

## 2007 Upstream of NEORSD CSO Areas Biological, Water Quality and Habitat Survey Results

### Introduction

During 2007, the Northeast Ohio Regional Sewer District<sup>1</sup> (NEORSD) conducted electrofishing, benthic macroinvertebrate and water chemistry sampling and habitat assessments on streams upstream from areas of Northeast Ohio Regional Sewer District (NEORSD)-owned combined sewer overflows (CSOs). The resulting upstream data were compared with the data obtained from these streams downstream of the NEORSD CSO areas in compliance with Ohio EPA NPDES Permit No. 3PA00002\*FD, to determine the extent to which downstream sites may be impacted by CSOs or other environmental factors. The downstream sampling is required on Big Creek, Mill Creek, Doan Brook, and Euclid Creek. Maps of the sampling locations are located in Appendix A, and Table 1 indicates the sampling site locations with respect to river mile (RM), description, latitude and longitude.

Table 1. Sample Site Locations				
Sites Downstream of NEORSD CSOs				
Stream	RM	Site Description	Latitude (°N)	Longitude (°W)
Big Creek	0.15	Downstream of Jennings Road	41.4460	81.6865
Mill Creek	0.12	Upstream of Canal Road	41.4178	81.6385
Doan Brook	0.75	Downstream of St. Clair Avenue	41.5330	81.6296
Euclid Creek	0.55	Downstream of Lake Shore Boulevard	41.5833	81.5594
Sites Upstream of NEORSD CSOs				
Big Creek	4.40	Cleveland Metroparks Memphis Picnic Area	41.4460	81.7540
Big Creek	4.70	Ford Branch Upstream of West 150 <sup>th</sup> Street	41.4230	81.8019
Mill Creek	8.30	Upstream of South Miles Road	41.4305	81.5442

<sup>1</sup> 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 (*2007 Benthic Macroinvertebrate Sampling Upstream of NEORSD CSO Areas*).

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Table 1. Sample Site Locations				
Sites Upstream of NEORSD CSOs				
Doan Brook	1.40	South Branch Upstream of Attleboro Road	41.4739	81.5590
Doan Brook	6.70	North Branch at Lee Road	41.4838	81.5643
Euclid Creek	1.65	Upstream of St. Clair Avenue	41.5738	81.5470
Euclid Creek	2.70	Upstream of Highland Road	41.5658	81.5358

### Water Chemistry Sampling

Water chemistry samples were collected from each site approximately every eight days during the macroinvertebrate colonization periods. The techniques that were used for the water chemistry sampling and chemical analyses followed the *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices* (2006). Field analyses included the use of a Marsh-McBirney FloMate Model 2000 Portable Flow Meter, which measures flow in feet per second, a YSI-556 MPS Multi-Parameter Water Quality Meter to measure dissolved oxygen, water temperature, specific conductivity and pH, and a Hanna HI 98129 meter to measure pH at the time of sampling. Three exceedances of applicable outside mixing zone maximum (OMZM) water quality criteria for the protection of aquatic life occurred in 2007 (Table 2), while no exceedances of 30-day outside mixing zone average water quality criteria for the protection of aquatic life occurred. The pH exceedance occurred following wet weather and may have been due to nonpoint sources of pollution. As the other two exceedances occurred during dry weather, it is uncertain what caused them. Raw data sheets for this sampling are available upon request.

Table 2. Water Quality Standards Exceedances				
Location	Date	Parameter	Analysis Result	Criterion
Euclid Creek RM 0.55	6/18/2007	Zinc	358 µg/L	224 µg/L
Mill Creek RM 0.12	6/18/2007	Zinc	371 µg/L	366 µg/L
Mill Creek RM 0.12	8/8/2007	pH	5.8 s.u.	6.5-9.0 s.u.

### Habitat Assessment

Qualitative Habitat Index Evaluations (QHEI) were conducted at each site in 2007. The QHEI, as described in Ohio EPA's, *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006) was used to assess aquatic habitat conditions at each sample location. While primarily used for electrofishing assessments, the QHEI measures the quality of substrate, instream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle/run quality and gradient. Three of the sites scored in the *Fair* range, while the rest were all *Good* (Table 3). Those with scores of at least 60 met Ohio EPA's target for WWH streams and are expected to be capable of meeting applicable biological criteria. QHEI sheets for each site are available upon request. Relevant habitat characteristics for each site are discussed within the electrofishing and macroinvertebrate results.

Site Location	Score	Rating
Big Creek RM 0.15	68.75	Good
Big Creek RM 4.40	60.75	Good
Big Creek RM 4.70	51.00	Fair
Mill Creek RM 0.12	63.00	Good
Mill Creek RM 8.30	65.00	Good
Doan Brook RM 0.75	57.00	Good
Doan Brook RM 6.70	57.50	Good
Doan Brook RM 1.40	50.75	Fair
Euclid Creek RM 0.55	65.75	Good
Euclid Creek RM 1.65	62.50	Good
Euclid Creek RM 2.70	50.50	Fair

## Electrofishing

### Methods

Electrofishing passes were conducted one time at each headwater site (drainage area < 20 square miles) and two times at each wading site (drainage area 20-500 square miles) in 2007. Sampling was conducted using longline electrofishing techniques and consisted of shocking all habitat types within a sampling zone, which was either 0.15 or 0.20 kilometers in length, while moving from downstream to upstream. The methods that were used followed Ohio Environmental Protection Agency protocol methods described in *Biological Criteria for the Protection of Aquatic Life, Volume III: Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities* (Updated September 30, 1989 and November 8, 2006). Fish were identified to species level, counted, and examined for the presence of external

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anomalies including deformities, erosions, lesions, and tumors (DELTS). The results from this sampling were used to calculate Index of Biotic Integrity (IBI) and, if applicable, Modified Index of Well-Being (MIwb) scores for each site.

**Results and Discussion**

Table 4 shows the IBI and, where applicable, MIwb scores that were calculated for each site. A list of the species, numbers, weights, pollution tolerances and incidence of DELT anomalies for fish collected during the electrofishing passes at each site is available upon request.

Stream	RM	Type	IBI Scores			MIwb Scores		
			Pass 1	Pass 2	Average	Pass 1	Pass 2	Average
Big Creek	0.15	Wading	28	28	28	5.1	5.3	5.2
Big Creek	4.40	Headwater	34	---	34	---	---	---
Big Creek	4.70	Headwater	16	---	16	---	---	---
Mill Creek	0.12	Headwater	32	---	32	---	---	---
Mill Creek	8.30	Headwater	22	---	22	---	---	---
Doan Brook	0.75	Headwater	26	---	26	---	---	---
Doan Brook	1.40	Headwater	24	---	24	---	---	---
Doan Brook	6.70	Headwater	24	---	24	---	---	---
Euclid Creek	0.55	Wading	26	28	27	7.0	7.7	7.4
Euclid Creek	1.65	Wading	24	26	25	4.6	5.7	5.2
Euclid Creek	2.70	Wading	24	26	25	4.2	6.0	5.1

**Big Creek Results and Discussion**

The site on Big Creek at RM 4.70 had an IBI score in the *Very Poor* range. Only three species were collected at this site and all were highly pollution tolerant. This site is designated as a Limited Resource Water and, therefore, no biocriteria apply. Although no water quality exceedances were found in 2007, past monitoring has indicated low dissolved oxygen concentrations during the summer when flow is low and temperatures are high. This, along with the lack of a functional riffle and only slow moving water in the electrofishing zone may have all contributed to the low IBI score that was received.

