NORTHEAST OHIO REGIONAL SEWER DISTRICT

2017 Cuyahoga River Environmental Monitoring

Prepared by
Water Quality and Industrial Surveillance Division

Introduction

In 2017, 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 the 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 *2017 Cuyahoga River Environmental Monitoring* approved by Ohio EPA on May 12, 2017.

The purpose 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 the 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. Fish communities and benthic macroinvertebrate communities were surveyed at eight sites in the Cuyahoga River between river mile (RM) 20.75 and RM 7.00. The results from these surveys will help to characterize the overall fish and macroinvertebrate community health in the river.

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.

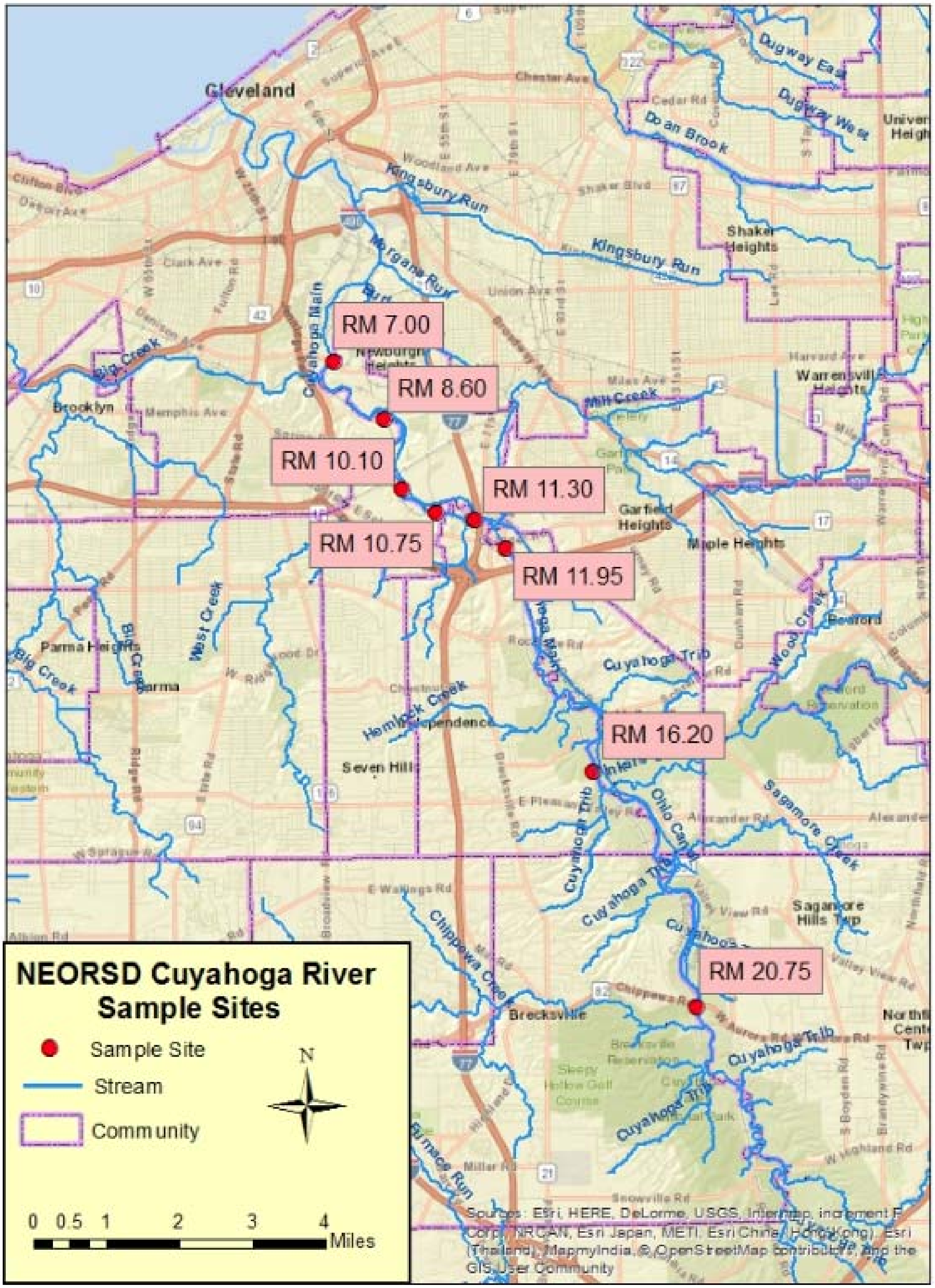


Figure 1. Sampling Locations

Table 1. Sample Locations					
Location	Latitude	Longitude	River Mile	Description	Purpose
Upstream of State Route 82	41.3207	-81.5875	20.75	Upstream of the State Route 82 dam and downstream of the confluence with Chippewa Creek	Evaluate upstream of Route 82 dam prior to potential removal
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
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
Downstream of Southerly WWTC	41.4242	-81.6638	10.10	Downstream of Southerly WWTC effluent discharge	Evaluate Southerly WWTC discharge on fish, habitat, and macroinvertebrates,
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	Evaluate Big Creek discharge on fish, habitat and macroinvertebrates

[a] HD and Water Chemistry Collection Site

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between July 11 and August 8, 2017, on the Cuyahoga River between RMs 20.75 and 7.00. 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, dissolved oxygen percent, pH, temperature, specific conductivity, 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, 2015).

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

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

The sites sampled in 2017, which are all upstream of the navigation channel, are designated warmwater habitat (WWH), agricultural water supply, industrial water supply, and primary contact recreation. Four field blanks and four duplicate samples were collected as part of this study in 2017. 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 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
Cr
Cu
DRP
Zn

For the duplicate samples, two instances occurred in which the acceptable RPD was exceeded (Table 3). The sampling on July 25, 2017 and August 1, 2017, were not considered wet weather[1]. Therefore, the reason for the unacceptable difference between the samples 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.

[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 3. Duplicate samples with RPDs greater than acceptable				
Site	Date	Parameter	Acceptable RPD	Actual RPD
11.30	8/1/2017	COD	61.4	62.0
7.00	7/25/2017	Al	33.4	41.3

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 2017, nine instances 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.

Table 4. Unacceptable Paired Parameter RPDs					
River Mile	Date	Paired Parameters	Acceptable RPD (%)	Actual RPD (%)	Qualifier
20.75	8/8/2017	TS/TDS	15.5	0.5	J
16.20	8/8/2017	TS/TDS	15.5	0.3	J
11.30	8/8/2017	TS/TDS	15.5	1.3	J
10.75	7/18/2017	TS/TDS	16.4	4.9	J
10.75	8/8/2017	TS/TDS	15.4	4.4	J
10.10	7/18/2017	TS/TDS	16.1	2.3	J
10.10	8/8/2017	TS/TDS	15.5	8.0	J
8.60	7/18/2017	TS/TDS	16.0	0.8	J
7.00	7/18/2017	TS/TDS	16.0	3.4	J
J=Result is estimated.					

