NORTHEAST OHIO REGIONAL SEWER DISTRICT

2015 Cuyahoga River Environmental Monitoring

Prepared by
Water Quality and Industrial Surveillance Division

Introduction

In 2015, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys in the lower Cuyahoga River. Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by Ohio Environmental Protection Agency (EPA) in Fish Community and Benthic Macroinvertebrate Biology, and Chemical Water Quality and Stream Habitat Assessments as explained in the NEORSD study plan *2015 Cuyahoga River Environmental Monitoring* approved by Ohio EPA on June 17, 2015.

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

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

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

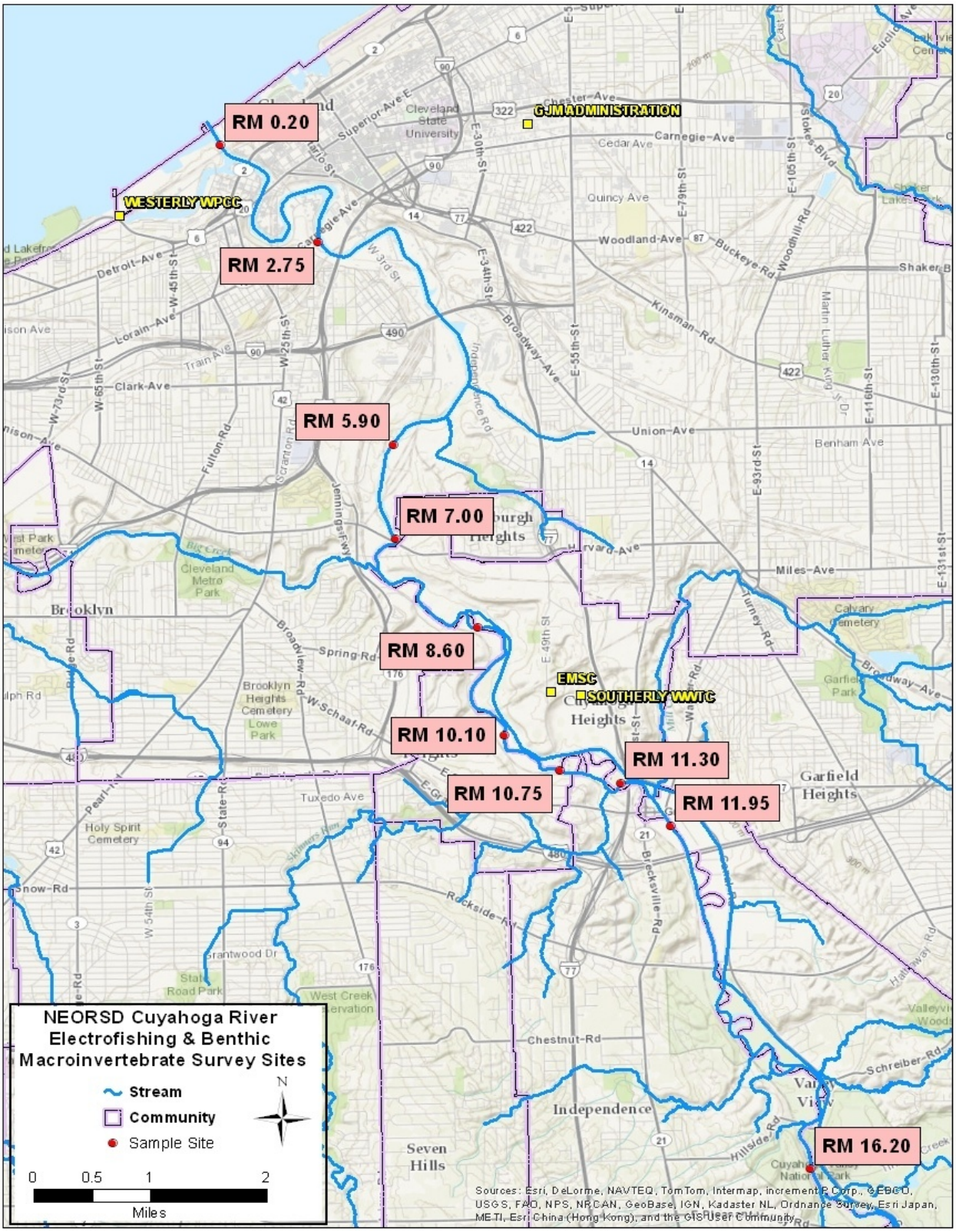


Figure 1. Sampling Locations

Table 1. Sample Locations					
Location	Latitude	Longitude	River Mile	Description	Purpose
Downstream of Tinkers Creek	41.3678	-81.6139	16.20	Downstream of the confluence with Tinkers Creek near Old Riverview Road	Background data for fish, habitat, macroinvertebrates.
Upstream of Mill Creek	41.4123 41.4101	-81.6364 -81.6346	12.10[a] 11.95	Upstream of the confluence with Mill Creek (I-480)	Evaluate Mill Creek discharge on fish, habitat and macroinvertebrates.
Downstream of Mill Creek	41.4179	-81.6446	11.30	Downstream of the confluence with Mill Creek	Evaluate Mill and West Creek discharges on fish, habitat and macroinvertebrates.
Upstream of Southerly WWTC	41.4196	-81.6547	10.75	Upstream of Southerly WWTC effluent discharge	Evaluate West Creek and Southerly WWTC discharges on fish, habitat and macroinvertebrates.
Downstream of Southerly WWTC	41.4242	-81.6638	10.10	Downstream of Southerly WWTC effluent discharge	Evaluate Southerly WWTC discharge on fish, habitat, macroinvertebrates.
Upstream of Big Creek	41.4381	-81.6680	8.60	Upstream of the confluence with Big Creek	Evaluate Big Creek discharge on fish, habitat and macroinvertebrates.
Downstream of Big Creek	41.4497	-81.6815	7.00	Downstream of the confluence with Big Creek/ Upstream of habitat restoration project	Evaluate Big Creek discharge on fish, habitat and macroinvertebrates and effectiveness of habitat restoration in navigation channel on fish.
Head of Navigation Channel	41.4619	-81.6816	5.90	Head of navigation channel/Upstream of restoration site	Evaluate effectiveness of habitat restoration in navigation channel on fish.
Restoration Site (formerly Scaravelli's Marina)	41.4881	-81.6938	2.75	Mid-navigation channel/Site of GLRI habitat restoration project	Evaluate effectiveness of habitat restoration in navigation channel on fish.
Cuyahoga River Mouth	41.5008	-81.7098	0.20	Near mouth of river in navigation channel	Evaluate effectiveness of habitat restoration in navigation channel on fish.

