Northeast Ohio
Regional Sewer District

2022 Chagrin River
Biological, Water Quality, and Habitat Study

Water Quality and Industrial Surveillance

Environmental Assessment Group

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Introduction

In 2022, as part of the Northeast Ohio Regional Sewer District (NEORSD) general watershed monitoring program, an ambient water quality assessment study was conducted to determine attainment and appropriateness of existing aquatic life use designations of the Chagrin River and two of its tributaries in the vicinity of the communities of Chagrin Falls, Pepper Pike, and Moreland Hills, Ohio. NEORSD also conducted water chemistry sampling, habitat assessments, and fish and macroinvertebrate community surveys to evaluate the biological, water quality, and habitat conditions downstream of two former wastewater treatment plants (WWTPs). This study is part of a multiyear study plan following the decommissioning of the Jackson Valley WWTP and the Creekside WWTP in May 2012. The Creekside WWTP discharged to Pepper-Luce Creek at river mile (RM) 3.40 and the Jackson Valley WWTP discharged to Willey Creek at RM 1.80. These two facilities did not consistently meet their National Pollutant Discharge Elimination System (NPDES) permit limits and were decommissioned in May of 2012 when flows were redirected to the NEORSD's Easterly WWTP via the SOM Relief Sewer (SOMRS). By removing these flows and conveying them to NEORSD, the water quality downstream of these WWTPs was expected to improve. Another purpose of this study was to evaluate the fish and macroinvertebrate communities downstream of the former WWTPs to determine whether the decommissioning led to an improvement in the biological communities of the receiving waters. Additionally, two sites upstream of the decommissioned WWTPs on the Chagrin River mainstem at RM 29.00, upstream of Miles Road, and RM 26.70, upstream of Willey Creek, were used as reference sites. Results from this study were compared to data collected by NEORSD during past studies in 2009, 2012, 2013, 2014, and 2021.

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 *2022 Chagrin River Biological, Water Quality, and Habitat Study* approved by Ohio EPA on May 5, 2022. All sampling and environmental assessments occurred between June 15, 2022 and September 30, 2022 (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* (2021) and compared to the Ohio Water Quality Standards for their designated use to determine attainment (Ohio EPA, 2022). 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.

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

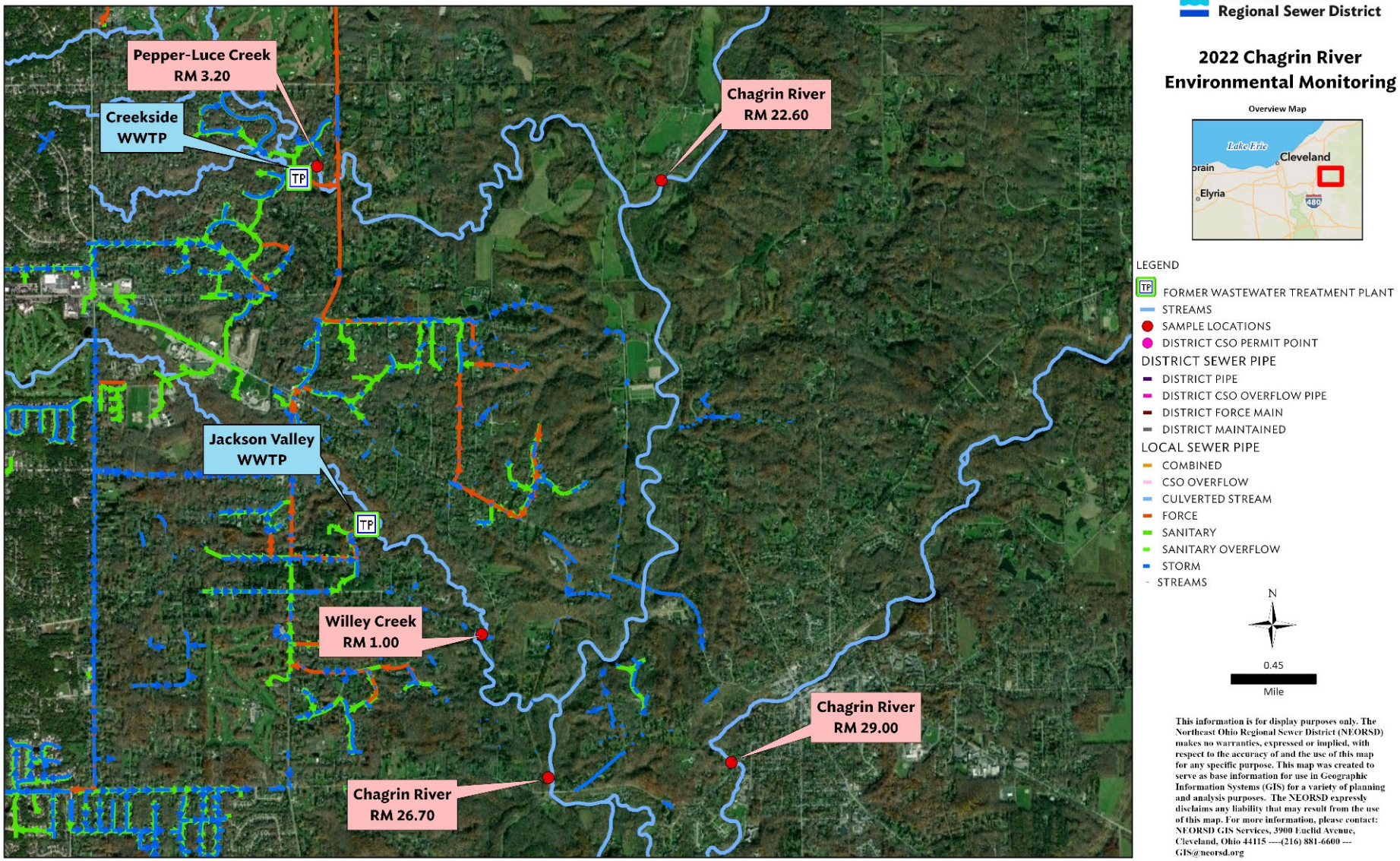

Figure 1. Sampling Locations

Table 1. 2022 Chagrin River and Tributaries Sampling Locations

Location	Latitude	Longitude	River Mile	Drainage Area	Station ID	Sampling Conducted
Chagrin River	41.4620	-81.3989	29.00	58 mi^2	D01S11	F, M, C
Chagrin River	41.4250	-81.4176	26.70	122 mi^2	DP01P03	F, M, C
Chagrin River	41.4764	-81.3982	22.60*	153 mi^2	301454	F, M, C
Pepper-Luce Creek	41.4719	-81.4401	3.20	7.5 mi^2	301455	F, M, C
Willey Creek	41.4360	-81.4242	1.00	3.7 mi^2	DP01P24	F, M, C

F = Fish community biology (includes habitat assessment)
M = Macroinvertebrate community biology
C = Water column chemistry
*This site was moved in 2012 approximately 0.60 RMs upstream from the 2009 sampling site; data from the 2009 site of Chagrin RM 22.00 will be directly compared to the 2012, 2013, 2014, 2021, and 2022 data from RM 22.60.

The Ohio EPA assigns designated uses to establish minimum water quality requirements for surface waters. These requirements represent measurable criteria for assessing the chemical, physical, and biological integrity of Ohio's surface waters consistent with Clean Water Act requirements. The beneficial use designations for the Chagrin River are listed below in Table 2 (Ohio EPA 2022).

Table 2. Beneficial Use Designations for Chagrin River

Stream	**Beneficial Use Designation**												
	Aquatic Life Habitat (ALU)							Water Supply			Recreation		
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
Chagrin River (RM 29.65 to the mouth)		+			+				+	+		+	
Pepper-Luce Creek		+							+	+		+	
Willey Creek	*					+			+	+		+	

SRW = state resource water; WWH = warmwater habitat; EWH = exceptional warmwater habitat; MWH = modified warmwater habitat; SSH = seasonal salmonid habitat; CWH = coldwater habitat; LRW = limited resource water
PWS = public water supply; AWS = agricultural water supply; IWS = industrial water supply; BW = bathing water; PCR = primary contact recreation; SCR = secondary contact recreation.
* Designated use based on the 1978 water quality standards

Water Chemistry and Bacteriological Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between June 22, 2022 and July 19, 2022, at the sites listed in Table 1. An additional bacteriological sample was collected at each site on September 13, 2022. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (2021). 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, conductivity, and specific conductance were collected using either a YSI 600XL or EXO1 sonde. Duplicate/replicate 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/replicate 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/replicate sample

The acceptable percent RPD is based on the ratio of the sample concentration and detection limit (Formula 2) (Ohio EPA, 2019).

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

X = sample/detection limit ratio

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

Water chemistry analysis sheets for each site are available upon request from the NEORSD WQIS Division. Dates of water chemistry sampling compared to Chagrin River flow data (USGS 04209000) are shown below in Figure 2.

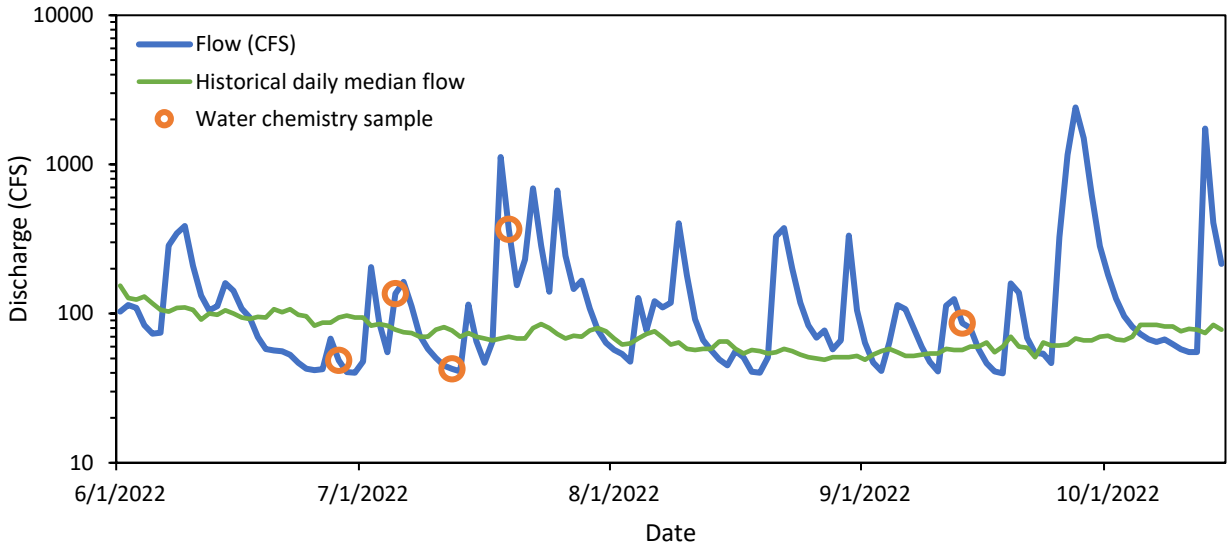

Figure 2. Daily mean discharge in cubic feet per second for Chagrin River at USGS Station 04209000. Shown are the daily mean discharge for 2022 and the historic median discharge (1924-2022). Orange circles indicate water chemistry sampling dates.