Exceedances of the recreational bacteriological criteria occurred at all of the sites during 2017. 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 the 90-day periods beginning on July 11, 2017 (Table 5). These exceedances were mostly due to a significant wet-weather event that occurred before the July 11, 2017, sampling. Exceedances of the 90-day geometric mean also occurred at all of the sites throughout the 2017 sampling period (Table 5). Potential sources of bacteria to the river could include stormwater runoff, illicit discharges, and combined sewer overflows (CSOs).

Table 5. 2017 Cuyahoga River *E. coli* Densities (most-probable number/100mL)								
Date	RM 20.75	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
7/11/2017*	12,120	25,920	12,549	8,390	19,040	19,890	29,090	21,420
7/18/2017	131	222	238	222	318	140	131	385
7/25/2017	281	350	301	294	256	269	181	274
8/1/2017	76	70	33	31	34	28	64	50
8/8/2017	254	172	178	238	128	250	225	161

* 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 average (OMZA) and the Human Health Non-Drinking OMZA occurred at RM 20.75, RM 16.20, and RM 7.00 during the 2017 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. 2017 Cuyahoga River Mercury Concentrations (ug/L)								
	RM 20.75	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
7/11/2017	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
7/18/2017	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
7/25/2017	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
8/1/2017	j 0.038	j 0.04	<0.025	<0.025	<0.025	<0.025	<0.025	j 0.33
8/8/2017	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025

Exceedance of Wildlife OMZA (0.0013 ug/L) and Human Health Non-Drinking OMZA (0.0031) 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, 2015a).

While all the parameters necessary for SNAP were not assessed in 2017, nutrients were assessed for general watershed monitoring at the sites. Table 7 shows the results of the geometric mean concentration and standard deviations of all five sampling events in 2017 of dissolved inorganic nitrogen, total phosphorus, and dissolved reactive phosphorus. Table 2 of SNAP (Figure 2) assesses a general ecological risk of nutrient enrichment based upon the dissolved inorganic nitrogen and total phosphorus concentrations.

Table 7: Nutrient results for the Cuyahoga River used for 2017 SNAP analysis.

River Mile	Geomean DIN (mg/L)	StdDev DIN	Geomean Total-P (mg/L)	StdDev Total-P	Geomean DRP (mg/L)	StdDev DRP
20.75	2.354	1.231	0.104	0.130	0.032	0.007
16.20	2.634	1.842	0.101	0.101	0.034	0.007
12.10*	2.636	1.732	0.099	0.100	0.033	0.007
11.30	2.571	1.648	0.098	0.094	0.035	0.008
10.75	2.523	1.600	0.099	0.097	0.033	0.009
10.10	4.086	2.368	0.177	0.062	0.092	0.049
8.60	4.005	2.014	0.182	0.091	0.089	0.048
7.00*	4.116	1.806	0.203	0.132	0.101	0.078

*SM4500-NO_2-B was also used along with EPA method 353.2 to differentiate between nitrogen containing compounds.

The results of using Table 2 of SNAP reveal a narrative of “enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat” for RM 10.10, RM 8.60, and RM 7.00. A narrative of “levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges” for RM 20.75, RM 16.20, RM 12.10, RM 11.30, and RM 10.75. Concentrations of dissolved inorganic nitrogen, total phosphorus, and dissolved reactive phosphorus were higher downstream of the Southerly WWTC. While Southerly WWTC appears to be a source of nutrients to the Cuyahoga River, the geometric mean concentrations of all five sampling events were not statistically significantly different from one site to another in 2017.

	TP Conc. (mg/l)	← DECREASING RISK DIN Concentration (mg/l) <0.44	0.44 < 1.10	1.10 < 3.60	3.60 < 6.70	≥6.70
DECREASING RISK ↑	<0.040	background levels typical of least disturbed conditions	levels typical of developed lands; little or no risk to beneficial uses	levels typical of modestly enriched condition in phosphorus limited systems; low risk to beneficial use if allied responses are within normal ranges	levels typical of enriched condition in phosphorus limited systems; moderate risk to beneficial use if allied responses are elevated	characteristic of tile-drained lands; otherwise atypical condition with moderate risk to beneficial use if allied responses are elevated (1.1% of observations)
	0.040-<0.080	levels typical of developed lands; little or no risk to beneficial uses	levels typical of developed lands; little or no risk to beneficial uses	levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges	levels typical of enriched condition in phosphorus limited systems; moderate risk to beneficial use if allied responses are elevated	characteristic of tile-drained lands; moderate risk to beneficial use if allied responses are elevated (1.1% of observations)
	0.080-<0.131	levels typical of modestly enriched condition in nitrogen limited systems; low risk to beneficial use if allied responses are within normal ranges	levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges	levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges	characteristic of tile-drained lands; moderate risk to beneficial use if allied responses are elevated; increased risk with poor habitat	characteristic of tile-drained lands; moderate risk to beneficial use if allied responses are elevated (1.0% of observations)
	0.131-<0.400	levels typical of modestly enriched condition in nitrogen limited systems; low risk to beneficial use if allied responses are within normal ranges	levels typical of enriched condition; low risk to beneficial use if allied responses are within normal ranges	levels typical of enriched condition; low risk to beneficial use if allied responses are within normal ranges; increased risk with poor habitat	enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat	enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors
	≥0.400	atypical condition (1.3% of observations)	atypical condition (1% of observations);	enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat	enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors ; increased risk with poor habitat	enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors

"allied responses" = allied response indicators (DO swing, benthic chlorophyll)

Figure 2: Table 2 of the Stream Nutrient Assessment Procedure (Ohio EPA, 2015a).

Land Cover Analysis

A land cover analysis was performed of the watershed areas that drain to each 2017 sample location. The United States Geologic Survey StreamStats Program was used to obtain a watershed polygon representing the watershed that drains to the location of each sample site. The corresponding watershed polygon was then imported to ArcMap 10.3 and the intersect tool was used to combine the watershed with the National Land Cover Database, 2011 (Homer et.al, 2015). The resulting figure represented the different types of land cover that drain to each sample location. The entire Cuyahoga River watershed is presented in Figure 3. Percentages of the total area at each site were then calculated. Similar land cover types were combined and are displayed in Figure 4.

A highly urban floodplain has been linked to numerous water-quality and flow effects. Pollutants associated with urban runoff include sediments, nutrients, pathogens, oxygen-demanding matter, heavy metals, and salts (Schueler, 1987). The percentage of impervious surface associated with developed urban land increases from downstream to upstream. Figure 3 also supports this by showing more developed land in the downstream areas of the Cuyahoga River watershed (red and orange color). RM 20.75 has the smallest percentage of developed land while RM 7.00 has the largest percentage of developed land draining to the site. These large amounts of developed urban landscape may have a negative effect on water quality in the Cuyahoga River.

