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DATE: December 2, 2008

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RE: *2006 Benthic
Macroinvertebrate Sampling
Upstream of NEORSD CSO
Areas*

Introduction

The objective of this study was to conduct benthic macroinvertebrate and water quality sampling upstream from areas of Northeast Ohio Regional Sewer District (NEORSD)-owned combined sewer overflows (CSOs). The resulting upstream data were compared with the macroinvertebrate data obtained from these streams downstream of the NEORSD CSO areas, in compliance with Ohio EPA NPDES Permit No. 3PA00002*FD, to evaluate the extent to which downstream macroinvertebrate communities may be impacted by CSOs or other environmental factors. The downstream sampling is required on Big Creek, Mill Creek, Doan Brook, and Euclid Creek.

The NEORSD conducted quantitative macroinvertebrate sampling by installing Hester-Dendy (HD) artificial substrate samplers at locations downstream (DS) of all NEORSD-owned CSO areas, as well as locations on each stream that were determined to be upstream (US) 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 sampling was conducted. Two six-week colonization periods occurred at each sampling site. A Surber sample was utilized when HD samplers were lost or buried. A total of five quadrats were sampled and composited to create one representative sample. If a Surber sample was collected in place of a HD sampler, the Invertebrate Community Index (ICI) score is not represented graphically or used to determine average ICI scores for individual sites, but is included for informational purposes only. 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.

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 described 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 NEORSO-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 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.

Water quality samples were collected and analyzed for each site approximately every eight days during the colonization period. Water quality sample results are available upon request.

The sample site locations are listed below and maps may found at the end of this report..

Table 1. Sample Site Locations				
Sites Downstream of NEORSO CSOs				
Site	River Mile	Site Description	Latitude (°N)	Longitude (°W)
Big Creek #25	0.15	DS of Jennings Road and CSOs	41.4460	81.6865
Doan Brook #16.1	0.75	DS of St Clair Avenue and CSOs	41.5330	81.6296
Euclid Creek #0.5	0.55	DS of Lake Shore Boulevard and CSOs	41.5833	81.5594
Euclid Creek #0.5a	0.56	DS of Lake Shore Boulevard and Upstream of Site #0.5	41.5825	81.5594
Mill Creek #31	0.12	US of Canal Road and DS of CSOs	41.4178	81.6385

Table 1. Sample Site Locations				
Sites Upstream of NEORSO CSOs				
Site	River Mile	Site Description	Latitude (°N)	Longitude (°W)
Big Creek #26	4.40	North Branch at Cleveland Metroparks Memphis Picnic Area	41.4460	81.7540
Big Creek #28.1	4.70	South Branch US of West 150 th Street	41.4230	81.8019
Mill Creek #34.6	8.30	US of South Miles Road	41.4305	81.5442
Doan Brook #18.1	1.40	North Branch at Lee Road	41.4838	81.5643
Doan Brook #19.5	6.70	South Branch US of Attleboro Road	41.4739	81.5590
Euclid Creek #1.5	2.70	US of Highland Road	41.5658	81.5358

Results and Discussion

ICI scores for each site, including ICI scores derived from Surber samples, are listed below for 2006. The aquatic life habitat use designation for each site is Warmwater Habitat (WWH), except for Site #28.1, 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 30 (non-significant departure (≤ 4 ICI units) from the WWH criterion of 34). As waters that have been designated LRW do not have a biocriterion, the WWH biocriterion was applied to Site #28.1 for comparison purposes only.

Table 2. 2006 ICI Scores			
Site	First Colonization	Second Colonization	Average
Big Creek #25	18	34	26
Big Creek #26	32	4 ^a	18
Big Creek #28.1	4	2 ^a	3
Mill Creek #31	12	28	20
Mill Creek #34.6	14	0 ^a	7
Doan Brook #16.1	26	30	28
Doan Brook #18.1	6	2	4
Doan Brook #19.5	12	4 ^{a,b}	8

Site	First Colonization	Second Colonization	Average
Euclid Creek #0.5	4 ^c	24	24 ^d
Euclid Creek #0.5a	- ^e	32	32
Euclid Creek #1.5	- ^e	- ^e	- ^e

a) 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)

b) Despite low-end scoring, ICI score suspect due to the collection of a single organism

c) Score based on a Surber sample. This data is included for informational purposes only.

d) ICI score from Surber sample excluded

e) HDs were not collected because they were either lost or buried during the colonization periods

Big Creek Results and Discussion

Average ICI score results from 2002 through 2006 are graphically displayed in Figure 1. Chemical water quality parameters exceeding the applicable statewide water quality criteria for the Protection of Aquatic Life are listed in Table 3.