[a] HD and Water Chemistry Collection Site

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between July 21 and August 18, 2015, on the Cuyahoga River between RMs 16.20 and 0.20. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual* (2013). Chemical water quality samples from each site were collected with a 4-liter disposable polyethylene cubitainer with a disposable polypropylene lid, three 473-mL plastic bottles and a 125-mL plastic bottle. The first 473-mL plastic bottle was field preserved with trace nitric acid, the second was field preserved with trace sulfuric acid and the third bottle received no preservative. The sample collected in the 125-mL plastic bottle (dissolved reactive phosphorus) was filtered using a 0.45-µm PVDF syringe filter. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles preserved with sodium thiosulfate. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using either a YSI 600XL or EXO1 sonde. Duplicate samples and field blanks were each collected at randomly selected sites, at a frequency not less than 5% of the total samples collected. Relative percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate sample (Formula 1).

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

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

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

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

X = sample/detection limit ratio

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

Mercury analysis for all of the sampling events was done using EPA Method 245.1. Because the detection limit for this method is above the criteria for the Human Health Nondrinking and Protection of Wildlife Outside Mixing Zone Averages (OMZA),

it generally cannot be determined if the Cuyahoga River was in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above those levels typically found in the river.

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

Results and Discussion

Two field blanks and three duplicate samples were collected as part of this study in 2015. For the field blanks, there were four parameters that showed possible contamination. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, and/or contaminated blank water. Table 2 lists water quality parameters that were listed as estimated, downgraded from Level 3 to Level 2 data, or rejected based on Ohio EPA data validation protocol.

Table 2. Parameters affected by possible blank contamination
COD
DRP
Sb
Tl

For the duplicate samples, six instances occurred in which the acceptable RPD was exceeded (Table 3). Neither of the dates in which these samples were collected were considered wet weather[1]. Therefore, the reason for the unacceptable difference between the samples remains unknown, but potentially could be due to lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity and/or improper handling of samples.

Table 3. Duplicate samples with RPDs greater than acceptable				
Site	Date	Parameter	Acceptable RPD	Actual RPD
RM 10.75	7/21/15	Al	17.7	38.6
RM 10.75	7/21/15	Fe	13.3	27.9
RM 10.75	7/28/15	NH_3	63.8	142.9
RM 10.75	7/28/15	NO_3+NO_2	16.8	195.0
RM 10.75	7/21/15	Ti	31.7	33.6
RM 10.75	7/28/15	TKN	47.1	165.3

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

The final QA/QC check for the samples that were collected was for paired parameters, or those parameters in which one is a subset of the other. In 2015, no instances occurred in which the data for the paired parameters needed to be qualified because the sub-parameter was greater than the parent one.

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

Exceedances of the recreation use bacteriological criteria occurred at all of the sites during 2015. The criteria for *Escherichia coli (E. coli)* consist of two components: a 90-day geometric mean and a value not to be exceeded in more than 10% of the samples collected during a 90-day period (statistical threshold value). For those streams designated primary contact recreation, these criteria are 126 colony counts/100mL and 410 colony counts/100mL, respectively. Both of these criteria were exceeded at all of the sites for a majority of the 90-day periods during the study (Table 4). These exceedances were mostly due to a significant wet-weather event that took place on August 10th, one day prior to one of the sampling events. Although August 4th was also considered a wet-weather sampling event, the amount of rain that fell prior to that day was much less than what occurred on August 10th. Potential sources of bacteria to the river could include stormwater runoff, illicit discharges, and CSOs.

Table 4. 2015 Cuyahoga River *E. coli* Densities (most-probable number/100mL)

Date	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90	RM 2.75	RM 0.20
7/21/2015	166	169	131	107	186	108	160	216	96	202
7/28/2015	166	107	62	71	42	76	321	108	36	56
8/4/2015*	61	86	40	24	35	35	158	126	372	150
8/11/2015*	4,722	15,214	8,476	12,224	9,666	11,716	13,542	10,674	16,041	1,571
8/18/2015	1,752	532	276	351	429	363	677	658	52	34

* Wet-weather event

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

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

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

and wildlife outside mixing zone averages (OMZA) occurred at seven of the sites during the sampling (Table 5). The sites that were not in exceedance were two of the ones in the navigation channel and the site immediately upstream of Southerly WWTC; for these sites, all of the samples were below the method detection limit. It is expected that the use of EPA Method 1631E, a low level method, instead of EPA Method 245.1 would have resulted in exceedances of the criteria throughout the sampling period at all of the sites.

Table 5. 2015 Cuyahoga River Mercury Concentrations (ug/L)

	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90	RM 2.75	RM 0.20
7/21/2015	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
7/28/2015	j0.009	j0.009	j0.007	<0.006	j0.013	j0.012	j0.01	J0.011	<0.006	<0.006
8/4/2015	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
8/11/2015	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
8/18/2015	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006

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

Exceedance of Wildlife (0.0013 ug/L) and Aquatic Life (0.0031 ug/L) OMZAs for 30-day period beginning with that date, assuming "j" values are actual concentrations and concentrations below the MDL are zero.

One other aspect of water quality that was examined in the Cuyahoga River in 2015 was that of nutrients. In 2013, Ohio EPA convened a technical advisory group to develop recommendations to determine if stream segments have been adversely affected by nutrients. The recommendations from the group were submitted to Ohio EPA in 2015 in the form of a "Stream Nutrient Assessment Procedure" (SNAP)(Ohio EPA, 2015) Within these recommendations were a table of total phosphorus (TP) and dissolved inorganic nitrogen (DIN) concentrations associated with various ecological conditions. The geometric means of these concentrations were then used to determine the potential for nutrient enrichment in the Cuyahoga River (Table 6). For the sites located upstream of Southerly WWTC, the concentrations that were measured were considered to be "Levels typical of working landscapes; low risk to beneficial use if allied response are within normal ranges." For most of the sites downstream of Southerly WWTC, the concentrations were "Enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat." The site near the confluence with Lake Erie, however, fell into the category of "Characteristic of tile-drained lands; moderate risk to beneficial use if allied responses are elevated." Although some of the concentrations that were measured indicate the potential for nutrients to be impairing the designated uses, the SNAP recommends the use of numerous other measures to determine if that is occurring. Because not all of those other measures were completed in 2015, a full determination of impacts from nutrients could not be made.

Table 6. 2015 Cuyahoga River Nutrient Concentrations Geometric Mean (mg/L)										
	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90	RM 2.75	RM 0.20
TP	0.11	0.11	0.11	0.11	0.23	0.18	0.17	0.16	0.15	0.13
DRP	0.04	0.03	0.03	0.03	0.10	0.07	0.07	0.08	0.06	0.06
DIN	2.47	2.53	2.51	2.41	4.75	3.98	3.99	4.24	4.21	3.95
	Levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges									
	Enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat									
	Characteristic of tile-drained lands; moderate risk to beneficial use if allied responses are elevated; increased risk with poor habitat									

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site in 2015 using the Qualitative Habitat Evaluation Index (QHEI). The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species by evaluating the physical attributes of a stream. The index is based on six metrics: stream substrate, instream cover, channel morphology, riparian zone and bank condition, pool and riffle quality, and stream gradient. The QHEI has a maximum score of 100, and a score of 60 or more suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2003). A more detailed description of the QHEI can be found in Ohio EPA's *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

