NORTHEAST OHIO REGIONAL SEWER DISTRICT

2016 Cuyahoga River Environmental Monitoring

Prepared by
Water Quality and Industrial Surveillance Division

Introduction

In 2016, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys in the lower Cuyahoga River. Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by Ohio Environmental Protection Agency (EPA) in Fish Community and Benthic Macroinvertebrate Biology, and Chemical Water Quality and Stream Habitat Assessments as explained in the NEORSD study plan *2016 Cuyahoga River Environmental Monitoring* approved by Ohio EPA on May 17, 2016.

One of the purposes of this study was to determine the attainment status of the river in relation to point and nonpoint sources of pollution. The lower Cuyahoga River has been designated as one of 42 Great Lakes Areas of Concern (AOC) by the International Joint Commission. Past monitoring indicated impairment of aquatic biota in the river and was the basis of a Total Maximum Daily Load (TMDL) for the Lower Cuyahoga River (Ohio EPA, 2003). The causes of impairment to the river were classified as organic enrichment, toxicity, low dissolved oxygen, nutrients, and flow alteration. In recent years, however, some of the river sites have been in full attainment of the biological criteria. This study was completed to determine current conditions in the river, identify any spatial and temporal trends in present and historic data, and measure the magnitude of any impacts.

The fish and macroinvertebrate community in the Cuyahoga River navigation channel was also monitored in support of three grants related to habitat restoration as part of the Great Lakes Restoration Initiative. These grants include the *Cuyahoga River Larval Fish Study* funded by the U.S. Army Corps of Engineers that is being implemented by the Cuyahoga County Planning Commission, the Cuyahoga County Engineer's Office project *Cuyahoga AOC Urban Riparian Habitat Restoration*, and the Ohio Department of Natural Resource's *Cuyahoga AOC Urban Riparian Habitat Restoration Opportunities*. Completion of the Scranton Peninsula Habitat Restoration Project as part of these grants occurred in 2013. Monitoring in 2016 was completed to determine the effectiveness of this project on improving the fish community.

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

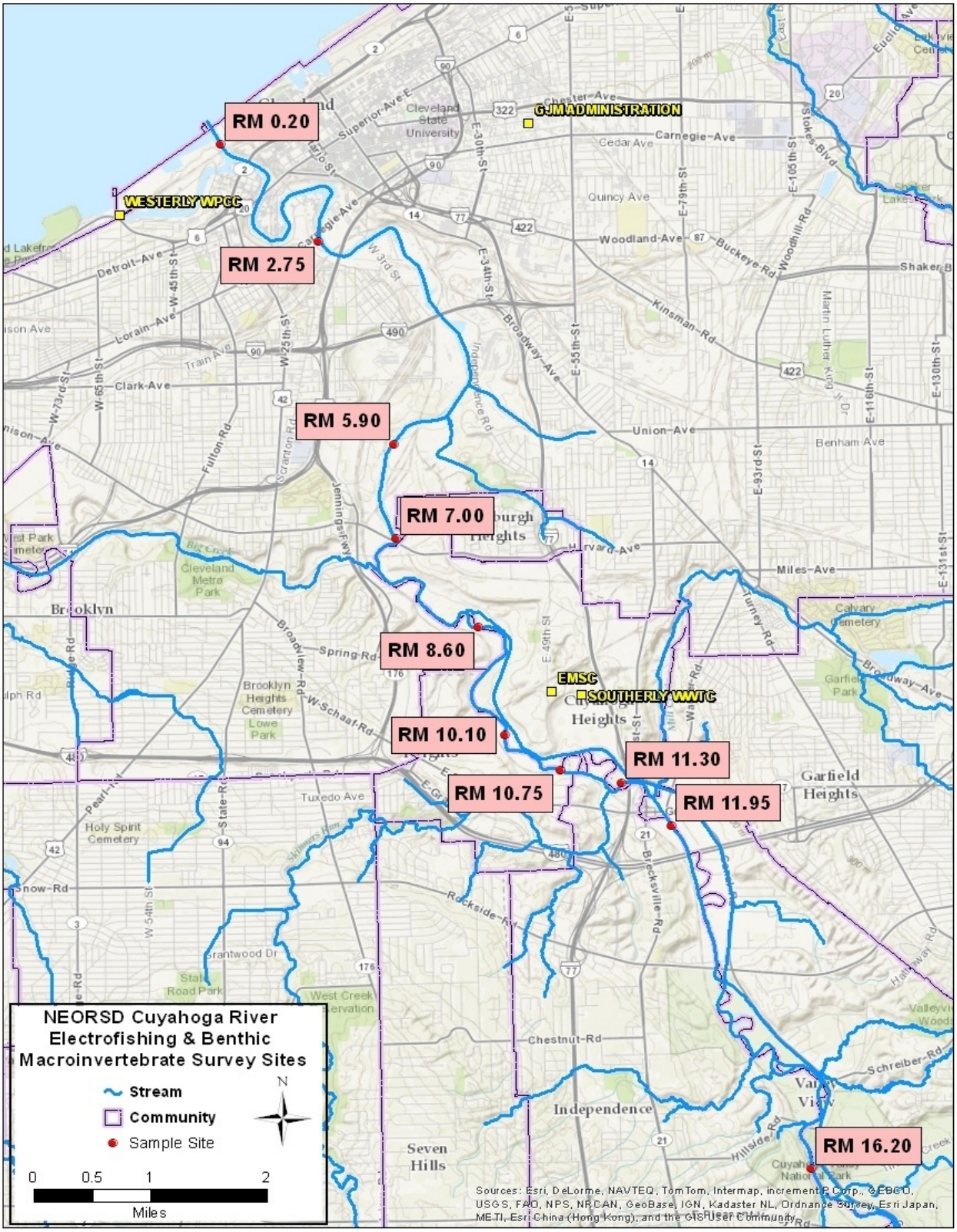


Figure 1. Sampling Locations

Table 1. Sample Locations					
Location	Latitude	Longitude	River Mile	Description	Purpose
Downstream of Tinkers Creek	41.3678	-81.6139	16.20	Downstream of the confluence with Tinkers Creek near Old Riverview Road	Background data for water chemistry and chlorophyll *a*
Upstream of Mill Creek	41.4123 41.4101	-81.6364 -81.6346	12.10[a] 11.95	Upstream of the confluence with Mill Creek (I-480)	Evaluate Mill Creek discharge on fish, habitat and macroinvertebrates
Downstream of Mill Creek	41.4179	-81.6446	11.30	Downstream of the confluence with Mill Creek	Evaluate Mill and West Creek discharges on fish, habitat and macroinvertebrates
Upstream of Southerly WWTC	41.4196	-81.6547	10.75	Upstream of Southerly WWTC effluent discharge	Evaluate West Creek and Southerly WWTC discharges on fish, habitat and macroinvertebrates, and Southerly WWTC discharge on chlorophyll *a* levels.
Downstream of Southerly WWTC	41.4242	-81.6638	10.10	Downstream of Southerly WWTC effluent discharge	Evaluate Southerly WWTC discharge on fish, habitat, macroinvertebrates, and chlorophyll *a* levels.
Upstream of Big Creek	41.4381	-81.6680	8.60	Upstream of the confluence with Big Creek	Evaluate Big Creek discharge on fish, habitat and macroinvertebrates
Downstream of Big Creek	41.4497	-81.6815	7.00	Downstream of the confluence with Big Creek/ Upstream of habitat restoration project	Evaluate Big Creek discharge on fish, habitat and macroinvertebrates; Southerly WWTC discharge on chlorophyll *a* levels; and effectiveness of habitat restoration in navigation channel on fish.

[a] HD and Water Chemistry Collection Site

Table 1. Sample Locations					
Location	Latitude	Longitude	River Mile	Description	Purpose
Head of Navigation Channel	41.4619	-81.6816	5.90	Head of navigation channel/Upstream of restoration site	Evaluate effectiveness of habitat restoration in navigation channel on fish.
Restoration Site	41.4881	-81.6938	2.75	Mid-navigation channel/Site of GLRI habitat restoration project	Evaluate effectiveness of habitat restoration in navigation channel on fish.
Cuyahoga River Mouth	41.5008	-81.7098	0.20	Near mouth of river in navigation channel	Evaluate effectiveness of habitat restoration in navigation channel on fish.

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between July 27 and August 24, 2016, on the Cuyahoga River between RMs 16.20 and 0.20. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (2015). Chemical water quality samples from each site were collected with a 4-liter disposable polyethylene cubitainer with a disposable polypropylene lid, three 473-mL plastic bottles and a 125-mL plastic bottle. The first 473-mL plastic bottle was field preserved with trace nitric acid, the second was field preserved with trace sulfuric acid and the third bottle received no preservative. The sample collected in the 125-mL plastic bottle (dissolved reactive phosphorus) was filtered using a 0.45-µm PVDF syringe filter. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles preserved with sodium thiosulfate. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using either a YSI 600XL or EXO1 sonde. Duplicate samples and field blanks were each collected at randomly selected sites, at a frequency not less than 5% of the total samples collected. Relative percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate sample (Formula 1).

Formula 1: $$RPD = \left(\frac{|X-Y|}{((X+Y)/2)} \right) * 100$$

X= is the concentration of the parameter in the primary sample
Y= is the concentration of the parameter in the duplicate sample

The acceptable percent RPD is based on the ratio of the sample concentration and detection limit (Formula 2) (Ohio EPA, 2013).

Formula 2: Acceptable % RPD = $[(0.9465X^{-0.344})*100] + 5$

X = sample/detection limit ratio

Those RPDs that were higher than acceptable may indicate potential problems with sample collection and, as a result, the data was not used for comparison to the water quality standards.

Mercury analysis for all of the sampling events was done using EPA Method 245.1. Because the detection limit for this method is above the criteria for the Human Health Nondrinking and Protection of Wildlife Outside Mixing Zone Averages (OMZA), it generally cannot be determined if the Cuyahoga River was in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above those levels typically found in the river.

