

NORTHEAST OHIO REGIONAL SEWER DISTRICT

2019 Cuyahoga River Environmental Monitoring



**Prepared by
Water Quality and Industrial Surveillance Division**

Introduction

The Cuyahoga River watershed is located in Northeast Ohio, flowing through the major cities of Akron and Cleveland before its final confluence with Lake Erie. In 2019, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community assessments on the lower Cuyahoga River. The objective of this study was to evaluate water quality attainment and identify any spatial and temporal trends between present and historic data. During the 2019 sampling season, seven stream locations were evaluated from river mile (RM) 16.20 downstream to RM 7.00. The site at RM 7.00 was not sampled for biological monitoring or habitat due to high water levels and the absence of a riffle within the zone.

Sampling was conducted by NEORSD Level 3 Qualified Data Collectors (QDCs) certified by the Ohio Environmental Protection Agency (EPA) in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessments as explained in the NEORSD study plan *2019 Cuyahoga River Environmental Monitoring* approved by Ohio EPA on May 14, 2019. All sampling and environmental assessments occurred between June 15, 2019 and September 30, 2019 (through October 15 for fish sampling assessments), as required in the Ohio EPA *Biological Criteria for the Protection of Aquatic Life Volume III* (1987b). The results gathered from these assessments were evaluated using the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), Modified Index of Well-Being (MIwb), and the Invertebrate Community Index (ICI). Water chemistry data was validated per methods outlined by the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (2018a) and compared to the Ohio Water Quality Standards for their designated use to determine attainment (Ohio EPA, 2018c). An examination of the individual metrics that comprise the IBI, MIwb, and ICI was used in conjunction with the water chemistry data and QHEI scores to assess the health of the stream.

The lower 46.5 miles of the Cuyahoga River was designated as one of the 42 Great Lakes Areas of Concern (AOC) in 1985 by the International Joint Commission. Past monitoring indicated impairment of the aquatic biota and recreational standards. The Ohio EPA listed the Cuyahoga River as an impaired waterway in 2018 according to the 2018 Integrated Water Quality Monitoring and Assessment Report (Ohio EPA, 2018b). In recent years, however, some sites have displayed full attainment of their respective biological criteria. Currently, there are four parameters included in the approved TMDL for the Cuyahoga River in NEORSD's service area. The major causes of impairment listed in the 2003 TMDL report were classified as organic enrichment, toxicity, low dissolved oxygen, nutrient enrichment, and flow alteration (Ohio EPA, 2003).

Figure 1 shows a map of the sampling locations, and Table 1 indicates the sampling locations with respect to 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.

