NORTHEAST OHIO REGIONAL SEWER DISTRICT

2013 Shaw Brook Biological, Habitat, and Water Chemistry Assessment Study

Prepared by
Water Quality and Industrial Surveillance Division

Introduction

In 2013, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate surveys on Shaw Brook, a tributary to Lake Erie, at river mile (RM) 0.40. The data collected were evaluated to determine the extent to which the downstream biological communities may be impacted by combined sewer overflow (CSO) discharge points and other environmental impairments. Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by the Ohio Environmental Protection Agency (EPA) in Fish Community, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessments as explained in the NEORSD study plan *2013 Shaw Brook Environmental Monitoring*, approved by the Ohio EPA on July 10, 2013. Shaw Brook was evaluated at RM 0.40 using Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), and Invertebrate Community Index Score (ICI).

Shaw Brook has not been assigned an aquatic life use designation. As of October 2013, the *Ohio Administrative Code* 3745-1-07 (Ohio EPA, 2009) indicated that the Class B primary contact recreation designated use, as well as the Outside Mixing Zone Maximum (OMZM) and Outside Mixing Zone Average (OMZA) water quality criteria identified for warmwater habitat use designation, apply to water bodies not assigned an aquatic life use designation. In 2013, chemical water quality criteria identified for the warmwater habitat (WWH) use designation were applied to Shaw Brook. Class B primary contact recreational use criteria for *Escherichia coli* (*E. coli*) were also applied to this site.

Table 1 provides GPS coordinates recorded at the downstream end of the electrofishing zone, site description, hydrological unit code (HUC), and types of surveys conducted at Shaw Brook RM 0.40. Figure 1 is a map of the sampling location. Shaw Brook is extensively culverted both upstream and downstream of the sampling site. The upstream section of Shaw Brook south of Interstate Route 90 has been diverted to the Easterly Main Branch Interceptor at combined sewer overflow (CSO) 232. CSO-232 is a

Table 1. Site Description

Location	Latitude	Longitude	River Mile	Description	HUC 8	Purpose
Shaw Brook	41.5554	-81.6018	0.40	Upstream of Lakeshore Boulevard	Ashtabula-Chagrin 04110003	Evaluate impacts to fish, macroinvertebrates, water chemistry, and habitat

