Indian Lake

Lake Vegetation Assessment and Plan

1/31/2023

Edward Kwietniewski

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Report Prepared By:

AQUA DOC Lake & Pond Management Inc.

10779 Mayfield Rd
Chardon, OH 44024
440-286-7663

Executive Summary

Indian Lake is a 5,163 acre reservoir located in Logan County, Ohio. It is the second largest recreational inland body of water in the state and hosts a myriad of seasonal activities that include boating, fishing, and swimming among others. The reservoir is the economic pinnacle of the local area, hosting a variety of businesses and residential properties. The reservoir itself is surrounded by 11 different townships (including three focused directly on the lake) and includes 6,597 acres of state-owned land. Indian Lake is managed by the Ohio Department of Natural Resources (ODNR) with its local head of operations residing at Indian Lake State Park, a public park that sports a variety of outdoor recreation activities and community events.

In 2020, ODNR staff and residents noticed submersed vegetation growth increasing in Indian Lake. The reservoir, which was traditionally noted for its light-limiting turbidity, was clearer. This improved clarity seemed to continue into future years allowing for more submersed vegetation biomass to persist and spread in the relatively shallow water body. Vegetation growth peaked during the growth season of 2022 where biomass was great enough to impede the reservoir for its best use, making it categorically impaired. During this time, the ODNR created a request to bid (RTB) for the creation of a wholistic vegetation management plan in order to study the lake and suggest a solution for the impaired reservoir.

In order to assist in the creation of a vegetation management plan, a study that incorporated the point intercept rake toss relative abundance method (PIRTRAM) was utilized along with sonar mapping. These two techniques allowed for an assessment of the species richness (number of species), spread, and abundance of the submersed plant population in Indian Lake. This study was conducted by two teams from July 5 – 8, 2022 to provide the best potential for collecting early, middle, and late season submerged plants. The reservoir was gridded with each grid intersection point corresponding with a rake toss location, for a total of 585 individual sampling points. At each sampleable point, a double-sided vegetation rake was thrown into the water and slowly brought back. The submerged vegetation that returned with the rake was separated out and identified. Overall rake vegetation density and the individual proportion of each specie were also calculated with each toss. While one team focused efforts on rake toss sampling methods, the other was generating transects for sonar mapping. Sonar mapping data was collected with a Lowrance Hook Reveal TS7 by “tracing” the perimeter of the lake at a slow (approximately two miles per hour) speed so that the device could “ping” and save data. Individual “pings” collected information regarding the reservoir depth and quantity of the water column filled with vegetation growth. This information was compiled and analyzed using Biobase® mapping software. The program allows the user to generate accurate heat maps of vegetation density and reservoir bathymetry. Chemical and physical parameters were also collected as supplemental information; while not necessary for the goals of the study, the information is important for future monitoring purposes.

The results of the survey indicated that Eurasian watermilfoil (*Myriophyllum spicatum*) and coontail (*Ceratophyllum demersum*) were the most abundant and widespread species of submersed plant noted in Indian Lake at the time of the study. These two submersed plants accounted for approximately 52% and 39% of all the sampled biomass in the reservoir respectively out of a total of 10 individually identified species. They also were estimated to encompass approximately 3,600 acres (Eurasian watermilfoil) and 3,150 acres (coontail) of the lake's total area. Spatially, Eurasian watermilfoil biomass was dominantly located near the shallow, western side of the lake (the recreational "open zone") while coontail biomass was dominantly located along the eastern portion and perimeter locations.

The findings of this survey confirm the need for intensive short-term vegetation management options that specifically target Eurasian watermilfoil and coontail growth in Indian Lake. Current suggested options include the use of selective herbicides that can target Eurasian watermilfoil specifically in the western "open zone" and mechanical harvesters to concentrate removal efforts on coontail biomass in other areas of the reservoir. Being selective with these two management options allows for the reduction of Eurasian watermilfoil fragmentation, collection of weakly rooted and possibly mobile coontail, and a reduced impact on desirable native flora. Short-term vegetation management options available to future Indian Lake managers should be selected based on the scale of future submersed aquatic plant growth in the lake and can include a myriad of physical, mechanical, and chemical options that are reviewed. Additional management options, such as whole-lake drawdown and biocontrol methods were reviewed but deemed ineffective for the shallow, highly eutrophic canal lake.

The long-term sustainability of Indian Lake must be considered to ensure the lake remains recreationally and economically viable. Nutrients (namely phosphorus and nitrogen) are the key influencers of nuisance growth in any body of water. A balance of adequate native and non-nuisance submersed plant growth is important to ensure there is competitive viability against the potential for harmful algal growth through nutrient sequestering in the reservoir. Additionally, the enactment and support of watershed best management practices (BMPs) will help to alleviate long-term nutrient loading into the reservoir over time. Finally, and most critically, a consistent monitoring program should be implemented to collect data, gauge management success and develop water quality thresholds that pertain specifically to Indian Lake.

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I. Introduction

Brief Historical Information

Prior to the 1850s, Indian Lake was a combination of a kettle lake and marsh system created by retreating glaciers 640 acres in size (ILCC 2019). In the early 1850s, it was expanded to assist feeding the Miami canal system during a time when canal transport was common (Ohio History Connection 2011). The expanded water body was named Lewistown Reservoir and was thought to have been enlarged multiple times to the size of approximately 6,000 acres by 1860 (Indian Lake Area 2015). In 1898, the reservoir was turned over to what would become the Ohio Department of Natural Resources (ODNR) as a public area designated for recreational purposes and renamed Indian Lake as a homage to its historical identity. After the state had taken responsibility for the reservoir, it quickly became a popular area for visitors to enjoy the outdoors sporting many recreational activities like hunting, shooting, and fishing (Indian Lake Area 2015).

As the 1900s arrived, Indian Lake took off as the definitive location in the area for entertainment and enjoyment. An increasing number of visitors were arriving with railway transportation becoming common and accommodations were developed to allow such tourists the opportunity to enjoy the reservoir and its local area. The draw of Indian Lake to tourists allowed for local townships to flourish including Lakeview and Russells Point among others. Speakers and entertainers commonly provided shows and programs for tourists and locals, further driving more tourism to the area. Into the economic height of the 1920s, an amusement park was constructed at Russells Point named Sandy Beach Amusement Park. This park offered visitors high quality entertainment for the day including carnival rides such as a roller coaster, merry-go-round, a Ferris wheel, and a dance hall that was considered one of the best for its time. A boardwalk was also constructed into the lake to allow swimmer access to Indian Lake and Sandy Beach Island, a beloved area with slides and diving towers. As the Great Depression emerged in the 1930s, Indian Lake was still considered a thriving community and hub for entertainment that hosted dance marathons and major Big Band acts of the day (Indian Lake Area 2015).

In 1949, Indian Lake was officially designated one of the original Ohio State Parks and the area continued to flourish into the 1950s with the amusement park and reservoir still drawing in visitors every year. As a testament to this, it is thought that the Ohio sesquicentennial, a major event for the area, brought in a crowd of about 100,000 people. In the mid-1960s, Indian Lake State Park's campground was constructed as a premier camping location and was immediately successful. Unfortunately, the same could not be said for the Sandy Beach Amusement Park which closed its doors in 1976 when it failed to compete with more modern emerging parks like Cedar Point (Indian Lake Area 2015).

Today the reservoir is a premier recreational gem in Ohio and still draws an impressive amount of tourism with the state park still in full operation and plenty of local restaurants, entertainment, and a plethora of outdoor activities including boating, fishing, hunting, and camping.

Current Designation and Impairment Information

Indian Lake is a reservoir that is approximately 5,163 acres (2,089 hectares) in size and is the second largest inland water body in the State of Ohio. It is located within Logan County, in west-central Ohio. Its geographic location is approximately 40°29’34.72” north latitude, 83°53’38.03” west longitude. It is one of two major water bodies northwest of Columbus, Ohio; the other being Grand Lake St. Marys located approximately 32 miles (52 km) to the west of Indian Lake. The reservoir is fed by five different inlets including the north and south forks of the Upper Great Miami River, Cherokee Mans Run, Blackhawk Creek, and Van Horn Creek. Although the State of Ohio does not classify water bodies by water quality thresholds and use designations, Indian Lake could be best categorized as a contact-recreation water body and future water quality threshold development should reflect this.

During the 2022 lake use season, Indian Lake did not fulfill its best categorical use as a contact-recreation body of water. The reservoir became inundated with submersed aquatic vegetation resulting in the reduced ability to navigate and recreate on the water body. The severity of the aquatic weed growth provided enough concern for the ODNR to study Indian Lake. Specifically, the Agency wanted to learn more about the aquatic plant community and techniques associated with reducing their impact in order to return the reservoir to its non-impaired status. The information used to characterize Indian Lake, the macrophyte community therein, and an assessment of the various tools and techniques associated with managing nuisance submersed plant growth is provided in the chapters below.

II. Reservoir Morphology and Watershed Characterization

Reservoir Morphology

The modern morphology of Indian Lake was generated when its original form as a 640-acre kettle lake/marsh area was reconstructed into the current 5,163-acre reservoir to accommodate for canal transportation needs (Ohio History Connection 2011). As a man-made reservoir, the morphology of Indian Lake is highly variable with a shallow mean water depth and a somewhat dendritic appearance. The original kettle lake or “Old Indian Lake” can be found just south of an area known to local stakeholders as “dream bridge” at approximately 40°29’28.28” north latitude, 83°51’47.70 west longitude. This location has the greatest amount of depth within the reservoir with a maximum deep point depth (Z_{max}) of 15.3 ft (4.6 m; 12.5 ft observed). This area is morphologically different from the rest of the water body which is characterized by a relatively shallow mean water depth of 5.0 ft (1.5 m). The largest open area known as the recreational open zone on the west end of Indian Lake demonstrates its shallow nature, with more than 1,600 acres of the lake having water depths between four to six feet. A naturalized area is present at the northeastern portion of the reservoir encompassing approximately 600 acres. This zone is characterized by riparian and emergent vegetation with channels that have been created to allow for recreational use and navigation. Multiple islands, coves, and channels are present throughout Indian Lake and add to morphometric variation. Many of the islands are highly populated and contain a maze of man-made channels to allow for access to the main portions of the reservoir. The primary outlet structure is a spillway located at the southeastern end (40°28’02.87” north latitude, 83°52’31.26” west longitude). Morphometric measurements of Indian Lake are summarized below (Tables 1). A bathymetric map of the lake is also provided with Figure 1.

Table 1: Summary of the physical morphology of Indian Lake, estimated using Biobase® bathymetric information collected during this study.

Reservoir Characteristic	Unit
Total Lake Area	5,162.9 ac
Total Lake Volume	23,745.0 ac ft
Max Length	18,600 ft
Max Width	14,875 ft
Max Depth	15.3 ft
Mean Depth	5.0 ft

Watershed Characteristics

Size and scope – The Indian Lake watershed is estimated to be approximately 62,208 acres (25,174.7 hectares) in size (USGS 2016). This creates an estimated watershed-to-lake ratio of 12:1. It extends dominantly to the north, northeast through Logan and Hardin counties as well as the towns of Belle Center, Northwood, north Huntsville, south Roundhead, south New Hampshire and south Jumbo. The north and south forks of the Great Miami River incorporate the greatest contributor to the Indian Lake watershed (Figure 2).

Land use and soils – A summary of estimated land use within the Indian Lake watershed is summarized by Figures 3 and 4 below. Its watershed is dominantly agricultural with cultivated crops and pasture/hay being estimated to account for 72% of the total watershed area. Forested regions make up the next greatest coverage accounting for approximately 9% of the total watershed area. Developed areas make up the third highest estimated coverage at just over 8%. The remaining land use is a mix of negligibly small percentage categories shown in Figure 4.

The Indian Lake watershed contains a large amount of variability within its soil classification characteristics but dominantly consists of silt and clay loam (Figure 5 supported by "Appendix A"). Silt and clay loams can hold nutrients and have a higher degree of erodibility than comparable sandy soils (Brown 2007).

Soils within the extent of the Indian Lake watershed are poorly suited for septic system use: 92.9% is considered "very limited" for proper functioning and 0.4% is considered "not limited" and suitable for use (Figures 6 and 7).

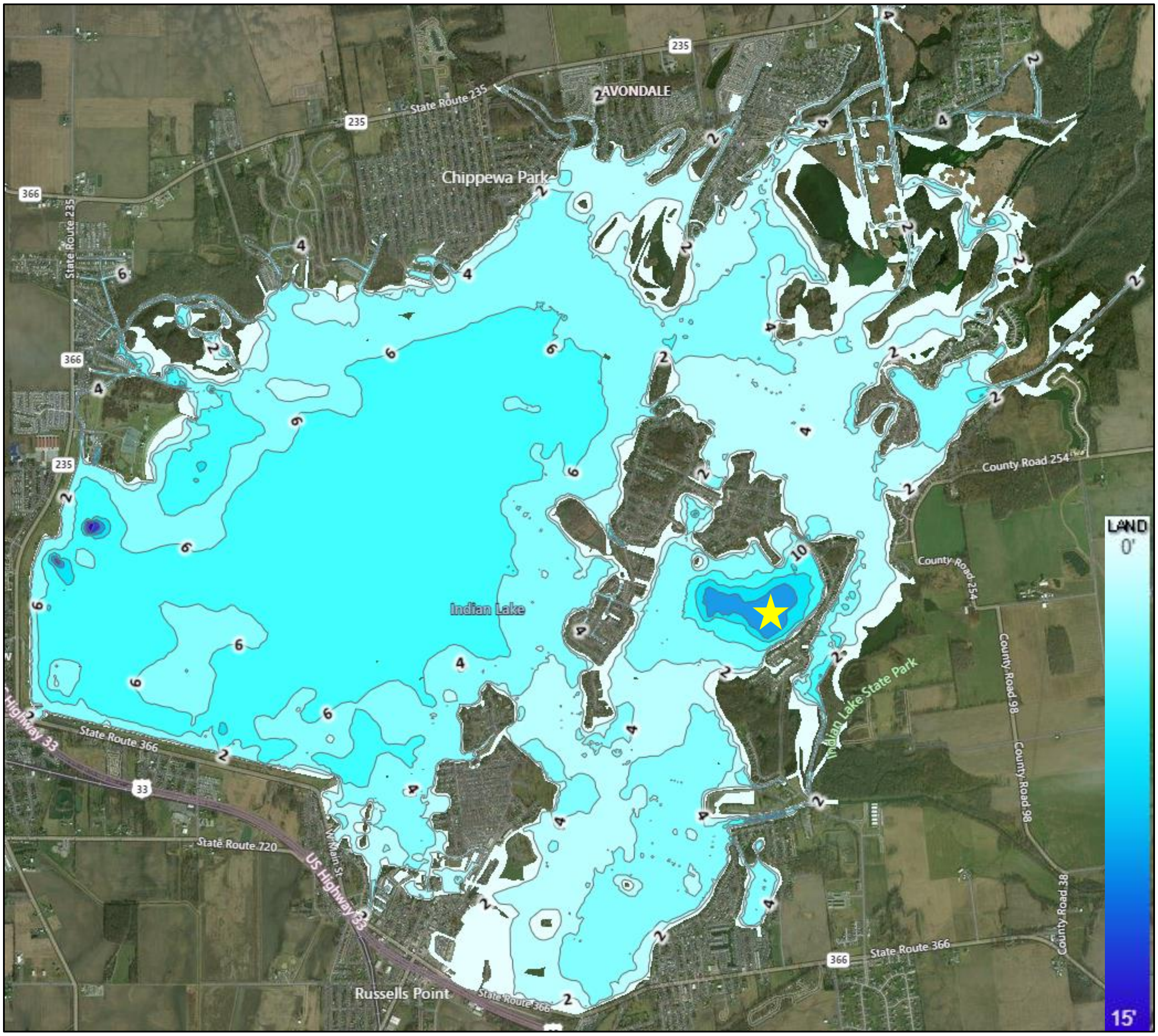


Figure 1: Bathymetric map of Indian Lake. Darker blue colors indicate increasing depth contours. Yellow star denotes the determined deepest point of the reservoir. Data for map collected during this survey using Biobase® mapping program.

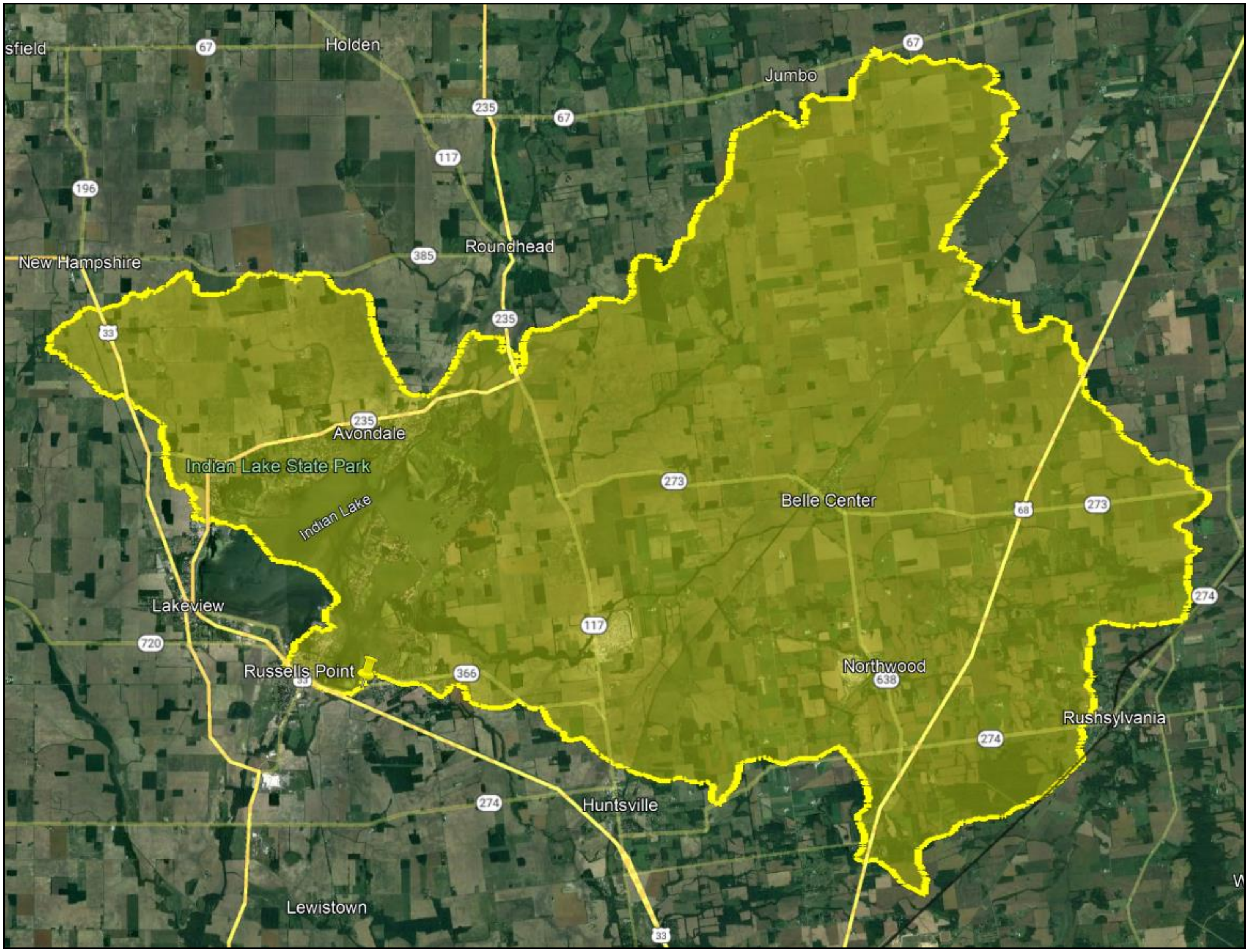


Figure 2: Indian Lake watershed (62,208 acres). Data retrieved with StreamStats (USGS 2016).

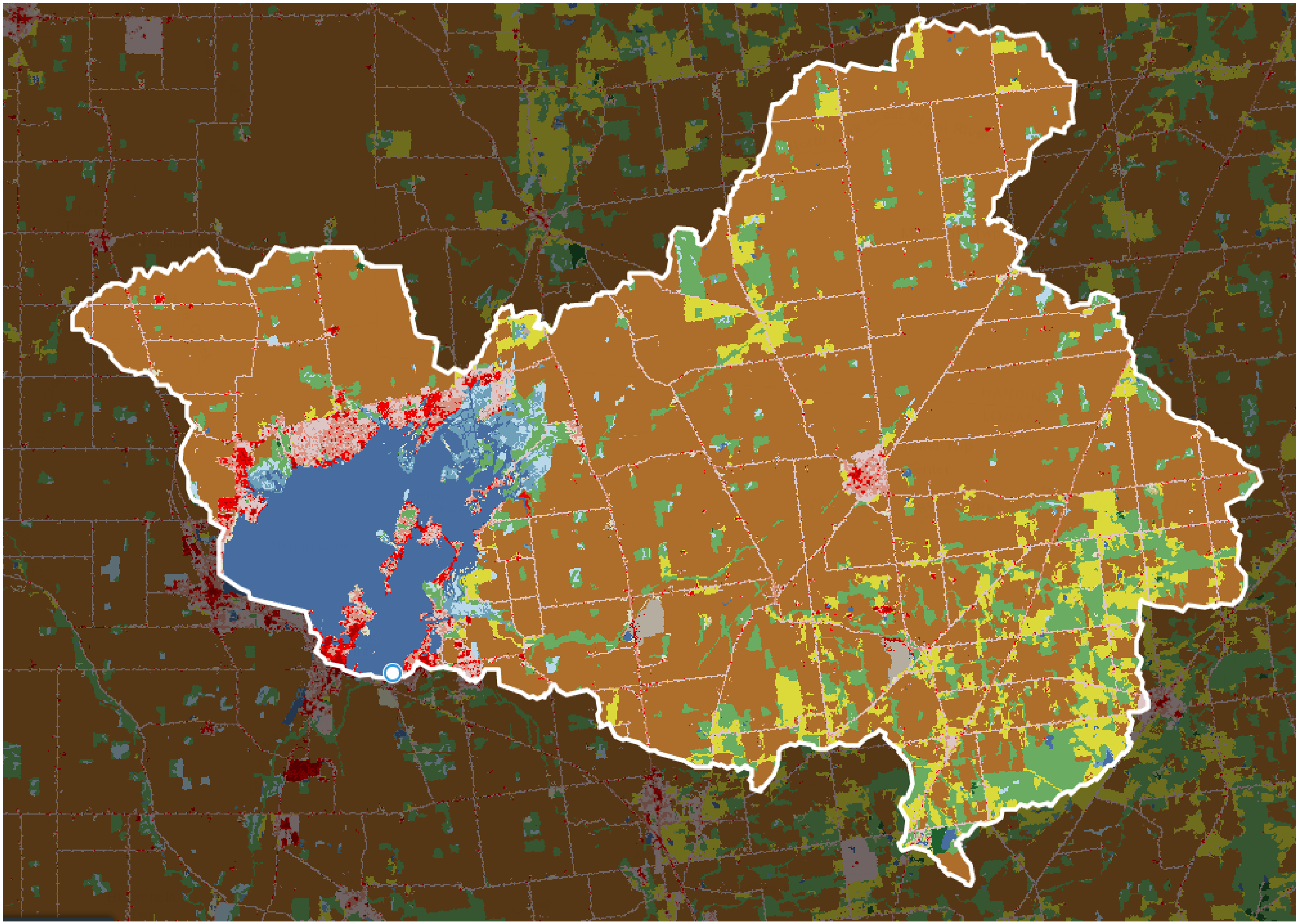


Figure 3: Indian Lake watershed land use map. Coloration matches the bar graph found in Figure 4. Data retrieved with Model My Watershed (Stroud Research Center 2017).

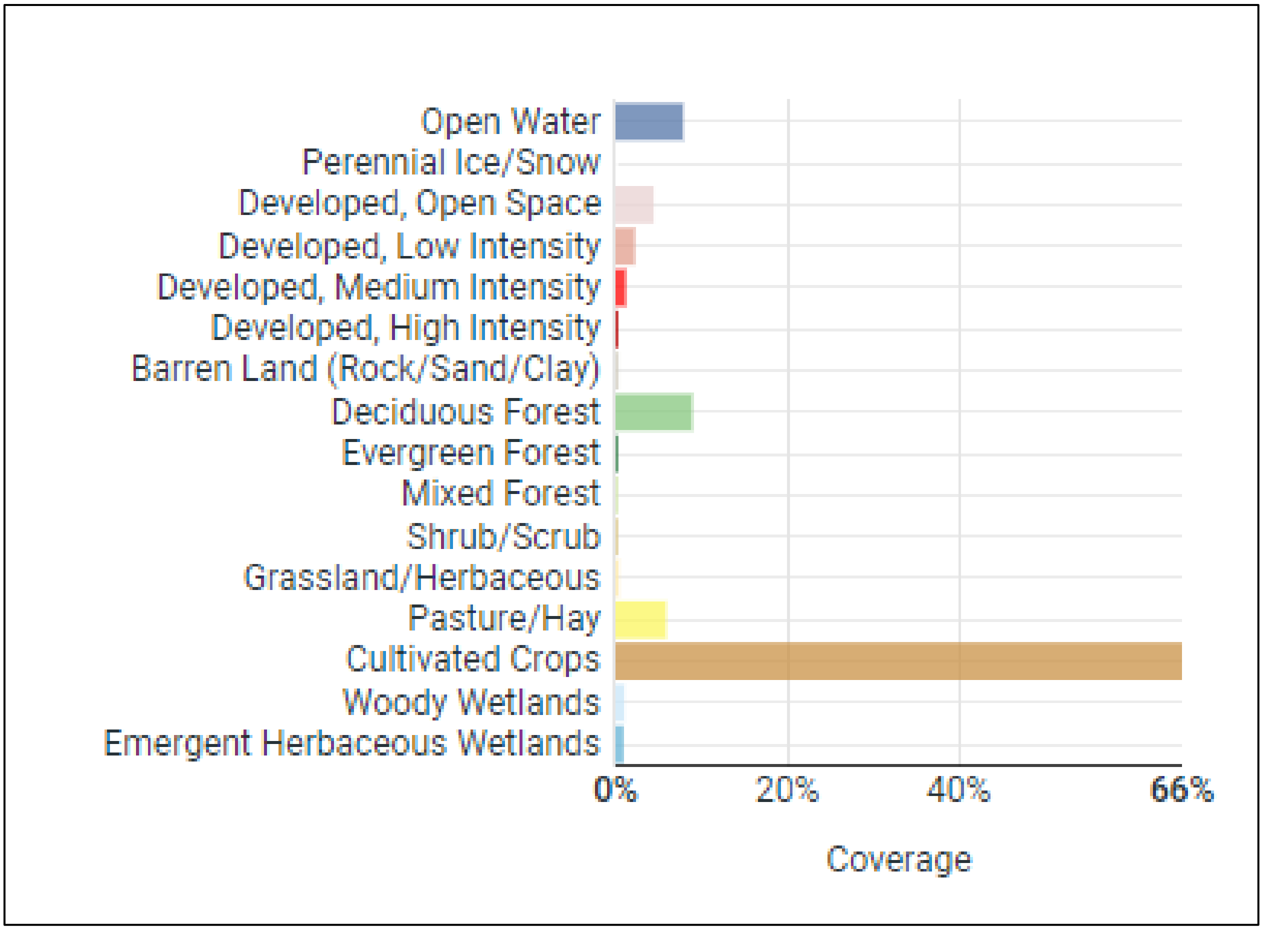


Figure 4: Land use coverage percentages in the Indian Lake watershed (Dewitz 2019).

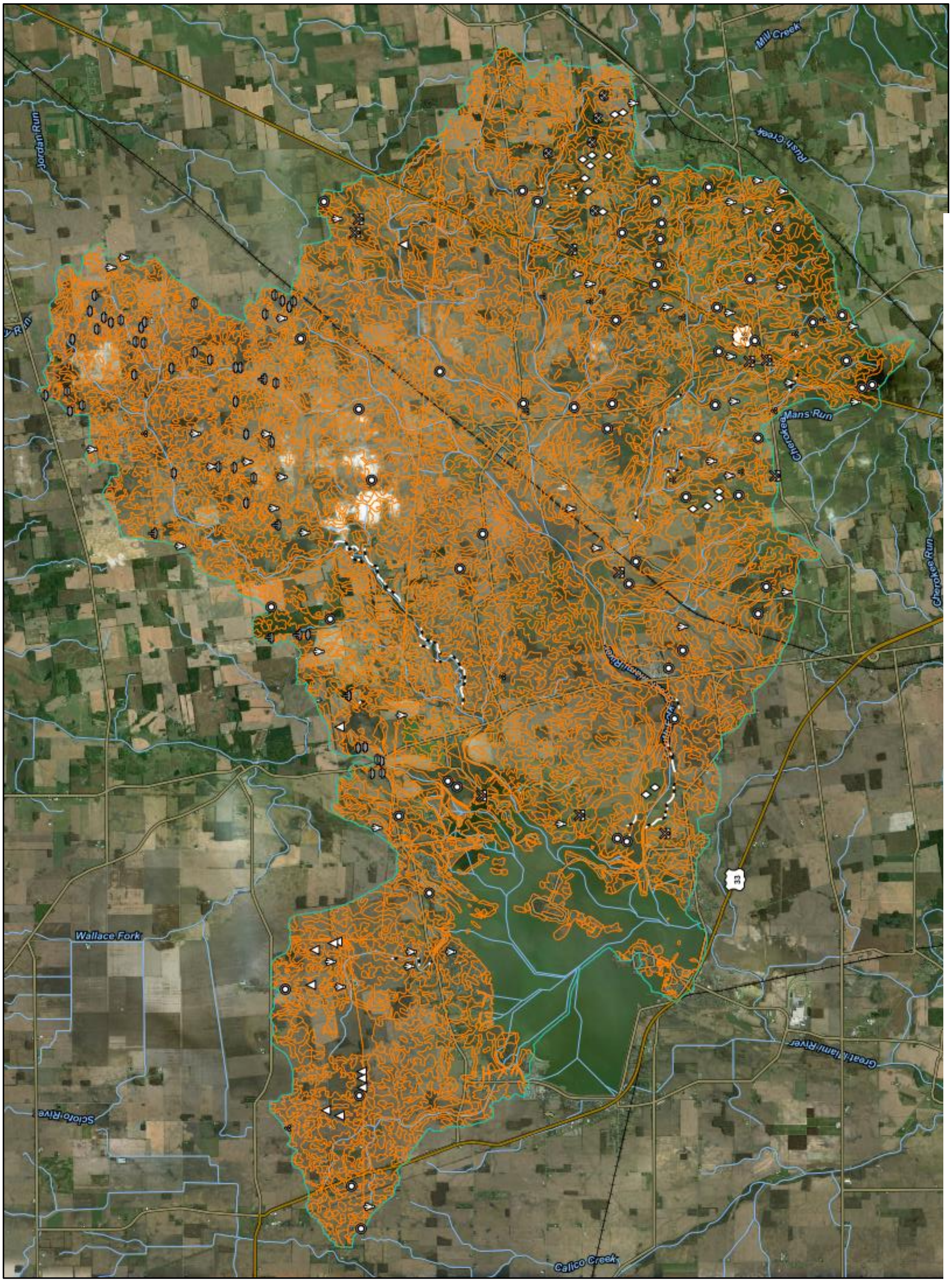


Figure 5: Indian Lake watershed soils map. Data retrieved with USDA’ s Web Soil Survey (USDA 2022).

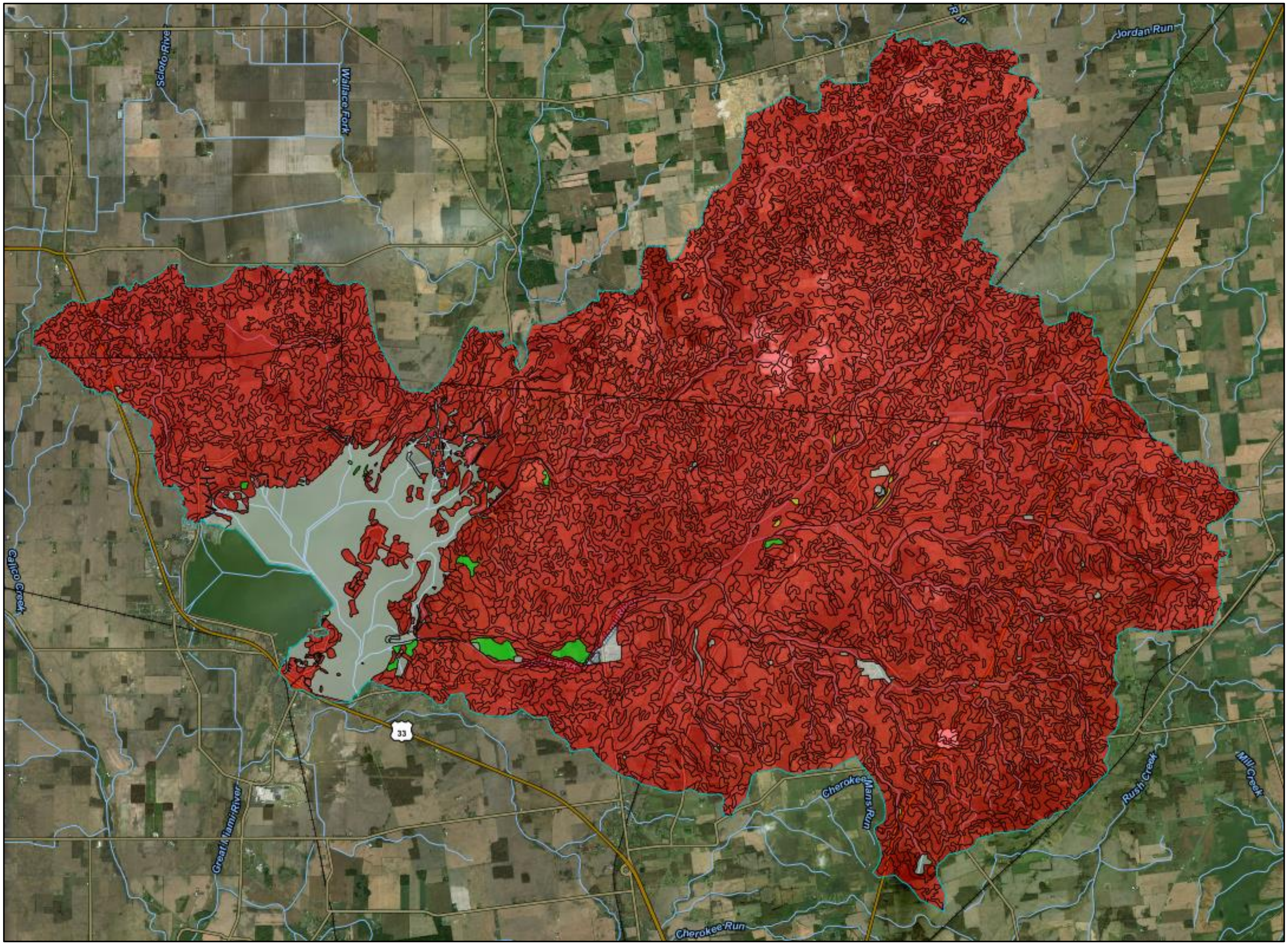


Figure 6: Indian Lake watershed soils map for septic suitability. Red indicates soil that is "very limited" while green indicates soil that is "not limited". Data retrieved with USDA's Web Soil Survey (USDA 2022).

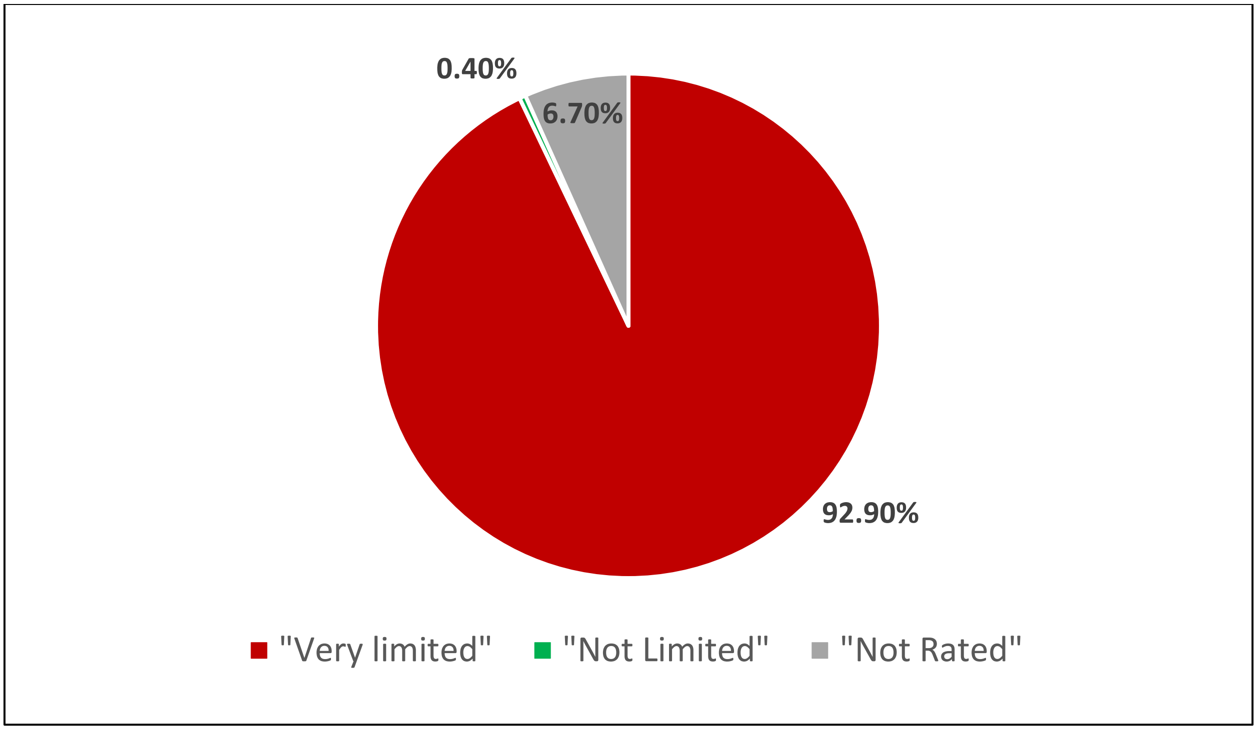


Figure 7: Soil suitability for septic systems in the Indian Lake watershed (USDA 2022).

III. Physical and chemical characteristics of Indian Lake

Introduction

Since Indian lake has never enacted a long-term monitoring program, there is relatively little information available regarding the physical and chemical parameters that define it. The information provided regarding these parameters is meant to be ancillary in order to supplement the primary goal of this report which is defining the extent of aquatic vegetation community. Physical and chemical characteristics of a body of water are imperative to collect as they can allow for lake managers to develop water quality goal thresholds, identify likely lake behaviors and risks, and allow for the assessment of management techniques pre- and post-enactment. Collected consistently over a long period of time, these characteristics can become a powerful assessment tool that can define Indian Lake as “impaired” or “non-impaired” beyond anecdotal observations.

Materials and Methods

The materials and methods reported in this study for the collection of the physical and chemical characteristics of Indian Lake during 2022 were situational. Indian Lake was sampled at its deepest known point (40°29’28.28” north latitude, 83°51’47.70 west longitude; z_{max} = 15.3 ft. suggested, 12.5 observed) on August 19, September 1, September 8, and September 14 to observe thermal stratification development and potential late season hypolimnetic oxygen loss. During these sampling events, a YSI ProQuatro Professional Plus multiparameter probe was used to measure temperature, dissolved oxygen (DO), specific conductivity, pH, and oxidation-reduction potential (ORP). The YSI probes were calibrated according to manufacturer’s specifications (YSI 2009). At the sampling location, the sonde was lowered from the surface to the bottom in one-foot increments. Data was recorded manually and transposed to Microsoft Excel for analysis (Microsoft Corp 2018).

The reservoir was also sampled as part of the 2022 ProcellaCOR®® treatment testing procedures on July 12 – 26, 2022 to account for first application and August 24 – Sept 8, 2022 for the second application. ProcellaCOR® application dates were July 12 – 13, 2022 and August 24 – 25, 2022. Both zones encompassed 200 acres of water. As a part of the assessment of the use of the herbicide, DO concentrations and nutrient data was collected to assess potential oxygen loss and elevated nutrient release from decomposition of submersed plant biomass. Five sampling locations were selected within each treatment zone (10 total; Tables 3 and 4) and a sampling location outside of the initial treatment zone was selected for comparison of the initial zone data. Location sampling ID numbers were established via transects from gridding the lake. At each location, DO and nutrient data were collected along with Secchi transparency. Turbidity and chlorophyll ɑ were also collected at two of the sampling locations in each treatment zone. These parameters were not sampled at every location due to budgetary constraints. DO levels were collected following the same methods as described above with the YSI probe. Nutrient data consisted of total phosphorus (TP) and total kjeldahl nitrogen (TKN). These along with turbidity and chlorophyll ɑ were collected as grab samples (elbow depth) at every sample location. Secchi transparency (SD) was collected following general procedures whereas the Secchi disk is lowered into the water column on the shade-side of the boat until it is no longer visible. The disk is then brought back up the water column until it becomes visible with the average of the two depths (when it disappears vs reappears) being the recorded Secchi transparency. Data was recorded manually and transposed to Microsoft Excel and R-statistical program for analysis (R Core Team 2022). Collected water samples were analyzed by SePro at their Research and Technology Campus (RTC) in Whitakers, NC. Samples were collected utilizing 250 mL high density polyethylene bottles. Nutrient bottles contained an acidic preservative for persulfate digestion and as such, a second, non-preserved bottle was required to collect samples in order to not dilute or hamper the preservative concentration in the primary sample bottle. Water samples were stored in a cooler and delivered overnight to the RTC.

Data analysis was conducted within Microsoft Excel. YSI collected information was used to create parameter depth profiles by graphing observed values to water depth in order to analyze data trends within the water column. R statistical program was utilized for statistical analyses.

Trophic state of Indian Lake – Carlson's Trophic State Index (TSI; Carlson 1977) is a commonly used predictor of how productive a water body is (its trophic state). It utilizes chlorophyll ɑ concentrations, surface TP, and Secchi transparency to provide index numbers that can be used on a scale to define the water bodies trophic state. The equations used to generate index numbers based off these parameters are described below (top equation is SD, middle equation is chlorophyll ɑ, and the bottom equation is TP; Carlson 1977 for SD and Cooke et al. 2005 for chlorophyll ɑ and TP derivatives):

$$TSI_{SD} = 10(6 - log_2 SD)$$

$$TSI_{Chl\ a} = 10(6 - log_2\ {}^{7.7}/_{chl\ a})^{0.68}$$

$$TSI_{TP} = 10(6 -\ log_2 \frac{48}{TP})$$

TSI values range from 0 to 100 where TSI < 40 may indicate oligotrophy (low productivity), 40 – 50 may indicate mesotrophy (middling productivity), and >50 eutrophy (Cooke et al 2005).

Table 3: Coordinates for the sampling locations within the July ProcellaCOR® treatment test zone.

Location ID	Treatment #	N Longitude	W Latitude
373	1	40°48’90.38”N	83°90’46.98”W
425	1	40°48’40.12”N	83°90’79.09”W
402	1	40°48’94.11”N	83°90’65.92”W
404	1	40°48’88.00”N	83°88’85.18”W
452	1	40°48’42.06”N	83°89’81.94”W
456	1	40°48’42.06”N	83°89’81.94”W

Table 4: Coordinates for the sampling locations within the August ProcellaCOR® treatment test zone.

Location ID	Treatment #	N Longitude	W Latitude
300	2	40°29'42.89"N	83°54'26.45"W
322	2	40°29'37.18"N	83°54'26.25"W
324	2	40°29'37.09"N	83°54'9.51"W
326	2	40°29'37.06"N	83°53'52.48"W
352	2	40°29'31.56"N	83°53'52.53"W

Results

Late season deep point sampling

Temperature – Indian Lake experienced variable stratification near the end of the reservoir use season (Figure 8). A stable and stronger thermocline was found to have developed during the 9/1/2022 and 9/14/2022 sampling periods. Weaker thermocline development can be argued for 8/19/2022 and 9/8/2022. A distinctive epilimnion (upper, warm water layer) exists above three feet of water depth on both strongly stratified sampling days along with a distinctive hypolimnion (lower, cold water layer) below this depth. Maximum temperature noted during these sampling periods was 82.1 °F at the surface of the water on 9/1/2022. Minimum temperature noted was 69.6 °F at the bottom 3 ft of the water column on 9/14/2022.

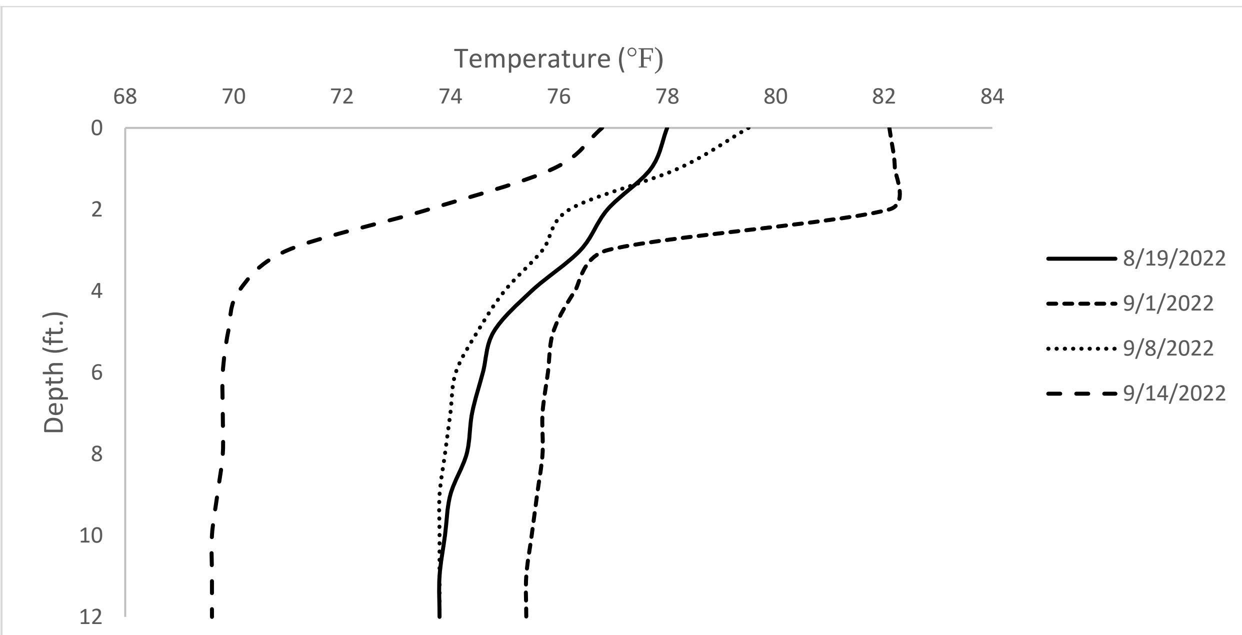


Figure 8: Temperature depth profiles of Indian Lake from 8/19/2022 to 9/14/2022.

Dissolved oxygen – DO concentrations generally followed suit with temperature patterns. Periods of distinctive water column stratification showcased higher epilimnetic DO levels coinciding with reducing hypolimnetic DO levels (Figure 9). DO levels dipped below 3.0 mg/L near the bottom of every sampling date. Maximum DO concentration was 11.88 mg/L observed at the surface of the sampling location on 9/1/2022. Minimum DO was 1.57 mg/L found at the very bottom of the lake on 8/19/2022.

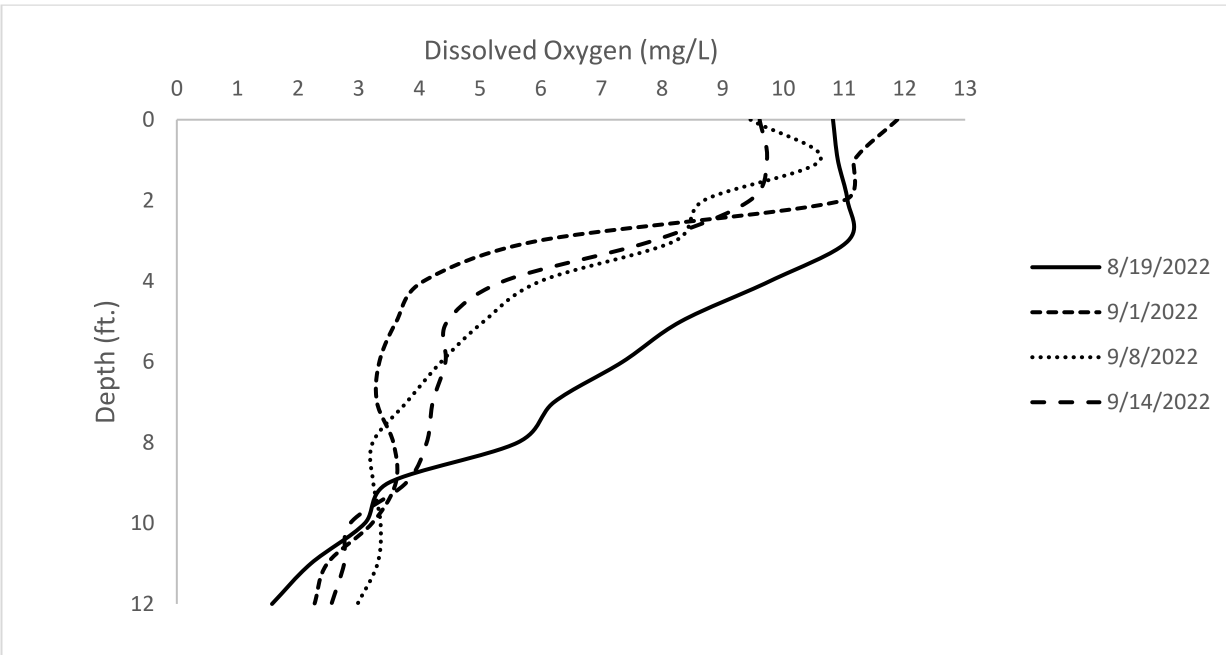


Figure 9: DO depth profiles of Indian Lake from 8/19/2022 to 9/14/2022.

pH – The pH of Indian Lake stayed within acceptable levels for gilled aquatic organisms (Figure 10; above 5.3 and below 11). The highest pH value recorded was found to be 9.37 at the surface of the sampling point on 9/1/2022 while the lowest value was 7.77 at the very bottom of the sampling point on 8/19/2022.

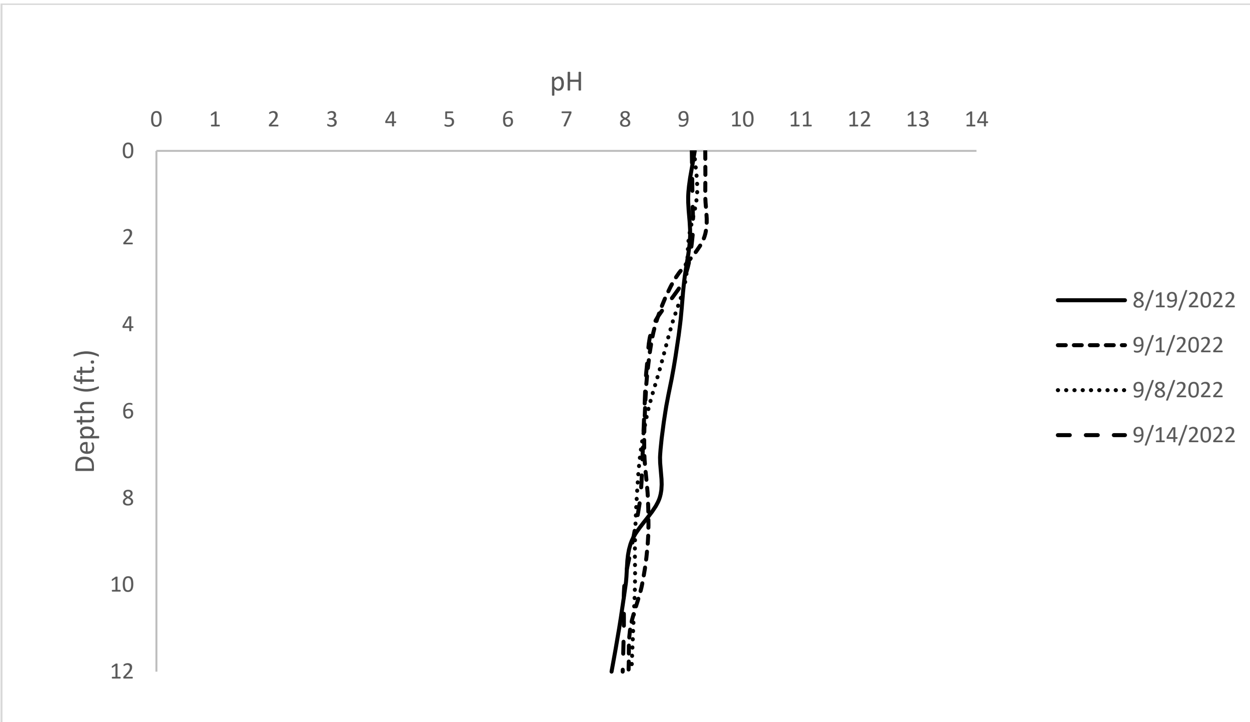


Figure 10: pH depth profiles of Indian Lake from 8/19/2022 to 9/14/2022.

Specific conductivity – Specific conductivity remained relatively consistent throughout the four sampling dates. The highest observed value was found to be 0.334 ms/cm at the bottom of the sampling location on 9/14/2022. The lowest was found to be 0.297 at the surface of the sampling point on 9/1/2022. Specific conductance trends within the water column are shown in Figure 11.

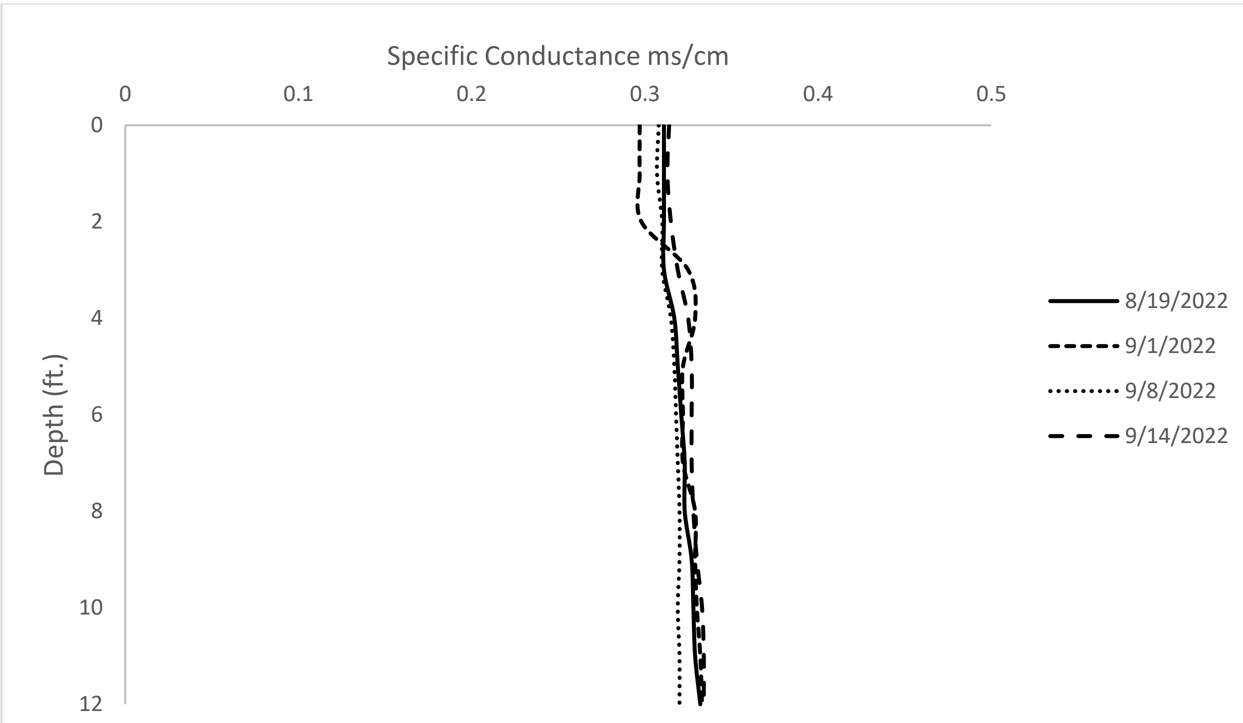


Figure 11: Specific conductance depth profiles of Indian Lake from 8/19/2022 to 9/14/2022.