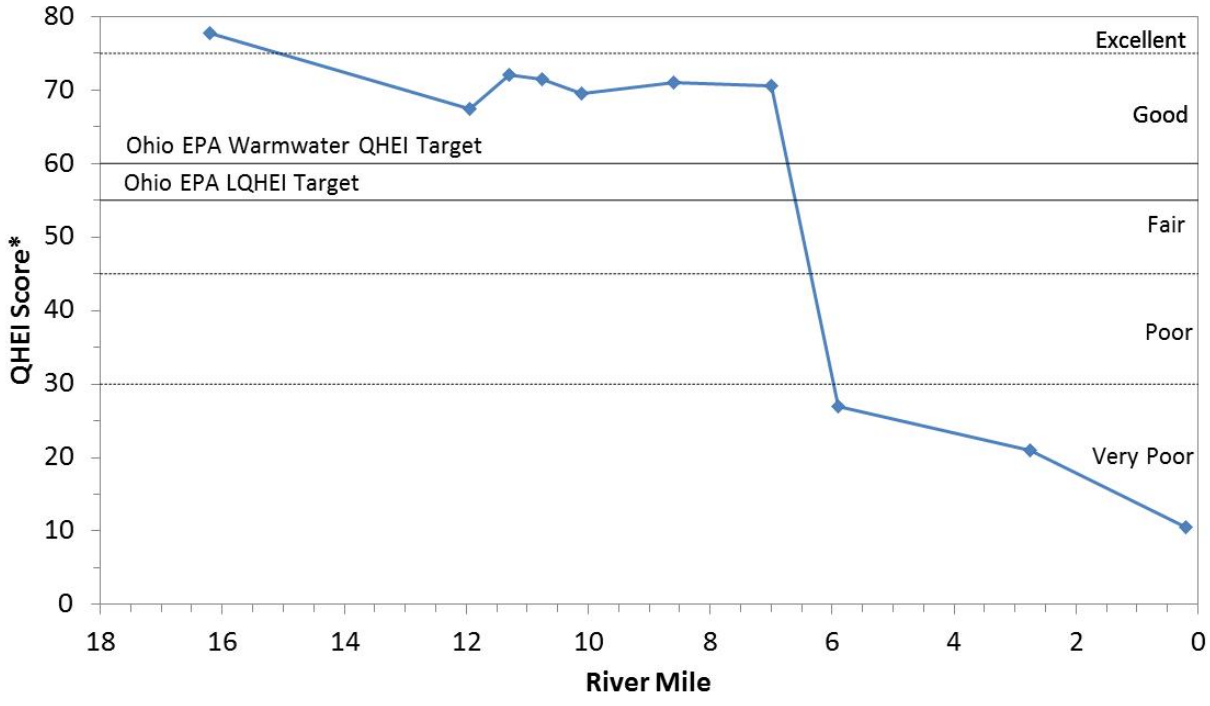
The habitat at the sites in the navigation channel were evaluated one time each in 2015 using the lacustuary QHEI (L-QHEI). Similar to the QHEI, the L-QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species, but in lacustuary zones or along the lake shoreline. The index is based on the metrics of substrate, cover types, shoreline morphology, riparian zone/bank erosion, and aquatic vegetation quality. The L-QHEI also has a maximum score of 100. More information can be found in Ohio EPA's *Methods for Assessing Habitat in Lake Erie Shoreline Waters Using the Qualitative Habitat Evaluation Index (QHEI) Approach (Version 2.1)* (2010). L-QHEI field sheets are also available upon request from the NEORSD WQIS Division.

Results and Discussion

All of the sites upstream of the navigation channel had QHEI scores that met Ohio EPA's target of 60 and, therefore, should be capable of supporting WWH fish communities (Figure 2). As in 2014, the highest score was found at the site immediately downstream of Tinkers Creek. This site scored in the *Excellent* range; the rest were all *Good*. No significant changes in scoring have occurred at these sites in recent years.

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

Figure 2. 2015 Cuyahoga River Qualitative Habitat Evaluation Index Scores



*Scores for sites at RMs 5.90, 2.75 and 0.20 were calculated using the Lacustuary Qualitative Habitat Evaulation Index (L-QHEI). Narrative ratings shown are for QHEI.

Of the sites upstream of the navigation channel, the one at RM 8.60 was most likely to be able to meet the WWH fish criteria based on these characteristics. It had only one moderate-influence MHW characteristic, while the rest of its attributes were all those considered to be WWH (Table 7). All of the sites had the WWH characteristics of maximum depths greater than 40 cm, and either had never been channelized or had recovered from it.

The specific characteristics at each of the sites was generally the same in both 2014 and 2015. One significant change that did occur was that a riffle was no longer present at the site at RM 7.00, most likely due to movement of the substrate. On the downstream side of the riffle that was previously there was a pool. During some significant rain events, there was potentially scouring of the pool that resulted in shifts in the substrate that led to elimination of the riffle. One additional consequence of this was that fast currents were no longer present at the site. Both these changes could directly influence the types of fish that could be found at that site, and therefore, the IBI score.

The sites in the navigation channel were evaluated using the L-QHEI and all failed to meet Ohio EPA's target score of 55 (Figure 2). The site characteristics that contributed heavily to the low scores included muck substrates, a general lack of instream cover, poor development, and a highly modified shoreline. Based on these attributes, it would not be expected that these sites would be able to support WWH fish communities. The sites at RMs 5.90 and 0.20 have remained essentially the same since NEORSD began conducting assessments there starting in 2010. The restoration project at RM 2.75 was completed in 2013. Since that time, no significant changes have occurred at that site. Additional, there has been only minimal establishment of aquatic plants in that area even though multiple plantings have taken place. This is thought to be a result of the heavy silt load in the area and disruption by freighters traveling in the river.

Table 7. Qualitative Habitat Evaluation Index scores and physical attributes

			MWH Attributes																													
			WWH Attributes											High Influence						Moderate Influence												
River Mile	QHEI Score	Habitat Rating	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinousity	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. Dept <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 Attribute**
16.20	77.75	Excellent	x			x		x	x		x		5						0			x			x				x	x		4
11.95	67.50	Good	x						x		x		3			x	x		2		x	x		x					x	x		5
11.30	72.00	Good	x						x		x		3				x		1		x	x		x	x				x	x		6
10.75	71.50	Good	x						x		x		3				x		1			x		x	x				x	x		5
10.10	69.50	Good	x			x			x		x		4				x		1		x	x			x				x	x		5
8.60	71.00	Good	x			x	x	x	x	x	x	x	8						0			x										1
7.00	70.50	Good	x				x	x		x	x		5						0					x				x			x	3

Fish Community Assessment

Methods

No surveys were conducted at the three most upstream sites due to conditions that prevented navigation of the boat to those locations. Two quantitative electrofishing passes were conducted at the rest of the sites except for RM 8.60, where only one pass was completed. A list of the dates when the surveys were completed, along with flow as measured at the United States Geological Survey gage station in either Independence or Newburgh Heights, is given in Table 8. Sampling was conducted using boat electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from upstream to downstream by slowly and steadily maneuvering the boat as close to shore and submergent objects as possible. The sampling zone was 0.5 kilometers for each site. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified, weighed and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

