Northeast Ohio
Regional Sewer District

2024 Mill Creek
Biological, Water Quality, and Habitat Study

Water Quality and Industrial Surveillance

Environmental Assessment Group

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Introduction

In 2024, the Northeast Ohio Regional Sewer District (NEORSD) conducted environmental monitoring of Mill Creek, a highly urbanized sub-watershed of the Cuyahoga River. This monitoring was performed as part of the NEORSD general watershed environmental monitoring program. The intent of the environmental monitoring program is to periodically assess all major watersheds in the NEORSD service area. Mill Creek originates in the cities of Shaker Heights and Beachwood and flows in a southwesterly direction, joining the Cuyahoga River at river mile (RM) 11.40. The Mill Creek Watershed drains approximately 18.5 square miles from the communities of Cuyahoga Heights, Garfield Heights, Maple Heights, Warrensville Heights, North Randall, Highland Hills, Beachwood, Shaker Heights, and Cleveland. Mill Creek has a natural waterfall, Mill Creek Falls (also known as Cataract Falls), located at RM 2.80, which is Cuyahoga County's largest waterfall at 48-feet tall. The falls present a natural barrier to fish migration by limiting the connectivity to the lower river system and the Cuyahoga River.

The Mill Creek Watershed is included in the Cuyahoga River Area of Concern (AOC). Current beneficial use impairments (BUIs) listed for the Cuyahoga River AOC include loss of fish habitat and the degradation of fish populations and benthos (macroinvertebrate community). Previous monitoring in the Mill Creek Watershed indicated that sanitary sewage cross-contamination is a primary cause of the recreational water quality impairments on Mill Creek. Possible sources of sanitary sewage contamination include common trench sewer inflow and infiltration, illicit discharges, combined sewer overflows (CSOs), and local sanitary sewer overflows. The Mill Creek Watershed is heavily urbanized, consisting of a vast landscape of impervious surfaces which quickly transports rainfall, increasing the stormwater runoff and peak flow rates within Mill Creek. Increased stormwater runoff leads to higher bank erosion and increased pollutants transferred to a stream across the urban landscape (USEPA, 1999). Pollutants associated with urban and industrial runoff include excess sediments, nutrients, pathogens, oxygen-demanding matter, and salts (Schueler, 1987).

Within recent years, the NEORSD has completed several capital improvement projects within the Mill Creek Watershed with the goal of providing wet-weather flow relief within the sanitary collections system, increased stormwater storage capacity, and reduction/elimination of CSOs for member communities. Water quality improvements in Mill Creek have been a long-term target of the NEORSD infrastructure investments. These projects focused on improved wet-weather conveyance and increased storage capacity to capture CSO discharges during wet-weather for subsequent treatment. The NEORSD completed the construction of the Miles Avenue Relief Sewer (MARS) in June 2010 and the Lee Road Relief Sewer (LRRS) in May 2012. The third and final leg of the Mill Creek storage tunnel was completed in February 2013.

Environmental monitoring sites were located on the Mill Creek Mainstem and at Wolf Creek RM 0.05, a Mill Creek direct tributary. The sites at river miles 11.52 and 10.70 along with the Wolf Creek RM 0.05 site were monitored for post-construction recovery following stream restoration activities. Table 1 lists each sampling location with respect to stream, river mile (RM), latitude/longitude, description, and the types of surveys conducted at each location. GPS

coordinates are recorded at the downstream end of each sampling zone. Figure 1 shows a study area map illustrating each sample location evaluated during the 2024 study. A digital photo catalog of the sampling locations is available upon request by contacting the NEORSD's Water Quality and Industrial Surveillance (WQIS) Division.

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 *2024 Cuyahoga River and Northern Tributaries Environmental Monitoring* study plan approved by Ohio EPA on April 24, 2024. All sampling and assessments occurred between June 15, 2024, and September 30, 2024 (through October 15 for fish sampling assessments), as required in the Ohio EPA *Biological Criteria for the Protection of Aquatic Life Volume III* (1987a). The results were evaluated using the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), and the Invertebrate Community Index (ICI). An examination of the individual metrics that comprise the IBI and ICI was used in conjunction with the water chemistry data and QHEI scores to assess the overall health of Mill Creek.

Table 1. 2024 Mill Creek Sampling Locations

Location	River Mile	Station ID	Latitude	Longitude	Drainage Area (mi^2)	Sampling Conducted
Mill Creek (19-006-000)						
Upstream of Kerruish Basin – North of Miles Road	8.30[H]	F01P06	41.4300	-81.5446	3.90	F, M, C
Downstream of Kerruish Basin	7.40[H]	302013	41.4258	-81.5577	4.42	F, M, C
Upstream of Mill Creek Falls/ Downstream of Wolf Creek	3.15[H]	F01S23	41.4422	-81.6216	14.60	F, M, C
Upstream of Warner Road Tributary	0.70[H]	200075	41.4240	-81.6374	18.20	F, M, C
Upstream of Canal Road	0.12[H]	502110	41.4178	-81.6385	18.50	F, M, C
Stream Restoration Sites						
Mill Creek (19-006-000)						
Upstream section of Highland Park Golf Course restoration	11.52[H]	301194	41.4622	-81.5216	1.30	F, M, C
Downstream section of Highland Park Golf Course restoration site	10.70[H]	301195	41.4520	-81.5254	1.80	F, M, C
Wolf Creek (19-006-003)						
Upstream of Mill Creek confluence in Garfield Park Reservation	0.05[H]	304230	41.4313	-81.605	2.20	F, M*, C

[H] = Headwater site (draining ≤ 20 $miles^2$)
F = Fish community biology (includes habitat assessment)
M = Macroinvertebrate community biology (* qualitative survey only)
C = Water chemistry

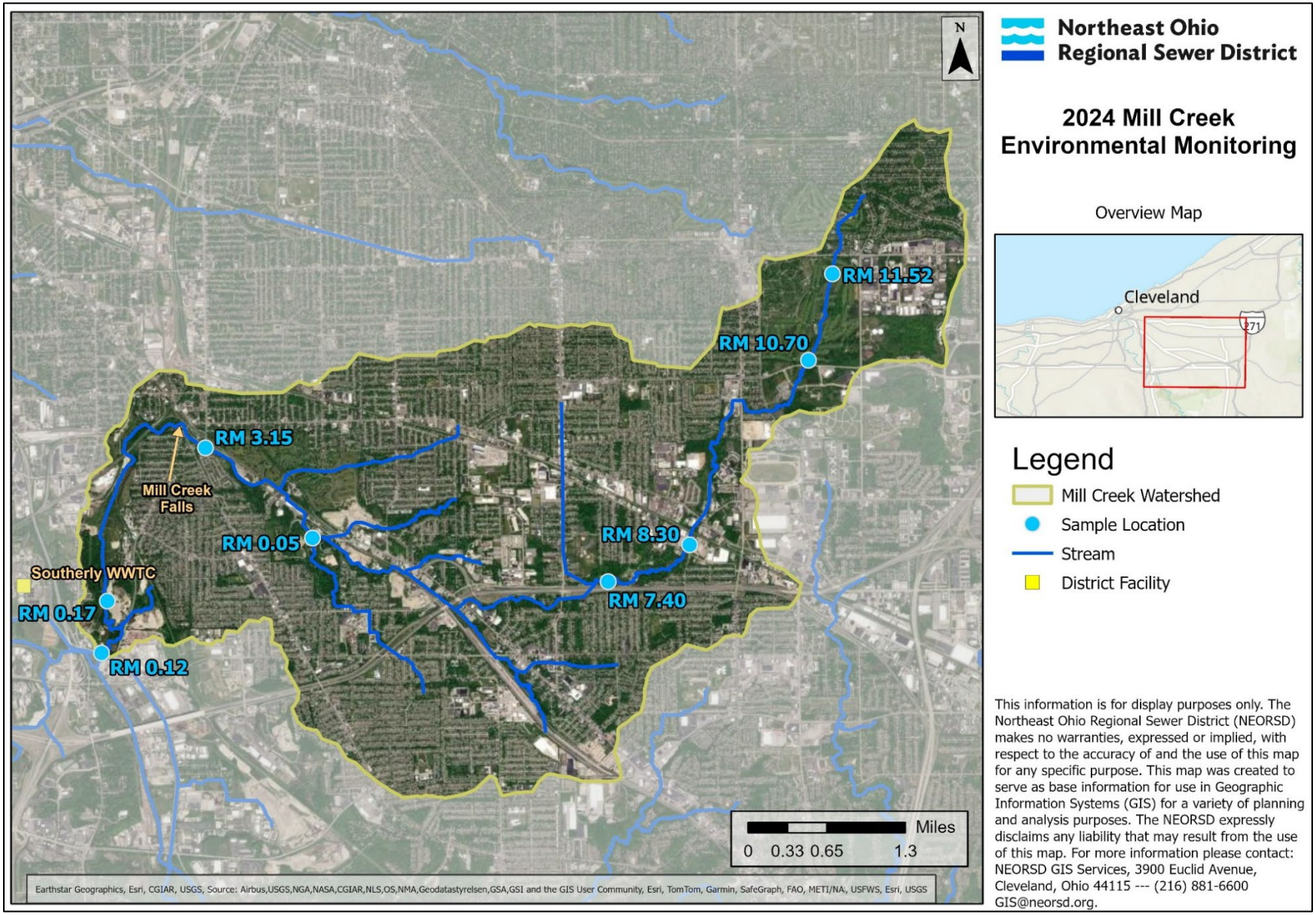


Figure 1. Sampling Locations Map

Water chemistry data was validated per methods outlined by the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (Ohio EPA, 2023) and compared to the Ohio Water Quality Standards (WQS) to determine attainment (Ohio EPA, 2024). 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.

In 2024, bacteriological water quality criteria for primary contact recreation, as well as the Outside Mixing Zone Maximum (OMZM) and Outside Mixing Zone Average (OMZA) chemical water quality criteria identified for the warmwater habitat (WWH) use designation were applied to Mill Creek and Wolf Creek. The beneficial use designations for Mill Creek were obtained from the Ohio Administrative Code (OAC) chapter 3745-1-26 (Cuyahoga River drainage basin) and are listed below in Table 2.

Table 2. Beneficial Use Designations for Mill Creek

Water Body Segment	**Beneficial Use Designation**												
	Aquatic Life Habitat (ALU)							Water Supply			Recreation		
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
Mill Creek (all segments)		+							+	+		+	

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 results of a biological field assessment performed by the Ohio EPA (OAC 3745-1-26).

Watershed Land Use Analysis

The majority of the Mill Creek Watershed has been impacted by urban development. This has altered the watershed by eliminating natural floodplains/wetlands, reducing the size of the riparian buffer, and increasing the stormwater runoff that affects erosion rates. The highly developed land consists of a vast landscape of impervious surfaces which quickly transports rainfall, increasing the stormwater runoff and peak flow rates in Mill Creek. This increased stormwater runoff leads to increased bank erosion and increased pollutants transferred to the stream across the urban landscape (U.S. EPA, 1999).

