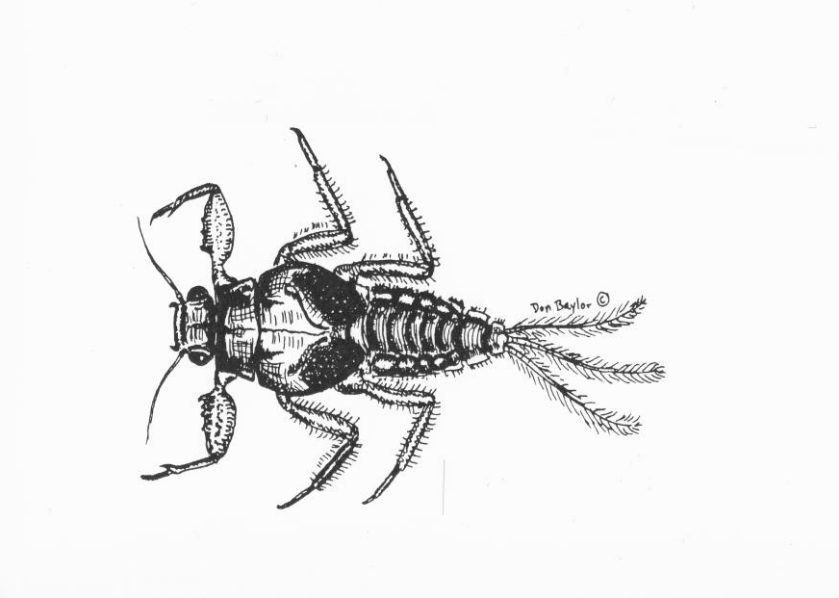
BENTHIC MACROINVERTEBRATES OF FOREST HILLS RUN

ABOVE AND BELOW

MOUNT POCONO MUNICIPAL AUTHORITY

WASTEWATER TREATMENT PLANT

OCTOBER 20, 2016



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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 a reference station above and two stations below the plant's discharge on May, June, and October of 2013; and April and October of 2014, 2015, and 2016.

On October 20, 2016, Station 1 above the WTP discharge had an very good IBI score of 86.62 indicating excellent water quality. Station 2 below Route 611 had an IBI score of 37.8, indicating considerable impairment relative to the upstream station. Station 3 below Grange Road showed considerable recovery over Station 2 with an IBI score of 59.67, though still indicating impairment relative to the reference. The October 2016 samples indicated a continuation of the improvement in downstream samples first found in October of 2015. Station 3 below Grange Road had an IBI score better than any since this monitoring program began in May of 2013.

BACKGROUND

On October 20, 2016, at the request of Mount Pocono Municipal Authority, Aquatic Resource Consulting (ARC) biologist Don Baylor sampled benthic macroinvertebrates at the same three stations sampled in May, June, and October of 2013; April and October of 2014; and April and October of 2015, and April of 2016 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 October 20 , 2016 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.

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METHODS

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, 2009). 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.

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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.

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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 20, 2016.

Metric	**Standardization Equation**	**Observed Metric Value**	**Standardized Metric Score**	**Adjusted Standardized Metric Score** Maximum =1.00
Total Taxa Richness	Observed value / 33	27	0.818	0.818
EPT Taxa Richness	Observed Value/ 19	14	0.737	0.737
Modified Beck's Index	Observed value/38	34	0.895	0.895
Hilsenhoff Biotic Index	10-observed value/ (10-1.89)	1.69	1.025	1.00
Shannon Diversity Index	Observed value / 2.86	2.41	0.843	0.843
Percent Sensitive Individuals	Observed value / 84.5	76.36	0.904	0.904
Average of adjusted standardized core metric scores x 100 = IBI score				**86.62**

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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 chose representative and similar habitat 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, 2016

Table 3 shows the taxa, numbers, and biotic index pollution tolerance value (PT) for benthic macroinvertebrate samples from Forest Hills Run on October 20, 2016. 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 $\geq$ 63 results in aquatic life use attainment, and an IBI score < 50 results in ALU impairment. For samples collected between June and September from smaller streams, an IBI score $\geq$ 50 results in ALU attainment and an IBI score of <40 results in ALU impairment (PA DEP 2012). For scores between these benchmarks, additional evaluation is required. For these samples, October-May small stream benchmarks were applicable.

