Northeast Ohio
Regional Sewer District

2020 Cuyahoga River
Biological, Water Quality, and Habitat Study

Water Quality and Industrial Surveillance

Environmental Assessment Group

March 2021

Table of Contents

List of Figures

List of Tables

Introduction

The Cuyahoga River is located in Northeast Ohio, flowing through the major cities of Akron and Cleveland before its final confluence with Lake Erie. In 2020, 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 2020 sampling season, five stream locations were evaluated from river mile (RM) 13.15 downstream to RM 8.60.

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 *2020 Cuyahoga River Environmental Monitoring* approved by Ohio EPA on June 15, 2020. All sampling and environmental assessments occurred between June 15, 2020 and September 30, 2020 (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* (2019) and compared to the Ohio Water Quality Standards for their designated use to determine attainment (Ohio EPA, 2020). 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 2020 according to the 2020 Integrated Water Quality Monitoring and Assessment Report (Ohio EPA, 2020). Despite this, historically 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. Cuyahoga River Sampling Locations

Table 1. Cuyahoga River Sampling Locations					
Location	Latitude	Longitude	River Mile	Station ID	Sampling Conducted
Upstream of Rockside Road and confluence with Mill Creek	41.3929	-81.6295	13.15	502020	F, M, C
Downstream of confluence with Mill Creek	41.4179	-81.6446	11.30	F01S10	F, M, C
Upstream of Southerly WWTC effluent discharge	41.4196	-81.6547	10.75	F01A25	F, M, C
Downstream of Southerly WWTC effluent discharge	41.4242	-81.6638	10.10	F99Q02	F, M, C
Downstream of Southerly WWTC effluent discharge	41.4381	-81.6680	8.60	200025	F, M, C

Water Chemistry and Bacteriological Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times on the Cuyahoga River between June 17 and July 15, 2020, at the five 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* (2019). 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).

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, 2019).

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 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. Dates of water chemistry sampling compared to Cuyahoga River flow data (USGS 04208000) are shown below in Figure 2.

Results and Discussion

Over the course of five sampling events in 2020, two field blanks and two duplicate samples were collected as part of this study. Parameters that showed possible contamination in the field blanks included cadmium, chromium, cobalt, COD, lead, silver and zinc. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, and/or contaminated blank water. Most of this data is still considered Level 3, but the COD data from July 7, 2020, was downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol.

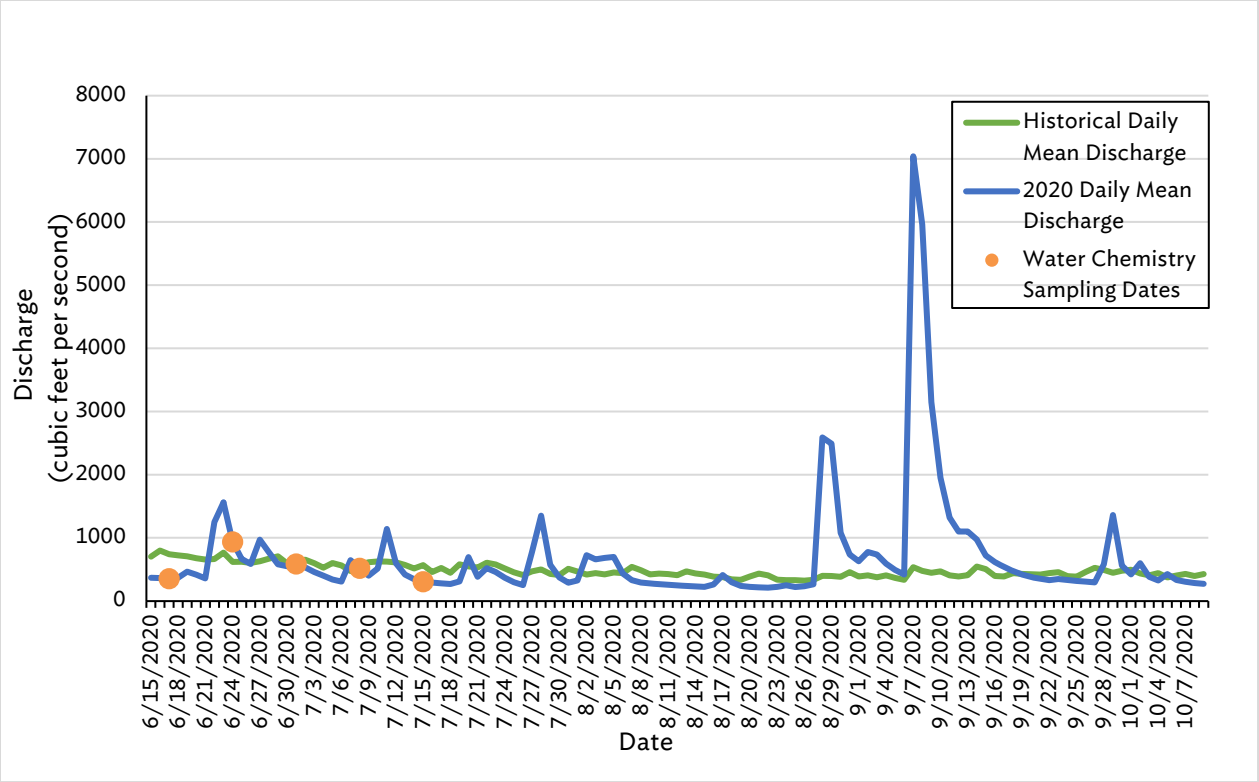

Figure 2. Daily mean discharge in cubic feet per second for the Cuyahoga River at USGS Station 0420800. Shown are the daily mean discharge for 2020 and the historical daily means. Orange circles indicate water chemistry sampling dates.

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 13.15	06/24/2020	Titanium	26.4	33.5
RM 11.30	06/17/2020	Nickel	32.6	70.3

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.

The Cuyahoga River sites sampled in 2020 are designated as a warmwater habitat (WWH) and primary contact recreation according to the Ohio EPA Water Quality Standards (2020). Exceedances of the recreational bacteriological criteria for primary contact recreation occurred at

all five sites during the 2020 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 five sites for the 90-day periods beginning on June 17, 2020 (Table 3). These exceedances may be due to significant wet-weather events* which occurred on two 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).

