MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
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STAFF REPORT

ALGAL TOXIN MONITORING IN MICHIGAN INLAND LAKES
2016 RESULTS

Introduction

The term “harmful algal bloom (HAB)” generally describes accumulations of cyanobacteria that are aesthetically unappealing and produce algal toxins. In 2015 the Michigan Department of Environmental Quality (MDEQ), Water Resources Division (WRD), developed the following definition of a HAB (Kohlhepp, 2015a): “An algal bloom in recreational waters is harmful if microcystin levels are at or above the 20 micrograms per liter (µg/L) World Health Organization (WHO) non-drinking water guideline, or other algal toxins are at or above appropriate guidelines that have been reviewed by MDEQ-WRD.” A bloom should be considered *potentially* harmful when “the chlorophyll *a* level is greater than 30 µg/L and visible surface accumulations/scum are present, or cells are visible throughout the water column.” A key concept of this HAB definition is that while high chlorophyll *a* concentration and visible surface/water column algal accumulation can indicate potential problems, the WRD’s focus is on the potential harm that toxins represent so water samples must be analyzed for the presence of toxins to confirm that a bloom may, in fact, be harmful to humans or wildlife. Visible appearance of blooms often cannot be used as a reliable predictor of toxin content.

The WRD receives reports each year about nuisance algal conditions, which may, or may not, be HABs, from district staff, lake associations, and the broader public. These reports can come in as concerns about algae, cyanobacteria, or about suspected pollutants or toxic substances in the water, such as “green paint spills,” which upon investigation, turn out to be cyanobateria. The number of such reports, particularly the occurrence of blue-green algal blooms and concern over the possible presence of toxins such as microcystin, appear to have increased in recent years, although this is difficult to quantitatively confirm (Parker, 2014, 2015, 2016a, 2016b). As a result, the MDEQ-WRD established an internal work group in March 2013 to develop an approach to monitor, assess, and report on nuisance and harmful algal conditions, to improve our understanding of the nature, extent, and frequency of algal blooms in inland waters and nearshore Great Lakes.

The need to understand and address HABs became more urgent in August 2014. Severe blooms were observed in the western basin of Lake Erie, and access to drinking water for hundreds of thousands of people served by the city of Toledo water treatment facility was temporarily interrupted due to elevated levels of an algal toxin associated with the bloom. This event caused the MDEQ-WRD to reexamine and expedite our efforts related to HABs.

Historic monitoring has found that microcystin concentrations in Michigan inland lakes are not typically very high across lakes that are randomly sampled. Sarnelle and Wandell (2008) found that only 2 of the 77 inland lakes sampled by volunteers in August and September 2006 had microcystin concentrations greater than 20 µg/L. Rediske et al. (2007) also sampled 7 drowned-river mouth lakes in western Michigan in 2006 and did not find any microcystin samples above 20 µg/L. During the United States Environmental Protection Agency’s (USEPA), National Lake Assessments (NLA), in 2007 and 2012, no samples exceeded 20 µg/L (Kohlhepp, 2015b).

Recently, the state of Ohio issued a recreational guidance of 6 µg/L for total microcystins *(The link provided was broken and has been removed)*. A revisit of Rediske et al. (2007) revealed 2 of the 7 drowned river mouth lakes sampled had instances where microcystin concentrations were greater than 6 µg/L. Using the state of Ohio guidance value did not change the number of elevated microcystin values found by Sarnelle and Wandell (2008) and in the NLA surveys.

In 2016, algal toxin monitoring occurred in targeted and randomly selected inland lakes, as well as lakes where citizens or staff reported algal blooms. This study was designed to allow the MDEQ to further understand: (1) the range of algal toxin concentrations across Michigan inland lakes; (2) how algal toxin concentrations change during a growing season in Michigan lakes; (3) if lake water chemistry parameters correlate with algal toxin concentrations; and (4) how microcystin results compare using rapid field test strips and laboratory, quantitative analysis.

Study Design

To achieve the study objectives, WRD biologists collected water quality data at randomly selected lakes, targeted inland lakes, and water bodies that concerned citizens or staff reported to the MDEQ concerning algal blooms. The random sites were selected to represent a large geographic range and to provide the ability to broadly understand conditions among Michigan's inland lakes during the summer growing season. The targeted lakes were selected because they are known to have high concentrations of nutrients and/or historic problems with algae blooms and were expected to represent some of the most productive lakes in Michigan.

Table 1. Michigan Department of Natural Resources (MDNR), Fisheries Division's (FD), randomly selected lakes sampled twice during summer 2016.

LAKE	County
Bear Lake	Hillsdale
Camp 41 Lake	Delta
Clark Lake	Luce
Dumont Lake	Allegan
Five Channels Lake	Iosco
Fourmile Pond	Alpena
Haithco Lake	Saginaw
Hoffman Lake	Isabella
Holloway Reservoir	Genesee
Johnson Lake	Ogemaw
Lake George	Baraga
Little Duck Lake	Gogebic
Long Lake	Ionia
Long Lake	Isabella
McDonald Lake	Gogebic
Milakokia Lake	Mackinac
Ocqueoc Lake	Presque Isle
Parent Lake	Baraga
Pearl Lake	Benzie/Leelanau
Pentwater Lake	Oceana
Pike Lake	Luce
Pretty Lake	Luce
Round Lake	Isabella
West Twin Lake	Muskegon
Upper Silver Lake	Oakland
Walloon Lake	Charlevoix/Emmett
West Londo Lake	Iosco

The 27 randomly selected inland lakes (Table 1, Figure 1) included in this project were monitored in 2016 utilizing the MDNR-FD's and MDEQ-WRD's status and trends programs. These lakes were sampled for microcystins twice during the 2016 summer growing season; in July by MDEQ-WRD staff and in August by MDNR-FD staff. On both dates, field crews visually assessed whether an algal bloom was occurring in any portion of the lake, collected up to 4 surface water samples per lake, and used Abraxis (Abraxis, Inc., Warminster, PA) test strips to estimate microcystin concentrations. General lake water chemistry samples were also collected at the center of the lake in July and August.

Two inland lakes were targeted for weekly monitoring from June to mid-September 2016: Crockery Lake, Ottawa County and Mona Lake, Muskegon County. Crockery Lake has a maximum depth of about 55 feet and is located in the headwaters of Crockery Creek, which is a major tributary to the Grand River. Crockery Lake is located in the North Branch Crockery Creek subwatershed (HUC 040500060601) where the land use is 72% agricultural, 6% developed, 19% forest and wetland, and 3% other (Parker and Rippke, 2016). Mona Lake is a drowned river mouth lake in west Michigan that is a tributary to Lake Michigan with a maximum depth of 27 feet. Crockery and Mona Lakes were chosen for targeted monitoring because large algal blooms had occurred in them previously. Finally, lakes were also sampled in response to citizen or staff concerns about observed algae blooms.

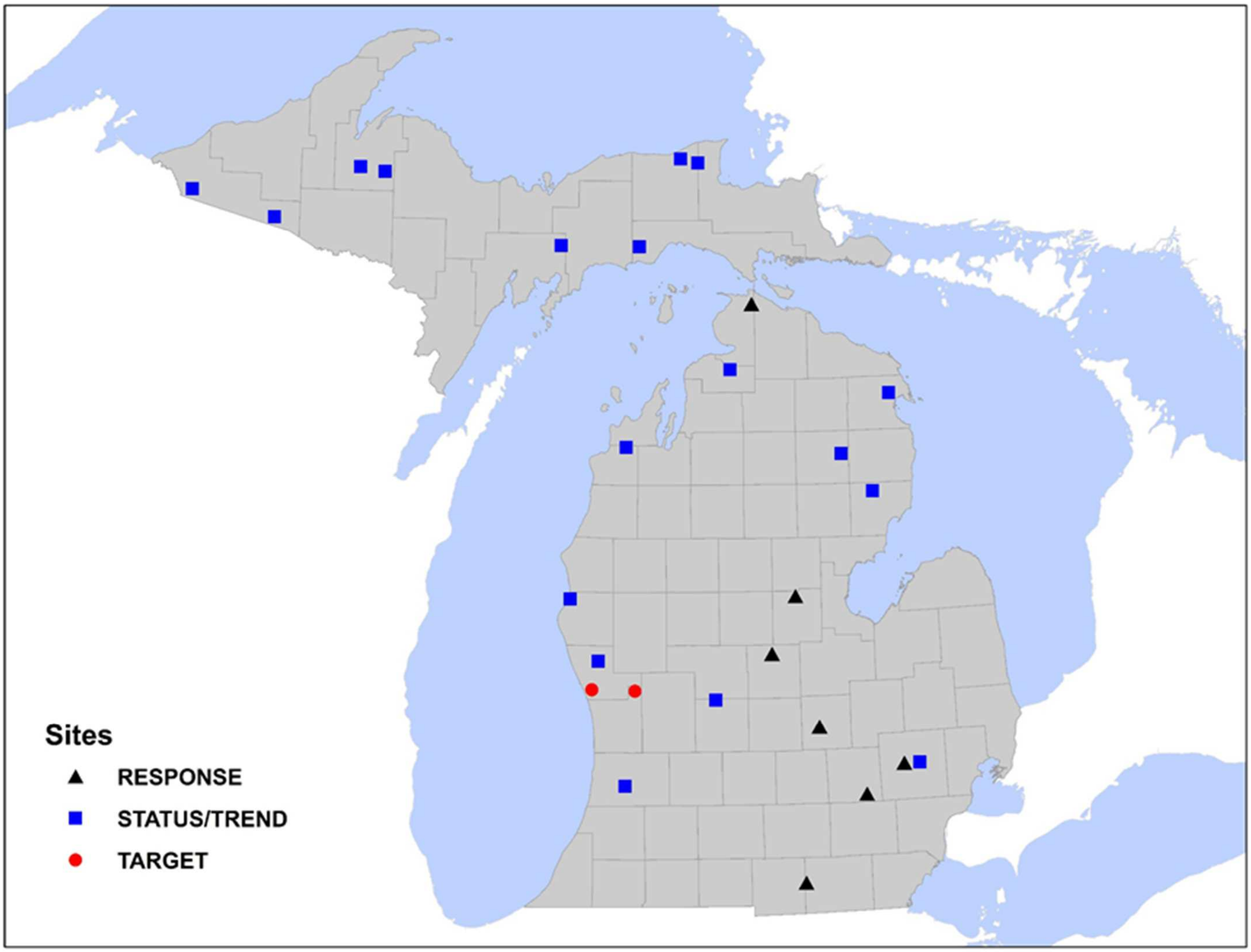

Figure 1. 2016 algal toxin monitoring locations. Lake Erie and Saginaw Bay data are summarized in a separate report.

Field Methods

Sampling occurred between early June and mid-October, with most monitoring occurring in July and August. During a monitoring event at a targeted lake, MDEQ-WRD staff took pictures of algal conditions, collected general water chemistry in the center of the lake, and collected water samples for algal toxin analysis from up to four locations around the lake. The algal toxin samples were analyzed using both Abraxis test strips to estimate microcystin concentration and tandem liquid chromatography mass spectrometry (LC/MS/MS) for quantitative assessment of a suite of algal toxins including microcystins, cylindrospermopsins, and anatoxins.

Survey Forms

A field sheet was completed during every targeted lake survey to document shoreline algae levels and accumulation.

Water Samples - General Chemistry

Water sample parameters collected at the status and trend lakes and the targeted lakes were generally similar. At all lakes, temperature, dissolved oxygen, conductivity, and pH were measured using a YSI sonde at the mid-lake location. At the same location as sonde sampling, water samples were collected for nutrient analyses and a Secchi disk reading was taken.

At all lakes, surface water samples were collected at approximately 1-foot depth using new, 250 milliliter (ml) polypropylene sample bottles that were triple-rinsed with site water. At targeted lakes and response lakes where a boat could be taken to the center of the lake, the following samples were collected: total phosphorus, total Kjeldahl nitrogen, nitrate+nitrite, ortho-phosphate, and chlorophyll *a*. The total phosphorus, total Kjeldahl nitrogen, and nitrate+nitrite were preserved with hydrochloric acid in the field. Chlorophyll *a* samples were collected using an integrated depth sampler. Samples were collected with the integrated sampler throughout the water column at two times the Secchi depth and samples were preserved with magnesium carbonate in the field. The samples were analyzed at the MDEQ Environmental Laboratory using standard USEPA methods (Table 2). At the status and trend lakes the same nutrient samples were collected, excluding ortho-phosphate.

Following collection, sample bottles were placed on ice or refrigerated for transport and storage prior to delivery to the laboratory. At targeted lakes, the nutrient samples were not collected at every sampling event if sampling occurred several times over a week. The August status and trend water chemistry samples were collected by MDNR-FD staff and analyzed by the Great Lakes Environmental Center.

Water Samples - Algal Toxins

At all lakes, 1 mid-lake sample and 3 shoreline samples were collected in 250 ml polyethylene terephthalate sample bottles at the water surface. Shoreline samples were typically collected at 2- to 6-foot depths. If an obvious surface scum was present, an additional sample of that material was collected to represent a “worst-case scenario” sample. The shoreline sampling locations were distributed approximately evenly around the shoreline of the lake. However, downwind locations, bays that may be used for recreation, areas impacted by river outlets, or beaches were preferentially targeted. Because of the cost of laboratory sample analysis, typically only one sample from a lake was analyzed for cyanotoxins.

Raw water and scum samples that were analyzed using qualitative and quantitative methods were kept on ice during transport back to the laboratory. Microcystin presence/absence was determined using test strips. This procedure was typically performed within 24 hours of initial collection on all samples. If the initial test strip indicated that microcystins were present in the sample, then it was delivered to the Michigan Department of Health and Human Services’ laboratory for quantitative analysis. Quantitative analysis of anatoxin-a, cylindrospermopsin, and 13 microcystin congeners was performed using LC/MS/MS.

Qualitative microcystin samples were held on ice or refrigerated for no more than 5 days prior to analysis. If microcystin samples were held longer than 5 days, they were frozen with care taken to reduce volume to allow for expansion. MDEQ-WRD staff analyzed the July status and trend samples and all targeted lake samples using the test strips. The August status and trend samples were analyzed by staff of the Great Lakes Environmental Center.

Table 2. Analytical methods and reporting limits.

Parameter	Analytical Method	Reporting Level (ug/L)
Microcystin LR	LC/MS/MS	0.008
Microcystin RR	LC/MS/MS	0.004
Microcystin YR	LC/MS/MS	0.008
Microcystin LA	LC/MS/MS	0.008
Microcystin LF	LC/MS/MS	0.008
Microcystin LW	LC/MS/MS	0.008
Microcystin LY	LC/MS/MS	0.008
Microcystin WR	LC/MS/MS	0.008
Microcystin HILR	LC/MS/MS	0.008
Microcystin HTYR	LC/MS/MS	0.008
Microcystin LR D-ASP3	LC/MS/MS	0.008
Microcystin RR D-ASP3	LC/MS/MS	0.004
Microcystin LR DHA7	LC/MS/MS	0.008
Anatoxin-a	LC/MS/MS	0.02
Cylindrospermopsin	LC/MS/MS	0.02
Qualitative Total Microcystin	Abraxis Test Strips (PN52022)	1
Total Phosphorus	USEPA 365.4	10
Kjeldahl Nitrogen	USEPA 351.2	100
Ammonia	USEPA 350.1	10
Nitrate+Nitrite	USEPA 353.2	10
Ortho-phosphate	USEPA 365.1	10
Chlorophyll *a*	10200H (Standard Methods)	1

Data Analysis

Trophic status indices (TSI) were calculated using the TSI equation from Fuller and Minnerick (2008) for lakes that were sampled at the maximum lake depth via boat, using the total phosphorus (milligrams per liter), chlorophyll *a* (µg/l), and mid-lake Secchi depth (meters) values. Molar N:P ratios were also calculated for Mona and Crockery Lakes (Downing and McCauley 1992). To evaluate the effect of observed chemical/physical parameters measured at the time microcystin samples were collected, a principal components analysis (PCA) was performed. The PCA was used to reduce the dimensionality of the correlated, independent variables, into a single value, or PC 1 score. The first PC score often represents the degree of anthropogenic disturbance that a system is experiencing. High PC 1 scores typically represent more disturbed systems, whereas low PC 1 scores often represent less disturbed environments

(Uzarski et al., 2005). Pearson correlations between the PC 1 scores, acting as a surrogate for disturbance, and microcystin values (log_{10}-transformed to homogenize variances) were performed to assess whether overall site conditions could explain observed toxin concentrations. Chemical/physical data for the above analyses were only used from specific sites where samples were sent to the laboratory for microcystin analysis. Linear regressions were also performed on total phosphorus and microcystin concentrations in Mona and Crockery Lakes. Xie et al. (2012) reported a positive relationship between total phosphorus and microcystin concentrations in Mona Lake in 2006 and we wanted to evaluate whether the same relationship existed in 2016.

A Welch two-sample t-test was performed on microcystin concentration values that originated from scum samples versus ambient water samples. Logistic regression was used to model the probability of the test strips to initially detect the presence of microcystin. Non-detections were scored a zero and any detection was scored a one. Those categorical data were then regressed against the laboratory data.

RESULTS

Water samples were collected and analyzed for microcystin from 38 different inland water bodies throughout the state in 2016. Out of 109 individual samples that were analyzed in the laboratory, only 3 were above 6 µg/l.

Status and Trend Lakes

Over the course of the July and August 2016 sampling, 216 microcystin test strips were run on discrete samples from the status and trend lakes. Those initial test strip results indicated that 1 of the lakes had microcystin present. Laboratory analysis of the 1 lake, Long Lake, Ionia County, found that it had 1 µg/l and 4.3 µg/l microcystin in the July and August samples, respectively. No anatoxin or cylindrospermopsin were detected in any of the status and trend lakes.

Targeted Lakes

Mona and Crockery Lakes were each visited on 13 separate occasions. Nutrient and chlorophyll *a* samples were collected on 12 of those trips. No anatoxin or cylindrospermopsin were detected in Mona or Crockery Lakes throughout 2016.