Results and Discussion

Quality Assurance / Quality Control

All sites monitored during the 2022 study, except for Willey Creek, are designated warmwater habitat, agricultural water supply, industrial water supply, and primary contact recreation (Ohio EPA, 2022). Willey Creek also has the latter three designations but is designated as a state resource water and coldwater habitat. All three sites on the Chagrin River mainstem have an additional designation of seasonal salmonid habitat, in effect from October through May. Duplicate/replicate samples, field blanks, and paired parameters were all utilized for QA/QC purposes and the results are as stated below.

Over the course of sampling, two field blanks were collected for QA/QC purposes. One was collected at Willey Creek RM 1.00 on June 28, 2022, and one was collected at Pepper-Luce Creek RM 3.20 on July 5, 2022. On June 28, 2022, one parameter, BOD, showed possible contamination. It is unclear how the field blank became contaminated and may be due to incorrect sample collection, handling, or contaminated field blank water. Ohio EPA's Credible Data program includes a data validation protocol for QA/QC samples. Using this protocol, all of the sample results for BOD from June 28, 2022, needed to be rejected ('R'). On June 28, 2022, at Chagrin River RM 29.00, the parameter nitrite-nitrate received a "J" qualifier and is considered estimated.

Three sets of duplicate/replicate samples were collected over the course of sampling for QA/QC purposes. One set of duplicate samples was collected at Chagrin River RM 26.70 on July 12, 2022. A set of replicate samples was collected at Pepper-Luce Creek RM 3.20 on July 19, 2022.

On September 13, 2022, bacteriological sampling was conducted again due to the bacteriological samples collected on July 19, 2022, being analyzed outside of the hold time resulting in the results being rejected. Another set of replicate samples was collected at this time at Pepper-Luce Creek RM 3.20. The duplicate sample at Chagrin River RM 26.70 and the replicate sample at Pepper-Luce Creek RM 3.20 revealed multiple parameters that were rejected due to RPDs that were greater than acceptable (Table 3). There may be numerous reasons for the difference between the samples, such as lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity, and/or improper handling of samples.

Table 3. Duplicate/Replicate Samples with RPD Greater than Acceptable

Site	Date	Parameter	Acceptable RPD	Actual RPD
Chagrin River RM 26.70	7/12/2022	Ammonia	51.2%	65.8%
		Manganese	17.1%	19.9%
		Selenium	66.4%	111.6%
		Strontium	14.7%	18.9%
Pepper-Luce Creek RM 3.20	7/19/2022	Tin	66.3%	111.7%
		Vanadium	67.9%	106.6%

Paired parameters are evaluated in tandem using %RPD because they are interlinked and can be used for QA/QC purposes. There were five instances where the data for the paired parameters had to be qualified due to the daughter parameter value being greater than the parent value. On June 28, 2022, all sample results for total dissolved solids were greater than total solids and the results were downgraded to estimated values.

Recreational Use Results and Discussion

Escherichia coli (*E. coli*) is a fecal indicator bacteria commonly found in the intestinal tract and feces of warm-blooded animals and is used to measure the presence of feces (USEPA, 2012). The primary contact recreation (PCR) criteria consist of two components. First is an *E. coli* criterion not to exceed a statistical threshold value (STV) of 410 colony counts or most probable number per 100 milliliters (410 MPN/100ml) in more than ten percent of the samples taken during any ninety-day period. The second component is a 90-day geometric mean criterion of 126 MPN/100mL (Ohio EPA, 2022). In accordance with the Ohio EPA procedure and practice to qualify *E. coli* exceedances for the Primary Recreation criteria, the geometric mean and STV are only calculated and compared when a minimum of five bacteriological samples have been collected.

Table 4 lists *E. coli* densities for all samples collected, as well as exceedances of the recreation season geometric mean criterion which occurred for all the sites in the Chagrin River and its tributaries. Chagrin River RM 26.70 and Chagrin River RM 22.60 did meet the STV criterion of no more than ten percent of the samples taken during the 90-day period exceeding 410

MPN/100ml. On average, the *E. coli* densities in 2022 were lower than those collected during 2021. This could be due to a greater number of wet-weather sampling events taking place in 2021 than 2022. In 2021, three of the five sampling events occurred during wet-weather events. In 2022, only one sampling event occurred during a wet-weather event. The level of precipitation during these wet-weather events could have caused polluted runoff and sanitary overflows that led to higher *E. coli* densities in the streams. The *E. coli* densities in 2022 were also, on average, lower compared to the previous studies NEORSD conducted on the Chagrin River watershed.

Table 4. 2022 *E. coli* Densities (MPN/100mL)

Date	Chagrin River RM 29.00	Chagrin River RM 26.70	Chagrin River RM 22.60	Pepper-Luce Creek RM 3.20	Willey Creek RM 1.00
6/22/2022	58	131	104	1203	30
6/28/2022	107	276	276	285	61
7/5/2022*	435	206	140	1986	1046
7/12/2022	43	104	52	51	80
9/13/2022	548	210	172	722.5	1300
90-day Geomean	144.8	174.7	129.2	478.5	181.9

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.

Water Column Chemistry Results and Discussion

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 sites were 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 stream. All sites had results below the method detection limit indicating that mercury was not found at levels exceeding those normally found in the watershed.

In 2015, the Ohio EPA Nutrients Technical Advisory Group released a proposed Stream Nutrient Assessment Procedure (SNAP) designed to determine the degree of impairment in a stream due to nutrient enrichment. The SNAP assigns designations for quality of surface waters based on factors including benthic chlorophyll *a*, total phosphorous, and dissolved inorganic nitrogen (Ohio EPA, 2015). NEORSD did not collect benthic chlorophyll *a* in 2022; however, nutrient concentrations were assessed for general watershed monitoring purposes.

The 2022 nutrient concentrations for all sampling sites are shown in Table 5. The results of dissolved inorganic nitrogen (DIN) and total phosphorous (TP) were compared to Table 2 listed in the SNAP document (Figure 3). According to this section of SNAP, Chagrin River RM 29.00 received an ecological risk narrative level described as "background levels typical of least disturbed conditions." Chagrin River RM 26.70 received an ecological risk narrative level described as "levels typical of developed lands; little or no risk to beneficial uses." The DIN geomean for Chagrin River RM 26.70 was calculated using only four sample results due to ammonia being rejected by QA/QC protocols on one of the samples. Chagrin River RM 22.60, Pepper-Luce Creek RM 3.20, and Willey Creek RM 1.00 all received an ecological risk narrative level described as "levels typical of working landscapes; low risk of beneficial use if allied responses are within normal ranges."

Table 5. Nutrient Results for the Chagrin River watershed used in 2022 SNAP Analysis

Stream	River Mile	Geomean DIN (mg/L)	Geomean TP (mg/L)	Geomean DRP (mg/L)
Chagrin River	29.00	0.418	0.039	0.014
	26.70	0.867*	0.074	0.037
	22.60	1.533	0.044	0.016
Pepper-Luce Creek	3.20	0.631	0.118	0.067
Willey Creek	1.00	1.144	0.100	0.061

Data used in Table 2 of SNAP (Ohio EPA, 2015b)

*only contains four sample results due to ammonia being rejected by QA/QC protocols

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

"allied responses" = allied response indicators (24-hour DO swing, benthic chlorophyll)

Figure 3. Table 2 of the Stream Nutrient Assessment Procedure (Ohio EPA, 2015b).

The Ohio EPA noted multiple stressors to the aquatic life use of Willey Creek and Pepper-Luce Creek (nutrients, organic enrichment, solids, etc.), as well as in the Chagrin River in the near downstream reaches in a 1995 report (Ohio EPA, 1997). The Ohio EPA also noted substantial algal growth on rock substrates which demonstrated the additional nutrient loadings from the WWTPs in Pepper-Luce Creek and Willey Creek. Consequently, macroinvertebrate communities were negatively affected in these reaches. Figure 4 below compares target nutrient concentrations before and after WWTP removals on Willey Creek and Pepper-Luce Creek. Clear reductions in TP and nitrate-nitrite (NO3+NO2) were noted in Pepper-Luce Creek since these WWTPs were decommissioned in May of 2012. A reduction in TP was also noted in Willey Creek. These reductions are not as notable in the Chagrin River downstream of where these two tributaries come in; however, the median has decreased. This is likely due to the Chagrin River having a larger drainage area and more point and nonpoint sources of pollution compared to the two tributaries. Ammonia concentrations have seen a wider variation in concentrations since 2012 although median concentrations are similar. This variation in ammonia may be correlated to ageing septic systems, existing WWTPs, and urban runoff. Of note, both the Ursuline College (Willey Creek) and University Schools (Pepper-Luce Creek) WWTPs exceeded NPDES permit limits for ammonia within the last 3 years (Ohio EPA, n.d.).

