NORTHEAST OHIO REGIONAL SEWER DISTRICT

2014 Dugway Brook Biological, Habitat, and Water Chemistry Assessment Study

Prepared by
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Introduction

In 2014, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate surveys on Dugway Brook, a tributary to Lake Erie. The objective of this study was to conduct environmental monitoring on Dugway Brook as part of the Northeast Ohio Regional Sewer District (NEORSD) general watershed monitoring program. In addition, this study provides post-construction data on the effects of the completion of the Dugway East Interceptor Relief System (DEIRS), as well as additional baseline data prior to the completion of the Dugway West Interceptor Relief System (DWIRS). In 2009 and 2010, the NEORSD conducted baseline environmental assessments at one site on the Dugway Brook Main Branch, two sites on the Dugway Brook East Branch, and two sites on the Dugway Brook West Branch (See Table 1 for site descriptions and Figure 1 for map of site locations). This baseline sampling was performed to assess the conditions of Dugway Brook prior to the completion of two capital improvement projects, the DEIRS and DWIRS, designed to reduce combined sewer overflow (CSO) events and increase interceptor capacity in portions of the cities of Cleveland, East Cleveland, and Bratenahl. Construction of DEIRS began in 2009 and was completed in 2011. Construction of DWIRS began in 2013 and is scheduled to be completed in 2016. In this report, the results of the 2014 Dugway Brook study are compared to the data collected at the same sites in 2009 and 2010 to evaluate the effects of the implementation of the DEIRS on the conditions of the stream.

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 *2014 Dugway Brook Environmental Monitoring*, approved by the Ohio EPA on April 14th, 2014. The majority of Dugway Brook is culverted. However, two of the sites selected for this study, river mile (RM) 0.37 and RM 2.40, exist as open sections of stream. Dugway Brook was evaluated at RM 0.37 and RM 2.40 for chemical water quality, habitat, and biological criteria, using Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), and Invertebrate Community Index Score (ICI). The three remaining sites in this study are located in culverted sections of Dugway Brook and are inaccessible for biological sampling and habitat evaluation. Therefore, only chemical water quality was evaluated at these sites.

Dugway Brook has not been assigned an aquatic life use designation. As of December 2014, 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 2014, chemical water quality criteria identified for the warmwater habitat (WWH) use designation were applied to Dugway Brook. Class B primary contact recreational use criteria for *Escherichia coli* (*E. coli*) apply to Dugway Brook RM 2.40 and RM 0.37, but do not apply to the three culverted sites. Class B primary contact recreational use criteria for *E. coli* were applied to the three culverted sites for comparative purposes only.

Table 1 provides GPS coordinates recorded at the downstream end of the electrofishing zones, site descriptions, and types of surveys conducted at Dugway Brook. Figure 1 is a map of the sampling locations.

Table 1. Site Descriptions

Location	Latitude	Longitude	River Mile	Description	Quadrangle	Purpose
Forest Hills Park at Forest Hills Blvd. and Forest Hills Ave.	41.5218	-81.5850	N/A	Dugway Brook, East Branch Upstream of DEIRS Alignment	East Cleveland	Evaluate water chemistry following DEIRS completion
East 110th Street Salt Dome Road	41.5479	-81.6076	N/A	Dugway Brook, East Branch Downstream of DEIRS Alignment	East Cleveland	Evaluate water chemistry following DEIRS completion
North of Lakeshore Blvd. North of NEORSD Netting facility	41.5509	-81.6086	0.37	Dugway Brook Main Branch North of Lakeshore Blvd.	East Cleveland	Evaluate water chemistry, fish, habitat and macroinvertebrates
Lakeview Cemetery downstream of NEORSD flood control dam.	41.5122	-81.5905	2.40	Dugway Brook, West Branch Upstream Section	East Cleveland	Evaluate water chemistry, fish, habitat and macroinvertebrates prior to DWIRS completion
10658 Dupont Avenue	41.5446	-81.6118	N/A	*Dugway Brook, West Branch Downstream Section	East Cleveland	Evaluate water chemistry prior to DWIRS completion

*This is the furthest downstream access location of all regulators tributary to the West Branch of Dugway Brook. It should be noted that there are two regulators (D-61 & D-03A) downstream of this location that were not captured during sample collection as there is no access to the culvert downstream of this location.

