MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
WATER RESOURCES DIVISION
AUGUST 2019

STAFF REPORT

ALGAL TOXIN MONITORING IN MICHIGAN INLAND LAKES: 2016-2018 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 Environment, Great Lakes, and Energy (EGLE), Water Resources Division (WRD), developed the following definition of a HAB (Kohlhepp, 2015): “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 EGLE-WRD.” A key concept of this HAB definition is that while high chlorophyll *a* concentration and visible surface/water column algal accumulations can indicate potential problems, the WRD’s focus is on the potential harm that toxins represent. Thus, water samples must be analyzed for the presence of toxins to confirm that a bloom may, in fact, be potentially harmful to humans, pets, or wildlife. Visible appearance of blooms cannot be used as a reliable predictor of toxin content.

Cyanobacteria are one of the oldest life forms on Earth (e.g., Schirrmeister et al., 2016) that can live in terrestrial, marine, and freshwater environments (Chorus and Bartram, 1999). The potential harmful effects of cyanobacteria on animals have been documented as far back as the 19th century (Francis, 1878; Arthur, 1889). More recent work has focused on the potential harmful effects of cyanobacterial toxins on humans and pets (Koreivienė et al., 2014; Trevino-Garrison et al., 2015; Zhang et al., 2015). Incidences of cyanobacterial blooms have increased worldwide in the last several decades (Carmichael, 2008; O’Neil et al., 2012; Taranu et al., 2015; Scholz et al., 2017). Given future climate scenarios and the increased amount of nutrients required for more intensive agricultural practices, the frequency, duration, and magnitude of cyanobacteria blooms are expected to increase worldwide (Jöhnk et al., 2008; Reichwaldt and Ghadouani, 2011; Posch et al., 2012; Michalak et al., 2013; Paerl, 2018).

In Michigan, previous research on inland lake HABs has focused on zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*) invasions and the subsequent increases in cyanobacteria biomass and microcystin production (Raikow et al., 2004; Sarnelle et al., 2005; Wilson et al., 2005; Knoll et al., 2008; Woller-Skar, 2009; Sarnelle et al., 2010; White et al., 2017; Gaskill and Woller-Skar, 2018). Other research has focused on cyanobacteria and microcystin production dynamics in specific water bodies of interest, particularly in west Michigan (Hong et al., 2006; Rediske et al., 2007; Gillett and Steinman, 2011; Xie et al., 2011; Xie et al., 2012; Gillett et al., 2015) and Ford and Belleville Lakes (Washtenaw and Wayne Counties; Lehman, 2007; Lehman et al., 2009; Lehman, 2014). The EGLE has been monitoring the number of citizen and staff complaints regarding nuisance algae and cyanobacteria (Parker, 2014; 2015; 2016a; 2016b; and 2018a) and monitoring the concentration of the cyanobacterial toxins microcystin, anatoxin-a, and cylindrospermopsin in the State of Michigan for the last several years (Holden, 2016; Parker 2017; 2018b).

This report summarizes cyanobacteria toxin monitoring from 2016 through 2018. The purpose of this report is to (1) evaluate the geographical extent of HABS throughout Michigan (i.e., how widespread is the problem?); (2) compare microcystin concentrations between cyanobacterial scums and nearby ambient water; (3) evaluate the efficacy of commercially available test strips for microcystin detection; and (4) explore any patterns that can explain cyanobacterial bloom occurrence and microcystin production throughout the state. Raw data from 2016 and 2017 are available in past reports (Parker 2017; 2018b). Raw data from 2018 are available at the end of this report (Appendix 1).

Sites

The lakes that are assessed in this report can be placed in three broad categories: randomly-selected lakes that were sampled for limnological parameters as part of the Inland Lakes Status and Trend Program (Walterhouse, 2015), targeted lakes that were visited because EGLE staff were aware of previous cyanobacteria blooms that had taken place in them, or because they were sampled as part of Total Maximum Daily Load (TMDL) development, and lakes that EGLE received complaints about either from citizens or staff (Figure 1).

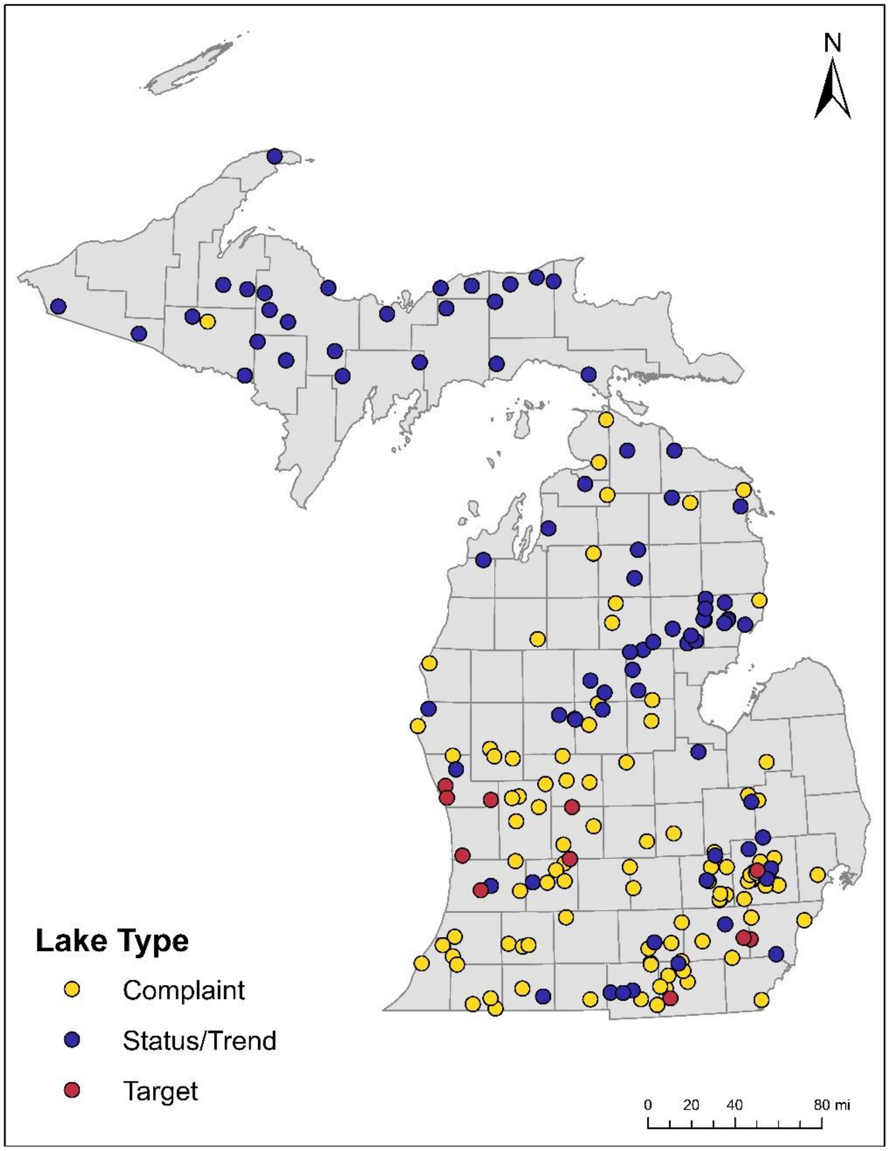


Figure 1. Different types of lakes sampled for cyanobacterial toxins from 2016-2018.

Field Methods

Sampling occurred between early May and late November, with most monitoring occurring in August and September. During a monitoring event at a lake, EGLE-WRD staff typically took pictures of algal conditions, collected general water chemistry in the center of the lake (if accessible by boat), and collected water samples for cyanobacteria toxin analysis from up to four locations around the lake. If a water body was inaccessible by boat, then only shoreline samples were collected for toxin analysis; however, nutrient and chlorophyll samples were not collected. The cyanobacteria toxin samples were analyzed using both Abraxis (Abraxis, Inc., Warminster, Pennsylvania) test strips to assess microcystin presence/absence and tandem liquid chromatography mass spectrometry (LC/MS/MS) for quantitative assessment of a suite of algal toxins including microcystins, cylindrospermopsin, and anatoxin-a (Table 1).

Water Samples - General Chemistry

Water sample parameters collected at the status and trend lakes, targeted lakes, and some response lakes were generally similar. At all lakes, temperature, dissolved oxygen, conductivity, pH, chlorophyll *a* concentration, chlorophyll relative fluorescence unit, phycocyanin concentration, and phycocyanin relative fluorescence unit were measured using an EXO sonde (YSI Incorporated, Yellow Springs, Ohio). In some cases, with the response lakes, the staff who were available to collect the water samples did not have access to an EXO sonde unit. In those cases, only water samples were collected for the purpose of cyanobacteria toxin analysis. Nutrient surface water samples were collected at approximately 0.5 feet below the water surface 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, Kjeldahl nitrogen, nitrate+nitrite, ortho-phosphate, and chlorophyll *a*. The total phosphorus, Kjeldahl nitrogen, and nitrate+nitrite were preserved with sulfuric acid in the field. Chlorophyll *a* samples were collected as an integrated sample of the photic zone (twice the Secchi depth) and preserved with magnesium carbonate in the field. The samples were analyzed at the EGLE Environmental Laboratory using standard United States Environmental Protection Agency (USEPA) methods (Table 1). At the status and trend lakes the same nutrient samples were collected, excluding ortho-phosphate. The August status and trend water chemistry samples were collected by Michigan Department of Natural Resources (MDNR)-Fisheries Division staff and analyzed by the Great Lakes Environmental Center, Traverse City, Michigan. 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.

Water Samples - Algal Toxins

At most lakes that were sampled by boat, one sample over the deepest part of the lake and at least three shoreline samples were collected in 250 ml polyethylene terephthalate sample bottles at the water surface. Shoreline samples were typically collected at 1- to 6-foot depths. If sampling by boat, the shoreline sampling locations were distributed approximately evenly around the shoreline of the lake. However, downwind locations, areas that may be used for recreation, or beaches were preferentially targeted. When boat access was not available, attempts were made to sample an even distribution of the shoreline; however, sampling locations were limited to areas of public access and/or private property that EGLE workers received permission to access. Prior to sampling, bottles were triple-rinsed with site water and samples were collected from an undisturbed area of water. Microcystin samples at the targeted and response lakes were collected at the water surface (i.e., the bottles were not submerged under water). At the status and trend lakes, sample bottles were collected about .5 feet below the water surface. When scum accumulations were present, and accumulated in a localized area, one surface scum sample was collected and one ambient (non-scum) sample was collected outside of the accumulation (Figure 2). The ambient samples were collected within 5-15 feet from the edge of the scum accumulations. In cases where surface scums were omnipresent either throughout an entire lake, or throughout a very large section of a lake with no clear demarcation between the scum and ambient water, only a scum sample was collected.

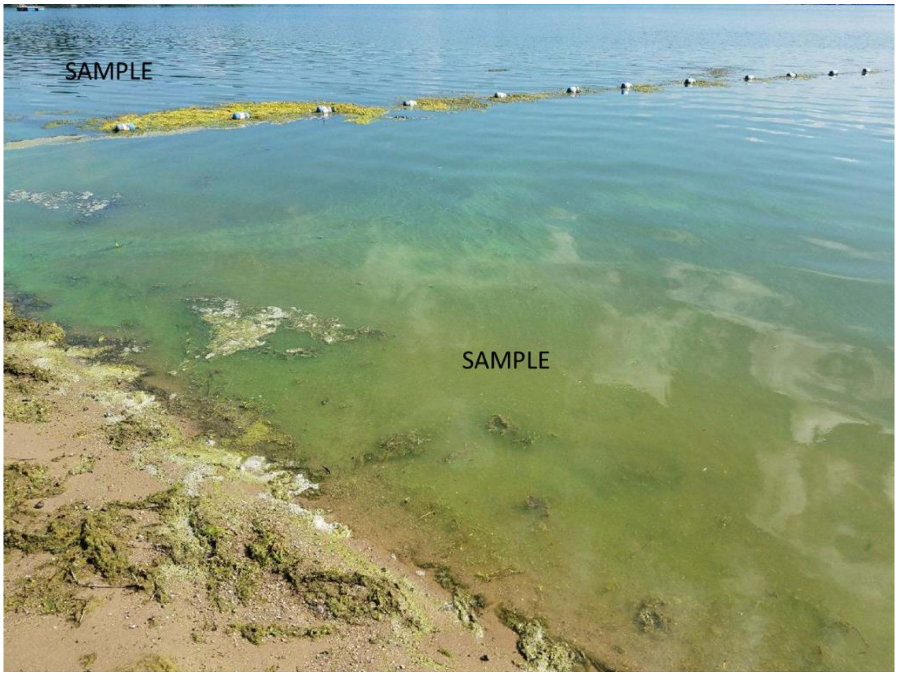


Figure 2. Example of a localized cyanobacteria scum accumulation in which a sample was collected from the scum and nearby ambient water.

At response lakes, often only shoreline samples were collected from an area with a cyanobacteria accumulation present, or in an area that previously had high concentrations of microcystins. Most of the samples were collected by EGLE staff, although in some cases citizens collected water samples and turned them into the EGLE district offices.

Ambient 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 and relative concentration estimate was determined using test strips. 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 (MDHHS) laboratory for quantitative analysis. Quantitative analysis of anatoxin-a, cylindrospermopsin, and 13 microcystin congeners (Table 1) was performed using LC/MS/MS. If the Abraxis test strips indicated that no microcystin was present in any samples from a lake, then only one sample was sent to the MDHHS laboratory for further quantitative analysis.

Microcystin samples were held on ice or refrigerated for no more than 48 hours prior to analysis. If microcystin samples needed to be held longer than 48 hours, they were frozen with care taken to reduce volume to allow for expansion. EGLE-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 and 1 sample from each lake was analyzed by the MDHHS laboratory.

Table 1. 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	EPA 365.4	10
Kjeldahl Nitrogen	EPA 351.2	100
Ammonia	EPA 350.1	10
Nitrate+Nitrite	EPA 353.2	10
Ortho-phosphate	EPA 365.1	10
Chlorophyll a	10200H (Standard Methods)	1

Data analysis

The number of water bodies that experienced at least one cyanobacteria bloom between 2016 and 2018 was quantified by reviewing field and laboratory data, photographs from sites that were visited by EGLE staff, and by reviewing photographs that were sent to EGLE from concerned citizens. The distribution of cyanobacteria blooms was assessed along a north-south gradient in Michigan. The centroid latitudes for each Michigan county were calculated using the Calculate Geometry tool function in ArcMap 10.4 (ESRI, 2011) using the NAD 1983 Geographic Coordinate System. For coastal counties, islands were excluded from the calculations, so latitude centroids were only for the mainland. A linear regression was performed on the number of confirmed cyanobacteria blooms (log +1- transformed) versus the centroid latitude for each county.

A logistic regression was performed on strip test data versus total microcystin laboratory concentration results. The strip test results were dichotomized as either microcystin detected (score of 1) or microcystin not detected (score of 0). The resulting slope and intercept from the regression were graphed to model the probability of correct microcystin detection using the strip tests.

To evaluate the effect of observed chemical/physical parameters measured at the time microcystin samples were collected, a principal components analysis (PCA) was performed on those data. The PCA was used to reduce the dimensionality of the correlated, independent, chemical/physical 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). A linear regression between the PC 1 scores, acting as a surrogate for disturbance, and microcystin concentrations was 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 both nutrient and microcystin analyses.

The scores of the PCA bi-plot were categorized as one of three lake types: natural (no dam or water control structure at the lake outlet), natural but with some type of water level control structure at the outlet, and reservoir impoundment (lentic environment only exists because flowing water was impounded). Lake type classifications were mostly obtained from the MiSwims database. To confirm visual interpretations of the PCA bi-plot, statistical differences between the three categories of lakes were tested with a multi-response permutation procedure (Mielke, 1984; Zimmerman et al., 1985). Euclidean distance measures and a natural weighting (n/sum[n]) recommended by Mielke (1984) was used.

Shoreline development factors (SDF) and maximum depths of water bodies that had experienced cyanobacteria blooms were compared between reservoirs, natural lakes with dams, and natural lakes with no water level control structure using analysis of variance (ANOVA) with Tukey's honestly significant difference post-hoc testing. These analyses were performed on different groups of water bodies than the PCA. The PCA was limited to lakes that were accessible by boat and had chemical/physical data collected in the center of the lake. However, SDF and water depths could be obtained for most lakes, regardless of whether they were visited or not. Maximum lake depths were mostly obtained from the MiSwims database. In some cases, where depth data were not available for a lake, other reliable sources were located, such as consultant or MDNR reports. A database of calculated SDF values for all Michigan lakes was provided by P. Tyning (Progressive AE, Grand Rapids, Michigan). Shoreline development factor is the degree of a lake's shoreline irregularity and is expressed as the ratio of shoreline length to the circumference of a circle of area equal to the lakes area (Horne and Goldman, 1994). A lake with the least amount of shoreline would be perfectly circular and have an SDF of 1.0. As shorelines become more irregular (less circular) the SDF increases. A Welch t test was used to compare the microcystin concentrations of all side-by-side scum and ambient water samples that were collected from 2016-2018. Statistical significance for all tests was set at $\alpha = 0.05$.

Results

From 2016-2018, water samples were collected and analyzed for microcystin from 81 different status and trend lakes, 60 complaint water bodies, and 11 targeted lakes. Of the 81 status and trend lakes that were sampled, only two of them had a minimum of one sample with detectable concentrations of microcystin, with the highest being 6.8 µg/l. Nine of the 11 targeted lakes contained microcystin. Of those nine targeted lakes with microcystin, six of them had samples with elevated concentrations that were >20 µg/l; Parker, 2017 and 2018b).

The number of water bodies for which EGLE has received complaints has increased in the last two years (Figure 3; Parker, 2018a). From 2016-2018, EGLE received complaints about algae in 102 different water bodies. Of those water bodies, EGLE staff confirmed, either by site visit or photograph, that cyanobacteria were present at 57. Of the sites that were sampled by EGLE staff, 30 water bodies contained microcystin, 13 of which had microcystin concentrations >20 µg/l in at least one sample.