Water chemistry analysis sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

Five field blanks and three duplicate samples were collected as part of this study in 2016. For the field blanks, there were five parameters that showed possible contamination. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, and/or contaminated blank water. Table 2 lists water quality parameters that were listed as estimated, downgraded from Level 3 to Level 2 data, or rejected based on Ohio EPA data validation protocol.

Table 2. Parameters affected by possible blank contamination
COD
Cr
DRP
NH_3
Sn

For the duplicate samples, six instances occurred in which the acceptable RPD was exceeded (Table 3). Four of the six instances in which the acceptable RPD was exceeded occurred during a wet-weather event on August 10, 2016, which may have caused an increase in flow and run-off. The sampling on August 3, 2016, was not considered wet weather[1]. Therefore, the reason for the unacceptable difference between the samples on August 3, 2016, remains unknown, but potentially could be due to lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity and/or improper handling of samples.

Table 3. Duplicate samples with RPDs greater than acceptable				
Site	Date	Parameter	Acceptable RPD	Actual RPD
RM 11.30	8/3/2016	Al	25.3	37.8
RM 11.30	8/3/2016	Fe	18.7	31.0
RM 8.60	8/10/2016	Al	29.0	57.6
RM 8.60	8/10/2016	Cr	50.6	56.9
RM 8.60	8/10/2016	Fe	21.7	36.0
RM 8.60	8/10/2016	Ti	57.5	63.4

The final QA/QC check for the samples that were collected was for paired parameters, or those parameters in which one is a subset of the other. In 2016, one instance occurred in which the data for the paired parameters needed to be qualified because the sub-parameter was greater than the parent one (Table 4). The reason for the TDS being greater is unknown, but may be due to the fact that there are two separate methods for analyzing the individual parameters.

[1] Wet-weather sampling events: greater than 0.10 inches of rain but less than 0.25 inches, samples collected that day and the following day are considered wet weather samples; greater than 0.25 inches, the samples collected that day and the following two days are considered wet weather samples.

Table 4. Unacceptable Paired Parameter RPDs					
River Mile	Date	Paired Parameters	Acceptable RPD (%)	Actual RPD (%)	Qualifier
7.00	8/24/2016	TS/TDS	16.7	30.7	R
R = rejected or unusable data. Data lies outside the acceptable RPD percentage.					

The sites upstream of the navigation channel are all designated warmwater habitat (WWH), agricultural water supply, industrial water supply, and primary contact recreation. Those in the navigation channel are designated limited resource water-navigation maintenance from June through January and whenever the river flow is less than 703 ft^3/s during the rest of the year and fish passage during the months of February through May when flow is equal to or greater than 703 ft^3/s. They are also designated industrial water supply and primary contact recreation.

Exceedances of the recreation use bacteriological criteria occurred at all of the sites during 2016. The criteria for *Escherichia coli (E. coli)* consist of two components: a 90-day geometric mean and a value not to be exceeded in more than 10% of the samples collected during a 90-day period (statistical threshold value). For those streams designated primary contact recreation, these criteria are 126 colony counts/100mL or most-probable number (MPN)/100mL and 410 colony counts/100mL or MPN/100mL, respectively. Both of these criteria were exceeded at all of the sites for a majority of the 90-day periods during the study (Table 5). These exceedances were mostly due to a significant wet-weather event that took place on August 9th, one day prior to one of the sampling events. Potential sources of bacteria to the river could include stormwater runoff and combined sewer overflows (CSOs).

Table 5. 2016 Cuyahoga River *E. coli* Densities (most-probable number/100mL)										
Date	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90	RM 2.75	RM 0.20
7/27/2016	377	710	531	450	475	312	320	600	278	79
8/3/2016	260	786	328	428	296	366	744	605	190	37
8/10/2016*	250	1,050	1,451	6,232	3,962	4,755	5,536	14,660	6,440	2,603
8/17/2016	500	533	516	336	368	226	1,189	1,064	262	139
8/24/2016	166	152	261	105	102	100	178	216	86	95

* Wet-weather event

Exceeds statistical threshold value and geometric mean criteria for 90-day period starting on that date

Exceeds geometric mean criterion for 90-day period starting on that date

Mercury was a second parameter that failed to meet the applicable criteria at some of these sites during the sampling that was conducted. Exceedances of the wildlife

outside mixing zone averages (OMZA) occurred at RM 5.90 during the 2016 sampling (Table 6). All other sites that were not in exceedance were below the method detection limit. It is expected that the use of EPA Method 1631E, a low-level method, instead of EPA Method 245.1 would have resulted in exceedances of the criteria throughout the sampling period.

Table 6. 2016 Cuyahoga River Mercury Concentrations (ug/L)

	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90	RM 2.75	RM 0.20
7/27/2016	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
8/3/2016	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	j 0.011	<0.005	<0.005
8/10/2016	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
8/17/2016	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
8/24/2016	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Exceedance of Wildlife OMZA (0.0013 ug/L) for 30-day period beginning with that date, assuming "j" values are actual values and concentrations below the MDL are zero.

In 2015, the Ohio EPA Nutrients Technical Advisory Group released a proposed Stream Nutrient Assessment Procedure (SNAP) designed to determine the degree of impairment in a stream due to nutrient enrichment. SNAP assigns designations for quality of surface waters based on factors including dissolved oxygen (DO) swings, benthic chlorophyll *a*, total phosphorous, and dissolved inorganic nitrogen (Ohio EPA, 2015).

In 2016, chlorophyll *a* levels in the Cuyahoga River were measured at four locations in the vicinity of a temporary data sonde. 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 river. While the primary purpose of the data sonde was to collect DO data, the data sonde also recorded measurements for specific conductance, pH, temperature, and turbidity in 15-minute increments. The data sondes, YSI 6600 sondes, locations are listed in Table 7. The data sondes were calibrated at NEORSD Environmental and Maintenance Services Center per the manufacturer's recommendations. Upon return from the field, data was downloaded and calibrations were checked for continued accuracy.

Table 7. Data sonde and chlorophyll *a* sampling site locations on the Cuyahoga River.			
River Mile	Sonde Site Latitude/Longitude	Sampling Site Latitude/Longitude	Sampling Site Description
16.20	41.3657/-81.6128	41.3657/-81.6128	Downstream of confluence with Tinkers Creek near Old Riverview Road
10.75	41.4181/-81.6471	41.4192/-81.6527	Upstream of Southerly WWTC effluent
10.10	41.4268/-81.6652	41.4235/-81.6637	Downstream of Southerly WWTC effluent
7.00	41.4475/-81.650	41.4487/-81.6832	Downstream of the confluence with Big Creek

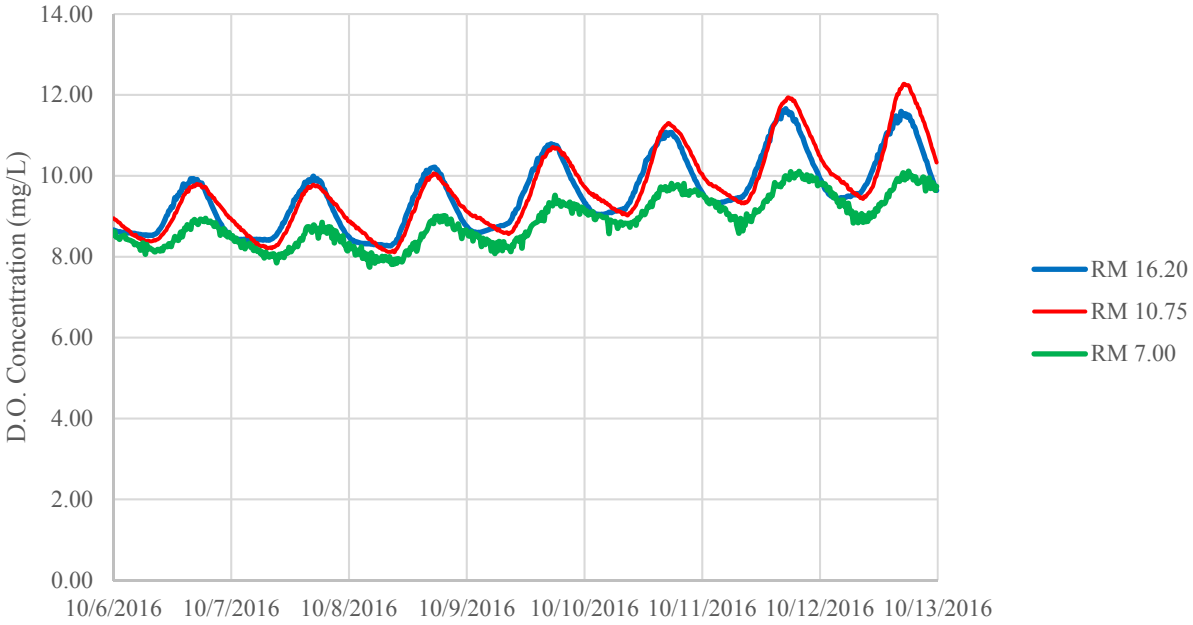
Chlorophyll *a* samples along with nutrient samples were collected on September 26, 2016, at RM 10.10 and October 12, 2016, at RMs 16.20, 10.75, and 7.00. All samples were not collected on September 26, 2016, due to a wet-weather event occurring between sampling sites. Chlorophyll *a* was analyzed from both the benthos and water column following NEORSD SOP-EA001-01, Chlorophyll *a* Sampling and Field Filtering. For benthic chlorophyll *a* analysis, at least 15 rocks were sampled from a variety of habitats at the sample site. Water chemistry and chlorophyll *a* results are listed below in Table 8.