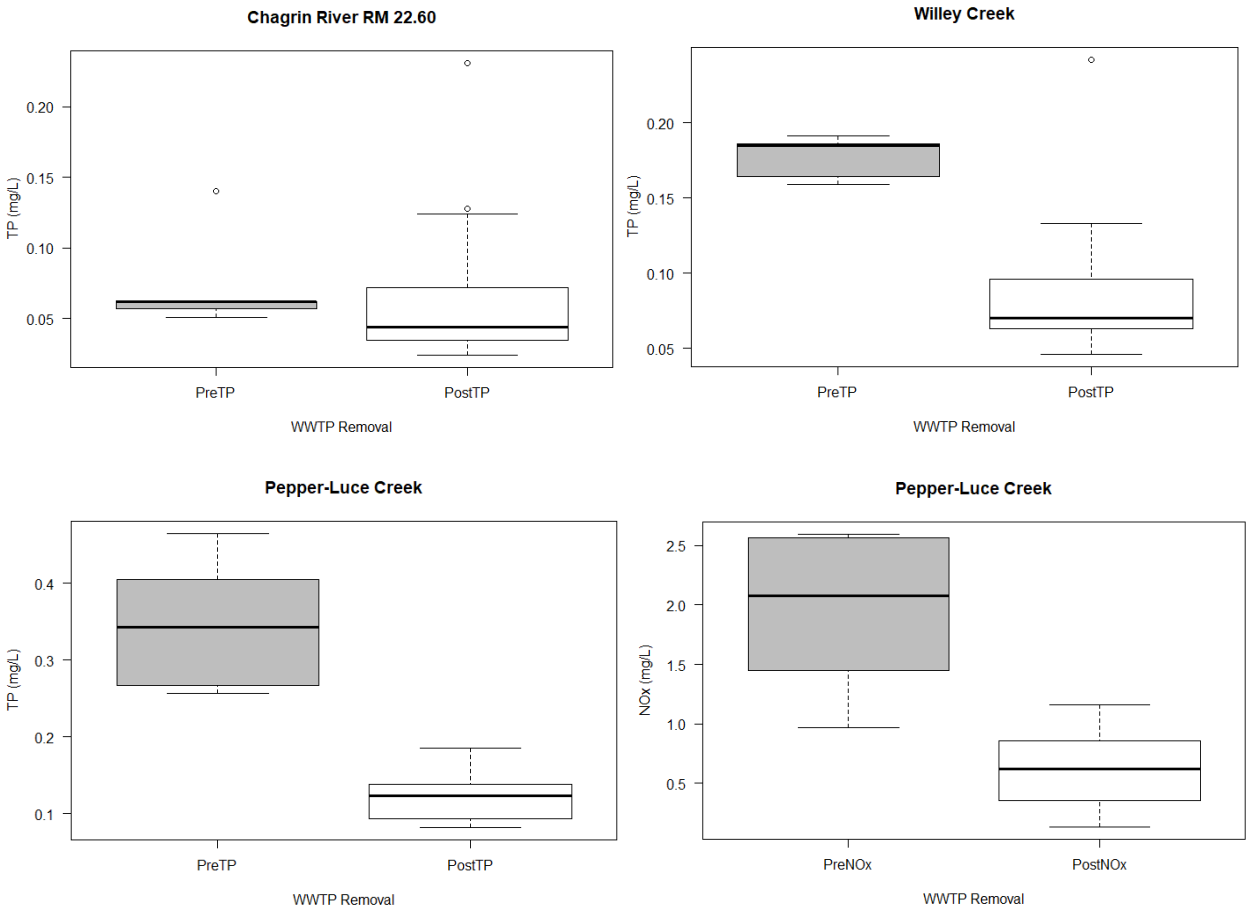

Figure 4. Boxplots for nutrient concentrations pre- and post- WWTP removal from sampling locations downstream of decommissioned WWTPs (Chagrin River RM 22.60, Willey Creek RM 1.00, and Pepper-Luce Creek RM 3.20).

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site in 2022 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; however, narrative ratings vary based on the drainage area of the stream (Table 6). For headwater streams, a score of 55 and higher, and for larger streams, a score of 60 and higher, 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.

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).

Table 6. Narrative Ranges Assigned to QHEI Scores

Narrative Rating	QHEI Range	
	Headwater Stream (Drainage Area ≤ 20 square miles)	Larger Stream (Drainage Area > 20 square miles)
Excellent	≥ 70	≥ 75
Good	55 – 69	60 – 74
Fair	43 – 54	45 – 59
Poor	30 – 42	30 – 44
Very Poor	< 30	< 30

Results and Discussion

Of the five sites studied in 2022, three received narrative ratings of *Excellent,* while the other two received narrative ratings of *Good* (Table 7). All five sites exceeded the target scores set by the Ohio EPA (Figure 5). These sites should all have the ability to support healthy warmwater habitat (and coldwater habitat in the case of Willey Creek) communities.

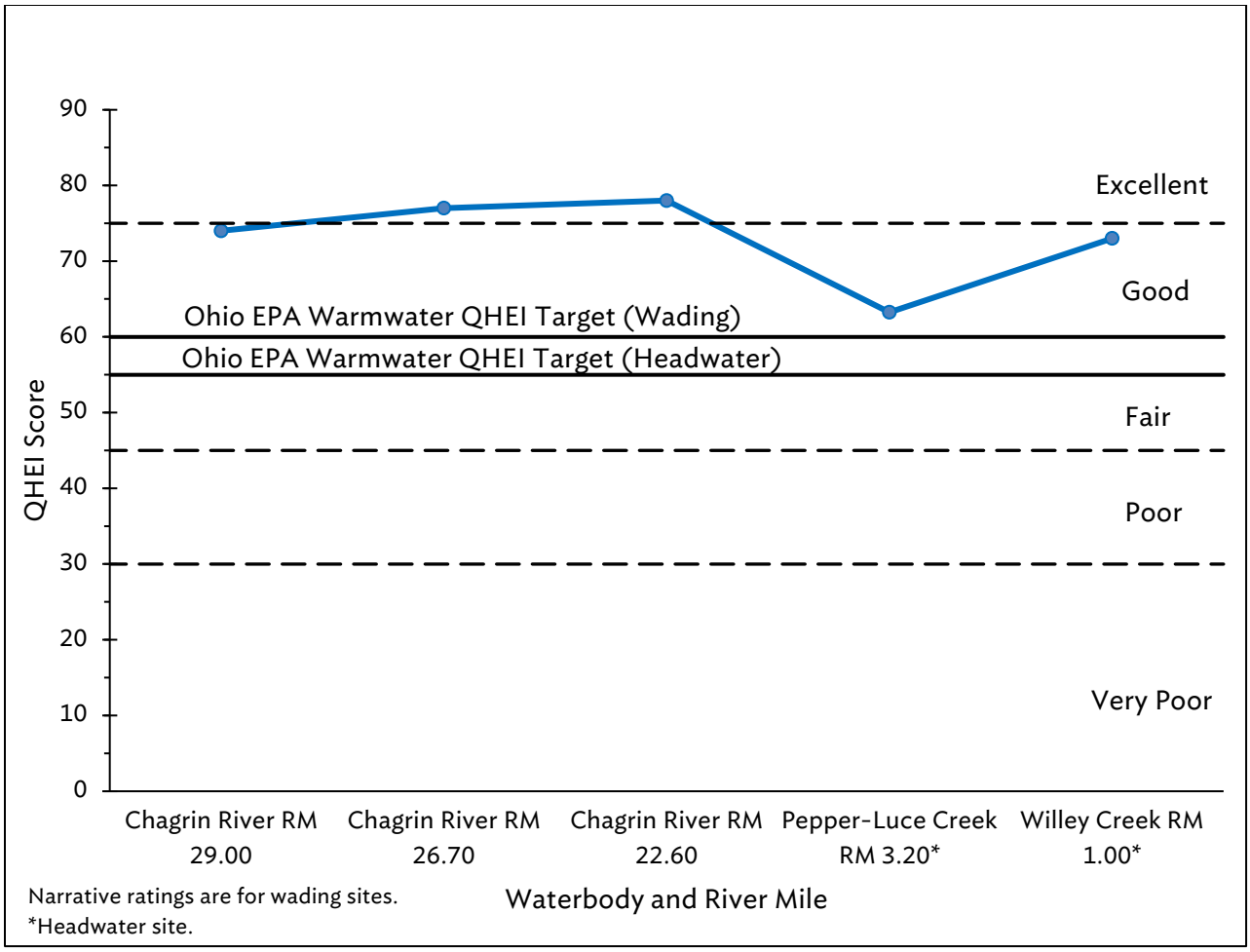

Figure 5. 2022 Chagrin River Watershed Qualitative Habitat Evaluation Index Scores

The QHEI assessment of the Chagrin River at RM 29.00 resulted in a score of 74 and a narrative rating of *Good*. The dominant substrates at this location were cobble and gravel. Boulders and sand were also present throughout the reach. Hardpan and silt were noted in the pools. This section of stream had normal to moderate amounts of silt and normal embeddedness. This section of stream is not channelized, moderately to highly stable, and has little to no erosion. It has low to moderate sinuosity and good development of pool, riffle, run habitat. Riffles with a depth of greater than 10 centimeters are present. The maximum depth of the runs was greater than 50 centimeters. The riffle/run substate is moderately stable to stable with little embeddedness. The QHEI score in 2022 was 74, which was a marginal decrease from a score of 77 in 2021. This resulted in a narrative rating shift from *Excellent* to *Good*. This could be due to a shift in the types and amount of instream cover present from 2021 to 2022. In 2022, a moderate amount of instream cover was present including rootmats, rootwads, boulders, and pools greater than 70 centimeters. In 2021, aquatic macrophytes and logs or woody debris were also noted in addition to the types present in 2022. Another cause of the decrease in the score was that in 2022, compared to 2021, the riffle/run substrates were noted to be somewhat less stable and somewhat more embedded.

The QHEI assessment of the Chagrin River at RM 26.70 resulted in a score of 77 and a narrative rating of *Excellent.* The dominant substrates at this location were boulder/slabs and bedrock. Boulders, cobble, gravel, and sand were also present throughout the reach. A moderate amount of instream cover was present consisting of shallows in slow water, rootmats, rootwads, pools greater than 70 centimeters deep, and boulders. This reach of the Chagrin River is not channelized, has good pool, riffle, and run development, but low sinuosity. Little to no bank erosion is present. This reach has a wide riparian zone consisting of forested habitat with some residential homes. This site also has pools deeper than 1 meter, riffles deeper than 10 centimeters, and runs deeper than 50 centimeters. This site is characterized with stable substrates and low riffle/run embeddedness.

