

NORTHEAST OHIO REGIONAL SEWER DISTRICT

2015-2016 Hemlock Creek Environmental Monitoring: Biological, Water Quality, and Habitat Survey Results

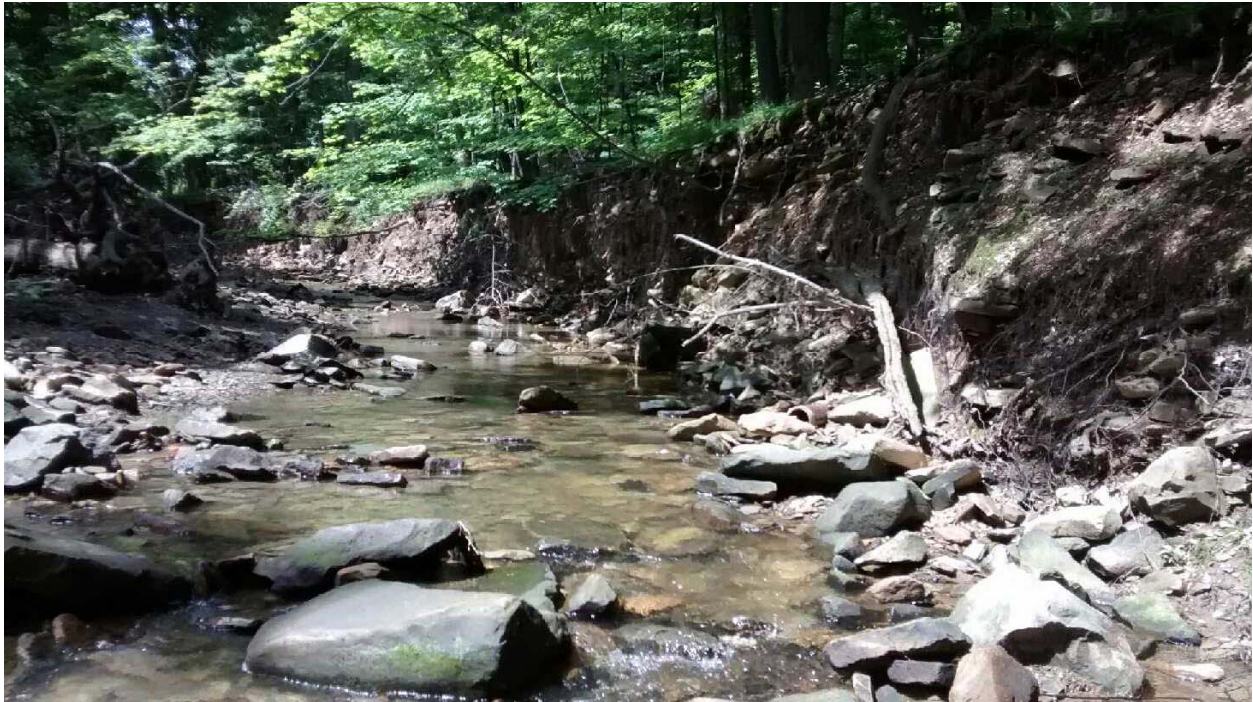


Photo: Hemlock Creek on July 15, 2015, River Mile 0.15

**Prepared by
The Water Quality and Industrial Surveillance Division**

Introduction

In 2015 and 2016, the Northeast Ohio Regional Sewer District (NEORS) conducted stream monitoring activities at four sites on Hemlock Creek, a tributary to the Cuyahoga River. NEORS assessed habitat and water chemistry conditions and evaluated the health of the fish and benthic macroinvertebrate communities at each site. The purpose of the monitoring was to track the health of the watershed and evaluate potential impacts. Three of the sites are along Hemlock Creek's Main Branch and are located at river miles (RM) 0.15, 1.15, and 2.50. The fourth site, RM 0.10, is located immediately southeast of the main branch on a separate direct tributary to the Cuyahoga River. These sites were selected to provide a representative overview of the watershed.

Stream monitoring activities were conducted at each site by NEORS Level 3 Qualified Data Collectors certified by Ohio EPA in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessment as explained in the NEORS Study Plans *2015 Hemlock Creek Environmental Monitoring* and *2016 Hemlock Creek Environmental Monitoring* approved by Ohio EPA on June 17, 2015, and May 17, 2016, respectively. The results obtained from these assessments were evaluated using the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), and Invertebrate Community Index (ICI). Water chemistry data was validated per the methods outlined by the Ohio EPA (2015) and compared to the Ohio Water Quality Standards (Ohio EPA, 2017) to determine attainment of applicable uses. An examination of the biological information was used in conjunction with the water quality data and QHEI results in order to assess the health of the stream and to show any temporal as well as spatial trends.

Figure 1 is a map of the sampling locations on Hemlock Creek, and Table 1 lists the sampling locations and their respective river mile, latitude/longitude, site description, and surveys conducted. A digital photo catalog of the sampling locations is available upon request by contacting the NEORS Water Quality and Industrial Surveillance (WQIS) Division.

