NORTHEAST OHIO REGIONAL SEWER DISTRICT

2009 Upstream of NEORSD CSO Areas
Biological, Water Quality and Habitat Survey Results

Prepared by
Water Quality and Industrial Surveillance's
Environmental Assessment Section

Introduction

During 2009, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys upstream from areas of NEORSD-owned combined sewer overflows (CSOs). In support of Ohio Environmental Protection Agency (Ohio EPA) National Pollutant Discharge Elimination System (NPDES) Permit No. 3PA00002*FD, the upstream CSO data was compared to the permit required data collected from areas downstream of the NEORSD CSOs on Big Creek, Doan Brook, Euclid Creek and Mill Creek.

According to the permit (1997), the goal is "that the discharges from combined sewer overflows shall not cause or significantly contribute to violations of water quality standards or impairment of designated uses." Thus, the permit-required macroinvertebrate and water chemistry sampling is conducted in order to assess this goal. Habitat assessments and fish community surveys were included as supplemental data.

This study helped to determine the effect CSOs and other environmental factors may have on downstream sites, as well as monitor improvement of streams over time. Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by Ohio EPA in Fish Community and Benthic Macroinvertebrate Biology, and Chemical Water Quality and Stream Habitat Assessments as explained in the NEORSD study plan approved by Ohio EPA on May 12, 2009 (*2009 Benthic Macroinvertebrate Sampling Upstream of NEORSD CSO Areas*). A map of the sampling locations is located in Appendix A. Table 1 (upstream CSO sites) and Table 2 (downstream CSO sites) indicate the sampling locations with respect to river mile (RM), latitude/longitude, description and surveys conducted.

Table 1. List of Sampling Locations Upstream of Combined Sewer Overflows

Stream Location	Latitude	Longitude	River Mile	Description	Purpose
Big Creek	N41.4460°	W81.7540°	4.40	Memphis MetroPark	Evaluate water chemistry, macroinvertebrates and habitat upstream of CSOs
Big Creek-Ford Branch	N41.4230°	W81.8019°	4.70	West 150th Street	Evaluate water chemistry, macroinvertebrates and habitat upstream of CSOs
Doan Brook-North Branch	N41.4838°	W81.5643°	6.70	Upstream of Lee Road	Evaluate water chemistry, macroinvertebrates and habitat upstream of CSOs
Doan Brook-South Branch	N41.4739°	W81.5593°	1.40	US Attleboro Road	Evaluate water chemistry, macroinvertebrates and habitat upstream of CSOs
Euclid Creek	N41.5658°	W81.5358°	2.70	Upstream of Highland Road	Evaluate water chemistry, macroinvertebrates and habitat upstream of CSOs
Euclid Creek	N41.5738°	W81.5470°	1.65	Upstream of St. Clair Avenue	Evaluate water chemistry, macroinvertebrates and habitat upstream of CSOs
Mill Creek	N41.4305°	W81.5442°	8.30	Upstream of South Miles Road	Evaluate water chemistry, macroinvertebrates and habitat upstream of CSOs

Table 2. List of Sampling Locations Required for Ohio EPA Permit No. 3PA00002*FD.

Stream Location	Latitude	Longitude	River Mile	Description	Purpose
Big Creek	N41.4460°	W81.6865°	0.15	Downstream of Jennings Road	Ohio EPA Permit No. 3PA00002*FD
Doan Brook	N41.5330°	W81.6296°	0.75	Downstream of St. Clair Avenue	Ohio EPA Permit No. 3PA00002*FD
Euclid Creek	N41.5833°	W81.5594°	0.55	Downstream of Lakeshore Avenue	Ohio EPA Permit No. 3PA00002*FD
Mill Creek	N41.4178°	W81.6387°	0.12	Upstream of Canal Road	Ohio EPA Permit No. 3PA00002*FD

Methods

Water Chemistry

Water chemistry samples were collected weekly during the macroinvertebrate colonization period from June 22, 2009 to July 20, 2009. Samples collected on June 22, 2009, July 13, 2009 and July 20, 2009 were associated with wet weather days[1]. A total of fifty-five samples were collected at

[1] Samples collected on a day with greater than 0.10 inches but less than 0.25 inches of rain and on the following day are considered "wet weather" samples; samples collected on a day with greater than 0.25 inches of rain and on the following two days are also considered "wet weather" samples.

locations upstream (7 sites) and downstream (4 sites) of NEORSD CSO outfalls. Collection techniques used for water chemistry and chemical analyses followed the *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices* (2009a). Field analyses included the use of three meters during sampling. A YSI-556 MPS Multi-Parameter Water Quality Meter or a YSI 600XL Sonde were calibrated weekly and utilized to measure dissolved oxygen, water temperature and specific conductance. A Hanna HI 98129 pH meter was used to measure pH when the YSI-556 MPS and YSI 600XL Sonde failed to meet quality assurance and quality control (QA/QC) requirements for pH calibration. However, it was determined on August 14, 2009, that the meters were not calibrated daily for pH as required by the Ohio EPA Surveillance Methods. Therefore, the pH measurements were not compared to the Ohio water quality criteria, since all of the measurements were collected before August 14, 2009.

Water chemistry samples were collected in two 4-liter polyethylene Cubitainers and two 473-milliliter plastic bottles. A NEORSD Surface Water Condition Sampling Field Data Form was completed with field parameters measured instream. Both plastic bottles used to collect samples were field preserved with either trace nitric acid or trace sulfuric acid. All samples were placed in a cooler with ice and stored in a locked NEORSD vehicle until the samples were transferred to the NEORSD's Analytical Services (AS) sample receiving, and released to an authorized AS employee with a Chain of Custody (COC).

All sites, except for Big Creek RM 4.70, are designated warmwater habitat (WWH), agricultural water supply, industrial water supply and primary contact recreation. Big Creek RM 4.70 is designated as Limited Resource Water (LRW) and no biocriteria apply; however, this site was compared to the WWH criteria for discussion purposes only. Additionally, Big Creek RM 4.70 data was compared to the other Big Creek sites as well as historical data to evaluate the progress of this section of Big Creek.

The quality assurance and quality control of water sample collections included obtaining sample duplicates at a frequency not less than 10% of the total samples collected, not including permit-required sites. Field blanks were collected at a frequency not less than 5% of the total samples collected, not including permit-required sites. The three field blanks that were collected showed no signs of contamination during the sampling and transporting process.

A total of four sample duplicates were obtained during the sampling period. Two sample duplicates were collected on July 20, 2009, one from Big Creek RM 4.70 and one Euclid Creek RM 2.70. One sample duplicate was obtained on July 6, 2009, from Euclid Creek RM 1.65 and another duplicate on June 29, 2009, from Doan Brook RM 6.70. The sample duplicate results were compared to the sample results using relative percent difference (RPD), see Formula 1.

Formula 1)

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

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

Each sample and sample duplicate was compared for each of the forty individual parameters reported on the Certificate of Analysis (COA), which did not include bacteriological analysis. After an RPD was calculated, any result greater than thirty percent was investigated to determine the reason for the discrepancy. A total of seven potential discrepancies were found. Three of the parameter values were less than ten times the practical quantitation limit. This is due to having very low concentrations. Differences in very low concentrations lead to high RPD values. The remaining four discrepancies could not be explained in this way and are listed in Table 3. A possible reason for the unexplained discrepancies could be due to a difference in time between the collection of the samples and the duplicates.

Table 3. Unexplained Water Quality Discrepancies

Stream	River Mile	Date Collected	Parameter	Units	Sample ID	Sample Result	Duplicate ID	Duplicate Result	RPD Value
Doan Brook	6.70	6/29/2009	Turbidity	NTU[2]	R-0906260006	1.77	R-0906260013	3.93	75.79
Euclid Creek	1.65	7/6/2009	Manganese	µg/L[3]	R-0907020009	23.87	R-0907020020	45.26	61.88
Euclid Creek	1.65	7/6/2009	Iron	µg/L	R-0907020009	155.20	R-0907020020	273.60	55.22
Euclid Creek	1.65	7/6/2009	Turbidity	NTU	R-0907020009	3.09	R-0907020020	8.56	93.91

Habitat Assessment

The Qualitative Habitat Evaluation Index scores (QHEI) were determined for each site in 2009 following the techniques described in the Ohio EPA's (2006) *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)*. The QHEI measures the stream substrate, instream cover, stream channel morphology, riparian and bank condition, pool and riffle

[2] NTU = Nephelometric Turbidity Units
[3] µg/L = micrograms per liter

quality and stream gradient in relation to fish community health. The Ohio EPA has set a QHEI target score of 60 for WWH. A QHEI score ≥60 indicates that the stream has adequate habitat diversity and should be able to attain a WWH fish community (Rankin, 1989).

Electrofishing

In 2009, electrofishing passes were conducted one time at each headwater (drainage area <20 square miles) and wading (drainage area 20-500 square miles) site. According to the Ohio EPA's *Biological Criteria for the Protection of Aquatic Life, Volume III: Standardized Biological Field Sampling Laboratory Methods for Assessing Fish and Macroinvertebrate Communities* (1987), assessments of wading sites should consist of at least two electrofishing passes, and at least one electrofishing pass at each headwater site. However, due to multiple equipment malfunctions, only one electrofishing pass was performed at the wading sites.

At each site, longline electrofishing techniques were used to shock all habitat types within a sampling zone. This zone was either 0.15 kilometers (for headwater sites) or 0.20 kilometers (for wading sites) in length, and shocking consisted of moving from downstream to upstream. Fish were identified to species level, counted, weighed (at wading sites only) and examined for the presence of external anomalies including deformities, erosions, lesions, and tumors (DELTs).

At headwater sites, results from electrofishing sampling were used to calculate the Index of Biotic Integrity (IBI). Wading sites required the use of the IBI as well as the Modified Index of Well Being (MIwb). The IBI, originally proposed by Karr (1981) is used to assess fish community health at a site. Twelve metrics comprise the IBI:

1. Number of Native Species
2. Number of Darter Species
3. Number of Sunfish Species (wading)/ Proportion of Headwater Species (headwater)
4. Number of Sucker (wading)/Minnow (headwater) Species
5. Number of Intolerant (wading)/Sensitive (headwater) Species
6. Proportion of Tolerant Species
7. Proportion of Omnivores
8. Proportion of Insectivores
9. Proportion of Top Carnivores (wading sites)/Pioneering Species (headwater sites)

10. Number of Individuals
11. Proportion of Simple Lithophils (wading)/Number of Simple Lithophilic Species (headwater)
12. Proportion that are Deformed, have Eroded Fins, Lesions or Tumors (DELTs)

The maximum possible IBI score is 60 and the minimum possible score is 12. The summation of the twelve individual metric scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional, Good, Marginally Good, Fair, Poor or Very Poor.* An IBI score of ≥40 at headwater sites indicates attainment of the WWH biocriteria in the Erie Ontario Lake Plain ecoregion, with a non-significant departure of ≤4 IBI units. Therefore, an IBI score between 36 and 39 indicates the site is within non-significant departure of the WWH biocriteria attainment. For wading sites, an IBI score of ≥38 demonstrates WWH biocriteria attainment and an IBI score between 34 and 37 is within non-significant departure of the WWH biocriteria attainment.

The MIwb (Formula 2) incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (H) (Formula 3) based on numbers and weight of fish. The MIwb is a result of a mathematical calculation based upon the formula.

Formula 2) $$MIwb = 0.5\ lnN + 0.5\ lnB + \overline{H}(No.) + \overline{H}(Wt.)$$

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

n_i = Relative numbers or weight of species
N = Total number or weight of the sample

For a wading site to be in full attainment of the WWH fish biocriterion, it must meet both the IBI and MIwb criteria. WWH attainment for the MIwb occurs when the score is ≥7.9, with non-significant departure being ≤0.5 MIwb units. Thus, a wading site is in full attainment of the WWH biocriteria if the IBI score is

≥38 and the MIwb is ≥7.9. Partial attainment occurs when either the IBI or MIwb criterion is achieved.

Macroinvertebrate Sampling

Macroinvertebrates were sampled quantitatively for one six-week period in 2009 using a modified Hester-Dendy artificial substrate sampler (HD) in conjunction with a qualitative assessment performed during retrieval. The modified HD is a type of passive sampling that has been utilized by the Ohio EPA since 1973 (DeShon, 1995).

The Invertebrate Community Index (ICI) was used as the principal measure of overall macroinvertebrate community condition. Developed by the Ohio EPA, the ICI is a modification of the Index of Biotic Integrity for fish (OEPA, 1987a). The ICI consists of ten individually scored structural community metrics:

1. Total number of taxa
2. Total number of mayfly taxa
3. Total number of caddisfly taxa
4. Total number of dipteran taxa
5. Percent mayflies
6. Percent caddisflies
7. Percent Tanytarsini midges
8. Percent other dipterans and non-insects
9. Percent tolerant organisms
10. Total number of qualitative EPT taxa

Metrics 1-9 are based on the quantitative sample, while Metric 10 is based on the number of Ephemeroptera (Mayflies), Plecoptera (Stoneflies) and Trichoptera (Caddisflies) in the qualitative sample. Metric 10 is also referred to as the EPT taxa.

Scoring criteria for all ten metrics is dependent upon drainage area. The scoring of an individual sample is based on the relevant attributes of that sample compared to equivalent data from 232 reference sites throughout Ohio. Metric scores have four different scoring categories (0, 2, 4, 6), ranging from six points for values comparable to exceptional community structure to zero points for values that deviate strongly from the expected range of values based on scoring criteria established by Ohio EPA (1989). The sum of the individual metric scores results in the ICI score for a particular location.

Calculation of the ICI was conducted using a computer program, written in 1994, for the software SAS® by EA Engineering, Science, & Technology, Incorporated (Deerfield, Illinois). According to EA's standard operating procedure for laboratory processing of benthic samples, this program is continually tested and updated to ensure its accuracy.

If a quantitative sample was not collected, then a qualitative sample was collected and compared to a Qualitative Community Tolerance Value (QCTV) score to help determine attainment status. The scoring applies to just the qualitative sampling. The QCTV score is the median pollution tolerance value calculated from the collected species that have an associated tolerance value recorded from a weighted ICI scoring. For an explanation on species tolerance values, refer to "Development and Application of the Invertebrate Community Index (ICI)" (DeShon, 1995). The QCTV score is used as a tool for assisting with the determination of attainment status.