The highest IBI score received at any of the sites occurred at Big Creek RM 4.40 in Memphis Metropark. With an IBI score of 34, this site was close to being within non-significant departure of the headwater WWH criterion of 38. Metric scores of 5, the highest possible, were received for the number of individuals, and the proportion of

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DELTS, tolerant species, omnivores, and pioneering species. Habitat limitations at this site include low sinuosity and development as the result of concrete walls at the upstream end of the zone and the lack of any pools.

The downstream site on Big Creek at RM 0.15 is a wading site and, therefore, two electrofishing passes were conducted in 2007. The average IBI score was in the *Very Poor* range and the average MIwb was *Poor*. A low number of individuals was collected during both passes, with the most predominant species being the common white sucker, a highly pollution tolerant species. Habitat may be the controlling factor for the fish community at this site. Throughout most of the zone, there is no functional riparian zone with sparse instream cover. In addition, there is a large amount of sand in the middle section of the zone that is easily scoured during heavy rainfall events and has resulted in shifting habitat characteristics, low stability and low development.

### ***Mill Creek Results and Discussion***

The site upstream of NEORSD CSOs on Mill Creek (RM 8.30) scored in the *Poor* range for the IBI. The fish collected here were mostly creek chubs and western blacknose dace. Out of all the fish that were collected, only one (pumpkinseed sunfish) was not considered to be highly tolerant to pollution. The most likely reasons for the predominately pollution tolerant fish community at this location are upstream nonpoint sources of pollution, moderate erosion, no riparian zone and an adjacent landfill.

The downstream site (RM 0.12) scored better than the upstream site and was in the *Fair* range for the IBI. Twelve different species were collected at this location. Because of its proximity to Cuyahoga River, the community here may have been influenced by fish migrating up into the creek. The limiting habitat characteristics that may be preventing attainment of the biocriterion include sparse instream cover, moderate to extensive embeddedness, and no riparian zone.

### ***Doan Brook Results and Discussion***

The two upstream sites on Doan Brook both received the lowest possible IBI scores. At RM 6.70, only green sunfish and creek chubs, both highly pollution tolerant species, were collected. At the other upstream site, RM 1.40, only green sunfish were collected. Both sites lack riffles and have poor-fair development and generally slow moving water. They are also located upstream of lakes that could be impeding fish movement. All of these things may be contributing to the *Poor* IBI scores at these sites.

The downstream site (RM 0.75) scored better than the upstream ones and was in the *Fair* range. Six different species were collected at this site, all being either

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moderately tolerant or tolerant to pollution. The metrics that scored well at this site were the proportions of tolerant species, insectivores and pioneering species. The main limitations to a healthy fish population include channelization, poor development, and sparse instream cover. This site is also affected by sudden changes in flow following storm events.

### ***Euclid Creek Results and Discussion***

The two upstream locations on Euclid Creek (RM 2.70 and 1.65) had average IBI and MIwb scores in the *Poor* range. Both sites scored well in the proportion of omnivores and number of DELTs over the two electrofishing passes that were conducted. Habitat limitations include sparse instream cover for both sites and a shifting substrate over shale at the most upstream one.

The downstream site on Euclid Creek (RM 0.55) had an average IBI score in the *Fair* range. The average MIwb score, however, was in the *Marginally Good* range, which is non-significant departure from the WWH criterion. This site is therefore considered to be in partial attainment. Many of the fish collected at this site may be migrating up from Lake Erie, as supported by the collection of mimic shiners, a pollution intolerant species, during the second pass. Although this site had a QHEI score greater than Ohio EPA's target of 60, its lack of an adequate riparian zone, fair development and low stability may be influencing the fish community. In addition, investigations by Water Quality and Industrial Surveillance (WQIS) personnel on Euclid Creek in 2005, 2006 and 2007 revealed at least six storm sewer outfalls downstream of RM 2.70, but upstream of RM 0.55. These outfalls had continuously elevated levels of *Escherichia coli* (*E. coli*) entering the creek during dry weather and may be negatively impacting the fish community at this location and preventing it from reaching full attainment status.

## **Macroinvertebrate Sampling**

### **Methods**

The NEORSD conducted quantitative macroinvertebrate sampling by installing five modified Hester-Dendy (HD) artificial substrate samplers at locations downstream of all NEORSD-owned CSO areas, as well as locations on each stream that were determined to be upstream of all NEORSD-owned CSO areas. A composite sampler, consisting of five individual HD samplers, was anchored in the creek with a concrete block attached to a length of rebar. After allowing six weeks for macroinvertebrate colonization, the sampler was removed and a qualitative kick sample was conducted. Two six-week colonization periods occurred at each sampling site to account for seasonal variability. A total of five individual HD samplers were composited to create one representative

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sample. Ohio EPA Volunteer Monitoring Program Macroinvertebrate Field Sheets were completed at each site during sampler retrieval and are available upon request. Additionally, several of the macroinvertebrate sampling sites upstream of the CSOs are considered to be headwater habitats, as the drainage area of these sites is less than 20 square miles. As indicated in the *Surface and Ground Water Monitoring and Assessment Strategy 2005-2009* (Ohio EPA, 2005), the use of HD samplers in headwater habitats is questionable.

It should be noted that the formalin solution used to preserve the first colonization samplers for 2007 was found to be defective in that all of the samples had signs of being under-preserved (septic odor and off-gassing when the container was opened). This resulted in the decomposition of the majority of the macroinvertebrates collected, with the remaining organisms not a true representation of the original sample collected. However, individual organism identifications indicate genus/species that were present in the macroinvertebrate communities. The cause of the under-preservation has been attributed to using a 5-gallon carboy of 10% formalin solution, previously opened in 2006, whereby the integrity of the container may have been compromised. This would have facilitated evaporation/degradation of the formalin, resulting in a weakened strength of solution. As a result, to prevent under-preservation in the future, all macroinvertebrate samples will be preserved using a 100% formalin solution (37% formaldehyde) from a container appropriately sized to be completely used during one field season. The solution in the sample container will then be diluted to the approximate 10% formalin solution using water from the sample site. Any scores derived from the first colonization period, July/August 2007, are suspect due to under-preservation. Therefore, these data are discussed and displayed below, but should not be used to assess the macroinvertebrate communities at these sites.

The benthic macroinvertebrate identifications and ICI application for the NEORSD sampling were performed by EA Engineering, Science and Technology. A list of collected taxa is available upon request. Detailed descriptions of the placement, collection, and processing of HD samplers can be found in the Ohio EPA's document titled *Biological Criteria for the Protection of Aquatic Life: Volume III: Standardized Field and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities* (September 30, 1989, updated November 8, 2006).