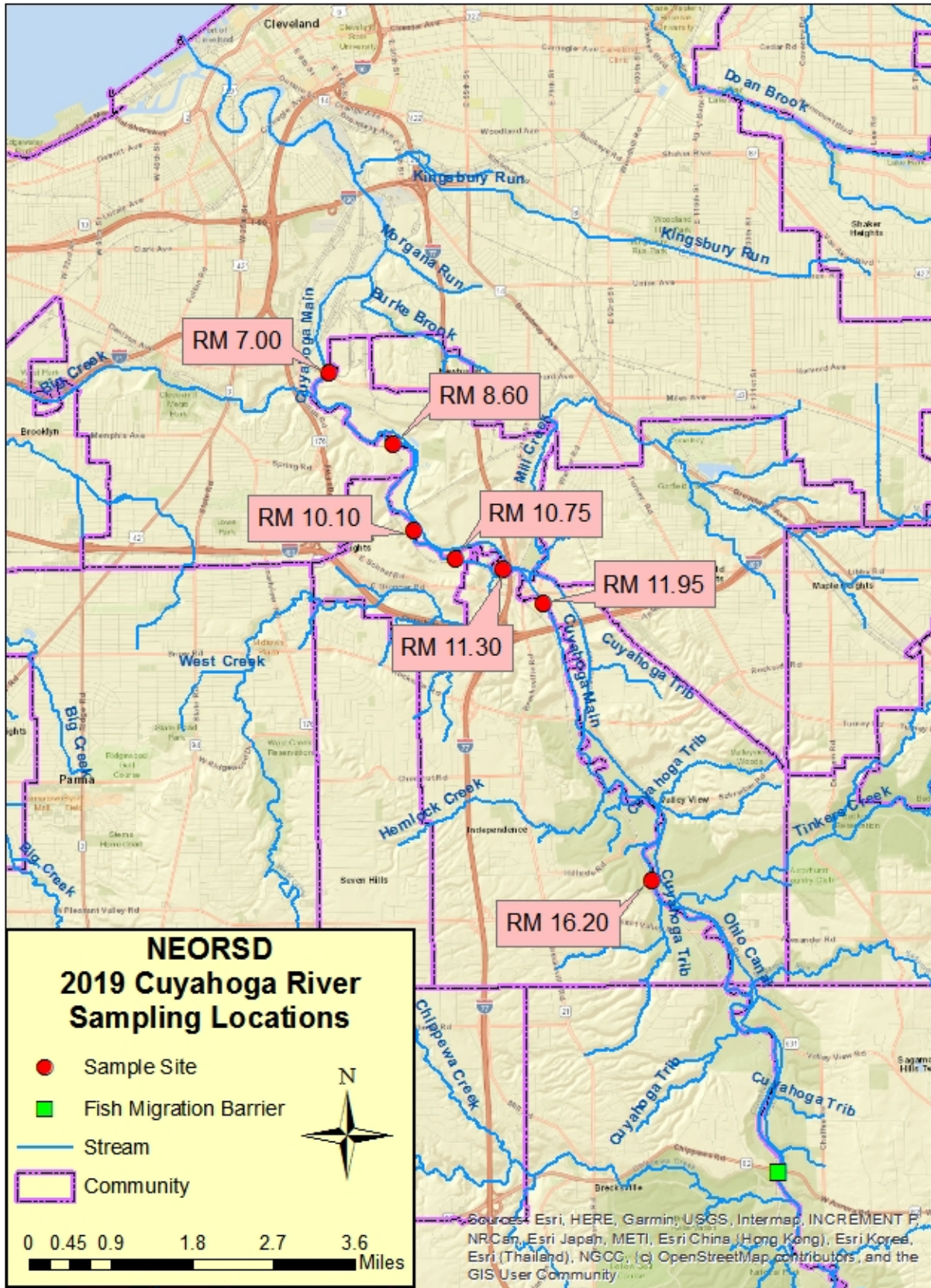


Figure 1. Sampling Locations

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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	Evaluate Tinkers Creek discharge on macroinvertebrate community and 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 community, habitat, macroinvertebrate community and water chemistry
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 community, habitat, macroinvertebrate community and water chemistry
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 community, habitat, macroinvertebrate community, and water chemistry
Downstream of Southerly WWTC	41.4242	-81.6638	10.10	Downstream of Southerly WWTC effluent discharge	Evaluate Southerly WWTC discharge on fish community, habitat, macroinvertebrates community, and water chemistry
Upstream of Big Creek	41.4381	-81.6680	8.60	Upstream of the confluence with Big Creek	Evaluate Big Creek discharge on fish community, habitat, macroinvertebrate, community, and water chemistry
Downstream of Big Creek	41.4497	-81.6815	7.00	Downstream of the confluence with Big Creek	Evaluate Big Creek discharge on water chemistry

^a HD and Water Chemistry Collection Site

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times on the Cuyahoga River between July 23 and August 20, 2019, at the seven sites listed in Table 1. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (2018a). 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 one 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 and 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).

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

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, 2018a).

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

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 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 Cuyahoga River sites sampled in 2019 are designated as a warmwater habitat (WWH) and primary contact recreation according to the Ohio EPA Water Quality Standards (2018c). Over the course of five sampling events in 2019, two field blanks and two duplicate samples were collected as part of this study. Three parameters, (As, Si, and Tl) showed possible contamination in the field blanks. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, and/or contaminated blank water. These parameters were listed as an estimate or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol.

Of the two duplicate samples collected, two instances occurred in which the acceptable RPD was exceeded (Table 2). Potential reasons for this discrepancy include lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity, and/or improper handling of samples.

Table 2. Duplicate Samples with RPDs Greater than Acceptable				
Location	Date	Parameter	Acceptable RPD	Actual RPD
RM 11.95	7/30/2019	TKN	66.5	73.6
RM 16.20	7/23/2019	Tl	99.7	105.9

The final QA/QC check was for paired parameters, or those parameters in which one is a subset of the other. There were no instances in which the data for the paired parameters needed to be qualified because the sub-parameter value was greater than the parent value.

Exceedances of the recreational bacteriological criteria occurred at all seven sites during the 2019 sampling season. The recreational 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 streams designated as 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. These calculations are formulated when there are at least five samples collected within a rolling 90-day period. Both criteria were exceeded at all seven sites for the 90-day periods beginning on July 23, 2019 (Table 3). These exceedances may be due to significant wet-weather events* which occurred on three of the five sampling dates. Potential sources of bacteria inputs may include stormwater runoff, illicit discharges, combined sewer overflows (CSOs), and failing household sewage treatment systems (HSTS).

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Table 3. 2019 Cuyahoga River <i>E. coli</i> Densities (MPN/100mL)							
Date	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
7/23/2019*	2,095	2,303	3,730	3,440	2,172	2,430	2,920
7/30/2019*	254	1,190	1,220	2,326	2,073	1,836	848
8/6/2019	132	96	166	170	200	165	81
8/13/2019	422	490	664	498	230	222	179
8/20/2019*	368	432	466	410	222	390	546
90-day Geomean	336.6	412.9	514.5	477.9	295.2	364.8	338.4
	Exceeds statistical threshold value						
	Exceeds geometric mean criterion for 90-day period						
*Wet-weather Event: 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.							

All mercury results in 2019 were below the method detection limit. Because the detection limit for EPA Method 245.1 is above the criteria for the Human Health Non-Drinking and Protection of Wildlife OMZAs, it cannot be determined if the sites were in attainment of those criteria. It is expected that the use of a low-level mercury analysis like EPA Method 1631E, instead of EPA Method 245.1, may have resulted in exceedances of the criteria throughout the sampling period. It is possible that mercury may be introduced into the Cuyahoga River from urban runoff and atmospheric deposition within the watershed.

In 2018, the Ohio EPA released an Early Stakeholder Outreach regarding Nutrient Water Quality Standards for Ohio’s Large Rivers (≥ 500 mi² drainage area). The proposed eutrophication standard, shown in Table 4, will establish standards based on Sestonic Chlorophyll, 5-day Biological Oxygen Demand (BOD), 24-hour Dissolved Oxygen Range (DO), Total Kjeldahl Nitrogen (TKN), and use Total Suspended Solids (TSS) for sites where chlorophyll data are lacking (Ohio EPA, 2018d).