Table 8. Sampling Dates and River Flows

Date	Sites sampled (RMs)	Daily Mean Flow (CFS)
7/31/15	0.20, 2.75	557*
8/6/15	7.00	323
8/8/15	5.90	499*
9/9/15	10.10, 10.75	216
9/23/15	5.90, 7.00	432*, 271
10/8/15	0.20, 2.75	418*
10/13/15	8.60	219
10/14/15	10.10, 10.75	221

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

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices, the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb). The IBI incorporates 12 community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites

located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12. The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional, Good, Marginally Good, Fair, Poor* or *Very Poor*. Sites at River Miles 5.90, 2.75, and 0.20 were evaluated using the lacustuary IBI (LIBI). The LIBI is intended to be used in those areas near the mouths of rivers that may be affected by lake levels. The 12 metrics utilized for boat and lacustuary sites are listed in Table 9.

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

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

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

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

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

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

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

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

Table 9. Index of Biotic Integrity Metrics	
Boat	Lacustuary
Number of native species	Number of native species
Percent round-bodied suckers	Number of sunfish species
Number of sunfish species	Number of cyprinid species
Number of sucker species	Number of benthic species
Number of intolerant species	Percent phytophilic
Percent tolerant	Percent top carnivores
Percent omnivores	Number of intolerant species
Percent insectivores	Percent omnivores
Percent top carnivores	Percent non-indigenous
Number of individuals	Percent tolerant
Percent simple lithophils	Percent DELTs
Percent DELTs	Number of individuals

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

Results and Discussion

For the four sites upstream of the navigation channel in which fish assessments were conducted, all except for the one at RM 7.00 had MIwb scores that met the WWH criterion (Table 10 and Figure 3). This was similar to what was found in 2014 (Table 11). For both years, the lower MIwb score at RM 7.00, which fell into the *Fair* narrative rating, was due to a lower total weight for all the fish collected. The other sites had average scores that were considered to be either *Good* or *Very Good*.

Table 10. 2015 Cuyahoga River IBI and MIwb Results

		1st Pass		2nd Pass		Average	
Location	River Mile	IBI	MIwb	IBI	MIwb	IBI	MIwb
Upstream from Southerly WWTC	10.75	34	**9.6**	32	**8.9**	33	**9.3**
Downstream from Southerly WWTC	10.10	30	**9.2**	26	**8.7**	28	**9.0**
Upstream from Big Creek	8.60	32	**8.8**	---	---	32	**8.8**
Downstream from Big Creek	7.00	28	7.2	34	*8.4*	31	7.8
Upstream of Newburgh SS RR Bridge*	5.90	13	6.1	21	6.8	17	6.5
Scranton Road Restoration Site*	2.75	22	7.1	28	7.3	25	7.2
Upstream of Confluence w/ Lake Erie*	0.20	23	6.0	29	6.3	26	6.2

