



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



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Native Whorled Watermilfoil

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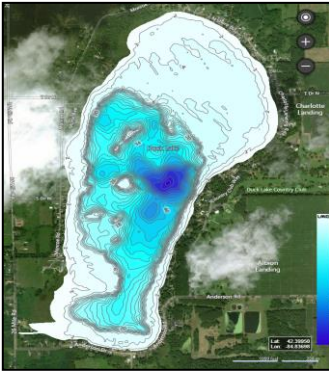
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According to RLS scientists, the overall condition of Duck Lake is ranked in the top 15% of developed lakes of similar size in the state of Michigan as measured in the late summer of 2023. The water clarity ranged from 10.0-22.0 feet in 2023 which is excellent.

Invasive species such as Eurasian Watermilfoil (EWM) and Curly-leaf Pondweed (CLP) are able to grow in moderate nutrient waters and thus are a challenge to the Duck Lake ecosystem. A newer systemic herbicide (ProcellaCOR®) was used in 2023, along with diquat given the overlap between EWM and CLP in many locations. Annual rotation of products reduces tolerance of the EWM and allows for improved efficacy. Protection of the twenty-five 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).

The lake was sampled on August 2, 2023. It was strongly stratified due to its great depth and the dissolved oxygen was plentiful at the surface and mid-depth with marked depletion near the lake bottom. Chlorophyll-a concentrations were also moderately low and also correlate with the observed high water clarity throughout the season. Conductivity was moderate and the pH was ideal. The nutrient (N and P) concentrations are moderate with elevated phosphorus near the bottom. The bottom TP is still remarkably low for a deep lake at only 47 µg/L, whereas many deep lakes have bottom TP concentrations over 100 µg/L.

Duck Lake Water Quality Data (2023)



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- $\mu\text{S}/\text{cm}$), total dissolved solids (mg/L), Secchi transparency (feet), total phosphorus and total nitrogen (both in mg/L), chlorophyll-a (in $\mu\text{g}/\text{L}$), and algal species composition. Water quality was measured in the deep basin of Duck Lake on August 2, 2023.

Table 1 below demonstrates how lakes are classified based on key parameters. Duck Lake would be considered mesotrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but has good water clarity and moderate algal growth. 2023 water quality data for Duck Lake is shown below in Table 2.

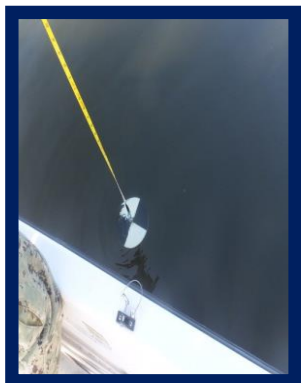
Table 1. Lake trophic classification (MDNR).

<i>Lake Trophic Status</i>	<i>Total Phosphorus ($\mu\text{g L}^{-1}$)</i>	<i>Chlorophyll-a ($\mu\text{g L}^{-1}$)</i>	<i>Secchi Transparency (feet)</i>
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. Duck Lake water quality parameter data collected in the deep basin (August 2, 2023).

<i>Depth (m)</i>	<i>Water Temp °C</i>	<i>DO mg/l</i>	<i>pH S.U.</i>	<i>Cond. μS cm⁻¹</i>	<i>Turb. NTU</i>	<i>TKN mg/l</i>	<i>TP mg/l</i>	<i>TSS mg/l</i>
0	26.0	8.3	8.7	347	0.3	0.7	0.027	<10
3	25.8	8.7	8.7	347	0.9	--	--	--
6	20.4	2.2	8.2	372	1.3	--	--	--
9	12.2	0.7	7.8	382	2.5	0.6	0.016	<10
12	10.6	0.1	7.8	390	2.9	--	--	--
15	10.0	0.0	7.7	392	3.3	--	--	--
16	10.0	0.0	7.7	393	3.8	--	--	--
17	9.8	0.0	7.6	400	3.8	1.5	0.047	<10

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. The transparency throughout Duck Lake was adequate in 2023 (10.0-22.0 feet; RLS data) to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake. 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. Other parameters such as turbidity (measured in NTU's) are correlated with water clarity and show an increase as clarity decreases. The turbidity and total dissolved solids in Duck Lake were quite low at ≤3.8 NTU's and ≤180 mg L⁻¹, respectively during the 2023 sampling event. Drinking water has turbidity values ≤5.0 NTU's. (NOTE: filter any lake water before drinking).

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 0.027 mg L⁻¹ at the surface to 0.047 mg L⁻¹ at the bottom during the August sampling event. It is interesting that the mid-depth TP concentration was lower than at the surface but this can occur in lake systems, especially if recent rains increased runoff in the upper water layer that could result in slightly elevated TP concentrations at the surface.