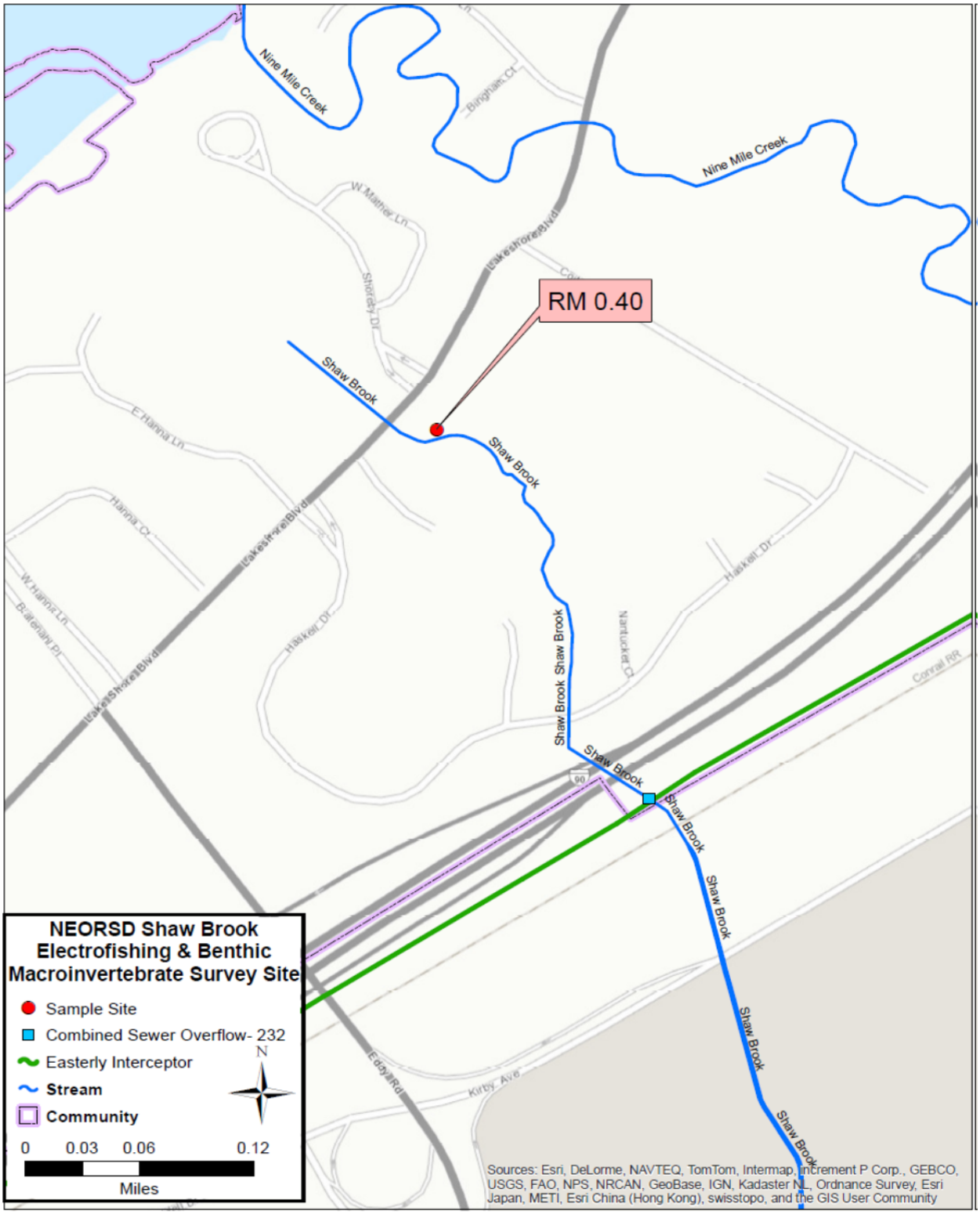

Figure 1. Sampling Location

leaping weir which allows elevated flows from the upstream section of Shaw Brook, south of I-90, to discharge to the downstream section, north of I-90 and CSO-232, during wet weather events.

Water Chemistry and Bacteriological Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between July 23, 2013, and August 20, 2013, on Shaw Brook at RM 0.40. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual* (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 a 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 a YSI 600XL 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.

Mercury analysis for all of the sampling events was done using EPA Method 245.1. Because the detection limit for this method is above the criteria for the Human Health Nondrinking and Protection of Wildlife OMZA, it generally cannot be determined if Shaw brook was in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above those levels typically found in the brook.

Results and Discussion

Shaw Brook is not assigned an aquatic life use designation. However, the OMZM and OMZA water quality criteria identified for WWH use designation apply to water bodies not assigned an aquatic life use designation (Ohio Administrative Code 3745-1-07). Therefore the WWH designated use was applied. The Lake Erie Drainage Basin (LEDB) human health non-drinking water criteria and the wildlife criteria also apply. The water chemistry samples collected at each site were compared to the applicable Ohio Water Quality Standards for the designated uses to determine attainment.

Based on Ohio EPA data validation protocol, four parameters were rejected for comparison to water quality standards due to unacceptable RPDs between duplicate samples collected on July 23rd, 2013. Table 2 gives results of the duplicate samples from those parameters rejected due to high RPD, which include aluminum, ammonia, lead, and tin. These samples were collected during a wet weather event at RM 0.40.[1] The

Table 2. RPD Rejected Parameters

Date	Parameter	Result	Acceptable RPD	Actual RPD	Qualifier
7/23/2013	Al	182	26.4	35.3	Rejected
7/23/2013	Al	127.4			
7/23/2013	NH3	0.398	22.6	86.3	Rejected
7/23/2013	NH3	0.158			
7/23/2013	Pb	4.006	27.6	38.0	Rejected
7/23/2013	Pb	2.728			
7/23/2013	Sn	0.178	99.7	187.1	Rejected
7/23/2013	Sn	5.351			

[1] 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.

increased flow at the sampling site may have resulted in less homogenization of the stream, due to runoff and potential overflow at CSO-232 upstream of the sample site, which may have resulted in the differences observed between the samples.

Due to possible contamination in the field blank performed on August 6th, 2013, an additional five parameters were rejected, estimated, or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol. It is unclear how the field blanks became contaminated. This may have been due to inappropriate sample collection and/or handling, contaminated blank water, and/or interference during analysis. Data validation for field blanks was calculated according to the methods described in the Ohio EPA *Surface Water Field Sampling Manual* (2013a). Data were qualified using the Sample/Field Blank Signal Ratio, which is the ratio of the concentration of the analyte measured in the sample to the concentration of the analyte measured in the field blank on the day in which the field blank was collected. Table 3 lists the results of water quality parameters that were rejected, estimated, or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol. Tin was found to be present in the field blank at levels greater than the corresponding practical quantitation limit (PQL), with a low Sample/Field Blank Signal Ratio, resulting in rejection of the data. Chromium, nitrate/nitrite, antimony, and total Kjeldahl nitrogen (TKN) were found to be present in the field blank at levels in between the method detection limit (MDL) and the PQL with moderate Sample/Field Blank Signal Ratios, resulting in the data being either estimated or downgraded from Level 3 to Level 2 quality data.

