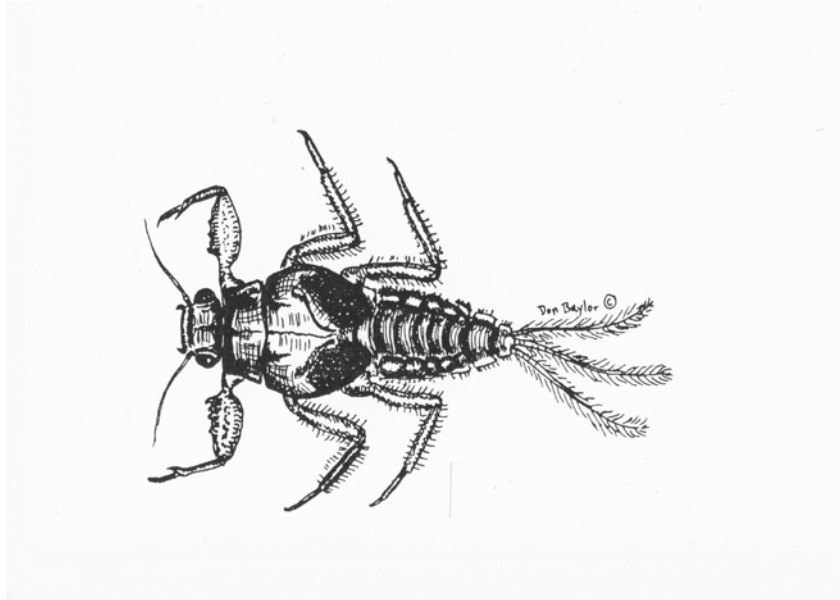


BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN
ABOVE AND BELOW
MOUNT POCONO MUNICIPAL AUTHORITY
WASTEWATER TREATMENT PLANT

October 16, 2019



Submitted by:

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BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN OCTOBER 16, 2019

EXECUTIVE SUMMARY

The purpose of this study was to evaluate the impact of the Mount Pocono Municipal Authority Wastewater Treatment Plant (WTP) discharge to the water quality of Forest Hills Run and to compare results with previous samplings of the same stations. Benthic Macroinvertebrates were sampled at one reference station above and two stations below the plant's discharge on May, June, and October of 2013; April and October of 2014, 2015, 2016, 2017, 2018, and 2019.

On October 16 of 2019, Station 1 above the WTP discharge had an excellent IBI score of 94.8, indicating exceptional water quality. Station 2 below Route 611 and Station 3 below Grange Road had IBI scores of 53.7 and 44.2, respectively, indicating considerable impairment at both downstream stations relative to the upstream station. The upstream station IBI score was well above the Aquatic Life Use (ALU) attainment benchmark IBI of 63. Stations 2 and 3 had scores below the ALU attainment benchmark. Scores at the upstream station were the best recorded since this sampling program began in 2013. Both downstream scores were comparable to scores for these stations since improvement evident since October of 2013.

BACKGROUND

On October 16, 2019, at the request of Mount Pocono Municipal Authority, Aquatic Resource Consulting (ARC) biologists Don Baylor and Chris Hartzler sampled benthic macroinvertebrates at the same three stations sampled in May, June, and October of 2013 and April and October of 2014, 2015, 2016, 2017, 2018 and April of 2019 on Forest Hills Run, Monroe County, PA. One station was above the Authority's Wastewater Treatment Plant (WTP) discharge and two were below the discharge. The purpose of the sampling was to evaluate the impact of the WTP discharge to Forest Hills Run.

Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically evenly represented numerically. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarcity of invertebrates (Plafkin, et al. 1989). In order to assure an accurate assessment, recent work in bio-monitoring stresses the use of several parameters, or metrics, to measure different components of the community structure.

BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN OCTOBER 16, 2019

Macroinvertebrate sampling methods followed those recommended by the US Environmental Protection Agency Protocol III (Plafkin, et al., 1989) with the latest modifications adopted by the PA Department of Environmental Protection for riffle/run freestone streams (PA DEP, 2012). At each station, six samples were taken with a D-frame kick net (Wildlife Supply Company #425-D5) of 500u nitex from the best riffle/run areas in a one hundred meter stretch. Samples were taken by placing the net against the substrate and disturbing approximately one square meter above the net by foot for one minute. Organisms and debris were composited for each station in a plastic container and preserved in alcohol for transport to the laboratory. Habitat was evaluated at each station using DEP's Water Quality Network Habitat Assessment forms for streams with riffle/run prevalence. Twelve habitat parameters were ranked on a scale of 1-20 and combined for a total habitat score.

In the laboratory, samples were rinsed in a USGS No. 35 sieve and placed in a white pan marked with a grid to delineate 28 squares measuring two inches on a side. Organisms were then picked from randomly selected grids until 200 organisms +/- 20% were obtained. Organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value (PA DEP, 2009). Metrics for riffle/run freestone streams were calculated for each subsample, including Total Taxa Richness, Ephemeroptera + Plecoptera + Trichoptera Taxa Richness (EPT), Modified Beck's Index, , Hilsenhoff Biotic Index, Shannon Diversity Index, , and Percent Sensitive Individuals. A description and brief rationale for each of the metrics follow:

1. **Total Taxa Richness** – is an index of diversity. The number of taxa (kinds) of invertebrates indicates the health of the benthic community through measurement of the variety of species present. Generally, number of species increases with increased water quality. However, variability in natural habitat (stream order and size, substrate composition, current velocity) also affects this number.

2. **Ephemeroptera, Plecoptera, and Trichoptera Taxa Richness (PTV 1-4)** Mayflies, stoneflies, and caddisflies, collectively referred to as EPT, are generally considered pollution sensitive (Plafkin et al. 1989). Thus, the total number of taxa within the EPT insect groups is used to evaluate community balance. This metric has been modified to include only the EPT taxa with pollution tolerance values of 1-4. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

**BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN
OCTOBER 16, 2019**

3. **Modified Beck's Index** is a weighted count of taxa with pollution tolerance values of 0, 1, or 2. This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution sensitive taxa. It is calculated by multiplying by 3 the number of taxa with a pollution tolerance value of 0, multiplying by 2 the number of taxa with a pollution tolerance value of 1, and multiplying by 1 the number of taxa with a pollution tolerance value of 2. The three values are added to yield the Modified Beck's Index score.

4. **Hilsenhoff Biotic Index** – is a direct measure of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Tolerance values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated.

Table 1. Evaluation of water quality using biotic index values (Hilsenhoff, 1987)		
BIOTIC INDEX	WATER QUALITY	DEGREE OF ORGANIC POLLUTION
0.00-3.50	Excellent	None Apparent
3.51-4.50	Very Good	Possible Slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly Significant
6.51-7.50	Fairly Poor	Significant
7.51-8.50	Poor	Very Significant
8.51-10.00	Very Poor	Severe

5. **Shannon Diversity Index** measures taxonomic richness and evenness of numbers of individuals across the taxa of a subsample. This metric is expected to decrease in values with increased anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and predominance of a few pollution-tolerant taxa.

6. **Percent Sensitive Individuals** is the percentage of individuals in the subsample with pollution tolerance values of 0-3. It is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem.

**BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN
OCTOBER 16, 2019**

INDEX CALCULATION

An overall index is used to integrate information from these various metrics and standardize them into one score for a subsample. The values for any standardized core metric are set to a maximum value of 1.00, with values closer to zero corresponding to increasing deviation from the expected reference condition and progressively higher values corresponding more closely to the biological reference condition. The adjusted standardized metric values for the six core metrics are averaged and multiplied by 100 to produce an index score ranging from 0-100. This number represents the index of biotic integrity (IBI) score for a sample. The following table shows metric standardization equations and index calculations for the sub-sample from Station 1 on Forest Hills Run.