The QHEI assessment of the Chagrin River at RM 22.60 resulted in a score of 78 and a narrative rating of *Excellent.* The dominant substrates at this location were cobble and sand, followed by boulders and gravel. Some silt was also noted in the pools. Sparse amounts, but of good quality, of instream cover were present consisting of shallows in slow water, pools greater than 70 centimeters deep, boulders, and woody debris. This reach of the Chagrin River is moderately stable, not channelized, and has good to excellent sinuosity and development. Some bank erosion is present. This reach of stream has a wide riparian zone consisting mostly of mature forest with some fenced pasture. This reach of the Chagrin River is stable with low embeddedness.

The QHEI assessment of Willey Creek at RM 1.00 resulted in a score of 73 and a narrative rating of *Excellent*. The dominant substrates are cobble and gravel. Boulders, sand, bedrock, hardpan, and silt are also present. A moderate amount of instream cover is present consisting of undercut banks, rootmats, rootwads, boulders, and pools greater than 70 centimeters deep. This section of Willey Creek is moderately sinuous, has good pool/riffle/run development, and is not channelized. Moderate erosion is present on river left; however, this section of Willey Creek overall has high stability and low/normal embeddedness. The riparian zone consists of a mixture of forest and residential.

The QHEI assessment of Pepper-Luce Creek at RM 3.20 resulted in a score of 63.25 and a narrative rating of *Good*. The dominant substrates at this location are cobble and gravel. Boulders were noted throughout the reach and sand and silt were noted in the pools. A moderate amount of silt was present and this reach was moderately to extensively embedded. A moderate to extensive amount of instream cover is present consisting of shallows in slow water, pools greater than 70 centimeters deep, rootwads, boulders, and logs and woody debris. This reach of Pepper-Luce is not channelized, moderately stable and sinuous, and has fair pool/riffle/run development. A functional riffle was not present in the sampling zone which contributed to a lower overall QHEI score compared to 2021. The QHEI score in 2021 was 72 with a narrative rating of *Excellent*. The score decreased by 8.75 and the narrative rating decreased from *Excellent* to *Good*. Some other factors that contributed to the lower score in 2022 included greater embeddedness in the stream, lower stability, and more erosion.

The individual components of the QHEI for all five sites were categorized as being indicative of either a WWH or a MWH to evaluate whether the site is capable of meeting its WWH designated use (Table 7). Pepper-Luce Creek RM 3.20 received five MWH attributes. All five were

characteristics of moderate influence on fish communities. The presence of one high or four or more moderate influence characteristics has been found to result in lower IBI scores. Pepper-Luce Creek RM 3.20 received an IBI score of 28 with a narrative evaluation of *Fair*. This IBI score puts this site in non-attainment status of the warmwater habitat criterion in 2022. Willey Creek RM 1.00 received only one moderate influence MWH attribute; however, the site received an IBI score of 31 with a narrative rating of *Fair.* Willey Creek RM 1.00 has excellent fish habitat but the low IBI score is likely due to a natural barrier (waterfalls) downstream inhibiting the upstream migration of fish from the Chagrin River. Chagrin River RM 29.00 received two moderate influence MWH attributes and Chagrin River RM 26.70 received one moderate influence MWH attributes; both sites received IBI scores of 48 with narrative ratings of *Very Good*. Chagrin River RM 22.60 received one high influence MWH attribute; however, this site still received an IBI score of 47 with a narrative evaluation of *Very Good*. This will further be evaluated in the *Fish Community Biology Assessment* section of this report.

Table 7. 2022 Qualitative Habitat Evaluation Index Scores and Physical Attributes.

				WWH Attributes											**MWH Attributes**															
															High Influence						Moderate Influence												
Stream	**River Mile**	**QHEI Score**	**Narrative 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	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**	**(MWH-H.I.+1) / (WWH+1) Ratio**	**(MWH M.I.+1) / (WWH+1) Ratio**
Chagrin River	29.00	74.00	*Good*	X	X		X	X	X	X	X	X	X	**9**						**0**		X			X							**2**	0.1	0.3
	26.70	77.00	*Excellent*	X	X		X		X	X	X	X	X	**8**						**0**					X							**1**	0.1	0.2
	22.60	78.00	*Excellent*	X	X		X	X		X	X	X	X	**8**				X		**1**												**0**	0.2	0.1
Pepper-Luce Creek	3.20	63.25	*Good*	X	X			X	X			X		**5**						**0**		X		X				X	X		X	**5**	0.2	1.0
Willey Creek	1.00	73.00	*Excellent*	X	X		X	X	X	X	X	X	X	**9**						**0**		X										**1**	0.1	0.2

Fish Community Biology Assessment

Methods

Two quantitative electrofishing passes were conducted at each site in 2022. A list of the dates when the surveys were completed, along with approved flow measurements from the United States Geological Survey (USGS) gage stations in 04209000 (Chagrin River) and 04208923 (Pepper-Luce Creek; also used for Willey Creek flows) are shown in Table 8. Sampling was conducted using longline electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream by slowly and steadily wading through the stream while sampling shoreline and submerged habitat. The sampling zone was 0.20 kilometers for the Chagrin River sites and 0.15 kilometers for the Pepper-Luce Creek and Willey Creek sites. Sampling protocols 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 8. Sampling Dates and River Flows

Date	Sites sampled (RMs)	Daily Mean Flow (CFS)
6/30/2022	Pepper-Luce RM 3.20	0.42
7/7/2022	Willey Creek RM 1.00	0.90
8/18/2022	Chagrin River RMs 26.70, 29.00	41
8/19/2022	Chagrin River RM 22.60	40
9/16/2022	Chagrin River RM 22.60	46
10/5/2022	Chagrin River RMs 26.70, 29.00	73
10/7/2022	Pepper-Luce RM 3.20, Willey Creek RM 1.00	N/A*
*Discharge data discontinued after 9/29/2022		

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 (Tables 9 and 10). These metrics vary based on sample site drainage area. 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*. The IBI was calculated for all sites for this study.

Table 9. IBI Metrics (Headwater sites)
Number of indigenous fish species
Number of darter species
Number of headwater species
Number of minnow species
Number of sensitive species
Percent tolerant species
Percent omnivore species
Percent insectivore species
Percent pioneering species
Number of individuals (minus tolerants)
Number of simple lithophilic species
Percent DELT anomalies

Table 10. IBI Metrics (Wading Sites)
Number of indigenous fish species
Number of darter species
Number of sunfish species
Number of sucker species
Number of intolerant species
Percent tolerant species
Percent omnivore species
Percent insectivore species
Percent of top carnivore species
Number of individuals (minus tolerants)
Percent of simple lithophilic spawners
Percent DELT anomalies

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 Chagrin River drainage area 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 38 for wading sites and 40 for headwater sites. A site is considered to be within non-significant departure if the score falls within 4 IBI units or 0.5 MIwb units of the criterion (Table 11). 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 11. Fish Community Biology Scores in the EOLP Ecoregion

Ohio EPA Narrative	Very Poor	Poor	Fair	Marginally Good	Good	Very Good	Exceptional
IBI Score - Headwater	12-17	18-27	28-35	36-39	40-45	46-49	50-60
IBI Score – Wading	12-17	18-27	28-33	34-37	38-45	46-49	50-60
MIwb Score (Wading only)	0-4.4	4.5-5.8	5.9-7.3	7.4-7.8	7.9-8.8	8.9-9.3	≥9.4
Ohio EPA Narrative	Non-Attainment			NSD	Attainment		
NSD – Non-Significant Departure of WWH attainment							

Results and Discussion

Chagrin River RM 29.00 was in full attainment of the warmwater habitat criteria in 2022 (Table 12). The site received an average IBI score of 48 (*Very Good*) and an average MIwb score of 8.8 (*Good*). During the two electrofishing passes, a total of 993 fish were collected. This total was comprised of 25 native species. No non-native or hybrid species were collected. During the surveys, four pollution-intolerant species were collected: bigeye chub, river chub, rosyface shiner, and stonecat madtom. Multiple individuals of all four species were collected during each survey. River chub was the most abundant species present (26%) in both surveys, followed by common shiner, bluntnose minnow, and rosyface shiner. 2022 was only the second year that NEORSD has conducted environmental monitoring at Chagrin River RM 29.00. Environmental monitoring was first done at Chagrin River RM 29.00 by NEORSD in 2021. The IBI and MIwb scores at Chagrin River RM 29.00 were the same in both years (Tables 13 and 14), indicating that the fish community is stable. The Ohio EPA conducted environmental monitoring at Chagrin River RM 29.00 in 1986, 1990, 1995, and 2003-2004 (Tables 13 and 14). This site has continuously met attainment for warmwater habitat criteria.

The two sampling events at Chagrin River RM 26.70 confirmed full attainment status for the site in 2022. The site received an average IBI score of 48 (*Very Good*) and an average MIwb score of 8.7 (*Good*) (Table 12). The IBI and MIwb scores both fell within the range of previous scores given to the site by NEORSD in 2009, 2012, 2014, and 2021 (no survey conducted in 2013), and by the Ohio EPA in 1986 and 1995, indicating stability within the fish population of this stream reach (Tables 13 and 14). A total of 960 fish were collected between both electrofishing surveys. The same four pollution-intolerant species that were collected at Chagrin River RM 29.00 were also collected at Chagrin River RM 26.70: bigeye chub, river chub, rosyface shiner, and stonecat madtom. Multiple individuals of river chub, rosyface shiner, and stonecat madtom were collected during each electrofishing pass. However, only one bigeye chub was collected on the second

electrofishing pass, and none were collected on the first pass. A total of twenty-six species were collected between the two surveys that were comprised of twenty-five native species and one hybrid (green sunfish x bluegill sunfish). Historical sampling events at Chagrin River RM 26.70 were in full attainment of the warmwater habitat criteria for fish communities and the site continues this attainment status in 2022. This continuation of attainment verifies that a healthy, stable fish community remains at RM 26.70.