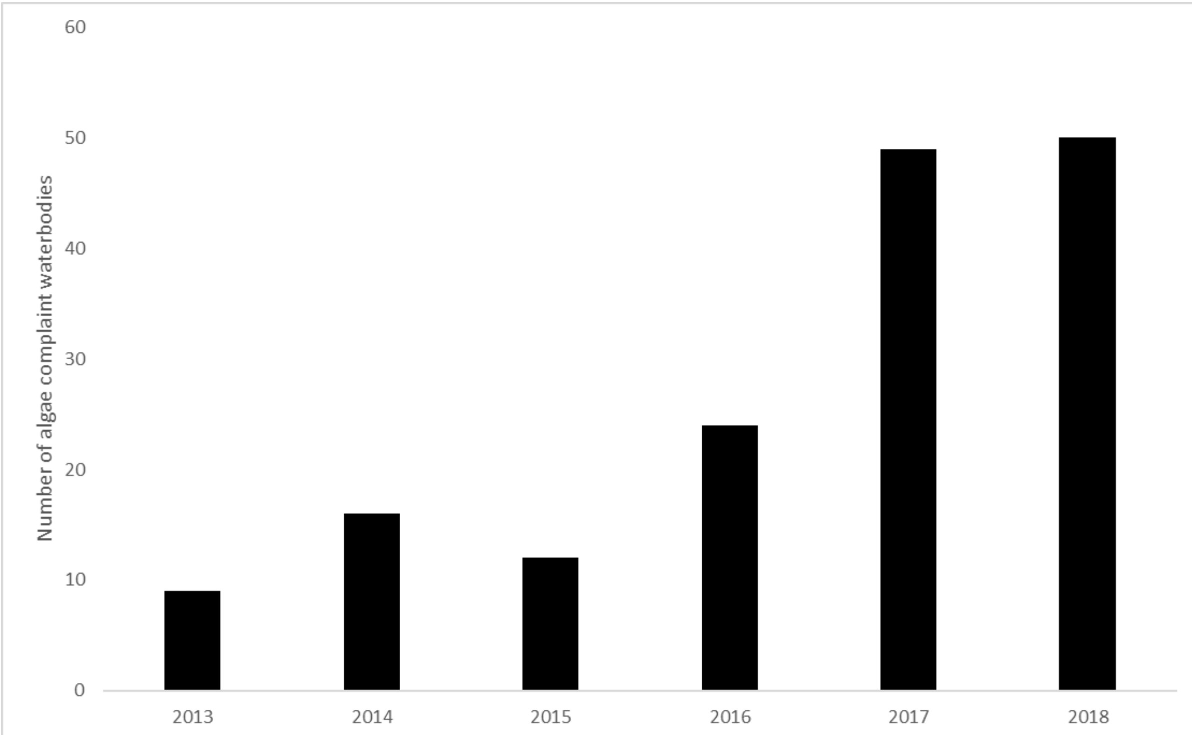


Figure 3. Number of different water bodies with complaints about algae or cyanobacteria from 2013-2018.

Throughout the state from 2016-2018, EGLE staff either observed, or were alerted to, 65 confirmed cyanobacteria blooms. All but one of those blooms was in the Lower Peninsula, with the majority of those in the southern half. There was a significant inverse relationship ($R^2 = 0.43$, $p < 0.001$; Figure 4) between the number of blooms per county and the county centroid latitude, which confirmed our visual interpretation of the map in Figure 5.

Of the lakes that had blooms, the majority of them were either reservoirs or natural lakes with a lake level control structure (25% reservoir, 32% natural with a dam, 43% natural; Figure 5). The exact number of impounded lakes throughout the state has been an elusive number for some time. Brown (1943) estimated that there were 700-800 impoundments (defined as any lake with a dam greater than 2 feet high) throughout the state, although dams were constructed after that report. The U.S. Army Corps of Engineers has a list of 1,059 impoundments in Michigan in its National Inventory of Dams, although that list includes many small dams that create impoundments <5 acres in size. Nevertheless, even with the 1,059-impoundment figure, that would put the total number of Michigan lakes that are impounded in some way at approximately 10% of all lakes in the state.

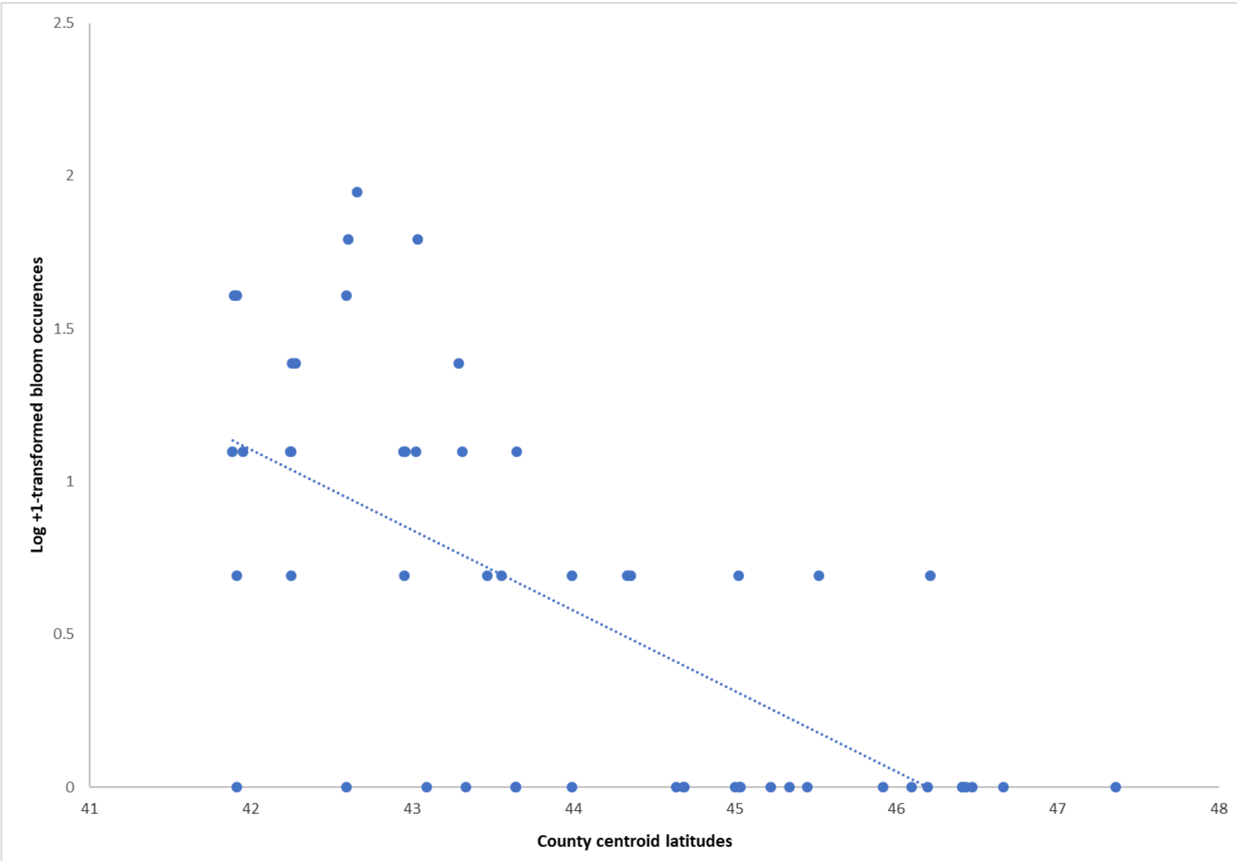
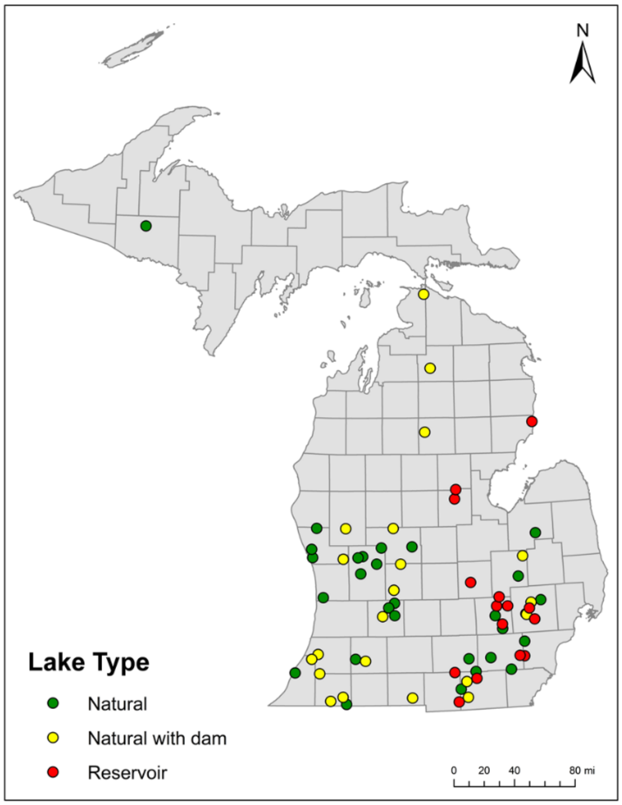


Figure 4. Regression of Log +1-transformed bloom occurrences per county and county centroid latitude.



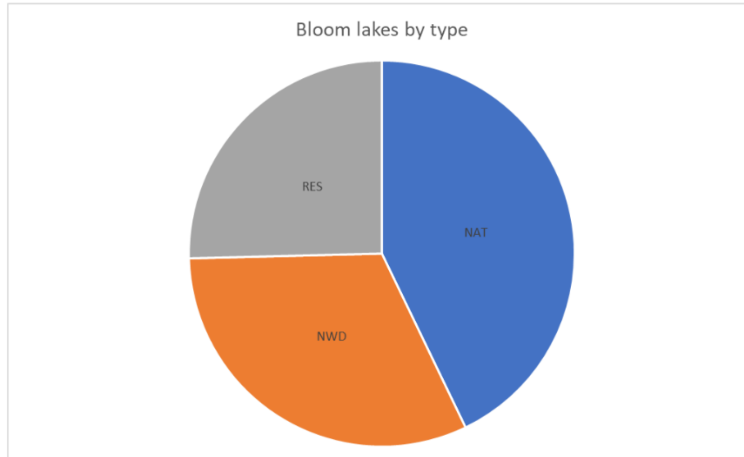


Figure 5. Map of confirmed cyanobacteria blooms by lake type and pie chart of different lake types that experienced blooms (NAT = natural, NWD = natural with dam, RES = reservoir).

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 between 1-2 µg/l (Figure 6). Microcystin detection using the test strips was significantly associated with increasing concentrations of microcystin ($p < 0.001$). Comparing the agreement between the estimated microcystin concentrations from the test strips to the concentration results from the mass spectrometry results revealed good agreement for non-detections, 1-10 µg/l of microcystin, and >10 µg/l of microcystin (Table 2). When actual concentrations were between a non-detection (detection limit – 0.5 µg/l of microcystin) and 1 µg/l of microcystin, the test strips often over-estimated the amount of microcystin (Table 2). There were four samples, from three separate lakes, that caused the strip tests to fail. The actual concentrations of microcystin in those samples ranged from 0.52-29 µg/l. In all of the instances of strip test failure, the cyanobacteria that was tested had a rare, purple hue (Figure 7).

Table 2.

	Test Strip Results			
Mass spec result	ND (208)	0-1 (20)	1-10 (78)	>10 (96)
ND	**67%**	10%	14%	1%
0-1	23%	**20%**	13%	1%
1-10	10%	70%	**61%**	21%
>10	0%	0%	12%	**77%**

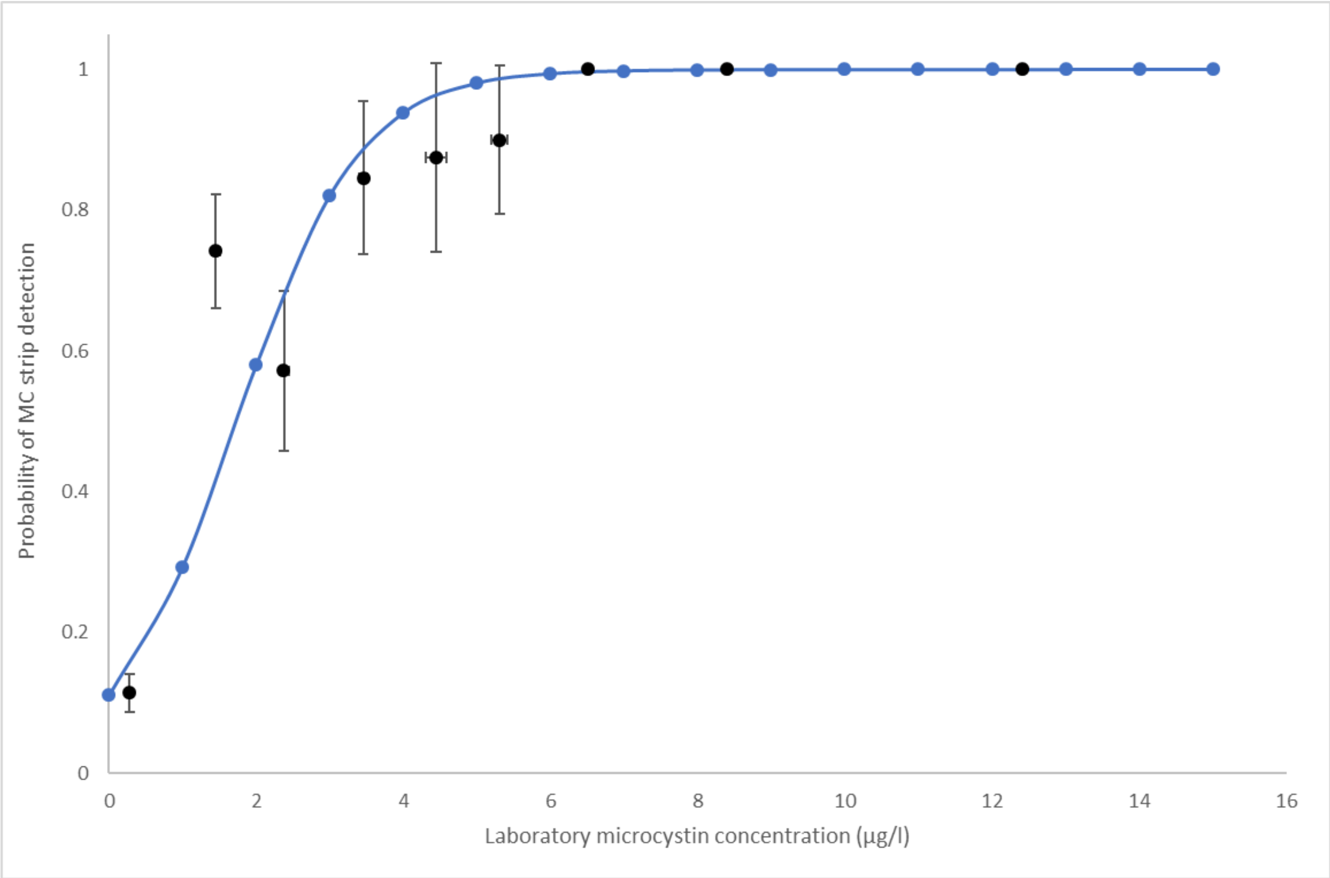


Figure 6. Probability of microcystin detection using test strip kits as a function of actual microcystin concentrations measured in the laboratory. Filled circles represent the mean (± SE) detections (scored as one) along the laboratory-measured microcystin gradient.

Figure 7. Example of cyanobacteria with a purple hue that caused test strip failures.

The PCA bi-plot representing lakes sampled across the state from 2016-2018 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, chlorophyll *a* (integrated samples), and phycocyanin; Uzarski et al., 2005) explained 42% of the variability in the chemical/physical matrix. The reservoirs appeared to exhibit the greatest amount of anthropogenic disturbance/productivity compared to natural lakes and natural lakes with dams (Figure 8). The multi-response permutation procedure results confirmed our visual interpretation of the PCA bi-plot as all lake types exhibited significant differences in chemical/physical characteristics ($A = 0.22$; $p < 0.001$). A linear regression of PC 1 scores versus $\log_{10}$-transformed microcystin concentrations showed no relationship between PC 1 scores and microcystin concentrations ($R^2 = 0.04$, $p = 0.10$; Figure 9).

There were significant depth differences between reservoirs and natural lakes with dams (ANOVA: $F = 3.6$, df = 2, 54, $p = 0.03$; Table 2), with reservoirs being shallower (Figure 10). Reservoirs had significantly greater SDFs than both natural and natural with dam lakes (ANOVA: $F = 8.3$, df = 2, 57, $p < 0.01$; Table 2; Figure 11).

A comparison of microcystin concentrations from side-by-side samples of cyanobacterial scum and nearby ambient water revealed that the scum contained more microcystin than the nearby clear water ($t = 2.62$, df = 40, $p = 0.01$; Figure 12).

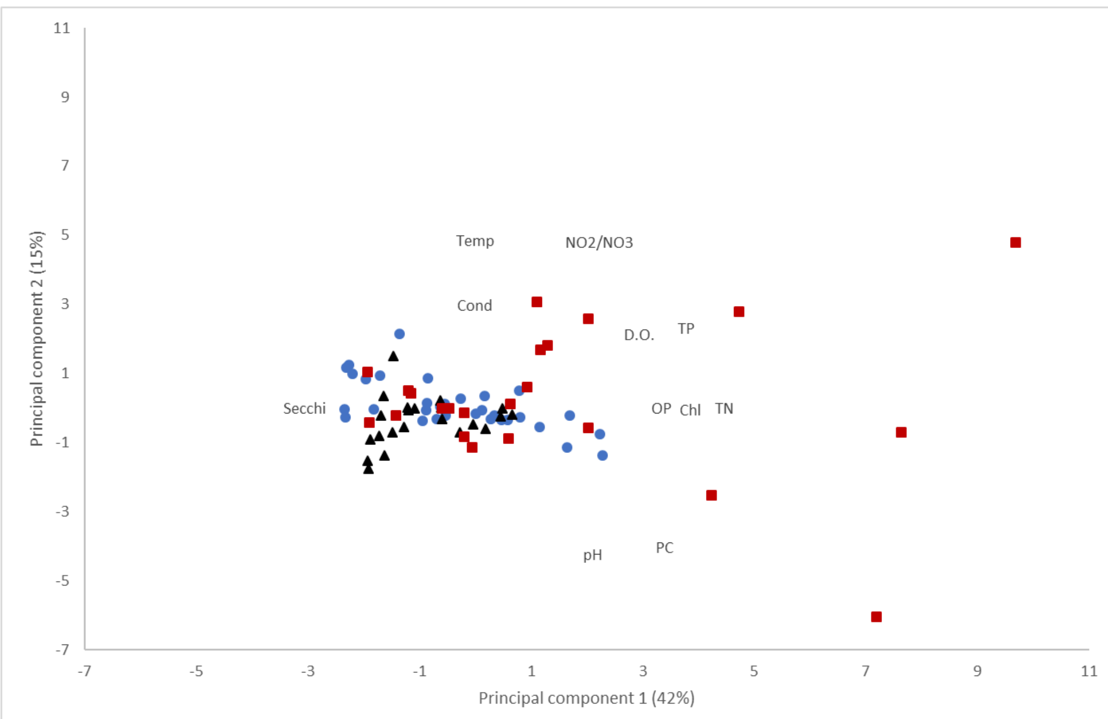


Figure 8. Principal component analysis bi-plot of chemical physical variables in Michigan lakes that were sampled in 2017. Red squares = reservoir, blue circles = natural lakes, black triangles = natural lakes with dams.