Oxidation – reduction potential – ORP remained positive and mostly consistent throughout the water column during all sampling dates (Figure 12). The exception to this is a noted severe decline at the very bottom of the 9/14/2022 sampling date (88 reduced to 46.3). Greatest ORP value observed was found to be 89.1 at 10 ft on 9/14/2022. Lowest value was 46.3 at the bottom of the same date.

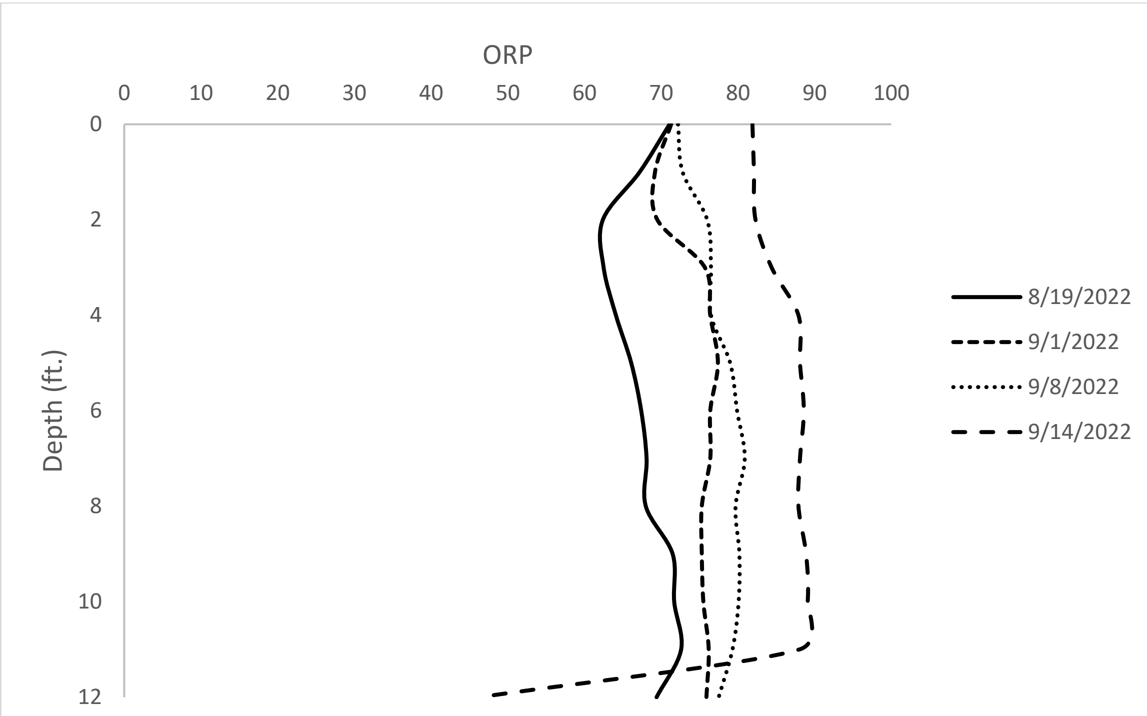


Figure 12: ORP depth profiles of Indian Lake from 8/19/2022 to 9/14/2022.

ProcellaCOR® test area physical and chemical information

Dissolved Oxygen – DO levels were variable in the test zones among the sampling dates as well as direct sampling locations. However, a general pattern of higher surface DO levels with a corresponding decrease in water column DO (with a minimum near the bottom) was present among every sampling event (Figures 13 and 14) The highest recorded DO concentration was 16.95 mg/L at site #425 (2.0 ft depth, zone 1, 7/15/2022). Lowest sampled concentration was 0.27 mg/L at site #373 (6.0 ft depth, zone 1, 7/15/2022).

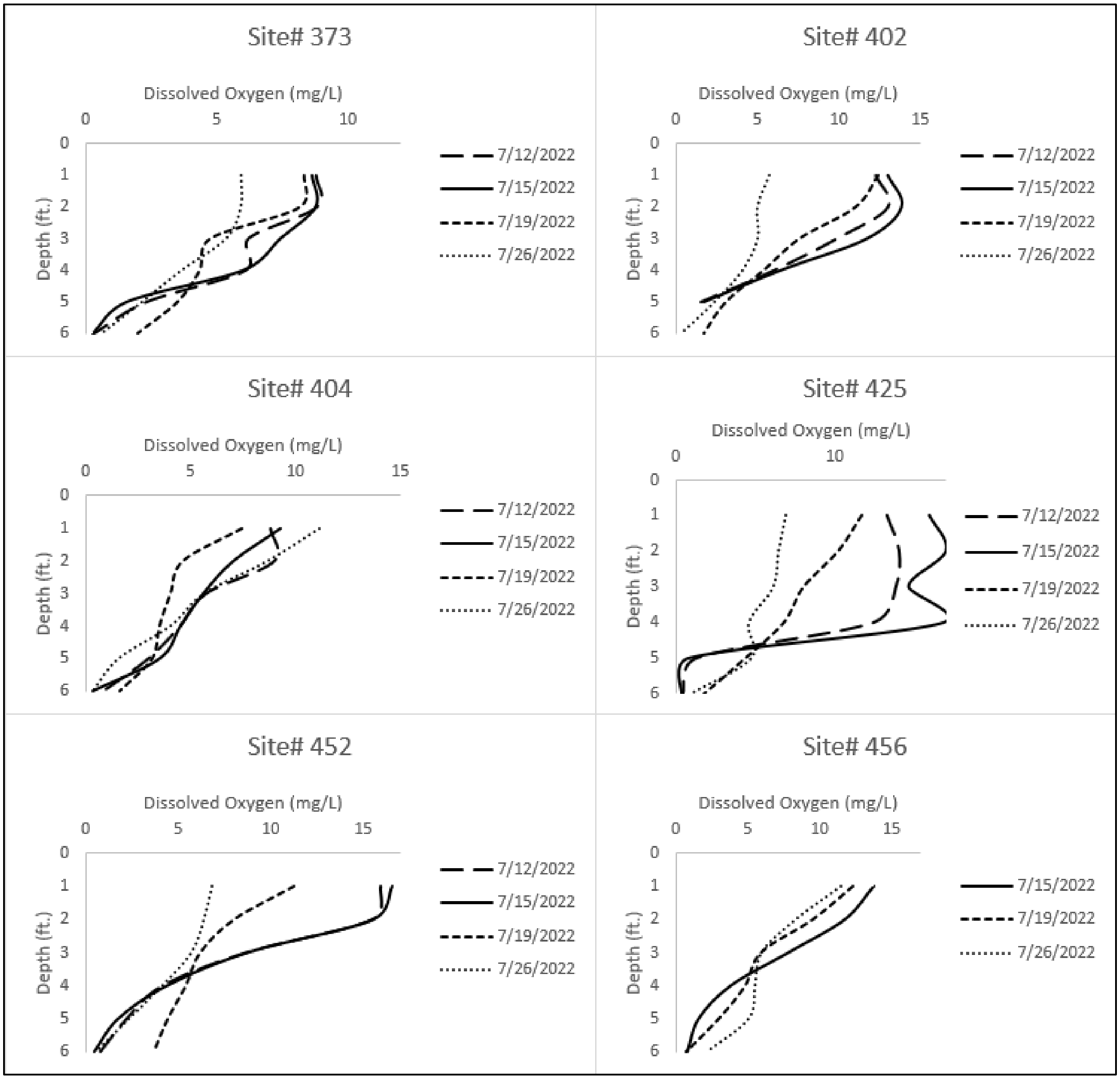


Figure 13: Dissolved oxygen profiles for the sampling locations of the initial ProcellaCOR® treatment zone from 7/12/2022 to 7/26/2022. Sites 373, 402, 404, 425, and 452 represent in-zone sampling locations. Site 456 was sampled outside of the test zone post-application for comparison.

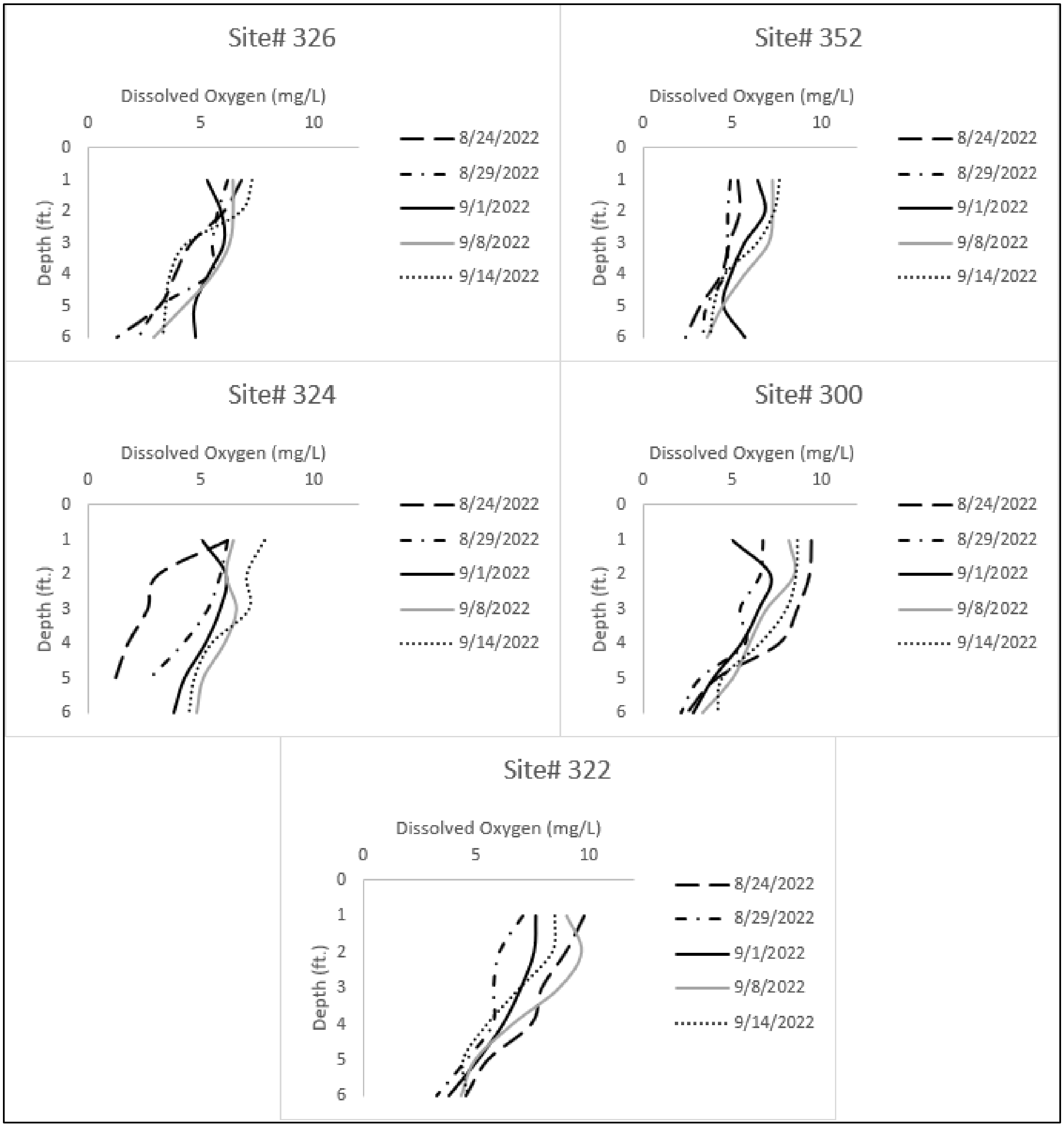


Figure 14: Dissolved oxygen profiles for the sampling locations of the second ProcellaCOR® treatment zone from 8/24/2022 to 9/14/2022. No sampling was conducted outside of the treatment zone due to the success of the first application and budgetary constraints.

Nutrient Data – TP levels within the treatment test zones were highly variable from one sampling date to another as well as within specific dates (Figures 15 and 16). Generally, and roughly speaking, TP in the initial application zone weakly trended toward lower (and less variable) concentrations from the preapplication data collection period (7/12/2022) to two weeks after the application (7/26/2022; Figure 15). TP trends in the second application zone were generally less variable overall and showcased an upward trend from preapplication (8/24/2022) to 2 weeks after (9/8/2022; Figure 16). Highest observed value was 600.2 ppb TP on 7/19/2022 in the first application test zone (possible outlier). Lowest recorded value was 29.2 ppb on 7/26/2022 also in the first application zone. Overall mean TP concentration was 95.6 ppb amongst all data points.

TKN levels appeared to mimic TP levels to an extent with higher variability in the initial treatment zone (Figures 17 and 18). TKN concentrations in both sampling zones did showcase a weak trend toward increasing from preapplication through post application dates. Maximum observed TKN value was found to be 4.6 mg/L in the initial treatment zone on 7/19/2022 while the minimum observed value was below detectable level (use value of "0") at three sampling locations also in the initial treatment zone on 7/15/2022. Overall mean TKN concentration was 1.5 mg/L amongst all data points.

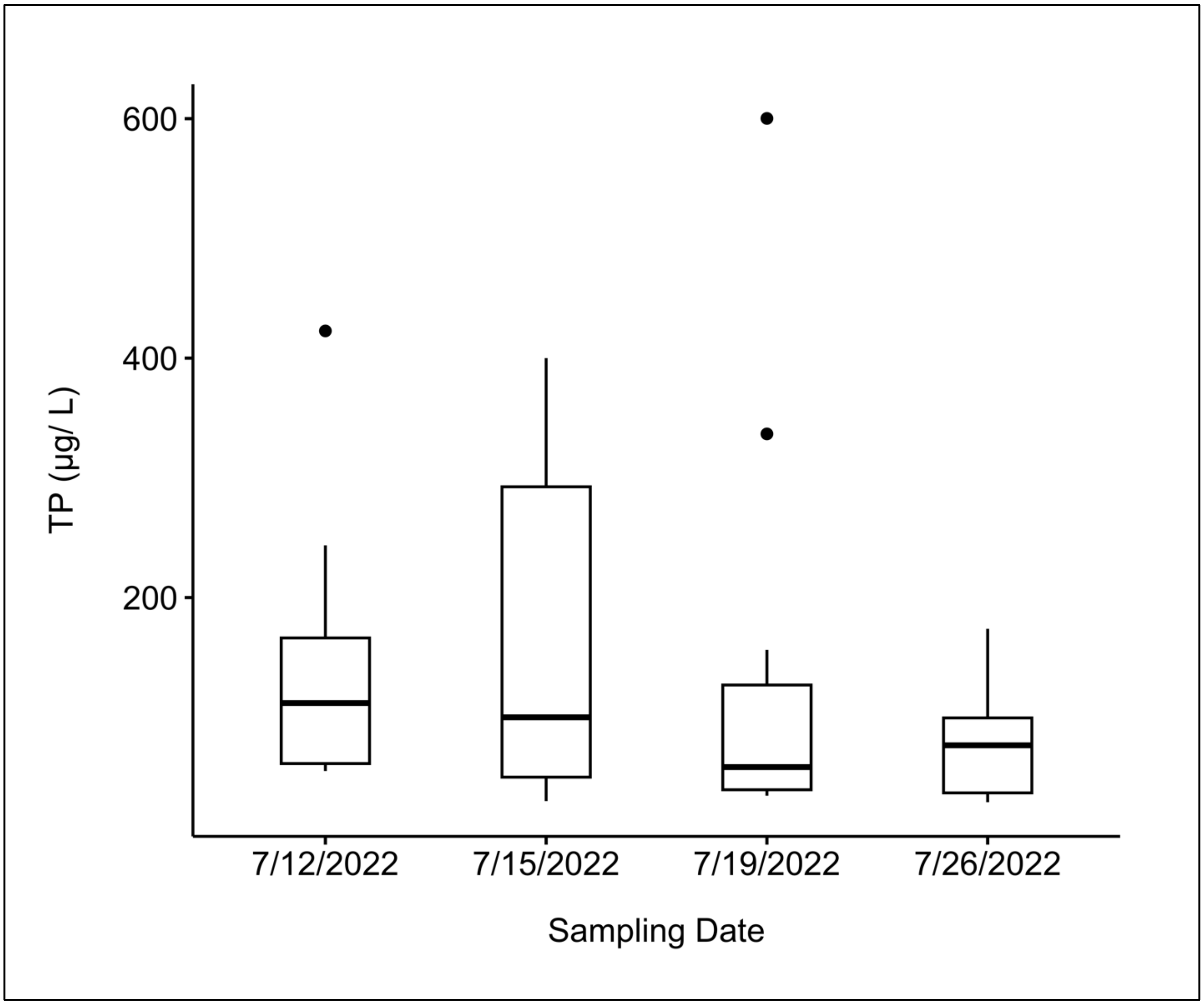


Figure 15: TP data spread from the initial ProcellaCOR® treatment zone. TP concentrations were highly variable. Note the scale on the Y-axis.

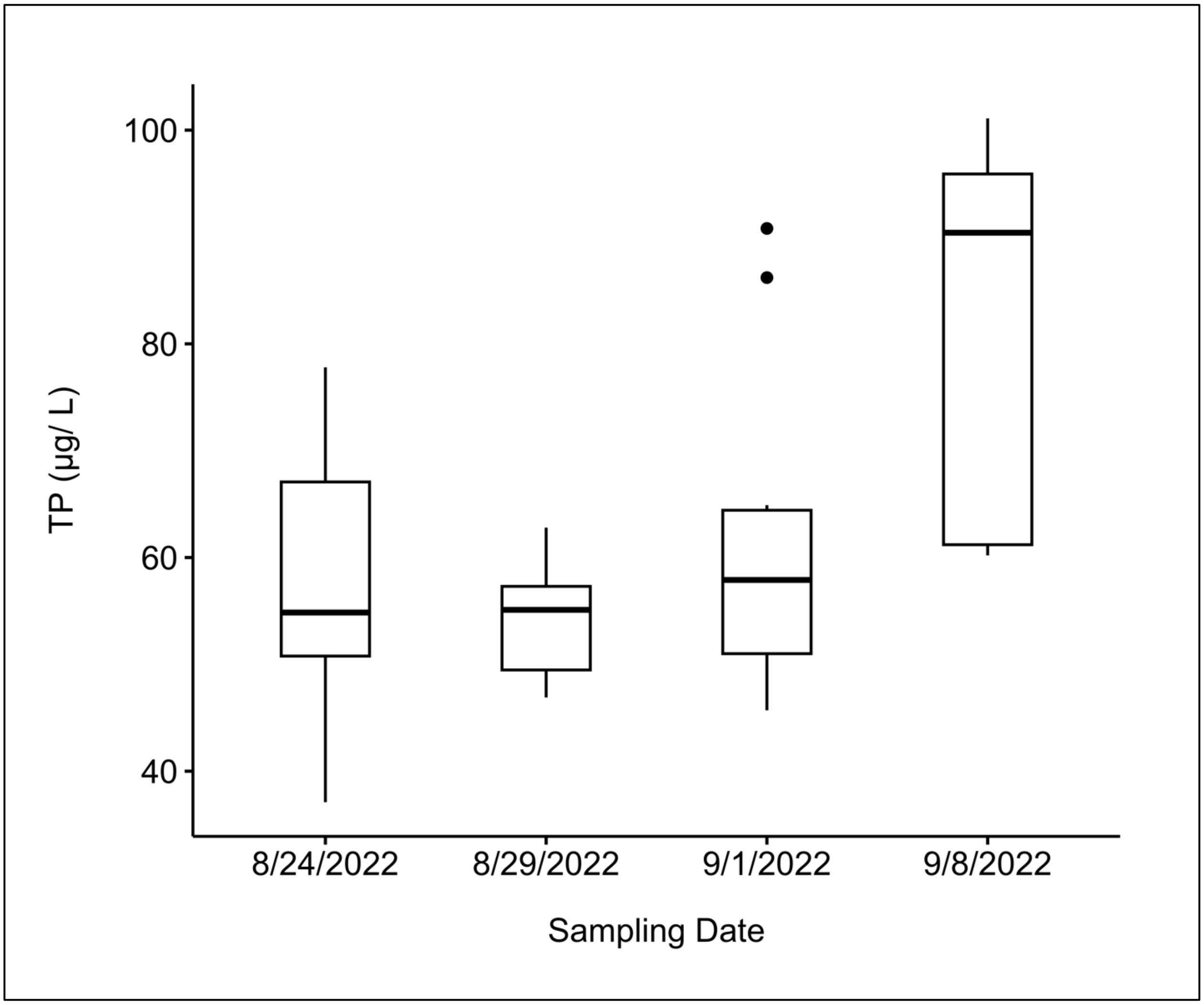


Figure 16: TP data spread from the second ProcellaCOR® treatment zone. TP concentrations were variable but less so than the initial application. Note the scale on the Y-axis.

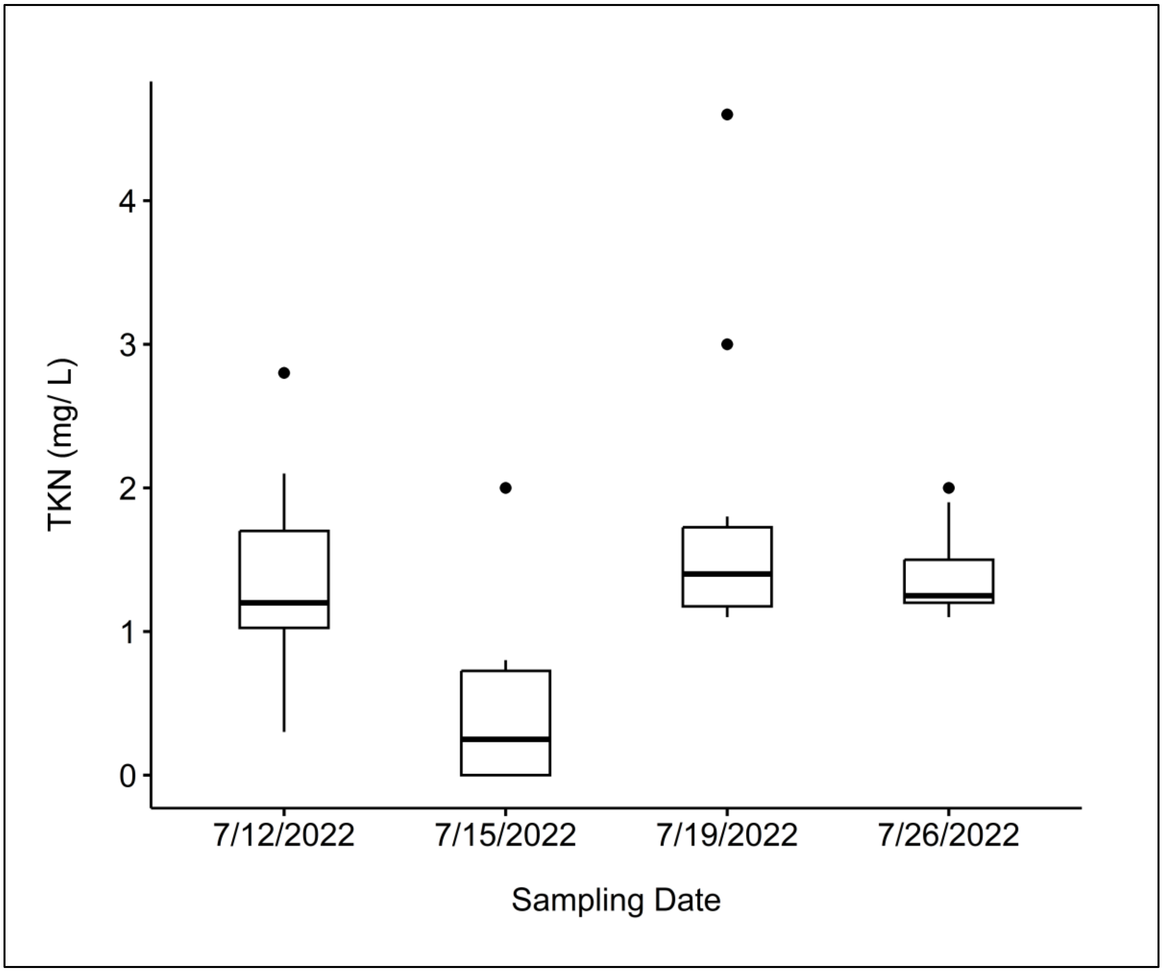


Figure 17: TKN data spread from the initial ProcellaCOR® treatment zone. TKN concentrations were highly variable. Note the scale on the Y-axis.

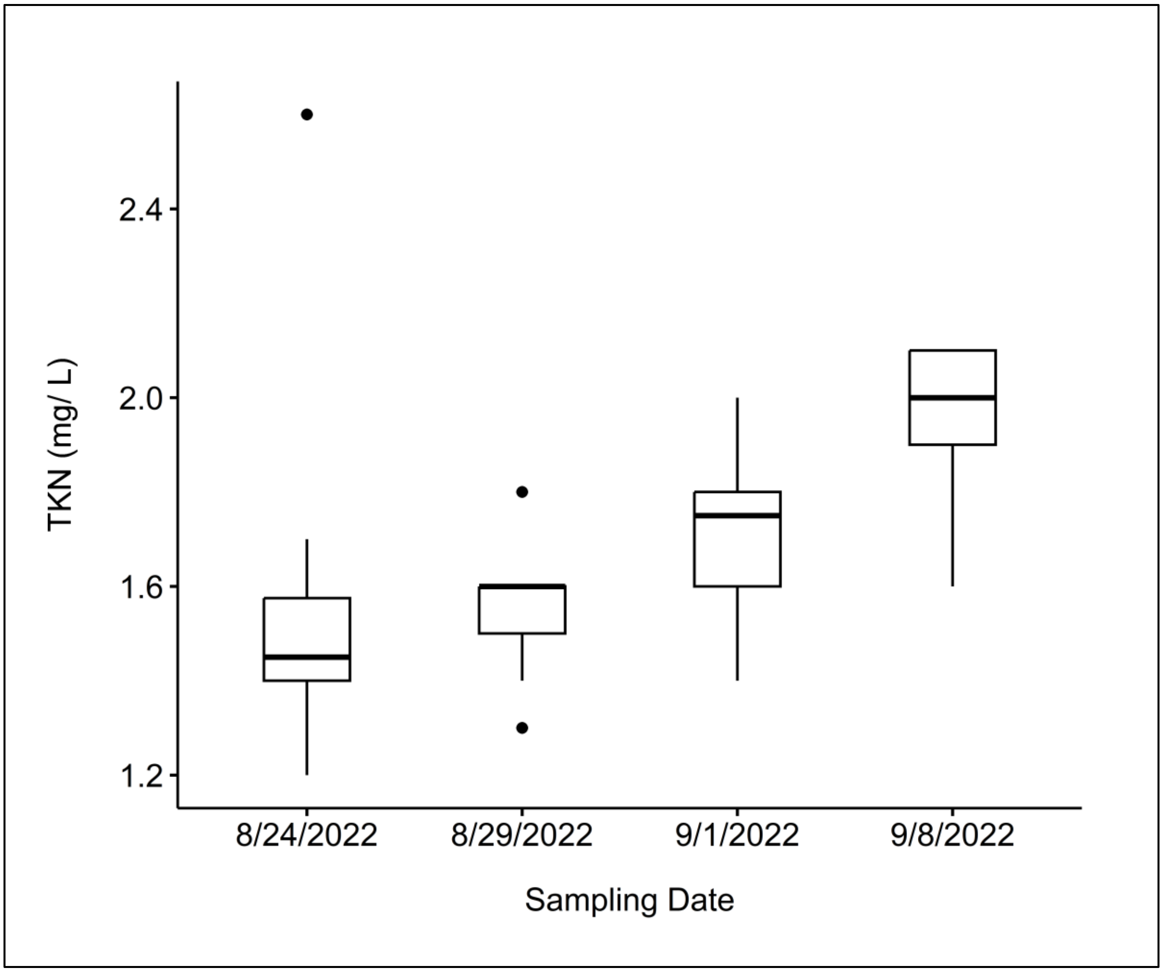


Figure 18: TKN data spread from the second ProcellaCOR® treatment zone. TKN concentrations were variable but less so than the initial application. Note the scale on the Y-axis.

Secchi transparency – Mean Secchi depth readings exhibited a decreasing trend from July 19 to September 14. Highest average was on 7/19/2022 with a depth of 5.5 ft. Lowest depth was 2.1 ft on 9/14/2022 (Figure 19).

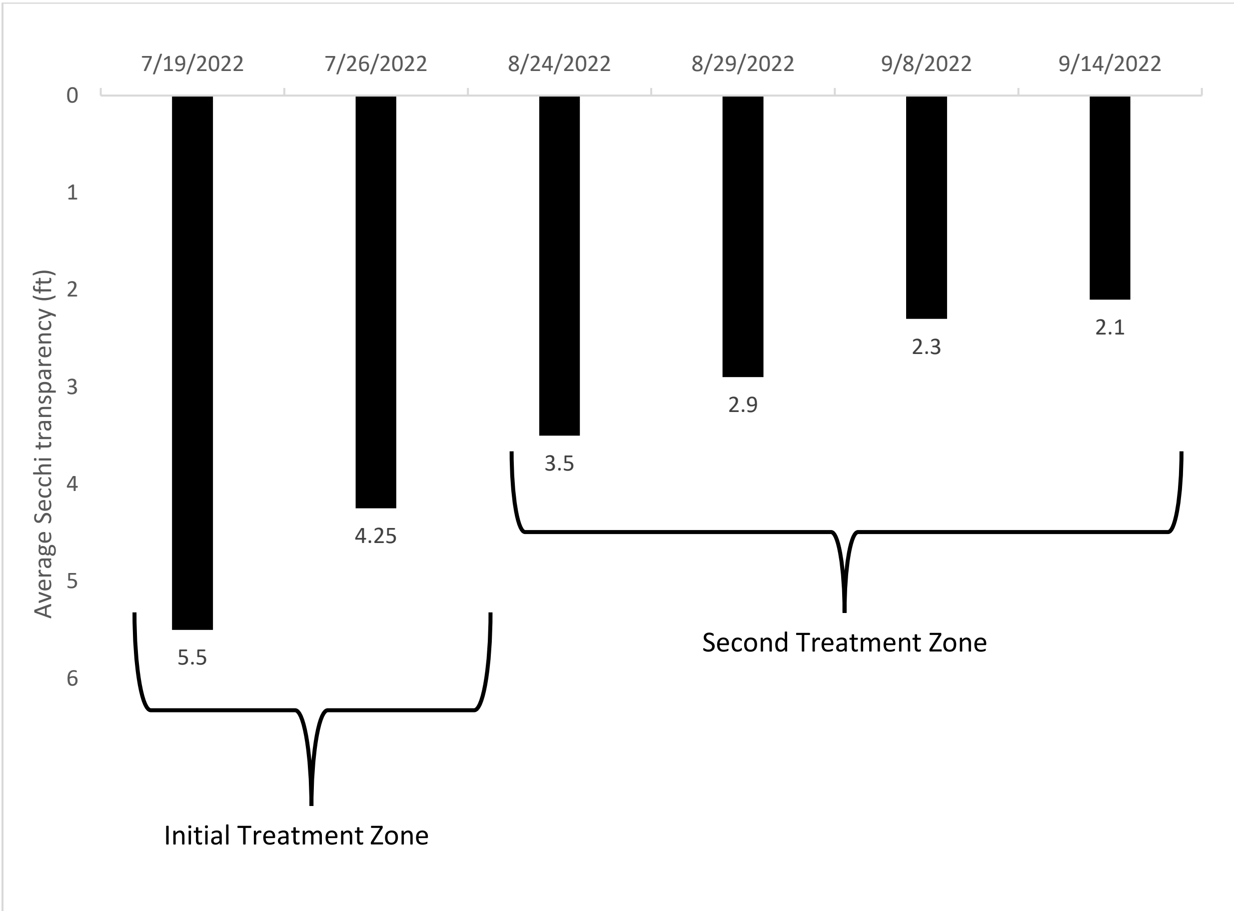


Figure 19: Average Secchi transparency from July 19 to the final sampling date on September 14 in the ProcellaCOR® treatment test zones.

Chlorophyll a – Chl *a* concentrations were relatively consistent within the initial treatment test zone but were highly variable for the second application (Figure 20). Highest recorded value was 47.7 µg/L on 8/24/2022 in the second treatment test zone. Lowest recorded concentration was BDL ("0") during the next sampling event on 9/1/2022 in the same zone. Mean Chl ɑ among all collected data was 17.9 µg/L.

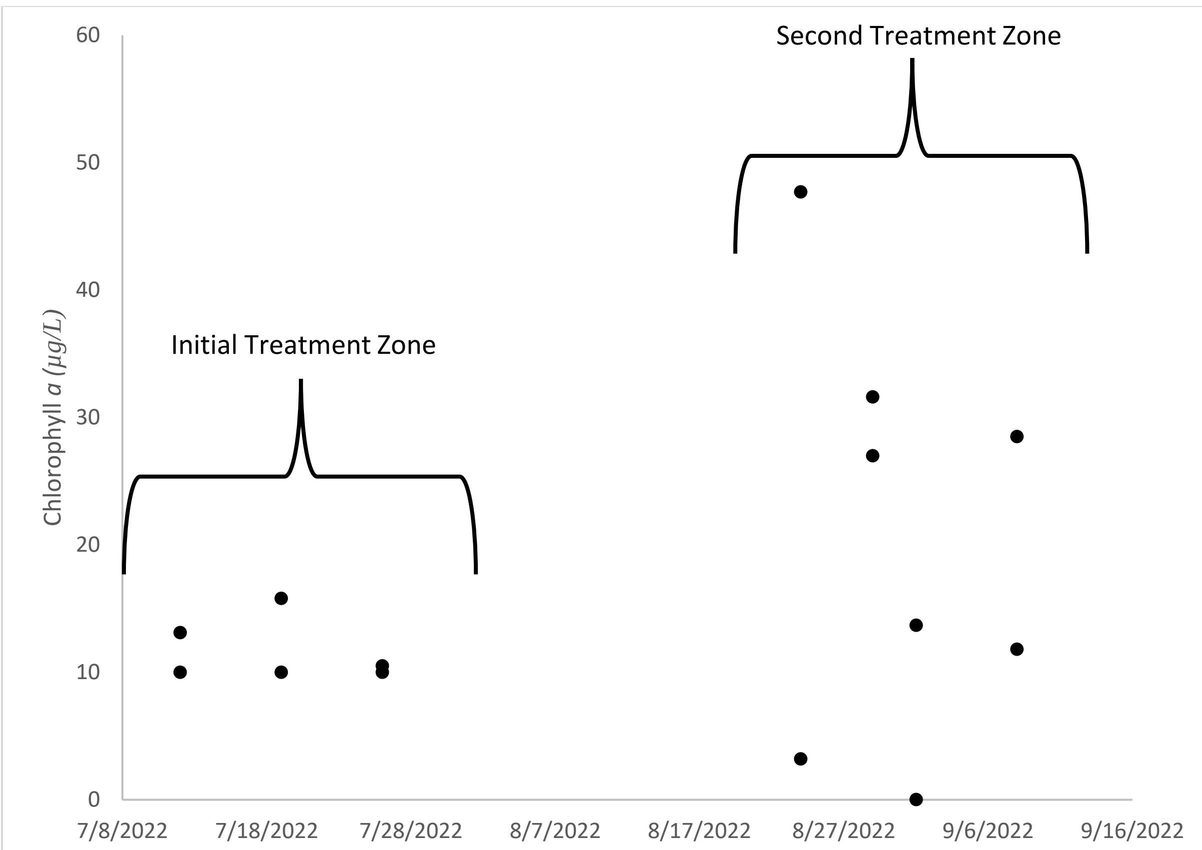


Figure 20: Chlorophyll *a* concentrations within both sampled ProcellaCOR® treatment test zones during the 2022 study period.

Turbidity – Turbidity remained relatively consistent through the initial application test zone and became slightly more variable at the second (Figure 21). Greatest observed turbidity value was found to be 16.4 mg/L on 8/24/2022 although this value may be considered an outlier relative to the rest of the data (next greatest is 4.6 mg/L on 9/8/2022). Lowest observed turbidity value was 2.3 mg/L on two sampling days (7/12/2022 and 9/1/2022). Mean turbidity concentration through all observed data points was 3.8 mg/L.

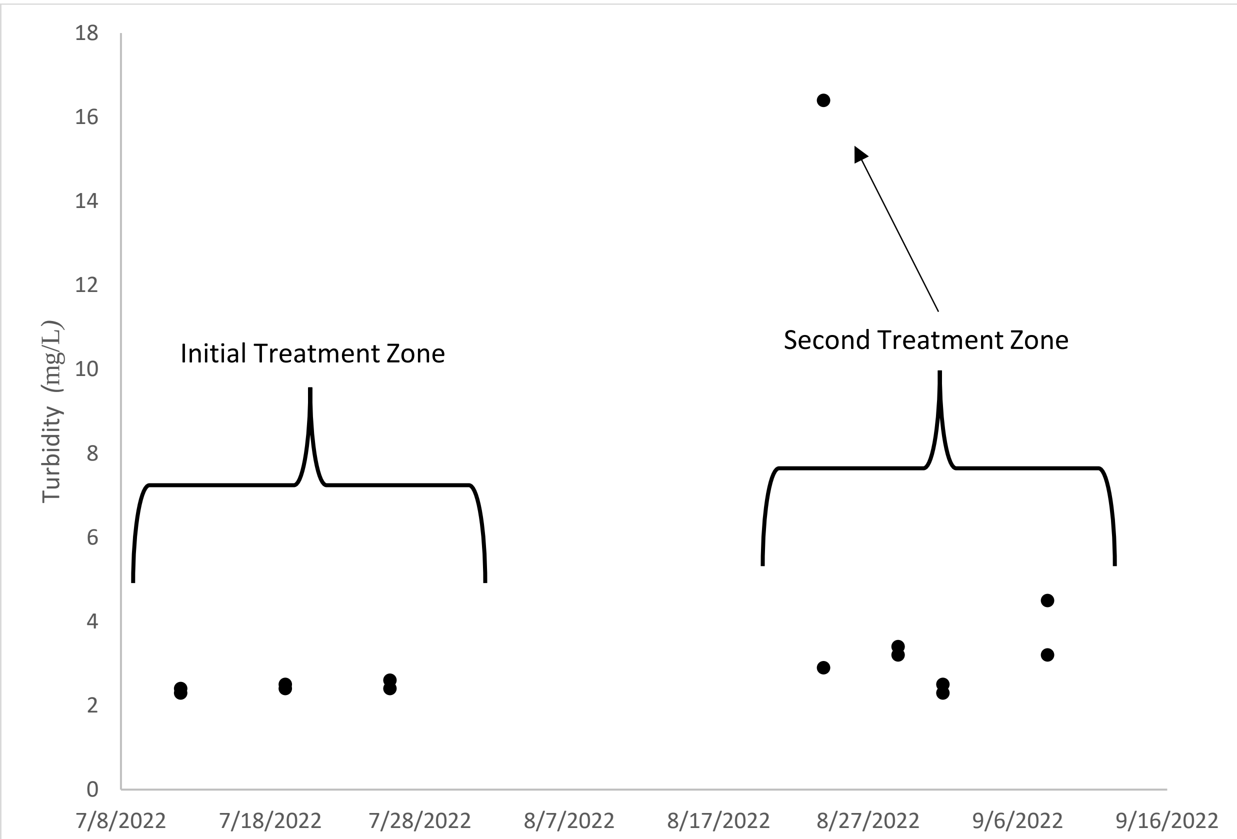


Figure 21: Turbidity concentrations within both sampled ProcellaCOR® treatment test zones during the 2022 study period.

Carlson's TSI (Trophic State of Indian Lake) – The trophic state of Indian Lake based off data within the ProcellaCOR sampling zones and Carlson's TSI (Carlson 1977) is firmly eutrophic from the analyzed information from TP, SD, and Chl. α (Figures 22 - 25). TSI_{TP} had the greatest sample size (n = 75) and seemed to showcase substantial variability in the initial test zone vs. the second zone (Figures 22 and 23). This relates to the greater variability in TP levels between these two sampling periods. Highest TSI_{TP} value amongst all collected data was 96.4 (7/19/2022), lowest TSI_{TP} value was 52.8 (7/26/2022), and the mean TSI_{TP} was 65.8. TSI_{Chla} did not experience as much variability as TSI_{TP} values but still suggest a lake that can be defined as eutrophic in nature (Figure 24). Two values, recorded on 8/24/2022 (41.8) and 9/1/2022 (40.6) did suggest a moment of defined mesotrophy but these data points appeared to be the exception rather than the rule when the rest of the TSI data is taken into consideration. Highest TSI_{Chla} value observed was 58.8 (8/24/2022), lowest TSI_{Chla} value was 40.6 (9/1/2022), and the mean TSI_{Chla} value was 53.9. TSI_{SD} echoes the suggestion that Indian Lake is defined as a eutrophic body of water (from the standpoint of the application zones; Figure 25). Lowest TSI_{SD} was 52.6 (7/19/2022), highest TSI_{SD} was 66.5 (9/14/2022), and the mean TSI_{SD} was 60.3.

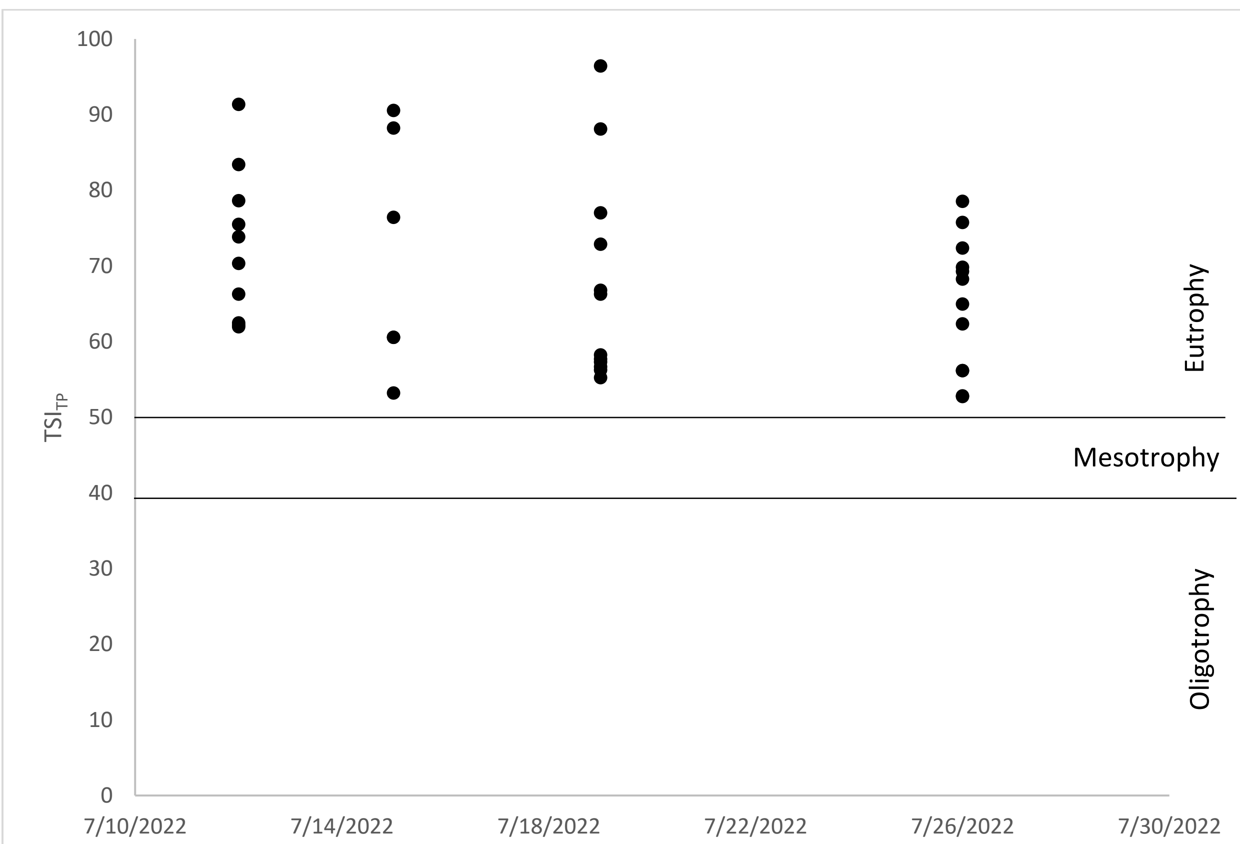


Figure 22: Carlson's TSI_{TP} values for Indian Lake from nutrient data collected in the initial ProcellaCOR® test zone (7/12/2022 – 7/26/2022). Different estimated trophic designations are identified on the right of the graph.

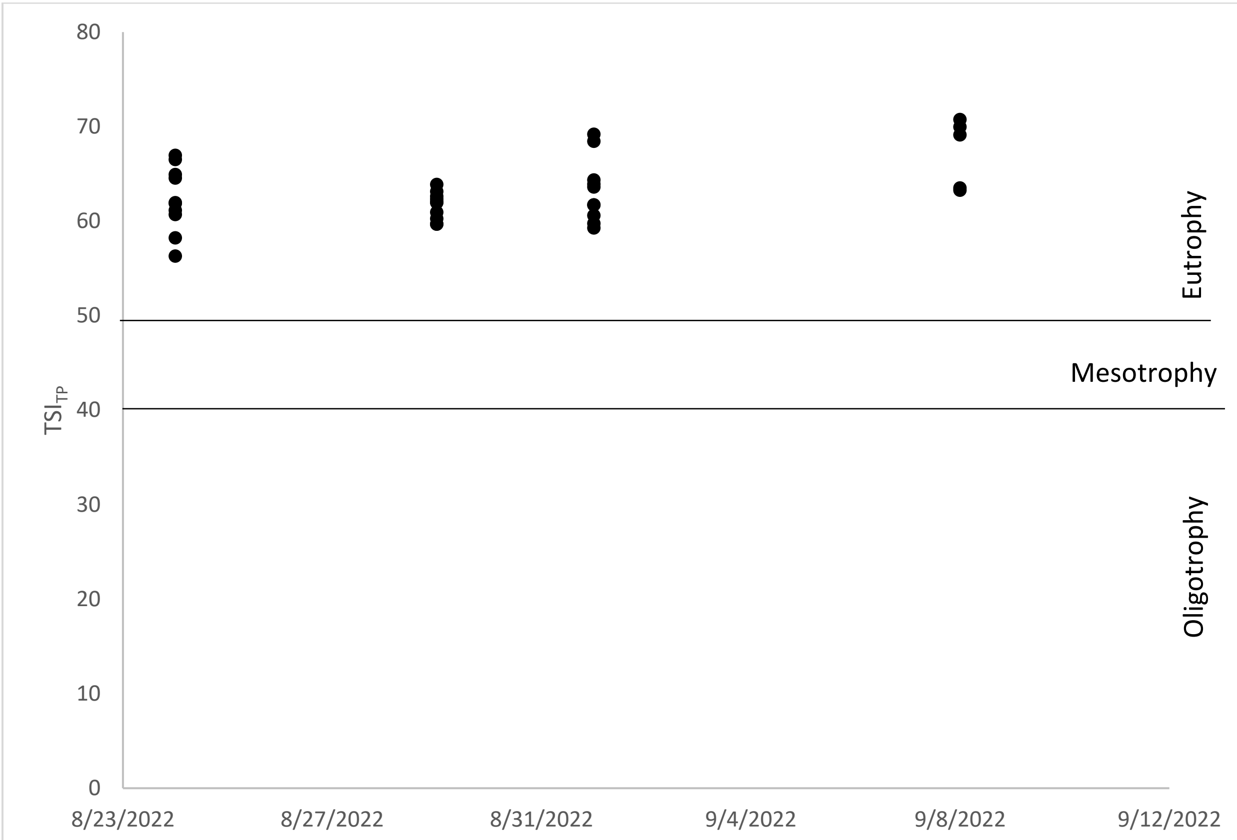


Figure 23: Carlson's TSI_{TP} values for Indian Lake from nutrient data collected in the second ProcellaCOR® test zone (8/24/2022 – 9/8/2022). Different estimated trophic designations are identified on the right of the graph.

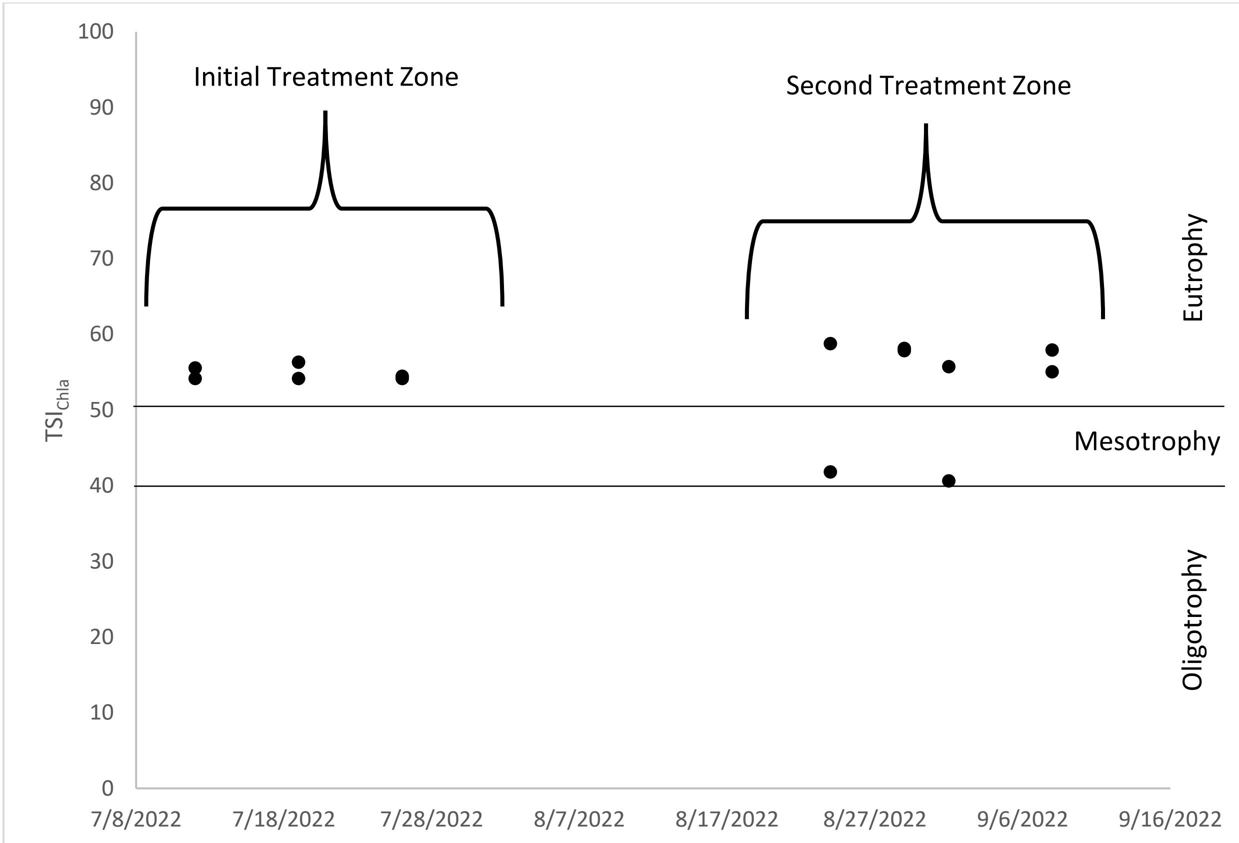


Figure 24: Carlson's TSI_{Chla} values (n = 14) for Indian Lake from nutrient data collected in both ProcellaCOR® test zones (7/12/2022 – 9/8/2022). Different estimated trophic designations are identified on the right of the graph.

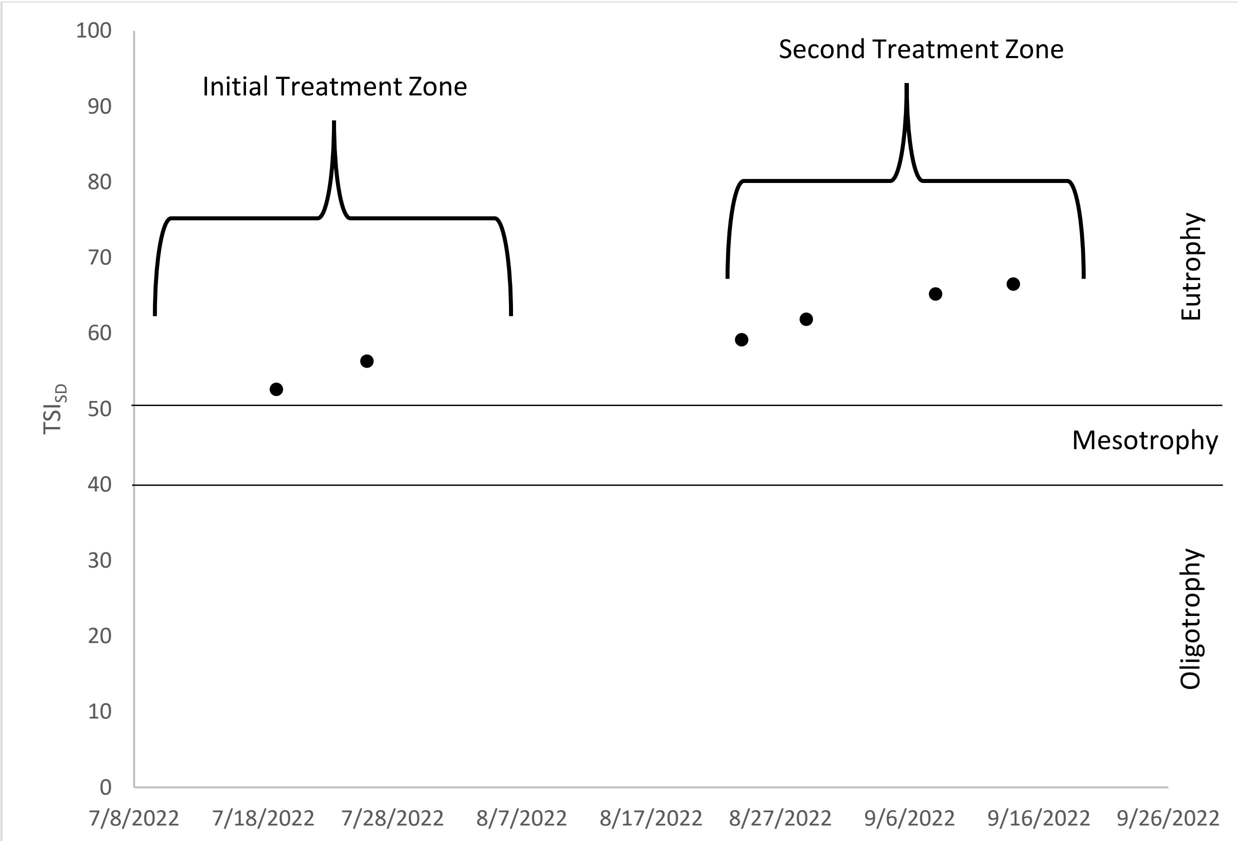


Figure 25: Carlson's TSI_{SD} values for Indian Lake from nutrient data collected in both ProcellaCOR® test zones (7/12/2022 – 9/8/2022). Different estimated trophic designations are identified on the right of the graph. Note: data points represent the average SD of the respective sampling date.