Table 2. Metric standardization and index of biotic integrity calculations for the benthic macroinvertebrate sample from Station 1 on Forest Hills Run, October 16, 2019.				
Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score Maximum =1.00
Total Taxa Richness	Observed value / 33	28	0.903	0.903
EPT Taxa Richness	Observed Value/ 19	14	0.875	0.875
Modified Beck's Index	Observed value/38	38	1.721	1.000
Hilsenhoff Biotic Index	10-observed value/ (10-1.89)	1.95	1.158	1.000
Shannon Diversity Index	Observed value / 2.86	2.60	0.909	0.909
Percent Sensitive Individuals	Observed value / 84.5	69.45	1.041	1.000
Average of adjusted standardized core metric scores x 100 = IBI score				94.8

BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN OCTOBER 16, 2019

Sampling Stations

Three stations were sampled for benthic macroinvertebrates on Forest Hills Run (Figure 1). Although the map of sampling stations agreed upon by DEP, The Authority, and Brodhead Watershed Association showed Station 2 beginning immediately downstream of Rt. 611, protocols direct the biologist in the field to pick the best riffle habitat within a reach and to attempt to choose representative and similar habitats at reference and candidate stations to minimize the effects of other variables. Directly below the Rt. 611 culvert is a plunge pool followed by boulder-strewn steep area not suitable for sampling protocols nor sufficiently similar to the other stations. Therefore, the sampling reach began farther downstream and ended approximately 30 meters below the Rt. 611 culvert.

Station 1. – Beginning at the PP&L power line crossing approximately 100 meters above Mt. Pocono Municipal Authority WTP discharge and progressing upstream 100 meters.

Station 2. - Beginning approximately 130 meters below where Forest Hills Run exits the Route 611 culvert and progressing upstream to 30 meters below the Route 611 culvert.

Station 3 – Beginning approximately 100 meters below where Forest Hills Run flows under Grange Road and progressing 100 meters up to the Grange Road crossing.

RESULTS AND DISCUSSION

Benthic Macroinvertebrate Communities on October 16, 2019

Table 3 shows the taxa, numbers, and biotic index pollution tolerance value (PT) for benthic macroinvertebrate samples from Forest Hills Run on October 16, 2019. Table 4 shows metric values and IBI scores for those samples according to DEP's 2012 protocols. Extensive analysis by DEP of samples from unimpaired Special Protection Pennsylvania streams found a natural variability of up to 11 points among samples from similar habitat and that a difference of greater than 11 points in IBI scores is indicative of anthropogenic impairment between similar stations (DEP 2012). For samples collected from smaller streams between October and May, an IBI score ≥ 63 results in Aquatic Life Use (ALU) attainment, and an IBI score < 63 results in ALU impairment (PA DEP 2012). For these samples, October-May small stream benchmarks were applicable.

BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN OCTOBER 16, 2019

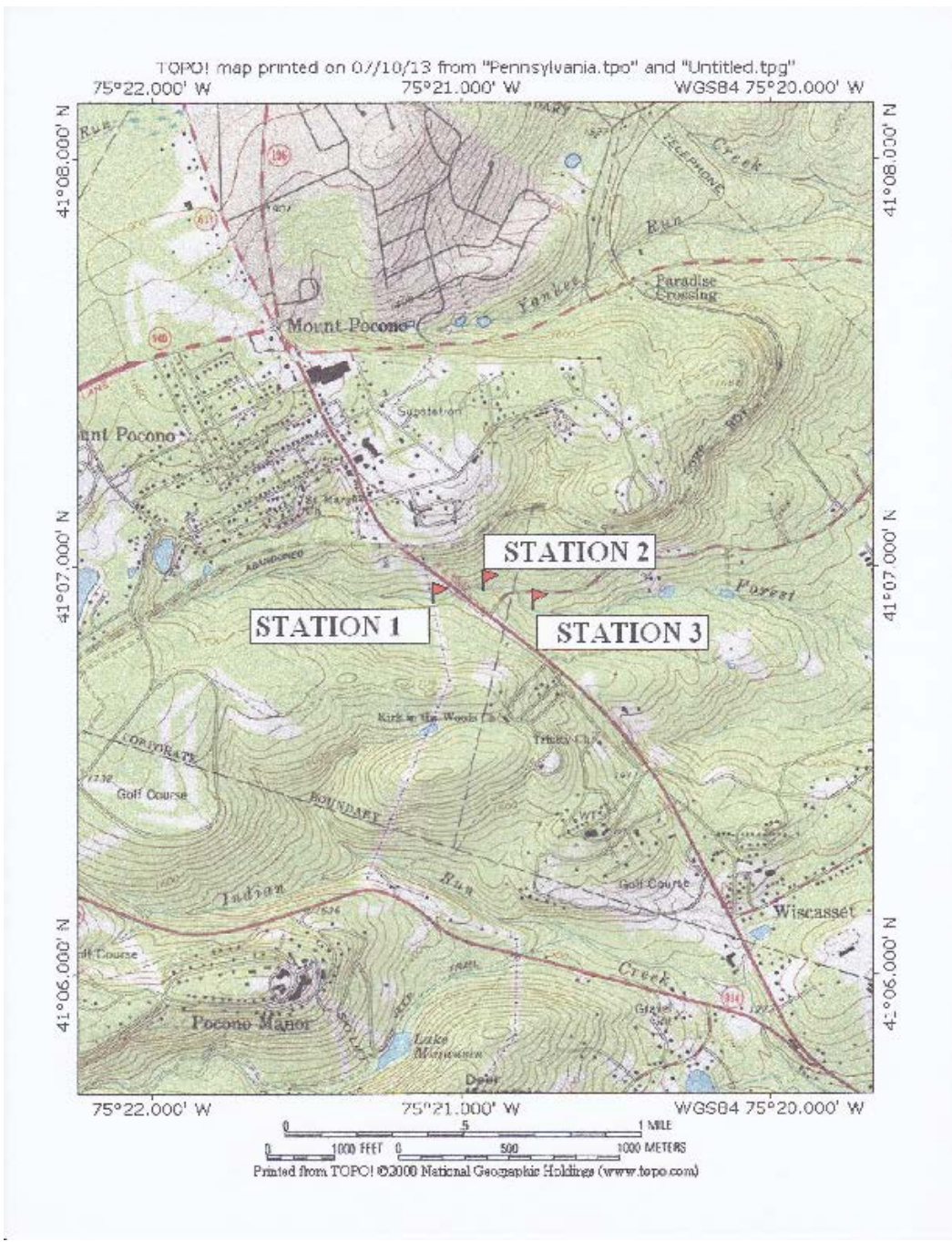


Figure 1. Stations sampled for macroinvertebrates on Forest Hills Run, October 16, 2019.

**BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN
OCTOBER 16, 2019**

Table 3				
Taxa, numbers, and biotic index pollution tolerance value (PT) for benthic macroinvertebrate samples from Forest Hills Run, October 16, 2019.				
TAXA	STATION 1 AboveWTP Discharge	STATION 2 Below Rt. 611	STATION 3 Below Grange Road	PT
Ephemeroptera (mayflies)				
<i>Ephemerella spp.</i>	5	-	-	1
<i>Baetis spp.</i>	7	9	15	6
<i>Heterocloeon spp.</i>	1	-	-	2
Trichoptera (caddisflies)				
<i>Rhyacophila spp.</i>	24	1	1	1
<i>Dolophilodes spp.</i>	19	20	13	0
<i>Parapsyche spp.</i>	1	-	-	0
<i>Diplectrona spp.</i>	56	17	76	0
<i>Ceratopsyche spp.</i>	17	68	90	5
<i>Hydropsyche spp.</i>	-	14	-	5
<i>Cheumatopsyche spp.</i>	3	-	-	6
<i>Apatania spp.</i>	1	-	-	3
<i>Polycentropus spp.</i>	-	1	-	6
Plecoptera (stoneflies)				
<i>Pteronarcys spp.</i>	2	1	-	0
<i>Tallaperla spp.</i>	4	-	-	0
Leuctridae	2	-	-	0
<i>Amphinemura spp.</i>	1	-	-	3
<i>Nemura spp.</i>	-	-	1	1
<i>Acroneuria spp.</i>	1	-	-	0
<i>Sayedina spp.</i>	2	-	-	0
<i>Utaperla spp.</i>	9	-	-	0

**BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN
OCTOBER 16, 2019**

Table 3. continued				
TAXA	STATION 1 AboveWTP Discharge	STATION 2 Below Rt. 611	STATION 3 Below Grange Road	PT
Diptera (true flies)				
Chironomidae	18	58	11	6
<i>Prosimulium spp</i>	-	6	-	2
<i>Simulium spp.</i>	-	7	4	6
<i>Ectemnia spp.</i>	3	-	-	1
<i>Antocha spp.</i>	1	-	-	3
<i>Tipula spp.</i>	3	7	5	4
<i>Limnophora spp.</i>	-	1	1	6
<i>Dixa spp.</i>	6	-	-	1
<i>Pericoma spp.</i>	3	-	-	4
<i>Hexatoma spp.</i>	1	-	-	2
<i>Antocha spp.</i>	1	-	-	3
<i>Empididae spp.</i>	1	-	-	6
Coleoptera (beetles)				
<i>Peomoresia spp.</i>	2	1	-	2
<i>Optioservus spp.</i>	7	-	-	4
Oligochaeta (worms)	3	2	5	10
Turbellaria (flatworms)	-	1	1	9

Macroinvertebrate samples from Station 2 below Route 611 and Station 3 below Grange Road had similar IBI scores, both indicating considerable impairment relative to the upstream reference (Table 4). The upstream reference Station 1 had a score of 94.8 indicating exceptional water quality well above the ALU attainment benchmark, Stations 2 and 3 scored 53.7 and 44.2 respectively, both somewhat below the ALU benchmark. IBI score differentials of 11 points or less between stations are considered attributable to natural variability. Station 2 below route 611 had an IBI score 41.1 points lower than the reference, and Station 3 below Grange Road scored 50.6 points below the reference, both indicating impairment. The IBI score differential between the downstream Stations 2 and 3 was 9.5, which is within the range attributable to natural variability. Therefore, no impairment was indicated between the downstream stations.

**BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN
OCTOBER 16, 2019**

There was a considerable loss of taxa and intolerant EPT taxa between the upstream and downstream stations (Table 4). There was also a considerable reduction in scores for Beck's Index and Percent Sensitive Individuals from the reference station to the downstream stations. Despite the impairment indicated between the upstream and downstream stations, both downstream stations had a fair number of intolerant taxa, namely *Dolophilodes spp.* and *Diplectrona spp.* caddisflies (Table 3). Thus both downstream stations had good standardized metric scores for Hilsenhoff Biotic Index. *Diplectrona spp.* caddisflies are known to persist only in streams that remain relatively cool during summer. Their abundance in the October 2019 downstream samples indicate improved stream temperatures compared with earlier years in the sampling of Forest Hills Run. The abundance at Station 1 and dearth at Stations 2 and 3 of stonefly taxa and individuals is an indication of some organic impairment. Most of the seven stonefly taxa at Station 1 were very intolerant (Table 3).

Comparison to Past Samples

The October 2019 downstream Stations 2 and 3 samples had IBI scores similar to several past samplings but superior to those for April 2019 (Table 5). All samplings starting in May of 2013 have indicated impairment between Station 1 and the downstream stations. However, starting in October 2015 samples have indicated some improvement in the benthic communities at those stations. Past downstream samples had a dearth of intolerant organisms while starting in October of 2015, downstream samples had representations of *Dolophilodes spp.* and or *Diplectrona spp.* caddis, both of which have a pollution tolerance value of 0. This resulted in improvement in Station 2 and 3 IBI scores at most samplings. The presence of more intolerant taxa in these last several downstream samplings is an indication of improved conditions, while the predominance of moderately tolerant organisms and a dearth of stoneflies downstream continues to be an indication of organic enrichment. IBI scores at the upstream reference station have been quite variable ranging in the past from an excellent 88.61 to a relatively poor 56.0. Apparently, there is periodic negative impact on water quality of Forest Hills Run occurring well above the Mount Pocono Municipal Authority wastewater discharge. The exceptional October 2019 IBI score of 94.8 at Station 1 was the best yet obtained and may be an indication of the exceptional water quality that would exist in Forest Hills Run in the absence of anthropogenic impairment.

