NORTHEAST OHIO REGIONAL SEWER DISTRICT

2016 Greater Cleveland Area Lake Erie Nutrient Study

Prepared by
Water Quality and Industrial Surveillance Division

Introduction

In 2011, an algal bloom, the majority of which consisted of *Microcystis,* spread east of Cleveland and persisted there until the middle of October. The increase in algae throughout the lake is thought to be due to increases in dissolved reactive phosphorus (Ohio EPA, 2011) coupled with favorable weather conditions. The algal bloom which occurred in 2014 left residents in the City of Toledo without drinking water for three days. The algae bloom in 2015 was the largest in this century according to the National Oceanic and Atmospheric Academy (NOAA, 2015). Northeast Ohio Regional Sewer District (NEORSD) facilities, such as its wastewater treatment plants and the combined sewer overflows (CSOs), are a source of nutrients to the lake. The extent to which these potential sources, along with other ones within the study area, are contributing to the problem is not well known.

The purpose of the 2016 study was to continue to monitor the levels of nutrients and algae in Lake Erie near the greater Cleveland area from April through October and further attempt to establish temporal and spatial trends and potentially relate them to level of precipitation. As in 2015, the major tributaries to Lake Erie in the Cleveland area were sampled, including the Rocky River, Euclid Creek, and the Cuyahoga River, as well as eight sites on the lake. Samples were collected at the District's three wastewater treatment plants for dissolved reactive phosphorus (DRP). Chlorophyll *a* was measured as a means of determining the total quantity of algae present. Nutrient analyses included both phosphorus and nitrogen. Other water quality parameters that may influence algal production were also measured. Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by Ohio Environmental Protection Agency (EPA) in Chemical Water Quality as explained in the NEORSD study plan *2016 Greater Cleveland Area Lake Erie Nutrient Study* approved by the Ohio Environmental Protection Agency (EPA) on April 20, 2016.

Figure 1 is a map of the sampling locations evaluated during the study, and Table 1 indicates the sampling locations with respect to latitude/longitude and description. A digital photo catalog of the sampling locations is available upon request by contacting the NEORSD's Water Quality and Industrial Surveillance Division (WQIS).

