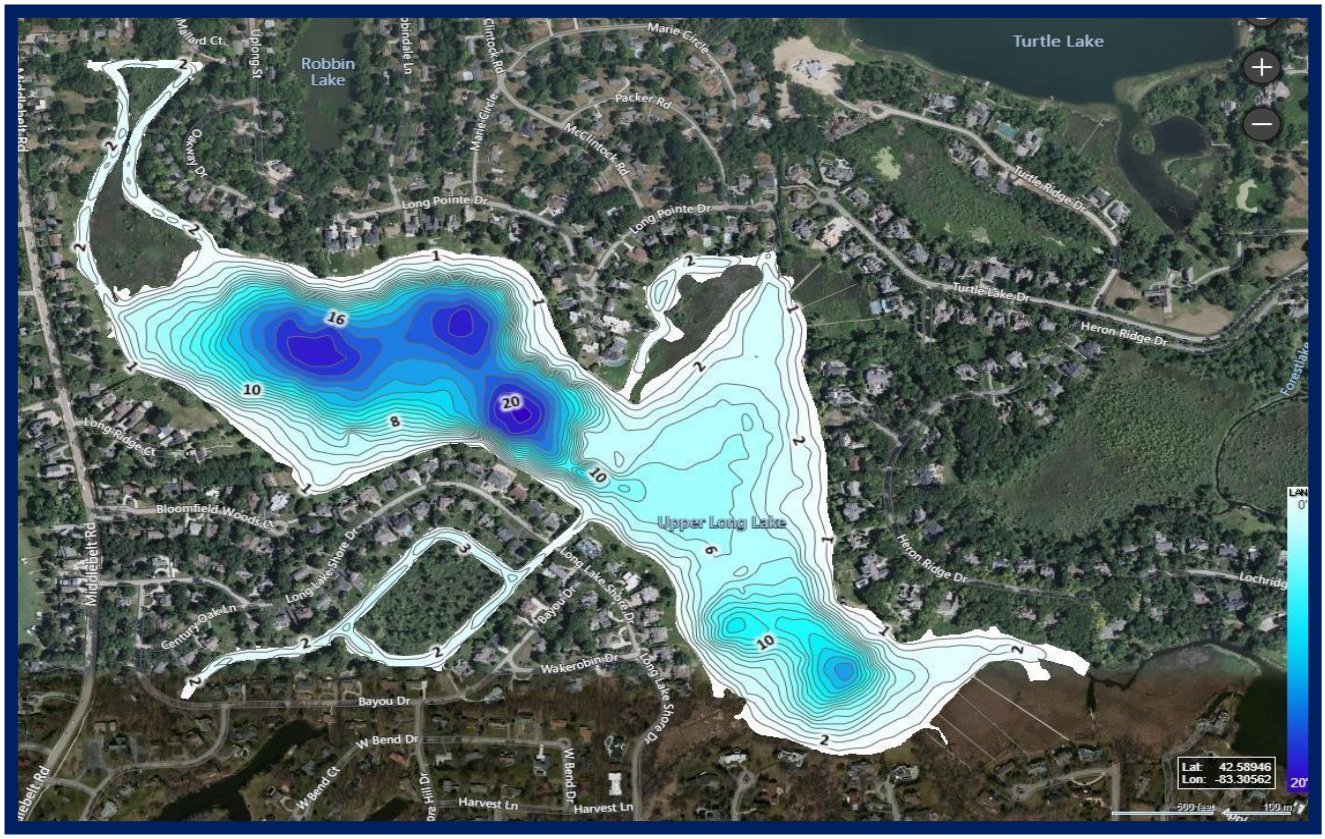
Upper Long Lake 2023 Aquatic Vegetation, Water Quality, and 2024 Management Recommendations Report



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Upper Long Lake 2023 Aquatic Vegetation, Water Quality, and 2024 Management Recommendations Report

The following information is a summary of key lake findings collected during 2023.

The water clarity and nutrients (phosphorus and nitrogen) for Upper Long Lake are favorable to support some algae and submersed aquatic plant growth. Invasive species such as Eurasian Watermilfoil (EWM), Curly-leaf Pondweed (CLP), Starry Stonewort, Purple Loosestrife, Flowering Rush, and Phragmites are able to grow in moderate nutrient waters and thus are a challenge to the Upper Long Lake ecosystem. During the 2023 survey, 73.5 acres of EWM were found, 2.9 acres of Starry Stonewort were found, and 1 location of Purple Loosestrife, 2 locations of Phragmites, and 7 locations of Flowering Rush were found.

Protection of the 23 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 (i.e., lily pads or nuisance growth in swim areas). The plan for 2024 will include whole-lake aquatic vegetation sampling and scanning and spot-treatment of remaining invasives (Eurasian Watermilfoil, Curly-leaf Pondweed, Starry Stonewort, Purple Loosestrife, Flowering Rush, and Phragmites) via harvesting or herbicide treatments as needed. RLS recommends reducing the increasing EWM cover with a safe and effective systemic herbicide such as ProcellaCOR. The water quality of Upper Long Lake in 2023 was good with a mean Secchi transparency of 10.2 feet and a mean total phosphorus concentration of 14.0 µg/L which is very good and well below the eutrophic threshold of 25.0 µg/L. The mean chlorophyl-a concentration was 2.7 µg/L which is also favorable. Dissolved oxygen concentrations did decline with depth at all three deep basins. The mean specific conductivity was 656 mS/cm which is an improvement from some recent years. The total Kjeldahl nitrogen was also ≤1.2 mg/L which is favorable.

Section

2

2023 Upper Long Lake Water Quality Data

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. These parameters include water temperature (measured in °F), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), conductivity (measured in micro-Siemens per centimeter-µS/cm), total dissolved solids (mg/L), Secchi transparency (feet), total phosphorus (in µg/L) and total Kjeldahl nitrogen (in mg/L), chlorophyll-*a* (in µg/L), and algal species composition. Water quality was measured in the three deep basin of Upper Long Lake (Figure 1) on June 21, 2023.