Higher QCTV scores are related to the presence of taxa associated with higher ICI scores. According to the OEPA Technical Report MAS/1997-12-4 (1999), if the QCTV score, in the Erie/Ontario Lake Plain (EOLP) ecoregion, is greater than 37.15, it is associated with better water quality. A score between 37.15 (the 25th percentile) and 34.30 (the 75th percentile) implies that the attainment status cannot be determined from the QCTV score and instead, best professional judgment should be used to help determine attainment. A score less than 34.30 indicates the presence of taxa seen in waters that are typically associated with poorer water quality.

Macroinvertebrate samples were shipped to EA Engineering, Science and Technology, Incorporated, for identification and enumeration. Specimens were identified to the lowest practical taxonomic level and whenever possible, to the level of taxonomy recommended in Ohio EPA's *Biological Criteria for the Protection of Aquatic Life, Volume III* (1987, updated September 30, 1989; November 8, 2006; and August 26, 2008). The taxa lists and enumerations are available upon request.

In previous years, different sample retrieval methods have been used. Prior methods involved placing a 3.70-gallon wash bucket equipped with #30 sieve under water, just downstream of the HD, with the opening of the bucket facing upstream. The individual HD samplers were detached from the cinder block and placed into the wash bucket while still under water. The wash bucket was then removed from the water. The individual HD samplers were disassembled in the wash bucket and all of the associated hardware was discarded. The remaining contents of the wash bucket, including the disassembled HD samplers, were placed into a 1,000-milliliter cylindrical, plastic screw-top container and approximately 5 milliliters of 37 percent formaldehyde were added.

In 2009, a wash bucket with #30 sieve was not utilized to collect HDs. It was believed that smaller organisms may have been able to escape through the #30 sieve; therefore sampling techniques were altered in 2009. Instead, each HD was

individually removed from the cinder block, placed in a 1-quart plastic container with preservative and sent to EA Engineering, Science and Technology, Incorporated for identification and enumeration. EA sorted the macroinvertebrates by placing a #40 sieve underneath a #30 sieve. In this manner, some smaller organisms that passed through the #30 sieve would be captured by the #40 sieve. This new method allowed for a higher accuracy in the enumeration of macroinvertebrates compared to previous years. However, it is important to note that an increase in the total number of organisms does not necessarily lead to a higher ICI score.

Anchoring methods of the HD have changed as well. In 2009, a 4"x 8"x 16" or a 16"x 8"x 8" cinder block was used as an anchor, and five HD artificial substrate samplers were tied across it using 3/16" braided nylon and polypropylene rope. The cinder block, with the HDs attached, was worked into the substrate, and larger rocks from the stream bed were repositioned until the cinder block was secured in place. By utilizing this anchoring technique, the HD was closer to the bottom sediment, providing a shorter distance for macroinvertebrates to get to the HD and colonize. In previous years, steel rebar was driven into the substrate and used to anchor the HDs; however, this technique posed some problems. During high flow conditions, the HD would often relocate to a different position while still attached to the rebar, creating a situation undesirable for macroinvertebrate colonization.

Results and Discussion

Big Creek

Water Chemistry

None of the grab samples collected on Big Creek were in exceedance of the water quality criteria for the protection of aquatic life. Therefore, all samples were in attainment of the applicable criteria of the Ohio Water Quality Standards, Ohio *Administrative Code* 3745-1-07 (2009b).

Habitat Assessment

Big Creek RM 4.70, which is located off of West 150th Street, north of Interstate 480, scored a 57.50 (*Good*) (Table 4). The best substrate types were sand and gravel. The instream cover was moderate to sparse and there was little to no bank erosion. The main limiting factor was the absence of a riffle. This site improved to *Good* in 2009 from *Fair* in 2008. In 2008, instream cover was sparse and the site had none to low sinuosity and slow current velocity.

Table 4. 2008 & 2009 Big Creek Qualitative Habitat Evaluation Index Scores

	QHEI Score			
River Mile	2008 Score	Narrative Rating	2009 Score	Narrative Rating
4.70	46.50	Fair	57.50	Good
4.40	66.50*	Good	61.75*	Good
0.15	64.00*	Good	73.25*	Good

*Site met Ohio EPA QHEI WWH target score (≥60)

Big Creek RM 4.40 scored a 61.75 (*Good*) (Table 4). This site is located on the East Branch at the Cleveland Metroparks Memphis Picnic Area, 100 feet upstream of the confluence with the West Branch. Containing mainly boulder and gravel substrate with little to no bank erosion, the site is within an urban/industrial and park area. The instream cover consisted of shallows and high quality boulders. This site received a similar rating in 2008 with both years meeting the Ohio EPA target for WWH streams.

Big Creek RM 0.15 scored a 73.25 (*Good*) (Table 4). This site begins downstream of the Jennings Road Pump Station CSO 045 and extends to approximately 300 feet upstream of the confluence with the Cuyahoga River. Consisting mainly of gravel and sand, this site had moderate sinuosity with good channel development. Riparian width was very narrow to almost none, and the surrounding area was primarily urban and industrial. A *Good* rating was also obtained at this site in 2008, and both years met the Ohio EPA's target for WWH streams.

Electrofishing

Big Creek RM 4.70 had the lowest IBI score of all the sites in 2009. This site is designated as Limited Resource Water (LRW) and no biocriteria apply; however, the IBI was evaluated for comparison purposes only. With an IBI score of 16 (Figure 1), it fell into the narrative range of *Very Poor*. This extremely low fish score was attributed to the fish community population being composed mainly of northern fathead minnow (91.20%) and common white sucker (8.10%), which are highly pollution tolerant species. Northern fathead minnows survive best without competition from other fish species, which is why they are seen in such high abundance at this site (Trautman, 1981). Although the QHEI had a narrative rating of *Good*, there were some habitat flaws that may have negatively affected the IBI score. The main habitat limitations include slow moving water and no functional riffle present. Additionally, water chemistry results reveal average turbidity, average total solids and average suspended solids that were significantly

higher than the other Big Creek sampling sites. In 2008, this site received a similar IBI score (Table 5).

Table 5. 2008 & 2009 Big Creek IBI & MIwb Scores

		IBI Scores & Narrative Ratings				MIwb Scores & Narrative Ratings			
River Mile	**Type**	**2008 Score**	**2008 Narrative Rating**	**2009 Score**	**2009 Narrative Rating**	**2008 Score**	**2008 Narrative Rating**	**2009 Score**	**2009 Narrative Rating**
4.70	Headwater	12	Very Poor	16	Very Poor	---	--	---	--
4.40	Headwater	32	Fair	36[b]	Marginally Good	---	--	---	--
0.15	Wading	32[a]	Fair	26	Poor	6.6[a]	Fair	5.6	Poor

[a]Average score
[b]WWH IBI attainment

Big Creek RM 4.40 obtained an IBI narrative rating of *Marginally Good*. With an IBI score of 36 (Figure 1), this site was within non-significant departure (≤ 4 IBI units) and attainment of the designated WWH IBI criterion. IBI metric scores revealed six metrics receiving the highest score of five: number of minnow species, proportion of tolerant species, proportion of omnivores, proportion of pioneering species, number of individuals and proportion of DELT anomalies. Of the fish collected, 75.16% were intermediately tolerant to moderately intolerant to pollution.

Additionally, a total of seven bigmouth shiners were collected at this site. Bigmouth shiners are limited in their distribution in Ohio streams, documented by Trautman (1981) as only inhabiting the Rocky and Black Rivers. It is listed as a threatened species by the Ohio Division of Wildlife. It is also intermediately tolerant to pollution (Barbour et al., 1999). In 2008, nine bigmouth shiners were collected, which indicates that there may be an established community of bigmouth shiners at this site. This species does not like clay silt on the bottom of streams (Trautman, 1981), and this site supports those preferences with normal silt quality and no clay hardpan present.

Also of importance is the collection of seven sand shiners, which is a moderately intolerant, sensitive species. In 2008 and 2007, six and two sand shiners were collected, respectively. Similar to the bigmouth shiner, the sand shiner may also be in the process of establishing a community at this site. Sand shiners prefer a habitat of sand and gravel with no silt. Additionally, this species is found in pools with considerable current and avoids aquatic vegetation (Trautman, 1981). The QHEI results at this site support the habitat preferences of this species with normal silt quality and fast to slow current velocity with no aquatic vegetation present.

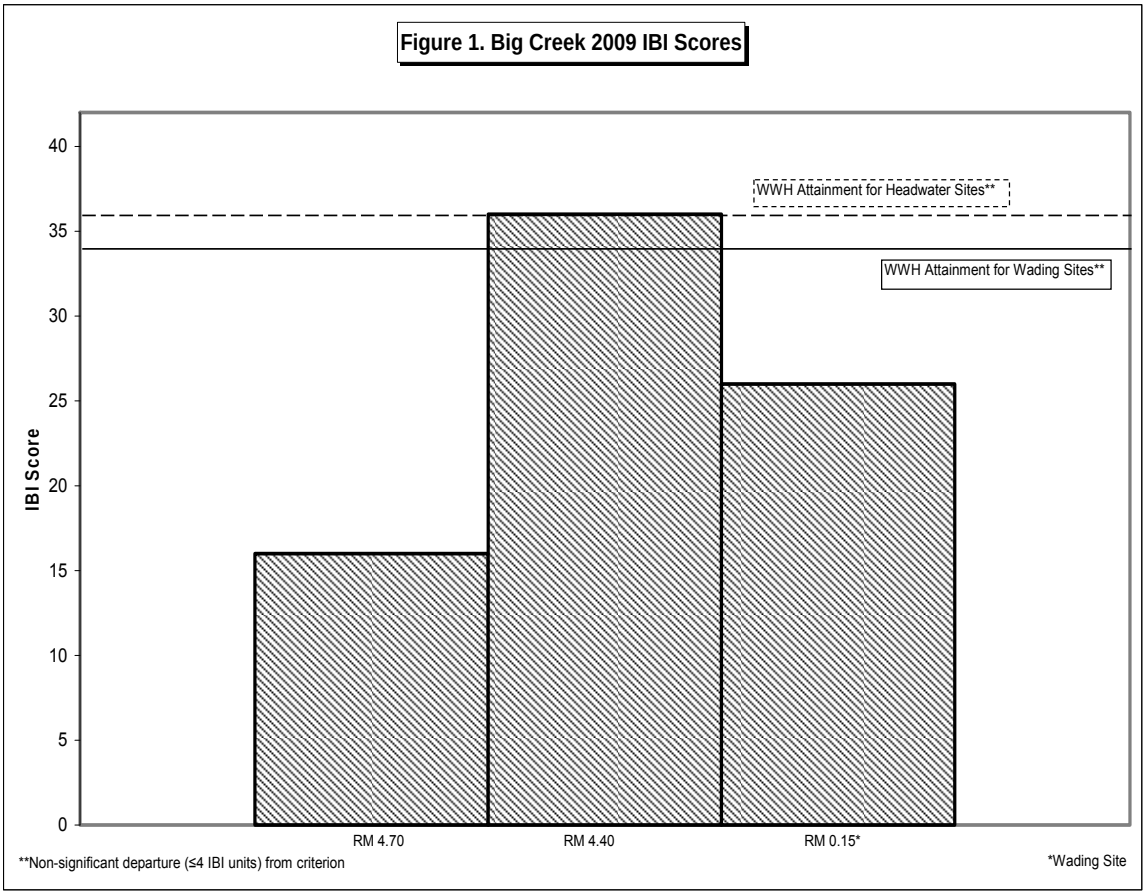
In 2008, Big Creek RM 4.40 obtained an IBI score of 32, which was in the *Fair* range (Table 5). The 2009 score increased from 2008 due to a decrease in the proportion of tolerant species and omnivores collected in 2009 (Table 6), which are both negative metrics. The site was not in attainment of the WWH IBI criterion in 2008, but was in 2009. Although Big Creek RM 4.40 was not in attainment in 2008, the 2008 IBI score was within 4 IBI units from the 2009 IBI score.

Table 6. Big Creek RM 4.40

	2008	**2009**
Tolerant Species Collected	43.73%	24.84%
Omnivorous Species Collected	23.08%	8.98%

Big Creek RM 0.15, a wading site, received an IBI score of 26 (*Poor*) and an MIwb narrative rating of *Poor*, indicating non-attainment of WWH criteria. The score dropped from 2008, when an average IBI and MIwb narrative ratings of *Fair* were obtained (Table 5). This score decrease may be attributed to the lack of carnivores, less sunfish species and fewer insectivores collected in 2009. The decrease in those fish metrics may be due to poorer water quality. Water chemistry results from 2008 showed overall healthier water quality than in 2009. Concentrations of total solids, total suspended solids, turbidity, iron and nickel were lower in 2008 than in 2009. Additionally, common white suckers, which are a highly pollution-tolerant species, comprised 29.85% of the fish collected in 2009. In 2008, only 12.17% and 17.57% of the total fish collected during the first and second electrofishing pass, respectively, were common white suckers.

The QHEI scored in the *Good* range at RM 0.15; however, the very narrow riparian width may allow pollutants, stormwater and urban runoff into the creek, which could explain why the IBI score was low and thus why there were fewer carnivore, sunfish and insectivore species collected. Additionally, silt quality was moderate to normal and river right had heavy to severe bank erosion, when there was moderate to little bank erosion in 2008. These negative QHEI characteristics may explain the poor IBI score at RM 0.15 in 2009.



Macroinvertebrate Sampling

Big Creek RM 4.70 received an ICI score of 12 (*Poor*) in 2009 (Figure 2). Every ICI metric obtained a score of zero except for the total number of taxa, total number of dipterans and percent tribe tanytarsini. The percent composition of macroinvertebrates on the HD shows tribe tanytarsini and other species such as *Oligochaeta* and members of the family Chironomidae, composing the entire sample (Figure 3). The low ICI score is likely due to the absence of a riffle, low current velocity and small drainage area, which is further supported by the QHEI score (57.5). In 2008, this site received the same score (Table 7) and historical data shows a positive trend in ICI scores, with a 142.86% improvement from 2007 to 2008 (Figure 4).

Table 7. 2008 & 2009 Big Creek ICI Scores

	ICI Scores & Narrative Ratings			
River Mile	**2008**	**2008 Narrative Rating**	**2009**	**2009 Narrative Rating**
4.70	12[a]	Poor	12	Poor
4.40	36[a,b]	Good	--	Good [c]
0.15	20[a]	Fair	28	Fair

[a]Average score
[b]WWH ICI attainment
[c] Based on best professional judgment

At Big Creek RM 4.40, the HD was not recovered during 2009, thus no ICI score was obtained. The HD was reinstalled three times during a six-week period due to it becoming buried or lost. With the last installation being unsuccessful, only qualitative sampling of the site was performed. Although an ICI score was not calculated, a QCTV score of 38.2 was obtained from the qualitative sampling. There were a total of 22 taxa collected with six being EPT taxa. The number of taxa collected during the qualitative sampling was not significantly different than the number of taxa collected on the HD in 2008. The QCTV score suggests that the site has the potential to achieve WWH criterion. In 2008, this site received an ICI score of 36 (*Good*) and was in attainment of the biocriterion for WWH (Table 7). Historical data shows a positive trend of ICI scores, indicating a possible improvement in water quality at this site (Figure 4).