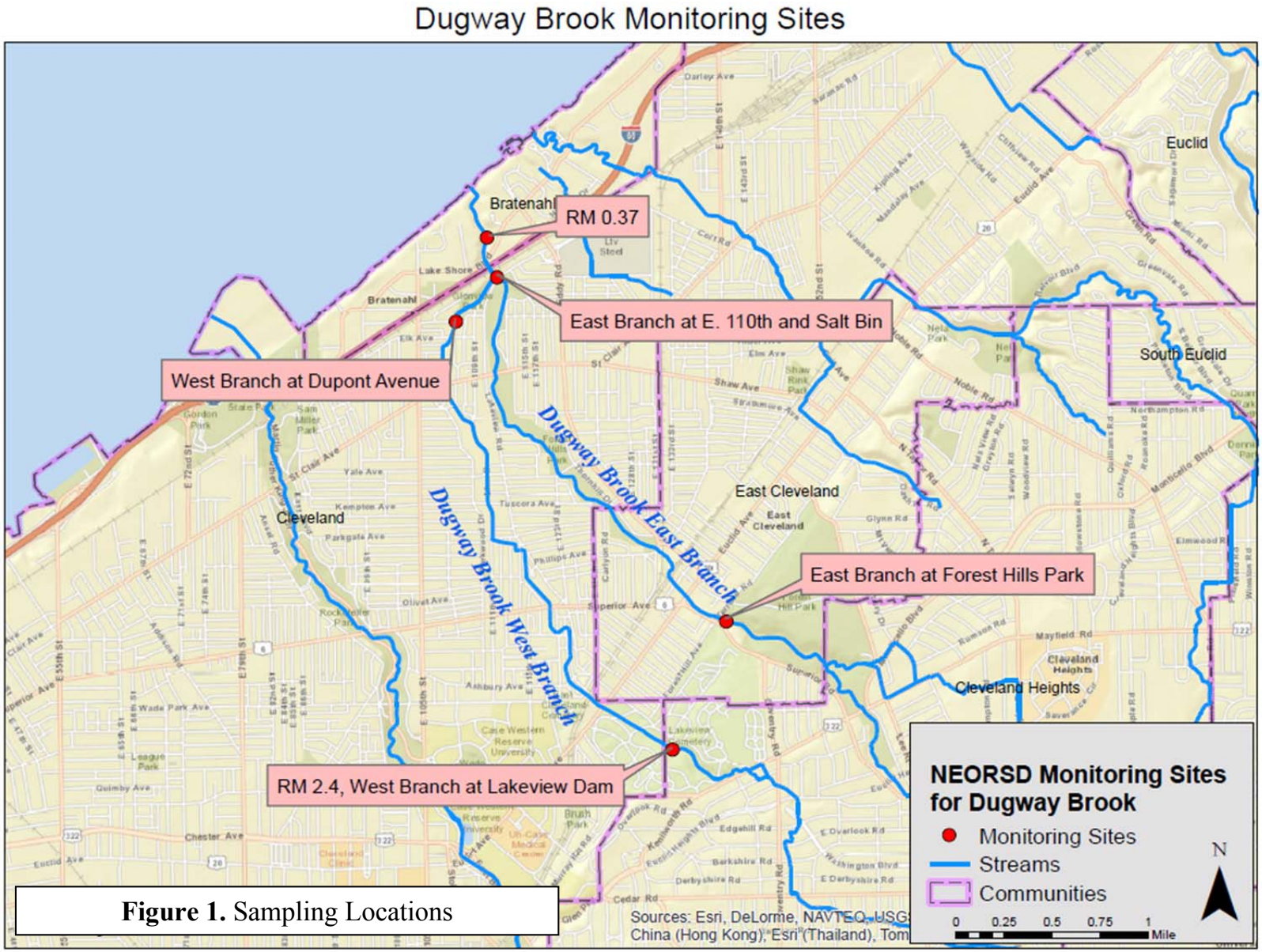


Figure 1. Sampling Locations

Water Chemistry and Bacteriological Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between July 22, 2014, and August 20, 2014, on Dugway Brook at all five sites with the exception of the East 110th St. Culvert Site, which was inaccessible due to construction on July 22, 2014. 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 EXO 1 sonde. Duplicate samples and field blanks were collected at randomly selected sites, each 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 Dugway 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 stream.

Results and Discussion

Dugway 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.

Duplicates and Field Blanks

Based on Ohio EPA data validation protocol, two parameters were rejected for comparison to water quality standards due to unacceptable RPDs between duplicate samples collected on August 6, 2014, at the Forest Hills Culvert Site, and on August 13, 2014, at RM 2.40. Table 2 gives the results of the duplicate samples from those parameters rejected due to high RPD, which include copper and thallium. The duplicate samples collected on August 13th were collected during a wet weather event.[1] The increased flow at the sampling site may have resulted in less homogenization of the stream and therefore the differences observed between the samples. The duplicate samples collected on August 6, 2014, were collected during dry weather. The concentrations of copper in the two samples were above the practical quantitation limit (PQL) of 2.0µg/L. The unacceptable RPD for copper on this date may have resulted from a lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity, and/or improper handling of samples.

