NORTHEAST OHIO REGIONAL SEWER DISTRICT

2016 Euclid Creek Environmental Monitoring
Biological, Water Quality and Habitat Survey Results

Prepared by
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Introduction

In 2016, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys on Euclid Creek. Euclid Creek drains the communities of South Euclid, Lyndhurst, Willoughby Hills, Richmond Heights, Highland Heights, Euclid and Cleveland before emptying into Lake Erie. Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by the Ohio Environmental Protection Agency (Ohio EPA) in Fish Community and Benthic Macroinvertebrate Biology, Chemical Water Quality and Stream Habitat Assessments as explained in the NEORSD study plan *2016 Euclid Creek Environmental Monitoring* approved by Ohio EPA on May 17, 2016.

The study objective at river miles (RM) 0.55 and RM 1.65, on the main branch of Euclid Creek, was to assess the attainment status of the stream segments. Stream monitoring at these sites included: fish community surveys, macroinvertebrate community surveys, habitat assessments, and water chemistry sampling. The sites at RM 0.55 and 1.65 are also required under the Ohio EPA National Pollutant Discharge Elimination System (NPDES) Permit No. 3PA00002*HD.

An additional objective at RMs 0.55 and 1.65 was to collect baseline data in support of three NEORSD capital improvement projects. The Euclid Creek Pump Station project began in late 2014 and the Tunnel Dewatering Pump Station and Euclid Creek Tunnel projects began in December 2010. These projects are expected to be complete in summer of 2017. Once complete, these construction projects are anticipated to control the number of CSO discharges to Euclid Creek to less than or equal to one overflow in a typical year.

Post-construction monitoring was also conducted at RM 0.40 where restoration work was completed in January 2013. The purpose of the project was to restore coastal and lacustrine wetlands, increase fish habitat and increase overall ecological function in the lower Euclid Creek. Results from the 2016 fish community surveys, macroinvertebrate community surveys, habitat assessments, and water chemistry sampling were used to help determine what effect, if any, the restoration had on the chemical, biological, and physical characteristics of the restored areas.

Table 1 lists the sampling sites with respect to RM, latitude/longitude, description, and types of surveys conducted, and Figure 1 is a map of the sampling locations on the creek.

Table 1. 2016 Euclid Creek Sampling Sites						
Water Body	Latitude	Longitude	River Mile	Location Information	USGS HUC 8 Number Name	Purpose
Euclid Creek, Main Branch	41.5741	-81.5467	1.65	Upstream of Saint Clair Avenue	04110003 Ashtabula-Chagrin	Evaluate water chemistry, habitat, fish & macroinvertebrates in support of Ohio EPA Permit No. 3PA00002*HD
Euclid Creek, Main Branch	41.5833	-81.5594	0.55	Downstream of Lake Shore Boulevard	04110003 Ashtabula-Chagrin	Evaluate water chemistry, habitat, fish & macroinvertebrates in support of Ohio EPA Permit No. 3PA00002*HD
Euclid Creek, Main Branch	41.5857	-81.5622	0.40	Upstream of Villa Angela Drive bridge	04110003 Ashtabula-Chagrin	Evaluate water chemistry, habitat, fish populations, and macroinvertebrate populations post-restoration.

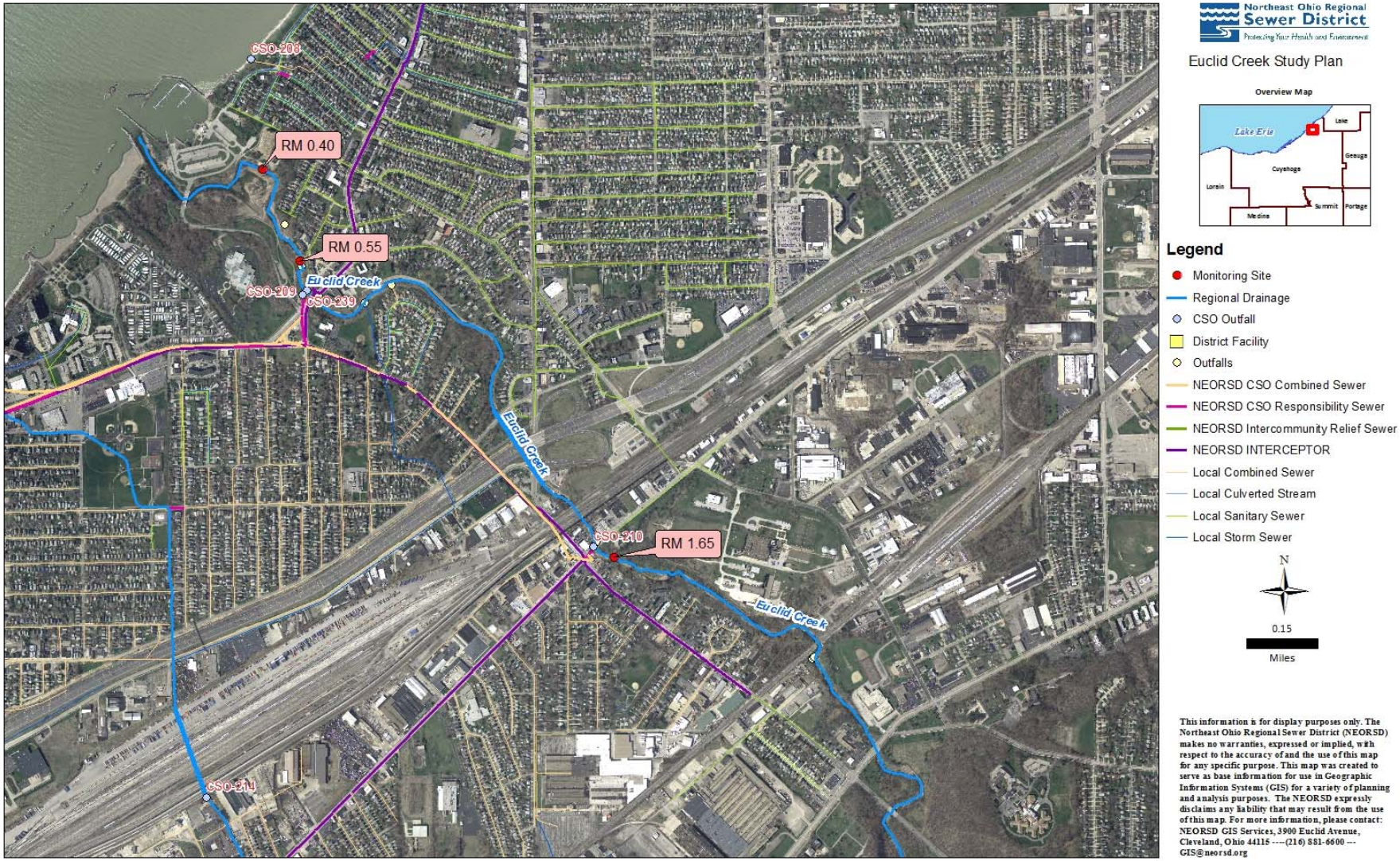


Figure 1. 2016 Sampling Locations on Euclid Creek

Water Chemistry & Bacteriological Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between June 15 and July 12, 2016. Techniques used for sampling and analyses followed the Ohio EPA's *Surface Water Field Sampling Manual for water chemistry, bacteria, and flows* (2013a). Chemical water quality samples from each site were collected with a 4-liter disposable polyethylene cubitainer with a disposable polypropylene lid, three 473-mL plastic bottles and one 125-mL plastic bottle. The first 473-mL plastic bottle was field preserved with trace nitric acid, the second was field preserved with trace sulfuric acid, and the third bottle received no preservative. The sample collected in the 125-mL plastic bottle (dissolved reactive phosphorus) was filtered using a 0.45-µm PVDF syringe filter. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles preserved with sodium thiosulfate. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using either a YSI 600XL sonde or YSI EXO1 sonde. Duplicate samples and field blanks were each collected at randomly selected sites, at a frequency not less than 5% of the total samples collected. Relative percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate sample (Formula 1).