Average ICI scores at Site #28.1, the most upstream site, remained in the *Very Poor* range from 2002 through 2006 (Figure 1). This site is designated a LRW by Ohio EPA as the site is subject to small drainageway maintenance. Exceedances of the Outside Mixing Zone Maximum (OMZM) water quality criteria for aquatic life protection occurred at this site on June 22, 2006 for zinc and on July 27, 2006 for zinc, copper and cadmium. Exceedances on both dates can be attributed to the effects of wet weather conditions. The small drainage area and lack of quality habitat likely contribute to the low ICI scores at Site #28.1.

Average ICI scores (Figure 1) at Site #26 have been in the *Fair* range from 2002 to 2006. Three exceedances of the OMZM water quality criteria for aquatic life protection occurred at this site in 2006 for copper, cadmium and zinc. These exceedances occurred during wet weather events and may be attributed to runoff or other nonpoint sources of pollution. ICI scores at Site #26 demonstrate the potential for high temporal variability of macroinvertebrate communities, as the first colonization period had an ICI score of 32 while the second period had an ICI score of 4. These scores represent the highest and lowest ICI scores produced at this site from 2002 through 2006.

At Site #25, the downstream site, average ICI scores were in the *Very Poor* to *Marginally Good* range (Figure 1). Seven exceedances of the OMZM water quality criteria (copper, cadmium, zinc, and dissolved oxygen) and one exceedance of the OMZA water quality criteria (copper) for aquatic life protection

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occurred at this site in 2006. The exceedances that occurred on June 22 and July 27 may be attributed to nonpoint sources of pollution during wet weather. The exceedances that occurred on August 3 may have been due to the disturbance of the substrate during bridge construction.

