# BENTHIC MACROINVERTEBRATES OF BUSHKILL CREEK,

# NORTHAMPTON COUNTY, PA

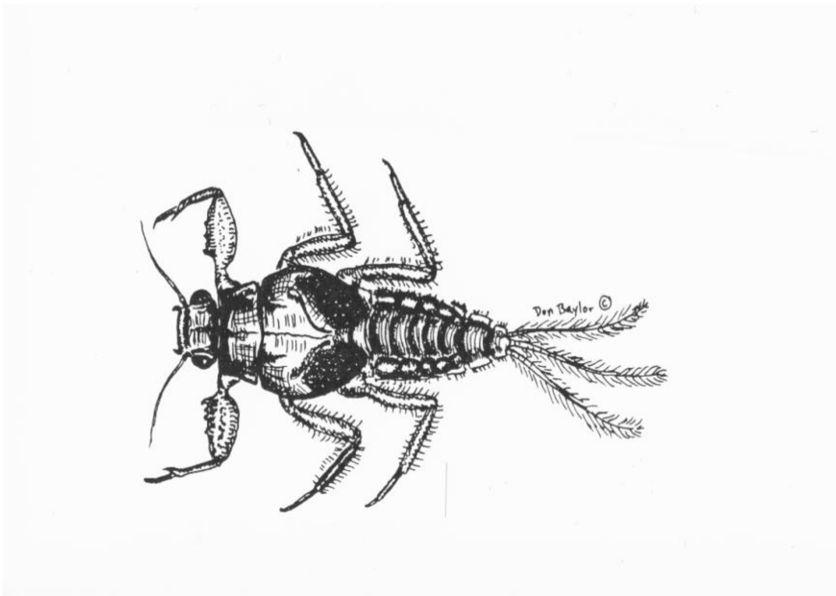
FOR

FORKS OF THE DELAWARE TROUT UNLIMITED

AND

BUSHKILL STREAM CONSERVANCY

APRIL 16, 2011

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## BENTHIC MACROINVERTEBRATES OF BUSHKILL CREEK, APRIL 16, 2011

### BACKGROUND

On April 16, 2011, at the request of Forks of the Delaware Trout Unlimited and the Bushkill Stream Conservancy, Aquatic Resource Consulting (ARC) biologist Don Baylor sampled benthic macroinvertebrates at three stations on Bushkill Creek, Northampton County, PA. The purpose of the study was to establish baseline data for comparison to future monitoring and to determine how data compare to designated use criteria established for Pennsylvania streams by Pennsylvania Department of Environmental Protection (DEP).

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.

### 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 (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.

**BENTHIC MACROINVERTEBRATES OF BUSHKILL CREEK, APRIL 16, 2011**

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 over 200 organisms 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** (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 with a pollution tolerance value of 0-4 is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

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.

**BENTHIC MACROINVERTEBRATES OF BUSHKILL CREEK, APRIL 16, 2011**

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.

## 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 Bushkill Creek.

**BENTHIC MACROINVERTEBRATES OF BUSHKILL CREEK, APRIL 16, 2011**

**Table 2. Metric standardization and index of biotic integrity calculations for the benthic macroinvertebrate sample from Station 1 on Bushkill Creek, April 16, 2011.**
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| Metric | Standardization Equation | Observed Metric Value | Standardized Metric Score | Adjusted Standardized Metric Score Maximum =1.00 |
|---|---|---|---|---|
| Total Taxa Richness | Observed value / 33 | 16 | 0.485 | 0.485 |
| EPT Taxa Richness | Observed Value/ 19 | 4 | 0.211 | 0.211 |
| Modified Beck's Index | Observed value/38 | 4 | 0.105 | 0.105 |
| Hilsenhoff Biotic Index | 10-observed value/ (10-1.89) | 4.67 | 0.658 | 0.658 |
| Shannon Diversity Index | Observed value / 2.86 | 2.743 | 0.959 | 0.959 |
| Percent Sensitive Individuals | Observed value / 84.5 | 25.21% | 0.298 | 0.298 |
| Average of adjusted standardized core metric scores x 100 = IBI score | | | | **45.27** |

## SAMPLING STATIONS

Three stations were sampled for benthic macroinvertebrates on Bushkill creek (Figure 1):

Station 1. – In the vicinity of Tatamy Ball Park below the bridge crossing of Nazareth Road at coordinates 40.4450N/75.1495W.

Station 2. - Above and below the bridge crossing of Mill Road in Zucksville at coordinates 40.4302N/75.1472W.

Station 3 – Above and below the bridge Crossing of $13^{th}$ Street in Easton at coordinates 40.4181N/75.1370W.