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

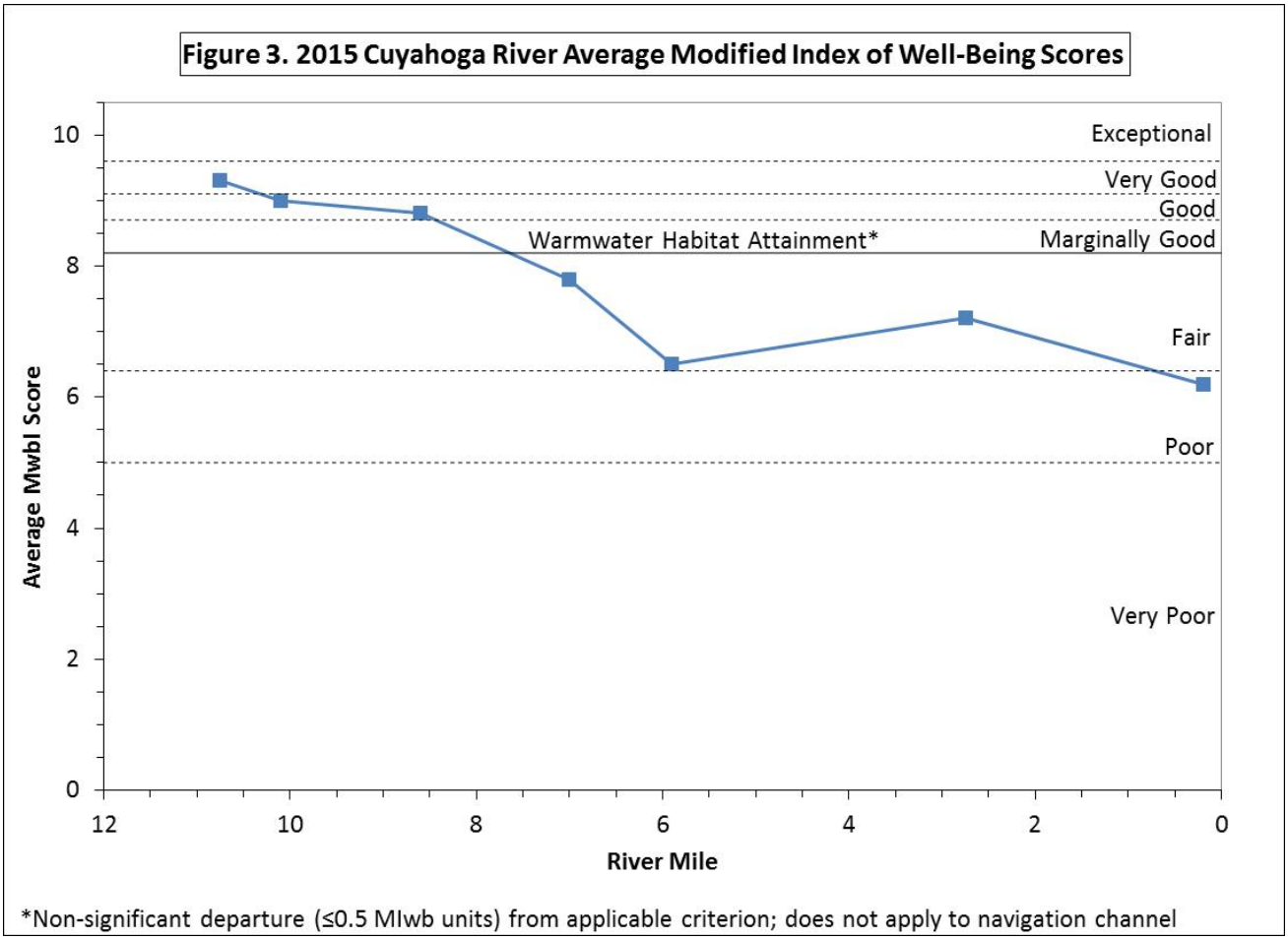


Table 11. Cuyahoga River Historic MIwb Scores (1990-2015)										
	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90*	RM 2.75*	RM 0.20*
1990	-	-	-	4.5	4.6	-	-	-	-	-
1991	-	-	-	5.5	5.6	-	6.1	-	-	-
1992	-	-	-	5.6	6.6	-	5.8	-	-	-
1997	-	-	-	7.5	6.1	-	6.1	-	-	-
1998	-	-	-	7.8	7.6	-	5.5	-	-	-
1999	-	-	-	8.2	*8.6*	-	7.0	-	-	-
2001	-	-	-	7.4	*8.2*	-	6.1	-	-	-
2003	-	-	-	7.6	7.8	-	7.0	-	-	-
2004	-	-	-	8.0	*8.4*	-	-	-	-	-
2006	-	-	-	**8.8**	*8.5*	-	7.8	-	-	-
2007	*8.6*	*8.5*	*8.3*	**9.4**	**9.7**	-	*8.3*	-	-	-
2008	**9.9**	*8.2*	**9.1**	**8.9**	**9.4**	-	*8.5*	-	-	-
2009	**9.9**	**8.8**	**9.5**	**9.1**	**9.2**	**9.0**	*8.5*	-	-	-
2010	**9.5**	**9.0**	**9.7**	**9.7**	**9.5**	**9.2**	**8.8**	6.2	7.2	6.3

Table 11. Cuyahoga River Historic MIwb Scores (1990-2015)										
	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90*	RM 2.75*	RM 0.20*
2011	**9.6**	**8.7**	**8.9**	**9.5**	**9.1**	**8.8**	*8.4*	7.3	8.1	6.8
2012	-	**9.2**	**9.5**	**9.6**	**10.1**	**9.6**	*8.6*	8.1	6.9	7.4
2013	-	8.3	**9.2**	**9.2**	**9.1**	**8.8**	8.3	6.3	-	5.9
2014	-	**9.1**	**9.3**	**9.0**	**9.5**	*8.2*	7.6	6.8	8.8	5.5
2015	-	**-**	**-**	**9.3**	**9.0**	**8.8**	7.8	6.5	7.2	6.2

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

Within the navigation channel, the biological criteria do not apply. Ohio EPA has proposed an interim biological criterion for lacustuary habitats for the MIwb of 8.6, with a final goal of 10.0 (Ohio EPA, undated). None of the three sites would have met the interim criterion. For the site at RM 2.75, this was a decrease from the previous year, when it would have been met.

For the IBI, none of the sites upstream of the navigation channel were in attainment or non-significant departure of the WWH criterion. All of these sites had lower scores than were found in 2014 (Figure 4 and Table 12). The biggest decrease occurred at the site at RM 10.10, which dropped 12 IBI units. Generally, one of the biggest reasons for the decline in scores was due to an increased number of eastern gizzard shad (*Dorosoma cepedianum*) that were collected during the sampling. Gizzard shad are considered to be omnivores and, therefore, their presence lowered that metric score. Because the proportion of omnivores increased, this also had the effect of also lowering the scores for the proportion of insectivores and carnivores in most cases. Without any gizzard shad present, the sites at RMs 10.75 and 8.60 would have been in attainment and the site at RM 10.10 would have averaged 5 IBI units higher.

Other metrics that generally scored poorly (metric score of 1) throughout the electrofishing surveys included the proportion of round-bodied suckers, the number of sunfish species, the number of intolerant species and the proportion of simple lithophils. Typically, these have been the same metrics that have not scored as highly at these sites in recent years. The lower scores for these metrics could be due to habitat characteristics or some impairments to water quality conditions as indicated by elevated *E. coli* densities during wet weather.

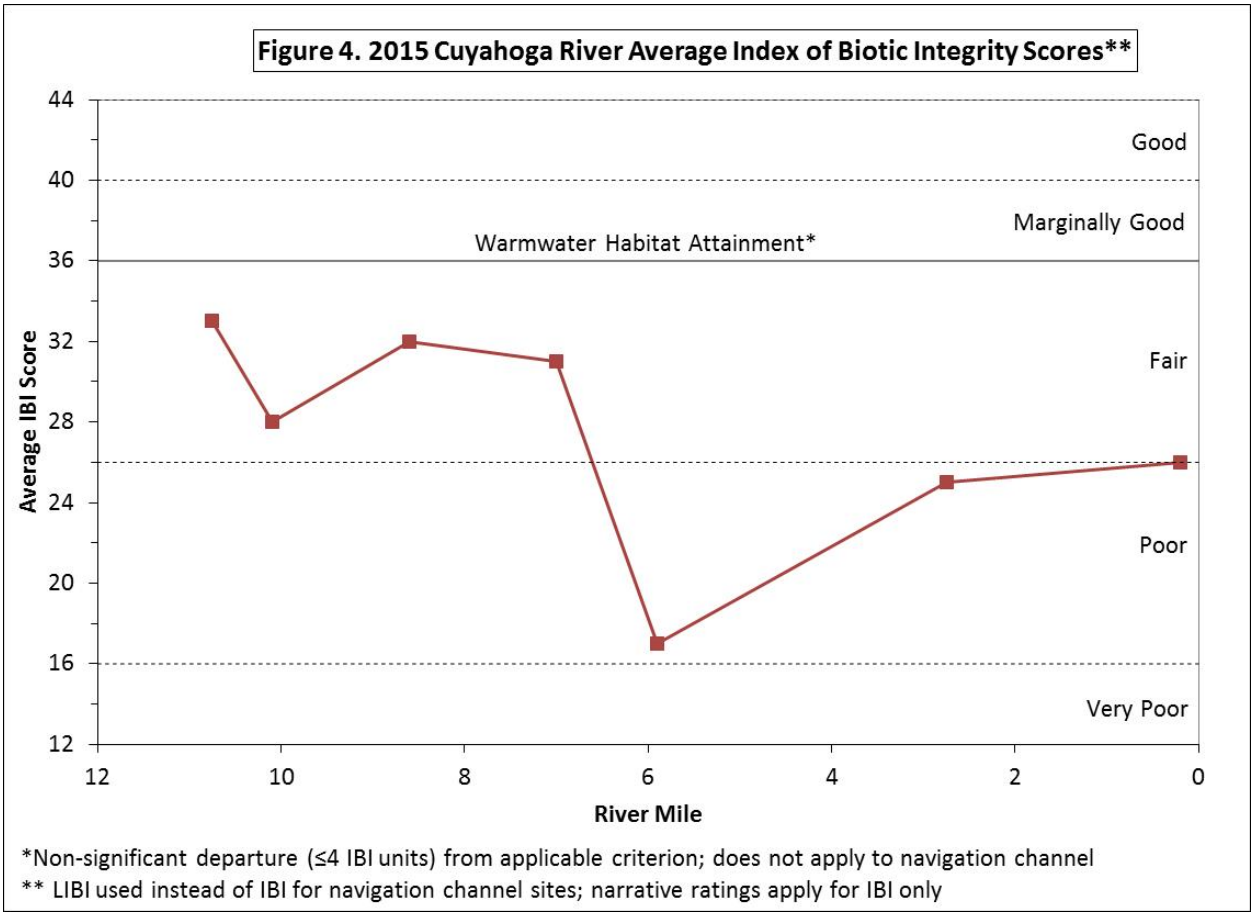


Table 12. Cuyahoga River Historic IBI Scores (1990-2015)