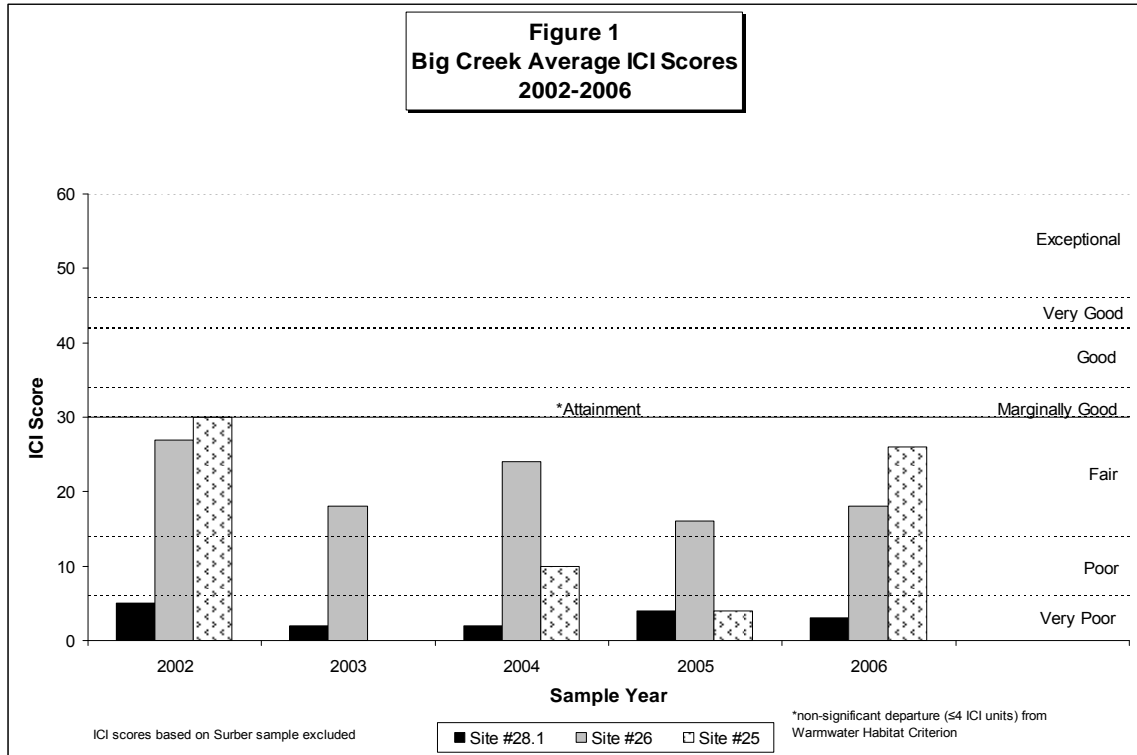


Table 3. 2006 Big Creek Aquatic Life Water Quality Criteria Exceedances				
Location	Date	Parameter	Analysis Result	Criterion (OMZM)
Site #25	6/22/2006	Copper	22.0 µg/L	17.8 µg/L
Site #25	7/27/2006	Copper	82.6 µg/L	17.3 µg/L
Site #25	7/27/2006	Cadmium	11.3 µg/L	5.8 µg/L
Site #25	7/27/2006	Zinc	330.0 µg/L	144.8 µg/L
Site #25	8/3/2006	Copper	140.0 µg/L	39.7 µg/L
Site #25	8/3/2006	Zinc	562.0 µg/L	305.7 µg/L
Site #25	8/3/2006	Dissolved Oxygen	3.9 µg/L	4.0 µg/L
Site #25	7/27-8/24/2006	Copper	48.6 µg/L**	19.0 µg/L*
Site #26	7/27/2006	Copper	68.0 µg/L	16.8 µg/L
Site #26	7/27/2006	Cadmium	11.0 µg/L	5.6 µg/L
Site #26	7/27/2006	Zinc	260.0 µg/L	140.8 µg/L
Site #28.1	6/22/2006	Zinc	231.0 µg/L	172.7 µg/L
Site #28.1	7/27/2006	Copper	44.0 µg/L	10.9 µg/L
Site #28.1	7/27/2006	Cadmium	4.0 mg/L	3.4 mg/L
Site #28.1	7/27/2006	Zinc	271.0 µg/L	96.0 µg/L
Copper, cadmium and zinc criteria are hardness-based Dissolved Oxygen has a minimum criterion rather than a maximum criterion *Outside Mixing Zone Average (OMZA) criterion **Average of five samples during period				

During the summer and fall of 2006, the Jennings Road bridge, located over Big Creek just upstream of Site #25, was rebuilt. This project caused a considerable amount of silt to enter the creek during both colonization periods. At times, investigators observed a plume of silt entering the Cuyahoga River at the confluence with Big Creek. The creek banks were straightened, and the substrate was reconfigured. Figure 2 shows the condition of Big Creek prior to the bridge construction. Figure 3 depicts the condition of the Big Creek during the bridge construction. In spite of the construction impact on the creek habitat, Site #25 produced the highest average score as well as the highest individual colonization score of all Big Creek sites in 2006. This site also showed considerable improvement over its 2004 and 2005 average scores. It is uncertain why this occurred, but suggests that there may be numerous factors affecting the ability of macroinvertebrates to colonize a given location.



Figure 2. Jennings Road bridge prior to construction.



Figure 3. Jennings Road bridge during construction.