Table 8. 2016 Benthic Chlorophyll *a* Results from 9/26/2016 and 10/12/2016 Sampling				
Parameter	RM 16.20	RM 10.75	RM 10.10	RM 7.00
Chlorophyll *a* (Water Column)	4.171 µg/L	7.958 µg/L	5.382 µg/L	3.762 µg/L
Chlorophyll *a* (Benthic)	510.7 mg/m^2	339.7 mg/m^2	251.5 mg/m^2	219.8 mg/m^2
Dissolved Inorganic Nitrogen	6.63 mg/L	6.00 mg/L	8.16 mg/L	8.09 mg/L
Dissolved Oxygen Swing	2.15 mg/L	2.84 mg/L	Assumed Low/Moderate	1.27 mg/L
DRP	0.054 mg/L	0.056 mg/L	0.212 mg/L	0.172 mg/L
Total Phosphorus	0.095 mg/L	0.096 mg/L	0.274 mg/L	0.228 mg/L
TSS	8.0 mg/L	14.3 mg/L	13.9 mg/L	9.4 mg/L
DO swing for RM 10.10 is assumed to be low to moderate level based upon upstream and downstream DO swings.				

DO diel swings were also evaluated from September 24, 2016, through October 13, 2016 (Figure 2). Daily maximum DO levels and daily minimum DO levels were calculated. The DO diel swing was calculated daily by subtracting the daily minimum from the daily maximum. DO diel swings used for SNAP evaluation were from the day of sampling (September 26, 2016 and October 12, 2016); however, each day was evaluated to ensure that the swing on the day of sampling was not atypical. A malfunction occurred with the data sonde located at RM 10.10 causing data to not be

properly recorded. Upstream and downstream DO swings were both low according to the criteria in step 2 of SNAP. Therefore, it was assumed that the DO swing at RM 10.10 was also low at the time of sampling.

Figure 2: Cuyahoga River Dissolved Oxygen Concentrations 10/6/2016-10/12/2016



Biological sampling and habitat assessment results from 2016 were used in the assessment through SNAP (Table 9). Per the minimum data requirements of SNAP, biological data was collected at comparable baseflows, but may have experienced changing flow events between the biological collections and chlorophyll *a* collection events. Additionally, some biological sampling and the habitat assessment were performed outside the suggested range of time from chlorophyll *a* sampling. However, all data collection occurred during the normal field season during 2016 for RM 10.75, 10.10, and 7.00. RM 16.20 was not sampled for biological and habitat assessment in 2016; thus, the most recent assessments were used.

Table 9. Biological sampling dates and scores for the Cuyahoga River

	RM 16.20		RM 10.75		RM 10.10		RM 7.00	
Sample Type	Date	Average Score	Date	Score	Date	Score	Date	Score
IBI	7/7/2011 & 8/30/2011	**47**	9/2/2016	*36*	9/2/2016	32	9/6/2016 & 10/6/2016	33
MIwb	7/7/2011 & 8/30/2011	**9.6**	9/2/2016	**9.7**	9/2/2016	**9.2**	9/6/2016 & 10/6/2016	**8.2**

Table 9. Biological sampling dates and scores for the Cuyahoga River								
	RM 16.20		RM 10.75		RM 10.10		RM 7.00	
ICI	9/9/2015	**44**	9/19/2016	*32*	9/15/2016	**38**	9/14/2016	*32*
QHEI	9/22/2015	77.75	9/2/2016	70	9/2/2016	66.5	9/6/2016	64.5
Bold = In attainment of the WWH biocriterion.								
Italics = non-significant departure of the WWH biocriterion.								

Nutrients were assessed during the chlorophyll *a* sampling. The minimum data requirements suggest at least three samples per location to be reported as a geometric mean. One set of nutrient data was collected at the same time as the chlorophyll *a* collection on September 26, 2016 or October 12, 2016. Nutrients were also assessed for general watershed monitoring at the sites in 2016. Table 10 shows the results of three dry-weather results and the calculated geometric mean and standard deviation as well as the results from September 26, 2016 or October 12, 2016. The nutrient concentrations used in the SNAP analysis were done so by comparing the geometric mean to the single sampling event. If the single sampling event differed outside the standard deviation, the higher of the two concentrations was used.

Table 10: Nutrient results for the Cuyahoga River used for SNAP analysis.						
RM 16.20						
Sample Date	8/3/2016	8/17/2016	8/24/2016	**GeoMean**	**StdDev**	10/12/2016
Total Phosphorus (mg/L)	0.154	0.099	0.082	0.108	0.037	0.095
DRP (mg/L)	0.086	0.052	0.034	0.053	0.026	0.054
Dissolved Inorganic Nitrogen (mg/L)	4.111	2.823	3.848	3.548	0.680	6.632
RM 10.75						
Sample Date	8/3/2016	8/17/2016	8/24/2016	**GeoMean**	**StdDev**	10/12/2016
Total Phosphorus (mg/L)	0.136	0.120	0.083	0.111	0.027	0.096
DRP (mg/L)	0.070	0.055	0.033	0.050	0.019	0.056
Dissolved Inorganic Nitrogen (mg/L)	3.352	2.575	3.439	3.096	0.476	6.00
RM 10.10						
Sample Date	8/3/2016	8/17/2016	8/24/2016	**GeoMean**	**StdDev**	9/26/2016
Total Phosphorus (mg/L)	0.177	0.237	0.174	0.194	0.036	0.274
DRP (mg/L)	0.106	0.165	0.112	0.125	0.032	0.212
Dissolved Inorganic Nitrogen (mg/L)	6.393	4.678	5.890	5.606	0.882	8.16
RM 7.00						
Sample Date	8/3/2016	8/17/2016	8/24/2016	**GeoMean**	**StdDev**	10/12/2016
Total Phosphorus (mg/L)	0.159	0.199	0.169	0.175	0.021	0.228
DRP (mg/L)	0.095	0.145	0.109	0.115	0.026	0.172
Dissolved Inorganic Nitrogen (mg/L)	5.864	4.140	5.421	5.067	0.895	8.10
When questions arose using these numbers, the geometric mean and the measurements taken on 9/26/2016 or 10/12/2016 were considered. If the same result was not the output from the tables, the worst case of the two measurements was used.						

SNAP uses a variety of flow charts to determine the best course of action for a stream segment. The results of these flow charts are shown in Table 11. Some sections of the flow charts require the use of best professional judgement and the result could be disputed. However, in the case of a dispute, often the same answer was ultimately reached through both pathways of the flow chart.

Table 11. SNAP Flow Chart Results	
RM 16.20	
Step/Question	**Result/Answer**
Step 1-Biological Criteria	All indices attaining or in non-significant departure
Step 2-DO Swing	Normal or low swings (≤6.5 mg/L)
Step 3-Benthic Chlorophyll *a*	High (>320 mg/m^2)
Step 4-Preliminary Assessment	Attaining use, but may be threatened.
Flow Chart A	
Do one or more biological indicators under-perform relative to existing habitat? (Refer to Table 1)	No
Are data for the evaluated waterbody available from two or more years?	Yes
Is biological condition deteriorating?	No
Stop, condition is not threatened.	
RM 10.75	
Step/Question	**Result/Answer**
Step 1-Biological Criteria	All indices attaining or in non-significant departure
Step 2-DO Swing	Normal or low swings (≤6.5 mg/L)
Step 3-Benthic Chlorophyll *a*	High (>320 mg/m^2)
Step 4-Preliminary Assessment	Attaining use, but may be threatened.
Flow Chart A	
Do one or more biological indicators under-perform relative to existing habitat? (Refer to Table 1)	Yes
Are stressors unrelated to nutrients responsible for observed conditions?	Yes (*E. coli*)
Document causal assessment and linkage to stressor(s).	
RM 10.10	
Step/Question	**Result/Answer**
Step 1-Biological Criteria	Non-attaining (one or more indices below non-significant departure)
Step 2-DO Swing	Normal or low swings (≤6.5 mg/L)
Step 3-Benthic Chlorophyll *a*	Low to moderate (≤320 mg/m^2)
Step 4-Preliminary Assessment	Impaired, but cause(s) other than nutrients
Flow Chart B	
Are stressors unrelated to nutrients responsible for observed conditions?	Yes (*E. coli*)
Document causal assessment and linkage to stressor(s)	

RM 7.00	
Step/Question	**Result/Answer**
Step 1-Biological Criteria	Non-attaining (one or more indices below non-significant departure)
Step 2-DO Swing	Normal or low swings (≤6.5 mg/L)
Step 3-Benthic Chlorophyll *a*	Low to moderate (≤320 mg/m^2)
Step 4-Preliminary Assessment	Impaired, but cause(s) other than nutrients
Flow Chart B	
Are stressors unrelated to nutrients responsible for observed conditions?	Yes (*E. coli*)
Document causal assessment and linkage to stressor(s)	

The results of SNAP on the Cuyahoga River determined that the best course of action with respect to nutrients is "document causal assessment and linkage to stressors" for RM 10.75, 10.10, and 7.00. RM 16.20 is determined to not be threatened with respect to nutrients. Sampling of RM 10.75, 10.10, and 7.00 revealed that there may be impairments due to sewage contamination. Thus, nutrients may be contributing to the but are not the primary cause of any impairment to the Cuyahoga River.

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site from RM 11.95 to RM 7.00 in 2016 using the Qualitative Habitat Evaluation Index (QHEI). The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species by evaluating the physical attributes of a stream. The index is based on six metrics: stream substrate, instream cover, channel morphology, riparian zone and bank condition, pool and riffle quality, and stream gradient. The QHEI has a maximum score of 100, and a score of 60 or more suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2003). A more detailed description of the QHEI can be found in Ohio EPA's *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

The habitat at the sites at RMs 5.90, 2.75, and RM 0.20 in the navigation channel were each evaluated one time in 2016 using the lacustuary QHEI (L-QHEI). Similar to the QHEI, the L-QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species, but in lacustuary zones or along the lake shoreline. The index is based on the metrics of substrate, cover types, shoreline morphology, riparian zone/bank erosion, and aquatic vegetation quality.