A land cover analysis was performed on the Mill Creek Watershed. The United States Geologic Survey StreamStats Program (U.S. Geological Survey, 2019) was used to obtain a boundary polygon representing the Mill Creek Watershed. The corresponding watershed boundary was imported into ArcGIS Pro and was intersected with the 2021 National Land Cover Database (NLCD v. 3.0) (Dewitz, 2023). Figure 2 illustrates the different land cover types that drain to Mill Creek within the entire watershed. Over 94% of the land use in the watershed is developed, comprised of residential, commercial, and industrial developments.

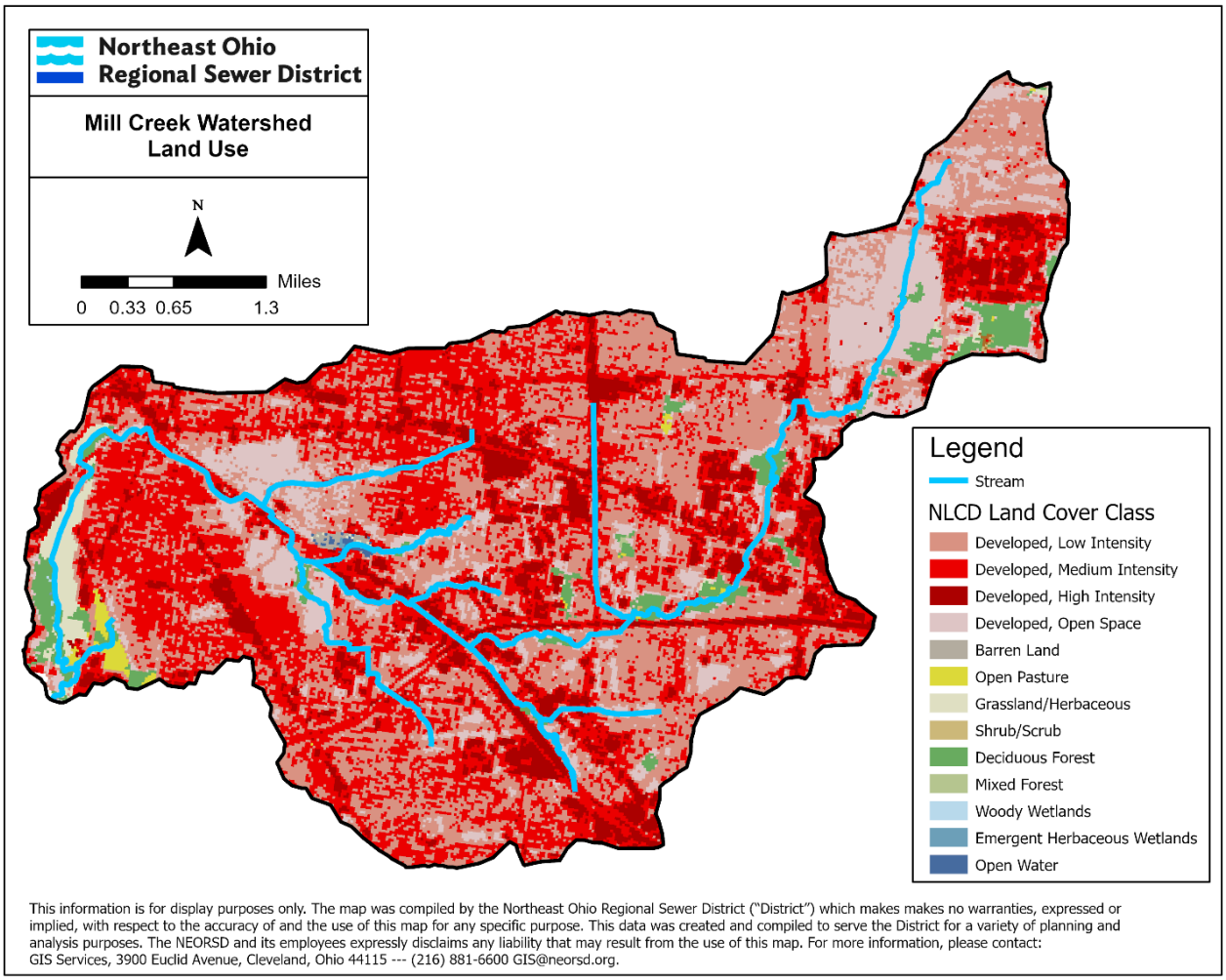


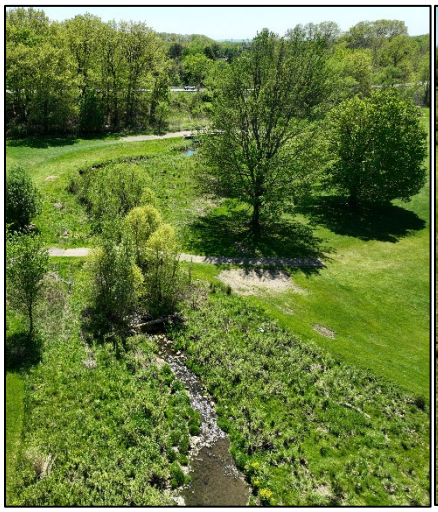
Figure 2. Mill Creek Watershed Land Use

Developed, low and medium intensity are the predominant land cover types in the watershed, representing 37.0% and 34.6%, respectively. Pollutants associated with urban and industrial runoff include excess sediments, nutrients, pathogens, oxygen-demanding matter, heavy metals, and salts (Schueler, 1987). The Mill Creek Watershed has approximately 5% of its open space that is comprised of forested tracks and open grassland or pasture. Open water and wetland type cover represents less than 0.2% of the watershed. The highly developed and urban

landscape of the Mill Creek Watershed may have a negative effect on the overall water quality and a degradation of aquatic biota. Land use disturbances and losses in habitat have been contributing factors that have listed Mill Creek as part of the Cuyahoga River AOC.

Stream Restoration Monitoring

Mill Creek RM 10.70 and RM 11.52 are headwater sites located in Highland Hills within the Highland Park Golf Course. A stream restoration project was completed along this stream reach in November 2016. Originally, this stretch of Mill Creek consisted of non-natural straightened stream which was bound by failing gabion walls and eroded streambanks.



Mill Creek RM 10.70

Mill Creek RM 11.52

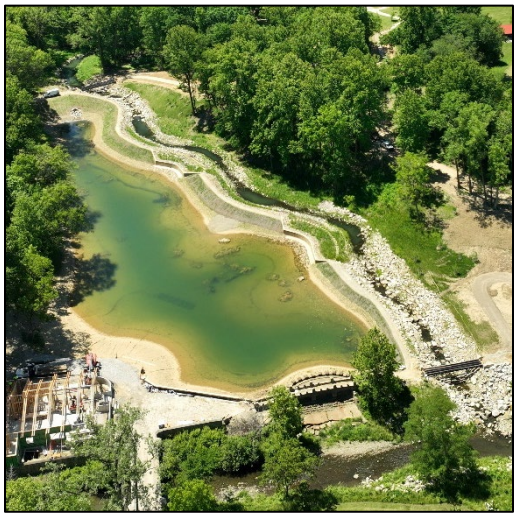
Approximately 4,516 linear feet of the creek and small tributaries were restored along with the partial removal of a dam near the downstream end of the project. These efforts reestablished 6.6 acres of floodplain and 8.4 acres of upland vegetated buffer.

Mill Creek RM 10.70

Mill Creek RM 11.52

Wolf Creek is a tributary to Mill Creek at RM 4.36. NEORSD partnered with Cleveland Metroparks, with funding from Ohio EPA's Section 319(h) program, to restore and stabilize approximately 1,600 linear feet of stream and riparian buffer along Wolf Creek, in the Garfield Park Reservation. In 2023, the creek and a former in-line pond were separated with the upper portion of the pond converted into a 3-acre riparian wetland and additional stream habitat improvements; this included the removal of a small dam near the mouth of Wolf Creek that may have been precluding upstream fish passage. The new wetland will filter stormwater runoff to improve water quality and provide additional wildlife habitat. The restoration used natural channel design and bioengineering methods to stabilize the streambank and improve floodplain connectivity, reducing sediment and nutrient loads in the creek and improving downstream water quality. The Ohio EPA conducted an assessment at Wolf Creek in 2020 as part of the Section 319(h) program pre-restoration monitoring to establish a biological and instream physical habitat baseline. In 2024, NEORSD conducted full biological assessments at each of these restoration project sites to document post-construction conditions following the completion of the respective stream improvement projects.

Wolf Creek RM 0.05
Looking Downstream



Wolf Creek RM 0.05
Looking Upstream from Mill Creek

Water Chemistry and Bacteriological Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between July 31 and August 28, 2024, at the locations listed in Table 1. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (Ohio EPA, 2023). 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 a YSI EXO1 sonde. Duplicate/replicate samples and field blanks were each collected at randomly selected sites at a frequency of 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). 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.

Formula 1: $$\text{RPD} = \left| \frac{x-y}{\left[\frac{(x-y)}{2}\right]} \right| \times 100$$

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: $$\text{Acceptable \% RPD} = [(0.9465x^{-0.344}) \times 100] + 5$$

x = sample/detection limit ratio

Water chemistry analysis sheets for each site are available upon request from the NEORSD WQIS Division. Dates of water chemistry sampling compared to Mill Creek flow data (USGS 04208460) and rain data from NEORSD's Southerly Wastewater Treatment Center (WWTC) precipitation gauge are shown below in Figure 3.

