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JAN 7 2013

ENVIRONMENTAL QUALITY BOARD

521 Quail Ridge Lane
Stroudsburg, PA 18360
December 27, 2012

Secretary
Pennsylvania Department of Environmental Protection
Rachel Carson State Office Building
Post Office Box 2063
Harrisburg, PA 17105-2063

Dear Mr. Secretary:

Enclosed is a petition to the Environmental Quality Board for the reclassification of Cranberry Creek, tributary to the Paradise Creek in Monroe County, PA. I am submitting it on behalf of the Brodhead Watershed Association, requesting that Cranberry Creek be upgraded from High Quality to Exceptional Value.

Letters of support for the petition from concerned landowners and interested parties will follow.

Sincerely,

Don Baylor

Don Baylor,
Aquatic Biologist
Director, Board of Brodhead Watershed Association

SECRETARY'S OFFICE

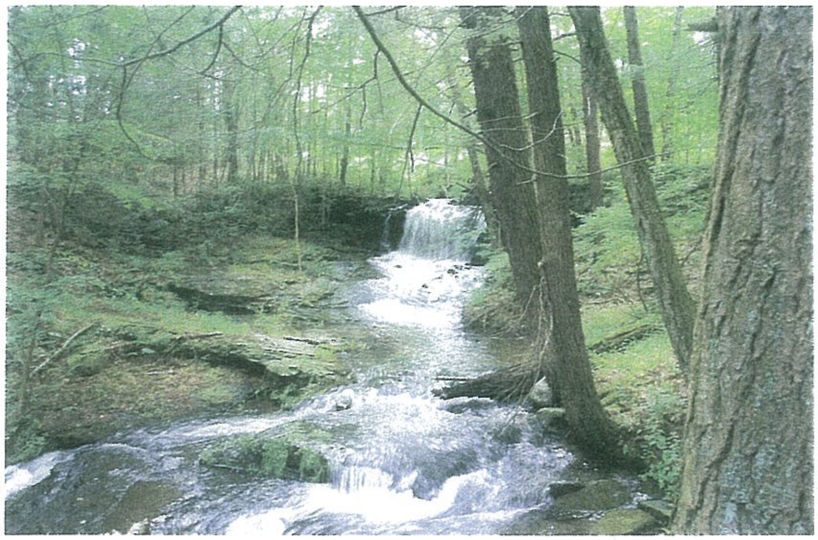
JAN 7 2013

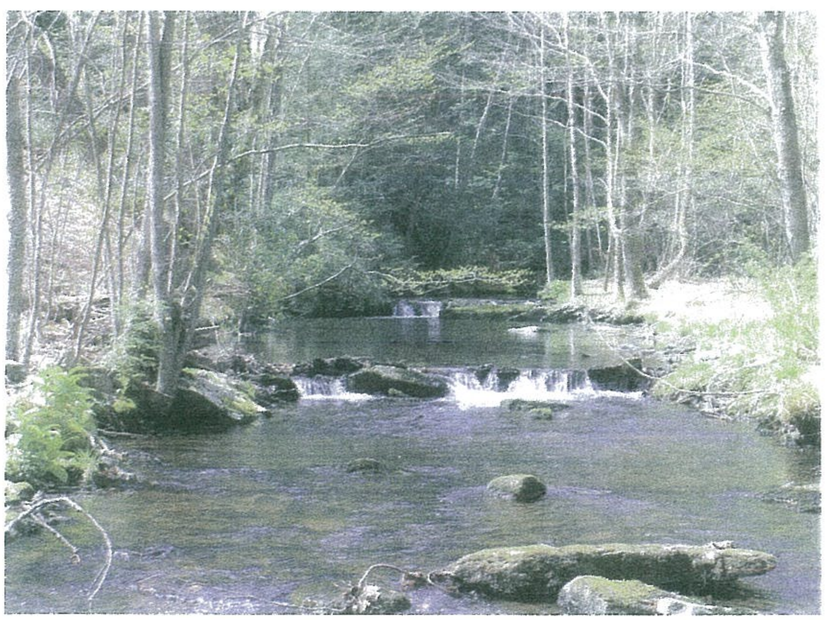
DEPARTMENT OF
ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA ENVIRONMENTAL QUALITY BOARD

PETITION FORM FOR THE UPGRADE OF CRANBERRY CREEK,

MONROE COUNTY, PA





Brodhead Watershed Association
Box 339, Henryville, PA 18332

COMMOPNWEALTH OF PENNSYLVANIA
ENVIRONMENTAL QUALITY BOARD

PETITION FORM

I. PETITIONER INFORMATION

A. Name: Brodhead Watershed Association

B. Mailing Address: Box 339, Henryville, PA 18332

C. Telephone No. (570) 839-1120

D. Date: December 27, 2012

II. PETITION INFORMATION

A. The petitioner requests the Environmental Quality Board to:

_______ Adopt a regulation

____X___ Amend a regulation (Citation: PADEP Chapter 93

Designation for Cranberry Creek to Exceptional Value – (EV)

________ Repeal a regulation

B. Why is the petitioner requesting this action from the Board? (Describe problems encountered under current regulations and the changes being recommended to address the problems. State factual and legal contentions and include supporting documentation that establishes a clear justification for the requested action.)

The Brodhead Watershed Association requests that Cranberry Creek, a tributary to Paradise Creek, be re-designated exceptional value waters (EV) from its current designation as high quality waters (HQ) based on the fact that the existing water quality is better than criteria applicable to Cranberry Creek's current designation. Cranberry Creek enters the Paradise Creek, which is tributary to the Brodhead Creek. Cranberry Creek watershed is a very beautiful and diverse ecosystem, much of which has been recently preserved through open-space purchase of riparian lands. However, it is surrounded by areas subject to increasing development pressure. There are currently no point source discharges to Cranberry Creek. In the Brodhead Watershed, there are several small streams on the Department's list of impaired waters - some due to permitted discharges. Since water quality in the watershed has suffered considerable compromise to development and anthropogenic impact, we feel the finest quality waters such as Cranberry Creek should be considerable compromise to development and anthropogenic impact, we feel the finest quality waters such as Cranberry Creek should be preserved at their current quality with no further degradation allowed. The exceptional quality of Cranberry Creek is supported by biological documentation of fish and macroinvertebrate communities included in the Supporting Material (Section E and Appendices). Some time ago, there was negative impact to a short section of Cranberry Creek, probably attributed to sedimentation from a peat mining operation (Appendix E). Recognizing the Exceptional Value of the resource will hopefully preclude any degradation in the future.

C. Describe the types of persons, businesses and organizations likely to be impacted by this proposal.

Because much of Cranberry Creek is now surrounded by public lands, and because the limited existing developments proximal to the stream have no point source discharges and are currently having no noticeable negative impacts, the petitioners anticipate minimal or no negative economic impact resulting from this proposal. There are four businesses located close to the stream: a quarry operation in close proximity to the origin of one unnamed tributary, a peat mine which may still be operating on the upper stream, Weiler Brush manufacturing, and Best Way lumber treatment center. The petitioners are not aware whether EV designation of Cranberry Creek would impact these operations. None has a discharge to the stream. However, the value of preserving the quality of this exceptional resource would easily balance any additional efforts required by these businesses to achieve that goal. There is a housing development, Cranberry Creek Estates, and a senior residential center in the watershed, but both have in ground or elevated sand mound sewage treatment.

There are many individuals and organizations that would reap positive benefits of an EV designation for Cranberry Creek. Cranberry Associates uses the lower portion of the stream as a private trout fishery. The Henryville Conservation Club and Brodhead Forest and Stream are trout fishing clubs on the Paradise Creek below Cranberry Creek. These historic fishing clubs are fervent protectors of the quality of their waters. Paradise Creek in the vicinity of the Cranberry Creek tributary has been shown to have a significant wild brown trout population with exceptional growth rates for freestone streams. However, surveys indicate that Paradise Creek in this area does not have an abundance of natural reproduction and may depend heavily on recruitment of young trout from tributaries such as Cranberry Creek. Below these fishing clubs, the Brodhead is an important public trout fishery and also serves as a water supply for the Brodhead Creek Regional Authority. The public will also benefit from the preservation of the exceptional water quality of Cranberry Creek as the recently acquired public access develops as a wild trout fishery and diverse outdoor laboratory. Thus it would serve the interest of many in the area if the water quality of the Paradise headwaters, including Cranberry Creek, were maintained at their present quality with no additional degradation allowed.

D. Does the action requested in the petition concern a matter currently in litigation?

Action requested in the petition does not concern any matter currently in litigation to the best of the petitioner's knowledge.

E. Supporting material

Description of Cranberry Creek Watershed

Cranberry Creek is one of two streams in Monroe County with this name. It is important to make a distinction between these two very different streams. The Cranberry Creek being proposed for this EV designation is located solely in Barrett and Paradise Townships and is a tributary to the Paradise Creek. The "other Cranberry" is located in Pocono Township and is a tributary to Pocono Creek.

Cranberry Creek starts as a spring fed stream in a small, forested wetland located off Rt. 191/390 in Mountainhome, Barrett Township. It shares a watershed divide with a small un-named tributary to Mill Creek, an EV stream in Barrett Township that flows into the upper Brodhead Creek. Within a short distance from its source, the Cranberry flows into an on-stream impoundment on the property of Weiler Brush, an industrial brush manufacturer in Barrett Township. Cranberry Creek flows southeast from its source over 5 miles to its mouth at the confluence with Paradise Creek in Paradise Township.
The Cranberry Creek watershed is located on the USGS 7.5 minute Buck Hill Falls and Mount Pocono Quadrangles (see attached map). Petitioners are requesting EV designation for the entire 5+ miles of Cranberry Creek from its source in Barrett Township to its mouth at the confluence with Paradise Creek in Parkside near Henryville in Paradise Township. In the 5 mile plus course of Cranberry Creek's travels from Mountainhome to Parkside near Henryville, the stream drops 500 feet in elevation from just over 1200 to 700 feet. In the course of this distance from source to mouth the Cranberry is fed by at least 6 continuous flowing tributaries (Hardytown Run and 5 other un-named tributaries). Cranberry Creek's more than 5 mille course is crossed by only four municipal bridges. The first bridge is on Sand Spring Road near it source in Barrett Township, two others are on Cranberry Creek Road in Paradise Township and the last on Timberhill Road near its mouth in Parkside. With limited road crossings and road frontage on the main stem of the stream, direct road runoff drainage into Cranberry Creek is limited. The stream also has two small on-stream impoundments, one near its source and a second about one mile above its mouth. There are also three smaller off-stream impoundments that flow via small tributaries into the Cranberry Creek.
For much of the Cranberry's course, it flows through both mixed deciduous hardwood and evergreen forests. There is very little non-forested, non canopied areas of stream and very limited agriculture on/near the banks of or in the watershed of the Cranberry Creek. This means that most of the stream is shaded

and cooled by forests and by numerous previously mentioned tributaries that are also shaded streams. Cranberry Creek maintains a cool water quality and significant year-round flow that supports a healthy PF&BC Class A wild trout fishery. This fishery includes both wild brown and brook trout and a notable population of brook/brown hybrid tiger trout (Figure 1).

Upper Section

The upper section of Cranberry Creek (less than 1/3 of the stream's total length) is the more developed, commercialized section of the stream. As the Cranberry Creek leaves the commercial area of southeastern Barrett Township (see land use information below), it enters into a more remote section that includes a steeper gradient, denser shading including hemlocks and a small limestone step falls that begins the Cranberry's repairs to the impacts of a lower gradient, slower flowing, and more commercialized upper section.

Mid Section

This mid section of the stream flows through and is surrounded by over 1400 acres of permanently preserved open space property (three parcels which are owned by Pocono Heritage land Trust, a local land conservation organization, and two owned by Paradise Township). This protected open space acreage includes several previously mentioned tributaries and about 1/3 of the stream's entire length. This section of the stream includes a beautiful step falls ravine known as Cranberry Falls and a beautiful wetland-laced, braided stream course.

Lower Section

The lower section of the Cranberry Creek watershed is primarily in private residential and hunting/fishing club ownership. These groups include: Paradise Falls Lutheran Association, Cranberry Associates, and Henryville Conservation Club. The stream in this section increases in gradient, is primarily forested and is impacted minimally by the limited residential development through which it flows. This section is privately owned and includes a large section of the stream in fishing club ownership by Cranberry Associates,

There are no point source discharges of either industrial or commercial sewage treatment into the Cranberry Creek. All current sewage treatment options in the Cranberry Creek watershed are in-ground septic or elevated sand mound treatment systems.

Maps

Figure 2 –topographic map of Cranberry Creek including the source in Barrett Township and the mouth at the confluence with Paradise Creek in Paradise Township.

Figure 3 – map showing the delineated boundary of the Cranberry Creek watershed.

Figure 4 – close-up view of the mid-section of Cranberry Creek showing all or portions of the protected open space properties mentioned above.