Mill Creek Results and Discussion

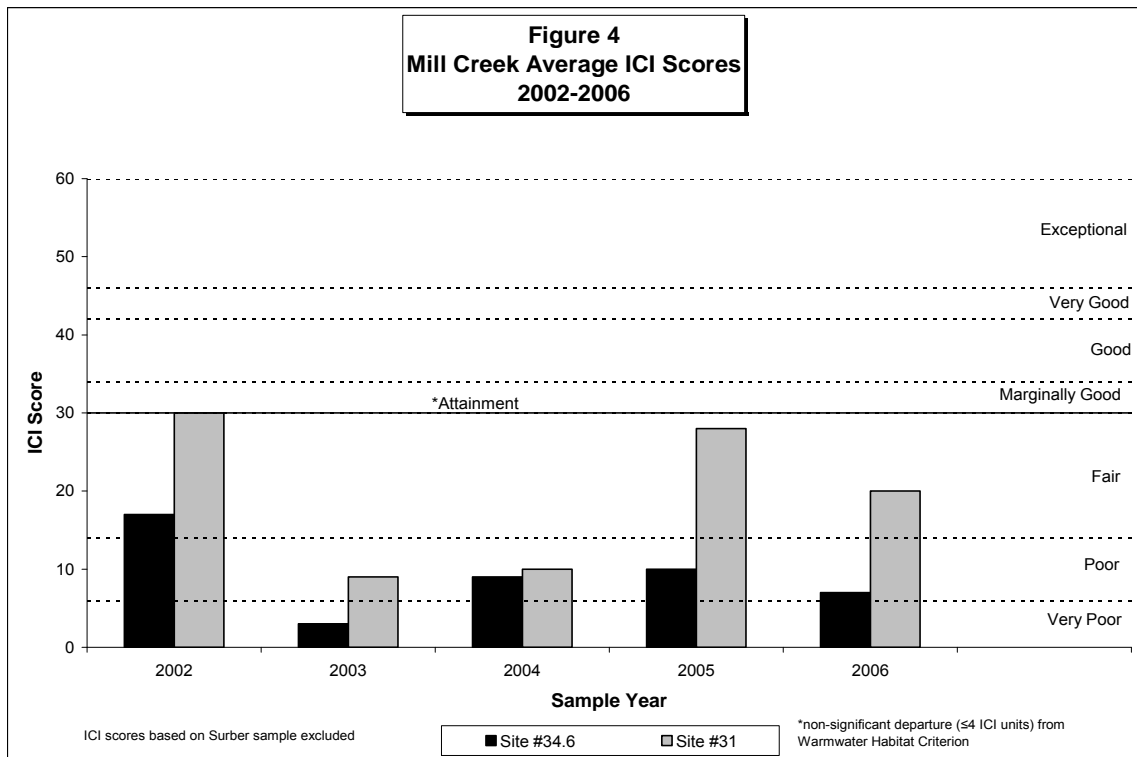
Average ICI score results from 2002 through 2006 are graphically displayed in Figure 4. Chemical water quality parameters exceeding the

applicable statewide water quality criterion for the Protection of Aquatic Life are listed in Table 4.

In 2006, ICI scores at Site #34.6, the furthest upstream site, ranged from 14 (Fair) to 0 (Very Poor). This site had one exceedance of Outside Mixing Zone Average water quality criteria for protection of wildlife (Table 4), which occurred during wet weather. These relatively low scores may be a reflection of the habitat quality at this site, including a very small drainage area of 3.9 square miles. This site is located in an industrial area with a minimal riparian zone.

Site #31, the downstream site, had ICI scores from 12 to 28 in 2006. This site also had two exceedances of OMZM water quality criteria for aquatic life protection (Table 4). The copper exceedance occurred during a wet weather event.

Noticeable differences in individual metrics between the Mill Creek sites occurred with Total Number of Caddisfly Taxa and Percent Caddisflies, both of which had higher scores at Site #31, possibly as a result of the larger drainage area of Site #31 of 18.1 square miles. The differences in caddisfly metrics between the Mill Creek sites have been consistent since 2002.



Location	Date	Parameter	Analysis Result	Criterion (OMZM)
Site #31	7/27/2006	Copper	27.0 µg/L	18.1 µg/L
Site #31	8/10/2006	Dissolved Oxygen	3.63 µg/L	4.0 µg/L
Site #34.6	9/14/2006	Mercury	7.72 µg/L	0.0013 µg/L

Copper criterion is hardness-based
 Dissolved Oxygen has a minimum criterion rather than a maximum criterion