Table 3. 2020 Cuyahoga River *E. coli* Densities (MPN/100mL)

Date	RM 13.15	RM 11.30	RM10.75	RM 10.10	RM 8.60
6/17/2020	88	91	106	126	102
6/24/2020*	1010	1482	1280	1263	1552
7/1/2020	148	186	130	228	124
7/8/2020*	4900	4150	8750	7300	3550
7/15/2020	99	180	284	128	135
90-day Geomean	363.9	451.4	535.0	508.2	393.3

Exceeds statistical threshold value of 410 MPN/100mL

Exceeds geometric mean criterion for 90-day period of 126 MPN/100mL

*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 2020 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, industrial wastewater discharge, 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 mi^2 drainage area). The proposed eutrophication standard, shown in Table 4, will establish standards based on sestonic chlorophyll, 5-day biochemical 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, 2018c).

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 the five sample locations during the five water chemistry sampling events in 2020. 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, two of these events were taken during or after wet-weather events (see Table 3 for wet-weather dates). TKN seasonal geomean levels at RM 13.15 (Table 5) exceeded the "over-enriched, acute condition" criterion for the proposed eutrophication standards. All five sites met the proposed target for total phosphorus of less than 0.130 mg/L.

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

Indicator	Acceptable	Enriched or Over Enriched Chronic Condition	Over Enriched Acute Condition
Sestonic Chlorophyll	<30 μg/L as seasonal average	<u>Magnitude</u> 30<100μg/L seasonal average with biological impairment <u>Frequency</u> ≥ 30 μg/L < 100μg/L as seasonal average in two of three years	<u>Magnitude</u> ≥ 100μg/L anytime with biological impairment <u>Frequency</u> ≥ 100μg/L multiple observations at base flow
BOD5	<2.5 mg/L as seasonal average	<u>Magnitude</u> ≥ 2.5mg/L < 6mg/L seasonal average with biological impairment <u>Frequency</u> ≥ 2.5mg/L < 6mg/L seasonal average in two of three years	<u>Magnitude</u> ≥ 6mg/L anytime with biological impairment and seasonal average chlorophyll ≥ 30μg/L <u>Frequency</u> ≥ 6mg/L two or more times during the base flow period
24-hour D.O. Range	<6.5 mg/L	≥ 7mg/L - 9mg/L (default to chlorophyll, BOD5 and biological indicators)	<u>Magnitude and Frequency</u> ≥ 9.0mg/L anytime with biological impairment

Table 4. Ohio EPA Proposed Eutrophication Standards for Ohio's Large Rivers			
Indicator	Acceptable	Enriched or Over Enriched Chronic Condition	Over Enriched Acute Condition
TKN	N/A	N/A	≥ 0.75mg/L may substitute for BOD5
TSS		~ 20mg/L; general screening level of inspection of data sets lacking chlorophyll observations.	

Table 5. 2020 Cuyahoga River Nutrient Analysis (Geomean)					
River Mile	**13.15**	**11.30**	**10.75**	**10.10**	**8.60**
TKN (mg/L)	0.772	0.723	0.736	0.744	0.638
DRP (mg/L)	0.029	0.029	0.028	0.061	0.057
TP (mg/L)	0.081	0.089	0.088	0.125	0.125
TSS (mg/L)	26.6	30.2	29.2	25.5	28.8
BOD (mg/L)	<2.2	<2.2	<2.2	<2.4	<2.2
Over-enriched - acute condition					

The increased phosphorus levels downstream of RM 10.75 are likely due to the discharge of treated wastewater from the NEORSD Southerly Wastewater Treatment Center (WWTC) at RM 10.57. Southerly WWTC is subject to the National Pollutant Discharge Elimination System (NPDES) permit number 3PF00002*OD, 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. Despite this NPDES permit limit well above the proposed total phosphorus target level, the phosphorus levels downstream of Southerly WWTC were not in acute condition at the time of sampling.

Land Cover Analysis

A land cover analysis was performed on the Cuyahoga River watershed. The United States Geologic Survey StreamStats Program (U.S. Geological Survey, 2012) was used to obtain a watershed polygon representing the Cuyahoga River wat ershed. The corresponding watershed polygon was then imported into ArcMap 10.3 and the intersect tool was used to combine the watershed with the 2016 National Land Cover Database (Homer et.al, 2016). The resulting figure represented the different types of land cover that drain to the Cuyahoga River. The entire Cuyahoga River watershed is presented in Figure 3. An analysis of the drainage specific to each of the sites monitored in 2020 was also conducted. Similar land cover types were combined, and the percentages of each land cover type were then calculated (Figure 4).