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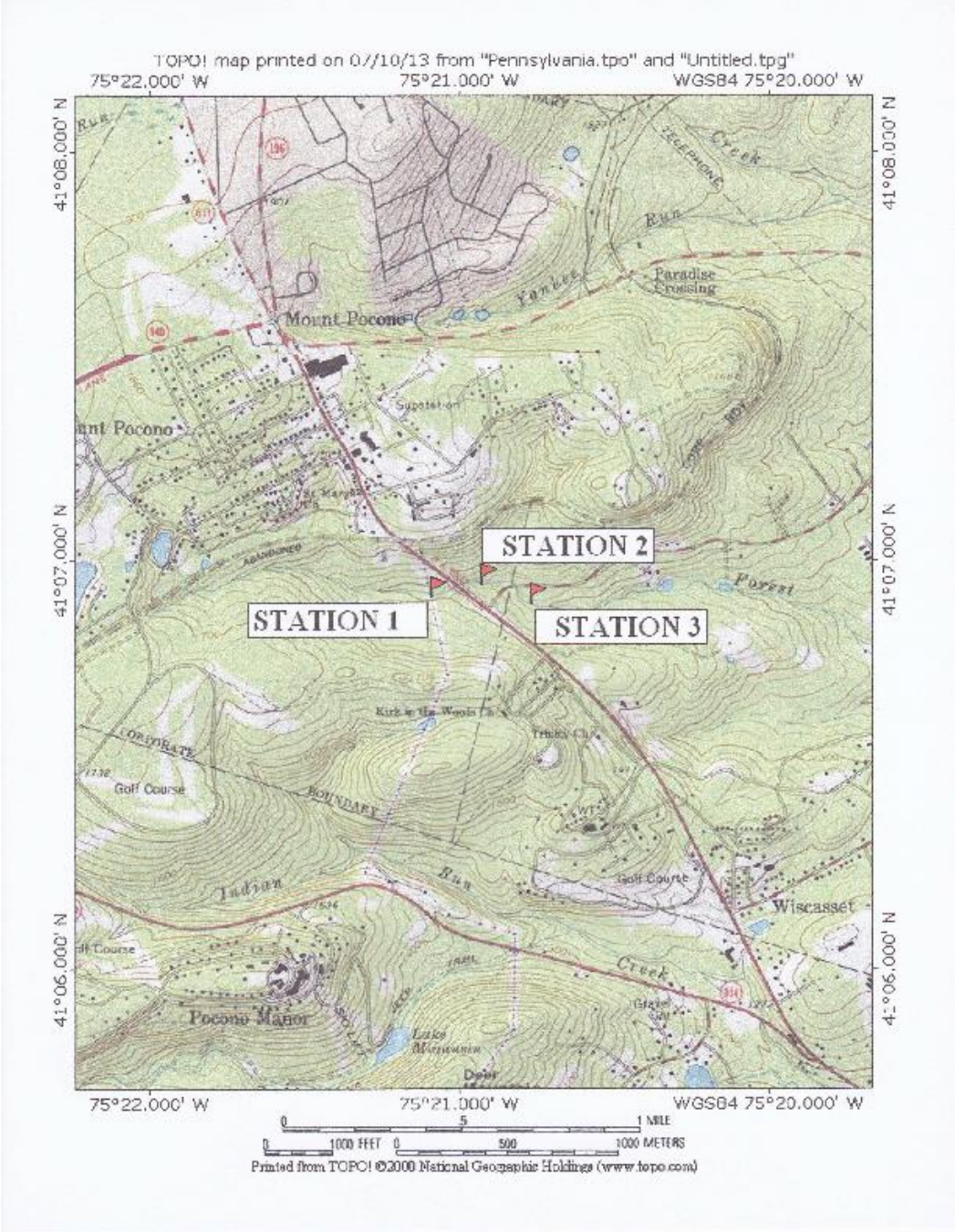

Figure 1. Stations sampled for macroinvertebrates on Forest Hills Run, October 20, 2016.

