0	0	0	0	89	**0.0**
39	Cattails	1	2	0	0	1	20	0	0	21	89	**0.2**
40	Bulrushes	0	0	0	0	0	0	0	0	0	89	**0.0**
41	Iris	0	0	0	0	0	0	0	0	0	89	**0.0**
42	Swamp Loosestrife	0	0	0	0	0	0	0	0	0	89	**0.0**
43	Purple Loosestrife	0	0	0	0	0	0	0	0	0	89	**0.0**
44	nitella	0	0	0	0	0	0	0	0	0	89	**0.0**
45	Phragmites	1	0	0	0	1	0	0	0	1	89	**0.0**
46	Flowering Rush	0	0	0	0	0	0	0	0	0	89	**0.0**
47	Wild Rice	0	0	0	0	0	0	0	0	0	89	**0.0**
48	Button Bush	0	0	0	0	0	0	0	0	0	89	**0.0**
49	Spike Rush	0	0	0	0	0	0	0	0	0	89	**0.0**
50	Beak Rush	0	0	0	0	0	0	0	0	0	89	**0.0**
51	Burr Reed	0	0	0	0	0	0	0	0	0	89	**0.0**
52	Water Pennywort	0	0	0	0	0	0	0	0	0	89	**0.0**
53	Twig Rush	0	0	0	0	0	0	0	0	0	89	**0.0**
54		0	0	0	0	0	0	0	0	0	89	**0.0**
55		0	0	0	0	0	0	0	0	0	89	**0.0**
												20.8

Status of Invasive (Exotic) Aquatic Plant Species in Lake LeAnn

The amount of Eurasian Watermilfoil (Figure 6), Curly-leaf Pondweed (Figure 7), and Starry Stonewort (Figure 8) present in Lake LeAnn varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients which were abundant in 2019-2020 due to intense rainfall events which occurred in the spring. Figures 9-20 demonstrate the locations of all invasives and nuisance plants treated during 2020. Figures 21-22 show the aquatic plant vegetation biovolume in both lakes, and Figures 23-24 display the relative sediment hardness measured in 2020.

Figure 6. Eurasian Watermilfoil

Figure 7. Curly-leaf Pondweed

Figure 8. Starry Stonewort

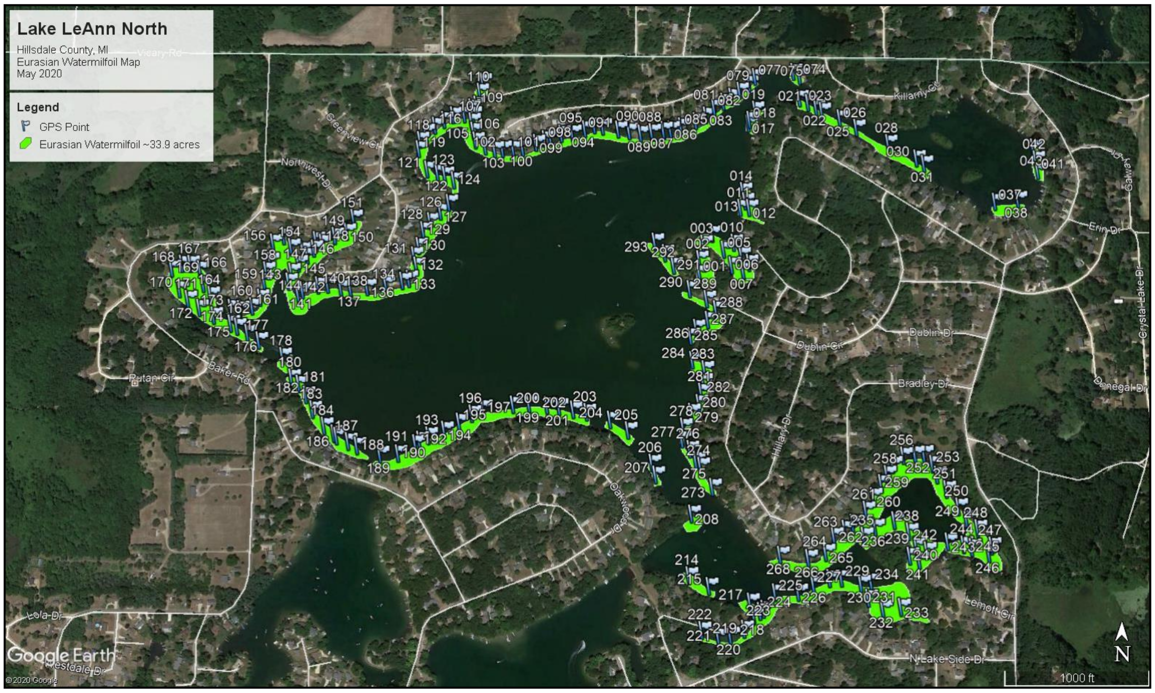


Figure 9. Lake LeAnn North Basin EWM locations (May 13, 2020).