Figure 1. Deep basin water quality sampling sites in Upper Long Lake (June 21, 2023).

Table 1 below demonstrates how lakes are classified based on key parameters. Upper Long Lake would be considered eutrophic (relatively productive) since it contains ample phosphorus, nitrogen, algae, and aquatic vegetation growth. The 2023 water quality data for Upper Long Lake is shown below in Tables 2-4.

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**

Deep Basin Water Quality Data

Table 2. Upper Long Lake water quality parameter data collected in the Western Deep Basin (Site #1) on June 21, 2023.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. $\mu S\ cm^{-1}$*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Chl-a μgL^{-1}*	*Total Phos. $\mu g\ L^{-1}$*
0	75.7	9.5	8.7	647.9	1.0	3.0	<10
10	73.5	9.8	8.7	645.9	1.0	--	<10
19	64.5	0.55	7.8	673.4	0.6	--	0.011

Table 3. Upper Long Lake water quality parameter data collected in the Central Deep Basin (Site #2) on June 21, 2023.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Chl-a µgL^{-1}*	*Total Phos. µg L^{-1}*
0	75.8	9.6	8.8	644.7	0.9	3.0	11
8	73.5	10.0	8.8	643.5	0.9	--	<10
16	66.8	3.3	8.1	665.8	0.9	--	<10

Table 4. Upper Long Lake water quality parameter data collected in the Eastern Deep Basin (Site #3) on June 21, 2023.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Chl-a µgL^{-1}*	*Total Phos. µg L^{-1}*
0	75.6	10.6	8.9	638.7	1.2	2.0	<10
8	70.0	11.4	8.9	637.0	1.1	--	<10
16	62.6	0.94	7.9	702.3	0.9	--	0.035

Water Clarity (Transparency) Data

Secchi transparency is a measure of water clarity using a weighted disk with black and white markings. The depth is recorded as a mean of the depth at which the disk disappears and reappears. Elevated Secchi transparency readings allow for more aquatic plant and algae growth. Secchi transparency depends on the amount 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. During the 2023 sampling event, Upper Long Lake had an average Secchi reading of 10.2 feet (Figure 2).

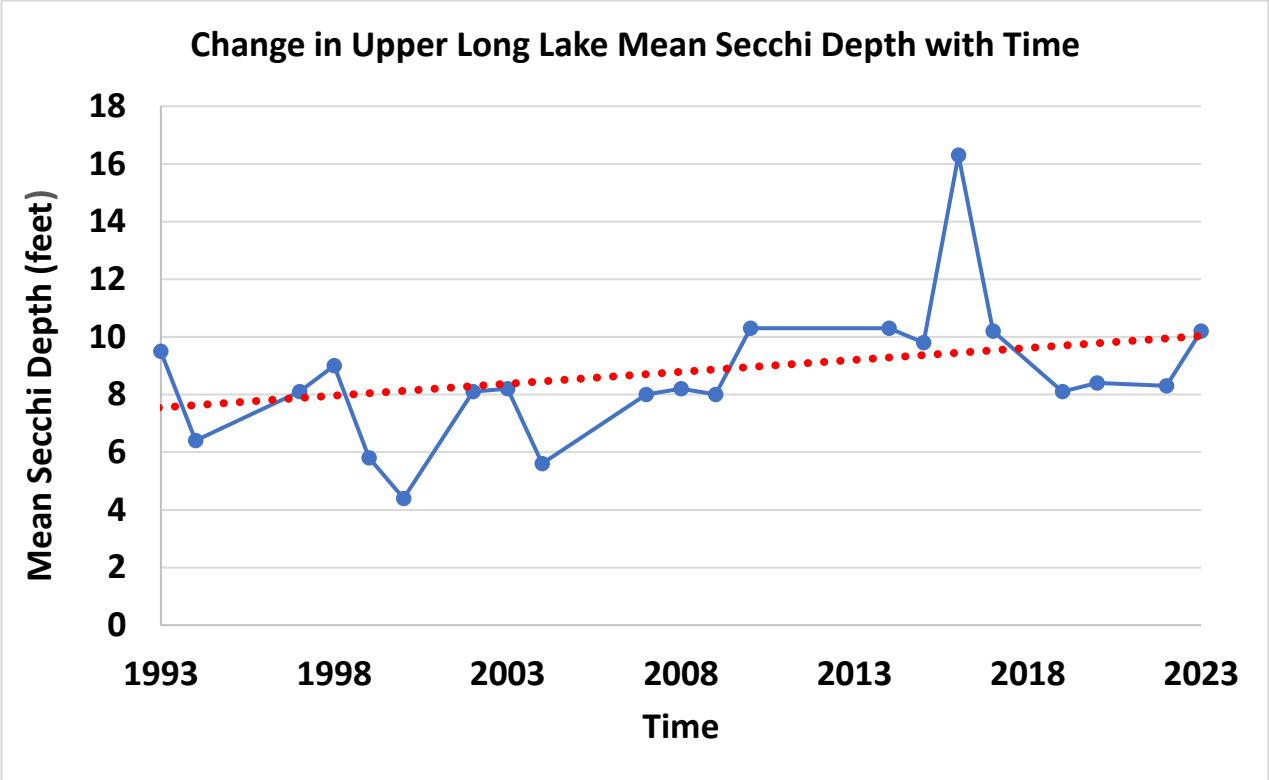

Figure 2. Graph showing changes in Upper Long Lake mean Secchi depth with time.

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 and due to mineralization. Phosphorus may also be released from sediments as pH increases. In summer, the dissolved oxygen levels are lower at the bottom and likely cause release of phosphorus from the bottom. TP concentrations ranged from <10-35 µg L^{-1} from top to bottom during the 2023 sampling event. These TP concentrations are moderate for a lake the size and depth of Upper Long Lake and are ample to promote aquatic vegetation and algae growth. Figure 3 shows the trend in TP in Upper Long Lake with time.