In Mona Lake, the highest recorded microcystin concentration was 2.8 µg/l recorded on August 22, 2016. The remaining samples either did not have detectable amounts of microcystin, or concentrations were less than 1 µg/l (Figure 2). The area of Mona Lake with the highest average microcystin concentrations was on the eastern side of the lake (Figure 3). Mona Lake's average TSI values ranged from high mesotrophic (48.5) to hypereutrophic (62) with an average TSI of 56.3 (eutrophic; Figure 4). The molar N:P ratio was 69 all season long with no fluctuation. Microcystin concentrations in Mona Lake were positively correlated with total phosphorus concentrations ($R^2 = 0.46$, $P = 0.015$).

Crockery Lake had very low microcystin concentrations throughout the 2016 sampling period. Most of the samples collected did not have detectable concentrations of microcystin. The highest microcystin concentration recorded was 0.045 µg/l on August 22, 2016 (Figure 5). Crockery Lake's average TSI values ranged from high mesotrophic (48.5) to hypereutrophic

(62) with an average TSI of 55.8 (eutrophic; Figure 6). The molar N:P ratio in Crockery Lake ranged from 99 – 157. There was no correlation between microcystin and total phosphorus ($R^2 = 0.09$, $P = 0.34$).

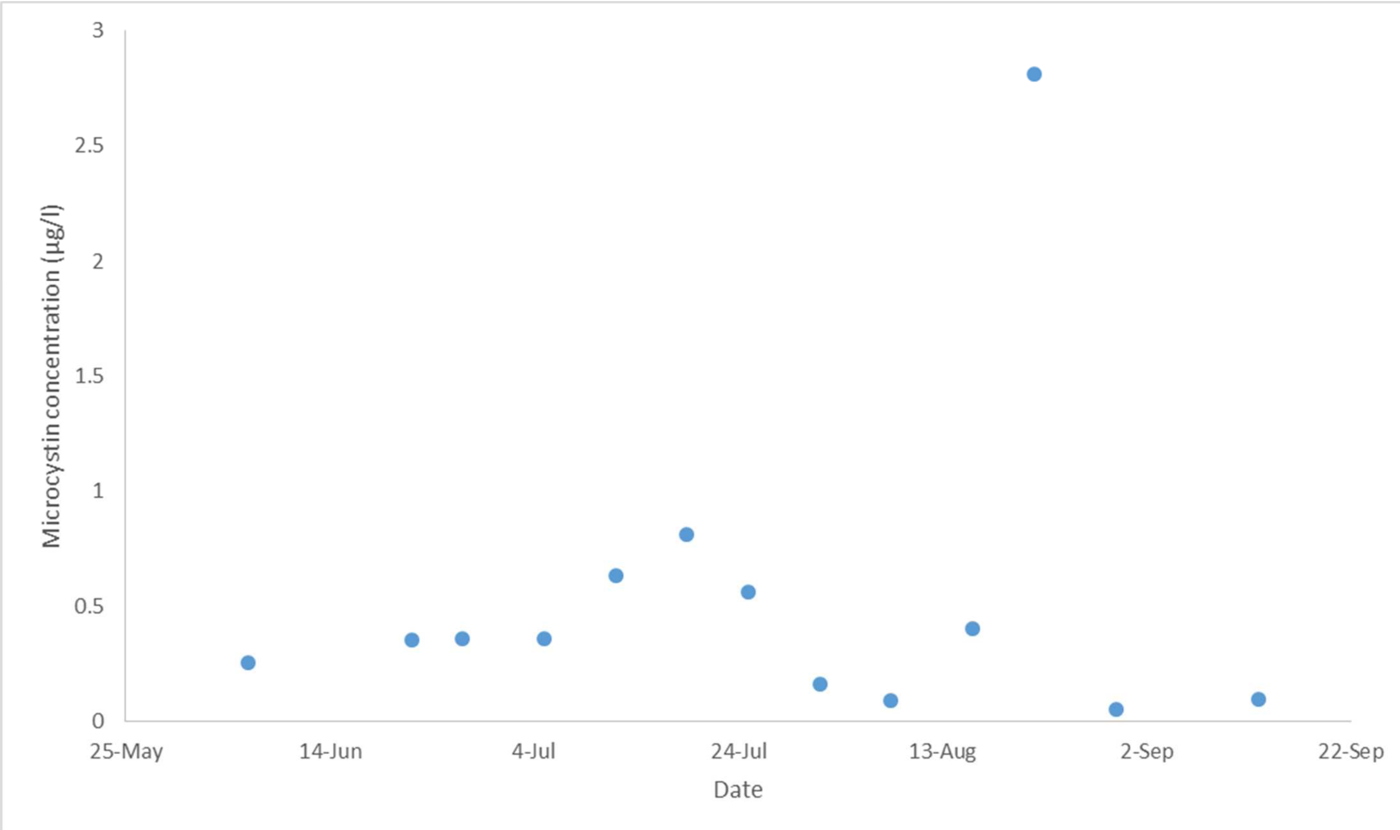

Figure 2. Microcystin concentrations from early June through mid-September 2016 in Mona Lake, Muskegon County.

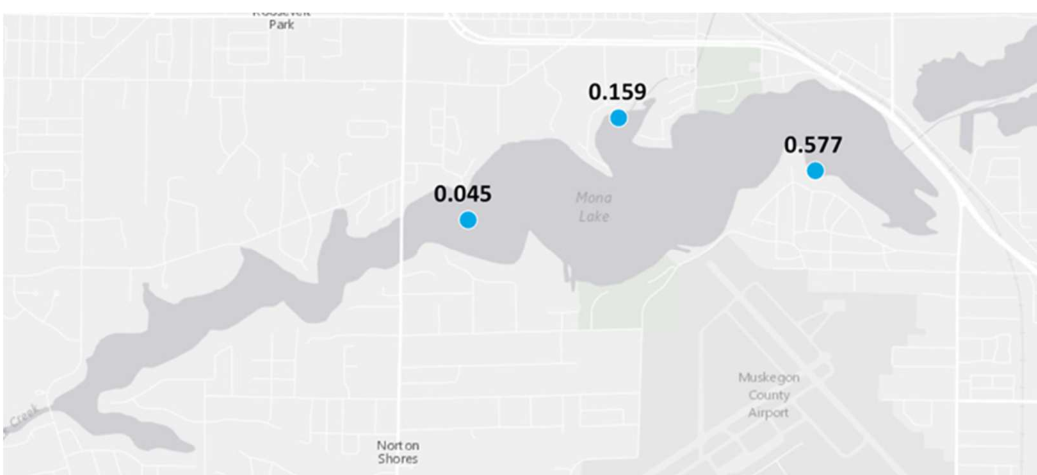

Figure 3. Average microcystin concentrations at different sampled areas of Mona Lake, Muskegon County, in 2016.

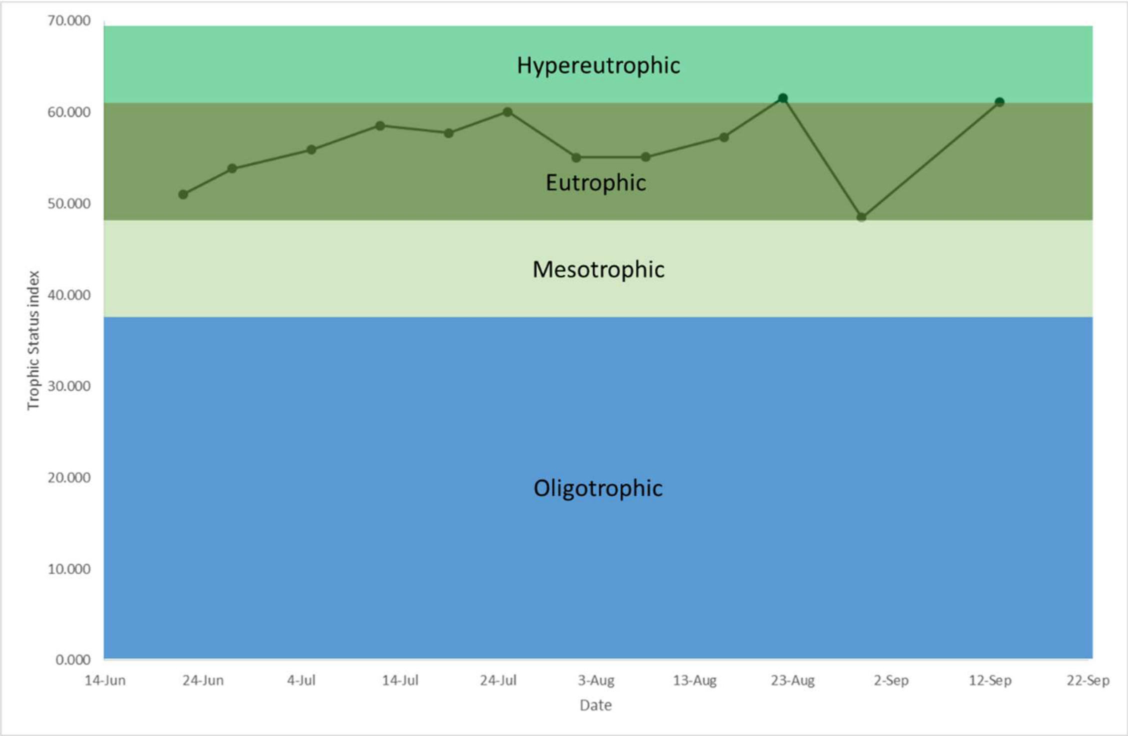

Figure 4. Trophic status indices calculated for Mona Lake throughout 2016 based on total phosphorus, chlorophyll *a*, and Secchi depth. Trophic status ranges from Fuller and Minnerick (2008) are as follows: oligotrophic: <38, mesotrophic 38-48, eutrophic 49-61, and hypereutrophic >61.

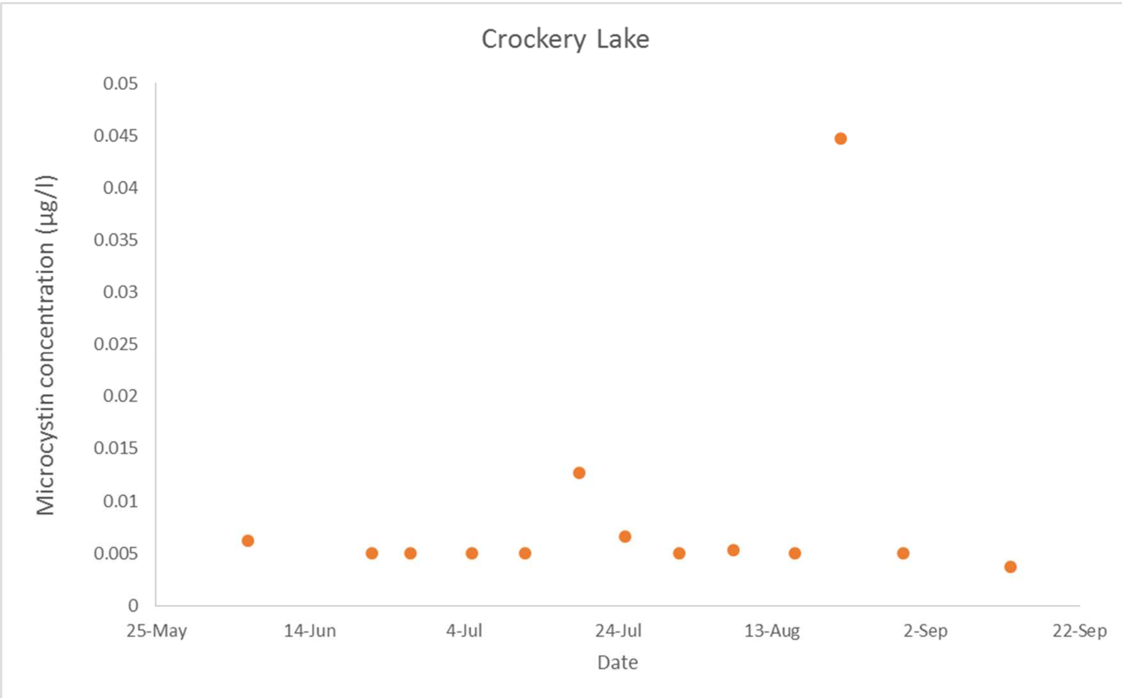

Figure 5. Microcystin concentrations from early June through mid-September 2016 in Crockery Lake, Ottawa County.

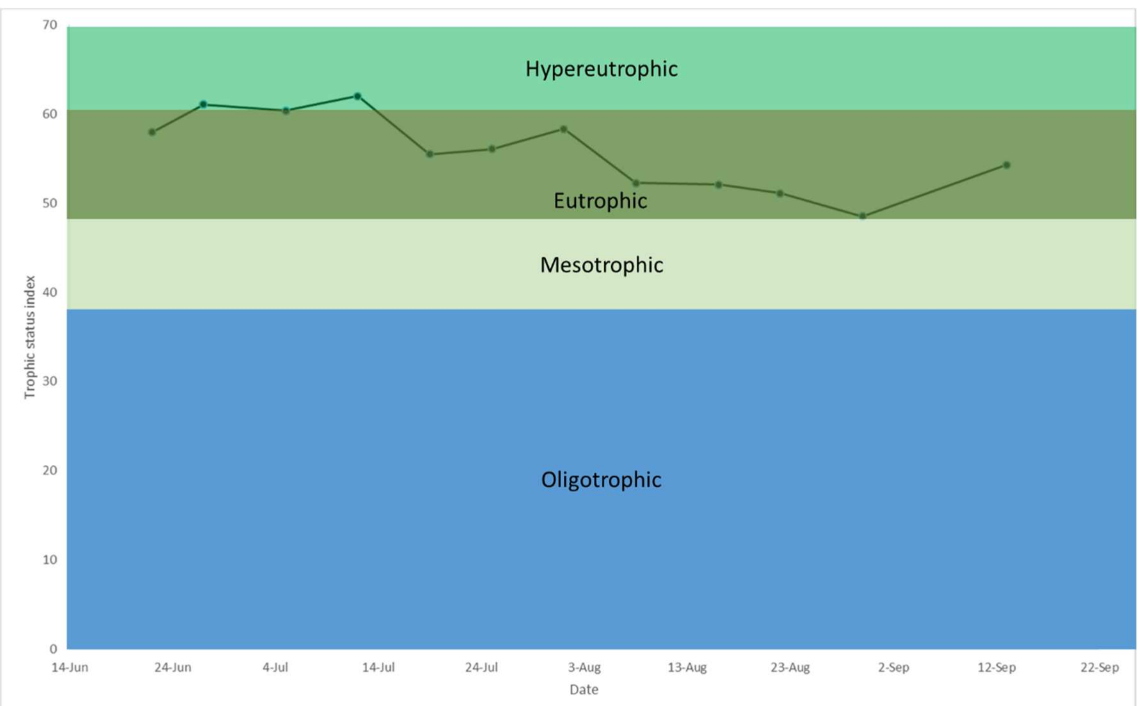

Figure 6. Trophic status indices calculated for Crockery Lake throughout 2016 based on total phosphorus, chlorophyll *a*, and Secchi depth. Trophic status ranges from Fuller and Minnerick (2008) are as follows: oligotrophic: <38, mesotrophic 38-48, eutrophic 49-61, and hypereutrophic >61.

Response Lakes

In 2016, WRD staff were contacted either by private citizens or staff about algae blooms occuring in 25 different water bodies throughout the state. Algal bloom complaints began in late June and continued into early November 2016. The majority of the complaints were in the southern half of the Lower Peninsula (Parker, 2016b). Response efforts were made at 9 different water bodies, in which water samples were collected and analyzed for microcystin. At 4 of those water bodies, microcystin concentrations from several samples were less than 1 µg/l. At the remaining water bodies, peak microcystin concentrations ranged from 5.1-122 µg/l (Appendix 1). Anatoxin was detected in low concentrations in Sanford Lake, Midland County (1.8 µg/l), St. Louis Impoundment (impoundment of the Pine River), Gratiot County (1.3 and 2.4 µg/l), and (little) Round Lake, Lenawee County (0.52 and 0.16 µg/l). These results were all lower than the state of Ohio’s anatoxin recreational guidance of 80 µg/l *(The link provided was broken and has been removed)*. No cylindrospermopsin was detected in any of the response lakes.

The highest microcystin concentrations were from surface scum samples. In total, 14 different scum samples were taken from the 9 different response lakes. Within the scum samples, 6 had microcystin concentrations less than 1 µg/l. The mean microcystin concentration within scum samples was higher than concentrations in ambient water, although the scum samples were highly variable (Figure 7). A Welch t-test comparing microcystin concentrations in the scum samples versus ambient water samples revealed no significant difference $t_{13} = -1.62$, $p = 0.13$.