	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90*	RM 2.75*	RM 0.20*
1990	-	-	-	15	15	-	-	-	-	-
1991	-	-	-	17	16	-	18	-	-	-
1992	-	-	-	20	19	-	21	-	-	-
1997	-	-	-	25	17	-	18	-	-	-
1998	-	-	-	26	27	-	21	-	-	-
1999	-	-	-	31	31	-	24	-	-	-
2001	-	-	-	30	29	-	22	-	-	-
2003	-	-	-	34	28	-	23	-	-	-
2004	-	-	-	35	35	-	-	-	-	-
2006	-	-	-	*39*	*36*	-	31	-	-	-
2007	*39*	30	*38*	34	35	-	33	-	-	-
2008	**44**	34	*38*	*37*	*36*	-	34	-	-	-
2009	**45**	*38*	**44**	*36*	31	**40**	31	-	-	-
2010	**43**	*39*	*39*	33	*37*	**41**	31	18	27	25
2011	**47**	*39*	35	**44**	*36*	**40**	32	28	25	27
2012	-	*36*	35	*38*	34	*38*	29	24	20	27

Table 12. Cuyahoga River Historic IBI Scores (1990-2015)										
	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00	RM 5.90*	RM 2.75*	RM 0.20*
2013	-	**41**	**42**	*36*	33	**41**	34	21	-	23
2014	-	**44**	**42**	*38*	**40**	34	32	11	29	23
2015	-	**-**	**-**	33	28	32	31	17	25	26

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

Within the navigation channel, LIBI scores were not significantly different at the two most downstream locations compared to 2014 and were still considered *Poor*. For the site at RM 5.90, the score increased from 2014, but was still rated as *Very Poor*. There have been no significant changes in habitat at RM 5.90 and 0.20, which explains why the fish community continues to be impacted from the highly modified conditions there. Although the restoration project at RM 2.75 helped to improve some of the habitat features at that site, a lack of establishment of aquatic vegetation and other higher quality instream cover is likely why the fish community has not improved there.

As in the sites upstream of the navigation channel, those within it lacked any pollution intolerant species. In addition, these sites score poorly (metric score of 0 or 1) for the number of benthic species, total number of fish, and proportion of non-indigenous species. The number of benthic species is related to sedimentation, toxicity and low oxygen conditions. The navigation channel has a high sediment load and, at times, potentially low DO levels, which could account for why more benthic species were not found there. For the proportion of non-indigenous species metric, common species that were found at these three sites included eastern gizzard shad, common carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), round goby (*Neogobius melanostomus*) and white perch (*Morone americana*).

Macroinvertebrate Sampling

Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa, inhabiting available habitats at the time of HD retrieval. Sampling was conducted at all of the locations listed in Table 1. Methods for sampling followed the Ohio EPA's Biological Criteria for the Protection of Aquatic Life, Volume III (1987b). HDs within the navigation channel were floated at a depth of approximately two feet below the surface. The recommended period for HDs to be installed is six weeks.

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

The overall aquatic macroinvertebrate community in the stream was evaluated using either Ohio EPA's Invertebrate Community Index (ICI) (Ohio EPA 1987a, Ohio EPA undated) or Lacustuary Invertebrate Community Index (LICI) (Ohio EPA 1987a, Ohio EPA undated). The ICI and LICI both consist of ten community metrics (Table 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. The total of the individual metric scores result in the overall score. This scoring evaluates the community against Ohio EPA's reference sites for each specific eco-region.

Table 13. Invertebrate Community Index Metrics	
ICI	LICI
Total Number of Taxa	Total Number of Taxa
Number of Mayfly taxa	Number of Dipteran Taxa
Number of Caddisfly taxa	Number of Sensitive Taxa
Number of Dipteran taxa	Percent Predominant Taxon
Percent Mayflies	Percent Other Diptera and Non-Insects
Percent Caddisflies	Percent Mayflies and Caddisflies
Percent Tanytarsini Midges	Percent Sensitive Taxa (excluding Dreissinids)
Percent Other Diptera and Non-Insects	Percent Collector-Gatherers
Percent Tolerant Organisms (as defined)	Dipteran Abundance
Number of Qualitative EPT Taxa	Number of Qualitative EPT Taxa

Results and Discussion

All of the Cuyahoga River sampling sites evaluated in 2015 upstream of the navigation channel (in which a HD sampler was collected) achieved ICI scores that attained the WWH criterion, with the exception of RM 7.00 (Table 18). RM 7.00 achieved an ICI score of 24, narratively *Fair*, for the 2015 sampling season. This score reflects a continued decline in score over the previous two seasons, from when the site met the WWH criterion in 2013 (Table 14). Based on observations from field investigators at the time of HD retrieval, there was a decline in available habitat that would support a macroinvertebrate population, including absence of a riffle within the

sample reach. Lack of habitat combined with dominance of organisms designated as tolerant to pollution as deemed by the Ohio EPA, may be contributing factors to the decline of the ICI score at this site.

The three sites within the navigation channel were evaluated using the LICI. The sample sites at RM 5.90 and RM 2.75 both scored narratively *Poor*, while the site at RM 0.20 scored narratively *Fair* (Table 18). During the period that NEORSD has assessed the macroinvertebrate community in the navigation channel, LICI scores have been highly variable. In 2015, scores for both RM 5.90 and RM 2.75 declined, while a slight improvement was found within the score for RM 0.20. It should be noted that only one other HD has been successfully collected at RM 2.75, in 2014. Additional sampling of this site should be completed to confirm any trends of degradation. In contrast with qualitative sampling from the previous year, EPT Taxa was found at RM 0.20 and RM 5.90. There were, however, no EPT Taxa reported present in the 2015 qualitative sample collected from RM 2.75, and only small concentrations of EPT taxa were found present on the collected HD samplers.

Figure 6 displays the percent composition of the sample populations collected at each Cuyahoga River study site. Of note are the metrics including % Mayflies, % Caddisflies, and % Tanytarsini (a tribe of the non-biting midge family Chironomidae). These above listed taxa groups are generally regarded as pollution sensitive and important indicators of a thriving macroinvertebrate community. As it can be seen in Figure 6, the proportion of these groups decline relative to the other organisms found in the sample as the sampling sites move downstream. The sites sampled in the navigation channel and RM 7.00 are almost entirely dominated by what is categorically “Other Organisms”. Further consideration of % Pollution Tolerant organism proportions for these sites (Table 15), a negative correlation can be seen regarding presence of these organisms in relation to mayflies, caddisflies, and the Tanytarsini, as it relates to ICI/LICI scores (Figures 5 and 6). Progressing downstream toward the navigation channel demonstrates the steady decline of thriving and diverse macroinvertebrate populations, culminating in poor composition at the confluence of the river as it enters Lake Erie. The lack of quality habitat within the navigation channel, as it is permanently maintained at a specific depth and the natural banks are covered by bulkhead, does not allow for the establishment of a healthy and diverse macroinvertebrate population as can be seen in the upstream sampling points. This permanent channel alteration may be one of the larger contributing factors to the decline of the macroinvertebrate population in the lower reach of the Cuyahoga River.