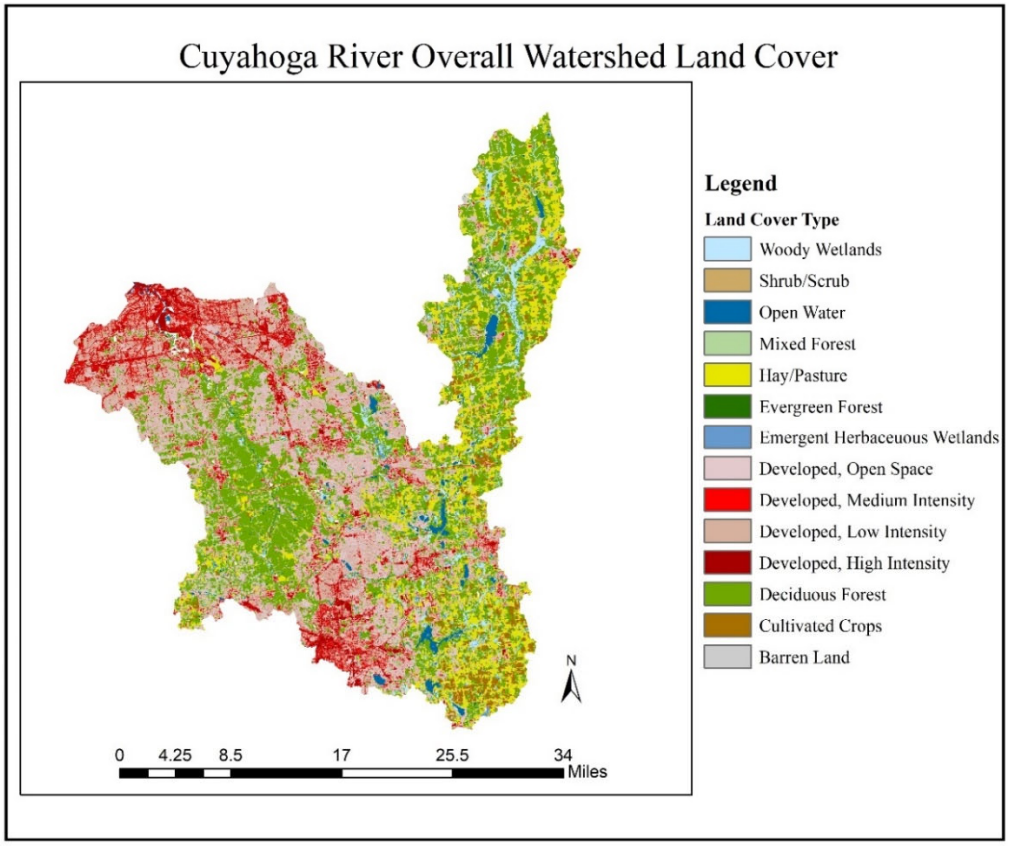

Figure 3. Cuyahoga River Watershed Land Cover Map

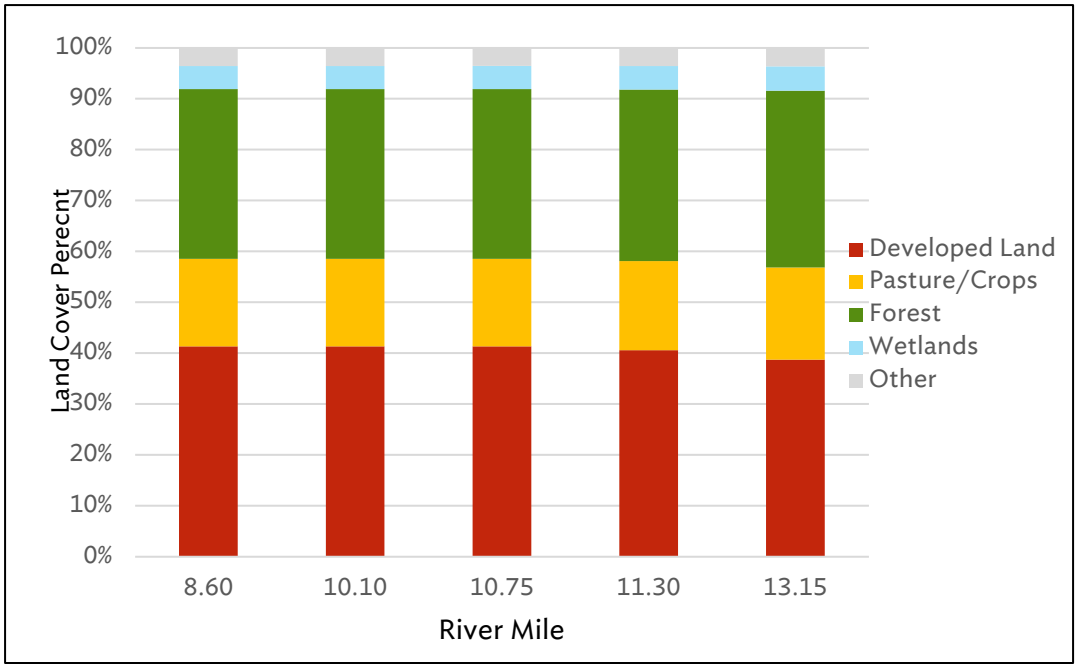

Figure 4. Percentage of land cover types draining to each of the sites monitored in 2020

The Cuyahoga River watershed contains a highly developed landscape as it flows through the major cities of Akron and Cleveland. Among the sites visited in 2020 approximately forty percent of the land draining to the sites is developed, with the most upstream site, RM 13.15, having only a slightly lower percentage of developed land when compared to all other sites. 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 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 13.15 to RM 8.60 in 2020 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 NEORSD WQIS Division.

Results and Discussion

All sites assessed in 2020, exceeded Ohio EPA's target of 60 and, therefore, should be capable of supporting a WWH fish assemblage (Figure 5). Four of the five sites scored ≥ 75 which resulted in a narrative rating of *Excellent*.