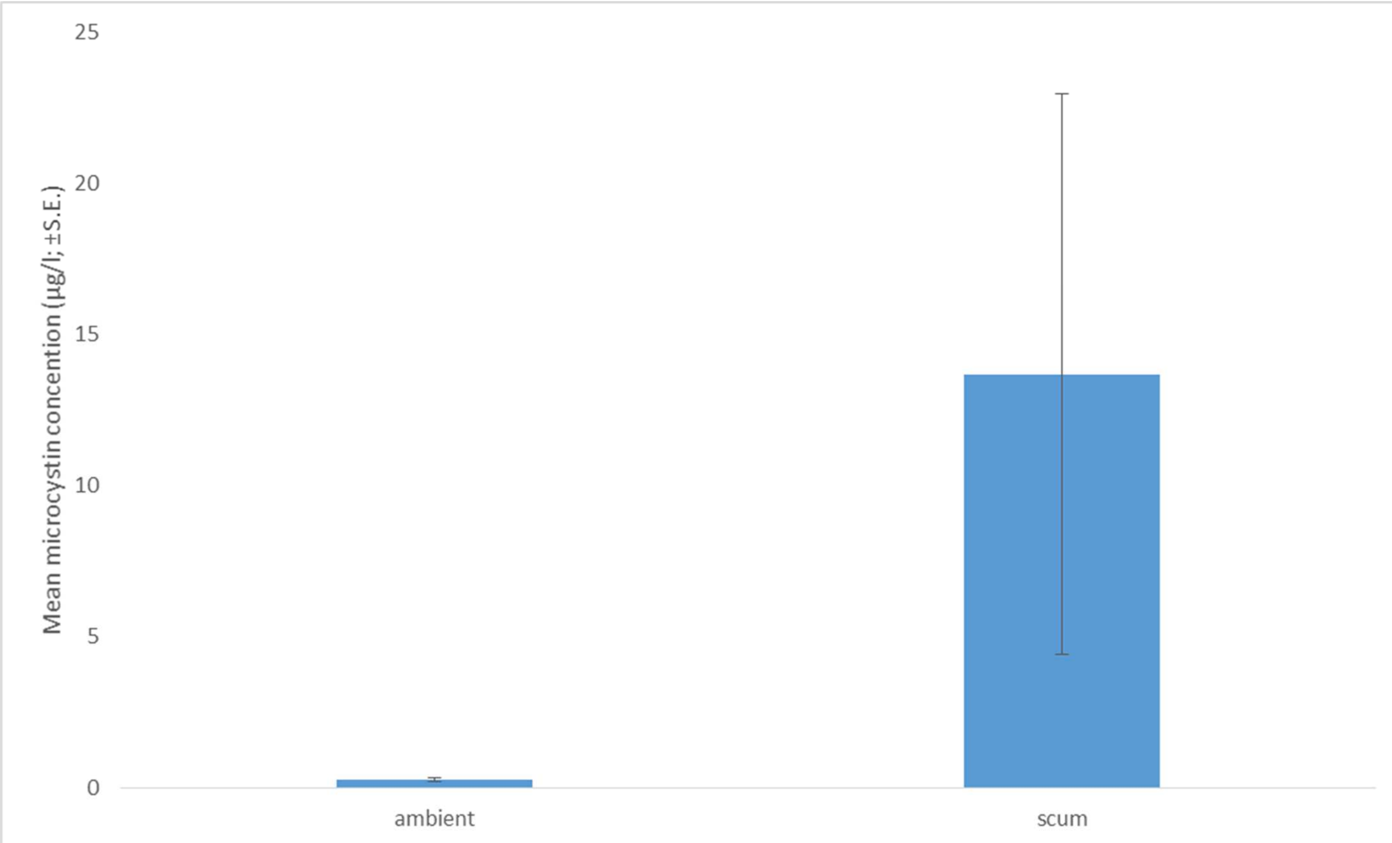

Figure 7. Mean microcystin concentrations (± S.E.) in ambient and scum samples.

Test Strip Efficacy

The logistic regression analysis indicated that the probability of microcystin detection with the test strip kits was greater than 50% when the actual concentrations were ≥ 2 µg/l (Figure 8). Microcystin detection using the test strips was significantly associated with increasing concentrations of microcystin ($p < 0.001$).

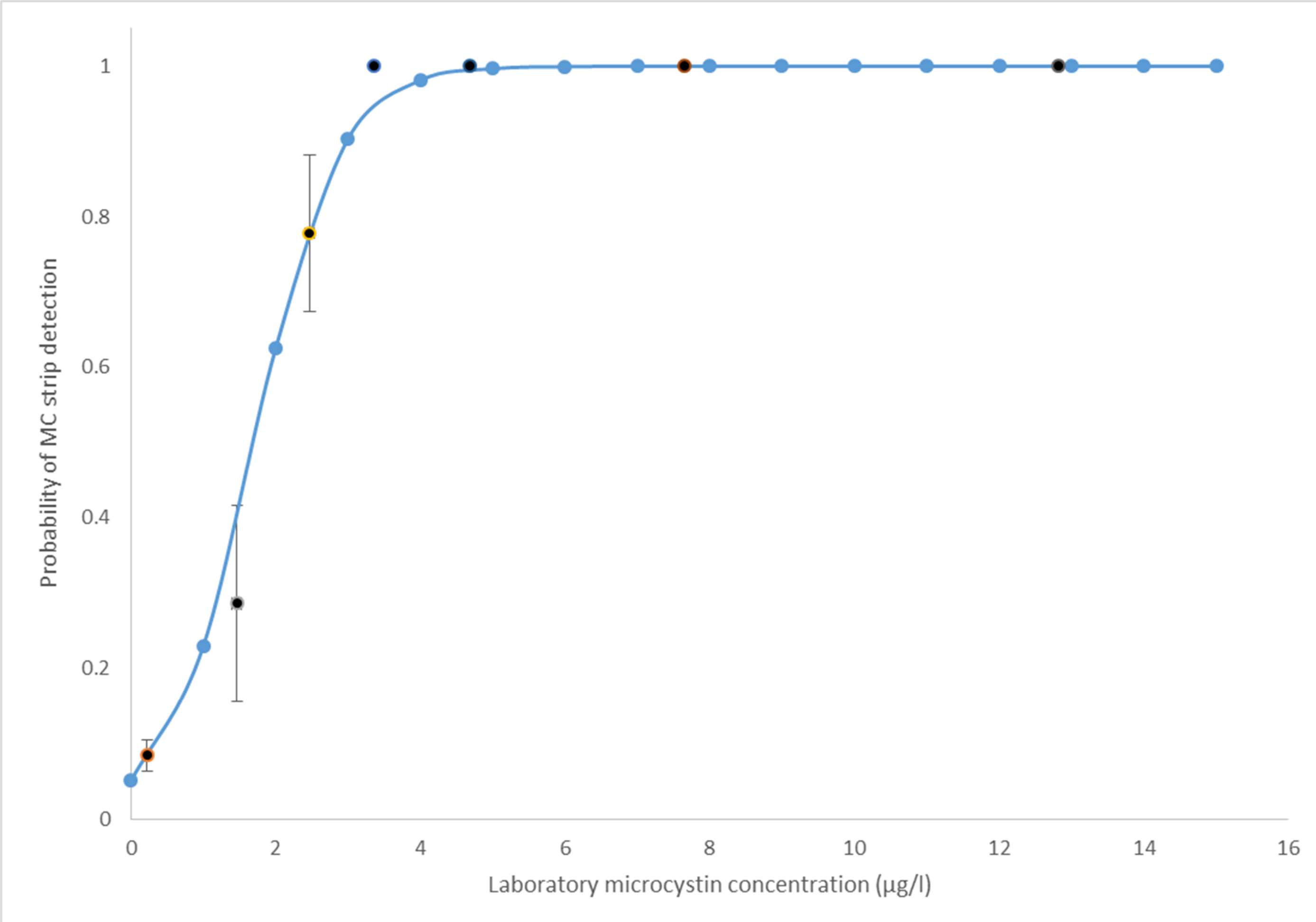

Figure 8. Probability of microcystin detection using test strip kits as a function of actual microcystin concentrations measured in the laboratory. Filled circles represent the mean (± SE) detections (scored as one) along the laboratory-measured microcystin gradient.

Chemical/Physical Predictors of Observed Microcystin Concentrations

The PCA bi-plot representing all of the lakes sampled across the state in 2016 revealed that lakes representing a wide range of conditions were assessed. The first principal component, which is best explained as a gradient of anthropogenic disturbance (increasing nutrients and conductivity; Uzarski et al., 2005) explained 36% of the variability in the chemical/physical matrix (Figure 9).

A linear regression of the PC-1 scores against lake latitudes revealed a significant inverse relationship ($R^2 = 0.30$, $P = 0.001$; Figure 10), with high scores (indicative of greater disturbance) in the lower latitudes and low scores (less disturbance) in the higher latitude lakes. A linear regression of PC-1 scores versus log_{10}-transformed microcystin concentrations showed a weak positive, but non-significant relationship ($R^2 = 0.09$, $P = 0.09$; Figure 11).

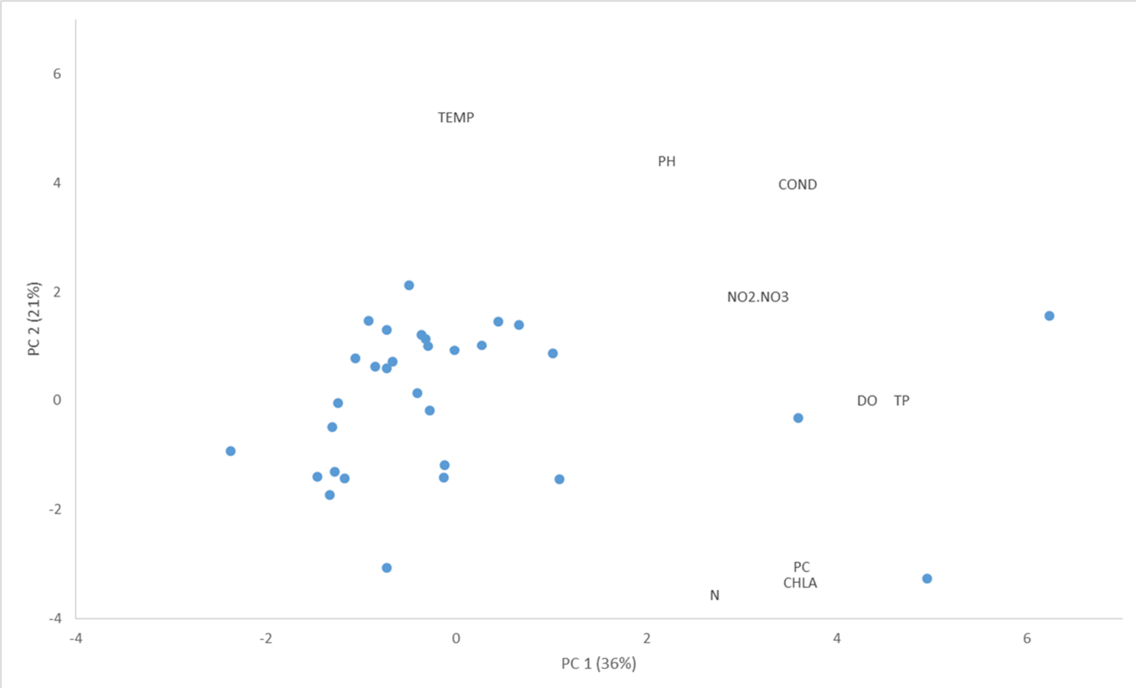

Figure 9. Principal component analysis bi-plot of chemical physical variables in Michigan lakes that were sampled in 2016.

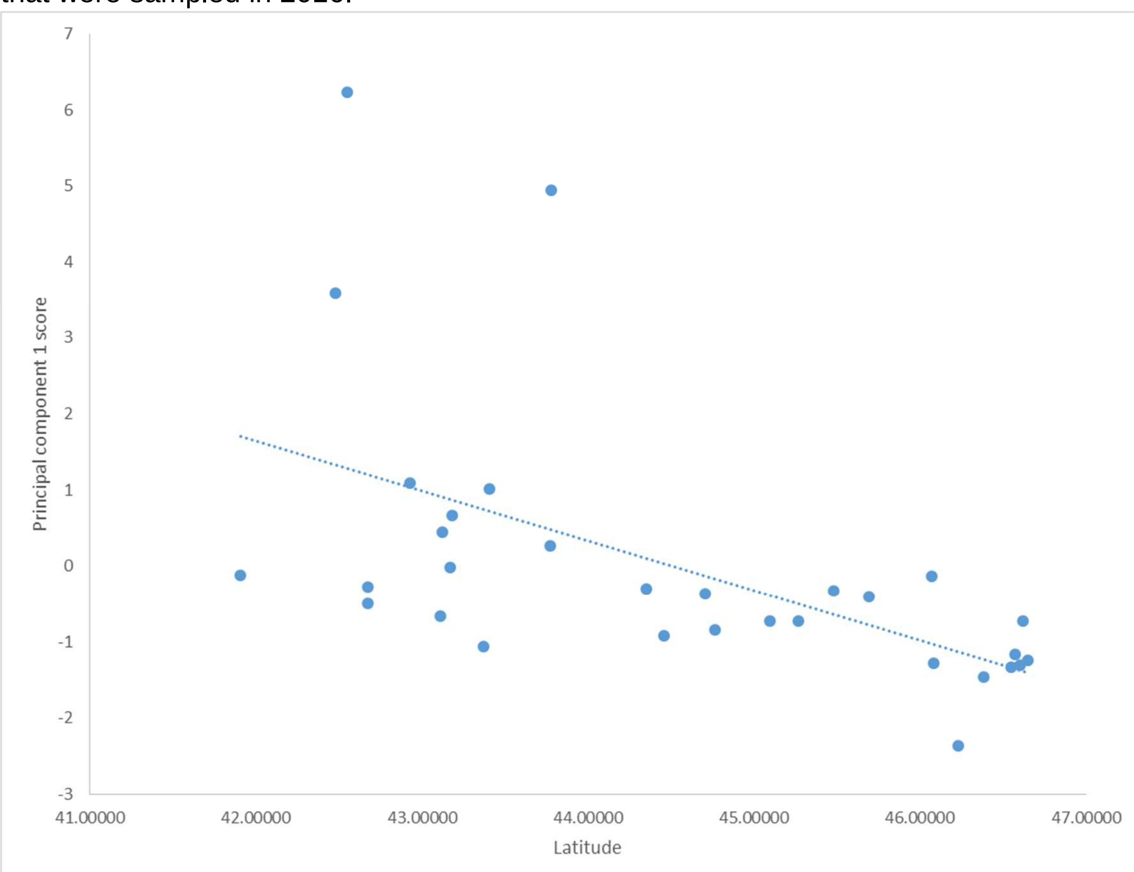

Figure 10. Linear regression of PC-1 scores versus lake latitude.

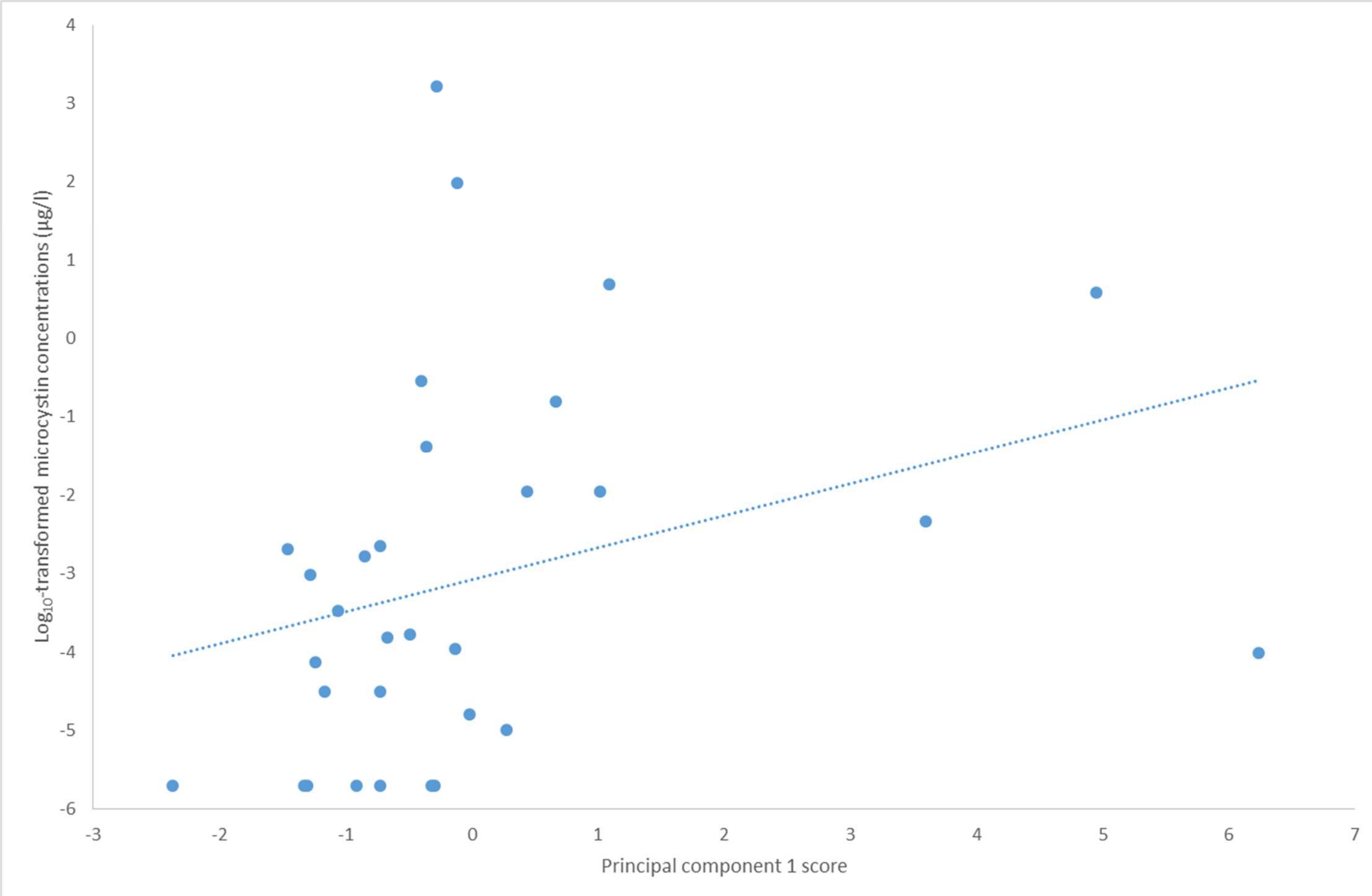

Figure 11. Linear regression of $\log_{10}$-transformed microcystin concentrations and PC-1 scores for each lake.

Discussion

The microcystin concentration results in 2016 were similar to the 2015 results reported by Holden (2016), with few inland lakes containing high toxin concentrations. In the randomly-selected, status and trend lakes, only one lake had any detectable microcystin concentrations. Even within the response lakes, when an observed cyanobacteria bloom was occurring, the highest microcystin concentrations were typically found within surface scum samples that were targeted for collection and analyzed for a "worst-case" exposure potential.