The Ohio EPA is also proposing a seasonal average, summer base-flow target level of total phosphorus at 0.130 mg/L as a management target for presently over-enriched waters (Miltner, 2017). The total phosphorus target of 0.130 mg/L has been proposed to reduce chlorophyll concentrations to less than 100 µg/L in large rivers. Chlorophyll concentrations greater than 100 µg/L contribute to elevated BOD, large daily DO swings, and a higher concentration of suspended solids; all of which display gross levels of enrichment and suggest a high likelihood of biological enrichment (Miltner, 2017).

Nutrient data was collected at seven sample locations during the five water chemistry sampling events in 2019. TKN, dissolved reactive phosphorus (DRP), total phosphorus, TSS, and BOD were collected at each site during water chemistry sampling. The proposed eutrophication standards require sampling during “summer base-flow conditions”. Of the five sampling events, three of these events were taken during or after wet-weather events (see Table 3 for wet-weather dates). TKN seasonal geomean levels for all seven sampling locations (Table 5) exceeded the “over-enriched, acute condition” criterion for the proposed eutrophication standards. Total

phosphorus levels were acceptable upstream of RM 10.10 but exceeded the proposed total phosphorus target level at RM 10.10 and the downstream sample sites.

Table 4. Ohio EPA Proposed Eutrophication Standards for Ohio’s Large Rivers

	Acceptable	Enriched or Over Enriched	Over Enriched
Indicator		Chronic Condition	Acute Condition
Sestonic Chlorophyll	<30 ug/l as seasonal average	<u>Magnitude</u> 30 < 100 ug/l seasonal average with biological impairment; <u>Frequency</u> ≥ 30 < 100 ug/l as seasonal average in two of three years	<u>Magnitude</u> ≥ 100 ug/l anytime with biological impairment; <u>Frequency</u> ≥ 100 ug/l multiple observations at base flow
BOD5	<2.5 mg/l as seasonal average	<u>Magnitude</u> ≥ 2.5 < 6 mg/l seasonal average with biological impairment <u>Frequency</u> ≥ 2.5 < 6 mg/l as seasonal average in two of three years	<u>Magnitude</u> ≥ 6 mg/l anytime with biological impairment and seasonal average chlorophyll ≥ 30 ug/l <u>Frequency</u> ≥ 6 mg/l two or more times during the base flow period
24-Hour D.O. Range	<6.5 mg/l	≥7 mg/l – 9.0 mg/l (default to chlorophyll, BOD5 and biological indicators)	<u>Magnitude and Frequency</u> ≥9.0 mg/l anytime with biological impairment
TKN	NA	NA	≥0.75 mg/l May substitute for BOD5
TSS		~20 mg/l; general screening level for inspection of data sets lacking chlorophyll observations.	

Table 5. Nutrient Seasonal Geomeans

River Mile	16.20	11.95	11.30	10.75	10.10	8.60	7.00
TKN (mg/L)	0.755	0.808	0.808	0.750	0.806	0.815	0.755
DRP (mg/L)	0.036	0.032	0.032	0.033	0.076	0.072	0.076
TP (mg/L)	0.087	0.089	0.089	0.095	0.148	0.143	0.138
TSS (mg/L)	25.4	30.5	35.3	34.7	28.1	28.1	25.4
BOD (mg/L)	<2.1	<2.1	<2.2	<2.2	<2.4	<2.4	<2.1

Exceedance of the total phosphorus target level of 0.130 mg/L
 Over-enriched - acute condition

The NEORSD Southerly Wastewater Treatment Center (WWTC) discharges treated wastewater to the Cuyahoga River at RM 10.57. Southerly WWTC contains National Pollutant Discharge Elimination System (NPDES) permit number 3PF00002*MD, as issued by the Ohio EPA. This permit limits total phosphorus effluent concentrations to 1.10 mg/L weekly and 0.70 mg/L monthly. With the NPDES permit limit well above the proposed total phosphorus target level, the Southerly WWTC will likely continue to contribute to elevated total phosphorus concentrations in the Cuyahoga River downstream of its effluent discharge.

Land Cover Analysis

A land cover analysis was performed on the watershed areas that drain to each 2019 sample location. The United States Geologic Survey StreamStats Program (U.S. Geological Survey, 2012) 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 into ArcMap 10.3 and the intersect tool was used to combine the watershed with the 2011 National Land Cover Database (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 2. Percentages of the total area at each site were then calculated.