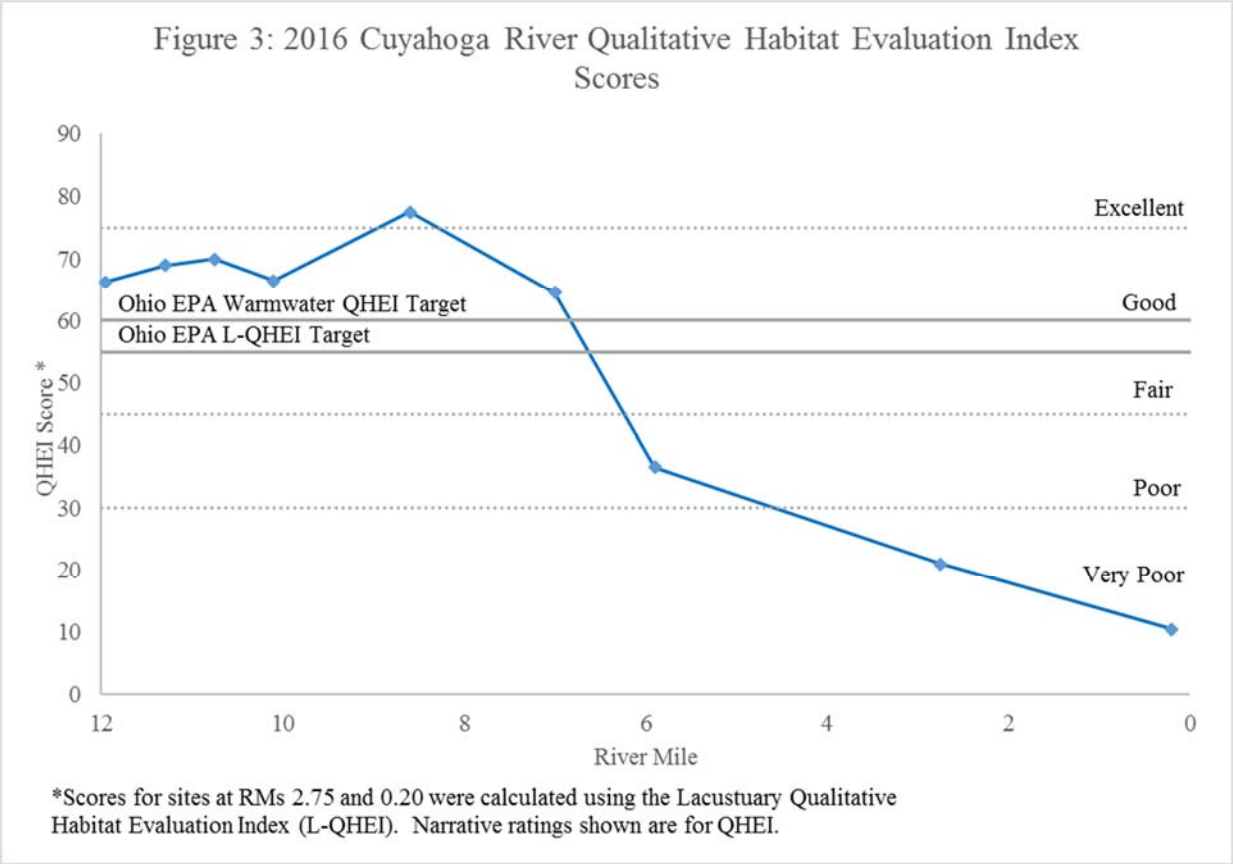
The L-QHEI also has a maximum score of 100. More information can be found in Ohio EPA's *Methods for Assessing Habitat in Lake Erie Shoreline Waters Using the Qualitative Habitat Evaluation Index (QHEI) Approach (Version 2.1)* (2010). L-QHEI field sheets are also available upon request from the NEORSD WQIS Division.

Results and Discussion

All of the sites upstream of the navigation channel had QHEI scores that met Ohio EPA's target of 60 and, therefore, should be capable of supporting WWH fish communities (Figure 3). The highest score RM 8.60 with a score of 77.50, which was the only site to score in the *Excellent* range.

Individual components of the QHEI can also be used to evaluate whether a site is capable of meeting the WWH designated use. This is done by categorizing specific attributes as indicative of either a WWH or modified warmwater habitat (MWH) (Rankin, 1995). Attributes that are considered characteristic of MWH are further classified as being of moderate or high influence to fish communities. The presence of one high or four moderate influence characteristics has been found to result in lower IBI scores, with a greater prevalence of these characteristics usually preventing a site from meeting WWH attainment (Ohio EPA, 1999).

Upstream of RM 7.00, the sites all had the WWH characteristics of fast currents and eddies, maximum depths greater than 40 cm, and either had never been channelized or had recovered from it (Table 12). All of the sites except for the one at RM 10.75 had sparse instream color, a high-influence MWH characteristics. The total number of moderate influence MWH attributes at each site ranged from four to seven; common characteristics shared by most or all of the sites included a sand substrate and low sinuosity. Based on the number of the MWH attributes at these sites, it would be more difficult for most of them to meet the WWH fish criteria, even though they are higher than the overall target score of 60.



RMs 5.90, 2.75 and 0.20 in the navigation channel were evaluated using the L-QHEI and all three sites failed to meet Ohio EPA's target score of 55 (Figure 3). The site characteristics that contributed heavily to the low scores included muck substrates, a general lack of instream cover, poor development, and a highly modified shoreline. Based on these attributes, it would not be expected that these sites would be able to support WWH fish communities. Some changes at RM 2.75 have occurred since the restoration project occurred. Between 2014 and 2015, an increase in the cover types and aquatic vegetation quality were observed. No significant changes were found at the sites between 2015 and 2016.

Table 12. 2016 Qualitative Habitat Evaluation Index scores and physical attributes

			WWH Attributes											**MWH Attributes**																	
														High Influence						Moderate Influence												
River Mile	QHEI Score	Habitat Rating	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max. Depth >40 cm	Low-Normal Riffle Embeddedness	**Total WWH Attributes**	Channelized or no Recovery	Silt/MucK Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW sites)	**Total High Influence Attributes**	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	**Total Moderate Influence Attributes**
11.95	66.25	Good	X	X					X		X		4				X		1			X		X	X						X	4
11.30	69.00	Good	X	X					X		X		4				X		1			X		X	X			X		X		5
10.75	70.00	Good	X	X					X		X		4						0			X			X				X	X		4
10.10	66.50	Good	X	X					X		X		4				X		1		X	X			X				X	X		5
8.60	77.50	Excellent	X	X		X			X	X	X	X	7				X		1			X			X							2
7.00	64.50	Good	X	X						X	X		4				X		1			X		X	X			X			X	5

Fish Community Assessment

Methods

Two quantitative electrofishing passes were conducted at each site in 2016, except at RMs 10.10, 10.75, and 16.20. One quantitative electrofishing pass was conducted at RMs 10.10 and 10.75. A second pass could not be conducted at RMs 10.10 and 10.75 due to unfishable river conditions during the last few weeks of the sampling season. There were no electrofishing surveys conducted at RM 16.20 due to a log jam that prevented the crew from navigating upstream. A list of the dates when the surveys were completed, along with flow as measured at the United States Geological Survey gage station in either Independence or Newburgh Heights, is given in Table 13. Sampling was conducted using boat electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from upstream to downstream by slowly and steadily maneuvering the boat as close to shore and submerged objects as possible. The sampling zone was 0.5 kilometers for each site. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified, weighed and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

Table 13. Sampling Dates and River Flows

Date	Sites sampled (RMs)	Daily Mean Flow (CFS)
7/28/16	5.90	494*
8/5/16	11.30, 11.95	222
8/24/16	0.20, 2.75	514*
9/2/16	8.60, 10.10, 10.75	271
9/6/16	5.90, 7.00	427*, 221
9/26/16	11.30	283
9/28/16	11.95	253
10/4/16	0.20, 2.75	867*
10/6/16	7.00, 8.60	368

*Measured at Newburgh Heights gage station; all other flows measured at Independence.

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices, the Index of Biotic

Integrity (IBI) and the Modified Index of Well-Being (MIwb). The IBI incorporates twelve community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12. The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional, Good, Marginally Good, Fair, Poor* or *Very Poor*. Sites at RMs 5.90, 2.75, and 0.20 were evaluated using the lacustuary IBI (LIBI). The LIBI is intended to be used in those areas near the mouths of rivers that may be affected by lake levels. The 12 metrics utilized for boat and lacustuary sites are listed in Table 14.

The second fish index utilized by Ohio EPA is the Modified Index of Well-being (MIwb). The MIwb, Formula 1 below, incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (H) (Formula 2 below) based on numbers and weight of fish. The MIwb is a result of a mathematical calculation based upon the formula.

Formula 1: $$MIwb = 0.5\ lnN + 0.5\ lnB + \overline{H}(No.) + \overline{H}(Wt.)$$

N = Relative numbers of all species excluding species designated as highly tolerant, hybrids, or exotics

B = Relative weights of all species excluding species designated as highly tolerant, hybrids, or exotics

$\overline{H}(No.)$ = Shannon Diversity Index based on numbers

$\overline{H}(Wt.)$ = Shannon Diversity Index based on weight

Formula 2: $$\overline{H} = -\sum\left[\left(\frac{n_i}{N}\right)log_e\left(\frac{n_i}{N}\right)\right]$$

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

Table 14. Index of Biotic Integrity Metrics	
Boat	Lacustuary
Number of native species	Number of native species
Percent round-bodied suckers	Number of sunfish species
Number of sunfish species	Number of cyprinid species
Number of sucker species	Number of benthic species

Table 14. Index of Biotic Integrity Metrics	
Boat	Lacustuary
Number of intolerant species	Percent phytophilic
Percent tolerant	Percent top carnivores
Percent omnivores	Number of intolerant species
Percent insectivores	Percent omnivores
Percent top carnivores	Percent non-indigenous
Number of individuals	Percent tolerant
Percent simple lithophils	Percent DELTs
Percent DELTs	Number of individuals

Lists of the species, numbers, weights, pollution tolerances and incidence of DELT anomalies for fish collected during the electrofishing passes at each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

The sites upstream of the navigation channel all had MIwb scores that met or were within non-significant departure from the WWH criterion (Table 15 and Figure 4). The data supports a gradual increase in scores over time at RM 7.00 (See Figure 5). This was the first time since 2013 that this site met or was within non-significant departure of the criterion (Table 16).