Formula 1:

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

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

The acceptable percent RPD is based on the ratio of the sample concentration and detection limit (Formula 2) (Ohio EPA, 2013a).

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

X = sample/detection limit ratio

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

Results and Discussion

Over the course of the sampling, one field blank was collected for QA/QC purposes on July 5, 2016, at RM 0.40. A total of two water quality parameters were estimated due to potential field blank contamination. It is unclear how the field blanks

became contaminated and may be due to inappropriate sample collection, handling, contaminated blank water and/or interference during analysis. Table 2 lists water quality parameters that were listed as estimated based on Ohio EPA data validation protocol.

Table 2. Potential Field Blank Contamination
COD
Cr

One duplicate sample was collected on July 12, 2016, at RM 0.40 for QA/QC purposes. The duplicate sample collected at RM 0.40 revealed four parameters that were rejected due to RPDs that were greater than the acceptable RPD (Table 3). There are numerous reasons for why parameters were rejected, such as a lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity and/or improper handling of samples.

Table 3. Unacceptable Duplicate RPDs					
Date	River Mile	Parameter	Acceptable RPD (%)	Actual RPD (%)	Qualifier
7/12/2016	0.40	Al	29.6	60.3	Rejected
		COD	50.0	67.6	Rejected
		Fe	21.4	36.4	Rejected
		TSS	40.3	98.3	Rejected

Paired parameters for all samples collected were also evaluated and compared for QA/QC purposes using the same RPD formula as with the duplicate samples. These comparisons revealed no instances in which the subset parameter was greater than the total parameter.

All sites on Euclid Creek are designated as Warmwater Habitat (WWH), Agricultural Water Supply, Industrial Water Supply, and Primary Contact Recreation (Ohio EPA, 2016). The results of the water chemistry and bacteriological samples were compared to the applicable water quality standards to determine attainment status for those designated uses. Of that comparison, exceedances were noted for *Escherichia coli*.

The Primary Contact Recreation criteria for Euclid Creek includes an *E. coli* criterion not to exceed a statistical threshold value (STV) of 410 colony counts per 100 milliliters in more than ten percent of the samples taken during any ninety-day period, and a ninety-day geometric mean criterion of 126 colony counts/100mL (Ohio EPA, 2016). The STV of 410 colony counts/100mL in more than ten percent of the samples collected was exceeded at both RM 0.55 and RM 1.65 for all 90-day periods. The STV at RM 0.40 was exceeded for all 90-day periods except for the one beginning on July 12, 2016. Additionally, all sites exceeded the ninety-day geometric mean criterion of 126 colony counts/100mL for all 90-day periods (Table 4).

Table 4. 2016 Euclid Creek *E. coli* Densities (most probable number/100mL)						
	RM 0.40		RM 0.55		RM 1.65	
Sample Date	*E. coli* (MPN/100 mL)	90-Day Geomean	*E. coli* (MPN/100 mL)	90-Day Geomean	*E. coli* (MPN/100 mL)	90-Day Geomean
6/15/2016	558	2,587	652	1,734	275	838
6/21/2016	27,375	3,796	16,275	2,214	9,300	1107
6/28/2016	896	1,965	628	1,139	317	544
7/5/2016*	10,240	2,910	4,228	1,533	2,889	713
7/12/2016	827	827	556	556	176	176

*Wet weather sampling events: greater than 0.10 inches of rain but less than 0.25 inches, samples collected that day and the following day are considered wet weather samples; greater than 0.25 inches, the samples collected that day and the following two days are considered wet weather samples.

	Exceeds statistical threshold value criterion for 90-day period starting on that date
	Exceeds 90-day geometric mean criterion

There are several possible reasons why these sites exceeded the STV and ninety-day geometric mean criteria. The NEORSD has three CSOs on Euclid Creek and there are additional CSOs upstream in the city of Euclid, all of which may cause elevated *E. coli* densities in the creek during wet-weather overflows. The sampling on July 5, 2016, was considered a wet-weather event. Elevated *E. coli* levels were observed with this wet-weather sampling. *E.* coli densities were highest at all sites on June 21, 2016, which was considered a dry-weather sampling event. While considered a dry-weather event, approximately 0.07 inches of rain fell between 0100 and 0200 hours on June 21, 2016. This rainfall before sampling may have contributed to elevated bacteria levels. Wet-weather may contribute to elevated bacteria levels by causing discharges from CSOs, storm sewer runoff, and urban runoff into Euclid Creek.

Additionally, there are numerous documented improper connections and bacteriologically contaminated storm sewers in the cities of Cleveland and Euclid, which could have an impact on the water quality in Euclid Creek during dry-weather conditions. The issue of storm sewer bacteriological contamination within the Euclid Creek watershed has been thoroughly investigated since 2012 and communicated to the appropriate community for eventual remediation. Between 2013 and 2016, NEORSD revisited many of the documented issues and have found that the majority were still active problems. Finally, bacteriological contamination from failing septic systems in the Euclid Creek watershed may also be impacting the water quality at the sample sites.

Mercury analysis for all of the sampling events was completed using EPA Method 245.1. The detection limit for this method is above the criteria for the Human Health Nondrinking and Protection of Wildlife Outside Mixing Zone Averages (OMZA), so it generally cannot be determined if the sites were in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above the detection limit. Based on the sampling that was

completed, mercury was not present at levels above those normally found in the watershed (USEPA, 2004).

In 2015, the Ohio EPA Nutrients Technical Advisory Group released a proposed Stream Nutrient Assessment Procedure (SNAP) designed to determine the degree of impairment in a stream due to nutrient enrichment. SNAP assigns designations for quality of surface waters based on factors including dissolved oxygen (DO) swings, benthic chlorophyll *a*, total phosphorous, and dissolved inorganic nitrogen (Ohio EPA, 2015a). NEORSD did not assess DO swings or benthic chlorophyll *a* in 2016 at RM 0.40 and RM 1.65; however, nutrients were assessed at these sites. DO swings and benthic chlorophyll *a* were assessed in 2016 just upstream of RM 0.55 along with nutrients.