Crockery Lake

Trophic status index calculations (Fuller and Minnerick, 2008) for Crockery Lake throughout the summer of 2016 ranged from high mesotrophic to hypereutrophic. Despite its high productivity (Appendix 1), Crockery Lake had very low amounts of cyanobacteria and associated microcystin. In 2015, the highest microcystin concentration recorded was 3.85 µg/l. Because microcystin concentrations in Crockery Lake were consistently low throughout 2015 and 2016, it is no longer being regularly sampled by WRD staff.

Mona Lake

The calculated trophic status indices for Mona Lake throughout 2016 ranged from high mesotrophic to hypereutrophic, which is consistent with what others have found in Mona Lake (Steinman et al., 2006; Steinman et al., 2009; Xie et al., 2012).

The Mona Lake watershed has a long history of anthropogenic degradation. Prior to the 1970s, Mona Lake received wastewater discharges from the cities of Muskegon Heights and Norton Shores. However, a large wastewater diversion plant has reduced the amount of nutrients entering Mona Lake (Evans, 1992; Steinman et al., 2006). Little Black Creek, a tributary to Mona Lake, drains a heavily urbanized and industrial area of Muskegon Heights. Within the Little Black Creek watershed is a petroleum refinery, foundries, metal finishing plants, a plating facility superfund site, and an abandoned landfill that did not contain a leachate collection system (Walker, 2000; Steinman, et al. 2006; Cooper et al., 2009). Based on 2005 data, land use in the Mona Lake watershed is: 46.6% natural, 37.8% developed, and 15.6% agricultural (Steinman et al., 2009). Steinman et al. (2009) found that the majority of the summer phosphorus input (68-82%) is from internal loading during thermal stratification.

Microcystin production in Mona Lake has fluctuated over the years, with maximum concentrations ranging from <1 to 317 µg/l (R. Rediske, personal communication in Gillett et al., 2015; Figure 12). Assessments of the phytoplankton community in Mona Lake have found that cyanobacteria tend to be the dominant taxa during the late summer (Xie et al., 2012; Gillett et al., 2015), which includes an invasive species of *Cylindrospermopsis* (Hong et al., 2006).

In 2016, microcystin concentrations were low compared to previous years, with the highest concentration being 2.81 µg/l. Similar to Xie et al. (2012), microcystin production in Mona Lake was correlated to total phosphorus. Xie et al. (2012) proposed that low dissolved inorganic nitrogen in Mona Lake coupled with high amounts of phosphorus may give N_2-fixing cyanobacteria a competitive advantage over other phytoplankton (Smith, 1983; Kahru et al. 2000).

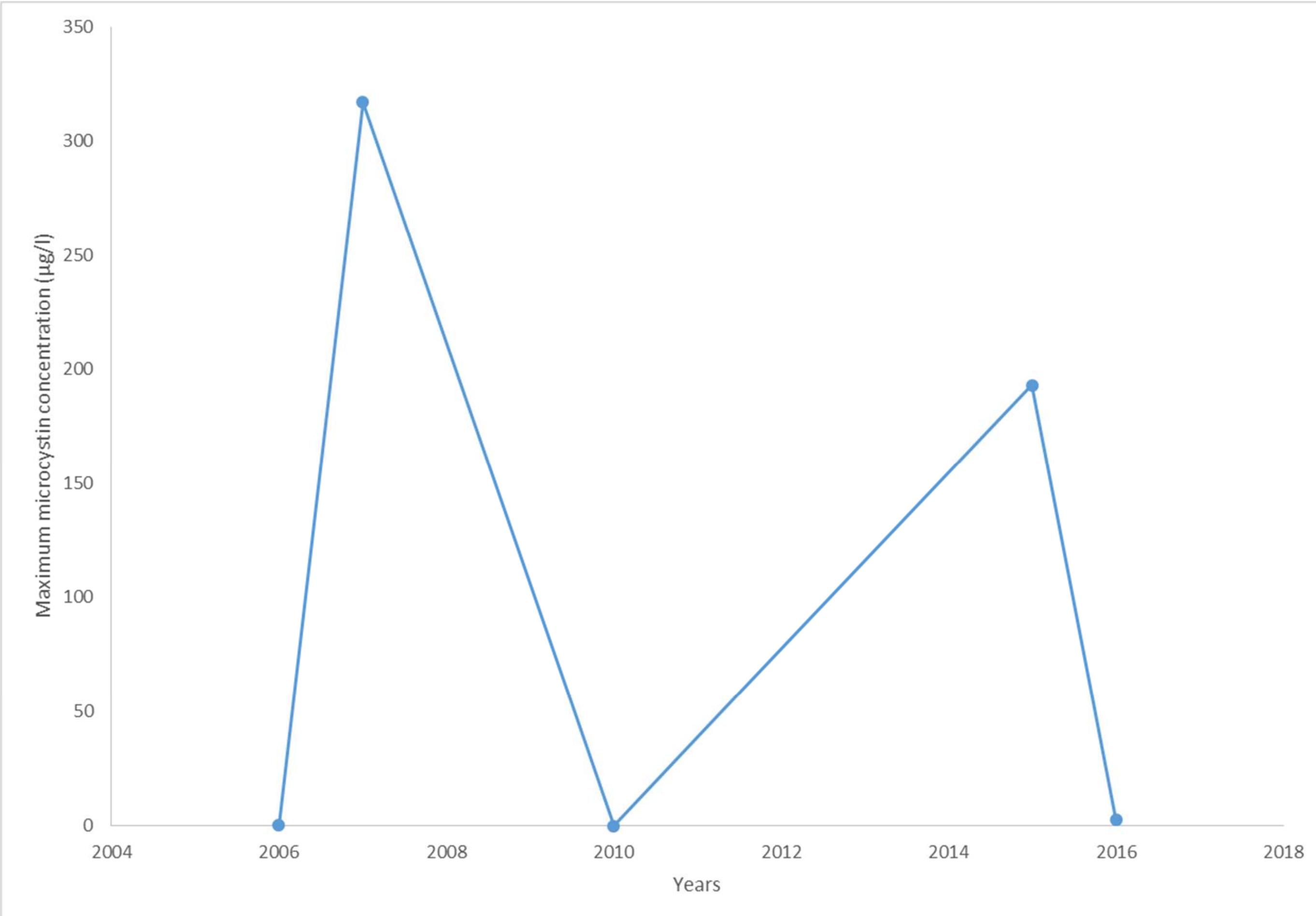

Figure 12. Maximum microcystin concentrations detected in Mona Lake. Microcystin concentration data are from the following sources: 2006: Rediske et al. (2007), 2007: R. Rediske personal communication in Gillett et al. (2015), 2010: Rediske et al. (2011), 2015: Holden (2016), and 2016: this report.

Response Lakes

MDEQ staff received complaints from concerned citizens and staff about 25 different water bodies throughout the state. The majority of these complaints were in the southern half of the Lower Peninsula (Parker, 2016b). In several cases, MDEQ staff were able to determine that the algae were non-toxin producing (e.g. *Cladophora*), or that the cyanobacteria blooms had dissipated by the time staff could respond.

In some cases, samples were collected and only a test strip analysis was necessary because the strip indicated that microcystin was not present. These latest results and Holden's (2016) results have shown that the microcystin test strips are effective at detecting elevated concentrations of the toxin. Holden (2016) found that if anything, the test strips may over-estimate the amount of microcystin in a water sample. Overall, the test strips have provided rapid screening information, sometimes within hours of collection, which is valuable for providing information to the Michigan Department of Health and Human Services and the public.

MDEQ staff were able to visit 9 different water bodies after receiving complaints. Most of the samples had low microcystin concentrations. Of the lakes that were visited, only Pontiac Lake, Oakland County, and (little) Round Lake, Lenawee County, had microcystin concentrations greater than the WHO's recreational guidance of 20 µg/l (WHO, 1999; Pontiac Lake maximum concentration: 122 µg/l, [little] Round Lake maximum concentration: 28 µg/l). Using the state of Ohio's recreational guidance of 6 µg/l *(The link provided was broken and has been removed)*, Pontiac Lake, (little) Round Lake, and Lamberton Lake, Kent County (10.6 µg/l microcystin), had elevated microcystin concentrations. The highest individual samples from those lakes were all collected from dense, surface scum accumulations, indicating that those areas are the most harmful and should be avoided by people and their pets when present.

Chemical/Physical Predictors of Observed Microcystin Concentrations

The PCA results revealed that, overall, the lakes in the southern Lower Peninsula were more productive/eutrophic. The southern Lower Peninsula has greater amounts of agricultural and developed land than in the Upper and northern Lower Peninsula. This latitudinal disturbance/productivity gradient has been observed in Great Lakes coastal wetlands (Uzarski et al., 2005; Parker et al., 2012) and Michigan inland lakes (Fuller and Taricska, 2012) by others as well. We found that lower PC1 scores were indicative of less disturbed/productive habitat, whereas higher scores were indicative of more disturbed/productive habitat.

Overall, there was no relationship between the environmental variables in all lakes combined and the amount of microcystin present. This is not too surprising, considering the amount of variation that has been observed in Michigan lakes for both cyanobacteria populations and microcystin production. For example, Xie et al. (2012) found that microcystins in Spring Lake and Mona Lake were correlated to different environmental variables, even though they are located within 10 kilometers of each other. Even more striking, Xie et al. (2011) found distinct cyanobacteria populations and different correlates to microcystin concentrations in Bear and Muskegon Lakes, which are hydrologically connected.

Michigan inland lakes have genetically diverse populations of *Microcystis aeruginosa* both within and among populations (Wilson et al., 2005). *Microcystis* and *Planktothrix* populations have also been shown to undergo seasonal succession of toxic and non-toxic genotypes. Thus, cyanobacterial biomass itself may not fully correspond with observed microcystin concentrations (Kardinaal et al., 2007). In their review, Kardinaal and Visser (2005) listed numerous environmental factors that have been associated with cyanobacteria and their toxins around the world. They concluded that dominance of cyanobacteria in lakes "cannot be attributed to a single master factor." Rather, they concluded that given the amount of diversity, in the form of physiology and growth requirements, amongst cyanobacteria populations that they are capable of exploiting, and adapting to, a wide variety of environmental conditions. This could explain why cyanobacterial growth and subsequent microcystin production seem to be site-dependent.

The only pattern that we were able to see was that microcystin concentrations were greater in the lower latitudes of Michigan, than the higher ones. However, environmental conditions in the lakes could not explain the observed microcystin concentrations. We also tend to observe more cyanobacteria blooms and receive more complaints about blooms in the southern Lower Peninsula (Parker, 2015; 2016a; 2016b). Thus more samples are collected in the southern Lower Peninsula, which increases the chances of finding sites with high microcystin concentrations. We did observe broad patterns of anthropogenic disturbance and increased productivity in water bodies from north to south in Michigan along with increased microcystin concentrations along the same gradient. Given the diverse genotypes of cyanobacteria throughout Michigan (Wilson et al., 2005), coupled with variable lake chemistry and land use patterns in the state, microcystin production is probably uniquely dependent on the water body in question.

In conclusion, because microcystin is not routinely found in the randomly-sampled lakes throughout the state, it does not appear to be a widespread, frequent problem. However, harmful cyanobacteria blooms do occur in some lakes, albeit at various intensities. Overall, in 2016, microcystin concentrations throughout the state were low, although recent sampling in 2017 has revealed much higher concentrations. The extreme temporal variation of microcystin production and bloom intensities highlights the need for continuous, long-term monitoring.

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Appendix 1. Raw data from sampled lakes.

LAKE	County	TYPE	STORET	Month	Latitude	Longitude	Site	Scum Sample?	Temperature (°F)	Dissolved oxygen (mg/l)	Conductivity (µs/cm)	pH	Phycocyanin RFU	Phycocyanin (µg/l)	Chlorophyl-a RFU	Chlorophyl-a (µg/l)
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	71.700	9.00	.	.	.	.	.	.
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	71.600	8.88	.	.	.	.	.	.
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	71.200	8.29	.	.	.	.	.	.
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	65.300	7.50	.	.	.	.	.	.
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	56.700	7.27	.	.	.	.	.	.
Mona	Muskegon	Targeted	610226	6	43.17601	-86.24657	S1	NO	.	.	.	.	.	.	.	.
Mona	Muskegon	Targeted	610226	6	43.18455	-86.24562	S2	NO	.	.	.	.	.	.	.	.
Mona	Muskegon	Targeted	610226	6	43.18272	-86.23197	S3	NO	.	.	.	.	.	.	.	.
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	74.800	9.25	454.6	8.62	-1.110	0.350	6.790	2
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	74.800	9.21	454.9	8.62	-1.080	0.370	7.300	2
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	74.000	9.05	451.1	8.61	-1.020	0.450	10.900	2.6
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	73.510	8.29	450.3	8.54	-0.970	0.470	9.300	2.9
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	62.400	0.48	391.8	7.64	-1.140	0.310	5.000	1.77
Mona	Muskegon	Targeted	610226	6	43.17829	-86.25986	DEEP	NO	60.050	0.15	379.1	7.56	-1.160	0.300	3.800	1.08
Mona	Muskegon	Targeted	610226	6	43.18458	-86.24550	S1	NO	76.390	9.20	473.8	8.66	-1.260	0.200	5.400	1.6
Mona	Muskegon	Targeted	610226	6	43.18458	-86.24550	S1	NO	75.130	9.14	470.0	8.61	1.060	0.390	9.900	3.2
Mona	Muskegon	Targeted	610226	6	43.17591	-86.24712	S2	NO	75.380	9.63	456.2	8.70	-1.110	0.380	7.000	1.8
Mona	Muskegon	Targeted	610226	6	43.17591	-86.24712	S2	NO	75.130	9.90	454.3	8.71	-1.090	0.390	7.900	2.9
Mona	Muskegon	Targeted	610226	6	43.18210	-86.23142	S3	NO	76.700	9.23	461.8	8.66	-0.940	0.520	11.000	2.8
Mona	Muskegon	Targeted	610226	6	43.18210	-86.23142	S3	NO	75.470	8.40	488.5	8.57	-1.100	0.378	9.300	2.8
Mona	Muskegon	Targeted	610226	6	43.17881	-86.25851	DEEP	NO	74.783	8.85	463.2	8.50	0.500	0.180	2.222	7.55
Mona	Muskegon	Targeted	610226	6	43.17881	-86.25851	DEEP	NO	74.693	8.83	463.1	8.50	0.576	0.250	2.742	10.44
Mona	Muskegon	Targeted	610226	6	43.17881	-86.25851	DEEP	NO	74.044	7.24	469.5	8.25	0.505	0.140	2.514	10.26
Mona	Muskegon	Targeted	610226	6	43.17881	-86.25851	DEEP	NO	69.442	1.37	466.0	7.64	0.340	0.000	2.037	9.25
Mona	Muskegon	Targeted	610226	6	43.17881	-86.25851	DEEP	NO	62.120	0.25	466.1	7.50	0.176	0.000	1.071	3.77
Mona	Muskegon	Targeted	610226	6	43.17601	-86.24657	S1	NO	75.856	9.80	463.9	8.63	0.499	0.140	1.998	7.5
Mona	Muskegon	Targeted	610226	6	43.18455	-86.24562	S2	NO	76.985	9.75	480.2	8.62	0.522	0.190	1.999	7.36
Mona	Muskegon	Targeted	610226	6	43.18272	-86.23197	S3	NO	79.003	11.05	461.3	8.75	0.700	0.390	2.636	9.67
Mona	Muskegon	Targeted	610226	7	43.17826	-86.25986	DEEP	NO	75.053	11.14	465.5	8.70	0.552	0.600	3.030	10.4
Mona	Muskegon	Targeted	610226	7	43.17826	-86.25986	DEEP	NO	74.460	11.07	462.2	8.72	0.790	0.860	4.810	14.72
Mona	Muskegon	Targeted	610226	7	43.17826	-86.25986	DEEP	NO	72.713	6.86	462.3	8.22	0.549	0.620	4.174	15.72
Mona	Muskegon	Targeted	610226	7	43.17826	-86.25986	DEEP	NO	69.320	1.11	448.5	7.50	0.468	0.540	4.590	18.1
Mona	Muskegon	Targeted	610226	7	43.17826	-86.25986	DEEP	NO	62.110	0.05	405.0	7.27	0.119	0.120	1.030	3.97
Mona	Muskegon	Targeted	610226	7	43.18510	-86.24678	S1	NO	76.680	11.58	474.4	8.75	0.557	0.620	10.760	10.5
Mona	Muskegon	Targeted	610226	7	43.18510	-86.24678	S1	NO	75.790	11.83	470.1	8.79	0.699	0.770	3.760	15.31
Mona	Muskegon	Targeted	610226	7	43.18510	-86.24678	S2	NO	75.723	11.60	468.8	8.77	0.653	0.740	3.549	14.1
Mona	Muskegon	Targeted	610226	7	43.18510	-86.24678	S2	NO	75.621	11.82	465.7	8.79	0.956	1.040	5.132	21.01
Mona	Muskegon	Targeted	610226	7	43.18267	-86.23198	S3	NO	76.484	11.87	465.7	8.81	0.747	0.830	3.500	13.21
Mona	Muskegon	Targeted	610226	7	43.18267	-86.23198	S3	NO	75.020	10.50	460.9	8.71	0.920	1.000	5.100	17.920
Mona	Muskegon	Targeted	610226	7	43.17913	-86.25811	DEEP	NO	77.800	10.48	471.8	8.74	471.800	10.480	3.080	12.400
Mona	Muskegon	Targeted	610226	7	43.17913	-86.25811	DEEP	NO	77.100	10.11	472.5	8.73	1.010	1.120	6.500	18.700
Mona	Muskegon	Targeted	610226	7	43.17913	-86.25811	DEEP	NO	74.700	4.83	486.2	8.02	0.610	0.690	3.600	14.100
Mona	Muskegon	Targeted	610226	7	43.17913	-86.25811	DEEP	NO	71.300	0.33	495.0	7.37	0.370	0.400	3.200	12.010
Mona	Muskegon	Targeted	610226	7	43.17913	-86.25811	DEEP	NO	64.600	0.14	485.0	7.18	0.170	0.170	1.060	4.070
Mona	Muskegon	Targeted	610226	7	43.17608	-86.24660	S1	NO	78.393	10.60	469.4	8.78	0.742	0.870	4.474	15.320
Mona	Muskegon	Targeted	610226	7	43.18530	-86.24577	S2	NO	78.000	10.14	506.0	8.65	0.936	0.930	7.786	12.560
Mona	Muskegon	Targeted	610226	7	43.18271	-86.23203	S3	NO	78.935	11.19	461.4	8.81	1.030	1.210	3.606	13.990
Mona	Muskegon	Targeted	610226	7	43.17842	-86.25976	DEEP	NO	79.700	8.25	477.9	8.62	0.250	0.260	1.600	5.900
Mona	Muskegon	Targeted	610226	7	43.17842	-86.25976	DEEP	NO	77.800	9.45	462.0	8.76	0.750	0.710	5.900	19.000
Mona	Muskegon	Targeted	610226	7	43.17842	-86.25976	DEEP	NO	76.300	8.22	457.0	8.61	0.650	0.620	4.900	14.000
Mona	Muskegon	Targeted	610226	7	43.17842	-86.25976	DEEP	NO	75.900	7.20	457.0	8.52	0.520	0.540	3.600	12.000
Mona	Muskegon	Targeted	610226	7	43.17842	-86.25976	DEEP	NO	68.900	0.40	414.0	7.56	0.100	0.090	0.990	3.600
Mona	Muskegon	Targeted	610226	7	43.18465	-86.24555	S1	NO	79.100	10.15	470.0	8.83	0.577	0.570	4.100	15.000
Mona	Muskegon	Targeted	610226	7	43.18465	-86.24555	S1	NO	78.600	10.30	461.0	8.83	0.718	0.680	5.700	21.300
Mona	Muskegon	Targeted	610226	7	43.17636	-86.24554	S2	NO	78.300	9.81	464.0	8.76	0.660	0.630	4.800	15.000
Mona	Muskegon	Targeted	610226	7	43.17636	-86.24554	S2	NO	77.000	9.52	459.0	8.75	0.790	0.770	5.800	23.000
Mona	Muskegon	Targeted	610226	7	43.18266	-86.23202	S3	NO	80.500	11.00	466.0	8.89	0.730	0.690	5.900	17.700
Mona	Muskegon	Targeted	610226	7	43.18266	-86.23202	S3	NO	76.000	5.40	460.0	8.28	0.960	0.910	7.000	23.000
Mona	Muskegon	Targeted	610226	7	43.17870	-86.25920	DEEP	NO	79.630	8.89	467.6	8.68	0.510	0.470	2.550	9.020