Table 3. Field Blank Qualifiers

Date	Parameter	Sample/Field Blank Signal Ratio	Interpretation
8/6/2013	Chromium	3.6	Downgraded to Level 2
8/6/2013	Nitrate/Nitrite	3.7	Downgraded to Level 2
8/6/2013	Antimony	3.3	Downgraded to Level 2
8/6/2013	Tin	0.1	Rejected
8/6/2013	TKN	5.4	Estimated
Data Qualification Ranges for Sample/Field Blank Signal Ratios Ratio ≤ 3 Rejected 3 < Ratio ≤ 5 Downgraded 5 < Ratio ≤ 10 Estimated			

All results for mercury at Shaw Brook RM 0.40 were below the MDL for mercury. Mercury did not exceed the OMZM and OMZA criteria for WWH aquatic life. Mercury

may have exceeded the human health nondrinking OMZA and Wildlife OMZA criterion as these criterion values are lower than the MDL for mercury according to the EPA Method 245.1.

Dissolved oxygen was found to be lower than the required OMZM criterion value for warmwater habitat aquatic life on all sampling dates. Table 4 lists the results for dissolved oxygen for all samples collected at Shaw Brook RM 0.40 during the 2013 field season. The lack of mixing of the surface water with atmospheric oxygen, caused by the slow current velocity and the absence of functional riffles observed at this site, contributes to the low levels of dissolved oxygen at Shaw Brook RM 0.40 (see the section "Habitat Assessment"). Additionally, oxidizable wastes present in sanitary sewage can lead to depletion of dissolved oxygen in streams as they are metabolized by naturally occurring aerobic bacteria (California State University 2008). Therefore, sanitary sewage contamination at this site, indicated by the high levels of *E. coli* observed at RM 0.40 (Table 5), may also contribute to the low levels of dissolved oxygen.

Table 4. Dissolved Oxygen

Date	Dissolved Oxygen (mg/L)	Criterion (mg/L)
7/23/2013	3.32	4.00
7/30/2013	2.59	4.00
8/6/2013	0.28	4.00
8/13/2013	2.30	4.00
8/20/2013	0.72	4.00

Class B primary contact water quality criteria were applied to Shaw Brook RM 0.40. The bacteriological criteria for *E. coli* consist of two components, a seasonal geometric mean and a single sample maximum not to be exceeded in more than 10% of the samples collected during a 30-day period. These criteria for Class B primary contact water are 161 colony-forming units per 100 milliliters (CFU/100mL) and 523 CFU/100mL, respectively. Table 5 lists all of the *E. coli* results from Shaw Brook RM 0.40 measured during the 2013 field season. Both the seasonal geometric mean and the single sample maximum criteria were exceeded for all 30 day periods, beginning on each sampling date, in which sampling was performed during the 2013 field season. The high *E. coli* levels observed at this site are most likely due to the presence of CSO-232, located upstream of RM 0.40. Samples collected on July 23, 2013, were collected during a wet weather event which may have resulted in a discharge from CSO-232 to the downstream

section of Shaw Brook. This may account for the high levels of *E. coli* observed on this date.

Table 5. *E. coli* levels		
Date	***E. coli* (CFU/100mL)**	**Single Sample Maximum Criterion Exceedance**
7/23/2013	10300*	Yes
7/23/2013	10000*	Yes
7/30/2013	3000	Yes
8/6/2013	6000	Yes
8/13/2013	7600	Yes
8/20/2013	1600	Yes
Seasonal Geometric Mean (CFU/100mL)		**Criterion (CFU/100mL)**
4670.2		161
* Samples were collected during a wet weather event (See subscript on Page 5 for definition of wet weather event).		

Ohio EPA's Trophic Index Criterion assigns designations for quality of surface waters based on multiple factors including nutrients, periphyton, dissolved oxygen, and biological assemblages. This criterion was published in 2011 as a draft, and in March 2013, some aspects of the paper were published in a document called, "Trophic Index Criterion- Rationale and Scoring" (Ohio EPA, 2013b). The scoring places the streams into one of three categories: impaired, threatened, or acceptable. NEORSD does not assess periphyton; however, nutrients were assessed. The scoring for the nutrient component is based on levels of Total Phosphorus and Dissolved Inorganic Nitrogen (DIN).