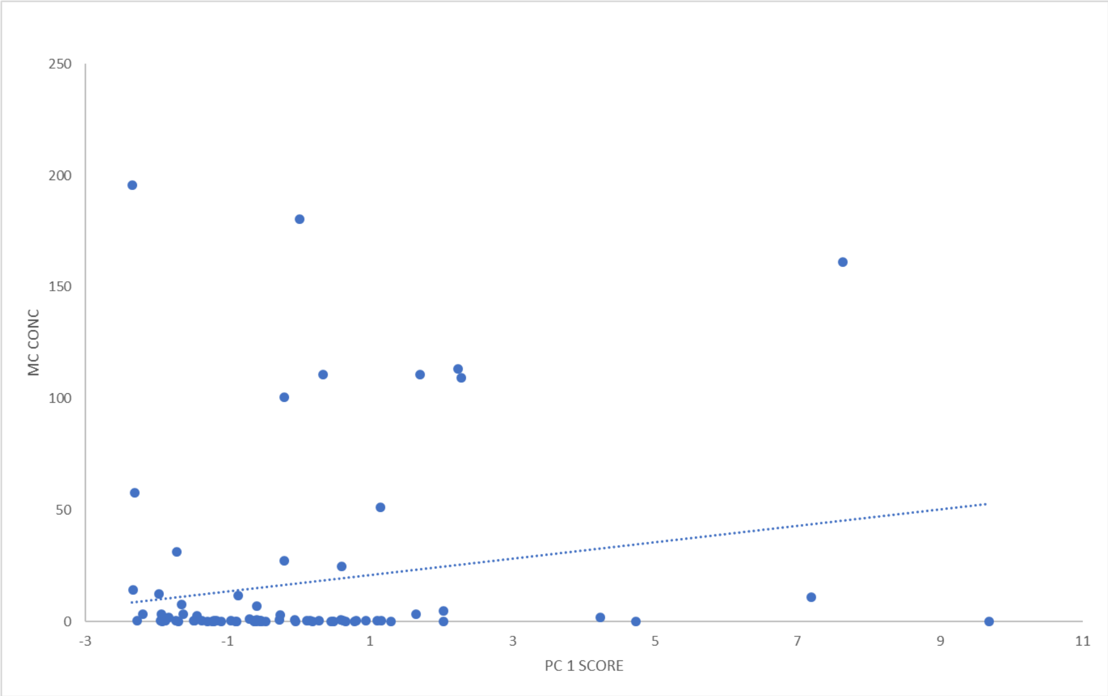


Figure 9. Linear regression of log10-transformed microcystin concentrations and PC 1 scores for each lake.

Table 2. Tukey's honestly significant differences between depths and shoreline development factors among lake types.

Depth				Shoreline development factor		
	Reservoir	Natural with dam			Reservoir	Natural with dam
Natural	0.37	0.25		Natural	**<0.01**	0.93
Natural with dam	**0.03**			Natural with dam	**<0.01**	

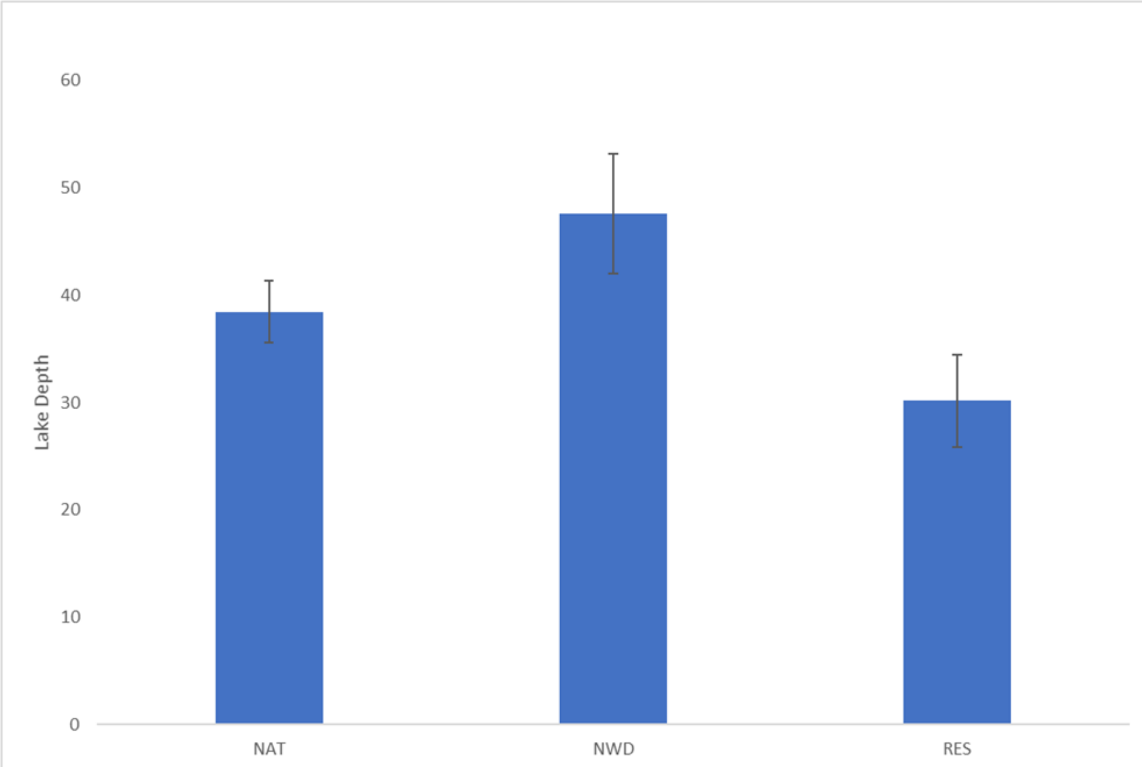


Figure 10. Mean depths (feet ± S.E.) among lake types.

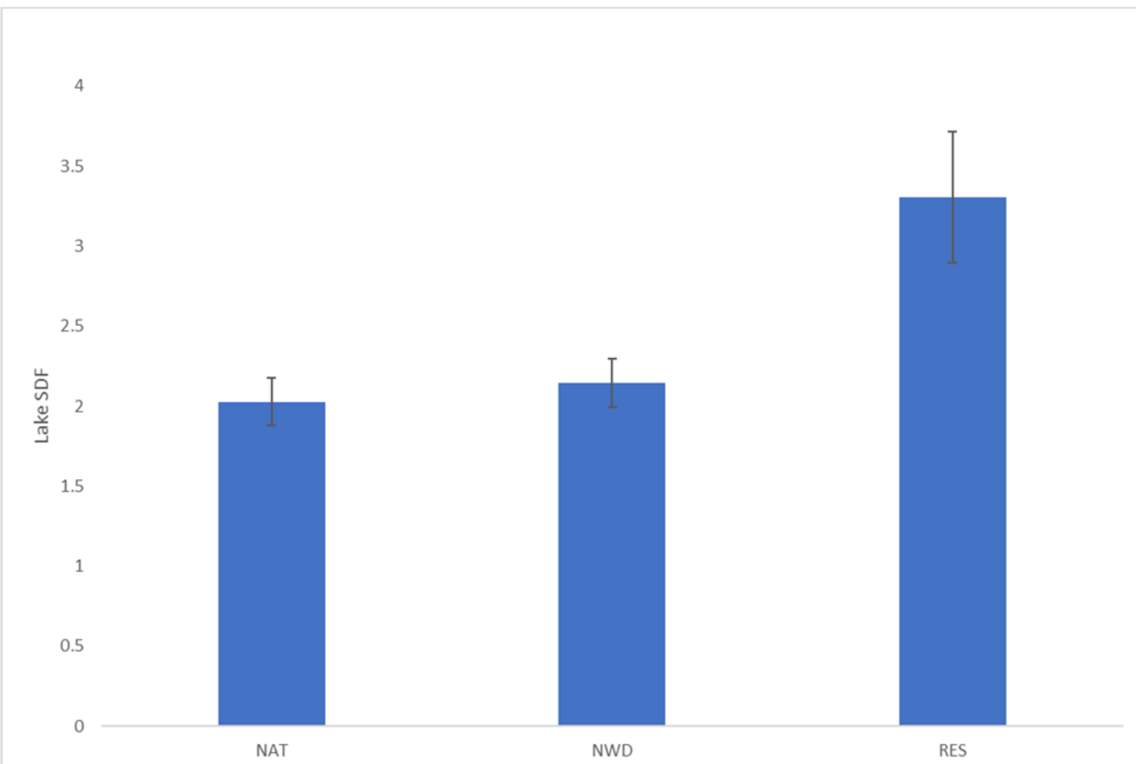


Figure 11. Mean shoreline development factors (± S.E.) among lake types.

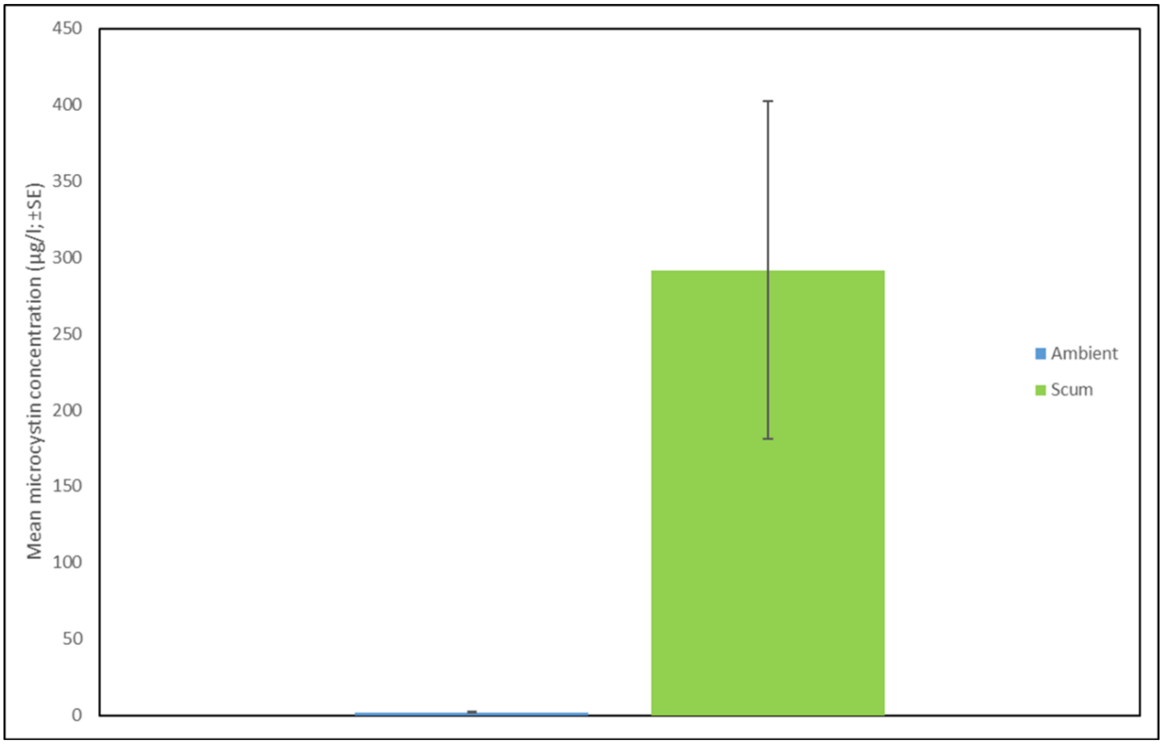


Figure 12. Mean microcystin concentrations (± S.E.) from scum and ambient water samples collected side by side.

Discussion

In the last couple of years, the number of complaints received by EGLE about nuisance cyanobacteria and algae have increased. EGLE (Parker, 2018b) and others (Cheung et al. 2013) have acknowledged that the increased awareness and attention that HABS have received recently may account for the increased reports. However, Cheung et al. (2013) maintained that the increasing number of reports is unlikely the sole result of increased attention. The consensus amongst most researchers is that the frequency, magnitude, and intensity of HABS is increasing worldwide, and that given future climate scenarios coupled with more intensive agricultural practices worldwide, HABS are only expected to get worse (Kosten et al., 2012; O'Neil et al., 2012; Paerl and Paul, 2012; Michalak et al., 2013; Scavia et al., 2014; Taranu et al., 2015; Scholz et al., 2017).

We have consistently found that, statewide, the vast majority of the randomly sampled lakes have not had active cyanobacteria blooms occurring and that the only time we do find active blooms is if we target specific lakes that have had them in the past, or if we are alerted to a bloom by citizens. Like others (Aranda-Rodriguez et al., 2015; Watson et al., 2017), we found that the test strips were reliable indicators of high amounts of microcystin. Consistent with previous results (Holden, 2016), we found that the test strips tend to over-estimate the actual concentrations of microcystin.

In general, the cyanobacterial blooms that we did observe were more prevalent in the southern Lower Peninsula of Michigan, which is the most populated area of the state and contains more agricultural areas. Using remote sensing, Torbick et al. (2013) also found that lakes in the southern Lower Peninsula were more productive and that cropland and urban land use was associated with more eutrophic lakes.

There is widespread consensus that water bodies with greater than 10% impervious cover in their watersheds will begin to exhibit water quality degradation (Schueler and Holland, 2000; Brabec et al., 2009; Carey et al., 2013). Urban and residential areas quickly convey nutrients and other pollutants to storm drains that then directly discharge to nearby water bodies (Steinman et al., 2006; Carey et al., 2013; Yang and Toor, 2016 and 2017; and Janke et al., 2017). Unlike streams, which will assimilate some nutrients in the sediment and plant biomass, pipes will direct all nutrients to a receiving water body (Steinman et al., 2006; Brabec et al., 2009). Lakes in more populated areas also tend to be largely developed along their immediate shoreline since lakefront property is highly desired. Residential land use along lake shorelines can contribute nutrients to the lake via lawn fertilizer application (Morton et al., 1988; Bierman et al., 2010; Carey et al., 2012; Steinman et al., 2015) and septic system leachate (Gilliom and Patmont, 1983; Tessier and Lauf, 1992; Swann, 2001; Brennan et al., 2016; Schellenger and Hellweger, 2019).

Agricultural nutrient runoff has been recognized as a contributing factor to cyanobacteria blooms, with much attention being focused on the re-eutrophication of western Lake Erie (Michalak et al., 2013; Scavia et al., 2014; and Bullerjahn et al., 2016). However, on a smaller scale, agriculture has also been implicated as contributing to cyanobacteria blooms in inland lakes as well (Torbick et al., 2013; Taranu et al., 2015 and 2017; Clement and Steinman, 2017; Marion et al., 2017). Increased dissolved reactive phosphorus loading via field tile drainage pipes has been cited as one of the main causes of cyanobacteria blooms in water bodies that are surrounded by agricultural land use (Bullerjahn et al., 2016; Clement and Steinman, 2017).

Similar to other work (Taranu et al., 2017; Gina LaLiberte, Wisconsin DNR, personal communication) we found that the majority of cyanobacteria blooms occurred in lakes with some kind of an impoundment structure. The six lakes that had confirmed cyanobacteria blooms in the northern Lower Peninsula were either reservoirs or natural lakes with a lake-level control structure. This is significant since the majority of inland lakes in Michigan are natural. The most recent lake inventory by the MDNR recognizes 10,759 inland lakes throughout the state that are greater than 5 acres. Based on conservative estimates, it is likely that only around 10% of those lakes are impoundments or natural lakes with a dam. Approximately 57% of the lakes with confirmed cyanobacteria blooms from 2016-18 were impounded in some way.

The reservoirs were the shallowest water bodies, had the highest shoreline development factors, and were the most productive systems that we sampled. In general, reservoir systems tend to age faster than natural systems (Ryder, 1978; Kimmel and Groeger, 1986). Reservoirs systems typically have larger catchment-to-lake-area ratios than natural lakes (Taranu et al., 2017). That is, they have larger watersheds draining into them from an upstream tributary than a typical, kettle lake will have. With larger watersheds, more nutrients are likely to flow into the receiving water bodies, thus increasing the chances for cyanobacteria blooms (Toporowska et al., 2018). Reservoir systems also tend to be created in either urban or agriculture-dominated areas (Kimmel and Groeger, 1986), which both contribute nutrients to water bodies as described above. Finally, some reservoirs were created for the sole purpose of developing residential communities around a water body (Nicholls and Crompton, 2018), in which case the majority of the shoreline is going to have residential land use along the immediate shoreline of the lake. Shallow lakes coupled with nutrient-rich sediment are prone to nutrient resuspension into the water column as a result of physical disturbances such as wind (Kristensen et al., 1992; Blottière et al., 2013), fish foraging (Havens, 1991), and boat traffic (Anthony and Downing, 2003).

We found that the shoreline development factors of reservoirs were higher than those of the natural and natural with dam lakes. This is not surprising since impoundments tend to flood historic tributary stream valleys and other low-lying areas. The resultant shoreline features of reservoirs, depending on the extent of impoundment and surrounding landscape features, are often numerous peninsulas, coves, canals, and islands throughout the water body. All of which extend the amount of shoreline along the water body. Given the inherent desirability of lakefront property and the fact that some reservoirs are created for the purpose of creating residential lake lots (Nicholls and Crompton, 2018), reservoirs tend to have a disproportionate number of residential dwellings along their entire shoreline compared to lakes of similar size, but with less shoreline. Each residential lake dwelling can then contribute nutrients to the water body via lawn fertilizer (Morton et al., 1988; Bierman et al., 2010; Carey et al., 2012; Steinman et al., 2015), pet waste (Schueller and Holland, 2000), loss of natural shoreline buffers (Woodard and Rock, 1995; Søndergaard and Jeppesen, 2007; Rosenberger et al., 2008), and septic systems (Gilliom and Patmont, 1983; Tessier and Lauf, 1992; Swann, 2001; Brennan et al., 2016; Schellenger and Hellweger, 2019). The shallow embayments that are characteristic of reservoir systems often offer calm areas of warm water that is conducive to cyanobacteria growth (Parker, 2018b).

Although the natural lakes with dams had similar depths and shoreline development factors as the natural lakes with no water level control structures, they were over-represented among the water bodies that experienced cyanobacteria blooms. Lake-level control structures are typically constructed at lake outlets to ensure that consistent water levels are maintained that can accommodate recreational activities. In fact, over half of the dams in Michigan on the National Inventory of Dams list have “recreation” as the primary purpose for the dam structure. Typically, lakes that have water-level control structures for recreational purposes are going to have a high number of residential units along the shoreline, which may contribute nutrients from lawns (Morton et al., 1988; Bierman et al,. 2010; Carey et al., 2012; Steinman et al., 2015) and/or be near urban centers that can contribute nutrients (Steinman et al., 2006; Carey et al., 2013; Yang and Toor, 2016 and 2017; and Janke et al., 2017). However, if lake-level control structures are constructed in lake outlets for the purpose of artificially raising water levels, then this will also artificially raise groundwater levels around the immediate riparian shoreline. If septic systems were in place prior to the groundwater level rising, then the amount of non-saturated soil to filter nutrients from the septic leachate will decrease, which then increases the risk of septic pollution entering the lake via groundwater (Gilliom and Patmont, 1983; Swann, 2001; Lusk et al., 2017).