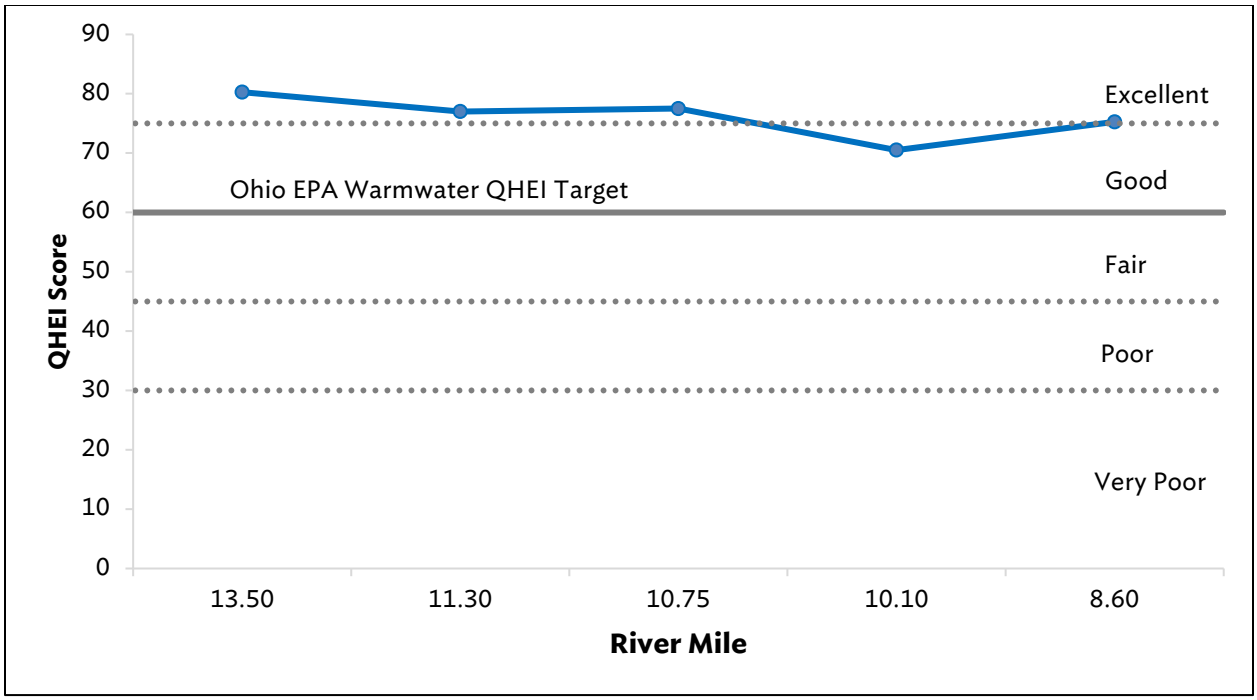

Figure 5. QHEI Scores for each site monitored in 2020

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 2020, displayed the WWH characteristics of either having never been channelized or have recovered from channelization, moderate to high sinuosity, extensive to moderate cover, fast current/eddies, and exhibited maximum depths greater than 40 cm as shown in Table 6. Comparing QHEI scores to the previous year, there were slight variations between 2019 and 2020; however, all sites sampled in both years maintained the same narrative ratings. In recent years, QHEI scores at all river miles have consistently met most WWH attributes. In 2020, there were only two high influence attributes across all sampled sites. Based on this information, habitat does not appear to be a limiting factor to fish communities living within this portion of the Cuyahoga River system.

Table 6. 2020 Cuyahoga River QHEI Scores and Physical Attributes

			WWH Attributes											**MWH Attributes**																				
														High Influence						Moderate Influence																
River Mile	**QHEI Score**	**Habitat Rating**	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max. Depth >40 cm	Low-Normal Riffle Embeddedness	**Total WWH Attributes**	Channelized or no Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW sites)	**Total High Influence Attributes**	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	**Total Moderate Influence Attributes**
13.15	80.25	*Excellent*	X	X		X	X	X	X	X	X		**8**						**0**		X	X		X					X	X		**5**
11.30	77.00	*Excellent*	X	X		X	X	X	X	X	X	X	**9**				X		**1**		X	X							X	X		**4**
10.75	77.50	*Excellent*	X	X		X	X	X	X		X		**7**						**0**		X	X							X	X		**4**
10.10	70.50	*Good*	X				X	X	X	X	X	X	**7**						**0**	X	X	X		X	X				X	X		**7**
8.60	75.25	*Excellent*	X	X		X	X	X	X		X		**7**				X		**1**		X	X							X	X		**4**

Fish Community Biology Assessment

Methods

Two quantitative electrofishing passes were conducted at each site in 2020. 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.

Table 7. Sampling Dates and River Flows

Date	Sites sampled (RMs)	Daily Mean Flow (CFS)
6/18/2020	13.15	369
7/17/2020	11.30	279
08/13/2020	10.75, 10.10, 8.60	238
09/22/2020	10.75, 10.10, 8.60	331
09/23/2020	11.30, 13.15	347

The electrofishing results were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices. The first index, the Index of Biotic Integrity (IBI), incorporates twelve community metrics representing structural and functional attributes (Table 8). The structural attributes are based upon fish community aspects such as fish abundance and diversity. The 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*.

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

Table 8. IBI Metrics (Boat Sites)
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

The second fish index used by the Ohio EPA is the Modified Index of Well-being (MIwb). The MIwb (calculated using Formula 1 below) incorporates four fish community measures: numbers of individuals, biomass, the Shannon Diversity Index ($\overline{H}$) (Formula 2 below) based on sample numbers, and the Shannon Diversity Index ($\overline{H}$) based on sample weights.

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

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 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 2020 IBI and MIwb scores from each assessment location are listed below in Table 10. For the IBI, no sites were found to be in attainment of the warmwater habitat criterion. For the MIwb, three sites were calculated to be in attainment of the warmwater habitat criterion, and two were calculated to be within non-significant departure of WWH criterion (Table 10).

Table 10. 2020 Cuyahoga River IBI and MIwb Results

Location	River Mile	IBI (Narrative)	MIwb (Narrative)
Upstream of Mill Creek	13.15	32 (Fair)	**8.9 (Good)**
Downstream of Mill Creek	11.30	33 (Fair)	*8.6 (Marginally Good)*
Upstream from Southerly WWTC	10.75	35 (Fair)	**9.2 (Very Good)**
Downstream from Southerly WWTC	10.10	35 (Fair)	**9.4 (Very Good)**
Upstream from Big Creek	8.60	28 (Fair)	*8.5 (Marginally Good)*

Bold = meets WWH criterion [IBI ≥40; MIwb ≥8.7]
Italics = non-significant departure from WWH criterion [IBI ≥36; MIwb ≥8.2]

During the 2020 sampling season, all five sites assessed for fish community biology resulted in a narrative rating of *Fair*, failing to meet the WWH IBI criterion of 40 (Table 11). Of the four sites that were sampled in both 2019 and 2020, RMs 11.30, 10.10, and 8.60 scored lower in 2020, while RM 10.75 saw a score increase. All sites received a QHEI score greater than 60, indicating that habitat is not a limiting factor in the fish community attaining the warmwater habitat criterion (Ohio EPA, 2006).

Individual metrics in the IBI were examined to determine specific components of the fish community that increased/decreased from the previous year. The score decrease at RM 11.30 was due to a decrease in the relative number of insectivore and top carnivore species. RM 10.10 saw a score decrease due to the presence of fewer pollution-intolerant species and fewer insectivorous species, with an increase in the relative number of omnivorous species. The score at RM 8.60 was negatively impacted by the absence of intolerant species as well as a decrease in the number of native species. Additionally, all five sites received a metric score of 1 (the minimum score) for the proportion of round-bodied suckers collected. Round-bodied suckers are known to be intolerant of highly turbid waters and siltation (Ohio EPA 1987a).