2) Curent Designated Uses

Cranberry Creek is listed in Drainage List C in 25 Pa. Code 93.9c, where it is designated High Quality Cold Water Fishery. The current HQ-CWF designation would allow degradation of the existing exceptional quality.

Figure 1. Wild tiger (brook/brown hybrid) trout from Cranberry Creek.

Figure 2. Topographic map of Cranberry Creek from origin near Cresco to the confluence with Paradise Creek at Parkside.

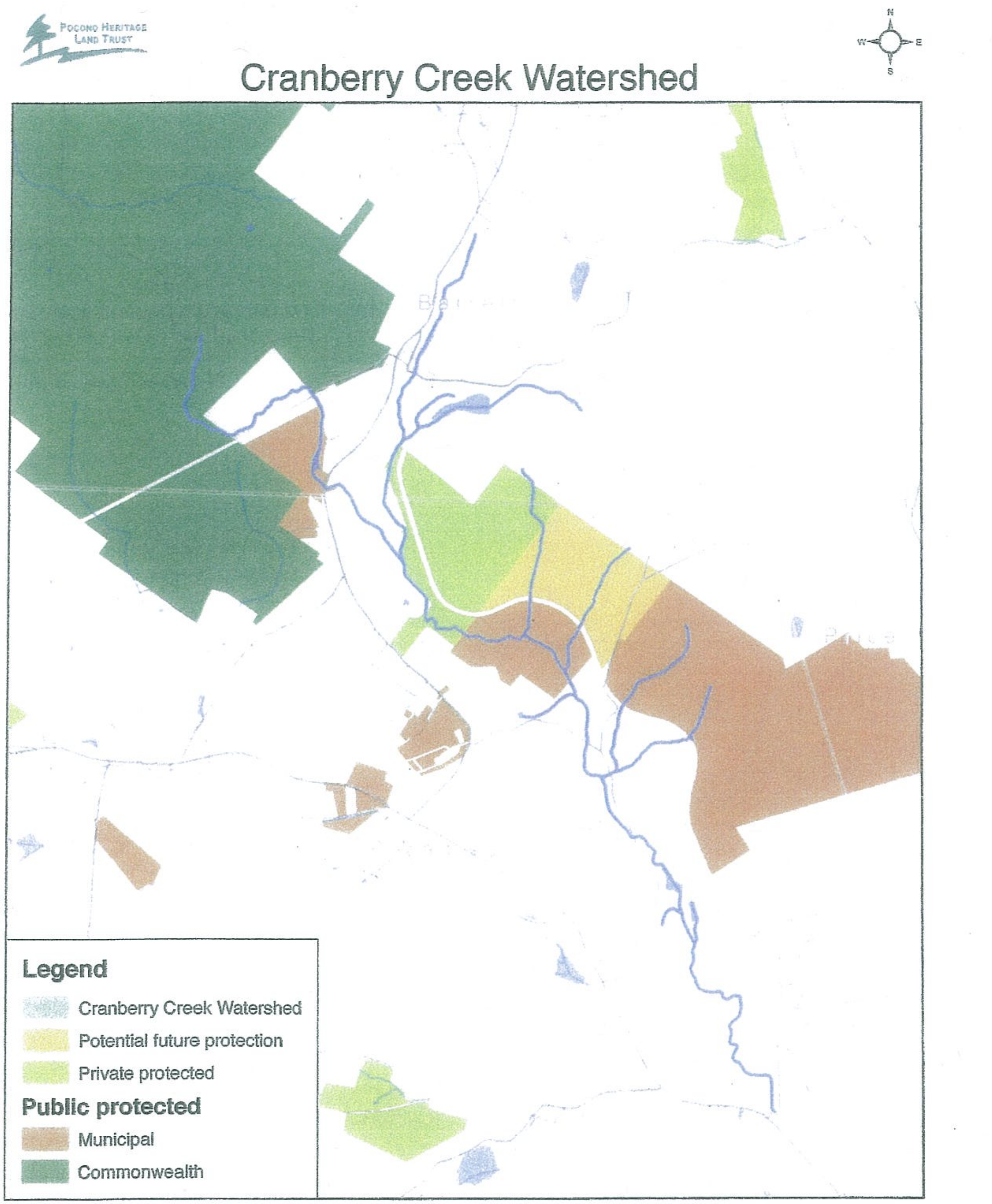


Figure 3. Map showing Cranberry Creek Watershed.

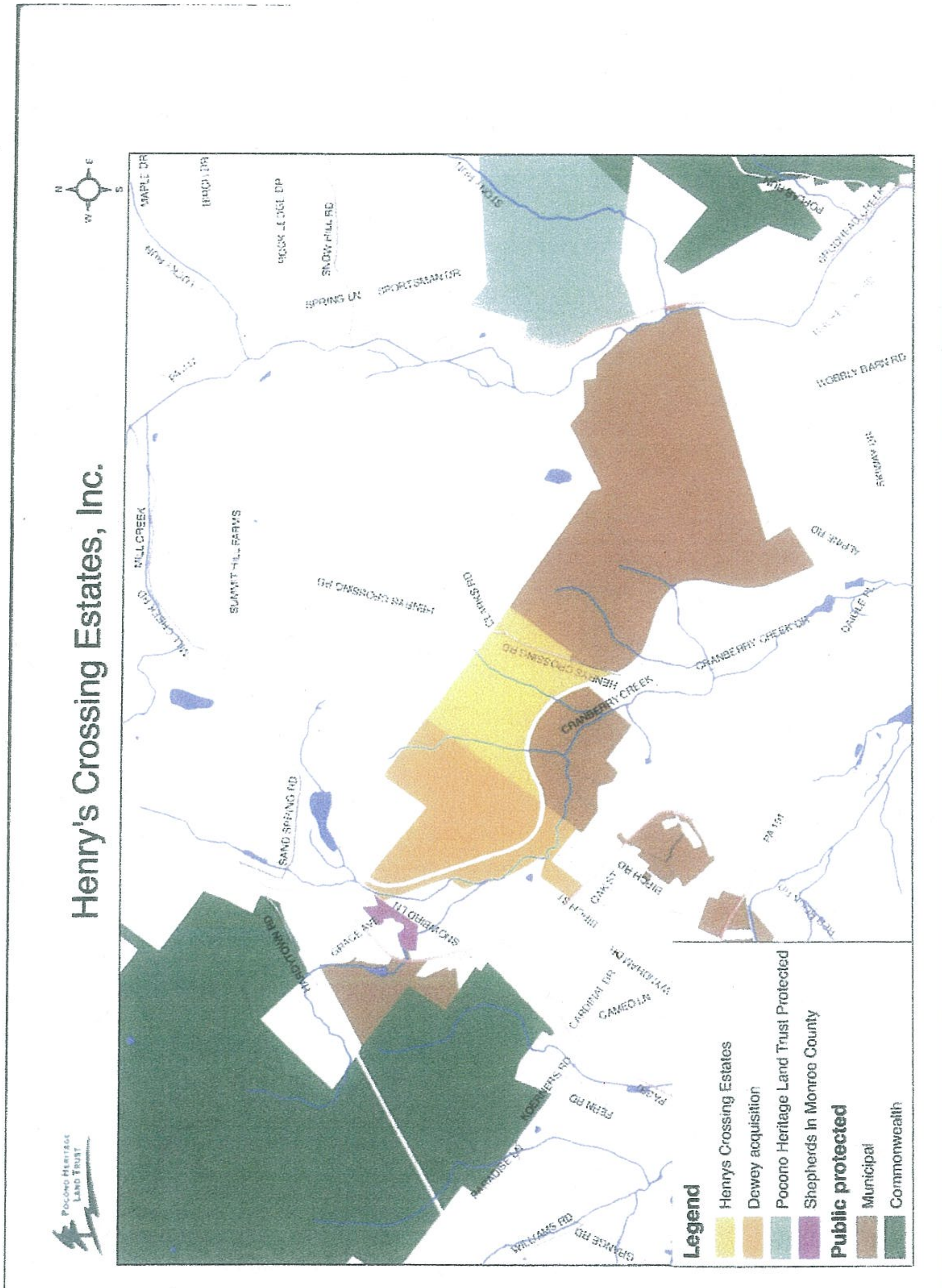


Figure 4. Mid-section of Cranberry Creek showing the all or portions of the protected open space properties mentioned above.

Requested Designated Uses

The requested designation for Cranberry Creek is Exceptional Value. This designation would protect the existing water quality.

Available Technical Data: Water Chemistry, Benthic Macroinvertebrates and/or Fishes.

Benthic Macroinvertebrates

Benthic Macroinvertebrates of Cranberry Creek, April 4, 2012 for Brodhead Watershed Association (Appendix A).

A benthic macroinvertebrate sample following the most recent PA DEP protocols for stream classification indicated exceptional water quality. At the request of Brodhead Watershed Association, Don Baylor of Aquatic Resource Consulting sampled benthic macroinvertebrates of Cranberry Creek in April of 2012. Sample analysis resulted in 4 out of 6 metrics scoring the optimal 1.00 Adjusted Standardized Metric Score with the other two metrics very close to optimal at 0.990 and 0.909. The overall IBI score was 98.3 out of a possible 100. This score suggest a very diverse population consisting primarily of taxa very intolerant of environmental perturbation. The score is within the range considered to be reflective of exceptional water quality.

Benthic Macroinvertebrates of the Paradise Watershed, June 11-26, 2009 for the Paradise Stormwater Facility Retrofit Design Project: a project of the Brodhead Watershed Association funded by a Growing Greener Grant (Appendix B).

In this study of benthic macroinvertebrates by Aquatic Resource Consulting at 21 stations in the Paradise Creek Watershed, three stations on Cranberry Creek had total IBI scores as follows: Station 1 upstream near Cresco -100, Station 2 farther downstream on Paradise Township property - 100, and Station 3 near the mouth - 95.63. Of the 21 stations, the only other station having an IBI score of 100 was on Devil's Hole Creek, which has the Exceptional Value designation on PA State Game Lands. Although PA DEP summer metrics (not applicable for stream classification) were applied to these June samples, the high scores support the spring 2012 findings that Cranberry Creek warrants Exceptional Value designation.

Benthic Macroinvertebrates of Paradise Creek and Cranberry Run – April 14, 2006 For Henryville Conservation Club (Appendix C).

In this study, the station on Cranberry Creek approximately 50 meters above its confluence with Paradise Creek had 27 macroinvertebrate taxa of which 21 were intolerant EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa. The modified Hilsenhoff Biotic Index value was an exceptional 0.66, and 74.87% of the organisms were intolerant mayflies.

Benthic Macroinvertebrates of Paradise Creek and Cranberry Creek, Monroe county, PA March 16, 1997 for Henryville Conservation Association (Appendix D).

In this study by Aquatic Resource Consulting, Cranberry Creek was sampled at the same station repeated in the above study. The sample scored an excellent 1.38 Hilsenhoff Biotic Index value, an equally excellent 3.83 diversity value, and 29 of the 40 taxa collected were EPT taxa. The organisms were 53% mayflies.

Benthic Macroinvertebrates of Cranberry Creek Near Cresco, PA Downstream from Blue Ridge Peat Mine, September 23, 1995 (Appendix E).

In this ARC study, the macroinvertebrate sample from a short distance below a peat mine near Cresco on Cranberry Run, a very sparse population was found. Many intolerant coldwater taxa were present. Biotic Index and Diversity values were excellent, indicating that the cause of the dearth of organisms was not organic oxygen demand. Sedimentation was judged to be the cause. Turbidity flowing from above the sampling site was observed after the sampling.

Benthic Macroinvertebrates of Unnamed Tributary to Cranberry Creek Near Cresco, PA, March 19, 1995 (appendix F).

An unnamed tributary originating southeast of Cresco and flowing south into Cranberry Creek was sampled for benthic macroinvertebrates in 1995. This tributary hosted a macroinvertebrate population consisting of very intolerant, coldwater taxa. Diversity and Biotic Index values were exceptional – 4.14 and 0.84, respectively. Number of taxa was 37, of which 25 were EPT. Ephemeroptera constituted 53% of the organisms.

Fishes

Cranberry Creek Stream Survey, Barrett Township, Monroe County. PA fish & Boat Commission February 4, 1993 (Appendix G).

PA Fish & Boat Commission lists Cranberry Creek as a Class A Wild Trout Fishery as a result of this survey in which multiple year classes of both brook and brown trout were collected at each of two 100 meter stations – one above and one below the Hardytown Run tributary.

Fishery survey of Paradise Creek and Tributaries prepared for Brodhead Watershed Association, 2009 (Appendix H).

In 2009, Aquatic Resource Consulting sampled fish communities at seven stations in the Paradise Watershed as part of a Growing Greener Grant. One station sampled was on Cranberry Creek on Paradise Township's Nothstein Preserve. Cranberry Creek had an estimated biomass of wild brown trout of 135 pounds per acre, more than 3 times the minimum required by the PA Fish & Boat Commission to qualify for Class A Wild Trout classification. In addition wild brook trout were present, as well as slimy sculpin found only in colder, silt-free, unpolluted streams.