Some broad conclusions can be made about the occurrences of cyanobacteria blooms throughout Michigan and possible causes of them. Similar to other work though (Kardinaal and Visser, 2005; Omidi et al., 2018), we found that microcystin production dynamics over a large geographic area are very unpredictable. For example, although cyanobacteria blooms are rare in the northern Lower Peninsula, the highest recorded total microcystin concentration that we observed (13,000 µg/l) occurred in a lake in Iosco County. And while cyanobacteria blooms are typically associated with eutrophic and hypereutrophic lakes, we have observed high microcystin concentrations in oligotrophic and mesotrophic lakes, possibly as a result of selective feeding by Dreissenid mussels (Raikow et al., 2004; Sarnelle et al., 2005 and 2010; Wilson et al., 2005; Knoll et al., 2008; Woller-Skar, 2009; White et al., 2017; and Gaskill and Woller-Skar, 2018). Finally, we have sampled obvious cyanobacteria scums that have not had any microcystin in them.

Whether a population of cyanobacteria produces microcystin is dependent on whether they possess the toxin-producing genotypes or not (Kardinaal and Visser, 2005). In Michigan, cyanobacterial populations are genetically diverse both between lakes, and within lake populations (Wilson et al., 2005). Even within a single lake, cyanobacteria species and genotypes will change throughout the year, meaning that toxins may only be found in a particular water body for part of the year (Kardinaal et al., 2007; Lehman, 2007; Lehman et al., 2009). Further complicating the understanding of microcystin dynamics is that the exact triggers for microcystin production by cyanobacteria are not fully understood (Sivonen and Jones, 1999; Kardinaal and Visser, 2005).

The factors that determine microcystin production by cyanobacteria are probably dependent on the particular genotypes and environmental conditions within individual water bodies (Kardinaal and Visser, 2005; Omidi et al., 2018). For some well-studied, individual lakes in Michigan, microcystin production can be predicted with some accuracy. For example, in Mona Lake, Muskegon County, microcystin concentrations have consistently been correlated with water column, total phosphorus concentrations (Xie et al., 2012; Parker, 2018b). In Ford Lake, Washtenaw County, and Belleville Lake, Wayne County, the cyanobacterial communities appear to exhibit predictable, seasonal shifts in species composition and toxicity (Lehman, 2007).

Although predicting microcystin production from lake to lake can be difficult, when we have found elevated concentrations in a water body, it has consistently been found in obvious cyanobacteria scum accumulations or obvious sheens on the water surface. Typically, when cyanobacteria are present in a lake, it is in a localized area that is protected from disturbance or along windswept shorelines. Only on rare occasions have we observed extensive, lake-wide blooms. Similar to others (Carmichael and Gorham, 1981; Bartram and Rees, 2000) we have found that microcystin concentrations are often much lower, or non-detectable in clear water that is within 10-15 feet of a cyanobacteria scum.

Conclusion

In general, cyanobacteria blooms do not appear to be a widespread problem in Michigan given how they are rarely observed when lakes are randomly sampled. Rather, we typically only observe cyanobacteria blooms and resultant toxin production in lakes that we either target, because they have experienced blooms in the past, or because citizens have alerted us to them. Typically the blooms that are observed occur in localized areas of a water body and any microcystin that is observed is typically found in obvious scums, whereas adjacent, clear water often has very little/no microcystin. The majority of the cyanobacteria blooms that we have observed in the last three years have been in the southern Lower Peninsula. The southern Lower Peninsula contains the most agricultural and urban areas in Michigan, which are known to contribute nutrients to water bodies. Despite only making up a small percentage of the total number of lakes in Michigan, lakes that were either reservoirs or natural, but with a lake-level control structure, made up the majority of the water bodies that experienced cyanobacteria blooms. These systems may have been over-represented since they are typically situated in populated areas and are usually heavily-developed along the riparian area. Reservoirs in particular tend to be shallow and have high shoreline development factors. We have observed cyanobacteria blooms in only a small percentage of the total number of Michigan lakes, albeit typically in the most densely populated areas of the state. Most experts agree that given future climate projections coupled with agricultural and urban land use scenarios, cyanobacteria blooms are expected to increase in occurrence and magnitude worldwide.

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Appendix 1: Raw lake data from 2018.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Cowan	Kent	RESPONSE	5	10	2018	43.118419	-85.426972	East shoreline	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	14	2018	42.790064	-83.820294	Haviland Beach DR	scum	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	14	2018	42.790064	-83.820294	Haviland Beach DR	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.79	-83.82035	Haviland Beach DR	ambient	.	.	18.966	9.55	570	8.16	0.085
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.79111	-83.84466	Dam outlet	ambient	.	.	20.631	10.43	581	8.11	0.04
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.77648	-83.8333	Bennett Lake outlet	ambient	.	.	19.603	8.38	599	7.94	0.013
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	0.23	.	20.096	9.47	546	8.14	0.031
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	8.08	.	18.818	9.39	548	8.08	0.036
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	16.07	.	12.463	7.74	545	7.84	0.113
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	24.17	.	6.502	9.5	545	7.92	0.103
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	32.05	.	5.871	9.42	543	7.91	0.118
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	40.22	.	5.546	8.51	597	7.84	0.083
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	48.15	.	5.386	8.1	549	7.79	0.142
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	56.07	.	5.283	7.76	451	7.76	0.099
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.78531	-83.83331	Deep	ambient	60.34	.	5.304	7.25	484.7	7.72	0.118
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.796048	-83.835097	Heath's Harbor	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.79773	-83.82214	NE Bay	ambient	.	.	.	9.7	.	8.14	0.176
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.781472	-83.818211	South Bay	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	18	2018	42.784156	-83.815883	SE Bay	ambient	.	.	.	.	.	.	.
Long	Montmorency	RESPONSE	5	18	2018	45.128333	-83.97721	Spur RD	ambient	.	.	.	.	.	.	.
Long	Montmorency	RESPONSE	5	18	2018	45.132899	-83.981348	Long Lake RD	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	24	2018	42.790064	-83.820294	Haviland Beach DR	scum	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	24	2018	42.79	-83.82035	Haviland Beach DR	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	24	2018	42.79111	-83.84466	Dam outlet	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	24	2018	42.77648	-83.8333	Bennett Lake outlet	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	24	2018	42.796048	-83.835097	Heath's Harbor	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	24	2018	42.786143	-83.84054	DNR boat launch	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	25	2018	42.783389	-83.835832	Peninsular Drive Canal	ambient	.	.	.	.	.	.	.
Cadillac	Wexford	RESPONSE	5	29	2018	.	.	Southeast corner	.	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	29	2018	42.790064	-83.820294	Haviland Beach DR	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	29	2018	42.781674	-83.817686	Selma Drive	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	29	2018	42.783389	-83.835832	Peninsular Drive Canal	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	5	29	2018	42.783351	-83.83622	McAleer's Bridge	ambient	.	.	.	.	.	.	.
Sherwood	Oakland	RESPONSE	6	1	2018	42.595587	-83.538743	Ledgewood CT	ambient with greens	.	.	.	.	.	.	.
Pontiac	Oakland	targeted monitoring	6	1	2018	42.66883	-83.46651	Hampton ST	ambient	.	.	.	.	.	.	.
Little Blue	Kalkaska	RESPONSE	6	1	2018	44.800999	-84.894035	Blue Lake RD	area canine had occupied	.	.	.	.	.	.	.
Little Blue	Kalkaska	RESPONSE	6	4	2018	44.800999	-84.894035	Blue Lake RD	ambient	.	.	.	.	.	.	.
Blue	Kalkaska	RESPONSE	6	4	2018	44.803768	-84.894258	DNR boat launch	ambient	.	.	.	.	.	.	.
Coldwater	Branch	RESPONSE	6	8	2018	41.806883	-84.983326	Tomahawk Trail	scum	.	.	23.809	10.07	425.8	8.43	0.953
Coldwater	Branch	RESPONSE	6	8	2018	41.814483	-84.977939	Iyopawa Road	ambient	.	.	24.969	8.54	416	8.32	0.057
Coldwater	Branch	RESPONSE	6	8	2018	41.833435	-84.988047	DNR boat launch	ambient	.	.	24.149	7.9	402.9	8.2	0.085
Coldwater	Branch	RESPONSE	6	8	2018	41.843218	-84.980771	Warren RD and Centennial	ambient	.	.	24.149	7.89	413.2	8.21	0.313
Coldwater	Branch	RESPONSE	6	8	2018	41.831348	-84.97091	Coldwater Lake Marina	ambient	.	.	24.139	9.71	390.5	8.42	0.041
Lobdell	Genesee/Livingston	RESPONSE	6	12	2018	42.790064	-83.820294	Haviland Beach DR	ambient	.	.	.	.	.	.	.
Lobdell	Genesee/Livingston	RESPONSE	6	12	2018	42.783389	-83.835832	Peninsular Drive Canal	ambient	.	.	.	.	.	.	.
Loch Erin	Lenawee	RESPONSE	6	12	2018	42.01515	-84.152743	8047 Stephenson	scum	.	.	.	.	.	.	.
Loch Erin	Lenawee	RESPONSE	6	13	2018	42.01512	-84.152652	8047 Stephenson RD	scum	.	.	.	.	.	.	.
Loch Erin	Lenawee	RESPONSE	6	20	2018	42.01009	-84.13937	Deep	ambient	.	.	25.49	6.75	491.3	8.21	0.952
Loch Erin	Lenawee	RESPONSE	6	20	2018	42.01838	-84.16399	Wolf Creek outlet	ambient	.	.	24.7	6.96	521	7.98	0.973

Appendix 1 cont.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	4300	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	present	5.8	Non-detect	Non-detect
0.06	0.924	3.68	.	.	.	.	.	.	.	Non-detect	non-detect	Non-detect	Non-detect
0.02	0.611	2.53	.	.	.	.	.	.	.	Non-detect	.	.	.
0	0.544	2.29	.	.	.	.	.	.	.	Non-detect	non-detect	Non-detect	Non-detect
0.02	0.451	1.95	10.5	.	3.4	0.52	0.011	ND	0.015	Non-detect	.	.	.
0.02	1.068	4.21	.	.	.	.	.	.	.	.	.	.	.
0.09	0.981	3.89	.	.	.	.	.	.	.	.	.	.	.
0.08	0.457	1.97	.	.	.	.	.	.	.	.	.	.	.
0.1	0.303	1.4	.	.	.	.	.	.	.	.	.	.	.
0.06	0.312	1.44	.	.	.	.	.	.	.	.	.	.	.
0.12	0.271	1.29	.	.	.	.	.	.	.	.	.	.	.
0.08	0.271	1.29	.	.	.	.	.	.	.	.	.	.	.
0.09	0.311	1.43	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	1	Non-detect	Non-detect
0.15	1.296	5.05	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	860	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	5-10	non-detect	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	non-detect	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	non-detect	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	.	13	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	.	non-detect	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	.	non-detect	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	.	non-detect	Non-detect	Non-detect
1.07	5.951	22.66	.	.	.	.	.	.	.	5-10	5.1	non-detect	non-detect
0.06	0.551	2.14	.	.	.	.	.	.	.	Non-detect	.	.	.
0.1	0.419	1.64	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.35	0.679	2.63	.	.	.	.	.	.	.	Non-detect	.	.	.
0.05	0.33	1.3	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	detect	17	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	non-detect	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	~5	1.8	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	detect	1.8	Non-detect	Non-detect
0.98	4.397	16.29	1.8	0.05	25	0.975	0.017	0.01	0.059	Non-detect	.	.	.
1	4.634	17.17	.	.	.	.	.	.	.	Non-detect	Non-detect	Non-detect	Non-detect

Appendix 1 cont.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Loch Erin	Lenawee	RESPONSE	6	20	2018	42.01448	-84.16189	Irish Mist	ambient	.	.	24.79	6.51	493.9	8.12	1.105
Loch Erin	Lenawee	RESPONSE	6	20	2018	42.01079	-84.16132	Dalton CT	ambient	.	.	24.29	6.44	493.6	8.12	1.47
Loch Erin	Lenawee	RESPONSE	6	20	2018	41.99886	-84.13136	Reed RD	ambient	.	.	25.22	5.56	484.1	8.1	0.792
Loch Erin	Lenawee	RESPONSE	6	20	2018	42.02023	-84.13904	Donegal DR	ambient	.	.	25.25	8.49	546	8.28	1.8
Pontiac	Oakland	RESPONSE	6	20	2018	42.66326	-83.44227	DNR boat launch	ambient	.	.	24.61	7.46	404.2	8.06	0.232
Pontiac	Oakland	RESPONSE	6	20	2018	42.66719	-83.45521	Deep	ambient	.	.	24.66	7.93	429.5	8.36	0.368
Pontiac	Oakland	RESPONSE	6	20	2018	42.66906	-83.45576	Skull Island	ambient	.	.	24.72	7.8	430.1	8.37	0.417
Pontiac	Oakland	RESPONSE	6	20	2018	42.6701	-83.44971	State park beach	ambient	.	.	24.55	7.46	433.9	8.24	0.422
Pontiac	Oakland	RESPONSE	6	20	2018	42.66497	-83.46123	Kingston	ambient	.	.	24.27	8.6	423.8	8.45	0.378
Pontiac	Oakland	RESPONSE	6	20	2018	42.66876	-83.46625	Hampton ST	ambient	.	.	24.9	7.99	450.8	8.35	0.37
Pontiac	Oakland	RESPONSE	6	20	2018	42.66988	-83.46949	Lighthouse Bay	ambient	.	.	24.03	8.28	436.8	8.26	0.324
Otter	Oakland	RESPONSE	6	20	2018	42.63554	-83.35378	East of Beverly Estates DR	ambient	.	.	24.46	9	879	7.87	1.218
Otter	Oakland	RESPONSE	6	20	2018	42.63509	-83.35358	West of Beverly Estates DR	ambient	.	.	25.16	7.8	869	7.94	2.1
Coldwater	Branch	RESPONSE	6	21	2018	41.806883	-84.983326	Tomahawk Trail	scum	.	.	19.41	11.63	562	7.57	0.707
Coldwater	Branch	RESPONSE	6	21	2018	41.806883	-84.983326	Tomahawk Trail	ambient	.	.	22	10.07	412.7	7.99	0.581
Coldwater	Branch	RESPONSE	6	21	2018	41.82989	-84.97759	Deep	ambient	.	.	24.28	7.86	370.6	8.31	0.072
Coldwater	Branch	RESPONSE	6	21	2018	41.84016	-84.97815	Warren RD/Lake DR	ambient	.	.	23.73	8.19	369.5	8.3	0.742
Coldwater	Branch	RESPONSE	6	21	2018	41.81106	-84.99289	Iyopawa/Spaulding DR	ambient	.	.	23.36	8.08	365.2	8.31	0.54
Coldwater	Branch	RESPONSE	6	21	2018	41.83342	-84.98807	DNR boat launch	ambient	.	.	23.36	8.19	369.7	8.38	0.67
Mona	Muskegon	targeted monitoring	7	11	2018	43.18635	-86.23609	Muskegon Heights boat launch	scum	.	.	26.301	10.69	456.4	8.34	0.765
Mona	Muskegon	targeted monitoring	7	11	2018	43.17873	-86.25916	Deep	ambient	.	.	26.373	9.36	468.8	8.14	0.585
Mona	Muskegon	targeted monitoring	7	11	2018	43.17597	-86.24609	Ross Park Beach	ambient	.	.	26.587	10.52	463.9	8.69	0.532
Mona	Muskegon	targeted monitoring	7	11	2018	43.18272	-86.2321	East, near Highgate RD	scum	.	.	26.762	10.01	462.8	8.71	0.7
Maston	Kent	RESPONSE	7	11	2018	43.270169	-85.359534	south channel	scum	.	.	21.982	7.85	476.4	7.54	5.194
Maston	Kent	RESPONSE	7	11	2018	43.27023	-85.35934	south Maston Lake	scum	.	.	29.158	13.2	380.7	8.38	2.087
Maston	Kent	RESPONSE	7	11	2018	43.27023	-85.35934	south Maston Lake	ambient	.	.	29.447	13.25	384.2	8.46	1.066
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.01214	-84.13582	Boat Launch	scum	.	.	26.583	9.76	497.7	7.94	7.976
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.01405	-84.15435	Private Dr A	scum	.	.	27.336	9.78	497.4	7.86	0.997
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.01518	-84.15269	Stephenson DR	scum	.	.	27.302	8.04	489.3	7.87	5.602
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.0205	-84.13898	Geddes Creek outlet	ambient	.	.	27.307	11.75	512	8.17	1.049
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.01003	-84.14169	Deep	ambient	.	.	27.029	8.8	483.4	8.16	1.319
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.01461	-84.16185	Irish Mist	ambient	.	.	27.869	9.62	500	8.08	0.51
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.01822	-84.16389	Wolf Creek outlet	ambient	.	.	28.101	9.05	518	8.16	0.596
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.01066	-84.16119	Dalton CT	ambient	.	.	28.011	8.75	499.3	8.04	0.515
Loch Erin	Lenawee	RESPONSE	7	13	2018	42.00111	-84.12714	O'Dowling	ambient	.	.	26.862	5.46	488.2	7.7	1.058
Bird Lake	Hillsdale	RESPONSE	7	13	2018	41.82555	-84.52341	Early Bird Beach DR	scum	.	.	29.251	8.92	431.6	7.94	-0.074
Bird Lake	Hillsdale	RESPONSE	7	13	2018	41.82555	-84.52341	Early Bird Beach DR	ambient	.	.	28.774	9.46	417.2	8.18	-0.12
Coldwater	Branch	RESPONSE	7	13	2018	41.80695	-84.9834	Tomahawk Trail	ambient	.	.	30.882	6.88	632	6.84	0.139
Coldwater	Branch	RESPONSE	7	13	2018	41.82753	-84.96906	Lake DR	scum	.	.	32.063	12.54	412.8	8.11	1.109
Coldwater	Branch	RESPONSE	7	13	2018	41.83055	-84.97587	Deep	ambient	.	.	28.943	9.31	400.5	8.01	-0.079
Coldwater	Branch	RESPONSE	7	13	2018	41.81133	-84.99467	Spaulding DR	ambient	.	.	31.404	11.38	415.4	8.13	-0.145
Coldwater	Branch	RESPONSE	7	13	2018	41.83338	-84.98806	DNR boat launch	ambient	.	.	30.667	9.74	436.5	7.88	-0.043
Earl	Livingston	RESPONSE	7	15	2018	42.603197	-83.892886	3110 Golf Club	scum	.	.	.	.	.	.	.
South Pond	Ottawa	RESPONSE	7	18	2018	42.96388	-85.97648	north side of pond, 10949 View Pond CT	ambient	.	.	26.231	9.06	422.1	8.2	0.313
Mona	Muskegon	targeted monitoring	7	18	2018	43.18635	-86.23609	Muskegon Heights boat launch	ambient	.	.	26.936	9.64	494.3	8.29	0.387
Mona	Muskegon	targeted monitoring	7	18	2018	43.17873	-86.25916	Deep	ambient	.	.	26.59	8.39	507	8.25	0.242
Mona	Muskegon	targeted monitoring	7	18	2018	43.17597	-86.24609	Ross Park Beach	ambient	.	.	26.964	9.63	497.3	8.64	0.167
Mona	Muskegon	targeted monitoring	7	18	2018	43.18272	-86.2321	East, near Highgate RD	ambient	.	.	27.684	10.64	497.8	8.69	0.522
Earl	Livingston	RESPONSE	7	18	2018	42.603197	-83.892886	3110 Golf Club	ambient	.	.	.	.	.	.	.