Cuyahoga River Overall Watershed Land Cover

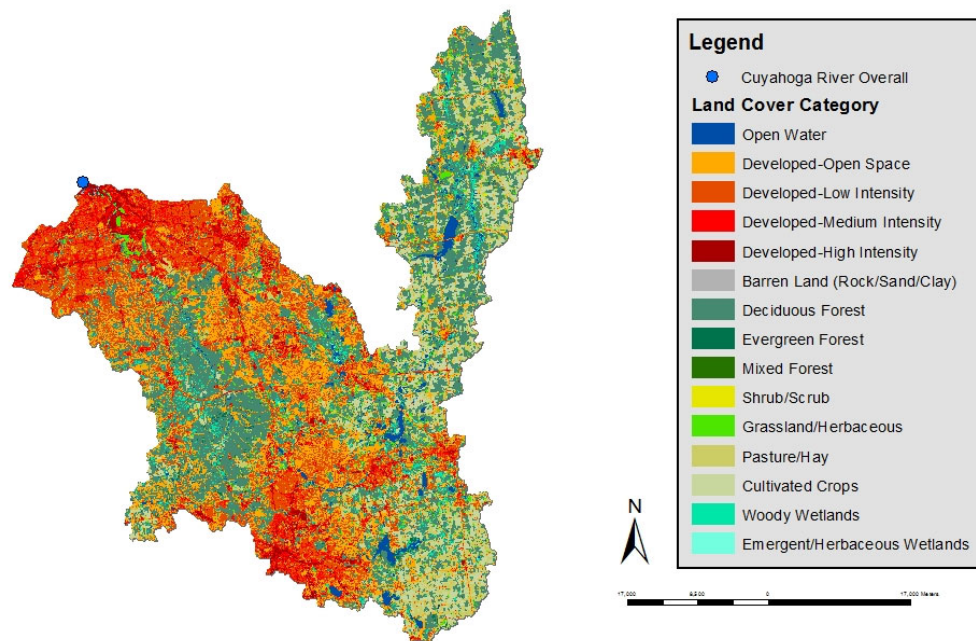


Figure 2. Cuyahoga River Watershed Land Cover Map

The Cuyahoga River watershed contains a highly developed landscape as it flows through the major cities of Akron and Cleveland. RM 16.20 contained the smallest percentage of developed land while RM 8.60 contained the largest percentage of developed land tributary to the sample site. Highly developed land consists of a vast landscape of impervious surfaces which quickly removes rainfall and increase stormwater runoff. This increased stormwater runoff leads

to increased peak discharges, increased erosion, and increased pollutants transferred to the stream (USEPA, 1993). Pollutants associated with urban and industrial runoff include excess sediments, nutrients, pathogens, oxygen-demanding matter, heavy metals, and salts (Schueler, 1987). The highly developed and the urban landscapes that comprise a majority of the Cuyahoga River watershed may be having a negative effect on the overall water quality and lead to the degradation of aquatic biota.

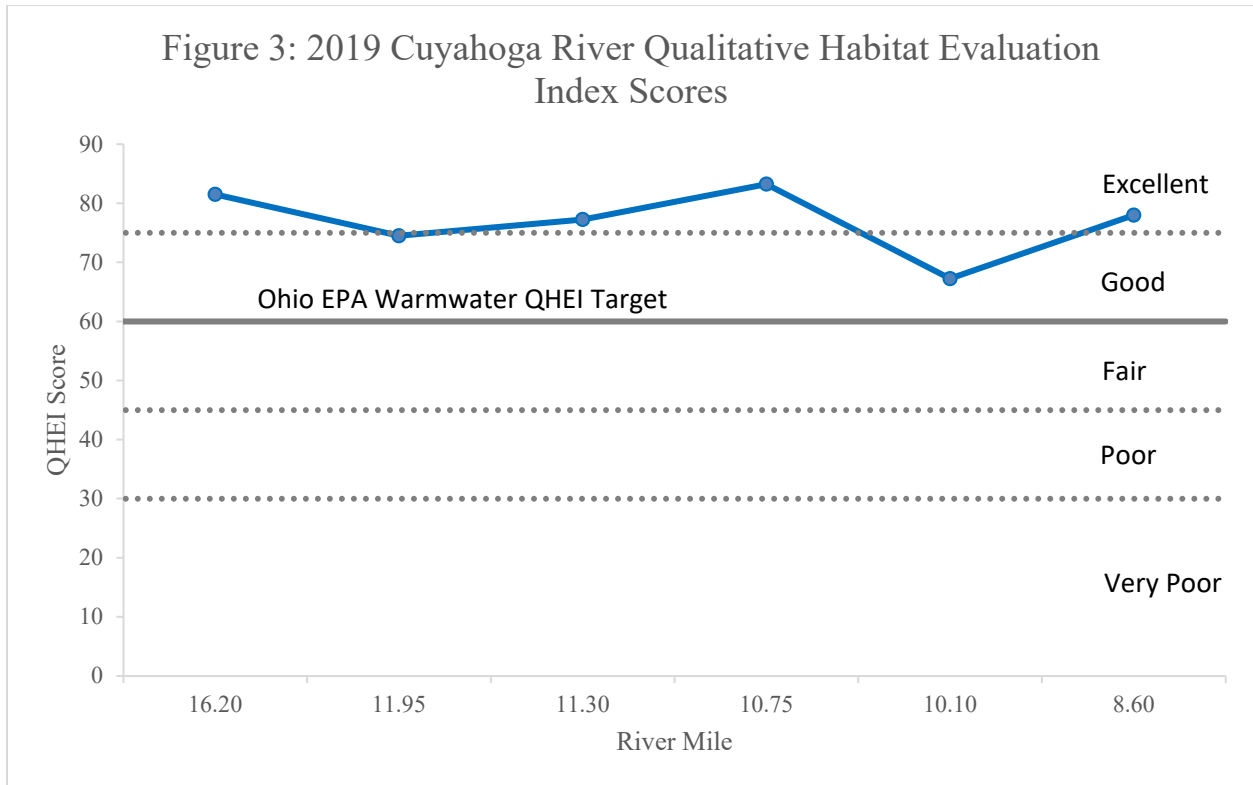
Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site from RM 16.20 to RM 8.60 in 2019 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 greater than 60 on streams greater than 20 square miles suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2006). Scores greater than 75 frequently demonstrate habitat conditions that have the ability to support exceptional warmwater faunas. 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 NEORSW WQIS Division.