All five sites also received the lowest score for pollution-intolerant species, with no site having more than one intolerant species collected. The three sites where they were found, however, did have unique intolerant species collected, with the rosyface shiner (*Notropis rubellus*) present at RM 13.15, the stonecat madtom (*Noturus flavus*) present at RM 10.75, and the mimic shiner (*Notropis volucellus*) present at RM 11.30.

The presence of one species, the Eastern gizzard shad (*Dorosoma cepedianum*), may have also affected the score calculations at some of the sites monitored in 2020. In some instances, it may be appropriate to exclude this species from sample results. As the season progresses, more gizzard shad migrate into the river from Lake Erie due to its warmer temperatures. This influx may skew results because of the large number of these fish that come into the river but that do not actually reside there. The presence of large numbers of gizzard shad among the collected samples may explain some of the yearly variations in IBI scores.

Overall, the IBI scores averaged slightly lower than scores for 2019. Table 11 shows the historic scores for sites sampled along the Cuyahoga as part of the NEORSD Cuyahoga River Environmental Monitoring, and Figure 6 shows the historic scores of the sites monitored in 2020.

Table 11. Cuyahoga River Historic IBI Scores (1990-2020)

Year	RM 20.75	RM 16.20	RM 13.15	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	-
2020	-	-	32	-	33	35	35	28	-
	Bold = meets WWH criterion [≥40] *Italics = non-significant departure from WWH criterion [≥36]* *Meets Exceptional WWH Criterion								

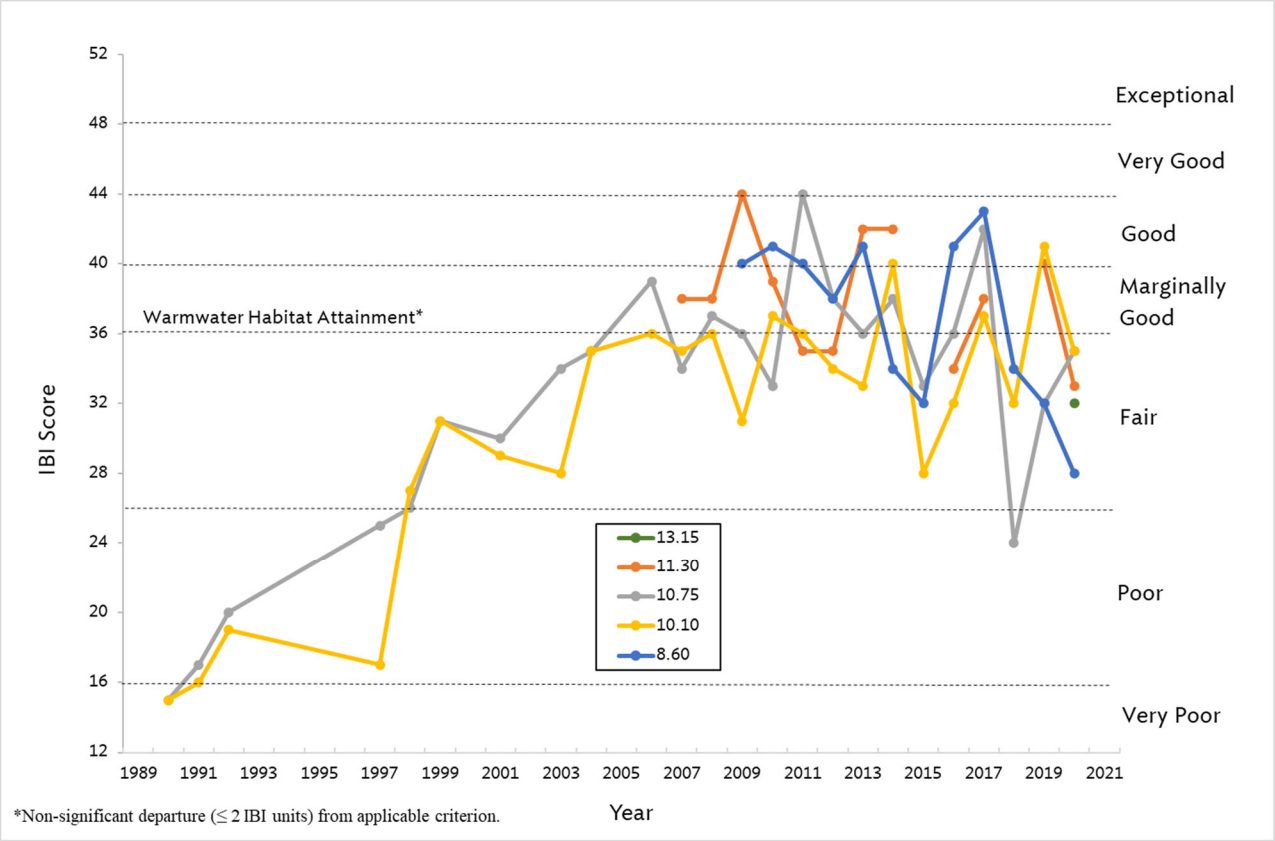

Figure 6. Historic IBI Scores of sites monitored in 2020

There was some variation in MIwb scores from 2019 and 2020, with a slight score decrease for RM 11.30, and a more significant score decrease at RM 8.60 from *Exceptional* to *Marginally Good*. This is likely due to lower diversity indices in 2020 contributing to the calculation of the MIwb. Table 12 shows the MIwb scores at various Cuyahoga River sites sampled over the last three decades, and Figure 7 shows historic MIwb scores for the sites monitored in 2020, indicating a general trend of score increases towards attainment of WWH criterion.