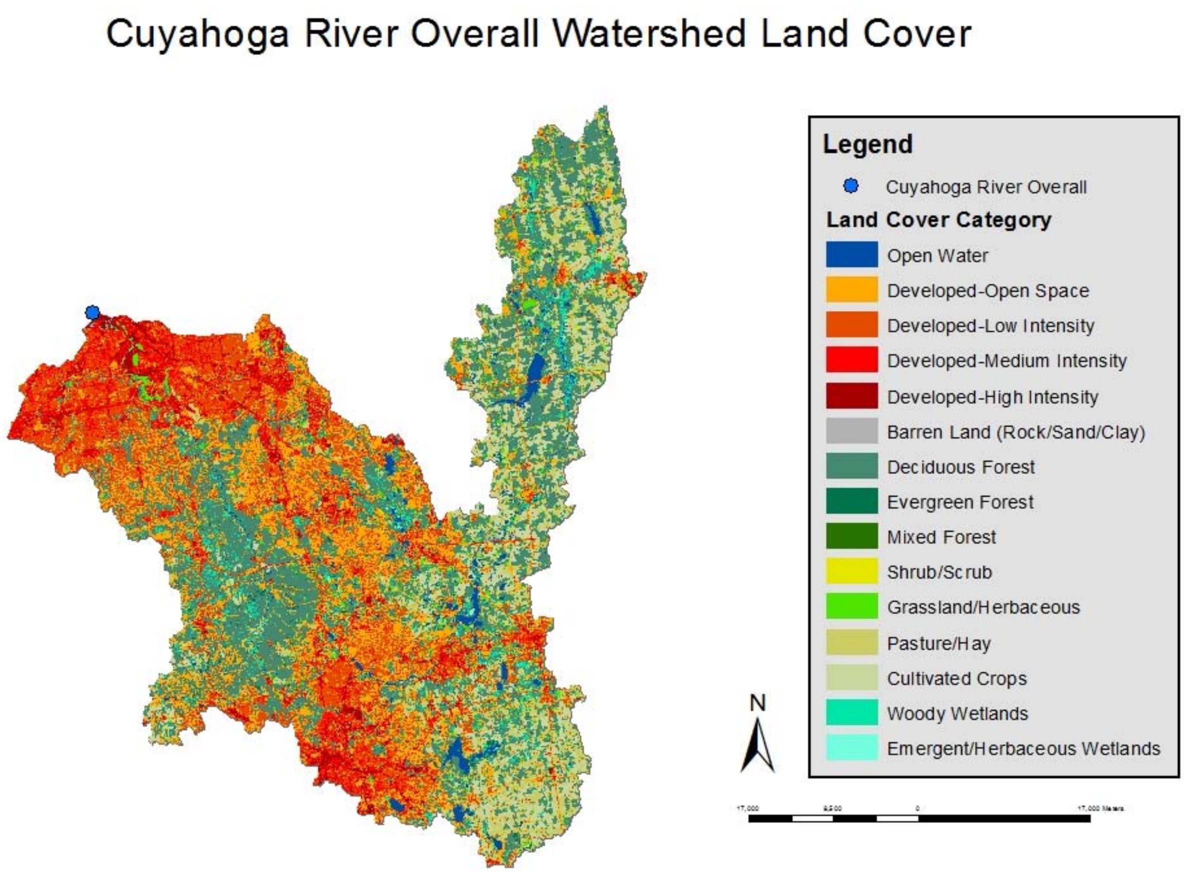
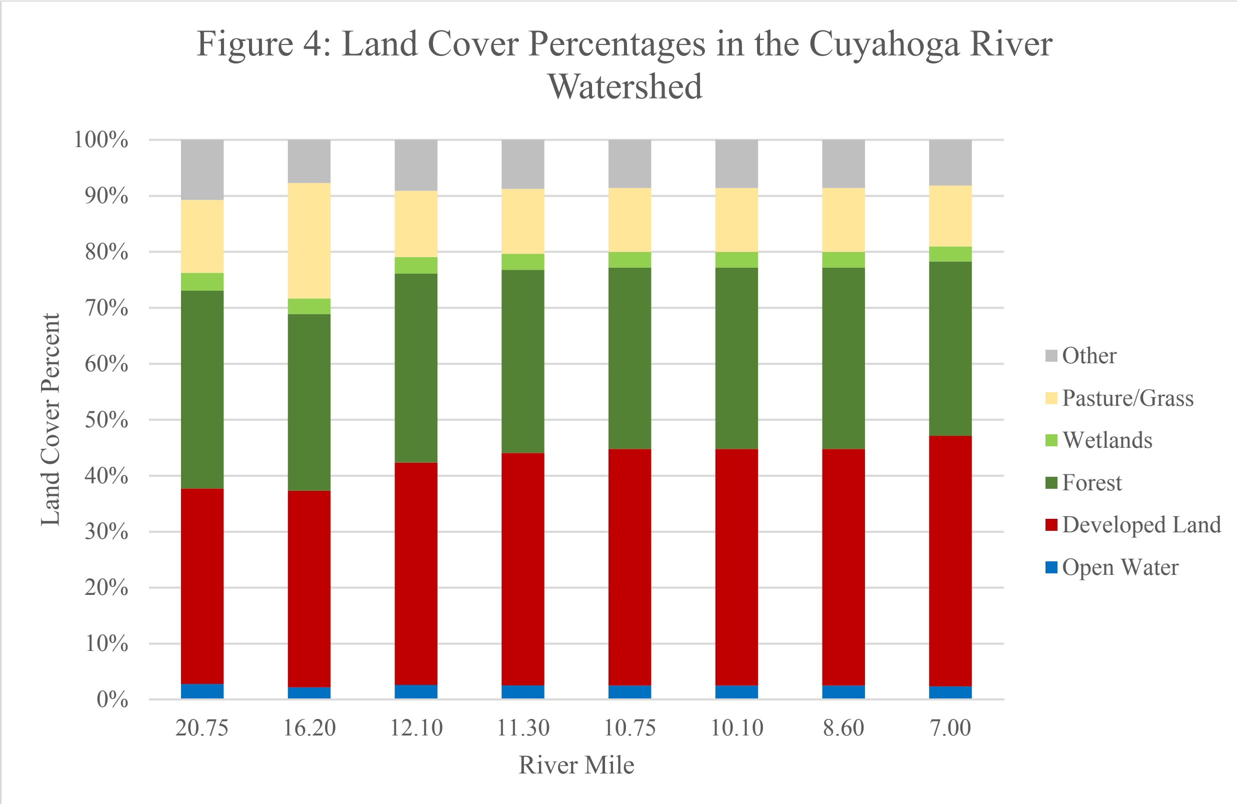


Figure 3: Cuyahoga River watershed land cover map.



Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site from RM 20.75 to RM 7.00 in 2017 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.

Results and Discussion

All of the sites with the exception of RM 7.00 had QHEI scores that met Ohio EPA's target of 60 and, therefore, should be capable of supporting WWH fish communities (Figure 5). The highest scores were at RM 16.20, RM 11.30, and RM 8.60 with scores in the *Excellent* (≥ 75) narrative 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 on 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).

With the exception of RM 20.75 and RM 7.00, the sites all had the WWH characteristics of fast currents and eddies. All sites evaluated in 2017 exhibited maximum depths greater than 40 cm, and either had never been channelized or had recovered from it (Table 8). RMs 20.75 and 7.00 exhibited the lowest scores during the 2017 sampling. Both sites had no riffle and received a score of 0 for this metric. Both sites also had a dominant substrate type of sand. RM 20.75 is immediately upstream of the Route 82 dam, causing this site to have a uniform depth and a lack of stream development. RMs 11.95, 11.30, 10.75, 10.10, 8.60, and 7.00 were also evaluated in 2016. RM 7.00 was the only site to exhibit a large decrease in overall QHEI scores. The score dropped from 64.50 in 2016 to 54.25 in 2017. A change in the silt quality, overall embeddedness, as well as a change throughout the channel morphology category was noted. A higher silt quality and a higher embeddedness score contributed to the decrease in scores from 2016 to 2017 at this site. These changes appeared to be due to a greater influence from Lake Erie on the site compared to previous years.