Results and Discussion

All of the sites received QHEI scores that exceeded Ohio EPA's target of 60 and, therefore, should be capable of supporting a WWH fish assemblage (Figure 3). Four of six sites received scores with narrative ratings in the *Excellent* (≥ 75) range.



Individual components of the QHEI can also be used to evaluate whether a site is capable of meeting its 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 a 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).

All sites evaluated in 2019 displayed the WWH characteristics of either having never been channelized or have recovered from channelization, had boulder/cobble/gravel substrates, fast current/eddies, and exhibited maximum depths greater than 40 cm as shown in Table 6. Comparing QHEI scores to the previous year, there was minimal variation between 2018 and 2019. All sites maintained the same narrative rating as in 2018. In recent years, QHEI scores at all river miles have consistently met most WWH attributes. In 2019, there were few/no high influence attributes at the sample sites. Based on this information, habitat does not appear to be a limiting factor to fish communities living within the Cuyahoga River system.

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Table 6. 2019 Qualitative Habitat Evaluation Index scores and physical attributes

River Mile	QHEI Score	Habitat Rating	WWH Attributes										MWH Attributes																			
			WWH Attributes										High Influence				Moderate Influence															
			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	
16.20	81.50	<i>Excellent</i>	X	X		X		X	X		X					6						X						X	X			4
11.95	74.50	<i>Good</i>	X			X		X	X		X			X		5			X			X	X					X	X			6
11.30	77.25	<i>Excellent</i>	X	X		X	X	X	X		X					7			X			X						X	X			4
10.75	83.25	<i>Excellent</i>	X	X		X	X	X	X	X	X	X				9																0
10.10	67.25	<i>Good</i>	X	X					X	X	X	X		X		6			X				X	X								2
8.60	78.00	<i>Excellent</i>	X	X	X	X	X	X	X		X					8												X	X			2

Fish Community Biology Assessment

Methods

Two quantitative electrofishing passes were conducted at four of the seven sampling sites in 2019 (RMs 11.95, 11.30, 10.75, and 10.10). One quantitative electrofishing pass was conducted on RM 8.60. A second pass could not be conducted at RM 8.60 due to the field season ending before enough time had passed after the first sampling event. Electrofishing sampling was not conducted at RM 16.20 due to electrofishing boat repairs. A list of the dates when the surveys were completed, along with approved flow measurements from the United States Geological Survey gage station in Independence are shown in Table 7. 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 shoreline and submerged habitat as possible. The sampling zone was 0.50 kilometers for each site and followed the Ohio EPA 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.

Date	Sites sampled (RMs)	Daily Mean Flow (CFS)
9/6/2019	11.30, 11.95	303
9/11/2019	10.10, 10.75	286
9/24/2019	8.60	352
10/9/2019	11.30, 11.95	243
10/10/2019	10.10, 10.75	230

The electrofishing results 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 abundance 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 8.

The second fish index utilized by Ohio EPA, is the 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:
$$MIwb = 0.5 \ln N + 0.5 \ln B + \bar{H}(No.) + \bar{H}(Wt.)$$

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

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

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

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

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

The Cuyahoga River is located completely within the Erie-Ontario Lake Plains (EOLP) ecoregion and follows the EOLP IBI metric scoring. The WWH IBI scoring criterion in the EOLP ecoregion is 40 and a site is considered to be within nonsignificant departure if the score falls within 4 IBI units or 0.5 MIwb units of the criterion (Table 9). Lists of the species diversity, abundance, 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.

Table 8. IBI Metrics (Boat sites)
Total Number of Indigenous Fish Species
Percent Round-bodied Suckers
Number of Sunfish Species
Number of Sucker Species
Number of Intolerant Species
Percent Tolerant Species
Percent Omnivore Species
Percent Insectivore Species
Percent of Top Carnivore Species
Number of Individuals in a Sample
Percent of Simple Lithophilic Spawners
Percent of Individuals with DELTs

Table 9. Fish Community Biology Scores for Boat Sites in the EOLP Ecoregion							
Ohio EPA Narrative	Very Poor	Poor	Fair	Marginally Good	Good	Very Good	Exceptional
IBI Score	12-17	18-27	26-35	36-39	40-43	44-47	48-60
MIwb Score	0-4.9	5.0-6.3	6.4-8.1	8.2-8.6	8.7-9.0	9.1-9.5	≥9.6
Ohio EPA Status	Non-Attainment			NSD	Attainment		
NSD – Non-Significant Departure of WWH attainment							

Results and Discussion

The 2019 IBI and MIwb scores from each assessment location are listed below in Table 10. For the MIwb, four of the five sites were calculated to be in attainment of the warmwater habitat criterion. The highest MIwb score was calculated at RM 8.60, which is upstream of the confluence with Big Creek. The lowest score was observed at RM 11.95, which is upstream of the confluence with Mill Creek.