In 2009, Big Creek RM 0.15 obtained an ICI score of 28 (Figure 2). Although this site only received a narrative rating of *Fair*, the densities of Ephemeroptera (mayflies) and Trichoptera (caddisflies) comprised 10% and 21% of the total sample, respectively (Figure 3). However, in 2008, mayflies comprised 3.35% and caddisflies comprised 5.65% of the total sample and the site received a *Fair* narrative ICI rating (Table 7). Mayflies and caddisflies are positive indicators that contribute to the ICI score. A significant increase in densities of members of these families will increase the ICI score at the site. Historical data at this site shows a positive trend in ICI scores throughout the years (Figure 4), potentially signifying an improvement in water quality, as evident in the increase in the numbers of mayflies and caddisflies.

Of importance is the increase in the total number of organisms (Table 8) at all Big Creek sites from 2008 to 2009 (except for RM 4.40 where no HD was collected in 2009). A change in sampling techniques from 2008 (anchoring and retrieval of HDs), may account for the higher total number of organisms in 2009. However, further sampling using the updated retrieval technique should be

performed to better understand the increase in total number of organisms collected.

Table 8. Big Creek 2008 & 2009 Total Number of Organisms on HD

River Mile	2008 (organisms)	2009 (organisms)	% Difference
4.70	1163*	1776	41.71%
4.40	639	--	--
0.15	644*	3817	142.26%

*Average number
--HD not recovered; no ICI score

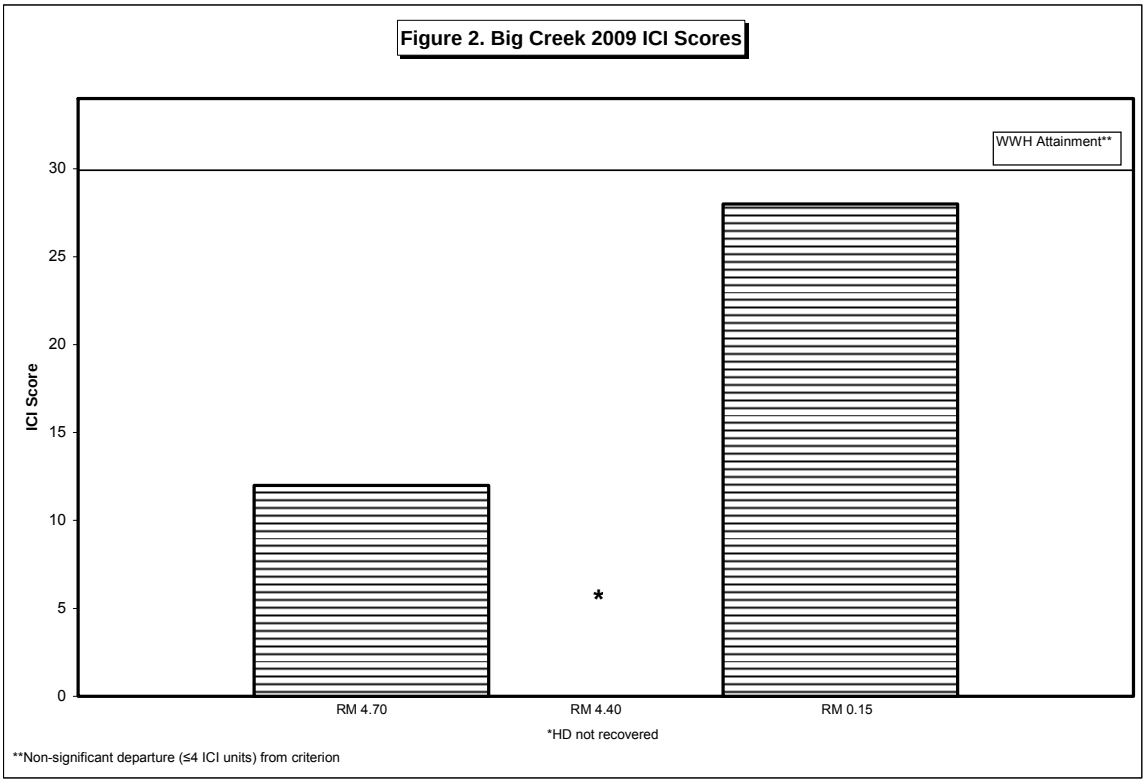


Figure 3. Big Creek 2009 HD Percent Composition

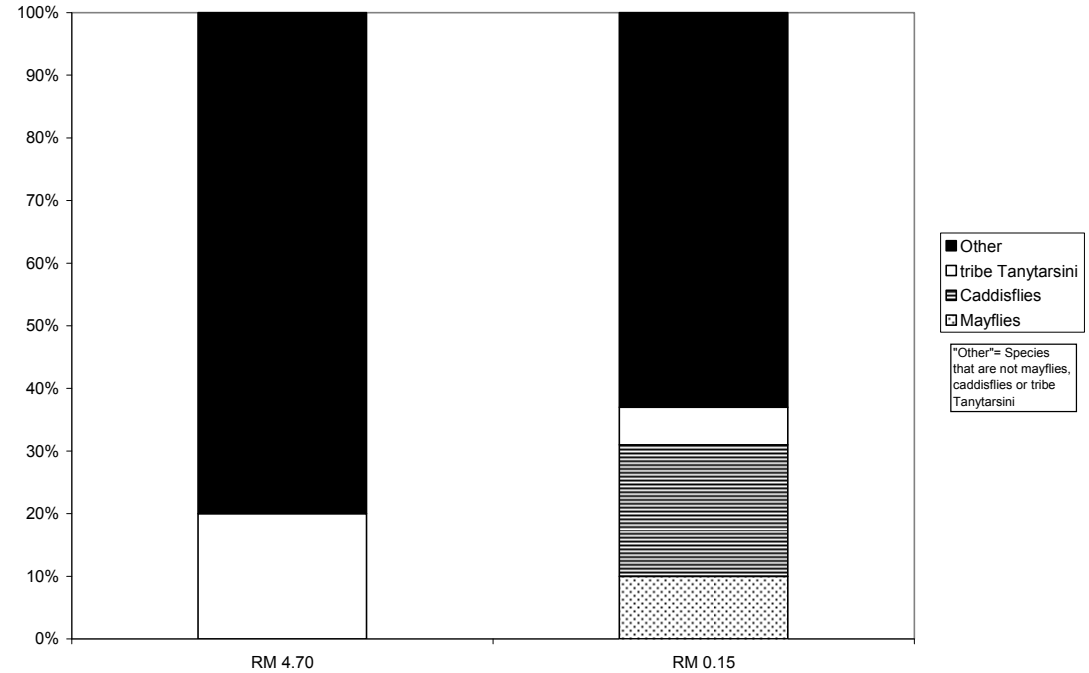
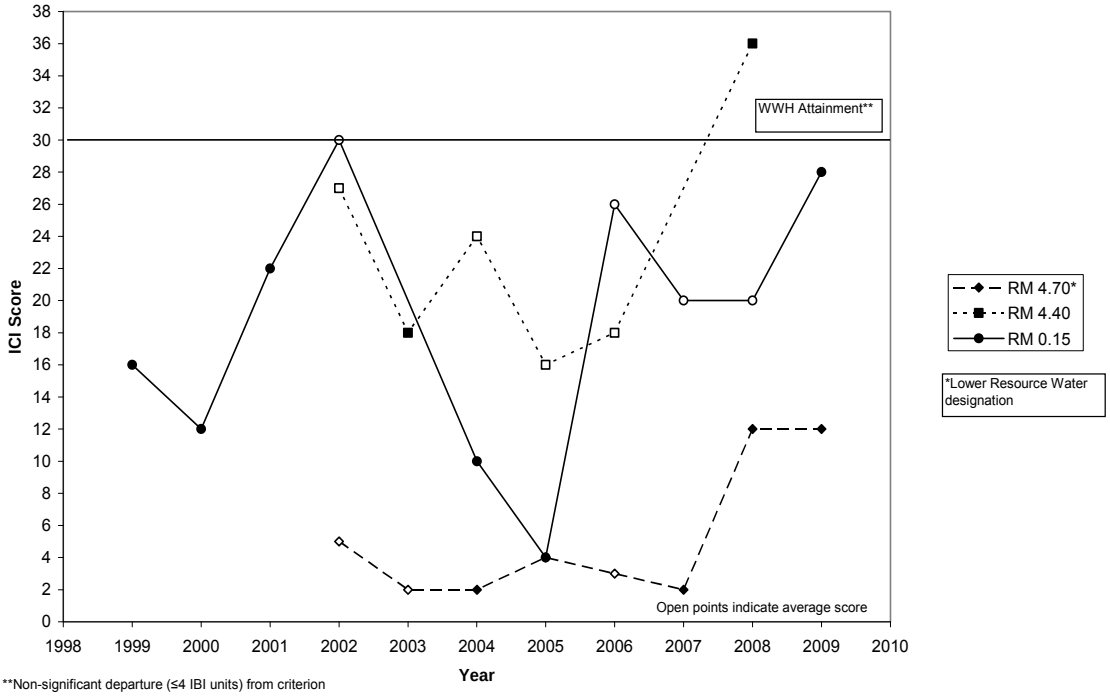


Figure 4. Big Creek Trend Graph



Conclusions

Due to the designation of Big Creek RM 4.70, no biocriteria apply, therefore, the data collected is used for comparison purposes only. This site was in non-attainment of the WWH biocriteria in 2009. The habitat limitations of RM 4.70 are the likely cause of its failure to achieve attainment.

Big Creek RM 4.40 was in partial attainment of the WWH biocriteria. The WWH IBI criterion was in attainment and the QHEI scored well; however, no HD was recovered and an ICI score was unavailable. A QCTV score from qualitative sampling suggests that the WWH criterion for macroinvertebrates has the potential to be in attainment. Better water quality and physical habitat may explain why this site exhibited improvements in fish and macroinvertebrate scores in 2009.

RM 0.15 was not in attainment of the WWH biocriteria. The IBI and ICI scores were poor and fair respectively; however, the QHEI score was the highest of all of the Big Creek sites. The low biological scores may be related to runoff, point and non-point sources of pollution or rain (11 wet weather days during the colonization period).

Due to the partial attainment at RM 4.40 and non-attainment at RM 0.15, it appears that CSOs may be negatively affecting fish and macroinvertebrate communities downstream. However, there were no identified water quality exceedances at any of the Big Creek sites based on the grab samples collected; therefore, other factors may be contributing to the poor biological scores, aside from CSOs. These include stormwater and urban runoff, pollutants, point and non-point sources, small drainage areas and documented sanitary sewer overflows (SSOs). The descriptions and locations of the SSOs can be found in the 2009 NEORSD Community Discharge Permit Program, SSO Status Report. Monitoring of Big Creek should continue to more accurately assess the factors affecting attainment.

Doan Brook

Water Chemistry

There were no exceedances of the water quality criteria for the protection of aquatic life throughout the five weeks of grab sampling, thus all samples were in attainment of the applicable criteria of the Ohio Water Quality Standards, Ohio *Administrative Code* 3745-1-07 (2009b). The water chemistry results in 2008 were similar, with only one exceedance, for copper, of the applicable Outside Mixing Zone Maximum (OMZM) at Doan Brook RM 0.75. An isolated thunderstorm on the east side of Cleveland, which caused high stream flows and may have caused CSO wet weather discharges, is believed to have been the cause of the exceedance.

Habitat Assessment

Doan Brook RM 6.70 on the North Branch is located near Lee Road, upstream of the Shaker Lakes Nature Center. A QHEI score of 56.5 (*Good*) was obtained, which was the lowest QHEI score calculated for all sites. Gravel and sand were the predominant substrate types, and the sparse instream cover consisted of undercut banks, shallows, rootmats, rootwads, boulders and logs or woody debris. Bank erosion was moderate to little, and riparian width was moderate. Channel development was fair and riffle and run embeddedness were moderate. The site is surrounded by residential homes and a park setting. The same narrative rating was obtained in 2008, however, the numerical QHEI score decreased in 2009 to below Ohio EPA's target score of 60 (Table 9). While the 2009 QHEI score was below the target score, it still obtained a *Good* narrative rating.

Table 9. 2008 & 2009 Doan Brook Qualitative Habitat Evaluation Index Scores

	QHEI Score			
River Mile	**2008 Score**	**2008 Narrative Rating**	**2009 Score**	**2009 Narrative Rating**
6.70	65*	Good	56.5	Good
1.40	59	Good	66*	Good
0.75	51	Fair	62*	Good

*Site met Ohio EPA QHEI WWH target score (≥60)

Doan Brook RM 1.40 obtained a QHEI score of 66 (*Good*) and is located on the South Branch near Attleboro Road. Gravel and sand were the best substrate types. Instream cover consisted of undercut banks, overhanging vegetation, shallows, rootmats, deep pools (>70 centimeters), rootwads, boulders and woody debris. The site contained moderate bank erosion with a moderate to narrow

riparian width and a residential park use. This site met the Ohio EPA's target for warmwater habitat streams in 2009, but not 2008, when the creek obtained a score of 59 (*Good*) (Table 9).

The QHEI at Doan Brook RM 0.75 scored a 62 (*Good*), even though this section of the brook is channelized. This site is located north of St. Clair Avenue and east of Martin Luther King Junior Drive. Cobble and sand were the predominant substrate type with sparse instream cover. There was little to no bank erosion and the surrounding area is residential park. In 2008, this site scored a 51 (*Fair*) due to poor channel development and lack of a functional riffle (Table 9).

Electrofishing

Doan Brook RMs 6.70 and 1.40 both received IBI scores in the *Poor* range (Figure 5), failing to meet the WWH IBI criterion (Table 10). At RM 6.70, green sunfish, creek chub, central stoneroller and common white sucker were the only species collected. Creek chubs (98.0% of sample) favor a bottom made of sand, gravel, boulders and bedrock (Trautman, 1981). The QHEI supports this preference with gravel and sand being the most prominent substrate type. However, the low QHEI score also indicates that this site is not currently able to support a WWH fish environment.