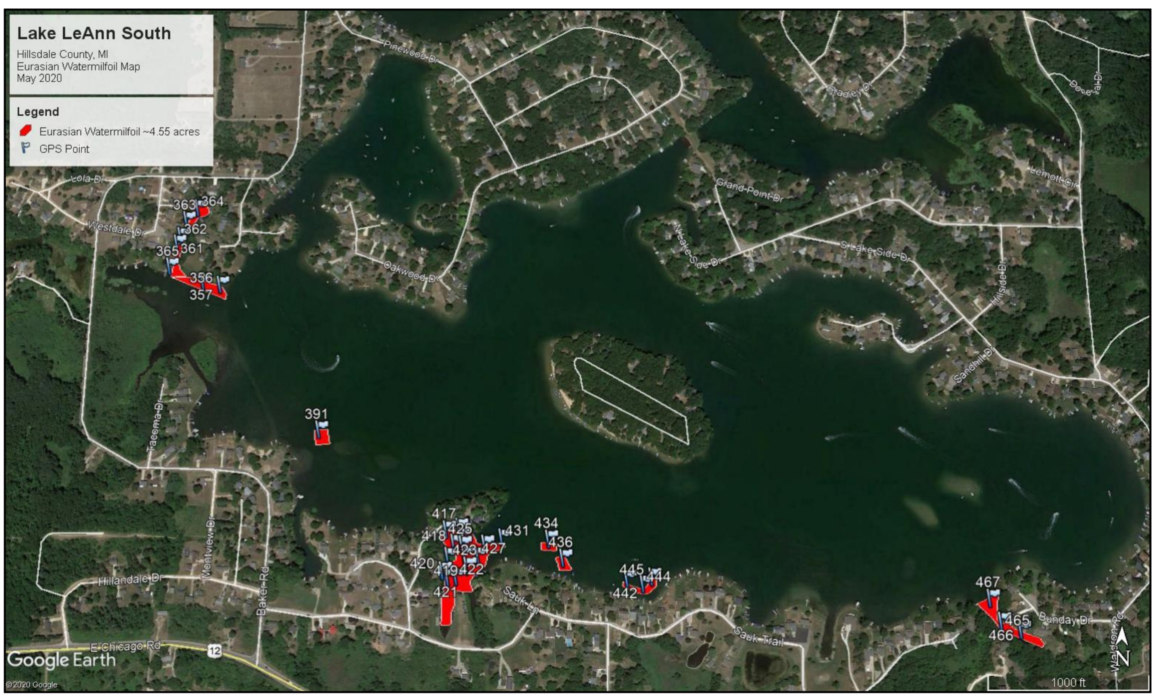


Figure 10. Lake LeAnn South Basin EWM Locations (May 13, 2020).

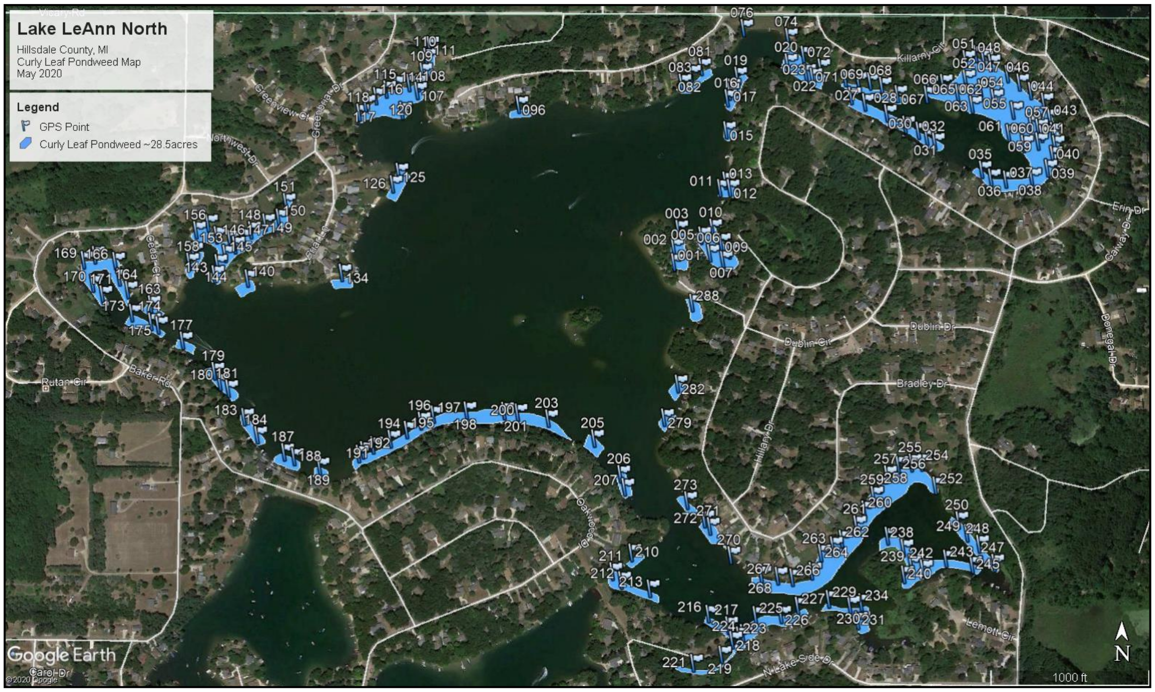


Figure 11. Lake LeAnn North Basin CLP locations (May 13, 2020).