Table 15. 2016 Cuyahoga River IBI and MIwb Results							
		1st Pass		2nd Pass		Average	
Location	River Mile	IBI	MIwb	IBI	MIwb	IBI	MIwb
Upstream of Grainger Rd Bridge	11.95	*38*	**8.8**	**40**	*8.4*	*39*	*8.6*
Downstream of Confluence with Mill Creek	11.30	34	**9.2**	34	**9.7**	34	**9.5**
Upstream from Southerly WWTC	10.75	*36*	**9.7**	---	---	*36*	**9.7**
Downstream from Southerly WWTC	10.10	32	**9.2**	---	---	32	**9.2**
Upstream from Big Creek	8.60	*38*	**9.1**	**44**	**9.0**	**41**	**9.1**
Downstream from Big Creek	7.00	30	*8.2*	*36*	8.1	33	*8.2*
Upstream of Newburgh SS RR Bridge*	5.90	28	**9.2**	24	6.7	26	8.0
Scranton Road Restoration Site*	2.75	24	**8.8**	30	**8.9**	27	**8.9**
Upstream of Confluence w/ Lake Erie*	0.20	27	6.4	22	6.2	25	6.3

Bold = meets WWH criterion [IBI ≥40; MIwb ≥8.7]
Italics = non-significant departure from WWH criterion [IBI ≥36; MIwb ≥8.2]
* WWH criteria do not apply; LIBI used instead of IBI

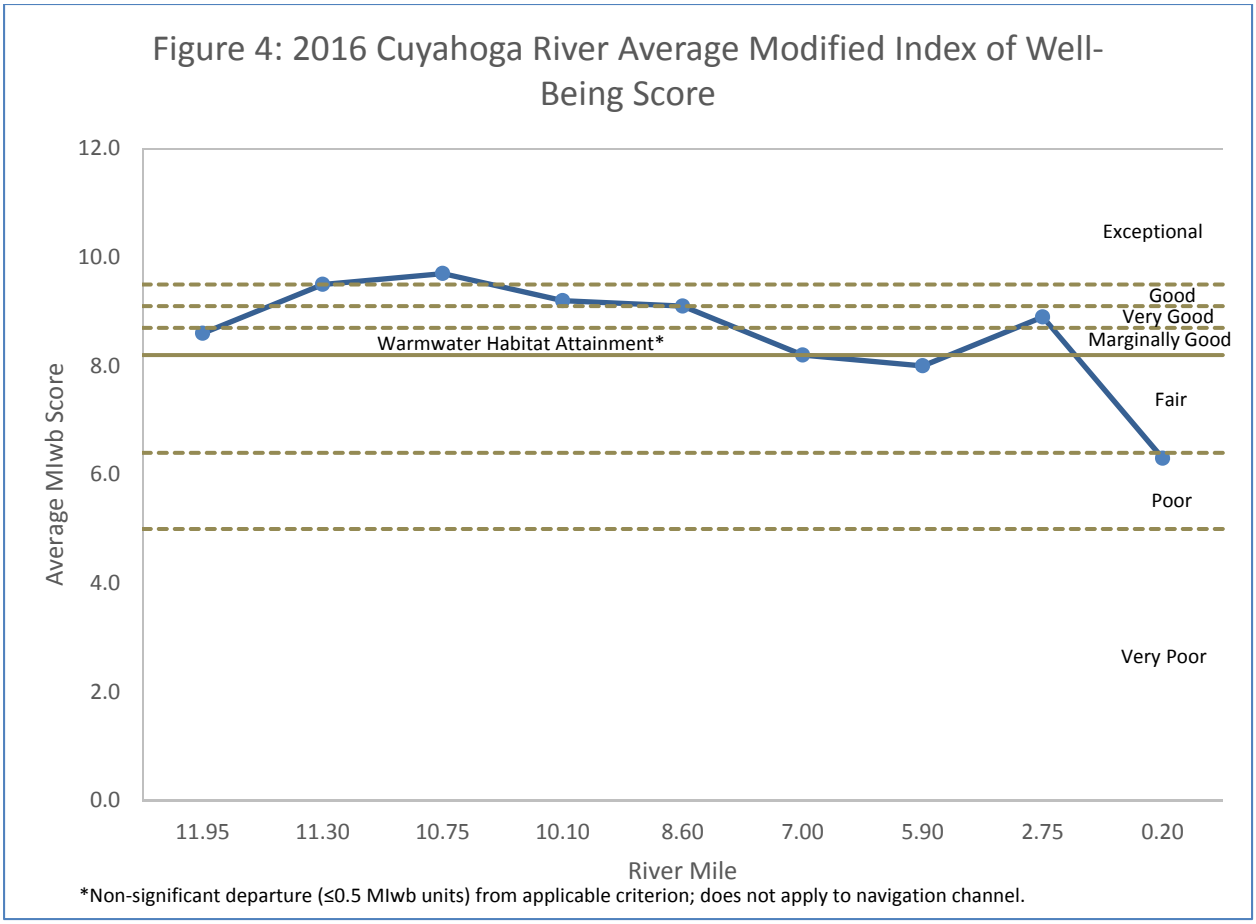


Figure 4: 2016 Cuyahoga River Average Modified Index of Well-Being Score
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Average MIwb Score
Exceptional
Good
Very Good
Marginally Good
Warmwater Habitat Attainment*
Fair
Poor
Very Poor
11.95
11.30
10.75
10.10
8.60
7.00
5.90
2.75
0.20
River Mile
*Non-significant departure (≤0.5 MIwb units) from applicable criterion; does not apply to navigation channel.

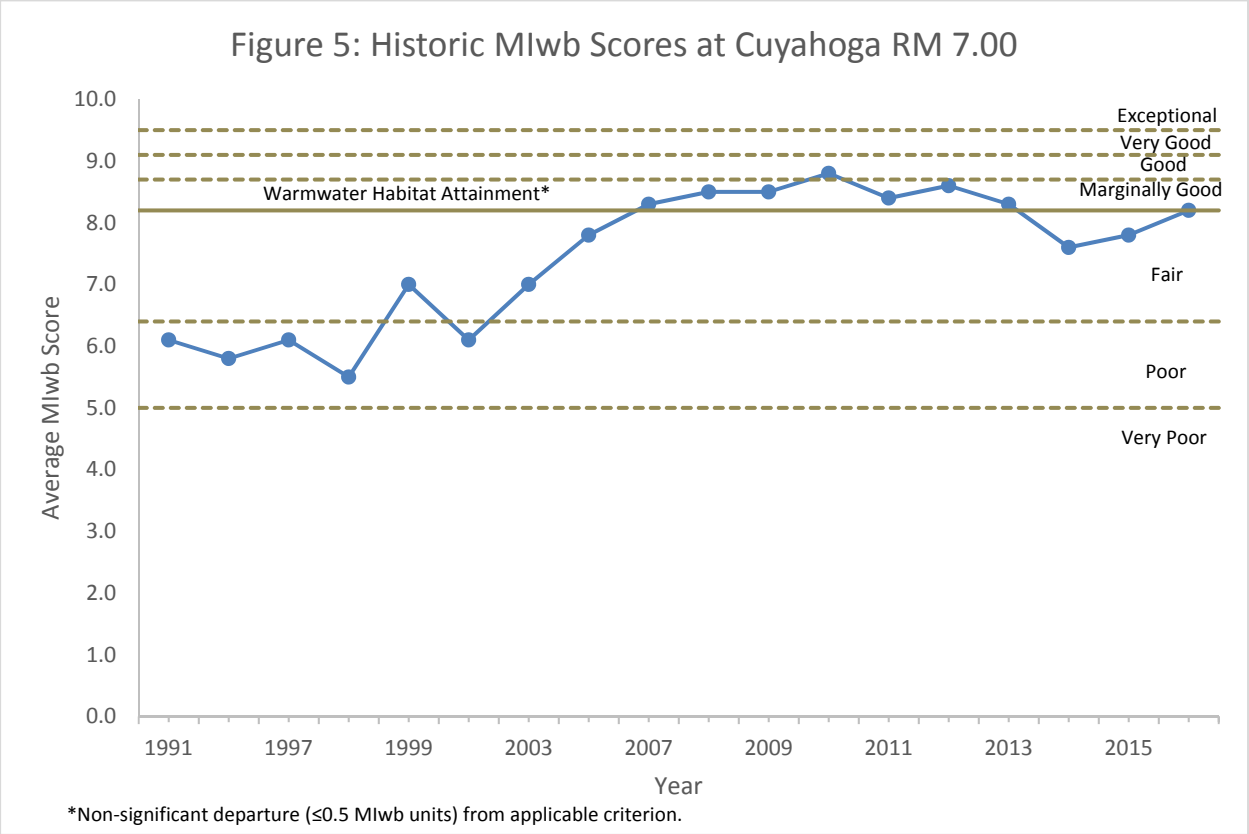


Table 16. Cuyahoga River Historic MIwb Scores (1990-2016)										
	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90*	RM 2.75*	RM 0.20*
1990	-	-	-	4.5	4.6	-	-	-	-	-
1991	-	-	-	5.5	5.6	-	6.1	-	-	-
1992	-	-	-	5.6	6.6	-	5.8	-	-	-
1997	-	-	-	7.5	6.1	-	6.1	-	-	-
1998	-	-	-	7.8	7.6	-	5.5	-	-	-
1999	-	-	-	8.2	*8.6*	-	7.0	-	-	-
2001	-	-	-	7.4	*8.2*	-	6.1	-	-	-
2003	-	-	-	7.6	7.8	-	7.0	-	-	-
2004	-	-	-	8.0	*8.4*	-	-	-	-	-
2006	-	-	-	**8.8**	*8.5*	-	7.8	-	-	-
2007	*8.6*	*8.5*	*8.3*	**9.4**	**9.7**	-	*8.3*	-	-	-
2008	**9.9**	*8.2*	**9.1**	**8.9**	**9.4**	-	*8.5*	-	-	-
2009	**9.9**	**8.8**	**9.5**	**9.1**	**9.2**	**9.0**	*8.5*	-	-	-
2010	**9.5**	**9.0**	**9.7**	**9.7**	**9.5**	**9.2**	**8.8**	6.2	7.2	6.3
2011	**9.6**	**8.7**	**8.9**	**9.5**	**9.1**	**8.8**	*8.4*	7.3	8.1	6.8