Table 10. Doan Brook 2008 & 2009 IBI Scores

		IBI Scores & Narrative Ratings			
River Mile	**Type**	**2008 Score**	**2008 Narrative Rating**	**2009 Score**	**2009 Narrative Rating**
6.70	Headwater	20	Poor	24	Poor
1.40	Headwater	22	Poor	24	Poor
0.75	Headwater	22	Poor	30	Fair

With a score of 24 (Figure 5), only goldfish and green sunfish, which are both highly pollution-tolerant species, were collected at RM 1.40. Green sunfish, which made up 96.49% of all species collected at RM 1.40, are very tolerant of turbid, silty waters and low oxygen levels (Bosanko, 2008; Trautman, 1981). RM 6.70 and RM 1.40 had heavy and moderate silt quality, respectively.

Water chemistry data at RM 6.70, where green sunfish were also collected, shows average turbidity that is higher and average dissolved oxygen that is lower than the other sites on Doan Brook. The BOD at RM 6.70 was consistently higher than the other Doan Brook sites, which may indicate organic enrichment and thus the lower average dissolved oxygen (Table 11). RM 6.70 is located downstream of Upper Shaker Lake, which historically, has had issues with nutrient pollution

(Olive & Karn, 1980). Therefore, the lake may be potentially affecting the dissolved oxygen, turbidity and BOD which, in turn, may affect the fish community at RM 6.70. Other factors, such as septic systems and urban runoff may also contribute.

Table 11. Doan Brook Water Chemistry

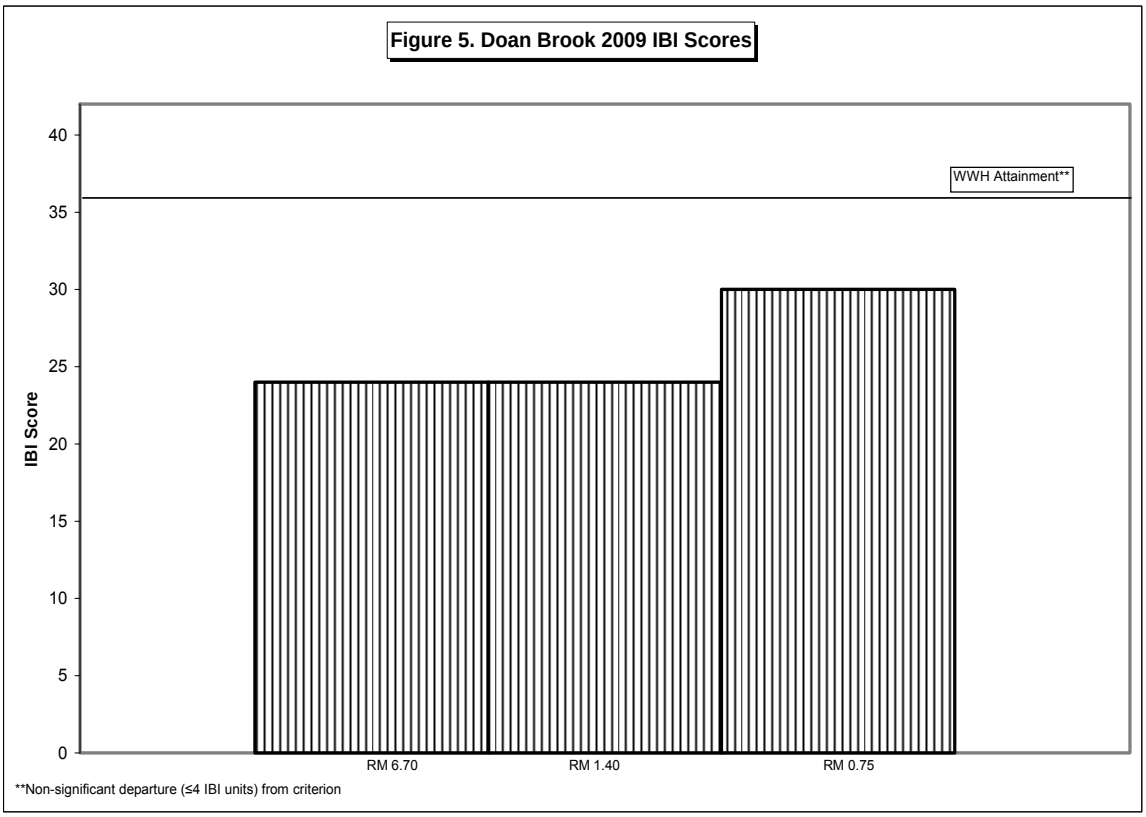
River Mile	Average Turbidity (NTU)	Average DO (mg/L)	Average BOD (mg/L)
6.70	4.23	11.72	2.42
1.40	1.83	10.08	<2*
0.75	1.8	8.95	<2*

*Minimum detection limit= 2.0 mg/L

The area surrounding RM 1.40 is heavily residential and the brook flows through a golf course just upstream of the sampling location. These factors may influence the turbidity in the stream. In 2008, both of these sites received similar IBI scores (Table 10).

The QHEI for RM 6.70 and RM 1.40 indicate fair channel development, which may be unsuitable for a healthy fish community. Also, the silt quality favors lower scoring fish species, as previously mentioned. Both of these factors may affect the fish community at these sites. Additionally, RM 1.40 is located upstream of a lake that could be impeding fish movement.

RM 0.75 obtained an IBI score in the *Fair* range (Figure 5). Of the fish collected, 76.32% were highly to moderately pollution tolerant, consisting of common white sucker, brown bullhead, northern bluegill sunfish and pumpkinseed sunfish. The only exception was the largemouth bass, which is intermediately pollution tolerant. The score increased from 2008 (*Poor*), most likely due to a decrease in the proportion of tolerant species and an increase in insectivorous species; however, WWH IBI attainment was still not achieved (Table 10). Better water quality in 2009, as evident by comparison of the water chemistry results, may explain why there were less tolerant and more insectivore species collected in 2008. In 2009, there was a decrease in total metals (RPD=67.88%), turbidity (RPD=135.71%), ammonia (RPD=71.14%), phosphorus (RPD=41.49%) and total suspended solids (RPD=152.94%), when compared to water chemistry results from 2008. The QHEI scored in the *Good* range (62); however, the sparse instream cover, channelization of the site and the lack of riparian width on river left may account for the lower IBI score.



Macroinvertebrate Sampling

Doan Brook RM 6.70 received an ICI score of 12 (*Poor*) in 2009 (Figure 6). The site was lacking in the number and percent of mayfly taxa, and had a high number of dipterans, high percentage of tolerant organisms and low EPT score. Figure 7 illustrates that the HD sample contained no mayflies or caddisflies.

During the HD installation, flow over the HDs on Doan Brook RM 6.70 was instantaneously measured at -0.035 feet per second (fps). Upon retrieval, the flow was measured at 0.03 fps. The minimum flow recommended by the Ohio EPA for good colonization is 0.3 fps. According to the Ohio EPA, the "amount of current tends to have the most profound effect on the types and numbers of organisms collected" (OEPA, 1987a). The negative flow measurement obtained during HD installation suggests that flow over the HD was going in the reverse direction. The flow variation and negative flow is possibly due to the effects of two small lakes, one upstream and one downstream of the site. The lack of current at this site, as well as rainfall (13 wet weather days during the 42 days of the colonization period) which may cause scouring of the HD, increased turbidity and small drainage area may account for the low ICI score. These factors can have a significantly negative effect on the macroinvertebrate community (DeShon, 1995).

In 2008, this site received the same ICI narrative rating (Table 12). The location of this site, upstream of all NEORSD CSOs, indicates that factors other than CSOs are having a negative impact on the macroinvertebrate community at RM 6.70.

Table 12. 2008 & 2009 Doan Brook ICI Scores

	ICI Scores & Narrative Ratings			
River Mile	**2008 Score**	**2008 Narrative Rating**	**2009 Score**	**2009 Narrative Rating**
6.70	4[a]	Poor	12	Poor
1.40	8[a]	Poor	20	Fair
0.75	--	--	28	Fair

[a]Average score

Doan Brook RM 1.40 obtained an ICI score of 20 (*Fair*) (Figure 6), which was an improvement from 2008 when the ICI narrative rating was *Poor* (Table 11). The highest scoring metric was percent caddisflies (1.3% of the sample); however, a large majority of the sample was composed of other species, such as Chironomidae (Figure 7). Similar to Doan Brook RM 6.70, the HD installation and retrieval indicated flow that was less than 0.3 fps. This, along with increased turbidity compared to the downstream site, rainfall and the low gradient of the stream, may have contributed to the low ICI score.

At Doan Brook RM 0.75, an ICI score of 28 with a narrative rating of *Fair* was obtained (Figure 6). This indicates that the WWH criterion is not being achieved for macroinvertebrates. Similar to the other Doan Brook sites, this site was comprised mainly of aquatic worms and midges (Figure 7). The limited amount of suitable habitat, extreme flow variation and rainfall are likely contributing to the low score. There was no ICI score in 2008 due to a lost HD.

The City of Cleveland reported, for Doan Brook, a dry weather overflow discharge event that occurred on June 23, 2009, eight days after HD deployment, approximately two miles upstream of RM 0.75. The overflow entered Doan Brook through CSO 234, which is located east of Martin Luther King Jr. Boulevard and north of Wade Oval. The overflow was due to sand, bricks and mud blocking the outlet to a regulator. This was the result of a contractor from the City of Cleveland excavating and replacing a collapsed pipe. The contractor over-pumped the broken sewer, causing the blockage. Whether this discharge negatively impacted the downstream macroinvertebrate community during the colonization period is unknown.

At all sites (except for RM 0.75, in which there was no HD retrieval in 2008), there was a higher density of organisms collected in 2009 compared to

2008 (Table 13). This may be explained by the use of the revised HD anchoring and retrieval techniques or more macroinvertebrates inhabiting the site since 2008.

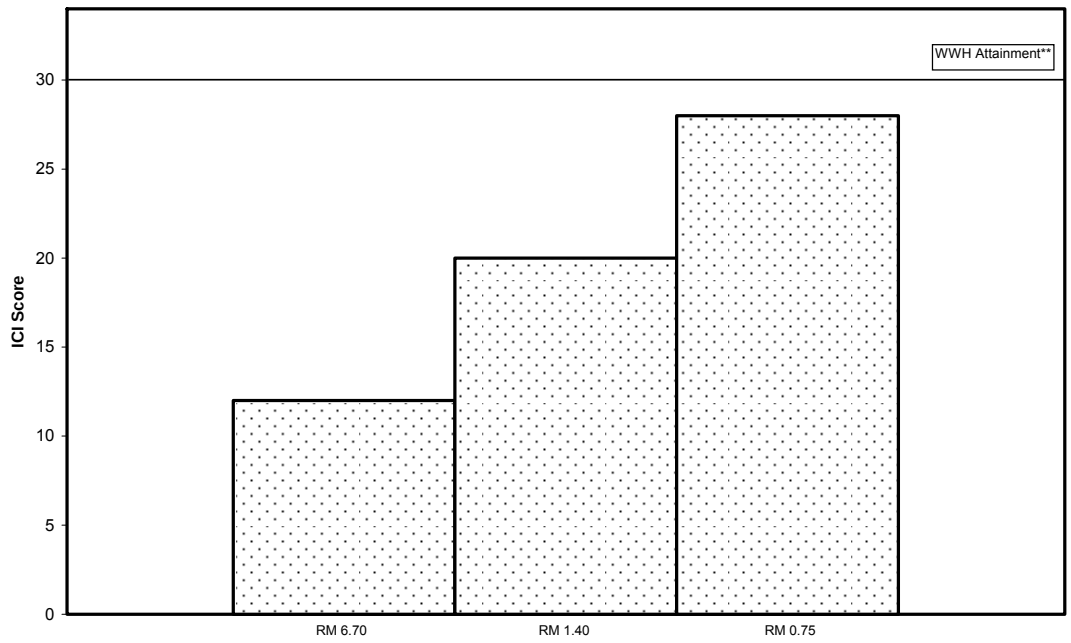
Table 13. Doan Brook 2008 & 2009 Total Number of Organisms on HD

River Mile	2008 (organisms)	2009 (organisms)	% Difference
6.70	1330	3150	81.25%
1.40	685*	1303	62.17%
0.75	--	4863	--

*Average number
--HD not recovered; no ICI score

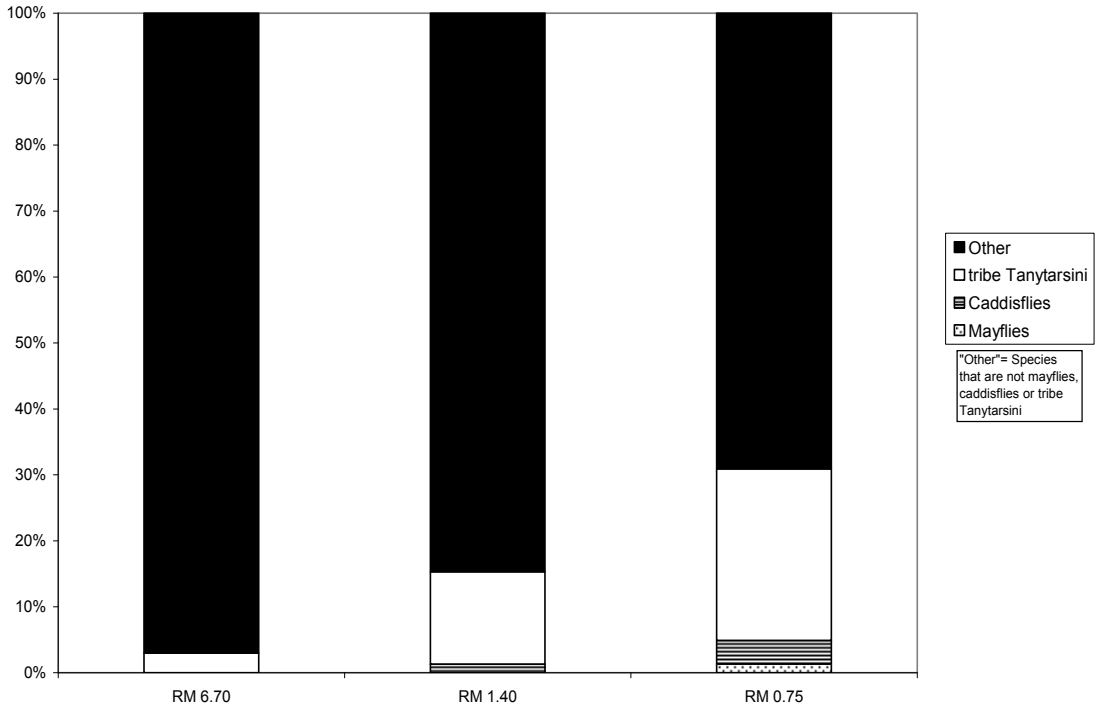
It appears that ICI trends within the last decade have not shown a significant positive trend in Doan Brook (Figure 8). Doan Brook RM 6.70 ICI scores show a negative trend over time. This likely indicates the persistent presence of a stressor or the accumulation of more stressors at this site. Doan Brook RM 0.75 has also shown a negative trend since sampling at this site began in 1999. However, the same ICI score (28) was obtained in 2006, 2007 and 2009 (HD not recovered in 2008), possibly indicating a stabilization of the stream at this site. Additionally, RM 0.75 has nearly always had higher ICI scores than the two upstream sites, potentially signifying little impact from upstream CSOs. The upstream sites may be exposed to other types of stressors that RM 0.75 is not. RM 1.40 was the only site on Doan Brook to show a positive trend of ICI scores since 2002. It is unknown why RM 1.40 has shown overall improvement while the other sites have not.