Table 2. RPD Rejected Parameters

Date	Parameter	Result (µg/L)	Acceptable RPD	Actual RPD	Qualifier
08/06/2014	Cu	3.73	28.4	31.9	R
08/06/2014	Cu	2.704			
08/13/2014	Tl	0.24	36.7	154.2	R
08/13/2014	Tl	0.031			

[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.

Table 3. Field Blank Qualifiers				
Date	**Site**	**Parameter**	**Sample/Field Blank Signal Ratio**	**Interpretation**
08/06/2014	Forest Hills	Chromium	3.7	Downgraded to Level 2
08/06/2014	Forest Hills	Chromium	2.4	Rejected
08/06/2014	Dupont Avenue	Chromium	3.8	Downgraded to Level 2
08/06/2014	E. 110th Street	Chromium	2.3	Rejected
08/06/2014	RM 0.37	Chromium	3.1	Downgraded to Level 2
08/06/2014	RM 2.40	Chromium	2.7	Rejected
08/06/2014	Forest Hills	Zinc	7.7	Estimated
08/06/2014	Forest Hills	Zinc	7.7	Estimated
08/06/2014	RM 2.40	Zinc	6.3	Estimated
08/20/2014	Forest Hills	Antimony	8.9	Estimated
08/20/2014	Dupont Avenue	Antimony	8.0	Estimated
08/20/2014	E. 110th Street	Antimony	8.5	Estimated
08/20/2014	RM 0.37	Antimony	9.3	Estimated
08/20/2014	RM 2.40	Antimony	9.0	Estimated
08/20/2014	Forest Hills	Thallium	3.9	Downgraded to Level 2
08/20/2014	Dupont Avenue	Thallium	3.7	Downgraded to Level 2
08/20/2014	E. 110th Street	Thallium	3.6	Downgraded to Level 2
08/20/2014	RM 0.37	Thallium	4.1	Downgraded to Level 2
08/20/2014	RM 2.40	Thallium	3.6	Downgraded to Level 2

Data Qualification Ranges for Sample/Field Blank Signal Ratios

Ratio ≤ 3	Rejected
3 < Ratio ≤ 5	Downgraded
5 < Ratio ≤ 10	Estimated

Field blanks were collected on August 6, and August 20, 2014, at RM 2.40. 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. On August 6th, chromium and zinc were detected in the field blank at concentrations equal to the minimum detection limit (MDL). This, coupled with the low concentration of chromium and zinc in the samples, resulted in low Sample/Field Blank Signal Ratios resulting in these parameters being rejected, estimated, or downgraded from Level 3 to Level 2 data. On August 20th, antimony and thallium were detected in the field blank at concentrations equal to the minimum detection limit (MDL) resulting in the data for antimony being qualified as estimated, and the data for thallium being downgraded from Level 2 to Level 3 data. It is unclear how the field blanks became contaminated. Contamination may have been due to inappropriate sample collection and/or handling, contaminated blank water, and/or interference during analysis.

Mercury Criteria

	Table 4. Mercury Concentrations (µg/L)				
Stream Branch	***Main***	***East (downstream)***	***East (upstream)***	***West (downstream)***	***West (upstream)***
Date	**RM 0.37**	**East 110th St.**	**Forest Hills**	**Dupont Ave.**	**RM 2.40**
07/22/2014	< 0.01	--	< 0.01	< 0.01	< 0.01
07/30/2014	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
08/06/2014	< 0.01	< 0.01	< 0.01†	< 0.01	< 0.01
08/13/2014	0.013*	0.015*	< 0.01	0.013*	0.011*,†
08/20/2014	0.013*	0.015*	0.015*	0.015*	0.017*

* Results between MDL and PQL. Concentrations qualified as estimated.
† Results expressed as average of duplicate samples.
Exceeded Human Health Nondrinking OMZA Criterion (0.0031 µg/L) and Protection of Wildlife Criterion (0.0013 µg/L) for 30-day period beginning on this date, assuming mercury concentrations below the MDL were zero.

Mercury exceedances of the human health nondrinking OMZA and the protection of wildlife OMZA criterion occurred on Dugway Brook at all five sites for all 30-day periods (Table 4). Mercury was detected at concentrations between the MDL and PQL at four sites on August 13, 2014, and at all five sites on August 20, 2014. For the remainder of the sampling events, levels of mercury were below the MDL for mercury according to the EPA Method 245.1 (MDL = 0.01µg/L). Mercury may have exceeded the human health nondrinking OMZA and protection of wildlife OMZA criterion on these dates, as these criterion values are lower than the above MDL for mercury. Mercury did not exceed the OMZM and OMZA criteria for WWH aquatic life at all sites sampled during the 2014 field season.