Table 16. Cuyahoga River Historic MIwb Scores (1990-2016)										
	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90*	RM 2.75*	RM 0.20*
2012	-	**9.2**	**9.5**	**9.6**	**10.1**	**9.6**	*8.6*	8.1	6.9	7.4
2013	-	8.3	**9.2**	**9.2**	**9.1**	**8.8**	*8.3*	6.3	-	5.9
2014	-	**9.1**	**9.3**	**9.0**	**9.5**	*8.2*	7.6	6.8	8.8	5.5
2015	-	-	-	**9.3**	**9.0**	*8.8*	7.8	6.5	7.2	6.2
2016	-	*8.6*	**9.5**	**9.7**	**9.2**	**9.1**	*8.2*	8.0	8.9	6.3

Bold = meets WWH criterion [≥8.7]
Italics = non-significant departure from WWH criterion [≥8.2]
Underline = meets proposed interim biological criteria for lacustuary habitats
*WWH criterion does not apply

Within the navigation channel, the biological criteria do not apply. Ohio EPA has proposed an interim biological criterion for lacustuary habitats for the MIwb of 8.6, with a final goal of 10.0 (Ohio EPA, undated). Based on the sampling that was conducted, the MIwb score at RM 2.75 (restoration) site would have met the proposed interim biological criteria for lacustuary habitats of 8.6, while the score at RM 5.90 and RM 0.20 would not have. The score at RM 2.75 in 2016 was the highest that has ever been measured there, which indicates that the changes to the habitat may be beneficial to the fish community. The 2016 score of 8.9 indicates that the fish community is continuing to benefit from the habitat changes. Monitoring at that site in the future will help to further determine any benefits from the project.

For the IBI, three of the sites upstream of the navigation channel had scores that met the WWH criterion or were within non-significant departure from it (Table 17 and Figure 6). The other three sites that failed to meet the criterion were RMs 11.30, 10.10, and 7.00. RM 11.30 saw a decrease of 8 IBI units. An IBI score of 34 is the lowest score on record at RM 11.30. Compared to the last sampling event at RM 11.30 in 2014, the 2016 surveys had fewer sunfish species collected as well as fewer proportions of omnivores, insectivores, top carnivores, and simple lithophils. River mile 8.60 saw an increase of nine units in IBI score when compared to 2015. This increase was due to an increase in the number of native species and sunfish species as well as an increase in the proportion of round bodied suckers, omnivores, and simple lithophils. For the other sites, scores from 2015 were comparable to those from 2016.

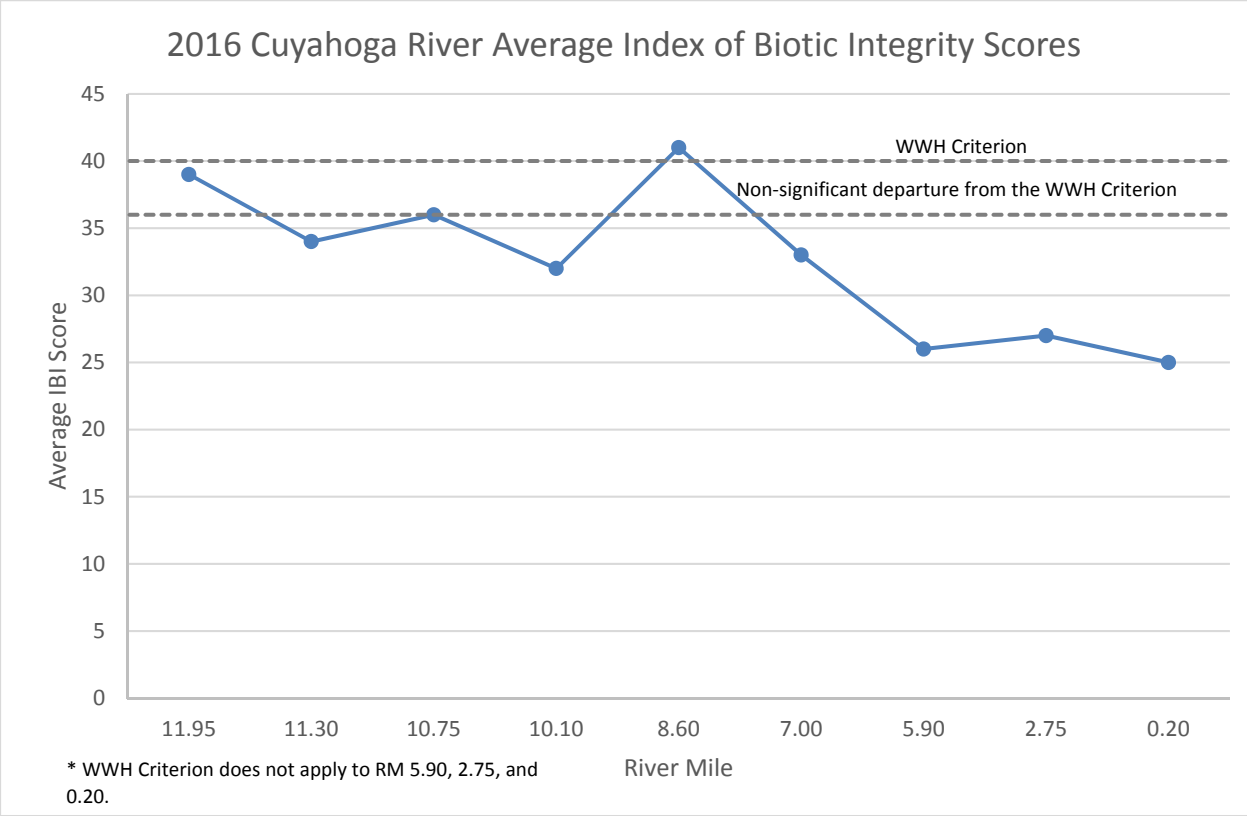
Table 17. Cuyahoga River Historic IBI Scores (1990-2016)										
	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90*	RM 2.75*	RM 0.20*
1990	-	-	-	15	15	-	-	-	-	-
1991	-	-	-	17	16	-	18	-	-	-

Table 17. Cuyahoga River Historic IBI Scores (1990-2016)										
	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90*	RM 2.75*	RM 0.20*
1992	-	-	-	20	19	-	21	-	-	-
1997	-	-	-	25	17	-	18	-	-	-
1998	-	-	-	26	27	-	21	-	-	-
1999	-	-	-	31	31	-	24	-	-	-
2001	-	-	-	30	29	-	22	-	-	-
2003	-	-	-	34	28	-	23	-	-	-
2004	-	-	-	35	35	-	-	-	-	-
2006	-	-	-	*39*	*36*	-	31	-	-	-
2007	*39*	30	*38*	34	35	-	33	-	-	-
2008	**44**	34	*38*	*37*	*36*	-	34	-	-	-
2009	**45**	*38*	**44**	*36*	31	**40**	31	-	-	-
2010	**43**	*39*	*39*	33	*37*	**41**	31	18	27	25
2011	**47**	*39*	35	**44**	*36*	**40**	32	28	25	27
2012	-	*36*	35	*38*	34	*38*	29	24	20	27
2013	-	**41**	**42**	*36*	33	**41**	34	21	-	23
2014	-	**44**	**42**	*38*	**40**	34	32	11	29	23
2015	-	-	-	33	28	32	31	17	25	26
2016	-	*39*	34	*36*	32	**41**	33	26	27	25

Bold = meets WWH criterion [≥40]
Italics = non-significant departure from WWH criterion [≥36]
*Lacustuary IBI; WWH criterion does not apply

Like past years, the metric for number of pollution-intolerant fish scored poorly at all the sites; there were no pollution-intolerant fish collected in 2016. Water quality conditions continue to be one reason for why these fish may be absent. Exceedances of the bacteriological criteria indicate that there may be some sanitary sewage present in the river. This could be due to improper connections and/or combined sewer overflows. The stress to fish associated with such pollutants could therefore be a hindrance to the establishment of those species.

An examination of the individual IBI metrics also showed that generally, the proportion of round-bodied suckers scored poorly (metric score of 1) at the sites lacking a good riffle/run habitat in 2016. Similar results have been seen historically. Sufficient habitat may be the main contributing factor for why more of this type of species was not collected. The site at RMs 8.60, 10.10, and 10.75 have a riffle/run sequence where most of the round-bodied suckers were collected. While the other sites also had riffles, the quality of the riffles was not as high and could have resulted in the lower number of round-bodied suckers collected there.