The average concentration of dissolved inorganic nitrogen including ammonia, nitrate, and nitrite at Shaw Brook RM 0.40 was 0.873 mg/L. The average concentration of total phosphorus was 0.170 mg/L. These levels of nutrients were considered to be "concentrations observed with high-intensity land use and WWTP (waste water treatment plant) loadings" (Ohio EPA, 2013b). The observed levels of nutrients are typical of streams with sanitary sewage contamination, which is also indicated by the high levels of *E. coli* and low dissolved oxygen observed at this site.

Table 6. Nutrient Component of the Ohio EPA Trophic Index Criterion					
Total Phosphorus (mg/l)	**Dissolved Inorganic Nitrogen (mg/l)**				
	≤0.44	**0.44-1.10**	**1.10-3.60**	**3.60-6.70**	**≥6.70**
≤0.04	6	3	3	1	0
0.04-0.08	3	3	3	1	0
0.08-0.13	3	3	1	1	0
0.13-0.40	1	1	1	0	0
≥0.40	0	0	0	0	0

Habitat Assessment

Methods

Instream habitat assessments were conducted once on Shaw Brook RM 0.40 in 2013 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 suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2006). 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)* (OEPA 2006). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

The stream segment at RM 0.40 obtained a QHEI score of 53.5 (*fair*). This value falls below the Ohio EPA's target score of 60 for the support of healthy fish and benthic macroinvertebrate communities (OEPA 2006). The most prominent substrate types present were gravel and hardpan. Other substrate types present included boulder, cobble, detritus, and artificial substrates. Moderate to extensive instream cover included undercut banks, overhanging vegetation, shallows, rootmats, rootwads, boulders, and woody debris. No functional riffles were found to be present along the entire length of the electrofishing zone of RM 0.40, which detracts from the overall QHEI score. This coupled with slow to intermittent current velocity most likely contributes to the low levels of dissolved oxygen measured at this site.

Electrofishing

Methods

One quantitative electrofishing pass was conducted at Shaw Brook RM 0.40 in 2013. Sampling was conducted using the backpack electrofishing technique and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream. The sampling zone was 0.15 kilometers. 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 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 7. IBI Metrics (Headwater)
Total number of Native Species
Number of Darters & Sculpins
Number of Headwater Species
Number of Minnow Species
Number of Sensitive Species
Percent Tolerant Species
Percent Pioneering Species
Percent Omnivores
Percent Insectivores
Number of Simple Lithophils
Percent DELT Anomalies
Number of Fish

The electrofishing results were compiled and utilized to evaluate fish community health through the application of the Ohio EPA Index of Biotic Integrity (IBI). 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*. The 12 metrics utilized for headwater sites are listed in Table 7.

Results and Discussion

No fish were collected during the electrofishing pass performed at Shaw Brook RM 0.40 in 2013, resulting in an IBI score of 12 (*Very Poor*). This site therefore failed to meet the WWH IBI criterion of 40. Dissolved oxygen levels at RM 0.40 were found to be below the criteria for warmwater habitat aquatic life for all water chemistry sampling events performed during the 2013 field season. Additionally, Shaw Brook is extensively culverted upstream and immediately downstream of the electrofishing zone at RM 0.40, which makes this site less accessible to fish populations. A QHEI score of 53.5 (*Fair*) at RM 0.40 also indicates that the necessary instream habitat is not present to support a robust fish community. The above listed characteristics of Shaw Brook RM 0.40 collectively contribute to the poor status of Shaw Brook in terms of the stream's ability to support fish communities.

Macroinvertebrate Sampling

Methods

Benthic macroinvertebrates were sampled quantitatively for one six-week period in 2013 using a modified HD substrate sampler in conjunction with a qualitative assessment performed during HD retrieval. The modified HD is a type of sampling that has been utilized by the Ohio EPA since 1973. Methods for sampling followed the Ohio EPA's Biological Criteria for the Protection of Aquatic Life, Volume III (1987b).

The Invertebrate Community Index (ICI) was used as the principal measure of overall macroinvertebrate community condition. Developed by the Ohio EPA, the ICI is a modification of the Index of Biotic Integrity for fish (OEPA 1987a). The ICI consists of ten individually scored structural community metrics listed in Table 8.

Macroinvertebrate qualitative samples were sent to Third Rock Consulting for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as recommended in Ohio EPA's *Biological Criteria for the Protection of Aquatic Life, Volume III* (1987, updated September 30, 1989; November 8, 2006; and August 26, 2008). The taxa lists and enumerations are available upon request.