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Table 1. Hemlock Creek Sampling Locations

Location	Latitude	Longitude	River Mile	Location Information	Purpose¹
Hemlock Creek	41.3775	-81.6597	2.50	At southern end of Oakwood Drive	Evaluate overall watershed health
Hemlock Creek	41.3767	-81.6386	1.15	Downstream of Brecksville Road	Evaluate overall watershed health
Hemlock Creek	41.3805	-81.6245	0.15	Upstream of Hemlock Road	Evaluate overall watershed health
Hemlock Creek, Lower Branch	41.3796	-81.6204	0.10	Southeast of Hemlock Road, trib to Cuyahoga	Evaluate overall watershed health

¹ Water Chemistry, habitat, fish, and benthic macroinvertebrates were evaluated at each site.

Hemlock Creek Monitoring Sites

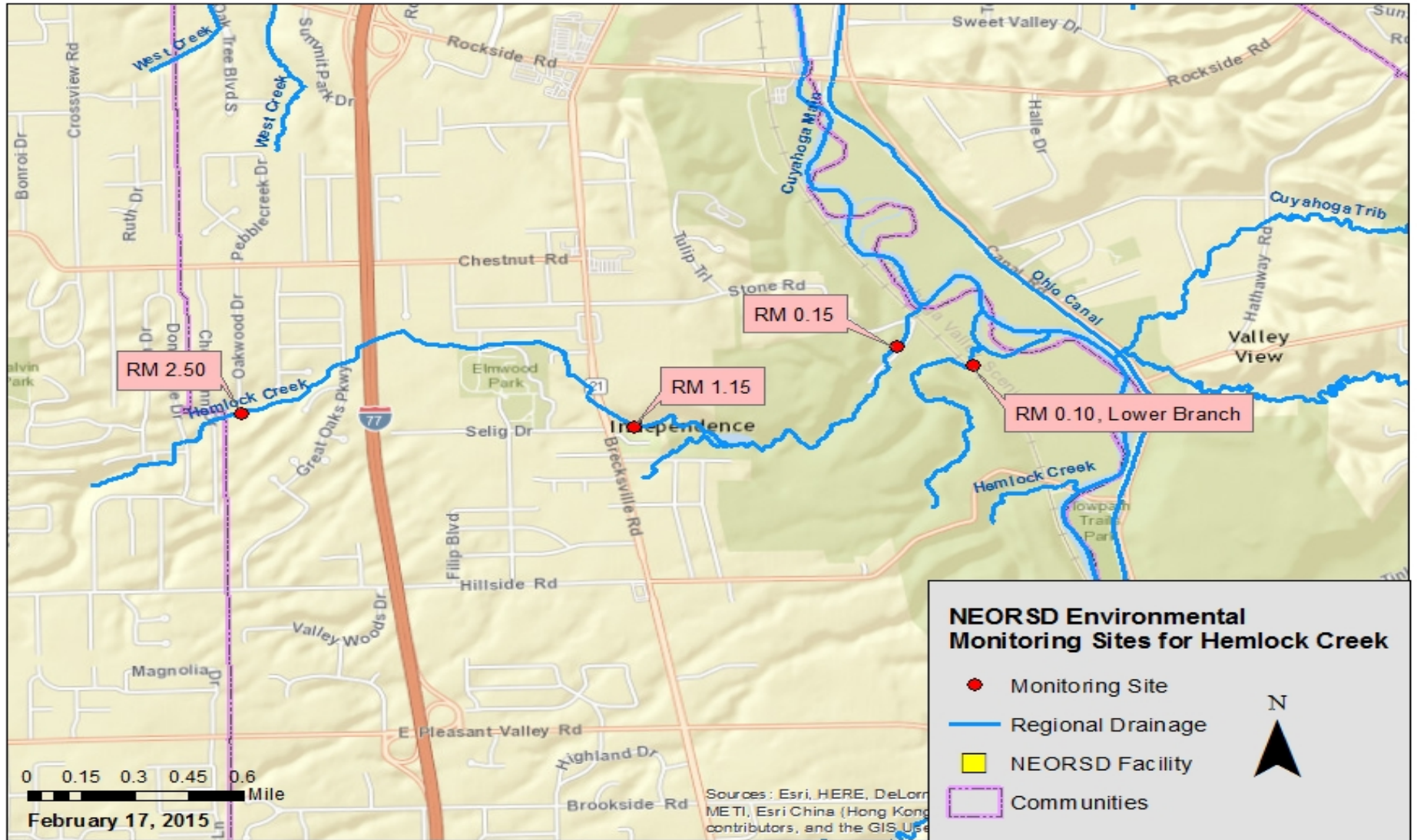


Figure 1. Sampling Locations

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times on Hemlock Creek at RMs 0.10, 0.15, 1.15, and 2.50 in both 2015 and 2016. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual* (2015). 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- μ m 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 an YSI 600XL or 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).

$$\text{Formula 1:} \quad \text{RPD} = \left(\frac{|X-Y|}{((X+Y)/2)} \right) * 100$$

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).

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

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.