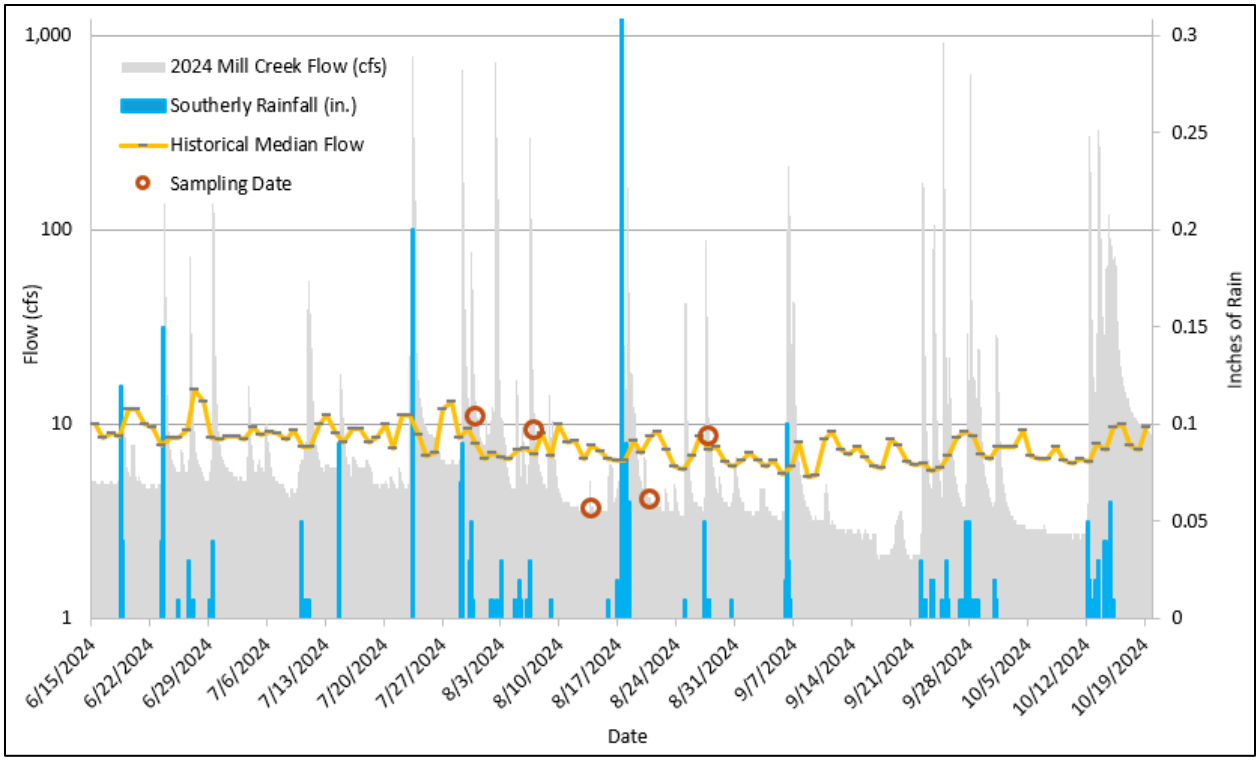


Figure 3. 2024 daily flow data and historical daily means from the USGS Mill Creek Station 04208460. Rainfall Data from NEORSD's Southerly WWTC Precipitation Gauge; Orange circles indicate NEORSD water chemistry sampling dates.

Results and Discussion

Quality Assurance / Quality Control

Over the course of the five sampling events in 2024, two duplicate samples, one replicate sample, and three field blanks were collected in support of quality assurance and quality control (QA/QC) guidelines (Ohio EPA, 2023). The duplicates samples were collected at Mill Creek RM 8.30 (July 31, 2024) and Wolf Creek RM 0.05 (August 21, 2024), and the replicate sample was collected from Mill Creek RM 11.52 (August 14, 2024). Of the three field duplicate/replicate samples collected, two instances occurred in which the acceptable RPD was exceeded (Table 3). These results were rejected based on Ohio EPA protocols. Potential reasons for this discrepancy include lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity, and/or improper handling of samples.

Table 3. Duplicate/Replicate Samples with RPDs Greater than Acceptable				
River Mile	Date	Parameter	Acceptable RPD	Actual RPD
Mill Creek (19-006-000)				
8.30	7/31/24	COD	61.7	88.9
11.52	8/14/24	Titanium	64.1	82.5

Field blank samples were collected on August 7, 2024, from Mill Creek RM 10.70 and Wolf Creek RM 0.05, and on August 28, 2024, from Mill Creek RM 0.70. Ohio EPA's Credible Data program includes a data validation protocol for QA/QC samples. Data were qualified using the factor of three method to differentiate a detected compound from background "noise" present in the analytical system. Therefore, the sample analyte concentration must be at least three times the field blank concentration to be considered reliably present in the sample, otherwise the sample data is qualified as rejected ("R"). Due to possible contamination in the analysis of the field blank samples collected on August 7, total BOD was rejected from each sample site on this sample date. The remaining results from each sample indicated that no other parameters were affected by possible field blank contamination.

Paired parameters, wherein one parameter is a subset of another, were also evaluated in accordance with QA/QC protocols for all samples collected at each sampling site. Table 4 lists parameters that had subset parameter results larger than the parent parameter results but are within the acceptable RPD range. These parameters were qualified as "estimated". No additional QA/QC qualifiers were observed.

Table 4. Paired Parameter Qualifiers						
River Mile	Date	Parent Parameter (Result)	Sub Parameter (Result)	Acceptable RPD	Actual RPD	Qualifier
Wolf Creek (19-006-003)						
0.05	8/21/24	Total Solids (392.0 mg/L)	Total Dissolved Solids (404.0 mg/L)	29.3	3.0	(J) Estimated

Recreation Use Results and Discussion

Escherichia coli (*E. coli*) is a fecal-indicator bacteria commonly found in the intestinal tract of warm-blooded animals and is used to measure the presence of feces in the environment (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 (MPN) per 100 milliliters (410 MPN/100ml) in more than 10% of the samples

collected during any 90-day period. The second component is a 90-day geometric mean criterion of 126 MPN/100mL (Ohio EPA, 2024). In accordance with the Ohio EPA procedure and practice to qualify *E. coli* exceedances for the PCR criteria, the geometric mean and STV are only calculated and compared when a minimum of five bacteriological samples have been collected within a rolling 90-day period.

The Mill Creek Watershed sites sampled in 2024 are designated as PCR according to the Ohio EPA Water Quality Standards (2024). Exceedances of the recreational bacteriological criteria for PCR occurred at all sites during the 2024 sampling season (Table 5). Each sample location was sampled for *E. coli* five times. When duplicate samples were collected at a sample location, the *E. coli* results were reported as an average. Of the forty total samples collected, eighty-five percent of the samples taken exceeded the *E. coli* STV of 410 MPN/100mL, resulting in PCR impairment at all sampling sites in 2024. Additionally, all sample locations exceeded the 90-day geometric mean criterion of 126 MPN/100mL (Table 5). Sampling dates during or after a wet-weather event are indicated in the following table; wet-weather determinations were used using NEORSD's precipitation gauge monitors located at Southerly WWTC and in the City of Maple Heights.

Table 5. *E. coli* Densities (MPN/100mL)

Date	Mill Creek							Wolf Creek
	RM 11.52	RM 10.70	RM 8.30	RM 7.40	RM 3.15	RM 0.70	RM 0.12	RM 0.05
7/31/2024*	1,414	921	2,360	3,840	6,570	3,410	5,560	5,730
8/7/2024*	3,720	9,600	15,290	10,190	8,800	10,190	12,910	2,460
8/14/2024	516	980	194	435	980	178	365	291
8/21/2024	488	345	1,300	1,300	1,553	411	548	400
8/28/2024*	18,600	10,220	51,720	12,810	9,870	10,860	11,450	9,060
90-day STV Exceedance (%)	100	80	80	100	100	80	80	60
90-day Geomean	1,850	1,982	3,424	3,094	3,870	1,842	2,774	1,716

Exceeds statistical threshold value of 410 MPN/100mL.
Exceeds 90-day STV criterion of 10%
Exceeds 90-day geometric mean criterion 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.

In addition to the loss of riparian and in-stream habitat, one of the greatest impacts on aquatic life in Ohio's urban watersheds are contributions of excessive nutrients, oxygen-

demanding wastes, and toxic chemical pollutants via urban runoff (Yoder et al., 1999). Three of the five sampling dates were conducted following wet-weather events, which may lead to elevated *E. coli* densities due to urban runoff, combined and sanitary sewer overflows, illicit discharges, and common trench sewers which are prevalent within the Mill Creek Watershed (Zgnelic, 2016). Local sanitary sewer overflows and leaking common trench sewers are likely contributing the highest baseline *E. coli* densities to Mill Creek. Elevated *E. coli* densities may also have significant contributions from domestic and/or wild animal waste and improper sanitary sewage connections to stormwater outfalls upstream of sampling locations.

NEORSD currently maintains 21 CSOs that discharge directly to Mill Creek and Wolf Creek (Figure 4). Rainfall resulted in 23 recorded wet-weather overflows (12.8 million gallons (MG)) to the Mill Creek Watershed during the period from June 15 to October 15, 2024 (Table 6), compared to 72 (24.7 MG) in 2023. These overflows contained a mixture of rainwater, urban and stormwater runoff, and untreated sanitary sewage. The year 2024 was dryer than normal with an average of approximately 85 inches of rain during the field season across the NEORSD service area compared to 130 inches of rain in 2023. During the 2024 survey, there were no dry-weather overflows reported at any of the NEORSD-controlled CSOs in the Mill Creek Watershed.