Chagrin River RM 22.60 was in full attainment of the warmwater habitat criteria in 2022. The site received an average IBI score of 47 (*Very Good*) and an average MIwb score of 9.2 (*Very Good*) (Table 12). The IBI score decreased from 51 (*Exceptional*) in 2021 to 47 (*Very Good*) in 2022. However, the 2022 IBI and Mlwb scores are still within range of previous survey results from 2009, 2012, 2013, 2014, and 2021 (Tables 13 and 14). This site has continuously been in attainment. In 2022, a total of 2,167 fish were collected which were comprised of twenty-six species, all of which were native species. Five pollution-intolerant species were collected: black redhorse, river chub, bigeye chub, rosyface shiner, and the stonecat madtom. Seven moderately intolerant species were collected. Even with the slight decrease in the IBI score from 2021 to 2022, full attainment status of warmwater habitat criteria at Chagrin River RM 22.60 in 2022 confirms that there have been no major negative impacts to this section of river when compared to previous NEORSD sampling data.

Pepper-Luce Creek RM 3.20 received an average IBI score of 28 (*Fair*) putting it in non-attainment status of the warmwater habitat criterion in 2022 (Table 12). A total of 2,318 fish were collected which were comprised of ten species, nine native species and one non-native species. This site was dominated by pollution-tolerant species (approximately 54%); no pollution-intolerant species were found and a low proportion of insectivorous fish (0.47%) were collected, reflecting historically poor water quality. This site received a QHEI score of 63.25 with a rating of *Good*, which indicates that this site has the habitat and physical components to support a healthy fish community; however, a dam and natural barriers downstream prevent the upstream migration of fish from the Chagrin River. Without the ability for fish to migrate upstream, this site will likely continue to fail to meet its aquatic life use designation.

In 2022, Willey Creek RM 1.00 was in non-attainment based on coldwater indicator species as listed in the Biological Criteria for the Protection of Aquatic Life, Volume II (Ohio EPA, 1987a). Since no IBI criteria has been established for use determination of coldwater habitat, the IBI score was used to help assess the overall health of the fish population. Willey Creek RM 1.00 received an average IBI score of 31 (*Fair*) in 2022, which is the highest score calculated at this site by NEORSD (Table 12). This is a slight increase from a score of 28 in 2021. Previous studies by NEORSD have never exceeded an IBI score of 30 (*Fair*) (Table 13). Although this site is designated as coldwater habitat, there were no species associated with this designation collected. Between the two electrofishing passes, a total of 1,321 fish were collected which were comprised of six species: common white sucker, blacknose dace, creek chub, central stoneroller minnow, bluegill sunfish, and pumpkinseed sunfish. This site was dominated by pollution-tolerant species (66.1%) and no pollution-intolerant species were found. Willey Creek received a QHEI score of 73 with a rating of *Excellent*. This suggests that this site should be able to support a healthy fish community based on

the warmwater habitat target. A natural barrier (waterfalls) downstream is likely inhibiting the upstream migration of fish from the Chagrin River. Due to this, failure to meet the aquatic life use designation will likely continue into the foreseeable future for Willey Creek RM 1.00.

Table 12. 2022 Fish Community Assessment Scores

Waterbody	River Mile	1st Pass		2nd Pass		Average	
		IBI	MIwb	IBI	MIwb	IBI	MIwb
Chagrin River	29.00	52[E]	8.9	44	8.6	48 (*Very Good*)	8.8 (*Good*)
Chagrin River	26.70	48	8.9	48	8.5	48 (*Very Good*)	8.7 (*Good*)
Chagrin River	22.60	54[E]	9.7[E]	40	8.7	47 (*Very Good*)	9.2 (*Very Good*)
Pepper-Luce Creek[H]	3.20	32*	-	24*	-	28* (*Fair*)	-
Willey Creek[H]	1.00	30*	-	32*	-	31* (*Fair*)	-

*Significant departure from biocriterion (>4IBI; >0.5 MIwb units).
Underlined scores are in the *Poor* or *Very Poor* narrative range
[ns] non-significant departure from biocriterion (≤4IBI; ≤0.5 MIwb units)
[E] Exceptional WWH score
[H] Headwater scoring criteria

Table 13. Chagrin River Historic IBI Scores (1986-2022)					
Year	Chagrin River			Pepper-Luce Creek[H]	Willey Creek[H]
	RM 29.00	RM 26.70	RM 22.60	RM 3.20	RM 1.00
1986*	**45**	**44**	-	-	-
1990*	35[ns]	-	-	-	-
1995*	**43**	**41**	-	-	_
2003/ 2004*	**48**	-	-	-	-
2009	-	**46**	**44**	34	24
2012	-	**48**	**56[E]**	32	32
2013	-	**-**	**42**	32	24
2014	-	**50[E]**	**46**	30	24
2021	**48**	**46**	**51[E]**	27	28
2022	**48**	**48**	**47**	28	31

Bold = meets WWH criterion (≥40 for headwater sites, ≥38 for wading sites)
* Data collected by the Ohio EPA
Underlined scores are in the *Poor* or *Very Poor* narrative range
[ns] non-significant departure from biocriterion (≤4IBI; ≤0.5 MIwb units)
[E] Exceptional WWH score
[H] Headwater scoring criteria
RMs are approximate, data collected within 0.5 mile of site.

Table 14. Chagrin River Historic MIwb Scores (1986-2022)			
Year	RM 29.00	RM 26.70	RM 22.60
1986*	**7.9**	**8.2**	-
1990*	7.4[ns]	-	-
1995*	7.8[ns]	7.4[ns]	-
2003/2004*	**9.2**	-	-
2009	-	**8.6**	**8.8**
2012	-	**9.7[E]**	**10.1[E]**
2013	-	-	**9.0**
2014	-	**9.1**	**8.2**
2021	**8.8**	**8.9**	**9.3**
2022	**8.8**	**8.7**	**9.2**

Bold = meets WWH criterion (≥7.9)
* Data collected by the Ohio EPA
[ns] non-significant departure from biocriterion (≤0.5 MIwb units)
[E] Exceptional WWH score
RMs are approximate, data collected within 0.5 mile of site.

At Willey Creek RM 1.00, other than highly tolerant species and the herbivorous stoneroller minnow, only a few stray sunfish have sporadically been collected. A total of seven species have ever been collected at Willey Creek RM 1.00 by NEORSD since 2009. In a 1995 assessment at Willey Creek RM 0.5 (downstream of all fish barriers) by the Ohio EPA, 17 species were collected including several intolerant species (Ohio EPA, 1997). The site received an IBI score of 44 with a narrative rating of *Very Good*. This shows the difference in the fish community upstream and downstream of the natural barriers, demonstrating the negative effects that the natural barriers have on Willey Creek. Similar observations have been made on Pepper-Luce Creek. IBI scores upstream of the barriers are consistently in the *Poor* to *Fair* range (Figure 7), while sites downstream of the barriers, near the confluence with the Chagrin River, have scored *Marginally Good* to *Exceptional* by the Ohio EPA.

The main stem of the Chagrin River has consistently received *Good* to *Exceptional* IBI and MIwb scores and continues to meet WWH attainment (Figure 6). The Chagrin River continues to maintain a healthy and stable fish community. In 2022, NEORSD collected a total of 241 bigeye chubs in the six electrofishing passes conducted on the mainstem of the Chagrin River. 2021 was the first year that the NEORSD collected bigeye chubs on the Chagrin River. In 2021, NEORSD collected a total of 107 individuals during the sampling season. The bigeye chub is a pollution-intolerant species that requires streams with clear water and silt free cobble, gravel, and sand substrates (Rice and Zimmerman, 2019). In the Ohio EPA's report, *Biological and Water Quality Study of the Chagrin River and Selected Tributaries 2003-2004*, only 11 bigeye chubs were collected in 58 electrofishing assessments throughout the watershed (Ohio EPA, 2006). This increase in the number of bigeye chubs collected shows improvement in the Chagrin River. NEORSD has not collected bigeye chubs in Pepper-Luce Creek or Willey Creek, likely due to the fish barriers in both streams.