The location in which chlorophyll *a* levels in Euclid Creek were measured was in the vicinity of a long-term data sonde station. While the primary purpose of the data sonde was to collect DO data, the data sonde also recorded measurements for specific conductance, pH, temperature, and turbidity in 15-minute increments. The data sonde, a YSI 6902V2 sonde, is located at RM 0.68 on the downstream side of the Lakeshore Boulevard bridge in Cleveland, OH (Lat: 41.5822, Lon: -81.5590). This location is approximately 150 meters upstream of the site at RM 0.55. Data from RM 0.55 was also used during the SNAP analysis. The data sonde was calibrated at NEORSD Environmental and Maintenance Services Center per the manufacturer's recommendations. Upon return from the field, data was downloaded and calibrations were checked for continued accuracy.

Chlorophyll *a* samples along with nutrient samples were collected on September 14, 2016. Chlorophyll *a* was analyzed from both the benthos and water column following NEORSD SOP-EA001-01, Chlorophyll *a* Sampling and Field Filtering. For benthic chlorophyll *a* analysis, at least 15 rocks were sampled from a variety of habitats at the sample site. Water chemistry and chlorophyll *a* results are listed below in Table 5.

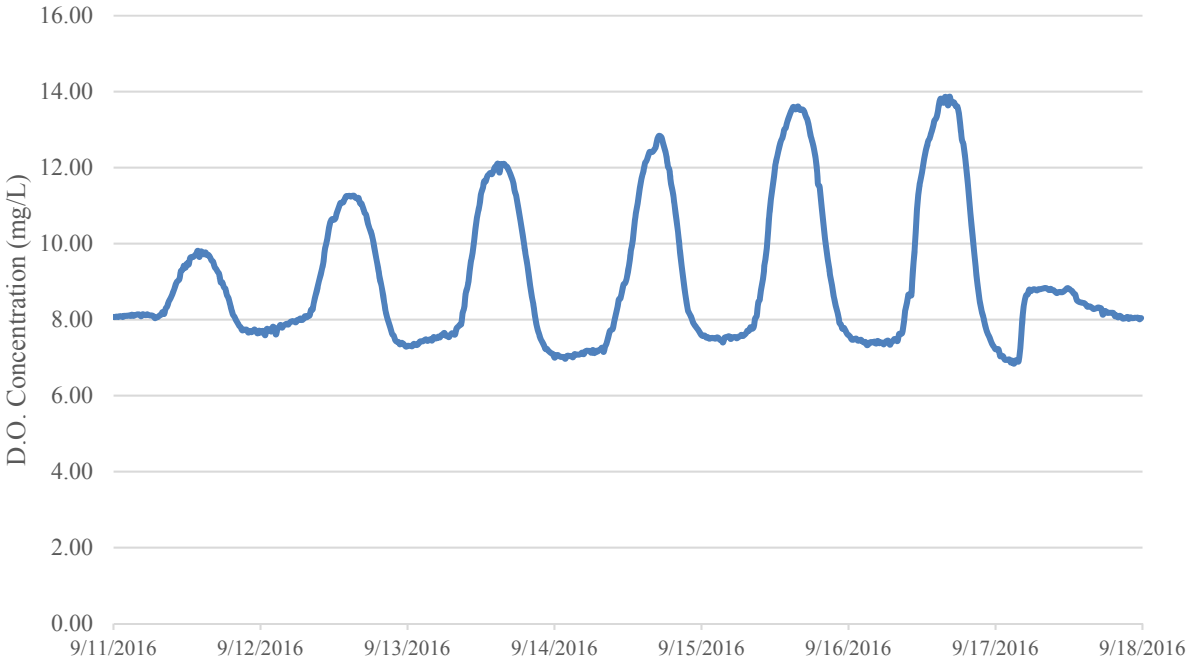
Table 5. 2016 Benthic Chlorophyll *a* Results from 9/14/2016 Sampling

Parameter	Result
Chlorophyll *a* (Water Column)	1.905 µg/L
Chlorophyll *a* (Benthic)	465.9 mg/m^2
Dissolved Inorganic Nitrogen	0.536 mg/L
Dissolved Oxygen Swing	5.86 mg/L
DRP	0.013 mg/L
Total Phosphorus	0.031 mg/L
TSS	0.7j mg/L

DO diel swings were also evaluated from August 30, 2016 through September 18, 2016 (See Figure 2). Daily maximum DO levels and daily minimum DO levels were calculated. The DO diel swing was calculated daily by subtracting the daily minimum

from the daily maximum. DO diel swings used for SNAP evaluation were from the day of sampling (September 14, 2016); however, each day was evaluated to ensure that the swing on the day of sampling was not atypical.

Figure 2. Euclid Creek Dissolved Oxygen Concentrations 9/11/2016-9/18/2016



Biological sampling and a habitat assessment results from 2016 were used in the assessment through SNAP (see Table 6). Per the minimum data requirements of SNAP, biological data was collected at comparable baseflows, but may have experienced changing flow events between the biological collections and chlorophyll *a* collection events. Additionally, biological sampling and the habitat assessment were performed outside the suggested range of time from chlorophyll *a* sampling. However, all data collection occurred during the normal field season during 2016.

Table 6. Biological sampling dates and scores for Euclid RM 0.55		
Sample Type	Date	Score
IBI	8/19/2016	*34*
MIwb	8/19/2016	*7.8*
ICI	7/27/2016 (HD Collection Date)	16
QHEI	6/23/2016	56.75
Italics=non-significant departure of the WWH biocriterion.		

Nutrients were assessed during the chlorophyll *a* sampling. The minimum data requirements suggest at least three samples per location to be reported as a geometric

mean. One set of nutrient data was collected at the same time as the chlorophyll *a* collection on September 14, 2016. Nutrients were also assessed at RM 0.55 for watershed monitoring. Table 7 shows the results of three dry-weather sampling events and the calculated geometric mean and standard deviation as well as the results from September 14, 2016. The nutrient concentrations used in the SNAP analysis were chosen by comparing the geometric mean to the single sampling event. If the single sampling event differed outside the standard deviation, the higher of the two concentrations was used.

Table 7. Nutrient results for Euclid Creek used for SNAP analysis.

Sample Date	6/21/2016	6/28/2016	7/12/16	GeoMean	StdDev	9/14/2016
Total Phosphorus (mg/L)	0.061	0.034	0.032	0.040	0.016	0.031
DRP (mg/L)	0.02	0.012	0.015	0.015	0.004	0.013
Dissolved Inorganic Nitrogen (mg/L)	0.698	0.123	0.064	0.176	0.350	0.536

When questions arose using these numbers, the geometric mean and the measurements taken on 9/14/16 were considered. If the same result was not the output from the tables, the worst case of the two measurements was used.

SNAP uses a variety of flow charts to determine the best course of action for a stream segment. The results of these flow charts are shown in Table 8. Some sections of the flow charts require the use of a best professional judgement and the result could be disputed. However, in the case of a dispute, often the same answer was ultimately reached by both pathways through the flow chart.

Table 8. SNAP flow chart results.