Table 10. 2019 Cuyahoga River IBI and MIwb Results			
Location	River Mile	IBI (<i>Narrative</i>)	MIwb (<i>Narrative</i>)
Upstream of Mill Creek	11.95	33 (Fair)	8.1 (Fair)
Downstream of Mill Creek	11.30	40 (Good)	9.4 (Very Good)
Upstream from Southerly WWTC	10.75	32 (Fair)	9.3 (Very Good)
Downstream from Southerly WWTC	10.10	41 (Good)	9.3 (Very Good)
Upstream from Big Creek	8.60	32 (Fair)	9.7 (Exceptional)
Bold = meets WWH criterion [IBI ≥40; MIwb ≥8.7]			
<i>Italics = non-significant departure from WWH criterion [IBI ≥36; MIwb ≥8.2]</i>			

All sites received a QHEI score greater than 60, suggesting that habitat is not a limiting factor in the fish community attaining the warmwater habitat criterion (Ohio EPA, 2006). There was an increase in MIwb scores at three of the five sites, compared to the previous sampling event at each location. This may be due to a higher abundance of species collected at RMs 10.75 and 8.60. RM 11.30 saw an increase in MIwb score when compared to the last sampling event in 2017. This increase may be due to an increase in relative weight when compared to 2017. Historical trends of the Cuyahoga River MIwb scores (Table 11) display a gradual increase over time, with scores consistently exceeding the WWH criterion since 2009.

Table 11. Cuyahoga River Historic MIwb Scores (1990-2019)								
Year	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

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Table 11. Cuyahoga River Historic MIwb Scores (1990-2019)								
Year	RM 20.75	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
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
2018	-	-	-	-	8.9	9.5	8.7	8.5
2019	-	-	8.1	9.4	9.3	9.3	9.7*	-
Bold = meets WWH criterion [≥ 8.7]								
<i>Italics = non-significant departure from WWH criterion [≥ 8.2]</i>								
*Meets Exceptional WWH Criterion								

During the 2019 sampling season, three of the five sites assessed for fish community biology failed to meet the WWH IBI criterion of 40 (Table 12). RMs 11.95, 10.75, and 8.60 received an IBI narrative of *Fair*, while RMs 11.30 and 10.10 both received IBI narratives of *Good*. Of the three sites that were sampled in both 2018 and 2019, a small decrease in IBI score from 2018 was observed at RM 8.60, while RMs 10.75 and 10.10 both saw increases in IBI scores in 2019. Individual metrics in the IBI were examined to determine specific components of the fish community that increased/decreased from the previous year. The decrease in IBI score at RM 8.60 is likely associated with the increased proportion of omnivores and the decreased proportion of insectivores that were collected when sampling in 2019. The increase in score at RM 10.75 can be attributed to an increased diversity and number of fish collected as well as a decrease in the number of DELT anomalies present in 2019. An increase in relative number of individuals, as well as a decrease in the number of DELT anomalies present, had a positive impact on the 2019 IBI scores at RM 10.10 when compared to 2018 score.

Every sampling event in 2019 consisted of a low proportion of round-bodied suckers that resulted in the minimum scoring criteria for that metric. Round-bodied suckers are known to be intolerant of highly turbid waters and siltation (Ohio EPA 1987a). The low proportions of round-bodied suckers at all 2019 sampling sites indicate that high turbidity and siltation may be having a negative impact on the fish community within the Cuyahoga River.

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Table 12. Cuyahoga River Historic IBI Scores (1990-2019)								
Year	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
2018	-	-	-	-	24	32	34	28
2019	-	-	33	40	32	41	32	-
Bold = meets WWH criterion [≥ 40]								
<i>Italics = non-significant departure from WWH criterion [≥ 36]</i>								
*Meets Exceptional WWH Criterion								

Water quality conditions most likely continue to be one reason why pollution-intolerant fish are rarely observed in the lower Cuyahoga River. Compared to past years, the metric for number of pollution-intolerant fish scores did increase at several sites as there were several pollution-intolerant fish, the black redhorse (*Moxostoma duquesnei*), mimic shiner (*Notropis volucellus*), river chub (*Nocomis micropogon*), and stonecat madtom (*Noturus flavus*), collected among all sites in 2019. This was the first time since NEORSB began conducting surveys on the Cuyahoga River in which scores above 1 were obtained for this metric. Exceedances of the bacteriological criteria, however, indicate that there may be sanitary sewage contamination present throughout the Cuyahoga River, especially during wet-weather events and periods of elevated flows. Sources of sanitary sewage may be due to combined sewer overflows, illicit discharges, stormwater runoff, and failing HSTS.

Macroinvertebrate Community Biology Assessment

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 locations listed in Table 1. The recommended period for HDs to be installed is six weeks.

The macroinvertebrate samples were sent to EA Engineering, Science, and Technology, Inc 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 NEORSD WQIS Department.

The macroinvertebrate sampling methods followed Ohio EPA protocols as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA's Invertebrate Community Index (ICI). The ICI consists of ten community metrics (Table 13), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while metric 10 is based on the qualitative EPT taxa collected. The sum of the individual metric scores result in the overall ICI score. This scoring evaluates the macroinvertebrate community against Ohio EPA's reference sites for each specific eco-region. The WWH ICI criterion in the EOLP ecoregion is 34 (Table 14) and a site is within non-significant departure if the score falls within 4 ICI units of the criterion.