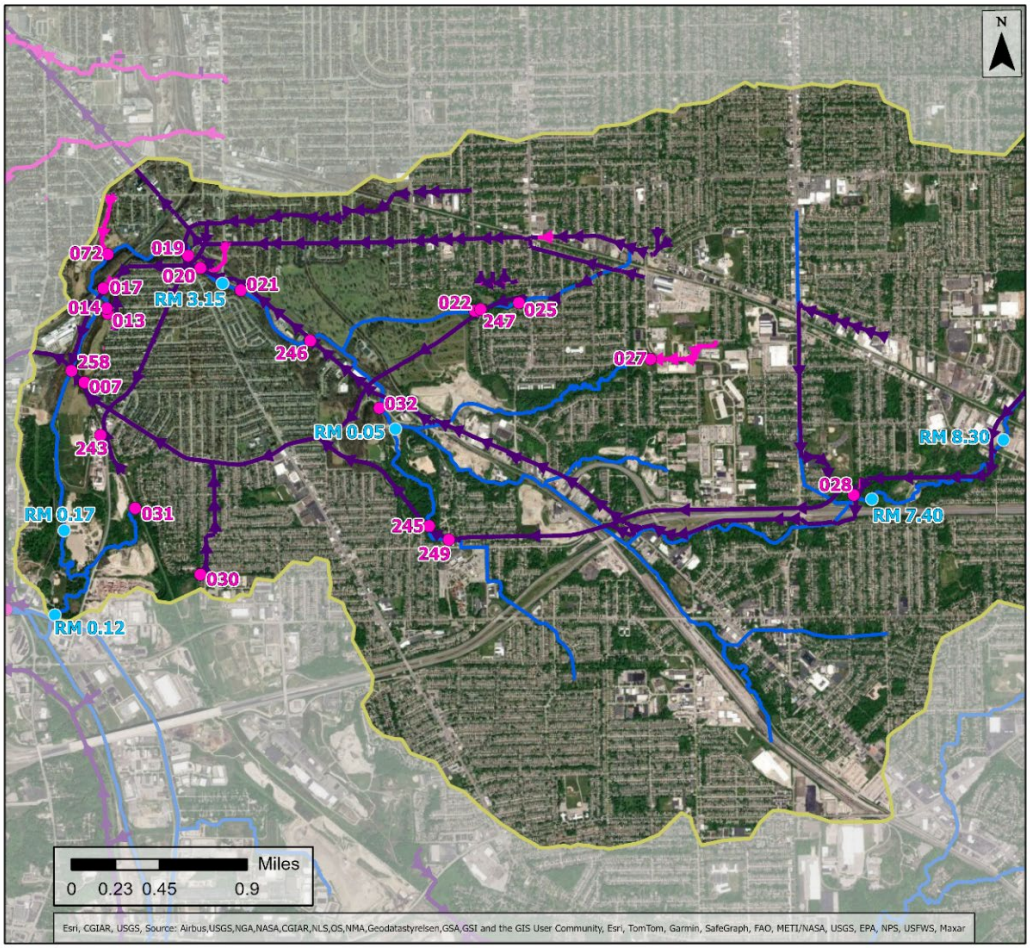


Figure 4. CSO locations

Table 6. Overflows to Mill Creek from June 15 to October 15, 2024			
Outfall Name	Location	Number of Overflows	Million Gallons (MG)
CSO 007	Bancroft Avenue, West of Warner Road	0	0.0
CSO 017	Dorver Avenue & East 77th Street	2	0.8
CSO 019	Broadway Road & Warner Road Bridge	1	< 0.1
CSO 022	East Boulevard Bridge, North of Cranwood	1	< 0.1
CSO 025	East 131st Street & Cranwood Park Boulevard	1	< 0.1
CSO 027	South Side of Johnston Road	4	0.39
CSO 30	East 88th Street & South Highland Avenue	3	1.19
CSO 031	East 81st Street & Vista Avenue	2	0.8
CSO 072	East 78th Street & Harvard Avenue	2	0.8
CSO 243	West of Warner Road, South of Garfield Road	2	< 0.2
CSO 247	East Boulevard, North of Thornhurst Avenue	0	0.0
CSO 249	East of East 119th Street & North of McCracken Road	3	< 0.3
CSO 252	East 71st Street & I-77	1	0.1
CSO 258	Shaft #3 Silo at Harvard Landfill (Mill Creek Tunnel Overflow)	1	8.0

Historically, the Mill Creek Watershed has been highly polluted throughout due to inadequate wastewater collection and treatment. The Mill Creek Long-Term Control Plan (LCTP) commenced in 1997, and the final stage of construction was completed in 2012 with the final phase of Mill Creek Tunnel. The tunnel was completed prior to the NEORSD's launch of a 25-year master plan, "Project Clean Lake", which is comprised of infrastructure investments and seven tunnels covering a network of 21 miles throughout the Cleveland area. The Mill Creek Tunnel totals about 42,000 feet in tunnel length that was constructed to convey and store flows during rain events with the goal of relieving the existing undersized collection system and CSO control in order to reduce pollution, in particular the bacteria loading in to Mill Creek. In 2024, the Mill Creek Tunnel captured a total of 4.8 billion gallons of combine sewage that would otherwise have been discharged to Mill Creek. Figure 5 below illustrates the combined volume of CSO from each NEORSD-permitted location in the Mill Creek Watershed from 2019 through 2024. Although the major issues regarding CSOs have been addressed by NEORSD via the installation of the Mill Creek tunnel, improper connections in the local system and urban runoff remain a source of impairment to the watershed.

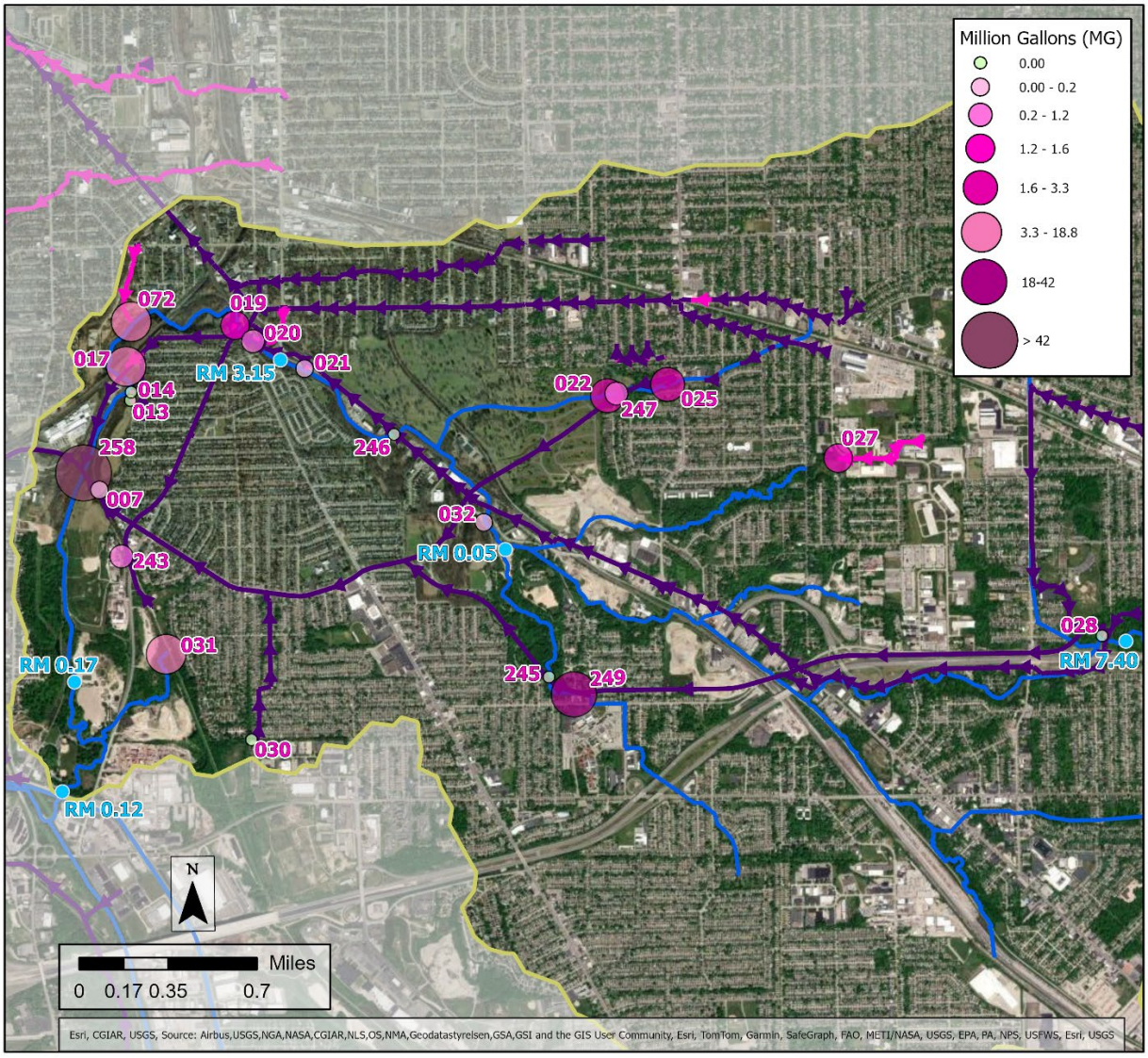


Figure 5. CSO volume contributed to Mill Creek per location from 2019-2024

Water Column Chemistry Results and Discussion

Mercury pollution is not uncommon in the Great Lakes region. Coal-fired power plants have historically lined the southern shores of Lake Erie. It was not until 2011 that the US Department of Energy established national standards to control mercury emissions. Three major coal fired power plants in the greater Cleveland area ceased operations in 2015 (Cleveland.com, 2015), as the parent company switched energy sources from coal over to natural gas. Other sources of mercury to surface waters are from atmospheric deposition, impervious surface runoff (Fulkerson et al., 2007), and other NPDES-permitted point sources within the watershed.

Mercury analysis for all the sampling events was analyzed using EPA Method 245.1. Because the detection limit for this method is above the criteria for the Human Health Non-drinking 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. On August 21, 2024, mercury was detected in four of the Mill Creek samples above the analytical method detection limit (MDL), but below the Practical Quantitation Limit (PQL); therefore, the results are considered to be estimated (Table 7). Mercury was not detected above MDLs in any other samples collected. No additional water quality exceedances were observed in the data set.

Table 7. Mercury Sample Results Above Detection Limit

River Mile	Date	Estimated Result (ug/L)	MDL (ug/L)	PQL (ug/L)
Mill Creek (19-006-000)				
11.52	8/21/24	0.015	0.015	0.05
10.70		0.016		
7.40		0.016		
0.12		0.017		

The Mill Creek Watershed is a high-density area with factors such as urban runoff and flow alterations that can contribute to low in-stream dissolved oxygen (DO) levels. Decomposing organic material and high nutrient levels cause both rapid algal growth and corresponding decay that leads to DO swings when algal blooms die off. Low DO levels can also be exacerbated due to summertime low-flow conditions, elevated water temperatures, and further organic enrichment. Low in-stream DO saturation can lead to a reduction in biological diversity within the watershed. For the protection of aquatic life, the minimum required dissolved oxygen (DO) criterion is 4.0 mg/L. Even with low flow through Mill Creek during an areawide drought in 2024, no DO levels in any of the samples collected were below the 4 mg/L threshold; a datasonde monitoring DO continuously would need to be utilized to better assess diel DO trends.

Stream Nutrient Assessment

In 2015, the Ohio EPA Nutrients Technical Advisory Group released a proposed Stream Nutrient Assessment Procedure (SNAP) designed to determine the degree of impairment in a stream due to nutrient enrichment. SNAP assigns designations for the quality of surface waters based on factors including DO swings, benthic chlorophyll *a*, total phosphorus (TP), and dissolved inorganic nitrogen (DIN) (Ohio EPA, 2015). The Ohio EPA uses causal associations to determine the risk association between nutrients [TP and dissolved inorganic nitrogen (DIN)] and biological performance. Figure 6 shows the risk categories from Ohio EPA's SNAP Table 2. NEORSD did not assess DO swings or benthic chlorophyll *a* in 2024 within the Mill Creek Watershed; however, nutrients were assessed.

Nutrient data was collected at the Mill Creek sample sites in 2024 during the summer months of May through October. Total Kjeldahl nitrogen (TKN), dissolved reactive phosphorus (DRP), total phosphorus (TP), total suspended solids (TSS), and biochemical oxygen demand (BOD) were collected at each site during water chemistry sampling. Three of the 2024 sampling events were completed during or after wet-weather events (see Table 5 for wet-weather dates). Table 8 lists the nutrient concentrations for the Mill Creek Watershed study sites and the narrative risk categories associated with the nutrient analysis based on Miltner (2010). The upstream location on Mill Creek (RM 11.52) displayed a moderate risk based on the TP geomean, indicative of enriched conditions. All other sample locations were classified in the low-risk range, with levels that are typical of developed lands and a working landscape.