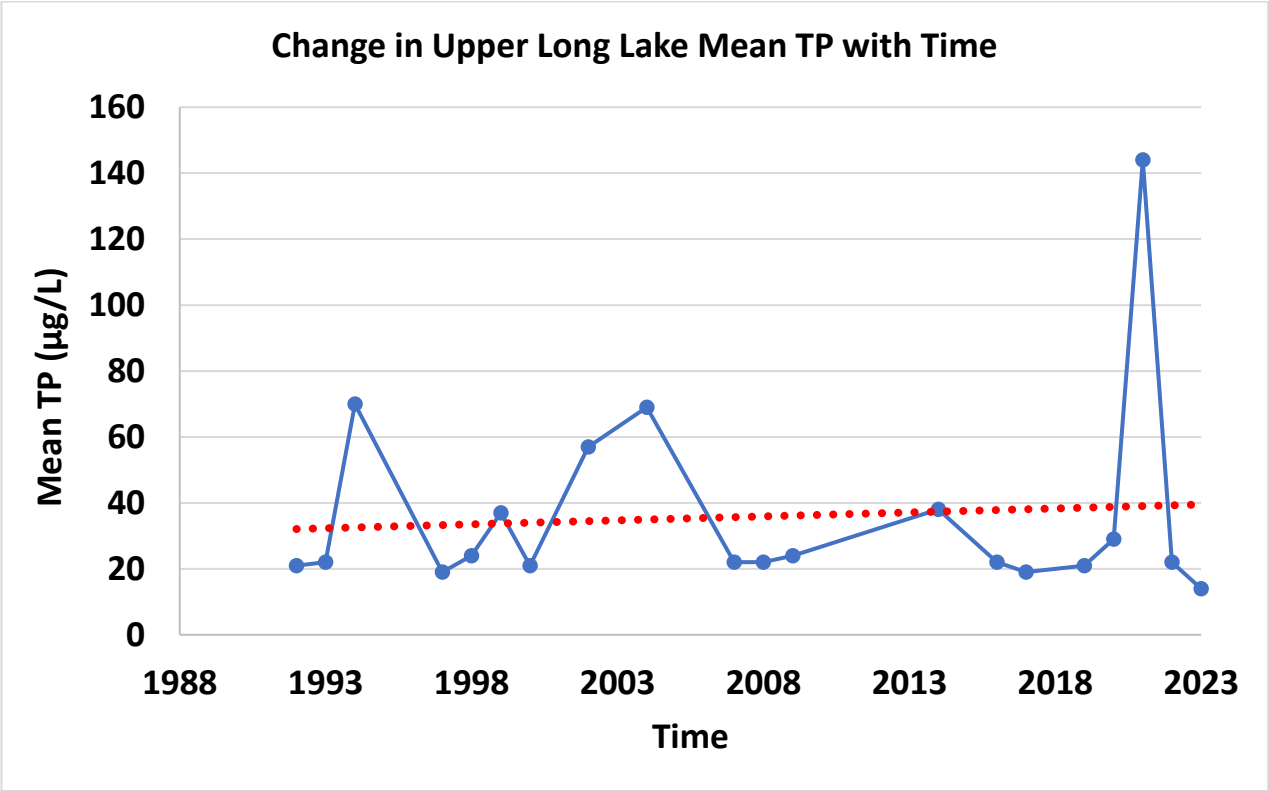

Figure 3. Graph showing changes in Upper Long Lake mean total phosphorus with time.

pH

Most Michigan lakes have pH values that range from 6.5 to 9.5 with typical being slightly basic (pH>7.0). 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). Upper Long Lake is considered "slightly basic" on the pH scale. The pH of Upper Long Lake ranged from 7.8-8.9 S.U. during the 2023 sampling event, which is ideal for an inland lake. pH is usually lower at the lake bottom and can increase when aquatic vegetation is actively growing due to photosynthesis. Figure 4 shows the trend in pH in Upper Long Lake with time.