Discussion

Late-season deep zone

Physical and chemical YSI in-situ data showcased observable stratification potential within Indian Lake (Figure 8). All observed sampling dates showcased the presence of a thermocline between 3 feet and 5 feet with the 9/1/2022 and 9/14/2022 sampling periods being particularly strong (largest difference in temperature at site of thermocline; Figure 8). Stratification itself is the act of two separate layers of water being present within the water column due to density differences driven by temperature. When warmer epilimnetic waters are heated by the sun, they decrease in density and remain closer to the atmosphere-hydrosphere interaction point denoted at the surface of the water. Cooler, denser water will sink toward the bottom (hypolimnion). As the difference between the warmer surface waters and cooler bottom waters becomes greater, a more significant thermocline (threshold that separates warm, upper waters and cooler, bottom waters) develops. The more significant noted thermocline presented on 9/1/2022 and 9/14/2022 are likely the result of calmer days that allowed for the thermocline to develop more strongly. Turbulent days such as those during rain or wind storms, strong fluctuations in ambient air temperature, or even heavy boat traffic causing increased wave action can alter the strength of stratification.

The strength and duration of stratification can have a substantial impact on other lake parameters including water column DO concentrations (e.g. Figure 9) as well as nutrient build-up in the hypolimnion. These parameters are often interconnected as stronger thermocline development (greater difference from epilimnetic and hypolimnetic temperatures) will create a stronger density difference. A strong density difference will limit the ability for epilimnetic waters to interact with hypolimnetic waters. The lack of mixing amongst these two layers generally results in a loss of DO in the hypolimnion as there is a loss of interaction with atmospheric oxygen (the epilimnion maintains interaction) and a net respiration rate that is higher than that of photosynthesis. As DO continues to lower within the hypolimnion to the point of anoxia (0.0 mg/L of DO), phosphorus (P) can be released from the sediment layer of the lake itself as iron as the ion Fe^{3+} is reduced to the ion Fe^{2+}. When iron is in the Fe^{3+} form, it will readily bind to phosphorus and make it biologically unavailable for use. However, when its in the Fe^{2+} form, there is a greater affinity for sulfur (S) in the form of the ion S^{2-} and will release P it was bound to. Since iron is no longer binding to P, it tends to build in the hypolimnion. If a thermal mixing event were to occur, this P can be released throughout the water column and may become available for algae or submersed plant growth. This concept is known as the iron-trap and is common amongst stratified lakes and reservoirs. Future management and monitoring considerations should look more closely into this as internal loading (build-up of P within the lake) can become a substantial contributor to P-availability in Indian lake if stratification and hypolimnetic anoxia commonly occur on the lake. This would have to be compared to external nutrient sources (e.g. watershed contributions) to determine which source deserves more management attention.

Deep point water column DO concentrations on Indian Lake followed stratification patterns as described above. In epilimnetic waters (approximately 0.0 – 4.0 ft depending on sampling date; Figure 8) DO levels were observed between approximately 9.0 and 12.0 mg/L (Figure 9), levels more than adequate for biological use by gilled and other aquatic organisms. Beyond this threshold, DO levels at the deep point demonstrated a decreasing pattern until the bottom of the reservoir where concentrations dropped below 3.0 mg/L at every sampling period. Levels below 3.0 mg/L could be concerning knowing DO further regresses at night with typical concentrations being the lowest just before sunrise. It should be noted that different aquatic gilled organisms have various necessary oxygen thresholds for survival. Fortunately, DO levels were only found to be below 3.0 mg/L at the very bottom of the lake and oxygen loss did not proceed toward the upper limits of the hypolimnion. In strongly stratified lakes and reservoirs, DO loss can persist from the bottom of the lake to the upper limits of the hypolimnion. In some instances, this can result in a large portion of the water column being an anoxic "dead zone" that can limit aquatic organism habitat, release phosphorus (as described above), and result in fish kills in particularly bad scenarios. As hypolimnetic DO loss typically progresses through the warmer months and peaks in early Fall, the data collected at the deep point of Indian Lake do not show substantial hypolimnetic oxygen loss. Should this have been an issue, it would be expected that there would be a much greater observed value difference in DO concentrations between epilimnetic and hypolimnetic waters at the time of sampling.

The observed pH values recorded in Indian Lake at the deep point were well within safe levels for aquatic organism survival, although slightly alkaline (between 8 – 9; Figure 10). pH values below 6.5 may start to show detrimental impacts on aquatic biota (Campbel and Stokes 1985) while acidic values (sometimes noted below 5.3) will alter aluminum ions in a water body to a form that can harm gills. Higher, more alkaline values can also have negative impacts on aquatic biota. pH fluctuations can be common in dynamic, aquatic ecosystems but are rarely robust enough to cause concern. Heightened photosynthetic activity however, is one way in which pH values can rise particularly in epilimnetic waters as calcium carbonate production increases, driving increased pH levels. With the likely substantial increase in photosynthetic activity from nuisance submersed vegetation growth in Indian Lake, pH values within localized vegetation beds likely increased. This was confirmed while sampling DO levels in the ProcellaCOR® test zones where pH values read during the same sampling period were noted to be above 11 in some instances (unreported as the data was not a part of the sampling protocols for the test zones). Although not directly a part of the deep point sampling, the heightened potential for highly alkaline pH levels in large submersed plant beds is important to note should vegetation (or algal) growth become substantial again in the future. pH levels becoming alkaline to the degree of becoming a high-risk scenario for aquatic biota could become a management concern and an additional point for continual monitoring of the reservoir.

Specific conductance did not showcase any values within the observed depth profiles that would suggest Indian Lake is impacted by excessive ions in its water during the time of sampling (e.g. road salts from the winter season; Figure 11). For many reservoirs, excess ions that enter from its watershed or other sources can create a dense layer of water that can remain at its bottom. In extreme instances, this layer of water can become dense enough to restrict interaction with the water column above it, resulting in a static layer of water that could demonstrate substantial oxygen loss (chemocline). A spike in conductance near the bottom of our sampling depth would demonstrate this but was not present at the deep point.

Oxidation-reduction potential remained positive throughout the water column during all sampling dates suggesting a drive toward oxidative reaction (Figure 12). The presence or absence of oxygen can alter chemical reactions in a water body. In the presence of oxygen, positive ORP values are typically observed and can suggest a strong likelihood for certain biological reactions such as biological P entrapment in iron (as described above) and nitrification. Negative values can suggest a reduced state in the water column and drive opposite reactions such as P release from iron and methane production.

ProcellaCOR® test area

Oxygen concentrations within the ProcellaCOR® testing zones during pre- and post-application sampling events showcased a similar trend of elevated surface concentrations that trend to hypoxia as you reach the bottom (Figures 13 and 14). During the initial July treatment, oxygen levels near the surface of select sampling locations were high enough to be considered supersaturated and could be attributed to heavy photosynthetic activity from immense submersed vegetation and filamentous algae growth (Sites: 402, 425, and 452 until two weeks after application for the first test zone; Figures 26a and 26b). Highly depressed levels near the bottom of all sampled July application zones are likely attributed to an increase in decomposition as surface growth shaded out any vegetation under it, resulting in a net respiration that exceeds photosynthetic capability. Mixing within the water column to stabilize oxygen levels was also highly unlikely during these periods of excessive vegetation and algae growth as the dense mats prevent wind action from interacting with the water and general water exchange. DO data collected during analysis of the ProcellaCOR® treatment test zones support these ideas as DO levels began to stabilize once heavy vegetation had been removed lessening surface photosynthetic activity, and opening the test zone to atmosphere interaction and likely, flow dynamics.

DO continued to be less variable and more stable into the second application test zone in August as the density of submersed vegetation was considerably less than the initial test zone in July (Figure 14). A trend of increasing hypoxia was still documented at every sampling event however, suggesting decomposition was still impacting bottom oxygen concentrations. Pre- vs post- application sampling events did not showcase an overall unacceptable drop with regard to water column oxygen concentrations even two weeks post application. Bottom oxygen concentrations were overall higher in the second treatment test zone from the initial application further supporting a rebound and stabilization from extremes demonstrated in the initial July test application.

Total phosphorus levels were highly variable within the July initial application zone displaying a range of 29.1 ppb (µg/L; two weeks after application, site 402) to 600.2 ppb (one week after application, site 452; Figure 15). This variability could be derived from sampling within heavy vegetation beds where phosphorus release from one sampling location to another could be variable due to the extensive vegetation biomass (Moss et al. 1996). The large amount of dense vegetation growth within the July treatment test zone likely localized TP concentrations and restricted homogeneity. This hypothesis is supported when looking at the TP concentrations at the last sampling date from the July application (7/26/2022) where data variability was notably reduced and vegetation was observed to be significantly reduced vs. pre-application (Figures 27a and 27b). This carried over into the August sampling of the second application test zone where variability throughout all data collection events (pre- and post-application) was notably lower than the initial July application data (Figure 16). The August sampling period showcased a weak trend toward increasing TP concentrations with a more condensed range of values (37.1 ppb to 101.1 ppb).

Similarly to TP values, TKN values were variable within the initial application zone and showcased a range of values from 0 to 4.6 mg/L (Figure 17, 7/15/22 to 1 week after application). The reasoning for this may be the same to the reasoning for TP variability listed above where TKN variability also reduced when vegetation density decreased (2 weeks post application). This also carried over into the August sampling period in the second application zone where overall variability was reduced but a significant increase in TKN was noted from preapplication concentrations to 2 weeks after and the maximum concentration was lower (2.6 mg/L, 8/24/2022; Figure 18)

Average Secchi depth (transparency) shallowed from the initial data collection date where observed values reached an average depth of 5.5 ft within the initial July test zone to 2.1 ft within the second application zone (Figure 19). These shallowing values corresponded with higher variability in chlorophyll *a* concentrations within the second application test zone as well as a noted increase in turbidity (Figures 20 and 21). These observations together could indicate an increase in algal growth potential as vegetation was being managed. As more submerged vegetation growth is eliminated from the reservoir, a greater net quantity of available P becomes usable to algal growth which can allow for chlorophyll *a* levels to fluctuate under additional adequate environmental conditions (e.g. when more sunlight is available and little wind action). It could also be surmised that the noted decrease in SD as well as the increase in turbidity could be the result of resuspension of bottom sediment material due to wind action once vegetation had been managed. Although possible, DO levels would also be consistent from surface to bottom during complete water column mixing which was never observed during our sampling. Turbidity quantification does not distinguish from sediment derived turbidity and algae derived turbidity so a better separation of the origin of the turbidity would need to be conducted to have a stronger grasp on its identification.

Stabilizing DO levels within both treatment zones post application is an encouraging sign for the use of the ProcellaCOR® as a future management option. However, care should be taken to ensure proper management practices are being adhered to reduce unnecessary harm on nontarget biota. The extreme difference in DO concentrations noted as supersaturation at the surface to the hypoxic concentrations near the bottom of the initial July application zone demonstrate the need for caution when considering herbicide application at a large scale and in dense areas of submerged vegetation. If too much vegetation is treated at one moment, there is the risk of oxygen concentrations crashing due to increased decomposition which would have severely detrimental impacts on gilled biota, including sport fish, as well as impact redox reactions within the zone.

Additionally, understanding how much vegetation can be removed without pushing the stable state of Indian Lake to an algal dominated system should be strongly considered. Submersed vegetation and algae compete for similar nutrient resources. When managing one potential nuisance (i.e. submersed vegetation), it is not uncommon to unintentionally give a competitive advantage to another. The result is a change in dominant biomass to a new nuisance that may require different management considerations. Perhaps the biggest concern would be a shift to cyanobacterial dominance in the lake that can produce harmful toxins to human and animal health.

Figure 26a and 26b: Images of the extent of the submerged vegetation growth within the initial July treatment test zone. Photos taken on 7/19/2022 (Photos: Edward Kwietniewski).

Figure 27a and 27b: Images of the initial July treatment zone 2 weeks post application. Photos taken on 7/26/2022 (Photos: Edward Kwietniewski).

IV. Indian Lake Macrophyte Community

Introduction

Macrophytes (submersed aquatic plants and macroalgae) play an important role in the overall sustainability of a water body by being an integral part of its food web as primary producers, along with phytoplankton (i.e. algae). They also provide a variety of ecological services for lake stakeholders such as erosion control for shoreline rehabilitation, nutrient sequestering to be a viable competitor to algae growth, provide habitat to a host of aquatic organisms which strengthens food web dynamics, and can support a hearty fishery, amongst a host of other benefits (Figure 28; Cooke et al. 2005, Wersal and Madsen 2012, Chapter 2). Despite these advantages to macrophyte growth in lakes and reservoirs, they often receive a bad reputation from lake users when they impede use of the system. When macrophyte growth overtakes an aquatic system to the point that the water body does not meet its intended categorical use, the water body is considered impaired. When this happens, management is typically necessary to ensure proper navigation, function, and form are restored to acceptable conditions. With cultural eutrophication (human induced P increases into water bodies) becoming a growing issue for inland lakes and reservoirs across the United States, more focus is being put on how to balance macrophyte growth with best use of their respective water body (e.g. Lake Monona, WI, Lake Kegonsa, WI; Marshall 2011, Marshall 2007). It is important to note that macrophytes are a necessary part of a lake or reservoir system, and complete eradication of all growth is never suggested nor realistic in most situations. However, management of nuisance biomass is imperative to ensure the water body meets its categorical designation and community sustainable social wellbeing is achieved.

Invasive macrophytes are submersed aquatic plants and macroalgal species that are present in a geographical region where they traditionally do not reside. These species have an increased capacity to become nuisances in nature and cause both ecological as well as lake-use harm. Within areas they invade, they rarely have natural grazers and possess traits that allow them to hold a competitive advantage over native flora in areas they invade. These combined factors allow for invasive macrophytes to flourish and spread rapidly within a system where a niche is available. Although many vegetation management plans focus on invasive species control, it is important to note that native vegetation can also become nuisance in behavior should conditions in the waterbody be favorable. Therefore, during the development of a lake vegetation management plan it is important to be able to identify what is considered a nuisance to the use of the system and whether the nuisance(s) are invasive or native. Management decisions would then need to prioritize controlling these macrophytes as they impose the greatest risk to sustaining a desired nonimpaired lake status.

Indian Lake experienced significant macrophyte growth during the 2022 season to the point of severe impairment for its use as a contact-recreation reservoir. This is markedly different from the widely accepted notion and reference condition that the reservoir experienced enough suspended sediment turbidity to limit light availability and thus, limit the range of potential macrophyte growth. Very little data is currently available to suggest that Indian Lake's reference turbidity was sediment-based vs algal based. However, satellite imagery suggests that the reservoirs major inlets could cause the turbidity to be sediment based from upstream erosion (Figure 29). Regardless, leading up to the 2022 season, light availability increased to the point where macrophyte growth could flourish in newer, opened niches present in the lake. The exact reason for the increase in light availability was never directly studied but, many stakeholders will point to the recent proliferation of invasive zebra mussels (*Dreissena polymorpha*, first noted in Indian Lake in 1990; ODNR 1990) as the ultimate factor. It is likely however, that the increase in light availability was the result of a web of different factors that, when combined, resulted in the 2022 macrophyte niche expansion (Figure 30). Regardless of the different reasons for the expansion of macrophyte growth through Indian Lake, the need for a vegetation management plan was apparent and is the focus of this study.

No previous macrophyte surveys have been conducted on Indian Lake prior to this study and very little is known about the submersed plant community prior to the 2022 vegetation expansion through the reservoir. To be able to develop a vegetation management plan for Indian Lake and its community, knowledge gaps on what nuisance vegetation is in the reservoir need to be filled in order to competently develop such a plan. In order to better understand the macrophyte community a study was designed to allow for a greater understanding of the identification, distribution, and density of submersed aquatic plants in Indian Lake.

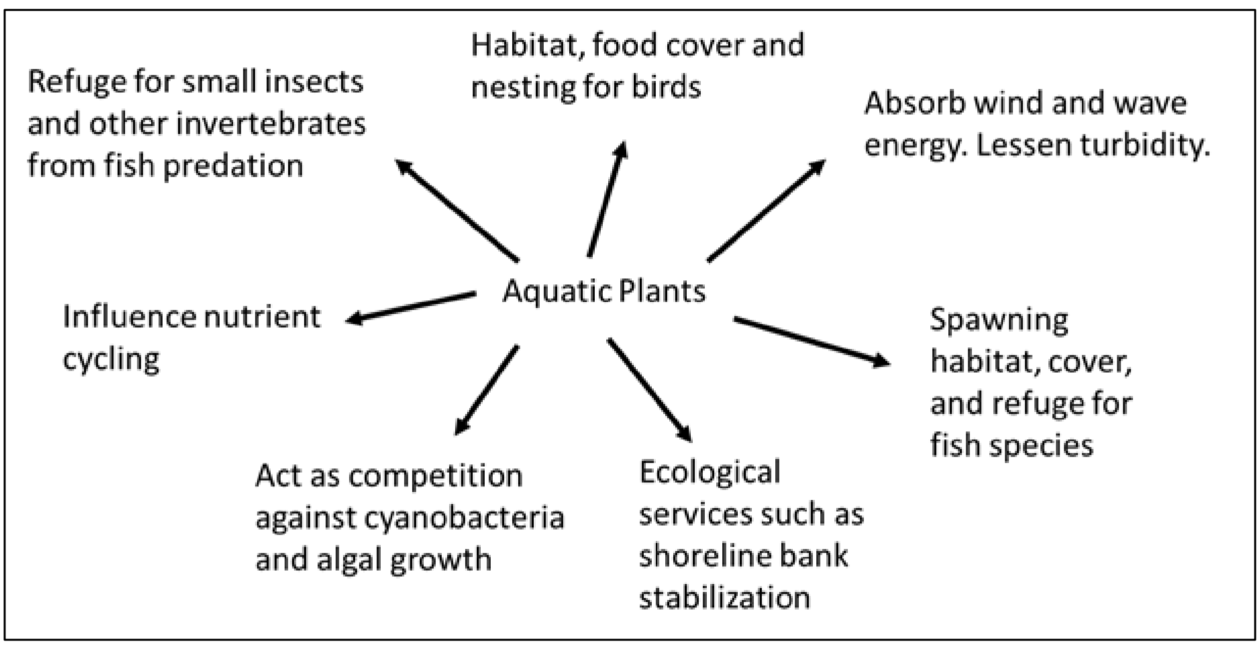


Figure 28: Diagram depicting some of the benefits and services submersed aquatic plants provide to a lake or reservoir environment (adapted from Cooke et al. 2005).

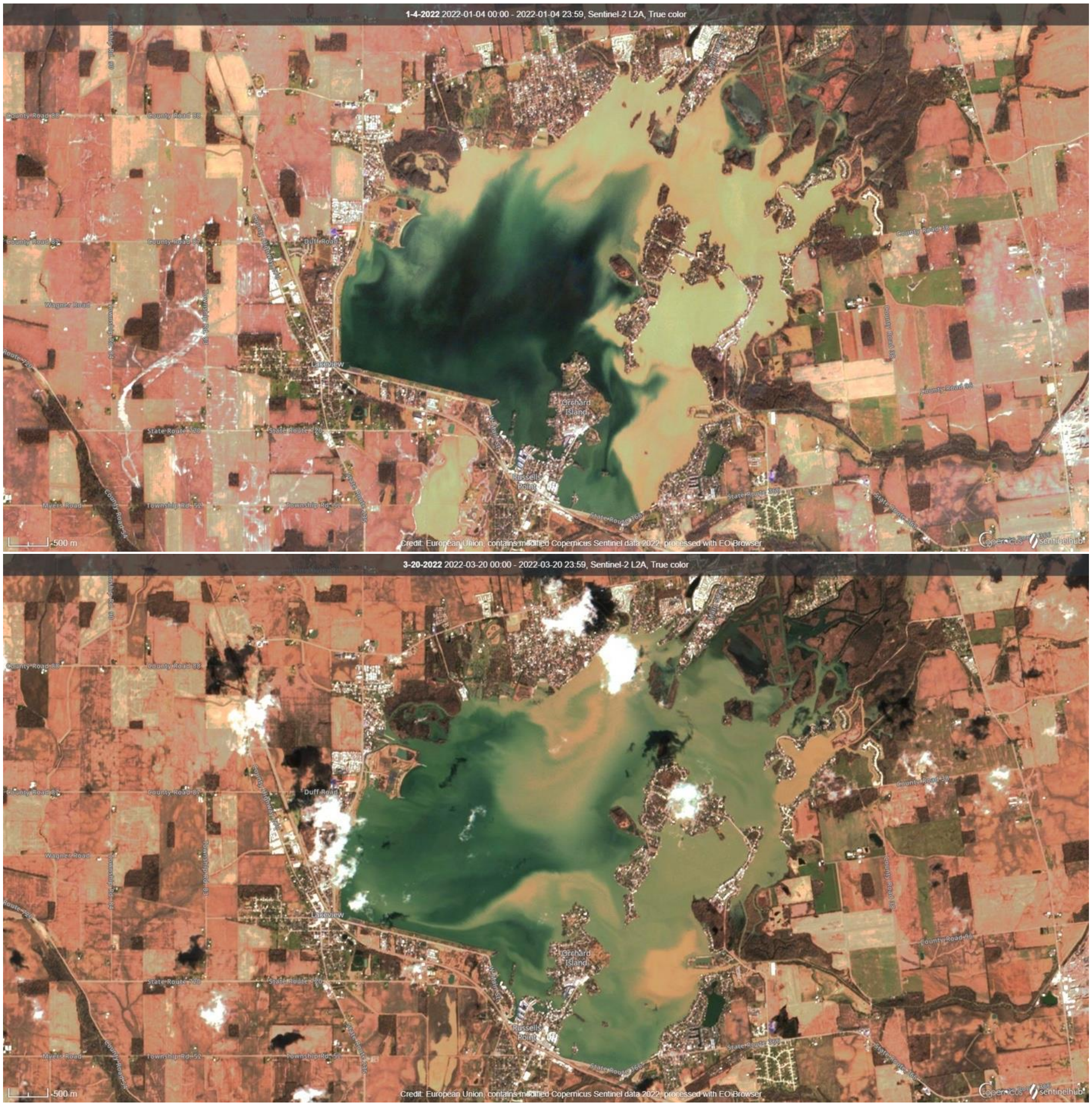


Figure 29: Satellite imagery of Indian Lake on January 4, 2022 (top) and March 20, 2022 (bottom) showcasing the impact of sedimentation and turbidity from Indian Lake's inlets.

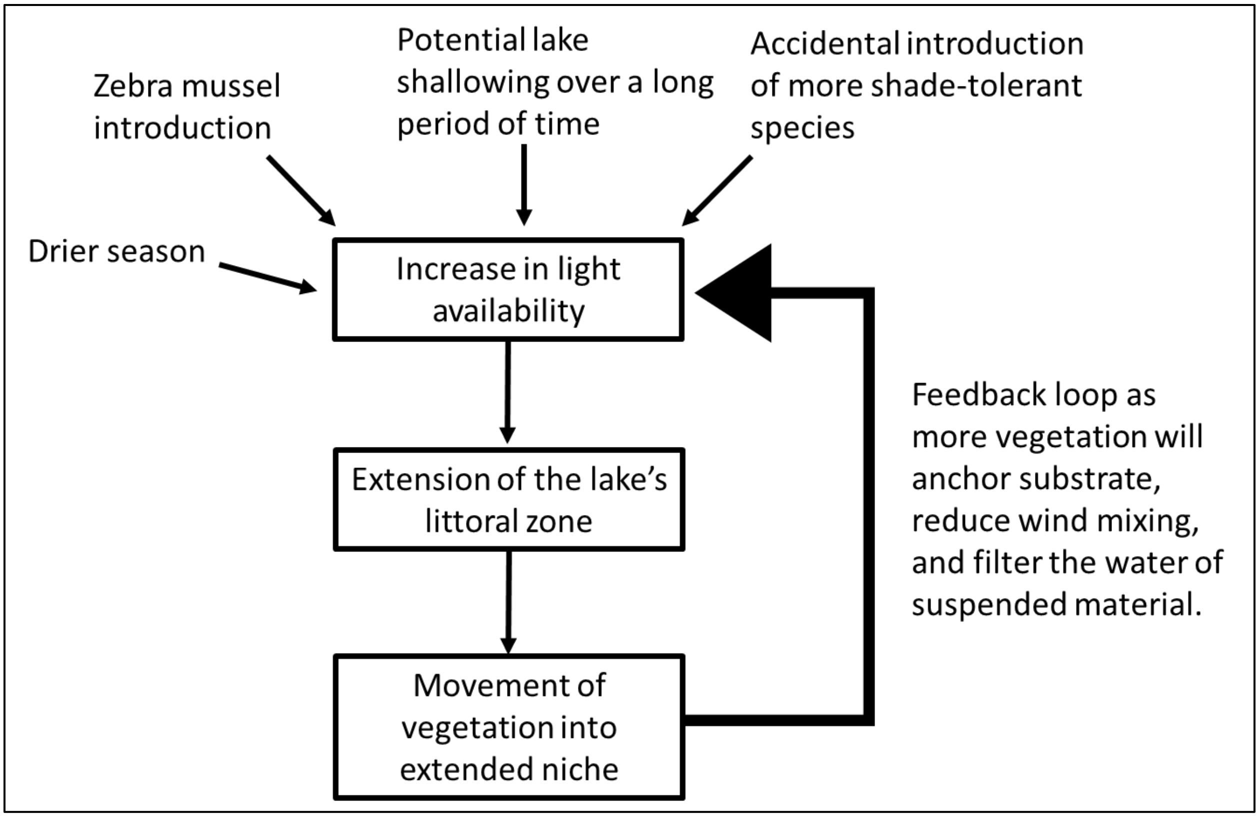


Figure 30: Diagram depicting a multi-factor scenario that could have resulted in the noted increase in light availability that ultimately allowed for submersed vegetation expansion in Indian Lake.

Materials and Methods

In order to characterize the Indian Lake macrophyte community, a modified version of the Point Intercept Rake Toss Relative Abundance Method (PIRTRAM; Lord and Johnson 2006) was performed in conjunction with plant density sonar mapping. Sampling was conducted from July 5 through 15, 2022 with two teams in order to collect as many different early, middle, and late season macrophyte species as possible and identify the best spread of potential aquatic plants present in the reservoir. The PIRTRAM technique involves the use of a modified rake (two metal rake heads welded together and attached to a line) tossed into a water body at pre-determined locations and slowly brought back to the boat, bringing any submersed aquatic plants with it. A general density number is then attached to the haul (based on the discretion of the one hauling in the rake; Table 5). Individual species of aquatic macrophytes are then separated out, identified, and an estimate of the proportion of each specie is determined (by percent of the total haul). Sampling points were determined through the creation of a gridded map of Indian Lake (Figure 31) which was generated using the program GE Path. Gridded locations were marked through Google Earth and converted into GPS coordinates that could communicate with GPS units for site location identification. Every reasonable intersection point on the grid was sampled once under the technique listed above and amounted to 585 distinct locations. Data was collected manually and included above information as well as any additional notes deemed important for the purpose of this study (e.g. harvested zones, presence of filamentous algae, important water conditions, etc.). Once all data was collected, it was analyzed through Microsoft Excel and combined with generated maps from Biobase®.

Vegetation density sonar mapping was conducted with Biobase® mapping programming. Biobase® utilizes sonar "pings" to identify the bottom of Indian Lake as well as any vegetation in the water column. Each "ping" would represent a data collection point where a timestamp, GPS coordinates, depth of the reservoir, and a percent of the water column covered in macrophyte biomass were collected (Figure 32, 58,185 total point "pings"). In order to collect necessary sonar data, a Lowrance Hook Reveal TS7 was used on a Carolina Skiff and a path was created by "tracing" Indian Lake slowly (2 – 3 mph) ensuring to cover as much of the reservoir as possible (Figure 33). In order to accommodate for the scale of Indian Lake, much of the reservoir had to be sampled in chunk sections and combined through the Biobase® analysis portal found online. The use of the online analytical portal also allowed for manual entry of data should an area have been restricted or missed by the Lowrance unit. Once the lake had been completely sonar scanned, Biobase® is able to generate a heat map layout for vegetation density as well as a bathymetric map for water depth (Figures 34 and 1). The program was also used to estimate biomass percentages and total water column coverage percentages throughout the reservoir.

Table 5: Plant density scale utilized to estimate macrophyte abundance when rake toss sampling from PIRTRAM (Lord and Johnson 2006).

Scale designation	Macrophyte abundance	Index Score
Zero	None	0
Trace	"Fingerful" of plants on rake	1
Sparce	"Handful" of plants on rake	2
Medium	Most of the rake is covered	3
Dense	Rake difficult to get in boat	4

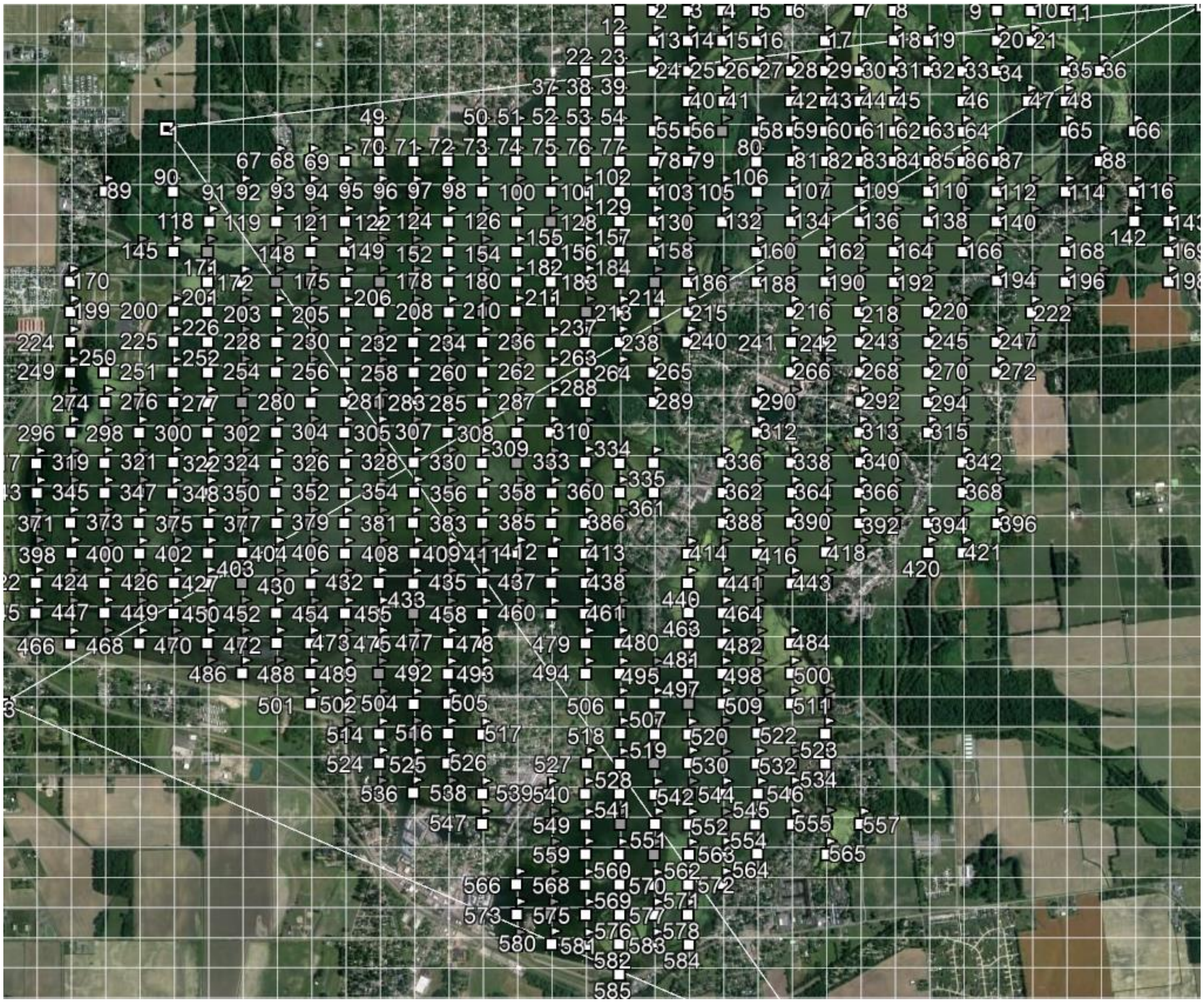
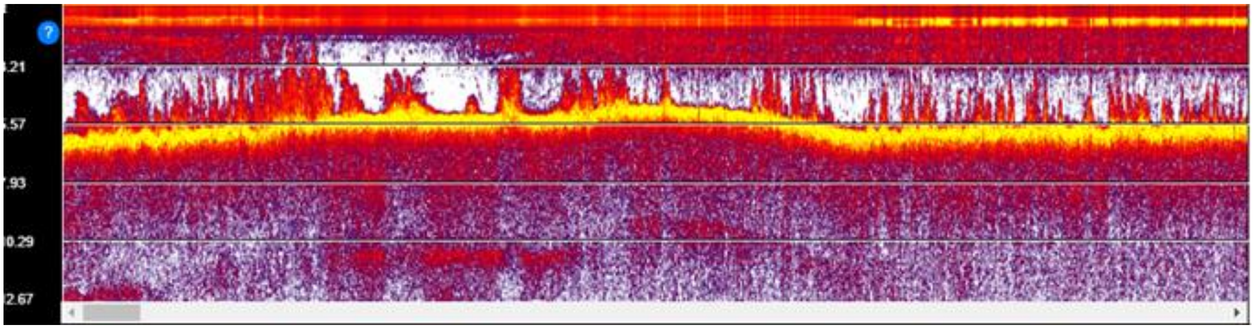


Figure 31: Map of PIRTRAM sampling locations used during the survey. GPS coordinates are located in Appendix G.



Timestamp	Lat	Lon	Depth (ft)	Height (ft)	BV %	Ref No	Modified	Delete
07/06/2022 20:30:07	40.4900912	-83.8700235	-6.12	0	0	0	No	☐
07/06/2022 20:30:08	40.4900848	-83.8700152	-6.11	1.67	27.33	1	No	☐
07/06/2022 20:30:10	40.4900772	-83.8700088	-6.01	0.46	7.65	2	No	☐
07/06/2022 20:30:11	40.4900690	-83.8700036	-5.97	1.22	20.44	3	No	☐
07/06/2022 20:30:13	40.4900602	-83.8699999	-6.10	1.35	22.13	4	No	☐
07/06/2022 20:30:14	40.4900518	-83.8699958	-5.86	0.51	8.7	5	No	☐
07/06/2022 20:30:15	40.4900433	-83.8699911	-6.04	0.96	15.89	6	No	☐
07/06/2022 20:30:15	40.4900338	-83.8699840	-5.86	1.4	23.89	7	No	☐

Showing 1 to 1,392 of 1,392 entries

Figure 32: An example of a track of “ping” readouts from Biobase® sonar mapping software. In this case, you can see the bottom of Indian Lake (bright yellow in the upper photo) as well as vegetation within the water column. On the bottom half, data from the track is collected for analysis (note: BV% indicates percent biovolume of plant material at that respective “ping”).

Figure 33: Map of the track used to sonar map macrophyte density utilizing Biobase®. Red lines indicate the boat track.

Results

Species richness

Ten individual species of submersed macrophytes were collected and identified during this study (Table 6). Of these species, three are invasive in the State of Ohio, including Eurasian watermilfoil (EWM, *Myriophyllum spicatum*), curly-leaf pondweed (CLP, *Potamogeton crispus*), and brittle naiad (*Najas minor*). In addition to the ten submersed species identified, five floating-leaf aquatic plants were also noted although not sampled during rake tosses due to their floating nature (Table 7).

Table 6: List of macrophyte species identified during study. Invasive species are denoted in red.

Common Name	Species Name
Eurasian watermilfoil	*Myriophyllum spicatum*
Coontail	*Ceratophyllum dermersum*
Common waterweed	*Elodea canadensis*
Curly-leaf pondweed	*Potamogeton crispus*
Sago pondweed	*Stuckenia pectinata*
Brittle naiad	*Najas minor*
Water stargrass	*Heteranthera dubia*
Narrow-leaf pondweed	*Potamogeton pusillus*
Bladderwort	*Utricularia spp.*
American pondweed	*Potamogeton nodosus*

Table 7: List of floating leaf species identified during study.

Common Name	Species Name
Spatterdock	*Nuphar spp.*
White water lily	*Nymphea spp.*
Water lotus	*Nelumbo spp.*
Duckweed	*Lemna spp.*
Watermeal	*Wolffia spp.*

Overall macrophyte abundance

Sonar mapping through Biobase® indicated that 75.4% of the area of Indian Lake was covered with macrophyte growth encompassing 45.8% of the total water column area during the time of the survey (average biovolume, Figure 33). When looking at these metrics by means of depth ranges, 0 – 1 m of water depth had 95.6% of its area covered in vegetation encompassing 88.3% of average biovolume. 1 – 2 m of water depth had 76.1% of its area covered in vegetation encompassing 33.9% of average biovolume. Other depth ranges are included in Table 8 below.

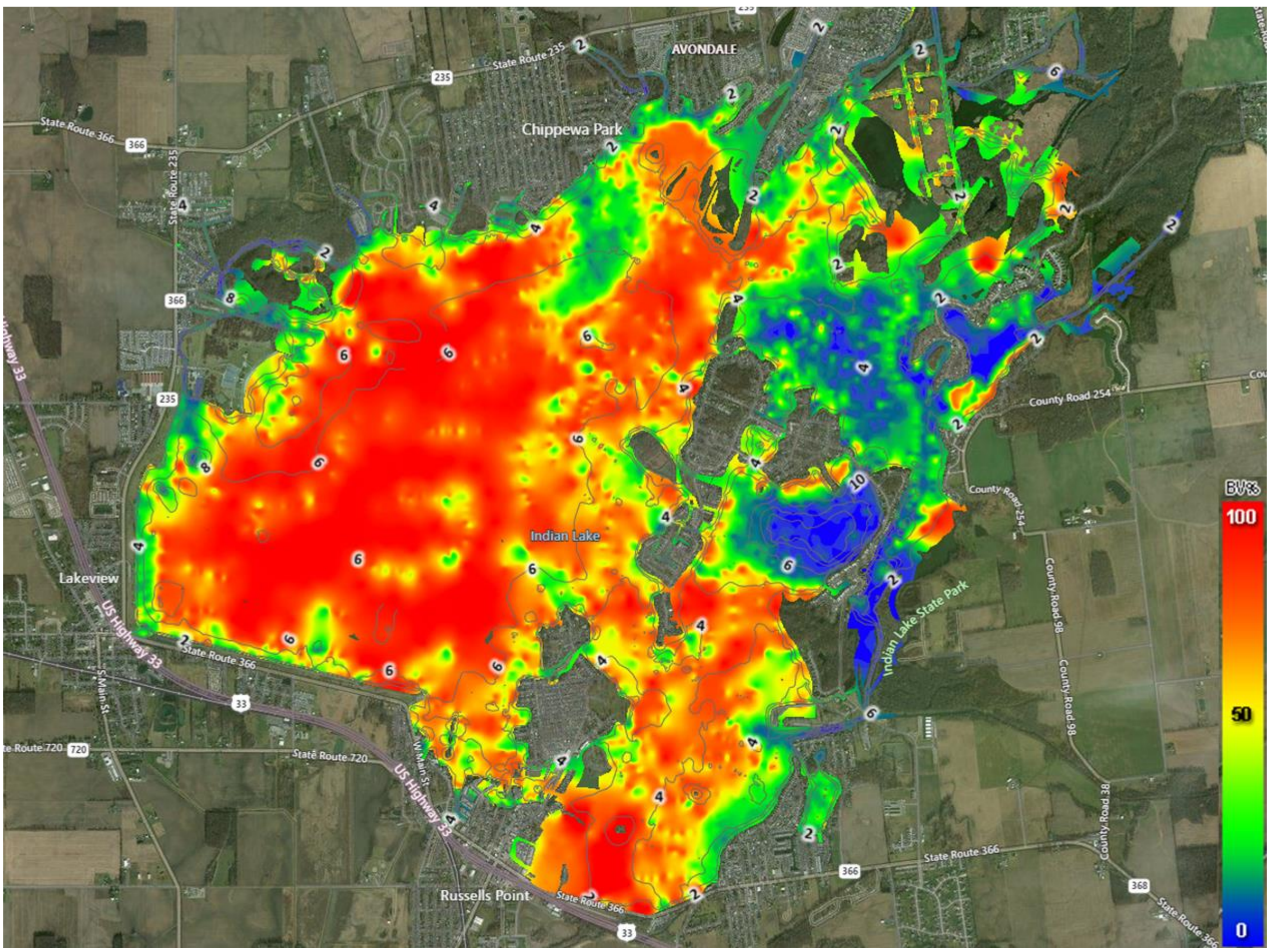


Figure 34: Heat map of vegetation spread and abundance in Indian Lake during the July vegetation survey. Areas in red represent the highest density of plant biomass while areas in blue represent the lowest.

Table 8: Vegetation cover on Indian Lake broken up by depth range including the area covered and average biovolume. Note: 1 m = 3.3 ft

Depth Range	Area Covered	Average Biovolume*
0 – 1 m	95.6%	88.3%
1 – 2 m	76.1%	33.9%
2 – 3 m	50.2%	49.6%
3 – 4 m	14.2%	9.6%

* Refers to the average water column percent occupied by aquatic vegetation growth.

Overall individual species abundance

During the time of this study, coontail was found to exhibit the highest density among all sampled macrophytes representing 52% of the sampled biomass. Eurasian watermilfoil was the second most dense at 39%. All other macrophyte species together accounted for the remaining 9% (Figure 35). Converted densities in g/m^2 (via Valley 2015) are included in Table 9 and Table 10. Individual species of importance spread and abundances are listed below.

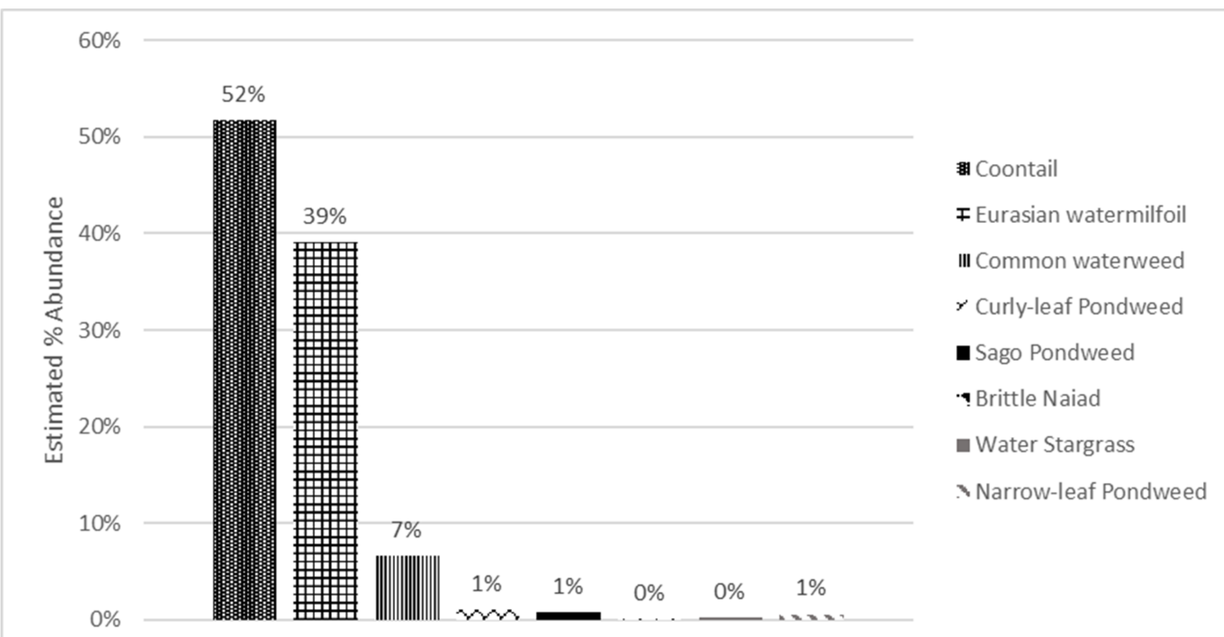


Figure 35: Calculated abundance densities for all species sampled during the study throughout the lake.

Table 9: Estimated density of major macrophyte species found in Indian Lake during the study based on Valley 2015 and Canfield et al. 1983.

Aquatic Vegetation	Estimated density (g/m^2)
Coontail	48,729.92
Eurasian watermilfoil	40,966.06
Common waterweed	7,084.03
Curly-leaf pondweed	1,054.46
Brittle naiad	51.47
All others	1,292.55

Table 10: Estimated average density per sample site of major macrophyte species found in Indian Lake during the study based on Valley 2015 and Canfield et al 1983.

Aquatic Vegetation	Estimated average density (g/m^2)
Coontail	83.30
Eurasian watermilfoil	70.03
Common waterweed	12.11
Curly-leaf pondweed	1.80
Brittle naiad	0.09
All others	2.21

Individual species of concern abundances and spread

Coontail – Coontail was present in 73.7% (430 locations) of all sampled locations during the study encompassing approximately 3,600 acres of area and an estimated density of 48,729.92 g/m^2 of biomass. Areas of greatest abundance included south of "old Indian Lake" and north of the spillway, west Fox Island to Bellefontaine Island, the perimeter of the recreational zone, the surrounding Pew Island area, and northeastern zones (particularly near and within the natural area; Figure 36). Many areas outside of these zones still showcased growth although not quite as dominant.

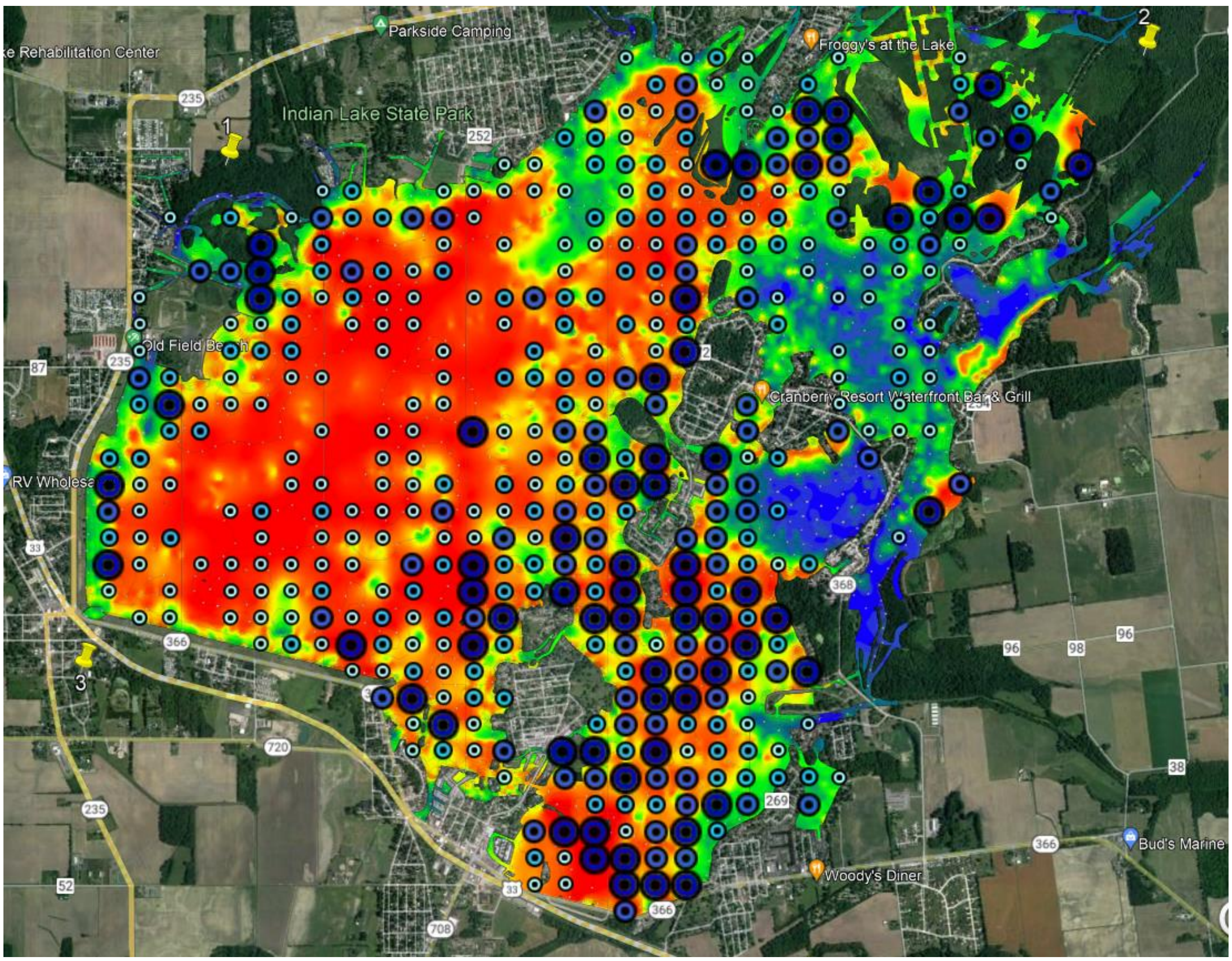


Figure 36: Biobase® general density map with coontail distribution imposed overtop. Each blue dot represents a location where coontail was observed during sampling. Larger dot size represents higher coontail sampled density.

Eurasian watermilfoil (EWM) – EWM was the second most abundant macrophyte present during the survey being represented in 64.6% of all sampled locations (377 locations) and encompassed approximately 3,150 acres with an estimated density of 40,966.06 g/m^2. Although widespread across the lake, EWM was present most dominantly within the recreational zone (Figure 37).

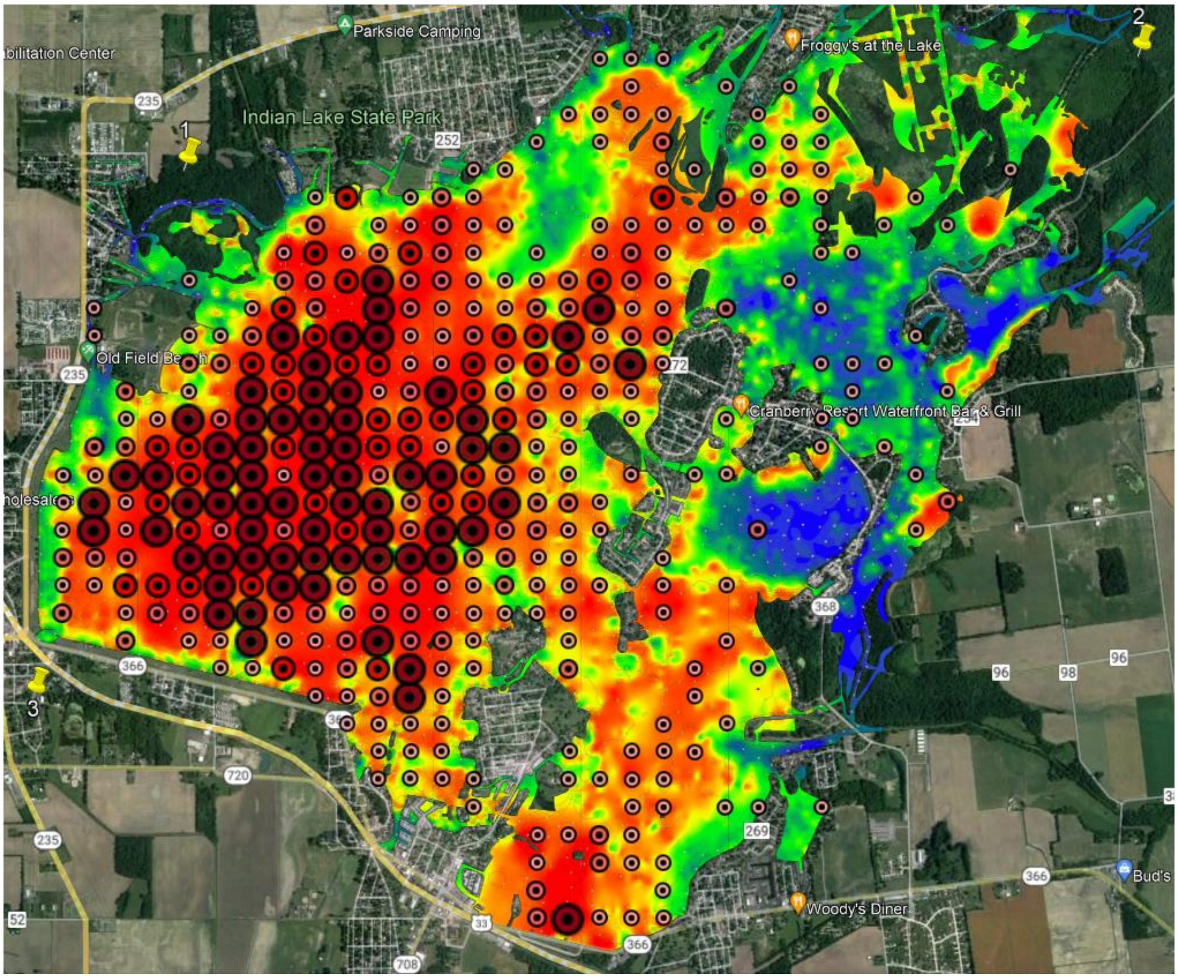


Figure 37: Biobase® general density map with EWM distribution imposed overtop. Each red dot represents a location where EWM was observed during sampling. Larger dot size represents higher EWM sampled density.

Common waterweed – Common waterweed was found within 25.9% (150 locations) of all sampled locations and was the 3rd most dominant plant during the time of our study. Common waterweed density was estimated to incorporate 7,084.03 g/m^2 of biomass in the lake. Areas of greater density included the recreational zone outside of Lakeview as well as near Bellefontaine Island and south of Fox Island (Figure 38).

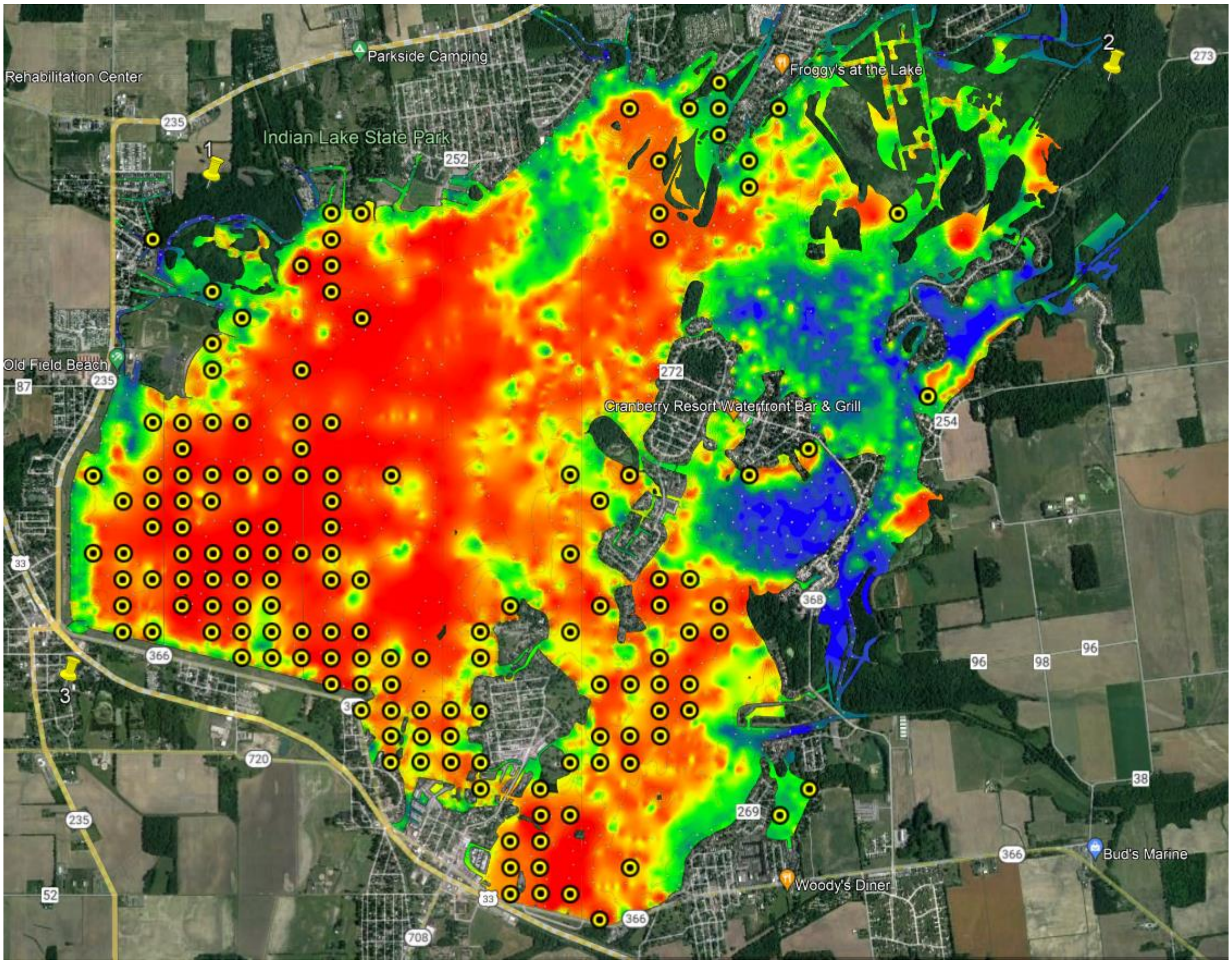


Figure 38: Biobase® general density map with common waterweed distribution imposed overtop. Each yellow dot represents a location where common waterweed was observed during sampling.