Water chemistry analysis sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

Over the course of sampling in 2015, there were two duplicate samples collected on June 24, 2015 (RM 0.15) and July 15, 2015 (RM 2.50). Each set of duplicate samples had one parameter that was rejected due to RPDs that were greater than the acceptable RPD (Table 2). In the 2016 study, there were two duplicate samples collected on July 6, 2016 (RM 1.15) and July 13, 2016 (RM 0.10). The sample collected on July 6, 2016 had multiple rejections (Table 3). The second duplicate collected on July 13, 2016 resulted in one rejection. There are numerous reasons for why parameters needed to be rejected, such as the collector mishandling the sample, environmental heterogeneity, inconsistent sampling methods and/or analytical errors.

Table 2. 2015 Duplicate samples with greater than acceptable RPDs					
River Mile	Date	Parameters	Acceptable RPD (%)	Actual RPD (%)	Qualifier
0.15	06/25/15	Fe (Iron)	13.8	14.9	Rejected
2.50	07/15/15	Al (Aluminum)	16.5	79.8	Rejected

Table 3. 2016 Duplicate samples with greater than acceptable RPDs					
River Mile	Date	Parameters	Acceptable RPD (%)	Actual RPD (%)	Qualifier
1.15	07/06/16	Al	48.4	91.7	Rejected
		COD (Chemical Oxygen Demand)	55.6	144.4	Rejected
		Fe	25.8	47.2	Rejected
0.10	07/13/16	TSS (Total Suspended Solids)	25.4	37.4	Rejected

In 2015, there were two field blanks collected on June 17, 2015 and July 1, 2015 at RM 2.50. In the 2016 study, there were two field blanks collected on June 29, 2016 at RM 0.15 and on July 13, 2016 at RM 2.50. Table 4 (2015) and Table 5 (2016) list water quality parameters that were rejected, estimated or downgraded from Level 3 to Level 2 data based on Ohio EPA (2015b) data validation protocol. It is unknown how the field blanks were contaminated and may have been the result of inappropriate sample collection, handling, contaminated blank water and/or bottles.

Table 4. 2015 Data Qualified Based on Applicable Field Blank Comparison			
RM	Date	Parameter	Qualifier Added
2.50	06/17/15	Cr (chromium)	Estimate
		Sn (tin)	Level 2

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Table 4. 2015 Data Qualified Based on Applicable Field Blank Comparison			
RM	Date	Parameter	Qualifier Added
	07/01/15	TKN (total Kjeldahl nitrogen)	Estimate
		Sb (antimony)	Estimate
		COD	Estimate
		NH3	Rejected
		Tl (thallium)	Level 2
1.15	06/17/15	Antimony	Estimate
		Sn	Rejected
	07/01/15	COD	Estimate
		NH3	Rejected
		Tl	Estimate
0.15	06/17/15	NH3 (ammonia)	Estimate
		Sn	Rejected
		TKN	Estimate
	07/01/15	COD	Estimate
		NH3	Rejected
		Tl	Level 2
0.10	06/17/15	DRP (dissolved reactive phosphorus)	Estimate
		SN	Estimate
		TKN	Estimate
	07/01/15	COD	Estimate
		NH3	Rejected
		Tl	Level 2

Table 5. 2016 Data Qualified Based on Applicable Field Blank Comparison			
RM	Date	Parameter	Qualifier Added
2.50	06/29/16	COD	Estimate
		Cr	Estimate
	07/13/16	COD	Estimate
1.15	06/29/16	COD	Estimate
		Cr	Estimate
	07/13/16	COD	Estimate
0.15	06/29/16	COD	Estimate
		Cr	Estimate
		TP (total phosphorus)	Estimate
	07/13/16	COD	Estimate
		TP	Estimate
0.10	06/29/17	COD	Estimate
		Cr	Estimate
	07/13/16	COD	Estimate
		(Dup)	COD

Table 5. 2016 Data Qualified Based on Applicable Field Blank Comparison			
RM	Date	Parameter	Qualifier Added
	07/13/16	TP	Estimate
	07/13/16 (Dup)	TP	Estimate

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).

No other exceedances were found when the Hemlock Creek results were compared to the water quality standards that apply. At RM 0.10 on the lower branch, however, the potassium levels were elevated compared to the other sites and neighboring streams. This may be the result of the construction aggregate-distributor in the area. Potassium is commonly found in shale which is sold as an aggregate. Although the levels were elevated, they were not high enough that they should have been toxic to the fish community.

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). NEORS did not assess DO swings or benthic chlorophyll *a* in either 2015 or 2016; however, nutrients were assessed.

Table 6 and 7 shows the results of four sites and the calculated geometric mean for 2015 and 2016. In 2015, RM 2.50 had a low risk to beneficial use; however, in 2016, the site possessed a moderate risk. In 2015, RM 1.15 this site was low risk to beneficial use; in 2016, the conditions were similar except for that the stream was moderately enriched in phosphorus. In 2015 and 2016, RM 0.15 had little risk of beneficial use. In 2015, RM 0.10 nutrient concentrations in the stream were low risk to beneficial uses; in 2016, the conditions were typical of a stream that was least disturbed.