The ICI, as followed in the Ohio EPA *Biological Criteria for the Protection of Aquatic Life Volume II* (1987, updated January 1, 1988 and November 8, 2006), has historically been applied to NEORSD-collected macroinvertebrates. The ICI consists of ten functional and structural community metrics, each with four scoring categories. The total of the individual metric scores results in the ICI score, where the higher the score, the less impacted the site. This point system evaluates the sample against the Ohio EPA's relatively undisturbed reference sites. In situations where less than 50 organisms

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are collected, low-end scoring is used to adjust the ICI score. Low-end scoring eliminates scores for metrics that are based on proportions of organisms in the sample. Such proportions are meaningless in very small samples.

### Results and Discussion

ICI scores for each site are listed in Table 5 for 2007. The aquatic life habitat use designation for each site is Warmwater Habitat (WWH), except for Big Creek RM 4.70, which is a Limited Resource Water (LRW). Therefore, the biocriterion attainment for macroinvertebrates at the WWH sites in the Erie/Ontario Lake Plains ecoregion is an ICI score of 34. As waters that have been designated LRW do not have a biocriterion, the WWH biocriterion was applied to Big Creek RM 4.70 for comparison purposes only.

Site	River Mile	First colonization <sup>b</sup>	Second colonization	Average score
Big Creek	0.15	20	22	22
Big Creek	4.40	8 <sup>a</sup>	-	-
Big Creek	4.70	0 <sup>a</sup>	2	2
Mill Creek	0.12	-	22	22
Mill Creek	8.30	0 <sup>a</sup>	14	14
Doan Brook	0.75	8 <sup>a</sup>	28	28
Doan Brook	1.40	10	8	8
Doan Brook	6.70	0 <sup>a</sup>	8	8
Euclid Creek	0.55	2 <sup>a</sup>	22	22
Euclid Creek	1.65	36	26	26
Euclid Creek	2.70	36	-	-

<sup>a</sup>Low-end scoring applied per Ohio EPA *Users Manual for Biological Field Assessment of Ohio Surface Waters: Biological Criteria for the Protection of Aquatic Life Volume II Update* (November 8, 2006)

<sup>b</sup>First Colonization scores are suspect due to under-preservation. Scores not included in averages.

### *Big Creek Results and Discussion*

Average ICI score results from 2002 through 2007 are displayed in Figure 1. At RM 4.70, the most upstream site, average ICI scores remained in the *Very Poor* range from 2002 through 2007 (Figure 1). This site is designated a LRW by Ohio EPA due to small drainageway maintenance. The small drainage area, 4.3 square miles (mi<sup>2</sup>), lack of quality habitat and slow moving water likely contribute to the low ICI scores found there.

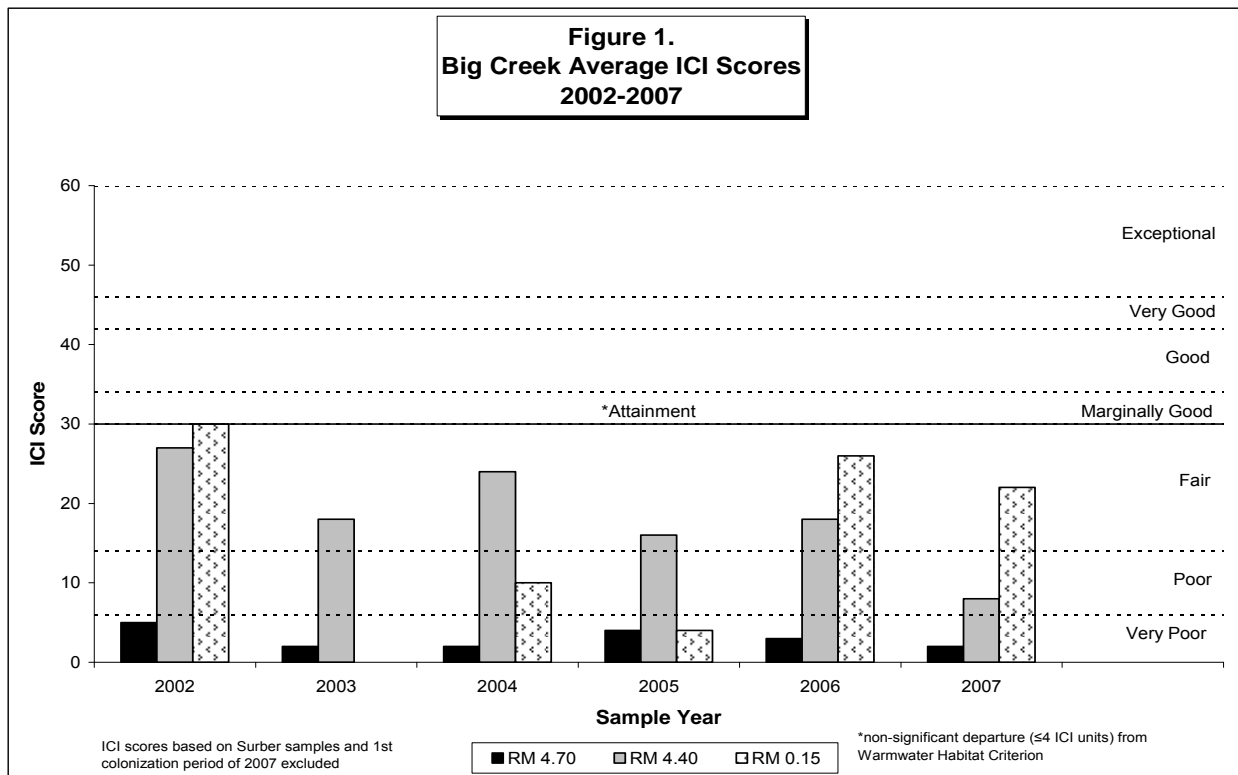


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The QHEI score was 51, less than the target score of 60 for WWH attainment, primarily due to the absence of a functional riffle. No exceedances of the OMZM water quality criteria occurred at this site in 2007.