2016 Greater Cleveland Area Lake Erie Nutrient Study
July 5, 2017

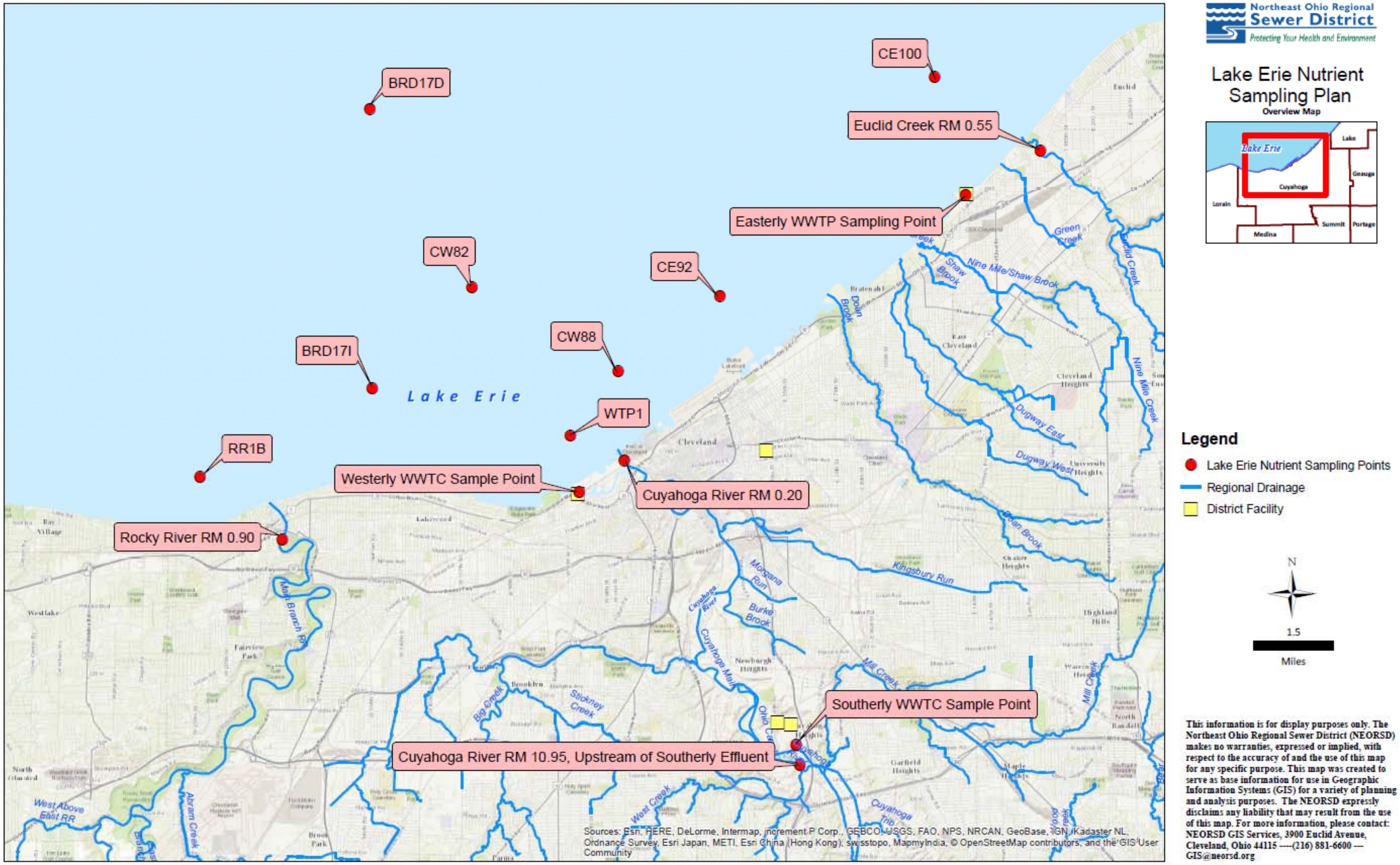

Figure 1. Sampling Locations

Table 1. Lake Erie Nutrient Study Sampling Locations						
Water Body	Latitude	Longitude	Station ID	Location Information	USGS HUC 8 Number -Name	Purpose
Lake Erie	41.49720	-81.86200	RR1B	Near Rocky River	04120200- Lake Erie	Determine trends in algal densities and nutrient concentrations in Lake Erie.
	41.59630	-81.80000	BRD17D	About 7 miles off shore of Lakewood		
	41.52080	-81.80000	BRD17I	Near Lakewood		
	41.54800	-81.76400	CW82	Near Garrett Morgan Water Intake		
	41.50765	-81.72907	WTP1	Near Westerly WWTC Diffusers		
	41.52500	-81.71170	CW88	Outside the City of Cleveland's Breakwall		
	41.54500	-81.67500	CE92	Outside the City of Cleveland's Breakwall		
	41.60333	-81.59717	CE100	2 miles north of Easterly WWTP outfall		
Rocky River	41.4802	-81.8327	RM 0.90	Upstream of Detroit Avenue	04110001 – Black/Rocky	Determine the contribution and effect to receiving waterbody.
Euclid Creek	41.5833	-81.5594	RM 0.55	Downstream of Lake Shore Boulevard	04110003 Ashtabula-Chagrin	
Cuyahoga River	41.5008	-81.7098	RM 0.20	Near mouth of river in navigation channel	04110002 - Cuyahoga	
Cuyahoga River	41.4182	-81.6479	RM 10.95	Chlorine-access railroad bridge, near ash lagoons	04110002 - Cuyahoga	
Easterly WWTP	14021 Lakeshore Blvd, Cleveland, OH 44110			Treated Effluent	Discharges to: 04120200- Lake Erie	
Westerly WWTP	5800 Cleveland Memorial Shoreway, Cleveland, OH 44102			Treated Effluent	Discharges to: 04120200- Lake Erie	
Southerly WWTP	6000 Canal Rd Cuyahoga Heights, OH 44125			Treated Effluent	Discharges to: 04110002- Cuyahoga	

Water Chemistry Sampling

Methods

Water chemistry sampling was conducted at most of the sites thirteen times between April 25th and October 26th. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual* (2015). These techniques were used for the lake sites and the three river sites. The effluent samples from the NEORSD wastewater treatment plants were grab samples using similar techniques. Chemical water quality samples from each site were collected with one 4-liter disposable polyethylene cubitainer with disposable polypropylene lids and two 473-mL plastic bottles, one which is preserved with sulfuric acid. An additional sample was analyzed for DRP and was filtered in the field using a 0.45-µm PVDF syringe filter and put into a 125-mL plastic bottle. All water quality samples were collected as grab samples at a depth of six to twelve inches below the surface. Samples collected at Westerly, Easterly, and Southerly Wastewater Treatment Plants (WWTP) were collected from the final treated effluent and were analyzed for DRP. Filtering was completed at time of collection using a 0.45-µm PVDF syringe filter and put into a 125-mL plastic bottle.

Duplicate samples and field blanks were collected at randomly selected sites at a frequency of not less than 5% of the total samples collected for this study. The acceptable relative percent difference (RPD) for field duplicate samples was less than or equal to $[(0.9465x^{-0.344})*100]+5$, where x = sample result/detection limit; results above this range were rejected. Acid preservation of the samples, as specified in the NEORSD laboratory's standard operating procedure for each parameter, also occurred in the field. Field analyses were collected by a YSI 600XL or EXO1 sonde and measured dissolved oxygen (DO), water temperature, conductivity and pH. Turbidity was measured using either a Hach 2100P IS Portable Turbidimeter or a Hach 2100Q Portable Turbidimeter.

Water column chlorophyll *a* samples were collected during each sampling using a 1L glass amber-colored jar. All chlorophyll *a* samples were collected as grab samples at a depth of six to twelve inches below the water's surface. One duplicate chlorophyll *a* sample was collected at randomly selected sites at a frequency of not less than 5% of the total samples collected for this study plan. After returning to the NEORSD Environmental and Maintenance Services Center, each sample was filtered in triplicate using 47 mm glass fiber filters and a vacuum with a pressure not exceeding 6 in. Hg. Filtered samples were stored in a freezer at -37°C for storage prior to analysis.

Microcystin samples were collected for four different analyses: microscope ID and enumeration, EPA 545 for Cylindrospermopsin and Anatoxin-A by LC/MS/MS1, EPA 544 for Microcystins and Nodularin by LC/MS/MS2, ISO 20179 Determination of Microcystins using SPE and HPLC with UV3, and ELISA (Enzyme-Linked-Immunosorbent Assay) protocol. These samples were collected at Lake Erie site CW82.

Results and Discussion

A copy of all analyses is available upon request by contacting the NEORSD's WQIS division.

Compliance and Quality Control

Fourteen sets of duplicate samples and eleven field blanks were collected during the study. For the field blanks, there were four parameters that showed possible contamination. It is unclear how the field blanks became contaminated and may be due to sample collection, handling, contaminated blank water and/or interference during chlorophyll *a* analysis. Table 2 lists water quality parameters that were rejected, estimated, or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol.