Lead Criteria

Lead exceeded the hardness-based limit for the protection of aquatic life OMZA criterion during the 30-day period beginning on August 13, 2014, at the Dupont Avenue Culvert Site. The samples collected on August 13th and August 20th were collected following a rain events of 2.32 and 1.28 inches of rain respectively (within 72 hours of sampling) according to the Cleveland Heights rain gauge. These rain events most likely contributed to the low hardness observed on August 13th and August 20th, resulting in a lower hardness-based criterion limit which was exceeded on August 13th (Table 5). Possible sources of lead contamination at this site may include contaminated groundwater and/or non-point source runoff from the urban and industrial environment surrounding this section of Dugway Brook. No other lead exceedances occurred for the other four sites monitored on Dugway Brook during the 2014 field season.

Table 5. Lead (Pb) Concentrations at Dupont Avenue Culvert Site

Date	Pb (µg/L)	30-Day Average Pb (µg/L)	Hardness as $CaCO_3$ (mg/L)	30-Day Average Hardness ($CaCO_3$ mg/L)	Aquatic Life OMZA Criterion Limit
07/22/14	9.067	5.99	205	168	12.4
07/30/14	3.477	5.22	202	159	11.6
08/06/14	1.267	5.80	217	145	10.3
08/13/14	6.774	8.06	124	109	7.11
08/20/14	9.351	--	93	--	--

Thirty-day average concentration exceeded the Protection of Aquatic Life OMZA Criterion

Bacteriological Criteria

Class B primary contact water quality criteria apply to Dugway Brook RM 2.40 and RM 0.37. For comparative purposes only, Class B primary contact water quality criteria were also applied to the three culverted sites on Dugway Brook. 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 6 lists all of the *E. coli* results from Dugway Brook measured during the 2014 field season. Both the seasonal geometric mean and the single-sample maximum criteria were exceeded at all sites, for all 30-day periods beginning on each sampling date during the 2014 field season. Multiple active CSO regulating structures exist in the culverted sections of the East and West Branches of Dugway Brook. Records of overflow events from these structures do not exist as these structures lack flow monitoring equipment. It is therefore not possible to determine the extent to which these regulating structures contributed to the elevated *E. coli* levels observed on Dugway

Table 6. *E. coli* Densities (MPN/100mL)

Stream Branch	***Main***	***East (downstream)***	***East (upstream)***	***West (downstream)***	***West (upstream)***	
Date	**RM 0.37**	**East 110th St.**	**Forest Hills**	**Dupont Ave.**	**RM 2.40**	**Criterion Limit**
07/22/14	70,680	--	7,415	30,655	1,584	
07/30/14	>120,980*	13,065*	15,380*	5,765*	5,765*	
08/06/14	70,680	13,775	5,958	6,770	992	***523***
08/13/14	37,370*	10,240*	35,700*	259,940*	9,600*	
08/20/14	38,940*	31,520*	39,120*	73,080*	24,220*	
Seasonal Geomean (2014)	61,496	15,524	15,683	29,601	4,621	
Historical Geomean (2010)	7,109	10,579	1,213	7,044	1,824	***161***
Historical Geomean (2009)	8,986	4,136	1,092	3,412	621	

* Sample collected during a wet-weather event as defined on page 6.

Brook. Overflows from these structures in conjunction with known and unknown overflow events from NEORSD and local collection systems most likely contributed to the majority of the elevated *E. coli* densities observed in this study (see table 7 for a list of known overflow events). Historical seasonal geomeans taken from the data collected in 2009 and 2010 at these sites are also compared to the data collected in 2014 in Table 6. Seasonal geomeans at all sites were elevated in 2014 compared to previous years. This may be in part attributed to the high levels of precipitation that occurred within 72 hours of several sampling events in the 2014 field season. The average precipitation in inches within 72 hours of a sampling event was 0.16, 0.47, and 0.99, in 2009, 2010, and 2014, respectively. The increased levels of precipitation prior to sampling events in 2014 may have resulted in an increase in wet-weather CSO events contributing to the elevated *E. coli* densities observed in 2014 compared to previous years.

Eleven dry-weather overflow events occurred in 2014 at four regulating structures tributary to Dugway Brook (Table 7). These events occurred due to sewer blockages which were cleared by Jet-Vac. Estimated total volumes of discharges to Dugway Brook as a result of these overflow events are given in Table 7. The majority of these events occurred on the West Branch of Dugway Brook, upstream of the Dupont Avenue Culvert Site and downstream of RM 2.40, and may have contributed to the elevated *E. coli* densities observed at Dupont Avenue and RM 0.37 during the 2014 field season.