Table 12. Cuyahoga River Historic MIwb Scores (1990-2020)

Year	RM 20.75	RM 16.20	RM 13.15	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

Table 12. Cuyahoga River Historic MIwb Scores (1990-2020)									
Year	RM 20.75	RM 16.20	RM 13.15	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
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*
2018	-	-	-	-	-	**8.9**	**9.5**	**8.7**	*8.5*
2019	-	-	-	8.1	**9.4**	**9.3**	**9.3**	**9.7***	-
2020	-	-	**8.9**	-	*8.6*	**9.2**	**9.4**	*8.5*	-
	Bold = meets WWH criterion [≥8.7] *Italics = non-significant departure from WWH criterion [≥8.2]* ***Meets Exceptional WWH Criterion**								

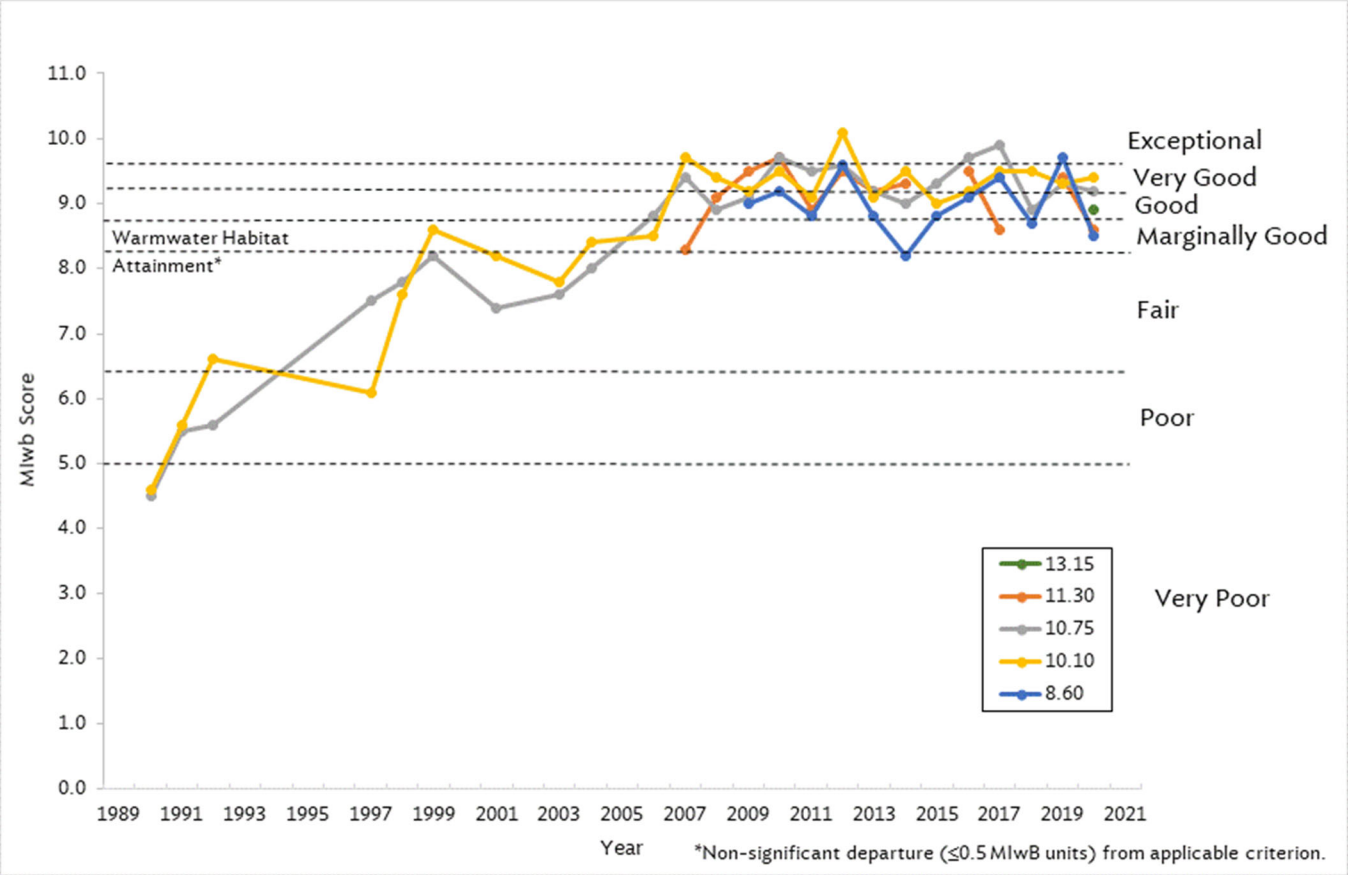

Figure 7. Historic MIwb Scores of sites monitored in 2020

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 Third Rock Consultants, LLC 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

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 2020 sampling season, all five sampling sites met the WWH criterion (Table 15), with three of the five attaining the highest narrative rating of *Exceptional*. Temporal data displayed in Table 16 shows an increase in ICI scores from the previous sampling year at all sites, with a significant increase at RM 10.75 from 26 (narratively *Fair*) in 2019 to 46 (narratively *Exceptional*) in 2020. Figure 8 shows the historic ICI scores for sites monitored in 2020.

Table 15. 2020 Cuyahoga River Macroinvertebrate Results

Location	River Mile	ICI Score	Total Number of Taxa	Number of Qualitative EPT Taxa	% Tolerant (as defined)	Narrative Rating
Upstream of Mill Creek	13.15	**52**	41	15	0.5	**Exceptional**
Downstream of Mill Creek	11.30	**40**	40	14	4.5	**Good**
Upstream of Southerly WWTC	10.75	**46**	50	16	3.5	**Exceptional**
Downstream of Southerly WWTC	10.10	**40**	44	13	6.8	**Good**
Upstream of Big Creek	8.60	**48**	41	16	3.7	**Exceptional**

Bold indicates attainment of WWH criterion of ≥ 34

Table 16. Cuyahoga River Historic ICI Scores

Year	RM 20.75	RM 16.20	RM 13.15	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*	---
2020	---	**---**	**52***	**--**	**40**	**46***	**40**	**48***	---