Appendix 1 cont.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
1.14	6.823	25.29	.	.	.	.	.	.	.	Non-detect	.	.	.
1.52	7.955	29.49	.	.	.	.	.	.	.	Non-detect	.	.	.
0.82	3.982	14.75	.	.	.	.	.	.	.	Non-detect	.	.	.
1.85	3.955	14.65	.	.	.	.	.	.	.	Non-detect	.	.	.
0.24	0.835	3.08	.	.	.	.	.	.	.	Non-detect	.	.	.
0.38	1.41	5.21	6.5	ND	6.7	0.61	0.005	ND	0.023	Non-detect	.	.	.
0.43	1.376	5.09	.	.	.	.	.	.	.	Non-detect	.	.	.
0.43	1.183	4.37	.	.	.	.	.	.	.	Non-detect	.	.	.
0.39	1.571	5.81	.	.	.	.	.	.	.	Non-detect	.	.	.
0.38	1.491	5.51	.	.	.	.	.	.	.	1-5	2.4	Non-detect	Non-detect
0.33	1.165	4.3	.	.	.	.	.	.	.	Non-detect	.	.	.
1.25	11.515	42.69	.	.	.	.	.	.	.	Non-detect	Non-detect	Non-detect	Non-detect
2.16	11.633	43.13	.	.	.	.	.	.	.	Non-detect	.	.	.
0.73	3.011	11.15	.	.	.	.	.	.	.	>10	22.6	.	.
0.6	1.715	6.34	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.07	0.622	2.29	10.9	0.13	2.6	0.75	0.23	ND	0.014	Non-detect	.	.	.
0.76	0.528	1.94	.	.	.	.	.	.	.	Non-detect	.	.	.
0.56	0.436	1.6	.	.	.	.	.	.	.	Non-detect	.	.	.
0.69	0.715	2.63	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.79	2.283	8.45	.	.	.	.	.	.	.	~10	2	non-detect	non-detect
0.6	2.304	8.53	5.9	0.01	17	0.66	0.12	ND	0.021	Non-detect	.	.	.
0.55	2.191	8.11	.	.	.	.	.	.	.	Non-detect	.	.	.
0.72	1.899	7.02	.	.	.	.	.	.	.	>10	21	non-detect	non-detect
5.35	8.031	29.77	.	.	.	.	.	.	.	>10	69	non-detect	non-detect
2.15	1.224	4.52	.	.	.	.	.	.	.	5-10	3.3	non-detect	non-detect
1.1	0.695	2.56	.	.	.	.	.	.	.	Non-detect	.	.	.
8.22	2.063	7.63	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
1.03	5.231	19.38	.	.	.	.	.	.	.	5-10	non-detect	non-detect	non-detect
5.77	4.162	15.42	.	.	.	.	.	.	.	Non-detect	.	.	.
1.08	2.829	10.47	.	.	.	.	.	.	.	Non-detect	.	.	.
1.36	1.758	6.5	1.8	0.01	28	0.92	ND	0.009	0.068	Non-detect	non-detect	non-detect	non-detect
0.53	2.466	9.13	.	.	.	.	.	.	.	Non-detect	.	.	.
0.61	3.46	12.82	.	.	.	.	.	.	.	Non-detect	.	.	.
0.53	3.351	12.41	.	.	.	.	.	.	.	Non-detect	.	.	.
1.09	1.475	5.45	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.08	3.444	12.76	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
-0.12	1.244	4.6	.	.	.	.	.	.	.	Non-detect	.	.	.
0.14	1.732	6.41	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
1.14	4.368	16.18	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.08	0.787	2.9	6.2	0.01	5.1	0.74	0.11	ND	0.011	Non-detect	0.58	non-detect	non-detect
-0.15	0.494	1.81	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.04	0.683	2.51	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	test fail	6.6	non-detect	non-detect
0.34	1.064	4.19	.	.	.	.	.	.	.	Non-detect	.	.	.
0.42	3.297	12.75	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.26	2.464	9.55	3.7	ND	16	0.64	0.006	ND	0.026	Non-detect	.	.	.
0.18	1.562	6.1	.	.	.	.	.	.	.	Non-detect	.	.	.
0.56	2.871	11.12	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	1-5	non-detect	non-detect	non-detect

Appendix 1 cont.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Earl	Livingston	RESPONSE	7	18	2018	42.603197	-83.892886	3110 Golf Club	ambient	.	.	.	.	.	.	.
Earl	Livingston	RESPONSE	7	18	2018	42.603197	-83.892886	3110 Golf Club	ambient	.	.	.	.	.	.	.
Pontiac	Oakland	targeted monitoring	7	19	2018	42.66326	-83.44227	DNR boat launch	ambient	.	.	25.538	9.38	411.5	7.02	0.214
Pontiac	Oakland	targeted monitoring	7	19	2018	42.66719	-83.45521	Deep	ambient	.	.	26.862	8.21	457.1	8.24	0.225
Pontiac	Oakland	targeted monitoring	7	19	2018	42.66906	-83.45576	Skull Island	ambient	.	.	26.77	8.21	456.9	8.37	0.195
Pontiac	Oakland	targeted monitoring	7	19	2018	42.6701	-83.44971	State park beach	ambient	.	.	26.284	9.15	438	8.19	0.181
Pontiac	Oakland	targeted monitoring	7	19	2018	42.66497	-83.46123	Kingston	ambient	.	.	26.516	8.34	452.9	8.28	0.159
Pontiac	Oakland	targeted monitoring	7	19	2018	42.66876	-83.46625	Hampton ST	ambient	.	.	26.47	7.95	455.9	8.11	0.195
Pontiac	Oakland	targeted monitoring	7	19	2018	42.66988	-83.46949	Lighthouse Bay	ambient	.	.	26.042	7.11	461.6	7.91	0.203
Sugden	Oakland	targeted monitoring	7	19	2018	42.61768	-83.49785	Deep	ambient	.	.	27.234	8.16	779	8.1	-0.122
Sugden	Oakland	targeted monitoring	7	19	2018	42.61828	-83.5006	Sugden Lake RD	ambient	.	.	28.114	9.66	788	8.27	-0.181
Sugden	Oakland	targeted monitoring	7	19	2018	42.61419	-83.49628	Bogie Lake RD	ambient	.	.	27.863	9.81	787	8.23	-0.16
Sugden	Oakland	targeted monitoring	7	19	2018	42.61515	-83.49438	Woodstone CT	ambient	.	.	27.898	8.97	789	8.1	-0.139
Sugden	Oakland	targeted monitoring	7	19	2018	42.6175	-83.49427	Bayview ST	ambient	.	.	27.591	8.25	784	8.13	-0.13
Lobdell	Genesee/Livingston	targeted monitoring	7	19	2018	42.78999	-83.82037	7377 Haviland Beach DR	ambient	.	.	28.695	11.55	445.4	8.68	-0.119
Lobdell	Genesee/Livingston	targeted monitoring	7	19	2018	42.79111	-83.8445	Dam outlet	ambient	.	.	27.963	10.08	538	7.99	0.054
Lobdell	Genesee/Livingston	targeted monitoring	7	19	2018	42.77629	-83.83333	Bennett Lake outlet	ambient	.	.	27.918	9.28	660	8.01	-0.147
Lobdell	Genesee/Livingston	targeted monitoring	7	19	2018	42.7856	-83.83298	Deep	ambient	.	.	28.166	8.97	517	8.13	-0.093
Lobdell	Genesee/Livingston	targeted monitoring	7	19	2018	42.7961	-83.83513	Heath's Harbor	ambient	.	.	28.228	8.96	507	8.07	0.058
Lobdell	Genesee/Livingston	targeted monitoring	7	19	2018	42.79782	-83.82195	Glen Hatt RD	ambient	.	.	29.141	10.52	482.3	8.38	-0.061
Lobdell	Genesee/Livingston	targeted monitoring	7	19	2018	42.78358	-83.83635	Peninsular Drive Canal	ambient	.	.	28.507	10.07	518	8.36	-0.033
Maston	Kent	RESPONSE	7	23	2018	43.270169	-85.359534	south channel	scum	.	.	18.75222	5.25	443	7.54	0.177
Maston	Kent	RESPONSE	7	23	2018	43.27023	-85.35934	south Maston Lake proper	ambient	.	.	24.86556	10.06	363.9	8.49	0.057
Mona	Muskegon	targeted monitoring	7	23	2018	43.18635	-86.23609	Muskegon Heights boat launch	ambient	.	.	24.61389	6.18	467.5	8.19	0.504
Mona	Muskegon	targeted monitoring	7	23	2018	43.1785	-86.2589	Deep	ambient	.	.	24.91167	7.27	468.1	8.39	0.653
Mona	Muskegon	targeted monitoring	7	23	2018	43.17597	-86.24609	Ross Park Beach	ambient	.	.	24.52278	7.08	464.8	8.32	0.763
Mona	Muskegon	targeted monitoring	7	23	2018	43.18272	-86.2321	East, near Highgate RD	ambient	.	.	24.60222	6.59	465	8.21	0.799
Mona	Muskegon	targeted monitoring	7	23	2018	43.16643	-86.28359	Turtle Bay	ambient	.	.	25.04056	8.07	467.9	8.48	0.579
Sugden	Oakland	RESPONSE	7	25	2018	42.61909	-83.49504	Castlewood ST	ambient	.	.	25.00111	8.9	715	7.58	0.004
Sugden	Oakland	RESPONSE	7	25	2018	42.61778	-83.49915	Deep	ambient	.	.	25.46611	8.71	723	7.99	-0.029
Sugden	Oakland	RESPONSE	7	25	2018	42.61895	-83.50034	forested area along Sugden Lake RD	scum	.	.	25.71889	8.36	727	7.96	-0.056
Sugden	Oakland	RESPONSE	7	25	2018	42.61411	-83.49617	Bogie Lake RD	scum	.	.	25.84722	8.76	731	7.92	-0.076
Sugden	Oakland	RESPONSE	7	25	2018	42.61514	-83.49435	Woodstone CT	scum	.	.	26.00833	8.98	732	7.99	-0.068
Sugden	Oakland	RESPONSE	7	25	2018	42.6176	-83.49426	Bayview ST	ambient	.	.	25.95278	8.36	731	7.85	-0.095
Earl	Livingston	RESPONSE	7	25	2018	42.60325	-83.89301	3110 Golf Club	scum	.	.	.	.	.	.	.
Fausett	Livingston	RESPONSE	7	26	2018	42.696475	-83.870502	4797 Waterwood Way	scum	.	.	.	.	.	.	.
Fausett	Livingston	RESPONSE	7	26	2018	42.696475	-83.870502	4797 Waterwood Way	ambient	.	.	.	.	.	.	.
Tyrone	Livingston	RESPONSE	8	2	2018	42.694893	-83.727609	6050 Bullard Road	scum	.	.	.	.	.	.	.
Tyrone	Livingston	RESPONSE	8	2	2018	42.694893	-83.727609	6050 Bullard Road	ambient	.	.	.	.	.	.	.
Sugden	Oakland	RESPONSE	8	3	2018	42.61795	-83.50222	Pond between Bogie and Sugden Lakes	ambient	.	.	22.8	5.37	814	7.03	0.472
Sugden	Oakland	RESPONSE	8	3	2018	42.61638	-83.49604	Boat Launch	scum	.	.	24.696	8.34	745	7.67	0.127
Sugden	Oakland	RESPONSE	8	3	2018	42.61752	-83.49885	Deep	ambient	.	.	25.033	8.77	746	7.8	0.133
Sugden	Oakland	RESPONSE	8	3	2018	42.61816	-83.49577	Castlewood ST	scum	.	.	25.051	8.87	744	8.03	0.12
Sugden	Oakland	RESPONSE	8	3	2018	42.61982	-83.49557	Estola	scum	.	.	24.601	8.15	152.2	7.62	1.698
Sugden	Oakland	RESPONSE	8	3	2018	42.61811	-83.50058	Sugden Lake RD	ambient	.	.	25.215	8.4	750	8.02	0.061
Sugden	Oakland	RESPONSE	8	3	2018	42.619	-83.50027	forested area along Sugden Lake RD	ambient	.	.	25.197	8.4	748	7.97	0.018
Sugden	Oakland	RESPONSE	8	3	2018	42.61449	-83.49644	Bogie Lake RD	scum	.	.	25.097	8.25	803	7.08	0.414
Sugden	Oakland	RESPONSE	8	3	2018	42.6152	-83.49439	Woodstone CT	ambient	.	.	25.135	8.19	758	7.67	0.278
Sugden	Oakland	RESPONSE	8	3	2018	42.61761	-83.49429	Bayview ST	scum	.	.	25.303	8.39	764	7.86	0.25

Appendix 1 cont.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
.	.	.	.	.	.	.	.	.	.	1-5	non-detect	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	1-5	non-detect	non-detect	non-detect
0.23	0.822	3.26	.	.	.	.	.	.	.	1-5 ug/l MC	non-detect	non-detect	non-detect
0.24	1.057	4.16	3.9	ND	7.2	0.68	0.008	ND	0.023	Non-detect	.	.	.
0.21	1.057	4.16	.	.	.	.	.	.	.	Non-detect	.	.	.
0.19	0.963	3.8	.	.	.	.	.	.	.	Non-detect	.	.	.
0.17	1.161	4.56	.	.	.	.	.	.	.	Non-detect	.	.	.
0.21	1.105	4.35	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.22	1.282	5.02	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.13	0.148	0.68	10.9	0.01	4.7	0.54	0.011	ND	0.006	Non-detect	.	.	.
-0.19	0.131	0.61	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.17	0.204	0.89	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.15	0.314	1.31	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
-0.14	0.3	1.26	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.13	0.403	1.65	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.06	1.129	4.44	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.16	0.458	1.87	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.1	0.511	2.07	7.7	ND	4.6	0.53	0.007	ND	0.011	Non-detect	.	.	.
0.06	0.99	3.91	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.07	0.594	2.39	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.03	1.037	4.08	.	.	.	.	.	.	.	Non-detect	.	.	.
0.19	0.917	3.62	.	.	.	.	.	.	.	>10	14.4	non-detect	non-detect
0.06	0.725	2.89	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.54	2.699	10.46	.	.	.	.	.	.	.	Non-detect	.	.	.
0.7	3.367	13.02	4.4	ND	15	0.62	0.005	0.007	0.027	Non-detect	.	.	.
0.82	3.505	13.55	.	.	.	.	.	.	.	Non-detect	.	.	.
0.86	3.78	14.6	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.62	3.566	13.78	.	.	.	.	.	.	.	Non-detect	1.89	non-detect	non-detect
0	0.323	1.35	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.03	0.246	1.05	9.6	0.009	3	0.51	0.008	ND	0.006	Non-detect	.	.	.
-0.06	0.173	0.77	.	.	.	.	.	.	.	5-10	3.5	non-detect	non-detect
-0.08	0.188	0.83	.	.	.	.	.	.	.	1-5	4.8	non-detect	non-detect
-0.07	0.245	1.05	.	.	.	.	.	.	.	1-5	1.4	non-detect	non-detect
-0.1	0.194	0.85	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	5-10	9.9	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	1-5	2.4	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	1-2.5	1.9	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	1-2.5	Non-detect	non-detect	non-detect
0.47	5.697	21.2	.	.	.	.	.	.	.	Non-detect	.	.	.
0.13	0.473	1.73	.	.	.	.	.	.	.	>10	60	non-detect	non-detect
0.13	0.359	1.3	10.66	ND	3.3	0.54	0.007	ND	0.006	Non-detect	.	.	.
0.12	0.371	1.35	.	.	.	.	.	.	.	>10	4.8	non-detect	non-detect
1.69	0.949	3.5	.	.	.	.	.	.	.	>10	160	non-detect	non-detect
0.06	0.389	1.42	.	.	.	.	.	.	.	Non-detect	.	.	.
0.02	0.36	1.31	.	.	.	.	.	.	.	Non-detect	.	.	.
0.41	0.391	1.42	.	.	.	.	.	.	.	5-10	6	non-detect	non-detect
0.28	0.313	1.13	.	.	.	.	.	.	.	Non-detect	.	.	.
0.25	0.456	1.66	.	.	.	.	.	.	.	>10	57	non-detect	non-detect