Table 7. 2014 Dry-Weather Overflow Events

Date	Location (Stream Branch)	Approximate Discharge (Gallons)
5/27/2014	CD-35 Tuscora Ave. and Linn Dr. (West)	4,800
6/2/2014	D-17 East 107th St. and Helana Ave. (West)	9,700
6/12/2014	CD-35 Tuscora Ave. and Linn Dr. (West)	4,800
6/19/2014	CD-35 Tuscora Ave. and Linn Dr. (West)	19,000
6/23/2014	CD-76 13505 Euclid Ave. (East)	4,700
7/28/2014	CD-37 Primrose Ave. and Linn Dr. (West	4,800
7/29/2014	CD-35 Tuscora Ave. and Linn Dr. (West)	9,700
8/5/2014	CD-35 Tuscora Ave. and Linn Dr. (West)	9,700
8/13/2014	CD-35 Tuscora Ave. and Linn Dr. (West)	4,800
8/28/2014	CD-35 Tuscora Ave. and Linn Dr. (West)	15,000
9/20/2014	CD-35 Tuscora Ave. and Linn Dr. (West)	4,800

Influence of DEIRS on the E. coli Densities of the East Branch of Dugway Brook

In 2009 and 2010, the NEORSD performed baseline environmental monitoring on Dugway Brook prior to the completion of DEIRS. DEIRS was constructed to reduce the number of CSO events to Dugway Brook East Branch, and to serve as a connection to the

future Dugway Storage Tunnel, which will provide further CSO relief. The Forest Hills Culvert Site is located upstream of several CSO regulating structures involved in the DEIRS project, including D-80, D-93A, D-93B and D-94. This site was therefore selected as an upstream reference control site for environmental assessment of the DEIRS project. The East 110th Street site is located downstream of the above listed regulators, near the confluence of Dugway Brook East Branch with Dugway Brook Main Branch, and serves as a downstream assessment point to evaluate the effects of the completion of the DEIRS project on Dugway Brook East Branch. Historical bacteriological data from the studies performed in 2009 and 2010 (prior to completion of the DEIRS construction), is compared to the data collected in 2014 (three years post-DEIRS construction) in Table 8 and Figure 2.

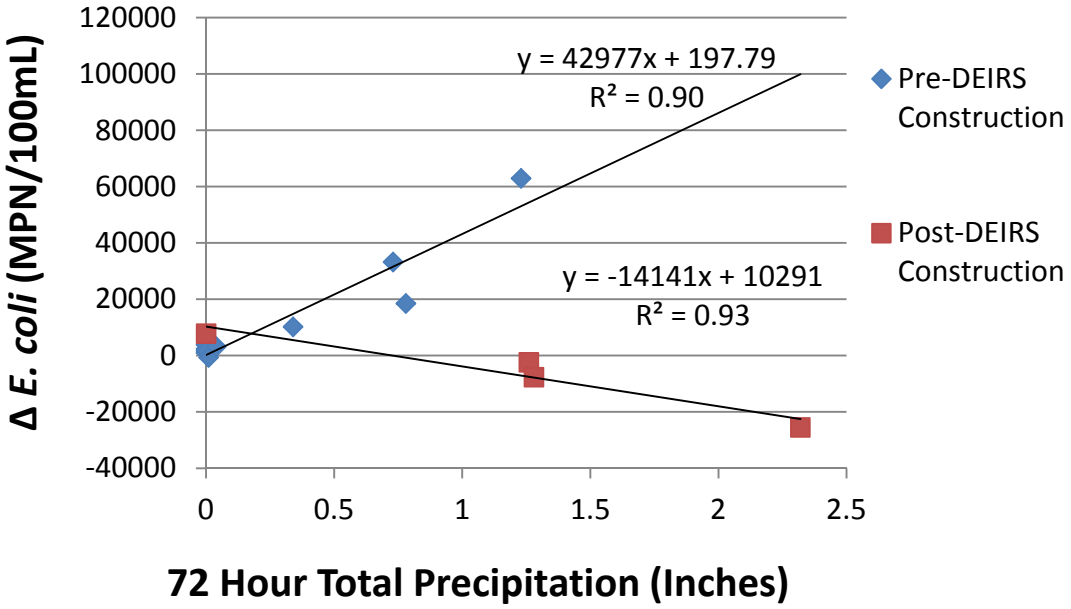
Table 8. Historical *E. coli* Densities for Dugway Brook East Branch

Date	East 100th St. (Downstream)	Forest Hills (Upstream)	Δ *E. coli* MPN/100mL (Downstream -Upstream)	72-hour Precip.
	CFU/100mL			Inches
7/22/2009	1,180	1,800	-620	0.01
8/5/2009	5,500	1,580	3,920	0.00
7/29/2009	3,900	720	3,180	0.04
8/11/2009	35,400	2,164	33,236	0.73
8/17/2009	1,350	350	1,000	0.00
7/29/2010	20,000	1,460	18,540	0.78
8/5/2010	67,000	4,059	62,941	1.23
8/12/2010	19,400	9,200	10,200	0.34
8/19/2010	2,549	175	2,374	0.00
8/26/2010	2,000	275	1,725	0.00
	MPN/100mL			Inches
7/22/2014	--	7,415	--	0.09
7/30/2014	13,065	15,380	-2,315	1.26
8/6/2014	13,775	5,958	7,817	0.00
8/13/2014	10,240	35,700	-25,460	2.32
8/20/2014	31,520	39,120	-7,600	1.28