Secchi depth (FT)	Lab Chlorophyl-a (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	Ortho phosphate (mg/l)	Total P (mg/l)	Microcystin test strip result (µg/l)	Microcystin lab results (µg/l)	Anatoxin-a (µg/l)	Cylindrospermopsin (µg/l)
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5.7	19.000	0.610	0.280	0.004	0.024	0.0	.	.	.
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5.3	.	.	.	.	.	0.0	0.356	0.250	0.250
5.4	31.000	0.660	0.067	0.005	0.025	0.0	.	.	.
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4.7	.	.	.	.	.	0.0	.	.	.
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3.9	.	.	.	.	.	0.0	0.348	0.250	0.250
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4.330	35.000	0.750	0.005	0.006	0.032	0.0	.	.	.
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2.66	.	.	.	.	.	0.0	0.630	0.250	0.250
3.500	23.000	0.590	0.005	0.003	0.029	0.0	0.646	0.250	0.250
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2.500	.	.	.	.	.	0.0	0.983	0.250	0.250
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4.000	.	.	.	.	.	0.0	.	.	.

LAKE	County	TYPE	STORET	Month	Latitude	Longitude	Site	Scum Sample?	Temperature (°F)	Dissolved oxygen (mg/l)	Conductivity (µs/cm)	pH	Phycocyanin RFU	Phycocyanin (µg/l)	Chlorophyll-a RFU	Chlorophyll-a (µg/l)
Mona	Muskegon	Targeted	610226	7	43.17870	-86.25920	DEEP	NO	79.240	8.34	468.9	8.61	0.730	0.700	4.200	16.700
Mona	Muskegon	Targeted	610226	7	43.17870	-86.25920	DEEP	NO	78.400	5.84	471.7	8.26	0.371	0.370	3.160	11.400
Mona	Muskegon	Targeted	610226	7	43.17870	-86.25920	DEEP	NO	75.100	1.15	480.0	7.73	0.140	0.130	1.900	7.080
Mona	Muskegon	Targeted	610226	7	43.17870	-86.25920	DEEP	NO	66.800	0.21	495.7	7.35	0.090	0.090	0.970	3.660
Mona	Muskegon	Targeted	610226	7	43.18460	-86.24560	S1	NO	80.770	8.84	455.5	8.69	0.440	0.400	2.250	8.300
Mona	Muskegon	Targeted	610226	7	43.17590	-86.24690	S2	NO	80.500	8.92	467.9	8.69	0.491	0.460	2.510	9.100
Mona	Muskegon	Targeted	610226	7	43.18240	-86.23180	S3	NO	81.860	9.59	452.1	8.67	0.855	0.820	4.430	15.400
Mona	Muskegon	Targeted	610226	8	43.17878	-86.25980	DEEP	NO	78.800	8.57	484.1	8.62	0.415	0.390	1.440	5.380
Mona	Muskegon	Targeted	610226	8	43.17878	-86.25980	DEEP	NO	78.150	8.73	488.0	8.65	0.660	0.620	3.800	12.310
Mona	Muskegon	Targeted	610226	8	43.17878	-86.25980	DEEP	NO	77.420	7.68	478.2	8.50	0.556	0.520	2.480	10.200
Mona	Muskegon	Targeted	610226	8	43.17878	-86.25980	DEEP	NO	74.700	1.73	476.1	7.70	0.338	0.330	2.050	7.900
Mona	Muskegon	Targeted	610226	8	43.17878	-86.25980	DEEP	NO	68.200	0.44	463.8	7.36	0.910	0.090	0.992	3.700
Mona	Muskegon	Targeted	610226	8	43.17878	-86.25980	DEEP	NO	65.620	0.19	451.0	7.25	0.083	0.090	1.050	3.890
Mona	Muskegon	Targeted	610226	8	43.18466	-86.24563	S1	NO	78.110	8.53	485.1	8.58	0.333	0.310	1.290	4.790
Mona	Muskegon	Targeted	610226	8	43.18466	-86.24563	S1	NO	77.400	8.07	482.9	8.50	0.400	0.380	2.180	8.050
Mona	Muskegon	Targeted	610226	8	43.17268	-86.24577	S2	NO	78.590	8.44	483.4	8.61	0.465	0.440	1.940	7.300
Mona	Muskegon	Targeted	610226	8	43.17268	-86.24577	S2	NO	78.420	8.48	482.2	8.61	0.583	0.570	2.600	9.530
Mona	Muskegon	Targeted	610226	8	43.18269	-86.23206	S3	NO	79.380	8.50	492.8	8.53	0.362	0.350	1.640	6.170
Mona	Muskegon	Targeted	610226	8	43.18269	-86.23206	S3	NO	79.220	8.57	491.1	8.52	0.387	0.360	1.720	6.370
Mona	Muskegon	Targeted	610226	8	43.17873	-86.25916	DEEP	NO	79.880	8.15	427.6	8.43	0.780	0.270	1.670	6.110
Mona	Muskegon	Targeted	610226	8	43.17873	-86.25916	DEEP	NO	79.170	8.46	422.7	8.47	0.510	0.460	3.270	12.120
Mona	Muskegon	Targeted	610226	8	43.17873	-86.25916	DEEP	NO	78.280	7.30	420.7	8.30	0.520	0.470	2.700	9.930
Mona	Muskegon	Targeted	610226	8	43.17873	-86.25916	DEEP	NO	73.330	0.30	408.2	7.49	0.290	0.260	1.290	4.770
Mona	Muskegon	Targeted	610226	8	43.17873	-86.25916	DEEP	NO	68.090	0.14	392.4	7.23	0.150	0.110	1.050	3.900
Mona	Muskegon	Targeted	610226	8	43.17873	-86.25916	DEEP	NO	67.040	0.12	397.1	7.13	0.160	0.140	1.200	4.350
Mona	Muskegon	Targeted	610226	8	43.17596	-86.24667	S1	NO	80.020	9.45	422.7	8.61	0.340	0.320	2.500	9.770
Mona	Muskegon	Targeted	610226	8	43.17596	-86.24667	S1	NO	79.320	9.38	419.4	8.60	0.460	0.420	2.960	10.700
Mona	Muskegon	Targeted	610226	8	43.18472	-86.24574	S2	NO	81.030	8.89	431.3	8.57	0.280	0.230	1.730	6.510
Mona	Muskegon	Targeted	610226	8	43.18472	-86.24574	S2	NO	79.860	9.05	425.1	8.58	0.360	0.310	2.670	9.700
Mona	Muskegon	Targeted	610226	8	43.18265	-86.23192	S3	NO	81.320	10.96	423.0	8.80	0.760	0.680	5.300	19.000
Mona	Muskegon	Targeted	610226	8	43.18265	-86.23192	S3	NO	79.630	9.94	416.0	8.70	0.750	0.690	4.500	17.000
Mona	Muskegon	Targeted	610226	8	43.17853	-86.25958	DEEP	NO	79.596	8.44	488.2	8.48	0.557	0.450	4.419	16.130
Mona	Muskegon	Targeted	610226	8	43.17853	-86.25958	DEEP	NO	78.952	8.53	484.2	8.48	0.531	0.430	5.047	18.800
Mona	Muskegon	Targeted	610226	8	43.17853	-86.25958	DEEP	NO	78.824	8.40	484.2	8.37	0.571	0.470	4.856	17.810
Mona	Muskegon	Targeted	610226	8	43.17853	-86.25958	DEEP	NO	73.571	0.58	475.0	7.30	0.293	0.190	1.631	6.200
Mona	Muskegon	Targeted	610226	8	43.17853	-86.25958	DEEP	NO	70.284	0.21	462.8	7.17	0.210	0.140	1.233	4.610
Mona	Muskegon	Targeted	610226	8	43.17853	-86.25958	DEEP	NO	68.182	0.10	461.0	7.11	0.356	0.250	1.465	5.380
Mona	Muskegon	Targeted	610226	8	43.18509	-86.24667	S1	NO	80.234	9.48	493.8	8.66	0.512	0.420	4.683	17.200
Mona	Muskegon	Targeted	610226	8	43.18509	-86.24667	S1	NO	79.080	6.20	527.0	7.96	1.896	1.560	5.633	12.020
Mona	Muskegon	Targeted	610226	8	43.17587	-86.24705	S2	NO	79.885	9.11	487.1	8.64	0.688	0.600	5.086	19.140
Mona	Muskegon	Targeted	610226	8	43.17587	-86.24705	S2	NO	79.773	9.23	485.9	8.64	0.774	0.610	5.663	20.520
Mona	Muskegon	Targeted	610226	8	43.18260	-86.23194	S3	NO	80.562	9.33	487.0	8.65	0.841	0.720	5.935	22.080
Mona	Muskegon	Targeted	610226	8	43.18260	-86.23194	S3	NO	78.297	6.61	477.9	8.22	0.573	0.480	3.199	11.880
Mona	Muskegon	Targeted	610226	8	43.17909	-86.25792	DEEP	NO	76.490	5.90	482.3	7.95	0.548	0.480	2.885	11.050
Mona	Muskegon	Targeted	610226	8	43.17909	-86.25792	DEEP	NO	75.880	5.27	479.1	7.88	0.640	0.500	3.285	11.450
Mona	Muskegon	Targeted	610226	8	43.17909	-86.25792	DEEP	NO	75.615	4.96	476.2	7.85	0.525	0.420	2.850	10.880
Mona	Muskegon	Targeted	610226	8	43.17909	-86.25792	DEEP	NO	75.557	4.62	476.8	7.82	0.460	0.380	2.630	9.550
Mona	Muskegon	Targeted	610226	8	43.17909	-86.25792	DEEP	NO	71.915	0.15	471.9	7.29	0.245	0.160	1.295	4.900
Mona	Muskegon	Targeted	610226	8	43.17586	-86.24684	S1	NO	77.525	8.00	484.1	8.33	0.740	0.600	3.850	14.180
Mona	Muskegon	Targeted	610226	8	43.18467	-86.24543	S2	NO	77.452	7.98	483.8	8.38	0.720	0.540	3.565	12.850
Mona	Muskegon	Targeted	610226	8	43.18261	-86.23204	S3	NO	78.830	9.73	487.6	8.61	0.800	0.780	4.770	16.500
Mona	Muskegon	Targeted	610226	8	43.17930	-86.25853	DEEP	NO	78.440	10.25	454.5	8.54	0.730	0.750	2.849	10.100
Mona	Muskegon	Targeted	610226	8	43.17930	-86.25853	DEEP	NO	77.290	9.82	449.9	8.47	1.040	1.040	3.793	14.200
Mona	Muskegon	Targeted	610226	8	43.17930	-86.25853	DEEP	NO	76.051	7.72	445.7	8.16	1.130	1.110	5.010	17.600
Mona	Muskegon	Targeted	610226	8	43.17930	-86.25853	DEEP	NO	74.250	1.17	443.8	7.39	0.540	0.530	2.703	10.100
Mona	Muskegon	Targeted	610226	8	43.17930	-86.25853	DEEP	NO	71.747	0.08	445.8	7.25	0.572	0.580	1.999	7.020
Mona	Muskegon	Targeted	610226	8	43.18462	-86.24564	S1	NO	78.920	10.69	455.9	8.62	0.701	0.710	2.667	9.540
Mona	Muskegon	Targeted	610226	8	43.18462	-86.24564	S1	NO	78.385	10.74	455.7	8.62	0.860	0.860	3.290	12.010
Mona	Muskegon	Targeted	610226	8	43.16908	-86.24641	S2	NO	78.830	10.71	454.2	8.66	0.710	0.720	2.869	10.810