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). Duck Lake is considered neutral to “slightly basic” on the pH scale. The pH of Duck Lake ranged from 7.6-8.7 S.U. 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. The lower pH observed near the lake bottom was likely due to increased respiration by sediment bacteria.



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 Duck Lake were moderate and ranged from 347-400 µS/cm which is within a similar range for previous years. 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.

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 $6 \mu\text{g L}^{-1}$ are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than $2.2 \mu\text{g/L}$ are found in nutrient-poor or oligotrophic lakes. The mean chlorophyll-*a* concentrations in August of 2023 in Duck Lake were around $2.0 \mu\text{g/L}$ which is moderate for an inland Michigan lake and favorable in the summer for the lake. These measurements were collected using a calibrated Turner Designs® *in situ* fluorimeter.

The algal genera were determined from composite water samples collected over the deepest basin of Duck Lake in 2023 were analyzed with a Zeiss® compound bright field microscope (photo below). The genera present included the Chlorophyta (green algae): *Chlorella* sp., *Ulothrix* sp., *Cosmarium* sp., *Rhizoclonium* sp., and *Merismopedia* sp. The Cyanophyta (blue-green algae): *Gleocapsa* sp., and *Nostoc* sp.; the Bascillariophyta (diatoms; Figure 3): *Synedra* sp., *Navicula* sp., *Fragilaria* sp., and *Cymbella* sp. The aforementioned species indicate a diverse algal flora and represent a good diversity of alga with an abundance of diatoms that are indicative of great water quality.



Aquatic Vegetation Data (2023)

Status of Native Aquatic Vegetation in Duck Lake

Native aquatic vegetation is essential for the overall health of the lake and the support of the lake fishery. Although there were three surveys conducted on the lake in 2023, late season inventory is best to record all native aquatic plant species since many do not germinate in the spring. The whole-lake aquatic vegetation survey on August 2, 2023 determined that there were a total of twenty-four native aquatic plant species. These include fourteen submersed species, five floating-leaved species, and six emergent species for a total of 25 native species. The most common native aquatic plant species in 2023 included Sago Pondweed (first photo) and the macro alga Chara (second photo). The current biodiversity of aquatic vegetation in Duck Lake is ideal to support a healthy fishery.

This means that there are a lot of different aquatic plants that serve varying functions in the ecology of Duck Lake. The overall percent cover of the lake by native aquatic plants is low relative to the lake size due to the great mean depth and thus these plants should be protected unless growing near swim areas at substantial nuisance levels. A list of all current native aquatic plant species is shown below in Table 3.



Table 3. Duck Lake Native Aquatic Plant Species and Relative Abundance (August 2, 2023).

Native Aquatic Plant Species Name	Native Aquatic Plant Common Name	Abundance in/around Duck Lake	Native Aquatic Plant Growth Habit
<i>Chara vulgaris</i>	Muskgrass	63.6	Submersed, Rooted
<i>Potamogeton pectinatus</i>	Thin leaf (Sago) Pondweed	79.0	Submersed, Rooted
<i>Potamogeton zosteriformis</i>	Flatstem Pondweed	0.9	Submersed, Rooted
<i>Potamogeton robbinsii</i>	Fern-leaf Pondweed	0.3	Submersed, Rooted
<i>Potamogeton amplifolius</i>	Large-leaf Pondweed	0.1	Submersed, Rooted
<i>Potamogeton gramineus</i>	Variable-leaf Pondweed	2.6	Submersed, Rooted
<i>Potamogeton richardsonii</i>	Clasping-leaf Pondweed	1.0	Submersed, Rooted
<i>Potamogeton pusillus</i>	Small-leaf Pondweed	0.2	Submersed, Rooted
<i>Potamogeton illinoensis</i>	Illinois Pondweed	30.5	Submersed, Rooted
<i>Vallisneria americana</i>	Wild Celery	7.5	Submersed, Rooted
<i>Myriophyllum verticillatum</i>	Whorled Watermilfoil	14.8	Submersed, Rooted
<i>Ceratophyllum demersum</i>	Coontail	0.1	Submersed, Non-Rooted
<i>Utricularia vulgaris</i>	Bladderwort	0.7	Submersed, Non-Rooted
<i>Najas guadalupensis</i>	Southern Naiad	50.5	Submersed, Rooted
<i>Nymphaea odorata</i>	White Waterlily	7.5	Floating-Leaved, Rooted
<i>Nuphar variegata</i>	Yellow Waterlily	5.9	Floating-Leaved, Rooted
<i>Brasenia schreberi</i>	Watershield	0.1	Floating-Leaved, Rooted
<i>Lemna minor</i>	Duckweed	2.0	Floating-Leaved, non-rooted
<i>Azolla</i> sp.	Watermeal	0.2	Floating-Leaved, non-rooted
<i>Typha latifolia</i>	Cattails	11.5	Emergent
<i>Schoenoplectus acutus</i>	Bulrushes	4.3	Emergent
<i>Sagittaria</i> sp.	Arrowhead	0.9	Emergent
<i>Pontedaria cordata</i>	Pickerelweed	0.9	Emergent
<i>Decodon verticillatus</i>	Swamp Loosestrife	3.3	Emergent
<i>Iris</i> sp.	Iris	0.1	Emergent