Fish Inventory of Paradise Creek and Tributaries, September 2003 prepared for paradise Township (Appendix I).

In this 2003 study, a station near the mouth of Cranberry Creek was electrofished. The Cranberry Creek station had an estimated biomass of 74.6 pounds per acre of wild brown trout. This biomass exceeds the PA fish & Boat Commission's standard for Class A Wild Brown Trout. The brown trout population was well balanced with abundant fingerlings evidence of very successful reproduction. Other species present were brook trout and slimy sculpin.

Water Chemistry

Water Analysis of Streams in the Brodhead Drainage, October 2003 prepared for the Brodhead Protective Association (Appendix J).

In this 2003 sampling, a station near the mouth of Cranberry Creek exhibited excellent water chemistry quality. Nitrate and total phosphorus levels were reported as not detectible. Fecal Coliform counts were very low, and BOD -5 was <2. No suspended solids were detected and dissolved solids were 46 mg/l.

Description of discharges

There are no point source discharges of either industrial or commercial sewage treatment into the Cranberry Creek. All current sewage treatment options in the Cranberry Creek watershed are in-ground septic or elevated sand mound treatment systems.

Biological Assessment Qualifier

The spring 2012 benthic macroinvertebrate sample with an IBI score of 98.3 suggest that Cranberry Creek meets the biological qualifier for EV designation. Other available macroinvertebrate data from Cranberry Creek and a tributary support the findings that it has exceptional water quality. The excellent, abundant, well balanced population of wild trout supports the petitioner's position that Cranberry Creek is an exceptional resource.

Land Use in the Watershed

Manufacturing and commercial/industrial activities are minimal in the Cranberry Creek watershed, and those that exist are all located in the headwaters of the stream. The largest of these includes Weiler Brush (which has little current impact on the stream), a peat extraction, and a stone quarrying business (which may have some limited impacts on the headwaters, and Best Way, a growing lumber treatment business. These businesses are located in a commercial/industrial zone of southeastern Barrett Township which also includes the Barrett Township Municipal Maintenance Facility and the restored historical Cresco Trail Station of the former Erie Lackawanna Rail Line. This area of the upper watershed also includes the Good Shepherd Senior housing complex (multi-unit and duplex housing) and Evergreen Community School. In the upper Barrett Township section of the stream beginning just south of the historic restored Cresco Train Station, the active working Erie Lackawanna Rail Line (owned by the Northeast PA Rail Authority) parallels Cranberry Creek for approximately 4 of the stream's more than 5 mile course.

Publicly funded Open Space land protection in the Cranberry Creek Watershed includes the following lands (currently protected or in progress in the order of their acquisition):

Seven Pines Park and Ice Lake Natural Area – 60 acres (Barrett, Paradise, Mt. Pocono Townships)

Skyview Park – 50 acres (Paradise Township)

Nothstein Cranberry Creek Preserve – 140 acres (Paradise Township)

Brodhead Falls (Echo Farms) Preserve – 777 acres (Paradise and Price Townships)

Upper Paradise (Dewey) Preserve – 270 acres (Pocono Heritage Land Trust)

Henry Crossings Preserve – 220 acres (Pocono Heritage Land Trust)

A named tributary of Cranberry Creek, Hardytown Run also drains a portion of the nearby 4000+ acre Devil's Hole State Gamelands #221.

Municipalities in the Watershed

The Cranberry Creek being proposed for this EV designation is located solely in Barrett and Paradise Townships. Following are the contacts:

Ms. Louise Troutman, Chairman, Paradise Township board of Supervisors

5912 Paradise Valley Road, Cresco, PA 18362. phone: 570-595-9880

Mr. Ralph G. Megliola, Chairman, Barrett Township Board of Supervisors,

993 Route 390, Cresco, PA 18326. phone: 570-595-2602

Appendix A

Benthic Macroinvertebrates of Cranberry Creek, April 4, 2012 for Brodhead Watershed Association

Benthic Macroinvertebrates of Cranberry Creek

April 4, 2012

For
Brodhead Watershed Association

Don Baylor
Aquatic Resource Consulting
521 Quail Ridge Lane

Stroudsburg, PA 18360

Benthic Macroinvertebrates of Cranberry Creek, April 4, 2012

Background

Cranberry Creek is a tributary to Paradise Creek in the Brodhead Drainage in Monroe County, PA. It originates near Cresco, PA and flows into the Paradise Creek near Henryville on property of the Henryville Conservation Association, Inc. A section of the creek flows through land purchased through the Open space Program and now owned by Paradise Township. A segment immediately upstream of that one flows through a large tract in the process of being purchased through the Open Space Program. Cranberry Creek is classified by the PA Department of Environmental Protection (DEP) as a High Quality Cold Water Fishery and by the PA Fish & Boat commission as a Class A Wild Trout Stream.

At the request of the Brodhead Watershed Association, Aquatic Resource Consulting biologist Don Baylor sampled and analyzed the benthic macroinvertebrate population of Cranberry Creek on April 4, 2012 to determine whether it meets the macroinvertebrate qualifier for reclassification to Exceptional Value Waters (EV).

Methods

Sampling and analysis methods followed those outlined in DEP's A Benthic Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania (PADEP 2009). In a 300 foot stream section, six samples were taken in the best riffle-run habitat. A wildlife Supply Company #425-D5 net was placed against the substrate, and substrate above the screen was disturbed in an approximate area of 1 square meter for one minute to dislodge organisms into the net. Organisms and debris were composited for the station and preserved in ethanol for transportation to the laboratory.

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.

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 (Table 2). 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 Cranberry Creek.

Table 2. Metric standardization and index of biotic integrity calculations for the benthic macroinvertebrate sample from Station 1 on Cranberry Creek, April 4, 2012..

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score Maximum =1.00
Total Taxa Richness	Observed value / 33	33	1.00	1.000
EPT Taxa Richness (PTV 0-4 only)	Observed Value/ 19	19	1.00	1.000
Modified Beck's Index (Version 3)	Observed value/38	46	1.211	1.000
Hilsenhoff Biotic Index	10-observed value/ (10-1.89)	1.97	0.990	0.990
Shannon Diversity Index	Observed value / 2.86	4.12	1.441	1.000
Percent Sensitive Individuals (PTV 0-3)	Observed value / 84.5	76.9	0.909	0.909
Average of adjusted standardized core metric scores x 100 = **IBI score**				**98.3**

Sampling Station

The 300 foot segment of Cranberry Creek sampled was near the lower border of the Nothstein Tract owned by Paradise Township, beginning at 41 degrees 07'901" N, 75 degrees16'031" W (Figure 1).

Results and Discussion

Metric values for the Cranberry Creek macroinvertebrate sample are given in Table 2. The list of taxa and numbers in the sample are given in Table 3. The IBI score for the Cranberry Creek sample taken on April 4, 2012 was 98.3 (Table 2). The score of 98.3 out of a possible 100 suggests that Cranberry Creek warrants consideration by PA DEP for reclassification to Exceptional Value.

The Cranberry Creek benthic macroinvertebrate sample was very diverse with a predominance of intolerant taxa (Table 3). Total taxa richness and EPT taxa richness values equaled the target standardization values to obtain the optimum standardized metric score (Table 2). The modified Beck's index and Shannon diversity index values were better than the target standardization values resulting in optimum standardized scores. Hilsenhoff biotic index and percent sensitive individuals values were very slightly below the target standardization values resulting in adjusted standardized metric scores of 0.990 and 0.909 respectively. Thus, only two of the six metrics for Cranberry Creek macroinvertebrates scored slightly less than optimum. Benthic macroinvertebrates also appeared to be relatively abundant in Cranberry Creek as only 4 of 28 grids from the initial pan were required, and 10 of 28 grids were subsampled from those initial 4 to obtain 216 organisms (Table 3).

Ephemerella spp. mayflies were the predominant taxon followed by *Epeorus* spp. mayflies. Both of these taxa are quite sensitive to environmental degradation. Of the ten mayfly taxa collected, only two are considered moderately tolerant. Of the seven stonefly taxa collected, five had a pollution tolerance value of 0 while the other two taxa had tolerance values of 2 (Table 3). The macroinvertebrate population represented in the April 4, 2012 sample characterizes Cranberry Creek as an undisturbed, pristine, cool headwater stream.

Figure 1. Station on Cranberry Creek sampled for benthic macroinvertebrates on April 4, 2012

Table 3. Taxa, pollution tolerance value, trophic classification,* and numbers or benthic macroinvertebrates collected from Cranberry Creek on April 4, 2012.

TAXON ORDER *GENERA/SPECIES*	POLLUTION TOLERANCE VALUE	TROPHIC CLASSIFICATION	NUMBER OF INDIVIDULAS
BIVALVIA (clams)			
Pisidium spp.	8	FC	1
DIPTERA (true flies)			
Blepharicera spp.	0	SC	2
Chironomidae	6	CG	3
Hexatoma spp.	2	PR	1
Pedicia spp.	6	PR	1
Antocha spp.	3	CG	2
Prosimulium spp	2	FC	5
EPHEMEROPTERA (mayflies)			
Epeorus spp.	0	SC	36
Ephemerella spp,	1	CG	43
Drunella spp.	1	SC	3
Seratella spp.	2	CG	5
Cynigmula spp,	1	CG	2
Rithrogena spp.	0	CG	1
Paraleptophlebia spp.	1	CG	3
Isonychia spp.	3	CG	5
Baetis spp.	6	CG	23
Diphetor spp.	6	CG	5
MEGALOPTERA (hellgramites)			
Nigronia spp.	2	PR	2
ODONATA (dragon/damsel flies)			
Lanthus spp.	5	PR	2
PLECOPTERA (stoneflies)			
Leuctridae	0	SH	2
Pteronarcys spp.	0	SH	4
Acroneuria spp.	0	PR	2
Sweltsa/Suwallia spp.	0	PR	8
Tallaperla spp.	0	SH	4
Clioperla spp.	2	PR	5
Isoperla spp.	2	PR	5

Table 3. Taxa, pollution tolerance value, trophic classification,* and numbers or benthic macroinvertebrates collected from Cranberry Creek on April 4, 2012.

TAXON	POLLUTION TOLERANCE VALUE	TROPHIC CLASSIFICATION	NUMBER OF INDIVIDULAS
TRICHOPTERA (caddisflies)			
Dolophilodes	0	FC	3
Polycentropus spp.	6	FC	1
Ceratopsyche spp.	5	FC	10
Cheumatopsyche spp.	6	FC	4
Diplectrona spp.	0	FC	7
Rhyacophila spp.	1	PR	15
Neophylax spp.	3	SC	1
TOTAL			216
Grids picked of 28 - 4 from pan 1, then 10 from pan 2			

*** FC – filtering collector, SC – scraper, CG – collector-gatherer, PR – predator, SH - shredder**

Appendix B

Benthic Macroinvertebrates of the Paradise Watershed, June 11-26, 2009 for the Paradise Stormwater Facility Retrofit Design Project: a project of the Brodhead Watershed Association funded by a Growing Greener Grant.

BENTHIC MACROINVERTEBRATES OF THE PARADISE WATERSHED

JUNE 11-26, 2009

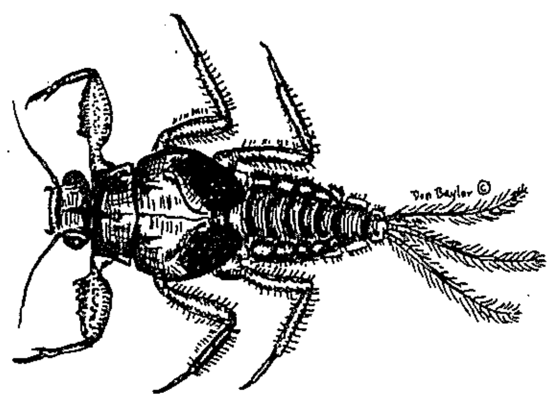
for the

PARADISE WATERSHED
STORMWATER FACILITY RETROFIT DESIGN PROJECT

a project of the

BRODHEAD WATERSHED ASSOCIATION

FUNDED BY A GROWING GREENER GRANT



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BENTHIC MACROINVERTEBRATES OF THE PARADISE CREEK WATERSHED, JUNE 11-26, 2009

BACKGROUND

From June 11 to June 26, 2009, at the request of at the request of the Paradise Watershed Stormwater Facility Retrofit Design Project, Aquatic Resource Consulting (ARC) biologist Don Baylor, with assistance from Don Miller, sampled benthic macroinvertebrates at 21 stations on the Paradise Creek Watershed. All the sampling sites were on stream segments classified by Pennsylvania Department of Environmental Protection (DEP) as High Quality Cold Water Fisheries. The purpose of the study was to establish baseline water quality data on stream segments that may potentially be impacted by stream work and to determine how the sites compare to designated use criteria established for Pennsylvania streams by Pennsylvania DEP. The study was part of a Growing Greener Grant obtained through the Brodhead Watershed Association.