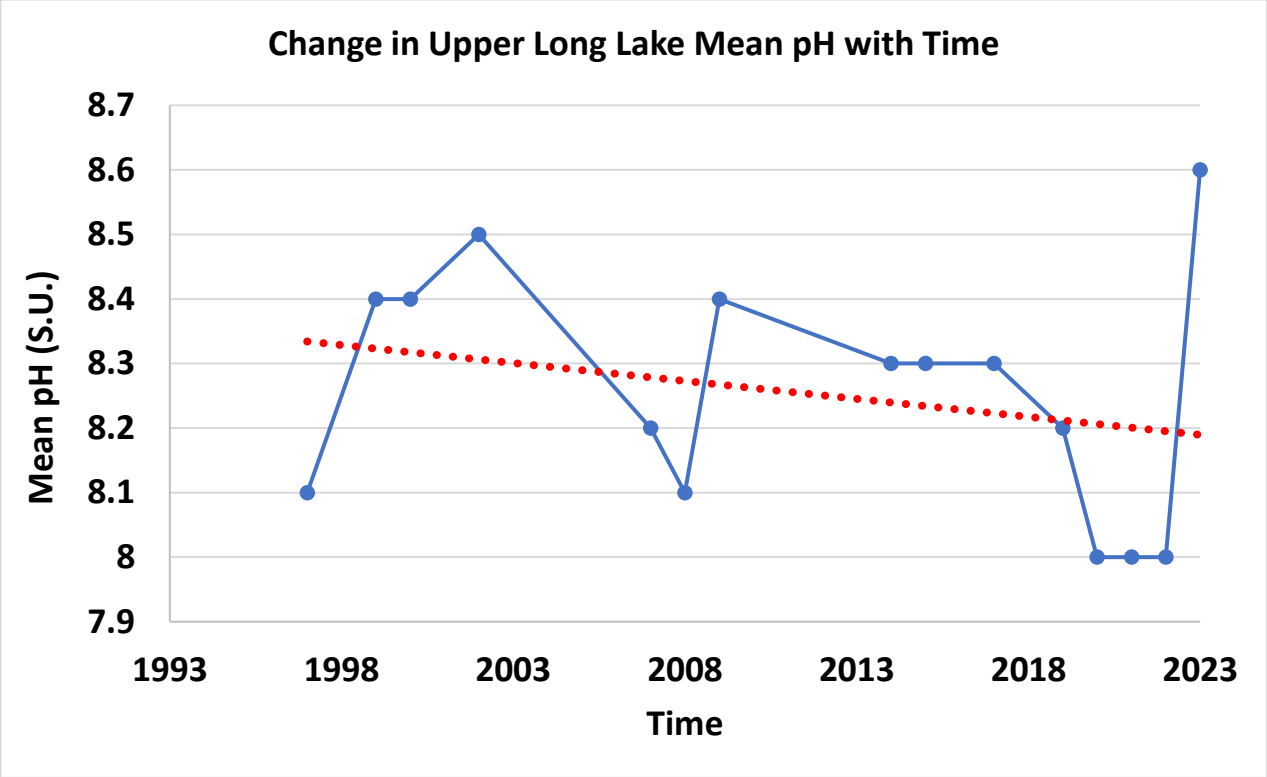

Figure 4. Graph showing changes in Upper Long Lake mean pH with time.

Conductivity

Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. The conductivity values for Upper Long Lake were moderate during the 2023 sampling event and ranged from 637.0-702.3 µS/cm. Severe water quality impairments in freshwater lakes do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm. Figure 5 shows the trend in conductivity in Upper Long Lake with time.

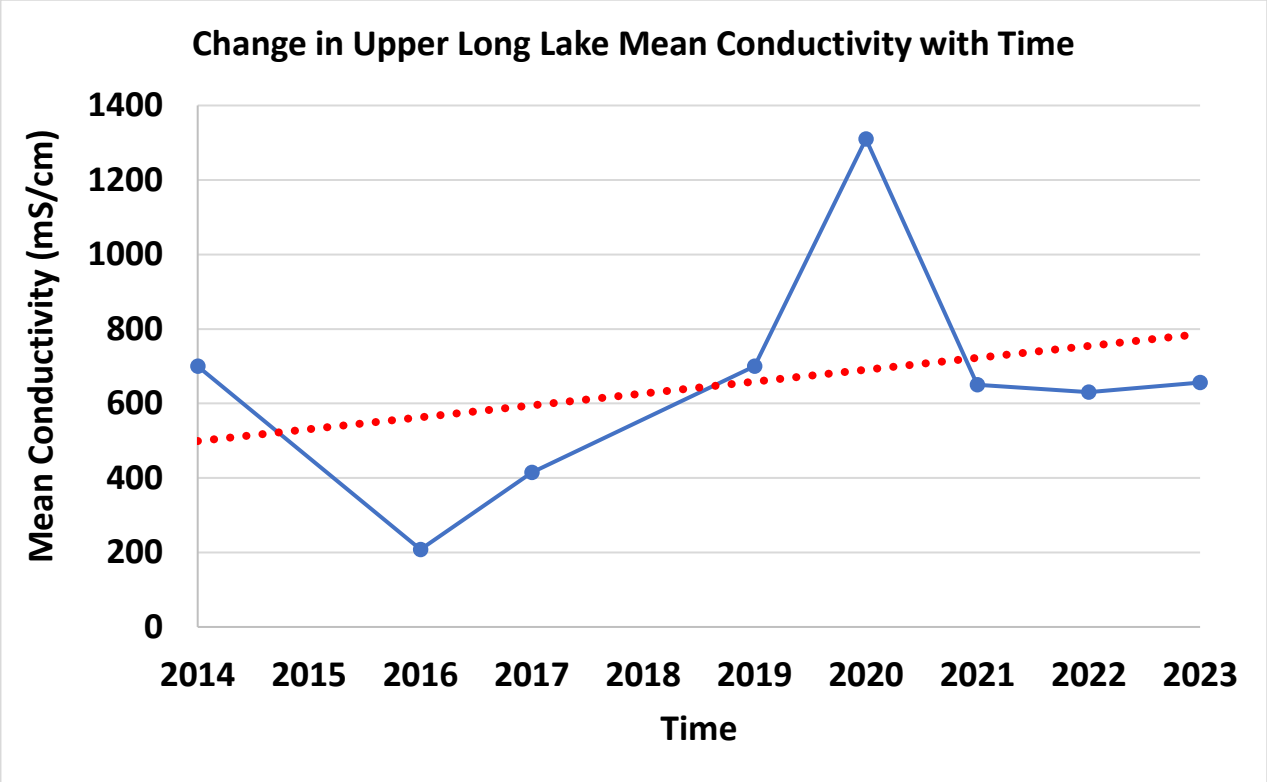

Figure 5. Graph showing changes in Upper Long Lake mean specific conductivity with time.

Chlorophyll-*a* and Algal Species Composition

Chlorophyll-a is the primary photosynthetic pigment found in all plants and algae. 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 µg 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 average chlorophyll-*a* concentration during the 2023 sampling event in Upper Long Lake was 2.7 µg/L which is moderate for an inland Michigan lake but could use some improvement.

The algal genera were determined from composite water samples collected over the deep basins of Upper Long Lake in 20223 and were analyzed with a bright field microscope. The genera present included the Chlorophyta (green algae; Figure 6): *Chlorella* sp., *Phacus* sp., and *Haematococcus* sp.; The Cyanophyta (blue-green algae; Figure 7): *Gleocapsa* sp.; the Bascillariophyta (diatoms)*: Fragilaria* sp. and *Cymbella* sp (Figure 8). The aforementioned species indicate a moderately diverse algal flora and represent a good diversity of algae. Photos of the general algae types are shown below.