		← 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 6. Table 2 of the Stream Nutrient Assessment Procedure (Ohio EPA, 2015)

Table 8. 2024 Nutrient Analysis (Geometric Means)

River Mile	DIN * (mg/L)	NO_3-NO_2 (mg/L)	DRP (mg/L)	TP * (mg/L)	Risk Category [R]
Mill Creek (19-006-000)					
11.52	0.921	0.877	0.100	0.135	Moderate
10.70	0.375	0.238	0.022	0.050	Low
8.30	0.461	0.410	0.028	0.061	Low
7.40	0.364	0.292	0.031	0.058	Low
3.15	0.401	0.325	0.053	0.090	Low
0.70	0.996	0.707	0.021	0.061	Low

Table 8. 2024 Nutrient Analysis (Geometric Means)

River Mile	DIN * (mg/L)	NO_3-NO_2 (mg/L)	DRP (mg/L)	TP * (mg/L)	Risk Category [R]
0.12	0.850	0.689	0.013	0.061	Low
Wolf Creek (19-006-003)					
0.05	0.974	0.910	0.097	0.130	Low

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

[R] Risk Categories based on Miltner (2010)

Risk Category	DIN	Total Phosphorus
Low	< 1.10	< 0.131
Moderate	≥ 1.10 and < 3.6	≥ 0.131 and < 0.4
High	≥ 3.6	≥ 0.4

Habitat Assessment

Methods

An instream habitat assessment was conducted at all stream sites 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 (Ohio EPA, 1989). The QHEI can be used to assess and evaluate a stream's aquatic habitat and determine which habitat components need to be improved to reach the QHEI target score. The QHEI is completed at least once for a sampling site each year during the study. An exception to this would be when substantial changes to the macrohabitat have occurred between electrofishing passes.

The QHEI has a maximum score of 100, and a score greater than 55 for streams with less than 20 mi^2 (headwater streams), which applies to the sites in the Mill Creek Watershed, suggests that sufficient habitat exists to support a fish community that attains the WWH criterion (Ohio EPA, 2006). Scores greater than 70 for headwaters frequently demonstrate habitat conditions that have the ability to support exceptional warmwater fish communities. A more detailed description of the QHEI can be found in Ohio EPA's *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

The Mill Creek Watershed sites were all evaluated in 2024 for physical habitat characteristics that are important in the support of fish communities. With the exception of Mill Creek RM 3.15, all sampling locations met the Ohio EPA WWH QHEI target for headwater streams indicating that sufficient functional habitat quality exists to support a healthy fish assemblage (Figure 7). The QHEI assessment at RM 3.15 resulted in a mean score of $\bar{x}$ = 54 (*Fair*); sparse instream cover along with a lack of cover types and poor stream development contributed to the site not meeting the QHEI target. Excluding RM 7.40, each of the Mill Creek field sites were surveyed annually from 2011 through 2014; 2024 was the first survey conducted at Mill Creek RM 7.40. In 2020, the Ohio EPA conducted pre-project monitoring at the Wolf Creek stream restoration site to establish a baseline for the instream physical habitat quality.

There were some variations in scores when compared to historical QHEI data, with scores either remaining similar or increasing slightly in 2024, with the exception of RM 3.15, where the narrative rating declined from *Good* to *Fair*. (Figure 7). The QHEI at RM 3.15 decreased significantly in 2024, likely due to changes with in-stream cover and increases in silt loadings covering the bottom substrates, generally causing moderate to extensive embeddedness. The lack in habitat at RM 3.15 could be related to flows being well below median causing available functional habitat to be out of the water during the site monitoring. The QHEIs conducted at the Mill Creek stream restoration sites (RM 10.70 and 11.52) showed an increase in scores due to increased in-stream habitat cover, decreased substrate embeddedness, and improved riffle substrates.

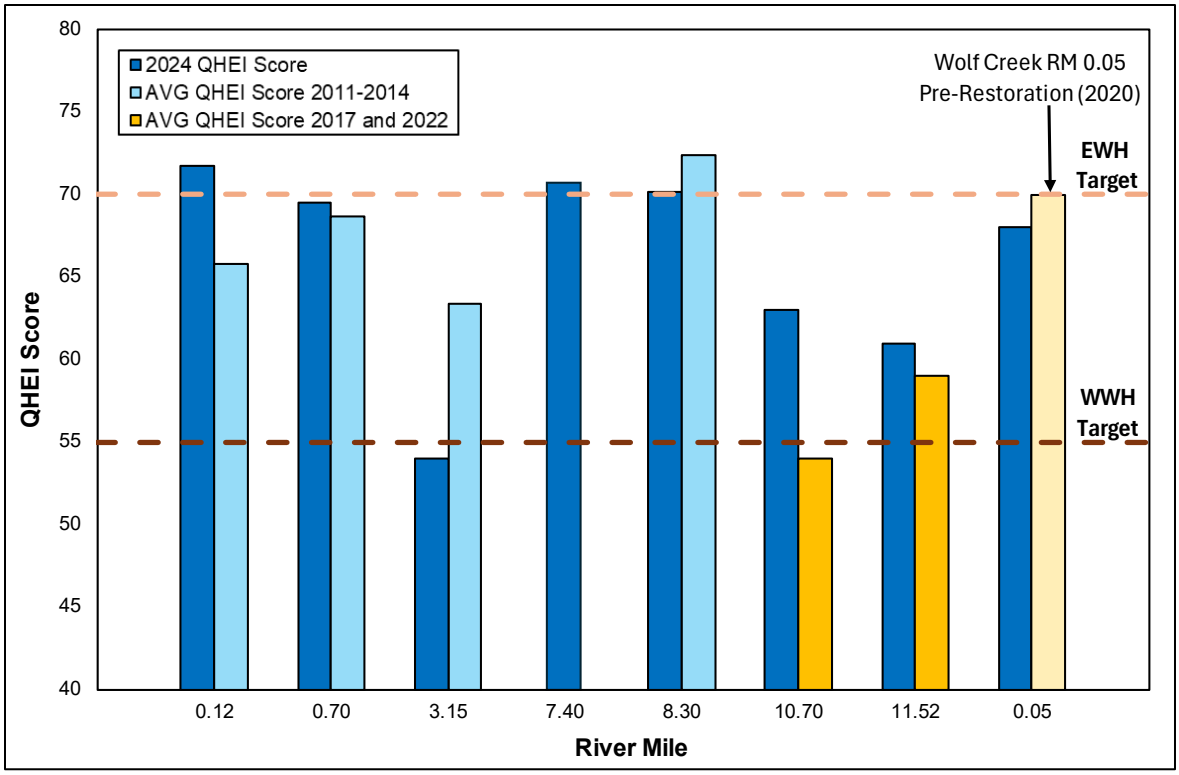


Figure 7. Mill Creek QHEI Scores.

Various attributes of stream habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional fish communities. Individual components of the QHEI can be used to evaluate whether a site is capable of meeting its WWH designated use (Table 7). 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, 2006).

Table 9 characterizes the QHEI scores and physical attributes for each stream segment and determines the influence each parameter has on the QHEI score. As negative habitat attributes begin to outnumber positive stream habitat characteristics, there is higher potential for habitat quality to limit the biological performance at a site (Rankin, 1989). With the exception of Mill Creek RM 8.30 and Wolf Creek RM 0.05, all sample locations had a combination of a minimum of one high or four moderate-influence characteristics, indicating that there was a greater prevalence of characteristics preventing these sites from meeting the WWH QHEI target. MWH attributes outnumbered WWH attributes at RM 3.15 and showed the highest MWH/WWH ratio, which was reflected in the lowest overall QHEI score (Table 9). Typically, as the MWH/WWH ratio increases above 2:1, there is a higher likelihood that the lack of instream habitat leads to degraded biological performance and impairments.

Table 9. QHEI Scores and Physical Attributes

			WWH Attributes											**MWH Attributes**																						
														High Influence						Moderate Influence																		
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	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	***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***	**(MWH-H.I.+1) / (WWH+1) Ratio**	**(MWH M.I.+1) / (WWH+1) Ratio**
Mill Creek (19-006-000)																																				
11.52	61.00	*Good*	X	X			X	X		X	X	X	***7***				X		***1***				X				X				***2***	**0.25**	**0.38**
10.70	63.00	*Good*	X	X			X	X		X	X	X	***7***				X		***1***				X				X				***2***	**0.25**	**0.38**
8.30	70.00	*Excellent*	X	X		X	X	X		X	X	X	***8***						***0***								X	X	X		***3***	**0.11**	**0.44**
7.40	70.75	*Excellent*	X	X		X	X	X			X		***6***						***0***		X						X	X	X		***4***	**0.14**	**0.71**
3.15	54.00	*Fair*	X	X							X		***3***				X		***1***				X	X	X		X	X	X		***6***	**0.50**	**1.75**
0.70	69.50	*Good*	X	X		X	X		X		X		***6***				X		***1***		X			X				X	X		***4***	**0.29**	**0.71**
0.12	71.75	*Excellent*	X	X		X	X		X		X		***6***				X		***1***		X							X	X		***3***	**0.29**	**0.57**
Wolf Creek (19-006-003)																																				
0.05	68.00	*Good*		X	X	X	X	X		X	X	X	***8***						***0***	X			X				X				***3***	**0.10**	**0.44**

Fish Community Biology Assessment

Methods

Two quantitative electrofishing assessments were conducted at each site in 2024. Sampling was conducted using longline electrofishing techniques and consisted of shocking all available habitat types within a sampling zone. The sampling zone was 0.15 kilometers for each site (headwaters) and followed the Ohio EPA methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were counted and then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

The electrofishing results were compiled and utilized to evaluate fish community health. The Index of Biotic Integrity (IBI) incorporates twelve community metrics representing structural and functional attributes (Table 10). 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. Fish IBI scores range from 12 (*Very Poor*) – 60 (*Exceptional*). The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating (Table 11).

Table 10. IBI Metrics
Headwater Sites (<20 sq. miles)
Total Number of Native 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 of Pioneering Species
Number of Individuals (minus Tolerants)
Number of Simple Lithophilic Species
Percent of Individuals with DELTs

The Mill Creek Watershed is located completely within the Erie-Ontario Lake Plains (EOLP) ecoregion and follows the EOLP fish community metric scoring. The WWH IBI scoring criterion for headwater sites in the EOLP ecoregion is 40 and sites are considered to be within non-significant departure if the score falls within 4 IBI points of the criterion (Table 11). This scoring criterion is

used for all of the sample locations in this study, as they have a WWH ALU designation. 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 for Headwater Sites in the EOLP Ecoregion

Ohio EPA Narrative	Very Poor	Poor	Fair	Marginally Good	Good	Very Good	Exceptional
IBI Score	12-17	18-27	28-35	36-39	40-45	46-49	50-60
Ohio EPA Status	Non-Attainment			NSD	Attainment		
NSD: Non-Significant Departure of WWH attainment							

Results and Discussion

The NEORSD collected 9,209 total fish among 23 unique species from the eight watershed study locations. Fish community biology scores in the Mill Creek Watershed ranged from *Poor* to *Good*. Table 12 lists a summary of the fish community biological scores for study locations.