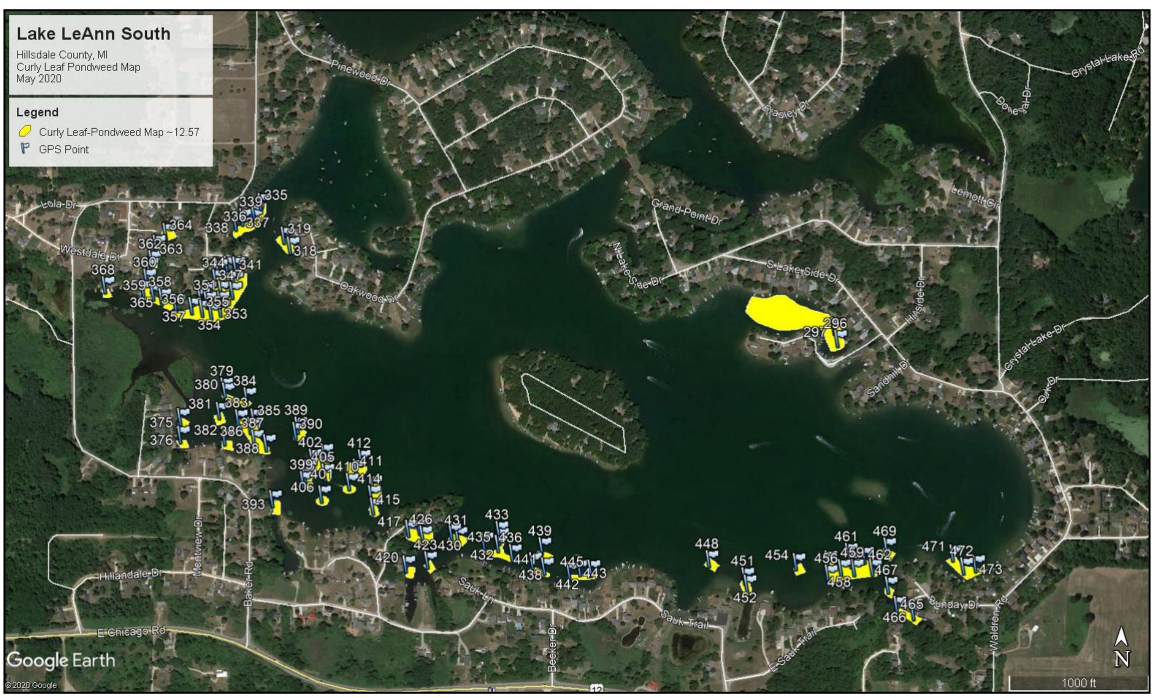


Figure 12. Lake LeAnn South Basin CLP locations (May 13, 2020).

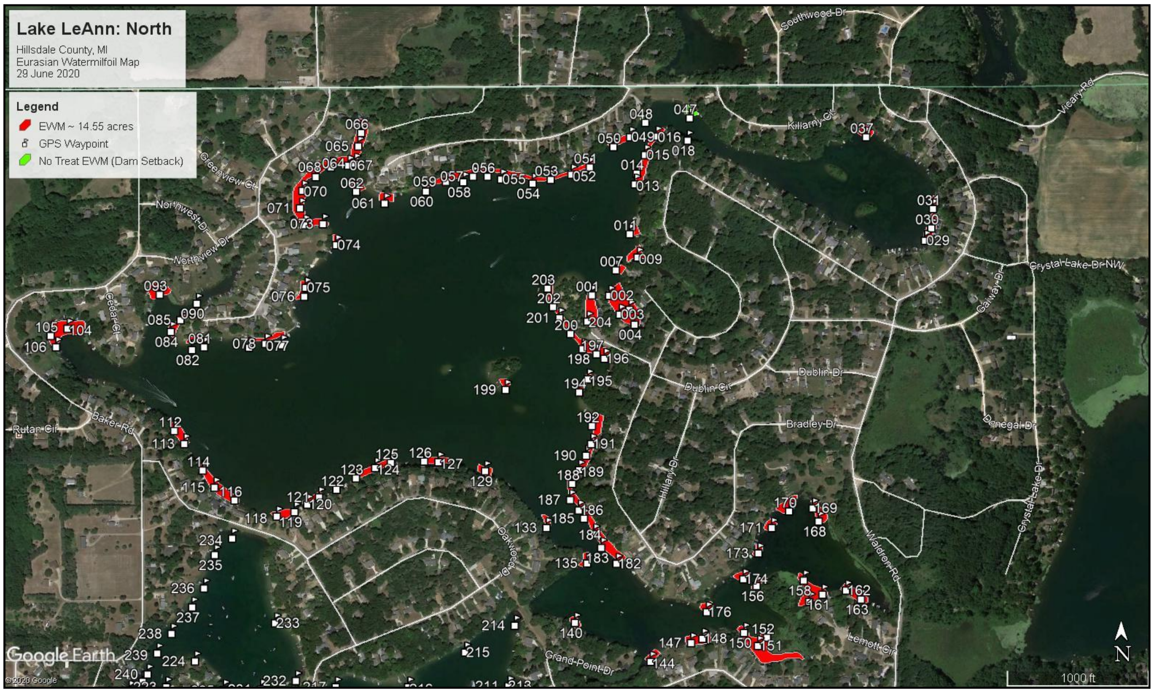


Figure 13. Lake LeAnn North Basin EWM locations (June 29, 2020).