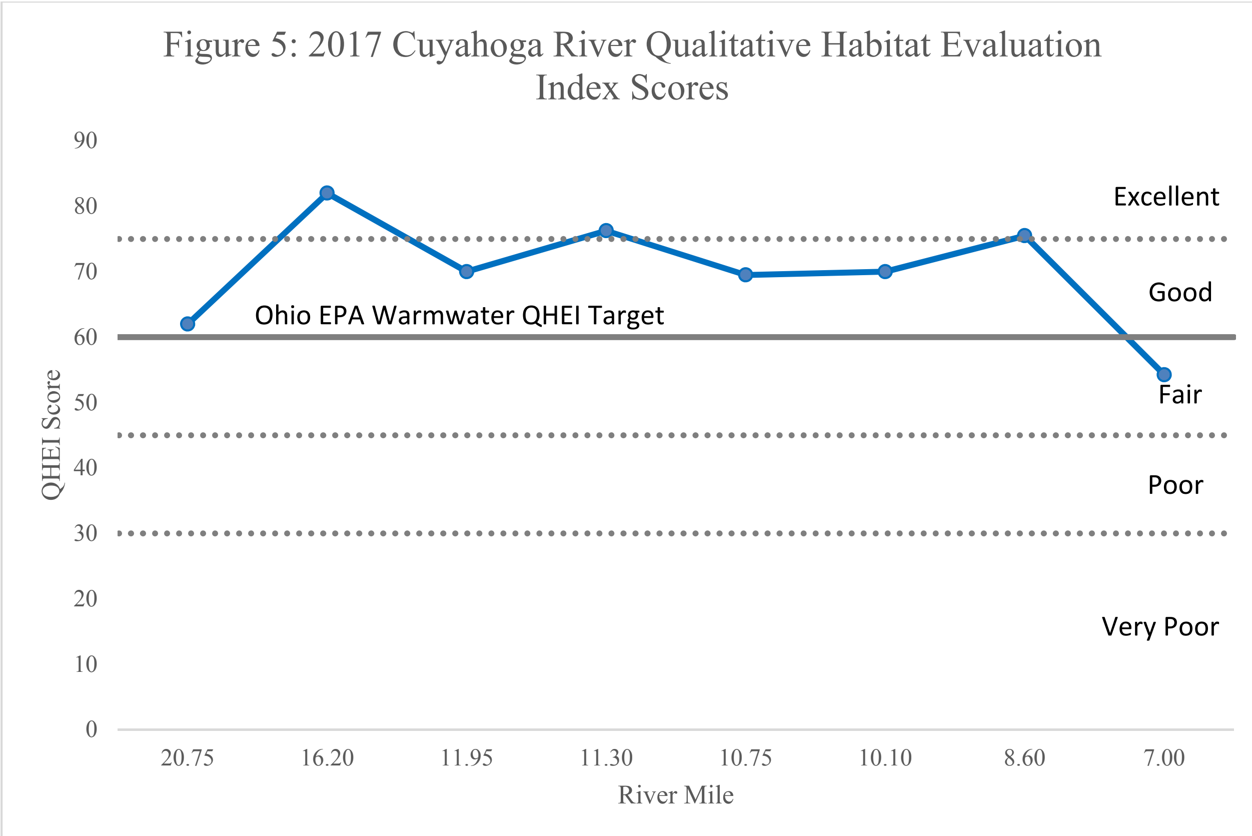


Figure 5: 2017 Cuyahoga River Qualitative Habitat Evaluation Index Scores
90
80
70
60
50
40
30
20
10
0
QHEI Score
Excellent
Good
Fair
Poor
Very Poor
Ohio EPA Warmwater QHEI Target
20.75
16.20
11.95
11.30
10.75
10.10
8.60
7.00
River Mile

Table 8. 2017 Qualitative Habitat Evaluation Index scores and physical attributes

														MWH Attributes																		
			WWH 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 Attribues**
20.75	62.00	*Good*	X	X				X		X	X		**5**		X				**1**			X		X	X			X			X	**5**
16.20	82.00	*Excellent*	X	X		X		X	X		X	X	7		X				**1**			X			X							**2**
11.95	70.00	*Good*	X	X				X	X		X		**5**		X				**1**		X	X		X	X				X	X		**6**
11.30	76.25	*Excellent*	X	X		X	X		X		X		**6**		X				**1**			X								X		**2**
10.75	69.50	*Good*	X	X					X		X		**4**		X				**1**			X			X				X	X		**4**
10.10	70.00	*Good*	X	X					X	X	X		**5**		X		X		**2**			X		X	X							**3**
8.60	75.50	*Excellent*	X	X				X	X		X	X	**6**		X				**1**		X	X			X				X			**4**
7.00	54.25	*Fair*	X								X		**2**		X		X		**2**		X	X		X	X			X	X		X	7

Fish Community Assessment

Methods

One quantitative electrofishing pass was conducted at each site in 2017 by NEORSD. An additional quantitative electrofishing pass was conducted at each site by the Ohio EPA with the exception of RM 16.20. A list of the dates when the surveys were completed, along with flow as measured at the United States Geological Survey gage station in Independence, is given in Table 9. 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, except for RM 20.75, which was 0.595 kilometers in length. 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 9. Sampling Dates and River Flows

Date	Sites sampled (RMs)	Daily Mean Flow (CFS)
7/19/17	11.95, 16.20	348
7/20/17	7.00, 8.60, 10.10, 10.75, 11.30	272
8/2/17	20.75	330
8/10/17	20.80	493
8/17/17	10.30, 11.33	443
8/28/17	10.95, 11.95	341
8/29/17	7.00, 8.60	374
8/30/17	10.10	274
Survey performed by Ohio EPA.		

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*. The 12 metrics utilized for boat sites are listed in Table 10.