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, two samples were taken from a riffle/run area with a D-frame kick net (Wildlife Supply Company #425-D5) of 500u nitex. Samples were taken by placing the net against the substrate and disturbing approximately one square meter above the net by foot. 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.

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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 summer riffle/run freestone streams were calculated for each subsample, including Modified Beck's Index #4, Hilsenhoff Biotic Index, Ephemeroptera + Plecoptera + Trichoptera Taxa Richness (EPT), Modified Caddis Taxa Richness, and Fc + Pr + Sh Functional Feeding Group Taxa Richness. A description and brief rationale for each of the metrics follows:

Modified Beck's Index #4 – is a weighted average of intolerant taxa, calculated by multiplying the Hilsenhoff Biotic Index Scores 0-1 by 2, and scores 2-4 by 1, then summing the results.

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

EPT – is the total number of taxa found within the orders Ephemeroptera, Plecoptera, and Trichoptera.

Modified Caddisfly (mcad) – is the number of caddisfly taxa with a Hilsenhoff score of less than five.

FC+PR+SH Richness – is the sum of all the taxa found in these 3 functional feeding groups: Filter Collector (Fc), Predator (Pr), and shredder (Sh).

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

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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 100, 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 five core metrics are averaged to produce an index score ranging from 0-100. This number represents the Total Biological Score for a sample. The following table shows metric standardization equations and index calculations for the sub-sample from Station 1 on Paradise Creek.

Table 2. Example total biological score calculation

Metric	5th or 95th Percentile Value (n=1104)	Equation	Observed Value Paradise Sta #1	Normalized Metric Score	Adjusted Metric Score
Beck's Index #4	19.9	(observed/19.9) x 100	28	140.70	100
EPT Taxa Richness	15.3	(Observed/15.3) x 100	16	104.58	100
Mod. Caddis	3.6	(Observed/3.6) x 100	2	55.55	55.55
FC+PR+SH Taxa Richness	11.6	(Observed/11.6) x 100	10	86.21	86.21
Hilsenhoff Index	3.26	100 x ((10-Observed) / (10-3.26))	3.32	99.11	99.11
Total biological Score					**88.17**
Benchmark for assesment category					**68**

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SAMPLING STATIONS

Twenty-one stations were sampled for benthic macroinvertebrates on the Paradise Watershed (Figure 1):

Paradise Creek #1 – the riffle area below the pool across the road from Keokee Chapel.

Paradise Creek #2 – approximately 20 yards above the bridge crossing on Red Rock Road.

Paradise Creek #3 – approximately 80 yards above Lower Swiftwater Road.

Paradise Creek #4 – approximately 100 yards above the railroad overhead crossing on property of Brodhead Forest & Stream.

Forest Hills Run #1 – upstream of the Mt. Pocono STP outfall, approximately 50 yards above route 611 stream crossing (above all discharge pipes).

Forest Hills Run #2 – below Mount Pocono STP discharge, approximately 75 yards upstream of Grange road stream crossing.

Forest Hills Run #3 – below the Mt. Airy STP discharge, approximately 30 yards upstream of Carlton road

Forest Hills Run #4 – near the mouth, approximately 40 yards upstream of the Lower Swiftwater Road stream crossing.

Cranberry Creek #1 – downstream of the peat mine in Cresco, approximately 670 yards downstream of the railroad stream crossing near Cresco – the first riffle area below the waterfall at the remains of an old dam.

Cranberry Creek #2 – a short distance above the trail footbridge crossing on the Paradise Township (formerly Nothstein) property.

Cranberry Creek #3 – near the mouth, approximately 30 yards upstream of the Cranberry Road stream crossing on Henryville Conservation Association property.

Swiftwater Creek #1 – approximately 25 yards upstream of the route 611 stream crossing.

Swiftwater Creek #2 – approximately 30 yards upstream of the confluence with Forest Hills Run.

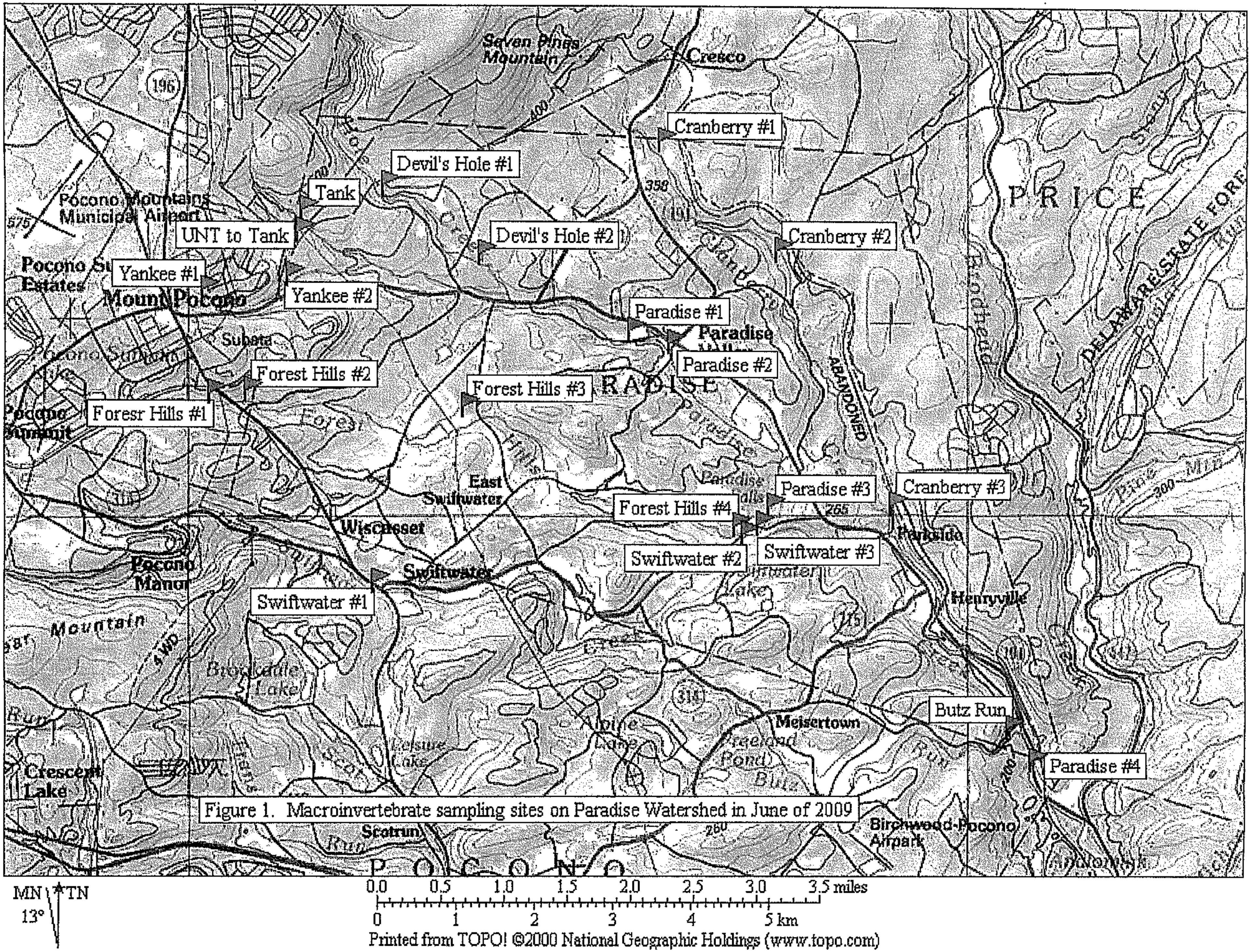

Figure 1. Macroinvertebrate sampling sites on Paradise Watershed in June of 2009

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Swiftwater Creek #3 – approximately 50 yards downstream of the confluence with Forest Hills Run.

Devil's Hole Creek #1 – approximately 40 yards below the railroad stream crossing and Approximately 500 yards downstream of the point where Devil's Hole Creek exits State Game Lands #221.

Devil's Hole Creek #2 – approximately 30 yards above the upstream bridge crossing on Paradise Stream Resort, and approximately 1.5 miles downstream of the point where Devil's Hole Creek exits State Game Lands #221.

Yankee Run #1 - approximately 40 yards above the large spring pool or approximately 0.6 mile upstream of Devil's Hole Road.

Yankee Run #2 - approximately 20 yards above Devil's Hole Road.

Unnamed Tributary to Yankee Run between Yankee Run and Tank Creek – approximately 20 yards below Devils Hole Road

Tank Creek - approximately 40 yards below Devil's Hole Road.

Butz Run - approximately 100 yards upstream from the mouth.

RESULTS AND DISCUSSION

A list of the benthic macroinvertebrate taxa collected from the Paradise Watershed is presented in Appendices A and B, along with pollution tolerance value and functional feeding group for each. Habitat scores for the sites are given in Appendix C. Table 3 shows the metric scores, and table 4 shows the Normalized Scores and the Total Biological Scores for the stations.

Seventeen of the 21 stations sampled on the Paradise Watershed had a Total Biological Score well above the DEP summer freestone benchmark score of 68 (Table 4). Two of three stations on Cranberry Creek and one of two on Devil's Hole Creek scored 100, correlating perfectly with the benchmark reference condition, indicating superior water quality. The other 14 of the 17 stations scoring above the benchmark scored in the range 81.90 to 98.30, indicating excellent water quality as well.

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Four stations scored below the benchmark, indicting impairment (Table 4). The station with the lowest Total Biological Score of 6.83, indicating severe impairment, was Forest Hills Run Station 2 below the Mt. Pocono STP outfall (Table 4). On the date of sampling, the outfall appeared cloudy and had a strong sewage odor. Forest Hills Run was cloudy from the effluent to Grange Road. Forest Hills Run Station 1 above the discharge scored 96.94 with a fairly diverse community. Only 4 taxa were collected at Station 2 below the discharge. The sample consisted primarily of aquatic worms, indicating organic enrichment, with only 4 *Baetis* sp mayfly larvae and Chironomid midge and Simulium blackfly larvae also present (Appendix A). Forest Hills Run Station 3 also scored below the benchmark – 33.84 – indicating impairment. Station 3 is a short distance below the Mount Airy STP discharge and a short distance above Carlton Road. Chironomidae (midge larvae) predominated in this sample, which had only 2 mayflies and no stoneflies. Near the mouth of Forest Hills Run, Station 4 water quality had recovered to a score of 88.16.

Yankee Run Station 1, above the springs and a short distance below the 5 points intersection in Mount Pocono also scored below the benchmark at 33.43 (Table 4). The area surrounding this station showed evidence of severe run-off. Flows at this station, and habitat quality were considerable poorer than downstream at Yankee Run Station 2, which scored highly – 92.35. Swiftwater Creek Station 3 is the remaining station to indicate impairment, scoring 58.04. Swiftwater stations 1 and 2 scored much higher, 81.90 and 85.01 respectively. The reason for the lower score at Station 3 than at upstream Swiftwater stations is not clear. Swiftwater Station 3 is a short distance below the mouth of Forest Hills Run, which showed severe impairment upstream. However the score for the sample near the mouth of Forest Hills Run – 88.16 - was higher than the score for Swiftwater Creek Station 3.

Only four of the stations sampled scored less than optimal for habitat according to DEP's Riffle/Run Prevalence Habitat Assessment Field Data Sheet (Appendix c). Those four scored in the suboptimal range. The Butz Run station had a high, severely eroded bank on the southern side. Yankee Run Station 1 had minimal flows, and the surrounding area displayed effects of severe run-off. Paradise Creek Station 2 above Red Rock Road scored suboptimal because of severe erosion and unstable banks. And Tank Creek scored suboptimal due to sedimentation, lack of flow diversity, and unstable banks.

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Table 3. Metric scores for benthic macroinvertebrate samples from Paradise Watershed, June 11-26, 2009.

Station	Number of Organisms/ Taxa	Beck's Index #4	Hilsen. Biotic Index	EPT	Mod. Caddis	Fc + Pr +Sh
Paradise #1	203/25	28	3.32	16	2	10
Paradise #2	227/22	27	3.76	17	3	12
Paradise #3	214/21	19	4.37	16	2	10
Paradise #4	208/24	26	3.55	18	3	11
Forest Hills #1	199/20	23	3.72	14	5	14
Forest Hills #2	191/ 4	0	8.72	1	0	1
Forest Hills #3	199/11	2	5.61	5	0	7
Forest Hills #4	180/22	18	4.47	13	3	13
Cranberry #1	210/30	30	2.70	18	14	17
Cranberry #2	231/26	34	2.59	13	3	12
Cranberry #3	221/23	25	2.78	19	3	11
Swiftwater #1	219/17	22	2.49	13	2	8
Swiftwater #2	235/20	18	5.53	13	3	12
Swiftwater #3	187/17	12	5.30	10	0	11
Devil's Hole #1	208/18	24	2.57	14	3	11
Devil's Hole #2	198/23	31	2.25	19	5	12
Yankee Run #1	75/11	9	5.87	4	0	4
Yankee Run #2	204/21	24	2.42	12	3	15
Tank Creek	205/18	23	2.88	14	3	11
UNT to Yankee	197/25	26	1.46	14	5	17
Butz Run	217/25	28	3.89	18	3	13

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Table 4. Normalized (adjusted) metric scores and total biological scores for benthic macroinvertebrate samples from Paradise Watershed, June 11-26, 2009.