Table 2. Parameters affected by possible blank contamination
DRP
NO_3-NO_2
Chlorophyll *a*
TP

Four instances occurred in which the RPD between duplicate samples was greater than acceptable (Table 3). There may be numerous reasons for why these parameters were rejected, such as a lack of precision and consistency in sample collection and/or analytical procedures, improper handling of samples and/or environmental heterogeneity.

Table 3. Duplicate samples with greater than acceptable RPDs

Site	Date	Parameter	Acceptable RPD (%)	Actual RPD (%)
Euclid Creek RM 0.55	9/26/16	TSS	38.2	53.0
CE92	7/12/16	DRP	77.2	128.5
CE100	6/28/16	DRP	40.0	50.1
CW82	10/11/16	Chlorophyll *a*	16.8	33.6

The final QA/QC check for the samples that were collected was for paired parameters, or those parameters in which one of them is a subset of the other. For this study, only total phosphorus (TP) and DRP fell into this category. During the sampling that was conducted in 2016, there was one instance in which these parameters needed to be qualified due to the subset parameter being greater than the other one (Table 4).

Table 4. Paired Parameter with greater than acceptable RPDs				
Site	Date	Parameters	Acceptable RPD (%)	Actual RPD (%)
CE100	6/28/16	TP/DRP	56.6	23.4

Ohio EPA Water Quality Standards Exceedance

For the rest of the parameters measured, there was an aquatic life OMZA (outside mixing zone average) exceedance of temperature on the Rocky River and a OMZM (outside of mixing zone minimum) for dissolved oxygen on the Cuyahoga River RM 0.20 (Table 5). Otherwise, all other parameters at the lake or river sites were acceptable for human health nondrinking, aquatic life, and agricultural criteria.

Table 5. Aquatic Life OMZA Exceedance			
Site	Date	Parameter	
Rocky River RM 0.90	6/13/2016	Field Temperature	Result: 24.6 ºC Daily Maximum Criterion: 24.4 ºC
Cuyahoga River RM 0.20	8/8/2016	Field DO	Result: 3.28 mg/L Criterion: 4.00 mg/L

Microcystin Analysis at CW82

Samples collected at lake site CW82 were analyzed for microcystin, a toxin which can be produced by cyanobacteria. CW82 was chosen due to its proximity to one of the City of Cleveland's main water intake locations. Microcystins come in different forms (congeners) based on the location and type of the amino acids on the main structure. NEORSD analyzed for seven congeners for several of the sampling dates. The state guideline for the Recreational Public Health Advisory is 6 µg/L microcystin (Ohio Department of Health, *Harmful Algal Bloom*, 2016). By adding the seven congeners together, a rough minimum estimate could be made of the amount of microcystin in a sample. All dates had results below 0.5 µg/L. This was lower on average than 2015.

Data Analysis

Wastewater Treatment Plant Analysis

In 2016, DRP measurements were collected at Southerly, Westerly, and Easterly WWTPs (Table 6). Southerly discharges to the Cuyahoga River. Easterly and Westerly WWTPs discharge to Lake Erie. There is a current limit of 0.7 mg/L for TP implemented through NEORSD's NPDES permits, but no limit specifically for DRP is imposed by the Ohio EPA. In April 2016, one grab sample every month to monitor DRP was added to all of three WWTP's NPDES permit requirements. Phosphorus has many anthropogenic and natural sources. It usually is a limited nutrient in a water body and increases can accelerate growth rates of algae and plants. Table 6 shows loading values for DRP, with Southerly contributing around 50 metric tons to the Cuyahoga River yearly. This value is more accurate than the loading calculations for the Cuyahoga River in general because more data points were available for DRP as well as better flow measurements from the plant.

Table 6. 2016 NEORSD WWTP DRP Loading and Related Values

Site	Average DRP Value (mg/L)	Average Volume (MGD)	Average Yearly Estimate (metric tons of DRP)	Highest Collected Value (mg/L)
Southerly	0.385	115	51.49	0.579, June 13
Westerly	0.348	25	9.33	0.603, August 8
Easterly	0.472	72	38.13	1.093, July 26

Land Site Analysis

The lake site values of concern, like total phosphorus and ammonia, were most elevated near the mouth of the Cuyahoga River at WTP1 as data has shown in the past. A recent study by Ohio EPA about Nutrient Mass Balance within the state analyzed data from the Cuyahoga River (Ohio EPA, 2016). A phosphorous loading comparison of the Cuyahoga River to other major rivers is presented in Figure 2. The Maumee, Portage, and Sandusky Rivers are tributary to Lake Erie. The Great Miami, Scioto, and Muskingum Rivers are tributary to the Ohio River, another drinking water source. A pour point on each tributary was used as a location where the total load is calculated and considered known by use of water chemistry and flow. The Cuyahoga River had natural land cover as the predominant cover whereas the other rivers which drain to Lake Erie had agriculture as the predominant cover. The study found that approximately 60% of the total phosphorus loading to the Cuyahoga River is due to nonpoint sources and 32% of the total nitrogen is from nonpoint sources. All NPDES permits and other point sources accounted for 29% of the total phosphorous and 62% of the total nitrogen. NEORSD’s WWTPs are considered Major NPDES permit holders and the contribution of all Major permit holders in the drainage area for total phosphorous was 56% of the 29% which all point sources are contributing (Figure 3). Of the three WWTPs, only Southerly contributes flow to the Cuyahoga River.