## RESULTS AND DISCUSSION

### Habitat

The three stations sampled on Bushkill Creek in April of 2011had habitat scores within the optimal range (Table 3). Stations did not differ significantly in terms of physical habitat. All three stations had similar substrate in the riffle areas sampled. All had excellent channel flow status, as water levels were relatively high in the spring of 2011. All stations scored suboptimal in terms of channel alteration because all were in close proximity to bridge crossings. Banks were least stable, exhibiting some erosion, at Station 1. Station 3 nearest Easton scored lower than the others regarding “Grazing or Other Disruptive Pressure” because of it’s location in an urbanized area. The three stations were sufficiently similar that differences in benthic macroinvertebrate communities among stations would not be expected due to physical habitat.

**Table 3. Habitat assessment of macroinvertebrate sampling stations on Paradise Creek, March 30, 2010.**

| HABAITAT PARAMETER | STATION 1 Tatamy | STATION 2 Zucksville | STATION 3 Easton |
|---|---|---|---|
| 1. Instream Cover | 15 | 17 | 19 |
| 2. Epifaunal Substrate | 18 | 19 | 17 |
| 3. Embeddedness | 17 | 18 | 16 |
| 4. Velocity/Depth Regimes | 20 | 18 | 19 |
| 5. Channel Alteration | 15 | 15 | 15 |
| 6. Sediment Deposition | 17 | 16 | 18 |
| 7. Frequency of Riffles | 17 | 19 | 17 |
| 8. Channel Flow Status | 20 | 20 | 20 |
| 9. Condition of Banks | 12 | 17 | 16 |
| 10. Bank Vegetative Protection | 16 | 18 | 17 |
| 11. Grazing or Other Disruptive Pressure | 17 | 17 | 15 |
| 12. Riparian Vegetative Zone Width | 19 | 18 | 17 |
| **TOTAL SCORE** | **203** | **212** | **206** |
| **Score ranges: Optimal 340-192, Suboptimal 180-132, Marginal 120-72, Poor <60** | | | |

**BENTHIC MACROINVERTEBRATES OF BUSHKILL CREEK, APRIL 16, 2011**

## Benthic Macroinvertebrate Communities

Appendix A shows the taxa, numbers, and biotic index pollution tolerance value (BI) for benthic macroinvertebrate subsamples from Bushkill Creek on April 16, 2011. Table 4 shows metrics and IBI scores for those samples according to DEP's 2009 protocols.

**Table 4. Benthic Macroinvertebrate Community Metrics for Three Stations on Bushkill Creek, April 16, 2011.**

| | STATION 1 TATAMY | | STATION 2 ZUCKSVILLE | | STATION 3 EASTON | |
|---|---|---|---|---|---|---|
| **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 | 242 | - | 216 | - | 218 | - |
| Number of Grids Picked /Subsample | 4/28 | - | 4/28 | - | 4/11 | - |
| Total Taxa Richness | 16 | 0.485 | 15 | 0.455 | 14 | 0.424 |
| EPT Taxa Richness | 4 | 0.211 | 4 | 0.211 | 4 | 0.211 |
| Beck's Index | 4 | 0.105 | 7 | 0.1842 | 6 | 0.158 |
| Shannon Diversity | 2.7430 | 0.9591 | 2.2772 | 0.7962 | 2.4024 | 0.8400 |
| Hilsenhoff Biotic Index | 4.6653 | 0.6578 | 5.2176 | 0.5897 | 5.2294 | 0.5882 |
| Percent Sensitive Individuals | 25.21 | 0.2983 | 12.50 | 0.1479 | 6.42 | 0.0760 |
| **Index of Biotic Integrity (IBI) Score** | | **45.26** | | **39.72** | | **38.28** |
| **Benchmark for assessment category October to May: >= 63 IBI not impaired** | | | | | | |

Pennsylvania DEP uses different metrics and IBI score calculations for streams classified as freestone (low alkalinity) riffle/run streams during October –May, riffle/run freestone streams in summer, multi-habitat glide/pool streams, and limestone streams (PA DEP, 2009). Headwaters of Bushkill Creek begin as a low alkalinity freestone streams. As the Bushkill flows downstream through the stations sampled in this study, it gains limestone influenced groundwater. Despite the limestone influences which increase alkalinity levels in Bushkill Creek above that found in the headwaters and in most freestone streams, alkalinity levels are not high enough to classify the Bushkill as a limestone stream in DEP's protocols. Therefore, Bushkill Creek falls within the DEP category "riffle/run freestone streams," and samples were evaluated using metrics applied to that category (Table 3).