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Table 6: 2015 Nutrient results for Hemlock Creek used for SNAP analysis						
RM 2.50						
Sample Date	06/17/15	06/24/15	07/1/15	07/8/15	07/15/15	GeoMean
Total Phosphorus (mg/L)	0.143	0.131	0.161	0.082	0.1625	0.132
DRP (mg/L)	0.075	0.05	0.096	0.021	0.059	0.054
Dissolved Inorganic Nitrogen (mg/L)	1.805	1.728	1.254	2.041	1.9715	1.735
RM 1.15						
Sample Date	06/17/15	06/24/15	07/1/15	07/8/15	07/15/15	GeoMean
Total Phosphorus (mg/L)	0.079	0.094	0.123	0.052	0.073	0.081
DRP (mg/L)	0.038	0.029	0.036	0.023	0.037	0.032
Dissolved Inorganic Nitrogen (mg/L)	0.887	0.835	0.659	0.789	0.864	0.802
RM 0.15						
Sample Date	06/17/15	06/24/15	07/1/15	07/8/15	07/15/15	GeoMean
Total Phosphorus (mg/L)	0.061	0.0685	0.09	0.041	0.052	0.060
DRP (mg/L)	0.032	0.0275	0.028	0.02	0.032	0.028
Dissolved Inorganic Nitrogen (mg/L)	0.732	0.7275	Data missing for NH3	0.642	0.754	0.713
RM 0.10						
Sample Date	06/17/15	06/24/15	07/1/15	07/8/15	07/15/15	GeoMean
Total Phosphorus (mg/L)	0.081	0.049	0.089	0.029	0.025	0.048
DRP (mg/L)	0.024	0.022	0.023	0.008	0.008	0.015
Dissolved Inorganic Nitrogen (mg/L)	0.439	0.554	0.366	0.411	0.086	0.316

Table 7: 2016 Nutrient results for Hemlock Creek used for SNAP analysis						
RM 2.50						
Sample Date	06/15/16	06/22/16	06/29/16	07/6/16	07/13/16	GeoMean
Total Phosphorus (mg/L)	0.065	0.19	0.082	0.096	0.099	0.099
DRP (mg/L)	0.035	0.041	0.043	0.052	0.067	0.046
Dissolved Inorganic Nitrogen (mg/L)	4.139	3.581	3.5	3.468	3.508	3.631
RM 1.15						
Sample Date	06/15/16	06/22/16	06/29/16	07/6/16	07/13/16	GeoMean
Total Phosphorus (mg/L)	0.037	0.04	0.043	0.0355	0.035	0.038
DRP (mg/L)	0.024	0.032	0.032	0.027	0.025	0.028
Dissolved Inorganic Nitrogen (mg/L)	1.695	1.34	1.325	1.416	1.201	1.386
RM 0.15						
Sample Date	06/15/16	06/22/16	06/29/16	07/6/16	07/13/16	GeoMean
Total Phosphorus (mg/L)	0.025	0.05	0.027	0.02	0.017	0.026
DRP (mg/L)	0.016	0.02	0.018	0.013	0.008	0.014

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Table 7: 2016 Nutrient results for Hemlock Creek used for SNAP analysis						
Dissolved Inorganic Nitrogen (mg/L)	1.036	0.88	0.724	0.795	0.44	0.746
RM 0.10						
Sample Date	06/15/16	06/22/16	06/29/16	07/6/16	07/13/16	GeoMean
Total Phosphorus (mg/L)	0.022	0.043	0.042	0.058	0.0295	0.037
DRP (mg/L)	0.005	0.006	0.008	0.008	0.01	0.007
Dissolved Inorganic Nitrogen (mg/L)	0.09	0.063	0.028	0.073	0.07	0.061

Hemlock Creek is designated as Primary Contact Recreation. The criteria for this is based on a statistical threshold value (STV); the *E. coli* cannot be over 410 colony counts per 100 milliliters in more than ten percent of the samples take over a 90-day period and a 90-day geometric mean, the *E. coli* cannot be greater than 126 colony counts per 100 mL. For the 2015 and 2016 data, Tables 8 and 9 show the *E. coli* results and exceedances of the STV; furthermore, Tables 10 and 11 show the 90-day geomean. In 2015, the majority of the samples collected exceeded the criteria; the exception was that the STV was met for the last 90-day period at RM 0.10. All of the sampling events in 2015 were considered to be wet weather¹.

Overall, in 2016, the *E. coli* density count improved at the majority of the sites in comparison to 2015. The biggest improvement was at RM 0.15, as there was a drastic decrease in the *E. coli* levels. RM 0.10 and 1.15 have shown significant improvement as well. There are many possibilities to why there was a decrease in *E. coli* densities; for instance, the main reason is due to dry weather. There may also be less wild animals in the area, the stormwater had less *E. coli*, or septic systems are being corrected or eliminated.

Table 8. 2015 Hemlock Creek <i>E. coli</i> Results (most probable number (MPN)/100 ml)				
Date	RM 0.10	RM 0.15	RM 1.15	RM 2.50
06/17/15*	484	557	1280	1701
06/24/15*	1650	1924.5	4378	1946
07/01/15*	2082	2934	4986	3912
07/08/15*	1930	1670	2594	2022
07/15/15*	356	573	1585	5210
Wet-Weather Event *				
Exceeds STV criterion for 90-day period starting on that day				

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.