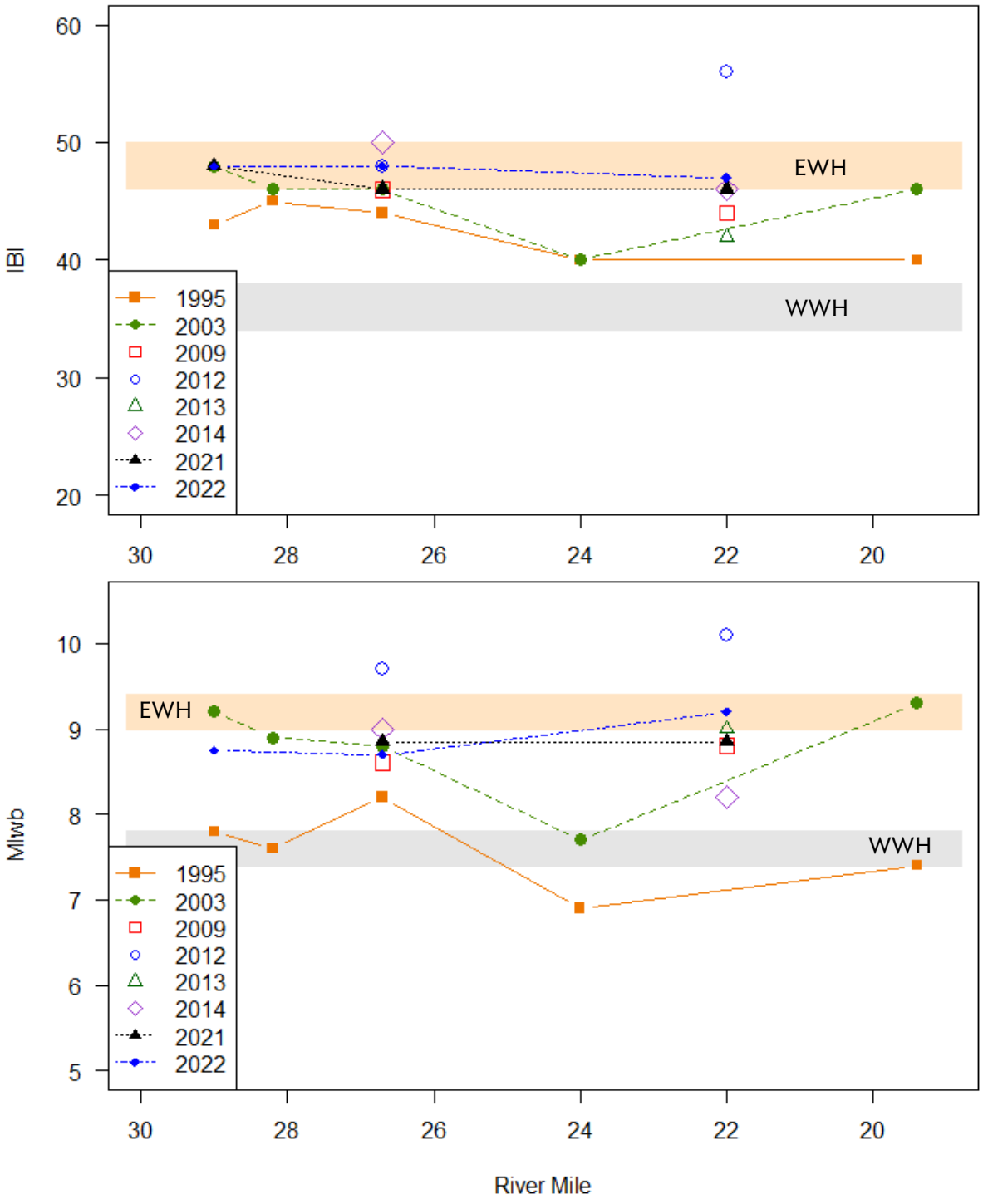

Figure 6. Fish community biology scores of the Chagrin River mainstem 1995-2022. Gray box represents range of WWH attainment and NSD; tan box represents range of EWH attainment and NSD.

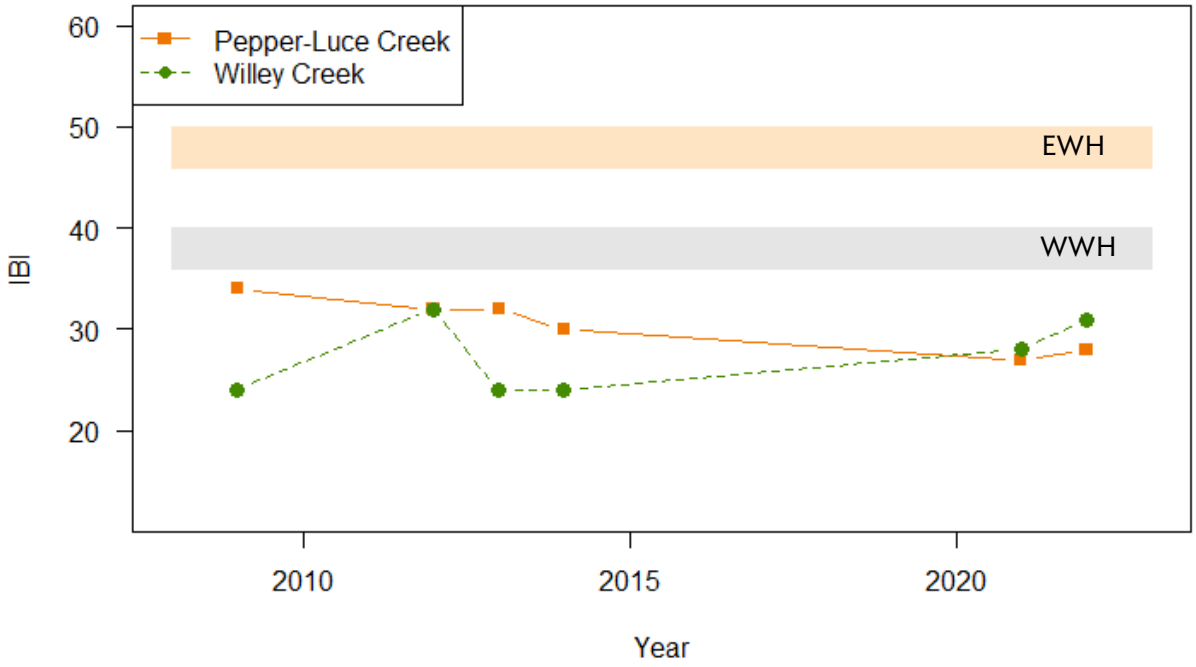

Figure 7. Fish community biology scores for Willey Creek RM 1.00 and Pepper-Luce Creek RM 3.20 from 2009-2022. Gray box represents range of WWH attainment and NSD; tan box represents range of EWH attainment and NSD.

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 the NEORSD WQIS Division.

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 15), 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 results 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 16) and a site is within non-significant departure if the score falls within 4 ICI units of the criterion.

Table 15. 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 16. 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

The five sites in the Chagrin River watershed were sampled quantitatively using HDs in conjunction with qualitative sampling in 2022. All five HDs were able to be recovered during the sampling season. In the Erie-Ontario Lake Plain region, an ICI score of 30 or greater is needed in order for a site to be considered in attainment. The three sample sites on the Chagrin River and the two tributary sites on Pepper-Luce and Willey Creeks met the WWH ICI criterion of 34 (Table 17).

Table 17. 2022 Macroinvertebrate Results

Stream RM	Density Qt. (ft^2) /Ql.	Ql./ Total Taxa	Ql. EPT/ sensitive Taxa	Qt. % Tolerant/ Sensitive taxa	Predominant orgs. on natural substrates	ICI	Narrative Evaluation
Chagrin River (15-001-000)							
29.00	390/M-H	69/85	25/32	4.51/19.0	Polycentropodidae, Philopotamidae, Heptageniidae, Hydropsychidae, Hydroptilidae. Elmidae	52	*Exceptional*
26.70	711/M-H	65/76	16/17	0.79/8.67	Hydropsychidae, Heptageniidae, Chironomidae, Baetidae	54	*Exceptional*
22.60	1497/M-L	71/77	16/18	3.1/6.65	Turbellaria, Baetidae, Heptageniidae	42	*Very Good*
Pepper-Luce Creek (15-001-008)							
3.20	165/M-L	43/53	8/3	3.64/0	Polycentropodidae, Chironomidae, Baetidae, Turbellaria, Isopoda	42	*Very Good*
Willey Creek (15-004-000)							
1.00	251/M-L	43/52	10/8	0.87/1.68	Baetidae, Hydropsychidae, Chironomidae, Elmidae, Amphipoda	50	*Exceptional*

Qt. Quantitative sample collected on Hester-Dendy artificial substrates
Ql. Qualitative sample collected from natural stream substrates
Qualitative sample relative density: L=Low, M=Moderate, H=High
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List (2019) as *Intolerant* or *Moderately Intolerant.*

Chagrin River RM 29.00 had 85 total taxa collected and an ICI score of 52 (*Exceptional*). Twenty-five EPT taxa were collected during qualitative sampling. There were 32 sensitive taxa collected at this site, four of which were pollution-intolerant species. A low number of pollution-tolerant species were collected at this site. 2022 was the second year that NEORSD sampled Chagrin River RM 29.00. In 2021, this site received an ICI score of 48 with a narrative rating of *Exceptional.* These findings indicate that this site has a healthy and diverse macroinvertebrate community and has the ability to maintain this community.

Chagrin River RM 26.70 had 76 total taxa collected and an ICI score of 54 (*Exceptional*). Sixteen EPT taxa were collected during qualitative sampling. Of the 76 total taxa collected, 17 were sensitive taxa with three of them being pollution-intolerant species. A low number of pollution-tolerant taxa were collected at this site. In 2021, Chagrin River RM 26.70 received an IBI score of 48 with a narrative evaluation of *Exceptional*. In 2014, the HD at this site was unable to be recovered but the site was given a narrative rating of *Exceptional*. In 2009, 2012, and 2013, this site received a narrative evaluation of *Very Good* (Table 18). The presence of high numbers of EPT and sensitive taxa, along with the increasing ICI scores since 2013, indicates that water quality continues to improve and that this site has the ability to maintain an exceptional macroinvertebrate community.

Chagrin River RM 22.60 received an ICI score of 42 (*Very Good*). A total of 77 taxa were collected during qualitative and quantitative sampling, with 18 of the taxa being sensitive taxa. Qualitative sampling yielded 16 EPT taxa. During quantitative sampling, a high percentage of Tanytarsini midges were collected and a moderate percentage of mayflies and caddisflies were found. These factors, along with a low percentage of tolerant organisms, contributed to the high ICI score. In 2021, this site received a narrative evaluation of *Good*. In 2014, the HD at this site was unable to be recovered but the site was given a narrative evaluation of *Good*. In 2009 and 2012, this site received a narrative evaluation of *Good*, and in 2013, it received a narrative evaluation of *Exceptional* (Table 18). This site has maintained high ICI scores over the years and is able to maintain a healthy and diverse macroinvertebrate community.

Pepper-Luce Creek RM 3.20 received an ICI score of 42 (*Very Good)*. Fifty-three total taxa were collected during qualitative and quantitative sampling this year. Eight EPT taxa and three sensitive taxa were collected at this site during qualitative sampling. In the qualitative sample, a moderate percentage of mayflies and Tanytarsini midges and a low percentage of tolerant organisms were collected, contributing to the ICI score. 2022 ICI scores for Pepper-Luce Creek RM 3.20 are comparable to scores given to this site in past years by NEORSD (Table 18).

Willey Creek RM 1.00 is designated as a coldwater habitat; however, like the absence of a criterion for the IBI, there is no established criterion for macroinvertebrates and the ICI for use determination of coldwater habitat. The CWH designation was originally changed from EWH in 1997, based on a 1995 Ohio EPA assessment. The Ohio EPA based this aquatic life use redesignation on a single macroinvertebrate qualitative assessment at RM 0.20 which yielded 34 total taxa, four coldwater taxa, and a 46-hour data sonde deployment demonstrating consistently high oxygen concentrations (Ohio EPA, 1997).