Table 12. 2024 Mill Creek Fish Community Assessment Results

River Mile	Total # of Species	Relative # / less Tolerants	Predominant Species (%)	IBI Score		
				1st pass	2nd pass	Average
Mill Creek (19-006-000)						
11.52	2	477 / 0	Creek Chub (68.9) Blacknose Dace (31.1)	22*	22*	22* (*Poor*)
10.70	2	2,004 / 0	Blacknose Dace (63.6) Creek Chub (36.4)	22*	24*	23* (*Poor*)
8.30	4	2,015 / 0	Creek Chub (52.1) Blacknose Dace (47.1)	24*	24*	24* (*Poor*)
7.40	2	1,340 / 0	Blacknose Dace (67.7) Creek Chub (32.3)	24*	22*	23* (*Poor*)
3.15	3	1,309 / 0	Creek Chub (59.0) Blacknose Dace (39.9)	20*	20*	20* (*Poor*)
0.70	17	3,822 / 3,252	Central Stoneroller (51.4) White Sucker (19.6) Creek Chub (6.8)	36 NS	42	39 NS (*Marginally Good*)
0.12	20	2,451 / 2,146	Central Stoneroller (49.4) White Sucker (17.4) Creek Chub (7.3)	40	44	42 (*Good*)

Table 12. 2024 Mill Creek Fish Community Assessment Results						
River Mile	Total # of Species	Relative # / less Tolerants	Predominant Species (%)	IBI Score		
				1st pass	2nd pass	Average
Wolf Creek (19-006-003)						
0.05	3	396 / 0	Creek Chub (96.2)	20*	22*	21* (*Poor*)
* Significant departure from the biocriterion (> 4 IBI points)						
NS: non-significant departure from biocriterion (≤ 4 IBI points)						

Fish assemblages throughout the upper reaches of the Mill Creek Watershed failed to meet the WWH IBI designated use scoring criterion in 2024. Most of the surveyed site locations were dominated by highly pollution-tolerant species of Creek Chubs and Blacknose Dace along with Central Stoneroller Minnows; these are species typically found in an urbanized watershed. The predominate species per site are listed in Table 12. The lower section of Mill Creek consisted of the highest fish IBI scores, as well as the highest species richness. Fish community biology scores in 2024 were consistent with scores from previous studies (Figure 8). A direct historical comparison is not available for RM 7.40 due to this site being surveyed for the first time in 2024. Pre-restoration baseline data from Wolf Creek RM 0.05 was collected by Ohio EPA's Ecological Assessment Unit (EAU) in 2020 (Ohio EPA, 2025).

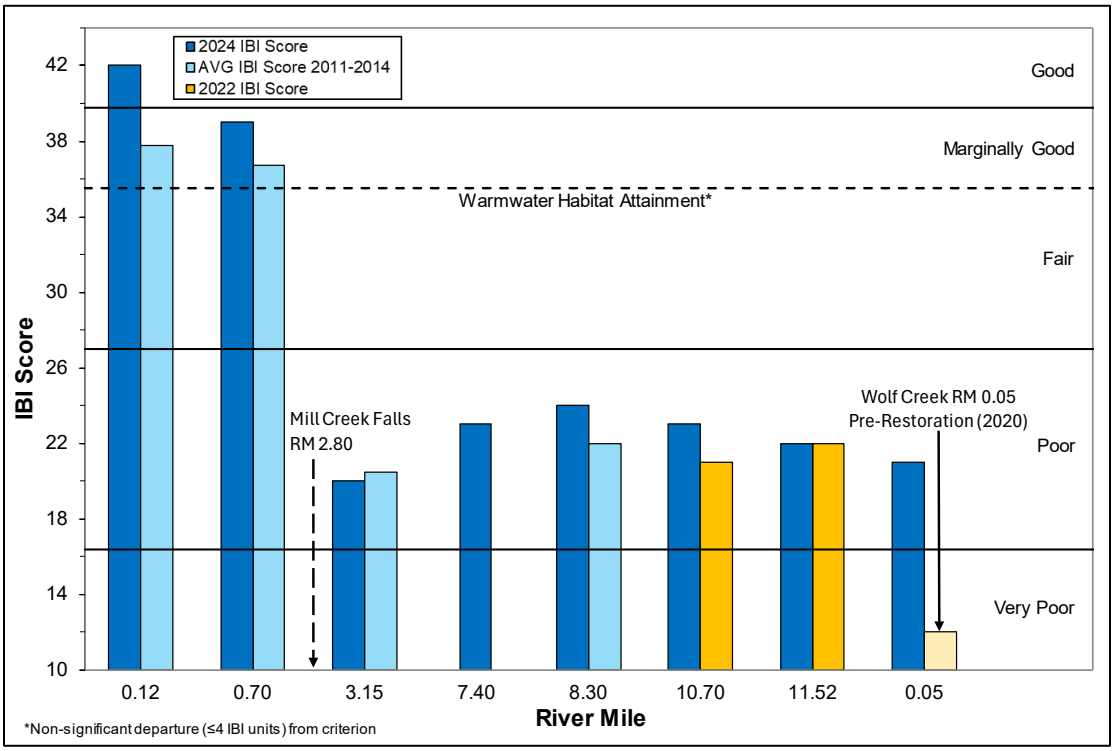


Figure 8. Mill Creek IBI Scores.

Numerous factors contribute to the composition of the fish communities at each location. Mill Creek at RM 0.12 and RM 0.70 are hydrologically connected to the Cuyahoga River and fish can easily move upstream to colonize this lower stream section. The fish community in the lower river is much more robust, containing a total of 22 species, compared to 4 species collected among the six upstream locations. The natural Mill Creek Falls located at RM 2.80 limits the movement of fish from the Cuyahoga River to the upper sections Mill Creek. Moving upstream on Mill Creek, compounding issues like historical pollution, channelization, and dense urbanization affect the observed fish populations. In Ohio headwater streams, darter species, headwater species, sensitive species and lithophilic spawning species are important components in the IBI scoring. Darter species are completely absent from the Mill Creek study locations upstream of the Mill Creek Falls fish barrier and overall species richness is poor.

During the Ohio EPA survey of Wolf Creek in 2020, no fish were collected despite the completion of a full electrofishing survey. Therefore, the lowest possible IBI score (12 – *Very Poor*) was assessed to the site. The small dam near the mouth of the creek may have been precluding upstream fish passage. This dam was removed during the restoration project and the IBI at Wolf Creek increased during the 2024 survey, with an average score of 21.

Stream habitat plays a major role in the fish community observed in streams. Most of the sites surveyed have sufficient habitat available which should support a healthy fish assemblage that has the capability of meeting the WWH scoring criterion. The lack of high-quality riffle habitat within the surveyed zones may contribute to the low darter and headwater species abundance observed. The lack of fast current velocity within the stream to form a suitable riffle also deposits fine sand and silt along the substrate. This does not offer adequate interstitial spaces between larger rocks for simple lithophilic spawning fish to successfully spawn. As noted in the physical habitat section, moderate to high overall embeddedness and riffle embeddedness was predominant within the fish sampling zone. Excessive fine-grained sediments have a major impact on the degradation of stream fish communities (Waters, 1995). Degraded water quality indicated by *E. coli* exceedances may be contributing to the lack of pollution-intolerant species within the Mill Creek Watershed. The corresponding effects of the urbanized land surrounding Mill Creek and influences from pollution are evident in the tolerant fish community.

Macroinvertebrate Community Biology Assessment

Methods

Macroinvertebrates were sampled at the seven Mill Creek mainstem sites quantitatively using modified Hester-Dendy (HD) samplers and by performing a qualitative assessment of macroinvertebrates inhabiting available habitats at the time of HD retrieval. Due to the shallow flow through the riffle habitat at Wolf Creek RM 0.05, a HD sampler was not retrieved, and macroinvertebrates were sampled using a single qualitative assessment of available habitats at the time of sampling. 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 (1987a). 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* (1987b) and *III* (1987a). The overall aquatic macroinvertebrate community within the Mill Creek mainstem was evaluated using Ohio EPA's Invertebrate Community Index (ICI). The ICI consists of ten community metrics (Table 13), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while metric 10 is based on the qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa. 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 ecoregion. The WWH ICI criterion in the EOLP ecoregion is 34 (Table 14) and a site is within non-significant departure if the score falls within 4 ICI points of the criterion. This scoring is used for each of the sample locations in this study, as they all have a WWH ALU designation.

Table 13. ICI Metrics
Total Number of Taxa
Number of Mayfly taxa
Number of Caddisfly taxa
Number of Dipteran taxa
Percent Mayflies
Percent Caddisflies
Percent Tanytarsini Midges
Percent Other Diptera and Non-Insects
Percent Tolerant Organisms (as defined)
Number of Qualitative EPT Taxa

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

Results and Discussion

The seven Mill Creek sites were sampled quantitatively using HDs in conjunction with qualitative kick sampling in 2024. All HD samplers were able to be recovered during the field sampling season. A narrative rating assessment was performed for Wolf Creek RM 0.05 based on data from a qualitative sample, and by utilizing the best professional judgment of the leading field QDCs. Table 15 presents a summary of the macroinvertebrate community biological scores for each sample location. With the exception of Mill Creek RM 11.52 and the Wolf Creek site, the remaining sampling locations met the applicable water quality standards for the macroinvertebrate community component with ICI scores ranging from 32 (*Marginally Good*) to 44 (*Very Good*).

The 2024 benthic macroinvertebrate community surveys have shown an improvement in ICI scores across most of the Mill Creek sites compared to historical average scores from 2012-2014 (Figure 9). A historical comparison is not available for Mill Creek RM 7.40 due to the site being surveyed for the first time in 2024. One of the reasons for the increase in overall ICI scores is due to a greater number of EPT taxa collected compared to previous years. There were also increases in the total number of qualitative and sensitive taxa collected at each site. The qualitative sample at RM 11.52 in 2024 contained less total taxa/density collected, less qualitative EPT taxa, and a much higher proportion of tolerant taxa compared to the survey conducted in 2022. This is reflected in the overall decrease in the score at the site from *Marginally Good* to *Low-Fair* when compared to the previous study year in 2022.