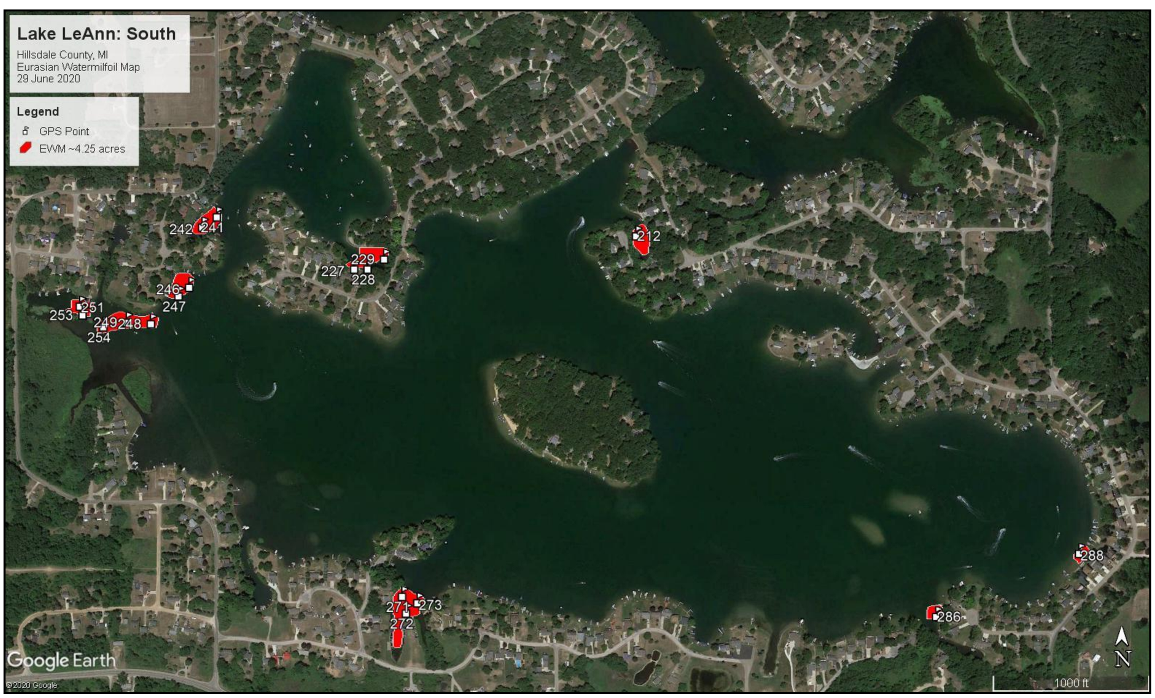


Figure 14. Lake LeAnn South Basin EWM Locations (June 29, 2020).

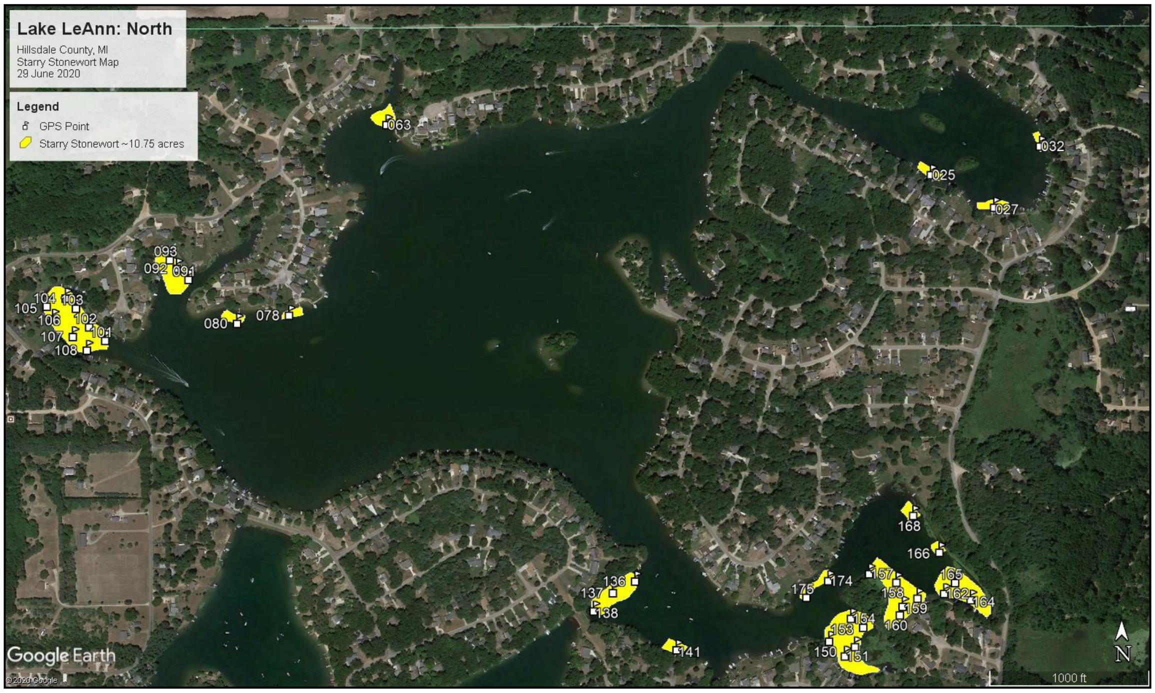


Figure 15. Lake LeAnn North Basin Starry Stonewort Locations (June 29, 2020).

Figure 16. Lake LeAnn South Basin Starry Stonewort Locations (June 29, 2020).