Step/Question	Result/Answer
Step 1-Biological Criteria	Non-attaining (one or more indices below non-significant departure)
Step 2-DO Swing	Normal or low swings (≤6.5 mg/L)
Step 3-Benthic Chlorophyll	High (>320 mg/m^2)
Step 4-Preliminary Assessment	Impaired; likely nutrients over-enriched: See flow chart C
Flow Chart C	
Are stressors unrelated to nutrients responsible for observed conditions?	Yes

Table 8. SNAP flow chart results.	
Step/Question	Result/Answer
Would abatement alone of stressors unrelated to nutrients restore biological condition?	No
Would additional abatement of nutrient stressors restore biological condition?	Table 2
Table 2	Levels typical of developed lands; little or no risk to beneficial use.
Use attainability analysis or collect additional data.	

The results of SNAP at Euclid Creek determined that the best course of action with respect to nutrients is "use attainability analysis or collect additional data." Previous sampling of RM 0.55 revealed that there may be impairments due to sewage contamination of the downstream sections of the creek. Thus, nutrients may be contributing to the non-attainment status of Euclid Creek, but are not the only cause of impairment.

NEORSD did not assess DO swings or benthic chlorophyll *a* at RM 0.40 or RM 1.65 in 2016; however, nutrients were assessed. Table 9 shows the nutrient concentrations for RMs 0.40 and 1.65 in 2016. The results of dissolved inorganic nitrogen and total phosphorous were compared to Table 2 of SNAP. According to this section of SNAP, RM 1.65 exhibits "background levels typical of least disturbed conditions." RM 0.40 exhibits "levels typical of developed lands; little or no risk to beneficial uses," (Ohio EPA, 2015a). This indicated that neither phosphorus or nitrogen are of a significant concern as a primary source of impairment at these two sites.

Table 9. 2016 Euclid Creek Nutrient Trophic Index Scores		
River Mile	Average Total Phosphorus (mg/L)	Average Dissolved Inorganic Nitrogen (mg/L)
1.65	0.035	0.389
0.40	0.051	0.333

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site on Euclid Creek in 2016 using the Qualitative Habitat Evaluation Index (QHEI). The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or

absence of fish species by evaluating the physical attributes of a stream. The index is based on six metrics: stream substrate, instream cover, channel morphology, riparian zone and bank condition, pool and riffle quality, and stream gradient. The QHEI has a maximum score of 100, and a score of 60 or more in streams >20 square miles suggests that sufficient habitat exists to support a fish community that meets the warmwater habitat criterion (Ohio EPA, 2005). A more detailed description of the QHEI can be found in Ohio EPA's *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

A lacustuary QHEI (LQHEI) was also conducted at RM 0.40. The LQHEI is similar to the QHEI in that it assesses aquatic habitat conditions; however, the LQHEI is specific to lacustuary zones. Lacustuary is defined as a transition zone in a river that flows into a freshwater lake and is the portion of the river affected by the water level of the lake (Ohio EPA, 1997). Additionally, the LQHEI is based on only five metrics: stream substrate, cover types, shoreline morphology, riparian bank erosion, and aquatic vegetation quality. A more detailed description of the LQHEI can be found in Ohio EPA's draft *Methods of Assessing Habitat in Lake Erie Shoreline Waters Using the Qualitative Habitat Evaluation Index (QHEI) Approach (Version 2.1)* (2010). According to Ohio EPA (2008), an LQHEI score greater than 55 is considered an acceptable target.

Results and Discussion

QHEI scores on Euclid Creek ranged from *Good* to *Excellent* in 2016. All the sites met Ohio EPA's target score, meaning that these sites have habitat suitable to support a community of warmwater habitat fish species (Table 10). Additionally, RM 0.40 met the LQHEI target score with a narrative rating of *Good*.

Table 10. 2016 Euclid Creek QHEI Results

River Mile	Type	Date	QHEI Score	Narrative
1.65	Wading	8/19/2016	77.75*	*Excellent*
0.55	Wading	6/23/2016	65.25*	*Good*
0.40	Boat	6/30/2016	63.0	*Good*
0.40	Lacustuary	8/4/2016	57.5	*Good*

* Site met Ohio EPA target score of 60

Site met Ohio EPA Lacustuary Qualitative Habitat Evaluation Index target score of 55

Euclid Creek RM 1.65 had the highest QHEI score in 2016, receiving an *Excellent* narrative rating. There were pools greater than 100 centimeters, riffle depths greater than ten centimeters, and riffles and runs with high stability. Cobble and boulder were the predominant substrate types with six of the best types of substrate present in the riffle areas. There was a sparse, but diverse, amount of instream cover including undercut

banks, overhanging vegetation, shallows, rootwads, rootmats, boulders and woody debris. The QHEI score at this site was not significantly different from 2015.

RM 0.55 also exceeded the Ohio EPA's target score of 60 for streams >20 square miles. RM 0.55 was comprised of predominately sand and gravel substrate with moderate instream cover including undercut banks, overhanging vegetation, shallows, logs or woody debris, and rootmats. This site exhibited low stability with no functional riffles. The QHEI score at this site was not significantly different from 2015. In the past, there has been a riffle present at the upstream end of the site at RM 0.55. This riffle has not been functional for multiple years and now appears to act as more of a shallows habitat area during normal flow conditions.

RM 0.40 received a LQHEI score of 57.5, exceeding the Ohio EPA target score. The LQHEI score increased by 13.5 from 2014 sampling. The increase in score was due to an increase in the amount of instream cover and an increase in the aquatic vegetation at the site. RM 0.40 also received a QHEI score of 63; exceeding the Ohio EPA target score. The QHEI score increased by 13.75 from 2014 sampling. The increase in score was due to an increase in the amount of instream cover and improved pool and glide quality reported since 2014.

Electrofishing

Methods

Two quantitative electrofishing passes were conducted at RM 0.55 and 1.65 (wading sites) and at RM 0.40 (boat site) in 2016. A list of the dates when the surveys were completed, along with flow as measured at the United States Geological Survey gage station 04208700 in Cleveland, is displayed in Table 11. Sampling was conducted using longline electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream. The sampling zone was 0.20 kilometers for the wading sites. RMs 1.65 and 0.55 are considered wading sites (drainage area >20 square miles). Euclid Creek RM 0.40 was sampled using boat electrofishing techniques and consisted of shocking all habitat types within a sampling zone (0.5 kilometers) while moving from upstream to downstream. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified, weighed and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

Table 11. 2016 Euclid Creek Electrofishing Surveys

Site	Date	Stream Discharge (ft^3/s)#
1.65	6/23/2016	8.2
	8/19/2016	20

Table 11. 2016 Euclid Creek Electrofishing Surveys		
0.55	6/23/2016	8.2
	8/19/2016	20
0.40	6/30/2016	5.8
	8/26/2016	18
[#] Approved flow data obtained from USGS 04208700 Euclid Creek flow gauge in Cleveland, Ohio		

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices, the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb). The IBI incorporates 12 community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12. The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional, Good, Marginally Good, Fair, Poor* or *Very Poor*. RM 0.40 was also evaluated using the lacustuary IBI (LIBI), due to its location near the mouth of the river. The 12 metrics utilized for wading and lacustuary sites are listed in Table 12.