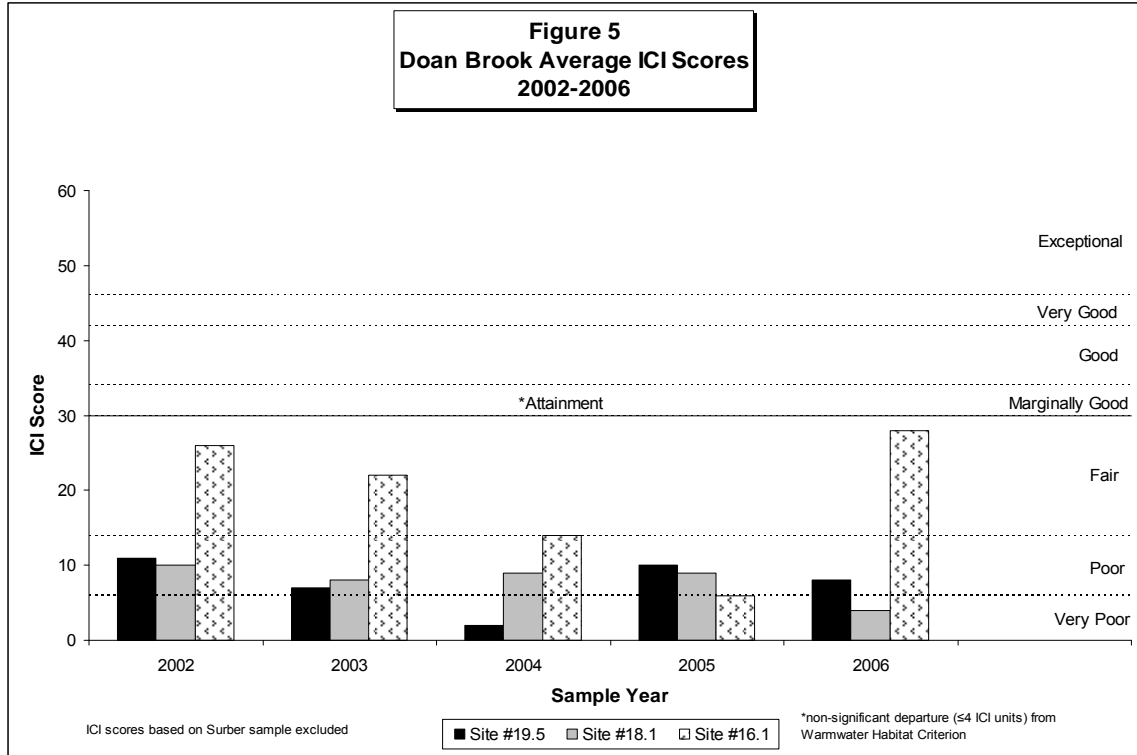
Doan Brook Results and Discussions

Average ICI score results from 2002 through 2006 are graphically displayed in Figure 5. Chemical water quality parameters exceeding the applicable statewide water quality criterion for the Protection of Aquatic Life are listed in Table 5.

ICI scores at Site #19.5, an upstream site on the South Branch of Doan Brook with a drainage area of 9 square miles, were in the *Very Poor* to *Poor* range. However, the score in the second colonization was based on the collection of a single organism (a caddisfly) in the sample and may be artificially high. There were no exceedances of the OMZM water quality criteria for aquatic life protection at this site in 2006.

ICI scores at Site #18.1, an upstream site located on the North Branch of Doan Brook, were in the *Very Poor* to *Poor* range. There were no water quality exceedances from the OMZM criteria for the protection of aquatic life at Site #18.1 in 2006 (Table 5). The average ICI score for 2006 was the lowest average score at this site since sampling began in 2002. The low ICI range at Site #18.1 may be partially due to the flow velocity at the site, which is continuously less than optimal, <0.3 feet per second, for macroinvertebrate colonization. Also, this site has an extremely small drainage area of 1.2 square miles and is situated alongside a golf course.

In 2006, the downstream site, Site #16.1, had its highest average ICI score since the two colonization sampling periods began in 2002 (Figure 5). OMZM water quality criteria for aquatic life protection were exceeded twice at this site in 2006 (Table 5). Although Site #16.1 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. The score for the second colonization period in 2006, 30, is within non-significant departure (≤ 4 ICI units) from the WWH criterion. 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.



Location	Date	Parameter	Analysis Result	Criterion (OMZM)
Site #16.1	7/27/2006	Copper	36.0 µg/L	10.7 µg/L
Site #16.1	7/27/2006	Zinc	122.0 µg/L	93.9 µg/L