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Table 9. 2016 Hemlock Creek <i>E. coli</i> Results (MPN/100 ml)				
Date	RM 0.10	RM 0.15	RM 1.15	RM 2.50
06/15/16	330	8	273	2275
06/22/16	232	56	110	1189
06/29/16	621	9	182	1210
07/06/16*	482	43	206.5	1826
07/13/16	399.5	55	114	778
Wet-Weather Event *				
Exceeds STV criterion for 90-day period starting on that day				

Table 10. 2015 Hemlock Creek <i>E. coli</i> Densities 90-day geomean				
Date	RM 0.10	RM 0.15	RM 1.15	RM 2.50
06/17/15	1027.0	1246.5	2582.5	2672.8
06/24/15	1239.5	1524.6	3077.9	2992.5
07/01/15	1126.8	1410.7	2736.8	3454.1
07/08/15	828.9	978.2	2027.7	3245.7
07/15/15	356.0	573.0	1585.0	5210.0
Exceeds geomean criterion for 90-day period starting on that day				

Table 11. 2016 Hemlock Creek <i>E. coli</i> Densities 90-day geomean				
Date	RM 0.10	RM 0.15	RM 1.15	RM 2.50
06/15/16	391.1	24.9	166.7	1359.8
06/22/16	408.1	33.0	147.3	1195.7
06/29/16	492.7	27.7	162.4	1197.9
07/06/16	438.8	48.6	153.4	1191.9
07/13/16	399.5	55.0	114.0	778.0
Exceeds geomean criterion for 90-day period starting on that day				

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site on Hemlock Creek in 2015 and 2016 using the 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)* (2006). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

The 2015 and 2016 QHEI scores for each of the sites are shown in Table 12. Throughout the two-year study, the RM 0.10, 0.15, and 1.15 sites met Ohio EPA's target score of 55. Having a score of 55 or above indicates that these sites have a habitat that will support a community of warmwater fish. According to the Ohio EPA, if the score is above 70, the site is considered to be in excellent condition.

Year	RM 0.10	RM 0.15	RM 1.15	RM 2.50
2015	65.00	67.00	58.75	56.00
2016	68.50	64.00	75.75	59.00

Through the two-year study, RMs 0.10 and 0.15 showed little change in their QHEI scores. RM 0.10 and RM 0.15 received good scores in both years. At RM 0.10, the substrate consisted mainly of gravel and sand. The instream cover has a moderate number of undercut banks, overhanging vegetation, shallows, rootmats, and rootwads. There were low amounts of oxbows/backwaters and aquatic macrophytes. In this stream, the sinuosity is high, development was fair, stability was low and there is no channelization. This site has very little bank erosion and shrub/old field along each side of the banks. At RM 0.15, the substrate consists mainly of boulders and bedrock. The instream cover is moderately diverse, which includes overhanging vegetation, shallows, rootmats, boulders, and logs/woody debris. The sinuosity is high to moderate with good development. At this site, the stability is low to moderate but there is severe bank erosion.

In the 2016 study, RM 1.15 received a high score of 75.75. For the period of 2015- 2016, the score at this site increased by 17 points, mostly due to an increase in instream cover. This site had a variety of substrates in the pool and riffle consisting of boulders, cobble, gravel and sand. The instream cover was diverse; there were moderate to extensive undercut banks, shallows, overhanging vegetation, rootmats, rootwads, boulders and logs. The sinuosity was moderate and there was no channelization. Although the site was very stable, there was moderate bank erosion. The maximum depth of the creek was 0.4 to 0.7m. One side of the creek was swamp and forest and the other side was residential.

In both 2015 and 2016, the site at RM 2.50 met the Ohio EPA's target score. In comparison to the other sites, this one had the lowest score both years. The creek had relatively decent substrates throughout the site that consisted of cobble, gravel, silt and some artificial. This site lacked a large amount of instream cover and it was not diverse. There were rootwads, boulders, logs/woody debris present in the stream. The channel morphology was in fair condition. The sinuosity was low and this site has not been channelized. The quality of the pools, riffles and runs were not in the best condition to support a fish community.

Electrofishing

Methods

One quantitative electrofishing pass was conducted at each site in 2015 and 2016. A list of the dates when the surveys were completed is given in Table 13. The creek is small and did not have the flow measured using a United States Geological Survey gage station. Sampling was conducted using longline or backpack electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream. The sampling zone was 0.15 kilometers for each site. 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.

Date	Sites sampled (RMs)	Method
07/22/15	0.10	Backpack
07/24/15	1.15	Longline
08/12/15	0.15	Longline
09/02/15	2.50	Longline
06/17/16	0.15	Longline
08/12/16	2.50	Longline
08/18/16	0.10	Longline
09/08/16	1.15	Longline

The electrofishing results for each pass 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 are listed in Table 14.

Table 14. 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

Lists of the species, numbers, pollution tolerances and incidence of DELT anomalies for fish collected during the electrofishing passes at each site are available upon request from the NEORSW WQIS Division.