This study shows that while the drainage area of the Cuyahoga is smaller and has more natural landscape than that of the Maumee River, the nonpoint source yield (lb/ac) is not much smaller than that of the Maumee. This indicates that while agricultural runoff is a large issue, nonpoint sources in the urban areas also carry total phosphorous, whether from erosion and stream degradation or streets. In addition, the point source yield of phosphorus from NPDES permits is one of the highest due to the watershed’s population density. NPDES permits also greatly contributed to the total nitrogen at 62%, much more than the other watersheds. This is indicative of regulations on total phosphorus and not total nitrogen at the major NPDES sites.

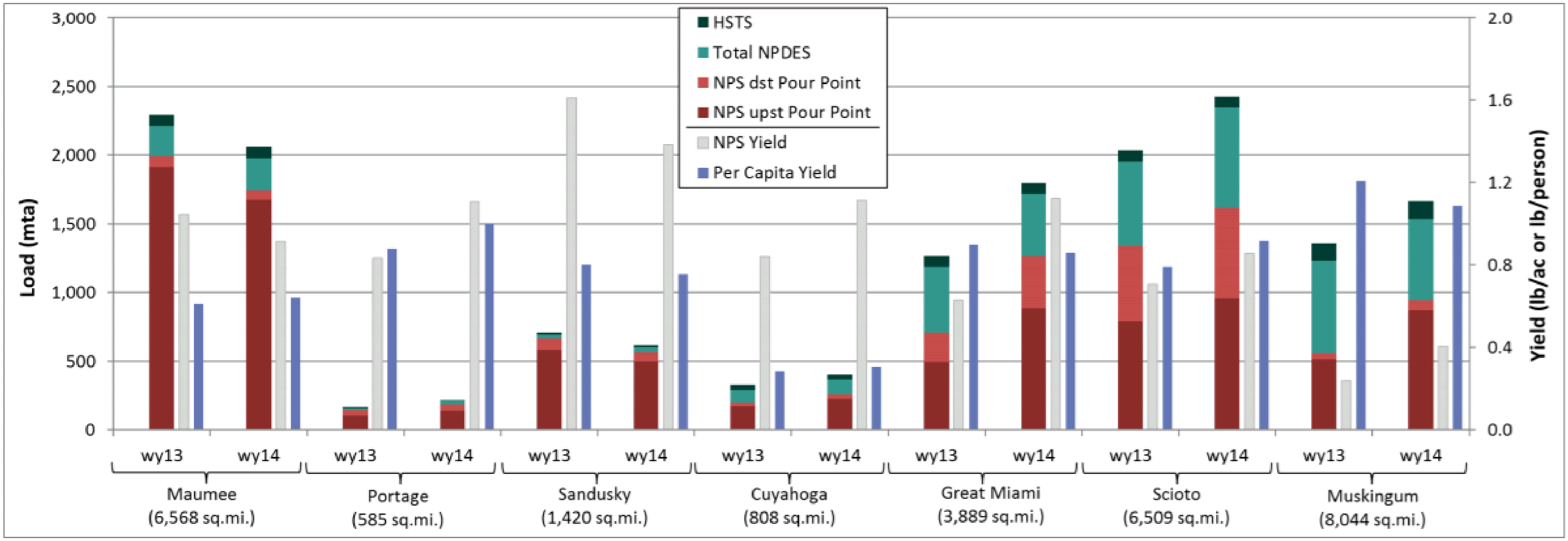

Figure 2. — Total phosphorus loading and nonpoint source yields as estimated using simplified nutrient balance methods. The nonpoint source yield is calculated as the residual load at the pour point divided by the area upstream of the pour point. Per capita yield is defined as the sum of NPDES and HSTS loads divided by the total number of people residing in the watershed; both are calculated at the watershed outlet. mta- metric tons per year. From Nutrient Mass Balance Study for Ohio’s Major Rivers (Ohio EPA, 2016)