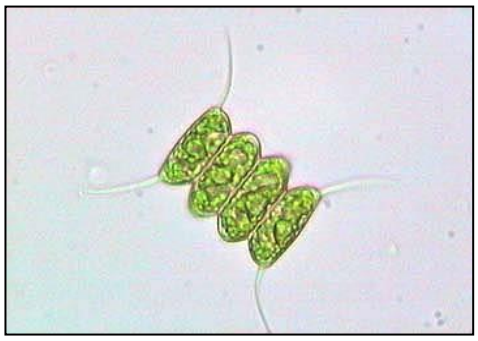

Figure 6. A Green Alga

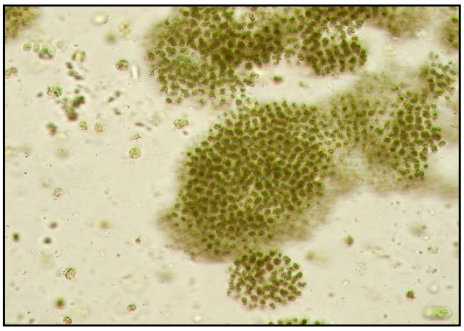

Figure 7. A Blue-Green Alga

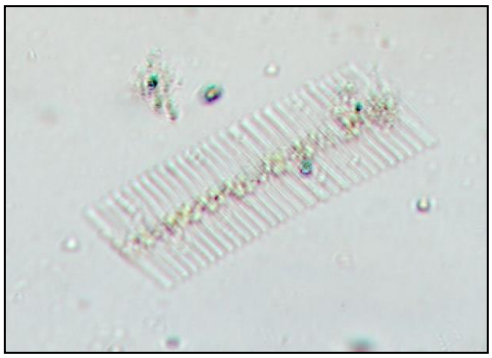

Figure 8. A Diatom Alga

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 5.0 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^{-1}) with the use of a calibrated Eureka Manta II® dissolved oxygen meter. June 21, 2023 dissolved oxygen (DO) concentrations in the sampling basins ranged from 0.9-11.4 mg L^{-1}, with the highest values measured at the mid-depth and lowest values near the lake bottom. The bottom of the lake produces a biochemical oxygen demand (BOD) due to microbial activity attempting to break down high quantities of organic plant and algal matter, which reduces dissolved oxygen in the water column at depth. Furthermore, the lake bottom is more 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. The mean DO in Upper Long Lake has remained similar over time (Figure 9).

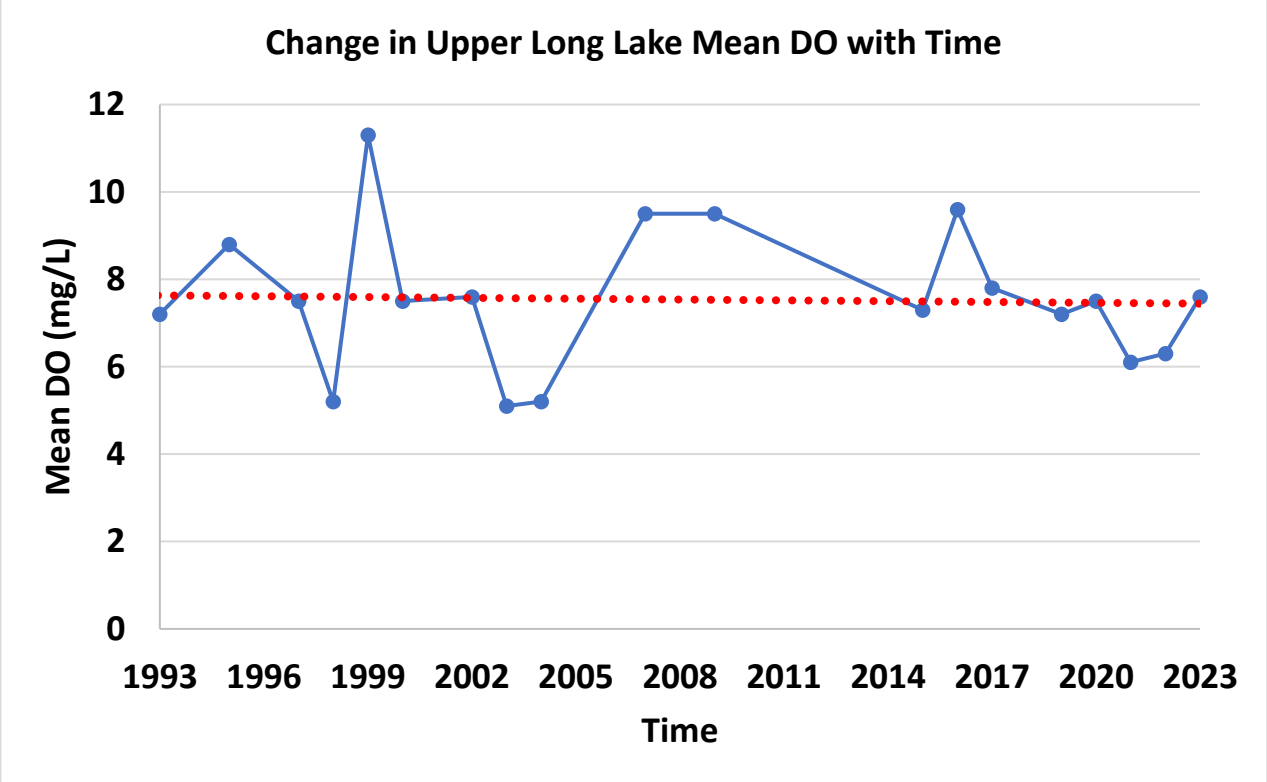

Figure 9. Graph showing changes in Upper Long Lake mean dissolved oxygen with time.

Lake Level Data

RLS reviewed recent and historical lake level data for Upper Long Lake to create Figure 10 below. As is evident, the lake level will fluctuate annually due to precipitation events. Based on the conductivity and other variable data graphed above, it is apparent that Upper Long Lake is prone to flashy storm events which may significantly increase conductivity or other parameters. The majority of the lake level values listed below fall between 26-39 inches. The mean lake level in 2023 was 31.6 inches. This occurrence is normal for a lake with an outlet control structure.