The sites within the navigation channel were evaluated using the lacustuary IBI (LIBI). The site at RM 2.75 had the highest score (27) of the three sites and rated *Fair*. The upstream (RM 5.90) and downstream (RM 0.20) scores were not significantly different in 2016 when compared to 2015. A lack of suitable habitat within the channel continues to be a main cause of the poor fish communities located in this stretch of river. RM 5.90 had an increase of nine IBI units in 2016. This was due to a reduction in the proportions of omnivores, tolerant individuals, and DELT anomalies that were collected in 2016. There have been no significant changes in habitat at the sites at RM 5.90 and 0.20, which explains why the fish community continues to be impacted from the highly modified conditions there. Although the restoration project at RM 2.75 may have helped to improve some of the habitat features at that site, a lack of establishment of aquatic vegetation and other higher quality instream cover is likely why the fish community has not improved there. As mentioned earlier regarding the sites upstream of the navigation channel, water quality issues continue to have an impact on the fish community within the navigation channel.

Macroinvertebrate Sampling

Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa, inhabiting available habitats at the time of HD retrieval. Sampling was conducted at all of the locations listed in Table 1 except for RM 16.20, because written permission was not obtained from one of the property owners there. Methods for sampling followed the Ohio EPA's Biological Criteria for the Protection of Aquatic Life, Volume III (1987b). HDs within the navigation channel were floated at a depth of approximately two feet below the surface. The recommended period for HDs to be installed is six weeks.

The macroinvertebrate samples were sent to Third Rock Consulting of Lexington, Kentucky, for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as defined by the Ohio EPA (1987b). Lists of the species collected during the quantitative and qualitative sampling at each site are available upon request from WQIS.

The overall aquatic macroinvertebrate community in the stream was evaluated using either Ohio EPA's Invertebrate Community Index (ICI) (Ohio EPA 1987a, Ohio EPA undated) or Lacustuary Invertebrate Community Index (LICI) (Ohio EPA 1987a, Ohio EPA undated). The ICI and LICI both consist of ten community metrics (Table 18), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while Metric 10 is based on the qualitative EPT taxa. The total of the individual metric scores result in the overall score. This scoring evaluates the community against Ohio EPA's reference sites for each specific eco-region.

Table 18. Metrics

ICI	LICI
Total Number of Taxa	Total Number of Taxa
Number of Mayfly taxa	Number of Dipteran Taxa
Number of Caddisfly taxa	Number of Sensitive Taxa
Number of Dipteran taxa	Percent Predominant Taxon
Percent Mayflies	Percent Other Diptera and Non-Insects
Percent Caddisflies	Percent Mayflies and Caddisflies
Percent Tanytarsini Midges	Percent Sensitive Taxa (excluding Dreissinids)
Percent Other Diptera and Non-Insects	Percent Collector-Gatherers
Percent Tolerant Organisms (as defined)	Dipteran Abundance
Number of Qualitative EPT Taxa	Number of Qualitative EPT Taxa

Results and Discussion

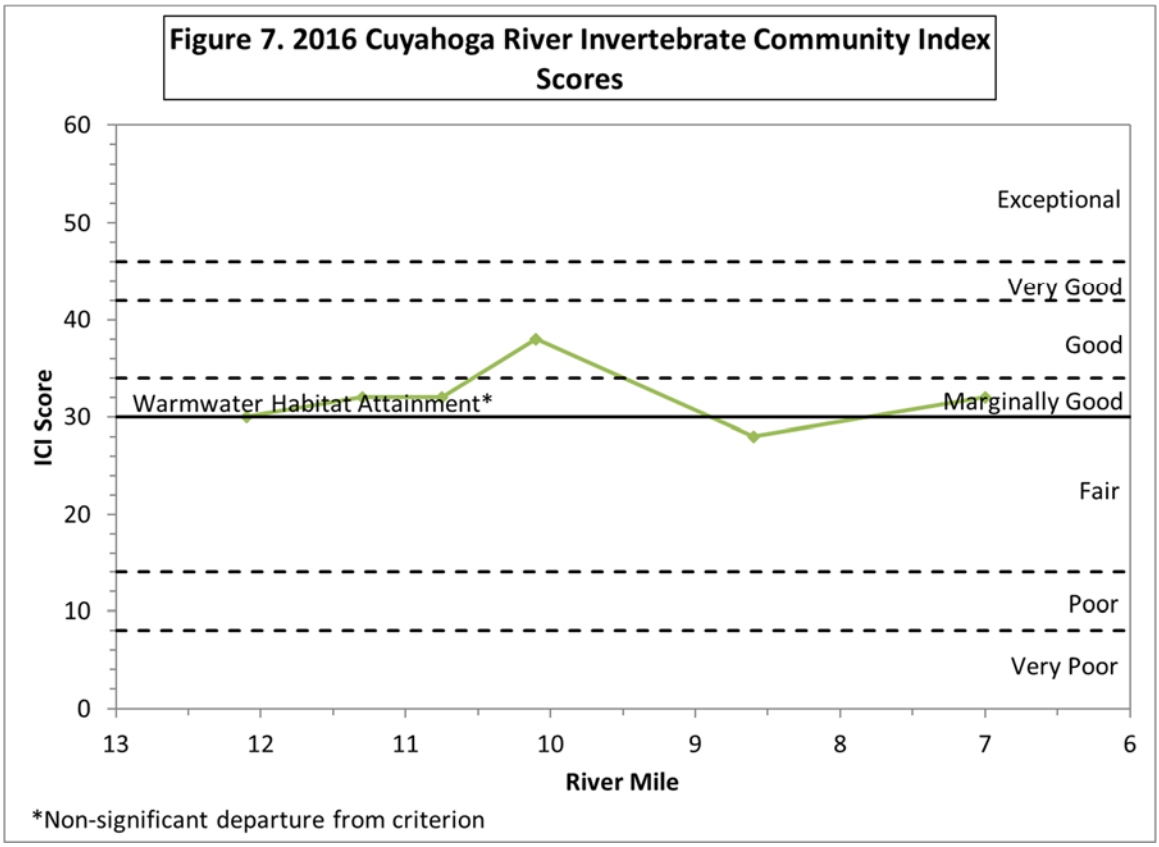
For the 2016 sampling season, all but one sampling site upstream of the navigation channel (RM 8.60) that was evaluated for macroinvertebrates, met the WWH criterion (Table 19 and Figure 7). The site at RM 16.20 was not assessed for macroinvertebrates in 2016, due to lack of permission by the property landowner. While still meeting the WWH criterion, there was a significant decline in overall ICI scores compared to the assessments conducted in 2015 (Table 20).

Table 19. 2016 Cuyahoga River Macroinvertebrate Results

Location	River Mile	ICI Score	LICI Score	Density (Organisms per square foot)	Total Number of Taxa	Number of Qualitative EPT Taxa	% Tolerant (as defined)	Narrative Rating
Upstream of Mill Creek	12.10	*30*	---	843.4	47	9	12.12	*Marginally Good*
Downstream of Mill Creek	11.30	*32*	---	1353	50	11	19.53	*Marginally Good*
Upstream of Southerly WWTC	10.75	*32*	---	594.4	50	11	18.07	*Marginally Good*
Downstream of Southerly WWTC	10.10	**38**	---	1071	59	10	15.00	*Good*
Upstream of Big Creek	8.60	28	---	861.4	44	7	23.33	*Fair*
Downstream of Big Creek	7.00	*32*	---	957.2	46	7	20.96	*Marginally Good*
Head of Navigation Channel	5.90	---	24	500	40	1	75.4	*Fair*
Restoration Site	2.75	---	16	1236.8	25	0	69.97	*Poor*
Cuyahoga River Mouth	0.20	---	26	844	13	0	44.81	*Poor*

Bold indicates attainment of WWH criterion

Italics indicates non-significant departure (≤4 ICI units) from criterion



One of the most significant declines in ICI score was that of RM 8.60. In 2015, the ICI score for this site was calculated at 44 (narratively *Very Good*). However, in 2016, RM 8.60 scored only a 28 (narratively *Fair*) on the ICI, and did not meet the WWH criterion. The number of organisms found in the 2016 HD sampler equated to only about 57% of the organisms found in 2015. Moreover, the increase of pollution tolerant organisms increased from only 1.2% in 2015 to 23.33% in 2016. There was also a significant decline in the presence of Ephemeropteran and Trichopteran taxa, averaging about an 80% to 50% decline in each group, respectively.