Secchi depth (FT)	Lab Chlorophyl-a (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	Ortho phosphate (mg/l)	Total P (mg/l)	Microcystin test strip result (µg/l)	Microcystin lab results (µg/l)	Anatoxin-a (µg/l)	Cylindrospermopsin (µg/l)
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4.500	2.200	0.580	0.002	0.007	0.027	0.0	0.045	0.001	0.008
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LAKE	County	TYPE	STORET	Month	Latitude	Longitude	Site	Scum Sample?	Temperature (°F)	Dissolved oxygen (mg/l)	Conductivity (µs/cm)	pH	Phycocyanin RFU	Phycocyanin (µg/l)	Chlorophyl-a RFU	Chlorophyl-a (µg/l)
Mona	Muskegon	Targeted	610226	8	43.16908	-86.24641	S2	NO	78.850	10.76	454.3	8.66	0.749	0.740	2.923	11.370
Mona	Muskegon	Targeted	610226	8	43.18258	-86.23193	S3	NO	81.701	11.21	466.4	8.72	0.849	0.840	2.849	10.340
Mona	Muskegon	Targeted	610226	8	43.18258	-86.23193	S3	NO	77.913	9.25	449.6	8.47	1.031	1.030	4.210	15.400
Mona	Muskegon	Targeted	610226	9	43.17854	-86.25957	DEEP	NO	73.960	8.47	450.3	8.28	1.157	1.070	5.306	19.490
Mona	Muskegon	Targeted	610226	9	43.17854	-86.25957	DEEP	NO	73.323	7.38	448.4	8.09	0.791	0.740	2.963	13.620
Mona	Muskegon	Targeted	610226	9	43.17854	-86.25957	DEEP	NO	71.448	0.25	467.0	7.32	0.851	0.780	3.516	13.620
Mona	Muskegon	Targeted	610226	9	43.18528	-86.24600	S1	NO	73.980	9.96	453.4	8.50	1.505	1.430	6.317	22.820
Mona	Muskegon	Targeted	610226	9	43.18528	-86.24600	S1	NO	61.550	6.99	695.0	7.53	0.304	0.300	3.712	6.670
Mona	Muskegon	Targeted	610226	9	43.17618	-86.24633	S2	NO	74.090	9.19	448.5	8.41	1.365	1.280	6.087	23.070
Mona	Muskegon	Targeted	610226	9	43.17618	-86.24633	S2	NO	73.936	9.23	447.5	8.41	1.452	1.340	6.321	24.500
Mona	Muskegon	Targeted	610226	9	43.18266	-86.23202	S3	NO	74.340	11.48	444.9	8.72	1.785	1.630	7.609	26.190
Mona	Muskegon	Targeted	610226	9	43.18266	-86.23202	S3	NO	73.705	9.57	446.2	8.49	1.315	1.240	5.892	24.770
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	73.400	9.07	.	.	.	.	.	.
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	68.500	7.28	.	.	.	.	.	.
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	46.800	1.21	.	.	.	.	.	.
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	43.900	0.35	.	.	.	.	.	.
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	43.600	0.25	.	.	.	.	.	.
Crockery	Ottawa	Targeted	700422	6	43.17192	-85.84606	S1	NO	.	.	.	.	.	.	.	.
Crockery	Ottawa	Targeted	700422	6	43.16776	-85.84889	S2	NO	.	.	.	.	.	.	.	.
Crockery	Ottawa	Targeted	700422	6	43.16407	-85.85841	S3	NO	.	.	.	.	.	.	.	.
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	76.200	9.46	368.8	8.94	0.512	0.000	1.930	7.600
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	75.790	9.13	366.6	8.91	0.630	0.000	2.851	11.930
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	75.000	8.11	365.8	8.82	0.556	0.000	3.400	12.200
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	58.200	0.33	339.8	7.79	0.601	0.000	3.500	12.400
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	44.720	0.03	299.7	7.51	0.570	0.000	0.989	3.200
Crockery	Ottawa	Targeted	700422	6	43.16541	-85.85698	DEEP	NO	44.100	0.00	296.7	7.43	0.590	0.000	0.760	2.450
Crockery	Ottawa	Targeted	700422	6	43.17198	-85.84622	S1	NO	76.500	9.53	360.0	8.95	0.770	0.000	3.300	12.000
Crockery	Ottawa	Targeted	700422	6	43.17198	-85.84622	S1	NO	76.400	9.60	369.0	8.95	0.640	0.000	3.200	11.200
Crockery	Ottawa	Targeted	700422	6	43.16780	-85.84892	S2	NO	76.250	8.90	371.2	8.90	0.576	0.000	2.806	10.420
Crockery	Ottawa	Targeted	700422	6	43.16780	-85.84892	S2	NO	75.610	7.46	368.9	8.75	0.622	0.000	3.200	10.600
Crockery	Ottawa	Targeted	700422	6	43.16398	-85.85841	S3	NO	76.470	9.42	369.0	8.94	0.410	0.000	1.670	6.000
Crockery	Ottawa	Targeted	700422	6	43.16398	-85.85841	S3	NO	76.350	9.44	368.0	8.95	0.570	0.000	2.550	9.050
Crockery	Ottawa	Targeted	700422	6	43.16581	-85.85667	DEEP	NO	77.478	9.87	363.3	8.79	0.709	0.350	3.077	11.780
Crockery	Ottawa	Targeted	700422	6	43.16581	-85.85667	DEEP	NO	77.340	9.86	363.3	8.78	0.826	0.490	4.555	19.680
Crockery	Ottawa	Targeted	700422	6	43.16581	-85.85667	DEEP	NO	77.265	9.71	363.4	8.76	0.821	0.510	4.885	19.990
Crockery	Ottawa	Targeted	700422	6	43.16581	-85.85667	DEEP	NO	74.799	6.80	373.5	8.55	0.775	0.470	5.099	20.000
Crockery	Ottawa	Targeted	700422	6	43.16581	-85.85667	DEEP	NO	69.116	0.77	391.1	7.95	0.555	0.220	2.910	10.910
Crockery	Ottawa	Targeted	700422	6	43.16581	-85.85667	DEEP	NO	56.110	0.03	425.7	7.56	0.494	0.140	2.251	8.600
Crockery	Ottawa	Targeted	700422	6	43.17192	-85.84606	S1	NO	78.080	10.07	326.3	8.79	0.825	0.530	4.478	16.510
Crockery	Ottawa	Targeted	700422	6	43.16776	-85.84889	S2	NO	77.896	8.64	365.4	8.66	0.765	0.420	3.864	15.790
Crockery	Ottawa	Targeted	700422	6	43.16407	-85.85841	S3	NO	77.750	9.89	364.5	8.79	0.821	0.500	4.170	16.170
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85690	DEEP	NO	76.090	8.84	369.5	8.44	0.685	0.780	4.680	17.990
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85690	DEEP	NO	75.700	8.28	368.7	8.37	0.681	0.750	5.580	21.020
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85690	DEEP	NO	73.550	4.11	368.8	7.87	0.410	0.460	3.410	13.000
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85690	DEEP	NO	68.660	0.11	366.1	7.57	0.370	0.390	3.200	9.560
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85690	DEEP	NO	54.320	0.08	338.0	7.27	0.290	0.320	2.150	8.200
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85690	DEEP	NO	44.550	0.07	305.0	7.14	0.135	0.140	0.906	3.420
Crockery	Ottawa	Targeted	700422	7	43.17193	-85.84595	S1	NO	76.200	8.65	374.9	8.43	0.679	0.740	3.900	14.800
Crockery	Ottawa	Targeted	700422	7	43.17193	-85.84595	S1	NO	76.200	8.72	374.6	8.43	0.680	0.750	5.060	19.310
Crockery	Ottawa	Targeted	700422	7	43.16775	-85.84888	S2	NO	76.389	8.83	374.9	8.44	0.680	0.760	4.870	19.000
Crockery	Ottawa	Targeted	700422	7	43.16775	-85.84888	S2	NO	75.760	8.56	375.4	8.42	0.761	0.850	6.120	24.000
Crockery	Ottawa	Targeted	700422	7	43.16428	-85.85862	S3	NO	76.790	9.27	372.3	8.51	0.622	0.690	4.000	15.000
Crockery	Ottawa	Targeted	700422	7	43.16428	-85.85862	S3	NO	76.020	8.59	369.7	8.44	0.864	0.940	6.570	24.400
Crockery	Ottawa	Targeted	700422	7	43.16598	-85.85680	DEEP	NO	78.600	9.53	374.1	8.56	0.711	0.820	5.300	18.780
Crockery	Ottawa	Targeted	700422	7	43.16598	-85.85680	DEEP	NO	75.500	3.50	388.6	7.82	0.490	0.540	3.800	15.000
Crockery	Ottawa	Targeted	700422	7	43.16598	-85.85680	DEEP	NO	49.500	0.03	458.1	7.17	0.280	0.310	2.000	7.280
Crockery	Ottawa	Targeted	700422	7	43.16598	-85.85680	DEEP	NO	44.800	0.00	467.0	7.12	0.210	0.210	1.100	4.420
Crockery	Ottawa	Targeted	700422	7	43.16598	-85.85680	DEEP	NO	44.200	0.00	470.6	7.10	0.170	0.180	0.970	3.690
Crockery	Ottawa	Targeted	700422	7	43.16598	-85.85680	DEEP	NO	43.200	0.00	493.4	6.92	0.260	0.240	0.940	3.600

Secchi depth (FT)	Lab Chlorophyl-a (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	Ortho phosphate (mg/l)	Total P (mg/l)	Microcystin test strip result (µg/l)	Microcystin lab results (µg/l)	Anatoxin-a (µg/l)	Cylindrospermopsin (µg/l)
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3.600	.	.	.	.	.	0.0	0.058	0.001	0.008
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3.200	26.000	0.680	0.034	0.011	0.049	0.0	.	.	.
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2.900	.	.	.	.	.	0.0	0.110	0.036	0.008
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1.900	.	.	.	.	.	0.0	.	.	.
2.500	.	.	.	.	.	0.0	.	.	.
3.200	22.000	0.960	0.049	0.006	0.048	0.0	.	.	.
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2.580	28.000	0.930	0.005	0.006	0.046	0.0	.	.	.
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LAKE	County	TYPE	STORET	Month	Latitude	Longitude	Site	Scum Sample?	Temperature (°F)	Dissolved oxygen (mg/l)	Conductivity (µs/cm)	pH	Phycocyanin RFU	Phycocyanin (µg/l)	Chlorophyl-a RFU	Chlorophyl-a (µg/l)
Crockery	Ottawa	Targeted	700422	7	43.17204	-85.84629	S1	NO	78.769	9.71	373.6	8.57	0.584	0.660	4.299	16.840
Crockery	Ottawa	Targeted	700422	7	43.16782	-85.84883	S2	NO	78.900	9.00	375.0	8.49	0.703	0.800	4.823	18.640
Crockery	Ottawa	Targeted	700422	7	43.16382	-85.85844	S3	NO	78.440	9.60	374.4	8.57	0.659	0.740	4.470	16.600
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85695	DEEP	NO	78.070	8.67	370.9	8.63	0.249	0.250	2.400	8.640
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85695	DEEP	NO	77.670	8.58	369.7	8.61	0.268	0.250	3.580	12.560
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85695	DEEP	NO	77.380	8.43	368.2	8.59	0.226	0.210	3.710	13.900
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85695	DEEP	NO	49.601	0.21	314.5	7.41	0.343	0.330	2.229	8.420
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85695	DEEP	NO	44.790	0.07	298.3	7.33	0.215	0.210	1.356	4.910
Crockery	Ottawa	Targeted	700422	7	43.16536	-85.85695	DEEP	NO	44.121	0.03	296.4	7.30	0.180	0.180	0.998	3.640
Crockery	Ottawa	Targeted	700422	7	43.17180	-85.84553	S1	NO	78.460	8.17	377.1	8.56	0.189	0.150	2.198	7.570
Crockery	Ottawa	Targeted	700422	7	43.17180	-85.84553	S1	NO	.	.	.	.	0.290	0.290	3.542	12.760
Crockery	Ottawa	Targeted	700422	7	43.16780	-85.84585	S2	NO	78.390	8.19	373.0	8.59	0.156	0.170	1.910	6.920
Crockery	Ottawa	Targeted	700422	7	43.16780	-85.84585	S2	NO	.	.	.	.	0.360	0.360	4.209	14.710
Crockery	Ottawa	Targeted	700422	7	43.16389	-85.85839	S3	NO	78.251	8.76	371.6	8.66	0.165	0.180	2.140	7.790
Crockery	Ottawa	Targeted	700422	7	43.16389	-85.85839	S3	NO	78.190	8.66	371.4	8.66	0.213	0.220	3.185	11.790
Crockery	Ottawa	Targeted	700422	7	43.16570	-85.85640	DEEP	NO	81.470	7.96	384.0	8.58	0.245	0.230	2.880	10.100
Crockery	Ottawa	Targeted	700422	7	43.16570	-85.85640	DEEP	NO	81.060	7.71	383.7	8.55	0.270	0.250	3.600	13.600
Crockery	Ottawa	Targeted	700422	7	43.16570	-85.85640	DEEP	NO	79.510	6.47	391.3	8.38	0.279	0.260	3.750	13.900
Crockery	Ottawa	Targeted	700422	7	43.16570	-85.85640	DEEP	NO	70.480	0.61	411.1	7.67	0.389	0.370	3.550	13.100
Crockery	Ottawa	Targeted	700422	7	43.16570	-85.85640	DEEP	NO	50.830	0.12	467.9	7.40	0.263	0.260	1.850	6.810
Crockery	Ottawa	Targeted	700422	7	43.16570	-85.85640	DEEP	NO	45.700	0.08	474.3	7.31	0.225	0.210	1.320	5.100
Crockery	Ottawa	Targeted	700422	7	43.17190	-85.84630	S1	NO	81.700	8.02	384.3	8.58	0.220	0.200	2.370	8.800
Crockery	Ottawa	Targeted	700422	7	43.16780	-85.84900	S2	NO	81.300	7.87	382.9	8.58	0.270	0.250	3.220	11.220
Crockery	Ottawa	Targeted	700422	7	43.16400	-85.85830	S3	NO	81.560	7.95	383.8	8.59	0.240	0.230	3.090	11.700
Crockery	Ottawa	Targeted	700422	8	43.16556	-85.85648	DEEP	NO	78.200	7.59	400.9	8.48	0.240	0.240	2.260	8.270
Crockery	Ottawa	Targeted	700422	8	43.16556	-85.85648	DEEP	NO	78.010	7.38	400.0	8.44	0.413	0.400	4.650	17.200
Crockery	Ottawa	Targeted	700422	8	43.16556	-85.85648	DEEP	NO	77.500	6.08	400.5	8.27	0.460	0.450	6.400	23.200
Crockery	Ottawa	Targeted	700422	8	43.16556	-85.85648	DEEP	NO	62.020	1.25	391.5	7.65	0.350	0.320	2.690	9.740
Crockery	Ottawa	Targeted	700422	8	43.16556	-85.85648	DEEP	NO	47.300	0.24	335.6	7.40	0.210	0.200	1.390	5.200
Crockery	Ottawa	Targeted	700422	8	43.16556	-85.85648	DEEP	NO	44.940	0.14	325.8	7.30	0.170	0.160	1.110	4.190
Crockery	Ottawa	Targeted	700422	8	43.17186	-85.84589	S1	NO	77.800	7.27	401.1	8.43	0.281	0.270	2.550	9.650
Crockery	Ottawa	Targeted	700422	8	43.17186	-85.84589	S1	NO	77.600	7.25	400.0	8.42	0.405	0.380	4.220	16.300
Crockery	Ottawa	Targeted	700422	8	43.16783	-85.84888	S2	NO	78.000	7.72	399.5	8.50	0.250	0.230	2.120	7.750
Crockery	Ottawa	Targeted	700422	8	43.16783	-85.84888	S2	NO	76.900	7.43	395.4	8.46	0.360	0.340	3.950	14.500
Crockery	Ottawa	Targeted	700422	8	43.16393	-85.85845	S3	NO	79.100	7.64	402.6	8.54	0.290	0.280	2.700	9.100
Crockery	Ottawa	Targeted	700422	8	43.16393	-85.85845	S3	NO	78.300	7.80	400.8	8.51	0.381	0.360	3.850	13.820
Crockery	Ottawa	Targeted	700422	8	43.16541	-85.85717	DEEP	NO	80.002	7.41	353.6	8.44	0.091	0.090	9.630	3.490
Crockery	Ottawa	Targeted	700422	8	43.16541	-85.85717	DEEP	NO	79.187	6.46	351.3	8.33	0.194	0.170	2.003	7.250
Crockery	Ottawa	Targeted	700422	8	43.16541	-85.85717	DEEP	NO	49.990	0.37	296.3	7.43	0.287	0.320	1.770	6.360
Crockery	Ottawa	Targeted	700422	8	43.16541	-85.85717	DEEP	NO	45.000	0.07	279.0	7.27	0.195	0.160	1.154	4.200
Crockery	Ottawa	Targeted	700422	8	43.16541	-85.85717	DEEP	NO	44.290	0.04	278.6	7.23	0.188	0.150	1.021	3.740
Crockery	Ottawa	Targeted	700422	8	43.16541	-85.85717	DEEP	NO	43.800	0.01	292.9	7.08	0.172	0.160	1.048	3.740
Crockery	Ottawa	Targeted	700422	8	43.17184	-85.84537	S1	NO	79.820	7.16	354.6	8.40	0.151	0.130	1.306	4.690
Crockery	Ottawa	Targeted	700422	8	43.17184	-85.84537	S1	NO	79.240	7.13	350.9	8.39	0.168	0.140	2.207	7.890
Crockery	Ottawa	Targeted	700422	8	43.16784	-85.84886	S2	NO	80.200	7.35	354.0	8.45	0.133	0.110	1.040	4.320
Crockery	Ottawa	Targeted	700422	8	43.16784	-85.84886	S2	NO	79.300	7.15	349.9	8.44	0.120	0.120	1.444	5.470
Crockery	Ottawa	Targeted	700422	8	43.16397	-85.85842	S3	NO	80.430	7.38	355.1	8.46	0.140	0.110	1.299	4.660
Crockery	Ottawa	Targeted	700422	8	43.16397	-85.85842	S3	NO	79.750	8.01	340.7	8.54	0.142	0.120	1.584	5.860
Crockery	Ottawa	Targeted	700422	8	43.16524	-85.85720	DEEP	NO	79.953	8.18	397.6	8.53	0.214	0.130	1.484	5.390
Crockery	Ottawa	Targeted	700422	8	43.16524	-85.85720	DEEP	NO	78.248	4.95	398.9	8.19	0.285	0.200	2.237	8.320
Crockery	Ottawa	Targeted	700422	8	43.16524	-85.85720	DEEP	NO	51.480	1.05	341.5	7.33	0.313	0.240	1.655	6.060
Crockery	Ottawa	Targeted	700422	8	43.16524	-85.85720	DEEP	NO	45.543	0.17	321.8	7.23	0.208	0.140	1.141	4.210
Crockery	Ottawa	Targeted	700422	8	43.16524	-85.85720	DEEP	NO	44.513	0.10	317.8	7.20	0.219	0.150	1.145	4.280
Crockery	Ottawa	Targeted	700422	8	43.16524	-85.85720	DEEP	NO	43.926	0.05	331.8	7.05	0.223	0.150	1.009	3.780
Crockery	Ottawa	Targeted	700422	8	43.17205	-85.84661	S1	NO	79.163	7.55	397.6	8.44	0.390	0.280	2.570	9.170
Crockery	Ottawa	Targeted	700422	8	43.17205	-85.84661	S1	NO	79.159	7.59	397.5	8.44	0.397	0.300	2.763	9.550
Crockery	Ottawa	Targeted	700422	8	43.16775	-85.84887	S2	NO	79.055	7.57	395.6	8.45	0.242	0.160	1.770	6.240
Crockery	Ottawa	Targeted	700422	8	43.16775	-85.84887	S2	NO	78.699	7.58	394.1	8.45	0.272	0.190	2.376	10.190
Crockery	Ottawa	Targeted	700422	8	43.16381	-85.85843	S3	NO	79.776	8.13	397.1	8.56	0.289	0.210	1.897	6.990

Secchi depth (FT)	Lab Chlorophyl-a (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	Ortho phosphate (mg/l)	Total P (mg/l)	Microcystin test strip result (µg/l)	Microcystin lab results (µg/l)	Anatoxin-a (µg/l)	Cylindrospermopsin (µg/l)
2.75	.	.	.	.	.	0.0	0.005	0.250	0.250
2.500	.	.	.	.	.	0.0	.	.	.
2.670	.	.	.	.	.	0.0	.	.	.
3.700	11.000	0.730	0.005	0.003	0.032	0.0	.	.	.
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4.500	.	.	.	.	.	0.0	.	.	.
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6.200	9.700	0.610	0.005	0.005	0.029	0.0	.	.	.
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4.300	.	.	.	.	.	0.0	.	.	.