Appendix 1 cont.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Earl	Livingston	RESPONSE	8	3	2018	42.60325	-83.89301	3110 Golf Club	ambient	.	.	25.074	7.66	1130	6.91	16.931
Earl	Livingston	RESPONSE	8	3	2018	42.60207	-83.90031	Canal - Earl Lake RD	ambient	.	.	25.828	8.66	1159	7.58	0.91
Earl	Livingston	RESPONSE	8	3	2018	42.60243	-83.90013	Canal - 2690 Golf Club RD	ambient	.	.	26.37	10.32	1166	7.8	1.939
Earl	Livingston	RESPONSE	8	3	2018	42.60223	-83.89777	Deep	ambient	.	.	25.564	8.05	1145	7.68	0.048
Earl	Livingston	RESPONSE	8	3	2018	42.60012	-83.89474	Char-Ann Dr	ambient	.	.	26.694	8.42	1171	7.95	0.117
Earl	Livingston	RESPONSE	8	3	2018	42.60193	-83.8987	Boat Launch	ambient	.	.	25.904	7.48	1157	7.55	0.231
Thornapple River	Barry	RESPONSE	8	4	2018	42.61648	-85.21237	Rivergate Park	scum	.	.	.	.	.	.	.
Maston	Kent	RESPONSE	8	6	2018	43.270169	-85.359534	south channel	ambient	.	.	23.304	8.2	394.5	7.95	0.576
Maston	Kent	RESPONSE	8	6	2018	43.27023	-85.35934	south Maston Lake proper	ambient	.	.	25.791	11.22	359.5	8.62	0.333
Mona	Muskegon	targeted monitoring	8	6	2018	43.18635	-86.23609	Muskegon Heights boat launch	ambient	.	.	25.855	6.84	475.3	8.17	0.987
Mona	Muskegon	targeted monitoring	8	6	2018	43.17597	-86.24609	Ross Park Beach	ambient	.	.	25.858	7.82	483.3	8.4	1.13
Mona	Muskegon	targeted monitoring	8	6	2018	43.18272	-86.2321	East, near Highgate RD	ambient	.	.	26.507	8.56	477.1	8.54	1.227
Mona	Muskegon	targeted monitoring	8	6	2018	43.16643	-86.28359	Turtle Bay	ambient	.	.	25.06	5.52	463.8	7.82	0.834
Mona	Muskegon	targeted monitoring	8	6	2018	43.17873	-86.25916	Deep	ambient	.	.	25.728	7.2	487.9	8.17	1.009
Van Etten	Iosco	RESPONSE	7	27	2018	44.47585	-83.35888	6785 Loud DR	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	7	27	2018	44.4518	-83.3366	East shore	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	8	8	2018	44.47585	-83.35888	6785 Loud DR	ambient	.	.	24.44	8	321	7.75	0.332
Van Etten	Iosco	RESPONSE	8	8	2018	44.46272	-83.3563	boat launch/beach	ambient	.	.	24.204	9.25	318.2	8.4	1.309
Van Etten	Iosco	RESPONSE	8	8	2018	44.46434	-83.35627	Deep	ambient	.	.	24.409	9.07	325.6	8.42	1.297
Van Etten	Iosco	RESPONSE	8	8	2018	44.48613	-83.36649	Loud Island	ambient	.	.	25.669	11.18	324.7	8.58	0.724
Van Etten	Iosco	RESPONSE	8	8	2018	44.48602	-83.38341	NW	ambient	.	.	25.875	9.97	333	8.53	1.198
Van Etten	Iosco	RESPONSE	8	8	2018	44.44934	-83.33828	Dam outlet	ambient	.	.	24.347	9.59	318.9	8.49	0.778
Lamberton	Kent	RESPONSE	8	10	2018	43.02295	-85.63046	1552 Lamberton Lake DR	scum	.	.	25.366	9.32	739	7.69	99.486
Lamberton	Kent	RESPONSE	8	10	2018	43.02295	-85.63046	1552 Lamberton Lake DR	ambient	.	.	25.86	9.68	765	7.66	1.461
Lamberton	Kent	RESPONSE	8	10	2018	43.02246	-85.62828	NE	scum	.	.	25.49	9.49	783	7.62	0.562
Lamberton	Kent	RESPONSE	8	10	2018	43.01951	-85.62988	Apartment	scum	.	.	26.628	9.49	862	6.87	84.651
Lamberton	Kent	RESPONSE	8	10	2018	43.01951	-85.62988	Apartment	ambient	.	.	26.064	9.59	764	7.72	0.786
Pontiac	Oakland	targeted monitoring	8	13	2018	42.66338	-83.44231	DNR boat launch	scum	.	.	25.285	7.46	401.5	8.06	0.85
Pontiac	Oakland	targeted monitoring	8	13	2018	42.66707	-83.4549	Deep	scum	.	.	26.414	8.37	434.3	8.43	0.628
Pontiac	Oakland	targeted monitoring	8	13	2018	42.66901	-83.44826	State park beach	ambient	.	.	25.772	8	431.6	8.33	0.919
Pontiac	Oakland	targeted monitoring	8	13	2018	42.6693	-83.4556	Skull Island	ambient	.	.	26.32	8.45	432.9	8.49	0.661
Pontiac	Oakland	targeted monitoring	8	13	2018	42.66488	-83.46117	Kingston ST	scum	.	.	25.791	8.55	418.8	8.48	0.781
Pontiac	Oakland	targeted monitoring	8	13	2018	42.66801	-83.46223	Kingston Island	scum	.	.	26.054	8.52	428.1	8.44	0.546
Pontiac	Oakland	targeted monitoring	8	13	2018	42.66877	-83.46616	Hampton ST	ambient	.	.	25.501	8.84	387.8	8.61	0.451
Pontiac	Oakland	targeted monitoring	8	13	2018	42.66989	-83.46951	Buckingham st	ambient	.	.	25.21	10.28	409.9	8.57	0.479
Sugden	Oakland	targeted monitoring	8	13	2018	42.61752	-83.49885	Deep	ambient	.	.	26.849	8.67	764	8.31	-0.041
Sugden	Oakland	targeted monitoring	8	13	2018	42.61971	-83.49552	Estola	purple mat	.	.	26.729	8.5	762	8.34	-0.012
Sugden	Oakland	targeted monitoring	8	13	2018	42.61818	-83.50058	Sugden Lake RD	ambient	.	.	27.096	8.66	769	8.37	-0.041
Sugden	Oakland	targeted monitoring	8	13	2018	42.61418	-83.49622	Bogie Lake RD	scum	.	.	27.096	8.66	769	8.37	-0.041
Sugden	Oakland	targeted monitoring	8	13	2018	42.61418	-83.49622	Bogie Lake RD	ambient	.	.	26.999	8.58	770	8.33	0.005
Sugden	Oakland	targeted monitoring	8	13	2018	42.61511	-83.49439	Woodstone CT	ambient	.	.	27.297	8.98	777	8.37	-0.045
Sugden	Oakland	targeted monitoring	8	13	2018	42.61754	-83.49423	Bayview ST	ambient	.	.	27.041	8.73	770	8.33	-0.08
Tyrone	Livingston	RESPONSE	8	13	2018	42.69509	-83.72794	Bullard RD	scum	.	.	30.853	16.24	10.6	9.23	139.056
Tyrone	Livingston	RESPONSE	8	13	2018	42.69509	-83.72794	Bullard RD	ambient, less cyano	.	.	28.476	10.63	486.3	8.49	2.465
Brighton	Livingston	RESPONSE	8	13	2018	42.52024	-83.78989	Brighton Lake boat launch	ambient	.	.	29.086	10.7	990	8.32	1.432
Brighton	Livingston	RESPONSE	8	13	2018	42.52296	-83.78997	Ore Creek inlet	ambient	.	.	28.228	7.46	1084	7.79	0.169
Brighton	Livingston	RESPONSE	8	13	2018	42.52084	-83.79426	Arbor Bay	scum	.	.	29.77	10.67	1011	8.32	1.103
Brighton	Livingston	RESPONSE	8	13	2018	42.51698	-83.80231	Dam	ambient	.	.	28.84	10.7	984	8.38	0.944
Brighton	Livingston	RESPONSE	8	13	2018	42.51999	-83.80135	Deep	ambient	.	.	29.047	11.25	978	8.41	1.045

Appendix 1 cont.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
16.87	9.152	34.07	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
0.9	11.708	43.6	.	.	.	.	.	.	.	Non-detect	.	.	.
1.93	15.667	58.35	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
0.05	5.05	18.79	6.25	ND	17	0.68	ND	ND	0.018	Non-detect	.	.	.
0.12	1.07	3.95	.	.	.	.	.	.	.	Non-detect	.	.	.
0.23	2.711	10.07	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	5-10	1.1	non-detect	non-detect
0.59	1.986	7.35	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
0.34	0.494	1.81	.	.	.	.	.	.	.	Non-detect	.	.	.
1.02	3.534	13.09	.	.	.	.	.	.	.	Non-detect	.	.	.
1.16	4.285	15.87	.	.	.	.	.	.	.	Non-detect	.	.	.
1.26	4.936	18.29	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
0.86	3.353	12.42	.	.	.	.	.	.	.	Non-detect	.	.	.
1.04	3.27	12.11	3.5	ND	16	0.58	ND	0.008	0.029	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	5-10	4.3	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	5-10	23	non-detect	non-detect
0.33	0.887	3.27	.	.	.	.	.	.	.	Non-detect	.	.	.
1.3	1.334	4.94	.	.	.	.	.	.	.	5-10	0.73	non-detect	non-detect
1.29	1.769	6.56	4	0.02	22	0.64	ND	0.005	0.025	5-10	1	non-detect	non-detect
0.72	1.079	3.99	.	.	.	.	.	.	.	5-10	0.7	non-detect	non-detect
1.19	2.023	7.51	.	.	.	.	.	.	.	5-10	0.57	non-detect	non-detect
0.77	1.581	5.86	.	.	.	.	.	.	.	1-5	Non-detect	non-detect	non-detect
99.14	13.519	50.34	.	.	.	.	.	.	.	>10	270	non-detect	non-detect
1.45	1.61	5.96	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
0.56	2.573	9.56	.	.	.	.	.	.	.	5-10	3.6	non-detect	non-detect
84.36	10.925	40.68	.	.	.	.	.	.	.	5-10	1.7	non-detect	non-detect
0.78	1.568	5.81	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
0.89	1.842	6.93	.	.	.	.	.	.	.	>10	9	non-detect	non-detect
0.66	1.113	4.22	4.1	ND	9.5	0.74	ND	0.006	0.025	>10	4	non-detect	non-detect
0.96	2.34	8.77	.	.	.	.	.	.	.	Non-detect	.	.	.
0.7	1.019	3.88	.	.	.	.	.	.	.	1-5	2.1	non-detect	non-detect
0.82	1.168	4.43	.	.	.	.	.	.	.	>10	17	non-detect	non-detect
0.58	1.151	4.36	.	.	.	.	.	.	.	>10	8	non-detect	non-detect
0.48	1.527	5.76	.	.	.	.	.	.	.	1-5	0.79	non-detect	non-detect
0.51	1.101	4.18	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.03	0.297	1.2	6.75	ND	2.6	0.54	ND	ND	0.007	Non-detect	.	.	.
0	0.297	1.2	.	.	.	.	.	.	.	1-5	2	non-detect	non-detect
-0.03	0.376	1.49	.	.	.	.	.	.	.	1-5	0.95	non-detect	non-detect
-0.03	0.376	1.49	.	.	.	.	.	.	.	>10	120	non-detect	non-detect
0.02	0.444	1.74	.	.	.	.	.	.	.	5-10	2.4	non-detect	non-detect
-0.03	0.338	1.35	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.07	0.207	0.86	.	.	.	.	.	.	.	Non-detect	.	.	.
143.25	27.782	103.15	.	.	.	.	.	.	.	>10	900	non-detect	non-detect
2.55	6.71	24.99	.	.	.	.	.	.	.	>10	5.5	non-detect	non-detect
1.49	3.586	13.4	.	.	.	.	.	.	.	Non-detect	.	.	.
0.19	1.37	5.18	.	.	.	.	.	.	.	Non-detect	.	.	.
1.15	2.557	9.58	.	.	.	.	.	.	.	Non-detect	Non-detect	1.1	non-detect
0.99	2.314	8.68	1.67	0.03	32	0.92	ND	0.008	0.039	Non-detect	.	.	.
1.09	2.635	9.87	.	.	.	.	.	.	.	Non-detect	.	.	.

Appendix 1 cont.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Brighton	Livingston	RESPONSE	8	13	2018	42.52217	-83.80116	Club House	ambient	.	.	30.192	10.85	1000	8.41	1.052
Brighton	Livingston	RESPONSE	8	13	2018	42.51831	-83.79137	Brighton Lake Rd	ambient	.	.	30.367	10.96	1004	8.43	0.711
Thornapple	Barry	RESPONSE	8	14	2018	42.6178	-85.19837	Boat Launch	ambient	.	.	26.605	9.91	563	.	.
Thornapple	Barry	RESPONSE	8	14	2018	42.62094	-85.194	beach	ambient	.	.	27.292	10.31	577	.	.
Thornapple	Barry	RESPONSE	8	14	2018	42.62424	-85.18908	Deep	ambient	.	.	26.985	10.38	563	.	.
Thornapple	Barry	RESPONSE	8	14	2018	42.62502	-85.18129	Barry's Resort	ambient	.	.	27.64	10.29	570	.	.
Thornapple	Barry	RESPONSE	8	14	2018	42.6291	-85.18431	NE	ambient	.	.	27.727	10.4	565	.	.
Thornapple	Barry	RESPONSE	8	14	2018	42.62473	-85.19412	NW	ambient	.	.	27.074	10.48	565	.	.
Thornapple	Barry	RESPONSE	8	14	2018	42.61648	-85.21237	Rivergate Park	scum	.	.	27.027	9.6	573	.	.
Long	Kalamazoo	RESPONSE	8	14	2018	42.19692	-85.524506	8261 W. Long Lake Drive, Scotts, MI	ambient	.	.	.	.	.	.	.
Loch Erin	Lenawee	RESPONSE	8	13	2018	42.008475	-84.146969	7577 Wadding Dr.	scum	.	.	.	.	.	.	.
Allegan	Allegan	TMDL Monitoring	8	14	2018	42.56137	-85.94833	Site 3	ambient	.	.	.	.	.	.	.
Belleville	Wayne	TMDL Monitoring	8	14	2018	42.2086	-83.5319	Bell 1	ambient	.	.	.	.	.	.	.
Belleville	Wayne	TMDL Monitoring	8	14	2018	42.5319	-83.5315	Bell 2	ambient	.	.	.	.	.	.	.
Ford	Washtenaw	TMDL Monitoring	8	14	2018	42.2109	-83.573	Boat launch	ambient	.	.	.	.	.	.	.
Ford	Washtenaw	TMDL Monitoring	8	14	2018	42.2194	83.5945	Ford 2	ambient	.	.	.	.	.	.	.
Macatawa	Ottawa	TMDL Monitoring	8	15	2018	42.777015	-86.180838	West Basin	ambient	.	.	.	.	.	.	.
Macatawa	Ottawa	TMDL Monitoring	8	15	2018	42.788936	-86.144225	Pine Creek Bay	ambient	.	.	.	.	.	.	.
Macatawa	Ottawa	TMDL Monitoring	8	15	2018	42.796257	-86.1186	Boat launch	scum	.	.	.	.	.	.	.
Lamberton	Kent	RESPONSE	8	20	2018	43.02295	-85.63046	1552 Lamberton Lake DR	ambient	.	.	26.623	9.6	742	8.34	0.122
Lamberton	Kent	RESPONSE	8	20	2018	43.02246	-85.62828	NE	ambient	.	.	27.012	11.42	735	8.46	0.129
Lamberton	Kent	RESPONSE	8	20	2018	43.01951	-85.62988	Apartment	ambient	.	.	26.365	9.14	731	8.29	0.06
Mona	Muskegon	targeted monitoring	8	20	2018	43.18635	-86.23609	Muskegon Heights boat launch	ambient	.	.	25.986	7.76	455.9	8.44	0.842
Mona	Muskegon	targeted monitoring	8	20	2018	43.17597	-86.24609	Ross Park Beach	ambient	.	.	26.274	8.08	466.6	8.58	0.744
Mona	Muskegon	targeted monitoring	8	20	2018	43.18272	-86.2321	East, near Highgate RD	ambient	.	.	26.48	8.58	459.1	8.59	0.925
Mona	Muskegon	targeted monitoring	8	20	2018	43.16643	-86.28359	Turtle Bay	ambient	.	.	26.061	7.8	451.8	8.31	0.876
Mona	Muskegon	targeted monitoring	8	20	2018	43.17873	-86.25916	Deep	ambient	.	.	26.152	7.61	468.6	8.48	0.841
Loch Erin	Lenawee	targeted monitoring	8	19	2018	42.012683	-84.129836	8573 Rose of Sharon Court	scum	.	.	.	.	.	.	.
Loch Erin	Lenawee	targeted monitoring	8	20	2018	42.012683	-84.129836	8573 Rose of Sharon Court	ambient	.	.	.	.	.	.	.
Loch Erin	Lenawee	targeted monitoring	8	18	2018	42.008572	-84.147276	7583 Wadding Drive	scum	.	.	.	.	.	.	.
Loch Erin	Lenawee	targeted monitoring	8	20	2018	42.008572	-84.147276	7583 Wadding Drive	ambient	.	.	.	.	.	.	.
Pontiac	Oakland	RESPONSE	8	22	2018	42.67071	-83.45836	Tackles DR boat launch	ambient	.	.	23.75722	7.85	434.5	6.46	0.896
Pontiac	Oakland	RESPONSE	8	22	2018	42.66761	-83.44708	State park beach	ambient	.	.	21.39778	8.63	376.2	7.41	1.229
Pontiac	Oakland	RESPONSE	8	22	2018	42.66338	-83.44237	DNR boat launch	ambient	.	.	23.27222	5.75	374.4	7.23	1.505
Pontiac	Oakland	RESPONSE	8	22	2018	42.66485	-83.4613	Kingston	ambient	.	.	23.01389	8.19	411.8	6.86	1.77
Pontiac	Oakland	RESPONSE	8	22	2018	42.66877	-83.46646	Hampton ST	ambient	.	.	24.10889	7.93	398.7	6.64	0.937
Pontiac	Oakland	RESPONSE	8	22	2018	42.6699	-83.46976	Buckingham st	ambient	.	.	22.90278	8.47	378.8	6.22	0.948
Sugden	Oakland	RESPONSE	8	22	2018	42.61636	-83.49604	boat launch	ambient	.	.	24.48889	8.17	696	7.18	0.774
Sugden	Oakland	RESPONSE	8	22	2018	42.61513	-83.49416	Woodstone CT	ambient	.	.	23.43111	8.27	705	7.1	1.014
Sugden	Oakland	RESPONSE	8	22	2018	42.61402	-83.49629	Bogie Lake RD	ambient	.	.	23.46333	8.28	686	6.64	1.104
Sugden	Oakland	RESPONSE	8	22	2018	42.61809	-83.50078	Sugden Lake RD	ambient	.	.	24.18667	8.33	724	5.81	1.131
Tyrone	Livingston	RESPONSE	8	22	2018	42.69507	-83.72784	Bullard RD	ambient	.	.	24.56389	7.77	441.9	7.34	1.409
Lobdell	Genesee/Livingston	RESPONSE	8	22	2018	42.77569	-83.83337	Bennett Lake outlet	ambient	.	.	24.175	8.15	591	6.56	1.091
Lobdell	Genesee/Livingston	RESPONSE	8	22	2018	42.7961	-83.83529	Heath's Harbor	ambient	.	.	23.95389	7.39	466.4	6.63	0.897
Lobdell	Genesee/Livingston	RESPONSE	8	22	2018	42.79	-83.82035	Haviland Beach DR	ambient	.	.	25.37444	7.32	472.3	7	0.969
Lobdell	Genesee/Livingston	RESPONSE	8	22	2018	42.79121	-83.84511	Dam	ambient	.	.	24.68167	7.83	542	6.86	0.774
Lobdell	Genesee/Livingston	RESPONSE	8	22	2018	42.7862	-83.84058	DNR boat launch	ambient	.	.	24.74222	8.02	570	6.45	0.953
Lobdell	Genesee/Livingston	RESPONSE	8	22	2018	42.78345	-83.8364	Peninsular Drive Canal	ambient	.	.	23.66833	7.96	489.1	6.19	1.067
Lobdell	Genesee/Livingston	RESPONSE	8	27	2018	42.77569	-83.83337	Bennett Lake outlet	ambient	.	.	26.394	9	645	7.59	-0.005

Appendix 1 cont.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
1.1	2.885	10.8	.	.	.	.	.	.	.	Non-detect	.	.	.
0.75	2.51	9.41	.	.	.	.	.	.	.	Non-detect	Non-detect	0.83	non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
.	.	.	3.2	ND	24	0.51	ND	0.005	0.026	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	5-10	1.4	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	Non-detect	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	1-5	2.5	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	1.7	non-detect	non-detect
0.14	1.591	6	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.15	1.42	5.36	.	.	.	.	.	.	.	Non-detect	.	.	.
0.08	1.06	4.03	.	.	.	.	.	.	.	Non-detect	.	.	.
0.88	3.618	13.52	.	.	.	.	.	.	.	Non-detect	.	.	.
0.78	2.938	10.99	.	.	.	.	.	.	.	Non-detect	.	.	.
0.97	5.192	19.35	.	.	.	.	.	.	.	Non-detect	.	.	.
0.92	4.244	15.84	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.88	3.164	11.83	3.5	ND	16	0.57	ND	0.007	0.027	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	7.7	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	1-5	1.8	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
0.94	0.436	1.71	.	.	.	.	.	.	.	Non-detect	.	.	.
1.28	0.674	2.6	.	.	.	.	.	.	.	Non-detect	.	.	.
1.57	2.95	11.04	.	.	.	.	.	.	.	Non-detect	.	.	.
1.84	1.204	4.56	.	.	.	.	.	.	.	Non-detect	0.89	non-detect	non-detect
0.98	0.602	2.33	.	.	.	.	.	.	.	Non-detect	.	.	.
0.99	0.457	1.79	.	.	.	.	.	.	.	Non-detect	.	.	.
0.81	0.326	1.3	.	.	.	.	.	.	.	Non-detect	.	.	.
1.06	0.345	1.37	.	.	.	.	.	.	.	Non-detect	.	.	.
1.15	0.374	1.49	.	.	.	.	.	.	.	Non-detect	0.61	non-detect	non-detect
1.18	0.384	1.52	.	.	.	.	.	.	.	Non-detect	.	.	.
1.47	11.93	44.35	.	.	.	.	.	.	.	Non-detect	non-detect	0.31	non-detect
1.14	0.371	1.47	.	.	.	.	.	.	.	Non-detect	.	.	.
0.94	0.847	3.24	.	.	.	.	.	.	.	Non-detect	.	.	.
1.01	1.076	4.09	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
0.81	0.527	2.05	.	.	.	.	.	.	.	Non-detect	.	.	.
1	0.476	1.86	.	.	.	.	.	.	.	Non-detect	.	.	.
1.11	0.44	1.73	.	.	.	.	.	.	.	Non-detect	.	.	.
0.01	0.882	3.37	.	.	.	.	.	.	.	Non-detect	.	.	.