Results and Discussion

On August 26, 2015, one electrofishing pass was conducted at the lower branch of Hemlock Creek RM 0.10. This site received an IBI score of 48 and was in attainment of the WWH biocriterion (Table 15). The site had a *Very Good* narrative rating and the highest score compared to the other sites. All of the fish that were collected were native species, but the majority were highly tolerant to pollution, which included the central mudminnow (*Umbra limi*). The following year on August 17, 2016, a second pass was conducted and the site was again in attainment of the WWH biocriterion, receiving a score of 46. Most of the fish species collected in 2015 were also collected in 2016; there were

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only a few different species that were found between the two passes. In 2015, the green sunfish (*Lepomis cyanellus*), northern fathead minnow (*Pimephales promelas*) and johnny darter (*Etheostoma nigrum*) were found in the creek; these species were not found in 2016. In 2016, the golden shiner (*Notemigonus crysoleucas*), bluntnose minnow (*Pimephales notatus*), and rainbow darter (*Etheostoma caeruleum*) were found at this site; however, they were not found in 2015. Due to the close proximity of this site to the Cuyahoga River, it is expected that the composition of the fish community at this site may vary based on what is present in the river at that time.

On August 12, 2015 and June 17, 2016, electrofishing was performed at RM 0.15. The site received an IBI score of 30 (*Fair*) in 2015, failing to meet the criterion. This site had a significant increase by 6 points in 2016 and was in non-significant departure of the criterion. The increase in score was due to a lower percentage of fish considered to be either tolerant or pioneering and an overall increase in the number of fish collected. There were six species of fish found each year; however, there were two different types of species present in each year. In 2015, quite a few highly tolerant species of fish were found at this site. Two species of fish were present in 2015 that were not in 2016; they were the yellow bullhead (*Ictalurus natalis*) and a johnny darter (*Etheostoma nigrum*). In 2016, the pumpkinseed sunfish (*Lepomis gibbosus*) and rainbow trout (*Oncorhynchus mykiss*) were found at the site. The rainbow trout was found in abundance.

On August 13, 2015 and September 8, 2016, electrofishing passes were performed at RM 1.15. Over the two-year study, the IBI score increased from 26 (*Poor*) to 28 (*Fair*), but still failed to be in attainment of the criterion. The same type of species was collected on both days, the only difference was the number of each species. The total number of fish collected in 2016 increased by 223. This pass was conducted later in the year than the one in 2015, which may have been a potential reason for the increase in the number of fish collected. There was also a decrease in the proportion of pioneering species, which was the reason why the narrative rating improved. All of the species were native to the area except for a goldfish (*Carassius auratus*). The goldfish may have been accidentally released into the stream by a nearby resident or the fish may have migrated through the waterways.

On September 2, 2015 and August 12, 2016, electrofishing passes were performed at RM 2.50; both passes had an IBI score of 20, which is considered *Poor* and not in attainment of the criterion. Only one type of species was found at this site, the creek chub (*Semotilus atromaculatus*). The creek chub is a fish that is highly tolerant to pollution. This may be because this site lacked in quality runs, riffles and pools. This site is also located immediately downstream of some failing home sewage treatment systems (HSTS), which as indicated by the elevated *E. coli* densities there, may have negatively impacted the water quality.

Table 15. 2015 Hemlock Creek IBI Results					
River Mile	Pass	IBI Score	Narrative Rating	Total No. of Species	No. of fish collected
0.10	1	48	<i>Very Good</i>	13	732
0.15	1	30	<i>Fair</i>	7	284
1.15	1	26	<i>Poor</i>	6	339
2.50	1	20	<i>Poor</i>	1	113
WWH Criterion IBI units \geq 40 Non-significant departure from WWH criterion \geq 36 IBI units					

Table 16. 2016 Hemlock Creek IBI Results					
River Mile	Pass	IBI Score	Narrative Rating	Total No. of Species	No. of fish collected
0.10	1	46	<i>Very Good</i>	12	392
0.15	1	36	<i>Marginally Good</i>	7	275
1.15	1	28	<i>Fair</i>	6	562
2.50	1	20	<i>Poor</i>	1	172
WWH Criterion IBI units \geq 40 Non-significant departure from WWH criterion \geq 36 IBI units					

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 all of the locations listed in 1. 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 (TRC) 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 NEORSD WQIS Division.

The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA’s Invertebrate Community Index (ICI) (Ohio EPA, 1987a, 2014a, 2014b). The ICI consists of ten community metrics (Table 17), 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 17. ICI Metrics	
1.	The total number of taxa on HD.
2.	Total number of Ephemeroptera taxa on HD.
3.	Total number of Trichoptera taxa on HD.
4.	Total number of Dipteran taxa on HD.
5.	Percent of Ephemeroptera in HD sample.
6.	Percent Trichoptera in HD sample.
7.	Percent Tribe Tanytarsini midges in HD sample.
8.	Percent Dipterans (excluding Tribe Tanytarsini) and all non-insects in HD sample.
9.	Percent Tolerant organisms (as defined by metric) in HD sample.
10.	Total number of Ephemeroptera, Plecoptera and Trichoptera collected in the qualitative sample.