Station	Beck's #4	EPT	Mod. Caddis	Fc, Pr & Sh	HBI	Total Biol. Score
Paradise #1	140.70 (100)	104.58 (100)	55.55	86.21	99.11	**88.17**
Paradise #2	135.68 (100)	111.11 (100)	83.33	103.45 (100)	92.58	**95.18**
Paradise #3	95.48	104.58 (100)	55.55	86.21	83.53	**84.15**
Paradise #4	130.65 (100)	117.65 (100)	83.33	94.83	95.70	**94.77**
Forest Hills #1	115.58 (100)	91.50	138.89 (100)	120.69 (100)	93.18	**96.94**
Forest Hills #2	0	6.45	0	8.62	18.99	**6.83**
Forest Hills #3	11.06	32.68	0	60.34	65.13	**33.84**
Forest Hills #4	90.45	84.97	83.33	112.07 (100)	82.05	**88.16**
Cranberry #1	150.75 (100)	117.65 (100)	111.11 (100)	146.55 (100)	108.31 (100)	**100**
Cranberry #2	170.85 (100)	124.18 (100)	138.89 (100)	137.93 (100)	109.94 (100)	**100**
Cranberry #3	125.63 (100)	124.18 (100)	83.33	94.83	107.12 (100)	**95.63**
Swiftwater #1	110.55 (100)	84.97	55.55	68.97	111.42 (100)	**81.90**
Swiftwater #2	90.45	84.97	83.33	103.45 (100)	66.32	**85.01**
Swiftwater #3	60.30	65.36	0	94.83	69.73	**58.04**
Devil's Hole #1	120.60 (100)	91.50	83.33	94.83	110.24 (100)	**93.93**
Devil's Hole #2	155.78 (100)	124.18 (100)	138.89 (100)	103.45 (100)	114.99 (100)	**100**
Yankee Run #1	45.23	26.14	0	34.48	61.28	**33.43**
Yankee Run #2	120.60 (100)	78.43	83.33	129.31 (100)	112.46 (100)	**92.35**
Tank Creek	115.58 (100)	91.50	83.33	94.83	105.64 (100)	**93.93**
UNT to Yankee	130.65 (100)	91.50	138.89 (100)	146.55 (100)	126.71 (100)	**98.30**
Butz Run	140.70 (100)	117.65 (100)	83.33.	112.07 (100)	90.65	**94.80**

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Appendix A. Taxa, numbers, pollution tolerance value (BI), and functional feeding Group (FG)* for benthic macroinvertebrate subsamples collected from 11 stations on Paradise Creek, Forest Hills Run, and Cranberry Creek, June 11-26, 2009

TAXA	STATIONS											BI	FG*
	PARADISE				FOREST HILLS				CRANBERRY				
	1	2	3	4	1	2	3	4	1	2	3		
Ephemeroptera													
Epeorus	1	2	-	-	-	-	-	-	-	-	4	0	Sc
Stenonema	3	-	4	1	-	-	-	4	-	-	2		
Leucrocuta	-	-	-	1	-	-	-	-	-	-	-		
Ephemerella	4	2	1	-	1	-	-	-	-	1	1		
Drunella	17	14	5	1	-	-	-	1	-	3	10	1	Sc
Serratella	1	1	1	64	-	-	-	-	4	1	12	2	Cg
Eurylophella	-	-	-	-	-	-	-	-	1	-	-	4	Sc
Dannella	-	-	-	-	5	-	-	-	-	-	-	2	cg
Paraleptophlebia	1	-	-	-	-	-	-	-	3	3	7	1	Cg
Isonychia	1	1	17	14	-	-	-	-	1	-	1	3	Cg
Baetis	86	102	46	31	73	4	1	21	12	61	53	6	Cg
Acentrella	-	2	21	6	-	-	1	1	1	3	16	4	Sc
Tricorythodes	-	-	-	1	-	-	-	-	-	-	-	4	Cg
Diphetor	-	-	-	-	-	-	-	-	2	-	-	6	Cg
Acerpenna	-	-	-	-	-	-	-	-	1	-	-	6	Cg
Trichoptera													
Rhyacophilla	1	7	-	1	3	-	-	3	5	7	-	1	Pr
Glossossoma	1	-	-	-	-	-	-	6	-	-	-	0	Sc
Dolophilodes	-	27	14	4	15	-	-	3	11	44	24	0	Fc
Chimarra	-	-	-	-	-	-	-	-	1	-	-	4	Fc
Brachycentrus	-	3	-	-	-	-	-	-	-	4	-	1	Fc
Micrasema	-	-	-	-	-	-	-	-	-	3	-	2	Sh
Diplectrona	-	-	1	-	2	-	-	-	2	3	1	0	Fc
Ceratopsyche	5	1	24	17	-	-	50	26	-	2	6	5	Fc
Hydropsyche	1	-	5	-	-	-	22	9	3	-	1	5	Fc
Cheumatopsyche	-	-	5	-	-	-	41	2	-	-	-	6	Fc
Polycentropus	3	12	-	-	3	-	-	-	-	1	3	6	Fc
Neureclipsis	-	-	-	1	-	-	-	5	-	-	-	7	Fc
Lepidostoma	-	-	-	3	2	-	-	-	-	-	1	1	Sh
Neophylax	-	-	-	-	1	-	-	-	-	-	-	3	Sc
Pycnopsyche	-	-	-	1	-	-	-	-	-	-	-	4	Sh
Ceraclea	-	-	-	-	-	-	-	-	-	-	3	3	cg

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Appendix A. continued													
TAXA	**STATIONS**											**BI**	**F G ***
	PARADISE				**FOREST HILLS**				**CRANBERRY**				
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**		
Plecoptera													
Acroneuria	2	2	6	10	-	-	-	5	3	1	17	0	Pr
Phasgonophora	-	1	-	4	-	-	-	-	-	-	1	2	Pr
Paragnetina	-	-	-	1	-	-	-	-	1	-	-	1	Pr
Isoperla	-	-	1	-	17	-	-	-	5	4	-	2	Pr
Leuctra	53	23	7	5	11	-	-	11	74	8	33	0	Sh
Suwalia/Sweltsa	-	-	-	-	15	-	-	-	-	1	-	0	Pr
Tallaperla	-	-	-	-	-	-	-	-	1	18	-	0	Sh
Amphinemura	1	2	1	-	13	-	-	-	-	-	-	3	Sh
Pteronarcys	-	2	-	-	2	-	-	-	-	12	-	0	Sh
Diptera													
Chironomidae	4	18	43	30	19	22	68	50	21	9	9	6	Cg
Antocha	3	-	2	-	1	-	-	-	-	-	-	3	Cg
Hexatoma	2	1	-	1	5	-	-	7	-	6	2	2	Pr
Simulium	-	-	8	-	3	35	1	5	11	8	3	6	Fc
Dicranota	-	-	-	-	4	-	-	-	-	-	-	3	Pr
Tipula	-	-	-	-	-	-	1	1	1	-	-	4	Sh
Blephariceria	2	1	-	-	-	-	-	-	-	-	-	0	Sc
Chrysops	-	-	-	-	-	-	-	1	2	-	-	7	Pr
Atherix	-	-	-	-	-	-	-	-	3	-	-	2	Pr
Coleoptera													
Psephenus	-	-	-	4	-	-	-	15	1	1	10	4	Sc
Promoresia	1	-	-	-	-	-	-	-	5	22	-	2	Sc
Stenelmis	-	-	1	5	-	-	-	-	13	-	-	5	Sc
Optioservus	3	1	-	1	-	-	-	-	-	-	-	4	Sc
Megaloptera													
Nigronia	5	-	-	-	-	-	5	1	4	3	-	2	Pr
Odonata													
Ophiogomphus	1	-	-	-	-	-	-	-	3	2	-	1	Pr
Progomphus	-	1	-	-	-	-	-	-	-	-	-	5	Pr
Cordulegaster	-	-	-	-	-	-	-	-	1	-	-	3	Pr
Oligochaeta	1	-	-	-	-	130	-	-	-	-	-	10	Cg

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Appendix A. continued													
TAXA	**STATIONS**											**BI**	**F G ***
	PARADISE				**FOREST HILLS**				**CRANBERRY**				
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**		
Turbellaria	-	-	-	-	4	-	-	-	-	-	-	9	Pr
Mollusca													
Pisidium	-	-	-	-	-	-	4	-	14	-	-	8	Fc
Physinae	-	-	1	1	-	-	5	-	-	-	-	8	Sc
Ferrissia	-	-	-	-	-	-	-	2	-	-	-	7	Sc
Gyralus	-	-	-	-	-	-	-	1	-	-	-	6	sc

* (Cg=collector/gatherer, Sc=scraper, Fc=filtering collector, Pr=predator, Sh=shredder)

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Appendix

Appendix B. Taxa, numbers, pollution tolerance value (BI), and functional feeding Group (FG)* for benthic macroinvertebrate subsamples collected from 10 stations on Swiftwater Crek, Devil's Hole Creek, Yankee Run, Tank Creek, Unnamed Tributary to Yankee Run, and Butz Run, June 11-26, 2009

TAXA	STATIONS										BI	FG*
	SWIFTWATER			DEVIL'S HOLE		YANKEE		TANK	UNT YANK	BUTZ		
	1	2	3	1	2	1	2					
Ephemeroptera												
Epeorus	7	-	-	38	21	-	4	29	-	-	0	Sc
Stenonema	-	-	-	-	2	-	-	-	-	4	3	Sc
Ephemerella	4	-	-	18	16	1	-	-	1	1	1	Cg
Drunella	1	1	2	22	35	1	-	28	-	6	1	Sc
Serratella	1	1	2	-	4	-	-	-	-	1	2	Cg
Paraleptophlebia	54	-	-	4	9	-	-	18	-	1	1	Cg
Isonychia	-	-	-	-	-	-	-	-	-	1	3	Cg
Habrophlebiodes	-	-	-	-	2	-	-	1	-	-	6	Sc
Baetis	49	49	64	54	51	6	42	69	3	116	6	cg
Acentrella	6	2	4	-	-	-	2	-	-	-	4	Sc
Trichoptera												
Rhyacophila	-	2	-	10	3	-	6	3	5	-	1	Pr
Agapetus	-	-	-	-	2	-	-	-	-	-	0	Sc
Glossossoma	-	-	-	-	-	-	-	-	-	3	0	Sc
Dolophilodes	58	1	-	7	30	-	45	-	113	20	0	Fc
Polycentropus	-	1	2	1	-	-	-	2	-	1	6	Fc
Nictiophylax	-	-	-	-	-	-	-	-	-	1	5	Pr
Diplectrona	1	-	-	1	1	-	6	5	5	11	0	Fc
Ceratopsyche	6	31	25	-	1	-	-	-	-	2	5	Fc
Hydropsyche	-	-	1	-	-	-	-	-	2	-	5	Fc
Cheumatopsyche	-	7	4	-	-	-	-	-	-	-	6	Fc
Psilotreta	-	-	-	-	-	-	-	1	-	-	0	Sc
Lepidostoma	-	-	-	-	1	-	1	-	3	-	1	Sh
Ceraclea	-	2	-	-	-	-	-	-	-	-	3	Cg
Pycnopsyche	-	-	-	-	-	-	-	-	2	-	4	sh