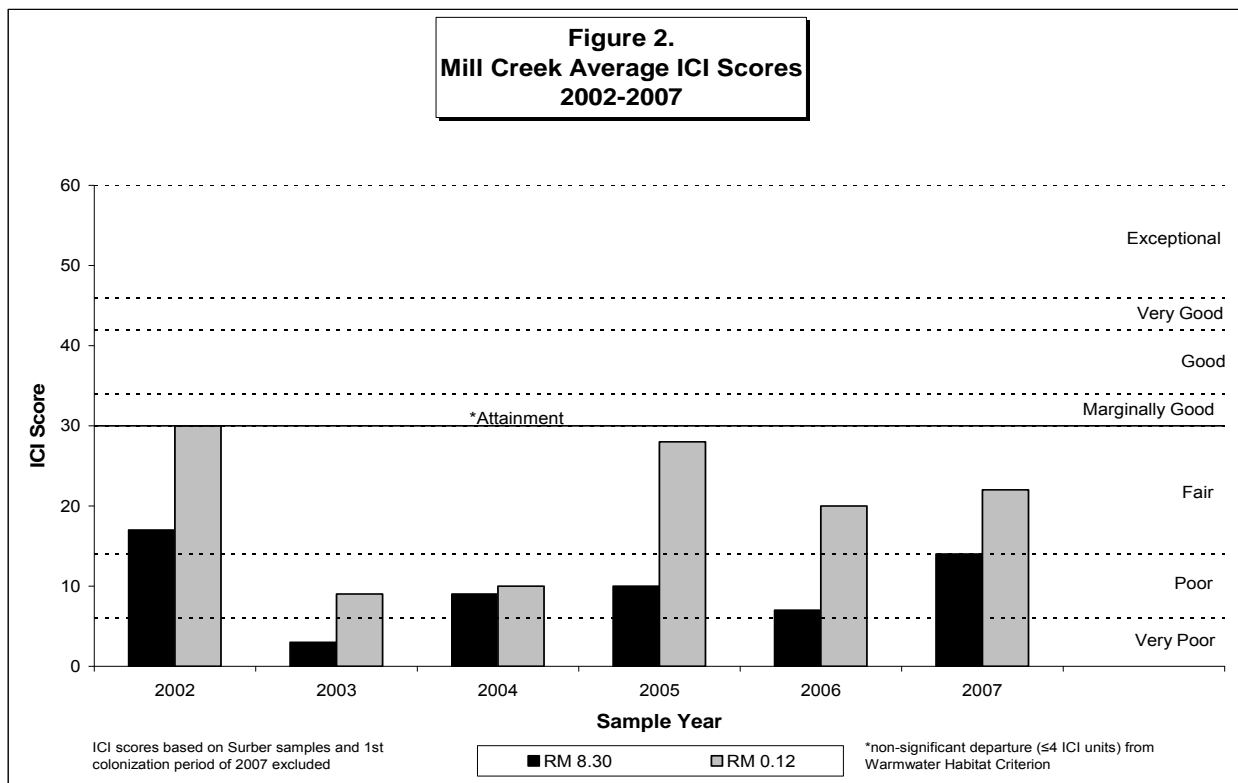
Average ICI scores at RM 4.40 were in the *Fair* range from 2002 to 2006, and then decreased to the *Poor* range in 2007 (Figure 1). The QHEI score at RM 4.40 was 60.75 mainly due to the lack of instream cover. The drainage area at this site is 19.3 mi<sup>2</sup>. No exceedances of the OMZM water quality criteria occurred at this site in 2007.



At RM 0.15, the downstream site, ICI scores were in the *Fair* range for two consecutive years, 2006 (average) and 2007 (second colonization period), indicating a general increase in macroinvertebrate community quality over previous years (Figure 1). It should be noted that the first colonization period was determined to be invalid due to under-preservation of the sample. The increase in score may be due to an inadvertent improvement in the riffle quality upstream of the HD location as a result of the Jennings Road bridge construction in 2006. The substrate of Big Creek just upstream of the HD site was disturbed during the construction, allowing cobble to wash downstream and accumulate within the already existing riffle. Although the QHEI score at this site was 68.75, there was still poor instream cover and channel morphology, no riparian zone and excessive bank erosion. The drainage area for RM 0.15 is 37.1 mi<sup>2</sup>.

**Mill Creek Results and Discussion**

Average ICI score results from 2002 through 2007 are displayed in Figure 2. There were two water quality exceedances of OMZM water quality criteria at RM 0.12 in 2007, but none at RM 8.30.



In 2007, the ICI score at RM 8.30, the furthest upstream site, was 14 or *Fair*. Since 2003, an ICI score of 14 has been the highest to occur at RM 8.30. These relatively low scores may be a reflection of the very small drainage area of 3.9 mi<sup>2</sup>, upstream nonpoint sources of pollution, lack of a riparian zone and streambank erosion. The QHEI score for RM 8.30 was 65, indicating that the habitat is sufficient for attainment of the WWH criterion.

RM 0.12, the downstream site, had an ICI score of 22 in 2007. Due to sand deposition during high flows, the HD was reset multiple times at this location, resulting in the collection of only one HD during the 2007 field season. The QHEI score at this

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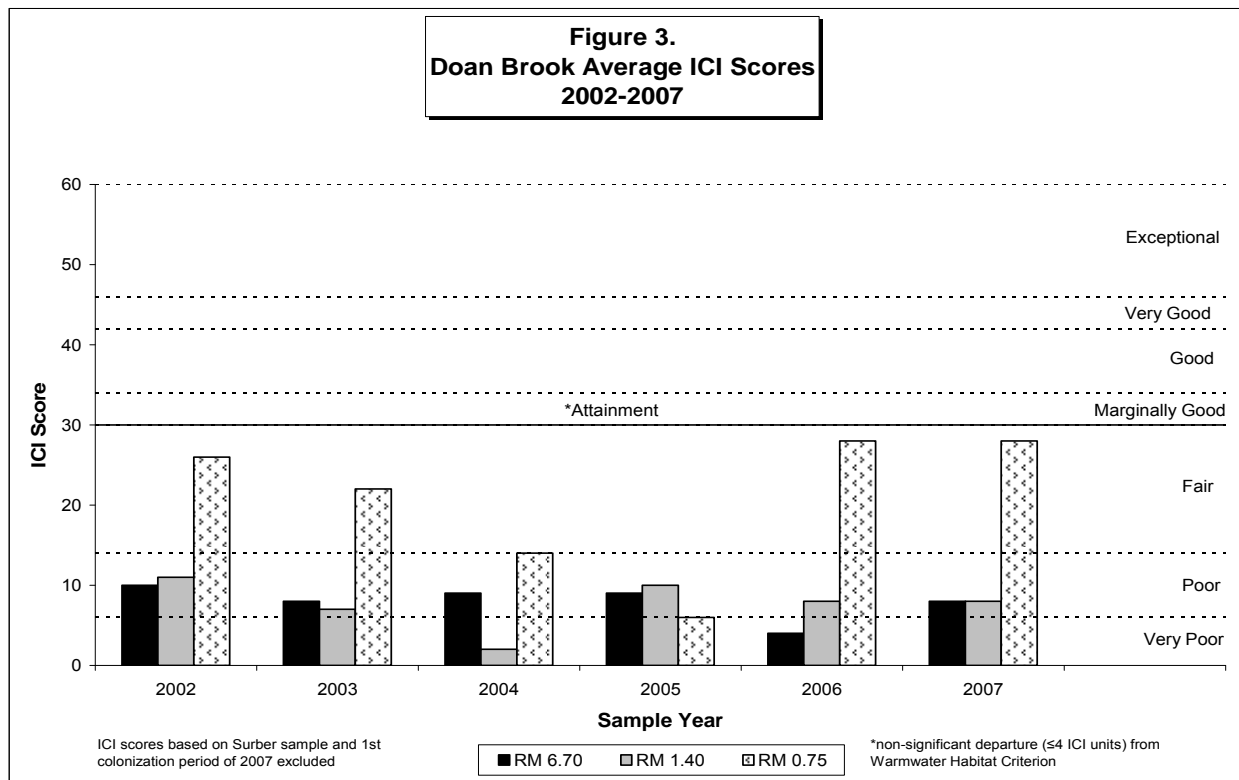
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site was 63, indicating that the habitat is sufficient for attainment of the WWH criterion. The low stability of the channel, sand dominating substrate, and a low amount of instream cover may be the primary causes of non-attainment.