Table 13. ICI 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

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Table 14. Invertebrate Community Index (ICI) Range for EOLP Ecoregion								
Ohio EPA Narrative	Very Poor	Poor	Low Fair	Fair	Marginally Good	Good	Very Good	Exceptional
ICI Score	0-6	8-12	14-20	22-28	30-32	34-40	42-44	46-60
Ohio EPA Status	Non-Attainment				NSD	Attainment		
NSD – Non-Significant Departure of WWH attainment								

Results and Discussion

For the 2019 sampling season, three of six sampling sites that were evaluated for macroinvertebrates met or were within non-significant departure of the WWH criterion (Table 15). RM 10.75 received a *Fair* narrative rating and did not meet or fall within non-significant departure of the WWH criterion. The HD at RM 16.20 was not identified due to an error in shipping. RM 10.10's HD was missing when it was time to be removed. Temporal data displayed in Table 16 shows a slight decrease in ICI scores from the previous sampling year at all sites except RM 12.10. Although the majority of the sites saw a decrease in ICI scores, all sites with the exception of RM 10.75 were calculated to be in or given narrative ratings equivalent of attainment of the WWH ICI criterion.

Table 15. 2019 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
Downstream of Tinkers Creek	16.20*	--	--	--	15	--	<i>Exceptional</i>
Upstream of Mill Creek	12.10	44	11,279	50	38	3.93%	<i>Very Good</i>
Downstream of Mill Creek	11.30	30	5,591	47	11	19.91%	<i>Marginally Good</i>
Upstream of Southerly WWTC	10.75	26	10,217	41	11	26.60%	<i>Fair</i>
Downstream of Southerly WWTC	10.10*	--	--	--	12	--	<i>Good</i>
Upstream of Big Creek	8.60	32	13,047	49	9	24.22%	<i>Marginally Good</i>
Bold indicates attainment of WWH criterion of 34							
*Data and interpretation from qualitative sampling only							

For the sites in which HDs were not retrieved or identified, narrative ratings were assigned. Factors considered in the assignment of narrative ratings included, but were not limited to:

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historical data from the site, total site drainage area, macroinvertebrate population composition in the qualitative sample with respect to the number of total taxa, EPT taxa, pollution-sensitive taxa, pollution-tolerant taxa, and organism abundance within individual families or groups noted during sample collection.

Table 16. Cuyahoga River Historic ICI Scores								
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
2018	---	44	38	34	38	36	40	18
2019	---	---	44	30	26	---	32	---

Bold indicates attainment of WWH criterion of 34
Italics indicates non-significant departure (≤ 4 ICI units) from criterion
***Meets Exceptional WWH Criterion**

The HD installed at Cuyahoga River RM 16.20 was not identified due to an error in shipping. The qualitative sample was used to determine a narrative rating assignment of *Exceptional* for this site in 2019. Macroinvertebrate data collected at this site by the NEORS D over the previous three years were compared to the data from the 2019 qualitative sample. Table 17 shows the numbers of taxa, EPT taxa, sensitive taxa, and tolerant taxa in qualitative samples, as well as historical ICI scores and narrative ratings used to assign the 2019 narrative rating. ICI scores from 2016-2018 ranged from 44 to 46 (*Very Good* to *Exceptional*). The total number of qualitative taxa, EPT taxa, sensitive taxa, and tolerant taxa in 2019 were all within a single standard deviation of the averages from 2016-2018. The number of EPT taxa and sensitive taxa in the qualitative sample in 2019 were greater than or equal to the numbers collected in 2016 and 2017, years for which the site obtained a narrative rating of *Exceptional*. Therefore, the narrative rating of *Exceptional* was assigned to Cuyahoga River RM 16.20 in 2019.

Table 17. Cuyahoga River RM 16.20 Narrative Rating Assignment

Year	2019	2018	2017	2016	2016-2018 Average ± Standard Deviation
Total taxa (qual)	41	44	45	43	44 ± 1
EPT taxa (qual)	15	13	12	15	13 ± 2
Sensitive taxa (qual)	11	14	9	11	11 ± 3
Tolerant Taxa (qual)	4	3	7	8	6 ± 3
ICI Score	---	44	46	46	45 ± 1
Narrative Rating	Exceptional	Very Good	Exceptional	Exceptional	N/A

The HD installed at Cuyahoga River RM 12.10 was found with a few leaves on the front of the HD, partially blocking some flow. A high percentage of caddisflies and 14 dipteran taxa helped boost the ICI score at RM 12.10. Based on an ICI score of 44 and achieving WWH attainment, it does not appear that the leaves had an impact on the results. The HD installed at Cuyahoga River RM 11.30 was found in good condition during the qualitative sampling and HD removal. The HD was calculated to have an ICI score of 30. This was a decrease in ICI score when compared to 2018 results, but still within non-significant departure of the WWH criterion.

One of the most significant declines in ICI score was at RM 10.75. In 2018, the ICI score for this site was calculated at 38 (narratively *Very Good*). However, in 2019, RM 10.75 resulted in an ICI score of 26 (narratively *Fair*) and did not meet the WWH criterion. In 2019, the HD installed at Cuyahoga River RM 10.75 was found during qualitative sampling with sticks and leaves in the front block. This may have partially blocked flow through the HD and reduced the amount of surface area for macroinvertebrates to live resulting in a negative impact on the ICI score. High percentages of “Other diptera and non-insects” and “Tolerant organisms”, both with scores of zero, had a negative impact on the ICI score.