Copper and zinc criteria are hardness-based

Euclid Creek Results and Discussions

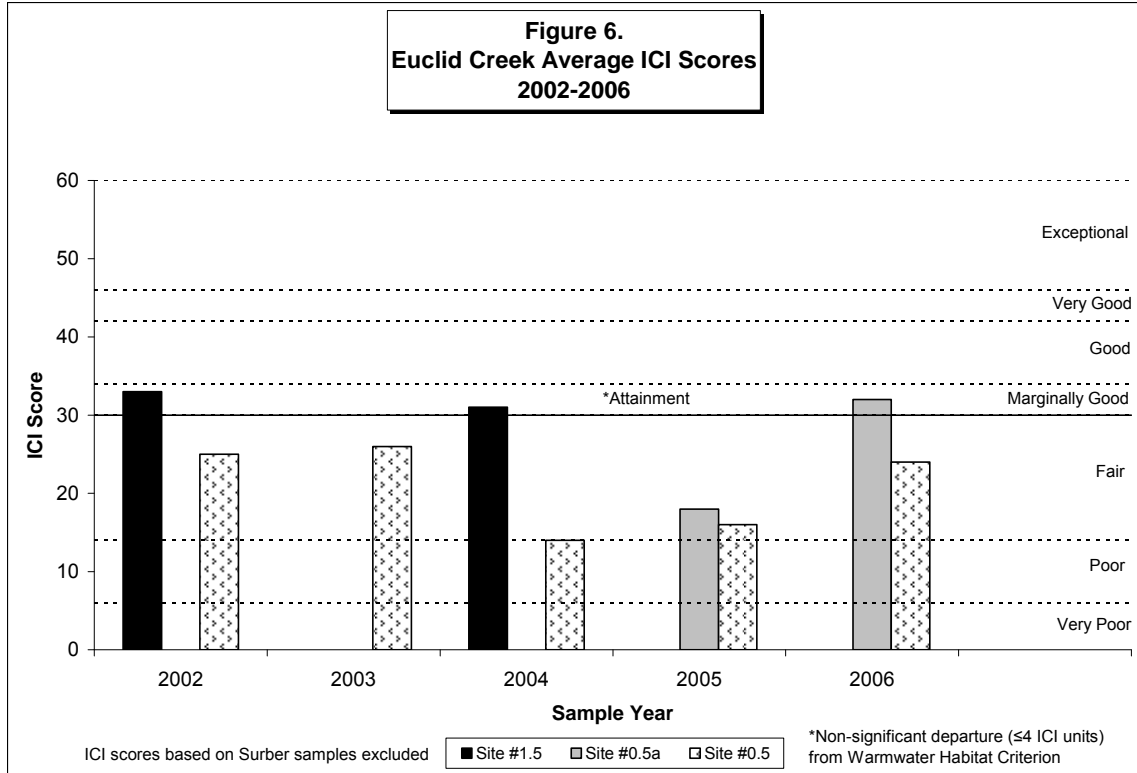
Average ICI score results from 2002 through 2006 are graphically displayed in Figure 6. There were no chemical water quality parameter exceedances of the applicable statewide water quality criterion for the Protection of Aquatic Life at either Site #1.5 or Site #0.5 in 2006. Due to its proximity to Site #0.5, chemical water quality sampling was not conducted at Site #0.5a.

No HDs were collected at Site #1.5 in 2006. The HDs set were lost or buried during the colonization periods. When the original HDs were lost, new ones were installed, but those were also lost or buried. The substrate at this location is comprised of cobble and small boulders on a bedrock creek bed. During high creek flows, the cobble, small boulders and bedrock significantly shift, resulting in buried and dislodged HDs.

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Site #0.5, with a drainage area of 23 square miles, had an ICI score of 24. A Surber sample, which had an ICI score of 4, was collected to replace a lost HD during the first colonization period. The ICI of 24 is higher than average scores from 2004 and 2005. Poor physical habitat conditions may be partly responsible for low ICI scores at Site #0.5. The substrate at Site #0.5 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 (*Euclid Creek Bacteriological Investigation* dated July 15, 2005; and *Euclid Creek 2006 Bacteriological Investigation* dated June 21, 2006, *2007 Euclid Creek Bacteriological Investigation* dated July 30, 2007) revealed at least six outfalls downstream of Site #1.5, but upstream of Site #0.5, which had continuously elevated densities of *Escherichia coli* during dry weather. The responsible communities were informed of these sources of dry weather flow to Euclid Creek, but as of 2007, these problems appear to be continuing. It is likely that these flows may have a deleterious effect on Site #0.5.