Curly-leaf pondweed (CLP) – CLP was found in 9.9% (58 locations) of all sampled locations and was the 4th most dominant aquatic plant found during the survey. CLP density was estimated at 1,054.46 g/m^2 of biomass in the lake. CLP biomass was mildly distributed through the lake but the Lakeview boat launch did showcase a small hot-spot of biomass (Figure 39).

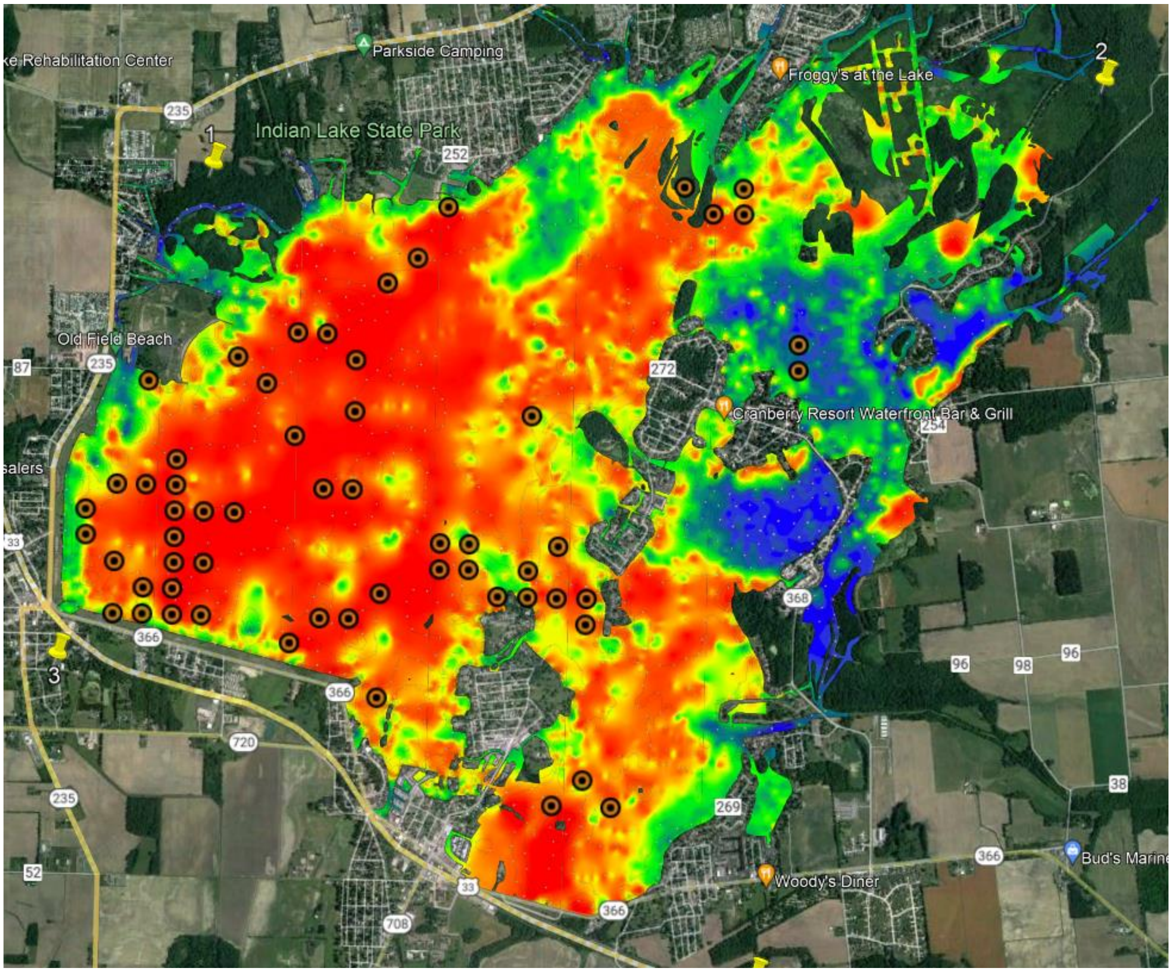


Figure 39: Biobase® general density map with CLP distribution imposed overtop. Each orange dot represents a location where CLP was observed during sampling.

Brittle naiad – Although brittle naiad was found sparingly in our sampling, its designation as an invasive macrophyte warrants its mention. It was only found in seven distinct locations in the Northern portion of Indian Lake (Figure 40). Biomass was estimated to be 51.47 g/m^2.

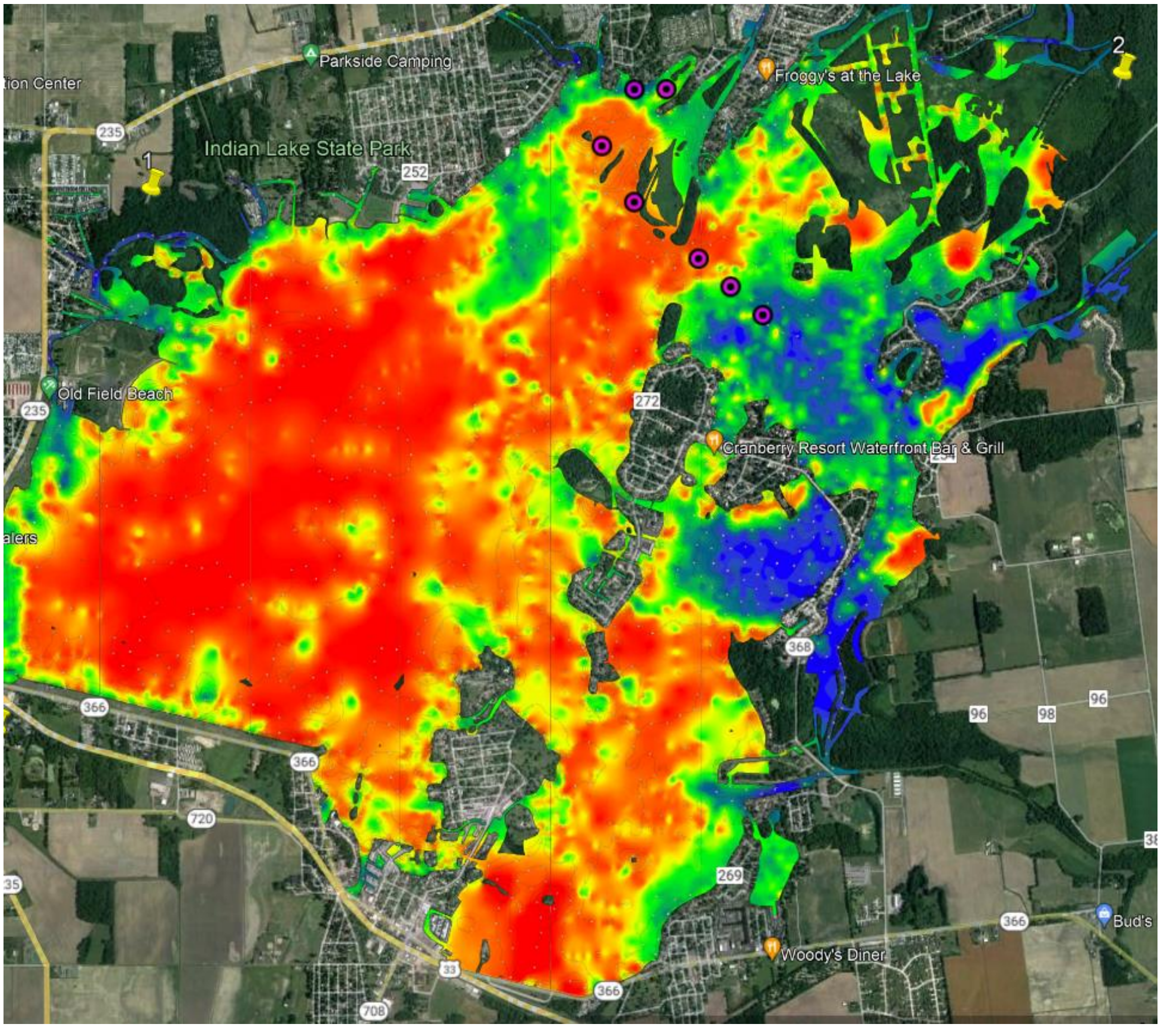


Figure 40: Biobase® general density map with brittle naiad distribution imposed overtop. Each purple dot represents a location where brittle naiad was observed during sampling.

Macrophyte Survey Discussion

The results of the July survey showcase Indian Lake as being dominantly covered by two different macrophyte species: invasive Eurasian watermilfoil and native coontail (Figures 36 and 37; 41a and 41b). Both of these species are commonly found throughout the State of Ohio and EWM in particular, is the focus of a number of vegetation management plans across the United States (e.g. Lake Kegonsa, WI, Twin Lakes, CT, Hidden Harbour, OH; Marshall et al 2007, AER 2015, Kwietniewski 2022). Interestingly, both species of submersed aquatic plant seemed to inhabit different areas within the relatively large reservoir. EWM encompassed the large majority of the western open recreational zone, while coontail was particularly dense near the eastern island and spillway areas. Considering the reference condition mentioned by local stakeholders of Indian Lake being a “turbid lake with reduced light penetration” the dominance of the shallow reservoir by these two particular macrophytes may not be unusual given EWM can respond to shade stress through positive upward growth (Abernethy et al. 1996) and coontail is a shade-tolerant generalist (Ejankowski and Solis 2015).

The distribution and noted high density zones of these two species also may provide some insight into how this hierarchy established itself. With the dominance of EWM within the open recreational zone, one could theorize that it was likely introduced from the Lakeview boat launch or from the Blackhawk launch. Fragmentation allowed it to expand throughout the vast open area. Heavy boat traffic and wind action could easily carry milfoil fragments in a north-south direction, allowing for the current noted density and distribution (Figure 36). This is simply a hypothesis, as information regarding the initial introduction or first observation of EWM in Indian Lake is unavailable at the time of this study. EWM could have persisted in the reservoir for many years. Coontail distribution was much more dispersed than that of EWM growth (Figure 36 vs. 37). This may suggest that coontail was already fairly well established around the reservoir and simply took advantage of the increased clarity to expand its range. Additionally, coontail does not need to be strongly rooted it its anchoring substrate to persist in its environment and can absorb nutrient through its foliar components (Denny 1972). This, combined with its ability to be shade tolerant gives it a competitive advantage over other native macrophytes and likely explains its top position as the most dominant plant in Indian Lake during the time of the study. Interestingly, extensive coontail growth has been attributed to higher water transparency even beyond the generality of more macrophyte growth relating to water clarity (Mjelde & Faafeng 1997; van Donk 1998)

Although both EWM and coontail dominated Indian Lake during the time of this survey, aquatic vegetation management techniques including harvesting and the use of aquatic herbicides were utilized during and after data collection for this study. The use of these management techniques impacted vegetation densities and growth within the lake. Future considerations should include a reassessment of the macrophyte community in Indian Lake in order to establish success or failure of these vegetation management techniques and reestablish baseline aquatic plant growth conditions.

Common waterweed was determined to be the third most dominant macrophyte found during the study (Figure 38). It is a native plant found throughout the State of Ohio. Care should be taken during future macrophyte sampling to ensure that Hydrilla (*Hydrilla verticillate*), a highly invasive species similar in appearance to common waterweed, does not go undetected in the event that it is present to the reservoir. Hydrilla has been confirmed in parts of Ohio, and has the potential to be unintentionally introduced to Indian Lake. Common waterweed is considered to be a beneficial submersed aquatic plant that provides adequate ecological services. Due to its relatively low growing height, relatively lower density in the reservoir, and native designation management of common waterweed does not need to be the focal point of continued control techniques in Indian Lake unless done for small, isolated patches of concern or future sampling suggests a nuisance designation.

Another invasive macrophyte, curly-leaf pondweed (CLP) was found at several sampling sites (Figure 39). CLP is widely distributed across the United States and is considered to be a cool-water plant. It typically appears early in spring in Ohio and may grow to the surface of the water column by May. As an early season macrophyte specie, it also finishes its reproduction cycle relatively quicker than other aquatic plants. As a result, many lakes in Ohio will find that CLP will regress in abundance by July due to increasing water temperatures. This may explain why it appeared to exist in such low abundances for our survey. The few specimens that were collected during sampling were likely the last members of the remaining cohort and exhibited signs of finishing their own reproductive cycle with the observed present of turion development (Figures 42a and 42b). These turions can be thought of in a similar sense as a seed, being produced when conditions become less favorable for the survival of the plant and dropping into the benthic sediments for when favorable conditions rearise (i.e. the coming colder Fall weather or the next Spring). With the confirmed observation of turions on CLP individuals during sampling, it is highly likely that heavy CLP growth will establish itself early during the 2023 season should macrophyte biomass dominate the reservoir. Early season macrophyte sampling is suggested to confirm this. Confirmation of potential CLP growth into the 2023 season could alter management decisions as it is possible that CLP could be the dominant submersed plant in the reservoir early in the lake-use season. Some lake managers choose to take limited action to manage CLP as it typically regresses early in the recreational season on its own and resources can be better devoted to manage late season plants such as EWM and coontail.

All other species of submersed aquatic macrophytes found during the July survey of Indian Lake were negligible in abundance and spread and not likely to be the concern of management decisions going into the 2023 season. These included a range of native pondweed species, water stargrass, and bladderwort. Although not important for managing recreational lake capabilities, these macrophytes do provide ecological services similar to those mentioned and should only be managed in targeted, isolated areas where it is deemed necessary unless they grow to nuisance abundances in future seasons.

Figures 41a and 41b: Images of EWM (left) and coontail (right) from Indian Lake. (Photos: Edward Kwietniewski)

Figures 42a and 42b: Images of CLP from Indian Lake with observed turion development. (photos: Edward Kwietniewski)

V. Assessment of Vegetation Management Techniques

Introduction

Macrophyte management within waterbodies can become a difficult task when considering costs, variability in success, and potential risks (e.g. cyanobacterial growth from nutrient availability following vegetation management). Additionally, choosing a management technique often become more complex depending on the scale of growth to be managed, the identification of the target plant(s), and technique feasibility when waterbody characteristics are taken into consideration. With all of this in mind, selecting a management technique to assist in the remediation of nuisance growth in Indian Lake should be multifaceted. That is, selection of how to manage nuisance growth in the reservoir should be flexible to account for changes in a dynamic system. This concept allows lake managers to more adequately plan ahead for potential issues to troubleshoot while adjusting techniques to fit specific locations where it is deemed necessary.

Successful management of nuisance growth in Indian Lake should entail the creation of an acceptable vegetative threshold allowance that balances a sustainable amount of native aquatic vegetation with the removal of undesirable species. Complete eradication of the aquatic plant community in Indian Lake is highly unlikely nor is it suggested as the removal of a significant competitor to algal growth could result in more favorable conditions for harmful algae blooms (HABs). The creation of favorable conditions in this manner could push Indian Lake to an algal dominated stable state that could be much more difficult, and costly, to manage (Figure 43). Due to the importance of this, attempting to create and maintain a balanced macrophyte community that reduces reservoir recreational use impairment should be an overarching goal as future decisions are made.

To address this point, this chapter in the report was created to assess the various management techniques that can be used to manage nuisance aquatic vegetation in Indian Lake while also setting the groundwork for potential lake assessment methodology. Some lake management techniques such as large-scale aeration, nutrient precipitants, and the use of bacterial additives are immediately deemed not suitable for control of vegetation on Indian Lake as they do not address the immediate concern of current vegetation growth in the reservoir. Future nutrient mitigation strategies can explore these options for viability if or when goals shift in that direction.

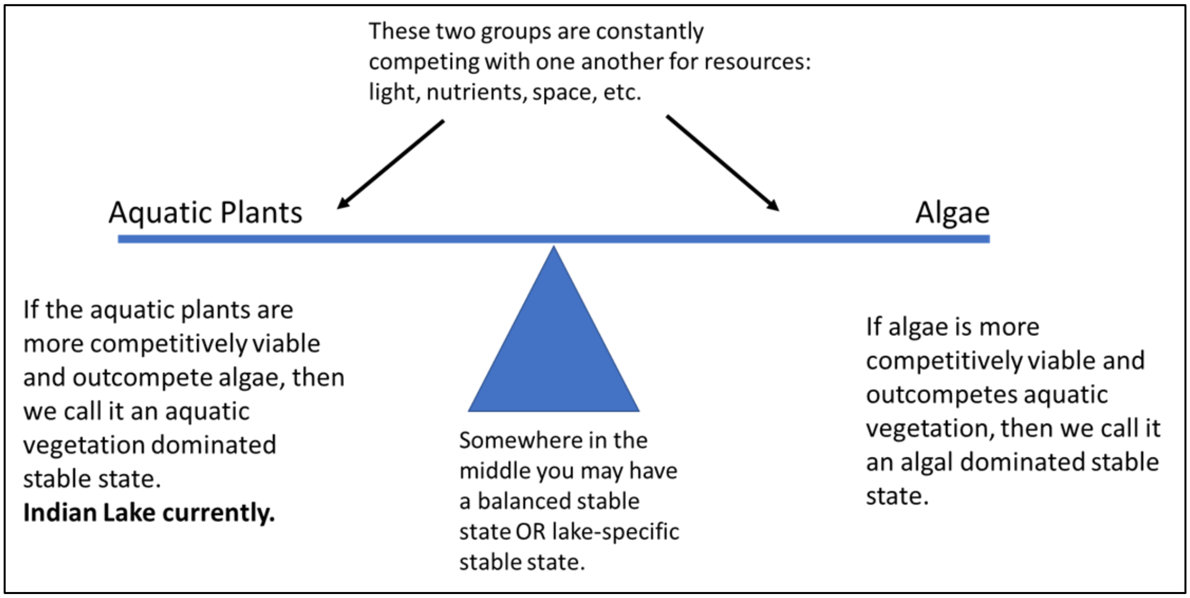


Figure 43: Diagram showcasing the relationship between algae vs. macrophyte dominated stable states.

Technique Identification and Assessment

Management of nuisance aquatic vegetation and algae can be broken down into four distinctive categories: physical, mechanical, biological, and chemical methods. Within these categories are a myriad of subcategories that allow for management flexibility based on the behavior of the lake in question, the identification and scale of the nuisance target(s), and stakeholder acceptance/ financial feasibility. All of the techniques within each of these categories can be successful for the management and control of growth in waterbodies. However, not all techniques are feasible in all situations and in some cases, are not suggested at all. Below is a summary of some of the various techniques associated with managing nuisance aquatic vegetation and their feasibility in Indian Lake.

Physical techniques

Benthic barriers – Benthic barriers consist of the use of a physical shading barrier material that is laid over the bottom of an area to prevent macrophyte growth and establishment. Perhaps the cheapest variety of this is a simple tarp (e.g. polyester, polyethylene, or canvas) that is anchored to the bottom of the waterbody at the target management area. More expensive varieties can consist of densely engineered materials produced by private companies that sink without added assistance and may require less maintenance. It should be mentioned that denser materials may be more efficient for vegetation control than less dense ones (Hofstra & Clayton 2012). Comparatively speaking, benthic barriers are a cheap option for those who want to manage small, isolated patches of nuisance aquatic plant growth. In large scale applications however, they become increasingly ineffective as the application and constant maintenance of a large-scale mat causes the technique to become impractical.

Maintenance of benthic barriers consists of cleaning settled debris off the mat's surface to ensure a layer of organic material does not persist and allow for vegetation reestablishment (on top of the barrier). This can be easily done through removal of the mat in the fall and reapplication in the spring (Mayer 1978). However, premature removal of benthic barriers can result in unwanted recolonization of submersed vegetation as quickly as 30 days post-removal (Eichler et al. 1995). Additionally, it is typically suggested that small slits or holes be torn into the mat in order to allow for gasses to escape from underneath if the barrier material is not porous. Not doing this may create a situation where the mat can become buoyant and peel off the bottom, making the technique ineffective. A downside to this is that vegetation can occasionally grow through generated slits but this may be preferred over mat peeling. Different species of vegetation may respond differently to shading from the mats but Laitala et al. found the initial standing biomass of EWM was reduced by approximately 75% after four weeks of mat use (Laitala et al. 2017). The technique is nonselective and any plant that is trapped under the mat will perish. Macroinvertebrates, such as mussels and other insects that reside near the benthic zone where mats are places may also be negatively impacted and should be considered prior to enactment.

Benthic barrier usage would be an ideal candidate on Indian Lake in areas where shoreline homeowners want a cheap, non-chemical means of controlling small patches of weeds in front of their property. It would be a particularly useful tool within boat lift sheds where the area of interest is small and access around the dock would make construction of the benthic barrier relatively easy. The owner would need to be sure to maintain the mat as described above and ensure it is anchored appropriately. Prospective shoreline owners looking to use benthic barriers would need to utilize a different technique for any floating vegetation (e.g. duckweed, watermeal, or floating "prop-chop") as this technique will only be effective on rooted vegetation at the bottom of the reservoir. These barriers can have synergistic qualities with other techniques as well. Hensel et al for example, utilized benthic barriers after a chemical application of 2,4-D to eliminate a small, new crop of EWM biomass within a four-to-six-week period while allowing for native vegetation to survive and reestablish itself (Helsel et al. 1996). Barr III and Ditomaso found that the use of rubber barriers combined with tapioca starch balls saturated with acetic acid was able to reduce curly-leaf pondweed turion recruitment and prevent sprouting (Barr III and Ditomaso 2014).

Hand-harvesting – The utilization of hand-harvesting is a relatively simple technique that can be used for extremely selective control of targeted submersed plant species. The basic concept involves pulling vegetation from the roots and discarding it from the waterbody. Care must be taken to ensure that the plant is pulled directly from the root system to slow or prevent regrowth from occurring. Use of the technique can be as simple as local stakeholders swimming and pulling plants to be discarded to purchasing the services of trained divers that utilize small barge systems to move and carry waste material. Costs are variable depending on whether you hire professional services or the stakeholder conducts the work as well as what equipment is deemed necessary. Large scale hand-harvesting can become impractical as the sheer mass of growth can be overwhelming to a small team of enthused stakeholders or expensive for professional removal. For example, in the Upper Saranac Lake in New York, six professional SCUBA teams were hired to hand-remove invasive EWM starting in 2004. Although there was a significant decrease in EWM biomass from 2004 – 2006 (1650 stems/ha to 63 stems/ha), financial costs ranged from $146,475/yr. to $351,748/yr. (Kelting and Laxson 2010). This financial burden may be too much for the typical, small to moderate sized lake association. Additionally, if selectivity is important the price per removed plant can increase if vegetation goals are aimed toward removing only targeted plants vs. all plants in a given area. This is due to the added time needed to find targeted plants in an area and selectively remove them without impacting desired vegetation. Technique longevity may also be variable depending on the ability for target species recolonization to occur and the productive behavior of the waterbody. EWM beds in Lake George, NY for example required reharvesting of managed zones every three or more years post-utilization of hand harvesting with SCUBA divers (Boylen et al. 1996). Although overwhelming in extreme vegetation densities, community-wide hand-harvesting events are common with larger stakeholder groups and local volunteer organizations. During these scenarios the events are typically repeated multiple times and conducted annually. Community-wide hand-harvesting events are also useful for scouting new infestations of nuisance or invasive plants as the harvesters are typically trained prior to events and can note new areas of interest.

Hand-harvesting can be a useful technique to employ in Indian Lake for a multitude of different reasons. For the individual shoreline homeowner, the technique would allow for selective removal of vegetation for little cost so long as the shoreline homeowner was willing to put in necessary effort. There would need to be disposal of the generated waste from plant pulling but it should be noted that this action has the added benefit of preventing the plant from decomposing in the reservoir, thus reducing individual sequestered phosphorus release. Large scale hand-harvesting may not be feasible to account for extreme plant densities such as those observed during the 2022 season however, it would be beneficial as a maintenance and stakeholder involvement technique following large scale management of nuisance growth.

Whole-lake drawdown – Water level drawdown is an extremely common practice in reservoirs across the United States and Ohio. For the purpose of aquatic plant control, water level drawdown entails the lowering of the resident pool beyond that of the normal waterbody littoral zone (area where sunlight can penetrate to the bottom and allow macrophyte growth to flourish, Figures 44a and 44b). The draining, exposure to ambient air, and desiccation eliminates vegetation growth, typically for an extended period of time under optimal conditions (freezing, high heat; 1 – 2 months Cooke 1980). Although drawdown is a commonly successful vegetation management technique, it is selective to submersed plants whose reproductive structures and strategies are able to survive desiccation (Table 11; Carmignani and Roy 2021, Holdren et al. 2001). Therefore, the use of this technique should be limited to those plants that are susceptible and there should be awareness that an increase in non-susceptible vegetation is likely to occur following die-offs of target species. Since drawdown requires the ability to release water, it is typically a technique that is reserved for reservoirs with the capacity to do so. Many natural lakes (e.g. kettle lakes, plunge pool, etc.) are unable to utilize this technique because of this. Costs associated with water drawdown are typically negligible if the reservoir already has the capacity to perform the technique.

As a reservoir, Indian Lake could have the capacity to release its water and conduct a drawdown. Additionally, EWM and coontail are considered to be susceptible to the technique (Table 11; e.g. Best and Carter 1975, Siver et al. 1986, McGowan et al. 2005). This allows for the assumption that a whole-lake drawdown would be an ideal candidate to manage the large majority of the nuisance growth experienced in 2022. However, further examination of the morphometry of the reservoir suggests that an attempt at a whole-lake drawdown would be ineffective and highly risky for Indian Lake. Since the large majority of the reservoir may be considered littoral zone during the 2022 season (Figure 34, 75.4% of the reservoir), a near complete drain of the basin's pool would need to occur in order to achieve desired results. A drain of this magnitude would likely only leave a resident pool of water near the Old Indian Lake section south of dream bridge. This much area being drained and exposed would likely decimate the local fish population within the reservoir as the small, remaining pool would not be able to carry over the current cool- and warm-water fishery that thrives in Indian Lake. Additionally, this scenario would only be applicable if the current spillway is capable of releasing water at a faster pace than the current input from all five local inlets. Finally, the bathymetry of Indian Lake may not support a whole-lake drawdown as the open recreational zone appears to be deeper than the area towards the spillway (Figure 1). This would suggest that the reservoir has a "dual basin" morphometry that would leave a large amount of resident water in one of the primary zones of concern for management, making the technique ineffective. Had the reservoir been constructed with the deepest zone near the spillway and a steady slope that progressed to it (like many in-ground swimming pools), water-level drawdown may have been an excellent management technique to control EWM and coontail in the reservoir. Unfortunately, this is not the case.

Table 11: Response of select species of submersed aquatic plants to water level drawdown (adapted from Holdren et al. 2001 to include Indian Lake species).

Decrease in abundance	Variable or no change	Increase in abundance
Brazilian elodea (*Egeria densa*)	*Bladderworts (*Utricularia sp.*)	*Duckweed (*Lemna spp.*)
*Coontail (*Ceratophyllum demersum*)	Cattails (*Typha sp.*)	*Naiads (*Najas spp.*)
Hydrilla (*Hydrilla verticillatum*)	*Common waterweed (*Elodea canadensis*)	*Pondweeds (*Potamogeton spp.*)
*Milfoil spp. (*Myriophyllum spp.*)	Eelgrass (*Vallisneria americana*)	Water bulrush (*Scirpus spp.*)
Yellow waterlily (*Nuphar sp.*)	Muskgrass (*Chara vulgaris*)	*Curly-leaf pondweed (*Potamogeton crispus*)
Southern naiad (*Najas quadalupensis*)		
Water shield (*Brasenia schreberi*)		

***** Denotes an aquatic plant observed in Indian Lake.
Red lettering denotes an invasive plant.

Figures 44a and 44b: Image of a winter whole lake drawdown of Green Lake in Orchard Park, NY (left) and partial drawdown of Rushford Lake in Canadea, NY (right). Exposed benthic sediment and materials are showcased in both images. (Photos: Edward Kwietniewski)

Mechanical techniques

Dredging – Sediment dredging for submersed plant reduction involves the excavation of built up organic material that accumulates at the bottom of lakes and reservoirs. Removal of this material deepens the lake, removes submersed plant growth media, and reduces internal nutrient concentrations (Cooke et al. 2005). It is important to note that most dredging operations are not centered around direct macrophyte biomass reduction, but rather removal of sediment where many aquatic plants sequester necessary nutrients (Carignan and Kalff 1980, Twilley et al. 1977). Therefore, by reducing sediment-derived in-lake nutrients, macrophyte growth can also be theoretically reduced. Dredging is the only true way to “reverse” lake and reservoir succession in some instances by returning the basin to a previous deepened form. The technique itself can be accomplished through the draining of the waterbody in question and then removing sediment or through in-lake removal if draining is not possible or acceptable. When drawdown is possible, sediment may be dried prior to removal to allow for heavy equipment transport on the lake bed as well as more easier material removal. In-lake removal could require more specialized equipment including barges, hydraulic cutter heads or grab buckets, and piping for material transport. Costs associated with a dredging operation are highly variable but often extreme. This makes the use of the technique impractical for many lake associations who simply cannot afford the costs.

Dredging operations can negatively impact the local environment and awareness of the potential impacts should be noted. For in-lake dredging operations, there will be an expected increase in sediment turbidity beyond typical lake or reservoir conditions (Herbich and Brahme 1991). Depending on the scale of the operation, this turbidity could increase across the expanse of the system and could degrade water quality until the operation has been completed and settling occurs. This may happen even if silt curtains are constructed as part of the operation. Additionally, there can be noted impacts on non-target fauna and flora, particularly the macroinvertebrate population that resides within the benthos of the waterbody. A reduction in the macroinvertebrate community may reverberate throughout the food web, impacting higher trophic level organisms such as fish that prey upon benthic insects. Thankfully these negative consequences are usually temporary and benthic environmental stabilization typically can be expected within a few years of finishing the operation (Carline and Brynildson 1977). Dredging that follows drawdown may be more impactful on benthic fauna (Cooke et al. 2005).

In-lake dredging could be a viable technique on Indian Lake and likely, the only way to adequately increase depth in the shallow reservoir. The undertaking of a large-scale dredging operation would be an intense and massive undertaking that should not be taken lightly. Preparations on the type of needed equipment, where sediment is to be transported, as well as an analysis of the sediment itself would likely need to be arranged prior to starting. Necessary permits and potential regulatory hurdles would also need to be planned out ahead of time. Once the operation is active, environmental conditions should be closely monitored as the extent of material needed to be removed may mean a multi-year process could be necessary. As mentioned above, potential negative side effects are likely to occur. It should be mentioned that the deepening of a waterbody does not necessarily eliminate all macrophyte growth potential from the dredged zone. If conditions are still favorable, recolonization is possible for particularly shallow waterbodies with adequate light availability (e.g. Tuggerah Lakes, Collett et al. 1981; Nichols 1984). It would also be suggested to reduce EWM densities as much as possible prior to enacting a large-scale dredging operation in Indian Lake. Tobiesson and Benjamin found that dredging Collin Lake in New York had reduced targeted CLP densities in the lake but noted an increase in EWM as the plant was capable of growing in the deeper waters (Tobiesson and Benjamin 1992). Nichols also found EWM increased after dredging in a small Wisconsin lake (Nichols 1984). These examples highlight the possibility that unintended consequences or imperfect results can arise even after an expensive and invasive procedure like dredging. As such, dredging is a necessary maintenance action for all lakes and reservoirs as geographical low-point “divots in the ground” are destined to fill in overtime. The action should not however, be considered a “silver bullet” for aquatic vegetation management vs. dynamic active management.

Mechanical harvesting – Mechanical harvesting entails the use of barge outfitted with a cutter head to trim down macrophyte growth in a similar fashion as that of a lawn mower (Figures 45a and 45b). Harvesters come in a variety of shapes and sizes but follow the same general premise of cutting plant material, pulling it onboard with a conveyor, and eventually offloading the cut material offsite. Larger harvesters may be able to carry their own individual load of vegetation with them while others may require a separate barge to contain and transport waste. Cutter heads are typically adjustable and can reach various depths to account for variations in water column depth (up to 8 ft depending on the make and model). Mechanical harvesting is one of the most commonly used in-lake techniques to reduce the impact of nuisance submersed macrophyte growth in larger lakes and reservoirs. Its immediate results and more "eco-friendly" perspective resulted in it often being a highly supported technique among lake stakeholders who have significant vegetation densities. This is especially true in situations where drawdown, dredging, and other techniques are costly or infeasible and aquatic herbicides are not supported by the community at large.

One of the biggest pros to utilizing harvesting as a method for aquatic vegetation removal is the additional removal of sequestered phosphorus from the biomass itself via disposing of vegetation waste offsite (Bartodziej et al. 2017). By preventing vegetation from decomposing within the waterbody itself, the decomposition positive-feedback loop is disrupted and theoretically can reduce nutrient recycling (Figure 46). Despite this major pro, criticism of harvester usage is common among lake stakeholders due to its expensive operation cost and the fact that harvesting only cuts vegetation and may not restrict regrowth if plant mass is left in the water column. This can be highlighted by data collected from Saratoga Lake in the Adirondack Park within NY where vegetation surveys showcased no significant change in vegetation density after more than a decade of harvester use (NYSFOLA 2009), Lake Wingra in WI where differences in plant diversity and biomass could not be attributed to mechanical harvester operation (Nichols and Lathrop 1994), and Lake Halverson in WI where aquatic plant density actually increased after harvester use when performed in early spring (Engel 1990). In these case studies Saratoga Lake and Lake Wingra both had similar submersed plant assemblages to Indian Lake while Halverson Lake was not influenced by EWM growth.

Performing multiple "cuts" per year is common amongst lakes with high nuisance weed pressure. The need for multiple passes with the harvester may be considered unacceptable by some stakeholders who are reliant on the technique for navigation purposes. The impact of mechanical harvesting on fish and macroinvertebrate populations also seems to be highly contested among those against the use of the technique. Various ranges from 2% - 30% of fish collected within harvested areas have been reportedly removed from during the act (Mikol 1985, Haller et al. 1980, Engel 1990). Most removed fish in these instances were warm water species such as bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) and primary incorporated small fry sizes. Unmuth et al. however, found that harvest removal of heavy infestations of EWM in a large seepage lake actually improved summer bluegill fishing post-harvest and observed an increase in larger bluegill (Unmuth et al. 2001). These variations in results and environmental impact showcase the need for in-situ assessment of mechanical harvesting on a per-waterbody basis as dynamic outcomes can be expected.

Vegetation fragmentation is also a common issue associated with the use of mechanical harvesters (and general boating activity). Certain macrophyte species such as EWM and naiads are capable of regrowth via broken fragments cut off by props or harvester cutters if not collected efficiently. These fragments can move around a waterbody and allow for repopulation of managed areas or even extend their distribution to new zones. It can be hypothesized that this is how EWM was able to effectively move around the recreational zone of Indian Lake so rapidly considering the area is a high-navigation space. Cutting vs. completely removing vegetation may also have the downside of supporting the growth of under canopy species that receive adequate light post canopy removal (Cooke et al. 2005). This can lead to new dominate vegetation species taking over harvested zones such as in Halverson Lake where dense pondweed canopies were harvested and gave way to water stargrass dominance (Engel 1990), In Chautauqua Lake in NY, EWM growth was thought to be enhanced by incidental fragmentation while attempting to harvest pondweed species (Nicholson 1981), and harvester use in New Zealand saw coontail, common waterweed, and CLP increase in Lake Ohakuri (Howard-Williams et al. 1996). All of these examples highlight the dynamic nature of aquatic plant growth in various lakes and suggest the need for individual assessment of harvester use.

Mechanical harvesting was implemented heavily on Indian Lake throughout the 2022 season to alleviate the impact of nuisance aquatic plant growth by reopening navigational channels. This technique is likely to continue into the 2023 season as one component of a multifaceted plan to manage nuisance plant growth. Although not ideal for the great expanses of dense vegetation growth observed on Indian Lake in the open recreational zone, mechanical harvesting would be an effective way to ensure navigation through the reservoir and its channels is maintained. Additionally, harvesters are ideal for collecting floating “prop-chop” as well as coontail which is commonly suspended and weakly rooted and may be easily picked up by harvesting equipment. Care should be taken to minimize fragmentation by harvesting. If harvesting through potential beds of EWM is deemed necessary, cutter heads should be positioned to the bottom of the reservoir as best as possible to increase the potential to damage root crowns and structures. This was accomplished n LaDue Reservoir and East Twin Lake, both in Ohio, and slowed the regrowth of EWM in these respective systems (Conyers and Cooke, 1982; Cooke et al. 1990).

Figures 45a and 45b: A smaller sized mechanical harvester (right) and its drop off conveyor (left) used to load dump trucks for disposal (Photos: Edward KwieTKNiewski).

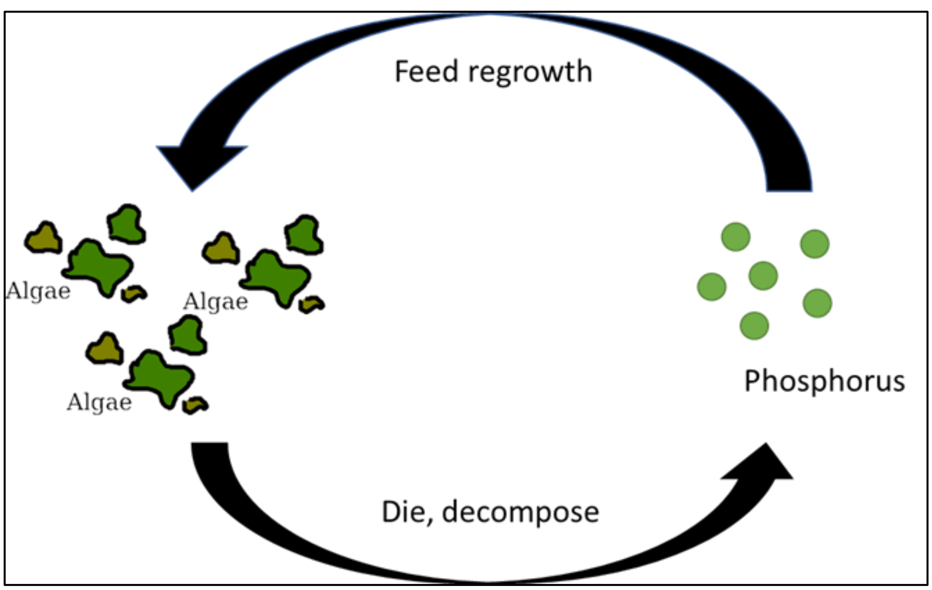


Figure 46: A simple image depicting the nutrient positive-feedback loop concept. Algae can be substituted with macrophyte growth for the purpose of Indian Lake.

Rotovating and hydroraking – Although perhaps not as common of a mechanical technique as harvesting, rotovating and hydroraking are growing as management techniques across the United States. Rotovating involves the use of a rototilling machine head attached to a barge that cuts and removes aquatic plant roots directly at the sediment layer. Hydroraking is similar but utilizes a mechanical rake head instead. Together with mechanical harvesting, one can think of these techniques as the lawn mower (harvester), garden rototiller (rotovating), and rake (hydroraking) equipment for aquatic vegetation management purposes. Both rotovating and hydroraking have similar pros and cons to mechanical harvesting although in some instances rotovating and hydroraking may remove vegetation at a faster pace and have longer term control due to removal at the sediment layer as well as damage to root structures and crowns (Cooke et al. 2005). Plant fragmentation is likely through the use of these techniques as collection of loose vegetation may not occur in some instances. However, both rotovating and hydroraking do have the benefit of being able to reach vegetation in areas harvesting cannot.

Rotovating and hydroraking can both be used in conjunction with harvesting on Indian Lake. Whereas harvesting can open up channels for navigation in open areas, rotovating and hydroraking can be utilized to move into areas harvesters may not be able to traverse. The combined efforts may be more effective overall but, the increase in potential fragmented material may dissuade use of these techniques together as “prop-chop” was a substantial issue for many Indian Lake stakeholders throughout the 2022 season. The use of curtains in zones where these techniques are feasible could help to alleviate this issue. Rotovating in particular may be successful for damaging milfoil root crowns, increasing management longevity but regrowth should be expected unless a substantial amount of the crowns are removed (British Columbia, Cooke et al. 2005).

Suction harvesting - Suction harvesting consists of the use of a high-powered vacuum device attached to a barge to “suction out” plants from the bottom of an area of interest. This technique can be thought of in a similar capacity to hand-harvesting where plants are removed from the roots and disposed of off-site. Divers are a required component to the technique. Benefits are similar to that of hand-harvesting with the added benefit of being able to remove vegetation at a faster pace and thus, be able to cover a larger area than traditional hand-harvesting. For very large expanses of dense macrophyte growth however, the technique may not be able to collect biomass at an acceptable rate (Cooke et al. 2005).

The use of suction harvesting could be a beneficial technique for Indian Lake if used to manage small to medium scale plant infestations. On Lake George for example, it was found that suction harvesting was able to adequately remove EWM in select local locations from 30% pre-harvest to 5% post (Boylen et al. 1996). Private shoreline homeowners who have extensive frontage beyond what is feasible to control by traditional hand-harvesting and mid-sized public recreational zones such as beach areas may benefit from the use of this technique.

Biological techniques

Grass carp/amurs (Ctenopharyngodon Idella) – Grass carp are herbivorous fish that can consume a considerable amount of their body weight in a given day. Being voracious consumers of aquatic vegetation, they are commonly stocked in water bodies across the United States and have been studied extensively for this purpose. Only triploid grass carp are allowed to be stocked for vegetation management purposes in the State of Ohio as this prevents the non-native fish from being able to reproduce and exhibit invasive behaviors. When stocking, it is important to consider the number of total fish being applied to the body of water relative to its size as stocking too many fish may lead to complete eradication of the submersed aquatic plant community. Although this may seem beneficial to the goals of some stakeholders who want a "weed-free" lake or reservoir, the more likely result would be an increase in HAB occurrences as the body of water would have shifted to an algal dominated system without macrophyte competition (Figure 43). Static stocking rates are typically suggested by natural resource organizations but dynamic stocking models that take lake characteristics and specific plants to be managed into consideration may be preferred (Cooke et al. 2005). This way stock adjustments can be made while minimizing the risk of overstocking. Once grass carp are introduced to a body of water, it is difficult to remove them without incredible effort.

To many lake or reservoir stakeholders, grass carp are considered a "natural" remedy to nuisance plant growth despite their non-native designation. Indeed, if stocking procedures are carried out correctly and overstocking has not occurred, grass carp are a relatively low maintenance approach to managing vegetation growth. However, there are setbacks to stocking these fish that should be considered. The largest of these being the need to ensure the body of water to be stocked is contained. It is unsuggested to stock grass carp in a waterbody where escape can be possible via outflow structure or inlet. This typically means that grass carp stocking is more common in smaller bodies of water where inlet and outlet significance is negligible for potential escape. Additionally, grass carp have palate preferences for different species of vegetation, meaning they may not graze upon targeted macrophytes (Table 12). Extensive knowledge of the local aquatic plant community should be obtained as stocking to remove a non-palatable specie of plant may be counterintuitive to management goals. This can be particularly concerning if the biocontrol agent prefers desired vegetation over non-desired ones, as eradication of desired plants may facilitate further expansion of targeted macrophytes (e.g. EWM). But if stocking is high enough, complete eradication of the macrophyte community may be observed. For example, stakeholders of Lake Conroe in Texas stocked grass carp at double suggested stocking rates (75 fish per vegetated ha for their situation) and saw near eradication of the macrophyte community in the 8,100-ha reservoir with negative impacts to water quality and the local fishery (Noble et al. 1986; Martyn et al. 1986). Dibble and Kovalenko 2009 further provide a review of the impacts grass carp stocking can have on lake and reservoir systems.

It is suggested that grass carp should not be used in Indian Lake because the reservoir is not considered a contained environment. Hypothetically, if the reservoir were to be contained the stocking of grass carp could help alleviate nuisance growth so long as stocking was conducted at a correct rate. It should be noted that one of the primary macrophytes of concern, EWM, is considered to be less palatable to grass carp (Table 12). Additionally, coontail is considered moderately palatable. As both of these species are high priority targets for management and native vegetation such as common waterweed and sago pondweed are considered more palatable, there is a high risk of substantial loss of native flora prior to adequate nuisance plant control. Additionally, risk of overstocking could result in loss of the entire vegetation community in the reservoir.

Table 12: List of common aquatic plants and their palatability to grass carp from highly palatable (left) to low palatability (right; adapted from NYSFOLA 2009).

High	Moderately high	Moderate	Moderately low	Low
Brazilian elodea (*Egeria densa*)	*Curly-leaf pondweed (*Potamogeton crispus*)	*Bladderwort (*Utricularia spp.*)	Eelgrass (*Vallisneria americana*)	*Cattails (*Typha spp.*)
*Common waterweed (*Elodea canadensis*)	*Duckweed (*Lemna spp.*)	*Coontail (*Ceratophyllum demersum*)	Slender spikerush (*Eleocharis acicularis*)	*Common reed (*Phragmites spp.*)
Hydrilla (*Hydrilla verticillatum*)	Illinois pondweed (*Potamogeton illinoensis*)	*Filamentous algae	*Watermilfoils (EWM/northern) (*Myriophyllum spp.*)	Water chesTKNut (*Trapas natans*)
Southern naiad (*Najas guatalupensis*)	*Naiads (*Najas spp.*)	*Pondweed species (*Potamogeton spp.*)	Water primrose (*Ludwigia spp.*)	Water lily (*Nuphar/Nymphaea*)
Musk grass (*Chara spp.*)	*Sago pondweed (*Stuckenia pectinatus*)	Stonewort (*Nitella sp.*)		Water shield (*Brasenia schreberi*)
		*Watermeal (*Wolffia sp.*)		Variable watermilfoil (*Myriophyllum heterophyllum*)

* Denotes a macrophyte identified during the 2022 Indian Lake vegetation survey.
Red lettering denotes an invasive plant.

Milfoil weevil (*Euhrychiopsis lecontei*) – The milfoil weevil is a native species of insect that was found to graze upon multiple milfoil species of submersed plant. Originally thought to prey upon native northern watermilfoil (*Myriophyllum sibricum*), research observing the insect has indicated that it will consume fast spreading EWM (Kangasniemi 1993). The weevil consumes portions of milfoil biomass and females will lay eggs into the meristem of the plant. In great abundance, these weevils have the potential to consume and hamper growth of large quantities of milfoil growth, reducing their competitive edge to other species that are not hampered by weevil grazing. The use of milfoil weevils is not an immediate result as grazing and reproduction do not immediately eliminate biomass. Rather, use of this biocontrol agent (like others) is meant to control nuisance and monotypic growth over sequential seasons. Additionally, noted in this section should be the milfoil moth (*Acentria ephemerella*) which is a naturalized insect used in similar capacity to the milfoil weevil and similar in its assessment.

Although the use of a biocontrol agent like the milfoil weevil may seem like a "silver bullet" of sorts, efficacy of the technique has shown high amounts of variability for success. Observations of stocking herbaceous insects in the State of New York to control EWM have showcased an inability to attribute control success to the stocking of the biocontrol agent itself and in many cases, failure possibly due to insects being heavily preyed upon by predatory fishes such as bluegill (*Lepomis* macrochirus) or pumpkinseed sunfish (*Lepomis gibbosus*; Lord 2004). Additionally, the use of a biocontrol agent such as the milfoil weevil does not have synergistic qualities with other management techniques. If other options to eliminate targeted milfoil beds are enacted while simultaneously stocking weevils, the weevil stocking will prove to be ineffective. Although this may seem obvious, many lake stakeholders do not have the patience to wait for successful biocontrol of milfoil while the waterbody is impaired for use and opt to abandon biocontrol stocking for techniques with faster results.

The use of herbaceous insects for biological control of milfoil growth in Indian Lake is possible, but due to inconsistencies with success and the likelihood that results would not be satisfactory to the community at large, not suggested at this time.

Chemical techniques

Dyes/colorant/shading – The premise behind aquatic dyes is simply to darken the waterbody as to attenuate light penetration to shrink the lake or reservoir's littoral zone. Most commercial aquatic dyes available are made of a non-toxic, vegetable-based material that is considered safe for aquatic organisms. Application is simple and generally entails pouring the correct amount of dye into the water and allowing it to spread on its own. The dyes themselves can come in multiple different colors but the most common for vegetation growth reduction is black and blue (an attempt to keep water color "natural"). The most common household named dye, Aquashade® is also known to contain shades of blue and yellow as to reduce certain wavelengths of UV light and turns the water blue in color (Madisen et al. 1999).

Aquatic dyes are an inexpensive way to slow aquatic plant growth when depth is adequate enough for a distinct littoral zone to be present. Shallow waterbodies may not experience any benefits to dye additions because the dye cannot restrict enough light in shallow waters to have an effect. Additionally, dye addition will not impact macrophyte growth that is already at the surface of the water column. This means if a monoculture of a fast-growing invasive plant is already present in the lake or reservoir and surfaced, applying dyes to manage that growth would be a fruitless endeavor. The longevity of a dye addition is highly dependent on the residence time of the waterbody in question. If the lake or reservoir is a less contained system with high variability in flow (most reservoirs), dye additions may be quickly flushed out and ineffective in slowing submersed plant growth. In some instances, dye flushing downstream may be considered unlawful. With many chemical additions, dyes included, it is important to ensure a correct rate is applied should the situation be preferable to dye addition. Low dye dosages (e.g. shoreline homeowner on large lake adding the occasional bottle) will have little to no effect on reducing plant growth when dilution is considered particularly considering the product itself is not toxic to plants and instead impedes light availability which will not impact nuisance biomass in low dosages (Spencer 1984). On the other hand, adding too much dye can result in an unsightly appearance, and in extreme cases, stain objects it comes into contact with.

The use of aquatic dyes in Indian Lake is not suggested. As a large reservoir without a calculated residence time, any dye that is applied may be quickly flushed out after an influx in inlet water. Additionally, since dye is more effective in deeper lakes, its ability to inhibit growth would likely be minimal.

Aquatic herbicides – Herbicides are a broad category for the purpose of examining potential macrophyte control techniques. They include chemical pesticides that directly kill or reduce the growth potential of aquatic plants. They can be broken into two distinct categories: contact and systemic herbicides. Contact herbicides are those that require direct contact with the plant and damage the plant at the contact point. Systemic herbicides on the other hand, are taken up by the target plant and impact biochemical functions and pathways post-sequestering. Chemical applications are successful based off their ability to be applied with the correct contact time and concentration. Should an incorrect concentration of product be applied to a target area or flushing of the product occur, the application may yield undesirable or ineffective results. One scenario of this is the use of a heavy chemical application rate with a high capacity for water flushing or movement which can cause loss of application control killing plants outside of the desired target zone. Some may consider underapplying as equally problematic however, since continuous use of underapplication rates may allow for chemical tolerances to build in target plants, forcing future higher quantities of chemicals to be needed for adequate results. Ensuring the use of adequate label rates and rotating products between applications can prevent these issues. Chemical applications result in the death of the target plant(s), which in turn decompose and become a component of the muck layer at the bottom of the application zone. A detailed summary of 15 aquatic herbicides is included in Table 13 for specifics on individual chemical products. This includes their respective mechanism of action (how they work), systemic vs. contact designation, and granular vs. liquid typing.

Table 13: Various chemical herbicides that can be used to manage aquatic vegetation growth (adapted from Gettys et al. 2021).

Herbicide	Contact vs. Systemic	Mechanism of Action	Formulations
Copper sulfate/ copper complexes	Contact	Plant cell toxicant	Granular/liquid
*Diquat	Contact	Photosystem I inhibitor	Liquid
*Endothall	Contact	Enzyme inhibitor	Granular/liquid
*2,4-D	Systemic	Auxin mimic, plant growth regulator	Granular/liquid
*Flumioxazin	Contact	Enzyme inhibitor	Granular/liquid
*Fluridone	Systemic	Enzyme inhibitor	Granular/liquid
*Glyphosate	Systemic	Enzyme inhibitor	Liquid
Triclopyr	Systemic	Auxin mimic, plant growth regulator	Liquid
*Florpyrauxifen-benzyl	Systemic	Auxin mimic, plant growth regulator	Liquid
Carfentrazone	Contact	Enzyme inhibitor	Liquid
Imazapyr	Systemic	Enzyme inhibitor	Liquid
Topramezone	Systemic	Enzyme inhibitor	Liquid
Penoxsulam	Systemic	Enzyme inhibitor	Liquid
Imazamox	Systemic	Enzyme inhibitor	Granular/liquid
Bispyribac-sodium	Systemic	Enzyme inhibitor	Granular (powder)

* Denotes known use in Indian Lake's history.

The use of chemical applications in aquatic systems is one of the most divisive subjects in the field of Lake Management. If chemical applications are used in an incorrect and unthoughtful manner, the potential for unnecessary environmental harm can be high. Some aquatic herbicides have use restrictions and all have rate limits that if not considered, may negatively impact nontarget flora and fauna. It should be noted that the chemicals themselves (at correct rates) are rarely the cause for concern when it comes to damage to non-target organisms and are broken down in the environment through photolysis (sunlight), microbial action, or other means (Table 14). Rather, it is the aftermath of an unthoughtful application that can become problematic. For example, increased decomposition from macrophyte death will likely note an uptick in respiration and oxygen consumption. For particularly dense beds of aquatic vegetation growth, this uptick can generate hypoxic or anoxic conditions which may result in gilled organism death (e.g. fishkill). Additionally, and as mentioned previously, the excessive removal of macrophytic growth increases the potential likelihood of a stable state change that can shift the waterbody to an algal dominated system (Figure 43). HABs could become more frequent due to this and derail potential management decisions. With all of this in mind though, all chemicals registered through the Environmental Protection Agency (EPA) will be labeled with instructions for correct use which include rates, application details, safety concerns, and best management practices that reduce the potential for unnecessary harm. With the potential risk involved with the incorrect use of aquatic herbicides, many lake stakeholders choose to utilize professional companies for their application although personal use may still be allowed in some states or privately-owned waters.

Table 14: Various chemical herbicides with their typical half-life and degradation pathway (adapted from Gettys et al. 2021)

Herbicide	General half-life	Mode of degradation
Copper sulfate/ copper complexes	Hours to 1+ day	Bound to chemical ions
*Diquat	0.5 – 7 days	Ionic binding/ microbial action
*Endothall	2 – 14+ days	Microbial action
*2,4-D	4 to 21+ days	Microbial action
*Flumioxazin	Minutes to 1+ day	Hydrolysis
*Fluridone	7 to 30+ days	Photolysis
*Glyphosate	Hours to 1+ day	Ionic binding/ microbial action
Triclopyr	3 to 14+ days	Photolysis
*Florpyrauxifen-benzyl	0.5 to 2 days	Photolysis

Carfentrazone	Hours to 5 days	Hydrolysis
Imazapyr	7 to 14+ days	Photolysis
Topramezone	14 to 30+ days	Photolysis
Penoxsulam	7 to 30+ days	Photolysis
Imazamox	7 to 14+ days	Photolysis
Bispyribac-sodium	30+ days	Microbial action

* denotes known use in Indian Lake's history.