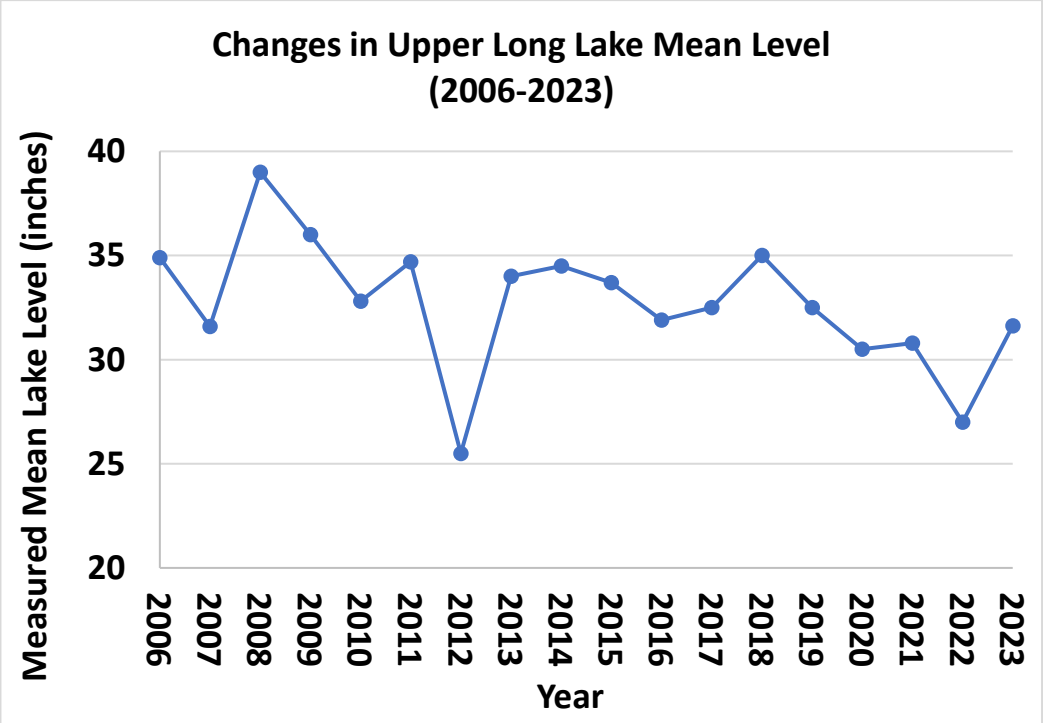

Figure 10. Graph showing changes in Upper Long Lake level with time.

Section

3

Aquatic Vegetation Data 2023

Status of Native Aquatic Vegetation in Upper Long Lake

Native aquatic vegetation is essential for the overall health of the lake and the support of the lake fishery. The whole-lake aquatic vegetation survey and aquatic vegetation biovolume scan (Figure 11) on June 21, 2023 utilized 217 geo-referenced GPS points and determined that there were a total of 23 native aquatic plant species. These include 14 submersed plant species, 1 floating-leaved plant species, and 8 emergent plant species. This indicates a very high biodiversity of aquatic vegetation in Upper Long Lake. The overall % cover of the lake by native aquatic plants can is low relative to the size and depth of the lake. These plants should be protected unless growing near swim areas at nuisance levels.

Among the most dominant native aquatic plants was the macro alga, Chara (Figure 12) which lies close to the lake bottom and serves as an excellent fish spawning habitat. In addition, Chara also helps to keep the small sediment particles from being suspended in the water column. This plant has a distinctive musky odor which smells skunk-like. The second most abundant species found was the Sago Pondweed (Figure 13), another submersed native that has thin, long, dense clumps of leaves that are placed alternately around the stem.

A list of all native aquatic plant species found in Upper Long Lake in 2023 is shown in Table 5 below.

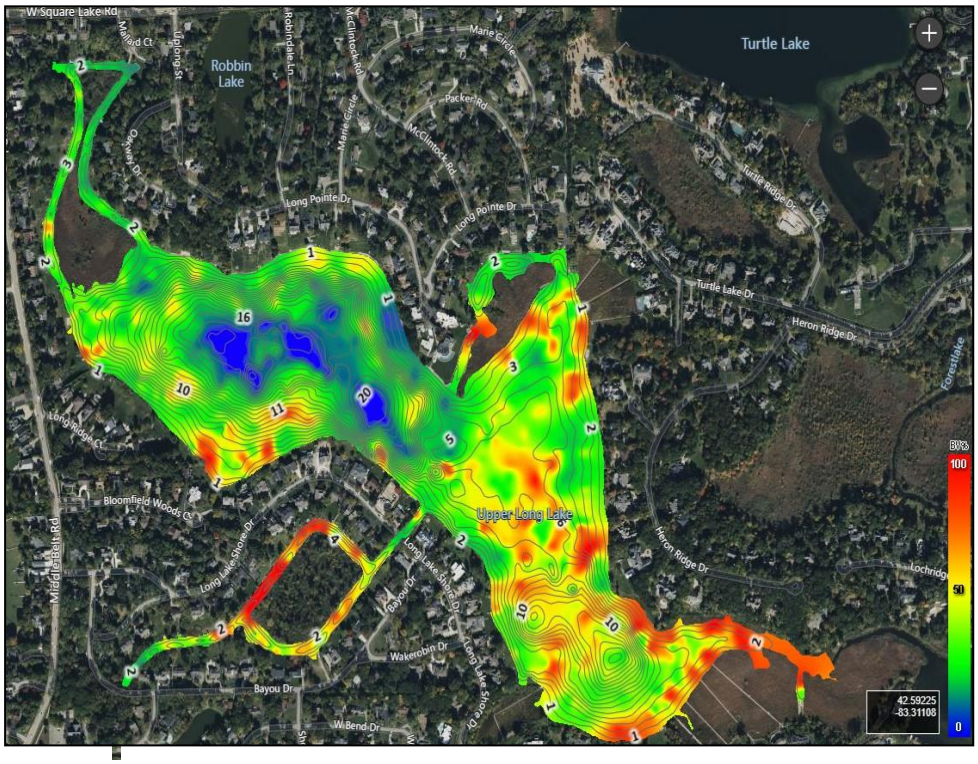

Figure 11. Biovolume of Upper Long Lake (June 21, 2023).