Table 12. IBI Metrics	
Wading	Lacustuary
Total Number of Native Species	Total Number of Native Species
Number of Darter species	Number of Benthic Species
Number of Sunfish Species	Number of Sunfish Species
Number of Sucker Species	Number of Cyprinid Species
Number of Intolerant Species	Percent of Phytophilic Individuals
Percent Tolerant Species	Percent of Top Carnivores
Percent Omnivores	Number of Intolerant Species
Percent Insectivores	Percent of Omnivores
Percent Top Carnivores	Percent of Non-indigenous Individuals
Percent Simple Lithophils	Percent of Tolerant Individuals
Percent DELT Anomalies	Percent with DELT Anomalies
Number of Fish	Number of Fish

The second fish index utilized by Ohio EPA is the Modified Index of Well-being (MIwb). The MIwb, Formula 3 below, incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (H) (Formula 4 below) based on numbers and weight of fish. The MIwb is a result of a mathematical calculation based upon the formula.

Formula 3: $$MIwb = 0.5\ lnN + 0.5\ lnB + \overline{H}(No.) + \overline{H}(Wt.)$$

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

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

An MIwb score ≥ 7.9 (*Good*) is in attainment of the WWH biocriterion for wading sites in the EOLP ecoregion. An MIwb score of 7.4 (*Marginally Good*) is also in attainment, as it is considered non-significant departure (≤ 0.5 MIwb units) from the criterion. An MIwb score of ≥ 8.6 (*Marginally Good*) is in attainment of the proposed interim lacustuary biocriterion for boat sites in the EOLP ecoregion.

Results and Discussion

RM 1.65 was in non-attainment of the WWH biocriteria and received an average IBI score of 25 and an average MIwb score of 4.9. The IBI metrics that received the highest scores (5) were for the Proportion of Omnivores, Proportion of Simple Lithophils, and Proportion with DELT Anomalies for both passes. The majority of the remainder of the metrics received the lowest score (1), with a majority of the fish collected being highly tolerant to pollution such as common white sucker (*Catostomus commersonii*), blacknose dace (*Rhinicthys atratulus*), and creek chub (*Semotilus atromaculatus*). The low score at this site may be due to the East 185th Street dam located at RM 1.50, which acts as a migration barrier preventing upstream fish passage. Therefore, attainment of the fish biocriteria at this site may never be achievable unless the dam is removed. Other contributing factors such as CSO discharges, improper connections, and urban runoff may be negatively impacting the fish community at this site as well.

RM 0.55 met the MIwb biocriterion for the first pass and received an average MIwb score of 8.0 (*Good*) and an average IBI score of 35 (*Marginally Good*), which is in non-significant departure of the WWH biocriterion. Collections from the two passes consisted of five species of fish that are moderately intolerant to pollution: golden redhorse (*Moxostoma erythrurum*), silver redhorse (*Moxostoma anisurum*), sand shiner (*Notropis stramineus*), smallmouth bass (*Micropterus dolomieu*), and northern logperch darter (*Percina caprodes*). The IBI metrics that received the highest scores (5) for both passes was the Number of Native Species, Number of Sucker Species, and Proportion of DELT Anomalies. Both passes also consisted of a higher number of native species and a higher number of sucker species as compared to sampling in 2015; these contributed to the increase in average IBI score of 3 points (Table 13).

Table 13. 2016 Euclid Creek IBI & MIwb Results

Site	Type	Date	IBI	MIwb
RM 1.65	Wading	6/23/16	26	4.5
		8/19/2016	24	5.2
RM 0.55	Wading	6/23/2016	*36*	**8.2**
		8/19/2016	*34*	*7.8*
RM 0.40	Boat	6/30/2016	26	*7.7*
		8/26/2016	22	*7.5*
RM 0.40	Lacustuary	6/30/2016	27	7.7
		8/26/2016	20	7.5

IBI criteria wading ≥38, boat ≥40 ; MIwb criteria wading ≥7.9, boat ≥8.7

Bold = meets biocriterion

Italics=Non-significant departure [IBI wading ≥34, boat ≥36; MIwb wading ≥7.4, boat ≥8.2]

*=Lacustuary Proposed Interim Criteria IBI ≥42; MIwb ≥8.6

RM 0.40 was evaluated for the IBI and received an average score of 24 (*Poor*). The IBI score remains unchanged from the 2014 score. RM 0.40 received an average MIwb score of 7.6 (*Fair*). The MIwb has increased since 2014, indicating that there may be small improvements in fish density and diversity at RM 0.40. More than fifty-percent of the catch from both passes were species defined as highly pollution tolerant. Additionally, no intolerant species or round-bodied sucker species were collected during either of the passes contributing to the non-attainment of the biocriterion.

The proposed interim criterion for the LIBI is ≥42 (*Good*) and RM 0.40 received an average LIBI score of 24 (*Poor*). The highest scoring metrics at RM 0.40 were Number of Native Species, Number of Cyprinid Species and Number of Phytophilic Individuals. Twenty-five-percent of the catch in the first pass and fifteen-percent of the second pass was comprised of phytophilic fish (fish that spawn on vegetation). These

species include golden shiner (*Notemigonus crysoleucas*), largemouth bass (*Micropterus salmoides*), pumpkinseed sunfish (*Lepomis gibbosus*) and yellow perch (*Perca flavescens*). This site was evaluated post-restoration in 2014 using the LIBI and received a score of 24. The LIBI score remains unchanged from 2014, indicating no significant improvement in fish biology at this site. During NEORSD's 2010 pre-restoration monitoring, RM 0.20 (located within the restoration zone) obtained an average LIBI score of 36 (*Fair*), also failing to meet the proposed biocriterion. Continued biological monitoring at this site is important in order to evaluate the long-term effectiveness of the habitat improvements made.