Table 10. Index of Biotic Integrity Metrics
Number of native species
Percent round-bodied suckers
Number of sunfish species
Number of sucker species
Number of intolerant species
Percent tolerant
Percent omnivores
Percent insectivores
Percent top carnivores
Number of individuals
Percent simple lithophils
Percent DELTs

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

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

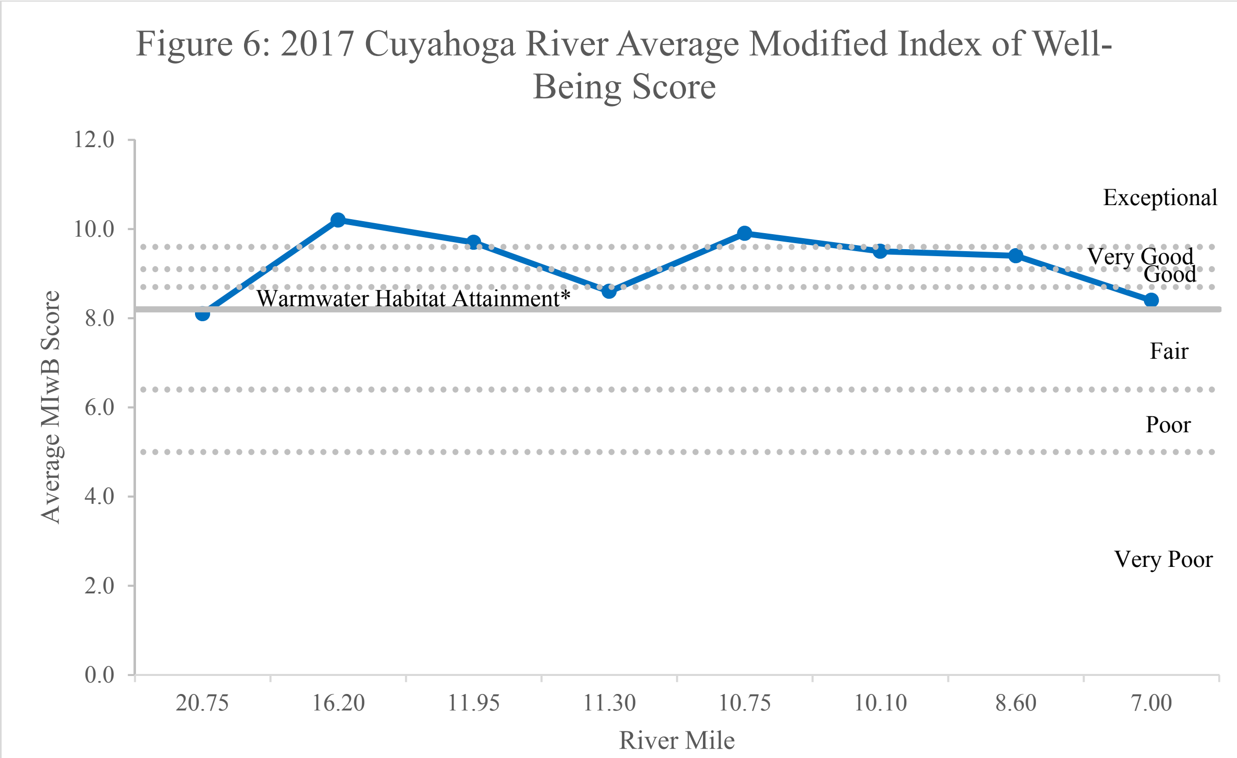
RMs 16.20, 11.95, 11.30, 10.75, 10.10, 8.60, and 7.00 were all in attainment or non-significant departure of the warmwater habitat criterion for the MIwb. RM 20.75 did not meet the WWH criterion for the MIwb, overall. However, the MIwb score at RM 20.75 during the second pass was within non-significant departure of the criterion. (Table 11 and Figure 6). The data supports a gradual overall increase in scores over time. This overall increase at RMs 10.75, 10.10 and 7.00 is represented in Figure 7 and Table 12.

Table 11. 2017 Cuyahoga River IBI and MIwb Results

		1st Pass (NEORSD)		2nd Pass (Ohio EPA)		Average	
Location	River Mile	IBI	MIwb	IBI	MIwb	IBI	MIwb
Upstream of the State 82 Dam	20.75	28	7.6	28	*8.5*	28	8.1
Downstream of Confluence with Tinkers Creek	16.20	**50**	**10.2**			**50**	**10.2**
Upstream of Granger Rd Bridge	11.95	34	**9.0**	**42**	**10.3**	*38*	**9.7**
Downstream of Confluence with Mill Creek	11.30	*38*	*8.5*	38	*8.6*	*38*	*8.6*
Upstream from Southerly WWTC	10.75	**40**	**9.3**	**44**	**10.5**	**42**	**9.9**
Downstream from Southerly WWTC	10.10	*36*	**9.2**	38	**9.8**	*37*	**9.5**
Upstream from Big Creek	8.60	**42**	*8.5*	**44**	**10.2**	**43**	**9.4**
Downstream from Big Creek	7.00	28	7.6	30	**9.2**	29	*8.4*

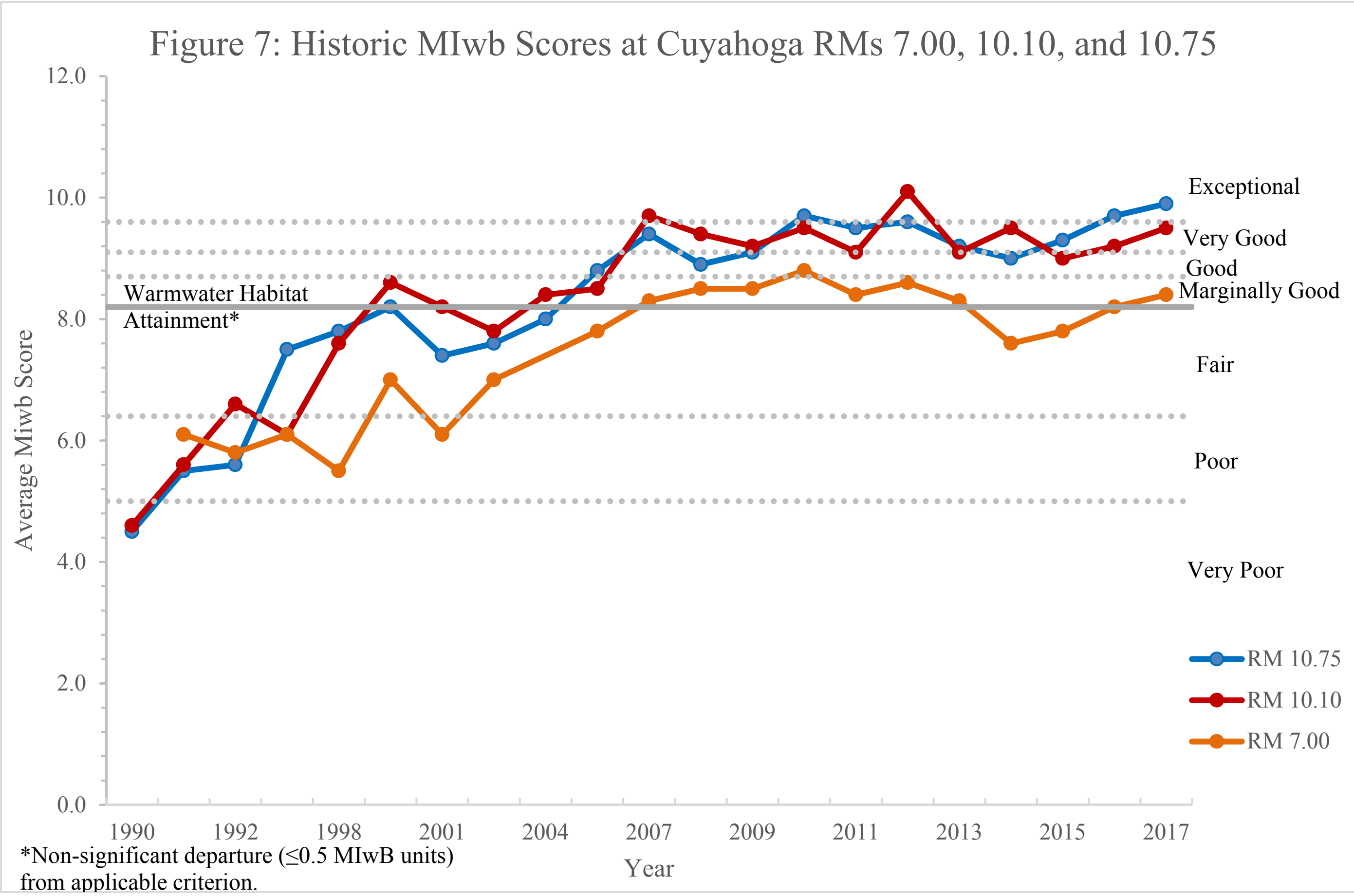
Bold = meets WWH criterion [IBI ≥40; MIwb ≥8.7]