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Appendix B. continued

TAXA	STATIONS										BI	FG*
	SWIFTWATER			DEVIL'S HOLE		YANKEE		TANK	UNT YANK	BUTZ		
	1	2	3	1	2	1	2					
Plecoptera												
Pteronarcys	-	-	-	5	2	-	16	5	-	-	0	Sh
Tallaperla	-	-	-	5	-	-	1	2	12	-	0	Sh
Leuctra	3	4	11	4	3	-	12	16	3	16	0	Sh
Amphinemura	-	-	-	1	-	-	32	-	2	4	3	Sh
Isoperla	1	-	-	17	1	2	6	2	1	-	2	Pr
Suwalia/Sweltsa	1	-	-	-	3	-	-	4	1	1	0	Pr
Phasgonophora	-	2	-	-	1	-	-	-	-	1	2	Pr
Acroneuria	-	3	1	-	-	-	-	-	2	8	0	Pr
Diptera												
Chironomidae	21	73	48	2	4	43	10	14	19	7	6	Cg
Simulium	1	36	18	15	-	6	-	-	-	1	6	Fc
Crysops	-	-	-	-	-	-	1	-	-	-	7	Pr
Hexatoma	-	-	-	-	3	-	3	3	-	3	2	Pr
Dicranota	-	-	1	3	-	-	-	1	2	-	3	Pr
Chelifera	-	-	-	-	-	-	-	2	8	-	6	Pr
Dolichopodidae	-	-	-	-	2	1	-	-	-	-	4	Pr
Blephariceria	4	-	-	-	-	-	-	-	-	-	0	Sc
Antocha	-	-	-	-	1	-	-	-	-	-	3	Cg
Coleoptera												
Psephenus	-	-	-	-	-	-	-	-	-	4	4	Sc
Promoresia	-	1	-	1	-	-	8	-	1	-	2	Sc
Stenelmis	-	3	-	-	-	-	1	-	-	-	5	Sc
Haliplis	-	-	-	-	-	4	-	-	-	-	5	Sh
Optioservus	-	-	-	-	-	-	-	-	1	1	4	sc
Megaloptera												
Nigronia	1	2	1	-	-	-	-	-	4	2	2	Pr
Odonata												
Progomphus	-	-	-	-	-	-	-	-	1	-	5	Pr
Ophiogomphus	-	1	1	-	-	-	4	-	-	-	1	Pr
Cordulegaster	-	-	-	-	-	-	1	-	-	-	3	Pr
Turbellaria	-	-	-	-	-	-	1	-	-	-	9	Pr
Oligochaeta	-	-	-	-	-	5	-	-	1	1	10	Cg

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Appendix B. continued

TAXA	STATIONS										BI	FG*
	SWIFTWATER			DEVIL'S HOLE		YANKEE		TANK	UNT YANK	BUTZ		
	1	2	3	1	2	1	2					
Isopoda												
Caecidotea	-	-	-	-	-	3	-	-	-	-	6	cg
Amphipoda												
Gammarus	-	-	-	-	-	3	-	-	1	-	4	Cg
Nematomorpha	-	-	1	-	-	-	-	-	1	-	9	cg
Mollusca												
Pisidium	-	13	1	-	-	-	1	-	3	-	8	fc

* (Cg=collector/gatherer, Sc=scraper, Fc=filtering collector, Pr=predator, Sh=shredder)

Appendix C. Habitat scores for Riffle/Run Prevalence at benthic macroinvertebrate sites on the Paradise Watershed sampled from July 11-26, 2009

Station	Habitat Parameter*												Total Score**
	1	2	3	4	5	6	7	8	9	10	11	12	
Paradise 1	16	18	12	17	18	20	20	20	17	14	16	11	199
Paradise 2	16	17	18	17	13	12	16	19	3	10	13	15	169
Paradise 3	17	19	15	13	19	14	20	20	14	19	18	19	207
Paradise 4	20	17	18	18	15	19	18	20	18	17	18	19	217
Forest Hills 1	16	18	16	14	16	16	18	20	6	13	20	18	191
Forest Hills 2	19	17	15	17	20	17	19	20	4	10	18	18	194
Forest Hills 3	13	15	17	11	15	16	20	20	18	18	18	18	199
Forest Hills 4	14	17	16	17	20	15	20	17	10	15	16	18	195
Cranberry 1	18	13	15	11	13	18	14	17	20	20	20	20	194
Cranberry 2	18	19	19	18	20	18	18	20	20	20	20	20	230
Cranberry 3	17	20	18	17	19	20	20	20	16	17	15	16	215
Swiftwater 1	18	20	20	18	20	20	20	17	14	18	16	15	216
Swiftwater 2	16	18	19	17	18	20	20	20	15	14	15	16	208
Swiftwater 3	18	19	14	16	19	18	19	20	13	19	20	19	214
Devil's Hole 1	17	18	19	13	20	20	20	19	14	18	19	17	214
Devil's Hole 2	16	19	18	17	15	19	20	20	15	17	18	14	208
Yankee 1	9	13	10	11	16	15	17	11	10	19	14	13	153
Yankee 2	16	18	12	14	19	14	18	20	16	18	20	18	203
Tank Creek	14	18	18	14	11	17	19	20	11	14	16	14	186
UNT to Yank	13	15	16	13	20	16	17	19	19	20	17	19	204
Butz Run	15	16	15	15	18	15	18	17	10	11	12	13	175

* 1-instream cover, 2- epifaunal substrate, 3 – embeddedness, 4- velocity/depth regimes, 5 – channel alteration, 6 – sediment deposition, 7 – frequency of riffles, 8- channel flow status, 9 – condition of banks, 10 – bank vegetative protection, 11 – grazing or other disruptive pressure, 12 – riparian vegetative zone width

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

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

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Appendix C

Benthic macroinvertebrates of Paradise Creek and Cranberry Run – April 14, 2006
For Henryville Conservation Club.

BENTHIC MACROINVERTEBRATES OF PARADISE CREEK AND CRANBERRY RUN – APRIL 14, 2006

FOR
HENRYVILLE CONSERVATION CLUB

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BENTHIC MACROINVERTEBRATES OF PARADISE CREEK AND CRANBERRY RUN - 2006

On April 14, 2006, at the request of the Henryville Conservation Club, Don Baylor of Aquatic Resource Consulting sampled benthic macroinvertebrates at two stations on Paradise Creek and one on Cranberry Run. Henryville Conservation Club members were interested in the status of the invertebrate populations of their waters after the spring and fall floods and midsummer draught of 2005. 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

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, 1997). At each station, two samples were taken from a riffle/run area with a D-frame Wildlife Supply Company #425-D5 kick net. Samples were taken by placing the net against the substrate and disturbing approximately one square meter above the net by foot. Organisms and debris were composited for each station in a plastic container and preserved in alcohol for transport to the laboratory.

In the laboratory, organisms were removed from the debris and placed in a white pan marked with a grid to delineate 21 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 (Environmental Analysts, 1990). Taxa richness, modified EPT index, percent modified mayflies, percent dominant taxon, and Hilsenhoff biotic index values (Hilsenhoff, 1987) were calculated for each station to apply PA DEP Central Office's most recent draft guidance for use with special protection and anti-degradation studies. A description and brief rationale for each of the five metrics follow:

1. 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. Modified EPT Index – is a measure of community balance. The insect orders Ephemeroptera, Plecoptera, and Trichoptera (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 minus those considered pollution tolerant (Modified EPT index) is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

3. Modified Hilsenhoff Biotic Index – is a direct measure of pollution tolerance. Since many of the aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollutants, a biotic index is also used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. This metric has been modified to use more recent pollution tolerance values, which range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated (Table 1).

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

4. Percent Dominant Taxon – measures evenness of community structure. It is the percent of the total abundance made up by the single most abundant taxon. Dominance of a few taxa may suggest environmental stress; however, the tolerance value of the dominant taxon must be considered.

5. Percent Modified Mayflies – is another measure of balance. Mayflies are considered one of the least tolerant orders to organic pollution and acidification. Undisturbed streams generally have an abundance of mayflies. Pennsylvania DEP uses the percent contribution of mayflies to the total number of organisms as an indication of water quality. The value is modified to exclude those mayflies considered pollution tolerant.

SAMPLING STATIONS

One station on Cranberry Run and two on Paradise Creek were sampled in spring of 2006 at the Henryville Conservation Club. Stations were chosen where historical benthic macroinvertebrate data were most available from past sampling by Aquatic Resource Consulting. Station numbers from past sampling for the Brodhead Protective Association were retained in this study. Station locations were as follows:

Station 2 – Paradise Creek – Paretta water – a riffle above the Route 191 bridge upstream from the clubhouse: latitude - 41degrees 06.030N, longitude – 075 degrees 15.053 W.

Station 3 – Paradise Creek – the riffle above Bridge Run: latitude - 41 degrees 05.567 N, longitude – 075 degrees 14.533W.

Station 5 – Cranberry Run – approximately 50 meters upstream from its confluence With Paradise Creek: latitude 41 degrees 06.095N, longitude 075 degrees 14.963W.

RESULTS AND DISCUSSION

Appendix A shows the taxa, numbers, and biotic index pollution tolerance value (BI) for benthic macroinvertebrates found at four stations on Paradise Creek and Cranberry Run in spring of 2006. Table 2 shows the community metrics for the same benthic macroinvertebrate samples, and Table 3 compares benthic community metrics from spring of 2006 with those for past spring samples from these stations.

<u>General Water Quality</u>

Benthic macroinvertebrate samples from stations 2, 3, and 5 were indicative of excellent water quality with no apparent organic pollution. These stations had somewhat similar species composition and balance (Appendix A). Biotic index values were excellent at all three stations, ranging from 0.66 and Station 5 to 2.40 at Station 3. These values are well within Hilsenhoff's "excellent" range, with the value for Cranberry Run being exceptional (Tables1 and 2). Samples consisted entirely of aquatic insects with the vast majority of the insects having very low tolerance to pollution. The percentage of intolerant mayflies was over 50% at all stations (Table 2). The percentage of the dominant taxon at all stations was near 50%, which could be considered an imbalance in the communities. However, the dominant taxon at each of these stations was

Table 2. Benthic macroinvertebrate community metrics for samples from Paradise Creek and Cranberry Run on April 14, 2006.

METRICS	STATION 2 PARETTA	STATION 3 BRIDGE RUN	STATION 5 CRANBERRY
Number of organisms in subsample	235	215	207
Taxa Richness	20	17	27
Modified EPT Index	11	12	21
Modified Hilsenhoff Biotic Index	2.25	2.40	0.66
Percent Dominant Taxon	50.63%	49.76%	46.38%
Percent Modified Mayflies	57.02%	56.74%	74.87%

the mayfly *Drunella cornuta*, which has a pollution tolerance of 0. In such cases where the dominant taxon is intolerant, the imbalance is considered to be a result of natural life cycles; a particular taxon may be particularly abundant just prior to its emergence.

Effects of Flooding in 2005

Although benthic macroinvertebrate samples from Paradise Creek and Cranberry Run were indicative of excellent water quality with little or no organic pollution, the benthic communities appeared significantly impacted by the floods of 2005. The primary impact was the reduction of numbers of taxa. Abundance of invertebrates remained quite good, but fewer kinds were collected than would be expected from past sampling. This impact was less severe on Cranberry Run than on the Paradise Creek, as would be expected because of the much smaller area draining to Cranberry Creek.

At both Paradise Creek stations, Trichoptera (caddisflies) and Plecoptera (stoneflies) were very poorly represented in the spring 2006 samples (Appendix A). This was a contrast a contrast to past samples. Of the more than 200 invertebrates subsampled from these stations, only ten and five caddis larvae were present from stations 2 and 3 respectively (Appendix A). In addition, there was only one stonefly in the subsample from Station 2 and only four from Station 3. Stoneflies remained fairly abundant in the Cranberry Run subsample. The mayflies *Ephemerella subvaria* , *E invaria*, and *E. dorothea*, which have been more abundant in the past, were not well represented in the Paradise Creek samples. Mayfles of *Stenonema ithica* and *S. vicarium* are usually well represented in spring samples from Paradise Creek and Cranberry Run. They were absent from the Paradise samples in April 2006.

It is interesting that the nymphs of the mayfly *Drunella cornuta* remained quite abundant in all three spring 2006 samples. It may be that the nymphs were small enough to avoid the severe impact of mobilized substrate in April of 2005 prior to their maturation, and that they were in egg or very early instar stages during the fall 2005 flood.

Because seasonality of benthic communities causes expected differences in spring and fall samples, spring 2006 samples were compared to past spring samples from the same stations in Table 3. Previous spring samples were collected at Stations 2 and 3 on May 5, 1985 and March 16 of 1997. From Station 5, a previous spring sample was collected on March16, 1997. Although some taxa emerge between mid-March and mid April, the April 14, 2006 samples should have had greater similarity to past spring samples in taxa richness and balance than was the case. Flooding in spring and fall of 2005 appears to have greatly reduced numbers of organisms among the taxa that were most mature and vulnerable at the times of flooding. The reduction in modified EPT Index value for April 2006 samples compared to past spring samples is simply a result of reduction in overall taxa by flooding, not a reflection of organic pollution. This assumption is supported by the predominance of intolerant taxa causing excellent biotic index values and a high percentage of intolerant mayflies (Table 3).

Table 3. Community metrics for spring benthic macroinvertebrate samples from Paradise Creek and Cranberry Run.

STATION - DATE	TAXA RICHNESS	MOD. EPT	MOD. H. BIOTIC INDEX	PERCENT DOMINANT TAXON	PERCENT MOD. MAYFLIES
STATION 2 - PARETTA					
May 5, 1985	35	19	1.94	27.95%	53.98%
March 16, 1997	26	20	3.29	35%	65%
April 14, 2006	20	11	2.25	50.63%	57.02%
STATION 3 – BRIDGE RUN					
May 5, 1985	37	23	2.70	19.45%	24.60%
March 16, 1997	31	22	2.24	20%	59%
April 14, 2006	17	12	2.40	49.76%	46.38%
STATION 5 – CRANBERRY					
March 16, 1997	40	26	1.38	28.99%	42.29%
April 14, 2006	27	21	0.66	46.38%	74.87%

My past experience with the impact of flooding on the aquatic insects of the Brodhead drainage is based primarily on observations and sampling of the lower Brodhead, below Analomink. Those experiences suggest that the taxa that are mature or largest at the time of substrate-mobilizing floods are most severely impacted. These larger taxa may be crushed or displaced by catastrophic drift. Past spring floods have severely curtailed numbers of *Ephemerella subvaria* (Hendricksons) and *E. invaria* (the larger sulfurs) in the Brodhead. *Ephemerella dorothea* (Pale Evening Duns) have survived spring floods better,probably because they are much smaller at that time.