To compare the *E. coli* data downstream and upstream of the DEIRS, the *E. coli* density of the upstream site (Forest Hills Culvert Site) was subtracted from the *E. coli* density of the downstream site (East 110th Street Culvert Site) for each sample collection date. This difference represents the *E. coli* (and hence sanitary sewage) input to the section of Dugway Brook East Branch between the two sites. The difference in *E. coli*

density between the two sites (Δ *E. coli* MPN/100mL) was then plotted against the total rainfall in inches 72 hours prior to each sampling event according to the Cleveland Heights rain gauge. Prior to DEIRS construction, a linear increase in *E. coli* density in response to increased precipitation was observed between the two sites (R^2=0.90). This increase in the *E. coli* density can be attributed in part to wet-weather CSO events from regulating structures between the two sites including D-80, D-93A, D-93B and D-94. Following construction of DEIRS, no increases in *E. coli* densities were observed at the downstream site during wet-weather events. Rather, a linear decrease in *E. coli* density in response to increased precipitation is observed between the two sites (R^2=0.93), which may be attributed to dilution of the *E. coli* by inbound storm water. This data suggests that implementation of the DEIRS has successfully resulted in a decrease in wet-weather CSO events in the East Branch of Dugway Brook, effectively reducing sanitary-sewage contamination to the stream during periods of wet weather.

Figure 2. *E. coli* density differences between downstream and upstream sites in response to precipitation before and after DEIRS construction.



Trophic Index Criterion

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 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 (Total-P) and Dissolved Inorganic Nitrogen (DIN) (Table 9: Ohio EPA, 2013b).

Table 9. 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

The average concentrations of Total-P and DIN, including ammonia, nitrate, and nitrite, observed on Dugway Brook during the 2014 field season are given in Table 10. 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* observed at these sites.

Table 10. Average Nutrient Concentrations					
	RM 0.37	**East 110th St.**	**Forest Hills**	**Dupont Ave.**	**RM 2.40**
DIN	1.962	1.123	1.936	1.255	1.687
Total-P	0.291	0.185	0.144	0.312	0.198
Score	1	1	1	1	1

Habitat Assessment

Methods

Instream habitat assessments were conducted once on Dugway Brook RM 2.40 and RM 0.37 in 2014 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 55 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

Evaluation of the stream segment at RM 0.37 resulted in a QHEI score of 70 (*Excellent*). This value meets the Ohio EPA's target score of 55 for the support of healthy fish and benthic macroinvertebrate communities (OEPA 2006). The most prominent substrate types present were cobble and sand. Other substrate types present included gravel, detritus, muck, and silt. Moderate to extensive instream cover included undercut banks, overhanging vegetation, rootmats, rootwads, logs and woody debris, and pools greater than 70cm in depth. The QHEI score at this site has improved over time from the score obtained in 2009 (See Table 11 for comparison of current and historical QHEI scores and individual QHEI metric scores). This is mainly due to the presence of a functional riffle in the upper section of the electrofishing zone, which was absent in previous years, and resulted in a great improvement in the score of the 5th metric, Pool/Glide and Riffle/Run Quality. The presence/absence of this riffle may be influenced by the level of Lake Erie, as this site is located near the confluence of Dugway Brook with Lake Erie. An increase in water level would result in a change of the classification of this section of stream from a riffle to a run, which would in turn lead to a decrease in the overall QHEI score of up to 12 points (based on QHEI data from 2009 shown in Table 11, metric 5). Increases in lake level due to wind direction or water level would therefore have a negative impact on the overall QHEI score of this site, and hence the ability of this site to support robust fish and macroinvertebrate communities. This may in part explain the discrepancy between the QHEI narrative rating of *excellent* and the IBI narrative rating of *poor* obtained at this site in 2014.

Evaluation of the stream segment at RM 2.40 resulted in a QHEI score of 53 (*Fair*). This value falls below the Ohio EPA's target score of 55 for the support of healthy fish and benthic macroinvertebrate communities (OEPA 2006). The most prominent substrate types present were cobble and gravel. Other substrate types present included boulder, sand, and artificial substrate. Instream cover was limited at this site, which detracted from the overall QHEI score, and included small amounts of boulders, rootmats, and shallows and backwaters of poor quality. A lack of development and

sinuosity in this segment of stream additionally detracts from the overall QHEI score. The stream segment lacks pools and consists of shallow, nonfunctional riffles, and runs with embedded substrate. This QHEI score and individual metric scores were consistent with the habitat assessment performed in 2010.