Table 15. 2024 Mill Creek Macroinvertebrate Results

River Mile	Density Qt. (ft^2) / Ql.	Ql. / Total Taxa	Ql. EPT / Sensitive Taxa	Qt. % Tolerant / % Sensitive Taxa	Predominant Orgs. on Natural Substrate	ICI	Narrative Rating
Mill Creek (19-006-000)							
11.52	167 / L	29 / 22	3 / 0	21.4/0.0	Baetid mayflies, hydroptilid caddisflies, flatworms, gastropods, midges	14	*Low-Fair*
10.70	327 / M-L	34 / 26	7 / 2	1.2/3.8	Baetid mayflies, hydropsychid caddisflies, flatworms, gastropods, midges	38	*Good*
8.30	435 / M-L	49 / 39	7 / 2	17.3/4.0	Baetid mayflies, hydropsychid caddisflies, philopotamid caddisflies, damselflies, flatworms, midges	38	*Good*
7.40	114 / M-L	50 / 37	5 / 3	5.2/2.5	Baetid mayflies, hydropsychid caddisflies, philopotamid caddisflies, damselflies, midges, isopods, amphipods	44	*Very Good*

Table 15. 2024 Mill Creek Macroinvertebrate Results							
River Mile	Density Qt. (ft^2) / Ql.	Ql. / Total Taxa	Ql. EPT / Sensitive Taxa	Qt. % Tolerant / % Sensitive Taxa	Predominant Orgs. on Natural Substrate	ICI	Narrative Rating
3.15	240 / L	41 / 28	7 / 4	2.4/43.6	Baetid mayflies, hydropsychid caddisflies, philopotamid caddisflies, gastropods, flatworms, amphipods, midges	32	*Marginally Good*
0.70	806 / M-L	47 / 40	9 / 5	4.6/14.5	Baetid mayflies, hydropsychid caddisflies, midges, amphipods, flatworms/leeches	36	*Good*
0.12	301 / L	49 / 54	10 / 4	11.0/0.3	Baetid mayflies, hydropsychid caddisflies, midges, amphipods	38	*Good*
Wolf Creek (19-006-003)							
0.05	-- / L	20 / --	2 / 1	--	Flatworms, amphipods, gastropods, midges	--	*Poor*

Qt. - Quantitative sample collected on Hester-Dendy artificial substrate.
Ql. - Qualitative sample collected from natural stream substrate.
Qualitative sample relative density: L=Low, M=Moderate, H=High

Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List (2019) as *Moderately Intolerant or Intolerant*

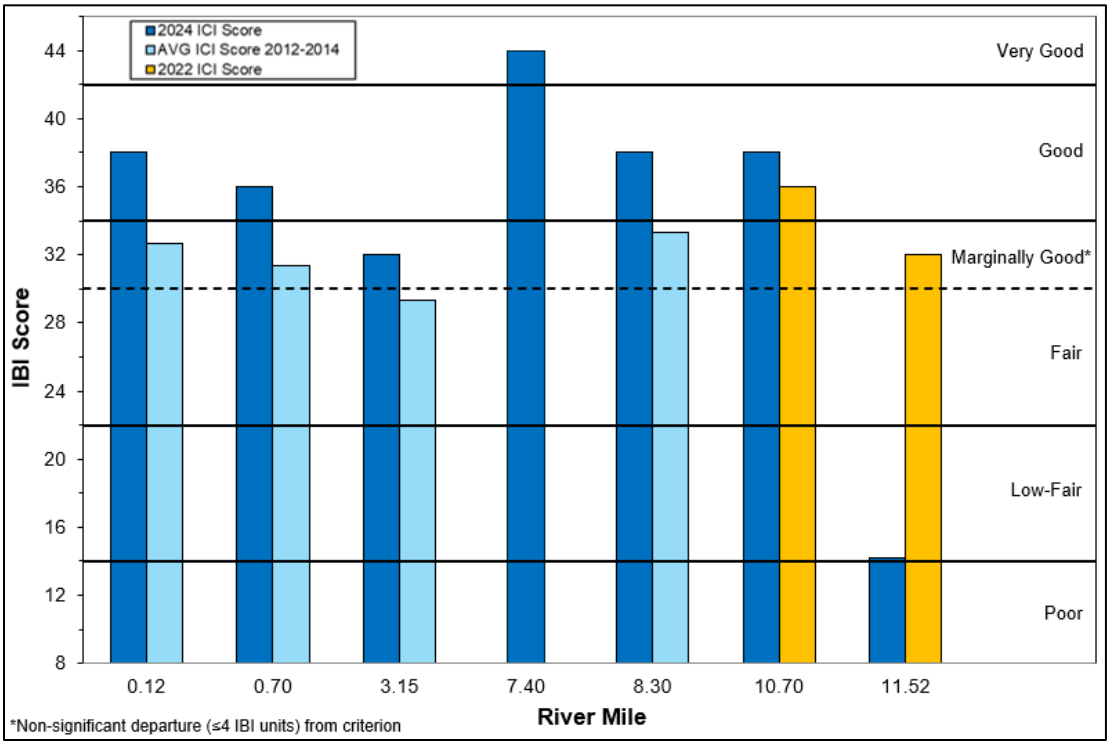


Figure 9. Mill Creek ICI Scores.

The macroinvertebrates can be combined into taxonomic groups to determine overall composition. Figure 10 below shows the breakdown in macroinvertebrate community composition of mayflies, caddisflies, tribe tanytarsini midges, and other organisms (including non-tanytarsini midges, other diptera, and non-insects) that colonized the HD sampler at each site. Higher quality macroinvertebrate communities are typically represented by a greater proportion of mayflies and caddisflies, which are in the EPT families.

The greater abundance of mayfly and caddisfly taxa, with the exception of RM 3.15 and 11.52, demonstrates the well-balanced benthic community and is reflected in the *Good* and *Very Good* ICI scores. The abundance of EPT taxa limits proportions of the more tolerant "other dipterans and non-insect" taxa throughout these stream reaches. RM 3.15 and 11.52 contained a lower proportion of EPT family taxa and a higher proportion of "other dipterans and non-insects". RM 11.52 also contained a higher percentage of pollution-tolerant taxa (Table 15). A decrease in the percent of caddisflies or mayflies, and an increase in percent "other organisms" at these study locations may be due to increases in substrate embeddedness, changes in urban land use, or changes in flow conditions due to a dryer than normal field season.

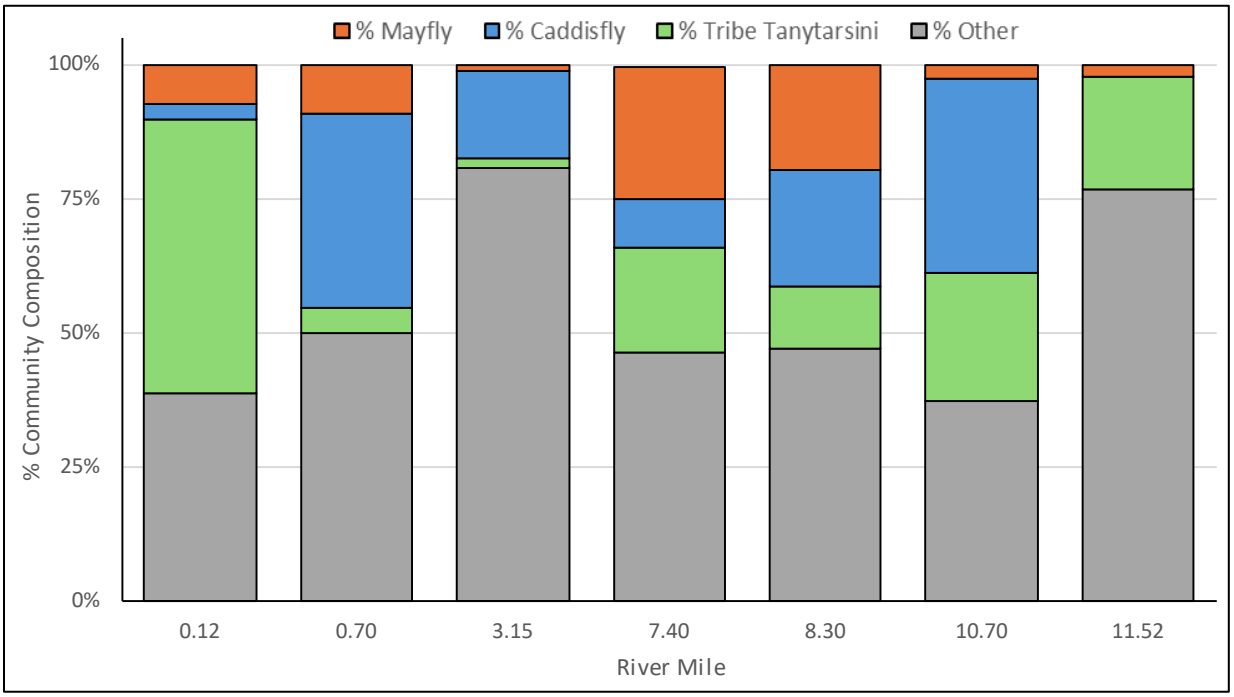


Figure 10. Mill Creek Main-Stem Macroinvertebrate Community Composition by Site.

Certain metrics of the macroinvertebrate ICI score can be used as a general indicator of water quality. The number of total taxa, qualitative taxa, qualitative EPT taxa, and number of qualitative sensitive taxa can be used to access improvements in water quality as these biodiversity measurements increase. Figure 11 below displays the averaged historical metric scores from 2011-2014 compared with the 2024 data. As previously mentioned, 2024 was the first survey conducted at Mill Creek RM 7.40; therefore, a historical comparison for this site is not available. Overall, the

2024 data showed an improvement in the macroinvertebrate community health across most sites surveyed within the Mill Creek Watershed. The increase in scores over time indicates a positive trend towards the attainment of the WWH criterion. RM 3.15 and 11.52 are the only sample locations that showed a large decline in some of the metrics.