Figure 12. Chara

Figure 13. Sago Pondweed

Table 5. Upper Long Lake Native Aquatic Plant Species (June 21, 2023).

Aquatic Plant Species	Common Name	Growth Form	Frequency (%)
Chara vulgaris	Muskgrass	Submersed	22.5
Potamogeton zosteriformis	Flat-stem Pondweed	Submersed	3.3
Potamogeton robbinsii	Robbins Pondweed	Submersed	0.2
Potamogeton richardsonii	Richardson's Pondweed	Submersed	1.2
Potamogeton illinoensis	Illinois Pondweed	Submersed	8.1
Potamogeton amplifolius	Large-leaf Pondweed	Submersed	2.3
Potamogeton nodosus	American Pondweed	Submersed	0.2
Potamogeton natans	Floating-leaf Pondweed	Submersed	1.2
Vallisneria americana	Wild Celery	Submersed	12.6
Myriophyllum verticillatum	Whorled Water Milfoil	Submersed	1.2
Elodea canadensis	Elodea	Submersed	7.9
Ceratophyllum demersum	Coontail	Submersed	0.2
Utricularia sp.	Bladderwort	Submersed	0.6
Stuckenia pectinata	Sago Pondweed	Submersed	13.2
Lemna minor	Duckweed	Floating-leaf	2.1
Nymphaea sp.	White Lily	Emergent	6.2
Nuphar sp.	Yellow Lily	Emergent	3.5
Brasenia sp.	Water Shield	Emergent	0.2
Sagittaria sp.	Pickerelweed	Emergent	1.4
Typha latifolia	Cattails	Emergent	8.7
Schoenoplectus sp.	Bullrushes	Emergent	1.0
Decodon verticillata	Swamp Loosestrife	Emergent	1.7
Iris sp.	Iris	Emergent	0.6

Status of Invasive (Exotic) Aquatic Vegetation in Upper Long Lake

The June 21, 2023 survey of aquatic plants in Upper Long Lake determined the presence of 4 invasive aquatic plant species, including, Eurasian Watermilfoil (Figure 14), Starry Stonewort (Figure 15), and the emergents Phragmites, Purple Loosestrife, and Flowering Rush (Figure 16). Based on this survey, approximately 73.5 acres of invasive watermilfoil were found throughout the lake, which is a large increase from 2022. In addition, approximately 2.9 acres of invasive Starry Stonewort were found throughout the lake. Invasive emergents were also found scattered around the lake shoreline and wetlands with 2 locations of Phragmites, 1 location of Purple Loosestrife, and 7 locations of Flowering Rush.

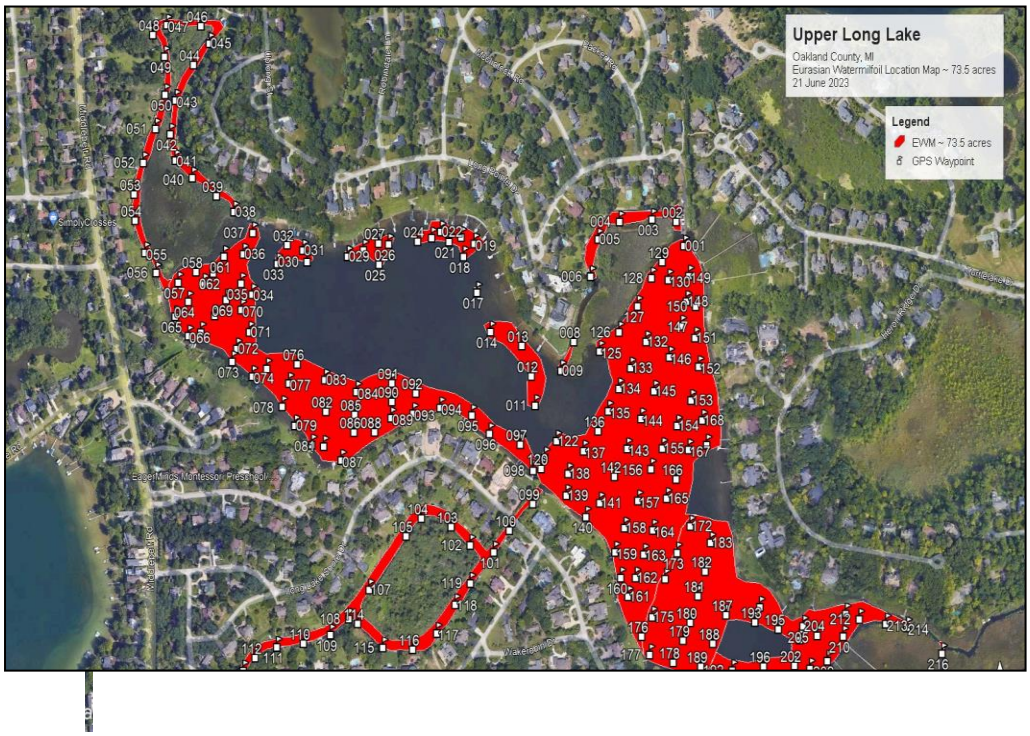

Figure 14. Invasive EWM found in Upper Long Lake (June 21, 2023).