LAKE	County	TYPE	STORET	Month	Latitude	Longitude	Site	Scum Sample?	Temperature (°F)	Dissolved oxygen (mg/l)	Conductivity (µs/cm)	pH	Phycocyanin RFU	Phycocyanin (µg/l)	Chlorophyl-a RFU	Chlorophyl-a (µg/l)
Crockery	Ottawa	Targeted	700422	8	43.16381	-85.85843	S3	NO	79.648	6.03	396.3	8.52	0.746	0.660	5.271	18.980
Crockery	Ottawa	Targeted	700422	8	43.16357	-85.85709	DEEP	NO	76.788	6.17	392.9	8.26	0.165	0.110	1.390	5.180
Crockery	Ottawa	Targeted	700422	8	43.16357	-85.85709	DEEP	NO	76.483	5.85	391.8	8.17	0.185	0.120	1.685	6.000
Crockery	Ottawa	Targeted	700422	8	43.16357	-85.85709	DEEP	NO	57.050	0.05	366.0	7.34	0.630	0.530	3.250	12.000
Crockery	Ottawa	Targeted	700422	8	43.16357	-85.85709	DEEP	NO	45.230	0.00	320.9	7.28	0.275	0.150	1.170	4.420
Crockery	Ottawa	Targeted	700422	8	43.16357	-85.85709	DEEP	NO	44.386	0.00	317.1	7.28	0.200	0.120	1.070	3.950
Crockery	Ottawa	Targeted	700422	8	43.16357	-85.85709	DEEP	NO	43.950	0.00	333.3	7.12	0.225	0.140	1.150	4.150
Crockery	Ottawa	Targeted	700422	8	43.17201	-86.84180	S1	NO	76.854	6.95	392.7	8.37	0.200	0.130	1.320	5.000
Crockery	Ottawa	Targeted	700422	8	43.16782	-85.84889	S2	NO	76.330	7.04	388.0	8.38	0.180	0.100	1.250	4.500
Crockery	Ottawa	Targeted	700422	8	43.16385	-85.85851	S3	NO	76.940	6.40	392.7	8.32	0.150	0.070	1.010	3.600
Crockery	Ottawa	Targeted	700422	8	43.16560	-85.85786	DEEP	NO	78.940	9.07	375.8	8.50	0.141	0.140	1.870	7.150
Crockery	Ottawa	Targeted	700422	8	43.16560	-85.85786	DEEP	NO	76.560	6.75	369.8	8.19	0.262	0.250	2.595	9.500
Crockery	Ottawa	Targeted	700422	8	43.16560	-85.85786	DEEP	NO	56.250	0.20	343.3	7.25	0.698	0.710	2.890	10.960
Crockery	Ottawa	Targeted	700422	8	43.16560	-85.85786	DEEP	NO	45.762	0.04	304.7	7.16	0.601	0.600	1.242	4.570
Crockery	Ottawa	Targeted	700422	8	43.16560	-85.85786	DEEP	NO	44.580	0.00	301.4	7.13	0.661	0.670	1.140	4.120
Crockery	Ottawa	Targeted	700422	8	43.17200	-85.84600	S1	NO	78.540	8.87	376.6	8.44	0.220	0.200	2.420	9.200
Crockery	Ottawa	Targeted	700422	8	43.17200	-85.84600	S1	NO	78.500	8.92	376.6	8.46	0.190	0.170	2.520	9.210
Crockery	Ottawa	Targeted	700422	8	43.16780	-85.84897	S2	NO	78.580	8.84	375.1	8.42	0.165	0.150	2.380	8.870
Crockery	Ottawa	Targeted	700422	8	43.16780	-85.84897	S2	NO	78.310	8.26	376.1	8.33	0.204	0.200	2.570	9.590
Crockery	Ottawa	Targeted	700422	8	43.16401	-85.85847	S3	NO	78.920	8.96	78.9	8.46	0.139	0.140	1.890	7.180
Crockery	Ottawa	Targeted	700422	8	43.16401	-85.85847	S3	NO	78.290	8.42	374.7	8.38	0.242	0.230	2.660	9.950
Crockery	Ottawa	Targeted	700422	9	43.16559	-85.85677	DEEP	NO	74.150	8.45	387.1	8.48	0.336	0.330	3.582	12.250
Crockery	Ottawa	Targeted	700422	9	43.16559	-85.85677	DEEP	NO	72.929	3.70	395.0	7.74	0.161	0.180	2.467	8.930
Crockery	Ottawa	Targeted	700422	9	43.17199	-85.84624	S1	NO	74.460	8.85	390.1	8.51	0.385	0.370	3.860	12.880
Crockery	Ottawa	Targeted	700422	9	43.17199	-85.84624	S1	NO	74.460	8.95	390.1	8.51	0.380	0.350	3.560	13.090
Crockery	Ottawa	Targeted	700422	9	43.16780	-85.84888	S2	NO	74.000	8.78	386.7	8.49	0.366	0.350	3.784	13.220
Crockery	Ottawa	Targeted	700422	9	43.16780	-85.84888	S2	NO	73.670	8.82	384.7	8.45	0.509	0.470	4.999	11.860
Crockery	Ottawa	Targeted	700422	9	43.16384	-85.85838	S3	NO	74.199	8.76	387.1	8.50	0.300	0.310	3.289	12.160
Lamberton	Kent	Response	410825	8	43.01946	-85.62991	APT	NO	83.120	12.37	639.0	8.41	0.143	0.110	1.410	5.160
Lamberton	Kent	Response	410825	8	43.02254	-85.62836	N END	NO	85.019	12.89	658.0	8.39	0.162	0.140	1.201	4.830
Lamberton	Kent	Response	410825	8	43.02254	-85.62836	N END	YES	87.270	8.06	669.0	8.12	40.190	35.000	10.200	32.390
Lamberton	Kent	Response	410825	8	43.02301	-85.63027	N END	YES	79.600	11.07	655.0	8.40	0.380	0.300	1.460	5.370
Lamberton	Kent	Response	410825	8	43.01944	-85.62992	APT	NO	76.890	11.81	621.0	8.48	0.167	0.100	1.377	5.050
Houghton	Roscommon	Response	720142	8	44.40020	-84.77326	CAMPGROUND	NO	72.000	8.58	220.0	8.51	0.270	0.250	1.100	4.200
Houghton	Roscommon	Response	720142	8	44.37717	-84.75795	CHANNEL 1	NO	71.950	7.90	228.0	8.34	0.250	0.240	1.190	4.480
Houghton	Roscommon	Response	720142	8	44.37355	-84.76952	CHANNEL 2	NO	71.880	6.59	284.0	7.80	0.510	0.470	5.000	21.600
Houghton	Roscommon	Response	720142	8	44.37647	-84.76291	CHANNEL 3	NO	72.400	8.35	247.0	8.10	0.230	0.210	1.980	7.400
Houghton	Roscommon	Response	720142	8	44.32953	-84.65134	CHANNEL 4	NO	75.880	7.71	353.0	7.92	1.440	1.310	2.500	9.400
Houghton	Roscommon	Response	720142	8	44.32609	-84.64035	CHANNEL 5	NO	74.420	7.03	298.0	7.77	0.430	0.400	1.850	6.600
Houghton	Roscommon	Response	720142	8	44.32388	-84.63420	LAKE 1	NO	76.019	9.48	239.8	8.59	0.152	0.120	0.670	2.500
Houghton	Roscommon	Response	720142	8	44.29996	-84.65520	BEACH/LAKE 2	NO	73.322	8.67	230.0	8.46	0.210	0.200	0.940	3.500
Paradise	Emmet	Response	240043	9	45.67626	-84.73769	S BAY	NO	73.422	8.33	229.8	8.43	0.052	0.040	0.522	1.970
Paradise	Emmet	Response	240043	9	45.67626	-84.73769	S BAY	NO	73.355	8.34	229.9	8.38	0.358	0.610	1.402	3.180
Paradise	Emmet	Response	240043	9	45.68202	-84.72352	east bay	NO	73.912	8.37	248.2	8.38	0.070	0.060	0.906	3.460
Paradise	Emmet	Response	240043	9	45.68202	-84.72352	east bay	NO	73.884	8.42	247.4	8.37	0.127	0.100	1.106	3.750
Paradise	Emmet	Response	240043	9	45.69266	-84.75528	DEEP	NO	73.814	8.95	229.4	8.64	0.352	0.280	0.920	2.530
Paradise	Emmet	Response	240043	9	45.69266	-84.75528	DEEP	NO	73.752	8.97	229.3	8.62	0.412	0.440	1.207	4.660
Paradise	Emmet	Response	240043	9	45.69266	-84.75528	DEEP	NO	73.723	8.95	229.3	8.60	0.250	0.180	1.407	5.230
Paradise	Emmet	Response	240043	9	45.69266	-84.75528	DEEP	NO	73.602	8.82	229.0	8.58	0.136	0.120	1.322	5.020
Paradise	Emmet	Response	240043	9	45.69266	-84.75528	DEEP	NO	73.404	8.67	228.8	8.52	0.115	0.100	1.173	4.460
Paradise	Emmet	Response	240043	9	45.69266	-84.75528	DEEP	NO	73.270	8.41	229.6	8.44	0.097	0.060	1.234	4.520
Paradise	Emmet	Response	240043	9	45.69778	-84.77057	S4	NO	75.132	8.37	233.4	8.51	0.074	0.070	0.656	2.240
Paradise	Emmet	Response	240043	9	45.69778	-84.77057	S4	NO	75.132	8.97	233.3	8.52	2.499	2.170	2.050	4.780
Paradise	Emmet	Response	240043	9	45.69744	-84.74828	S3	NO	75.096	8.95	238.3	8.57	0.078	0.070	0.538	2.110
Paradise	Emmet	Response	240043	9	45.69744	-84.74828	S3	NO	75.141	6.89	239.6	8.54	1.324	0.740	0.574	2.160
Paradise	Emmet	Response	240043	9	45.68861	-84.73590	NE BAY	NO	73.360	8.95	231.0	8.64	0.089	0.080	1.098	3.990
Paradise	Emmet	Response	240043	9	45.68861	-84.73590	NE BAY	NO	73.340	8.95	.	.	.	.	.	.
Paradise	Emmet	Response	240043	9	45.68861	-84.73590	NE BAY	NO	73.288	8.80	.	.	.	.	.	.
Paradise	Emmet	Response	240043	9	45.68861	-84.73590	NE BAY	NO	73.027	8.27	.	.	.	.	.	.

Secchi depth (FT)	Lab Chlorophyl-a (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	Ortho phosphate (mg/l)	Total P (mg/l)	Microcystin test strip result (µg/l)	Microcystin lab results (µg/l)	Anatoxin-a (µg/l)	Cylindrospermopsin (µg/l)
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7.400	9.300	0.620	0.003	0.004	0.029	0.0	.	.	.
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7.000	6.200	0.670	0.002	0.004	0.021	0.0	0.004	0.001	0.008
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5.000	11.000	0.690	0.066	0.013	0.034	0.0	.	.	.
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5.500	.	.	.	.	.	0.0	0.004	0.001	0.008
1.500	.	.	.	.	.	0.0	0.153	0.009	0.008
1.500	.	.	.	.	.	0.0	0.148	0.003	0.008
0.000	.	.	.	.	.	10.0	10.590	0.030	0.060
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1.500	.	.	.	.	.	0.0	.	.	.
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3.800	.	.	.	.	.	0.0	0.430	0.001	0.008
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2.200	.	.	.	.	.	0.0	0.548	0.001	0.008
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4.700	34.000	0.930	0.005	0.003	0.017	0.0	0.331	0.001	0.008
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2.500	.	.	.	.	.	0.0	0.884	0.001	0.008
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LAKE	County	TYPE	STORET	Month	Latitude	Longitude	Site	Scum Sample?	Temperature (°F)	Dissolved oxygen (mg/l)	Conductivity (µs/cm)	pH	Phycocyanin RFU	Phycocyanin (µg/l)	Chlorophyl-a RFU	Chlorophyl-a (µg/l)
Paradise	Emmet	Response	240043	9	45.68861	-84.73590	NE BAY	NO	72.980	7.44	.	.	.	.	.	.
Paradise	Emmet	Response	240043	9	45.69061	-84.77374	WEST BAY	NO	74.400	8.53	230.2	8.55	0.101	0.070	1.049	4.040
Paradise	Emmet	Response	240043	9	45.69061	-84.77374	WEST BAY	NO	74.420	8.53	.	.	.	.	.	.
Paradise	Emmet	Response	240043	9	45.69061	-84.77374	WEST BAY	NO	74.300	8.47	.	.	.	.	.	.
Paradise	Emmet	Response	240043	9	45.69061	-84.77374	WEST BAY	NO	73.100	7.49	.	.	.	.	.	.
Sanford	Midland	Response	560169	9	43.68042	-84.37211	DEEP	NO	73.638	9.71	353.6	8.60	6.093	6.400	1.715	6.540
Sanford	Midland	Response	560169	9	43.68042	-84.37211	DEEP	NO	73.590	9.56	353.5	5.59	6.116	6.230	1.843	6.990
Sanford	Midland	Response	560169	9	43.68042	-84.37211	DEEP	NO	73.549	9.54	352.6	8.60	5.985	6.190	1.975	7.320
Sanford	Midland	Response	560169	9	43.68042	-84.37211	DEEP	NO	73.521	9.60	352.1	8.60	6.806	7.000	2.560	7.820
Sanford	Midland	Response	560169	9	43.68042	-84.37211	DEEP	NO	73.462	9.43	352.1	8.58	6.242	6.440	1.851	6.850
Sanford	Midland	Response	560169	9	43.68042	-84.37211	DEEP	NO	73.428	8.70	350.4	8.56	5.310	5.350	3.111	8.870
Sanford	Midland	Response	560169	9	43.68192	-84.38047	BEACH	NO	71.080	14.40	327.4	9.30	82.320	84.850	8.910	33.890
Sanford	Midland	Response	560169	9	43.78038	-84.39944	NORTH	YES	72.352	8.83	411.9	8.10	95.990	96.010	171.555	636.150
Sanford	Midland	Response	560169	9	43.78038	-84.39944	NORTH	YES	70.858	7.26	408.0	7.90	1.212	1.280	10.018	40.070
Sanford	Midland	Response	560169	9	43.72905	-84.38978	E COVE	NO	71.923	9.50	370.7	8.23	15.031	16.940	18.223	70.340
Sanford	Midland	Response	560169	9	43.69829	-84.38905	S BAY	NO	74.009	11.68	357.3	8.71	8.418	8.380	2.241	8.860
Sanford	Midland	Response	560169	9	43.67984	-84.38279	BOAT LAUNCH	YES	74.179	12.74	346.6	8.82	152.333	150.800	54.482	91.128
St. Louis Impoundment	Gratiot	Response	290064	9	43.40713	-84.61861	DEEP	NO	70.222	7.59	507.0	7.86	0.078	0.120	1.370	5.050
St. Louis Impoundment	Gratiot	Response	290064	9	43.40713	-84.61861	DEEP	NO	69.528	7.20	498.3	7.79	4.969	5.930	42.568	54.132
St. Louis Impoundment	Gratiot	Response	290064	9	43.40699	-84.61935	BOAT LAUNCH	NO	71.931	13.54	491.3	8.18	0.421	0.400	2.831	8.860
St. Louis Impoundment	Gratiot	Response	290064	9	43.40002	-84.61893	S CHEESMAN	NO	71.699	7.27	514.0	7.81	0.476	0.550	1.939	7.887
St. Louis Impoundment	Gratiot	Response	290064	9	43.40131	-84.61554	N CHEESMAN	NO	70.851	8.12	503.0	7.89	0.527	0.610	2.782	11.750
St. Louis Impoundment	Gratiot	Response	290064	9	43.40492	-84.61437	CRAWFORD	NO	70.495	7.94	510.0	7.95	0.309	0.330	1.581	5.840
Manitou	Shiawassee	Response	780233	10	42.92630	-84.20754	APACHE WEST	YES	64.708	10.65	353.8	8.40	1.685	1.560	0.958	3.560
Manitou	Shiawassee	Response	780233	10	42.92640	-84.20600	APACHE EAST	YES	65.305	9.41	375.7	8.27	96.927	74.720	12.831	40.250
Manitou	Shiawassee	Response	780233	10	42.92754	-84.20132	MANITOU	YES	64.352	9.21	357.8	8.18	1.375	1.250	0.717	2.610
Manitou	Shiawassee	Response	780233	10	42.92327	-84.19920	SUNSET	YES	62.985	10.11	355.1	8.30	2.202	2.040	1.712	5.870
Round	Lenawee	Response	460384	10	41.90822	-84.35087	292 SUNSET	NO	63.874	8.88	348.9	8.20	0.471	0.410	0.937	3.590
Round	Lenawee	Response	460384	10	41.90822	-84.35087	292 SUNSET	YES	52.700	1.80	931.0	7.14	133.000	124.880	26.136	95.270
Round	Lenawee	Response	460384	10	41.90816	-84.35091	292 SUNSET SCUM	YES	63.488	9.23	345.7	8.25	0.677	0.020	0.923	3.800
Round	Lenawee	Response	460384	10	41.90799	-84.35115	BOTTOM SCUM	YES	62.858	9.18	344.0	8.25	0.650	0.610	0.985	3.530
Round	Lenawee	Response	460384	10	41.90793	-84.35125	DOCK SCUM	YES	63.903	8.99	350.0	8.24	1.160	0.910	9.340	3.460
Ore	Livingston	Response	470569	9	42.48000	-83.80005	DEEP	NO	74.961	10.77	774.0	8.59	0.347	0.310	2.217	7.440
Ore	Livingston	Response	470569	9	42.48000	-83.80005	DEEP	NO	74.970	10.78	774.0	8.58	0.384	0.360	2.192	8.150
Ore	Livingston	Response	470569	9	42.48000	-83.80005	DEEP	NO	59.847	1.61	693.0	7.42	0.153	0.160	0.530	2.010
Ore	Livingston	Response	470569	9	42.48000	-83.80005	DEEP	NO	46.796	0.51	608.0	7.38	0.200	0.190	0.576	2.150
Ore	Livingston	Response	470569	9	42.48000	-83.80005	DEEP	NO	44.472	0.74	588.0	7.37	0.185	0.170	0.486	1.870
Ore	Livingston	Response	470569	9	42.48000	-83.80005	DEEP	NO	43.850	0.33	585.0	7.31	0.161	0.150	0.391	1.540
Ore	Livingston	Response	470569	9	42.47633	-83.79954	S SHORE	NO	75.379	11.52	774.0	8.67	108.798	98.050	25.217	88.500
Ore	Livingston	Response	470569	9	42.47937	-83.80093	W SHORE	NO	75.895	11.26	782.0	8.63	1.819	1.650	9.634	15.472
Pontiac	Oakland	Response	631094	9	42.66628	-83.45310	DEEP	YES	74.770	10.10	360.2	8.76	1.368	1.270	2.776	10.180
Pontiac	Oakland	Response	631094	9	42.66628	-83.45310	DEEP	YES	73.808	8.90	358.8	8.70	1.539	1.400	2.983	11.060
Pontiac	Oakland	Response	631094	9	42.66628	-83.45310	DEEP	YES	72.670	3.65	357.1	7.71	1.196	1.120	1.579	5.940
Pontiac	Oakland	Response	631094	9	42.66628	-83.45310	DEEP	YES	71.829	0.72	365.5	7.48	0.689	0.630	1.492	5.840
Pontiac	Oakland	Response	631094	9	42.66628	-83.45310	DEEP	YES	70.719	0.19	356.5	7.48	0.685	0.620	1.325	5.000
Pontiac	Oakland	Response	631094	9	42.66628	-83.45310	DEEP	YES	65.357	0.10	384.1	7.43	0.577	0.560	0.965	3.670
Pontiac	Oakland	Response	631094	9	42.66628	-83.45310	DEEP	YES	56.200	0.06	372.4	7.09	0.562	0.510	1.002	3.800
Pontiac	Oakland	Response	631094	9	42.67487	-83.46409	S1	NO	74.137	7.08	378.6	8.36	1.723	1.640	5.109	16.290
Pontiac	Oakland	Response	631094	9	42.67487	-83.46409	S1	NO	73.921	6.89	379.4	8.14	2.486	2.260	10.109	40.920
Pontiac	Oakland	Response	631094	9	42.66808	-83.44733	BEACH	NO	74.513	8.95	361.7	8.64	1.352	1.270	2.414	9.690
Pontiac	Oakland	Response	631094	9	42.66808	-83.44733	BEACH	NO	74.415	9.16	361.1	8.65	1.448	1.340	2.900	11.200
Pontiac	Oakland	Response	631094	9	42.66543	-83.66543	S3	YES	75.128	5.48	387.4	7.94	1.488	1.390	3.619	13.780
Pontiac	Oakland	Response	631094	9	42.66543	-83.66543	S3	YES	75.191	5.06	388.1	7.79	2.179	4.139	3.288	14.010
Pontiac	Oakland	Response	631094	9	42.66343	-83.44294	BOAT LAUNCH	NO	75.061	7.40	373.0	8.25	1.326	1.250	3.520	13.180
Pontiac	Oakland	Response	631094	9	42.66343	-83.44294	BOAT LAUNCH	NO	74.404	4.83	380.0	7.87	2.410	1.930	2.715	12.860
Belleville	Wayne	TMDL	821162	6	42.21012	-83.49474	DEEP	NO	.	.	.	.	.	.	.	.
Belleville	Wayne	TMDL	821162	7	42.21012	-83.49474	DEEP	NO	.	.	.	.	.	.	.	.
Ford	Washtenaw	TMDL	810209	6	42.21984	-83.59483	DEEP	NO	.	.	.	.	.	.	.	.
Ford	Washtenaw	TMDL	810209	8	42.21984	-83.59483	DEEP	NO	79.500	9.28	769.0	8.28	1.530	1.560	2.670	10.560