In April of 2011, samples from the three stations on Bushkill Creek had IBI scores indicative of impairment for High Quality, riffle/run freestone streams. Scores ranged from 45.26 at Station 1 to 38.28 at station 3 (Table 4). Scores of 63 or lower are indicative of impairment. The benthic communities of all three stations had somewhat low diversity with a predominance of more tolerant taxa (Appendix A). Stoneflies (Plecoptera) were very poorly represented. They were absent from subsamples from Stations 1 and 3, and only two were in the Station 2 subsample. In each of the subsamples, only three mayfly (Ephemeroptera) taxa were found. Among the Ephemeroptera, *Ephemerella* spp. and *Baetis* spp. predominated at each station. These two taxa commonly predominate in limestone streams, which also tend to have fewer mayfly taxa than freestone streams. Relatively tolerant midge larvae – Chironomidae – were the predominant taxon at each station. Crustaceans, especially *Gammarus* spp. (freshwater shrimp), usually most numerous in limestone streams, were much more abundant at the lower Station 3 than at the upstream stations (Appendix A). The percentage of sensitive individuals, Shannon diversity, Hilsenhoff biotic index, and total taxa richness values were slightly superior at Station 1, resulting in a better overall IBI score than at Stations 2 and 3 (Table 4).

A slight decline in water quality was indicated by macroinvertebrate communities at Stations 2 and 3 compared to Station 1 upstream. That decline, and the impairment indicated at all three stations according to PA DEP metric calculations for riffle/run freestone streams, may be due, at least in part, to anthropogenic impacts. However, since the macroinvertebrate communities resemble those expected in limestone streams, the lower scores may be partly due to the limestone influence found in this stream section. Calculation of metrics for these samples using PA DEP's limestone stream protocols resulted in scores of 86.2, 75.8, and 71.0 for stations 1,2, and 3 respectively – substantially superior to the scores of 45.27, 39.72, and 38.28 for stations 1, 2, and 3 using the freestone riffle/run protocols.

In 1980, macroinvertebrate samples from two headwater branches of Bushkill Creek yielded IBI scores of 80.1 and 78.97 from the east and west branches, respectively, using the riffle/run freestone metrics (Leonhardt 2008). However, these sampling stations are upstream of the limestone influences. Thus, the lower IBI scores for stations in this study may be partly a reflection of changes in water chemistry due to those limestone influences, rather than a result of organic pollution. In communications with PA DEP Northeast Regional Office biologist Tim Daley, he expressed that his work on Bushkill Creek near Easton revealed IBI scores indicative of impairment similar to those in this study. He, too, felt that the limestone influence may cause lowering of scores when freestone metrics are used.

Because of the limestone influences on benthic communities and the potential for man-made impacts, macroinvertebrate samples from stations 1, 2, and 3 collected in April 2011 may be important benchmarks against which to measure future water quality trends in Bushkill Creek.

## BENTHIC MACROINVERTEBRATES OF BUSHKILL CREEK, APRIL 16, 2011

**Appendix A. Taxa, numbers, and biotic index values for benthic macroinvertebrate samples from Bushkill Creek, April 16, 2011.**

| TAXA | STATION 1 TATAMY | STATION 2 ZUCKSVILLE | STATION 3 EASTON | BI |
|---|---|---|---|---|
| Ephemeroptera (mayflies) | | | | |
| *Ephemerella (invaria)* | 38 | 14 | 10 | 1 |
| *Seratella spp* | - | 1 | - | 2 |
| *Baetis spp.* | 34 | 29 | 32 | 6 |
| *Acentrella spp.* | 1 | - | 1 | 4 |
| Trichoptera (caddisflies) | | | | |
| *Chimarra spp.* | 7 | 3 | 4 | 4 |
| *Ceratopsyche spp.* | 12 | 14 | 6 | 5 |
| *Cheumatopsyche spp.* | 4 | - | 1 | 6 |
| *Lepidostoma spp* | 1 | 1 | - | 1 |
| *Agapetus spp.* | - | - | 1 | 0 |
| Plecoptera (stoneflies) | | | | |
| *Taeniopteryx spp.* | - | 2 | - | 2 |
| Diptera (true flies) | | | | |
| Chironomidae | 100 | 124 | 87 | 6 |
| *Antocha spp.* | 1 | 2 | - | 4 |
| *Prosimulium spp.* | 22 | 9 | 3 | 2 |
| *Rhabdomastix spp.* | 2 | 4 | 1 | 4 |
| Amphipoda (shrimp) | | | | |
| *Gammarus spp.* | 7 | 1 | 60 | 4 |
| Isopoda (sowbugs) | | | | |
| *Caecidotea spp.* | - | - | 1 | 6 |
| Coleoptera (beetles) | | | | |
| *Psephenus spp.* | 5 | 8 | - | 4 |
| *Optioservus spp* | 2 | 2 | 1 | 4 |
| Gastropoda (snails) | | | | |
| *Pisidium spp.* | 1 | - | - | 8 |
| Oligochaeta (worms) | 5 | 2 | 10 | 10 |

**BENTHIC MACROINVERTEBRATES OF BUSHKILL CREEK, APRIL 16, 2011**

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