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

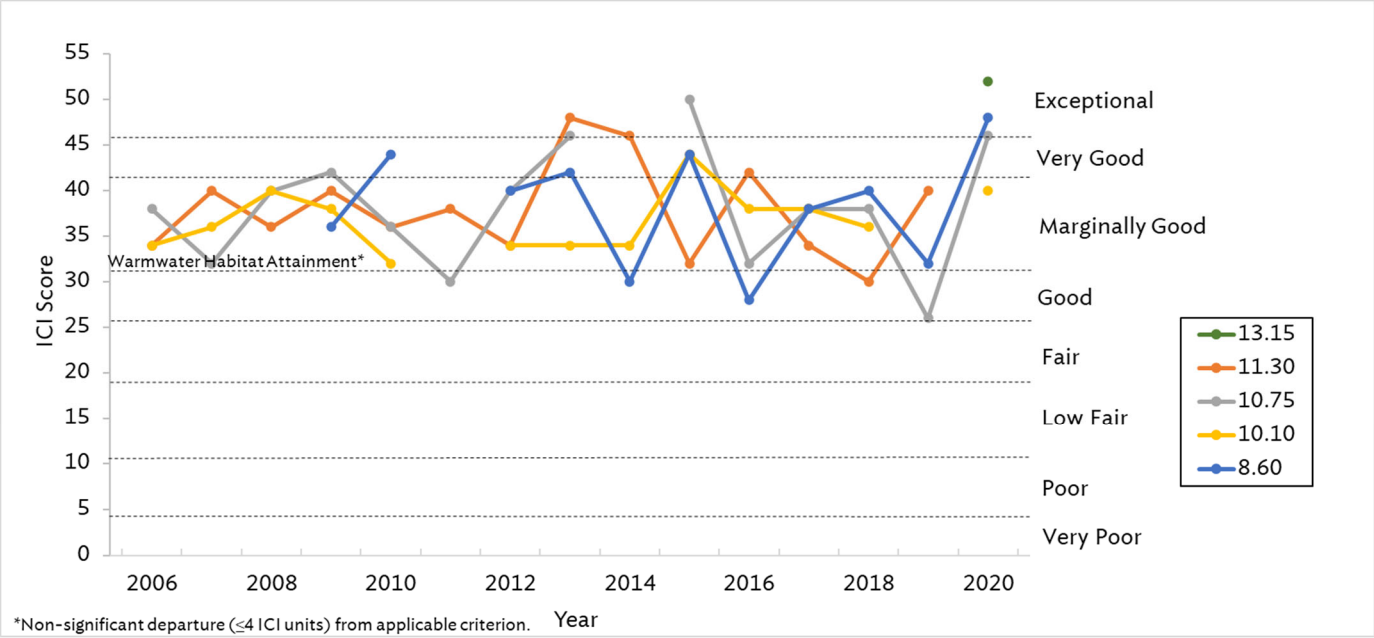

Figure 8. Historic ICI scores of sites monitored in 2020

The significant score increase at RM 10.75 was likely due to a combination of factors. In 2019, the HD was found to be partially obstructed by debris at the time of collection, which may have resulted in lower recruitment of macroinvertebrates to the artificial substrate that year. Moreover, the 2020 assessment revealed a substantially lower percentage of organisms in the "other diptera and non-insects" metric, as well as a decrease in the percentage of pollution-tolerant taxa. The large presence of caddisfly larva and the overall number of taxa also contributed to the attainment of the *Exceptional* score for 2020.

The newest site at RM 13.15 had the highest of the ICI scores at 52 (narratively *Exceptional*). Particularly contributing to this high score was having highest number of mayfly taxa of all the sites as well as having less than one percent of the organisms collected classified as pollution tolerant. Additionally, a large percentage of caddisfly species and low percentage of "other diptera and non-insects" lead to the highest ICI score attained during NEORSD sampling on the Cuyahoga River to date.

There was also a substantial ICI score increase at RM 8.60, reaching its highest ICI score of 48, and a narrative rating of *Exceptional* for the first time since NEORSD monitoring. This was the largest score increase for this site since 2015. Driving this increase was a high percentage of caddisflies and significantly lower percentages of pollution-tolerant organisms and "other dipterans and non-insects" for which it received the lowest score in 2019. Figure 9 shows the breakdown of the composition of the macroinvertebrate community at each site.