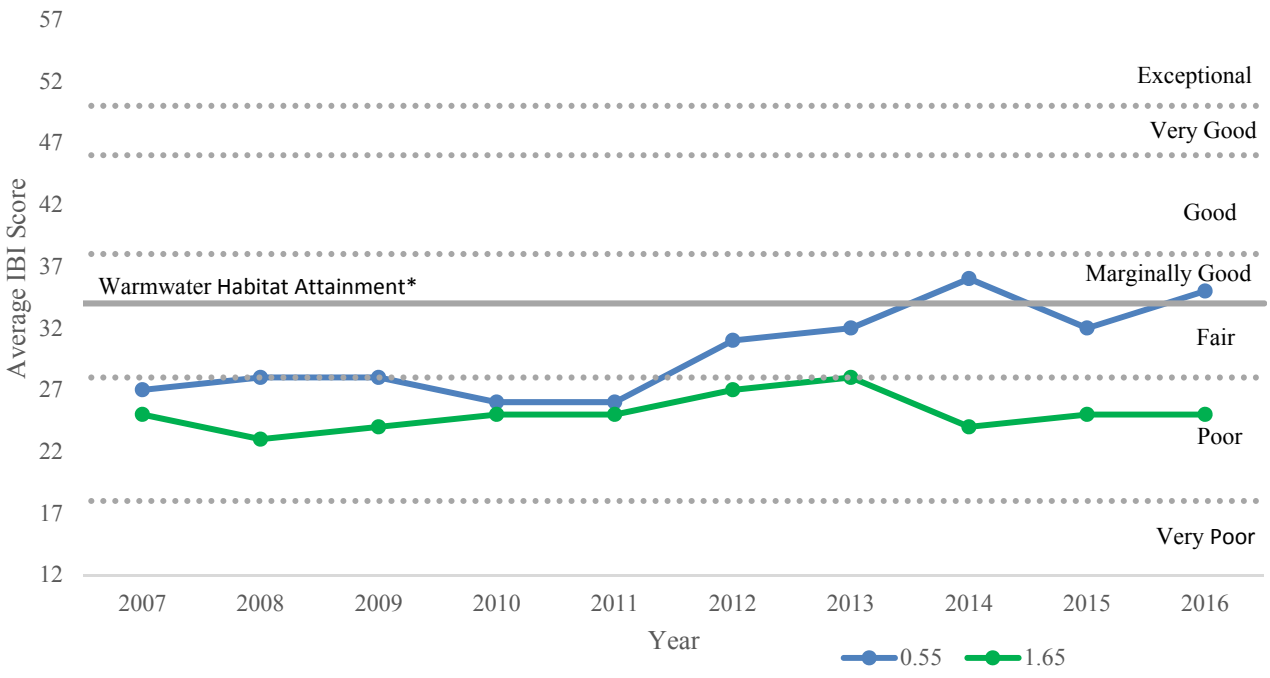
RMs 1.65 and 0.55 have been evaluated for fish since as early as 2007 in order to determine the impact that NEORSD-owned CSOs may have on downstream biological communities. In 2016, RM 0.55 scored higher than the upstream site; however, again, this is most likely due to the East 185th Street dam that is impeding fish movement upstream. Historical IBI data on Euclid Creek at RM 1.65 shows consistent scoring, again possibly attributable to the dam that may be preventing a diverse and healthy fish community at these sites (Table 14 and Figure 3). RM 0.55 has shown an overall increase in scoring, with 2014 being the highest ever IBI score and 2016 being the highest MIwb score for the site since NEORSD began conducting sampling.

Table 14. 2007 - 2016 Euclid Creek Average IBI & MIwb Scores

	RM 1.65		RM 0.55	
Year	IBI	MIwb	IBI	MIwb
2007	25	5.2	27	7.4
2008	23	6.2	28	7.4
2009	24	6.2	28	6.9
2010	25	5.5	26	6.6
2011	25	4.9	26	6.8
2012	27	6.2	31	**7.6**
2013	28	5.6	32	7.3
2014	24	4.9	**36**	7.0
2015	25	5.4	32	6.9
2016	25	4.9	**35**	**8.0**

Bold indicates nonsignificant departure of WWH biocriterion

Figure 3: Historic IBI Scores at Euclid Creek RMs 1.65 and 0.55



*Non-significant departure (≤4 IBI units) from applicable criterion.

In 2016, RM 1.65 was in non-attainment of the WWH biocriteria for IBI and MIwb. RM 0.40 within the restoration area was also in non-attainment of the WWH biocriteria for LIBI , IBI and MIwb. Euclid Creek RM 0.55 was in non-significant departure of the WWH MIwb biocriteria for IBI and MIwb. This is the first year that RM 0.55 has been in full-attainment of the WWH biocriteria for fish since sampling began in 2007.

Macroinvertebrate Sampling

Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa, inhabiting available habitats at the time of HD retrieval. Sampling was conducted at RMs 1.65, 0.55, and 0.40. The sampling at RM 0.40 consisted of two HDs; one HD placed in the stream channel and one HD in the south end of the restored wetland area. Methods for sampling followed the Ohio EPA's Biological Criteria for the Protection of Aquatic Life, Volume III (1987b). The recommended period for HDs to be installed is six weeks.

The macroinvertebrate samples were sent to Third Rock Consulting of Lexington, Kentucky, for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as defined by the Ohio EPA (1987b). Lists of the species collected during the quantitative and qualitative sampling at each site are available upon request from the WQIS Division.

The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA's Invertebrate Community Index (ICI) (Ohio EPA 1987a). The ICI consists of ten community metrics (Table 15), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while Metric 10 is based on the qualitative EPT taxa. The total of the individual metric scores result in the overall score. This scoring evaluates the community against Ohio EPA's reference sites for each specific eco-region.

Table 15. ICI Metrics
Total number of taxa
Number of mayfly taxa
Number of caddisfly taxa
Number of dipteran taxa
Percent mayflies
Percent caddisflies
Percent Tanytarsini midges
Percent other diptera and non-insects
Percent tolerant organisms (as defined)
Number of qualitative EPT taxa

Results and Discussion

In 2016, HDs were installed at Euclid Creek RM 1.65, 0.55 and 0.40 and all were retrieved along with a qualitative sampling at all sites. RM 1.65 was in attainment of the WWH ICI biocriterion; however, RM 0.55, and RM 0.40 were not (Table 16).

Table 16. 2016 Euclid Creek Macroinvertebrate Results						
River Mile	ICI Score	LICI Score	Narrative Rating	Total Quantitative Taxa	Total Qualitative Taxa	Total Qualitative EPT Taxa
1.65	**38**		*Good*	33	26	7
0.55	16		*Fair*	19	19	0
0.40	20	28	*Fair*	23	32	2
Bold indicates attainment of WWH biocriterion						

RM 1.65 obtained the highest ICI score (38) in 2016 with a narrative rating of *Good.* The highest scoring metrics were Number of Caddisfly Taxa, Percent Caddisflies, Percent Tanytarsini Midges and Percent Tolerant Organisms. Additionally, five taxa collected were considered moderately intolerant of pollution. RM 1.65 has been sampled for macroinvertebrates since 2002 (Table 17). Of nine years of sampling, six of the years were in attainment of the WWH ICI biocriterion. This site received an ICI score of 36 in 2015. The reason the score increased in 2016 was due to the increase in the Percent Tanytarsini Midges from 2015 (Figure 4).

RM 0.55 received ICI scores of 16 in 2016 with a narrative rating of *Fair.* The highest scoring metric was Percent Tanytarsini Midges and Percent Tolerant Organisms. RM 0.55 has been sampled for macroinvertebrates since 2002 (Table 17). Of these samples, two years were in attainment of the WWH ICI biocriterion. This site received a score of 34 in 2013 and 2014. The reason for the significant score decrease in 2015 and 2016 was due to a decrease in Total Number of Taxa, Number of Caddisfly Taxa, Percent Mayflies and Percent Caddisflies.