Aquatic herbicide usage is common throughout the United States with many successful (and non-successful) case studies of proper usage. For the standpoint of holistic lake management, chemical applications should have the overall goal of reducing nuisance submersed plant species to allow for reduced impairment of the system in question, not for total annihilation of the submersed plant community (for reasons already explained). Results can vary from waterbody to waterbody. For example, in 1992 the Minnesota Department of Natural Resources (MSDNR) utilized whole-lake fluridone applications on 3 separate lake systems to gauge the effectiveness of selectively treating for EWM while maintaining a standing crop of native submersed plant species (Welling et al. 1997). The results within the three systems varied but did observe reductions in EWM as well as various other macrophyte species. The MSDNR noted that unavoidable damage to non-target fauna and potential environmental impacts were great enough to dissuade permitting of future whole-lake fluridone applications. A similar fluridone product was used within Random Lake in WI also targeting EWM (Cooke et al. 2005). In this case, an acceptable reduction in EWM (from a 60% frequency in the lake preapplication to 9% two years post) was also met with preserving a more acceptable aquatic plant community. Smaller scale maintenance applications were required in future years but longevity in management success was achieved. Both of these examples highlight how use of the same product on different lake systems can have dynamic results. It should be noted that these lake systems had different concentrations and contact times associated with their applications which can substantially alter success or failure (as mentioned). Testing of products on a smaller scale can provide insight to the likely vegetation response prior to larger-scaled usage and allow for rate adjustments, improving potential efficiency.

Aquatic chemical usage has been common in recent history for Indian Lake as the sudden extreme nuisance growth has provoked many shoreline stakeholders to utilize chemical applications to clear individual shorelines. Additionally, the use of the recently EPA approved Florpyrauxifen-benzyl (ProcellaCOR®) has been tested in the open-recreational zone for use to control excessive EWM growth. When selecting herbicide products to use on Indian Lake it is crucial to know what aquatic plant is to be targeted and choose a subsequent product that can adequately manage it (Table 15). Many products are selective meaning they will impact some species of plant but not others which can be based off alterations in rate as well as the different products themselves. It is unlawful to utilize any herbicide product outside of its labelled instructions. Many products also come in granular and liquid varieties (Table 13). Granular products are preferred for those without proper equipment to apply liquid varieties and are useful where anticipated water exchange may be present in the application zone. This could make them ideal for shoreline property owners who wish to clear small areas in front of their properties more easily without needing equipment or additional spray adjuvants (chemical tank mix additions to help increase liquid product efficiency, usually methylated seed oil). Applications should be staggered at least 2 – 3 weeks to reduce DO loss.

Table 15: Target macrophytes and the known herbicides that have been used on Indian Lake for their control.

Target Macrophyte	Herbicides that have shown control on Indian Lake
Eurasian watermilfoil (*M. spicatum*)	Florpyrauxifen-benzyl, Endothall, 2,4-D, Diquat, Flumioxazin
Coontail (*C. demersum*)	Endothall, 2,4-D, Diquat, Flumioxazin
Common waterweed (*E. canadensis*)	2,4-D, Diquat, Flumioxazin
Curly-leaf pondweed (*P. crispus*)	Endothall, Diquat, Flumioxazin
Pondweeds (P*otamogeton spp.*)	Endothall, Diquat, Flumioxazin
Watermeal/Duckweed	Flumioxazin

Discussion of Vegetation Management Techniques for Indian Lake

2022 Management Overview

During the 2022 lake season, active management of plant biomass in Indian lake consisted of the use of mechanical harvesters to generate channels and remove vegetation in select areas as well as the use of herbicide products. Shoreline homeowners had the option to utilize private companies for chemical applications if they desired. Additionally, 400 total acres of area were selected to test ProcellaCOR EC® (Florpyrauxifen-benzyl) within the open recreational zone for EWM control.

Mechanical harvesting efforts were extensive to account for extreme macrophyte growth in the lake and included as many as seven total harvesters that removed approximately

1,323,000 ft^3 of vegetation from the reservoir by August (starting in April). Harvesters operated every weekday with costs that exceeded $1.25 million. Mechanical harvesting occurred throughout the lake where flexible weekly goals deemed its use necessary however common areas included near the spillway, around Pew Island, near Oldfield Beach and around Seminole and Orchard Islands. Many of these zones had distinct drop-off locations to increase efficiency. Harvesting efforts on Indian Lake in 2022 was a team-oriented procedure amongst ODNR owned harvesters as well as private consultants working conjointly.

Two 200-acre zones within the open recreational area were selected for ProcellaCOR EC® trials to assess its ability to manage EWM growth. The first zone was located just outside of the Lakeview public launch area (Figures 47a and 47b). The treatment was conducted on July 12 – 13 of 2022 with a rate goal of 2.2 – 2.5 prescription dosing units (PDUs; a metric generated by the retailer of the product, rate within milfoil control bounds) based on an average depth between 5.0 – 5.5 ft. within the area of interest (AOI). Prior to the application, east-west channels needed to be cut to allow for vegetation relief for the treatment vessel (Figures 45a and 45b). The application was conducted with the use of a high-pressured firehose through a 30-gal tank on an 18' fiberglass vessel. The use of the high-pressured hose allowed for penetration through the dense canopy of milfoil growth, which more traditional submerged hose systems can struggle to accomplish. Overall time for the completion of the application was approximately 12 hours. The second application occurred on August 24 – 25, 2022 and followed the same procedures for the first zone. Application location was north of the previous location and south of Oldfield Beach (Figures 47a and 47b). As the EWM canopy was not as dense within the second application zone, no channels were needed to be cut for navigation.

Prior to the applications, information regarding DO levels and productivity was collected and compared to data collected in intervals post-application (See chapter 2). This was done to address concerns of potential oxygen loss and nutrient release from enhanced decomposition within the treatment zone post-application. Pre-application DO levels in the initial application zone were found to be supersaturated near the surface where dense canopy milfoil had mixed together with filamentous algae (Figures 48a and 48b). Below this, DO levels quickly regressed to hypoxic concentrations as decomposition respiration surpassed photosynthetic activity due to shading from the surfaced mats of vegetation. Post-application DO levels did seem to show signs of stabilization 1 – 2 weeks post application resulting in less variability from surface to bottom. However, oxygen levels still trended to lower concentrations two weeks after the application suggesting benthic respiration was still overcoming potential oxygen additions.

Overall, DO concentrations did not appear to be negatively impacted to the point of concern for gilled organisms within the initial treatment zone and that the zone was adequately recovering. Overall, DO concentrations did not appear to negatively impact fish and the treatment zones recovered adequately. The severity of the discretion between the surface DO levels and mid-water column to benthic DO levels prior to application do raise oxygen loss concerns should larger treatment zones be suggested in the future. Using chemical applications on extreme quantities of vegetation biomass run a real risk of causing oxygen collapse within the waterbody. To avoid this, it is typically suggested to break larger applications of dense biomass into smaller portions with time between them to allow for oxygen recovery. This is a standard practice for most applicators who have experienced bodies of water inundated with nuisance growth and suggested on many chemical labels as a best management practice. TP data showcased a large amount of variation within the application zone pre- and post-application but also appeared to stabilize after two weeks (Figure 15). This large range of nutrient variability may be a generalized component of a shallow system dominated by macrophyte growth (Moss et al. 1996).

Data collection within the second application zone demonstrated far less variation as described in chapter 2. With milfoil biomass being less dense than the initial application zone, water movement may have allowed for more homogenous data collection, which in turn would have created less variability in collected information. DO levels did not seem to showcase any harmful reduction from pre- to post application dates (Figure 14). However, noted increases in productivity were prevalent during the 2-week sampling period from pre- to post application with a noticeable rise in TP concentrations and a decrease in Secchi transparency (Figures 16 and 19). Anecdotal observations of an increase in planktonic algal growth was also noted in the following months from September through October, though these were not directly sampled.

It could be surmised that elimination of milfoil growth had started pushing nutrient availability toward algal growth, and increased algae biomass accounted for the regressing Secchi transparency values. This is consistent with chlorophyll a data collected at the time which had become far more variable with higher maximum values in the second treatment zone vs. the first (Figure 20). While direct milfoil control could be the reason behind the increase in algal productivity, it should also be noted that natural plant regression could also have coincided with the treatment to generate an ideal environment for growth. Planktonic algae, specifically cyanobacteria tend to thrive in the late summer/early fall in Ohio where warm waters persist but macrophyte growth begins to decline. Regardless, future management decisions should consider the impact of elevated nutrient levels pushing Indian Lake to an algal dominated stable state as this condition may be considered just as, if not more hazardous for recreational use than the aquatic plant dominated state experienced in 2022.

The overall results of the use of ProcellaCOR® within the two test zones did appear to showcase a high degree of success in controlling EWM with both zones exhibiting a noticeably substantial decrease in surfaced macrophyte biomass (Figures 49a and 49b; Appendix I). These results coinciding with acceptable DO and productivity data showcase substantial promise for continued control of EWM with ProcellaCOR ® as previous experiences with the relatively new product have resulted in multi-year control. It should be noted that although the use of ProcellaCOR® was successful for milfoil control, milfoil accounted for 39% of the biomass in Indian Lake compared to coontail's 52% at the time of this study. A multifaceted approach will need to be enacted in order to account for all nuisance vegetation in Indian Lake as

ProcellaCOR® is not considered to be as effective in controlling coontail growth as it is on milfoil species. Additionally, although DO and productivity metrics did not regress to the point of additional impairment to the reservoir, the collected information does show signs of the potential for DO and productivity concerns should chemical usage be used without best management practices in mind. As mentioned before, a real scenario of a stable state change to an algal dominated system and/or substantial DO loss is possible should too much vegetation be chemically treated at too fast a pace. The best course of action for larger scale chemical usage during times of heavy and dense macrophyte growth is a slow and steady pace that allows for AOI recovery post application. It should also be mentioned that the timing of any herbicide application can be important to reducing potential risk as early-season applications can allow for control of nuisance vegetation before the biomass is great enough to cause potential negative concerns. The ProcellaCOR® applications utilized in 2022 were a reactive response to unprecedented macrophyte growth and unfortunately, early season usage was unattainable. This could be one alteration to make with regards to management decisions in 2023.

Figures 47a and 47b: Adjusted images to denote the two ProcellaCOR® application test zones (top is initial application, bottom is second application). Perimeter latitude and longitude coordinates are included in the photos. Red lines in the initial application denote suggested channels for harvesting.

Figure 48a and 48b: Images of the extent of EWM and filamentous algae growth within the initial ProcellaCOR® application zone. Pictures were taken on July 19, 2022. (Photos: Edward Kwietniewski).

Figure 49a and 49b: Images of the initial ProcellaCOR® application zone on July 26, 2022. The left and right images are in the same locations as the left and right photos in Figures 48a and 48b. (Photos: Edward Kwietniewski)

Potential Management Options for 2023

Based on the collected information discussed thus far into this report, two primary macrophyte species can be designated as primary concerns for 2023 management decisions: coontail (52% of biomass at 48,729.92 g/m^2) and EWM (39% of biomass at 40,966.06 g/m^2). Both of these species represent the vast majority of vegetative biomass that contributes to the impaired recreational status of Indian Lake during the 2022 season (encompassing approximately 3,600 and 3,150 acres of area respectively). CLP should be considered a third potential species of concern as it may be expected to grow to substantial levels during the early months of the lake-use season. However, as mentioned previously, its low tolerance of warm water temperatures means the plants would likely die-off naturally in the summer. If the need for CLP management arises, it may require resources to be allocated from EWM and coontail removal efforts in order to preserve the lake's best use.

When considering what options to choose to manage these macrophytes into the 2023 season, understanding the target response to selected techniques as well as the scale of the target's potential infestation will be critical for proper selection (Figure 50). The available pool of feasible management options changes depending on the scale of the target infestation and should result in a reassessment of what technique to employ. This is not to say continuous use of a consistently successful management tool is problematic or not suggested but rather a way to remain dynamic to ensure the best technique is selected given changing circumstances. In addition, a dynamic management strategy may have the added benefit of reducing unintended risk to Indian Lake and its environment as management solutions that focus on small, isolated plots of nuisance growth typically have a smaller ecological footprint compared to larger, more invasive techniques. For example, hand pulling is highly selective with a low capacity for potential harm to non-target organisms but a whole-lake drawdown will have considerable impact on all aspects of a reservoir's food web paradigm. However, hand-pulling would not be an effective technique to eliminate vast and dense populations of vegetation. This emphasizes the importance of assessment prior to technique selection.

Of the eleven techniques listed in the assessment of viable macrophyte control techniques above, seven can be considered viable for use on Indian Lake at different scales of use. This includes two physical techniques in hand-pulling and benthic barriers, four mechanical techniques in mechanical harvesting, suction-harvesting, rototilling/hydroraking, and dredging, and one chemical technique in herbicide usage. These techniques can be more effective in small scale situations or be viable for large scale management (Figure 48). The four other noted techniques that are not suggested for Indian Lake include whole-lake drawdown, biocontrol agents (grass carp and milfoil weevils), and light-limiting dye. The reasoning for these suggestions is included in their respective sections above.

Scale of the nuisance growth is important when considering what technique to employ but proper target identification can be equally as important for success. With EWM and coontail being the most impactful species to Indian Lake's impairment. Techniques that can target these two macrophytes specifically should be given more consideration to those that are non-selective especially at larger scales. Assessment of the noted potential management techniques to the primary species of concern is listed in Tables 16, 17, and 18 below. Each table indicates the technique, its categorical type (physical, mechanical, biological, or chemical), some minor noted details of the technique with respect to the macrophyte in question, and a short list of pros/cons of the technique. Overall suggested techniques based on target and scale is included in Table 19.

Table 16: Assessment of suggested Indian Lake vegetation management techniques for EWM.

Management Technique	Type	Details	Pros/Cons
Benthic Barriers (Small Scale)	Physical	Shading of a small area with benthic barriers is feasible.	Cost is low (+), Little skill is needed for application (+), non-selective (-), mat requires maintenance (-)
Hand-Harvesting (Small Scale)	Physical	Hand pulling in small areas is feasible if the plant is pulled from the root.	Cost is negligible if done by homeowner (+), Little skill is needed (+), highly selective (+), Labor intensive (-), Costly if hiring professionals (-), Slow process (-)
Suction Harvesting (Medium Scale)	Mechanical	Suction harvesting has the potential to remove milfoil from the roots and remove biomass from the reservoir. Faster than hand-pulling	Faster than hand-harvesting (+), Suctioning may reduce fragmentation (+), Cost can become high with more area (-), Requires specialized skills and equipment (-)
Mechanical Harvesting (Small to Large Scale)	Mechanical	Cutting of milfoil fragments can immediately open up or channelize a given area. Risk of fragmentation is high creating high risk to increase milfoil spread.	Have immediate results (+), removal of biomass from waterbody also removes nutrients (+), Specialized equipment is expensive to buy, maintain, and operate (-), Plant fragmentation risk is high (-)
Rototilling/Hydroraking (Small to Medium Scale)	Mechanical	Ripping of plants from the roots can restrict growth in singular area but potential for fragmentation may be high.	Have immediate results (+), Raking material from water will remove nutrients (+), Specialized equipment is expensive to buy, maintain, and operate (-), Plant

			fragmentation risk is high (-).
Dredging (Large Scale)	Mechanical	Removal of sediment can restrict growth potential; increased depth will reduce capacity for plant to surface.	Removal of deposited material reverses eutrophication (+), Deepening of lake will slow upward plant growth (+), Long-term results likely (+), Costs are extreme (-), Highly specialized and skilled workers with equipment necessary (-), High impact on local environment (-)
Herbicides (Small to large Scale)	Chemical	A range of chemical products have been shown to control EWM. 2,4-D and Floropyrauxifen-benzyl have shown particular effectiveness.	Biomass will quickly die and decay (+), Individual products and rates can be selective (+), Killing of plant matter will increase organic material and oxygen demand (-), Potential nutrient release for decomposing plants (-)

Table 17: Assessment of suggested Indian Lake vegetation management techniques for coontail.

Management Technique	Type	Details	Pros/Cons
Benthic Barriers (Small Scale)	Physical	Shading of a small area with benthic barriers is feasible but floating coontail biomass will be unaffected.	Cost is low (+), Little skill is needed for application (+), non-selective (-), mat requires maintenance (-)
Hand-Harvesting (Small Scale)	Physical	Hand pulling in small areas is feasible if the plant is pulled from the root. Surface plant biomass can be raked out by hand.	Cost is negligible if done by homeowner (+), Little skill is needed (+), highly selective (+), Labor intensive (-), Costly if hiring professionals (-), Slow process (-)
Suction Harvesting (Medium Scale)	Mechanical	Suction harvesting has the potential to remove lightly rooted coontail. Floating biomass will be unaffected.	Faster than hand-harvesting (+), Suctioning may reduce fragmentation (+), Cost can become high with more area (-), Requires specialized skills and equipment (-)
Mechanical Harvesting (Small to Large Scale)	Mechanical	Cutting of coontail fragments can immediately open up or channelize a given area. Weakly rooted and floating biomass is highly susceptible to harvesting.	Have immediate results (+), removal of biomass from waterbody also removes nutrients (+), Specialized equipment is expensive to buy, maintain, and operate (-), Plant fragmentation risk is high (-)
Rototilling/Hydroraking (Small to Medium Scale)	Mechanical	Ripping of plants from the roots can restrict growth in singular area.	Have immediate results (+), Raking material from water will remove nutrients (+), Specialized

		Coontail may be susceptible.	equipment is expensive to buy, maintain, and operate (-), Plant fragmentation risk is high (-).
Dredging (Large Scale)	Mechanical	Removal of sediment can restrict growth potential; increased depth will reduce capacity for plant to surface. May not impact floating coontail biomass.	Removal of deposited material reverses eutrophication (+), Deepening of lake will slow upward plant growth (+), Long-term results likely (+), Costs are extreme (-), Highly specialized and skilled workers with equipment necessary (-), High impact on local environment (-)
Herbicides (Small to large Scale)	Chemical	Coontail can be controlled by herbicide usage but can be considered hardy and tolerant to some applications.	Biomass will quickly die and decay (+), Individual products and rates can be selective (+), Killing of plant matter will increase organic material and oxygen demand (-), Potential nutrient release for decomposing plants (-)

Table 18: Assessment of suggested Indian Lake vegetation management techniques for CLP.

Management Technique	Type	Details	Pros/Cons
Benthic Barriers (Small Scale)	Physical	Shading of a small area with benthic barriers is feasible but would need to be installed early to be applicable to CLP.	Cost is low (+), Little skill is needed for application (+), non-selective (-), mat requires maintenance (-)
Hand-Harvesting (Small Scale)	Physical	Hand pulling in small areas is feasible if the plant is pulled from the root. Growth potential ending by July may make technique undesirable.	Cost is negligible if done by homeowner (+), Little skill is needed (+), highly selective (+), Labor intensive (-), Costly if hiring professionals (-), Slow process (-)
Suction Harvesting (Medium Scale)	Mechanical	Suction harvesting has the potential to remove biomass with added benefit of potential sediment turion removal.	Faster than hand-harvesting (+), Suctioning may reduce fragmentation (+), Cost can become high with more area (-), Requires specialized skills and equipment (-)
Mechanical Harvesting (Small to Large Scale)	Mechanical	Cutting of CLP l fragments can immediately open up or channelize a given area. Can be started early in season to get ahead of growth.	Have immediate results (+), removal of biomass from waterbody also removes nutrients (+), Specialized equipment is expensive to buy, maintain, and operate (-), Plant fragmentation risk is high (-)
Rototilling/Hydroraking (Small to Medium Scale)	Mechanical	Ripping of plants from the roots can restrict growth in singular area. If done	Have immediate results (+), Raking material from water will remove nutrients (+), Specialized

		during turion development, it may increase likelihood of spread.	equipment is expensive to buy, maintain, and operate (-), Plant fragmentation risk is high (-).
Dredging (Large Scale)	Mechanical	Removal of sediment can restrict growth potential; increased depth will reduce capacity for plant to surface. May remove turion seed bank and reduce future populations.	Removal of deposited material reverses eutrophication (+), Deepening of lake will slow upward plant growth (+), Long-term results likely (+), Costs are extreme (-), Highly specialized and skilled workers with equipment necessary (-), High impact on local environment (-)
Herbicides (Small to large Scale)	Chemical	CLP is highly susceptible to low dosages of appropriate herbicides. Particularly endothall, diquat, and others.	Biomass will quickly die and decay (+), Individual products and rates can be selective (+), Killing of plant matter will increase organic material and oxygen demand (-), Potential nutrient release for decomposing plants (-)

Table 19: Overview of suggested vegetation management techniques based on target.

Macrophyte	Suggested Techniques Small Scale	Suggested Techniques larger Scale
Eurasian watermilfoil (*M. spicatum*)	Benthic barriers, Hand-pulling, Light herbicide usage (2,4-D, Floropyrauxifen-benzyl)	Herbicide usage (2,4-D, Floropyrauxifen-benzyl)
Coontail (*C. demersum*)	Hand-pulling, Mechanical harvesting, Hydroraking,	Mechanical harvesting
Curly-leaf pondweed (*P. crispus*)	Benthic barriers, Hand-pulling, Light herbicide usage (endothall, diquat), Suction harvesting	Herbicide usage (endothall, diquat), Mechanical harvesting, Dredging

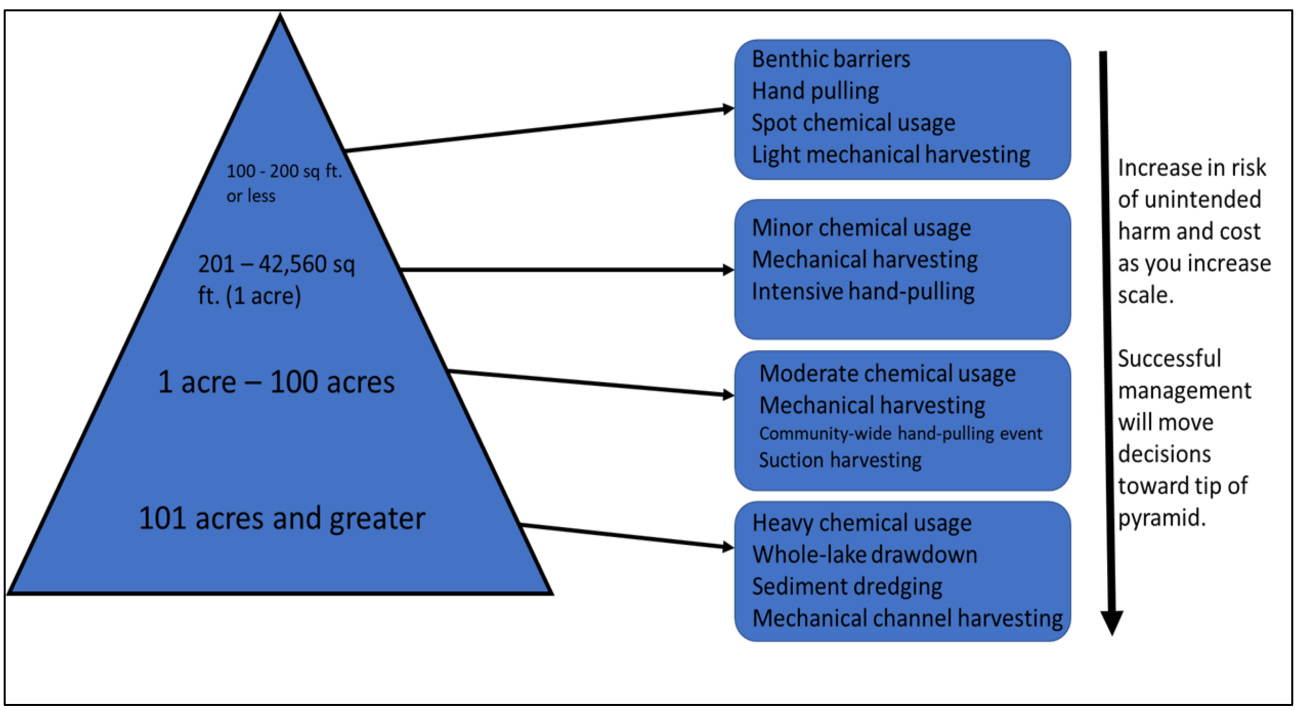


Figure 50: Diagram depicting how choices in management decisions can be altered in response to changes in target scale. Thinking in this manner may be one way to assist in making vegetation management choices.

VI. Beyond 2023: Long-Term Monitoring and Management

Introduction

Proper management of lakes and reservoirs requires adequate long-term data sets in order to properly define the waterbody in question, identify reference conditions, and develop realistic water quality thresholds. Without this information, management can become reliant on anecdotal observations from local stakeholders which, although important, can occasionally prove to be unreliable. Additionally, long-term data sets allow for a constant, critical reflection of management decisions. This elevated level of reflection over time supports dynamic planning and allows for lake managers to dissuade from the use of techniques that are proven inefficient on the system while supporting successful management practices with hard data. Long-term monitoring involves the consistent collection of relevant water quality information whether it be nutrient water samples, in-situ multi-parameter probe profiles, biological assessment studies, sediment analyses, and others. Although a generalized water quality monitoring program is adequate for most unimpaired bodies of water and for comparison of one system to another, individualized monitoring programs are preferred in order to assess lake or reservoir-specific issues or concerns.

Unfortunately, Indian Lake does not have a well recorded history of monitoring data for use in a long-term assessment of the reservoir. The information that was collected for the purpose of this study as well as the ancillary physical and chemical information reported as a supplement is only a snap-shot of what the lake resembled during the 2022 season on the days the data was collected. Because of this, it is imperative that a monitoring program be designed and implemented in order to best understand the system for future management considerations. Without monitoring, making management suggestions for the long-term benefit of Indian Lake would be the equivalent to a doctor or physician assigning a patient medication without knowing any health information about the patient.

In addition to long-term monitoring of Indian Lake, improving the sustainability and longevity of acceptable reservoir conditions warrant the suggestion to enact certain best management practices (BMPs) within the lake and watershed community. These BMPs can be thought of as behavioral changes that alter how the surrounding watershed is utilized which can reduce the impacts of cultural eutrophication overtime. It is important to remember that water management goals require acceptable short-term management strategies to provide relief from a potential impaired use-status while simultaneously acting to pursue continual and realistic water quality threshold goals. The majority of this report has thus far looked into only the short-term solutions for vegetation management in 2023. This chapter is meant to provide the other side to holistic lake management: monitoring Indian Lake and long-term suggestions.

Indian Lake Monitoring

Monitoring programs that are used to collect data sets on lakes are broadly centered around the collection of physical, chemical, and biological parameters necessary for assessment of the waterbody. Within these categories is a large assortment of various pieces of information that need to be considered when attempting to complete the water quality monitoring puzzle. Many stakeholders mistakenly collect water quality information without knowledge of what they are collecting and why it is necessary to do so. This poses an issue as desired water quality information from the standpoint of drinking water from your sink will be far different from water quality information needed for recreational water body management purposes. Additionally, there is a need to understand the best categorical use of the water body being sampled. A drinking water reservoir for example would likely have more stringent acceptable water quality thresholds than a storm water retention basin. This is why it is important that thresholds need to be determined based on the proper definition of the waterbody as well as with a determination of what may be considered typical data wise. These two points are determined through a simple observation of the primary uses of the waterbody in question (its best categorical use) in conjunction with a few years' worth (3 – 5) of monitoring data to begin determining trends in its data set. Although it may seem inefficient to need multiple years' worth of information to develop water quality goal thresholds, it is imperative to understand the typical water body conditions. Collecting a single year's worth of information during an unusual year for the lake relative to its water quality may result in the incorrect assumption that the outlier year is typical of the system. This could lead to thresholds that are actually atypical of the waterbody and thus push toward poor management practices for the lake or reservoir. As more information is collected overtime, thresholds can be altered and adjusted to reflect stronger data driven trends. It is also noteworthy to mention that this mentality is meant to allow for comparison of the singular waterbody to itself overtime. Comparisons of multiple waterbodies would need consistent data as well but a single year's worth of information can still be a powerful comparison tool when doing larger geographical analyses of different lakes and reservoirs for a given year.

Collecting and analyzing water quality information can be a daunting task for typical stakeholders who may lack the knowledge to understand how to interpret water quality data. This section will highlight some important pieces of data to collect and attempt to simply explain their importance. Necessary tools to collect the data is also described. Note that some of this information has been presented in chapter 3 where physical and chemical data collected on Indian Lake in 2022 was discussed.

In-situ multiprobe data

In-situ (collected within the waterbody) multiprobe data consists of information that is collected through the use of a sampling sonde with probe(s) that can collect water quality information in real time. Most devices for water quality purposes have a sonde with a selection of desired probes that collect various parameters at once, cabling to drop the sonde at desired depths, and a readout interface. Many devices are handheld but some can be attached to buoys for constant real-time data collection. This allows for quick and efficient data sampling and recording on a spatial scale (wherever in the lake or reservoir you want to sample) as well as vertical scale (at whatever depth you want to sample). In-situ mutiprobes are an essential tool for the creation of depth profiles or the mapping of data from the surface of a body of water to the bottom. The ability to map this data allows a data collector or analyzer to watch for noticeable vertical alterations in collected data that can indicate the presence/absence of important physical and chemical changes in the water column. This can include temperature thresholds that define mixing characteristics and the likelihood for internal phosphorus release, heightened chlorophyll levels that may denote a below-surface algae bloom, and other characteristics depending on the probes present on the sonde. It should be noted that some of the listed characteristics can be analyzed through collected water samples as well but the use of a sonde provides near immediate values that increase efficiency and depth profile capability. Common multiparameter sonde data includes the following:

Temperature – physical characteristic that describes how hot or cold the water is. When collected as a depth profile, temperature trends can determine the location of the thermocline (if at all present), which allows one to determine if the body of water is experiencing thermal stratification. The presence of thermal stratification throughout the season allows for the estimation of the lake or reservoirs mixing regime (how many times does the lake turnover if at all). This is important when considering a stratified lake can alter benthic sediment chemistry and result in internal release of phosphorus (one of the leading nutrients that drive nuisance growth in lakes and reservoirs). This allows lake managers to determine if internal nutrient reduction is a necessary action vs external watershed reduction (or both). Temperature information is also important to consider for organism habitat requirements. The most notable example of this are the various species of fish that can live in a given lake or reservoir environment which can be categorized by their thermal habitat requirements: warm-water, cool-water, and cold-water. Cold-water species such as trout for example, cannot typically survive in lakes or reservoirs that have thermal qualities that only support warm-water species. The thermal qualities of a lake or reservoir will change depending on the local climate as well as the thermal conditions of incoming water from the watershed. Water is most dense at 39.2°F (3.98°C) which allows for frozen water to become buoyant when ambient air temperatures reach freezing levels.

Dissolved oxygen (DO) – DO is one of the most critical pieces of information to collect on a lake or reservoir for its importance to the survival of gilled organisms as well as its potential to alter redox reactions (oxidation-reduction reactions). When collected as a depth profile, data collectors can observe whether the lake or reservoir has a hypoxic (low oxygen) condition or anoxic (no oxygen) condition. Oxygen loss is typically seen from the bottom of a waterbody and moves upward in the water column and anoxic conditions are one of the drivers for internal nutrient release from bottom sediments (oxygen loss can match thermal density changes). DO levels fluctuate based on the mixing regime of the lake or reservoir, amount of photosynthetic activity vs. respiration, and the flushing rate of the waterbody (particularly if oxygen rich water is entering the system). It should also be noted that a loss in DO should be expected at night when no photosynthetic activity is occurring usually resulting in the lowest DO concentrations occurring just before sunrise. Although DO concentration requirements vary from one organism to another, desired concentrations above 3.0 mg/L are often a minimum suggestion. Concentrations between 3.0 and 10.0 mg/L can be typical but again, will vary from one waterbody to another. DO can be reported in mg/L (direct concentration of DO) or as a percent saturation (amount of DO that the water is holding vs can hold based on temperature, colder water can hold more DO). Reporting the concentration (mg/L) is more common for threshold development.

pH – a waterbody's pH is the measured ratio of H^+ ions to OH^- ions. This ratio is related to s singular number that corresponds to a scale ranging from 0 to 14. Numbers below seven are considered acidic while numbers above seven are considered alkaline (basic). Seven itself is considered neutral. pH values that fall outside of acceptable ranges for aquatic organism survival may experience "dead lake" scenarios where biological life cannot be supported by the waterbody but individual pH ranges can vary. Natural pH ranges for a body of water are highly dependent on the local geography surrounding the lake or reservoir, the amount of photosynthetic activity that can push pH to alkaline conditions, and acid deposition from rain water or other sources among other factors. pH is also related to alkalinity or the buffering capacity of water (measured in $CaCO_3$ content) which affects how well a waterbody can resist pH changes. Lakes and reservoirs with low alkalinities may be more susceptible to acid rain or acidic deposition which is a common issue for mountain region lakes and reservoirs that exist in rocky geographical locations with little in pH buffering soils. Many lakes and reservoirs in Ohio do not need to be concerned with this as the state generally has rich, adequate soils for pH buffering.

Conductivity – conductivity is a measurement of the ease at which electrical current can pass through water, which is obtained by determining the quantity of ions present in the water at the point of sampling. It is a useful tool to give a rough account of water hardness as harder waters will empress higher conductivity values. Perhaps more useful for many lake managers is its ability to demonstrate enhanced impact from inlet erosion materials that can severely impact conductivity levels for a short period of time especially from the addition of road salts during the winter. Conductivity is measured in µmho/cm or µs/cm (micromhos per centimeter and microSiemens per centimeter, respectively) and usually stays consistent throughout the year unless there is an influx in materials entering the waterbody.

Oxidation-reduction potential (ORP) – ORP describes whether chemical reactions are moving toward an oxidative state (positive higher values) or reduced state (negative lower values). Collected in millivolts (mV), ORP can estimate the likelihood of certain chemical reactions occurring and whether certain waste materials may be produced due to reaction changes in the water. This information typically coincides with DO levels and temperature readings to better determine the potential strength of internal phosphorus release. Very low ORP levels may indicate that anoxia has been present for some time and that high amounts of phosphorus release may have been occurring (which can then be confirmed with P sampling). Many lake managers also utilize ORP to track potential pollutants that may be hypothesized to be present in a waterbody if they are considered to be redox reactive. This may be more useful in wastewater discharge situations however as prior knowledge or assumption of a pollutant being discharged needs to be known as ORP cannot determine what pollutant is present.

Chlorophyll a – chlorophyll a is one of the dominant pigments found in photosynthetic organisms. Collection of chlorophyll a data can be an excellent estimator to the quantity of algae growth at the sampling site. Collected as a depth profile, elevated quantities can also determine where built up algae growth is present as some algal varieties such as cyanobacteria, can move up and down the water column to preferred depths for survival. Chlorophyll a is also one of the three (Chlorophyll a, Secchi transparency, and P concentrations) indicators to help describe a waterbodies productivity which is essential to defining excessive growth likelihoods and estimating lake or reservoir identity behaviors. Chlorophyll a levels that range between 8 – 10+ ug/L are more indicative of productive (more growth) systems that are pushing to elevated levels of eutrophy. Levels below eight start to show signs of less productivity (less growth) that may be considered mesotrophic or oligotrophic waterbody. Chlorophyll a is also commonly collected via water samples but is reported the same.

Water Sample Data

Many lake stakeholders hold the belief that collecting a sample of surface water in a bottle laying around their home is sufficient to analyze an incredible amount of information. Although the initiative of an individual who collects samples to analyze the water quality of a waterbody is commended, procedures for water sample collection can be more complicated. It is important to know what analysis need to be conducted as some laboratories may require preservatives, darkened bottles, or other conditions to be met prior to conducting any lab tests. Additionally, how the sample is collected is equally as important as most surface water samples should be collected as a “grab sample” (at elbow depth) to reduce bias that may come from skimming material off the waters’ surface. Collecting samples beyond surface level may require the use of a specialized sampling device called a Kemmerer tube which allows for the sampler to collect water samples at various desired depths. Most lake stakeholders and even private firms do not have onsite laboratories to analyze water samples and as such, utilize third party labs to test and report water sample findings. It is important to follow the procedures given by these laboratories to ensure water samples arrive in an acceptable condition for analysis. Usually this entails storing water samples on ice or in coolers as well as shipping samples overnight. Sample bottles are typically provided by these labs as well. The following are some commonly collected water samples:

Nutrient Information (Phosphorus and Nitrogen) – Nutrient concentration data is incredibly important for the assessment of a lake or reservoir system. Phosphorus (which can be broken into organic and inorganic sampled varieties) is considered a limiting nutrient found in aquatic systems. This means that small quantities of added phosphorus can have a substantial impact on algae and macrophyte growth in in a lake or reservoir system. Most stakeholders use total phosphorus (TP; ug/L; includes organic and inorganic varieties) concentrations for analysis purposes but collection of other varieties can be useful for a more integrated nutrient budget of the waterbody. TP is also one of the three (Chlorophyll a, Secchi transparency, and TP) indicators to help describe a waterbodies productivity which is essential to defining excessive growth likelihoods and estimating lake or reservoir identity behaviors. Levels above 20 ug/L are more indicative of productive (more growth) systems that are pushing to elevated levels of eutrophy. Levels below 20 start to show signs of less productivity (less growth) that may be considered mesotrophic or oligotrophic. Elevated concentrations of TP may correlate with internal loading, excessive runoff from the watershed, lack of adequate nutrient reduction best management practices by shoreline homeowners, and many other sources.

Although typically given a "back seat" to phosphorus, nitrogen can also act as a limiting nutrient that contributes to aquatic plant and algae growth. Also, similarly to phosphorus different species of nitrogen can be collected based off what is desired by the data collector. Total Kjeldahl Nitrogen (TKN or TKN; mg/L) includes all organic forms that may be utilized by biological functioning as well as ammonia and is likely the most commonly collected by typical stakeholders to assess nitrogen quantities. Nitrate and Nitrite are collected as one unit and include inorganic and organic forms of nitrogen that can be used for biological processes. Ammonia is also commonly collected but more so to assess its potential as a fish toxicant. This is only typically an issue under anoxic conditions as ammonia will build up under very low ORP values where stratification is present. Nitrogen is not commonly used to define lake productivity like TP is but, excessive levels can contribute to greater macrophyte and algal growth.

E.coli/F. coliforms – *E.coli* and fecal coliform sampling is conducted when concerns of elevated levels that may lead to human health concerns. Collection of one over the other is simply a decision of how specific the collector wants to be as *E. coli* is a component of fecal coliforms. Regardless, the collection of *E. coli* or fecal coliform samples is typically reserved for high contact recreational use areas like beaches and other swim zones where exposure can result in illness. Most states have recommended standards that possess safe concentration thresholds with Ohio suggesting an *E. coli* threshold of 235 colony forming units (CFUs) as the risk threshold (ODH 2022). An advisory is posted over recreational zones if levels exceed this threshold until additional sampling suggest they have regressed. *E. coli* and coliform levels fluctuate highly as much as hour to hour depending on a variety of conditions from runoff potential to waterfowl presence. This means reoccurring samples are highly recommended throughout a recreational use season. Sampling of *E. coli* or coliforms occurs through standard "grab samples" (described above) and need to be delivered to a proper laboratory relatively quickly (usually within 6 – 7 hours) in order for proper incubation of the sample to occur.

Microcystin (HAB monitoring) - Microcystin is a known toxin that is produced by the cyanobacteria *Microcystis.* Although not the only cyanobacteria to produce toxins, Microcystis may be considered one of the more common varieties. The sampling of its toxin is a general component of beach safety monitoring across Ohio. Elevated levels (beyond 8 µg/L) can be considered harmful to human health. All cyanobacteria have the potential to produce various toxicants that can impact liver function, neurological functions, or damage the skin. Sampling is typically conducted when a visual cyanobacteria bloom is noticed as toxin level is thought to increase with algal density. A visual bloom does not always indicate the presence of toxins however, as it is not fully understood why cyanobacteria produce these toxins nor what triggers their release. Microcystin and *E. coli* sampling together are a common component of contact recreation safety procedures and account for most beach or even lake/reservoir advisories. Sampling procedures for Ohio waterways is outlined in state's HAB response strategies.

Other Pieces of Data

Since every lake and reservoir is different from one another, it may be critical to lake management goals to collect other pieces of data. What has been listed thus far includes some of the common water quality parameters for general water quality threshold development and lake or reservoir behavior identification. Further collected information can be related to direct goals including biological surveys for organism management, sediment surveys, and watershed data collection and mapping. Some of these procedures (i.e. vegetation surveying and watershed mapping) have been covered in previous chapters.

Creating a Monitoring program for Indian Lake

What should be sampled? - The creation of a monitoring program for Indian Lake should include the collection of standard water quality information such as depth profiles for temperature, DO, pH, and ORP. Nutrient information should also be included for analysis and involve TP as well as TKN concentrations as "grab samples" as well as near the bottom of the sampling sites. Data involving human health concerns such as *E. coli* and microcystin concentrations shall continue to be collected in areas where contact recreation is common (and when a cyanobacteria bloom is noted with regards to microcystin per the 2020 State of Ohio Harmful Algal Bloom (HAB) Recreational Response protocol). This information should be the standard for monitoring purposes for typical water quality parameters. Additionally, as submersed aquatic vegetation is the primary reason for Indian Lake's impaired status, vegetation surveys such as the one completed for this study should also be conducted to monitor vegetation growth and gauge vegetation management success. As management needs and concerns change, the addition of more sampling procedures may need to be included.

Who should monitor? – lake and reservoir monitoring can be conducted by a wide array of different individuals, groups, or agencies. Many lake associations may collect data internally but usually this is limited in scope and disorganized. Lake stakeholders may opt to hire a professional lake management company to monitor their waters but this can prove to be costly at times which may limit the scope of what is feasible to collect as the cost becomes a burden to the association. Since Indian Lake is managed through the ODNR, adequate resources may be available for the purpose of private company monitoring however, costs can be alleviated through the use of a citizen's monitoring program. Citizen's monitoring incorporates the community into the active management of their lake or reservoir system. Typically, enthusiastic community members are brought together and trained on the procedures associated with data collection on their respective system. Once trained, they themselves are tasked with the collection of relevant information and in some cases, the analysis as well. Community monitoring programs save in monitoring costs by cutting out the middle man associated with data collection. Additionally, community engagement increases "lake-mindedness" allowing for more individuals to be educated on how their particular lake or reservoir functions. This may allow for greater community support once management decisions are formally decided on as there will be a greater understanding of why those respective decisions were made. The added community engagement also allows for more frequent sampling dates as individuals typically live directly on the waterbody. This can allow for a better track of data trends overtime, strengthening its assumptions. However, individuals must be well trained in order to correctly collect relevant information as improper collection procedures could produce biased or incorrect data. Consistency is also important for proper data analysis. With the presence of a large number of enthusiastic individuals on Indian Lake, there would assume to be no problem with finding community members who would like to be involved. The use of professional company or group to monitor the lake until a citizen's monitoring program can be developed is a feasible response. Monitoring for E. coli, fecal coliform and/or cyanobacteria shall continue to be conducted by trained ODNR, Ohio Environmental Protection Agency (OEPA), Ohio Department of Health (ODH) or local health department staff to ensure accuracy and immediate reporting. A template for a citizen monitoring training course is included in Appendix J of this report.

Where should monitoring occur? – Choosing a location or locations to sample varies from one system to another and depends on the goals of monitoring as well as what is being monitored. For example, if one was attempting to assess how in-lake nutrient concentrations were impacted by inlet additions, one may want to sample at the mouth of the inlet for normal flow nutrient concentrations as well as post-precipitation nutrient concentrations. Information regarding the inlet flow at these times would also be critical as there would be a hypothetical constant influx of incoming nutrients that should be reported as a rate. Another example could be assessing DO level alterations from a herbicide application. One may need to determine pre-application DO conditions and compare them to various post-application conditions to track changes and monitor for acceptable threshold levels. This would have to be conducted within the treatment zone. In both of these examples, the location, collected information, and timing of data collection is important to successfully accomplish the goals of monitoring. For general monitoring purposes however, sample at a) the deepest point of the waterbody as it will be the most data-inclusive and best represent the lake or reservoir and b) wherever the data collector believes there may be a sampling location necessary for the best possible monitoring of the individual system. In the case of Indian Lake, which has a variable morphometry due to it being a reservoir, multiple locations will likely be needed to best collect relevant data. One location should be the deepest known point while the others can be spread out to other "sub-basins" where there may be importance in collected data. Location specific data such as those described in the examples above or for human health reasons should focus on the areas where the respective data is needed (e.g. beaches for contact safety sampling).

When should monitoring occur? – Data collection that has established direct goals should occur with the completion of said goals in mind. HAB monitoring with microcystin sampling should occur when a visual bloom is noticed for example. For general monitoring however, consistency is needed for success. Many plans utilize a monitoring schedule that is different from one water body to the next but at a minimum, it may be suggested to monitor on a monthly basis. However, biweekly is better than monthly and weekly is better than biweekly.

Developing realistic water quality thresholds

Once a monitoring program has been enacted and long-term data becomes available, the creation of individual water quality thresholds can be developed. It should be mentioned that the development of management thresholds can be arbitrary at times as differences for the uses for water, the agencies that manage and regulate water, and individual community perspectives can all lead to the development of different acceptable parameter thresholds based on their individual goals. It would be wise to try and unify these different threshold development pressures for both consistency and to avoid confusion. Proper thresholds should be realistic to the typical and acceptable conditions of the waterbody in question. This again, is why it is important to ensure adequate data over an acceptable span of time is collected as “typical” conditions can vary from year to year. Long-term data sets allow for the observation of trends that allow for the proper denotation of what may be considered “typical”. Once thresholds have been developed, management of the waterbody can be more streamlined to allow for the acquisition and distribution of resources to the improvement of those parameters that need it.

Long-Term Management Concepts: BMPs

Along with long-term monitoring, sustainable management practices that go well beyond the 2023 season should be considered in order to maintain acceptable conditions while actively improving water quality. Most of the techniques highlighted in this report can be considered short-term solutions to reduce the impaired status of Indian Lake. What many of these techniques don’t accomplish however, is the necessary reduction in nutrient loading that is the basis for continued and sustained reduction in algae and macrophyte growth. Although there are some active management techniques that can be used to reduce nutrient concentrations within a waterbody such as nutrient inactivation and oxygenation, these techniques may not be well suited for a shallow, large reservoir such as Indian Lake. With this in mind however, the enactment of best management practices (BMPs) is typically suggested for all bodies of water to reduce nutrient impact over a long period of time. BMPs are actions that various stakeholders can take to reduce their individual impact footprint on a lake or reservoir and can be broken up into a number of different categories from shoreline homeowner BMPs to agricultural BMPs. Many BMPs reduce nutrient loading into a waterbody directly or slow down their path to the waterbody. Table 20 lists many common BMPs that are utilized by different constituents to help alleviate nutrient loading into bodies of water.

Table 20: List of some common best management practices (BMPs) that can be enacted on Indian Lake and its watershed.

Shoreline Homeowners	Construction	Agricultural	Other
Use reduced or no-P fertilizer	Use silt fencing on slopes where necessary	Ensure vegetated buffer strips are used to protect riverine systems	Allow for “greenways” to persist to sequester nutrients before they reach the lake
Ensure septic systems are up to date if applicable	Cover or stabilize barren soils	Enact fertilizer management practices	Follow wake zone rules to reduce erosion

Allow for a vegetated buffer strip to exist on your shoreline	Build sedimentation basins if necessary	Consider contour farming	Construct rain gardens to take in water before it reaches the lake
Consider using permeable surfaces when possible	Install swales in ditches	Enact crop rotation practices	
Conserve water usage as much as possible		Reduce livestock waste movement into moving waters	

Long-Term Management Concepts: Prevention

The cheapest and easiest way to ensure nuisance growth has as minimal of an impact on a body of water as possible is to prevent the nuisance from ever arriving in the first place. Based on the findings of this study, Indian Lake contains three different species of invasive macrophyte (Eurasian watermilfoil, curly-leaf pondweed, and brittle naiad; Table 6). In addition, it is thought that the invasive zebra mussel also impacts the reservoir's water quality and has been noted during this survey. These invading organisms are not a historical component of the reservoir environment and could have been brought into Indian Lake from a wide assortment of possible vectors (e.g. boat traffic, bait buckets, aquarium trade, inlet transport from upstream locations, etc.). Although it is difficult to determine the exact timeline and location of these and future invasions on Indian Lake, common prevention tactics will assist in avoiding the introduction of unestablished invaders (e.g. Hydrilla, round-goby, spiny water flea). Some states have established prevention tactics as regulations such as New York where it is unlawful to transport known invasive species and "reasonable precautions" need to be taken to prevent aquatic invasive species (AIS) spread (AIS; 6 NYCRR Part 576). Some communities also restrict invasive organism spread into their own systems by enforcing access to private recreational waterbodies and educating their communities on AIS (Twin Lakes in Kent, OH; Lake Cardinal in Rome, OH). The following are some considerations for AIS prevention:

- Clean, drain, and dry boats after use on any body of water. Especially if there is intent to move to another body of water.
- Pull aquatic plants off trailers when they exit the waterbody for the day.
- Adequately dispose of any bait that was brought onto the body of water. Dispose far offsite where there is little to no risk of introduction to a non-native environment.
- Clean fishing or boating gear that may have been exposed to potential invaders.

- Have a boat inspection program that ensures boats entering the system are clean of AIS and can turn away those that fail inspections.
- Put up signs to educate potential lake-users of the risks associated with AIS (accomplished on Indian Lake).

By enacting preventative measures to inhibit invasion by non-native species, the costs associated with potential management can be severely reduced (Figure 51; Ahmed et al. 2022). This in conjunction with local awareness of AIS, early detection through observations and monitoring, and rapid response to new invasions can improve the efficacy and reduce the cost to contain or even eradicate potential future invaders.

Enactment of prevention techniques have resulted in the creation of inspection and wash stations at public launch points in lakes across the United States (e.g. Tenmile Lake, OR, Otsego Lake, NY, Lake Mead, AZ). These stations may collect a fee from an operator who conducts the inspection and can clean boats if necessary. In some instances, these operators are given the power to turn away potential failing boats (Otsego Lake; Horvath 2008). The fee in many instances can offset the cost associated with enacting the preventative technique (averages $30,000 per year at Otsego Lake, 2008 values). Heated power washers can be utilized in some of these instances where temperatures of 60°C are suggested to result in 100% mortality of invasive plants, mussels, and various insects (Mohit et al. 2021). Wash stations and inspectors positioned at public locations could be a means to reduce new incoming AIS into Indian Lake although the costs for construction and maintenance may be high. This is a decision that would have to be made with local stakeholder support as some may raise questions about restricting public access to a public water body.

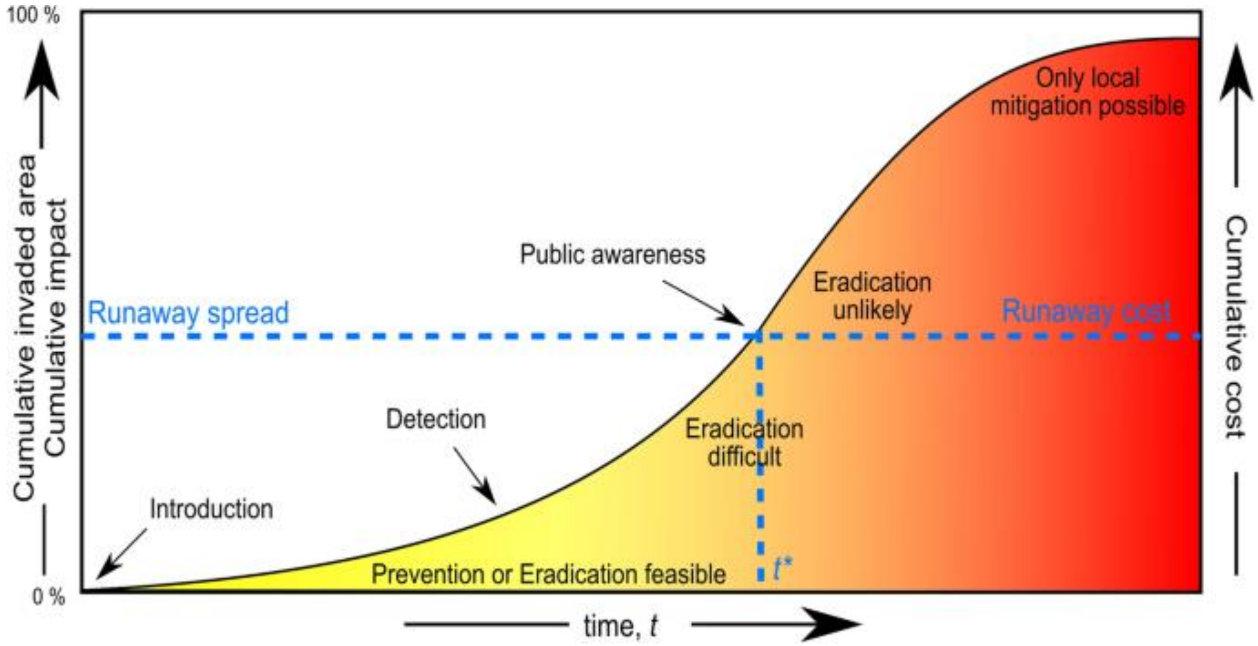


Figure 51: Generalized invasion curve depicting the relationship between costs, feasibility of eradication, and area of impact of an invader over time (Ahmed et al. 2022).

VII. Vegetation Management Plan

Directives

With an unprecedented amount of nuisance EWM and coontail growth inhibiting local stakeholders from utilizing Indian Lake to its best potential recreational use in 2022, a call for planned and substantiated management procedures is suggested for 2023. These procedures are meant to act as a guide to assist the ODNR and the Indian Lake community at large to reduce the impaired status of Indian Lake. For the purpose of this vegetation plan, "impaired" is defined by the inability of Indian Lake to provide its best categorical activities as a contact-recreation waterbody. Based on the noted concern above and the information within this report, it is suggested that the following be priorities for a comprehensive approach to managing Indian Lake:

1) The use of intensive short-term management strategies beginning early in the lake use season (after ice off) to reduce the impact of large-scale nuisance aquatic vegetation growth in 2023 which can include:
    a. Continued use of mechanical harvesting to target specifically coontail biomass as well as floating vegetation and waste,
    b. The use of selective herbicide products to assist in the management of EWM, particularly in the open-recreational zone.
2) The adaptive use of small-scale short-term management strategies as vegetation is controlled or isolated areas of nuisance growth are discovered as described in this report.
3) The generation of a comprehensive reservoir monitoring program that allows for water quality thresholds to be developed throughout the primary lake recreational season (May – October).
4) The education and enactment of lake best management practices for shoreline homeowners, watershed landowners, and general lake stakeholders to progress lake-mindedness and reduce the impact of eutrophication overtime.
5) Protect Indian Lake from future invasions from aquatic invasive species (AIS) and also prevent the spread of current AIS into other bodies of water.

As the primary decision maker, funding agent, and protector of Indian Lake, the ODNR will be the final decision-making body for any management directives that involve the reservoir and these priorities. However, it should also be noted that Indian Lake contains a strong community of passionate stakeholders with an eagerness to see the reservoir and its community improve. This can be tapped into to assist in efforts to improve the reservoir. There are already various groups and organizations established within the community such as the Indian Lake Watershed Project (ILWP) whose directives and goals coincide with those of this report. Collaboration among different agencies, stakeholder groups, and government officials is critical to the success and progressive development of this and future plans for Indian Lake. The ODNR and these groups should have a unified mentality toward the best overall management of the reservoir as it is the only way to ensure priorities are accomplished in a way that supports the sustainable social wellbeing of Indian Lake and its community.