Noticeable differences in individual metrics between the Mill Creek sites occurred with Total Number of Caddisfly Taxa and Percent Caddisflies and Total Number of Mayfly Taxa and Percent Mayflies, both of which had higher scores at RM 0.12, possibly as a result of the larger drainage area of RM 0.12 of 18.1 square miles.

## Doan Brook Results and Discussion

Average ICI score results from 2002 through 2007 are displayed in Figure 3. No exceedances of the OMZM water quality criteria occurred at RM 6.70, RM 1.40 or RM 0.75 in 2007.



ICI scores at RM 1.40, an upstream site on the South Branch of Doan Brook with a drainage area of 3.4 square miles, were in the *Poor* range. The low ICI score at this site may be due to flow velocity, lack of a functional riffle and a small drainage area.

ICI scores at RM 6.70, an upstream site located on the North Branch of Doan Brook, were in the *Poor* to *Very Poor* range. As with RM 1.40, the low ICI range at Site RM 6.70 may be partially due to the flow velocity at the site, which is continuously less

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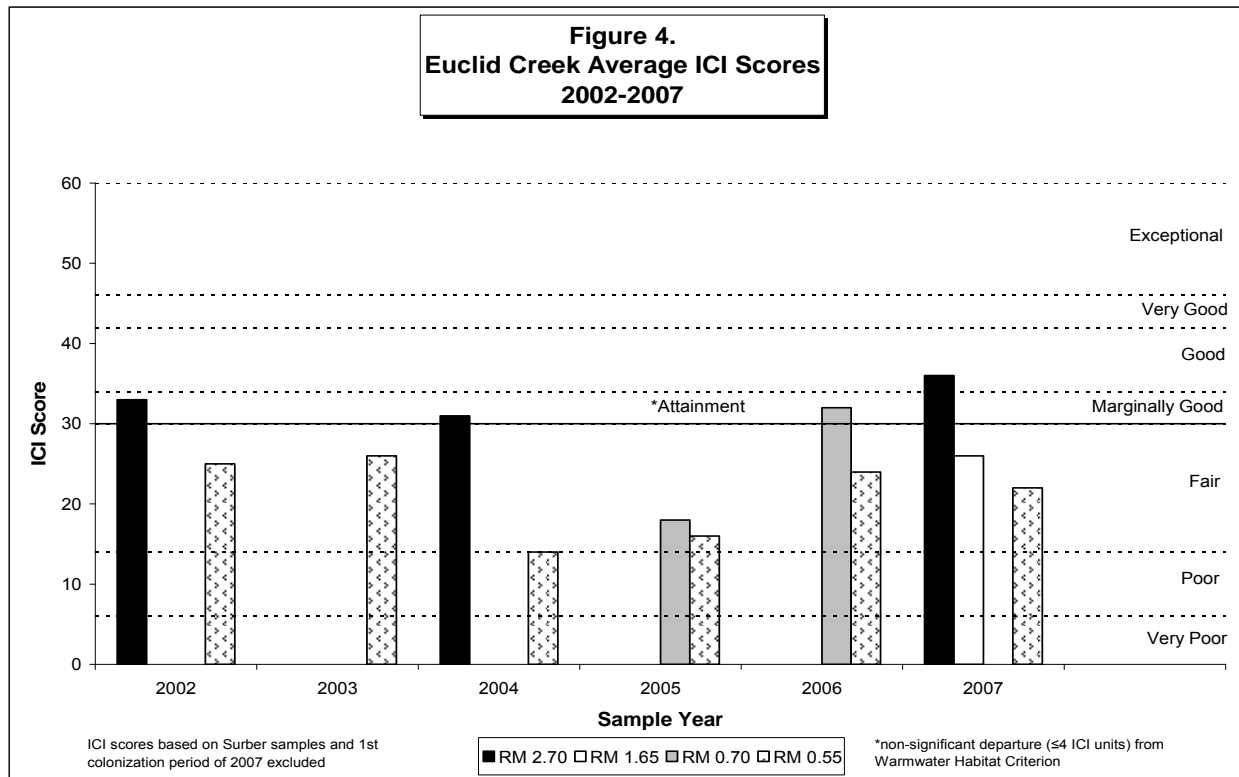
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than optimal, 0.3 feet per second, for macroinvertebrate colonization and the lack of a functional riffle. Also, this site has an extremely small drainage area of 1.6 square miles and is situated alongside a golf course.

In 2007 the downstream site, RM 0.75, had an ICI score for the second colonization period of 28. While this is not in attainment of the WWH criterion, it is in the *Fair* range. Although RM 0.75 is located in an urban park within a channelized stream section having little or no riparian zone, and is downstream of NEORSD-owned CSOs, it has consistently had better average ICI scores than the other two Doan Brook sites. It is possible that a better flow regime has enough impact at this site to overcome habitat or water chemistry stressors and thus produce higher ICI scores as compared to the other Doan Brook sites.

## Euclid Creek Results and Discussions

Average ICI score results from 2002 through 2007 at Euclid Creek are graphically displayed in Figure 4. No exceedances of the OMZM water quality criteria occurred at RM 2.70, RM 1.65 or RM 0.55 in 2007.



During the first colonization period in 2007, one HD was collected at RM 2.70, and resulted in an ICI score of 36. This indicates attainment of the WWH criterion for

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2007. Since 2002, RM 2.70 has been in attainment, or within non-significant departure, of the WWH criterion whenever a HD sampler has been retrieved. The sampling location at RM 2.70 is conducive to macroinvertebrate colonization, as it often has flows greater than 1 foot per second and has a drainage area of 21.4 square miles.

RM 1.65 was added as a sampling site in 2007 because it is still upstream of NEORSD CSOs, but downstream of other CSOs and other point sources. A HD was collected during each colonization period, resulting in ICI scores of 36 for the first colonization period and 26 for the second colonization period. Although this site has a more stabilized substrate compared to RM 2.70, it has sparse instream cover.

The downstream site, RM 0.55, has a drainage area of 23 square miles and received an ICI score of 22 for the second colonization period. The first colonization period ICI score was considered invalid due to under-preservation of the HD sample. Poor physical habitat conditions may be partly responsible for low ICI scores at RM 0.55. The substrate at RM 0.55 consists of sand, while the flows are deep and sluggish under normal flow conditions. This produces a less than ideal habitat for macroinvertebrates.