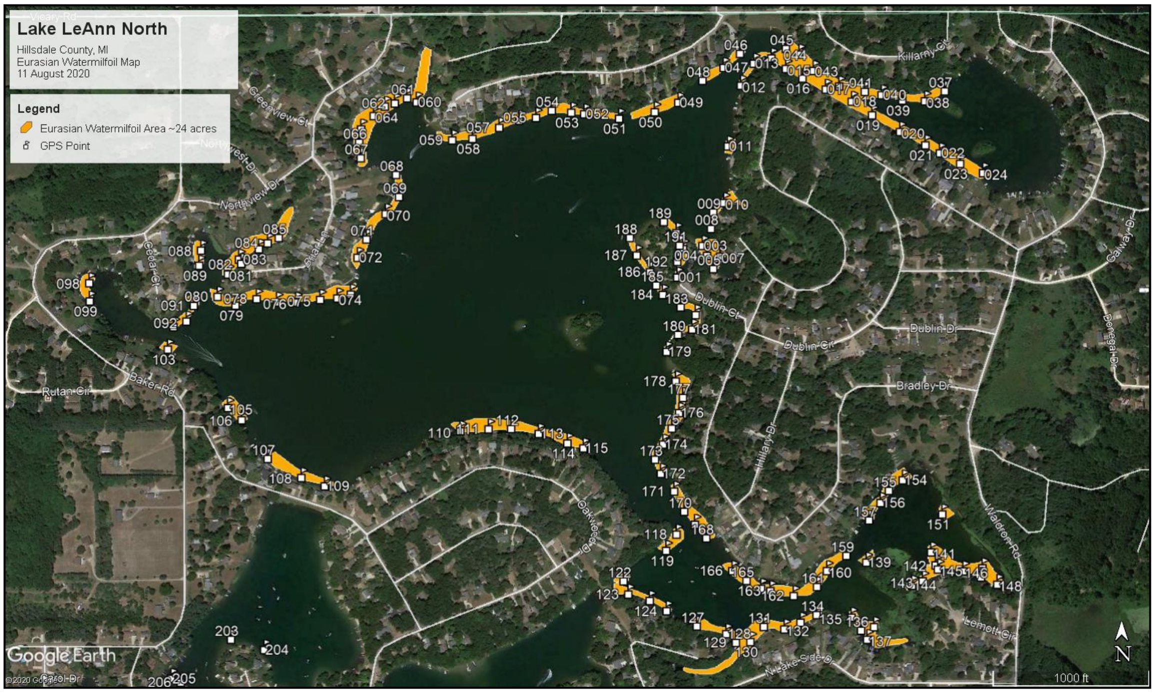


Figure 17. Lake LeAnn North Basin EWM Locations (August 11, 2020).

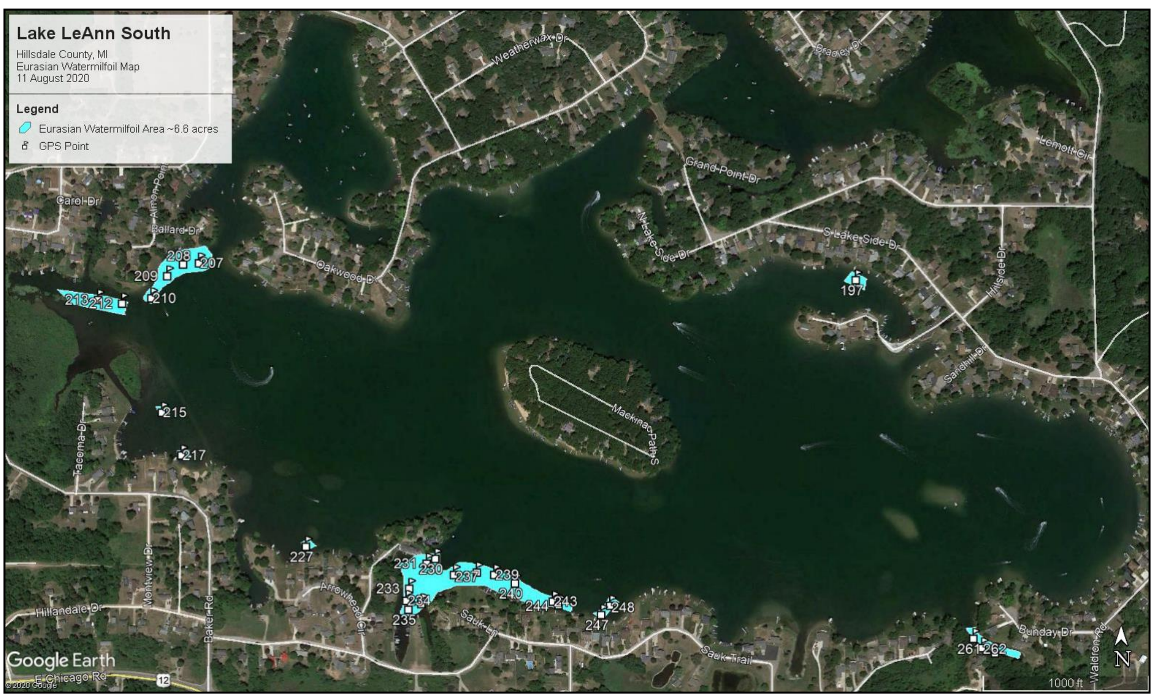


Figure 18. Lake LeAnn South Basin EWM Locations (August 11, 2020).