Introduction

This section of the "Indian Lake Aquatic Plant Management Survey and Vegetation Management Plan" is meant to use the information from the 2022 aquatic vegetation study to generate a comprehensive management plan. The control of nuisance vegetation in the reservoir needs to be a dynamic process that incorporates adaptive short-term solutions in conjunction with long-term, sustainable actions that will allow for an immediate reduction in Indian lake's impaired status as well as improved longevity of a generated acceptable condition. As this is one of the first plans of its kind to be generated for Indian Lake, and data regarding the reservoir's water quality is scarce, it is imperative that a comprehensive monitoring program be enacted and this plan be revisited on an annual basis as new information is collected. This way this plan can become a dynamic component of future management and change as new information and perspectives appear. The groundwork for a citizen monitoring training presentation is included in Appendix J of this report. Additionally, a general glossary of terms that may be helpful for those reading through this document are included in Appendix H.

2022 Vegetation Survey Results Summarized

In order to properly assess nuisance aquatic vegetation concerns in Indian Lake a study of the macrophyte community was conducted from July 5 – 15, 2022 utilizing a modified point intercept rake toss relative abundance method (PIRTRAM) survey as well as the use of sonar mapping through BioBase® mapping software. The reservoir was evenly gridded out to 585 distinct locations throughout the main basin as PIRTRAM sampling zones. At each of these zones, a submersed aquatic plant sampling rake was utilized to collected any macrophyte growth with collected metrics on the various plant's identification and relative density. Sonar mapping was conducted by slowly tracing and filling the reservoir with sonar pings via slow travel around Indian Lake. This information is then uploaded to Biobase® to generate heat maps that designate depth as well as macrophyte abundance throughout the reservoir. These methods allowed for a greater understanding of the distribution, density, and identification of all collected submersed aquatic plant species throughout Indian Lake.

Collected data from the PIRTRAM study noted ten individual species of submersed aquatic plants. Five Individual species of floating-leaf plants were also noted during visual observations during the study. Eurasian watermilfoil (EWM; *Myriophyllum spicatum*) and coontail (*Ceratophyllm demersum*) accounted for the largest majority of submersed aquatic plants by distribution as well as density. Coontail was the most abundant and widespread at the time of the study being found at 73.7% of all sampled locations (accounting for approx. 3,600 acres) with an estimated 48,729.92 g/m^2 of biomass present in the reservoir. EWM was the next most abundant and widespread being found at 64.6% of all sampled locations (accounting for approximately 3,150 acres) with an estimated 40,966.06 g/m^2 of biomass present in the reservoir at the time of the study. All other species of submersed aquatic plants were sampled at levels insignificant for management purposes. Coontail and EWM growth are the primary macrophytes of concern that carried the heaviest weight for impairment of Indian Lake during the 2022 season. Curly-leaf pondweed (CLP) was also collected during the survey and noted with turion presence. This submersed plant should also be considered for its potential to grow to nuisance levels during the early-season. Geographically, coontail seemed to primarily impact eastern portions of the lake including the spillway and residential island areas. EWM was primarily located within the open-recreational zone of the reservoir. These results create the framework for likely target identification in 2023 and for this plan.

2022 Management Overview Summarized

Two techniques were primarily used to provide relief from excessive aquatic vegetation growth during the 2022 lake-use season: mechanical harvesting and herbicide usage. Mechanical harvesting in Indian Lake saw the use of as many as seven total harvesters that collected 1,323,000 cubic feet of total material from the reservoir. Navigation pathways were successfully created through the use of this technique to allow recreational boaters access to various parts of Indian Lake. Fragmentation was common during the 2022 season and may have been enhanced utilizing this technique and with “prop-chop” from recreational boaters. This generated floating “islands” of vegetation at times that would move around the lake, ending up in coves and other areas where water movement would regress. For many lake stakeholders, the creation of substantial fragmentation is unacceptable as it can impede recreational use of the resource as much as rooted vegetation does. Reducing the impact of fragmentation can occur by focusing the use of harvesting on harvest-susceptible species that are not known to be aggressive fragment spreaders. Coontail and CLP can both be managed effectively by this whereas EWM is a known aggressive fragment spreader.

Herbicide usage in Indian Lake consisted of private shoreline applications that targeted submersed plants on a case-by-case basis as well as a trial of Floropyrauxifen-benzyl (trade name ProcellaCOR®) to specifically target EWM within the open-recreational zone. Testing of ProcellaCOR® was conducted on two, 200-acre plots from July 12 – 13, 2022 and August 24 – 25, 2022. The first zone was located just north of the Lakeview public boat launch. Visible positive results were noted after two weeks of the initial application with a substantial reduction in surface EWM growth. The second application occurred just north of the initial application (south of Oldfield Beach) with similar results. The successful trials of these two applications showcase ProcellaCOR® as a potential tool for EWM management on Indian Lake but, care must be taken not to overwhelm the reservoir with an over-reliance of herbicide usage that could have unintended negative consequences such as increased oxygen loss or enhanced nutrient release. These issues can be addressed through the use of herbicide best management practices that allow for the use of products such as ProcellaCOR® at a larger scale while limiting potential for unnecessary harm. In addition to ProcellaCOR®, other herbicide products such as endothall (Aquathol K), diquat (Tribune, Alligare diquat), 2,4-D (Navigate, Depth Charge), and others have also been shown to manage EWM and other potential nusiances. Rotating these products and not becoming reliant on one will reduce the potential for tolerance build up in targeted submersed plants.

2023 Nuisance Vegetation Management Approach

With coontail and EWM being the focus of management concerns for the lake-use season in 2023, management techniques that can effectively target these submersed plants should be given a priority. It should be noted that this approach is specific towards collected data from 2022. As lakes and reservoirs are dynamic systems, it is possible that the 2023 lake-use season is not represented by the information collected in 2022. Should the lake experience another stable state change post ice-off or experience a different nuisance that fulfilled the niche opened through management decisions in 2022, an alteration in this plan will need to occur. Because of this, monitoring of the submersed vegetation in the reservoir will need to start early in the season while preparations are being made. It would be strongly suggested to repeat the methods of this survey as early as April to assess 1) the potential of curly-leaf pondweed growth as an early season nuisance for the recreational use of Indian Lake, 2) to observe any regrowth in the ProcellaCOR® application zones, and 3) to identify zones where potential for regrowth in 2023 may be high. Understanding this information early on will allow for a better understanding of potential 2023 vegetation growth in Indian Lake.

Once confirmation of aquatic plant growth potential has occurred, any large-scale herbicide usage should be enacted early in the season (late April – June) to address high priority targets while biomass quantity is relatively low. This will allow for control of targeted species while reducing the potential for oxygen loss and nutrient release as the smaller plant size will reduce decomposition potential and sequestered nutrient capacity. This will also allow for a greater likelihood that the lake will remain unimpaired for recreational use before the peak-recreational season. Based on information collected during the 2022 season, ProcellaCOR® and 2,4-D are both suggested for EWM control in Indian Lake. ProcellaCOR® would work particularly well for areas dominated by EWM with little water exchange while 2,4-D would be ideal for areas where water movement (e.g. wind action, flow, etc.) may be considered as 2,4-D has granular formulations that can improve contact time with the target. CLP growth is also highly susceptible to herbicide application, though the selective products listed above may have little impact on CLP growth. Relatively low dosages of many contact herbicides (e.g. diquat and endothall) can yield successful CLP control as stated in this report. Further suggestions regarding the use of herbicides include:

- Harvesting an area first followed up with granular herbicide application to reduce over decomposed biomass, reducing oxygen demand and increasing harvested area control.
- Utilize granular products in zones where there may be expected high water exchange or boat traffic to increase concentration and contact time.

- Ensure large-scale applications are done in relatively small, meaningful chunks to reduce potential unnecessary risk of harm to non-target biota and water quality.
- Rotate herbicide products that impact the same target to reduce the likelihood of target resistance build-up.

Harvesting should also continue until the end of the lake-use season to ensure navigation channels are maintained and harvest susceptible species are accounted for to the best of the operator's capabilities. Although harvesting is a non-selective technique and an operator may not have complete control over what is entirely picked up by a harvester, care should be taken to reduce harvester navigation through known EWM beds to reduce fragmentation. Harvesting could also be successfully used on CLP growth which is not a known aggressive fragment reproducer. The conjoined actions of herbicide applications for EWM control and harvesting can reduce the two most prevalent nuisances in Indian Lake from the 2022 season. If harvesting through EWM beds is necessary (e.g. for navigation or a mixed bed of vegetation with coontail), attempts at cutting close to the sediment layer should be made as it could impact root and crown structures, increasing harvesting longevity. Additional suggestions to improve harvesting efficiency and reduce undesired impacts include:

- Ensuring drop off points are pre-established and reduce the overall carry distance or consider the purchasing of a barge to hold waste material.
- Be as selective as possible and focus on coontail or CLP removal over milfoil.
- Utilize harvesting as the primary tool for cultivating and maintaining channels for navigation through the reservoir.

With potential large-scale vegetation management techniques being enacted early-on, opportunities for maintenance procedures can be conducted and continued throughout the peak-season to accommodate for smaller or isolated patches of nuisance vegetation. These techniques can vary based on the scale and identification of the targeted vegetation and highlighted in Figure 50. Selection of small-scale management areas should focus on relative zone importance for use and includes such areas as public access locations like beaches and boat launches, navigational zones, and individual areas of importance to the community. It is the hope that with these techniques a feasible reduction of nuisance vegetation can be accomplished to allow for 70% navigability of Indian Lake by July 4, 2023. The majority of which, should allow for use of the open recreational zone. Costs associated with these techniques is highlighted in Table 21.

Once the peak-season ends (near the end of September) reassessment of the vegetation community should occur. This time, to gauge how effective management approaches were and to make alterations for the 2024 season. This dynamic approach is paramount to having a constantly flexible plan that is fluid to changes in Indian Lake's issues of concern as well as the perspectives of the community at large. A general timeline of events that highlight what has been mentioned above is provided with Figure 53 below.

Suggesting the information collected in 2022 is representative of 2023, the following can be enacted based on the individual targeted nuisance to be controlled in Indian Lake and is provided as a general guideline for the continued management of these nuisances (Greater assessment in chapter 5):

Targeted Nuisances

1) Management of Eurasian watermilfoil

As EWM is an invasive submersed plant that fragments and spreads readily, the utilization of mechanical harvesters or hydrorakers is not suggested as the primary means of management for this species. Necessary harvesting to generate navigational pathways should still be performed but harvesting through areas of primary milfoil growth without need should be discouraged. The behavior, morphometry, and open nature of Indian Lake also do not support the use of milfoil specific biocontrol agents or whole-lake drawdown. Due to these restrictions, large-scale management of EWM would fall on chemical control based on the success of ProcellaCOR® and other herbicide products such as, 2,4-D, endothall, and diquat. 2,4-D in particular seems to have shown effective control. Small to mid-sized management needs can continue to utilize these products but also include suction harvesting, hand-pulling, and benthic barriers. These techniques can control EWM growth while restricting the potential for spread via fragmentation.

2) Management of coontail

Coontail is a native submersed plant that does not require a deeply anchored root system for it to survive. As such, it can naturally become a component of the “prop-chop” that many stakeholders find a nuisance. Because of this however, coontail can be effectively controlled through harvesting which can collect floating beds of plants and remove weakly rooted vegetation in its entirety. Coontail can be resistant to some chemical applications and may require a higher label-rate use if chemical treatment is desired but as similarly described above, water-level drawdown and biocontrol agents will not be feasible for coontail control. In small to mid-sized plots coontail can be controlled with suction harvesting, hand-pulling, and the use of benthic barriers.

3) Management of Curly-leaf pondweed

As a cool-water species of submersed plant, CLP would likely dominate the early part of the lake use season up until approximately early July. With this in mind, decisions would have to be made regarding whether to invest substantial resources into CLP management or simply maintain a lower threshold of lake usability until the plant finishes its reproductive cycle when recreational lake use starts becoming heavier. This would allow more resources to go to management of EWM and coontail early-mid season. Regardless of the decision, CLP is the least hardy of the 3 submersed plants of concern and is susceptible to a number of management techniques including chemical control, mechanical harvesting, suction harvesting, hand-pulling, and benthic barrier usage from large to smaller scales. Control of CLP prior to turion production may result in yearly reductions in overall CLP biomass.

Site Selection for Management

Based on the information gathered by this survey, EWM biomass was dominant within the open-recreation zone of Indian Lake while coontail biomass dominated the eastern portion of the lake near the spillway and residential islands in July. In a broad sense, techniques that effectively control coontail growth should be utilized on the eastern portion of the lake while those that target EWM more directly should be done in the open-recreation zone. However, this should remain dynamic to account for any observed changes in the macrophyte assemblage on the lake in 2023. Active management in 2022 did reduce the impact of nuisance growth by the end of the lake-use season. As such, it may be suggested to concentrate efforts on regions where no active management was highlighted in 2022, where macrophyte control is considered important, and where growth seemed to remain by the end of the use-season. This may provide an adequate starting point to pick up from where 2022 left off. Suggested zones for this purpose are highlighted in Figure 52 (Image from the end of the 2022 lake-use season: September 1, 2022). This area encompasses approximately 700 acres of remaining surfaced aquatic plant mass. It should again be highlighted that these areas of concern are generated from information collected in 2022. CLP growth will also need to be assessed early in the 2023 season as stated above to provide insight into potential management location needs. Growth in 2023 can be variable and additional information regarding the macrophyte community should be collected again early in the 2023 season to confirm or alter these suggestions.

Beyond 2023 Long-term management suggestions

Beyond the dynamic short-term management model described within this report, long-term suggestions also need to be recommended. Amongst these concepts is the creation and continued support of a monitoring program to collect long-term data sets overtime as well as the enactment of watershed and in-lake best management practices (BMPs; Chapter 6 above). Although the ODNR can hire professionals to collect water quality information and monitor Indian Lake, the use of a citizen-ran monitoring program can also be utilized to best serve the reservoir and its community. As previously mentioned, a starting point for this is available in Appendix J. Regardless of whether monitoring is conducted by ODNR constituents or citizens, information should be made widely available to the public in order to continue to educate and enhance their knowledge of current reservoir conditions. BMP additions should be considered by the ODNR. Those that center around erosion reduction and a decrease in nutrient loading within the watershed may want to be highlighted particularly due to its soil structure (Figure 5; Appendix A some of this has been accomplished by the Indian Lake Watershed Project (ILWP) but should continue to be built upon). A nutrient budget (estimating nutrient inputs vs outputs) would further assist in continued development of a threshold goal for nutrient reduction but, as mentioned substantial monitoring data is required to accurately create such a budget.

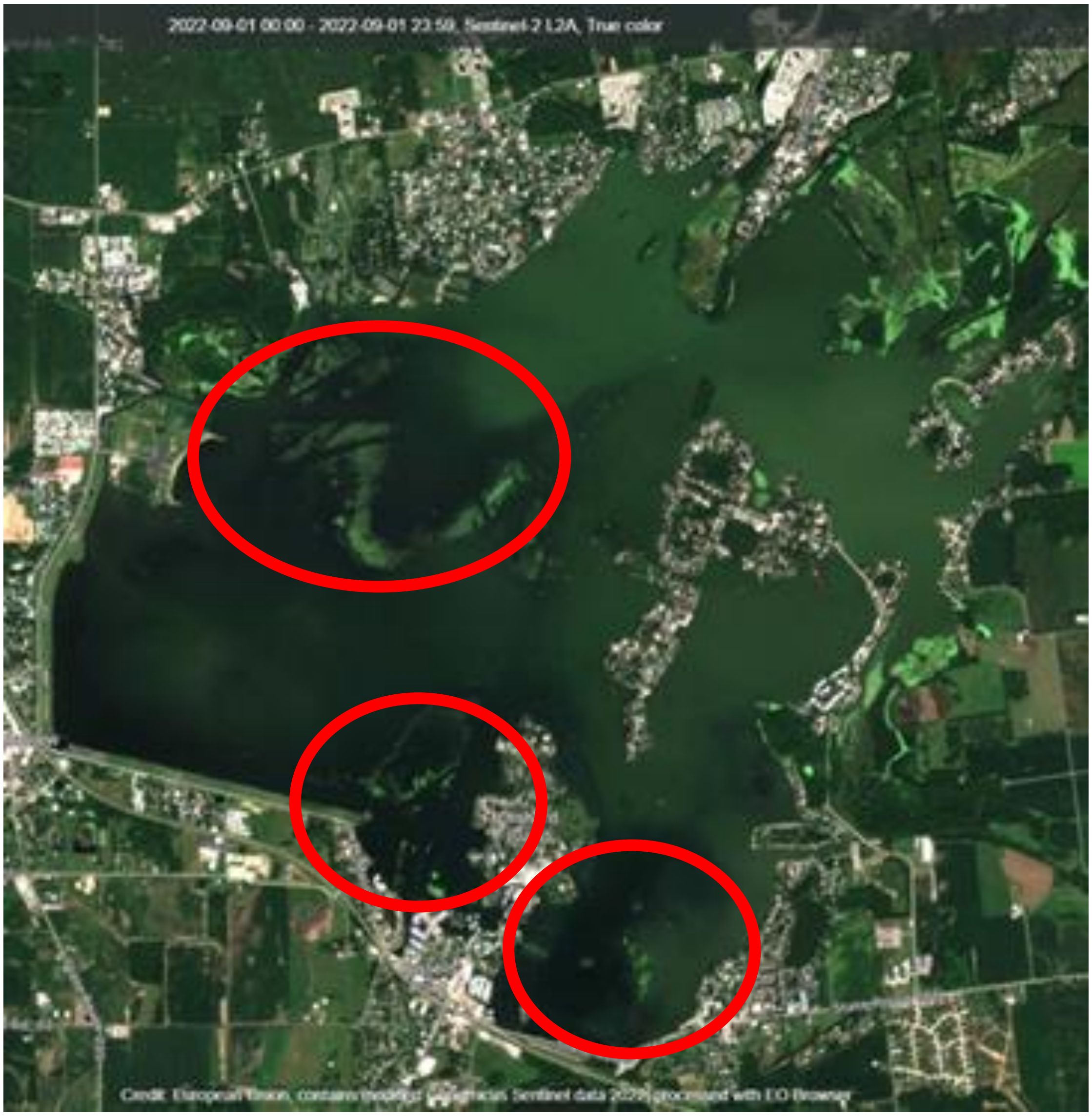


Figure 52: Satellite imagery of Indian Lake from 9/1/2022. Areas outlined in red indicate locations where it may be suggested to focus on vegetation management for 2023.

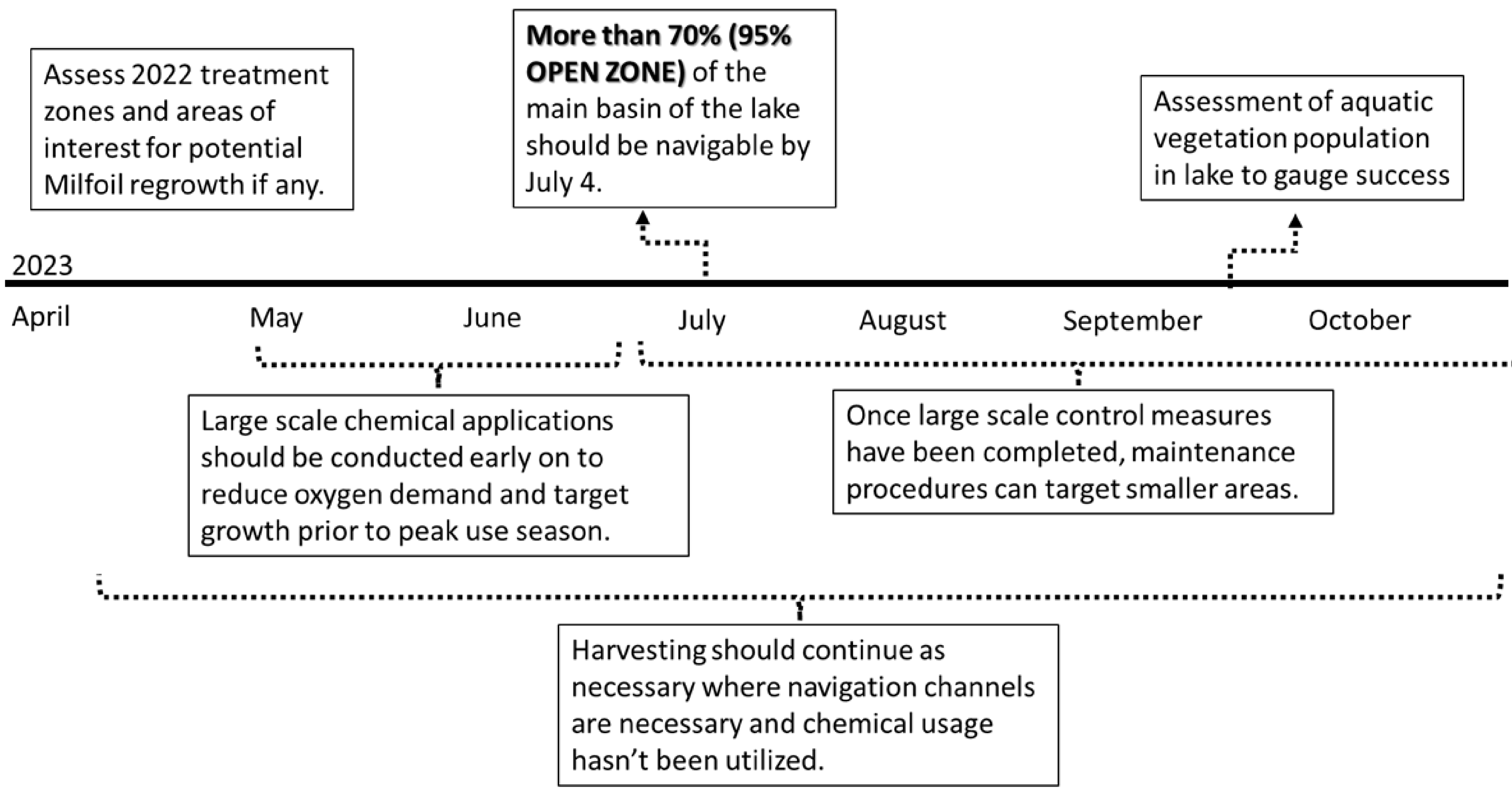


Figure 53: A suggested timeline of events for the short-term management of submersed aquatic vegetation in Indian Lake for the 2023 season.

Table 21: Cost ranges for the various techniques mentioned in this plan. Please note that cost estimations are complex and differ from lake-to-lake accounting for the wide cost variations noted.

Technique	Estimated cost per acre (Holdren et al 2001; adjusted for inflation)	Estimated cost per acre (NYSFOLA 2009; adjusted for inflation)	A Few Considerations
Chemical application*	$300 - $3,000	$250 - $1,900	What is the chemical choice and what rates need to be used? What equipment is needed?
Dredging (average sediment depth of 5 ft)	$60,000 - $120,000	$1,500 - $60,000 (average sediment depth of 3 ft)	Where will removed material go? What permits, licenses, etc. are needed? How deep do you need to dredge?
Harvesting (Mechanical)	$1,500 - $2,250	$124,000 - $248,000 (purchase machine, does not include operator salary)	How many harvesters are needed? What salary do you pay operators? How often will they run?
Benthic barrier installation/removal/maint.	$30,000 - $75,000 (Professionally)	$12,500 - $25,000 (Professionally)	What material are you using? Can you maintain it?
Hand-pulling with biomass removal	$150 - $750	>$1,200 (Professionally)	How dense are the plants and how big is the area of concern?
Suction harvesting	$7,500 - $15,000	$1,200 - $31,000 excluding equipment costs	How many employees are needed? What kind of equipment is being run? How dense are the plants and how large is the area?

*Note: 2022 ProcellaCOR cost was $163,500 per 200-acre application.

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Appendix A: Summary of soil types from soils report (Soils Survey Staff 2022)

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ble1A1	Blount silt loam, end moraine, 0 to 2 percent slopes	250.2	0.4%
Ble1B1	Blount silt loam, end moraine, 2 to 4 percent slopes	131.8	0.2%
Blg1A1	Blount silt loam, ground moraine, 0 to 2 percent slopes	527.3	0.8%
Blg1B1	Blount silt loam, ground moraine, 2 to 4 percent slopes	106.6	0.2%
DeA	Del Rey silt loam, till substratum, 0 to 3 percent slopes	188.4	0.3%
Gwd5C2	Glynwood clay loam, 6 to 12 percent slopes, eroded	9.2	0.0%
Gwe1B1	Glynwood silt loam, end moraine, 2 to 6 percent slopes	36.2	0.1%
Gwg1B1	Glynwood silt loam, ground moraine, 2 to 6 percent slopes	11.6	0.0%
Gwg5C2	Glynwood clay loam, ground moraine, 6 to 12 percent slopes, eroded	21.5	0.0%
HkA	Haskins loam, 0 to 3 percent slopes	3.3	0.0%
McA	McGary silt loam, 0 to 4 percent slopes	53.0	0.1%
Mnl3A	Minster silty clay loam, till substratum, 0 to 1 percent slopes	110.0	0.2%
Mns3A	Minster silty clay loam, 0 to 1 percent slopes	536.3	0.9%
Pt	Pewamo silty clay loam, 0 to 1 percent slopes	681.3	1.1%
Subtotals for Soil Survey Area		**2,666.7**	**4.3%**
Totals for Area of Interest		**62,154.9**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ble1A1	Blount silt loam, end moraine, 0 to 2 percent slopes	725.6	1.2%
Ble1B1	Blount silt loam, end moraine, 2 to 4 percent slopes	3,752.0	6.0%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Blg1A1	Blount silt loam, ground moraine, 0 to 2 percent slopes	1,680.2	2.7%
Blg1B1	Blount silt loam, ground moraine, 2 to 4 percent slopes	1,975.4	3.2%
Ca	Carlisle muck, Central Ohio clayey till plain, drained, 0 to 2 percent slopes	137.6	0.2%
DeA	Del Rey silt loam, 0 to 3 percent slopes	88.8	0.1%
Ee	Eel silt loam, 0 to 2 percent slopes, occasionally flooded	122.8	0.2%
FoA	Fox silt loam, till plain, 0 to 2 percent slopes	84.6	0.1%
FoB	Fox silt loam, till plain, 2 to 6 percent slopes	689.9	1.1%
FpC2	Fox clay loam, 6 to 12 percent slopes, eroded	19.9	0.0%
Gwd5C2	Glynwood clay loam, 6 to 12 percent slopes, eroded	521.3	0.8%
Gwe1B1	Glynwood silt loam, end moraine, 2 to 6 percent slopes	422.4	0.7%
Gwe5B2	Glynwood clay loam, end moraine, 2 to 6 percent slopes, eroded	222.3	0.4%
Gwg1B1	Glynwood silt loam, ground moraine, 2 to 6 percent slopes	152.9	0.2%
Gwg5B2	Glynwood clay loam, ground moraine, 2 to 6 percent slopes, eroded	113.0	0.2%
Gwg5C2	Glynwood clay loam, ground moraine, 6 to 12 percent slopes, eroded	123.4	0.2%
HkA	Haskins silt loam, 0 to 2 percent slopes	44.9	0.1%
HkB	Haskins silt loam, 2 to 6 percent slopes	15.6	0.0%
KaB	Kendallville silt loam, 2 to 6 percent slopes	56.1	0.1%
Ln	Linwood muck	60.8	0.1%
Mc	McGuffey muck	17.6	0.0%
Mf	Milford silty clay loam, 0 to 2 percent slopes	93.1	0.1%
MnI3A	Minster silty clay loam, till substratum, 0 to 1 percent slopes	56.2	0.1%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Mny3A	Minster silty clay loam, gravelly substratum, 0 to 1 percent slopes	242.0	0.4%
MrD2	Morley clay loam, 12 to 18 percent slopes, eroded	46.9	0.1%
MsC2	Morley-Belmore complex, 6 to 15 percent slopes, eroded	7.5	0.0%
Ot	Olentangy silt loam	7.3	0.0%
PkA	Pewamo silty clay loam, 0 to 1 percent slopes	4,611.6	7.4%
Ro	Roundhead muck	62.2	0.1%
Sa	Saranac silty clay loam, 0 to 2 percent slopes, frequently flooded	6.4	0.0%
SkA	Sleeth silt loam, 0 to 3 percent slopes	214.4	0.3%
SmA	Sleeth silt loam, 0 to 2 percent slopes	12.5	0.0%
W	Water	2.7	0.0%
Wa	Wallkill silt loam, frequently flooded	11.3	0.0%
Wb	Wallkill silt loam	1.8	0.0%
We	Westland clay loam	629.9	1.0%
Wf	Westland silty clay loam, clay substratum	41.2	0.1%
Subtotals for Soil Survey Area		**17,074.1**	**27.5%**
Totals for Area of Interest		**62,154.9**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ag	Algiers silt loam	1,223.2	2.0%
Ble1A1	Blount silt loam, end moraine, 0 to 2 percent slopes	1,150.9	1.9%
Ble1B1	Blount silt loam, end moraine, 2 to 4 percent slopes	1,461.2	2.4%
Blg1A1	Blount silt loam, ground moraine, 0 to 2 percent slopes	1,856.0	3.0%
Blg1B1	Blount silt loam, ground moraine, 2 to 4 percent slopes	1,740.5	2.8%
Bs	Brookston silty clay loam, fine texture, 0 to 2 percent slopes	19.4	0.0%
Ca	Carlisle muck, Central Ohio clayey till plain, drained, 0 to 2 percent slopes	57.8	0.1%
Cc	Carlisle muck, Central Ohio clayey till plain, 0 to 2 percent slopes	510.8	0.8%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CdD2	Casco-Eldean complex, 12 to 18 percent slopes, moderately eroded	47.6	0.1%
CrA	Crosby silt loam, Southern Ohio Till Plain, 0 to 2 percent slopes	36.6	0.1%
CrB	Crosby silt loam, Southern Ohio Till Plain, 2 to 6 percent slopes	0.2	0.0%
Ed	Edwards muck	4.9	0.0%
Ee	Eel silt loam, 0 to 2 percent slopes, occasionally flooded	173.9	0.3%
EmA	Eldean silt loam, 0 to 2 percent slopes	259.3	0.4%
EmB	Eldean silt loam, 2 to 6 percent slopes	476.2	0.8%
EmC2	Eldean silt loam, 6 to 12 percent slopes, moderately eroded	175.6	0.3%
FlA	Fox loam, till plain, 0 to 2 percent slopes	287.8	0.5%
FlB	Fox loam, till plain, 2 to 6 percent slopes	395.0	0.6%
FnB	Fox silt loam, till plain, 2 to 6 percent slopes	74.9	0.1%
FuA	Fulton silt loam, 0 to 4 percent slopes	178.4	0.3%
Gn	Genesee silt loam, 0 to 2 percent slopes, occasionally flooded	218.6	0.4%
Gwd5C2	Glynwood clay loam, 6 to 12 percent slopes, eroded	293.9	0.5%
Gwe1B1	Glynwood silt loam, end moraine, 2 to 6 percent slopes	56.0	0.1%
Gwg1B1	Glynwood silt loam, ground moraine, 2 to 6 percent slopes	45.2	0.1%
Gwg5C2	Glynwood clay loam, ground moraine, 6 to 12 percent slopes, eroded	370.0	0.6%
HdA	Haskins loam, 0 to 3 percent slopes	175.5	0.3%
HdB	Haskins loam, 2 to 6 percent slopes	258.6	0.4%
HeA	Henshaw silt loam, 0 to 2 percent slopes	22.4	0.0%
HoA	Homer silt loam, 0 to 2 percent slopes	427.9	0.7%
HoB	Homer silt loam, 2 to 6 percent slopes	311.8	0.5%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
La	Latty silty clay	1,127.0	1.8%
Lb	Latty silty clay, occasionally flooded	66.2	0.1%
Ln	Linwood muck	25.5	0.0%
Lp	Lippincott silty clay loam, 0 to 2 percent slopes	956.6	1.5%
Ma	Martisco mucky silt loam	2.3	0.0%
MmC2	Miamian Variant silt loam, 6 to 15 percent slopes, moderately eroded	5.6	0.0%
Mnl3A	Minster silty clay loam, till substratum, 0 to 1 percent slopes	589.6	0.9%
Mns3A	Minster silty clay loam, 0 to 1 percent slopes	72.6	0.1%
Mny3A	Minster silty clay loam, gravelly substratum, 0 to 1 percent slopes	37.5	0.1%
MoB	Milton silt loam, 2 to 6 percent slopes	56.0	0.1%
MoC2	Milton silt loam, 6 to 12 percent slopes, moderately eroded	153.0	0.2%
MoD2	Milton silt loam, 12 to 18 percent slopes, moderately eroded	25.7	0.0%
MyD2	Morley silt loam, 12 to 18 percent slopes, eroded	42.3	0.1%
Mz	Muskego muck	8.3	0.0%
NaA	Nappanee silt loam, 0 to 2 percent slopes	1,239.7	2.0%
NaB	Nappanee silt loam, 2 to 6 percent slopes	6,967.5	11.2%
OcA	Ockley silt loam, Southern Ohio Till Plain, 0 to 2 percent slopes	227.2	0.4%
OcB	Ockley silt loam, Southern Ohio Till Plain, 2 to 6 percent slopes	28.6	0.0%
Pc	Patton Variant silt loam	40.6	0.1%
Pd	Paulding clay	1,021.4	1.6%
Pe	Pewamo silty clay loam, 0 to 1 percent slopes	3,137.0	5.0%
Pg	Pits, gravel	4.7	0.0%
Pk	Pits, quarries	192.3	0.3%
ScB	St. Clair silt loam, 2 to 6 percent slopes	1,157.9	1.9%
ScC2	St. Clair silt loam, 6 to 12 percent slopes, moderately eroded	4,042.1	6.5%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
ScD2	St. Clair silt loam, 12 to 18 percent slopes, moderately eroded	609.9	1.0%
SlA	Sleeth silt loam, 0 to 2 percent slopes	861.3	1.4%
SmA	Sleeth silt loam, 0 to 3 percent slopes	20.6	0.0%
Ud	Udorthents	82.2	0.1%
W	Water	3,869.2	6.2%
Wa	Wallkill silt loam	15.9	0.0%
Ws	Westland clay loam	434.6	0.7%
Wt	Westland silty clay loam, Southern Ohio Till Plain, 0 to 2 percent slopes	7.4	0.0%
Wu	Westland silty clay loam, clay substratum	1,514.9	2.4%
Wv	Wetzel silty clay loam	1,422.9	2.3%
Wx	Willette muck	37.9	0.1%
Subtotals for Soil Survey Area		**42,414.1**	**68.2%**
Totals for Area of Interest		**62,154.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a

Appendix B: YSI probe data collected at the deepest known point of the lake.

Date	Depth (ft.)	Temperature (F)	Dissolved Oxygen (mg/L)	pH	Sp. Cond.	ORP
8/19/2022	0	78	10.82	9.19	0.311	71.1
8/19/2022	1	77.7	10.9	9.08	0.311	67.2
8/19/2022	2	76.9	11.06	9.11	0.311	62.4
8/19/2022	3	76.4	11.07	9.01	0.311	62.5
8/19/2022	4	75.5	9.78	8.94	0.317	64.1
8/19/2022	5	74.8	8.31	8.83	0.319	66.1
8/19/2022	6	74.6	7.35	8.69	0.321	67.4
8/19/2022	7	74.4	6.22	8.6	0.323	68.1
8/19/2022	8	74.3	5.62	8.59	0.323	68
8/19/2022	9	74	3.49	8.11	0.327	71.5
8/19/2022	10	73.9	3.1	8.01	0.328	71.7
8/19/2022	11	73.8	2.21	7.9	0.329	72.6
8/19/2022	12	73.8	1.57	7.77	0.332	69.4
9/1/2022	0	82.1	11.88	9.37	0.297	71.3
9/1/2022	1	82.2	11.17	9.37	0.297	69.2
9/1/2022	2	82.1	10.99	9.35	0.298	69.5
9/1/2022	3	76.9	5.96	8.83	0.325	75.7
9/1/2022	4	76.3	4.07	8.52	0.329	76.4
9/1/2022	5	75.9	3.62	8.39	0.322	77.4
9/1/2022	6	75.8	3.34	8.34	0.322	76.4
9/1/2022	7	75.7	3.3	8.33	0.322	76.4
9/1/2022	8	75.7	3.57	8.39	0.329	75.3
9/1/2022	9	75.6	3.61	8.39	0.329	75.3
9/1/2022	10	75.5	3.22	8.29	0.33	75.5
9/1/2022	11	75.4	2.48	8.09	0.332	76.2
9/1/2022	12	75.4	2.27	8.06	0.333	75.9
9/8/2022	0	79.5	9.46	9.18	0.308	72.2
9/8/2022	1	78.2	10.61	9.23	0.307	72.8
9/8/2022	2	76.2	8.69	9.09	0.31	76
9/8/2022	3	75.7	8.22	9.03	0.31	76.5
9/8/2022	4	75	6	8.8	0.315	76.5
9/8/2022	5	74.5	5.06	8.6	0.317	79
9/8/2022	6	74.1	4.36	8.39	0.318	79.9
9/8/2022	7	74	3.79	8.26	0.319	80.9
9/8/2022	8	73.9	3.23	8.2	0.32	79.7
9/8/2022	9	73.8	3.24	8.17	0.32	80.2
9/8/2022	10	73.8	3.36	8.17	0.319	80.1

9/8/2022	11	73.8	3.31	8.14	0.32	79.3
9/8/2022	12	73.8	2.98	8.11	0.32	77.5
9/14/2022	0	76.8	9.61	9.14	0.314	81.9
9/14/2022	1	75.9	9.73	9.15	0.313	82.1
9/14/2022	2	73.6	9.45	9.15	0.315	82.3
9/14/2022	3	71	7.85	8.99	0.319	84.4
9/14/2022	4	70.1	5.39	8.49	0.325	87.9
9/14/2022	5	69.9	4.46	8.37	0.327	88.1
9/14/2022	6	69.8	4.43	8.33	0.327	88.6
9/14/2022	7	69.8	4.22	8.3	0.327	88.1
9/14/2022	8	69.8	4.12	8.26	0.328	87.9
9/14/2022	9	69.7	3.78	8.13	0.33	88.9
9/14/2022	10	69.6	2.86	7.99	0.333	89.1
9/14/2022	11	69.6	2.76	7.98	0.334	88
9/14/2022	12	69.6	2.55	7.96	0.334	46.3

Appendix C: Dissolved oxygen data from the ProcellaCOR® testing zones.

Date	Treatment #	Site Designation #	Depth (ft)	DO (mg/L)
7/12/2022	1	373	1	8.79
7/12/2022	1	373	2	8.83
7/12/2022	1	373	3	6.22
7/12/2022	1	373	4	6.12
7/12/2022	1	373	5	2.35
7/12/2022	1	373	6	0.33
7/12/2022	1	402	1	12.25
7/12/2022	1	402	2	13.02
7/12/2022	1	402	3	9.88
7/12/2022	1	402	4	6.02
7/12/2022	1	402	5	1.52
7/12/2022	1	404	1	8.84
7/12/2022	1	404	2	9.02
7/12/2022	1	404	3	5.77
7/12/2022	1	404	4	4.52
7/12/2022	1	404	5	3.02
7/12/2022	1	404	6	0.86
7/12/2022	1	425	1	13.29
7/12/2022	1	425	2	14.05
7/12/2022	1	425	3	13.85
7/12/2022	1	425	4	12.45
7/12/2022	1	425	5	1.27
7/12/2022	1	425	6	0.42
7/12/2022	1	452	1	15.89
7/12/2022	1	452	2	15.46
7/12/2022	1	452	3	8.65
7/12/2022	1	452	4	4.15
7/12/2022	1	452	5	2.2
7/12/2022	1	452	6	0.77
7/15/2022	1	373	1	8.65
7/15/2022	1	373	2	8.79
7/15/2022	1	373	3	7.45
7/15/2022	1	373	4	6.04
7/15/2022	1	373	5	1.59
7/15/2022	1	373	6	0.27
7/15/2022	1	402	1	13.02
7/15/2022	1	402	2	13.86
7/15/2022	1	402	3	11.74
7/15/2022	1	402	4	6.42

7/15/2022	1	402	5	1.68
7/15/2022	1	404	1	9.3
7/15/2022	1	404	2	7.05
7/15/2022	1	404	3	5.62
7/15/2022	1	404	4	4.53
7/15/2022	1	404	5	3.54
7/15/2022	1	404	6	0.35
7/15/2022	1	425	1	15.9
7/15/2022	1	425	2	16.95
7/15/2022	1	425	3	14.61
7/15/2022	1	425	4	16.81
7/15/2022	1	425	5	0.8
7/15/2022	1	425	6	0.36
7/15/2022	1	452	1	16.55
7/15/2022	1	452	2	15.54
7/15/2022	1	452	3	8.78
7/15/2022	1	452	4	4.44
7/15/2022	1	452	5	1.8
7/15/2022	1	452	6	0.51
7/15/2022	1	456	1	13.73
7/15/2022	1	456	2	11.74
7/15/2022	1	456	3	7.84
7/15/2022	1	456	4	3.84
7/15/2022	1	456	5	1.61
7/15/2022	1	456	6	0.83
7/19/2022	1	373	1	8.32
7/19/2022	1	373	2	8.17
7/19/2022	1	373	3	4.75
7/19/2022	1	373	4	4.34
7/19/2022	1	373	5	3.5
7/19/2022	1	373	6	1.97
7/19/2022	1	402	1	12.36
7/19/2022	1	402	2	10.99
7/19/2022	1	402	3	7.56
7/19/2022	1	402	4	5.38
7/19/2022	1	402	5	3.06
7/19/2022	1	402	6	1.71
7/19/2022	1	404	1	7.41
7/19/2022	1	404	2	4.62
7/19/2022	1	404	3	4.03
7/19/2022	1	404	4	3.51

7/19/2022	1	404	5	3.17
7/19/2022	1	404	6	1.63
7/19/2022	1	425	1	11.69
7/19/2022	1	425	2	10.22
7/19/2022	1	425	3	8.05
7/19/2022	1	425	4	6.81
7/19/2022	1	425	5	4.4
7/19/2022	1	425	6	1.8
7/19/2022	1	452	1	11.25
7/19/2022	1	452	2	8.01
7/19/2022	1	452	3	6.18
7/19/2022	1	452	4	5.4
7/19/2022	1	452	5	4.42
7/19/2022	1	452	6	3.67
7/19/2022	1	456	1	12.25
7/19/2022	1	456	2	9.48
7/19/2022	1	456	3	5.89
7/19/2022	1	456	4	4.8
7/19/2022	1	456	5	2.97
7/19/2022	1	456	6	0.69
7/26/2022	1	373	1	5.92
7/26/2022	1	373	2	5.91
7/26/2022	1	373	3	5.35
7/26/2022	1	373	4	3.66
7/26/2022	1	373	5	2.16
7/26/2022	1	373	6	0.62
7/26/2022	1	402	1	5.7
7/26/2022	1	402	2	4.96
7/26/2022	1	402	3	4.98
7/26/2022	1	402	4	4.06
7/26/2022	1	402	5	2.35
7/26/2022	1	402	6	0.31
7/26/2022	1	404	1	11.13
7/26/2022	1	404	2	8.66
7/26/2022	1	404	3	5.65
7/26/2022	1	404	4	4.04
7/26/2022	1	404	5	1.58
7/26/2022	1	404	6	0.36
7/26/2022	1	425	1	6.95
7/26/2022	1	425	2	6.49
7/26/2022	1	425	3	6.16

7/26/2022	1	425	4	4.6
7/26/2022	1	425	5	4.75
7/26/2022	1	425	6	0.88
7/26/2022	1	452	1	6.82
7/26/2022	1	452	2	6.38
7/26/2022	1	452	3	5.71
7/26/2022	1	452	4	4.13
7/26/2022	1	452	5	2.34
7/26/2022	1	452	6	0.54
7/26/2022	1	456	1	11.43
7/26/2022	1	456	2	8.29
7/26/2022	1	456	3	5.93
7/26/2022	1	456	4	5.47
7/26/2022	1	456	5	5.04
7/26/2022	1	456	6	2.13
8/24/2022	2	326	1	6.81
8/24/2022	2	326	2	6.02
8/24/2022	2	326	3	4.56
8/24/2022	2	326	4	3.85
8/24/2022	2	326	5	3.15
8/24/2022	2	326	6	1.26
8/24/2022	2	352	1	5.34
8/24/2022	2	352	2	5.44
8/24/2022	2	352	3	4.86
8/24/2022	2	352	4	4.4
8/24/2022	2	352	5	3.22
8/24/2022	2	352	6	2.4
8/24/2022	2	324	1	6.19
8/24/2022	2	324	2	3.1
8/24/2022	2	324	3	2.64
8/24/2022	2	324	4	1.76
8/24/2022	2	324	5	1.22
8/24/2022	2	300	1	9.43
8/24/2022	2	300	2	9.33
8/24/2022	2	300	3	8.64
8/24/2022	2	300	4	7.6
8/24/2022	2	300	5	4.12
8/24/2022	2	300	6	2.47
8/24/2022	2	322	1	9.76
8/24/2022	2	322	2	8.95
8/24/2022	2	322	3	7.89

8/24/2022	2	322	4	7.43
8/24/2022	2	322	5	5.5
8/24/2022	2	322	6	4.53
8/29/2022	2	326	1	6.17
8/29/2022	2	326	2	5.74
8/29/2022	2	326	3	5.5
8/29/2022	2	326	4	5.41
8/29/2022	2	326	5	3.21
8/29/2022	2	326	6	2.27
8/29/2022	2	352	1	4.87
8/29/2022	2	352	2	4.73
8/29/2022	2	352	3	4.72
8/29/2022	2	352	4	4.58
8/29/2022	2	352	5	3.56
8/29/2022	2	352	6	3.38
8/29/2022	2	324	1	6.16
8/29/2022	2	324	2	5.84
8/29/2022	2	324	3	5.28
8/29/2022	2	324	4	4.17
8/29/2022	2	324	5.5	2.7
8/29/2022	2	300	1	6.74
8/29/2022	2	300	2	6.59
8/29/2022	2	300	3	5.46
8/29/2022	2	300	4	5.74
8/29/2022	2	300	5	3.23
8/29/2022	2	300	6	2.18
8/29/2022	2	322	1	7.07
8/29/2022	2	322	2	6.03
8/29/2022	2	322	3	5.77
8/29/2022	2	322	4	5.74
8/29/2022	2	322	5	4.56
8/29/2022	2	322	6	3.23
9/1/2022	2	326	1	5.28
9/1/2022	2	326	2	5.93
9/1/2022	2	326	3	6.05
9/1/2022	2	326	4	5.34
9/1/2022	2	326	5	4.7
9/1/2022	2	326	6	4.75
9/1/2022	2	352	1	6.4
9/1/2022	2	352	2	6.8
9/1/2022	2	352	3	5.65

9/1/2022	2	352	4	4.89
9/1/2022	2	352	5	4.48
9/1/2022	2	352	6	5.68
9/1/2022	2	324	1	5.05
9/1/2022	2	324	2	6.1
9/1/2022	2	324	3	5.84
9/1/2022	2	324	4	5.19
9/1/2022	2	324	5.5	4.28
9/1/2022	2	324	6	3.81
9/1/2022	2	300	1	5.02
9/1/2022	2	300	2	7.16
9/1/2022	2	300	3	6.5
9/1/2022	2	300	4	5.51
9/1/2022	2	300	5	3.95
9/1/2022	2	300	6	2.83
9/1/2022	2	322	1	7.67
9/1/2022	2	322	2	7.6
9/1/2022	2	322	3	7.01
9/1/2022	2	322	4	6.21
9/1/2022	2	322	5	5.08
9/1/2022	2	322	6	3.77
9/8/2022	2	326	1	6.44
9/8/2022	2	326	2	6.45
9/8/2022	2	326	3	6.3
9/8/2022	2	326	4	5.55
9/8/2022	2	326	5	4.29
9/8/2022	2	326	6	2.93
9/8/2022	2	352	1	7.23
9/8/2022	2	352	2	7.24
9/8/2022	2	352	3	7.02
9/8/2022	2	352	4	5.69
9/8/2022	2	352	5	4.48
9/8/2022	2	352	6	3.63
9/8/2022	2	324	1	6.45
9/8/2022	2	324	2	6.12
9/8/2022	2	324	3	6.59
9/8/2022	2	324	4	6.04
9/8/2022	2	324	5.5	5.09
9/8/2022	2	324	6	4.8
9/8/2022	2	300	1	8.17
9/8/2022	2	300	2	8.46

9/8/2022	2	300	3	6.92
9/8/2022	2	300	4	5.97
9/8/2022	2	300	5	5.06
9/8/2022	2	300	6	3.39
9/8/2022	2	322	1	9.03
9/8/2022	2	322	2	9.69
9/8/2022	2	322	3	8.71
9/8/2022	2	322	4	6.65
9/8/2022	2	322	5	4.97
9/8/2022	2	322	6	4.35
9/14/2022	2	326	1	7.3
9/14/2022	2	326	2	6.78
9/14/2022	2	326	3	4.37
9/14/2022	2	326	4	3.63
9/14/2022	2	326	5	3.44
9/14/2022	2	326	6	3.32
9/14/2022	2	352	1	7.69
9/14/2022	2	352	2	7.38
9/14/2022	2	352	3	6.42
9/14/2022	2	352	4	4.6
9/14/2022	2	352	5	4
9/14/2022	2	352	6	3.81
9/14/2022	2	324	1	7.83
9/14/2022	2	324	2	7.03
9/14/2022	2	324	3	7.13
9/14/2022	2	324	4	5.43
9/14/2022	2	324	5.5	4.68
9/14/2022	2	324	6	4.45
9/14/2022	2	300	1	8.67
9/14/2022	2	300	2	8.6
9/14/2022	2	300	3	8.05
9/14/2022	2	300	4	6.55
9/14/2022	2	300	5	4.44
9/14/2022	2	300	6	4.2
9/14/2022	2	322	1	8.48
9/14/2022	2	322	2	8.37
9/14/2022	2	322	3	6.94
9/14/2022	2	322	4	5.5
9/14/2022	2	322	5	4.42
9/14/2022	2	322	6	4.62

Appendix D: Nutrient data from the ProcellaCOR® testing zones.

Date	Treatment #	Site Designation #	Nutrient ID	Value
7/12/2022	1	373	TP (a)	55.9
7/12/2022	1	373	TKN (a)	1
7/12/2022	1	373	TP (b)	57.1
7/12/2022	1	373	TKN (b)	1
7/12/2022	1	402	TP (a)	243.6
7/12/2022	1	402	TKN (a)	1.7
7/12/2022	1	402	TP (b)	98.3
7/12/2022	1	402	TKN (b)	0.3
7/12/2022	1	404	TP (a)	174.7
7/12/2022	1	404	TKN (a)	2.1
7/12/2022	1	404	TP (b)	125.5
7/12/2022	1	404	TKN (b)	1.7
7/12/2022	1	425	TP (a)	55.1
7/12/2022	1	425	TKN (a)	1.1
7/12/2022	1	425	TP (b)	74.2
7/12/2022	1	425	TKN (b)	1.1
7/12/2022	1	452	TP (a)	140.9
7/12/2022	1	452	TKN (a)	1.3
7/12/2022	1	452	TP (b)	422.7
7/12/2022	1	452	TKN (b)	2.8
7/15/2022	1	373	TP	30
7/15/2022	1	373	TKN	ND
7/15/2022	1	402	TP	50
7/15/2022	1	402	TKN	2
7/15/2022	1	404	TP	50
7/15/2022	1	404	TKN	ND
7/15/2022	1	425	TP	400
7/15/2022	1	425	TKN	0.8
7/15/2022	1	452	TP	150
7/15/2022	1	452	TKN	ND
7/15/2022	1	456	TP	340
7/15/2022	1	456	TKN	0.5
7/19/2022	1	373	TP (a)	42.5
7/19/2022	1	373	TKN (a)	1.4
7/19/2022	1	373	TP (b)	41
7/19/2022	1	373	TKN (b)	1.1
7/19/2022	1	402	TP (a)	37.1
7/19/2022	1	402	TKN (a)	1.2
7/19/2022	1	402	TP (b)	34.5

7/19/2022	1	402	TKN (b)	1.4
7/19/2022	1	404	TP (a)	39.9
7/19/2022	1	404	TKN (a)	1.1
7/19/2022	1	404	TP (b)	38.2
7/19/2022	1	404	TKN (b)	1.1
7/19/2022	1	425	TP (a)	74.3
7/19/2022	1	425	TKN (a)	1.7
7/19/2022	1	425	TP (b)	77
7/19/2022	1	425	TKN (b)	1.3
7/19/2022	1	452	TP (a)	336.7
7/19/2022	1	452	TKN (a)	3
7/19/2022	1	452	TP (b)	600.2
7/19/2022	1	452	TKN (b)	4.6
7/19/2022	1	456	TP (a)	117.2
7/19/2022	1	456	TKN (a)	1.5
7/19/2022	1	456	TP (b)	156.3
7/19/2022	1	456	TKN (b)	1.8
7/26/2022	1	373	TP (a)	91.5
7/26/2022	1	373	TKN (a)	1.3
7/26/2022	1	373	TP (b)	85.3
7/26/2022	1	373	TKN (b)	1.2
7/26/2022	1	402	TP (a)	29.2
7/26/2022	1	402	TKN (a)	1.2
7/26/2022	1	402	TP (b)	29.1
7/26/2022	1	402	TKN (b)	1.2
7/26/2022	1	404	TP (a)	36.9
7/26/2022	1	404	TKN (a)	1.1
7/26/2022	1	404	TP (b)	36.8
7/26/2022	1	404	TKN (b)	1.2
7/26/2022	1	425	TP (a)	94.9
7/26/2022	1	425	TKN (a)	1.9
7/26/2022	1	425	TP (b)	113.3
7/26/2022	1	425	TKN (b)	1.5
7/26/2022	1	452	TP (a)	67.9
7/26/2022	1	452	TKN (a)	1.5
7/26/2022	1	452	TP (b)	56.6
7/26/2022	1	452	TKN (b)	1.3
7/26/2022	1	456	TP (a)	173.9
7/26/2022	1	456	TKN (a)	2
7/26/2022	1	456	TP (b)	143.2
7/26/2022	1	456	TKN (b)	1.2

8/24/2022	2	326	TP (a)	67.5
8/24/2022	2	326	TKN (a)	1.7
8/24/2022	2	326	TP (b)	75.4
8/24/2022	2	326	TKN (b)	2.6
8/24/2022	2	352	TP (a)	65.8
8/24/2022	2	352	TKN (a)	1.4
8/24/2022	2	352	TP (b)	54.7
8/24/2022	2	352	TKN (b)	1.5
8/24/2022	2	324	TP (a)	55
8/24/2022	2	324	TKN (a)	1.3
8/24/2022	2	324	TP (b)	77.8
8/24/2022	2	324	TKN (b)	1.4
8/24/2022	2	300	TP (a)	42.4
8/24/2022	2	300	TKN (a)	1.4
8/24/2022	2	300	TP (b)	37.1
8/24/2022	2	300	TKN (b)	1.2
8/24/2022	2	322	TP (a)	50.4
8/24/2022	2	322	TKN (a)	1.5
8/24/2022	2	322	TP (b)	51.9
8/24/2022	2	322	TKN (b)	1.6
8/29/2022	2	326	TP (a)	47
8/29/2022	2	326	TKN (a)	1.5
8/29/2022	2	326	TP (b)	46.9
8/29/2022	2	326	TKN (b)	1.6
8/29/2022	2	352	TP (a)	59.6
8/29/2022	2	352	TKN (a)	1.6
8/29/2022	2	352	TP (b)	62.8
8/29/2022	2	352	TKN (b)	1.4
8/29/2022	2	324	TP (a)	56.4
8/29/2022	2	324	TKN (a)	1.5
8/29/2022	2	324	TP (b)	57.6
8/29/2022	2	324	TKN (b)	1.6
8/29/2022	2	300	TP (a)	48.9
8/29/2022	2	300	TKN (a)	1.6
8/29/2022	2	300	TP (b)	51.2
8/29/2022	2	300	TKN (b)	1.6
8/29/2022	2	322	TP (a)	55
8/29/2022	2	322	TKN (a)	1.8
8/29/2022	2	322	TP (b)	55.2
8/29/2022	2	322	TKN (b)	1.3
9/1/2022	2	326	TP (a)	86.2

9/1/2022	2	326	TKN (a)	2
9/1/2022	2	326	TP (b)	90.8
9/1/2022	2	326	TKN (b)	1.9
9/1/2022	2	352	TP (a)	47.2
9/1/2022	2	352	TKN (a)	1.6
9/1/2022	2	352	TP (b)	54
9/1/2022	2	352	TKN (b)	1.5
9/1/2022	2	324	TP (a)	50
9/1/2022	2	324	TKN (a)	1.7
9/1/2022	2	324	TP (b)	45.7
9/1/2022	2	324	TKN (b)	1.6
9/1/2022	2	300	TP (a)	64.9
9/1/2022	2	300	TKN (a)	1.8
9/1/2022	2	300	TP (b)	54.1
9/1/2022	2	300	TKN (b)	1.4
9/1/2022	2	322	TP (a)	63
9/1/2022	2	322	TKN (a)	1.8
9/1/2022	2	322	TP (b)	61.7
9/1/2022	2	322	TKN (b)	1.8
9/8/2022	2	326	TP (a)	95.9
9/8/2022	2	326	TKN (a)	2
9/8/2022	2	352	TP (a)	101.1
9/8/2022	2	352	TKN (a)	2.1
9/8/2022	2	324	TP (a)	90.4
9/8/2022	2	324	TKN (a)	1.9
9/8/2022	2	300	TP (a)	60.2
9/8/2022	2	300	TKN (a)	2.1
9/8/2022	2	322	TP (a)	61.2
9/8/2022	2	322	TKN (a)	1.6

Appendix E: PIRTRAM Data collected at every sampling location for this study.