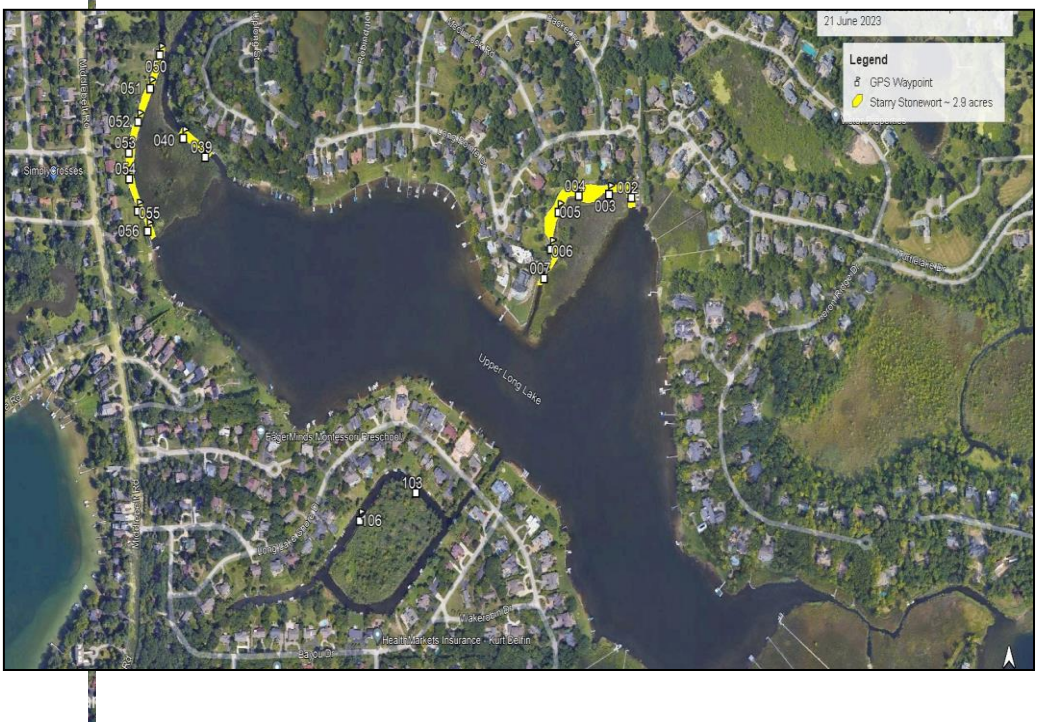

Figure 15. Invasive Starry Stonewort found in Upper Long Lake (June 21, 2023).

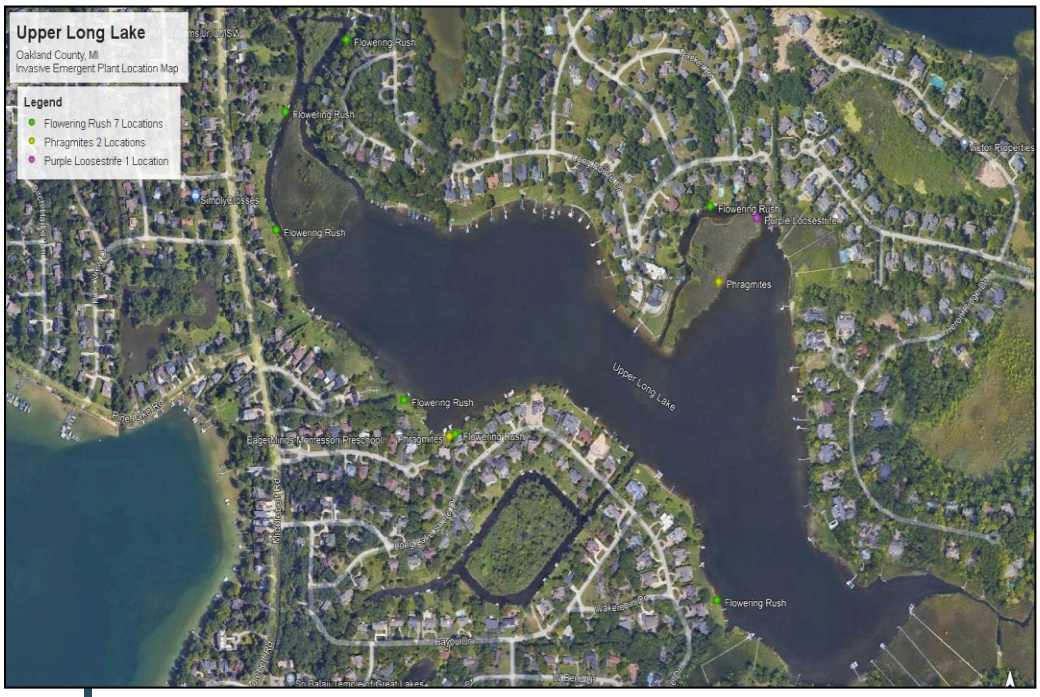

Figure 16. Invasive emergent Flowering Rush and *Phragmites* found in Upper Long Lake (June 21, 2023).

Section

4

Management Recommendations for 2024

Continuous aquatic vegetation surveys are needed to determine the precise locations of EWM or other problematic invasives or dense nuisance native aquatic vegetation in and around Upper Long Lake. These surveys should occur in late May to early-June and again post-harvest in 2024. The lake-wide aquatic vegetation scan and survey of Upper Long Lake by RLS in 2023 determined the presence of 23 native aquatic plant species but this will differ each season. Efforts to preserve this biodiversity should be continued which includes the removal of nuisance milfoil biomass with mechanical harvesting as in previous years or consideration of a systemic herbicide treatment to effectively reduce the EWM cover that continues to threaten the native aquatic plant biodiversity.

Water quality monitoring of the lake deep basins by RLS in 2023 showed the presence of reduced nutrients such as phosphorus and nitrogen and favorable chlorophyll-a concentrations. The TP and TKN concentrations were much lower in 2023 at all depths and this is likely due to less rainfall and runoff throughout the season. This may indicate that Upper Long Lake is very sensitive to runoff. The conductivity was also lower in 2023 which is favorable and indicative of less runoff.

RLS still recommends biofilters at some of the key drainage areas and also continued monitoring from RLS scientists once the filters are in place to compare baseline data to post-filtration data. This requires permission and a permit from EGLE but was shown by RLS in 2023 to have substantial efficacy on nutrient reduction from drains on a lake in Oceana County.