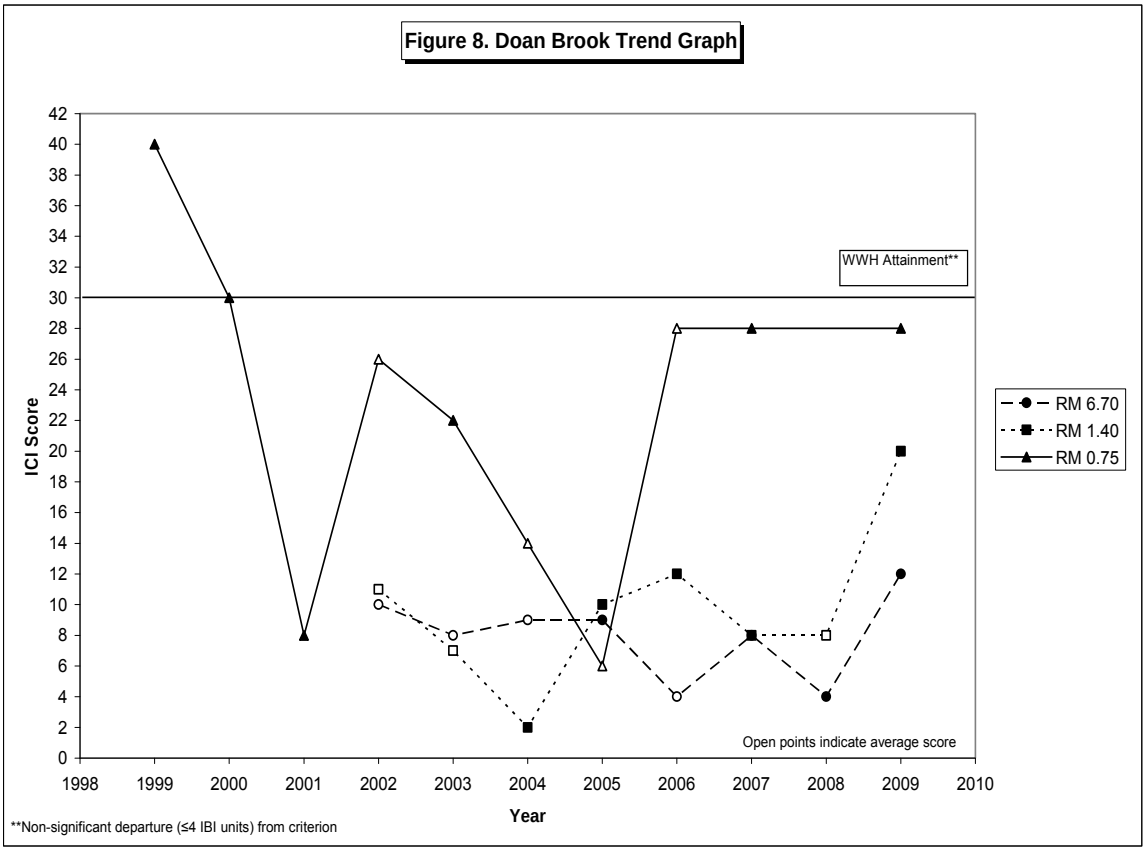
Figure 6. Doan Brook 2009 ICI Scores



**Non-significant departure (≤4 ICI units) from criterion

Figure 7. Doan Brook 2009 HD Percent Composition





Conclusions

All three Doan Brook sites were in non-attainment of the WWH biocriteria in 2009. The IBI and ICI scores for RM 0.75 were higher than at the two upstream sites. This indicates that there may be minimal impact from upstream CSOs at the downstream site on Doan Brook. However, the poor biological scores and good QHEI scores indicate ongoing water quality issues on Doan Brook, evident from historical ICI scores. Other factors, such as runoff, pollutants, point and non-point sources, low flow velocities, SSOs and physical habitat limitations, including the effect of lakes in the area, may have contributed to the Doan Brook sites not achieving attainment. Further monitoring of Doan Brook is necessary to more accurately assess the variables involved.

Euclid Creek

Water Chemistry

All samples were in attainment of the applicable criteria of the Ohio Water Quality Standards, Ohio *Administrative Code* 3745-1-07 (2009b).

Habitat Assessment

Euclid Creek RM 2.70, upstream of Highland Road, obtained a QHEI score of 61.5 (*Good*), meeting the Ohio EPA's target score. This site is comprised mainly of bedrock with sparse instream cover consisting of shallows, boulders, and backwaters. Riparian width was wide to moderate and bank erosion along the site was moderate. The surrounding area is a park setting. This site scored *Fair* in 2008 due to low channel stability and riffle, run and pool depths that were less than in 2009 (Table 14).

Table 14. 2008 & 2009 Euclid Creek Qualitative Habitat Evaluation Index Scores

	QHEI Score			
River Mile	2008 Score	2008 Narrative Rating	2009 Score	2009 Narrative Rating
2.70	58.5	Fair	61.5*	Good
1.65	67.0*	Good	75.0*	Excellent
0.55	68.0*	Good	67.5*	Good

*Site met Ohio EPA QHEI WWH target score (≥60)

Euclid Creek RM 1.65, upstream of St. Clair Avenue, scored a 75.0 (*Excellent*) for the QHEI, meeting the Ohio EPA's target for WWH streams. The best substrate type was cobble and gravel. Instream cover was moderate to sparse consisting of undercut banks, overhanging vegetation, shallows, rootmats, deep pools, boulders, backwaters and woody debris. A narrow to very narrow riparian width with moderate bank erosion were observed. In 2008, this site scored *Good* due to less instream cover (Table 14).

Euclid Creek RM 0.55, downstream of Lakeshore Boulevard, received a QHEI score of 67.5 (*Good*). Cobble and sand were the best substrate types. There was moderate to sparse instream cover with undercut banks, overhanging vegetation, deep pools, rootwads, boulders and woody debris. A very narrow riparian width was present, but there was very little bank erosion. The surrounding area is in a park and urban industrial setting. In 2008, the site received the same rating and both years met the Ohio EPA's target for WWH streams (Table 14).

Electrofishing

Euclid Creek RM 2.70, a wading site, obtained an IBI narrative rating of *Poor*. With an IBI score of 26 (Figure 9), 57.74% of the fish were highly pollution-tolerant species, with the rest of the catch consisting of central stoneroller minnows (42.26%), which are intermediately pollution-tolerant. The highest scoring metrics were the proportion of omnivores, number of individuals and proportion of DELT anomalies. The MIwb score was 6.9 with a narrative rating of *Fair*, thus this site was in non-attainment of the WWH biocriterion. In 2008, this site obtained a similar average IBI score (Table 15) and nearly the same percentages of highly pollution-tolerant species and central stoneroller minnows collected. Although the QHEI at this site scored *Good* and had suitable fish habitat, it appears that there may be negative water quality impacts, such as urban and stormwater runoff, and the site's close proximity to a major roadway that may have a negative effect on the fish community. Additionally, the low IBI score may be due to a dam located downstream at East 185th Street, south of Interstate 90. This dam appears to be acting as migration barrier, inhibiting fish movement.

Table 15. Euclid Creek 2008 & 2009 IBI & MIwb Scores

		IBI Scores & Narrative Ratings				MIwb Scores & Narrative Ratings			
River Mile	Type	2008 Score	2008 Narrative Rating	2009 Score	2009 Narrative Rating	2008 Score	2008 Narrative Rating	2009 Score	2009 Narrative Rating
2.70	Wading	26[a]	Poor	26	Poor	6.6[a]	Fair	6.9	Fair
1.65	Wading	23[a]	Poor	24	Poor	6.2[a]	Fair	6.2	Fair
0.55	Wading	28[a]	Fair	28	Fair	7.4[a]	Marginally Good	6.9	Fair

[a]Average score

Euclid Creek RM 1.65, a wading site, had an IBI score in the *Poor* range and an MIwb narrative rating of *Fair* (Figure 9). Similar to Euclid Creek RM 2.70, this site consisted only of highly pollution-tolerant species (59.17%) and central stoneroller minnows (40.83%). Similar to RM 2.70, the dam located downstream of the sampling site may be impeding fish migration upstream to the sampling site. Similar average IBI and MIwb scores were obtained in 2008 (Table 15), and both years the site failed to meet attainment of the WWH biocriterion.

The QHEI narrative rating at RM 1.65 was *Excellent*. However, bank erosion was moderate and the riparian width was narrow to very narrow. These factors may allow pollutants in stormwater and urban runoff to enter the creek, contributing to the poor IBI score.

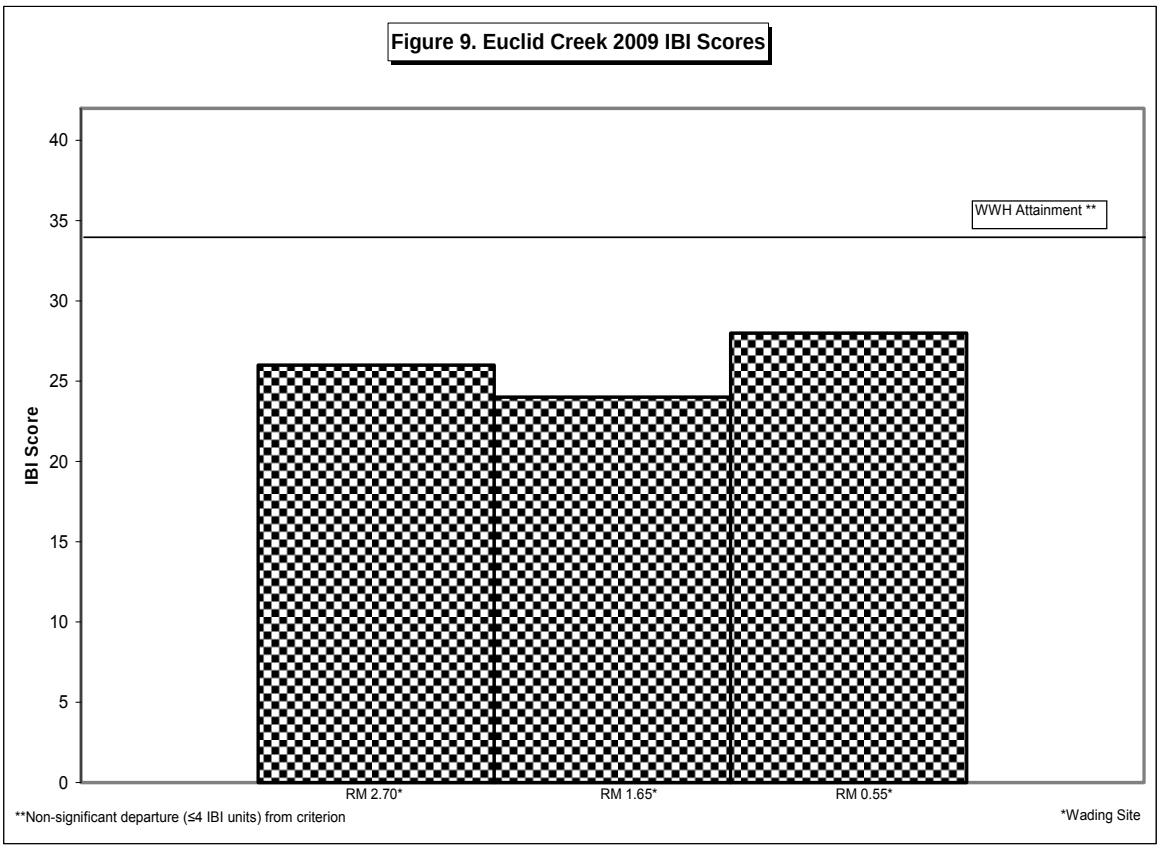
Euclid Creek RM 0.55, a wading site, had an IBI score of 28 (*Fair*) (Figure 5) and an MIwb score of 6.9 (*Fair*). Fish collected at this site included the sand shiner, smallmouth bass and northern logperch darter, which are all moderately intolerant species (1.02%), plus five species of intermediate tolerance (18.56%). However, the rest of the species caught were highly to moderately pollution tolerant (78.86%), with the exception of the mimic shiner (1.57%).

The mimic shiner, which is designated a common intolerant species, is found in streams of highest quality (OEPA, 1987a & 1987b). It is designated an Exceptional Warmwater Habitat (EWH) species and the collection of this fish reveals exceptional biotic integrity (OEPA, 1998). However, it may be the site's close proximity to Lake Erie which allows the mimic shiner to migrate up to the sampling site.

Additionally, the site scored well in the number of native species, number of sunfish species, proportion of simple lithophils and the proportion of DELT anomalies. However, the remaining seven metrics each scored a one (lowest possible score), which contributed to the low IBI score and non-attainment of the WWH biocriterion. In 2008, this site received a similar average IBI score, with an MIwb score of 7.4 (*Marginally Good*) (Table 15).

The QHEI at Euclid Creek RM 0.55 received a narrative rating of *Good*, but the unstable riffle and run substrate and poor channel morphology may have made the habitat undesirable for some warmwater fish, such as sand shiners, darters and hogsuckers. Additionally, upstream CSOs, SSOs, storm sewer discharges and illicit discharges may be having an impact on the water quality which, in turn, may be negatively affecting the fish community.