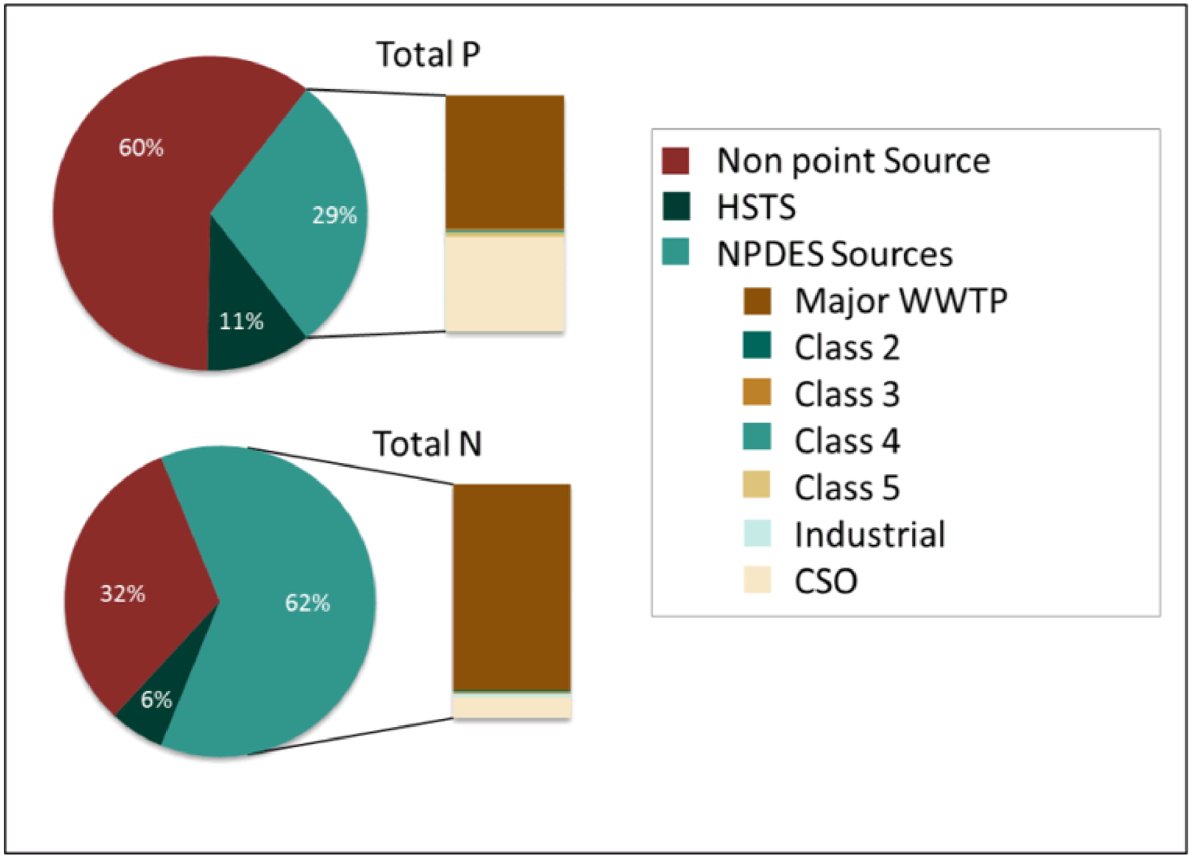

Figure 3. Total phosphorus and nitrogen load from different sources relative to total load for the Cuyahoga watershed in wy13. NPDES sources: Major WWTP – sewage treatment >1.0 mgd, Class 2 – sewage treatment 0.5-1.0 mgd, Class 3 – sewage treatment 0.25-1.0 mgd, Class 4 – sewage treatment 0.1-0.25 mgd, Class 5 – sewage treatment. From Nutrient Mass Balance Study for Ohio's Major Rivers (Ohio EPA, 2016

Table 7 lists the discharge amounts from tributaries which drain to the lake and were sampled for the study. The averages collected by USGS were much higher for the Rocky River and Euclid Creek than the averages on the days when samples were collected by NEORSD. Lower flow data is the result of not sampling during large rain events where higher flows would have been sustained throughout the year. This will affect the loading data presented in Tables 11 and 12. The Cuyahoga River as discussed is the largest tributary to Lake Erie in the Northeast Ohio Regional Sewer District's service area. The Rocky River had not as elevated levels as the Cuyahoga, presumably because the drainage area is smaller and it is not as industrial. The Rocky River does have siltation and sedimentation problems and many of the tributaries are partially or fully impaired for the designated aquatic life uses and recreational use. While sediment and particulate loading is less for the Rocky River, the contribution to Lake Erie is still of concern. Euclid Creek is the smallest of the sampled waterbodies, but is located very close to public beaches, making it an area with high recreation and fishing. In addition, it is a densely-populated watershed with 10 of the 40 plus river miles culverted.

Table 7. USGS 2016 Discharge for Major Northeast Ohio Tributaries to Lake Erie	
Water Body	ft^3/s as reported by USGS (average ft^3/s at time of samples collected)
Cuyahoga River at Newburgh Heights, OH	1,050 (843.63)
Rocky River at Berea, OH	273.5 (64.18)
Euclid Creek at Lakeshore Drive, Cleveland, OH	28.1 (9.85)

Results from stream sampling can be found in Table 8. In 2016, chlorophyll *a* levels in Euclid Creek were measured at one location in the vicinity of a long-term data sonde station. The purpose of this sampling was to provide a more comprehensive understanding of the relationship among algal production, nutrient levels, and DO diel swings in the creek. Benthic chlorophyll *a* had a high result and biological criteria was in non-attainment. Results suggest that nutrients may be contributing to the non-attainment status of Euclid Creek, but, if so, are not the only cause of impairment (NEORSD, 2017). Similar study by NEORSD was done on the Rocky River at RM 4.0 and it was found that nutrients did not appear to be contributing as significantly to attainment status biological criteria. Benthic chlorophyll a data on the Cuyahoga River showed that nutrients may be contributing to non-attainment in the lower reaches of the river, but, if so, are likely not the only factor.

Table 8. 2016 River Site Average Values												
	TP	DRP	NO_3-NO_2	NH_3	Alkalinity	TSS	pH	Conductivity	DO	Temperature	Turbidity	Chlorophyll *a*
Site	mg/L	mg/L	mg/L	mg/L	mg/L CaCO3	mg/L	S.U.	uS/cm	mg/L	ºC	NTU	ug/L
Euclid Creek RM 0.55	0.033	0.017	0.212	0.00967	109.39	3.15	7.84	885.7	8.82	18.0	2.85	4.10
Cuyahoga River RM 0.20	0.144	0.076	4.16	0.246	111.87	21.39	7.56	862.1	5.78	22.2	23.16	6.59
Rocky River RM 0.90	0.065	0.022	2.34	0.065	110.56	10.58	8.11	759.7	7.82	20.8	9.99	6.81
Cuyahoga River RM 10.95	0.120	0.068	3.31	0.378	122.73	17.80	8.00	829.7	8.95	20.5	17.24	9.91