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Table 3
Taxa, numbers, and biotic index pollution tolerance value (PT) for benthic macroinvertebrate samples from Forest Hills Run, October 20, 2016.

TAXA	STATION 1 AboveWTP Discharge	STATION 2 Below Rt. 611	STATION 3 Below Grange Road	PT
Ephemeroptera (mayflies)				
Baetis spp.	5	1	7	6
Ephemerella spp.	-	-	4	1
Trichoptera (caddisflies)				
Rhyacophila spp.	78	-	4	1
Dolophilodes spp.	25	42	30	0
Parapsyche spp.	12	-	1	0
Diplectrona spp.	24	16	32	0
Wormaldia spp.	1	-	-	0
Ceratopsyche spp.	14	11	40	5
Lepidostome spp.	5	-	3	1
Glossossoma spp.	-	-	1	0
Hydropsyche spp.	-	10	42	5
Cheumatopsyche spp.	1	-	1	6
Micrasema spp.	5	-	1	2
Molanna spp.	-	-	1	6
Pycnopsyche spp.	1	-	-	4
Neophylax spp.	2	-	-	3
Plecoptera (stoneflies)				
Acroneuria spp.	4	-	-	0
Pteronarcys spp.	3	1	1	0
Leuctradae. spp.	1	-	-	0
Tallaperla spp.	1	-	-	0
Chloroperlidae spp.	1	-	-	0

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Table 3. continued				
TAXA	**STATION 1 AboveWTP Discharge**	**STATION 2 Below Rt. 611**	**STATION 3 Below Grange Road**	**PT**
Chironomidae	**8**	**18**	**15**	**6**
Simulium spp.	**3**	**40**	**17**	**6**
Hexatoma spp.	**1**	**-**	**-**	**2**
Tipula spp.	**10**	**2**	**6**	**4**
Ceratapagonidae app.	**2**	**-**	**-**	**6**
Dixa spp.	**2**	**-**	**-**	**1**
Limnophora spp.	**-**	**2**	**2**	**6**
Coleoptera (beetles)				
Promoresia spp.	**3**	**-**	**-**	**2**
Optioservus spp.	**6**	**-**	**2**	**4**
Chrysomelidae spp.	**1**	**-**	**-**	**5**
Turbellaria (flatworms)	**-**	**74**	**7**	**9**

Station 1, the reference above the STP discharge, had a very good IBI score - 86.62. The score indicated excellent water quality. A strong predominance of sensitive organisms was reflected in high metric scores for Hilsenhoff Biotic Index and Percent Sensitive Organisms (Table 4). Several intolerant taxa predominated, including *Rhyacophila, Dolophilodes,* and *Diplectrona* caddisflies (Table 3). Several intolerant stonefly taxa were also present, though not as numerous, at Station 1. The IBI score was well above thresholds for Aquatic Life Use (ALU) attainment.

Stations 2 and 3 had lower IBI scores, indicating impairment relative to Station 1. The differences between the reference Station 1 and the downstream Stations 2 and 3 IBI scores exceeded the 11 point range attributable to natural variability. The Station 2 IBI score was 48.82 points lower than the score for Station 1, and the Station 3 IBI score was 26.95 points lower than the reference score (Table 4). Stations 2 and 3 had a good

representation of intolerant *Dolophilodes* and *Diplectrona* caddis, but metric scores were lowered by reductions in Total Taxa Richness, EPT Taxa Richness, and numerous intolerant or moderately tolerant organisms, especially at Station 2 (Table 4). More than half of the taxa at Station 1 were lost at Station 2 (Table 4). Station 2 had a predominance of tolerant Turbellaria flatworms (PT=9) constituting 34 percent of the sample organisms (Table 3). Station 3 below Grange Road displayed considerable recovery over Station 2 with a 21.9 point rise in IBI score. Many fewer Turbellarians were found at Station 3. There was also appreciable recovery in numbers of taxa, diversity, and Hilsenhoff Biotic Index. Only one stonefly was collected in each downstream sample (Tabale 3).