Results and Discussion

An HD sampler was unable to be obtained from Hemlock Creek Lower Branch RM 0.10 in 2015; therefore, the site was assigned a narrative rating of *Low Fair* based on the qualitative sample, failing to meet WWH attainment (Table 18). A total of 31 taxa were collected in the qualitative sample with pollution tolerance values ranging from tolerant to moderately intolerant according to the Ohio EPA Macroinvertebrate Taxa List. EPT taxa included four Ephemeroptera, *Baetis flavistriga*, *Baetis intercalaris*, *Callibaetis sp.*, and *Caenis sp.*; and two Trichoptera, *Cheumatopsyche sp.* and *Hydropsyche depravata group*. Five pollution tolerant taxa (as designated by the Ohio EPA) were present in the qualitative sample including Oligochaeta, *Cricotopus (C.) bicinctus*, *Cricotopus (Isocladius) sylvestris group*, *Chironomus (C.) decorus group*, and *Polypedilum (P.) illinoense*. Only a single sensitive taxon, with a classification of moderately intolerant to pollution, was found to be present at the site, *Boyeria grafiana*. This taxon was noted as rare (fewer than 10 specimens observed) according to field notation from the Qualified Data Collector.

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While six EPT taxa were present in the qualitative sample, the population densities of these taxa were also noted as rare. Macroinvertebrate population density was found to be low overall at this site. All taxa collected, with the exception of Chironomidae and Gastropoda, were also noted as rare. While EPT and overall taxa diversity was not poor at this site, the low density of macroinvertebrates observed, coupled with the high number of tolerant taxa present, were the primary considerations for the narrative assignment of *Low Fair* for this site in 2015.

In 2016, this site received an ICI score of 14, which is considered *Fair* and not in attainment of the WWH criterion. The majority of the macroinvertebrate population found on the HD consisted of *Dicrotendipes neomodestus* and *Physella sp.*, with the latter being a pollution-tolerant organism. One caddisfly taxon was collected in the HD, with an additional two taxa in the qualitative sample. No mayfly taxa were collected at this site, which also contributed to it not being in attainment of the criterion.

The Hemlock Creek RM 0.15 site had an ICI score of 36, or *Good*, in 2015 and was in attainment of the WWH criterion. Two types of caddisflies were collected from the HD; *Polycentropus sp.*, a moderately intolerant species, and *Ceratopsyche sparna*, a facultative tolerant taxa species. The most predominant organism collected was *Baetis flavistriga*, a mayfly species, but a high number of *Crangonyx sp* and *Thienemannimyia group* were also found at this location. The qualitative sample consisted of 21 different taxa; 8 of those were found to be EPT taxa.

In 2016, this site had an ICI score of 40, which was also in attainment of the criterion and considered to be *Good*. There were three different species of caddisflies that were discovered at this site and consisted of *Cheumatopsyche sp*, *Ceratopsyche sparna*, and *Hydroptila sp*. The *Baetis flavistriga* mayfly and the *Coenagrionidae* damselfly were also present at this site. The most predominant taxon obtained was the *Tanytarsus glabrescens*.

The ICI score at Hemlock Creek RM 1.15 in 2015 was 26, or *Fair*, failing to be in attainment of the criterion. The macroinvertebrate community at this site had a low percentage of tolerant organisms and a relatively high percentage of Tanytarsini midges, which are generally pollution sensitive, but lacked any mayfly species. The total number of taxa in the qualitative sample was 18, with 5 of those being EPT taxa.

In 2016, this site received a higher score of 36, which is considered *Good* and was in attainment of the criterion. Although, there were less organisms found compared to 2015, there were more pollution-sensitive taxa present. Three different caddisfly species, which included *Chimarra aterrima*, *Cheumatopsyche sp*, and *Ceratopsyche sparna* were collected at this site, along with one species of mayfly, the *Baetis flavistriga*. The highest number of organisms obtained was from the *Thienemannimyia group*. The qualitative sample had a total of 6 EPT taxa, which was slightly higher than the previous year.

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During the 2015 sampling season, the HD sampler was recovered at RM 2.50, allowing for the computation of a calculated ICI score of 28, with a narrative rating of *Fair*. The majority of the organisms collected on the HD were dipterans or other insects, which detracted from the overall score. Only one mayfly taxon and two caddisfly taxa were collected on the HD, with four EPT taxa present in the qualitative sample. The total number of taxa collected at this site in both the qualitative and quantitative samples was similar to the other sites on Hemlock Creek that were evaluated during the study.

Hemlock Creek RM 2.50 was assigned a narrative rating of *Fair* in 2016 based on the qualitative sample. Overall, 20 different macroinvertebrate taxa were collected during the qualitative sampling event at Hemlock Creek RM 2.50 in 2016. Of those 20 total taxa, five were found to be EPT taxa. At the time of collection, it was noted that there was an abundance in population of Baetid mayflies. However, this abundance was represented by only one species present in collection, *Baetis flavistriga*. The presence of three different Hydropsychid caddisfly species, *Cheumatopsyche sp.*, *Ceratopsyche sparna*, and *Hydropsyche depravata* group, all considered facultative tolerant taxa, should also be noted. Regarding pollution tolerance, only three taxa found were classified as moderately tolerant or worse according to the Ohio EPA Macroinvertebrate Taxa List. Most of the taxa collected (15 of 20), were in the facultative tolerance category. The population composition collected in the 2016 qualitative sample demonstrated similar composition characteristics to the sample collected during 2015. Based on this historical data, as well as evaluation of the composition of the macroinvertebrates collected during the 2016 sampling event, RM 2.50 was again assigned a narrative rating of *Fair*.