Appendix 1 cont.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Lobdell	Genesee/Livingston	RESPONSE	8	27	2018	42.7961	-83.83529	Heath's Harbor	ambient	.	.	25.9	6.2	531	6.63	0.27
Lobdell	Genesee/Livingston	RESPONSE	8	27	2018	42.79	-83.82035	Haviland Beach DR	ambient	.	.	25.423	8.49	443.8	7.8	0.439
Lobdell	Genesee/Livingston	RESPONSE	8	27	2018	42.79121	-83.84511	Dam	ambient	.	.	25.927	8.31	533	7.65	-0.058
Lobdell	Genesee/Livingston	RESPONSE	8	27	2018	42.7862	-83.84058	DNR boat launch	ambient	.	.	25.172	8.82	557	7.52	-0.124
Lobdell	Genesee/Livingston	RESPONSE	8	27	2018	42.78345	-83.8364	Peninsular Drive Canal	ambient	.	.	26.661	6.66	526	7.41	0.101
Paw Paw	Berrien	RESPONSE	8	22	2018	42.19656	-86.29218	Paw Paw Lake Public Access at Island Court	scum	.	.	.	.	.	.	.
Paw Paw	Berrien	RESPONSE	8	22	2018	42.19656	-86.29218	Paw Paw Lake Public Access at Island Court	ambient	.	.	.	.	.	.	.
Porter	Iron	RESPONSE	8	22	2018	46.323879	-88.572997	East shore, Fire #173	scum	.	.	.	.	.	.	.
Mona	Muskegon	targeted monitoring	9	4	2018	43.18635	-86.23609	Muskegon Heights boat launch	scum	.	.	25.052	11.5	445	8.01	32.736
Mona	Muskegon	targeted monitoring	9	4	2018	43.18635	-86.23609	Muskegon Heights boat launch	ambient	.	.	.	.	.	.	.
Mona	Muskegon	targeted monitoring	9	4	2018	43.17597	-86.24609	Ross Park Beach	ambient	.	.	24.688	9.02	423.6	8.42	1.028
Mona	Muskegon	targeted monitoring	9	4	2018	43.18272	-86.2321	East, near Highgate RD	scum	.	.	25.29	9.63	423.4	8.56	1.15
Mona	Muskegon	targeted monitoring	9	4	2018	43.16643	-86.28359	Turtle Bay	ambient	.	.	24.137	7.77	431.9	7.97	1.434
Mona	Muskegon	targeted monitoring	9	4	2018	43.17873	-86.25916	Deep	ambient	.	.	24.481	9.01	425.4	8.41	1.151
Van Etten	Iosco	RESPONSE	8	30	2018	44.47585	-83.35888	6785 Loud DR	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	8	30	2018	44.46272	-83.3563	boat launch/beach	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	8	30	2018	44.48613	-83.36649	Loud Island	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	8	30	2018	44.48602	-83.38341	NW	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	8	30	2018	44.44934	-83.33828	Dam outlet	clear	.	.	.	.	.	.	.
Lake Michigan	Muskegon	RESPONSE	9	6	2018	43.221871	-86.337573	Pere Marquette Park	clear	.	.	.	.	.	.	.
Mona	Muskegon	RESPONSE	9	6	2018	43.18635	-86.23609	Muskegon Heights boat launch	clear	.	.	.	.	.	.	.
Mona	Muskegon	RESPONSE	9	6	2018	43.182844	-86.224414	Hidden Cove Park	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	9	11	2018	44.47585	-83.35888	6785 Loud DR	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	9	11	2018	44.46272	-83.3563	boat launch/beach	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	9	11	2018	44.46272	-83.3563	boat launch/beach	ambient	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	9	11	2018	44.451742	-83.3366	End of Oscoda ST	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	9	11	2018	44.448468	-83.340144	Below dam	ambient	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	9	11	2018	44.471606	-83.372365	DNR boat launch	scum	.	.	.	.	.	.	.
Van Etten	Iosco	RESPONSE	9	11	2018	44.471606	-83.372365	DNR boat launch	ambient	.	.	.	.	.	.	.
Belleville	Wayne	TMDL Monitoring	9	12	2018	42.21397	-83.47318	Boat launch	scum	.	.	22.532	6.77	751	8.12	3.449
Belleville	Wayne	TMDL Monitoring	9	12	2018	42.21082	-83.51996	B2	scum	.	.	22.596	8.2	774	8.08	1.082
Ford	Washtenaw	TMDL Monitoring	9	12	2018	42.21080	-83.57304	Boat launch	scum	.	.	23.855	8.4	792	8.22	2.17
Ford	Washtenaw	TMDL Monitoring	9	12	2018	42.22017	-83.59378	F2	scum	.	.	23.337	9.91	781	8.51	1.202
Lobdell	Genesee/Livingston	RESPONSE	9	14	2018	42.77569	-83.83337	Bennett Lake outlet	ambient	.	.	24.32778	9	591	8.23	0.234
Lobdell	Genesee/Livingston	RESPONSE	9	14	2018	42.7961	-83.83529	Heath's Harbor	ambient	.	.	23.00611	8.03	478.7	7.93	0.084
Lobdell	Genesee/Livingston	RESPONSE	9	14	2018	42.79	-83.82035	Haviland Beach DR	ambient	.	.	22.50444	9.29	448	8.34	0.676
Lobdell	Genesee/Livingston	RESPONSE	9	14	2018	42.79	-83.82035	Haviland Beach DR	scum	.	.	25.37333	5.62	550	8.01	77.872
Lobdell	Genesee/Livingston	RESPONSE	9	14	2018	42.79121	-83.84511	Dam	ambient	.	.	22.61389	9.03	521	8.02	0.594
Lobdell	Genesee/Livingston	RESPONSE	9	14	2018	42.7862	-83.84058	DNR boat launch	ambient	.	.	23.275	9.22	564	7.93	0.52
Lobdell	Genesee/Livingston	RESPONSE	9	14	2018	42.78345	-83.8364	Peninsular Drive Canal	scum	.	.	24.49389	9.83	487.8	8.44	27.302
Mona	Muskegon	targeted monitoring	9	17	2018	43.18635	-86.23609	Muskegon Heights boat launch	scum	.	.	23.13389	11.13	394.9	8.69	1.63
Mona	Muskegon	targeted monitoring	9	17	2018	43.17597	-86.24609	Ross Park Beach	ambient	.	.	23.59278	13.45	392.2	8.98	1.593
Mona	Muskegon	targeted monitoring	9	17	2018	43.18272	-86.2321	East, near Highgate RD	scum	.	.	23.39889	12.73	394.6	8.83	2.055
Mona	Muskegon	targeted monitoring	9	17	2018	43.16643	-86.28359	Turtle Bay	ambient	.	.	22.85	12.01	395.6	8.66	2.831
Mona	Muskegon	targeted monitoring	9	17	2018	43.17873	-86.25916	Deep	ambient	.	.	23.39889	12.63	394.2	8.84	1.7
Tyrone	Livingston	RESPONSE	9	17	2018	42.69507	-83.72784	Bullard RD	scum	.	.	.	.	.	.	.
Tyrone	Livingston	RESPONSE	9	17	2018	42.69507	-83.72784	Bullard RD	ambient	.	.	.	.	.	.	.
Ford	Washtenaw	RESPONSE	9	19	2018	42.21080	-83.57304	Boat launch	scum	.	.	24.878	16.64	604	8.38	25.168
Ford	Washtenaw	RESPONSE	9	19	2018	42.22017	-83.59378	F2	ambient	.	.	24.844	14.89	631	8.45	4.415

Appendix 1 cont.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
0.29	0.707	2.72	.	.	.	.	.	.	.	Non-detect	.	.	.
0.47	1.696	6.39	.	.	.	.	.	.	.	Non-detect	non-detect	non-detect	non-detect
-0.04	0.707	2.72	.	.	.	.	.	.	.	Non-detect	.	.	.
-0.11	0.412	1.63	.	.	.	.	.	.	.	Non-detect	.	.	.
0.12	1.519	5.73	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	7.8	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	>10	5.3	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	non-detect	non-detect	non-detect	non-detect
32.65	7.892	29.35	.	.	.	.	.	.	.	>10	280	non-detect	non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	1.2	non-detect	non-detect
1.06	3.112	11.54	.	.	.	.	.	.	.	Non-detect	.	.	.
1.18	2.577	9.55	.	.	.	.	.	.	.	>10	260	non-detect	non-detect
1.46	4.18	15.52	.	.	.	.	.	.	.	Non-detect	.	.	.
1.18	2.604	9.65	3.6	ND	25	0.62	0.089	0.005	0.034	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	15	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	>10	29	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	>10	390	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	>10	83	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	non-detect	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	4900	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	5-10	3.4	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	0.7	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	>10	13000	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	360	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	~1	non-detect	Non-detect	Non-detect
3.57	1.042	3.96	.	.	.	.	.	.	.	.	700	Non-detect	Non-detect
1.13	1.148	4.36	.	.	.	.	.	.	.	.	120	Non-detect	Non-detect
2.25	0.883	3.37	.	.	.	.	.	.	.	.	1300	Non-detect	Non-detect
1.25	9.503	35.35	.	.	.	.	.	.	.	.	168	Non-detect	Non-detect
0.21	1.172	4.36	.	.	.	.	.	.	.	Non-detect	.	.	.
0.06	0.833	3.1	.	.	.	.	.	.	.	Non-detect	.	.	.
0.65	0.785	2.92	.	.	.	.	.	.	.	~1	non-detect	Non-detect	Non-detect
77.58	14.711	54.81	.	.	.	.	.	.	.	>10	450	Non-detect	Non-detect
0.57	0.671	2.49	.	.	.	.	.	.	.	Non-detect	.	.	.
0.5	0.405	1.5	.	.	.	.	.	.	.	Non-detect	.	.	.
27.19	6.124	22.81	.	.	.	.	.	.	.	>10	330	Non-detect	Non-detect
1.69	4.915	18.33	.	.	.	.	.	.	.	>10	360	0.43	non-detect
1.66	4.967	18.52	.	.	.	.	.	.	.	Non-detect	.	.	.
2.13	6.056	22.56	.	.	.	.	.	.	.	>10	53	0.29	non-detect
2.93	10.05	37.38	.	.	.	.	.	.	.	Non-detect	.	.	.
1.77	5.274	19.66	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	>10	580	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	5-10	13	Non-detect	Non-detect
24.9	5.437	19.88	.	.	.	.	.	.	.	>10	440	Non-detect	Non-detect
4.22	1.903	6.71	.	.	.	.	.	.	.	Non-detect	non-detect	Non-detect	Non-detect

Appendix 1 cont.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Ford	Washtenaw	RESPONSE	9	19	2018	42.220161	-83.575357	north cove	scum	.	.	25.045	15.93	620	8.45	8.386
Ford	Washtenaw	RESPONSE	9	19	2018	42.206215	-83.563945	deep	ambient	.	.	25.025	17.51	612	8.52	7.047
Ford	Washtenaw	RESPONSE	9	19	2018	42.213416	-83.595941	south cove	ambient	.	.	24.345	10.85	660	8.23	3.114
Ford	Washtenaw	RESPONSE	9	19	2018	42.228714	-83.604176	Huron River inlet/I-94	ambient	.	.	23.612	6.81	721	8.04	0.392
Belleville	Wayne	RESPONSE	9	19	2018	42.21397	-83.47318	Boat launch	ambient	.	.	24.878	11.8	624	8.65	3.226
Belleville	Wayne	RESPONSE	9	19	2018	42.211944	-83.459523	East cove	ambient	.	.	24.867	12.26	624	8.66	2.964
Belleville	Wayne	RESPONSE	9	19	2018	42.214818	-83.443344	deep	ambient	.	.	24.579	12.23	624	8.72	3.281
Belleville	Wayne	RESPONSE	9	19	2018	42.20703	-83.484833	belleville cove	ambient	.	.	24.731	10.71	626	8.51	3.29
Belleville	Wayne	RESPONSE	9	19	2018	42.215977	-83.499118	two bridges cove	ambient	.	.	25.022	10.85	633	8.5	4.165
Belleville	Wayne	RESPONSE	9	19	2018	42.209266	-83.507899	west cove	ambient	.	.	24.848	14.02	630	8.55	3.668
Van Etten	Iosco	RESPONSE	9	20	2018	44.47585	-83.35888	6785 Loud DR	scum	.	.	20.475	8.88	148.9	8.43	1.099
Van Etten	Iosco	RESPONSE	9	20	2018	44.46272	-83.3563	boat launch/beach	scum	.	.	20.498	8.73	257.9	8.37	23.48
Van Etten	Iosco	RESPONSE	9	20	2018	44.451742	-83.3366	End of Oscoda ST	scum	.	.	20.438	8.71	158.6	8.33	2.127
Van Etten	Iosco	RESPONSE	9	20	2018	44.451742	-83.3366	End of Oscoda ST	ambient	.	.	20.33	8.78	253.8	8.32	2.119
Van Etten	Iosco	RESPONSE	9	20	2018	44.448468	-83.340144	Below dam	ambient	.	.	20.92	8.51	259	8.27	0.888
Van Etten	Iosco	RESPONSE	9	20	2018	44.471606	-83.372365	DNR boat launch	scum	.	.	20.707	8.68	260.7	8.38	16.213
Lobdell	Genesee/Livingston	RESPONSE	9	20	2018	42.77569	-83.83337	Bennett Lake outlet	ambient	.	.	24.9	8.6	487.8	8.17	0.573
Lobdell	Genesee/Livingston	RESPONSE	9	20	2018	42.7961	-83.83529	Heath's Harbor	ambient	.	.	23.903	8.7	390.6	8.06	0.481
Lobdell	Genesee/Livingston	RESPONSE	9	20	2018	42.79	-83.82035	Haviland Beach DR	ambient	.	.	23.882	8.83	379.3	8.35	0.721
Lobdell	Genesee/Livingston	RESPONSE	9	20	2018	42.79121	-83.84511	Dam	ambient	.	.	24.861	8.51	462.2	7.87	0.587
Lobdell	Genesee/Livingston	RESPONSE	9	20	2018	42.7862	-83.84058	DNR boat launch	ambient	.	.	24.643	8.67	464.9	7.84	0.442
Lobdell	Genesee/Livingston	RESPONSE	9	20	2018	42.78345	-83.8364	Peninsular Drive Canal	ambient	.	.	24.02	8.17	398.5	8.1	0.505
Pontiac	Oakland	targeted monitoring	9	24	2018	42.67071	-83.45836	Tackles DR boat launch	ambient	.	.	18.864	8.88	349.3	.	0.509
Pontiac	Oakland	targeted monitoring	9	24	2018	42.66761	-83.44708	State park beach	ambient	.	.	19.269	8.97	347.2	.	0.714
Pontiac	Oakland	targeted monitoring	9	24	2018	42.66338	-83.44237	DNR boat launch	ambient	.	.	18.573	7.15	341.9	.	0.373
Pontiac	Oakland	targeted monitoring	9	24	2018	42.66485	-83.4613	Kingston	scum	.	.	19.918	8.32	179.4	.	0.801
Pontiac	Oakland	targeted monitoring	9	24	2018	42.66877	-83.46646	Hampton ST	scum	.	.	18.644	9.05	357.7	.	11.052
Pontiac	Oakland	targeted monitoring	9	24	2018	42.6699	-83.46976	Buckingham st	scum	.	.	18.735	8.18	354	.	1.914
Sugden	Oakland	targeted monitoring	9	24	2018	42.61636	-83.49604	boat launch	ambient	.	.	20.395	9.2	630	.	0.176
Sugden	Oakland	targeted monitoring	9	24	2018	42.61513	-83.49416	Woodstone CT	ambient	.	.	20.097	8.52	646	.	0.54
Sugden	Oakland	targeted monitoring	9	24	2018	42.61402	-83.49629	Bogie Lake RD	ambient	.	.	19.977	8.6	760	.	0.734
Sugden	Oakland	targeted monitoring	9	24	2018	42.61809	-83.50078	Sugden Lake RD	ambient	.	.	19.595	8.94	620	.	0.438
Tyrone	Livingston	RESPONSE	9	24	2018	42.69507	-83.72784	Bullard RD	scum	.	.	19.432	9.13	195.4	.	45.838
Tyrone	Livingston	complaint follow up	9	24	2018	42.69507	-83.72784	Bullard RD	ambient	.	.	20.168	8.45	394.6	.	1.201
Lobdell	Genesee/Livingston	complaint follow up	9	24	2018	42.7961	-83.83529	Heath's Harbor	ambient	.	.	19.685	8.56	421.4	.	0.094
Lobdell	Genesee/Livingston	complaint follow up	9	24	2018	42.79	-83.82035	Haviland Beach DR	ambient	.	.	20.884	8.27	423.5	.	0.565
Lobdell	Genesee/Livingston	complaint follow up	9	24	2018	42.7862	-83.84058	DNR boat launch	ambient	.	.	19.947	8.34	512	.	-0.001
Lobdell	Genesee/Livingston	complaint follow up	9	24	2018	42.78345	-83.8364	Peninsular Drive Canal	ambient	.	.	20.021	8.35	451.9	.	0.16
Ford	Washtenaw	follow up	9	25	2018	42.21080	-83.57304	Boat launch	scum	.	.	21.281	9.32	463.8	.	91.816
Ford	Washtenaw	follow up	9	25	2018	42.22992	-83.60712	North Bay Park	ambient	.	.	20.71	8.31	715	.	0.462
Ford	Washtenaw	follow up	9	25	2018	42.20414	-83.5643	Lakeside Park	ambient	.	.	21.527	7.88	680	.	0.873
Ford	Washtenaw	follow up	9	25	2018	42.21849	-83.5845	Loon Feather Point Park	scum	.	.	20.917	8.59	713	.	1.265
Belleville	Wayne	follow up	9	25	2018	42.20978	-83.53947	West boat launch	ambient	.	.	21.156	7.62	716	.	0.593
Belleville	Wayne	follow up	9	25	2018	42.21069	-83.49339	Main ST and Denton, Belleville	ambient	.	.	21.102	6.54	701	.	1.271
Belleville	Wayne	follow up	9	25	2018	42.21384	-83.47319	Belleville boat launch	ambient	.	.	21.267	6.2	683	.	1.455
Belleville	Wayne	follow up	9	25	2018	42.21268	-83.4427	Edison Lake RD	ambient	.	.	21.315	5.9	675	.	1.332
Belleville	Wayne	follow up	9	25	2018	42.21248	-83.5251	Van Buren Park	scum	.	.	21.305	7.79	688	.	1.389
Otsego	Otsego	complaint	9	25	2018	44.984378	-84.683295	Tall Tree 1	scum	.	.	.	.	.	.	.
Otsego	Otsego	complaint	9	25	2018	44.984378	-84.683295	Tall Tree 2	scum	.	.	.	.	.	.	.