The HD installed at Cuyahoga River RM 10.10 was found to be missing at the time of qualitative sampling on September 23, 2019. Therefore, a narrative assessment was designated for this site based on data from qualitative sampling, and by utilizing the best professional judgment of the lead QDC. Macroinvertebrate data collected at this site by the NEORSD over the previous three years were compared to the data from the 2019 qualitative sample. Table 18 shows the numbers of taxa, EPT taxa, sensitive taxa, and tolerant taxa, in qualitative samples as well as historical ICI scores and narrative ratings used to assign the 2019 narrative rating. ICI scores from 2016-2018 ranged from 36 to 38 (*Good*). The total number of qualitative taxa, EPT taxa, and tolerant taxa in 2019 were all within a single standard deviation of the averages from 2016-2018. The number of EPT taxa and sensitive taxa in the qualitative sample were improved in 2019 compared to the previous three years. At the time of sample collection, the lead QDC assigned a field narrative rating assessment of *Good* to the site, based partially on the relative abundance of EPT and sensitive taxa observed at the site during sample collection. This field narrative rating agrees with the comparison of the 2019 qualitative data to qualitative data from previous years for which the ICI score had been calculated. Therefore, a narrative rating of *Good* was assigned to Cuyahoga River RM 10.10 in 2019.

Table 18. Cuyahoga River RM 10.10 Narrative Rating Assignment					
Year	2019	2018	2017	2016	2016-2018 Average ± Standard Deviation
Total Taxa (qual)	36	30	46	40	39 ± 8
EPT Taxa (qual)	12	8	11	10	10 ± 2
Sensitive Taxa (qual)	9	7	7	7	7 ± 0
Tolerant Taxa (qual)	7	4	12	10	9 ± 4
ICI Score	N/A	36	38	38	38 ± 1
Narrative Rating	Good	Good	Good	Good	N/A

The HD installed at Cuyahoga River RM 8.60 was found to be in good condition during the time of qualitative sampling. Although there was a decrease in ICI score of 40 in 2018, to 32 in 2019, RM 8.60 was still within non-significant departure of the WWH criterion. Large percentages of “other diptera and non-insects” and “tolerant organisms” did not help improve the ICI score at RM 8.60 in 2019.

Overall, ICI scores in 2019 were slightly lower compared to previous years, yet still meeting the ICI WWH criterion at all sample sites except RM 10.75. In prior sampling seasons like 2016, it was thought that this decline may have been due to a lack of overall rainfall. The five year average for rainfall during the HD colonization period was 3.4 inches. The 2019 colonization period received 3.1 inches of rain, while 2016 received 2.9 inches of rain. 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 overall reduction in ICI scores from 2018 suggests that the 2019 sampling season may have been affected by an anomaly such as weather as opposed to a true indication of water quality.

Conclusions

For the 2019 sampling season, two of the six Cuyahoga River sites were in full attainment of the aquatic life criterion (Table 19). A full bioassessment (fish, macroinvertebrate, and water chemistry) was conducted on four of the six Cuyahoga River sites in 2019. RM 16.20 was not assessed for fish and no quantitative macroinvertebrate community score was calculated due to a missing HD. A qualitative macroinvertebrate sample and water chemistry sampling were conducted at RM 16.20. The 2017 fish community biology scores at RM 16.20 were shown to meet the IBI WWH criterion, suggesting that if this site was assessed for fish community biology in 2019, it would likely achieve full WWH attainment. No ICI score for RM 10.10 was calculated due to a missing HD in 2019; however, a qualitative sample was collected. Results based on the qualitative sample indicated that RM 10.10 would likely achieve full WWH attainment if a quantitative sample had occurred.

As in years past, assessments in 2019 showed water quality impairments at all sites which may be preventing the establishment of a healthier biological community. Following significant rainfall events, significant Water Quality Standards exceedances for *E. coli* densities may be

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attributable to combined sewer overflows and urban runoff, as well as other sources. 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 effluent discharge and did not increase downstream. All mercury results in 2019 were below the method detection limit. Because the detection limit for EPA Method 245.1 is above the criteria for the Human Health Non-Drinking and Protection of Wildlife OMZAs, it cannot be determined if the sites were in attainment of those criteria.

Overall, monitoring of the Cuyahoga River since the 1990s has shown improvements in water quality over time. Fewer water quality exceedances are being observed and overall biological assessments have shown increased scores. While some water quality parameters may still be contributing to impairments in the river, the overall health of the sites sampled in 2019 has greatly improved since sampling first began. The Route 82 dam was removed in July 2020. The removal of this dam will eliminate a fish passage barrier and improve the water quality of the river by restoring it to its natural and free flowing state. Although the removal of this dam may have contributed to increased sediment loading downstream during construction, the dam removal will likely result in improvements to water quality and biological communities in the long term. Future monitoring is recommended to track these and other changes to the health of the river.

Table 19. 2019 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	--	--	--	-- (Exceptional)	80.00 (Excellent)	<i>E. coli</i> , Mercury,
12.10/11.95	PARTIAL	33 (Fair)	8.1 (Fair)	44 (Very Good)	76.50 (Excellent)	<i>E. coli</i> , Mercury,
11.30	FULL	40 (Good)	9.4 (Very Good)	30 (Marginally Good)	77.25 (Excellent)	<i>E. coli</i> , Mercury,
10.75	PARTIAL	32 (Fair)	9.3 (Very Good)	26 (Fair)	85.00 (Excellent)	<i>E. coli</i> , Mercury,
10.10	FULL**	41 (Good)	9.3 (Very Good)	-- (Good)	87.25 (Excellent)	<i>E. coli</i> , Mercury,
8.60	PARTIAL	32 (Fair)	9.7 (Exceptional)	32 (Marginally Good)	78.0 (Excellent)	<i>E. coli</i> , Mercury,
7.00	--	--	--	--	--	<i>E. coli</i> , Mercury,

WWH biocriteria 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
 **Based on macroinvertebrate qualitative narrative

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