Table 18. 2015 and 2016 Macroinvertebrate Results

River Mile	Year	ICI Score	Narrative Rating	Total Number of Taxa	Number of Qualitative Taxa	Number of Qualitative EPT Taxa	Number of Quantitative Taxa
0.10	2015	---	<i>Low Fair*</i>	---	31	6	---
	2016	14	<i>Fair</i>	22	17	2	15
0.15	2015	36	<i>Good</i>	34	21	8	25
	2016	40	<i>Good</i>	38	17	7	32
1.15	2015	26	<i>Fair</i>	36	18	5	24
	2016	36	<i>Good</i>	37	25	6	26
2.50	2015	28	<i>Fair</i>	37	23	4	27

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Table 18. 2015 and 2016 Macroinvertebrate Results							
River Mile	Year	ICI Score	Narrative Rating	Total Number of Taxa	Number of Qualitative Taxa	Number of Qualitative EPT Taxa	Number of Quantitative Taxa
	2016	---	<i>Fair</i> *	---	20	5	---
WWH criterion is ≥ 34 ICI units Non-significant departure from WWH criterion is ≥ 30 ICI units --- No ICI score available * Based on best professional judgment Bold indicates attainment of WWH biocriterion							

Conclusions

The Hemlock Creek watershed is one of the smaller ones in the NEORS D service area. Hemlock Creek was evaluated in 2015 and 2016 to monitor the conditions of the watershed; several tests and parameters were used to determine the health of the stream, see Table 19 and Table 20.

Table 19. 2015 Hemlock Creek Survey Results					
River Mile	Aquatic Life Use Attainment Status	Water Quality Exceedances	Habitat (Narrative Rating)	IBI Score (Narrative Rating)	ICI Score (Narrative Rating)
0.10	Partial ¹	<i>E. coli</i>	65 (<i>Good</i>)	48 (<i>Very Good</i>)	--- <i>Fair</i> ²
0.15	Partial	<i>E. coli</i>	67 (<i>Good</i>)	30 (<i>Fair</i>)	36 (<i>Good</i>)
1.15	Non	<i>E. coli</i>	62.75 (<i>Good</i>)	26 (<i>Poor</i>)	26 (<i>Fair</i>)
2.50	Non	<i>E. coli</i>	56 (<i>Good</i>)	20 (<i>Poor</i>)	28 (<i>Fair</i>)

¹Based on IBI score and best professional judgment

²Narrative rating based on best professional judgment and habitat evaluation

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Table 20. 2016 Hemlock Creek Survey Results					
River Mile	Aquatic Life Use Attainment Status	Water Quality Exceedances	Habitat (Narrative Rating)	IBI Score (Narrative Rating)	ICI Score (Narrative Rating)
0.10	Non	<i>E. coli</i>	68.5 (Good)	46 (Very Good)	14 (Poor)
0.15	Full	None	64 (Good)	36 (Fair)	40 (Good)
1.15	Partial	<i>E. coli</i>	75.75 (Excellent)	28 (Poor)	36 (Good)
2.50	Non ¹	<i>E. coli</i>	63 (Good)	20 (Poor)	---Fair ²

¹Based on IBI score and best professional judgment

²Narrative rating based on best professional judgment and habitat evaluation

Overall, the creek is suitable for a healthy community of fish based on habitat, but not all sites were in attainment of the IBI WWH criterion. RM 0.10 on the lower branch scored the highest and was in attainment both years. RM 0.15 improved from 2015 to 2016 and was in attainment for the latter. This site was on the low end of meeting the criterion and there are still some areas for improvement in the fish community, as no sensitive species were collected during either year. RM 1.15 had an excellent habitat score; however, this did not reflect in the IBI score, as it received a *Fair* rating during both years. Only one species of fish was found over the course of two years at RM 2.50. The habitat at this site was not as good as the other ones and it is immediately downstream of an area with a large percentage of failing septic systems.

The macroinvertebrate results showed varying results as well, based on the site. At two of the sites for one year each, the HDs were not located (RM 0.10 and RM 2.50). Based on best professional judgment and the results from the other year of sampling, these sites were considered to not be meeting WWH status. Over the course of the study, there were two sites that were in attainment of the ICI criteria, though. For both years, RM 0.15 met the criteria. In 2016, RM 1.15 was in attainment, which was an improvement from 2015.

The City of Seven Hills has plans to connect many of the failing septic tank systems in the area to local sanitary sewers in 2017 and 2018, which should improve bacteriological conditions in the creek. Monitoring of Hemlock Creek once the project is complete will help to demonstrate any improvements to water quality and the biological communities that have resulted from it. It is expected that a lower percentage of

pollution-tolerant organisms will be found then along with less exceedances of the primary contact recreation criteria.

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