Table 11. QHEI Metric Scores for Dugway Brook RM 0.37 and RM 2.40

Metric	RM 0.37			RM 2.40		Maximum Possible Score
	2009	2010	**2014**	2010	**2014**	
1) Substrate	12	8.5	14	18	17	20
2) Instream Cover	13	16	14	6	7	20
3) Channel Morphology	12	13.5	13	11	11	20
4) Bank Erosion and Riparian Zone	9	6.5	8	7	7.5	10
5) Pool/Glide and Riffle/Run Quality	5	15	17	4	6.5	20
6) Gradient	4	4	4	4	4	10
QHEI Total Score (Narrative Rating)	55 (*Good*)	63.5 (*Good*)	**70 (*Excellent*)**	50 (*Fair*)	**53 (*Fair*)**	100

Electrofishing

Methods

One quantitative electrofishing pass was conducted at Dugway Brook at RM 2.40 and RM 0.37 in 2014. 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 zones were 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.

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 (Table 12). 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 12.

Table 12. 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

Results and Discussion

An IBI score of 12 (*Very Poor*) was calculated for RM 2.40, as no fish were collected at this site during the electrofishing pass performed in 2014. The sampling zone for this site is situated between Lakeview Dam, which is approximately ¼ mile upstream of the site, and two Lakeview Cemetery ponds, which the west branch of Dugway Brook drains into before entering the culverted section near Euclid Avenue. The population of fish in the sampling zone may be impacted by the unsuitable habitat upstream and downstream of the sampling zone. Upstream of the sampling zone, the brook consists of a concrete bottom up to the dam. In addition, the ponds downstream of the sampling zone may not be suitable for fish propagation due to limited upstream fish migration. Even though the biological criterion is not applicable to Dugway Brook,

this site obtained the lowest possible score for the calculation of an IBI for headwater sites. This score is consistent with the score obtained in 2010 at this site.

An IBI score of 24 (*Poor*) was calculated for RM 0.37 for the electrofishing pass performed in 2014. Ten species of fish were collected. From these, three species made up 90% of the collected specimens. Fifty-one percent of the fish collected were common white suckers (highly tolerant), 22% were pumpkinseed sunfish (moderately tolerant), and 17% were northern fathead minnows (highly tolerant). The percentage of tolerant species was high at this site at 69.4%. A small number (2.3% of total fish population) of the moderately intolerant species, sand shiners, were also collected. 2014 was the first year that this intolerant species was collected by NEORSD at this site. The IBI score at this site was significantly decreased from the score obtained at this site in 2009 and 2010. In 2009 and 2010, pumpkinseed sunfish was the dominant species followed by the common emerald shiner. An increase in the proportions of tolerant species and omnivores, as well as a decrease in the proportions of insectivores, and the number of fish, all contributed to the decreased IBI score obtained in 2014 compared to previous years. It should also be taken into consideration that this site is very near to the confluence of Dugway Brook with Lake Erie, and that IBI scores may be influenced by populations of fish temporarily migrating in from the lake. This may account for the variation in the overall IBI scores as well as the number of pumpkinseed sunfish observed from year to year at this site.

Table 13. Index of Biotic Integrity Scores

Site	Year		
	2009	**2010**	**2014**
RM 2.40	--	12 (*Very Poor*)	**12 (*Very Poor*)**
RM 0.37	36 (*Marginally Good*)	37 (*Marginally Good*)	**24 (*Poor*)**

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 RM 0.37 and RM 2.40. 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 WQIS.

The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA's Invertebrate Community Index (ICI) (OEPA 1987a, Ohio EPA undated). The ICI consists of ten community metrics (Table 14), 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.

Results and Discussion

The HD samplers at Dugway Brook RM 2.40 and RM 0.37 were set on August 6, 2014, and were collected on September 17, 2014, exactly 6 weeks following installation. Current over the HDs was within the recommended range at the time of both installation and collection. Current was estimated as greater than the minimum recommended current of 0.30ft/sec at the time of installation, and was measured at 0.33ft/sec and 0.71ft/sec at the time of collection at RM 2.40 and RM 0.37, respectively. Qualitative sampling was performed at both sites immediately following HD collection.