It should be noted that investigations by WQIS personnel on Euclid Creek in 2005, 2006 and 2007 revealed at least six storm sewer outfalls downstream of RM 2.70, but upstream of RM 0.55, which had continuously elevated levels of *E. coli* entering the creek during dry weather. The responsible communities were informed of these sources of dry weather flow to Euclid Creek. It is likely that these flows may have a deleterious effect on RM 0.55.

### *Comparisons among Streams*

Figure 5 depicts the average ICI scores for all sites. It should be noted that the downstream site average ICI scores, depicted by the gray columns, generally fall in the middle of the graph. It would appear from this figure that while CSOs may be having some impact on benthic macroinvertebrate communities (because the downstream sites do not have the highest scores overall), other factors, such as point/non-point sources, the lack of suitable macroinvertebrate colonization habitat and stream order are causing even lower ICI scores upstream of the CSOs. Point sources with potential impact include SSOs, storm sewer outfalls, upstream tributaries and home sewage treatment systems. Non-point sources with potential impact include urban runoff, landfill leachate and spills.

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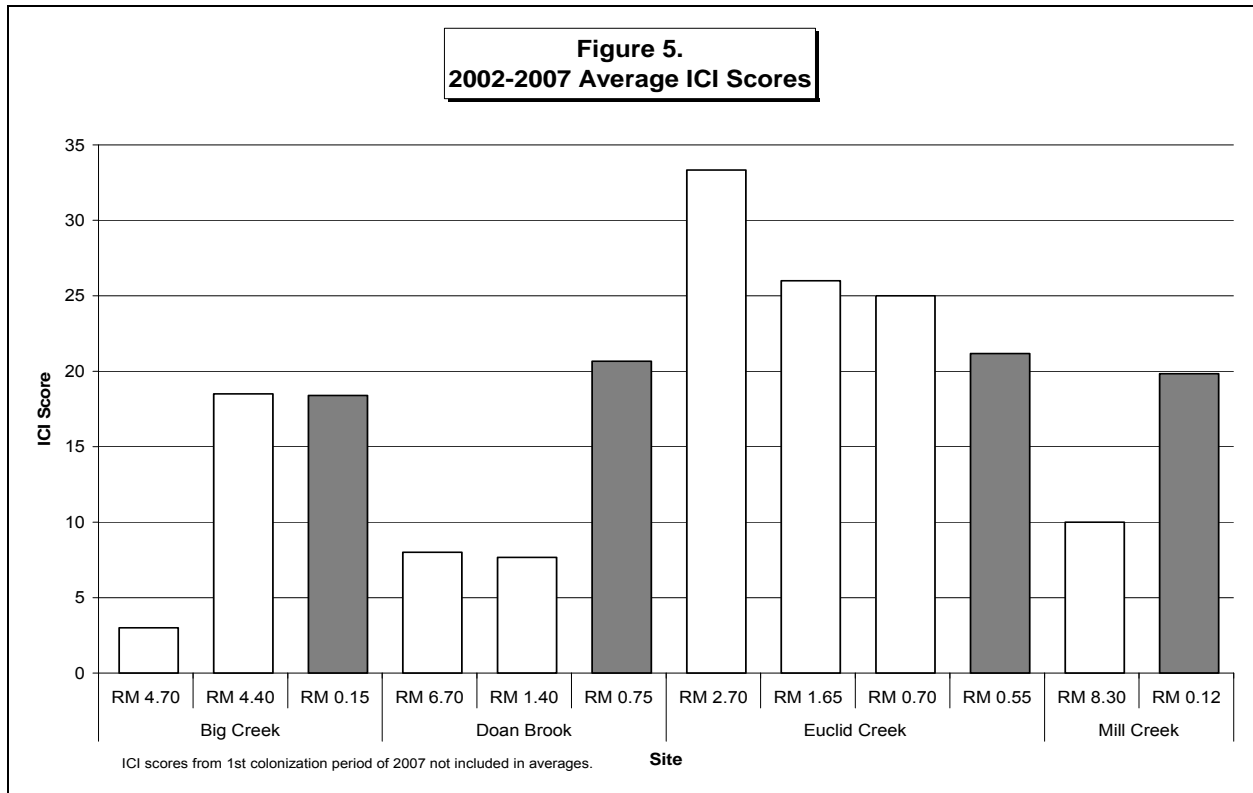
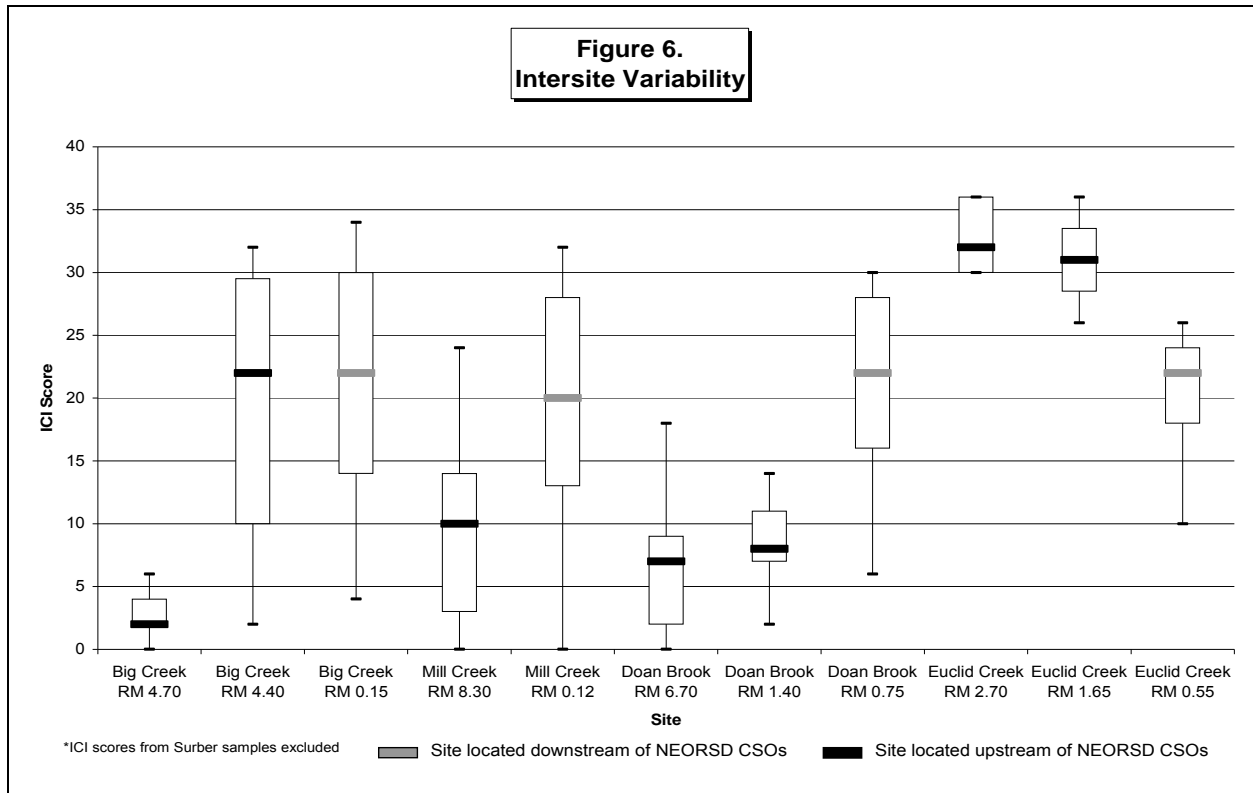
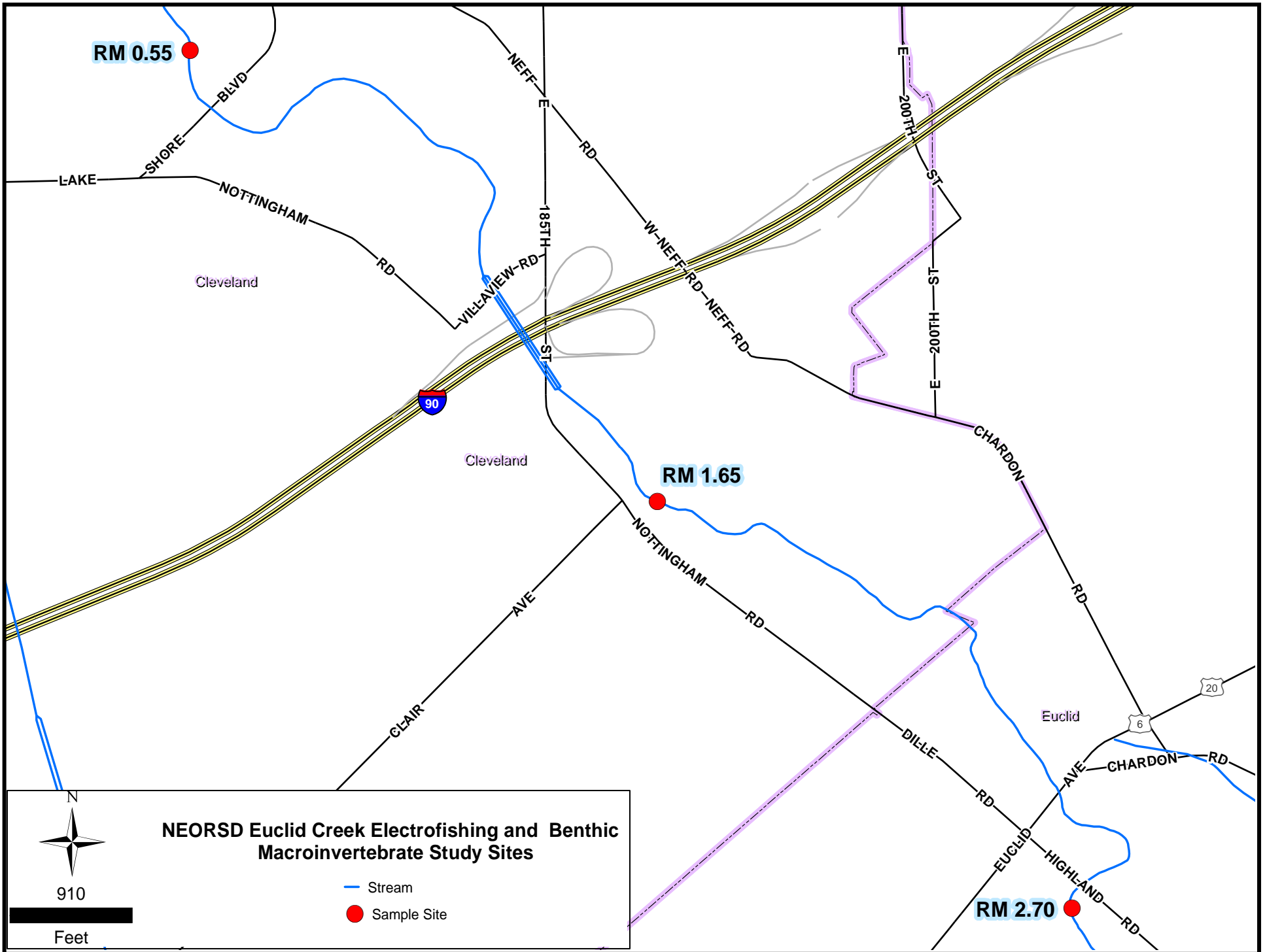