Investigations by WQIS personnel on Euclid Creek in 2005, 2006 and 2007 revealed at least six storm sewer outfalls between RM 0.55 and RM 2.70 which had continuously elevated levels of *Escherichia coli* entering the creek during dry weather. Euclid Creek RM 0.55 has also been sampled daily for *E. coli* as part of the NEORSD Beach Study in 2006 and from 2008 to 2009. *E. coli* results from those studies have consistently shown elevated bacteriological contamination. In addition, there were nine wet weather overflows from CSO 239, located at Lakeshore Boulevard at Euclid Creek, during the study period. These dry and wet weather flows, as well as documented cross-connections in the area, suggest that contamination by sewage, usually accompanied by other pollutants, may be preventing a healthy fish and macroinvertebrate community at this site on Euclid Creek.



Macroinvertebrate Sampling

Euclid Creek RM 2.70 received an ICI score of 36 (*Good*), indicating attainment of the WWH ICI aquatic life use criterion (Figure 10). The sample consisted of 21% mayflies and 32% caddisflies, which are positive water quality indicators (Figure 11). Moreover, only 1.6% of the sample was composed of pollution-tolerant organisms. In 2008, RM 2.70 had an average ICI score of 28 (*Fair*) (Table 16). The lower ICI score in 2008 may be due to the higher percentage of non-insect species, such as flatworms, scuds and isopods, which negatively affect the ICI score. Additionally, there was a higher percentage of tolerant organisms observed in 2008. A healthier macroinvertebrate community was evident in 2009, especially with the increase in the total number of organisms collected from 2008 (Table 17).

Table 16. 2008 & 2009 Euclid Creek ICI Scores				
	ICI Scores & Narrative Ratings			
River Mile	**2008 Score**	**2008 Narrative Rating**	**2009 Score**	**2009 Narrative Rating**
2.70	28[a]	Good	36[b]	Good
1.65	26[a]	Poor	38[b]	Good
0.55	12[a]	Fair	24	Fair

[a]Average score
[b]WWH ICI attainment

In 2009, Euclid Creek RM 1.65 obtained an ICI score of 38 (Figure 10). This site was in attainment of the WWH ICI criterion. Similar to RM 2.70, there were a large percentage of mayflies and caddisflies in the sample (17% and 40%, respectively) (Figure 11). Also, only 3.8% of the sample was composed of pollution-tolerant species, giving that metric the highest possible score of six. In 2008, the average ICI score was 26 (*Fair*). This site's ICI score improved greatly from 2008 (Table 16) and may be the result of improved HD anchoring and retrieval techniques, or better water quality, which may have resulted in a higher number of organisms in 2009.

Table 17. Euclid Creek 2008 & 2009 Total Number of Organisms on HD			
River Mile	**2008 (organisms)**	**2009 (organisms)**	**% Difference**
2.70	743*	3015	120.92%
1.65	1067*	1493	33.28%
0.55	846*	3209	116.55%

*Average number

In 2009, Euclid Creek RM 0.55 obtained an ICI score of 24 (*Fair*) (Figure 10). During the HD installation, dry-weather flow on Euclid Creek was instantaneously measured at -0.08 fps, which is less than the minimum flow of 0.3 fps recommended by the Ohio EPA for good colonization. This negative flow is likely due to northerly winds on Lake Erie that cause water in Euclid Creek to reverse and flow in an upstream direction. During HD retrieval, flow was measured at 0.16 fps, indicating that during the colonization period, flow was extremely variable. Additionally, this site lacks a functional riffle and contains poor quality margins. The lack of a functional riffle is evident in the percent compositions of mayflies and caddisflies which were 0.0 and 0.7, respectively (Figure 11). However, the total number of organisms has increased since 2008 (Table 17).

ICI scores on Euclid Creek RMs 2.70 and 1.65 have shown a positive trend since sampling began (Figure 12). These upstream sites have consistently shown higher ICI scores than the downstream site. Historically, the ICI scores at RM 0.55 have shown non-attainment of the WWH biocriterion with 2008 receiving an ICI score of 12 (*Poor*), which is the third lowest score this section of stream has ever received (Table 16). The lack of a functional riffle, variable stream flow and bacteriological contamination due to overflows and/or dry weather discharges to the creek may be plaguing the macroinvertebrate community. Since sampling began in 1999 at RM 0.55, there has been a slight positive trend of ICI scores, however, this trend is very weak (Figure 12).

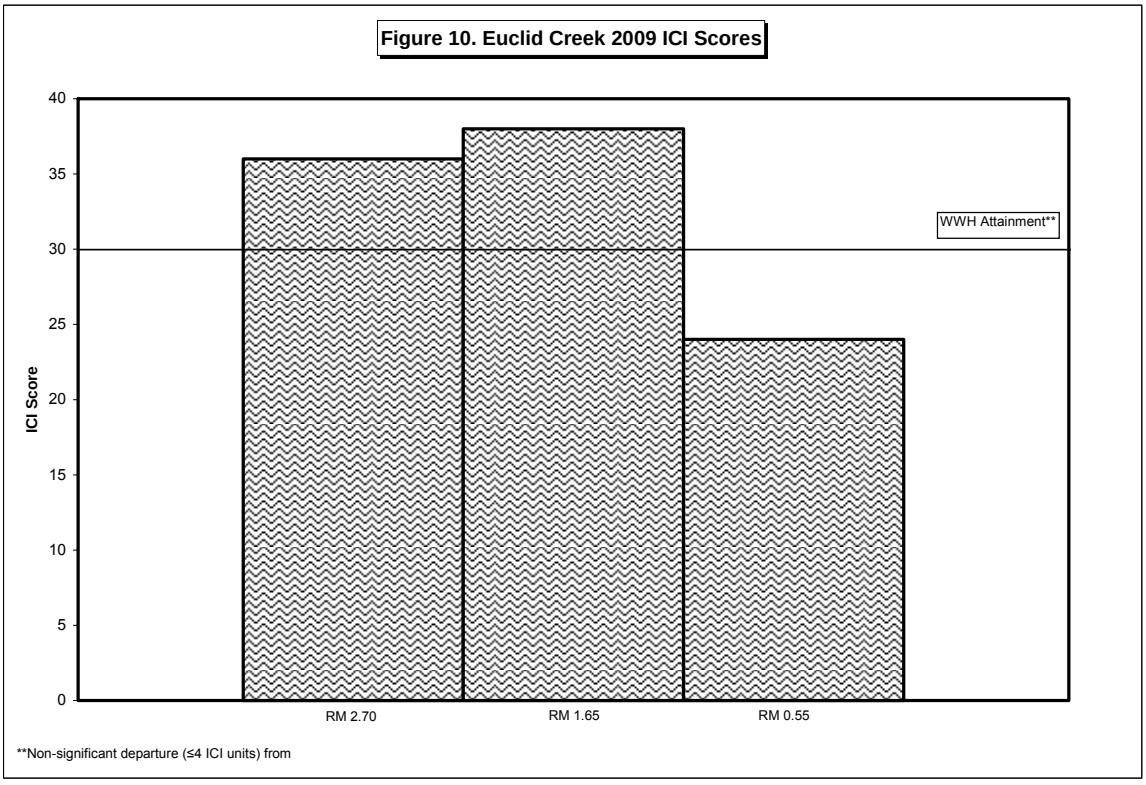


Figure 11. Euclid Creek 2009 HD Percent Composition

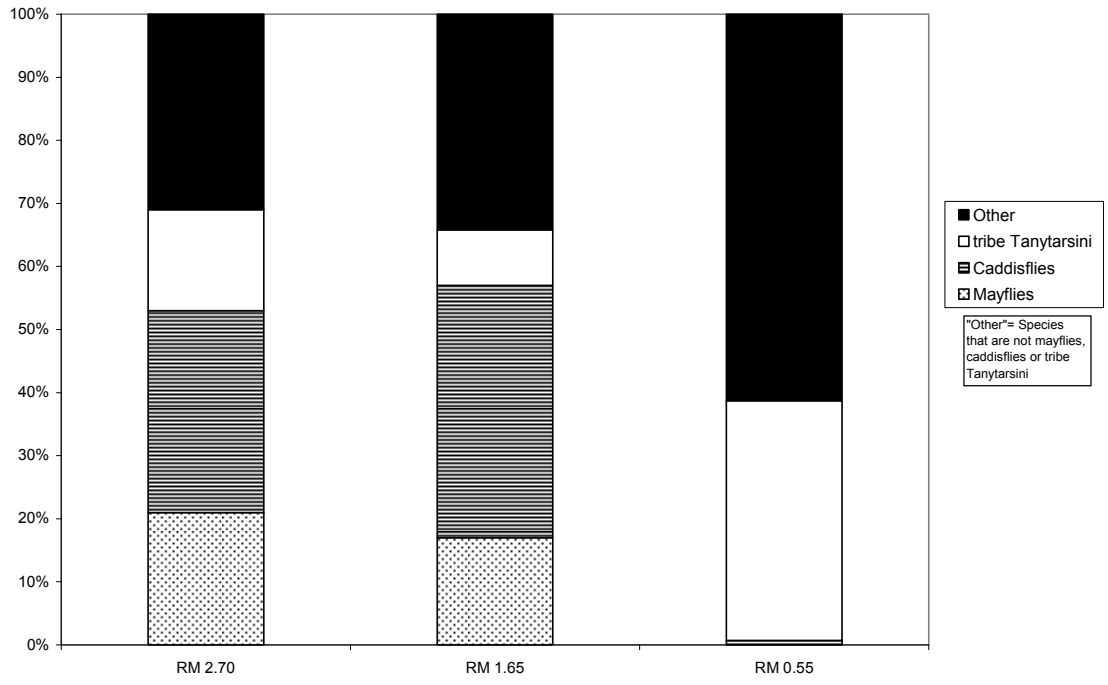
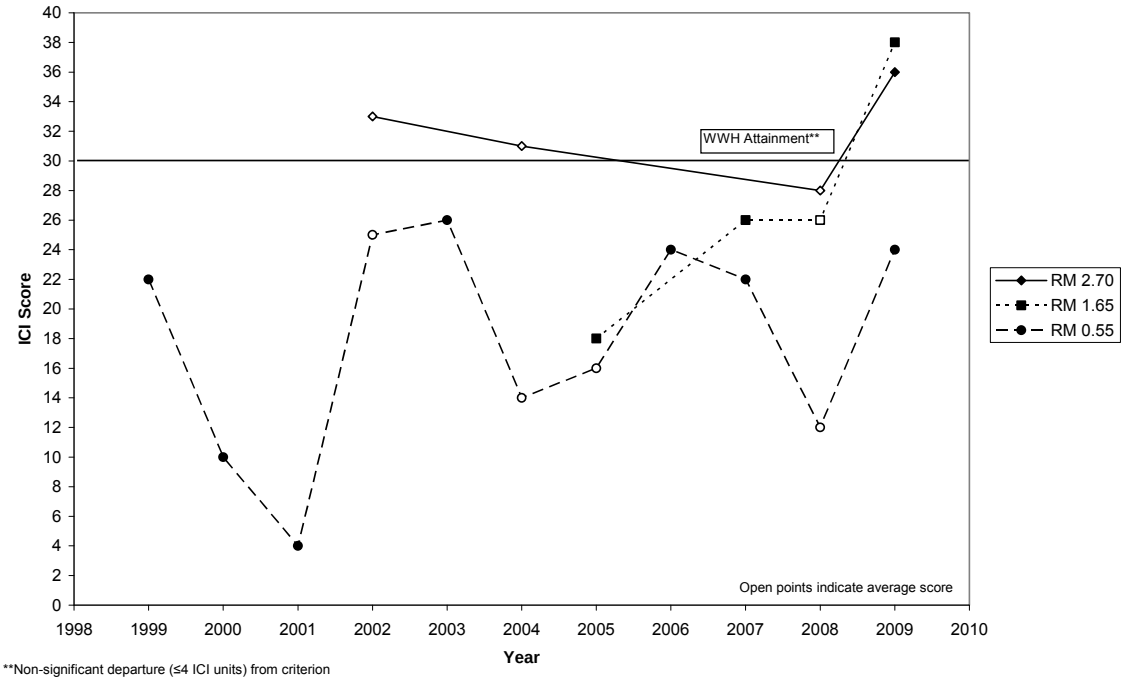


Figure 12. Euclid Creek Trend Graph



Conclusions

In 2009, the two upstream Euclid Creek sites were in partial attainment, while the downstream site was in non-attainment of the WWH biocriteria. RMs 2.70 and 1.65 met the ICI criterion, but not the IBI/MIwb criteria. A dam located upstream of RM 0.55 and downstream of RM 1.65 may be impeding fish movement, therefore negatively affecting the fish community at RMs 1.65 and 2.70. The QHEI at RM 2.70 had a narrative score of *Good*; however, the IBI score is not reflective of the good QHEI and ICI scores due to the large dam. A similar situation is evident at RM 1.65, where the QHEI and ICI scored well, but the IBI and MIwb scores were poor. Again, this is most likely due to the downstream dam.

Although RMs 2.70 and 1.65 failed to meet the WWH biocriteria for fish, they did meet ICI WWH criterion. Physical habitat characteristics were conducive to good macroinvertebrate colonization, leading to better ICI scores.

The downstream site at RM 0.55 did not achieve WWH attainment in 2009; however, the IBI score was the highest of the three sites. This indicates that upstream CSOs may be having an impact on water quality downstream on Euclid Creek. However, other factors such as combined and storm sewer outfalls, SSOs, urban runoff, bacteriological contamination, low flow velocity, septic systems and poor physical habitat characteristics may also play a role. Further sampling of these sites is necessary to accurately evaluate the issues affecting water quality on Euclid Creek.

Mill Creek

Water Chemistry

All ten samples collected during five weeks of sampling were in attainment of the applicable criteria of the Ohio Water Quality Standards, Ohio *Administrative Code* 3745-1-07 (2009b).

Habitat Assessment

Mill Creek RM 8.30 received a QHEI score of 68.5 (*Good*). The habitat zone begins approximately 500 feet upstream of the South Miles Road Bridge. Gravel and sand were the best substrate types. Moderate instream cover consisted of undercut banks, shallows, rootmats, deep pools, rootwads, boulders and woody debris. Channel development was good to fair with moderate stability. There was little to no bank erosion, but very narrow to no riparian width. This site is located in an industrial and construction setting. In 2008, this site scored a narrative rating of *Excellent*. The best substrate type in 2008 was boulder and sand with a more stable riffle and run substrate of cobble and boulder. In 2009, the type of substrate shifted to less desirable conditions, possibly due to natural evolution of the stream. The creek may be going through a substrate evolution until conditions become desirable. In 2009, there was the introduction of silt and garbage, which have not been seen in the last two years. This shift may account for the decreased score; however, both years scored well enough to meet the Ohio EPA's target for WWH (Table 18).