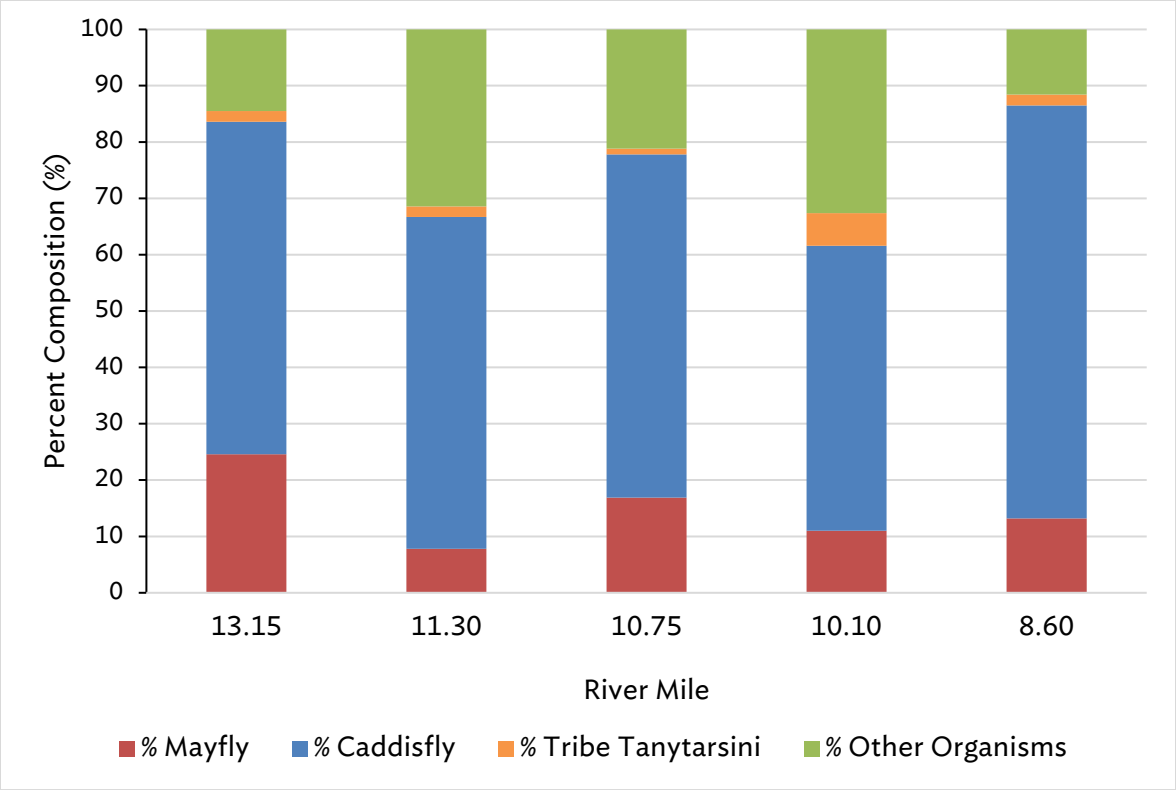

Figure 9. 2020 Cuyahoga River Macroinvertebrate Community Composition

The ICI scores were not only increased at all five sites, but for RM 10.10, it was the highest score attained since 2008, and the highest score ever attained for RM 8.60. One factor that was identified for the lower scores in previous years was reduced rainfall, with a past five-year average of 3.4 inches during the HD colonization period. In 2020, nearly double the amount of rain fell within that same window, with a recorded 6.3 inches of rain between the date of HD installation and the date of retrieval. This undoubtedly contributed to faster flows, preventing the buildup of silt and sediment around the HDs and increasing recruitment. While the QHEI assessments did indicate moderately silted substrates at all sites which may have impacted the fish indices, the habitat and fish assessments were conducted early in the recruitment period or after the HDs had been collected, so it is possible that the seasonal timing of rain and silt deposition in relation to sampling can impact scores. Thus, it was not an increase in habitat quality that drove the uptick in ICI scores, but more likely hydrological conditions that were more conducive to recruitment of macroinvertebrates at the time of collection.

Conclusions

For the 2020 sampling season, all five sites were in partial attainment of the aquatic life criterion (Table 17). All five sites met the WWH target for QHEI and criterion for ICI and met or were within non-significant departure for the MIwb criterion, while failing to meet the WWH criterion for IBI.

As in years past, assessments in 2020 showed water quality impairments at all sites which may be preventing the establishment of a healthier biological community. Following significant rainfall events, Water Quality Standards exceedances for *E. coli* densities may be attributable to combined sewer overflows and urban runoff. 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 2020 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 2020 has greatly improved since sampling first began. An additional improvement to the Cuyahoga River was the removal of the Route 82 dam in July of 2020. The removal of this dam will eliminate a fish passage barrier and improve water quality by restoring the river to its natural and free flowing state. Future monitoring is recommended to track these and other changes to the health of the river.

Table 17. 2020 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
13.15	PARTIAL	32 *(Fair)*	**8.9 *(Good)***	**52 *(Exceptional)***	80.25 *(Excellent)*	*E. coli*, Mercury,
11.30	PARTIAL	33 *(Fair)*	*8.6 (Marginally Good)*	**40 *(Good)***	77 *(Excellent)*	*E. coli*, Mercury,
10.75	PARTIAL	35 *(Fair)*	**9.2 *(Very Good)***	**46 *(Exceptional)***	77.5 *(Excellent)*	*E. coli*, Mercury,
10.10	PARTIAL	35 *(Fair)*	**9.4 *(Very Good)***	**40 *(Good)***	70.5 *(Good)*	*E. coli*, Mercury,
8.60	PARTIAL	28 *(Fair)*	*8.5 (Marginally Good)*	**48 *(Exceptional)***	75.25 *(Excellent)*	*E. coli*, 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

Acknowledgments

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

Daniel Neelon, Author
Hannah Boesinger
Kevin Fitzgibbons
Joseph Schiel
Mark Matteson
Eric Soehnlen
Justin Telep
Lindsay Baker
William Stanford
Donna Friedman
Seth Hothem
John W. Rhoades
Analytical Services Division – Completed analysis for all water chemistry sampling

References

Homer, Collin G., Dewitz, Jon A., Jin, Suming, Xian, George, Costello, C., Danielson, Patrick, Gass, L., Funk, M., Wickham, J., Stehman, S., Auch, Roger F., Riitters, K. H., Conterminous United States land cover change patterns 2001–2016 from the 2016 National Land Cover Database: ISPRS Journal of Photogrammetry and Remote Sensing, v. 162, p. 184–199, at https://doi.org/10.1016/j.isprsjprs.2020.02.019

Miltner, Robert J. (2017). Eutrophication Endpoints for Large Rivers in Ohio, USA. Springer International Publishing AG.

Ohio Environmental Protection Agency. (1987a). *Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters* (Updated January 1988; September 1989; November 2006; August 2008). Columbus, OH: Division of Water Quality Monitoring and Assessment.

Ohio Environmental Protection Agency. (1987b). *Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities* (Updated September 1989; March 2001; November 2006; and August 2008). Columbus, OH: Division of Water Quality Monitoring and Assessment.

Ohio Environmental Protection Agency. (1999). *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (MAS/1999-1-1). Columbus, OH: Division of Surface Water.

Ohio Environmental Protection Agency. (2003). Total Maximum Daily Loads for the Lower Cuyahoga River. Ohio EPA, Division of Surface Water. Water Standards and Technical Support Section.

Ohio Environmental Protection Agency. (2006). *Methods for assessing habitat in flowing waters: using the Qualitative Habitat Evaluation Index (QHEI)*. (Ohio EPA Technical Bulletin EAS/2006-06-1). Columbus, OH: Division of Surface Water; Division of Ecological Assessment Section.

Ohio Environmental Protection Agency. (2019. *Surface Water Field Sampling Manual for water quality parameters and flows*. Columbus, Ohio: Division of Surface Water.

Ohio Environmental Protection Agency. (2018c). *Early Stakeholder Outreach – Nutrient Water Quality Standards for Ohio's Large Rivers (OAC 3745-1-36)*. Division of Surface Water.

Ohio Environmental Protection Agency (2020). *Ohio 2020 Integrated Water Quality Monitoring and Assessment Report*. Division of Surface Water

Ohio Environmental Protection Agency. (2020). *State of Ohio Water Quality Standards Ohio Administrative Code Chapter 3745-1* Columbus, OH: Division of Surface Water, Standards and Technical Support Section.

Rankin, E.T. (1995). Habitat indices in water resource quality assessments. In W.S. Davis and T. Simon (eds.). *Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making* (pp. 181-208). Boca Raton, FL: Lewis Publishers.

U.S. Geological Survey (2012). *The StreamStats program for Ohio*, online at https://water.usgs.gov/osw/streamstats/ohio.html