Italics = non-significant departure from WWH criterion [IBI ≥36; MIwb ≥8.2]



*Non-significant departure (≤0.5 MIwB units) from applicable criterion.

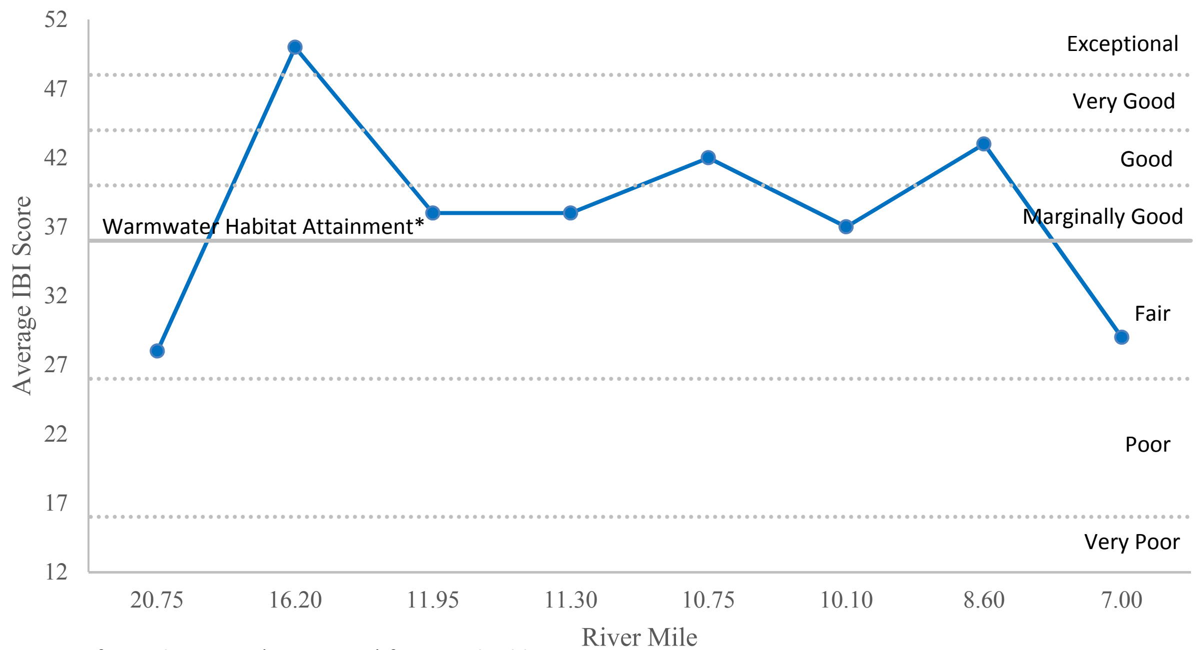
Table 12. Cuyahoga River Historic MIwb Scores (1990-2017)								
	RM 20.75	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
1990	-	-	-	-	4.5	4.6	-	-
1991	-	-	-	-	5.5	5.6	-	6.1
1992	-	-	-	-	5.6	6.6	-	5.8
1997	-	-	-	-	7.5	6.1	-	6.1
1998	-	-	-	-	7.8	7.6	-	5.5
1999	-	-	-	-	8.2	*8.6*	-	7.0
2001	-	-	-	-	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**
2011	-	**9.6**	**8.7**	**8.9**	**9.5**	**9.1**	**8.8**	*8.4*
2012	-	-	**9.2**	**9.5**	**9.6**	**10.1**	**9.6**	*8.6*
2013	-	-	8.3	**9.2**	**9.2**	**9.1**	**8.8**	*8.3*
2014	-	-	**9.1**	**9.3**	**9.0**	**9.5**	*8.2*	7.6
2015	-	-	-	-	**9.3**	**9.0**	*8.8*	7.8
2016	-	-	*8.6*	**9.5**	**9.7**	**9.2**	**9.1**	*8.2*
2017	8.1	**10.2**	**9.7**	*8.6*	**9.9**	**9.5**	**9.4**	*8.4*
	Bold = meets WWH criterion [≥8.7] *Italics = non-significant departure from WWH criterion [≥8.2]*							



For the IBI, all of the sites sampled with the exception of RM 20.75 and RM 7.00 had scores that met the WWH criterion or were within non-significant departure from it (Table 13 and Figure 8). RM 20.75 is located upstream of the Route 82 dam. The habitat at RM 20.75 contains a uniform depth, sand and silt substrate, and no riffle. While the overall habitat score meets the WWH target, the lack of habitat diversity may be one reason for the lower IBI score at RM 20.75. Similarly, RM 7.00 had no riffle and a sandy substrate. The QHEI score at RM 7.00 did not meet the WWH target and may be one reason for the lower IBI score at this site.

Table 13. Cuyahoga River Historic IBI Scores (1990-2017)								
	RM 20.75	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
1990	-	-	-	-	15	15	-	-
1991	-	-	-	-	17	16	-	18
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
2011	-	**47**	*39*	35	**44**	*36*	**40**	32
2012	-	-	*36*	35	*38*	34	*38*	29
2013	-	-	**41**	**42**	*36*	33	**41**	34
2014	-	-	**44**	**42**	*38*	**40**	34	32
2015	-	-	-	-	33	28	32	31
2016	-	-	*39*	34	*36*	32	**41**	33
2017	28	**50**	*38*	*38*	**42**	*37*	**43**	29
	Bold = meets WWH criterion [≥40] *Italics = non-significant departure from WWH criterion [≥36]*							

Figure 8: 2017 Cuyahoga River Average Index of Biotic Integrity Scores



*Non-significant departure (≤4 IBI units) from applicable criterion.

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 2017. 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 illicit discharges and/or combined sewer overflows. Additionally, stormwater runoff could also be a source of bacteriological contamination. The stress to fish associated with such pollutants could therefore be a hindrance to the establishment of those species.