Site #	Abundance Score	# of Spp.	% per Spp: Eurasian watermilfoil	Coontail	Common waterweed	Curly-leaf pondweed	Sago pondweed	Brittle naiad	Water stargrass	Narrow-leaf pondweed	Bladderwort	American pondweed	Notes
1	1	3	10	80	0	0	10	0	0	0	0	0	
2	1	1	100	0	0	0	0	0	0	0	0	0	
3	1	3	33	33	0	0	0	33	0	0	0	0	
4	2	2	0	99	0	0	0	1	0	0	0	0	
5	1	2	0	80	20	0	0	0	0	0	0	0	FA
6	0	0	0	0	0	0	0	0	0	0	0	0	
7	1	1	0	100	0	0	0	0	0	0	0	0	Site 8 All spatterdock
8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
9	1	1	0	100	0	0	0	0	0	0	0	0	OBV/Bladderwort/Creeping water primrose
10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
11	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
13	2	3	10	80	10	0	0	0	0	0	0	0	
14	3	1	0	100	0	0	0	0	0	0	0	0	
15	1	2	0	90	10	0	0	0	0	0	0	0	
16	1	4	25	25	25	0	25	0	0	0	0	0	Lotus DW
17	3	4	10	40	40	0	10	0	0	0	0	0	
18	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
19	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
20	2	1	0	100	0	0	0	0	0	0	0	0	
21	4	1	0	100	0	0	0	0	0	0	0	0	
22	3	2	1	99	0	0	0	0	0	0	0	0	
23	1	2	50	50	0	0	0	0	0	0	0	0	
24	1	4	10	70	0	0	10	10	0	0	0	0	
25	4	3	20	75	0	0	0	0	5	0	0	0	DW/large bed of vegetation in middle of channel

26	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
27	1	3	0	75	20	0	20	0	0	0	0	0	OBV-site 26 + 27 spatterdocks
28	1	3	33	33	0	0	33	0	0	0	0	0	
29	4	1	0	100	0	0	0	0	0	0	0	0	
30	4	2	20	80	0	0	0	0	0	0	0	0	Very dense/ lots of floating debris
31	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
32	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
33	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
34	3	1	0	100	0	0	0	0	0	0	0	0	
35	2	1	0	100	0	0	0	0	0	0	0	0	
36	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
37	2	2	10	90	0	0	0	0	0	0	0	0	
38	2	1	0	100	0	0	0	0	0	0	0	0	
39	1	2	10	90	0	0	0	0	0	0	0	0	
40	3	3	40	40	20	0	0	0	0	0	0	0	
41	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
42	4	4	5	70	20	0	0	0	5	0	0	0	
43	3	3	1	98	0	0	1	0	0	0	0	0	
44	4	2	10	90	0	0	0	0	0	0	0	0	
45	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
46	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
47	3	1	0	100	0	0	0	0	0	0	0	0	
48	4	1	0	100	0	0	0	0	0	0	0	0	
49	0	0	0	0	0	0	0	0	0	0	0	0	Chemically treated
50	1	2	5	95	0	0	0	0	0	0	0	0	
51	1	2	50	50	0	0	0	0	0	0	0	0	
52	0	0	0	0	0	0	0	0	0	0	0	0	
53	2	1	0	100	0	0	0	0	0	0	0	0	
54	2	1	0	100	0	0	0	0	0	0	0	0	
55	2	1	0	100	0	0	0	0	0	0	0	0	
56	3	4	25	25	0	0	25	25	0	0	0	0	
57	4	4	1	97	0	1	1	0	0	0	0	0	DW/OBV-near Bladderwort

58	4	3	0	98	0	0	1	0	1	0	0	0	
59	4	5	4	75	10	1	10	0	0	0	0	0	
60	4	2	5	95	0	0	0	0	0	0	0	0	
61	3	3	10	80	0	0	0	0	0	10	0	0	Thin-leaf ID in question
62	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
63	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
64	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
65	1	2	40	60	0	0	0	0	0	0	0	0	
66	4	1	0	100	0	0	0	0	0	0	0	0	
67	1	1	0	100	0	0	0	0	0	0	0	0	
68	4	3	20	40	40	0	0	0	0	0	0	0	
69	4	3	60	0	20	0	0	0	20	0	0	0	
70	0	0	0	0	0	0	0	0	0	0	0	0	Chemically treated
71	2	2	50	50	0	0	0	0	0	0	0	0	
72	3	3	60	20	0	20	0	0	0	0	0	0	
73	1	2	50	50	0	0	0	0	0	0	0	0	
74	1	1	0	100	0	0	0	0	0	0	0	0	
75	1	1	0	100	0	0	0	0	0	0	0	0	
76	0	0	0	0	0	0	0	0	0	0	0	0	
77	1	1	0	100	0	0	0	0	0	0	0	0	
78	2	1	0	100	0	0	0	0	0	0	0	0	
79	3	3	75	15	10	0	0	0	0	0	0	0	
80	4	5	40	40	0	5	5	0	10	0	0	0	Heavy density
81	2	4	25	25	0	25	25	0	0	0	0	0	
82	3	2	40	60	0	0	0	0	0	0	0	0	
83	1	2	50	50	0	0	0	0	0	0	0	0	
84	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
85	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
86	4	3	5	90	5	0	0	0	0	0	0	0	
87	2	1	0	100	0	0	0	0	0	0	0	0	
88	3	1	0	100	0	0	0	0	0	0	0	0	
89	1	2	0	80	20	0	0	0	0	0	0	0	
90	2	1	0	100	0	0	0	0	0	0	0	0	

91	1	1	0	100	0	0	0	0	0	0	0	0	
92	4	2	0	60	0	0	0	0	0	0	0	0	40-flat-stemmed pw
93	4	3	40	40	20	0	0	0	0	0	0	0	
94	2	1	0	100	0	0	0	0	0	0	0	0	
95	3	2	5	95	0	0	0	0	0	0	0	0	
96	3	2	5	95	0	0	0	0	0	0	0	0	
97	2	2	60	40	0	0	0	0	0	0	0	0	
98	1	1	100	0	0	0	0	0	0	0	0	0	
99	1	1	100	0	0	0	0	0	0	0	0	0	
100	0	0	0	0	0	0	0	0	0	0	0	0	
101	2	1	0	100	0	0	0	0	0	0	0	0	
102	2	2	10	90	0	0	0	0	0	0	0	0	
103	2	2	10	90	0	0	0	0	0	0	0	0	
104	3	3	30	60	10	0	0	0	0	0	0	0	
105	2	2	1	99	0	0	0	0	0	0	0	0	
106	1	4	20	50	0	0	0	20	0	0	0	0	10-flat-stemmed pw
107	2	2	1	99	0	0	0	0	0	0	0	0	
108	0	0	0	0	0	0	0	0	0	0	0	0	
109	3	3	10	80	0	0	10	0	0	0	0	0	
110	4	2	5	95	0	0	0	0	0	0	0	0	DW/ large mat of vegetation
111	2	1	0	100	0	0	0	0	0	0	0	0	
112	4	2	10	90	0	0	0	0	0	0	0	0	
113	4	1	0	100	0	0	0	0	0	0	0	0	
114	0	0	0	0	0	0	0	0	0	0	0	0	
115	1	1	0	100	0	0	0	0	0	0	0	0	
116	0	0	0	0	0	0	0	0	0	0	0	0	
117	0	0	0	0	0	0	0	0	0	0	0	0	
118	4	1	0	100	0	0	0	0	0	0	0	0	
119	4	3	10	40	50	0	0	0	0	0	0	0	
120	3	2	80	0	20	0	0	0	0	0	0	0	
121	1	1	100	0	0	0	0	0	0	0	0	0	Harvested zone
122	2	1	100	0	0	0	0	0	0	0	0	0	

123	4	4	60	10	0	10	20	0	0	0	0	0	
124	2	1	100	0	0	0	0	0	0	0	0	0	
125	1	2	50	50	0	0	0	0	0	0	0	0	
126	0	0	0	0	0	0	0	0	0	0	0	0	
127	1	2	20	80	0	0	0	0	0	0	0	0	
128	1	1	0	100	0	0	0	0	0	0	0	0	
129	2	2	50	50	0	0	0	0	0	0	0	0	
130	2	2	70	30	0	0	0	0	0	0	0	0	
131	3	2	5	95	0	0	0	0	0	0	0	0	
132	2	1	0	100	0	0	0	0	0	0	0	0	
133	2	1	0	100	0	0	0	0	0	0	0	0	
134	2	2	0	95	0	0	0	5	0	0	0	0	
135	1	1	0	100	0	0	0	0	0	0	0	0	
136	1	1	100	0	0	0	0	0	0	0	0	0	
137	1	3	40	40	0	0	20	0	0	0	0	0	
138	2	1	0	100	0	0	0	0	0	0	0	0	
139	3	1	0	100	0	0	0	0	0	0	0	0	
140	1	1	0	100	0	0	0	0	0	0	0	0	
141	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
142	0	0	0	0	0	0	0	0	0	0	0	0	
143	0	0	0	0	0	0	0	0	0	0	0	0	
144	3	1	0	100	0	0	0	0	0	0	0	0	
145	3	3	20	60	20	0	0	0	0	0	0	0	
146	4	1	0	100	0	0	0	0	0	0	0	0	
147	3	2	50	50	0	0	0	0	0	0	0	0	Harvested zone
148	4	3	30	60	10	0	0	0	0	0	0	0	
149	4	2	60	40	0	0	0	0	0	0	0	0	
150	4	3	80	5	0	5	0	0	0	0	0	0	
151	3	2	50	50	0	0	0	0	0	0	0	0	
152	2	1	100	0	0	0	0	0	0	0	0	0	
153	1	1	100	0	0	0	0	0	0	0	0	0	
154	1	1	100	0	0	0	0	0	0	0	0	0	
155	1	2	60	40	0	0	0	0	0	0	0	0	

156	2	1	100	0	0	0	0	0	0	0	0	0	
157	4	2	70	30	0	0	0	0	0	0	0	0	
158	3	2	40	60	0	0	0	0	0	0	0	0	
159	3	2	5	95	0	0	0	0	0	0	0	0	
160	1	1	0	100	0	0	0	0	0	0	0	0	
161	0	0	0	0	0	0	0	0	0	0	0	0	
162	1	3	33	33	0	0	0	33	0	0	0	0	
163	0	0	0	0	0	0	0	0	0	0	0	0	
164	1	1	0	100	0	0	0	0	0	0	0	0	
165	1	1	0	100	0	0	0	0	0	0	0	0	
166	1	1	0	100	0	0	0	0	0	0	0	0	
167	0	0	0	0	0	0	0	0	0	0	0	0	
168	0	0	0	0	0	0	0	0	0	0	0	0	
169	0	0	0	0	0	0	0	0	0	0	0	0	
170	1	2	50	50	0	0	0	0	0	0	0	0	
171	4	2	0	98	2	0	0	0	0	0	0	0	Very dense
172	2	3	20	60	0	0	0	0	0	0	0	0	20-flat-stemmed pw/ Harvested zone
173	3	2	80	20	0	0	0	0	0	0	0	0	
174	3	2	50	50	0	0	0	0	0	0	0	0	
175	2	2	0	50	50	0	0	0	0	0	0	0	
176	4	2	95	5	0	0	0	0	0	0	0	0	
177	2	1	100	0	0	0	0	0	0	0	0	0	
178	2	2	50	50	0	0	0	0	0	0	0	0	
179	2	2	5	95	0	0	0	0	0	0	0	0	
180	3	2	10	90	0	0	0	0	0	0	0	0	
182	3	2	50	50	0	0	0	0	0	0	0	0	
183	4	2	50	50	0	0	0	0	0	0	0	0	
184	4	1	100	0	0	0	0	0	0	0	0	0	
185	2	2	50	50	0	0	0	0	0	0	0	0	Harvested zone
186	4	2	10	90	0	0	0	0	0	0	0	0	
187	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
188	4	2	40	60	0	0	0	0	0	0	0	0	

189	1	1	0	100	0	0	0	0	0	0	0	0	
190	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
191	1	2	50	50	0	0	0	0	0	0	0	0	
192	1	1	0	100	0	0	0	0	0	0	0	0	
193	0	0	0	0	0	0	0	0	0	0	0	0	
194	0	0	0	0	0	0	0	0	0	0	0	0	
195	0	0	0	0	0	0	0	0	0	0	0	0	
196	0	0	0	0	0	0	0	0	0	0	0	0	
197	0	0	0	0	0	0	0	0	0	0	0	0	
198	0	0	0	0	0	0	0	0	0	0	0	0	
199	1	2	40	60	0	0	0	0	0	0	0	0	
200	3	5	17.5	30	17.5	0	17.5	0	17.5	0	0	0	
201	1	2	10	90	0	0	0	0	0	0	0	0	
202	4	2	50	50	0	0	0	0	0	0	0	0	
203	4	3	90	0	0	5	0	0	5	0	0	0	
204	4	3	60	20	0	20	0	0	0	0	0	0	
205	4	2	80	20	0	0	0	0	0	0	0	0	
206	4	2	90	10	0	0	0	0	0	0	0	0	
207	1	1	100	0	0	0	0	0	0	0	0	0	
208	1	1	100	0	0	0	0	0	0	0	0	0	
209	2	2	95	5	0	0	0	0	0	0	0	0	
210	3	2	95	0	0	0	5	0	0	0	0	0	
211	4	2	60	40	0	0	0	0	0	0	0	0	FA zone
212	4	1	100	0	0	0	0	0	0	0	0	0	
213	2	2	10	90	0	0	0	0	0	0	0	0	Harvested zone
214	2	2	80	20	0	0	0	0	0	0	0	0	Harvested zone
215	4	2	50	50	0	0	0	0	0	0	0	0	
216	2	1	0	100	0	0	0	0	0	0	0	0	
217	0	0	0	0	0	0	0	0	0	0	0	0	
218	1	1	0	0	0	100	0	0	0	0	0	0	
219	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
220	1	1	0	100	0	0	0	0	0	0	0	0	
221	1	2	60	40	0	0	0	0	0	0	0	0	

222	0	0	0	0	0	0	0	0	0	0	0	0	
223	0	0	0	0	0	0	0	0	0	0	0	0	
224	1	1	0	100	0	0	0	0	0	0	0	0	
225	3	4	40	40	19	0	0	0	1	0	0	0	
226	3	3	50	49	0	1	0	0	0	0	0	0	
227	4	2	60	40	0	0	0	0	0	0	0	0	
228	3	2	90	0	10	0	0	0	0	0	0	0	
229	4	1	100	0	0	0	0	0	0	0	0	0	
230	4	3	60	20	0	20	0	0	0	0	0	0	
231	3	1	100	0	0	0	0	0	0	0	0	0	
232	1	2	50	50	0	0	0	0	0	0	0	0	
233	1	1	100	0	0	0	0	0	0	0	0	0	
234	3	1	100	0	0	0	0	0	0	0	0	0	
235	4	2	50	50	0	0	0	0	0	0	0	0	
236	3	1	100	0	0	0	0	0	0	0	0	0	FA zone
237	3	2	80	20	0	0	0	0	0	0	0	0	
238	2	1	100	0	0	0	0	0	0	0	0	0	Harvested zone
239	4	2	90	10	0	0	0	0	0	0	0	0	
240	4	2	5	95	0	0	0	0	0	0	0	0	
241	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
242	0	0	0	0	0	0	0	0	0	0	0	0	
243	1	3	10	80	0	10	0	0	0	0	0	0	
244	1	1	100	0	0	0	0	0	0	0	0	0	
245	1	2	50	50	0	0	0	0	0	0	0	0	
246	1	1	0	100	0	0	0	0	0	0	0	0	
247	0	0	0	0	0	0	0	0	0	0	0	0	
248	0	0	0	0	0	0	0	0	0	0	0	0	
249	3	1	0	100	0	0	0	0	0	0	0	0	
250	4	3	50	49	0	1	0	0	0	0	0	0	
251	2	2	50	50	0	0	0	0	0	0	0	0	Harvested zone
252	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
253	4	3	90	5	0	5	0	0	0	0	0	0	
254	3	2	90	10	0	0	0	0	0	0	0	0	

255	4	1	100	0	0	0	0	0	0	0	0	0	
256	4	1	100	0	0	0	0	0	0	0	0	0	
257	1	1	100	0	0	0	0	0	0	0	0	0	
258	2	2	60	40	0	0	0	0	0	0	0	0	
259	4	10	90	0	0	0	0	0	0	0	0	0	
260	4	2	60	40	0	0	0	0	0	0	0	0	
261	4	2	50	50	0	0	0	0	0	0	0	0	FA noted
262	4	2	50	50	0	0	0	0	0	0	0	0	
263	2	3	20	60	0	0	20	0	0	0	0	0	Harvested zone
264	3	2	20	80	0	0	0	0	0	0	0	0	
265	4	2	5	95	0	0	0	0	0	0	0	0	FA noted
266	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
267	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
268	1	1	0	100	0	0	0	0	0	0	0	0	
269	1	1	100	0	0	0	0	0	0	0	0	0	
270	2	1	0	100	0	0	0	0	0	0	0	0	
271	1	1	0	100	0	0	0	0	0	0	0	0	
272	1	2	50	0	50	0	0	0	0	0	0	0	
273	2	2	0	99	0	0	0	0	1	0	0	0	Harvested zone
274	4	3	10	80	10	0	0	0	0	0	0	0	FA noted
275	2	3	40	50	10	0	0	0	0	0	0	0	Harvested zone
276	4	3	98	1	1	0	0	0	0	0	0	0	
277	3	3	60	20	20	0	0	0	0	0	0	0	
278	4	1	100	0	0	0	0	0	0	0	0	0	FA noted
279	4	2	99	0	1	0	0	0	0	0	0	0	FA noted
280	4	2	99	0	1	0	0	0	0	0	0	0	FA noted
281	4	2	99	0	0	1	0	0	0	0	0	0	FA noted
282	3	2	70	30	0	0	0	0	0	0	0	0	FA noted
283	3	2	90	10	0	0	0	0	0	0	0	0	FA noted
284	3	2	90	0	0	0	10	0	0	0	0	0	FA noted
285	4	4	100	0	0	0	0	0	0	0	0	0	FA noted
286	3	2	100	0	0	0	0	0	0	0	0	0	FA noted
287	4	3	45	45	0	10	0	0	0	0	0	0	

288	2	2	50	50	0	0	0	0	0	0	0	0	
289	3	2	10	90	0	0	0	0	0	0	0	0	
290	3	2	1	99	0	0	0	0	0	0	0	0	
291	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
292	1	2	50	50	0	0	0	0	0	0	0	0	
293	1	1	100	0	0	0	0	0	0	0	0	0	
294	1	1	0	100	0	0	0	0	0	0	0	0	
295	0	0	0	0	0	0	0	0	0	0	0	0	
296	2	1	100	0	0	0	0	0	0	0	0	0	Harvested zone
297	4	2	50	50	0	0	0	0	0	0	0	0	FA noted
298	4	3	60	30	10	0	0	0	0	0	0	0	
299	3	1	100	0	0	0	0	0	0	0	0	0	
300	4	1	100	0	0	0	0	0	0	0	0	0	
301	4	1	100	0	0	0	0	0	0	0	0	0	
302	3	4	70	20	10	1	0	0	0	0	0	0	
303	4	1	100	0	0	0	0	0	0	0	0	0	FA noted
304	4	2	95	5	0	0	0	0	0	0	0	0	
305	3	2	95	5	0	0	0	0	0	0	0	0	
306	3	1	100	0	0	0	0	0	0	0	0	0	
307	4	2	1	99	0	0	0	0	0	0	0	0	
308	4	2	95	5	0	0	0	0	0	0	0	0	FA noted
309	4	2	99	1	0	0	0	0	0	0	0	0	FA noted
310	4	3	10	70	0	0	20	0	0	0	0	0	
311	3	2	5	95	0	0	0	0	0	0	0	0	Harvested zone
312	3	1	0	100	0	0	0	0	0	0	0	0	
313	3	3	10	80	10	0	0	0	0	0	0	0	
314	1	1	0	100	0	0	0	0	0	0	0	0	
315	1	2	50	50	0	0	0	0	0	0	0	0	
316	1	1	0	100	0	0	0	0	0	0	0	0	
317	2	3	20	70	10	0	0	0	0	0	0	0	Deeper location/ revisit
318	2	2	5	95	0	0	0	0	0	0	0	0	
319	4	2	95	0	5	0	0	0	0	0	0	0	
320	4	3	95	0	2.5	2.5	0	0	0	0	0	0	FA noted

321	3	2	95	0	5	0	0	0	0	0	0	0	FA noted
322	4	2	98	0	2	0	0	0	0	0	0	0	
323	4	3	95	2.5	2.5	0	0	0	0	0	0	0	
324	4	2	5	0	95	0	0	0	0	0	0	0	
325	4	2	98	0	2	0	0	0	0	0	0	0	
326	4	2	98	2	0	0	0	0	0	0	0	0	
327	4	3	45	10	45	0	0	0	0	0	0	0	
328	4	1	100	0	0	0	0	0	0	0	0	0	
329	4	1	100	0	0	0	0	0	0	0	0	0	
330	3	1	100	0	0	0	0	0	0	0	0	0	
331	2	2	80	20	0	0	0	0	0	0	0	0	Harvested zone
332	2	3	45	45	0	0	10	0	0	0	0	0	Harvested zone
333	4	2	9	90	1	0	0	0	0	0	0	0	Harvested zone
334	2	1	0	100	0	0	0	0	0	0	0	0	Harvested zone
335	4	3	9	90	1	0	0	0	0	0	0	0	
336	4	2	1	99	0	0	0	0	0	0	0	0	FA noted
337	1	2	50	50	0	0	0	0	0	0	0	0	
338	2	2	0	80	20	0	0	0	0	0	0	0	
339	0	0	0	0	0	0	0	0	0	0	0	0	
340	0	0	0	0	0	0	0	0	0	0	0	0	
341	3	1	0	100	0	0	0	0	0	0	0	0	
342	1	1	100	0	0	0	0	0	0	0	0	0	
343	4	2	2	98	0	0	0	0	0	0	0	0	
344	4	4	80	10	5	5	0	0	0	0	0	0	
345	3	5	10	10	60	10	0	0	0	10	0	0	Small hole/ milfoil not topped out
346	3	3	95	0	2.5	2.5	0	0	0	0	0	0	FA noted
347	4	2	99	0	1	0	0	0	0	0	0	0	
348	4	1	100	0	0	0	0	0	0	0	0	0	Heavy matted area
349	4	2	95	5	0	0	0	0	0	0	0	0	
350	4	2	95	5	0	0	0	0	0	0	0	0	FA
351	3	3	90	0	5	5	0	0	0	0	0	0	
352	4	3	98	1	0	1	0	0	0	0	0	0	

353	4	2	95	5	0	0	0	0	0	0	0	0	
354	4	2	50	50	0	0	0	0	0	0	0	0	
355	3	1	100	0	0	0	0	0	0	0	0	0	
356	4	2	60	40	0	0	0	0	0	0	0	0	
357	4	2	80	20	0	0	0	0	0	0	0	0	Zebra mussels noted
358	3	3	50	50	0	0	0	0	0	0	0	0	
359	4	2	30	70	0	0	0	0	0	0	0	0	
360	4	3	19	80	1	0	0	0	0	0	0	0	
361	4	1	0	100	0	0	0	0	0	0	0	0	
362	3	2	0	80	0	0	20	0	0	0	0	0	
363	3	1	0	100	0	0	0	0	0	0	0	0	
364	0	0	0	0	0	0	0	0	0	0	0	0	
365	0	0	0	0	0	0	0	0	0	0	0	0	
366	0	0	0	0	0	0	0	0	0	0	0	0	
367	0	0	0	0	0	0	0	0	0	0	0	0	
368	0	0	0	0	0	0	0	0	0	0	0	0	
369	4	2	30	70	0	0	0	0	0	0	0	0	
370	4	3	15	70	0	15	0	0	0	0	0	0	
371	4	2	95	5	0	0	0	0	0	0	0	0	
372	4	2	10	0	90	0	0	0	0	0	0	0	FA
373	4	3	95	0	4	1	0	0	0	0	0	0	
374	4	3	75	20	0	5	0	0	0	0	0	0	
375	3	6	50	35	5	5	0	0	0	5	0	0	Stonewort
376	4	4	95	0	2.5	0	1.5	0	0	1	0	0	
377	4	2	50	50	0	0	0	0	0	0	0	0	
378	4	3	95	2.5	2.5	0	0	0	0	0	0	0	
379	3	2	90	10	0	0	0	0	0	0	0	0	
380	4	2	99	1	0	0	0	0	0	0	0	0	
381	4	2	40	60	0	0	0	0	0	0	0	0	
382	4	2	99	1	0	0	0	0	0	0	0	0	
383	4	2	80	20	0	0	0	0	0	0	0	0	
384	3	2	50	50	0	0	0	0	0	0	0	0	
385	4	2	40	60	0	0	0	0	0	0	0	0	

386	2	2	20	80	0	0	0	0	0	0	0	0	Harvested zone
387	2	2	10	90	0	0	0	0	0	0	0	0	Zebra mussels noted
388	3	1	0	100	0	0	0	0	0	0	0	0	
389	3	1	0	100	0	0	0	0	0	0	0	0	
390	3	2	50	50	0	0	0	0	0	0	0	0	
391	0	0	0	0	0	0	0	0	0	0	0	0	
392	0	0	0	0	0	0	0	0	0	0	0	0	
393	0	0	0	0	0	0	0	0	0	0	0	0	
394	0	0	0	0	0	0	0	0	0	0	0	0	
395	4	1	1	100	0	0	0	0	0	0	0	0	FA noted
396	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
397	4	3	30	50	1	9	0	0	0	0	0	0	
398	4	3	40	20	40	0	0	0	0	0	0	0	Very heavy density
399	3	2	60	40	0	0	0	0	0	0	0	0	
400	3	4	15	15	69	1	0	0	0	0	0	0	FA
401	4	2	98	0	2	0	0	0	0	0	0	0	
402	4	4	95	1.5	2.5	0	0	0	0	1	0	0	Heavy matted area
403	4	2	95	0	5	0	0	0	0	0	0	0	
404	4	3	90	9	1	0	0	0	0	0	0	0	
405	4	3	98	1	1	0	0	0	0	0	0	0	
406	4	2	90	10	0	0	0	0	0	0	0	0	
407	4	1	100	0	0	0	0	0	0	0	0	0	
408	4	2	99	1	0	0	0	0	0	0	0	0	
409	4	3	80	19	0	1	0	0	0	0	0	0	
410	4	3	35	60	0	5	0	0	0	0	0	0	
411	2	3	60	39	0	0	1	0	0	0	0	0	Harvested zone
412	4	2	10	90	0	0	0	0	0	0	0	0	
413	4	4	20	70	5	5	0	0	0	0	0	0	Harvested zone
414	3	2	20	80	0	0	0	0	0	0	0	0	
415	3	1	0	100	0	0	0	0	0	0	0	0	
416	2	1	0	100	0	0	0	0	0	0	0	0	
417	0	0	0	0	0	0	0	0	0	0	0	0	
418	0	0	0	0	0	0	0	0	0	0	0	0	

419	0	0	0	0	0	0	0	0	0	0	0	0	
420	1	1	0	100	0	0	0	0	0	0	0	0	
421	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
422	4	2	5	95	0	0	0	0	0	0	0	0	
423	2	4	10	10	70	10	0	0	0	0	0	0	Harvested
424	3	2	95	0	5	0	0	0	0	0	0	0	
425	4	4	70	15	14	1	0	0	0	0	0	0	FA
426	4	4	60	10	25	5	0	0	0	0	0	0	
427	4	3	95	2.5	1.5	0	0	0	0	1	0	0	
428	4	3	70	20	10	0	0	0	0	0	0	0	
429	4	2	90	10	0	0	0	0	0	0	0	0	
430	4	4	85	5	5	0	0	0	0	5	0	0	
431	4	4	40	0	10	0	25	0	0	25	0	0	
432	4	2	40	60	0	0	0	0	0	0	0	0	Harvested zone
433	3	2	50	50	0	0	0	0	0	0	0	0	
434	4	4	10	80	0	9	0	0	0	1	0	0	Harvested zone
435	3	3	25	50	0	25	0	0	0	0	0	0	
436	3	3	45	45	0	0	10	0	0	0	0	0	Harvested zone
437	3	3	20	70	0	10	0	0	0	0	0	0	
438	2	2	10	90	0	0	0	0	0	0	0	0	Harvested zone
439	4	2	20	80	0	0	0	0	0	0	0	0	
440	4	3	1	98	1	0	0	0	0	0	0	0	FA noted
441	3	2	0	99	1	0	0	0	0	0	0	0	
442	2	2	1	99	0	0	0	0	0	0	0	0	
443	2	2	0	50	0	0	50	0	0	0	0	0	
444	2	1	0	100	0	0	0	0	0	0	0	0	
445	2	2	70	30	0	0	0	0	0	0	0	0	Harvested at some point
446	2	3	5	90	5	0	0	0	0	0	0	0	
447	2	4	50	30	0	10	0	0	0	10	0	0	FA/ Harvested
448	3	4	40	0	50	5	0	0	0	5	0	0	
449	3	4	60	10	29	0	0	0	0	1	0	0	
450	4	3	95	2.5	2.5	0	0	0	0	0	0	0	FA noted
451	4	3	95	2.5	2.5	0	0	0	0	0	0	0	

452	4	2	50	50	0	0	0	0	0	0	0	0	
453	2	2	80	0	0	0	0	0	0	20	0	0	
454	2	4	10	30	0	0	30	0	0	30	0	0	
455	3	2	50	49	0	1	0	0	0	0	0	0	
456	3	50	50	0	0	0	0	0	0	0	0	0	
457	4	2	10	90	0	0	0	0	0	0	0	0	
458	2	2	20	80	0	0	0	0	0	0	0	0	Harvested zone
459	4	4	12.5	50	25	12.5	0	0	0	0	0	0	
460	4	3	15	80	0	5	0	0	0	0	0	0	
461	2	3	20	70	0	10	0	0	0	0	0	0	Harvested zone
462	4	3	0	90	5	5	0	0	0	0	0	0	
463	4	3	2.5	95	2.5	0	0	0	0	0	0	0	
464	2	1	0	100	0	0	0	0	0	0	0	0	
465	4	2	0	99	1	0	0	0	0	0	0	0	FA noted
466	2	3	0	45	45	9	0	0	0	1	0	0	Harvested
467	4	4	30	10	30	30	0	0	0	0	0	0	FA noted
468	2	3	31	40	0	30	0	0	0	0	0	0	Harvested zone
469	1	5	25	25	40	9	0	0	0	1	0	0	
470	3	4	5	4	90	0	0	0	0	1	0	0	Harvested zone
471	4	4	95	2.5	1.5	0	0	0	0	1	0	0	
472	4	4	5	70	5	0	0	0	0	20	0	0	Harvested zone
473	3	6	10	10	5	5	5	0	0	65	0	0	
474	4	5	40	40	50	10	0	0	0	5	0	0	
475	4	2	98	2	0	0	0	0	0	0	0	0	
476	3	2	40	60	0	0	0	0	0	0	0	0	
477	4	2	30	70	0	0	0	0	0	0	0	0	
478	4	3	9	90	1	0	0	0	0	0	0	0	
479	4	3	5	90	5	0	0	0	0	0	0	0	
480	4	2	0	99	0	1	0	0	0	0	0	0	Harvested zone
481	4	1	0	100	0	0	0	0	0	0	0	0	Harvested zone
482	4	2	0	95	5	0	0	0	0	0	0	0	FA noted
483	3	3	20	40	40	0	0	0	0	0	0	0	FA noted
484	4	1	0	100	0	0	0	0	0	0	0	0	FA noted

485	1	3	25	50	25	0	0	0	0	0	0	0	Harvested zone
486	3	4	10	40	10	0	0	0	0	40	0	0	Harvested zone
487	4	4	70	5	5	20	0	0	0	0	0	0	
488	4	4	10	85	2.5	0	0	0	0	2.5	0	0	
489	4	3	45	45	10	0	0	0	0	0	0	0	
490	3	2	95	1	4	0	0	0	0	0	0	0	
491	4	3	90	5	5	0	0	0	0	0	0	0	
492	4	2	20	80	0	0	0	0	0	0	0	0	
493	3	3	20	40	40	0	0	0	0	0	0	0	
494	3	2	40	60	0	0	0	0	0	0	0	0	
495	3	1	0	100	0	0	0	0	0	0	0	0	Harvested zone
496	1	1	0	100	0	0	0	0	0	0	0	0	
497	3	2	0	99	1	0	0	0	0	0	0	0	
498	3	2	10	90	0	0	0	0	0	0	0	0	
499	4	1	0	100	0	0	0	0	0	0	0	0	
500	2	2	20	80	0	0	0	0	0	0	0	0	Harvested zone
501	4	3	2.5	2.5	95	0	0	0	0	0	0	0	
502	4	3	10	10	80	0	0	0	0	0	0	0	
503	4	3	40	50	10	0	0	0	0	0	0	0	
504	4	2	95	5	0	0	0	0	0	0	0	0	
505	2	2	2	98	0	0	0	0	0	0	0	0	Harvested zone
506	3	2	0	60	40	0	0	0	0	0	0	0	Harvested zone
507	4	2	0	99	1	0	0	0	0	0	0	0	Harvested zone
508	3	2	0	90	10	0	0	0	0	0	0	0	Harvested zone
509	4	3	10	80	10	0	0	0	0	0	0	0	FA noted
510	2	1	0	90	0	0	0	0	0	0	0	0	
511	3	1	0	100	0	0	0	0	0	0	0	0	Harvested zone
512	4	1	0	100	0	0	0	0	0	0	0	0	FA noted
513	3	3	10	70	20	0	0	0	0	0	0	0	Harvested zone
514	4	4	15	80	4	1	0	0	0	0	0	0	
515	4	3	25	25	50	0	0	0	0	0	0	0	Harvested zone
516	4	3	10	45	45	0	0	0	0	0	0	0	Harvested zone

517	2	2	0	90	10	0	0	0	0	0	0	0	Chemically treated, FA noted
518	3	1	0	100	0	0	0	0	0	0	0	0	
519	4	1	0	100	0	0	0	0	0	0	0	0	FA noted
520	4	3	10	80	10	0	0	0	0	0	0	0	FA noted
521	3	2	0	95	5	0	0	0	0	0	0	0	
522	1	3	33.3	33.3	0	0	0	0	0	33.3	0	0	
523	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
524	3	3	33.3	33.3	33.3	0	0	0	0	0	0	0	Harvested zone
525	4	3	2.5	95	2.5	0	0	0	0	0	0	0	Harvested zone
526	4	3	10	20	70	0	0	0	0	0	0	0	
527	2	2	20	80	0	0	0	0	0	0	0	0	
528	3	2	0	99	1	0	0	0	0	0	0	0	Harvested zone
529	3	3	10	80	10	0	0	0	0	0	0	0	FA noted
530	3	3	20	60	20	0	0	0	0	0	0	0	FA noted
531	2	2	1	99	0	0	0	0	0	0	0	0	
532	1	1	0	100	0	0	0	0	0	0	0	0	
533	0	0	0	0	0	0	0	0	0	0	0	0	
534	1	1	0	100	0	0	0	0	0	0	0	0	Dredge
535	2	3	20	40	40	0	0	0	0	0	0	0	
536	2	3	9	90	1	0	0	0	0	0	0	0	Harvested zone
537	3	3	30	10	60	0	0	0	0	0	0	0	
538	3	3	10	80	10	0	0	0	0	0	0	0	
539	4	1	0	100	0	0	0	0	0	0	0	0	Chemically treated
540	4	3	10	80	10	0	0	0	0	0	0	0	FA noted
541	3	3	25	50	25	0	0	0	0	0	0	0	Harvested zone
542	4	3	5	90	5	0	0	0	0	0	0	0	
543	1	2	10	90	0	0	0	0	0	0	0	0	
544	2	1	0	100	0	0	0	0	0	0	0	0	
545	2	1	0	100	0	0	0	0	0	0	0	0	
546	1	1	0	100	0	0	0	0	0	0	0	0	
547	4	3	5	15	80	0	0	0	0	0	0	0	Harvested zone
548	3	2	0	90	10	0	0	0	0	0	0	0	Harvested zone

549	3	1	0	100	0	0	0	0	0	0	0	0	
550	4	2	0	95	0	10	0	0	0	0	0	0	
551	3	2	1	99	0	0	0	0	0	0	0	0	
552	3	2	5	95	0	0	0	0	0	0	0	0	FA
553	2	1	0	100	0	0	0	0	0	0	0	0	
554	2	2	2	98	0	0	0	0	0	0	0	0	
555	2	2	1	99	0	0	0	0	0	0	0	0	
556	2	1	0	100	0	0	0	0	0	0	0	0	
557	1	3	45	45	10	0	0	0	0	0	0	0	FA
558	4	2	1	0	99	0	0	0	0	0	0	0	
559	2	4	10	70	10	10	0	0	0	0	0	0	
560	4	3	45	45	10	0	0	0	0	0	0	0	
561	2	3	30	60	0	10	0	0	0	0	0	0	FA
562	3	1	0	100	0	0	0	0	0	0	0	0	FA
563	4	1	0	100	0	0	0	0	0	0	0	0	
564	3	1	0	100	0	0	0	0	0	0	0	0	
565	3	2	0	95	5	0	0	0	0	0	0	0	
566	4	2	0	70	30	0	0	0	0	0	0	0	
567	4	3	1	95	4	0	0	0	0	0	0	0	
568	4	1	0	100	0	0	0	0	0	0	0	0	
569	2	2	90	10	0	0	0	0	0	0	0	0	
570	3	2	5	95	0	0	0	0	0	0	0	0	FA
571	4	2	5	95	0	0	0	0	0	0	0	0	FA
572	2	1	0	100	0	0	0	0	0	0	0	0	
573	4	2	0	50	50	0	0	0	0	0	0	0	
574	4	3	50	25	25	0	0	0	0	0	0	0	
575	4	1	0	100	0	0	0	0	0	0	0	0	
576	4	1	0	100	0	0	0	0	0	0	0	0	
577	3	2	0	90	10	0	0	0	0	0	0	0	
578	3	2	1	99	0	0	0	0	0	0	0	0	FA noted
579	4	2	0	5	95	0	0	0	0	0	0	0	
580	4	3	50	25	25	0	0	0	0	0	0	0	
581	4	2	95	0	5	0	0	0	0	0	0	0	

582	4	2	20	80	0	0	0	0	0	0	0	0	FA noted
583	4	2	20	80	0	0	0	0	0	0	0	0	FA noted
584	4	2	20	80	0	0	0	0	0	0	0	0	FA noted
585	3	2	0	80	20	0	0	0	0	0	0	0	

Appendix F: PIRTRAM data converted into g/m^2.

Site #	Abundance Score	Biomass Estimate (g/m2)	# of Spp.	Eurasian watermilfoil (g/m2)	Coontail	Common waterweed	Curly-leaf pondweed	Sago pondweed	Brittle naiad	Water stargrass	Narrow-leaf pondweed	Bladderwort	American pondweed	Notes
1	1	1.00005	3	0.100005	0.80004	0	0	0.100005	0	0	0	0	0	
2	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
3	1	1.00005	3	0.3300165	0.33001 65	0	0	0	0.3300 165	0	0	0	0	
4	2	71.0005	2	0	70.2904 95	0	0	0	0.7100 05	0	0	0	0	
5	1	1.00005	2	0	0.80004	0.20001	0	0	0	0	0	0	0	FA
6	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	Site 8 all spatterdock
8	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
9	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	OBV/Bladder wort/ Creeping water primrose
10	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
11	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
12	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
13	2	71.0005	3	7.10005	56.8004	7.10005	0	0	0	0	0	0	0	
14	3	185.0005	1	0	185.000 5	0	0	0	0	0	0	0	0	
15	1	1.00005	2	0	0.90004 5	0.100005	0	0	0	0	0	0	0	
16	1	1.00005	4	0.2500125	0.25001 25	0.2500125	0	0.2500125	0	0	0	0	0	Lotus DW
17	3	185.0005	4	18.50005	74.0002	74.0002	0	18.50005	0	0	0	0	0	
18	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
19	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
20	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	

21	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
22	3	185.0005	2	1.850005	183.150495	0	0	0	0	0	0	0	0	
23	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
24	1	1.00005	4	0.100005	0.700035	0	0	0.100005	0.100005	0	0	0	0	
25	4	340.0005	3	68.0001	255.000375	0	0	0	0	17.000025	0	0	0	DW/large bed of vegetation in middle of channel
26	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
27	1	1.00005	3	0	0.7500375	0.20001	0	0.20001	0	0	0	0	0	OBV-site 26 + 27 spatterdocks
28	1	1.00005	3	0.3300165	0.3300165	0	0	0.3300165	0	0	0	0	0	
29	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
30	4	340.0005	2	68.0001	272.0004	0	0	0	0	0	0	0	0	Very dense/ lots of floating debris
31	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
32	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
33	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
34	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
35	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
36	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
37	2	71.0005	2	7.10005	63.90045	0	0	0	0	0	0	0	0	
38	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
39	1	1.00005	2	0.100005	0.900045	0	0	0	0	0	0	0	0	
40	3	185.0005	3	74.0002	74.0002	37.0001	0	0	0	0	0	0	0	
41	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE

42	4	340.0005	4	17.000025	238.00035	68.0001	0	0	0	17.000025	0	0	0	
43	3	185.0005	3	1.850005	181.30049	0	0	1.850005	0	0	0	0	0	
44	4	340.0005	2	34.00005	306.00045	0	0	0	0	0	0	0	0	
45	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
46	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
47	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
48	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
49	0	0	0	0	0	0	0	0	0	0	0	0	0	Chemically treated
50	1	1.00005	2	0.0500025	0.9500475	0	0	0	0	0	0	0	0	
51	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
52	0	0	0	0	0	0	0	0	0	0	0	0	0	
53	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
54	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
55	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
56	3	185.0005	4	46.250125	46.250125	0	0	46.250125	46.250125	0	0	0	0	
57	4	340.0005	4	3.400005	329.800485	0	3.400005	3.400005	0	0	0	0	0	DW/OBV-near Bladderwort
58	4	340.0005	3	0	333.20049	0	0	3.400005	0	3.400005	0	0	0	
59	4	340.0005	5	13.60002	255.000375	34.00005	3.400005	34.00005	0	0	0	0	0	
60	4	340.0005	2	17.000025	323.000475	0	0	0	0	0	0	0	0	
61	3	185.0005	3	18.50005	148.0004	0	0	0	0	0	18.50005	0	0	Thin-leaf ID in question
62	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
63	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
64	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
65	1	1.00005	2	0.40002	0.60003	0	0	0	0	0	0	0	0	

66	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
67	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
68	4	340.0005	3	68.0001	136.0002	136.0002	0	0	0	0	0	0	0	
69	4	340.0005	3	204.0003	0	68.0001	0	0	0	68.0001	0	0	0	
70	0	0	0	0	0	0	0	0	0	0	0	0	0	Chemically treated
71	2	71.0005	2	35.50025	35.50025	0	0	0	0	0	0	0	0	
72	3	185.0005	3	111.0003	37.0001	0	37.0001	0	0	0	0	0	0	
73	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
74	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
75	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
76	0	0	0	0	0	0	0	0	0	0	0	0	0	
77	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
78	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
79	3	185.0005	3	138.750375	27.750075	18.50005	0	0	0	0	0	0	0	
80	4	340.0005	5	136.0002	136.0002	0	17.000025	17.000025	0	34.00005	0	0	0	Heavy density
81	2	71.0005	4	17.750125	17.750125	0	17.750125	17.750125	0	0	0	0	0	
82	3	185.0005	2	74.0002	111.0003	0	0	0	0	0	0	0	0	
83	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
84	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
85	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
86	4	340.0005	3	17.000025	306.00045	17.000025	0	0	0	0	0	0	0	
87	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
88	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
89	1	1.00005	2	0	0.80004	0.20001	0	0	0	0	0	0	0	
90	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
91	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	

92	4	340.0005	2	0	204.0003	0	0	0	0	0	0	0	0	40-flat-stemmed pw
93	4	340.0005	3	136.0002	136.0002	68.0001	0	0	0	0	0	0	0	
94	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
95	3	185.0005	2	9.250025	175.750475	0	0	0	0	0	0	0	0	
96	3	185.0005	2	9.250025	175.750475	0	0	0	0	0	0	0	0	
97	2	71.0005	2	42.6003	28.4002	0	0	0	0	0	0	0	0	
98	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
99	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
100	0	0	0	0	0	0	0	0	0	0	0	0	0	
101	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
102	2	71.0005	2	7.10005	63.90045	0	0	0	0	0	0	0	0	
103	2	71.0005	2	7.10005	63.90045	0	0	0	0	0	0	0	0	
104	3	185.0005	3	55.50015	111.0003	18.50005	0	0	0	0	0	0	0	
105	2	71.0005	2	0.710005	70.290495	0	0	0	0	0	0	0	0	
106	1	1.00005	4	0.20001	0.500025	0	0	0	0.20001	0	0	0	0	10-flat-stemmed pw
107	2	71.0005	2	0.710005	70.290495	0	0	0	0	0	0	0	0	
108	0	0	0	0	0	0	0	0	0	0	0	0	0	
109	3	185.0005	3	18.50005	148.0004	0	0	18.50005	0	0	0	0	0	
110	4	340.0005	2	17.000025	323.000475	0	0	0	0	0	0	0	0	DW/ large mat of vegetation
111	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
112	4	340.0005	2	34.00005	306.00045	0	0	0	0	0	0	0	0	
113	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
114	0	0	0	0	0	0	0	0	0	0	0	0	0	
115	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
116	0	0	0	0	0	0	0	0	0	0	0	0	0	
117	0	0	0	0	0	0	0	0	0	0	0	0	0	

118	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
119	4	340.0005	3	34.00005	136.0002	170.00025	0	0	0	0	0	0	0	
120	3	185.0005	2	148.0004	0	37.0001	0	0	0	0	0	0	0	
121	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	Harvested zone
122	2	71.0005	1	71.0005	0	0	0	0	0	0	0	0	0	
123	4	340.0005	4	204.0003	34.00005	0	34.00005	68.0001	0	0	0	0	0	
124	2	71.0005	1	71.0005	0	0	0	0	0	0	0	0	0	
125	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
126	0	0	0	0	0	0	0	0	0	0	0	0	0	
127	1	1.00005	2	0.20001	0.80004	0	0	0	0	0	0	0	0	
128	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
129	2	71.0005	2	35.50025	35.50025	0	0	0	0	0	0	0	0	
130	2	71.0005	2	49.70035	21.30015	0	0	0	0	0	0	0	0	
131	3	185.0005	2	9.250025	175.750475	0	0	0	0	0	0	0	0	
132	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
133	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
134	2	71.0005	2	0	67.450475	0	0	0	3.550025	0	0	0	0	
135	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
136	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
137	1	1.00005	3	0.40002	0.40002	0	0	0.20001	0	0	0	0	0	
138	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
139	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
140	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
141	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
142	0	0	0	0	0	0	0	0	0	0	0	0	0	
143	0	0	0	0	0	0	0	0	0	0	0	0	0	
144	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	

145	3	185.0005	3	37.0001	111.0003	37.0001	0	0	0	0	0	0	0	
146	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
147	3	185.0005	2	92.50025	92.50025	0	0	0	0	0	0	0	0	Harvested zone
148	4	340.0005	3	102.00015	204.0003	34.00005	0	0	0	0	0	0	0	
149	4	340.0005	2	204.0003	136.0002	0	0	0	0	0	0	0	0	
150	4	340.0005	3	272.0004	17.000025	0	17.000025	0	0	0	0	0	0	
151	3	185.0005	2	92.50025	92.50025	0	0	0	0	0	0	0	0	
152	2	71.0005	1	71.0005	0	0	0	0	0	0	0	0	0	
153	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
154	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
155	1	1.00005	2	0.60003	0.40002	0	0	0	0	0	0	0	0	
156	2	71.0005	1	71.0005	0	0	0	0	0	0	0	0	0	
157	4	340.0005	2	238.00035	102.00015	0	0	0	0	0	0	0	0	
158	3	185.0005	2	74.0002	111.0003	0	0	0	0	0	0	0	0	
159	3	185.0005	2	9.250025	175.750475	0	0	0	0	0	0	0	0	
160	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
161	0	0	0	0	0	0	0	0	0	0	0	0	0	
162	1	1.00005	3	0.3300165	0.3300165	0	0	0	0.3300165	0	0	0	0	
163	0	0	0	0	0	0	0	0	0	0	0	0	0	
164	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
165	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
166	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
167	0	0	0	0	0	0	0	0	0	0	0	0	0	
168	0	0	0	0	0	0	0	0	0	0	0	0	0	
169	0	0	0	0	0	0	0	0	0	0	0	0	0	
170	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
171	4	340.0005	2	0	333.20049	6.80001	0	0	0	0	0	0	0	Very dense

172	2	71.0005	3	14.2001	42.6003	0	0	0	0	0	0	0	0	20-flat-stemmed pw/ Harvested zone
173	3	185.0005	2	148.0004	37.0001	0	0	0	0	0	0	0	0	
174	3	185.0005	2	92.50025	92.50025	0	0	0	0	0	0	0	0	
175	2	71.0005	2	0	35.50025	35.50025	0	0	0	0	0	0	0	
176	4	340.0005	2	323.000475	17.000025	0	0	0	0	0	0	0	0	
177	2	71.0005	1	71.0005	0	0	0	0	0	0	0	0	0	
178	2	71.0005	2	35.50025	35.50025	0	0	0	0	0	0	0	0	
179	2	71.0005	2	3.550025	67.450475	0	0	0	0	0	0	0	0	
180	3	185.0005	2	18.50005	166.50045	0	0	0	0	0	0	0	0	
182	3	185.0005	2	92.50025	92.50025	0	0	0	0	0	0	0	0	
183	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	
184	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
185	2	71.0005	2	35.50025	35.50025	0	0	0	0	0	0	0	0	Harvested zone
186	4	340.0005	2	34.00005	306.00045	0	0	0	0	0	0	0	0	
187	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
188	4	340.0005	2	136.0002	204.0003	0	0	0	0	0	0	0	0	
189	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
190	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
191	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
192	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
193	0	0	0	0	0	0	0	0	0	0	0	0	0	
194	0	0	0	0	0	0	0	0	0	0	0	0	0	
195	0	0	0	0	0	0	0	0	0	0	0	0	0	
196	0	0	0	0	0	0	0	0	0	0	0	0	0	

197	0	0	0	0	0	0	0	0	0	0	0	0	0	
198	0	0	0	0	0	0	0	0	0	0	0	0	0	
199	1	1.00005	2	0.40002	0.60003	0	0	0	0	0	0	0	0	
200	3	185.0005	5	32.3750875	55.50015	32.3750875	0	32.3750875	0	32.3750875	0	0	0	
201	1	1.00005	2	0.100005	0.900045	0	0	0	0	0	0	0	0	
202	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	
203	4	340.0005	3	306.00045	0	0	17.000025	0	0	17.000025	0	0	0	
204	4	340.0005	3	204.0003	68.0001	0	68.0001	0	0	0	0	0	0	
205	4	340.0005	2	272.0004	68.0001	0	0	0	0	0	0	0	0	
206	4	340.0005	2	306.00045	34.00005	0	0	0	0	0	0	0	0	
207	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
208	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
209	2	71.0005	2	67.450475	3.550025	0	0	0	0	0	0	0	0	
210	3	185.0005	2	175.750475	0	0	0	9.250025	0	0	0	0	0	
211	4	340.0005	2	204.0003	136.0002	0	0	0	0	0	0	0	0	FA zone
212	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
213	2	71.0005	2	7.10005	63.90045	0	0	0	0	0	0	0	0	Harvested zone
214	2	71.0005	2	56.8004	14.2001	0	0	0	0	0	0	0	0	Harvested zone
215	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	
216	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
217	0	0	0	0	0	0	0	0	0	0	0	0	0	
218	1	1.00005	1	0	0	0	1.00005	0	0	0	0	0	0	
219	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
220	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
221	1	1.00005	2	0.60003	0.40002	0	0	0	0	0	0	0	0	
222	0	0	0	0	0	0	0	0	0	0	0	0	0	
223	0	0	0	0	0	0	0	0	0	0	0	0	0	
224	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	

225	3	185.0005	4	74.0002	74.0002	35.150095	0	0	0	1.850005	0	0	0	
226	3	185.0005	3	92.50025	90.650245	0	1.850005	0	0	0	0	0	0	
227	4	340.0005	2	204.0003	136.0002	0	0	0	0	0	0	0	0	
228	3	185.0005	2	166.50045	0	18.50005	0	0	0	0	0	0	0	
229	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
230	4	340.0005	3	204.0003	68.0001	0	68.0001	0	0	0	0	0	0	
231	3	185.0005	1	185.0005	0	0	0	0	0	0	0	0	0	
232	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
233	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
234	3	185.0005	1	185.0005	0	0	0	0	0	0	0	0	0	
235	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	
236	3	185.0005	1	185.0005	0	0	0	0	0	0	0	0	0	FA zone
237	3	185.0005	2	148.0004	37.0001	0	0	0	0	0	0	0	0	
238	2	71.0005	1	71.0005	0	0	0	0	0	0	0	0	0	Harvested zone
239	4	340.0005	2	306.00045	34.00005	0	0	0	0	0	0	0	0	
240	4	340.0005	2	17.000025	323.000475	0	0	0	0	0	0	0	0	
241	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
242	0	0	0	0	0	0	0	0	0	0	0	0	0	
243	1	1.00005	3	0.100005	0.80004	0	0.100005	0	0	0	0	0	0	
244	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
245	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
246	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
247	0	0	0	0	0	0	0	0	0	0	0	0	0	
248	0	0	0	0	0	0	0	0	0	0	0	0	0	
249	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
250	4	340.0005	3	170.00025	166.600245	0	3.400005	0	0	0	0	0	0	
251	2	71.0005	2	35.50025	35.50025	0	0	0	0	0	0	0	0	Harvested zone