Figure 6 shows the variability of ICI scores for each site, using an averaged ICI score each year from 2002 through 2007. If CSOs were having a very strong impact on downstream sites, it would be expected that the downstream sites would always have the lowest median scores. The WWH site with the lowest median score (Doan Brook RM 1.40) is an upstream site. Doan Brook and Mill Creek had higher median scores at the downstream locations than the upstream locations.



## Conclusions

Overall, macroinvertebrate and fish communities at the downstream locations of each stream generally indicate nearly as good, if not better, water quality conditions than their respective upstream locations. Poor ICI and IBI scores at the upstream sites may be due to poor habitat, poor riparian zone quality and slow velocity. The ICI scores may also be affected by the small drainage areas. Since these conditions are often also seen at the downstream sites, this may be an indication that CSOs are not the only variable adversely affecting the communities located downstream of the discharges. Continued monitoring is necessary to determine long term trends as CSO discharges continue to be controlled.



RM 0.55

RM 1.65

RM 2.70

**NEORSD Euclid Creek Electrofishing and Benthic Macroinvertebrate Study Sites**

- Stream
- Sample Site

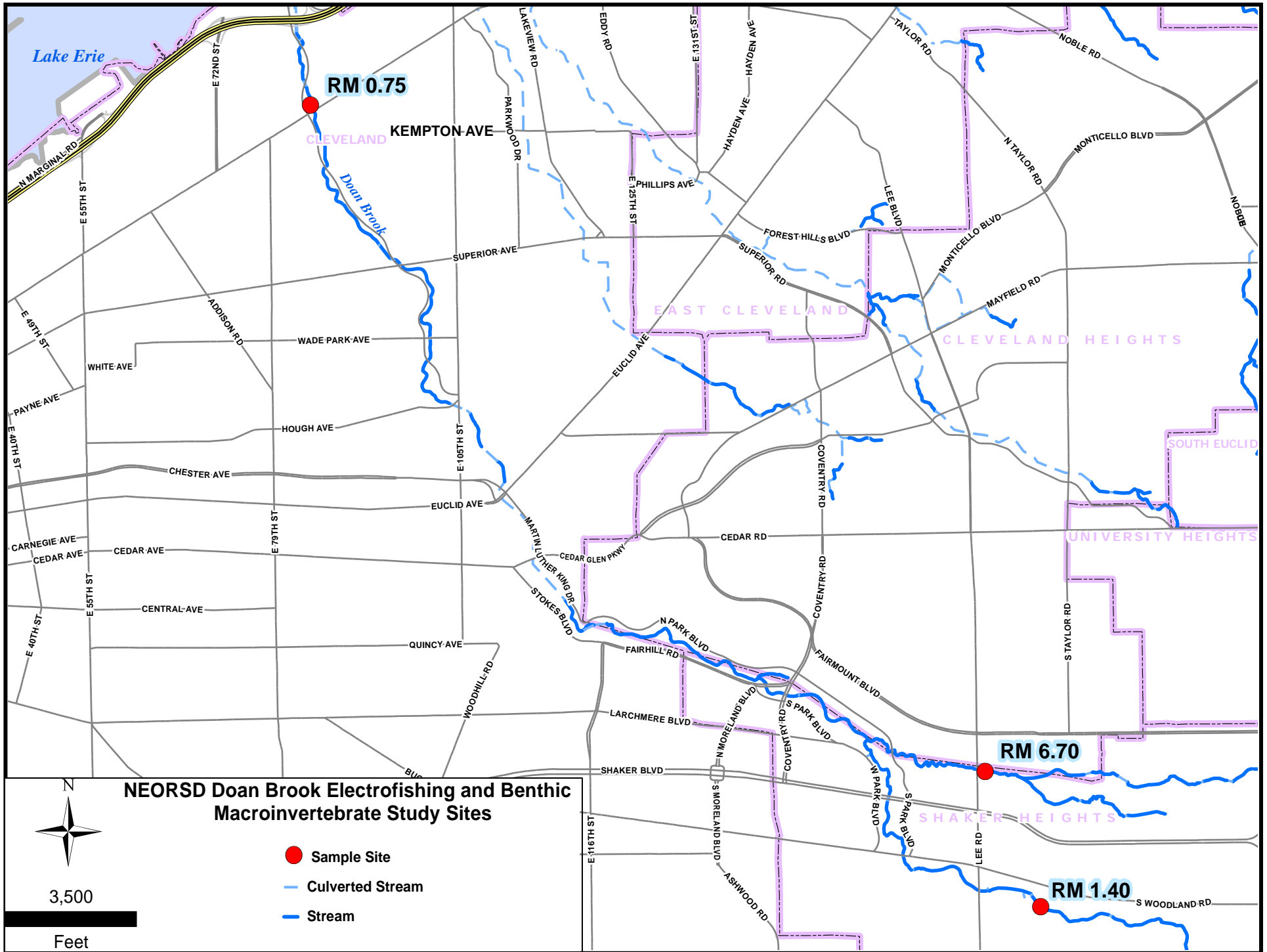


910



Feet





Lake Erie

**RM 0.75**

CLEVELAND

KEMPTON AVE

Doan Brook

EAST CLEVELAND

CLEVELAND HEIGHTS

SOUTH EUCLID

UNIVERSITY HEIGHTS

**RM 6.70**

SHAKER HEIGHTS

**RM 1.40**

S WOODLAND RD

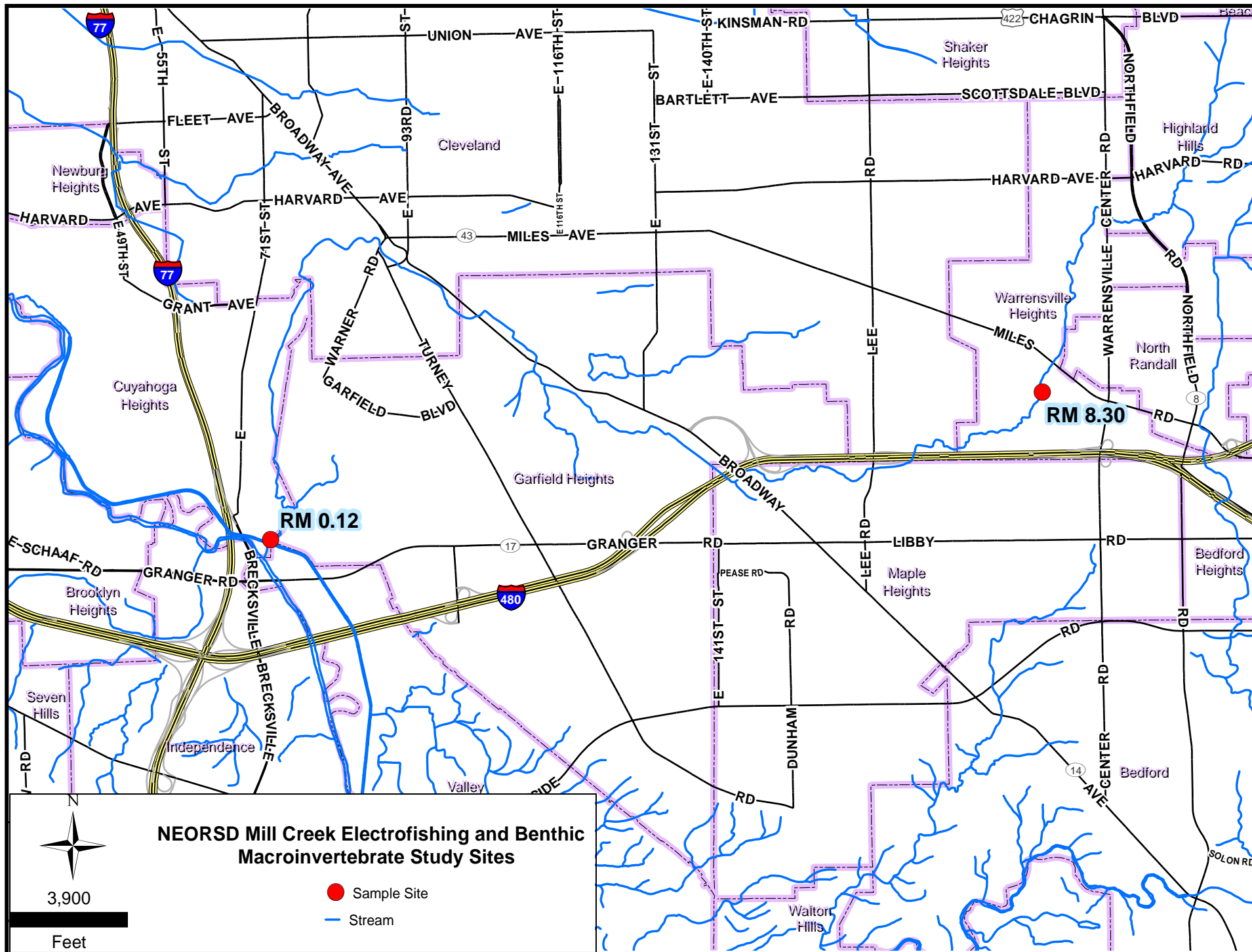


**NEORS Doan Brook Electrofishing and Benthic Macroinvertebrate Study Sites**

3,500

Feet





**NEORSD Mill Creek Electrofishing and Benthic Macroinvertebrate Study Sites**

● Sample Site  
 — Stream

3,900 Feet