In 2022, Willey Creek RM 1.00 was given an ICI score of 50 (*Exceptional*). This is an increase from the ICI score in 2021 of 40 with a narrative evaluation of *Good*. In 2022, a total of 52 taxa were collected during qualitative and quantitative sampling. Eight sensitive taxa were collected and no coldwater taxa were collected. This is the first year that NEORSD has not collected any coldwater taxa at this site. NEORSD has collected between two and six coldwater taxa each year that sampling has been conducted since 2009. In 2022, a high percentage of mayflies and tanytarsini midges and a low percentage of tolerant organisms collected during the quantitative sampling contributed to the ICI score. During the qualitative sampling, ten EPT taxa were collected which also contributed to the ICI score. This is the highest score that Willey Creek RM 1.00 has received since NEORSD began conducting environmental monitoring at this site in 2009 (Table 18). Since 2009, this site has received narrative evaluations of *Good* or *Very Good* every year studied. This increase in the ICI score in 2022 shows that this site has the ability to support an exceptional macroinvertebrate community. However, it was not meeting the coldwater habitat designated use.

Table 18. Chagrin River Historic ICI Scores (1995-2022)					
Year	Chagrin River			Pepper-Luce	Willey Creek
	RM 29.00	RM 26.70	RM 22.60	RM 3.20	RM 1.00
1995	**Exceptional**	**46 [E]**	-	-	-
2003	**48 [E]**	**Very Good**	-	-	-
2009	-	**44**	**38**	**40**	**36**
2012	-	**42**	**40**	**34**	**42**
2013	-	**42**	**48 [E]**	32[ns]	**40**
2014	-	*	*	**42**	**40**
2021	**48 [E]**	**50 [E]**	**40**	**46 [E]**	**40**
2022	**52 [E]**	**54 [E]**	**42**	**42**	**50 [E]**

*Indicates qualitative sample only.
Bold indicates attainment of applicable criterion.
[ns] non-significant departure from biocriterion
[E] Exceptional WWH score
[1]Pepper-Luce was sampled at RM 3.30 in 2009, 2012, 2013, and 2014. It was sampled at RM 3.20 in 2021 and 2022.
[2] ICI does not apply to Coldwater Habitat use designation; data used for comparative purposes only.
1995 and 2003 data collected by the Ohio EPA

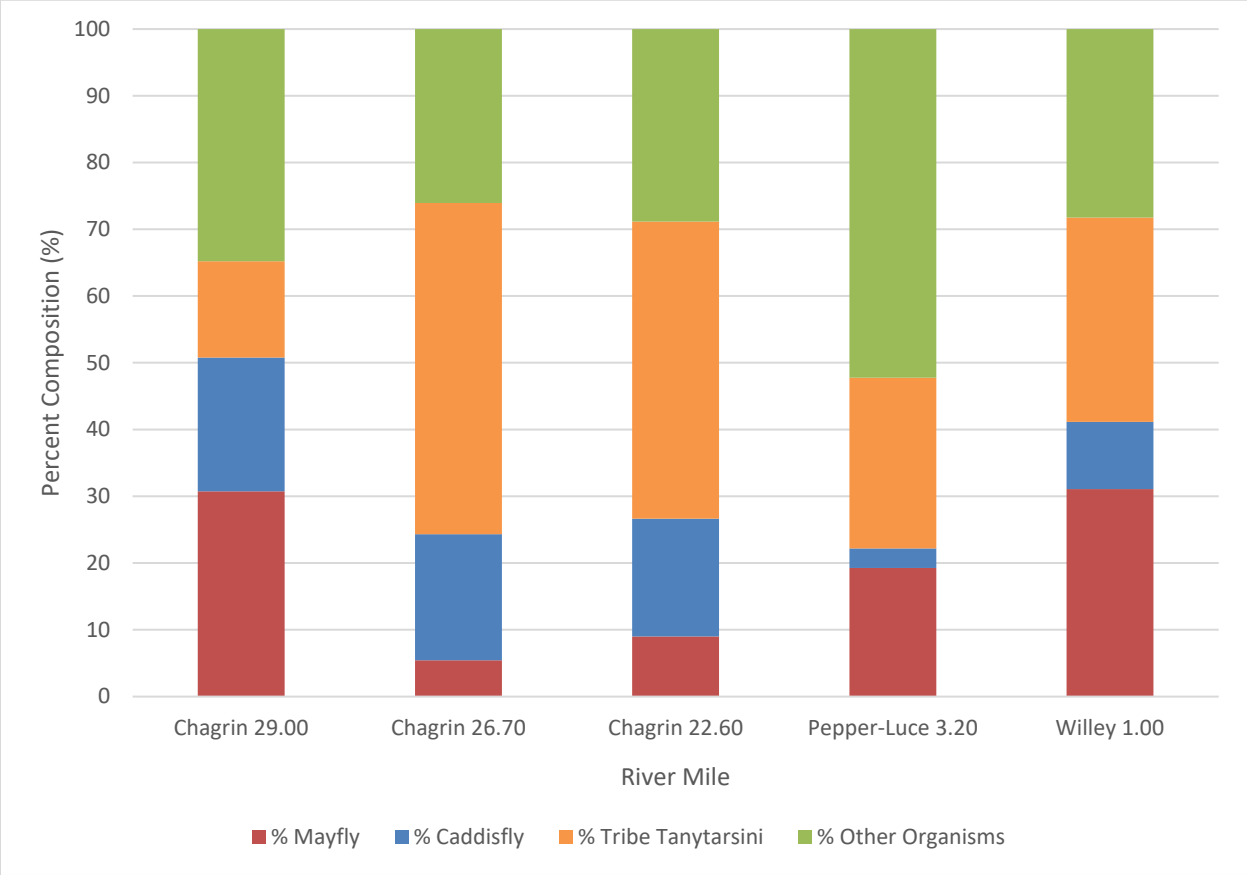

Figure 8. 2022 Macroinvertebrate Community Composition

The main stem of the Chagrin River has consistently received *Very Good to Exceptional* ICI scores and continues to meet full attainment (Figure 9). Overall trends of ICI scores at Willey Creek RM 1.00 and Pepper-Luce Creek RM 3.20 have increased from 2009 to 2022 (Figure 10). The number of EPT taxa collected at each site has also increased overall between 2009 and 2022 (Figure 11). These are positive trends showing improvement in the overall health of both Willey Creek and Pepper-Luce Creek.

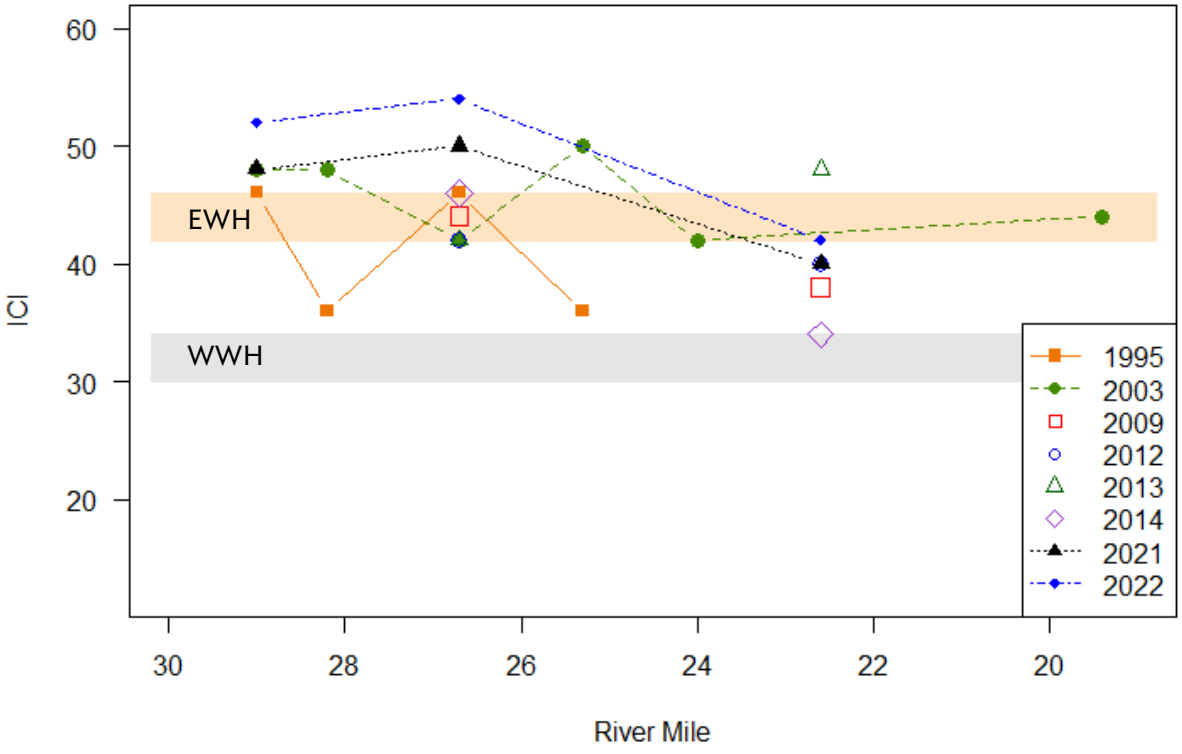

Figure 9. Macroinvertebrate community biology scores of the Chagrin River mainstem 1995-2022. Gray box represents range of WWH attainment and NSD; tan box represents range of EWH attainment and NSD.