Table 9. 2016 Lake Erie Average Values												
	TP	DRP	NO_3-NO_2	NH_3	Alkalinity	TSS	pH	Conductivity	DO	Temperature	Turbidity	Chlorophyll *a*
Site	mg/L	ug/L	mg/L	mg/L	mg/L CaCO3	mg/L	S.U.	uS/cm	mg/L	ºC	NTU	ug/L
RR1B	0.0195	3.22	0.456	0.0067	83.16	2.60	8.32	271.6	9.64	20.11	2.73	5.92
BRD17D	0.015	2.19	0.394	0.0056	83.76	1.21	8.27	253.68	9.64	19.49	1.42	3.805
BRD17I	0.018	3.22	0.432	0.0065	83.91	2.04	8.34	265.98	9.69	20.03	2.33	5.99
CW82	0.015	2.67	0.389	0.005	84.05	1.68	8.33	258.56	9.74	19.72	1.85	3.82
WTP1	0.025	6.74	0.668	0.0213	85.32	3.25	8.26	305.92	9.59	20.29	3.51	8.64
CW88	0.021	3.38	0.497	0.0058	83.16	2.73	8.29	278.59	9.67	19.98	2.45	8.01
CE92	0.020	4.78	0.470	0.0117	83.25	2.38	8.24	276.3	9.42	20.38	2.52	7.16
CE100	0.018	4.16	0.439	0.0090	82.6	1.84	8.21	263.84	9.66	19.78	1.94	5.35

aaaaa = Highest average value for that parameter

Lake Erie Chlorophyll a *Concentrations and Nutrient Loading*

Climatologically, the summer of 2016 was warmer than average. Between July 1 and the end of September, Cleveland had 25 days over 90 degrees when the average is 8 days. In addition, it was about 4 degrees warmer overall from July to September, and 5 degrees warmer on average for August and October. Cleveland also received 3 inches less of precipitation between July and August, and considerably less rain in June than in 2015 when the algae bloom was the most severe in history (National Weather Service Forecast Office). The forecast for 2016's algal bloom was between 3 and 7, and the actual severity was 3.2, much lower than previous years (Figure 4, NOAA). This was due to the low amount of rain that the areas surrounding the Maumee and Sandusky Rivers received in the planting and fertilizing season.

The Lake Erie data shows lower levels of chlorophyll *a* compared to 2015 overall (Figures 5 and 6). According to the NOAA, the bloom of 2016, "had a 'double peak,' one in August, followed by a decrease in biomass, then a brief reappearance in late September. This differs from the typical year in which the bloom grows through August to a peak in early September and then gradually decreases through September. Isolated pockets of Microcystis also persisted into October" (NOAA, 2016). Data collected by the district showed a peak in October (Table 10). This could be due to warmer temperatures and elevated rain in September 2016.

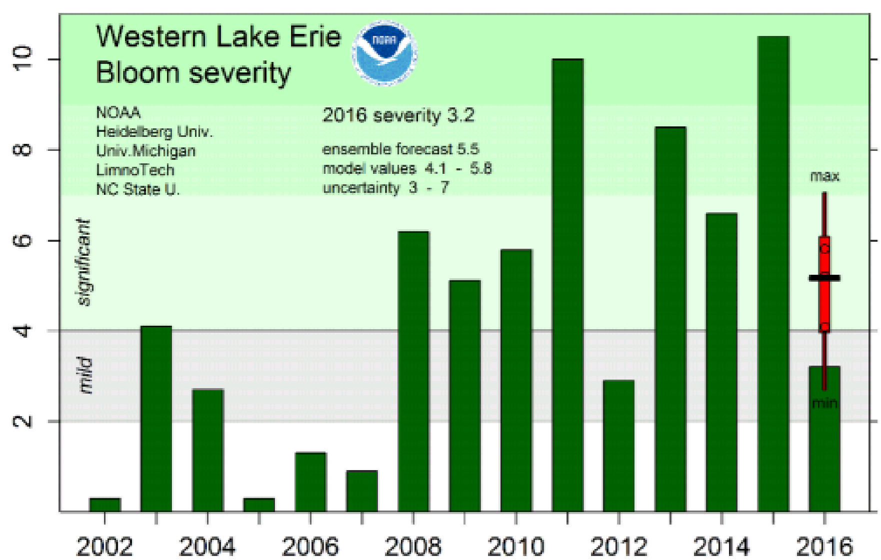

Figure 4. Bloom severity index for 2002-2016, and the forecast for 2016.

Figure 5. 2016 Average Lake Erie Chlorophyll *a* Concentrations (ug/L)

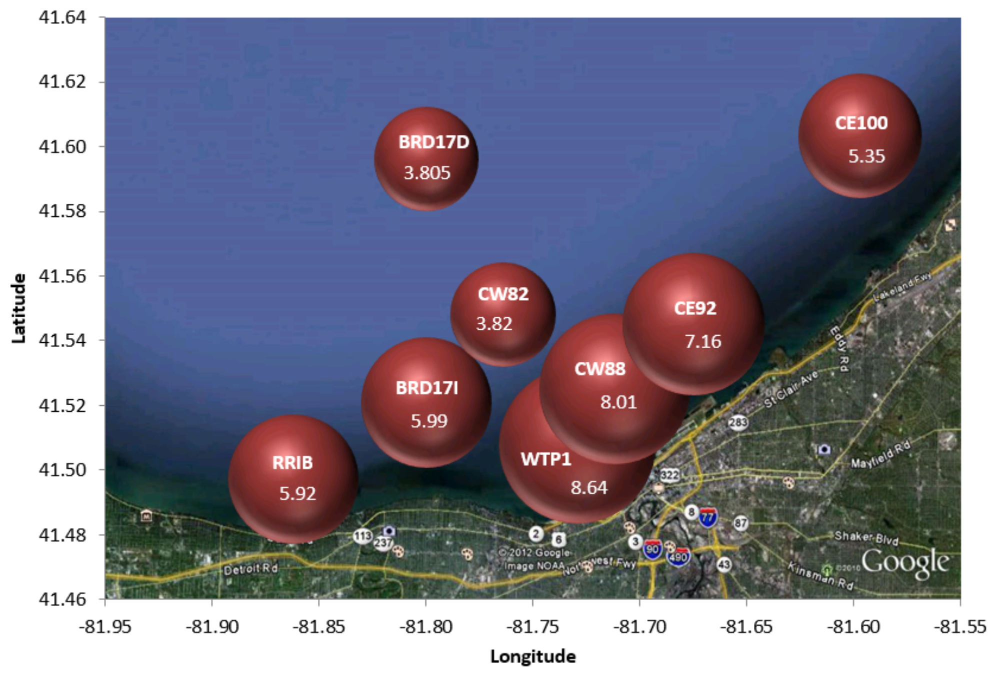

Figure 6. 2015 Average Lake Erie Chlorophyll *a* Concentrations (ug/L)