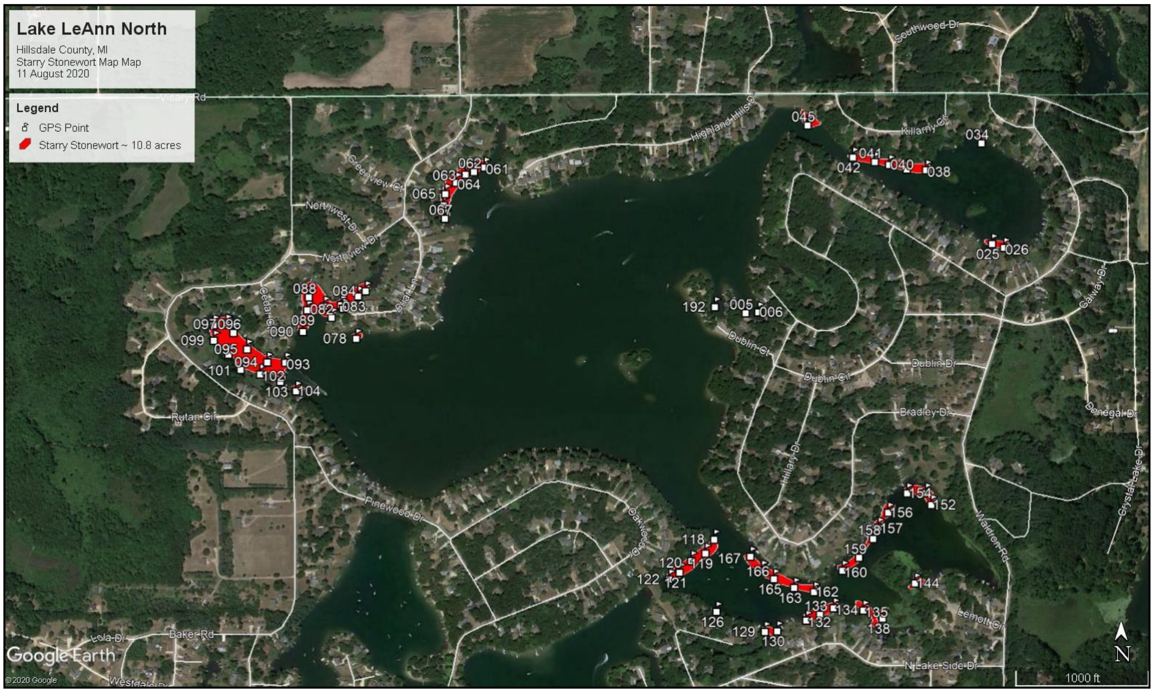


Figure 19. Lake LeAnn North Basin Starry Stonewort Locations (August 11, 2020).

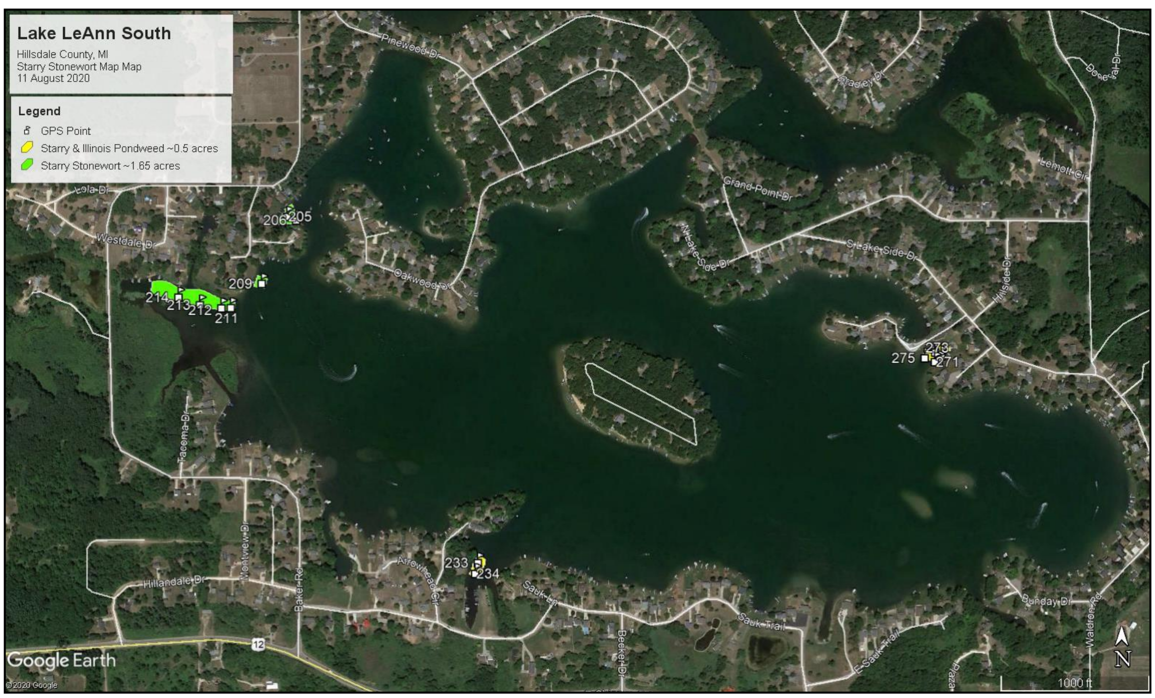


Figure 20. Lake LeAnn South Basin Starry Stonewort Locations (August 11, 2020).

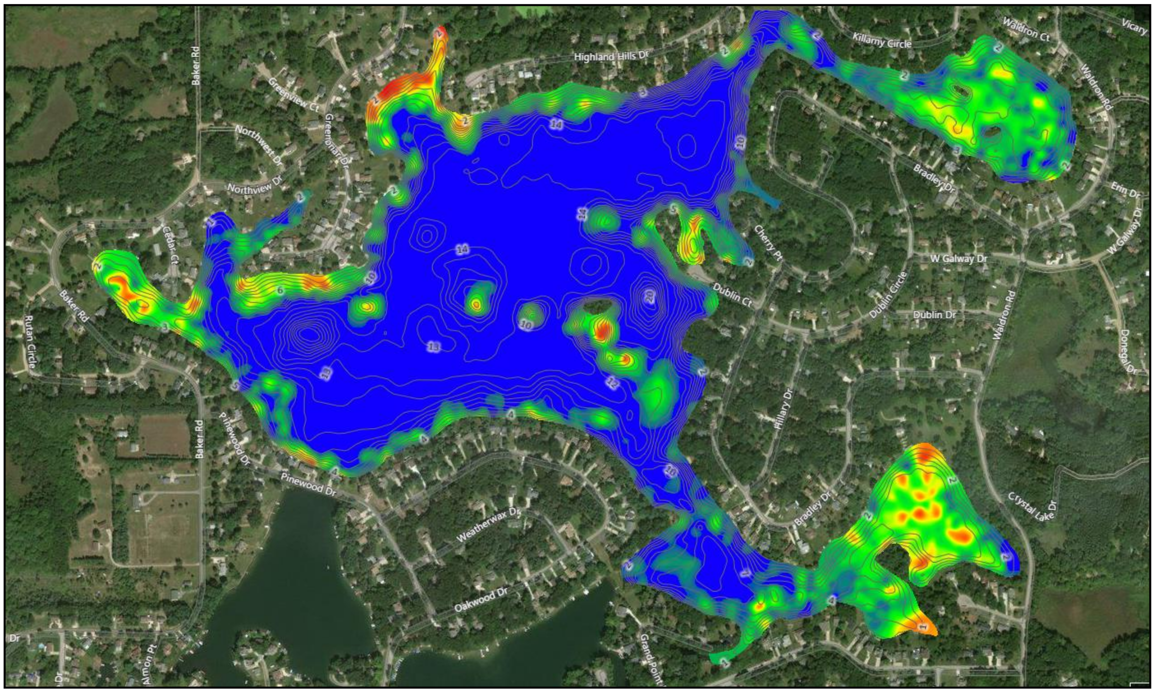


Figure 21. Lake LeAnn North Basin Aquatic Vegetation Biovolume (2020).