The fact that intolerant organisms were fairly well represented at Stations 2 despite the predominance of Turbellarians and lower IBI scores may reflect organic enrichment immediately below the discharge with water temperatures remaining cool enough to maintain good levels of dissolved oxygen (DO). Turbellarians proiferate in organically enriched environments. At the same time, the intolerant *Dolophilodes* and *Diplectrona* found there and at Station 3 require good DO levels. An increase in fine particulate organic matter may also be indicated at Stations 2 and 3 by the numerous filter-feeders in those samples - *Simulium* blackflies at Station 2 and *Hydropsyche* and *Ceratopsyche* caddisflies at Station 3 (Table 3).

Comparison to Past Samples

The October 2015 and April and October 2016 samples indicated considerable improvement in the benthic communities at Stations 2 and 3 over past samples (Table 5). Downstream IBI scores improved considerably over those for spring and fall of 2013, 2014, and spring of 2015 samples. Past downstream samples had a dearth of intolerant organisms while starting in October of 2015, samples had an abundance of *Dolophilodes spp*. caddis and some *Diplectrona spp*. caddis, both of which have a pollution tolerance value of 0. This resulted in a considerable improvement in Station 2 and 3 IBI scores. The presence of more intolerant taxa in these last three downstream samplings is an indication of improved conditions, while the predominance of moderately tolerant organisms and a dearth of stoneflies downstream was an indication of some degree of organic enrichment. The notable rise in IBI score at Station 1 from April to October of 2016 reflects recovery from an unknown impact upstream of all stations prior to April of 2016. The IBI score below Grange Road in October 2016 was the best recorded since sampling began in 2013.

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Table 4.
Metric scores, adjusted standardized metric scores, and Index of biotic Integrity (IBI) scores for benthic macroinvertebrate samples from forest Hills Run, October 20, 2016.

	STATION 1 Above WTP Discharge		STATION 2 Below 611		STATION 3 Below Grange Road	
METRIC	**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	220	-	217	-	217	-
Number of Grids Picked /Subsample	16	-	8	-	11	-
Total Taxa Richness	27	0.818	11	0.333	20	0.606
EPT Taxa Richness (PT 0-4)	14	0.737	3	0.158	7	0.368
Beck's Index	34	0.895	9	0.237	22	0.579
Shannon Diversity	2.41	0.843	1.82	0.636	2.33	0.815
Hilsenhoff Biotic Index	1.69	1.00	5.28	0.582	3.58	0.792
Percent Sensitive Individuals	76.36	0.904	27.19	0.322	35.48	0.420
Index of Biotic Integrity (IBI) Score		**86.62**		**37.80**		**59.67**

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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, and April and October of 2016.

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

Habitat Assessment

On October 20, 2016, only slight changes from past sampling dates was evident in the physical substrate at Stations 1, 2, and 3 (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. Despite an extended period of little precipitation and low flows, good riffle habitat was available at all stations. Habitat scores for all stations fell into the suboptimal range mainly due to the small stream size limiting instream cover, low flows, and deeply incised channels with some erosion evident. Stations 2 and 3 were scored lower for disruptive pressure because they were below road crossings.

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Table 6
Habitat Assessment of Sampling Stations on Forest Hills Run, October 20, 2016.

Parameter	**Station 1**	**Station 2**	**Station 3**
1. Instream Cover	13	16	14
2. Epifaunal Substrate	14	15	16
3. Embeddedness	14	15	15
4. Velocity/Depth Regimes	12	15	13
5. Channel Alteration	17	15	18
6. Sediment Deposition	15	16	17
7. Frequency of Riffles	19	19	19
8. Channel Flow Status	13	13	13
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	**175**	**178**	**186**

Score ranges: Optimal 340-192, Suboptimal 180-132, Marginal 120-72, Poor <60

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