Appendix 1 cont.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
8.17	1.967	6.95	.	.	.	.	.	.	.	>10	43	Non-detect	Non-detect
6.84	2.601	9.31	1.2	0.009	130	2	0.013	0.011	0.078	Non-detect	.	.	.
2.92	2.415	8.62	.	.	.	.	.	.	.	Non-detect	.	.	.
0.21	1.553	5.41	.	.	.	.	.	.	.	Non-detect	.	.	.
3.03	1.131	3.84	.	.	.	.	.	.	.	>10	4.9	Non-detect	Non-detect
2.77	1.61	5.62	.	.	.	.	.	.	.	Non-detect	.	.	.
3.09	1.538	5.35	2.8	0.009	34	0.99	ND	0.006	0.048	1-5	3.8	Non-detect	Non-detect
3.1	1.215	4.15	.	.	.	.	.	.	.	5-10	5.1	Non-detect	Non-detect
3.97	1.283	4.4	.	.	.	.	.	.	.	Non-detect	.	.	.
3.47	1.674	5.86	.	.	.	.	.	.	.	Non-detect	.	.	.
0.91	1.776	6.24	.	.	.	.	.	.	.	>10	83	Non-detect	Non-detect
23.22	5.932	21.72	.	.	.	.	.	.	.	>10	50	Non-detect	Non-detect
1.94	0.14	0.14	.	.	.	.	.	.	.	>10	300	Non-detect	Non-detect
1.93	0.534	1.61	.	.	.	.	.	.	.	Non-detect	0.82	Non-detect	Non-detect
0.7	0.68	2.16	.	.	.	.	.	.	.	Non-detect	.	.	.
15.97	3.589	12.99	.	.	.	.	.	.	.	>10	240	Non-detect	Non-detect
0.39	0.662	2.09	.	.	.	.	.	.	.	Non-detect	.	.	.
0.3	0.685	2.17	.	.	.	.	.	.	.	Non-detect	.	.	.
0.54	0.96	3.2	.	.	.	.	.	.	.	Non-detect	non-detect	Non-detect	Non-detect
0.4	0.65	2.04	.	.	.	.	.	.	.	Non-detect	.	.	.
0.26	0.381	1.04	.	.	.	.	.	.	.	Non-detect	.	.	.
0.32	0.749	2.41	.	.	.	.	.	.	.	Non-detect	0.81	Non-detect	Non-detect
0.56	0.391	1.47	.	.	.	.	.	.	.	Non-detect	.	.	.
0.79	2.077	7.88	.	.	.	.	.	.	.	1-5	.	.	.
0.4	1.562	5.92	.	.	.	.	.	.	.	Non-detect	.	.	.
0.88	0.617	2.33	.	.	.	.	.	.	.	>10	.	.	.
12.34	3.208	12.18	.	.	.	.	.	.	.	>10	.	.	.
2.13	2.044	7.75	.	.	.	.	.	.	.	>10	.	.	.
0.18	0.621	2.35	.	.	.	.	.	.	.	Non-detect	.	.	.
0.59	0.767	2.9	.	.	.	.	.	.	.	Non-detect	.	.	.
0.81	0.356	1.34	.	.	.	.	.	.	.	Non-detect	.	.	.
0.48	0.239	0.9	.	.	.	.	.	.	.	Non-detect	.	.	.
51.21	41.603	158.07	.	.	.	.	.	.	.	>10	.	.	.
1.33	9.109	34.6	.	.	.	.	.	.	.	Non-detect	.	.	.
0.09	0.646	2.44	.	.	.	.	.	.	.	Non-detect	.	.	.
0.62	1.387	5.26	.	.	.	.	.	.	.	5-10	non-detect	Non-detect	Non-detect
-0.01	0.339	1.28	.	.	.	.	.	.	.	Non-detect	.	.	.
0.17	0.73	2.76	.	.	.	.	.	.	.	Non-detect	.	.	.
102.59	10.696	40.63	.	.	.	.	.	.	.	>10	930	Non-detect	Non-detect
0.5	0.335	1.26	.	.	.	.	.	.	.	Non-detect	.	.	.
0.96	0.861	3.26	.	.	.	.	.	.	.	Non-detect	.	.	.
1.4	0.653	2.47	.	.	.	.	.	.	.	5-10	1.5	Non-detect	Non-detect
0.65	0.152	0.56	.	.	.	.	.	.	.	Non-detect	.	.	.
1.41	0.63	2.38	.	.	.	.	.	.	.	Non-detect	.	.	.
1.61	0.88	3.33	.	.	.	.	.	.	.	Non-detect	.	.	.
1.48	0.523	1.97	.	.	.	.	.	.	.	Non-detect	.	.	.
1.54	0.636	2.4	.	.	.	.	.	.	.	5-10	1.6	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	>10	240	Non-detect	Non-detect
.	.	.	.	.	.	.	.	.	.	>10	58	Non-detect	Non-detect

Appendix 1 cont.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Townline	Montcalm	complaint	9	27	2018	43.461227	-85.207918	Channel DR	ambient	.	.	.	.	.	.	.
Townline	Montcalm	complaint	9	27	2018	43.461874	-85.207992	Channel weir	ambient	.	.	.	.	.	.	.
Townline	Montcalm	complaint	9	27	2018	43.458906	-85.194593	boat launch	ambient	.	.	.	.	.	.	.
Ford	Washtenaw	follow up	10	4	2018	42.21080	-83.57304	Boat launch	ambient	.	.	19.114	6.42	692	7.88	0.696
Ford	Washtenaw	follow up	10	4	2018	42.22992	-83.60712	North Bay Park	ambient	.	.	18.641	8.04	723	7.68	0.771
Ford	Washtenaw	follow up	10	4	2018	42.20414	-83.5643	Lakeside Park	ambient	.	.	19.335	6.68	695	7.83	0.588
Ford	Washtenaw	follow up	10	4	2018	42.21849	-83.5845	Loon Feather Point Park	ambient	.	.	19.596	7.17	699	7.87	1.175
Belleville	Wayne	follow up	10	4	2018	42.20978	-83.53947	West boat launch	ambient	.	.	19.144	5.77	697	7.78	0.311
Belleville	Wayne	follow up	10	4	2018	42.21069	-83.49339	Main ST and Denton, Belleville	ambient	.	.	18.978	8.07	667	7.88	0.848
Belleville	Wayne	follow up	10	4	2018	42.21384	-83.47319	Belleville boat launch	ambient	.	.	19.688	6.88	663	7.84	1.046
Belleville	Wayne	follow up	10	4	2018	42.21268	-83.4427	Edison Lake RD	ambient	.	.	19.301	7.79	696	7.76	0.764
Belleville	Wayne	follow up	10	4	2018	42.21248	-83.5251	Van Buren Park	ambient	.	.	20.134	7.02	710	7.91	0.86
Pontiac	Oakland	follow up	10	4	2018	42.67071	-83.45836	Tackles DR boat launch	ambient	.	.	17.259	8.91	331.3	8.07	0.744
Pontiac	Oakland	follow up	10	4	2018	42.66761	-83.44708	State park beach	ambient	.	.	19.666	8.69	342	8.06	0.838
Pontiac	Oakland	follow up	10	4	2018	42.66338	-83.44237	DNR boat launch	ambient	.	.	17.942	8.34	328.4	8.1	0.509
Pontiac	Oakland	follow up	10	4	2018	42.66485	-83.4613	Kingston	ambient	.	.	18.112	8.69	337.1	8.24	0.567
Pontiac	Oakland	follow up	10	4	2018	42.66877	-83.46646	Hampton ST	scum	.	.	18.372	9.16	344.2	8.21	0.669
Pontiac	Oakland	follow up	10	4	2018	42.6699	-83.46976	Buckingham st	ambient	.	.	18.245	8.54	357.5	8.15	0.615
LeAnn	Hillsdale	complaint	10	10	2018	42.06836	-84.42872	Dublin CT launch	scum	.	.	19.63611	9.39	439	7.08	24.495
LeAnn	Hillsdale	complaint	10	10	2018	42.05904	-84.42529	Look Out Point launch	ambient	.	.	19.77	7.46	491.4	6.89	1.369
LeAnn	Hillsdale	complaint	10	10	2018	42.05402	-84.4293	Sauk Trail	ambient	.	.	19.56389	7.8	537	5.85	1.754
LeAnn	Hillsdale	complaint	10	10	2018	42.0547	-84.43936	Sauk Trail Park	ambient	.	.	19.45333	7.89	538	5.91	1.135
LeAnn	Hillsdale	complaint	10	10	2018	42.0569	-84.44099	Baker Rd Park	ambient	.	.	19.65889	8.08	523	6.63	0.293
LeAnn	Hillsdale	complaint	10	10	2018	42.06443	-84.43795	Pineview DR	scum	.	.	20.21611	8.51	435.9	7.04	19.011
LeAnn	Hillsdale	complaint	10	10	2018	42.06443	-84.43795	Pineview DR	ambient	.	.	20.17833	8.38	431.4	7.16	0.869
LeAnn	Hillsdale	complaint	10	10	2018	42.06137	-84.4359	Oakwood Dr	ambient	.	.	20.28722	8.16	488.6	6.53	1.006
LeAnn	Hillsdale	complaint	10	10	2018	42.07032	-84.43614	Briar Lane	ambient	.	.	20.51389	8.99	503	6.48	3.505
Hanna Web Lake	Iron	S/T	8	23	2018	46.35463	-88.72115	.	.	.	.	.	.	.	.	.
Kingston Lake	Alger	S/T	8	13	2018	46.58364	-86.22115	.	.	.	.	.	.	.	.	.
Fox Lake	Alger	S/T	8	14	2018	46.59198	-86.03441	.	.	.	.	.	.	.	.	.
Beaver Lake	Alger	S/T	8	13	2018	46.57690	-86.33437	.	.	.	.	.	.	.	.	.
Belle Lake 1	Luce	S/T	8	14	2018	46.48600	-85.80878	.	.	.	.	.	.	.	.	.
Weber Lake	Dickinson	S/T	.	.	2018	46.20065	-88.08875	.	.	.	.	.	.	.	.	.
Pickerel Lake	Dickinson	S/T	8	23	2018	46.08058	-87.81097	.	.	.	.	.	.	.	.	.
No Name Lake	Marquette	S/T	.	.	2018	46.149423	-87.34565	.	.	.	.	.	.	.	.	.
Long Lake	Hillsdale	S/T	8	20	2018	41.87471	-84.79443	.	.	.	.	.	.	.	.	.
Hall Lake	Barry	S/T	8	21	2018	42.61474	-85.48181	.	.	.	.	.	.	.	.	.
Torch Lake	Antrim	S/T	8	9	2018	44.97283	-85.31332	.	.	.	.	.	.	.	.	.
Brevoort Lake	Mackinac	S/T	8	27	2018	45.99519	-84.91591	.	.	.	.	.	.	.	.	.
South Tomahawk Lake	Montmorency	S/T	.	.	2018	45.16504	-84.14777	.	.	.	.	.	.	.	.	.
Shupac Lake	Crawford	S/T	8	29	2018	44.82262	-84.47604	.	.	.	.	.	.	.	.	.
Chain Lake	Iosco	S/T	8	20	2018	44.48626	-83.85464	.	.	.	.	.	.	.	.	.
Sand Lake	Iosco	S/T	.	.	2018	44.32101	-83.68648	.	.	.	.	.	.	.	.	.
Long Lake	Iosco	S/T	.	.	2018	44.42126	-83.86009	.	.	.	.	.	.	.	.	.
Peach Lake	Ogemaw	S/T	.	.	2018	44.29152	-84.16840	.	.	.	.	.	.	.	.	.
Hardwood Lake	Ogemaw	S/T	.	.	2018	44.24380	-83.99953	.	.	.	.	.	.	.	.	.
Bush Lake	Ogemaw	S/T	8	21	2018	44.19244	-84.03509	.	.	.	.	.	.	.	.	.
Five Lakes	Clare	S/T	.	.	2018	43.87466	-84.80827	.	.	.	.	.	.	.	.	.
Hoister Lake	Gladwin	S/T	.	.	2018	44.14185	-84.56631	.	.	.	.	.	.	.	.	.

Appendix 1 cont.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
0.73	0.943	3.6	.	.	.	.	.	.	.	Non-detect	Non-detect	Non-detect	Non-detect
0.81	0.666	2.57	.	.	.	.	.	.	.	Non-detect	.	.	.
0.62	0.841	3.21	.	.	.	.	.	.	.	Non-detect	.	.	.
1.23	1.764	6.64	.	.	.	.	.	.	.	Non-detect	.	.	.
0.34	0.556	2.16	.	.	.	.	.	.	.	Non-detect	.	.	.
0.89	0.981	3.73	.	.	.	.	.	.	.	Non-detect	.	.	.
1.09	0.822	3.14	.	.	.	.	.	.	.	Non-detect	.	.	.
0.8	0.291	1.17	.	.	.	.	.	.	.	Non-detect	.	.	.
0.9	1.217	4.61	.	.	.	.	.	.	.	Non-detect	.	.	.
0.78	0.348	1.39	.	.	.	.	.	.	.	Non-detect	.	.	.
0.88	0.638	2.46	.	.	.	.	.	.	.	Non-detect	.	.	.
0.54	0.918	3.5	.	.	.	.	.	.	.	Non-detect	.	.	.
0.6	0.486	1.9	.	.	.	.	.	.	.	Non-detect	.	.	.
0.71	1.075	4.08	.	.	.	.	.	.	.	>10	6.6	Non-detect	Non-detect
0.65	0.553	2.15	.	.	.	.	.	.	.	Non-detect	.	.	.
25.25	3.475	12.99	.	.	.	.	.	.	.	5-10	.	.	.
1.43	1.521	5.74	.	.	.	.	.	.	.	Non-detect	.	.	.
1.82	2.554	9.57	.	.	.	.	.	.	.	Non-detect	.	.	.
1.18	0.714	2.75	.	.	.	.	.	.	.	Non-detect	.	.	.
0.32	1.016	3.86	.	.	.	.	.	.	.	Non-detect	.	.	.
19.6	15.744	58.5	.	.	.	.	.	.	.	>10	.	.	.
0.91	0.741	2.85	.	.	.	.	.	.	.	Non-detect	.	.	.
1.05	2.277	8.54	.	.	.	.	.	.	.	Non-detect	.	.	.
3.63	1.499	5.66	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.

Appendix 1 cont.

LAKE	County	TYPE	MONTH	DAY	YEAR	LAT	LONG	SITE	scum/ambient	SITE_DEPTH	SAMP_DEPTH (FT)	TEMP (F)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	PH	PC RFU
Bennett Lake	Livingston	S/T	.	.	2018	42.77391	-83.82893	.	.	.	.	.	.	.	.	.
Cass Lake	Oakland	S/T	8	27	2018	42.60909	-83.36907	.	.	.	.	.	.	.	.	.
Barton Pond	Washtenaw	S/T	8	30	2018	42.31281	-83.75604	.	.	.	.	.	.	.	.	.
Boney Lakes Impoundment	Delta	S/T	8	21	2018	45.98296	-87.26828	.	.	.	.	.	.	.	.	.
Heron Lake	Oakland	S/T	8	13	2018	42.80976	-83.52547	.	.	.	.	.	.	.	.	.
Londo Lake	Iosco	S/T	8	21	2018	44.34522	-83.86899	.	.	.	.	.	.	.	.	.
Michigamme Impoundment	Dickinson	S/T	8	22	2018	.	.	.	.	.	.	.	.	.	.	.
Perch Lake	Dickinson	S/T	8	22	2018	46.33685	-87.80137	.	.	.	.	.	.	.	.	.
Pratt	Gladwin	S/T	8	23	2018	44.02396	-84.54696	.	.	.	.	.	.	.	.	.
Ross	Gladwin	S/T	8	22	2018	43.88431	-84.49793	.	.	.	.	.	.	.	.	.
Tawas	Iosco	S/T	8	29	2018	44.30632	-83.49573	.	.	.	.	.	.	.	.	.
Thompson	Livingston	S/T	8	15	2018	42.61122	-83.91145	.	.	.	.	.	.	.	.	.

PC CONC. (µg/l)	CHLA RFU	CHLA CONC. (µg/l)	SECCHI D. (FT)	NH3 (mg/l)	LAB CHL (µg/l)	Kjeldahl N (mg/l)	NO2/NO3 (mg/l)	ORTHO PO4 (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB TOT MC (µg/l)	LAB ANATOX (µg/l)	LAB CYLINDRO (µg/l)
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
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.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.
.	.	.	.	.	.	.	.	.	.	Non-detect	.	.	.