Table 17. 2002– 2016 Euclid Creek ICI Scores

Year	RM 1.65	RM 0.55
2002	--	25
2003	--	26
2004	--	14
2005	--	16
2006	--	24
2007	26	22
2008	26	12
2009	**38**	24
2010	**42**	18
2011	**36**	24
2012	**36**	24
2013	Fair	**34**
2014	*30*	**34**
2015	**36**	18
2016	**38**	16

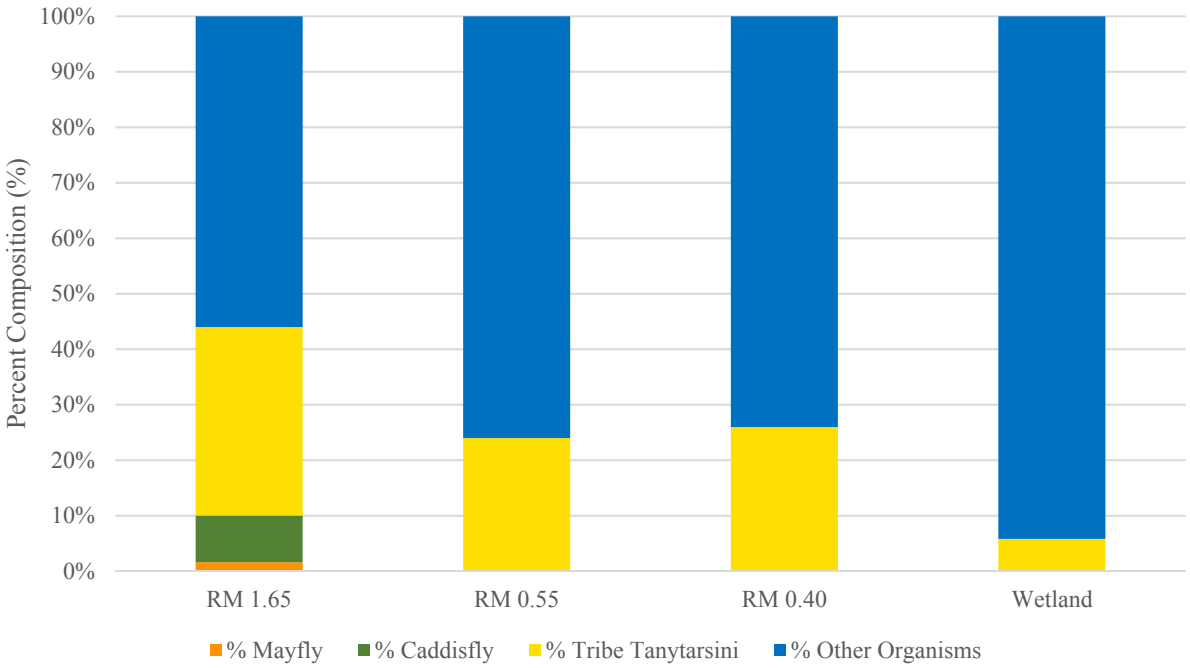
Bold indicates attainment of WWH biocriterion

Italics indicates non-significant departure of WWH biocriterion

--Macroinvertebrates not evaluated

HD not collected; qualitative assessment only

Figure 4: 2016 Macroinvertebrate Community Composition

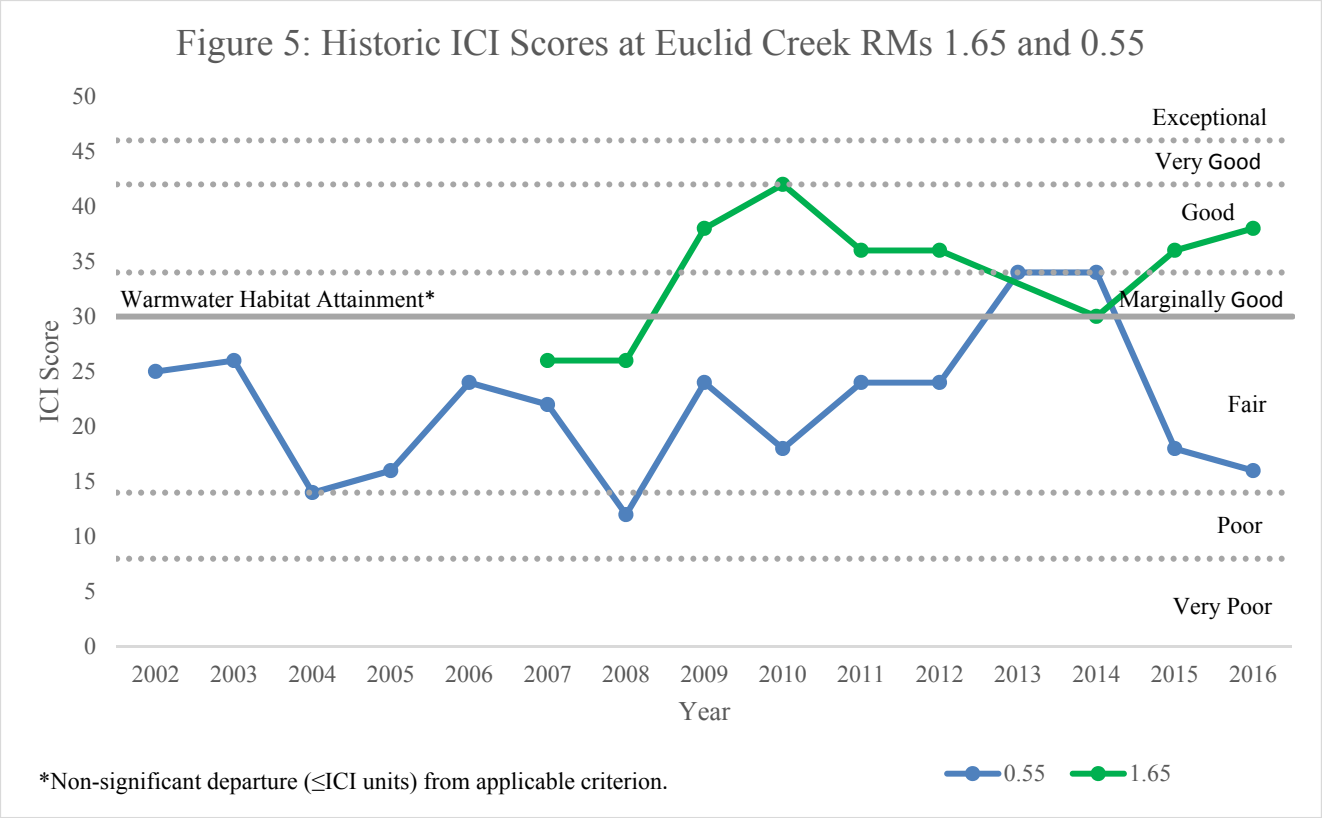


At RM 0.40, the LICI score was calculated at 28 (*Fair*), failing to meet the proposed interim criterion of 34. The HD at RM 0.40 was comprised of 23 taxa and had one metric, Percent Collector-Gatherer Taxa, receive the highest score of 6. One species collected, *Chimarra aterrima*, is moderately intolerant to pollution. RM 0.40 also exhibited a high Percent Diptera and Non-Insects and a high Dipteran Abundance. While the LICI score at this site decreased from 52 in 2014, the number of organisms present on the HD were found to have increased by greater than three-fold. There was a decrease in the stream velocity over the HD as compared to the sampling in 2014 at this site. A minimum stream velocity of 0.30 feet per second has been demonstrated to have a high influence on macroinvertebrate populations second only to water chemistry (DeShon, 1995). The flow in 2016 at the time of collection was 0.23 feet per second as compared to the 2014 flow velocity of 0.53 feet per second. This decrease in flow may have contributed to the decrease in the LICI score. Similarly, there was a decrease in ICI score at RM 0.40 from 2014. The ICI decreased by 18 during this time. The decrease in ICI and LICI scores was due to a decrease in both Total Quantitative and Qualitative (EPT) Taxa, Total Sensitive Taxa, and Percent Tolerant Organisms.