Ecological principles would suggest that species that have more than one generation per season will recover most rapidly. My observations are that this is the case on the Brodhead with *Baetis* species and *Isonychia bicolor* recovering fairly rapidly because of their two to three generations per year. The larger Ephemerella mayfly populations may take several years to recover. Recovery will occur as behavioral drift of immatures and adult mating flights repopulate devastated area from less impacted areas and tributaries. Recovery, of course, will depend on several years without recurrence of severe floods. *Epeorus pluralis* (Quill Gordons) were not impacted as severely as some spring mayflies and may recover more rapidly, probably because – although they are thought of as an early spring hatch – they do not all mature at once and emerge over a more extended period. Samples collected on the lower Brodhead just prior to the April 2005 flood were devoid of *Ephemerella subvaria* (Hendricksons), which have apparently not recovered from previous spring floods, before which they were very abundant.

Appendix A. Taxa, numbers, and biotic index values (BI) of benthic macroinvertebrates from Paradise Creek and Cranberry Run, April 14, 2006.

TAXA	PARADISE CREEK		CRAN. RUN	BI
	STATION 2	STATION 3	STATION 5	
Ephemeroptera (mayflies)				
Epeorus pluralis/punctata	11	10	39	0
Stenonema Ithaca	-	-	4	3
Ephemerella dorothea	2	4	7	1
E subvaria	1	1	-	1
Eurylophella verisimilis	1	-	2	4
Drunella counuta	119	107	96	0
Isonychia sp.	1	-	3	3
Paraleptophlebia sp.	-	-	1	2
Baetis tricaudatus	10	6	-	6
Diphetor hageni	-	-	3	5
Trichoptera (cadisflies)				
Rhyacophila fuscula	1	1	1	0
R. Manistee	-	-	1	1
Psilotreta labida	-	-	1	0
Dolophilodes distinctus	1	1	-	0
Polycentropus sp.	1	1	-	6
Diplectrona modesta	-	1	4	0
Ceratopsyche sparna	5	1	-	1
C. sp.	2	-	1	5
Lepidostoma sp.	-	-	1	1
Plecoptera (stoneflies)				
Acroneuria abnormis	1	1	3	0
A. carolinensis	-	-	2	0
Phasgonophora capitata	-	1	-	2
Isoperla orata	-	1	2	2
I. bilineata	-	-	2	4
Suwalia sp.	-	-	2	0
Pteronarcys biloba	-	-	2	0
Tallaperla sp.	-	-	1	0
Strophopteryx fasciata	-	1	-	3

Appendix A. continued.

TAXA	PARADISE CREEK		CRAN. RUN	BI
	STATION 2	STATION 3	STATION 5	
Megaloptera (hellgrammites)				
Nigronia serricornis	1	-	1	0
Coleoptera (beetles)				
Psephenus herricki	1	-	4	4
Diptera (true flies)				
Chironomidae	67	70	1	6
Prosimulium sp.	3	2	20	2
Hexatoma sp.	1	-	1	2
Blepharecera sp.	2	-	2	0
Chelifera sp.	4	6	-	6

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Appendix D

Benthic Macroinvertebrates of Paradise Creek and Cranberry Creek, Monroe county, PA March 16, 1997 for Henryville Conservation Association

BENTHIC MACROINVERTEBRATES

OF

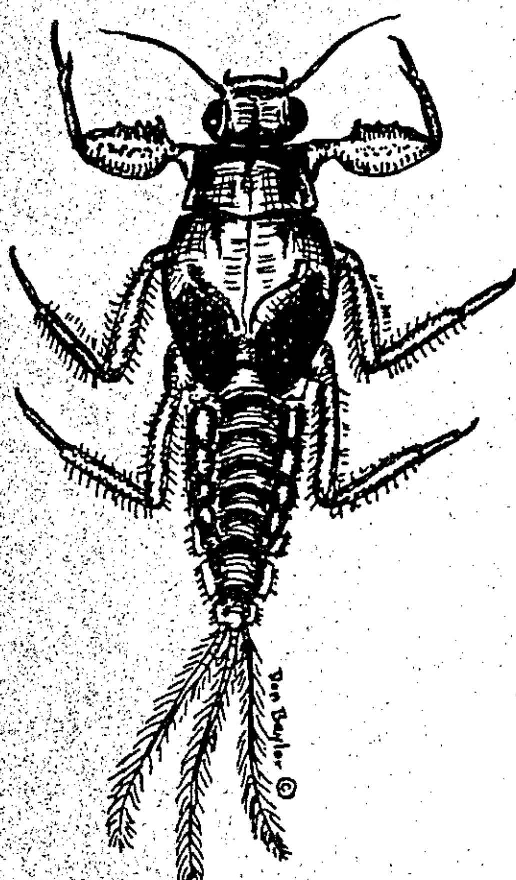
PARADISE CREEK AND CRANBERRY CREEK

MONROE COUNTY, PA

MARCH 16, 1997

FOR

HENRYVILLE CONSERVATION ASSOCIATION



Submitted by

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for

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BENTHIC MACROINVERTEBRATES OF PARADISE CREEK AND CRANBERRY CREEK, MONROE COUUNTY, PA, MARCH 16, 1997, FOR HENRYVILLE CONSERVATION ASSOCIATION

BACKGROUND

At the request of Henryville Conservation Association, Aquatic Resource consulting sampled benthic macroinvertebrates of Paradise Creek and Cranberry Run, Monroe County PA, on March 16, 1997. The purposes of the sampling were to establish baseline data on lower Cranberry Run and to compare invertebrate data on Paradise Creek with past data, and especially to evaluate the impact of the transport of silt from an upstream pond dredging during the winter of 1997.

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 community structure.

Species Diversity

Species diversity calculations measure the number of taxa present and the evenness of the distribution of individuals among the taxa. Diversity values in unpolluted streams generally range from 3 to 4; in polluted streams, they often fall below 1 (Wilhm 1973).

Equitability

Equitability is a metric which compares the distribution of individuals among the taxa in the sample to those in samples from undisturbed streams. Equitability in unpolluted streams generally ranges from 0.60 to 0.80 and may fall below 0.10 in polluted streams. Equitability is not used in most recent protocols but is retained here to provide comparisons to past data.

Biotic Index

Since many of the aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollutants, a biotic index is also used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated (Table 1).

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

EPT Index

The insect orders Ephemeroptera, Plecoptera, and Trichoptera (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 (EPT index) is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

Number of Taxa

Taxa richness indicates the health of the benthic community through a measurement of the variety of species present. Generally, number of species increases with increased water quality. Variability in natural habitat, however, affects this number.

Percent Dominant Taxon

The contribution of the dominant taxon to the total community abundance is another measure of evenness or community balance. Dominance of a few taxa may indicate environmental stress. In evaluating organic pollution, however, the tolerance values of the dominant taxa are important to consider.

Ratio of Scrapers to Filtering Collectors

The scraper and filtering collector ratio reflects the riffle-run community food base (Plafkin et al.,1989). Shifts in dominance of a particular feeding group may indicate an overabundance of a perticular food source. Filtering collectors are vulnerable to toxicants that are bound to suspended particles, and are first to decrease when such toxicants are present.

Percentage of Filtering Collectors

Filtering collectors are most severely affected by suspended solids in the water column during siltation. This metric was used to show the effects on the riffle community of the siltation in the Paradise Creek during the winter of 1997.

SAMPLING STATIONS

Five stations were sampled - four on Paradise Creek and one on Cranberry Run (Figure 1). Following are descriptions of the stations:

Station 1. Paradise Creek - the riffle below Jefferson's Flume
Station 2. Paradise Creek - a riffle above the Route 191 bridge upstream from the club house.
Station 3. Paradise Creek - the riffle above Bridge Run
Station 4. Paradise Creek - the riffle below Elbow Pool
Station 5. Cranberry Run - approximately 50 meters upstream from its confluence with Paradise Creek.

Stations 2 and 3 had been sampled previously as part of a Brodhead Protective Association watershed study and for Henryville Conservation Association.

METHODS

Sampling methods followed those recommended by Hilsenhoff (1982) and the Environmental Protection Agency (Plafkin, 1989). At each station, a riffle area was sampled with a kick screen device of 521 micron nytex until more than 100 macroinvertebrates were obtained. The substrate was disturbed with a four pronged cultivator tool and by hand to dislodge organisms into the screen. Rocks were also randomly selected and cleaned by hand to dislodge organisms firmly attached. Organisms were picked from the debris in the

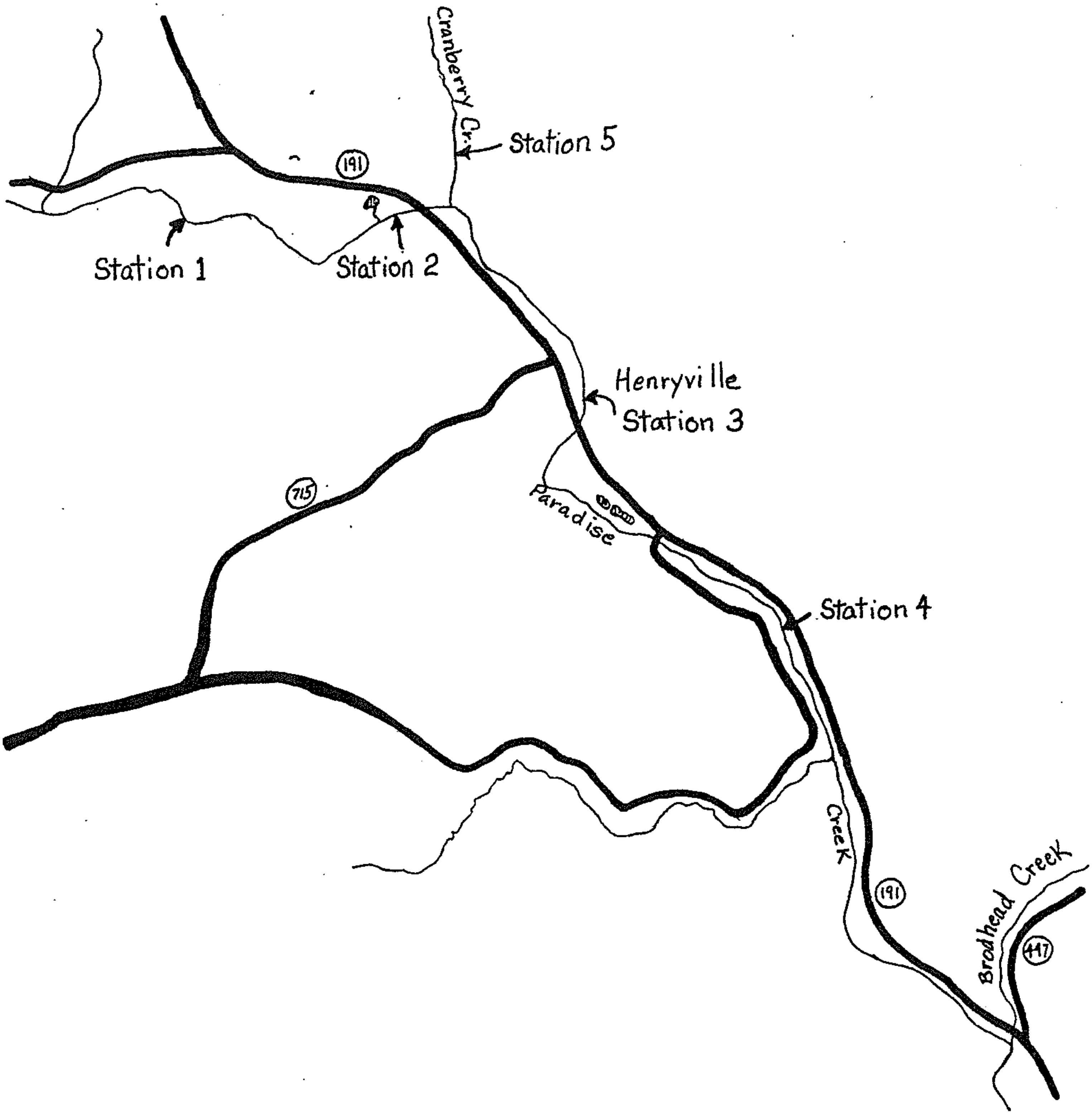

Figure 1. Sampling stations for benthic macroinvertebrates on Paradise Creek and Cranberry Run, March 16, 1997.

field, composited for each station, and preserved in Kahle's solution for transport to the laboratory.