Status of Invasive (Exotic) Aquatic Vegetation in Duck Lake

Eurasian Watermilfoil (EWM) is an invasive, submersed aquatic plant that spreads through fragmentation, seed dispersal, and underground stolons. A lake management plan study conducted by RLS in 2015 found that approximately thirty acres infested the lake.

The amount of EWM or Curly-leaf Pondweed present in Duck Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. There are other aquatic plants that resemble invasive EWM, such as native Whorled watermilfoil and even the rootless bladderwort.

The initial June 5, 2023 survey revealed approximately 25 acres of Curly-leaf Pondweed and 3.5 acres of EWM were present in the lake. Both were treated on June 14, 2023 with systemic ProcellaCOR® for the EWM and diquat for the CLP. An additional August 2, 2023 full lake survey indicated 0.1 acres of EWM and numerous locations where invasive emergent Purple Loosestrife was found. As previously indicated in the lake management plan report, this species should be removed by hand and discarded as it displaces native plants. The figures below show the distribution of these invasives during the 2023 season.



Eurasian Watermilfoil



Curly-leaf Pondweed



Purple Loosestrife

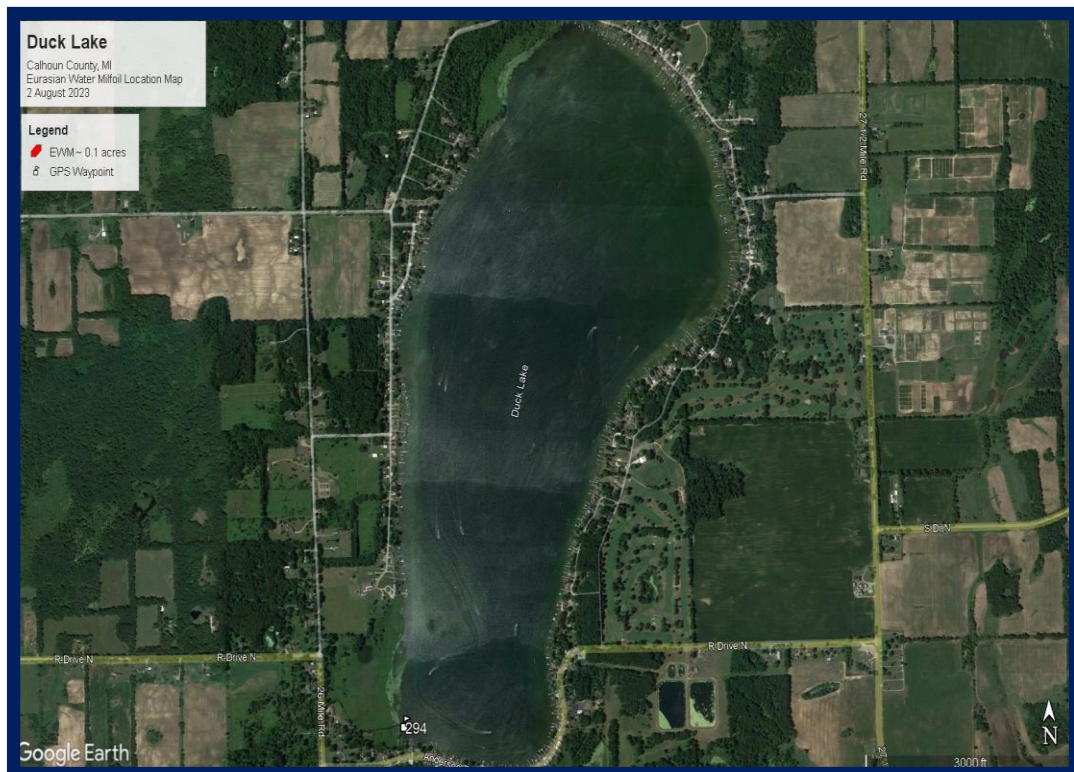


Figure 8. Distribution of EWM in Duck Lake (August 2, 2023).