In 2006, the ICI score for Site #0.5a was within non-significant departure (≤ 4 ICI units) from the WWH criterion. Water quality samples were not collected at this site due to the proximity of Site #0.5. Sites #0.5 and #0.5a are within 200 feet of each other, and are both downstream from CSOs. The difference in scores at these sites in 2006 is not due to number of taxa collected (Site #0.5 had 29 taxa while Site #0.5a had 28 taxa). Rather, Site #0.5a had more Total Caddisflies, a higher Percent Tribe Tanytarsini, a lower Percent Other Dipterans and Non-Insects, and a lower Percent Tolerant Organisms. The major difference between these sites is habitat. Site #0.5 has a sandy substrate, with deep and sluggish flows. Site #0.5a is located in the last riffle on Euclid Creek before its confluence with Lake Erie. The substrate is a mix of cobble and gravel, and flow velocities are better than at #0.5. Site #0.5a, however, was found through dye testing in November 2006 to not be within a location of complete mixing of CSO discharges near Lake Shore Boulevard. Therefore, it is not an appropriate replacement for site #0.5.



Conclusions

Figure 7 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 always 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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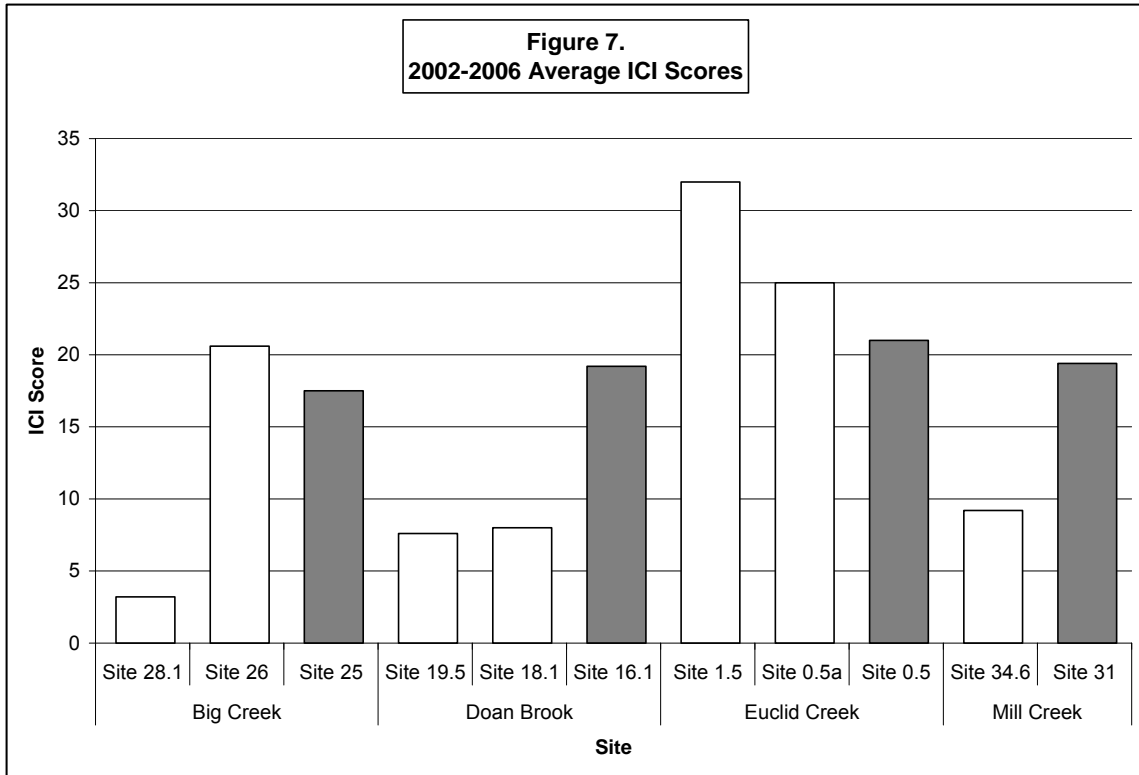
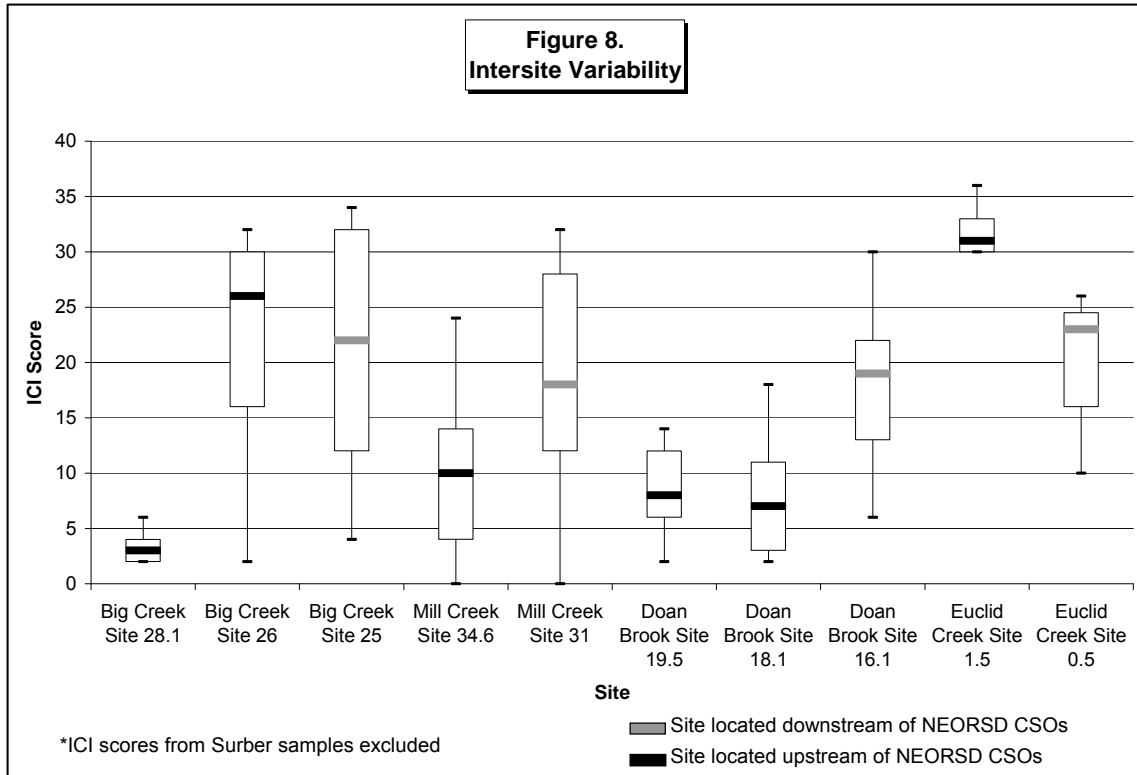