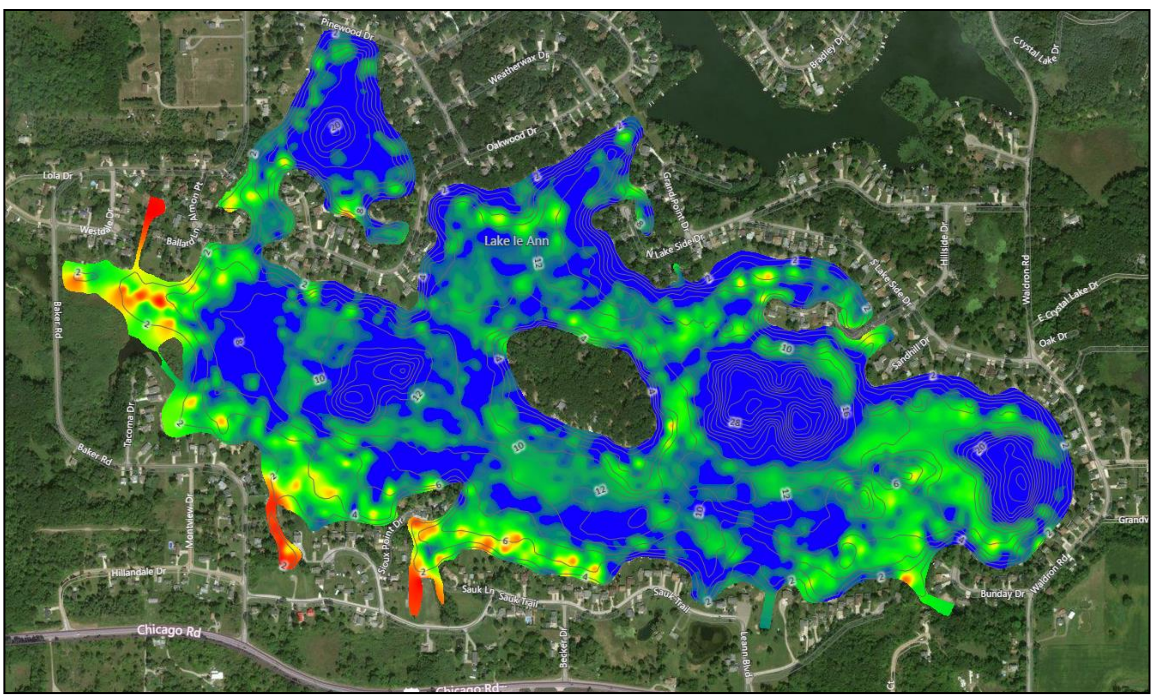


Figure 22. Lake LeAnn South Basin Aquatic Vegetation Biovolume (2020).

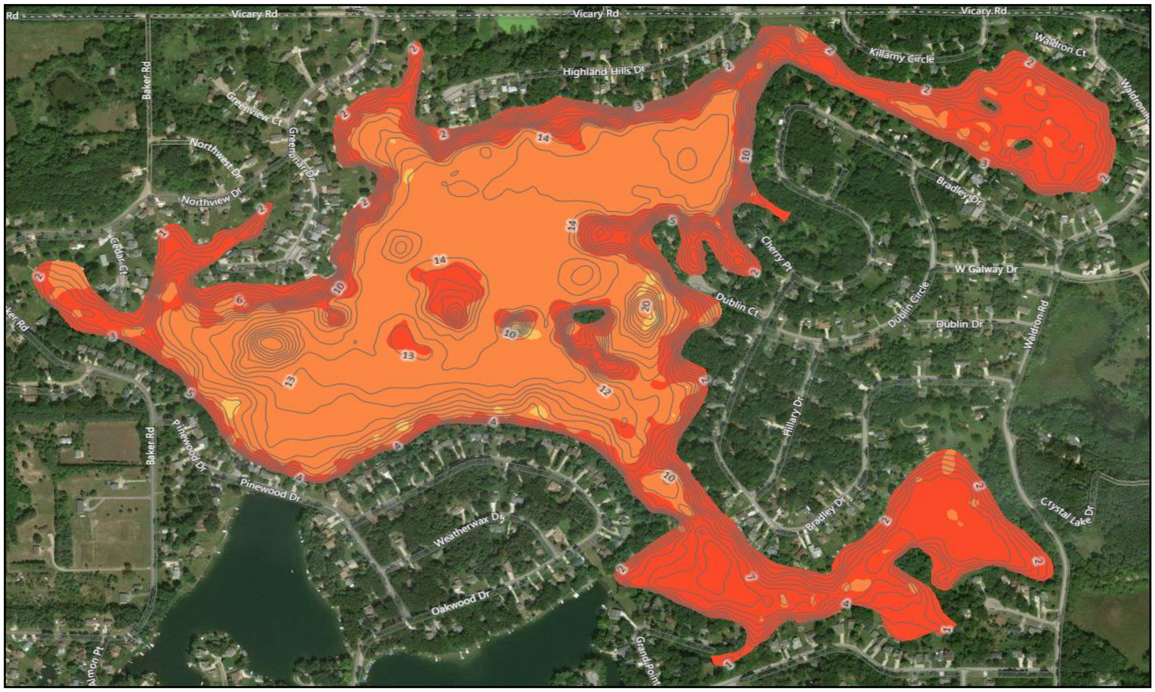


Figure 23. Lake LeAnn North Basin Sediment Bottom Hardness (2020).