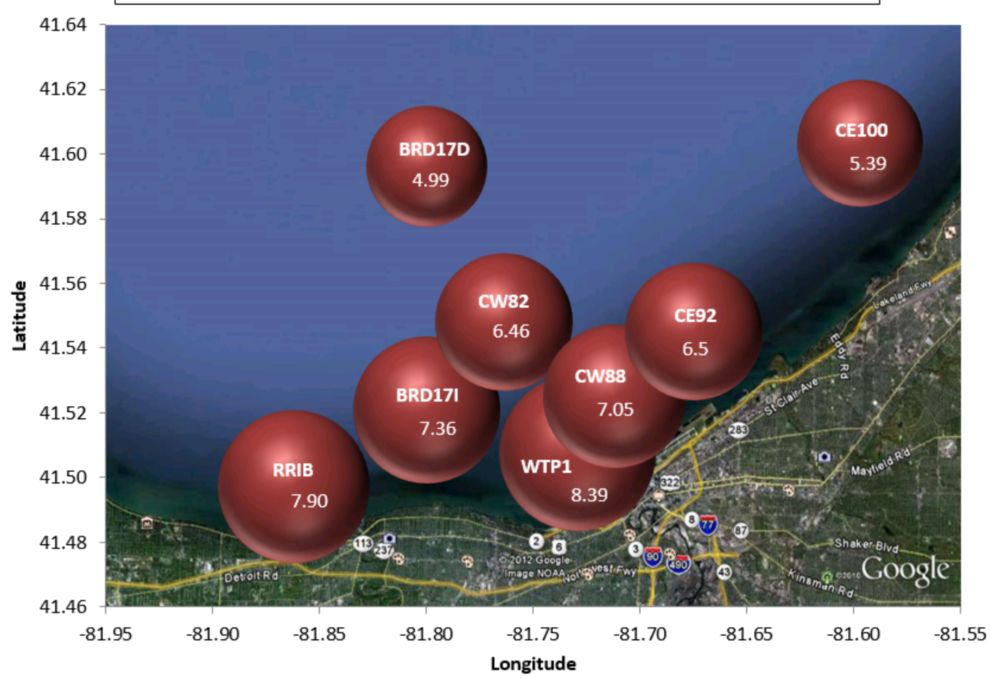

Table 10. 2016 Chlorophyll *a* Concentrations (ug/L)									
	RR1B	BRD17D	BRD17I	CW82	WTP1	CW88	CE92	CE100	Average:
5/3/2016	7.26	6.07	14.80	2.97	5.99	7.75	3.43	**1.66**	6.24
5/9/2016	9.55*	6.74	13.99	10.63*	12.36	12.79	14.39	17.86	13.02
5/24/2016	**1.47**	**1.75**	**1.55**	**1.03**	**1.17**	**0.88**	--	**0.52**	**1.20**
6/14/2016	**1.12**	**1.40**	**1.70**	**2.20**	3.65	**0.97**	**1.49**	**1.18**	**1.71**
6/28/2016	3.55	**1.35**	3.72	3.24	5.25	4.31	**2.53**	**1.83***	3.42
7/12/2016	3.58	**1.90**	4.36	5.02	8.46	7.41	5.37*	6.08	5.26
7/25/2016	3.34	**2.39**	**2.21**	--	3.79	3.05	3.79	**1.86**	2.92
8/9/2016	3.33	**1.66**	**1.74**	**2.59**	11.81	5.49	4.50	**1.41**	4.07
8/23/2016	7.19	3.02	2.91	2.79	9.94	11.11*	13.52	2.99	6.05
9/13/2016	7.75*	3.47	3.94	3.15	10.40	6.33	7.03	3.35	5.38
10/11/2016	16.67	12.88	17.03	--	26.63	31.69	17.68	18.27	20.12
10/26/2016	6.25	3.03	3.98	4.60	4.29	4.33	5.01	7.13	4.83
Average:	5.92	3.81	5.99	3.82	8.64	8.01	7.16	5.35	6.09

Meets GLWQA Target
*Average of duplicate and sample

Rivers in Northwest Ohio experience higher increases in phosphorus loading during rain events when compared to Northeast Ohio. This is because agriculture in the west is the main source of phosphorous. While this is the case, phosphorus loading does increase in the Northeast Ohio region during rain events. Table 11 shows Euclid Creek's estimated loading in metric tons annually (mta) during 2015 (13 sampling events) when Northeast Ohio received much more rain compared to 2016's estimated loading (10 sampling events).