Table 18. 2008 & 2009 Mill Creek Qualitative Habitat Evaluation Index Scores

	QHEI Score			
River Mile	2008 Score	2008 Narrative Rating	2009 Score	2009 Narrative Rating
8.30	73.00*	Excellent	68.50*	Good
0.12	68.75*	Good	79.50*	Excellent

*Site met Ohio EPA QHEI WWH target score (≥60)

Mill Creek RM 0.12, located on the main stem approximately 600 feet upstream of the confluence with the Cuyahoga River, obtained a QHEI score of 79.50 (*Excellent*). The best substrate type was cobble and sand, and the site was located within an old field and park setting. Instream cover was moderate to sparse with undercut banks, overhanging vegetation, shallows, deep pools, rootwads, boulders, backwaters and woody debris. Channel sinuosity was moderate with excellent to good development. There was little to no bank erosion, but a narrow to very narrow riparian width. Riffle and run substrate was stable to moderately stable. This QHEI score with its associated characteristics is

indicative of an EWH (>75) and may be able to support an EWH fish community. In 2008, this site obtained a rating of *Good* (Table 18); however, improved channel morphology and more instream cover could explain the better QHEI score in 2009.

Electrofishing

Mill Creek RM 8.30 received an IBI score in the *Poor* range (Figure 13). All fish collected were highly pollution-tolerant species, consisting of western blacknose dace, creek chub, northern fathead minnow and green sunfish. The highest scoring metrics were Proportion of Omnivores and Proportion of DELT Anomalies. This site received a similar IBI score in 2008 and did not attain the WWH IBI criterion in either year (Table 19). The QHEI score was *Good*; however, the site is adjacent to a landfill and stormwater runoff from the landfill may be impeding higher fish community scores. Although water chemistry results for this site showed no identifiable exceedances, there is the potential for persistent pollutants to accumulate into the sediment of the stream and therefore not be detected in the water chemistry samples. In the future, sediment sampling may be necessary to confirm the presence of pollutants that would otherwise not be seen with regular water chemistry sampling.

Table 19. Mill Creek 2008 & 2009 IBI Scores

		IBI Scores & Narrative Ratings			
River Mile	**Type**	**2008 Score**	**2008 Narrative Rating**	**2009 Score**	**2009 Narrative Rating**
8.30	Headwater	20	Poor	22	Poor
0.12	Headwater	24	Poor	36 [b]	Marginally Good

[b]WWH IBI attainment

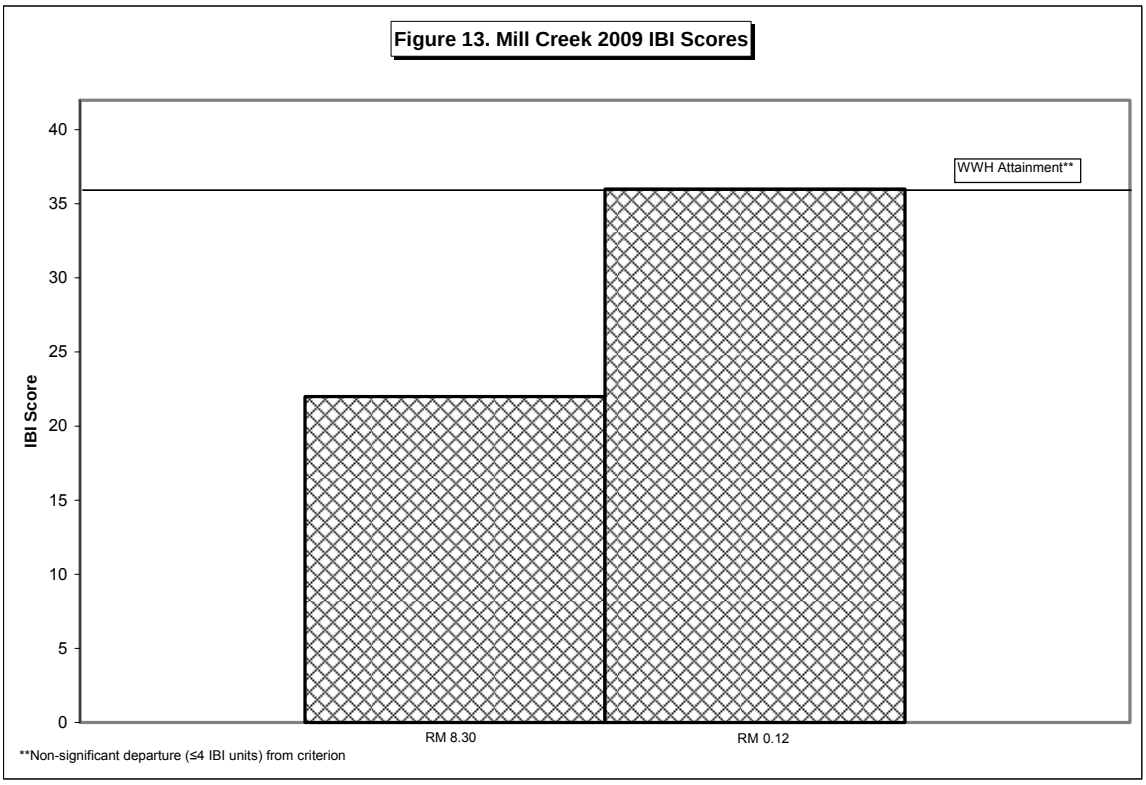
Mill Creek RM 0.12 obtained an IBI score of 36 (*Marginally Good*) (Figure 13). For the first time since monitoring began on Mill Creek, this site was within non-significant departure and in full attainment of the designated WWH aquatic life use criteria. There were three moderately intolerant, sensitive species collected, consisting of northern hog sucker, sand shiner, and greenside darter; however, no EWH fish species indicative of EWH were collected. In 2008, this site scored an IBI of 24 (*Poor*), with a larger proportion of highly pollution-tolerant species collected and an overall lower total number of fish caught (Table 19).

The collection of six greenside darters at RM 0.12 in 2009 is significant, since this species has only been collected at this site once before. In 2007, one greenside darter was collected. This species prefers large rocks and stones in wide

riffles with a fast current (Trautman, 1981). The QHEI indicates stable to moderately stable riffle and run substrate, consisting of cobble, boulder and large gravel with little embeddedness. Additionally, riffle width was greater than pool width and current velocity was fast to slow at this site. Thus, the QHEI supports the habitat preferences of the greenside darter.

The northern hog sucker is another pollution sensitive species that was collected at RM 0.12. Similar to the greenside darter, the northern hog sucker is typically found in stable, swift flowing riffles of clean sand, gravel and boulders (Trautman, 1981).

The significant increase in the IBI score and capture of more pollution sensitive fish species from 2008 to 2009 may be partly attributable to control measures (i.e., the Mill Creek Tunnel) in place to minimize CSO discharges to the Mill Creek drainage area. The Mill Creek Tunnel was built to capture wet weather discharges from CSOs and is expected to be fully completed in 2011. Additionally, the historic NEORSD illicit discharge detection and elimination efforts are likely contributory to the ongoing improvement at this site.



Macroinvertebrate Sampling

Mill Creek RM 8.30 received an ICI score of 24 (*Fair*) in 2009 (Figure 14). The best scoring metric was the percent caddisflies (3.6% of the sample), with the majority of the sample composed of other dipterans, mainly midges (Figure 15). This site did not show a large improvement from 2008 (Table 20), when the average ICI score was 21 (*Fair*). It appears that the macroinvertebrate community has stabilized in the past two years. However, the scores are an improvement from 2007 when the ICI score was 14. The total number of organisms from 2008 to 2009 decreased (Table 21); however the total taxa richness is similar. Therefore, the diversity of organisms has not changed from 2008. The 2009 sampling location was moved approximately 100 feet upstream of the 2008 sampling site due to undesirable flow conditions. However, this change of the sampling site may account for the decreased number of organisms seen in 2009, due to differences in habitat between the two locations.

Table 20. 2008 & 2009 Mill Creek ICI Scores

	ICI Scores & Narrative Ratings			
River Mile	**2008 Score**	**2008 Narrative Rating**	**2009 Score**	**2009 Narrative Rating**
8.30	21[a]	Fair	24	Fair
0.12	31[a,b]	Marginally Good	34[b]	Good

[a]Average score
[b]WWH ICI attainment

In 2009, Mill Creek RM 0.12 samplers had to be reinstalled one week into the deployment period because the HD had become buried by sediment due to heavy rainfall (a total of 1.12 inches over four days). The Mill Creek site obtained an ICI score of 34 (Figure 14), indicating WWH ICI attainment, and was within non-significant departure in 2008 (Table 20). The majority of the sample was composed of tribe tanytarsini, which is a metric that positively contributes to the ICI score (Figure 15).

As with the fish at this site, the Mill Creek Tunnel and the historic NEORSD illicit discharge detection and elimination efforts may be factors in the healthier macroinvertebrate community. There was an increase in the total number of organisms collected in 2009 (Table 21), similar to the other CSO sites. There were also no reported dry weather overflows into Mill Creek during the colonization period.

Table 21. Mill Creek 2008 & 2009 Total Number of Organisms on HD			
River Mile	**2008 (organisms)**	**2009 (organisms)**	**% Difference**
8.30	3182*	2486	-24.56%
0.12	440*	2632	142.71%

*Average number

Historical data shows a positive ICI trend for both sites on Mill Creek (Figure 16). This indicates that ICI scores have improved, especially since the early 2000s, possibly due to control measures on the creek. Mill Creek RM 0.12 has also consistently shown higher ICI scores compared to RM 8.30. Therefore, it appears CSO impact on the downstream site is minimal, if any.