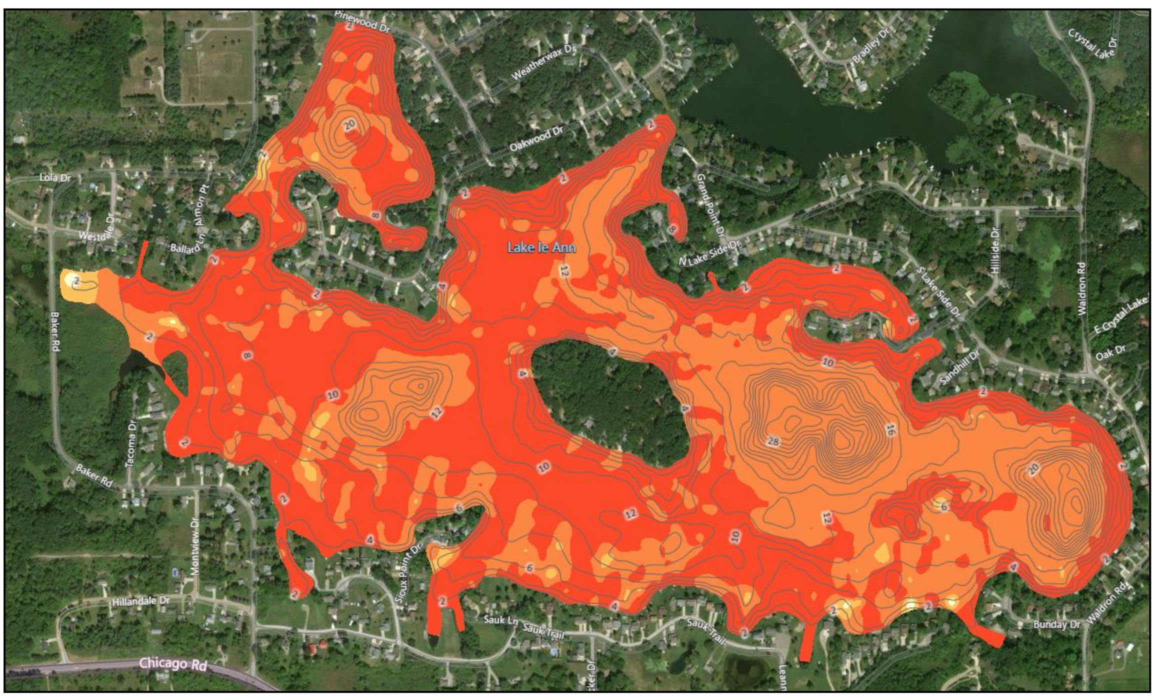


Figure 24. Lake LeAnn South Basin Sediment Bottom Hardness (2020).

Section

4

Management Recommendations for 2021

Continuous aquatic vegetation surveys are needed to determine the precise locations of Eurasian Watermilfoil (EWM), Curly-leaf Pondweed (CLP), Starry Stonewort (SS), or other problematic invasives and nuisance native aquatic plants in Lake LeAnn. These surveys should occur in late-May to early-June and again post-treatment in 2021 and are dependent upon weather conditions.

To reduce the prevalence of blue-green algae, treatment of native aquatic vegetation in Lake LeAnn should be minimized to the extent possible as submersed aquatic plants compete with algae for nutrients. Without an abundance of native aquatic plants, the algae are able to grow to nuisance levels. The plan for 2021 includes the use of high dose systemic aquatic herbicides for milfoil spot-treatments (liquid or granular formula) as EWM plants have become tolerant of the overuse of diquat over the past few years. Systemic herbicides are more costly but effectively reduce the plants through killing milfoil roots. Nuisance CLP can be treated with a contact herbicide such as diquat or hydrothol early in the season. It is important to continue to alternate use of different herbicides annually to avoid tolerance issues with the invasives.

RLS will again oversee all major treatments and will complete an audit form for these treatments.

Water quality parameters in both lakes will also be monitored as required by EGLE for the new laminar flow aeration (LFA) permit. RLS will be working closely with EGLE and the LLPOA Board to assure careful and thorough scientific evaluation of the LFA system and all impacts it has on Lake LeAnn. RLS is hopeful that the primary goals such as reduction of blue-green algae and nutrients are achieved with measurable results within a year or two. RLS has developed several metrics for objectively evaluating efficacy of the LFA system to help the LLPOA in future decision-making relative to the technology and lake benefits. RLS will issue an annual report that will be in the EGLE-required format but will be accompanied by a summary for all to quickly interpret annual results.

In conclusion, Lake LeAnn is a lake with favorable aquatic plant biodiversity that is currently threatened by an abundance of submersed aquatic plants. It has fair to good water clarity. The lake has elevated nutrient levels that arise from external tributaries that are also being addressed. The elevated nutrient loads increase the amount of all types of algae in the lake. Blue-green algae in particular have increased and can secrete toxins that prevent all forms of lake recreation and also can harm pets. RLS and the LLPOA are working collaboratively to manage both the immediate watershed and the lake basin through a combination of both in basin (LFA) and external (tributary and drain improvements) nutrient reductions.