Table 8 ICI Metrics
Total Number of Taxa
Total Number of Mayfly Taxa
Total Number of Caddisfly Taxa
Total Number of Dipteran Taxa
Percent Mayflies
Percent Caddisflies
Percent Tanytarsini Midges
Percent Other Dipterans and Non-Insects
Percent Tolerant Organisms
Total Number of Qualitative EPT Taxa

Results and Discussion

The HD sampler at Shaw Brook RM 0.40 was installed on July 30, 2013, and was retrieved after 6 weeks on September 9, 2013. Stream current at the time of both HD installation and retrieval was measured to be less than 0.3 feet per second, which is below the recommended amount of current for HD sampling according to the Ohio EPA's *Biological Criteria for the Protection of Aquatic Life, Volume II* (1987a). Such low-flow conditions are common in smaller streams with drainage areas less than 10 square miles. The drainage area of Shaw Brook RM 0.40 is 0.04 square miles, accounting for the low current over the HD. Shaw Brook also has a low stream gradient (18.87 feet/mile) also contributing to the low current over the HD.

Table 9 shows the results and scores calculated at this site for the ten individual ICI metrics. The site obtained a total ICI score of 14 (*Fair*) below the Ohio EPA warmwater habitat biological criterion value of 34. The HD sampler was poorly populated with only 64 organisms present, representing only 12 taxa. Eleven taxa were collected during qualitative sampling including 4 taxa that were also present on the HD sampler. No EPT (Ephemerotera, Plecoptera and Tricoptera) taxa were found to be present in the qualitative sample. The pollution tolerance of the taxa present in the stream ranged from facultative to very tolerant. All individual ICI metrics scored low with the exception of metrics 3 and 6, total number of caddisfly taxa and percent caddisflies, respectively. These metrics scored a 4 and 6, respectively, despite the fact that only a single caddisfly specimen was found to be present in the quantitative sample. The small drainage area of the sampling site and low total number of organisms on the HD sampler contributed to the high scores for the caddisfly metrics relative to the low number of caddisflies present in the sample.

Septic conditions and low oxygen levels observed at Shaw Brook RM 0.40 most likely are the main contributors to the low ICI score at this site. Aside from water

quality, flow over an HD has the greatest effect on the organisms found on an HD (DeShon, 1995). Therefore, the low level of current over the HD also contributed to the low ICI score.

Table 9. ICI Scoring for Shaw Brook RM 0.40			
Metric Number	**Metric description**	**Result**	**Metric Score (Range 0-6)**
1	Total Number of Taxa	12	0
2	Total Number of Mayfly Taxa	0	0
3	Total Number of Caddisfly Taxa	1	4
4	Total Number of Dipteran Taxa	10	2
5	Percent Mayflies	0.00	0
6	Percent Caddisflies	1.56	6
7	Percent Tanytarsini Midges	3.13	2
8	Percent other Diptera and Non-Insects	95.31	0
9	Percent Tolerant Organisms	68.75	0
10	Total Number of Qualitative EPT Taxa	0	0
Total ICI Score			14

Conclusions

Shaw Brook RM 0.40 was found to be in nonattainment of Class B primary contact recreation designated use criteria for *E. coli*, as well as WWH aquatic life designated use criteria for dissolved oxygen, and fish and macroinvertebrate biological criteria. Sanitary sewage contamination indicated by elevated densities of *E. coli,* as well as lack of functional riffles and low stream current, together contribute to the low dissolved oxygen levels in this small stream that negatively affected the biological communities. Impairments to Shaw Brook include CSO-232, lack of functional habitat, low stream gradient, and extensive culverted sections of stream.

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References

California State University. (2008). Operation of Wastewater Treatment Plants – Volume I. Seventh Edition. Sacremento, CA: Office of Water Programs, College of Engineering and Computer Science.

DeShon, J. E. (1995). Development and Application of the Invertebrate Community Index (ICI). In W. Davis and T. Simon (Ed.), Biological assessment and criteria, tools for water resource planning and decision making (pp. 217-243). Boca Raton, FL: Lewis Publishers.

Ohio Environmental Protection Agency. (2013a). *Surface Water Field Sampling Manual for water column chemistry, bacteria and flows*. Columbus, Ohio: Division of Surface Water.

Ohio EPA. (2013b). *Trophic Index Criterion—Rational and Scoring.* Columbus, Ohio: Division of Surface Water, Division of Environmental Services.

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

Ohio Environmental Protection Agency. (1987b). Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Columbus, OH: Division of Water Quality Monitoring and Assessment. (Updated September 1989; March 2001; November 2006; August 2008; and February 2013).

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

Ohio Environmental Protection Agency. (2009). State of Ohio Water Quality Standards *Ohio Administrative Code* Chapter 3745-1. Revision: Adopted December 15, 2009; Effective March 15, 2010.