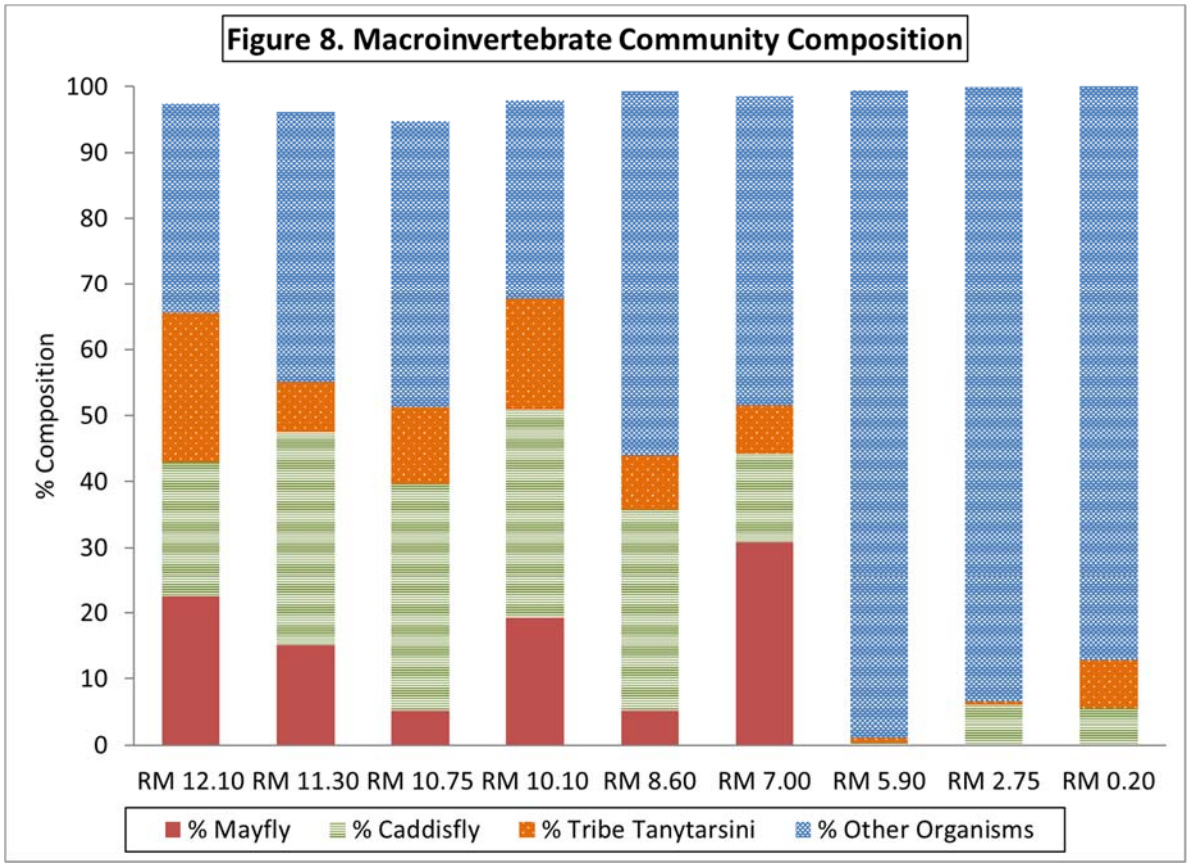
The two most dominant organisms found in the 2016 sample from RM 8.60 included *Cheumatopsyche sp.* (facultative pollution tolerance) and Class Oligochaeta (pollution tolerant). There were fewer organisms present in the 2016 sample, in comparison to the 2015 sample, that classified as intolerant or moderately intolerant to pollution. In 2016, it was evident that these taxa were dominated or replaced altogether by more pollution tolerant organisms. This shift in the population composition as well as the decrease of organism density were the main contributing factors to the significant decline in the ICI score at RM 8.60 in 2016.

Table 20. Cuyahoga River Historic ICI Scores (2006-2016)										
Year	16.20	12.10	11.30	10.75	10.10	8.60	7.00	5.90*	2.75*	0.20*
2006	30	---	---	**38**	**34**	---	---	---	---	---
2007	**34**	**35**	**34**	*32*	**36**	---	**38**	---	---	---
2008	**40**	**40**	**40**	**40**	**40**	---	**38**	---	---	---
2009	**36**	**38**	**36**	**42**	**38**	**36**	**42**	---	---	---
2010	**36**	**40**	**40**	**36**	32	**44**	**34**	---	---	---
2011	**40**	**36**	**36**	*30*	---	---	26	46	---	36
2012	**40**	**44**	**38**	**40**	**34**	**40**	*30*	28	---	16
2013	**36**	**40**	**34**	**46**	**34**	**42**	**38**	36	---	---
2014	**44**	**---**	**48**	**---**	**34**	*30*	28	28	36	26
2015	**44**	**44**	**46**	**50**	**44**	**44**	24	24	16	32
2016	**---**	*30*	*32*	*32*	**38**	28	*32*	24	16	26
Bold indicates attainment of WWH criterion										
Italics indicates non-significant departure (≤4 ICI units) from criterion										
**LICI instead of ICI*										

Another contributing factor to the overall decline of the ICI scores of the Cuyahoga River sampling sites may be rainfall. Comparing the total rainfall received in the 2016 sampling season to 2015, the total amount was about 50% of the total rainfall in the previous year. Lack of rainfall can contribute to lower and slower flow within the river, thereby increasing the opportunity for silt and sediment to collect within the reach and decrease the availability for quality habitat that would sustain a healthy and robust macroinvertebrate population. This may be an explanation for the vast shift in population proportions to higher concentrations of pollution tolerant taxa.

Figure 8 displays the overall composition of each sample population collected with regard to four major metrics: Percent Mayflies, Percent Caddisflies, Percent Tribe Tanytarsini, and Percent Other Organisms. The first three above-mentioned taxa groups are predominantly sensitive to pollution and are a good indicator of healthy streams when the organisms are present in abundant densities. However, when considering the "Other Organisms" metric, it is not necessarily that these organisms are all pollution tolerant and therefore an indicator of poor stream quality. Instead, an overwhelming dominance in

density of these various taxa can be an indication toward a shift to tolerant organisms, explaining lack of healthy supporting habitat. Further consideration of % Pollution Tolerant organism proportions for these sites (Table 18), a negative correlation can be seen regarding presence of these organisms in relation to Mayflies, Caddisflies, and the Tanytarsini, as it relates to ICI/LICI scores (Figures 6 and 7). As can be demonstrated in Figure 8, the dominance of other organisms becomes larger closer to the mouth of the Cuyahoga River, noting large percentages in the navigation channel sampling sites at RMs 5.90, 2.75, and 0.20.



An HD sampler was successfully recovered from all three sites in the navigation channel during the 2016 sampling season. The three sites within the navigation channel were evaluated using the LICI; one site scoring in the *Fair* narrative range (RM 5.90), while the other two sites scored in the *Poor* range (RMs 0.20 and 2.75). No mayfly taxa were collected at either RM 5.90 or RM 0.20. Only one organism from the species *Baetis intercalaris* (*Facultative* pollution tolerance) was present in the sample collected from RM 2.75. All three sites within the navigation channel were dominated by pollution tolerant taxa, including Class Oligochaeta (aquatic worms – pollution tolerant), and various tolerant species of Chironomidae (non-biting midge). The lack of quality habitat and slow flow within the navigation channel, as it is permanently maintained at a specific

depth and the natural banks are covered by bulkhead, does not allow for the establishment of a healthy and diverse macroinvertebrate population as can be seen in the upstream sampling points. This permanent channel alteration may be one of the larger contributing factors to the decline of the macroinvertebrate population in the lower reach of the Cuyahoga River.

Conclusions

In 2016, the sampling that was conducted indicated that RMs 11.95 and 10.75 were in full attainment of the biological criteria (Table 21). The site at RM 16.20 was not sampled for biological criteria in 2016; if sampling could have been conducted there, it is predicted that this site would have been in full attainment as in the past. At RMs 11.30, 10.10 and 7.00, the ICI and MIwb criteria were met, while the IBI criterion was not. At RM 8.60, the IBI and MIwb criteria was met, while the ICI criterion was not.

Table 21. 2016 Cuyahoga River Survey Results

River Mile	Aquatic Life Use Attainment Status	IBI Score (Narrative Rating)	MIwb Score (Narrative Rating)	ICI Score (Narrative Rating)	QHEI Score (Narrative Rating)	Water Quality Exceedances
16.20						*E. coli*
11.95	FULL	39 *(Marginally Good)*	8.6 *(Marginally Good)*	30 *(Marginally Good)*	66.25 *(Good)*	*E. coli*
11.30	PARTIAL	34 *(Fair)*	9.5 *(Exceptional)*	32 *(Marginally Good)*	69.00 *(Good)*	*E. coli*
10.75	FULL	36 *(Marginally Good)*	9.7 *(Exceptional)*	32 *(Marginally Good)*	70.00 *(Good)*	*E. coli*
10.10	PARTIAL	32 *(Fair)*	9.2 *(Very Good)*	38 *(Good)*	66.50 *(Good)*	*E. coli*
8.60	PARTIAL	41 *(Good)*	9.1 *(Very Good)*	28 *(Fair)*	77.50 *(Excellent)*	*E. coli*
7.00	PARTIAL	33 *(Fair)*	8.2 *(Marginally Good)*	32 *(Marginally Good)*	64.50 *(Good)*	*E. coli*
5.90	N/A	26 *(Fair)*	8.0 *(Fair)*	24 *(Fair)*	36.50 *(Poor)*	*E. coli*, Mercury
2.75[1]	N/A	27 *(Fair)*	8.9 *(Good)*	16 *(Fair)*	21.00 *(Very Poor)*	*E. coli*
0.20[1]	N/A	25 *(Poor)*	6.3 *(Poor)*	26 *(Fair)*	10.50 *(Very Poor)*	*E. coli*

WWH biocriterion attainment: IBI score of 40; MIwb score of 8.2; ICI score of 34

Non-significant departure: ≤4 IBI units; ≤0.5 MIwb units; ≤4 ICI units

[1]Lacustuary scoring

As in years past, assessments in 2016 showed that for all of the sites, some water quality impairments may be preventing establishment of healthier biological communities. Exceedances of the water quality standards occurred for *E. coli*, indicating the presence of some sanitary sewage in the river. Potential sources of pollution include illicit discharges, CSOs, stormwater runoff, and flow from upstream tributaries. Effluent from Southerly WWTC did not appear to significantly contribute to these exceedances since the *E. coli* concentrations are also elevated upstream of the Southerly WWTC and do not increase downstream of Southerly WWTC. At RM 5.90, there were exceedances of the mercury wildlife and aquatic life criteria on two sampling dates. These exceedances, however, did not indicate any contamination above those levels normally found in streams in northeast Ohio.

Although the biological criteria do not apply to sites with the navigation channel, assessments completed their generally indicated the presence of impacted biological communities. Habitat evaluations at those sites resulted in scores that fell into the *Poor* and *Very Poor* categories. Some improvements to the fish community, as indicated by a *Good* MIwb score, did occur at RM 2.75 when compared to sampling from past years. This improvement may have been a result of the restoration project that was completed there in 2013. The remaining biological scores for RM 2.75 and all of the biological scores for RM 5.90 and RM 0.20 showed the need for improved habitat and flow conditions in order for healthier fish and macroinvertebrate communities to be present.

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