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. Methods for sampling followed the Ohio EPA's Biological Criteria for the Protection of Aquatic Life, Volume III (1987b). 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 the Ohio EPA's Invertebrate Community Index (ICI) (Ohio EPA 1987a, Ohio EPA undated). The ICI consists of ten community metrics (Table 14), 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 14. Metrics
Total Number of Taxa
Number of Mayfly taxa
Number of Caddisfly taxa
Number of Dipteran taxa
Percent Mayflies
Percent Caddisflies
Percent Tanytarsini Midges
Percent Other Diptera and Non-Insects
Percent Tolerant Organisms (as defined)
Number of Qualitative EPT Taxa

Results and Discussion

For the 2017 sampling season, all sampling sites that were evaluated for macroinvertebrates met or were within non-significant departure of the WWH criterion (Table 15 and Figure 9). There was an overall increase in ICI scores as compared to the 2016 assessment (Table 16). An HD sampler was recovered from each site sampled in 2017.

Table 15. 2017 Cuyahoga River Macroinvertebrate Results

Location	River Mile	ICI Score	Density (Organisms per square foot)	Total Number of Taxa	Number of Qualitative EPT Taxa	% Tolerant (as defined)	Narrative Rating
Upstream of State Route 82	20.75	*30*	601	51	7	19.21	*Marginally Good*
Downstream of Tinkers Creek	16.20	**46**	1,935	55	12	0.03	*Exceptional*
Upstream of Mill Creek	12.10	**48**	1,866	58	13	1.75	*Exceptional*
Downstream of Mill Creek	11.30	**42**	1,480	52	13	1.11	*Very Good*
Upstream of Southerly WWTC	10.75	**38**	991	53	10	4.36	*Good*
Downstream of Southerly WWTC	10.10	**38**	1,830	53	11	8.39	*Good*
Upstream of Big Creek	8.60	**38**	1,540	47	7	7.52	*Good*
Downstream of Big Creek	7.00	*32*	744	39	6	3.25	*Marginally Good*
Bold indicates attainment of WWH criterion of 34							
Italics indicates non-significant departure (≤4 ICI units) from criterion							

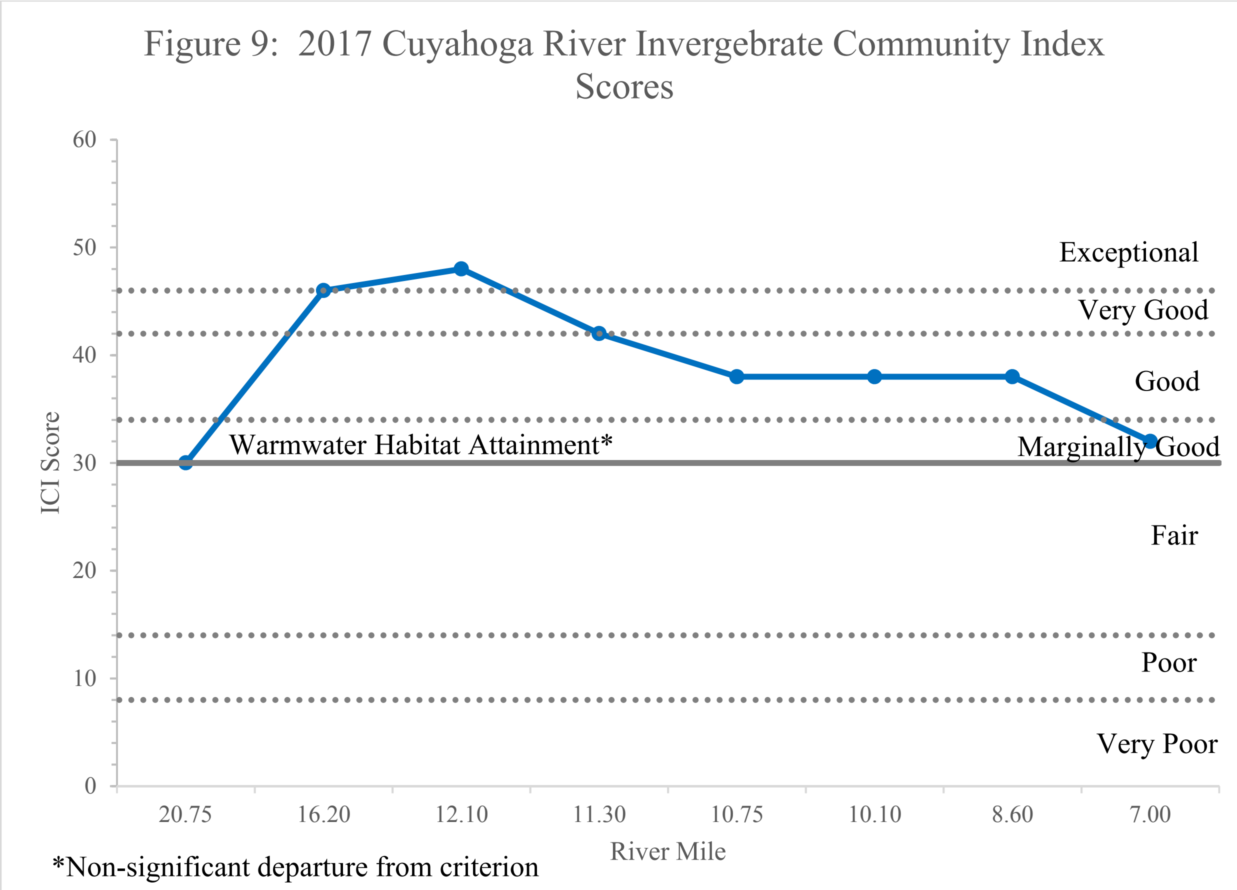


Figure 9: 2017 Cuyahoga River Invergebrate Community Index Scores
60
50
40
30
20
10
0
ICI Score
Exceptional
Very Good
Good
Marginally Good
Warmwater Habitat Attainment*
Fair
Poor
Very Poor
20.75
16.20
12.10
11.30
10.75
10.10
8.60
7.00
River Mile
*Non-significant departure from criterion

Table 16. Cuyahoga River Historic ICI Scores (2006-2017)