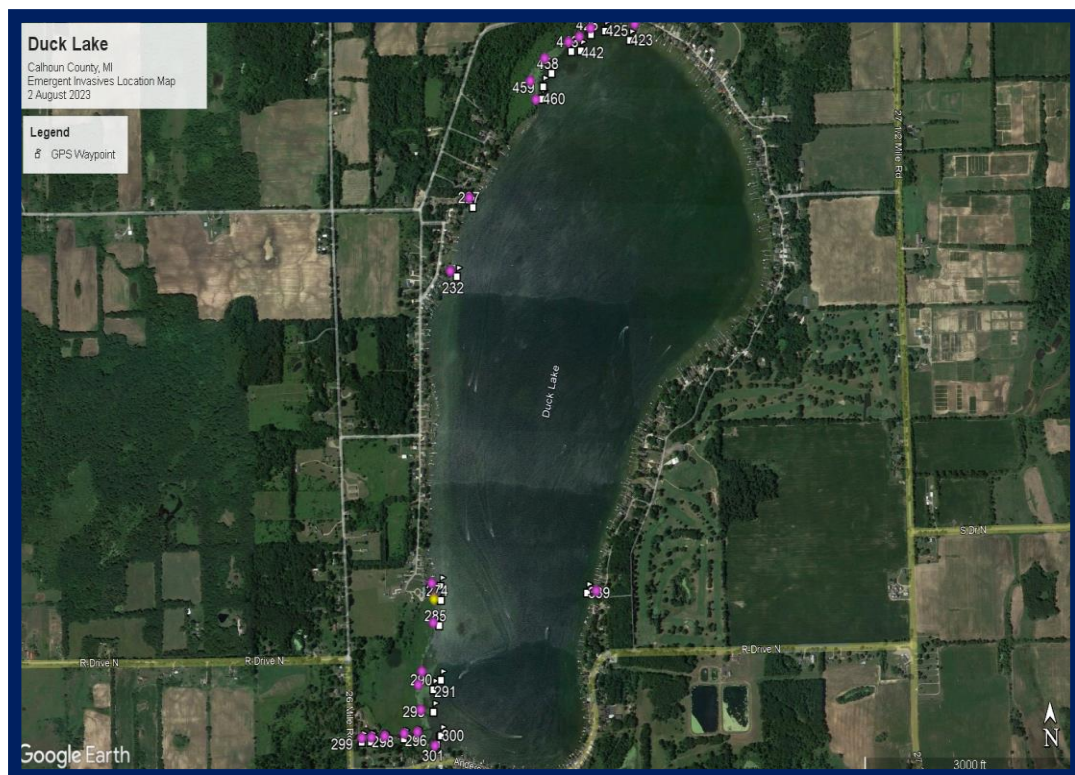


Figure 9. Invasive Emergents around Duck Lake (August 2, 2023).

Management Recommendations for 2024

Continuous aquatic vegetation surveys in Duck Lake are needed to determine the precise locations of EWM, Curly-leaf Pondweed (CLP), or other problematic invasives in and around Duck Lake. Protection of the 25 native aquatic plant species in Duck Lake is encouraged as these are critical for the lake fishery and health. These surveys should occur in late-May to early-June and again post-treatment(s) in 2024.

Due to the great overall depths of Duck Lake and limited areas with native aquatic vegetation in Duck Lake (due to depths), the treatment of these species with aquatic herbicides is not recommended. The plan for 2024 includes whole-lake surveys and the use of high dose systemic aquatic herbicides for effective Eurasian Watermilfoil control if EWM is present in the lake and canal. To reduce the probability for tolerance of EWM for triclopyr or 2,4-D, RLS recommends use of ProcellaCOR® systemic herbicide with diquat for EWM control in 2024 with another rotation in 2025. It is a costly herbicide but very effective in season-long control. Invasive Curly-leaf Pondweed will respond well to Aquathol-K® or diquat at 1-2 gallons per acre if found but should only be treated in dense areas since it naturally dies back in mid to late summer.

Water quality parameters in the lake will also be monitored in 2024 and given in the annual report.

In conclusion, Duck Lake is a healthy lake with excellent aquatic plant biodiversity, high water clarity, moderate/high nutrients (depending on depth and season as these are lower in fall), and a healthy lake fishery. Management of the EWM, Curly-leaf Pondweed, and emergent invasive Purple Loosestrife and protection of the water quality are paramount for the long-term health of the lake.