Figure 8 shows the variability of ICI scores for each site, using an averaged ICI score each year from 2002 through 2006. If CSOs were having a very strong impact on downstream sites, it would be expected that the downstream sites would generally have the lowest median scores. The site with the lowest median score (Big Creek Site #28.1) is an upstream site. Doan Brook and Mill Creek had higher median scores at the downstream locations than at the upstream locations.



Due to the fact that Ohio EPA NPDES Permit No. 3PA00002*FD requires only the collection of a benthic macroinvertebrate assemblage at the downstream sites, this assemblage is also the only one collected at the upstream sites. Conditions indicated by the ICI scores would be better defined by collection of a second biological assemblage (i.e. fish). This assemblage would also allow data to be gathered in areas where HDs are typically lost.

Finally, some of the better ICI scores downstream of CSOs could be attributed to more suitable flow regimes in the downstream stretches of the streams. However, we were not able to test this hypothesis. The downstream HD sites are located as close as possible to the creek mouths (per Ohio EPA NPDES Permit No. 3PA00002*FD). Therefore, collections cannot be made any further downstream to look at the impact of flow separated from the impacts of CSOs. An ideal study would sample several sites upstream and downstream of each point source along the river reaches of interest. However, the cost in both time and money of such a study was, at this time, prohibitive.

Overall, macroinvertebrate communities at the downstream locations of each stream indicate nearly as good, if not better, water quality conditions than their respective upstream locations. While poor ICI scores may be due to several conditions at the upstream sites, such as drainage areas less than 20 square miles, poor habitat, poor riparian zone quality and slow velocity, these conditions are

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often also seen at the downstream sites. Therefore, this data may be an indication that CSOs are not the only variable adversely affecting the macroinvertebrate communities located downstream of the discharges. Continued monitoring is necessary to determine long term trends as CSO discharges continue to be controlled.

from the NEORSD service area as part of the 30-Year CSO Control Progr