252	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
253	4	340.0005	3	306.00045	17.000025	0	17.000025	0	0	0	0	0	0	
254	3	185.0005	2	166.50045	18.50005	0	0	0	0	0	0	0	0	
255	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
256	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
257	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
258	2	71.0005	2	42.6003	28.4002	0	0	0	0	0	0	0	0	
259	4	340.0005	10	306.00045	0	0	0	0	0	0	0	0	0	
260	4	340.0005	2	204.0003	136.0002	0	0	0	0	0	0	0	0	
261	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	FA noted
262	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	
263	2	71.0005	3	14.2001	42.6003	0	0	14.2001	0	0	0	0	0	Harvested zone
264	3	185.0005	2	37.0001	148.0004	0	0	0	0	0	0	0	0	
265	4	340.0005	2	17.000025	323.000475	0	0	0	0	0	0	0	0	FA noted
266	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
267	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
268	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
269	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
270	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
271	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
272	1	1.00005	2	0.500025	0	0.500025	0	0	0	0	0	0	0	
273	2	71.0005	2	0	70.290495	0	0	0	0	0.710005	0	0	0	Harvested zone
274	4	340.0005	3	34.00005	272.0004	34.00005	0	0	0	0	0	0	0	FA noted
275	2	71.0005	3	28.4002	35.50025	7.10005	0	0	0	0	0	0	0	Harvested zone
276	4	340.0005	3	333.20049	3.400005	3.400005	0	0	0	0	0	0	0	
277	3	185.0005	3	111.0003	37.0001	37.0001	0	0	0	0	0	0	0	

278	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	FA noted
279	4	340.0005	2	336.600495	0	3.400005	0	0	0	0	0	0	0	FA noted
280	4	340.0005	2	336.600495	0	3.400005	0	0	0	0	0	0	0	FA noted
281	4	340.0005	2	336.600495	0	0	3.400005	0	0	0	0	0	0	FA noted
282	3	185.0005	2	129.50035	55.50015	0	0	0	0	0	0	0	0	FA noted
283	3	185.0005	2	166.50045	18.50005	0	0	0	0	0	0	0	0	FA noted
284	3	185.0005	2	166.50045	0	0	0	18.50005	0	0	0	0	0	FA noted
285	4	340.0005	4	340.0005	0	0	0	0	0	0	0	0	0	FA noted
286	3	185.0005	2	185.0005	0	0	0	0	0	0	0	0	0	FA noted
287	4	340.0005	3	153.000225	153.000225	0	34.00005	0	0	0	0	0	0	
288	2	71.0005	2	35.50025	35.50025	0	0	0	0	0	0	0	0	
289	3	185.0005	2	18.50005	166.50045	0	0	0	0	0	0	0	0	
290	3	185.0005	2	1.850005	183.150495	0	0	0	0	0	0	0	0	
291	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Sampleable
292	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
293	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
294	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
295	0	0	0	0	0	0	0	0	0	0	0	0	0	
296	2	71.0005	1	71.0005	0	0	0	0	0	0	0	0	0	Harvested zone
297	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	FA noted
298	4	340.0005	3	204.0003	102.00015	34.00005	0	0	0	0	0	0	0	
299	3	185.0005	1	185.0005	0	0	0	0	0	0	0	0	0	
300	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
301	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
302	3	185.0005	4	129.50035	37.0001	18.50005	1.850005	0	0	0	0	0	0	
303	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	FA noted
304	4	340.0005	2	323.000475	17.000025	0	0	0	0	0	0	0	0	

305	3	185.0005	2	175.750475	9.250025	0	0	0	0	0	0	0	0	
306	3	185.0005	1	185.0005	0	0	0	0	0	0	0	0	0	
307	4	340.0005	2	3.400005	336.600495	0	0	0	0	0	0	0	0	
308	4	340.0005	2	323.000475	17.000025	0	0	0	0	0	0	0	0	FA noted
309	4	340.0005	2	336.600495	3.400005	0	0	0	0	0	0	0	0	FA noted
310	4	340.0005	3	34.00005	238.00035	0	0	68.0001	0	0	0	0	0	
311	3	185.0005	2	9.250025	175.750475	0	0	0	0	0	0	0	0	Harvested zone
312	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
313	3	185.0005	3	18.50005	148.0004	18.50005	0	0	0	0	0	0	0	
314	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
315	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
316	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
317	2	71.0005	3	14.2001	49.70035	7.10005	0	0	0	0	0	0	0	Deeper location/ revisit
318	2	71.0005	2	3.550025	67.450475	0	0	0	0	0	0	0	0	
319	4	340.0005	2	323.000475	0	17.000025	0	0	0	0	0	0	0	
320	4	340.0005	3	323.000475	0	8.5000125	8.5000125	0	0	0	0	0	0	FA noted
321	3	185.0005	2	175.750475	0	9.250025	0	0	0	0	0	0	0	FA noted
322	4	340.0005	2	333.20049	0	6.80001	0	0	0	0	0	0	0	
323	4	340.0005	3	323.000475	8.5000125	8.5000125	0	0	0	0	0	0	0	
324	4	340.0005	2	17.000025	0	323.000475	0	0	0	0	0	0	0	
325	4	340.0005	2	333.20049	0	6.80001	0	0	0	0	0	0	0	
326	4	340.0005	2	333.20049	6.80001	0	0	0	0	0	0	0	0	
327	4	340.0005	3	153.000225	34.00005	153.000225	0	0	0	0	0	0	0	
328	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
329	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
330	3	185.0005	1	185.0005	0	0	0	0	0	0	0	0	0	

331	2	71.0005	2	56.8004	14.2001	0	0	0	0	0	0	0	0	Harvested zone
332	2	71.0005	3	31.950225	31.950225	0	0	7.10005	0	0	0	0	0	Harvested zone
333	4	340.0005	2	30.600045	306.00045	3.400005	0	0	0	0	0	0	0	Harvested zone
334	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	Harvested zone
335	4	340.0005	3	30.600045	306.00045	3.400005	0	0	0	0	0	0	0	
336	4	340.0005	2	3.400005	336.600495	0	0	0	0	0	0	0	0	FA noted
337	1	1.00005	2	0.500025	0.500025	0	0	0	0	0	0	0	0	
338	2	71.0005	2	0	56.8004	14.2001	0	0	0	0	0	0	0	
339	0	0	0	0	0	0	0	0	0	0	0	0	0	
340	0	0	0	0	0	0	0	0	0	0	0	0	0	
341	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
342	1	1.00005	1	1.00005	0	0	0	0	0	0	0	0	0	
343	4	340.0005	2	6.80001	333.20049	0	0	0	0	0	0	0	0	
344	4	340.0005	4	272.0004	34.00005	17.000025	17.000025	0	0	0	0	0	0	
345	3	185.0005	5	18.50005	18.50005	111.0003	18.50005	0	0	0	18.50005	0	0	Small hole/ milfoil not topped out
346	3	185.0005	3	175.750475	0	4.6250125	4.6250125	0	0	0	0	0	0	FA
347	4	340.0005	2	336.600495	0	3.400005	0	0	0	0	0	0	0	
348	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	Heavy matted area
349	4	340.0005	2	323.000475	17.000025	0	0	0	0	0	0	0	0	
350	4	340.0005	2	323.000475	17.000025	0	0	0	0	0	0	0	0	FA
351	3	185.0005	3	166.50045	0	9.250025	9.250025	0	0	0	0	0	0	
352	4	340.0005	3	333.20049	3.400005	0	3.400005	0	0	0	0	0	0	
353	4	340.0005	2	323.000475	17.000025	0	0	0	0	0	0	0	0	
354	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	

355	3	185.0005	1	185.0005	0	0	0	0	0	0	0	0	0	
356	4	340.0005	2	204.0003	136.0002	0	0	0	0	0	0	0	0	
357	4	340.0005	2	272.0004	68.0001	0	0	0	0	0	0	0	0	Zebra mussels noted
358	3	185.0005	3	92.50025	92.50025	0	0	0	0	0	0	0	0	
359	4	340.0005	2	102.00015	238.00035	0	0	0	0	0	0	0	0	
360	4	340.0005	3	64.600095	272.0004	3.400005	0	0	0	0	0	0	0	
361	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
362	3	185.0005	2	0	148.0004	0	0	37.0001	0	0	0	0	0	
363	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
364	0	0	0	0	0	0	0	0	0	0	0	0	0	
365	0	0	0	0	0	0	0	0	0	0	0	0	0	
366	0	0	0	0	0	0	0	0	0	0	0	0	0	
367	0	0	0	0	0	0	0	0	0	0	0	0	0	
368	0	0	0	0	0	0	0	0	0	0	0	0	0	
369	4	340.0005	2	102.00015	238.00035	0	0	0	0	0	0	0	0	
370	4	340.0005	3	51.000075	238.00035	0	51.000075	0	0	0	0	0	0	
371	4	340.0005	2	323.000475	17.000025	0	0	0	0	0	0	0	0	
372	4	340.0005	2	34.00005	0	306.00045	0	0	0	0	0	0	0	FA
373	4	340.0005	3	323.000475	0	13.60002	3.400005	0	0	0	0	0	0	
374	4	340.0005	3	255.000375	68.0001	0	17.000025	0	0	0	0	0	0	
375	3	185.0005	6	92.50025	64.750175	9.250025	9.250025	0	0	0	9.250025	0	0	Stonewort
376	4	340.0005	4	323.000475	0	8.5000125	0	5.1000075	0	0	3.400005	0	0	
377	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	
378	4	340.0005	3	323.000475	8.5000125	8.5000125	0	0	0	0	0	0	0	
379	3	185.0005	2	166.50045	18.50005	0	0	0	0	0	0	0	0	

380	4	340.0005	2	336.600495	3.400005	0	0	0	0	0	0	0	0	
381	4	340.0005	2	136.0002	204.0003	0	0	0	0	0	0	0	0	
382	4	340.0005	2	336.600495	3.400005	0	0	0	0	0	0	0	0	
383	4	340.0005	2	272.0004	68.0001	0	0	0	0	0	0	0	0	
384	3	185.0005	2	92.50025	92.50025	0	0	0	0	0	0	0	0	
385	4	340.0005	2	136.0002	204.0003	0	0	0	0	0	0	0	0	
386	2	71.0005	2	14.2001	56.8004	0	0	0	0	0	0	0	0	Harvested zone
387	2	71.0005	2	7.10005	63.90045	0	0	0	0	0	0	0	0	Zebra mussels noted
388	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
389	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
390	3	185.0005	2	92.50025	92.50025	0	0	0	0	0	0	0	0	
391	0	0	0	0	0	0	0	0	0	0	0	0	0	
392	0	0	0	0	0	0	0	0	0	0	0	0	0	
393	0	0	0	0	0	0	0	0	0	0	0	0	0	
394	0	0	0	0	0	0	0	0	0	0	0	0	0	
395	4	340.0005	1	3.400005	340.0005	0	0	0	0	0	0	0	0	FA noted
396	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not sampleable
397	4	340.0005	3	102.00015	170.00025	3.400005	30.600045	0	0	0	0	0	0	
398	4	340.0005	3	136.0002	68.0001	136.0002	0	0	0	0	0	0	0	Very heavy density
399	3	185.0005	2	111.0003	74.0002	0	0	0	0	0	0	0	0	
400	3	185.0005	4	27.750075	27.750075	127.650345	1.850005	0	0	0	0	0	0	FA
401	4	340.0005	2	333.20049	0	6.80001	0	0	0	0	0	0	0	
402	4	340.0005	4	323.000475	5.1000075	8.5000125	0	0	0	0	3.400005	0	0	Heavy matted area
403	4	340.0005	2	323.000475	0	17.000025	0	0	0	0	0	0	0	
404	4	340.0005	3	306.00045	30.600045	3.400005	0	0	0	0	0	0	0	

405	4	340.0005	3	333.20049	3.400005	3.400005	0	0	0	0	0	0	0	
406	4	340.0005	2	306.00045	34.00005	0	0	0	0	0	0	0	0	
407	4	340.0005	1	340.0005	0	0	0	0	0	0	0	0	0	
408	4	340.0005	2	336.600495	3.400005	0	0	0	0	0	0	0	0	
409	4	340.0005	3	272.0004	64.600095	0	3.400005	0	0	0	0	0	0	
410	4	340.0005	3	119.000175	204.0003	0	17.000025	0	0	0	0	0	0	
411	2	71.0005	3	42.6003	27.690195	0	0	0.710005	0	0	0	0	0	Harvested zone
412	4	340.0005	2	34.00005	306.00045	0	0	0	0	0	0	0	0	
413	4	340.0005	4	68.0001	238.00035	17.000025	17.000025	0	0	0	0	0	0	Harvested zone
414	3	185.0005	2	37.0001	148.0004	0	0	0	0	0	0	0	0	
415	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
416	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
417	0	0	0	0	0	0	0	0	0	0	0	0	0	
418	0	0	0	0	0	0	0	0	0	0	0	0	0	
419	0	0	0	0	0	0	0	0	0	0	0	0	0	
420	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
421	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
422	4	340.0005	2	17.000025	323.000475	0	0	0	0	0	0	0	0	
423	2	71.0005	4	7.10005	7.10005	49.70035	7.10005	0	0	0	0	0	0	Harvested zone
424	3	185.0005	2	175.750475	0	9.250025	0	0	0	0	0	0	0	
425	4	340.0005	4	238.00035	51.000075	47.60007	3.400005	0	0	0	0	0	0	FA
426	4	340.0005	4	204.0003	34.00005	85.000125	17.000025	0	0	0	0	0	0	
427	4	340.0005	3	323.000475	8.5000125	5.1000075	0	0	0	0	3.400005	0	0	
428	4	340.0005	3	238.00035	68.0001	34.00005	0	0	0	0	0	0	0	
429	4	340.0005	2	306.00045	34.00005	0	0	0	0	0	0	0	0	

430	4	340.0005	4	289.000425	17.000025	17.000025	0	0	0	0	17.000025	0	0	
431	4	340.0005	4	136.0002	0	34.00005	0	85.000125	0	0	85.000125	0	0	
432	4	340.0005	2	136.0002	204.0003	0	0	0	0	0	0	0	0	Harvested zone
433	3	185.0005	2	92.50025	92.50025	0	0	0	0	0	0	0	0	
434	4	340.0005	4	34.00005	272.0004	0	30.600045	0	0	0	3.400005	0	0	Harvested zone
435	3	185.0005	3	46.250125	92.50025	0	46.250125	0	0	0	0	0	0	
436	3	185.0005	3	83.250225	83.250225	0	0	18.50005	0	0	0	0	0	Harvested zone
437	3	185.0005	3	37.0001	129.50035	0	18.50005	0	0	0	0	0	0	
438	2	71.0005	2	7.10005	63.90045	0	0	0	0	0	0	0	0	Harvested
439	4	340.0005	2	68.0001	272.0004	0	0	0	0	0	0	0	0	
440	4	340.0005	3	3.400005	333.20049	3.400005	0	0	0	0	0	0	0	FA noted
441	3	185.0005	2	0	183.150495	1.850005	0	0	0	0	0	0	0	
442	2	71.0005	2	0.710005	70.290495	0	0	0	0	0	0	0	0	
443	2	71.0005	2	0	35.50025	0	0	35.50025	0	0	0	0	0	
444	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
445	2	71.0005	2	49.70035	21.30015	0	0	0	0	0	0	0	0	Harvested at some point
446	2	71.0005	3	3.550025	63.90045	3.550025	0	0	0	0	0	0	0	
447	2	71.0005	4	35.50025	21.30015	0	7.10005	0	0	0	7.10005	0	0	FA/ Harvested
448	3	185.0005	4	74.0002	0	92.50025	9.250025	0	0	0	9.250025	0	0	
449	3	185.0005	4	111.0003	18.50005	53.650145	0	0	0	0	1.850005	0	0	
450	4	340.0005	3	323.000475	8.5000125	8.5000125	0	0	0	0	0	0	0	FA noted
451	4	340.0005	3	323.000475	8.5000125	8.5000125	0	0	0	0	0	0	0	
452	4	340.0005	2	170.00025	170.00025	0	0	0	0	0	0	0	0	
453	2	71.0005	2	56.8004	0	0	0	0	0	0	14.2001	0	0	

454	2	71.0005	4	7.10005	21.30015	0	0	21.30015	0	0	21.30015	0	0	
455	3	185.0005	2	92.50025	90.650245	0	1.850005	0	0	0	0	0	0	
456	3	185.0005	50	92.50025	0	0	0	0	0	0	0	0	0	
457	4	340.0005	2	34.00005	306.00045	0	0	0	0	0	0	0	0	
458	2	71.0005	2	14.2001	56.8004	0	0	0	0	0	0	0	0	Harvested zone
459	4	340.0005	4	42.5000625	170.00025	85.000125	42.5000625	0	0	0	0	0	0	
460	4	340.0005	3	51.000075	272.0004	0	17.000025	0	0	0	0	0	0	
461	2	71.0005	3	14.2001	49.70035	0	7.10005	0	0	0	0	0	0	Harvested zone
462	4	340.0005	3	0	306.00045	17.000025	17.000025	0	0	0	0	0	0	
463	4	340.0005	3	8.5000125	323.000475	8.5000125	0	0	0	0	0	0	0	
464	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
465	4	340.0005	2	0	336.600495	3.400005	0	0	0	0	0	0	0	FA noted
466	2	71.0005	3	0	31.950225	31.950225	6.390045	0	0	0	0.710005	0	0	Harvested
467	4	340.0005	4	102.00015	34.00005	102.00015	102.00015	0	0	0	0	0	0	FA
468	2	71.0005	3	22.010155	28.4002	0	21.30015	0	0	0	0	0	0	Harvested zone
469	1	1.00005	5	0.2500125	0.2500125	0.40002	0.0900045	0	0	0	0.0100005	0	0	
470	3	185.0005	4	9.250025	7.40002	166.50045	0	0	0	0	1.850005	0	0	Harvested zone
471	4	340.0005	4	323.000475	8.5000125	5.1000075	0	0	0	0	3.400005	0	0	
472	4	340.0005	4	17.000025	238.00035	17.000025	0	0	0	0	68.0001	0	0	Harvested zone
473	3	185.0005	6	18.50005	18.50005	9.250025	9.250025	9.250025	0	0	120.250325	0	0	
474	4	340.0005	5	136.0002	136.0002	170.00025	34.00005	0	0	0	17.000025	0	0	
475	4	340.0005	2	333.20049	6.80001	0	0	0	0	0	0	0	0	
476	3	185.0005	2	74.0002	111.0003	0	0	0	0	0	0	0	0	

477	4	340.0005	2	102.00015	238.00035	0	0	0	0	0	0	0	0	
478	4	340.0005	3	30.600045	306.00045	3.400005	0	0	0	0	0	0	0	
479	4	340.0005	3	17.000025	306.00045	17.000025	0	0	0	0	0	0	0	
480	4	340.0005	2	0	336.600495	0	3.400005	0	0	0	0	0	0	Harvested zone
481	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	Harvested zone
482	4	340.0005	2	0	323.000475	17.000025	0	0	0	0	0	0	0	FA noted
483	3	185.0005	3	37.0001	74.0002	74.0002	0	0	0	0	0	0	0	FA noted
484	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	FA noted
485	1	1.00005	3	0.2500125	0.500025	0.2500125	0	0	0	0	0	0	0	Harvested zone
486	3	185.0005	4	18.50005	74.0002	18.50005	0	0	0	0	74.0002	0	0	Harvested zone
487	4	340.0005	4	238.00035	17.000025	17.000025	68.0001	0	0	0	0	0	0	
488	4	340.0005	4	34.00005	289.000425	8.5000125	0	0	0	0	8.5000125	0	0	
489	4	340.0005	3	153.000225	153.000225	34.00005	0	0	0	0	0	0	0	
490	3	185.0005	2	175.750475	1.850005	7.40002	0	0	0	0	0	0	0	
491	4	340.0005	3	306.00045	17.000025	17.000025	0	0	0	0	0	0	0	
492	4	340.0005	2	68.0001	272.0004	0	0	0	0	0	0	0	0	
493	3	185.0005	3	37.0001	74.0002	74.0002	0	0	0	0	0	0	0	
494	3	185.0005	2	74.0002	111.0003	0	0	0	0	0	0	0	0	
495	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	Harvested zone
496	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
497	3	185.0005	2	0	183.150495	1.850005	0	0	0	0	0	0	0	
498	3	185.0005	2	18.50005	166.50045	0	0	0	0	0	0	0	0	
499	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	

500	2	71.0005	2	14.2001	56.8004	0	0	0	0	0	0	0	0	Harvested zone
501	4	340.0005	3	8.5000125	8.5000125	323.000475	0	0	0	0	0	0	0	
502	4	340.0005	3	34.00005	34.00005	272.0004	0	0	0	0	0	0	0	
503	4	340.0005	3	136.0002	170.00025	34.00005	0	0	0	0	0	0	0	
504	4	340.0005	2	323.000475	17.000025	0	0	0	0	0	0	0	0	
505	2	71.0005	2	1.42001	69.58049	0	0	0	0	0	0	0	0	Harvested zone
506	3	185.0005	2	0	111.0003	74.0002	0	0	0	0	0	0	0	Harvested zone
507	4	340.0005	2	0	336.600495	3.400005	0	0	0	0	0	0	0	Harvested zone
508	3	185.0005	2	0	166.50045	18.50005	0	0	0	0	0	0	0	Harvested zone
509	4	340.0005	3	34.00005	272.0004	34.00005	0	0	0	0	0	0	0	FA noted
510	2	71.0005	1	0	63.90045	0	0	0	0	0	0	0	0	
511	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	Harvested zone
512	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	FA noted
513	3	185.0005	3	18.50005	129.50035	37.0001	0	0	0	0	0	0	0	Harvested zone
514	4	340.0005	4	51.000075	272.0004	13.60002	3.400005	0	0	0	0	0	0	
515	4	340.0005	3	85.000125	85.000125	170.00025	0	0	0	0	0	0	0	Harvested zone
516	4	340.0005	3	34.00005	153.000225	153.000225	0	0	0	0	0	0	0	Harvested zone
517	2	71.0005	2	0	63.90045	7.10005	0	0	0	0	0	0	0	Chemically treated, FA noted
518	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
519	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	FA noted
520	4	340.0005	3	34.00005	272.0004	34.00005	0	0	0	0	0	0	0	FA noted
521	3	185.0005	2	0	175.750475	9.250025	0	0	0	0	0	0	0	

522	1	1.00005	3	0.33301665	0.33301665	0	0	0	0	0	0.33301665	0	0	
523	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NOT SAMPLABLE
524	3	185.0005	3	61.6051665	61.6051665	61.6051665	0	0	0	0	0	0	0	Harvested zone
525	4	340.0005	3	8.5000125	323.000475	8.5000125	0	0	0	0	0	0	0	Harvested zone
526	4	340.0005	3	34.00005	68.0001	238.00035	0	0	0	0	0	0	0	
527	2	71.0005	2	14.2001	56.8004	0	0	0	0	0	0	0	0	
528	3	185.0005	2	0	183.150495	1.850005	0	0	0	0	0	0	0	Harvested zone
529	3	185.0005	3	18.50005	148.0004	18.50005	0	0	0	0	0	0	0	FA noted
530	3	185.0005	3	37.0001	111.0003	37.0001	0	0	0	0	0	0	0	FA noted
531	2	71.0005	2	0.710005	70.290495	0	0	0	0	0	0	0	0	
532	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	
533	0	0	0	0	0	0	0	0	0	0	0	0	0	
534	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	Dredge
535	2	71.0005	3	14.2001	28.4002	28.4002	0	0	0	0	0	0	0	
536	2	71.0005	3	6.390045	63.90045	0.710005	0	0	0	0	0	0	0	Harvested zone
537	3	185.0005	3	55.50015	18.50005	111.0003	0	0	0	0	0	0	0	
538	3	185.0005	3	18.50005	148.0004	18.50005	0	0	0	0	0	0	0	
539	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	Chemically treated
540	4	340.0005	3	34.00005	272.0004	34.00005	0	0	0	0	0	0	0	FA noted
541	3	185.0005	3	46.250125	92.50025	46.250125	0	0	0	0	0	0	0	Harvested zone
542	4	340.0005	3	17.000025	306.00045	17.000025	0	0	0	0	0	0	0	
543	1	1.00005	2	0.100005	0.900045	0	0	0	0	0	0	0	0	
544	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
545	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
546	1	1.00005	1	0	1.00005	0	0	0	0	0	0	0	0	

547	4	340.0005	3	17.000025	51.000075	272.0004	0	0	0	0	0	0	0	Harvested zone
548	3	185.0005	2	0	166.50045	18.50005	0	0	0	0	0	0	0	Harvested zone
549	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
550	4	340.0005	2	0	323.000475	0	34.00005	0	0	0	0	0	0	
551	3	185.0005	2	1.850005	183.150495	0	0	0	0	0	0	0	0	
552	3	185.0005	2	9.250025	175.750475	0	0	0	0	0	0	0	0	FA
553	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
554	2	71.0005	2	1.42001	69.58049	0	0	0	0	0	0	0	0	
555	2	71.0005	2	0.710005	70.290495	0	0	0	0	0	0	0	0	
556	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
557	1	1.00005	3	0.4500225	0.4500225	0.100005	0	0	0	0	0	0	0	FA
558	4	340.0005	2	3.400005	0	336.600495	0	0	0	0	0	0	0	
559	2	71.0005	4	7.10005	49.70035	7.10005	7.10005	0	0	0	0	0	0	
560	4	340.0005	3	153.000225	153.000225	34.00005	0	0	0	0	0	0	0	
561	2	71.0005	3	21.30015	42.6003	0	7.10005	0	0	0	0	0	0	FA
562	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	FA
563	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
564	3	185.0005	1	0	185.0005	0	0	0	0	0	0	0	0	
565	3	185.0005	2	0	175.750475	9.250025	0	0	0	0	0	0	0	
566	4	340.0005	2	0	238.00035	102.00015	0	0	0	0	0	0	0	
567	4	340.0005	3	3.400005	323.000475	13.60002	0	0	0	0	0	0	0	
568	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
569	2	71.0005	2	63.90045	7.10005	0	0	0	0	0	0	0	0	
570	3	185.0005	2	9.250025	175.750475	0	0	0	0	0	0	0	0	FA

571	4	340.0005	2	17.000025	323.000475	0	0	0	0	0	0	0	0	FA
572	2	71.0005	1	0	71.0005	0	0	0	0	0	0	0	0	
573	4	340.0005	2	0	170.00025	170.00025	0	0	0	0	0	0	0	
574	4	340.0005	3	170.00025	85.000125	85.000125	0	0	0	0	0	0	0	
575	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
576	4	340.0005	1	0	340.0005	0	0	0	0	0	0	0	0	
577	3	185.0005	2	0	166.50045	18.50005	0	0	0	0	0	0	0	
578	3	185.0005	2	1.850005	183.150495	0	0	0	0	0	0	0	0	FA noted
579	4	340.0005	2	0	17.000025	323.000475	0	0	0	0	0	0	0	
580	4	340.0005	3	170.00025	85.000125	85.000125	0	0	0	0	0	0	0	
581	4	340.0005	2	323.000475	0	17.000025	0	0	0	0	0	0	0	
582	4	340.0005	2	68.0001	272.0004	0	0	0	0	0	0	0	0	FA noted
583	4	340.0005	2	68.0001	272.0004	0	0	0	0	0	0	0	0	FA noted
584	4	340.0005	2	68.0001	272.0004	0	0	0	0	0	0	0	0	FA noted
585	3	185.0005	2	0	148.0004	37.0001	0	0	0	0	0	0	0	

Appendix G: Longitude and latitude of PIRTRAM sampling locations

Site #	Longitude	Latitude
1	-83.87844258	40.51639575
2	-83.8772686	40.51691843
3	-83.87406532	40.51650076
4	-83.87010827	40.51655272
5	-83.86889716	40.51663147
6	-83.86597856	40.51628782
7	-83.86271556	40.51649278
8	-83.85913311	40.51647993
9	-83.85304677	40.51598757
10	-83.85082333	40.51667073
11	-83.84949974	40.51656161
12	-83.87874521	40.51557281
13	-83.8745944	40.51534938
14	-83.87339806	40.51550054
15	-83.87072521	40.51561601
16	-83.86835908	40.51576555
17	-83.86490721	40.51548025
18	-83.862718	40.51553821
19	-83.85891592	40.51550872
20	-83.85333639	40.51590857
21	-83.85099326	40.51565043
22	-83.87937081	40.51437168
23	-83.87224661	40.51461636
24	-83.87224661	40.51461636
25	-83.87224661	40.51461636
26	-83.87070179	40.51395685
27	-83.87070179	40.51395685
28	-83.86562464	40.51356317
29	-83.86562464	40.51356317
30	-83.86143979	40.51371337
31	-83.85901331	40.51375514
32	-83.85772471	40.51379377
33	-83.85581043	40.51386301
34	-83.85314006	40.51395601
35	-83.84938167	40.51421493
36	-83.84613064	40.51412723
37	-83.88395262	40.51217836
38	-83.88347054	40.51255145
39	-83.88010804	40.51279596

40	-83.87410744	40.51266515
41	-83.87146813	40.51232135
42	-83.86650636	40.51233081
43	-83.86331772	40.51225015
44	-83.86331772	40.51225015
45	-83.85914554	40.5108785
46	-83.8549536	40.51118716
47	-83.85246219	40.51164198
48	-83.84739272	40.51178741
49	-83.89509911	40.51020999
50	-83.88786464	40.51043401
51	-83.88445385	40.51061739
52	-83.88228271	40.51091051
53	-83.87915581	40.51085896
54	-83.87915581	40.51085896
55	-83.87573737	40.51100867
56	-83.87314082	40.51108657
57	-83.87044721	40.51072497
58	-83.86683716	40.51086695
59	-83.86683716	40.51086695
60	-83.86372182	40.51102157
61	-83.86256961	40.51084781
62	-83.85731114	40.5107532
63	-83.85659014	40.51000372
64	-83.85659014	40.51000372
65	-83.85248139	40.51006999
66	-83.8465082	40.50898973
67	-83.90097114	40.50816115
68	-83.89930309	40.50859051
69	-83.89628733	40.50898439
70	-83.89383061	40.50903218
71	-83.88976302	40.50914645
72	-83.8885904	40.50949519
73	-83.8849917	40.50943269
74	-83.88267206	40.50947759
75	-83.8791719	40.50982501
76	-83.8791719	40.50982501
77	-83.8791719	40.50982501
78	-83.8791719	40.50982501
79	-83.8791719	40.50982501
80	-83.87032372	40.51006856

81	-83.87032372	40.51006856
82	-83.87032372	40.51006856
83	-83.86570634	40.51027681
84	-83.85839711	40.50884017
85	-83.85839711	40.50884017
86	-83.85505091	40.50911456
87	-83.85357783	40.5091727
88	-83.84768837	40.50922496
89	-83.91275501	40.50746878
90	-83.91005368	40.50706023
91	-83.90747483	40.5070798
92	-83.9031242	40.50713817
93	-83.89925423	40.50747867
94	-83.8980574	40.50744029
95	-83.89497445	40.50757967
96	-83.89139797	40.50742707
97	-83.8895446	40.50756522
98	-83.88750838	40.50751025
99	-83.88494049	40.50769328
100	-83.88105968	40.5077962
101	-83.88018394	40.50784644
102	-83.87761047	40.50767381
103	-83.87493311	40.50765327
104	-83.87256492	40.50770447
105	-83.87043819	40.50797315
106	-83.86869636	40.50790123
107	-83.86643641	40.50797382
108	-83.86499717	40.50802925
109	-83.86225139	40.50798736
110	-83.85622302	40.50801383
111	-83.85549472	40.50747163
112	-83.85225871	40.50783886
113	-83.85225871	40.50783886
114	-83.8482285	40.50734692
115	-83.84689378	40.50743887
116	-83.84424018	40.50753379
117	-83.84236948	40.50759708
118	-83.90749227	40.50646563
119	-83.90244109	40.50595442
120	-83.90244109	40.50595442
121	-83.89807366	40.50595479

122	-83.8953761	40.50610463
123	-83.89222202	40.50617886
124	-83.88933953	40.50623475
125	-83.88490649	40.50614948
126	-83.88490649	40.50614948
127	-83.88257241	40.5058944
128	-83.88257241	40.5058944
129	-83.87373994	40.50595409
130	-83.87373994	40.50595409
131	-83.87373994	40.50595409
132	-83.87373994	40.50595409
133	-83.86544948	40.50630193
134	-83.86544948	40.50630193
135	-83.86544948	40.50630193
136	-83.85843766	40.5059872
137	-83.85843766	40.5059872
138	-83.85843766	40.5059872
139	-83.85386281	40.50591177
140	-83.84985361	40.50561042
141	-83.84985361	40.50561042
142	-83.8474214	40.50558509
143	-83.84067315	40.5057976
144	-83.91186668	40.50381889
145	-83.91186668	40.50381889
146	-83.90578418	40.50388787
147	-83.90578418	40.50388787
148	-83.89646175	40.50420906
149	-83.89646175	40.50420906
150	-83.89646175	40.50420906
151	-83.889995	40.50432853
152	-83.889995	40.50432853
153	-83.889995	40.50432853
154	-83.88225686	40.50438732
155	-83.88225686	40.50438732
156	-83.88225686	40.50438732
157	-83.87577184	40.50448209
158	-83.87577184	40.50448209
159	-83.87045509	40.50451153
160	-83.86774395	40.50457572
161	-83.86348411	40.50440873
162	-83.86348411	40.50440873

163	-83.86348411	40.50440873
164	-83.85569921	40.50416994
165	-83.85569921	40.50416994
166	-83.85569921	40.50416994
167	-83.84849781	40.50395574
168	-83.84950118	40.5038698
169	-83.842718	40.50395016
170	-83.91292231	40.50300333
171	-83.91292231	40.50300333
172	-83.90070393	40.5028003
173	-83.90070393	40.5028003
174	-83.89056903	40.50230527
175	-83.89056903	40.50230527
176	-83.89056903	40.50230527
177	-83.89056903	40.50230527
178	-83.88373851	40.5028139
179	-83.88373851	40.5028139
180	-83.88373851	40.5028139
182	-83.87541468	40.50293018
183	-83.87541468	40.50293018
184	-83.87541468	40.50293018
185	-83.87541468	40.50293018
186	-83.86754848	40.503745
187	-83.86877526	40.50317736
188	-83.86877526	40.50317736
189	-83.86664316	40.50311625
190	-83.86043183	40.50318074
191	-83.86043183	40.50318074
192	-83.86043183	40.50318074
193	-83.85440407	40.50328223
194	-83.85259763	40.5033643
195	-83.84882918	40.50287794
196	-83.84647833	40.50292942
197	-83.84647833	40.50292942
198	-83.84242704	40.50309478
199	-83.90725144	40.50121681
200	-83.90725144	40.50121681
201	-83.90171031	40.5014362
202	-83.90171031	40.5014362
203	-83.89880187	40.50050988
204	-83.89880187	40.50050988

205	-83.89880187	40.50050988
206	-83.88817014	40.50032827
207	-83.88817014	40.50032827
208	-83.88150607	40.50320868
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212	-83.88150607	40.50320868
213	-83.88150607	40.50320868
214	-83.87199695	40.50228905
215	-83.87199695	40.50228905
216	-83.86748623	40.50219203
217	-83.86152975	40.50221776
218	-83.86152975	40.50221776
219	-83.86152975	40.50221776
220	-83.85854503	40.50174997
221	-83.85854503	40.50174997
222	-83.85330852	40.50177104
223	-83.85330852	40.50177104
224	-83.91091388	40.49887194
225	-83.91091388	40.49887194
226	-83.90634087	40.49923407
227	-83.90253602	40.49956074
228	-83.89827654	40.49967389
229	-83.89827654	40.49967389
230	-83.89827654	40.49967389
231	-83.88905974	40.4990864
232	-83.88905974	40.4990864
233	-83.88905974	40.4990864
234	-83.88905974	40.4990864
235	-83.8815003	40.49929285
236	-83.87765509	40.49945775
237	-83.87765509	40.49945775
238	-83.87765509	40.49945775
239	-83.87000432	40.49973594
240	-83.87000432	40.49973594
241	-83.86406911	40.50013209
242	-83.86406911	40.50013209
243	-83.85852384	40.50012727
244	-83.85852384	40.50012727
245	-83.85852384	40.50012727

246	-83.85502134	40.499561
247	-83.85502134	40.499561
248	-83.84950478	40.50000092
249	-83.91496088	40.49730065
250	-83.91496088	40.49730065
251	-83.90781546	40.49823429
252	-83.90781546	40.49823429
253	-83.89947909	40.4982536
254	-83.89947909	40.4982536
255	-83.89947909	40.4982536
256	-83.89479642	40.49810182
257	-83.89479642	40.49810182
258	-83.89091443	40.49803395
259	-83.89091443	40.49803395
260	-83.89091443	40.49803395
261	-83.87931724	40.49817386
262	-83.87931724	40.49817386
263	-83.87931724	40.49817386
264	-83.87931724	40.49817386
265	-83.87931724	40.49817386
266	-83.86898222	40.49756162
267	-83.86477118	40.49772673
268	-83.86477118	40.49772673
269	-83.85856272	40.49782863
270	-83.85856272	40.49782863
271	-83.85856272	40.49782863
272	-83.84788737	40.49793096
273	-83.91464294	40.49591568
274	-83.91464294	40.49591568
275	-83.91464294	40.49591568
276	-83.90788968	40.49691236
277	-83.90255588	40.49632519
278	-83.90255588	40.49632519
279	-83.89535829	40.49652214
280	-83.89535829	40.49652214
281	-83.89535829	40.49652214
282	-83.89535829	40.49652214
283	-83.88525393	40.49664214
284	-83.88525393	40.49664214
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Appendix H: Glossary of Useful Terms Related to Lake Management

Benthos/Benthic – A term used to describe or imply the bottom of a waterbody.

Epilimnion – When a body of water is stratified (has distinct density layers), this is the depth of water closer to the surface (upper layer). In the summer, it is between the thermocline and water/air interface.

HAB – Harmful algal bloom, describes excessive growth of cyanobacteria which are a type of algae known to be able to produce harmful toxins. These toxins can be harmful to human and animal health at high enough quantities.

Hypolimnion – When a lake is stratified (has distinct density layers), this is the depth of water near the bottom of the waterbody. In the summer, it is defined as the area under the thermocline.

Internal Loading – a term used to describe the phenomenon of increased phosphorus levels in the hypolimnion of a stratified lake when oxygen is depleted in this region. Changes in the chemistry of iron in the sediment layer cause phosphorus to be released from these sediments.

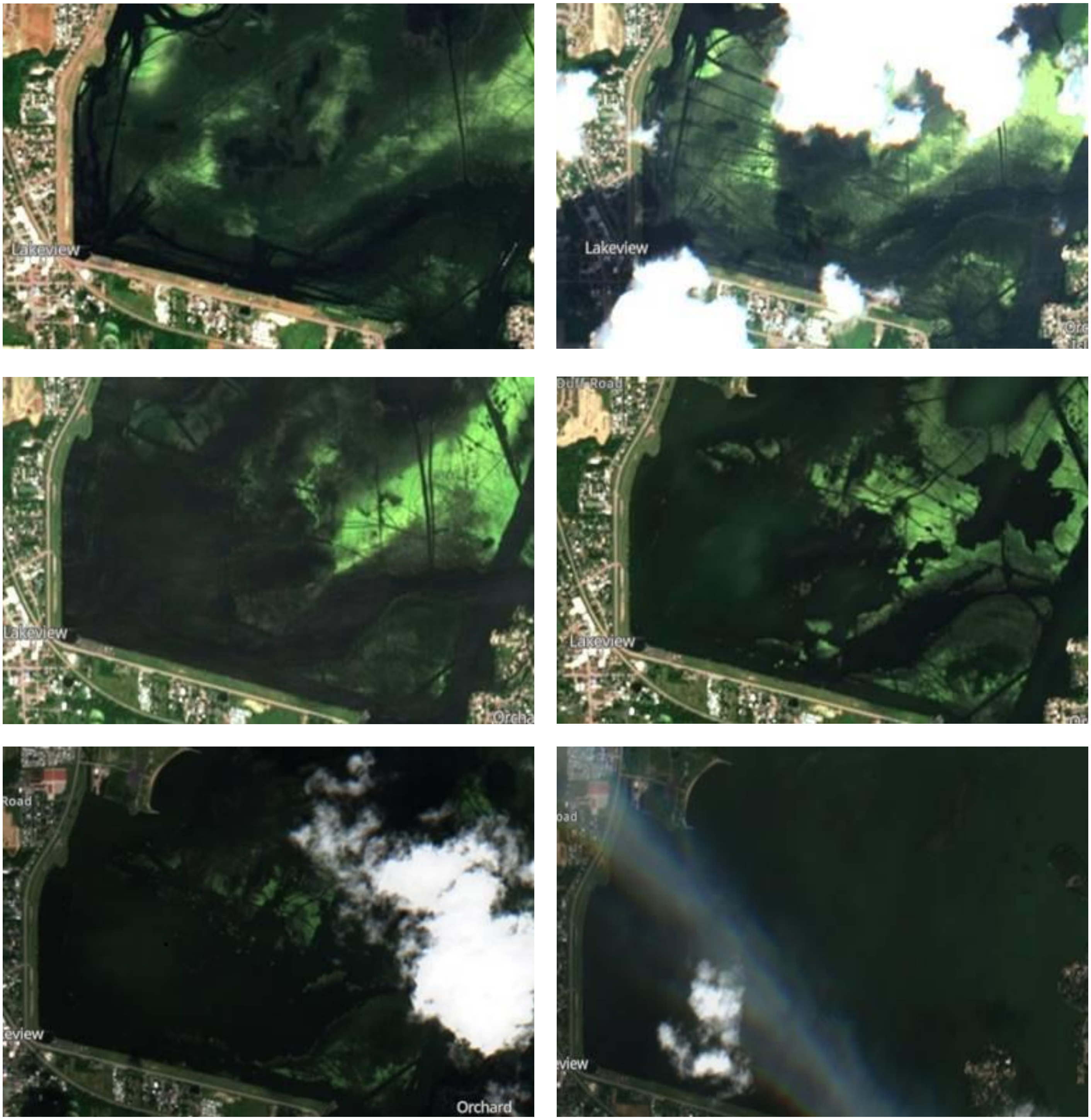
Littoral Zone – The area of a lake where macrophytes can grow due to the availability of light for growth.

Macrophytes – A term that describes aquatic plants as well as some species of "plant-like" algae.

Production – A way to describe plant and algae growth potential in a waterbody. Typically it is described by quantity of chlorophyll *a* (primary photosynthetic pigment of many algal species), Secchi transparency (how clear the lake is), and the amount of available phosphorus for biological uptake (primary growth nutrient in limited quantities in water).

Thermocline – The depth designated as to where the greatest change in temperature is.

Appendix I: Satellite Imagery of Open Recreational Zone During ProcellaCOR® Applications (7/3, 7/13, 7/28, 8/17, 8/27, 9/16 2022 starting top left)



Appendix J: Water Quality Training for Lake Communities Presentation

Water Quality Training for Lake Communities

Goal: Provide an introductory course for basic recreational water quality data collecting and educate on things to look out for while on a lake.

- This is meant for the common person. We'll try to keep things simple!

Water Quality Training for Lake Communities

What is water quality?

- Physical, chemical, and biological components of water.
- Defined based on perspective and use of water.
- What makes ”good” water quality vs. “bad”?

Water Quality Training for Lake Communities

Overview of topics:

-Why even collect the information?
- What is water quality?
- What do we want to collect?
- What does the information mean?
- What should we look out for?

Water Quality Training for Lake Communities

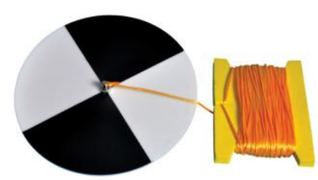
<u>What is water quality?</u>

- Physical, chemical, and biological components of water.
- Defined based on perspective and use of water.
- What makes ”good” water quality vs. “bad”?

Water Quality Training for Lake Communities

<u>What do we want to collect?</u>

- Information relevant to recreational waterbodies:
    1. Nutrient information (phosphorus and nitrogen)
    2. Secchi Transparency or depth
    3. Chlorophyll a
    4. Oxygen levels
    5. Temperature at depth
    6. “Lake specific” information



Water Quality Training for Lake Communities

What do we want to collect?

- Information relevant to recreational waterbodies:
    1. Nutrient information (phosphorus and nitrogen)

How to sample: Take a "grab sample" by collecting water in a proper sample bottle at arm depth. Be sure to open the cap under the water at the proper depth vs. out of the water.

Van Dorn Bottle Sampler

Collecting samples at different depths will require the use of a sampling device like a Van Dorn bottle.

Be aware there may be preservatives in bottles being sent to labs.

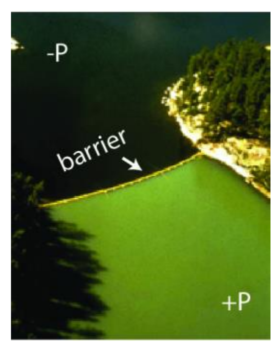
Water Quality Training for Lake Communities

What do we want to collect?

- Information relevant to recreational waterbodies:
    1. Nutrient information (phosphorus and nitrogen)

Important notes: Make sure water samples (all samples) are put on ice after collection. When I ship them out to labs I put a ice pack (from a local pharmacy) in with the samples and put it all in a labelled gallon plastic bag. A chain of custody needs to be filled out for lab samples.
Make sure the bottles are also labelled with the following:

- Date
- Location
- Water Depth
- Water test to be performed



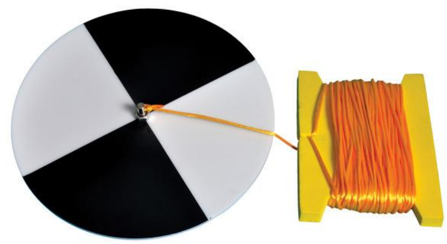
Water Quality Training for Lake Communities

<u>What do we want to collect?</u>

- Information relevant to recreational waterbodies:
  2. Secchi Transparency or depth

<u>How to collect:</u> We use a Secchi disk (pictured). Drop the disk on the *shady side* of a boat/dock until you cannot see it anymore. Then slowly raise it up until you can just barely see it. Take the average of these two numbers to get your Secchi depth.

Make sure you're not wearing sunglasses



Water Quality Training for Lake Communities

<u>What do we want to collect?</u>

- Information relevant to recreational waterbodies:
  2. Secchi Transparency or depth

Make your own! https://youtu.be/sbQ2nVt_5GY

Video from NALMS: https://www.nalms.org/secchidipin/monitoring-methods/quick-start-video/

* Environmental conditions (clouds, etc.) may impact readings*

Water Quality Training for Lake Communities

What do we want to collect?

- Information relevant to recreational waterbodies:
  3. Chlorophyll a

How to sample: See nutrient collection in previous slides. Procedures are the same! Just be sure to utilize a non-preserved bottle or a preserved bottle suggested by the laboratory (vary depending on technique they employ but most I've seen use vacuum filtration). LABEL!

Youtube link (simple!):
https://youtu.be/99VxjlslYBk

Water Quality Training for Lake Communities

What do we want to collect?

- Information relevant to recreational waterbodies:
  4. Oxygen levels

How to sample: A sampling probe will be needed here! Follow the procedures for use of the sampling device (may need to calibrate it, ensure you don't dry our probe membranes, etc.).

Most handheld probes have a readout unit, connection line, and probe assembly (picture). Surface units may be handheld but I would suggest one that can sample at various depths.
General guide: https://www.youtube.com/watch?v=YrA602_d-SI

Water Quality Training for Lake Communities

<u>What do we want to collect?</u>

- Information relevant to recreational waterbodies:
    5. Temperature at depth

<u>How to sample</u>: Same as oxygen!

Water Quality Training for Lake Communities

<u>What do we want to collect?</u>

- Information relevant to recreational waterbodies:
    6. "Lake specific" information

<u>How to sample</u>: Depends on what you're collecting!

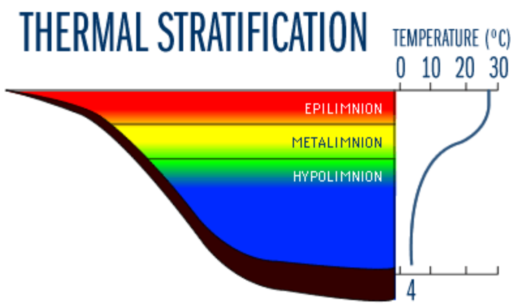
Aquatic plant sampling with a "macrophyte rake"

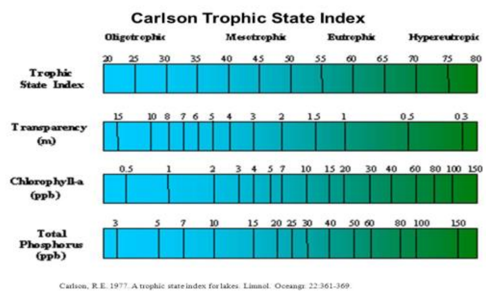
Depth and sediment depth with a sediment probe

Water Quality Training for Lake Communities

<u>What does the data mean?</u>

- Nutrients, Secchi Transparency, Chlorophyll a
  - ➢ Relate to lake productivity. How much growth (algae and plants) should be expected? Can you expect this to change overtime?
- Temperature and oxygen
  - ➢ Relate to gilled organism survival and habitat availability. Also allows us look into lake *stratification.*





Water Quality Training for Lake Communities

<u>What does the data mean?</u>

ALL DATA IS MORE POWERFUL AND IMPORTANT WHEN COLLECTED OVER A LONG PERIOD OF TIME!

Water Quality Training for Lake Communities

<u>What should lake communities look out for?</u>

- You don't need to always collect water quality info to be a part of helping the lake!
- Look out for these things:
  1. Identifying Harmful Algae Blooms (cyanobacteria)
  2. Identifying invasive species
  3. Knowing "water colors"

Water Quality Training for Lake Communities

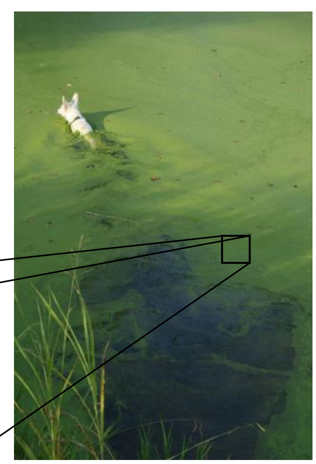
<u>What should lake communities look out for?</u>

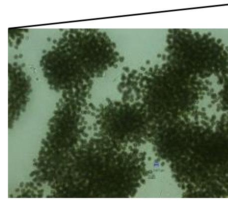
- Look out for these things:
  1. Identifying Harmful Algae Blooms (cyanobacteria)

HAB: Harmful Algae Bloom. Occur when a large bloom of cyanobacteria occurs and harmful ***cyanotoxins*** are potentially produced:

Toxin Type	What does it Harm?
Neurotoxin	Nervous System
Hepatoxin	Liver
Dermatoxin	Skin

Everyone should know how to Identify what a potential HAB looks like for their safety.





Zoomed in *Microcystis*

Water Quality Training for Lake Communities

What should lake communities look out for?

- Look out for these things:
  1. Identifying Harmful Algae Blooms (cyanobacteria)

Neon-green "paint-like" spatter

Odd smell from geosmin release

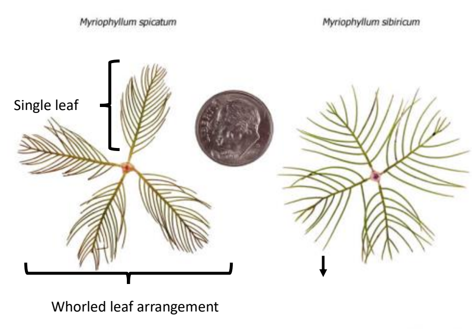
"Blue-green" color

Water Quality Training for Lake Communities

What should lake communities look out for?

- Look out for these things:
  2. Identifying Invasive Species

- Eurasian watermilfoil (*Myriophyllum spicatum*)
- Northern watermilfoil (*Myriophyllum sibiricum*)
- Parrotfeather (*Myriophyllum aquaticum*)



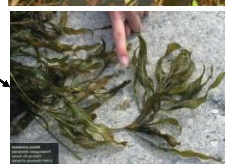
Northern watermilfoil and Eurasian watermilfoil are very similar in appearance to each other. Note the difference in leaflet structures per leaf. Also, there is the "hold upside down" trick.

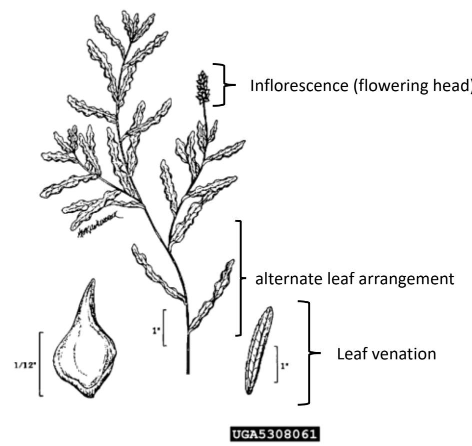
Water Quality Training for Lake Communities

What should lake communities look out for?

- Look out for these things:
  2. Identifying Invasive Species

- Curly-leaf pondweed (*Potamogeton crispus*)
- Long-leaved/ American pondweed (*Potamogeton nodosus*)
- Illinois pondweed (*Potamogeton illinoensis*)
- ***Hundreds*** more species…



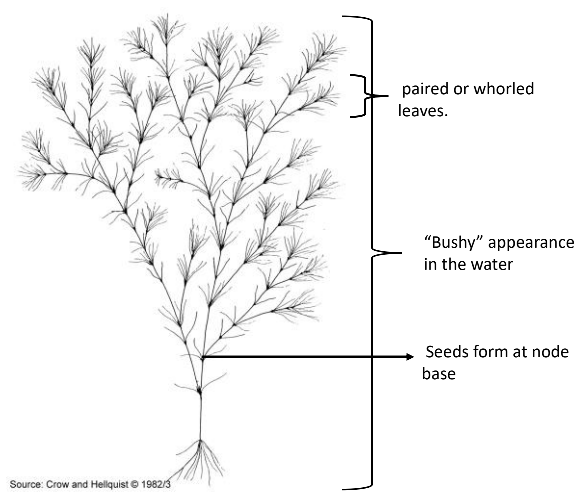


Water Quality Training for Lake Communities

What should lake communities look out for?

- Look out for these things:
  2. Identifying Invasive Species

- Brittle naiad (*Najas minor*)
- Slender naiad (*Najas flexilis*)

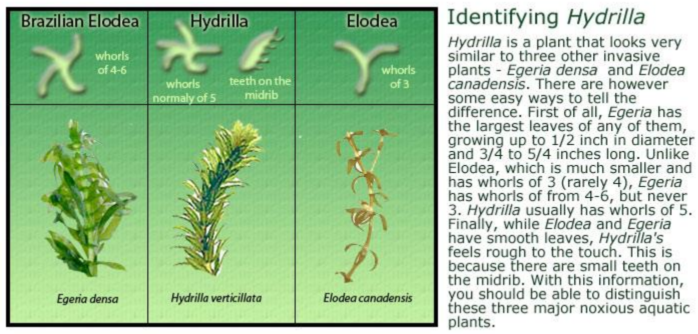


Water Quality Training for Lake Communities

What should lake communities look out for?

- Look out for these things:
  2. Identifying Invasive Species

- Hydrilla (*Hydrilla verticillata*)
- Brazilian Elodea (*Egeria densa*)
- Common waterweed (*Elodea canadensis*)



Water Quality Training for Lake Communities

What should lake communities look out for?

- Look out for these things:
  2. Identifying Invasive Species – Natives found in the lake

- Eels grass (*Vallisneria americana*)
- Bladderwort (*Utricularia*)

- Coontail (*Ceratophyllum demersum*)
- Sago pondweed (*Stuckenia pectinata*)

Water Quality Training for Lake Communities

What should lake communities look out for?

- Look out for these things:
  3. Knowing "water colors"

Clear-water

Nutrient-Rich

High Sedimentation

Blue-Green Algae

Iron-Source