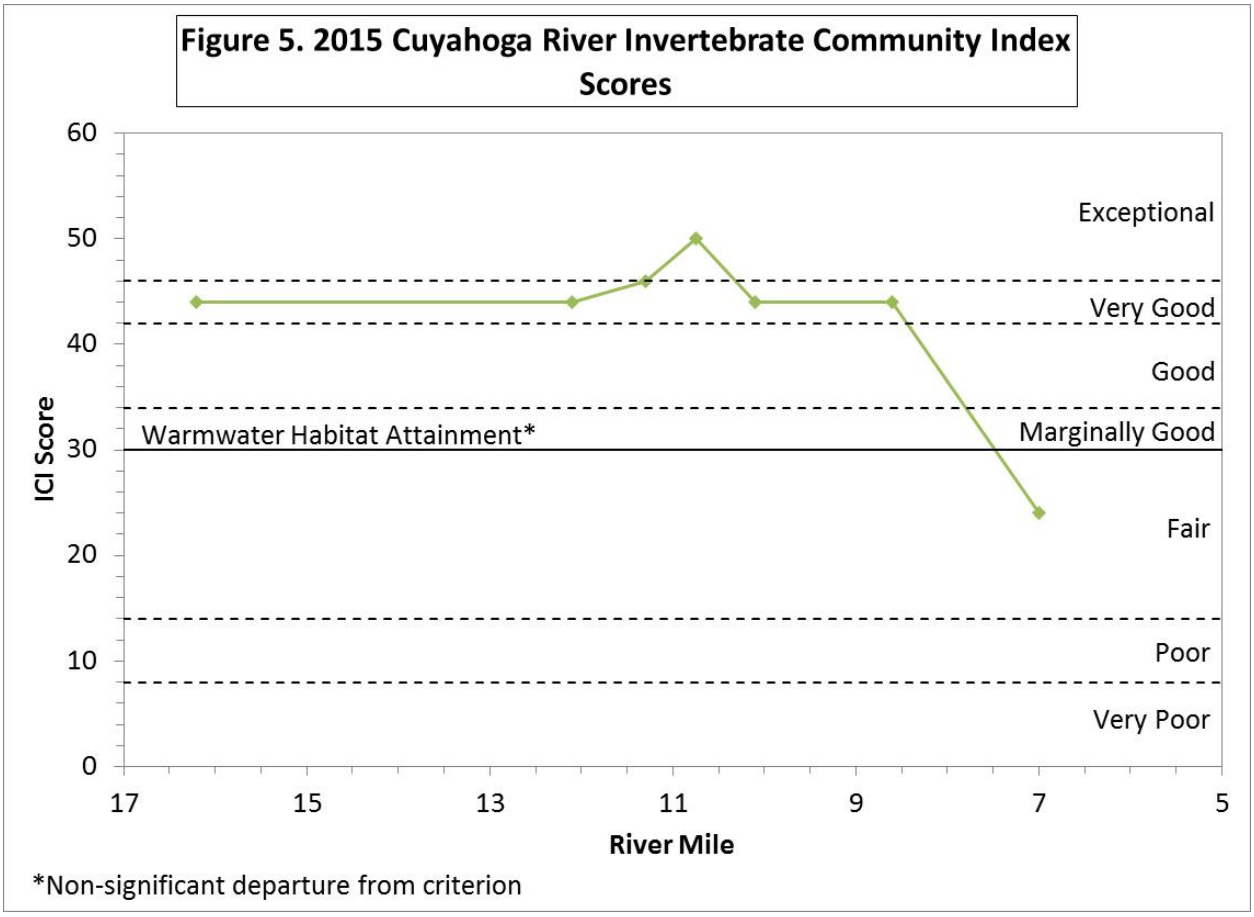
Table 14. Cuyahoga River Historic ICI Scores (2006-2015)										
Year	16.20	12.10	11.30	10.75	10.10	8.60	7.00	5.90*	2.75*	0.20*
2006	30	---	---	**38**	**34**	---	---	---	---	---
2007	**34**	**35**	**34**	*32*	**36**	---	**38**	---	---	---
2008	**40**	**40**	**40**	**40**	**40**	---	**38**	---	---	---
2009	**36**	**38**	**36**	**42**	**38**	**36**	**42**	---	---	---
2010	**36**	**40**	**40**	**36**	32	**44**	**34**	---	---	---
2011	**40**	**36**	**36**	*30*	---	---	26	46	---	36
2012	**40**	**44**	**38**	**40**	**34**	**40**	*30*	28	---	16
2013	**36**	**40**	**34**	**46**	**34**	**42**	**38**	36	---	---
2014	**44**	**---**	**48**	**---**	**34**	*30*	28	28	36	26
2015	**44**	**44**	**46**	**50**	**44**	**44**	24	24	16	32
Bold indicates attainment of WWH criterion										
Italics indicates non-significant departure (≤4 ICI units) from criterion										
** - LICI instead of ICI*										