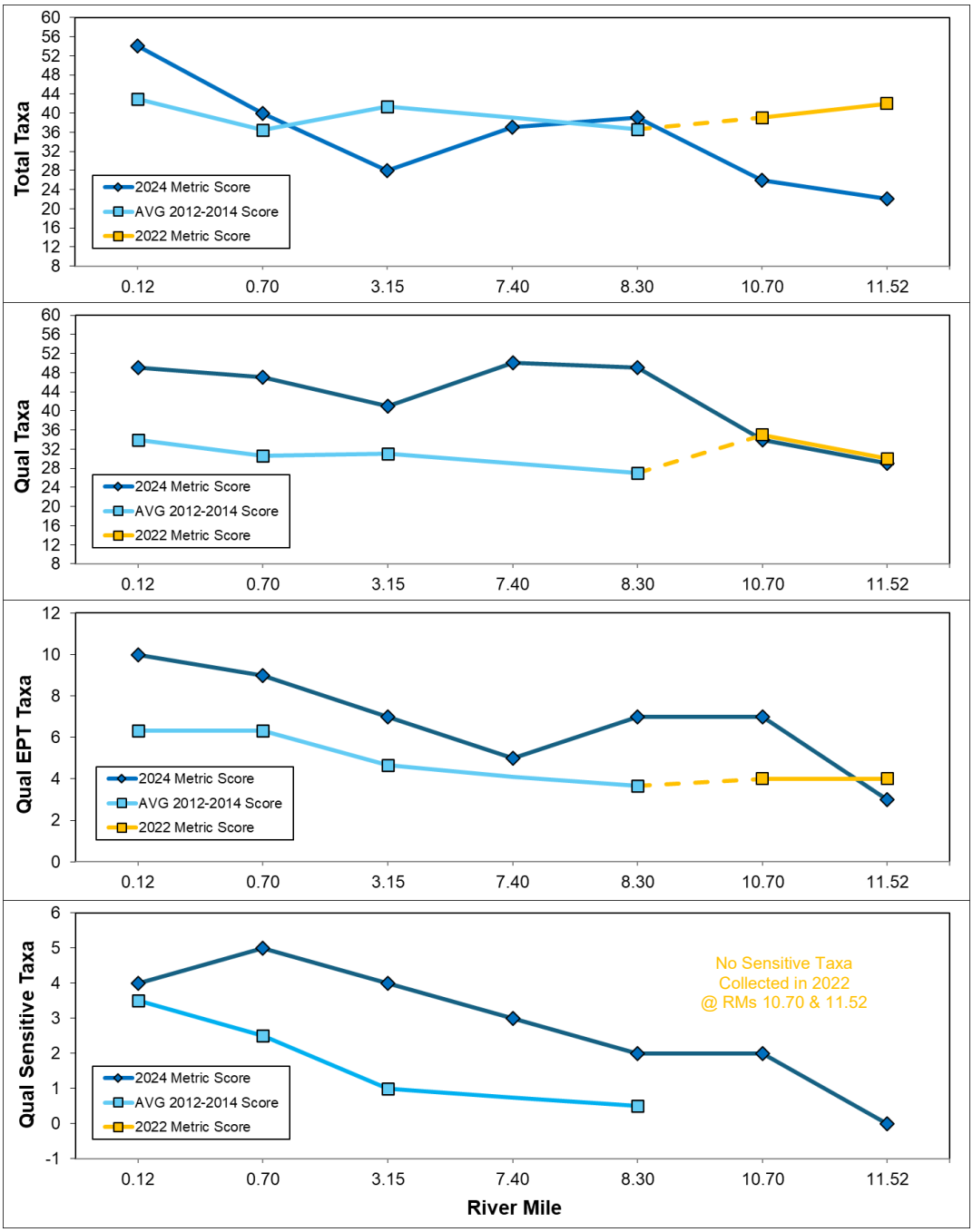


Figure 11. Mill Creek trends for Qual. Taxa, Qual. EPT Taxa, and Qual. Sensitive Taxa richness scores.

The aquatic macroinvertebrate community at Wolf Creek RM 0.05 was evaluated using expectations developed by NEORSD in 2021 using threshold limit models (NEORSD 2023). These models were developed using QDC Level 3 macroinvertebrate data provided by the Ohio EPA from the EOLP from the ten-year period between 2005 and 2014 (threshold limit model analysis available upon request). Table 16 provides the expectation threshold limits for qualitative total taxa, qualitative EPT taxa, and qualitative sensitive taxa metrics for headwater drainage areas. In addition to these threshold limits, field observations including, but not limited to, relative taxa abundance and a field narrative rating were considered in the assessment of the narrative rating for the Wolf Creek site based on the results of qualitative sampling.

Table 16. NEORSD Recommended Expectation Threshold Limits for Narrative Rating Assignments in the EOLP

Drainage Category	Designation	Qualitative Total Taxa	Qualitative EPT Taxa	Qualitative Sensitive Taxa
Headwater (0-20 miles^2)	EWH	38	12	6
	WWH	27	7	2
	Fair	23	4	1

A total of 20 taxa were collected in the qualitative sample at Wolf Creek RM 0.05, which falls below the *Fair* expectation threshold for a headwater stream (Table 15). Only two EPT taxa were collected at this site, which falls below the *Fair* expectation of four. A single sensitive taxon, (*Elimia sp*.) was collected, which falls below the WWH expectation threshold. Snails and flatworms were noted as the predominant groups during sample collection. The site was given a field narrative rating of *Very Poor* at the time of sample collection. The pollution tolerance of the identified taxa during the survey ranged from moderately intolerant to tolerant with the majority of taxa being categorized as facultative. This site was noted to have a very low drainage area of 2.2 square miles, which was considered when comparing diversity to the threshold values provided in Table 15, as diversity expectations decrease with lower drainage areas. Based on these findings, the Wolf Creek site was assigned a narrative rating of *Poor* in 2024. In 2020, the Ohio EPA conducted a baseline biological assessment as part of the Section 319(h) grant project monitoring (Ohio EPA, 2025). A narrative evaluation was also used in lieu of an ICI score. The pre-restoration macroinvertebrate assessment yielded a narrative rating of *Fair* in 2020.

It should be noted that the stream restoration project at Wolf Creek RM 0.05 was completed in 2024. It would be expected that the construction disturbance from the restoration project in conjunction with the placement of substrate for stream stabilization would have an impact on the macroinvertebrate community. One other potential impact at this site was that when the qualitative sample was collected, the flow in the stream was low enough that it was interstitial in some areas.

Substrate embeddedness and increased siltation was observed at the site by NEORSD field staff in 2024, which could also have a negative effect on the overall benthos. Urban development, impervious surfaces, and storm sewers may cause higher erosion rates in the upstream reaches and increase substrate embeddedness throughout the watershed. Low stream gradient, stream channelization, sparse instream cover, poor marginal habitat, and potential sanitary sewage contamination indicated by elevated levels of *E. coli* may also contribute to the lack of a healthier macroinvertebrate community within Mill Creek.

Conclusions

The aquatic life habitat use designation for the Mill Creek Watershed is WWH. According to the Ohio EPA (2022), WWH streams are capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms having a species composition, diversity, and functional organization comparable to the twenty-fifth percentile of the identified reference sites within its respective ecoregion. The results of NEORSD's 2024 Mill Creek Watershed study, which included water chemistry sampling, habitat assessments, and fish/benthic macroinvertebrate community surveys, indicate limiting conditions exist throughout the watershed. The lowermost reaches of Mill Creek, below the natural falls at RM 2.80, were found to be in full attainment of the biological criteria for WWH; however, the survey locations upstream of the falls were not found to be in attainment of the designated ALU criteria during the 2024 sampling season. A summary of the 2024 Mill Creek water quality survey results is provided in Table 17.

Table 17. 2024 Mill Creek ALU Attainment Status

River Mile	DA (mi^2)	Attainment Status	IBI Score	ICI Score/ Narrative Rating	QHEI Score	Cause(s)	Source(s)
Mill Creek (19-006-000) – WWH							
11.52^H	1.30	NON	22*	14*	61.00	Organic enrichment, Nutrient enrichment, Pollutants in urban stormwater	Urban runoff/stormwater, urbanization
10.70^H	1.80	NON	23*	38	63.00	Pollutants in urban stormwater, Fish barrier	Urban runoff/stormwater, urbanization
8.30^H	3.90	NON	24*	38	70.00	Pollutants in urban stormwater, Fish barrier	Urban runoff/stormwater, urbanization
7.40^H	4.42	NON	23*	44	70.75	Organic enrichment, Fish barrier, Pollutants in urban stormwater	Urban runoff/stormwater, Urbanization, municipal point sources

Table 17. 2024 Mill Creek ALU Attainment Status

River Mile	DA (mi^2)	Attainment Status	IBI Score	ICI Score/ Narrative Rating	QHEI Score	Cause(s)	Source(s)
3.15[H]	14.60	NON	20*	32[NS]	54.00	Sedimentation, Low gradient, Poor habitat, Fish barrier, Pollutants in urban stormwater	Urban runoff/stormwater, Urbanization, municipal point sources
0.70[H]	18.20	FULL	39[NS]	36	69.50		
0.12[H]	18.50	FULL	42	38	71.75		
Wolf Creek (19-006-003) – WWH							
0.05[H]	2.20	NON	21*	*Poor**	71.00	Organic enrichment, Nutrient enrichment, Habitat modification	Urban runoff/stormwater, urbanization,

[NS] Non-significant departure from WWH biocriteria (≤4 ICI; ≤4 IBI; ≤0.5 MIwb units)
* Significant departure from WWH biocriteria (> 4 ICI; > 4IBI; > 0.5 MIwb units)
Underlined scores are in the *Poor* or *Very Poor* narrative range
[H] Headwater scoring criteria

The results of water chemistry sampling, habitat assessments, and fish/benthic macroinvertebrate community surveys conducted by NEORSD indicate that the Mill Creek Watershed may be impacted by a variety of environmental stressors, as mentioned previously. As in years past, assessments in 2024 showed water quality impairments within Mill Creek which may be preventing the establishment of a healthier biological community. Water chemistry sampling found exceedances of both the PCR STV and geomean recreational criteria for *E. coli* (Table 4). This is common in urbanized watersheds due to improper sanitary connections, CSOs, failing household sewage treatment systems, and urban stormwater runoff.

Habitat scores met WWH expectations at all sites, except at RM 3.15, which received a low score due to substrate embeddedness and a lack of functional habitat along with a low diversity of instream cover types. The Mill Creek Watershed, like most urban watersheds within the NEORSD service area, continues to experience a loss of functional habitat along with increases in erosion rates that leads to higher sedimentation which affects important riffle habitat. The habitat suggests that it should be capable of supporting a healthy fish community, but the fish metric scores, along with fish species diversity, decrease drastically upstream of the large Mill Creek Falls at RM 2.80. In addition to the natural falls, there are additional fish barriers along Mill Creek. There is an earthen dam that functions as a major stormwater control structure in the Kerruish Park basin. The facility is intended to provide flood control while protecting properties downstream from flooding in the cities of Cleveland and Maple Heights. There is also a concrete sewer pipe that crosses the stream which acts as a low-head dam upstream of Kerruish Park retention basin and the concrete floor of culvert that crosses under South Miles Road is raised, which acts as a fish barrier.

Mill Creek at RM 0.12 and 0.70 were the only sites to achieve full attainment of the WWH ALU (Table 15). With the exception of Mill Creek RM 11.52 and Wolf Creek RM 0.05, the macroinvertebrate community scores met the WWH ALU criterion at all sample locations. However, the fish community was poor at all sample locations upstream of the Mill Creek Falls, resulting in the non-attainment status at these sample locations. Primary causes for the ALU impairment include the fish passage barrier that limits fish recolonization of the upper Mill Creek stream reaches and dense urbanization of the watershed. Historical surface water pollution from surface runoff and undersized wastewater collection infrastructure have likely locally extirpated higher quality fish species from upper portions of the watershed. The sites below the falls had a lower percentage of tolerant species, higher species richness, and a greater number of fish collected, which is reflected in the higher IBI scores. Upstream of the falls, the sites had only tolerant fish species; all of the upstream sites had over 96% of the fish composition composed of highly tolerant species (Creek Chub and Blacknose Dace). At the sites downstream of the falls, the fish community appeared healthier; although a low number of darter and headwater species may indicate that there are still water quality impacts as these species are typically found in areas with low environmental stress (Ohio EPA, 1987b). The highly developed and urban landscape throughout the Mill Creek Watershed has a negative effect on the overall water quality and a degradation of the aquatic biota. Sedimentation from urban runoff and high *E. coli* densities appear to be the main contributors of the impairments to the fish community component.

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