Table 11. Nutrient Loading at Euclid Creek RM 0.55			
Year	Total phosphorus (mta)	Dissolved Reactive Phosphorus (mta)	Total Inorganic Nitrogen (mta)
2015	2.61	1.27	17.74
2016	0.36	0.19	2.96

Below is the loading (metric tons) for 2016 from the streams sampled (Table 12). The closest gage station used for calculating the loading of the Rocky River is in Berea below the confluence of the East and West Branches. This gage station is around RM 12.00; therefore, the actual loading is most likely higher than the estimate shown in Table 12. The Ohio EPA Nutrient Mass Study mentioned earlier also documented the loading of the Cuyahoga River. The Ohio EPA used water years 2014 and 2013 to calculate loading. During these years, referring to Figure 4, Lake Erie's algal blooms were severe compared to 2016. The loading documented by the Ohio EPA for the Cuyahoga River is in Table 13. Note that NEORSD data shows total inorganic nitrogen, while the Ohio EPA data shows total nitrogen. While the numbers are at about half the loading for 2013/2014 that the Ohio EPA collected, the severity of the bloom for 2016 was smaller by almost half and the loading should correspond with the bloom.

Table 12. 2016 Estimated Yearly Loading Data for Tributaries to Lake Erie

Tributary	Drainage area at outlet (sq. mi.)	Total Phosphorus (metric tons)	Total Inorganic Nitrogen (metric tons)
Euclid Creek	23.3	0.37	2.96
Rocky River	294	3.81	126.37
Cuyahoga Upstream		43.04	1,154.33
Cuyahoga Mouth	808	118.00	3,333.80

Note: Values are based on grab samples and discharge levels from USGS meters at the time of the sample. On average, discharge was lower than the yearly average. Refer to Table 7.

Table 13. — Annual total phosphorus and total nitrogen loads (by water year) and relative percent difference (RPD, percent) for the seven watersheds examined in this study. Load and drainage area calculated at the outlet of each watershed. (Ohio EPA, 2016)

Watershed	Drainage Area at Outlet (sq. mi.)	Total P Load (mta)			Total N Load (mta)		
		wy13	wy14	RPD (from wy13 to wy14)	wy13	wy14	RPD (from wy13 to wy14)
Maumee	6,568	2,295	2,062	-10%	43,698	37,853	-13%
Portage	585	168	219	30%	3,882	3,068	-21%
Sandusky	1,420	711	615	-14%	11,407	8,356	-27%
Cuyahoga	808	327	402	23%	6,163	5,971	-3%
Great Miami	3,889	1,266	1,798	42%	18,638	20,805	12%
Scioto	6,509	2,036	2,426	19%	22,943	27,971	22%
Muskingum	8,044	1,360	1,666	23%	19,963	23,456	17%

It is also important to note the RPD that the Ohio EPA saw from one year to the next. It is up to 23% for Total P on the Cuyahoga River and that is with the consideration that 2013 and 2014 were relatively similar years for the bloom index. It is possible that smaller streams, like Euclid Creek in Table 11, are flashier and may have even higher RPD year-to-year proportionally than larger rivers like the Cuyahoga. The data is congruent with what other sources are showing; yearly loading and, in turn, blooms change based on rain amounts and events in the early spring season. While this affects agricultural areas more, the watersheds in northeast Ohio are still affected by rain quantity.

Conclusion

The sampling of Lake Erie for 2016 indicates that the rain events and runoff heavily dictate the severity of the bloom during the summer. Microcystin levels at lake site CW82 were lower this year compared to 2015. In addition, chlorophyll *a* concentrations were also lower at most sites. Lake site WTP1 at the mouth of the Cuyahoga River had higher average concentrations of the parameters of concern, like phosphorus, nitrogen and total suspended solids. Concentrations of chlorophyll *a* were more likely to be at or below the target level at sites which were further from the city center of Cleveland and its larger tributaries like the Rocky and Cuyahoga Rivers. This includes BRD17D, CE100 and BRD17I. While the data from our collection time-period reflected lower flows in the tributary systems, loading this year is thought to be reduced compared to previous years. This is evident by the Euclid Creek loading comparison (Table 11) and by the lack of bloom in 2016.

In 2015, there were heavy rains during planting season and this resulted in the highest index seen in recent years. Dissolved reactive phosphorus has many sources, but most sources present in the Cleveland area are less responsive to rain events. While local contributions are from the wastewater treatment plants, non-point sources, and erosion in streams, the focus of the study going forward will be to monitor the impact of the western basin's input on the central basin during particularly severe blooms. In addition, with the baseline data gathered in past years, sampling will be able to show increases and decreases of input in relation to changing climate, development, and regulatory procedures in the northeast Ohio area.

Acknowledgments

Field activities and report review completed by the following, except where otherwise noted:

Kelsey Amidon
Nya Aron
Donna Friedman, Author
Seth Hothem
Mark Matteson
Mario Meany
Denise Phillips
John Rhoades
Eric Soehnlen
Nicole Velez

WQIS Interns: Bryanna Boggan, Lindsay Baker, James Ferritto and Joseph Schiel.

Analytical Services Division – Completed analysis for all water chemistry sampling

References

Ohio Environmental Protection Agency. *Nutrient Mass Balance Study for Ohio's Major Rivers*. Division of Surface Water. December 30, 2016. URL: http://epa.ohio.gov/Portals/35/documents/Final%20Nutrient%20Mass%20Balance%20Report_12_30_16pdf.pdf

Northeast Ohio Regional Sewer District. *2016 Benthic Chlorophyll Summary for Euclid Creek*. Water Quality and Industrial Surveillance. March 2017.

National Weather Service Forecast Office. *Seasonal Climate Report*. Accessed March 2017. URL: https://www.weather.gov/climate/index.php?wfo=cle .

National Oceanic and Atmospheric Administration. *Experimental Lake Erie Harmful Algal Bloom Bulletin.* Bulletin 30, November 1, 2016. URL: http://www2.nccos.noaa.gov/coast/lakeerie/bulletin/bulletin_current.pdf.