The wetland area at RM 0.40 was also assessed for macroinvertebrates. The ICI and LICI are not intended to be used in wetland areas due to a general lack of flow and different habitat conditions. Instead, specific characteristics of the macroinvertebrate community were examined to determine if the wetland was functioning as intended. One of the goals for the restoration project was to increase the number of filter-feeding midges (*Dicrotendipes neomodestus*, *Paratendipes albimanus*, *Tanytarsus glabrescens grp*. and

Paratanytarsus) in the wetland area (Riverworks, 2013). In 2016, only 5.8% of the total organisms collected on the HD that was installed there belonged to one of those four taxa, which was significantly lower than both the project goal and the adjacent stream area (65.6% of total organisms collected). The total number of taxa collected in the wetland was 45, which was similar to what was found in the stream. The dominant organisms, however, were Oligochaeta and *Dicrotendipes simpsoni*, two pollution-tolerant collector-gatherers. Although DO was not collected in the wetland area, low oxygen levels may be present there, especially during low-flow conditions in the summer, based on the types and number of macroinvertebrates collected.

RMs 1.65 and 0.55 have been evaluated for macroinvertebrates since as early as 2002 to help determine the impact that NEORSD-owned CSOs may have on downstream biological communities (Table 17 and Figure 5). In 2016, RM 1.65 was in attainment and RM 0.55 was not in attainment of the WWH ICI biocriterion; therefore, NEORSD-owned CSOs may have had a negative impact on the health of the macroinvertebrate community in 2016. However, other factors may have also had an influence on the score. At RM 0.55 in 2015 and 2016, the HD was in a different location during the sampling, which may account for some of the difference in scores from 2014. Furthermore, the flow regime at RM 0.55 has been in an alternating state potentially due to the wetland restoration downstream. There is no longer a functional riffle within the site and this may be causing changes within the macroinvertebrate populations. The flow over the HD in 2016 was measured at 0.08 feet per second when the HD was installed and 0.33 feet per second when the HD was removed. Flow less than 0.30 feet per second is considered inadequate for proper sampling and may have also influenced the colonization of the HD. Additionally, it was noted on the field sheet that the some of the HD blocks were partially buried. This would impede proper colonization of the HD and was a result of the sand sediment present at this site. Furthermore, the site location is within a recreational park and has the potential to be disturbed by visitors. Additionally, there are known illicit connections that discharge to Euclid Creek near RM 0.55. Furthermore, RM 0.55 is considered to have lacustuary influences. These influences may have an impact on the macroinvertebrate populations contributing to the non-attainment of the WWH ICI biocriterion. Sampling of RM 0.55 and 1.65 will be conducted again in 2017. This will help determine if the low ICI score at RM 0.55 in 2015 and 2016 is a trend.



Conclusions

The results of NEORSD's water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys indicate that the Euclid Creek watershed may be impacted by a variety of aquatic habitat limitations and environmental stressors, as mentioned previously. Biological assessments that were conducted at all three sites showed non or partial attainment of WWH biological criteria (Table 18). The East 185th dam, located downstream of RM 1.65, is inhibiting fish migration to the upper reaches of the watershed. This may account for RM 1.65 being in attainment for the macroinvertebrate community assessment, but being in non-attainment for the fish community assessments. There is sufficient habitat at all three sites to support a robust fish community. Water chemistry results at all sites exhibited exceedances for *E. coli*, an indicator of sewage contamination. Potential sources of pollution include illicit discharges, CSO discharges and urban runoff. This contamination may be responsible for the non-attainment of RM 0.1.65 and 0.40 and may also be negatively impacting RM 0.55.

Table 18. 2016 Euclid Creek Survey Results

River Mile	Aquatic Life Use Attainment Status	Average IBI Score (*Narrative Rating*)	Average MIwb Score (*Narrative Rating*)	ICI Score (*Narrative Rating*)	QHEI Score (*Narrative Rating*)	Water Quality Exceedances
1.65	NON	25 *Poor*	4.9 *Poor*	38 *Good*	77.75 *Excellent*	*E. coli*
0.55	PARTIAL	35 *Marginally Good*	8.0 *Good*	16 *Fair*	65.25 *Good*	*E. coli*
0.40	NON	24 *Poor*	7.6 *Fair*	20 *Fair*	63 *Good*	*E. coli*
0.40 Lacustuary	NON	24 *Poor*	7.6 *Fair*	28 *Fair*	57.5 *Good*	*E. coli*
WWH biocriterion attainment: IBI score of 38; MIwb score of 7.9; ICI score of 34						
Non-significant departure: ≤4 IBI units; ≤0.5 MIwb units; ≤4 ICI units						
Lacustuary criteria for LQHEI, LIBI, and LICI						

One of the objectives of this study was to determine the impact of NEORSD-owned CSOs on the downstream biological community at RM 0.55. Macroinvertebrate assessments at RM 0.55 showed that the benthic community was not meeting the WWH ICI biocriterion, but this site has only met the criteria twice in 14 years of sampling. RM 1.65, which is located upstream of NEORSD-owned CSOs, was in attainment of the WWH ICI biocriterion. Additionally, a restoration project was recently completed at RM 0.40 and was anticipated to increase the overall health of lower Euclid Creek. It is recommended that further fish assessments at RM 0.40 continue in order to monitor attainment status as the site has time to further stabilize.

Overall, the water quality status of the Euclid Creek watershed is fair. Many of the sites may be negatively impacted by sources of pollution associated with bacteriological contamination from CSO discharges, improper connections, failing septic systems, and urban runoff. Moreover, documented storm sewer bacteriological contamination in Cleveland and Euclid remains an issue. Until these problems are remediated, bacteriological contamination continues to be an important concern by NEORSD for Euclid Creek.

Future monitoring of Euclid Creek will be vital as current and proposed NEORSD capital improvement projects are anticipated to control the number of CSO discharges to Euclid Creek. The Tunnel Dewatering Pump Station and Euclid Creek Tunnel projects began in December 2010 and the Euclid Creek Pump Station project began in the fall of 2014 with an anticipated completion in the summer of 2017 for these projects. Further

sampling post-construction will help determine the effectiveness of the projects and any improvements on the water quality, habitat and biological communities in Euclid Creek.

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