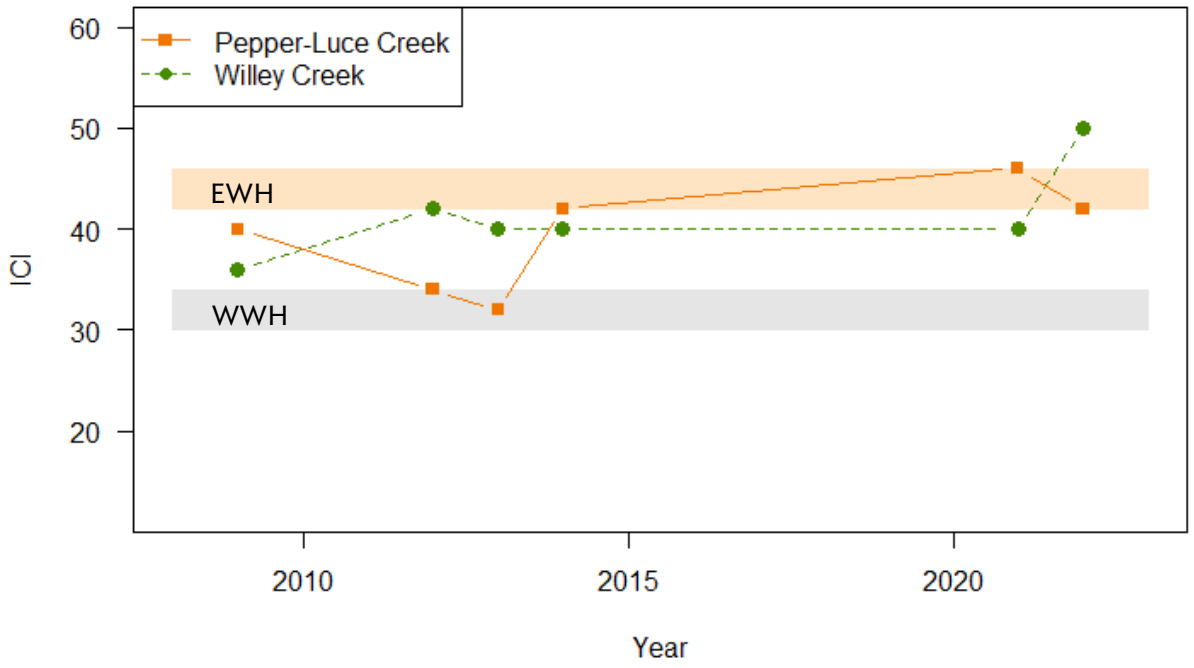

Figure 10. Macroinvertebrate community biology scores of Willey Creek RM 1.00 and Pepper-Luce Creek RM 3.20 2009-2022. Gray box represents range of WWH attainment and NSD; tan box represents range of EWH attainment and NSD.

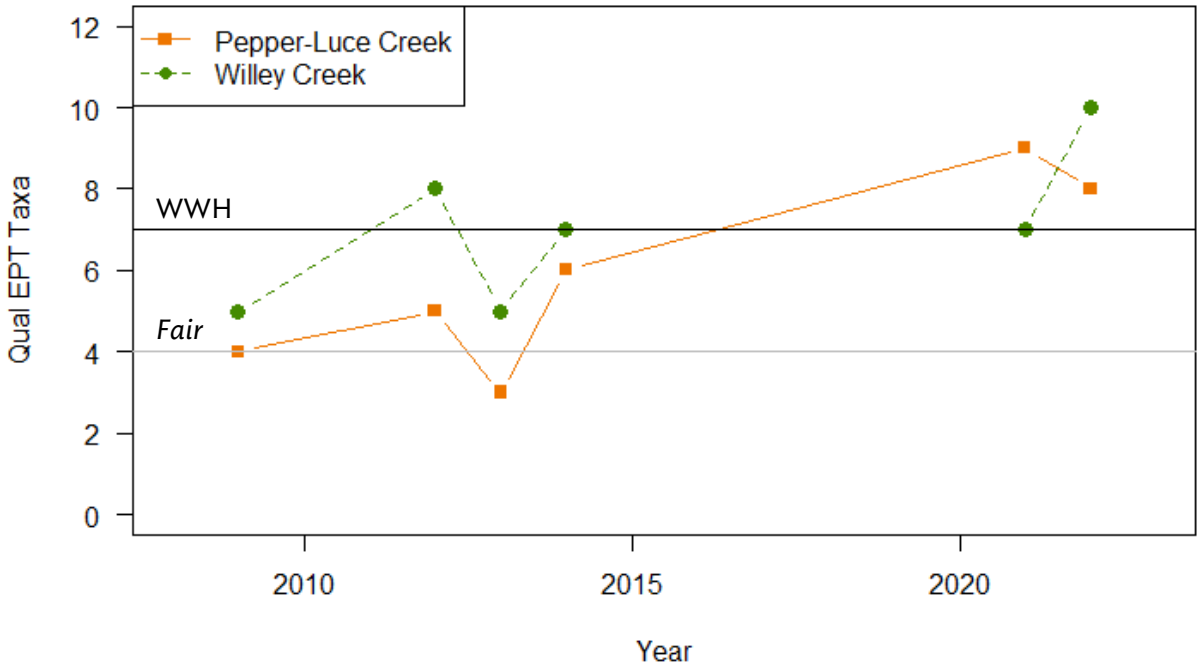

Figure 11. Qualitative EPT Taxa collected at Willey Creek RM 1.00 and Pepper-Luce Creek RM 3.20 2009-2022. Black line represents WWH expectation; gray line represents *Fair* expectation.

Conclusions

The purpose of this study was to collect general watershed monitoring data within the Chagrin River watershed. This data was also used to further document if the decommissioning of the two WWTPs in 2012 has had any effect on the water quality and biological communities of the Chagrin River and its tributaries downstream of the former WWTPs. Results from water chemistry data, fish surveys, and macroinvertebrate surveys (Table 19) suggest that there are no impacts from the tributaries on the overall health of the mainstem of the Chagrin River. Previous studies by NEORSD on the Chagrin River have indicated similar results of full attainment of the biocriteria. Improvements have been observed in both Pepper-Luce Creek and Willey Creek downstream of the two decommissioned WWTPs since 2012. Reductions in TP and NO3+NO2 have been observed and overall trends of ICI scores have increased from 2009 to 2022. However, site-specific factors hindered these tributary sites that were assessed from fully meeting their designated uses.

Table 19. 2022 Chagrin River Watershed Survey Results

RM	DA (mi^2)	Attainment Status	IBI Score	MIwb Score	ICI Score	QHEI Score	Cause(s)	Source(s)
Chagrin River (WWH Existing)								
29.00	58	FULL	48	8.8	52[E]	74.00	-	-
26.70	122	FULL	48	8.7	54[E]	77.0[E]	-	-
22.60	153	FULL	47	9.2	42	78.0[E]	-	-
Pepper-Luce Creek (WWH Existing)								
3.20[H]	7.50	PARTIAL	28*	--	42	63.25	Physical barrier (dam)	Fish barrier downstream
Willey Creek (CWH Existing)								
1.00[H]	3.70	NON**	31*	--	50[E]	73.0[E]	Physical barrier (natural waterfalls)	Fish barrier downstream

*Significant departure from WWH biocriterion (> 4ICI; > 4IBI; > 0.5 MIwb units). Underlined scores are in the *Poor* or *Very Poor* narrative range
**CWH attainment based on indicator species as listed in *Biological Criteria for the Protection of Aquatic Life, Volume II*
[H] Headwater scoring criteria
[E] *Exceptional* narrative range

Water quality monitoring results had minimal changes from the 2021 study. On average, *E. coli* densities were lower in 2022 compared to 2021, but this could be due to a greater number of wet-weather sampling events taking place in 2021 than 2022. Mercury was not present at levels above those normally found within the watershed. The heightened *E. coli* densities could be induced by illicit discharges, failing home septic sewage systems, and runoff from ponds, agricultural fields, and recreational fields located within the watershed. No other exceedances were found.

Since the Jackson Valley WWTP and the Creekside WWTP were decommissioned in May 2012, clear reductions in TP and NO3+NO2 have been observed. However, ammonia concentrations have increased since 2012. This increase may be correlated to ageing septic systems, existing WWTPs, and urban runoff.

The QHEI analyses of the five study sites indicate that they should all be able to support healthy fish communities with the potential to meet applicable ALU criteria. Three of the five sample sites, Chagrin River RM 26.70, Chagrin River RM 22.60, and Willey Creek RM 1.00, received *Excellent* QHEI narrative ratings. The sites at Chagrin River RM 29.00 and Pepper-Luce Creek RM 3.20 both received narrative ratings of *Good* but should still have the ability to support a healthy fish population based on the habitat available.

The IBI and MIwb scores at the three sampling sites on the Chagrin River confirmed a healthy fish community at all three locations. The main stem of the Chagrin River has consistently received high IBI and MIwb scores and continues to meet WWH criteria. The sites at Pepper-Luce Creek RM 3.20 and Willey Creek RM 1.00 did not meet their biological criteria designations in 2022. Pepper-Luce Creek RM 3.20 and Willey Creek RM 1.00 both received narrative ratings of *Fair* for the IBI score in 2022. Both were similar ratings to previous assessments completed by NEORSD in 2009, 2012-2014, and 2021. Fish barriers on both streams are likely preventing attainment of the WWH and CWH designated uses, respectively, at these sites.

The macroinvertebrate communities on the Chagrin River sites verified that healthy, diverse communities exist at each of the sample sites. All three locations exceeded the WWH biocriterion in 2022 and the ICI scores all increased from 2021. Pepper-Luce Creek RM 3.20 also surpassed the WWH biocriterion this sampling season. The score did decrease slightly from 2021. In 2021, the ICI score was 46 with a narrative evaluation of *Exceptional*, and in 2022, the ICI score was 42 with a narrative evaluation of *Very Good.* Even with the decrease in score, the site still exceeds the WWH biocriterion and supports a healthy and diverse macroinvertebrate community. At Willey Creek RM 1.00, no coldwater taxa were collected in 2022; therefore, the site did not meet the coldwater habitat designated use. If Willey Creek RM 1.00 was designated as warmwater habitat, the site would have exceeded the warmwater habitat criterion, indicating that there is still a healthy macroinvertebrate community at the site. Overall trends for the ICI scores and number of EPT taxa collected in the qualitative assessment show improvement in the macroinvertebrate communities at both sites.

The mainstem sites at Chagrin River RMs 26.70 and 22.60 have had minimal variation when compared to the previous studies by NEORSD that began in 2009. The site at Chagrin River RM

29.00 was first assessed by NEORSD in 2021. The results from 2022 were comparable to those found in 2021 as well as Chagrin River RM 26.70 and Chagrin River RM 22.60. All three sites support healthy fish and macroinvertebrate populations and are in full attainment of the biocriteria. Pepper-Luce Creek RM 3.20 had an ICI score that met the biocriterion with a narrative evaluation of *Very Good*, but overall, the site is considered to be in partial attainment due to the IBI score of *Fair.* Willey Creek RM 1.00 is in non-attainment of the biocriteria based on CWH standards. Both sites support healthy macroinvertebrate populations based on WWH standards. The fish community at each location is likely hindered by fish barriers that prevent the migration of fish upstream to the sample sites.

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