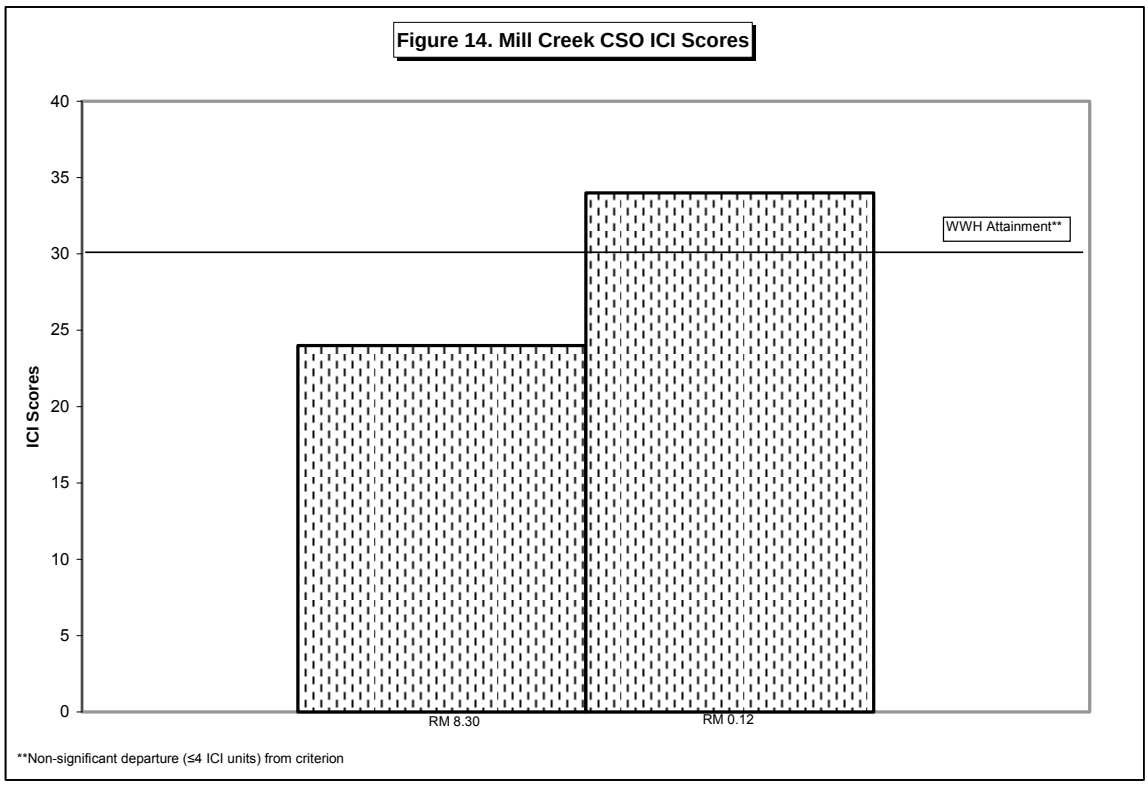


Figure 15. Mill Creek 2009 HD Percent Composition

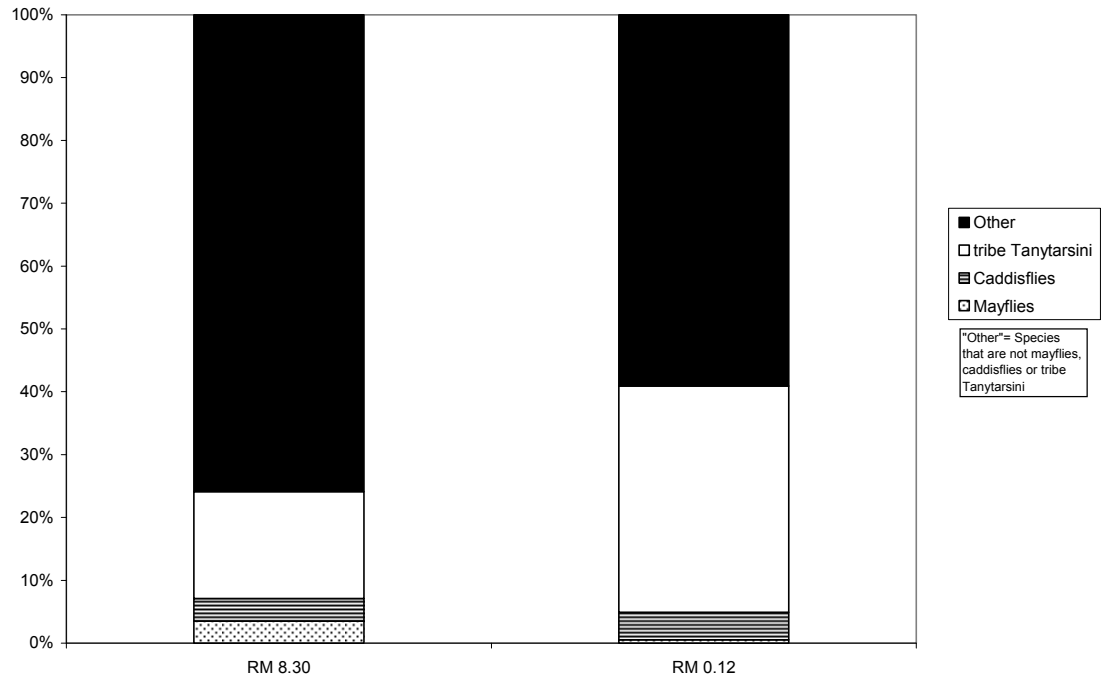
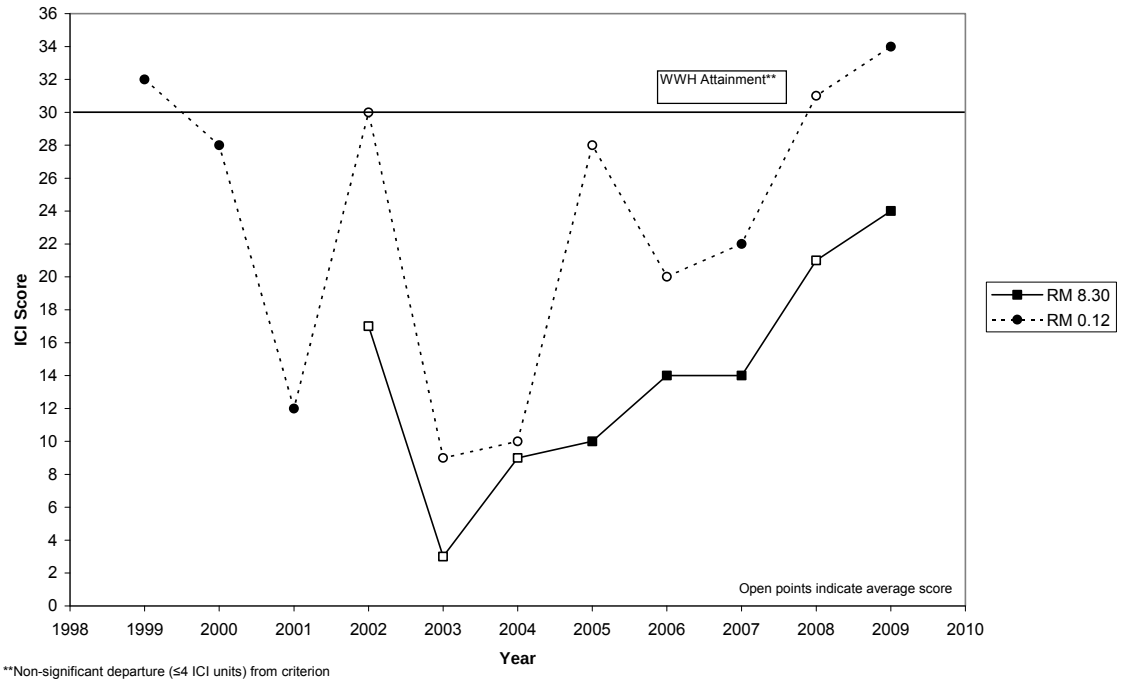


Figure 16. Mill Creek Trend Graph



**Non-significant departure (≤4 ICI units) from criterion

Conclusions

Mill Creek RM 8.30 was in non-attainment of the WWH biocriteria in 2009, having poor and fair IBI and ICI scores, respectively, but a good QHEI score. However, the downstream site at RM 0.12 was in full attainment of the WWH aquatic life use criteria. The Mill Creek Tunnel and historic efforts associated with the NEORSD illicit discharge detection and elimination may have helped this site reach full attainment. Monitoring should continue on Mill Creek to see if a positive trend continues to develop at Mill Creek RM 0.12, related to the Mill Creek Tunnel and further recovery of the macroinvertebrate community.

Overall Conclusions

Generally speaking, it is difficult to definitively state that any of the streams are improving or declining. Historical biological trends must be assessed to get a better understanding of the condition of each stream. For some sites, such as Doan Brook RMs 6.70 and 0.75, the ICI score has shown a negative trend over the years, while all the other stream sites have been improving. For others, such as Big Creek RM 0.15, Euclid Creek RM 1.65 and Mill Creek RM 8.30, it is the IBI scores that are showing a decreasing pattern since 2007. This indicates variability, not only among streams, but also among sampling sites on the same stream. Although some habitat and biological scores appear to be progressing from year to year, there is still much improvement that needs to be made.

There are several NEORSD CSO Long-Term Control Plan projects that are under construction to reduce CSOs. Projects such as the Euclid Creek Storage Tunnel and Mill Creek Tunnel will reduce the number of overflows to the streams, as well as provide wet weather flow relief in the existing collection system. It is anticipated that after the completion of these projects, the local receiving streams will begin to show signs of improvement or continue to improve, as is the case with Mill Creek.

Overall, it is difficult to attribute the non-attainment of water quality and biological criteria to a particular source. Multiple factors are involved that may affect water quality, QHEI, IBI and ICI scores and all factors must be considered when making conclusions as to the source of the problem. The fact that most of the sites, both upstream and downstream of CSOs, are exhibiting biological scores that do not meet attainment, indicate that there are negative impacts occurring such as stormwater and urban runoff, CSOs, SSOs, physical habitat limitations, and point and non-point sources.

According to the *2004 National Water Quality Inventory: Report to Congress*, sources of impairment include urban runoff, habitat alterations, atmospheric deposition, natural sources (i.e., wildlife and floods), and unspecified nonpoint and unknown sources (USEPA, 2009). Of importance to the Greater Cleveland area streams is urban runoff/stormwater which was ranked as a leading cause of water quality impairment in rivers of the United States (USEPA, 2009). According to the United States Environmental Protection Agency (USEPA) (2005), urban runoff causes problems in our streams such as "changes in flow, increased sedimentation, higher water temperature, lower dissolved oxygen, degradation of aquatic habitat structure, loss of fish and other aquatic populations and decreased water quality due to increased levels of nutrients, metals, hydrocarbons, bacteria and other constituents" (p. 0-1).

Even though some sites were in partial or full attainment of the WWH aquatic life use criteria, all of the streams still require continued monitoring to better characterize and isolate the issues that may be negatively impacting these streams.

References

Barbour M.T., Gerritsen J., Snyder B.D., & Stribling J.B. (1999). Rapid Bioassessment Protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. *Second Edition. Rep. EPA/841-B-99–002*, USEPA, Office of Water, Washington, DC.

Bosanko, D. (2008). *Fish of Ohio field guide*. Cambridge, MN: Adventure Publications, Inc.

DeShon, J.E. (1995). Development and Application of the Invertebrate Community Index (ICI). In: Davis and Simon, editors. Biological assessment and criteria, tools for water resource planning and decision making. Boca Raton, FL: Lewis Publishers; 1995. p 217-43.

Karr, J.R. (1981). Assessment of biotic integrity using fish communities. *Fisheries, 6*, 21-27.

Northeast Ohio Regional Sewer District. (2009). Northeast Ohio Regional Sewer District Wastewater Treatment Plant National Pollutant Discharge Elimination System Permits, Community Discharge Program Status Report. Cleveland, Ohio.

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

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

Ohio Environmental Protection Agency (OEPA). (1997). Ohio Environmental Protection Agency Authorization to Discharge under the National Pollutant Discharge Elimination System. Permit No. 3PA00002*FD, Part II Section F, for the Northeast Ohio Regional Sewer District, Cleveland, Ohio.

Ohio Environmental Protection Agency (OEPA). (1998). Voluntary Action Program, Biocriteria Training Manual, Fish Sampling Methods. Columbus, Ohio: Division of Surface Water and Emergency and Remedial Action.

Ohio Environmental Protection Agency (OEPA). (1999). Biological and Water Quality Study of the Cuyahoga River and Selected Tributaries Volume 1. Columbus, Ohio: Division of Surface Water. Ohio EPA Technical Report MAS/1997-12-4.

Ohio Environmental Protection Agency (OEPA). (2006). *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI).* Columbus, Ohio: Division of Surface Water; Division of Ecological Assessment Section. Ohio EPA Technical Bulletin EAS/2006-06-1.

Ohio Environmental Protection Agency (OEPA). (2009a). *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices.* Columbus, Ohio: Division of Surface Water.

Ohio Environmental Protection Agency (OEPA). (2009b). State of Ohio Water Quality Standards *Ohio Administrative Code* Chapter 3745-1. Revision: Adopted July 9, 2009; Effective October 9, 2009. Columbus, Ohio: Division of Surface Water, Standards and Technical Support Section.

Olive, J.H. & B.P. Karn. (1980). Trophic assessment of ten publicly-owned northeastern Ohio lakes. *Ohio Journal of Science, 80*(5), 223-231.

Rankin, E. T. (1989). *The Qualitative Habitat Evaluation Index (QHEI): rationale, methods, and application*. Columbus, Ohio: Ohio EPA, Division of Surface Water. .

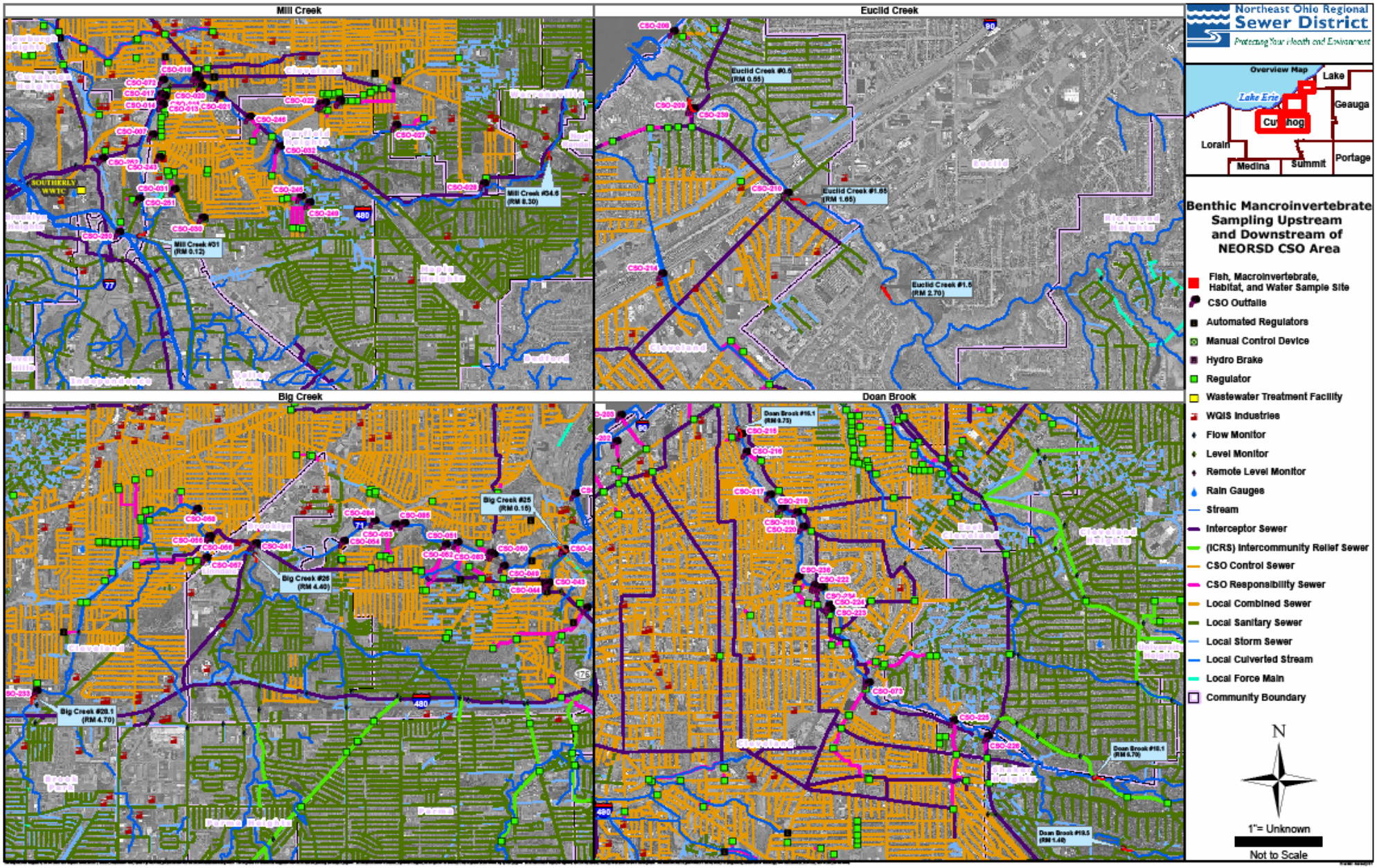
Stormwater Management Program, Stream System Manager: Monitoring. NEORSD, 22 July 2008. Web. Accessed 30 Jan. 2009. < http://www.neorsd.org/stormwater.php>.

Trautman, M.B. (1981). The fishes of Ohio. Columbus, OH: The Ohio State University Press in collaboration with the Ohio Sea Grant Program Center for Lake Erie Area Research.

U.S. Environmental Protection Agency (USEPA). (2005). National Management Measures to Control Nonpoint Source Pollution from Urban Areas. U.S. Environmental Protection Agency, Office of Water, Washington, DC. http://www.epa.gov/nps/urbanmm/pdf/urban_guidance.pdf. Accessed March 31, 2010.

U.S. Environmental Protection Agency (USEPA). (2009). *2004 National Water Quality Inventory: Report to Congress*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. http://www.epa.gov/owow/305b/2004report/report2004pt3.pdf. Accessed March 31, 2010.

Appendix A


Mill Creek
Euclid Creek
Big Creek
Doan Brook
Northeast Ohio Regional Sewer District
Protecting Your Health and Environment
Overview Map
Lake
Lake Erie
Geauga
Cuyahoga
Lorain
Medina
Summit
Portage
Benthic Mancroinvertebrate Sampling Upstream and Downstream of NEORSD CSO Area
Fish, Macroinvertebrate, Habitat, and Water Sample Site
CSO Outfalls
Automated Regulators
Manual Control Device
Hydro Brake
Regulator
Wastewater Treatment Facility
WQIS Industries
Flow Monitor
Level Monitor
Remote Level Monitor
Rain Gauges
Stream
Interceptor Sewer
(ICRS) Intercommunity Relief Sewer
CSO Control Sewer
CSO Responsibility Sewer
Local Combined Sewer
Local Sanitary Sewer
Local Storm Sewer
Local Culverted Stream
Local Force Main
Community Boundary
N
1"= Unknown
Not to Scale