METRIC	STATION 1 Above WTP Discharge		STATION 2 Below 611		STATION 3 Below Grange Road	
	Observed Metric Value	Adjusted Standardized Metric Score Maximum =1.00	Observed Metric Value	Adjusted Standardized Metric Score Maximum =1.00	Observed Metric Value	Adjusted Standardized Metric Score Maximum =1.00
Number of Organisms	203	-	214	-	223	-
Number of Grids Picked /Subsample	11	-	7	-	7	-
Total Taxa Richness	28	0.903	16	0.516	12	0.364
EPT Taxa Richness (PT 0-4)	14	0.875	4	0.250	3	0.158
Beck's Index	38	1.000	14	0.636	10	0.263
Shannon Diversity	2.60	0.909	1.97	0.689	1.57	0.549
Hilsenhoff Biotic Index	1.95	1.000	4.38	0.809	3.22	0.836
Percent Sensitive Individuals	69.45	1.000	21.49	0.322	40.81	0.483
Index of Biotic Integrity (IBI) Score		94.8		53.7		44.2

Table 5.			
Comparison of IBI scores for benthic macroinvertebrate samples from Forest Hills Run on May, June, and October, 2013; April and October of 2014, 2015, 2016, 2017, 2018, and 2019.			
DATE	STATIONS		
	1 Above WTP Discharge	2 Below Rt. 611	3 Below Grange Rd.
May 28, 2013	88.4	16.1	25.5
June 19, 2013	70.2	18.0	37.1
Oct. 14, 2013	82.1	20.2	32.5
Apr. 24, 2014	79.4	27.3	25.5
Oct. 23, 2014	88.61	9.62	17.33
Apr. 17, 2015	63.8	20.9	14.9
Oct. 5, 2015	73.3	51.2	49.9
Apr. 11, 2016	56.0	41.8	38.9
Oct. 20, 2016	86.62	37.8	59.7
April 18, 2017	75.6	46.3	43.9
Oct. 13, 2017	81.6	36.7	44.6
Apr. 25, 2018	76.3	37.1	30.8
Oct. 17, 2018	75.9	61.4	44.3
April 25, 2019	63.1	35.2	32.3
Oct. 16, 2019	94.8	53.7	44.2
Note - Aquatic Life Use Attainment benchmark score is 63			

On October 16, 2019, habitat was the same as that found in recent samplings. (Table 6). Embeddedness at Station 1 was not as severe as in the recent past. Stations 1 and 2 were located in deeply incised channels, while Station 3 was less incised. Good riffle habitat was available at all stations. Habitat scores were in the low optimal range at Station 3 and between optimal and suboptimal for stations 1 and 2. Habitat scores were influenced by small stream size limiting instream cover and depth regimes, and deeply incised channels with some erosion evident. Stations 2 and 3 were scored lower for disruptive pressure because they were below road crossings.

BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN

OCTOBER 16, 2019

Table 6			
Habitat Assessment of Sampling Stations on Forest Hills Run, April 25, 2019			
Parameter	Station 1	Station 2	Station 3
1. Instream Cover	15	18	16
2. Epifaunal Substrate	14	15	16
3. Embeddedness	14	15	15
4. Velocity/Depth Regimes	14	17	15
5. Channel Alteration	17	15	18
6. Sediment Deposition	15	16	17
7. Frequency of Riffles	19	19	19
8. Channel Flow Status	19	19	19
9. Condition of Banks	7	7	13
10. Bank Vegetative Protection	14	14	15
11. Grazing or Other Disruptive Pressure	18	14	14
12. Riparian Vegetative Zone Width	19	17	19
TOTAL SCORE	185	187	197
Score ranges: Optimal 340-192, Suboptimal 180-132, Marginal 120-72, Poor <60			

BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN

OCTOBER 16, 2019

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