Secchi depth (FT)	Lab Chlorophyl-a (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	Ortho phosphate (mg/l)	Total P (mg/l)	Microcystin test strip result (µg/l)	Microcystin lab results (µg/l)	Anatoxin-a (µg/l)	Cylindrospermopsin (µg/l)
.	.	.	.	.	.	.	.	.	.
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1.330	45.000	1.200	0.005	0.024	0.056	.	.	.	.
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1.7	.	.	.	.	.	0.0	0.5	0.0	0.0
.	.	.	.	.	.	.	.	.	.
0.700	.	.	.	.	.	0.0	0.018	0.003	0.030
0.900	.	.	.	.	.	0.0	0.860	0.001	0.008
.	.	.	.	.	.	0.0	5.8	1.8	0.3
3.600	4.000	0.690	0.660	0.026	0.045	0.0	0.250	1.300	0.250
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
2.900	.	.	.	.	.	0.0	0.034	2.400	0.070
1.900	.	.	.	.	.	0.0	.	.	.
2.900	.	.	.	.	.	.	.	.	.
.	54.000	1.000	0.005	0.003	0.035	0.0	0.406	0.001	0.008
.	.	.	.	.	.	10.0	2.300	0.030	0.300
1.000	.	.	.	.	.	0.0	0.198	0.001	0.008
0.100	.	.	.	.	.	10.0	5.100	0.030	0.300
2.000	5.700	1.000	0.005	0.003	0.012	0.0	0.025	0.001	0.008
.	.	.	.	.	.	.	.	.	.
1.000	.	.	.	.	.	5.0	28.000	0.520	0.300
0.500	.	.	.	.	.	0.0	0.590	0.160	0.300
2.000	.	.	.	.	.	5.0	0.450	0.030	0.300
4.000	.	.	.	.	.	0.0	0.044	0.001	0.008
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
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.	.	.	.	.	.	.	.	.	.
0.800	14.000	1.200	0.072	.	0.034	0.0	0.150	0.001	0.008
1.500	.	.	.	.	.	0.0	.	.	.
2.300	.	.	.	.	.	0.0	.	.	.
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.	.	.	.	.	.	.	.	.	.
1.500	27.000	1.200	0.050	.	0.026	0.0	0.100	0.006	0.015
.	.	.	.	.	.	.	.	.	.
1.800	.	.	.	.	.	0.0	0.230	0.007	0.015
.	.	.	.	.	.	.	.	.	.
1.800	.	.	.	.	.	2.5	0.300	0.012	0.015
SCUM	.	.	.	.	.	10.0	122.000	0.041	0.050
2.700	.	.	.	.	.	1.0	1.600	0.011	0.015
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	0.021	0.25	0.25
.	.	.	.	.	.	.	0.041	0.25	0.25
.	.	.	.	.	.	.	0.037	0.25	0.25
.	.	.	.	.	.	0.0	.	.	.

LAKE	County	TYPE	STORET	Month	Latitude	Longitude	Site	Scum Sample?	Temperature (°F)	Dissolved oxygen (mg/l)	Conductivity (µs/cm)	pH	Phycocyanin RFU	Phycocyanin (µg/l)	Chlorophyl-a RFU	Chlorophyl-a (µg/l)
Ford	Washtenaw	TMDL	810209	8	42.22334	-83.59797	S1	NO	77.170	6.21	632.0	7.63	0.218	0.230	1.651	6.140
Ford	Washtenaw	TMDL	810209	8	42.21093	-83.57302	S2	NO	82.000	7.18	777.0	8.15	0.499	0.520	0.990	3.690
Allegan	Allegan	TMDL	30594	6	42.55116	-85.936987	S2	NO	79.150	11.96	659.0	8.50	1.790	1.580	7.878	29.610
Allegan	Allegan	TMDL	30594	6	42.55116	-85.936987	S2	NO	78.610	10.64	671.0	8.41	1.248	1.050	60.130	21.530
Allegan	Allegan	TMDL	30594	6	42.55116	-85.936987	S2	NO	77.840	9.43	674.0	8.35	0.780	0.490	5.180	16.490
Allegan	Allegan	TMDL	30594	6	42.55116	-85.936987	S2	NO	77.760	9.10	674.0	8.32	0.500	0.170	3.052	9.480
Allegan	Allegan	TMDL	30594	6	42.55116	-85.936987	S2	NO	77.770	8.79	675.0	8.30	0.460	0.120	3.152	11.910
Allegan	Allegan	TMDL	30594	6	42.55116	-85.936987	S2	NO	77.630	7.84	678.0	8.22	0.540	0.180	3.328	12.480
Allegan	Allegan	TMDL	30595	7	42.54817	-85.9159332	S1	NO	82.100	15.75	631.0	8.39	0.832	0.000	6.872	22.310
Allegan	Allegan	TMDL	30595	7	42.54817	-85.9159332	S1	NO	81.490	15.35	633.0	8.37	0.956	0.000	7.574	26.950
Allegan	Allegan	TMDL	30595	7	42.54817	-85.9159332	S1	NO	79.720	9.92	656.0	8.04	1.090	0.000	8.044	28.810
Allegan	Allegan	TMDL	30595	7	42.54817	-85.9159332	S1	NO	79.470	9.06	655.0	8.00	1.582	0.000	10.222	29.630
Allegan	Allegan	TMDL	30594	8	42.56273	-85.9508009	S3	NO	80.300	15.84	625.0	8.64	1.370	0.870	9.003	35.430
Allegan	Allegan	TMDL	30594	8	42.56273	-85.9508009	S3	NO	79.30	14.95	623	8.59	1.09	0.605	7.187	28.06
Allegan	Allegan	TMDL	30594	8	42.56273	-85.9508009	S3	NO	78.10	13.94	618	8.53	0.71	0.282	4.998	18.83
Allegan	Allegan	TMDL	30594	8	42.56273	-85.9508009	S3	NO	77.90	13.02	617	8.46	0.63	0.188	4.422	17.08
Allegan	Allegan	TMDL	30594	8	42.56273	-85.9508009	S3	NO	77.70	12.26	617	8.44	0.51	0.093	4.628	16.85
Allegan	Allegan	TMDL	30594	8	42.56273	-85.9508009	S3	NO	77.50	12.16	616	8.41	0.47	0.074	4.178	15.63
Allegan	Allegan	TMDL	30594	9	42.56273	-85.9508009	S3	NO	73.38	13.85	670	8.34	0.76	0.321	6.017	22.16
Allegan	Allegan	TMDL	30594	9	42.56273	-85.9508009	S3	NO	73.34	14.05	670	8.31	0.68	0.261	5.444	20.28
Allegan	Allegan	TMDL	30594	9	42.56273	-85.9508009	S3	NO	73.28	13.94	670	8.3	0.71	0.278	5.584	19.58
Allegan	Allegan	TMDL	30594	9	42.56273	-85.9508009	S3	NO	73.22	13.91	670	8.29	0.64	0.217	5.03	18.67
Allegan	Allegan	TMDL	30594	9	42.56273	-85.9508009	S3	NO	72.97	13.02	673	8.25	0.49	0.077	4.045	17.36
Allegan	Allegan	TMDL	30594	9	42.56273	-85.9508009	S3	NO	72.94	11.98	681	8.22	0.45	0.038	4.172	15.24
Allegan	Allegan	TMDL	30594	9	42.56273	-85.9508009	S3	NO	72.75	10.24	688	8.12	0.38	0	3.548	13.42
Allegan	Allegan	TMDL	30594	9	42.56273	-85.9508009	S3	NO	72.01	5.20	684	7.81	0.38	0	3.204	12.25
Macatawa	Ottawa	TMDL	700574	6	42.78302	-86.14558	.	NO	.	.	.	.	.	.	.	.
Macatawa	Ottawa	TMDL	700574	7	42.78302	-86.14558	S2	NO	.	.	.	.	.	.	.	.
Macatawa	Ottawa	TMDL	700574	7	42.78302	-86.14558	S3	NO	.	.	.	.	.	.	.	.
Macatawa	Ottawa	TMDL	700574	8	42.78302	-86.14558	LAUNCH	NO	.	.	.	.	.	.	.	.
Macatawa	Ottawa	TMDL	700574	9	42.78302	-86.14558	.	NO	.	.	.	.	.	.	.	.
Holloway Reservoir	Genesee	Status/trend	2504461	7	43.12455	-83.48719	.	NO	.	.	.	.	.	.	.	.
Hoffman	Isabella	Status/trend	370161	7	43.70166	-85.08548	.	NO	.	.	.	.	.	.	.	.
Long	Ionia	Status/trend	340100	7	43.11203	-85.12600	.	NO	.	.	.	.	.	.	.	.
Long	Ionia	Status/trend	340100	8	43.11203	-85.12600	.	NO	.	.	.	.	.	.	.	.
Little Duck	Gogebic	Status/trend	270225	8	46.22712	-89.22844	.	NO	.	.	.	.	.	.	.	.
Camp 41	Delta	Status/trend	210326	8	46.08084	-86.53061	.	NO	.	.	.	.	.	.	.	.
Parent	Baraga	Status/trend	070044	8	46.57286	-88.43408	.	NO	.	.	.	.	.	.	.	.
Dumont	Allegan	Status/trend	030725	8	42.59246	-85.85847	.	NO	.	.	.	.	.	.	.	.
McDonald	Gogebic	Status/trend	270111	8	46.38333	-90.01386	.	NO	.	.	.	.	.	.	.	.
Bear	Hillsdale	Status/trend	300141	8	41.87004	-84.68232	.	NO	.	.	.	.	.	.	.	.
Ocqueoc	Presque Isle	Status/trend	710162	8	45.47817	-84.11401	.	NO	.	.	.	.	.	.	.	.
Pretty	Luce	Status/trend	480077	8	46.60104	-85.66165	.	NO	.	.	.	.	.	.	.	.
West Londo	Iosco	Status/trend	350232	8	44.35094	-83.87901	.	NO	.	.	.	.	.	.	.	.
Fourth	Hillsdale	Status/trend	300294	8	41.88613	-84.59656	.	NO	.	.	.	.	.	.	.	.
Round	Isabella	Status/trend	370159	8	43.69777	-85.07986	.	NO	.	.	.	.	.	.	.	.
Twin	Muskegon	Status/trend	610407	8	43.36907	-86.17531	.	NO	.	.	.	.	.	.	.	.
Upper Silver	Oakland	Status/trend	631233	8	42.67703	-83.32777	.	NO	.	.	.	.	.	.	.	.
Pentwater	Oceana	Status/trend	640089	8	43.77272	-86.42999	.	NO	.	.	.	.	.	.	.	.
Haithco	Saginaw	Status/trend	730378	8	43.46687	-83.95784	.	NO	.	.	.	.	.	.	.	.
Holloway Reservoir	Genesee	Status/trend	2504461	8	43.11430	-83.46292	.	NO	.	.	.	.	.	.	.	.
Johnson	Ogemaw	Status/trend	650141	8	44.20689	-83.95648	.	NO	.	.	.	.	.	.	.	.
Pearl	Benzie/Leelanau	Status/trend	100160	8	44.76468	-85.92394	.	NO	.	.	.	.	.	.	.	.
Walloon	Charlevoix/Emmet	Status/trend	150075	8	45.26749	-84.96363	.	NO	.	.	.	.	.	.	.	.
Long	Isabella	Status/trend	370160	8	43.69959	-85.08482	.	NO	.	.	.	.	.	.	.	.
Five Channels	Iosco	Status/trend	350256	8	44.45577	-83.67792	.	NO	.	.	.	.	.	.	.	.
Four Mile Pond	Alpena	Status/trend	040195	8	45.09389	-83.50397	.	NO	.	.	.	.	.	.	.	.
Pike	Luce	Status/trend	480018	8	46.64639	-85.40639	.	NO	.	.	.	.	.	.	.	.
George	Baraga	Status/trend	070141	8	46.54803	-88.20045	.	NO	.	.	.	.	.	.	.	.
Milakokia	Mackinac	Status/trend	490035	8	46.07199	-85.79570	.	NO	.	.	.	.	.	.	.	.
Clark	Luce	Status/trend	480076	8	46.61927	-85.24296	.	NO	.	.	.	.	.	.	.	.

Secchi depth (FT)	Lab Chlorophyl-a (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	Ortho phosphate (mg/l)	Total P (mg/l)	Microcystin test strip result (µg/l)	Microcystin lab results (µg/l)	Anatoxin-a (µg/l)	Cylindrospermopsin (µg/l)
.	.	.	.	.	.	0.0	.	.	.
.	.	.	.	.	.	.	0.365	0.001	0.008
1.500	58.000	1.300	0.650	0.015	0.120	.	0.005	0.250	0.250
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	0.780	0.730	0.009	0.068	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	0.780	0.730	0.013	0.080	.	.	.	.
2.300	110.000	0.860	0.310	0.011	0.071	0.0	.	0.001	0.008
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	1.000	0.350	0.012	0.088	.	.	.	.
1.800	75.000	2.600	0.790	0.021	0.310	0.0	0.04575	0.005	0.050
.	.	.	.	.	.	.	.	.	.
.	.	0.890	0.810	0.012	0.062	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	0.930	0.830	0.014	0.083	.	.	.	.
3.400	40.000	0.710	0.650	0.006	0.047	2.5	0.00375	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	0.680	0.670	0.004	0.043	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	1.000	0.670	0.014	0.120	.	.	.	.
.	.	.	.	.	.	.	0.0195	0.25	0.25
.	.	.	.	.	.	.	0.3478	0.25	0.25
.	.	.	.	.	.	.	1.2591	0.25	0.25
.	.	.	.	.	.	.	0.108	0.00075	0.0075
.	.	.	.	.	.	.	0.0124	0.019	0.0075
.	.	.	.	.	.	0.0	0.141	0.022	0.05
.	.	.	.	.	.	0.0	0.019	0.005	0.05
.	.	.	.	.	.	0.0	1	0.005	0.05
.	.	.	.	.	.	1.0	4.3	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05
.	.	.	.	.	.	0.0	0.049	0.005	0.05
.	.	.	.	.	.	0.0	0.011	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05
.	.	.	.	.	.	0.0	0.068	0.005	0.05
.	.	.	.	.	.	0.0	0.14	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05
.	.	.	.	.	.	0.0	0.13	0.005	0.05
.	.	.	.	.	.	0.0	0.12	0.005	0.05
.	.	.	.	.	.	0.0	0.031	0.005	0.05
.	.	.	.	.	.	0.0	0.023	0.017	0.05
.	.	.	.	.	.	0.0	0.0068	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.022	0.05
.	.	.	.	.	.	0.0	0.25	0.005	0.05
.	.	.	.	.	.	0.0	0.062	0.005	0.05
.	.	.	.	.	.	0.0	0.071	0.005	0.05
.	.	.	.	.	.	0.0	0.022	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05
.	.	.	.	.	.	0.0	0.011	0.005	0.05
.	.	.	.	.	.	0.0	0.016	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05
.	.	.	.	.	.	0.0	0.019	0.005	0.05
.	.	.	.	.	.	0.0	0.00335	0.005	0.05