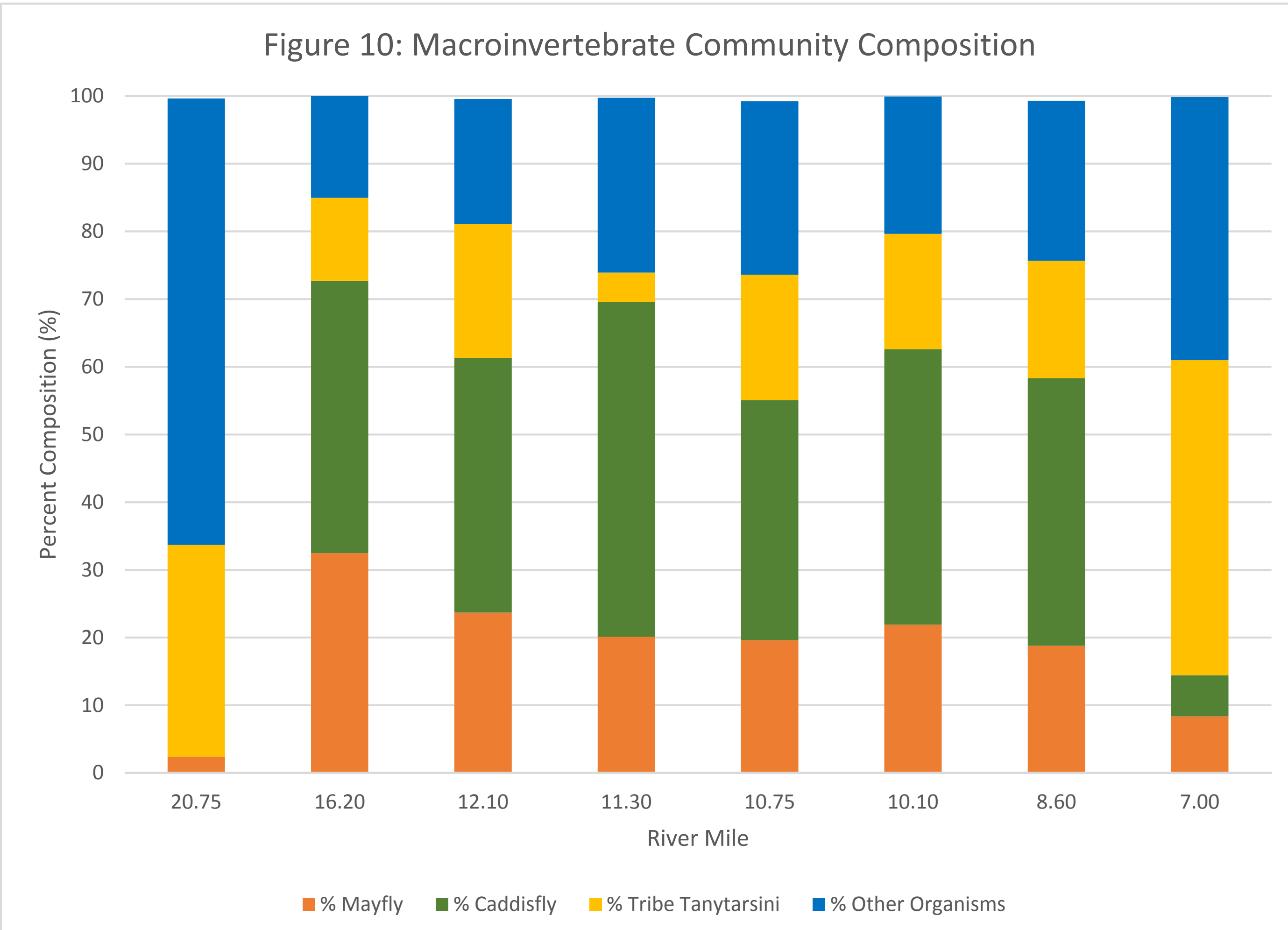
Year	RM 20.75	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
2006	---	30	---	---	**38**	**34**	---	---
2007	---	**34**	**35**	**34**	*32*	**36**	---	**38**
2008	---	**40**	**40**	**40**	**40**	**40**	---	**38**
2009	---	**36**	**38**	**36**	**42**	**38**	**36**	**42**
2010	---	**36**	**40**	**40**	**36**	32	**44**	**34**
2011	---	**40**	**36**	**36**	*30*	---	---	26
2012	---	**40**	**44**	**38**	**40**	**34**	**40**	*30*
2013	---	**36**	**40**	**34**	**46**	**34**	**42**	**38**
2014	---	**44**	---	**48**	---	**34**	*30*	28
2015	---	**44**	**44**	**46**	**50**	**44**	**44**	24
2016	---	---	*30*	*32*	*32*	**38**	28	*32*
2017	*30*	**46**	**48**	**42**	**38**	**38**	**38**	*32*

Bold indicates attainment of WWH criterion
Italics indicates non-significant departure (≤4 ICI units) from criterion

Overall, lower scores were observed in 2016. It was thought that this decline in 2016 may have been due to a lack of overall rainfall. 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. The increase in scores in 2017 aids in showing that the 2016 sampling season may have been affected by an anomaly such as weather as opposed to a true indication of water quality.

Figure 10 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.

RM 20.75 and RM 7.00 had the lowest percentages of mayflies and caddisflies, but the highest percentages of other organisms. These characteristics differ from the other sites sampled in 2017. This was part of the reason that the ICI scores at RM 20.75 and RM 7.00 were within non-significant departure rather than in attainment of the WWH criterion.



Conclusions

In 2017, the sampling that was conducted indicated that RMs 16.20, 11.95, 11.30, 10.75, 10.10, and 8.60 were in full attainment of the biological criteria (Table 17). RM 16.20 also met the criteria for exceptional warmwater habitat (EWWH) for IBI, MIwb, and ICI. This supports the capability of RM 16.20 to support and maintain an exceptional community of aquatic organisms. At RMs 20.75 and 7.00, the ICI and MIwb were within non-significant departure of the WWH criteria while the IBI score did not meet the WWH criterion.

As in years past, assessments in 2017 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* densities were also elevated upstream of the Southerly WWTC and did not increase downstream of it. At RMs 20.75, 16.20, and 7.00, there were exceedances of the mercury wildlife and human health nondrinking criteria. These exceedances, however, did not indicate any contamination above those levels normally found in streams in northeast Ohio.

Overall, monitoring of the Cuyahoga River since the 1990's has shown improvements in water quality. Fewer water quality exceedances are observed and overall biological assessments have seen increases in scores. While some water quality parameters are still likely causing impairments to the river, the overall health of the sites sampled in 2017 has greatly improved since sampling first began. The impairment at RM 20.75 is attributed to the Route 82 dam. The Route 82 dam is scheduled for removal to begin as early as fall of 2018 and may be completed by the end of the year with favorable weather conditions. This will allow a more natural flow pattern to develop and improvements in water quality and biological assessments would be expected. RM 7.00 is also affected by the overall habitat. Additionally, RM 7.00 is located within a more urbanized area and anthropogenic effects could be inhibiting the establishment of a healthy biological population.

Table 17. 2017 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
20.75	PARTIAL	28 *(Fair)*	8.1 *(Marginally Good)*	30 *(Marginally Good)*	62.00 *(Good)*	*E. coli*, Mercury
16.20	FULL	50 *(Exceptional)*	10.2 *(Exceptional)*	46 *(Exceptional)*	82.00 *(Excellent)*	*E. coli*, Mercury
11.95	FULL	38 *(Marginally Good)*	9.7 *(Exceptional)*	48 *(Exceptional)*	70.00 *(Good)*	*E. coli*
11.30	FULL	38 *(Marginally Good)*	8.6 *(Good)*	42 *(Very Good)*	76.25 *(Excellent)*	*E. coli*
10.75	FULL	42 *(Good)*	9.9 *(Exceptional)*	38 *(Good)*	69.50 *(Good)*	*E. coli*
10.10	FULL	37 *(Marginally Good)*	9.5 *(Very Good)*	38 *(Good)*	70.00 *(Good)*	*E. coli*
8.60	FULL	43 *(Good)*	9.4 *(Very Good)*	38 *(Good)*	75.50 *(Excellent)*	*E. coli*
7.00	PARTIAL	29 *(Fair)*	8.4 *(Marginally Good)*	32 *(Marginally Good)*	54.25 *(Fair)*	*E. coli*, Mercury
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						

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