An ICI score of 24 (*Fair*) was calculated for RM 2.40 (See Table 9 for individual ICI metric results and scores, and historical ICI scores). Just over half of the quantitative sample (53.1%) consisted of seven tolerant taxa with *Oligochaeta* being the most dominant organism. Only two EPT taxa were present in the qualitative sample, which detracted from the overall ICI score. These taxa included *Baetis flavistrigia* and *Hydropsyche depravata group*. One additional caddisfly taxa, *Cheumatopsyche sp.*, was present in the quantitative sample for a total of three EPT taxa collected at this site. The low number of mayfly taxa, and the high percent tolerant organisms and percent other diptera and non-insects in the quantitative sample also detracted from the overall ICI score at this site during the 2014 field season. The ICI score for this site in 2014 was similar to that observed in 2010, indicating that there has been no improvement in the health of the macroinvertebrate community at this site over the past 4 years.

An ICI score of 16 (*Fair*) was calculated for RM 0.37. The majority of the quantitative sample (65.8%) consisted of seven tolerant taxa, of which *Oligochaeta*, *Physella sp.*, and *Polypedilum (P.) illinoense* were the dominant organisms (at 28.4%, 21.9% and 12.6% of specimens identified, respectively). Only a single EPT taxa, *Baetis flavistrigia*, was present in the qualitative sample, which detracted from the overall ICI score. One caddisfly taxa, *Hydropsyche depravata group*, was present in the quantitative sample for a total of two EPT taxa collected at this site. The low number of mayfly taxa and low percent mayflies, as well as the high percent tolerant organisms and percent other diptera and non-insects in the quantitative sample, also detracted from the overall ICI score at this site during the 2014 field season. Based on these results and those obtained in 2009 and 2010, there has been no improvement in the health of the macroinvertebrate community at this site over the past 5 years.

Table 14. ICI Scoring for Shaw Brook RM 0.40

Metric Number	Metric description	Result		Metric Score (Range 0-6)	
		RM 2.40	RM 0.37	RM 2.40	RM 0.37
1	Total Number of Taxa	27	22	4	2
2	Total Number of Mayfly Taxa	1	1	0	0
3	Total Number of Caddisfly Taxa	2	1	4	4
4	Total Number of Dipteran Taxa	17	13	4	2
5	Percent Mayflies	18.34	0.49	4	2
6	Percent Caddisflies	1.97	0.82	6	4
7	Percent Tanytarsini Midges	3.35	1.54	2	2
8	Percent other Diptera and Non-Insects	76.33	97.15	0	0
9	Percent Tolerant Organisms	53.06	65.79	0	0
10	Total Number of Qualitative EPT Taxa	2	1	0	0
Total ICI Score 2014				**24 (Fair)**	**16 (Fair)**
2010				22 (Fair)	10 (Poor)
2009				--	(Fair*)

*No HD sampler collected; narrative rating based on best professional judgment

Conclusion

Table 15 summarizes the results of the 2014 Dugway Brook survey. Dugway Brook was in non-attainment of the human health nondrinking OMZA criterion and the protection of wildlife OMZA criterion at all five sites due to mercury exceedances. The Dupont Avenue Culvert Site was additionally in non-attainment of the protection of aquatic life OMZA criterion due to a lead exceedance. All sites exceeded Class B primary contact recreational criteria for *E. coli*. Both open sections of stream studied, Dugway Brook RM 2.40 and RM 0.37, would have been in non-attainment for the biological criteria for fish and macroinvertebrates in 2014 had these criteria applied to these sites. This is in spite of the *excellent* QHEI narrative rating result at RM 0.37, suggesting that poor water quality rather than lack of habitat contributes, at least in part, to the poor fish and macroinvertebrate communities observed at this site. The *E. coli* data from this study strongly suggests that structural improvements to the NEORSD collection system provide CSO relief, reducing the levels of CSO contamination during wet-weather events to Dugway Brook. However, Dugway Brook remains a highly impacted urban stream with high levels of sanitary-sewage contamination. This is indicated by the elevated *E. coli* densities observed at all sites in this study. This contamination prevents the achievement of the fishable and swimmable goals set forth in the Clean Water Act of 1972 for this stream.

Table 15. 2014 Dugway Brook Survey Results

Site	Aquatic Life Use Attainment Status	IBI Score (Narrative Rating)	ICI Score (Narrative Rating)	QHEI Score (Narrative Rating)	Water Quality Exceedances
RM 0.37 *	NON	24 (*Poor*)	16 (*Fair*)	70 (*Excellent*)	*E. coli*, Mercury
East 110th St. †	N/A	N/A	N/A	N/A	*E. coli*, Mercury
Forest Hills †	N/A	N/A	N/A	N/A	*E. coli*, Mercury
Dupont Ave. †	N/A	N/A	N/A	N/A	*E. coli*, Lead, Mercury
RM 2.40 *	NON	12 (*Very Poor*)	24 (*Fair*)	53 (*Fair*)	*E. coli*, Mercury

N/A – Culverted Site, habitat and biological criteria not evaluated.
* Biological Criteria do not apply, but were evaluated for comparative purposes only.
† Recreational use criteria do not apply but were evaluated for comparative purposes only.

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