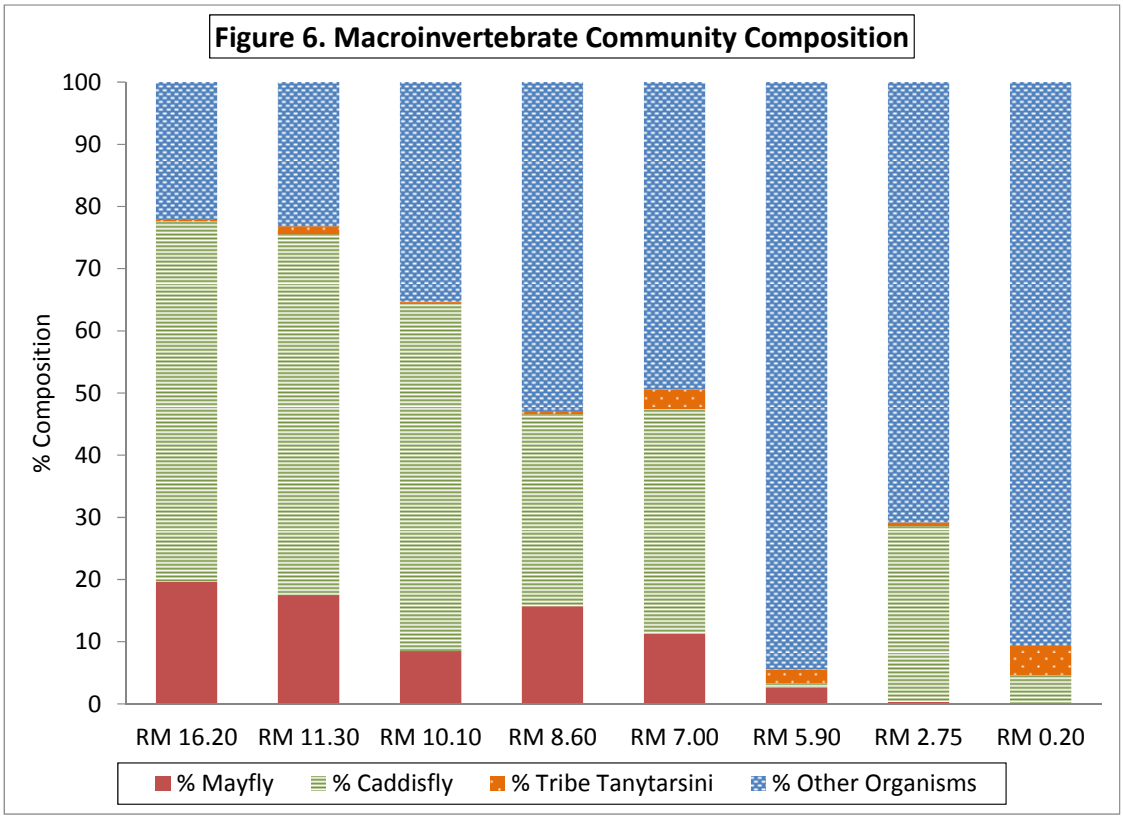
Table 15. Macroinvertebrate Results for 2015 Sampling								
Location	River Mile	ICI Score	LICI Score	Density (Organisms per square foot)	Total Number of Taxa	Number of Qualitative EPT Taxa	% Tolerant (as defined)	Narrative Rating
Downstream of Tinkers Creek	16.20	**44**	---	2284	55	10	0.30	Very Good
Upstream of Mill Creek	12.10	**44**	---	1080	49	11	0.00	Very Good
Downstream of Mill Creek	11.30	**46**	---	643	43	12	0.06	Exceptional
Upstream of Southerly WWTC	10.75	**50**	---	908	59	11	0.93	Exceptional
Downstream of Southerly WWTC	10.10	**44**	---	1862	52	11	0.70	Very Good
Upstream of Big Creek	8.60	**44**	---	1496	45	11	1.20	Very Good
Downstream of Big Creek	7.00	24	---	166	42	6	52.11	Fair

Table 15. Macroinvertebrate Results for 2015 Sampling								
Location	River Mile	ICI Score	LICI Score	Density (Organisms per square foot)	Total Number of Taxa	Number of Qualitative EPT Taxa	% Tolerant (as defined)	Narrative Rating
Head of Navigation Channel	5.90	---	24	329	38	1	61.24	Poor
Restoration Site	2.75	---	16	1047	28	0	60.66	Poor
Cuyahoga River Mouth	0.20	---	32	386	20	1	23.99	Fair

Bold indicates attainment of WWH criterion

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





Conclusions

During the sampling that was conducted in 2015, the three most upstream sites, at RMs 16.20, 11.95 and 11.30, were found to be in full attainment of the biocriteria (Table 16). This was based on the ICI scores and best professional judgment, as no fish community assessments could be completed due to an inability to get the electrofishing boat within that section of the river. Previous assessments at those sites have indicated attainment of the fish biocriteria. At RMs 10.75, 10.10 and 8.60, partial attainment of the biocriteria were achieved. The criteria for both the ICI and MIwb were met, while the one for the IBI was not. The site at RM 7.00 was in non-attainment and was considered to be *Fair* based on all three indices.

Water chemistry sampling conducted at the sites showed exceedances of applicable water quality standards for *E. coli* and mercury. The *E. coli* exceedances, an indication of sanitary sewage within the river, were, for the most part, directly related to wet weather prior to one of the sampling events; densities were generally low during dry weather. Potential sources of pollution include illicit discharges, CSOs, stormwater runoff, and flow from upstream tributaries. Effluent from Southerly WWTC did not appear to significantly contribute to these exceedances. For mercury, the levels that were measured were considered typical for watersheds within this region.

Table 16. 2015 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	(FULL[1])			44 *(Very Good)*	77.75 *(Excellent)*	*E. coli,* Mercury
11.95	(FULL[1])			44 *(Very Good)*	67.50 *(Good)*	*E. coli,* Mercury
11.30	(FULL[1])			46 *(Exceptional)*	72.00 *(Good)*	*E. coli,* Mercury
10.75	PARTIAL	33 *(Fair)*	9.3 *(Very Good)*	50 *(Exceptional)*	71.50 *(Good)*	*E. coli*
10.10	PARTIAL	28 *(Fair)*	9.0 *(Good)*	44 *(Very Good)*	69.50 *(Good)*	*E. coli,* Mercury
8.60	PARTIAL	32 *(Fair)*	8.8 *(Good)*	44 *(Very Good)*	71.00 *(Good)*	*E. coli,* Mercury
7.00	NON	31 *(Fair)*	7.8 *(Fair)*	24 *(Fair)*	70.50 *(Good)*	*E. coli,* Mercury
5.90[4]	N/A	17 *(Very Poor)*	6.5 *(Fair)*	24 *(Poor)*	27.00 N/A	*E. coli*, Mercury
2.75[4]	N/A	25 *(Poor)*	7.2 *(Fair)*	16 *(Poor)*	21.00 N/A	*E. coli*
0.20[4]	N/A	26 *(Poor)*	6.2 *(Fair)*	32 *(Fair)*	10.50 N/A	*E. coli*

WWH biocriterion attainment: IBI score of 40; MIwb score of 8.2; ICI score of 34
Non-significant departure: ≤4 IBI units; ≤0.5 MIwb units; ≤4 ICI units
--HD not collected; qualitative assessment only
[1]Based on ICI score and best professional judgment
[3]Narrative rating based on best professional judgment and habitat evaluation
[4]Lacustuary scoring

At the sites in which fish assessments could be completed, MIwb scores were similar to those found in 2014. IBI scores, however, declined and for some sites, significantly so. Generally, the decrease in IBI scores was due an increase in the number of gizzard shad that were collected during the surveys and exclusion of them would have resulted in attainment of the criterion at RMs 10.75 and 8.60. Overall, the sites that were assessed continue to go back and forth between being in attainment and nonattainment of the IBI criterion, depending on the year.

The results from the macroinvertebrate assessments differed from those for fish. The macroinvertebrate community in 2015 improved compared to the previous year. All ICI scores upstream of the navigation channel, except for the one at RM 7.00, were

considered to be either *Very Good* or *Exceptional*. For many of the sites, these were the highest ICI scores ever received as part of NEORSD sampling.

The sites within the navigation channel continue to show the impacts from it being a highly-modified habitat. The biological criteria do not apply at these locations because the navigation channel is considered to be a limited resource water. When comparing the results obtained at these sites to interim goals for lacustuary areas set by Ohio EPA, none of the targets were met in 2015. This will most likely continue to occur unless significant changes take place in that section of the river.

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