In the laboratory, organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value if known (Environmental Analysts, 1990). Metrics were calculated for each station according to Hilsenhoff (1987) Weber (1973) and Plafkin et al.(1989). Many of the metrics used here were not applied to previous samples from Henryville waters, so calculations of newer metrics were done for past samples for comparison to 1997 samples.

RESULTS AND DISCUSSION

On March 16, 1997, all stations sampled on Henryville Conservation Association waters yielded macroinvertebrates indicative of little or no organic pollution. Biotic index values were all in the "excellent" range except at Station 1 below Jefferson's Flume where the rating was "very good" (Table 2). Diversity values were all within the clean stream range of 3 to 4. All stations had nemerous taxa, EPT taxa, and mayfly organisms. The slightly poorer biotic index at Station 1 may have been due to slightly slower current speed than at other riffle areas sampled on Paradise Creek, which would have allowed more deposition of silt in the substrate.

Table 3 shows data for stations 2 and 3 at various sampling times since 1985. Indicators of organic pollution such as biotic index and diversity suggest that in March of 1997, stations 2 and 3 compared favorably to past samples from the same stations (Table 3). These data suggest that these stations did not suffer effects of organic loading from the winter 1997 siltation.

However, the effects of suspended solids from the siltation is demonstrated in changes in the ratio of scrapers to filtering collectors (SC/FC) and decreases in percentage of filtering collectors (%FC) in the samples. Percentages of filterers were considerably reduced from any other sampling time, spring or fall. At Station 3, for example, the lowest percentage of filtering collectors recorded prior to March of 1997 was 46% in May of 1985. In March of 1997, the percentage was 16%. At Station 2 the filtering collector percentage was 14% - considerably lower than in any previous sample. Although past data suggest that filtering collectors may naturally constitute a larger percentage of the invertebrates in Paradise Creek in fall than in spring, spring 1997 samples displayed reduced percentages compared to the spring 1985 samples.

Table 2. Evaluation of benthic macroinvertebrate samples from Paradise and Cranberry creeks for Henryville Conservation Association, March 16, 1997.

D - diversity index
E - equitability
BI - biotic index
EPT - Ephemeroptera, Plecoptera, Trichoptera index (taxa)
TAXA - number of taxa
%MAYS - percent of mayfly organisms
% DT - percent of the dominant taxon
SC/FC - ratio of scrapers to filtering collectors
% FC - percent filtering collectors in sample

	STATIONS				
	1 BELOW FLUME	2 ABOVE CLUBHOUSE	3 BRIDGE RUN	4 BELOW ELBOW	5 CRAN-BERRY
D	3.16	3.46	3.99	3.79	3.83
E	0.40	0.57	0.70	0.68	5.83
BI	3.82 V.GOOD	3.29 EXCEL.	2.24 EXCEL.	2.41 EXCEL.	1.38 EXCEL.
EPT	23	20	26	23	29
TAXA	29	26	32	28	40
% MAYS	67%	65%	59%	59%	53%
% DT	46%	35%	20%	27%	29%
SC/FC	1.42	1.58	1.58	1.72	2.21
% FC	15%	14%	16%	16%	14%
ORGANISMS	301	225	230	299	376

Table 3. Historical comparison of benthic macroinvertebrate populations from Station 2 (above the clubhouse) and Station 3 (above Bridge Run) on Henryville Conservation Association waters.

D - diversity index
E - equitability
BI - Biotic Index
EPT - Ephemeroptera, Plecoptera, Trichoptera index
TAXA - number of taxa
% Mays - percent of mayfly organisms
% DT - percent of the dominant taxon
SC/FC - ratio of scrapers to filtering collectors
% FC - percent filtering collectors in sample

	5/5/85	9/8/85	10/3/89	9/24/92	11/8/92	3/16/97
STATION 2						
D	3.82	3.73	3.15	3.69	2.96	3.46
E	0.56	0.62	0.65	0.77	0.32	0.57
BI RATING	1.94 excel.	2.98 excel.	2.88 excel.	2.97 excel.	2.97 excel.	3.29 excel.
EPT	24	22	15	14	22	20
TAXA	37	31	18	23	31	26
% MAYS	54%	25%	46%	34%	73%	65%
% DT	26%	25%	37%	23%	38%	35%
SC/FC	0.51	0.08	0.07	0.11	0.61	1.58
% FC	26%	70%	72%	66%	54%	14%

Table 3. continued

D - diversity index
E - equitability
BI - Biotic Index
EPT - Ephemeroptera, Plecoptera, Trichoptera index
TAXA - number of taxa
% Mays - percent of mayfly organisms
% DT - percent of the dominant taxon
SC/FC - ratio of scrapers to filtering collectors
% FC - percent filtering collectors in sample

	5/5/85	9/8/85	10/3/89	9/24/92	11/8/92	3/16/97
STATION 3						
D	4.04	3.66	3.57	3.01	3.66	3.99
E	0.63	0.68	0.73	0.54	0.60	0.70
BI	2.70	2.60	2.55	2.73	2.45	2.24
RATING	excel.	excel.	excel.	excel.	excel.	excel.
EPT	27	17	17	13	20	26
TAXA	38	27	22	19	29	32
% MAYS	27%	21%	33%	59%	56%	59%
% DT	19%	30%	27%	47%	33%	20%
SC/FC	0.15	0.12	0.18	0.09	0.41	1.58
%FC	46%	65%	64%	72%	49%	16%

Percentages of mayflies in March 1997 samples were quite high - generally a good indication regarding organic pollution. However, a reduction in net spinning, filtering caddis organisms due to suspended solids probably caused this high percentage rather than an increase in mayfly abundances.

Generally, the March 1997 samples from the Paradise Creek did not have the expected numbers of filtering, net spinning taxa such as Philopotamidae (Chimarra and Dolophilodes) or Hydropsychidae (Hydropsyche, Ceratopsyche, and Cheumatopsyche) caddis. This impact, probably from suspended silt, was similar to the impact indicated by invertebrate samples in November of 1992 when Paradise Creek suffered similar siltation from an upstream dredging operation (Baylor 1992). Filter feeding organisms seem to have been more severely reduced in 1997 than in 1992, however (Table 3).

Fast riffle areas such as those used in this study are recommended for stream macroinvertebrate sampling because they are inhabited by the majority of taxa. Although these areas show the impact of suspended solids from siltation, they do not adequately demonstrate the impacts of settled solids from siltation. In high gradient streams, high current velocities in riffle areas prevent fine solids from settling out of the water column heavily in such areas. Areas of lower current velocity such as eddies and margins of pools may be blanketed by sediment, eliminating habitat niches for aquatic organisms.

SUMMARY

Macroinvertebrate samples from the Henryville area of Paradise Creek in March of 1997 indicated little or no organic pollution compared to established standards or to past macroinvertebrate data. Reduction in filtering collector organisms, especially net spinning caddis species, indicated impacts from suspended solids when compared to past macroinvertebrate data. Baseline macroinvertebrate samples from Cranberry Creek in March 1997 indicated excellent water quality.

Appendix A. Taxa, numbers, and pollution tolerance or biotic index value (BI) of benthic macroinvertebrates from Paradise Creek and Cranberry Creek - Henryville Conservation Association waters - March 16, 1997. Stations: 1 - below Jefferson's Flume, 2 - above the bridge near the clubhouse, 3 - above Bridge Run, 4 - below Elbow, 5 - Cranberry Creek.

TAXA	NUMBERS					BI
	STATIONS					
	1	2	3	4	5	
Ephemeroptera (mayflies)						
<u>Epeorus pluralis</u>	20	28	40	62	109	0
<u>Epeorus vitrea</u>	-	-	4	2	6	0
<u>Stenonema ithaca</u>	22	27	12	15	-	3
<u>Stenonema femoratum</u>	1	-	-	-	-	6
<u>Stenonema vicarium</u>	1	-	-	2	-	2
<u>Ephemerella subvaria</u>	-	-	-	-	1	0
<u>Ephemerella dorothea</u>	-	-	2	1	2	1
<u>Ephemerella invaria/rotunda</u>	8	10	9	9	12	1
<u>Drunella cornuta/cornutella</u>	5	6	18	12	27	0
<u>Eurylophella</u> sp.	1	-	-	-	1	1
<u>Paraleptophlebia adoptiva</u>	-	-	1	2	-	2
<u>Isonychia</u> sp.	1	3	3	9	1	2
<u>Baetis tricaudatus</u>	138	90	47	62	42	6
<u>Baetis bruneicolor</u>	4	1	-	-	-	4
<u>Accentrella</u> sp.	-	-	1	-	-	4
Trichoptera (caddisflies)						
<u>Chimarra aterrima</u>	1	1	1	-	3	3
<u>Dolophilodes distinctus</u>	2	-	-	-	5	0
<u>Ceratopsyche sparna</u>	-	3	3	5	2	1
<u>Ceratopsyche morosa</u>	-	5	2	5	-	6
<u>C</u>. sp.	-	-	-	-	1	5
<u>Hydropsyche betteni</u>	2	-	1	-	-	6
<u>Cheumatopsyche</u> sp.	-	2	-	-	1	5
<u>Diplectrona modesta</u>	-	-	-	-	1	0
<u>Rhyacophila fuscula</u>	4	3	2	2	10	0
<u>R</u>. <u>manistee</u>	6	6	3	2	-	1
<u>Rhyacophila melita</u>	2	1	-	1	-	1
<u>Rhyacophila carolina</u>	-	-	-	-	4	1
<u>Polycentropus</u> sp.	-	-	-	-	1	6
<u>Lepidostoma</u> sp.	-	-	-	-	1	1
Plecoptera (stoneflies)						
<u>Acroneuria abnormis</u>	10	6	10	7	10	0
<u>Acroneuria carolinensis</u>	-	-	-	-	1	0

Appendix A. continued

TAXA	NUMBERS STATIONS 1	2	3	4	5	BI
Paragnetina media	1	2	3	3	5	1
Paragnetina immarginata	1	-	1	-	-	1
Isogenoides hansoni	-	1	5	7	-	2
Pteronarcys biloba	-	-	-	-	2	0
Strophopteryx fasciata	14	15	20	33	19	3
Taeniopteryx sp.	-	-	1	-	-	2
Sweltsa sp.	3	5	2	1	8	0
Tallaperla sp.	1	-	1	8	20	0
Ostrocerca truncata	2	5	6	12	-	2
Diploperla duplicata	-	1	-	-	-	2
Isoperla marlynia	-	-	-	2	-	4
Isoperla lata	-	-	-	-	3	0
Isoperla orata	-	-	-	-	5	2
Isoperla sibleyi	-	-	-	-	4	0
Diptera (true flies)						
Hexatoma sp.	1	-	-	-	1	3
Tipula sp.	-	-	-	-	4	1
Atherix sp.	1	2	2	1	-	3
Chironomidae	23	9	5	5	4	-
Prosimulium arvum	9	13	10	18	34	2
Prosimulium sp.	16	9	12	9	3	2
Dicranota sp.	-	-	-	-	1	3
Dasyhelea sp.	-	-	-	-	12	5
Bezzia sp.	-	-	-	-	6	1
Megaloptera (Hellgramites)						
Nigronia serricornis	-	1	3	-	1	0
Coleoptera (beetles)						
Psephenus herricki	-	2	1	-	-	4
Odonata (dragonflies)						
Boyeria sp.	-	-	-	-	1	2
Oligochaeta (worms)						
Lumbriculidae	1	-	-	-	2	8
Lumbricina	-	-	-	2	-	6

Appendix A. Taxa, numbers, and pollution tolerance or biotic index value (BI) of benthic macroinvertebrates from Paradise Creek and Cranberry Creek - Henryville Conservation Association waters - March 16, 1997. Stations: 1 - below Jefferson's Flume, 2 - above the bridge near the clubhouse, 3 - above Bridge Run, 4 - below Elbow, 5 - Cranberry Creek.

TAXA	NUMBERS STATIONS 1	2	3	4	5	BI
Ephemeroptera (mayflies)						
Epeorus pluralis	20	28	40	62	109	0
Epeorus vitrea	-	-	4	2	6	0
Stenonema ithaca	22	27	12	15	-	3
Stenonema femoratum	1	-	-	-	-	6
Stenonema vicarium	1	-	-	2	-	2
Ephemerella subvaria	-	-	-	-	1	0
Ephemerella dorothea	-	-	2	1	2	1
Ephemerella invaria/rotunda	8	10	9	9	12	1
Drunella cornuta/cornutella	5	6	18	12	27	0
Eurylophella sp.	1	-	-	-	1	1
Paraleptophlebia adoptiva	-	-	1	2	-	2
Isonychia sp.	1	3	3	9	1	2
Baetis tricaudatus	138	90	47	62	42	6
Baetis bruneicolor	4	1	-	-	-	4
Accentrella sp.	-	-	1	-	-	4
Trichoptera (caddisflies)						
Chimarra aterrima	1	1	1	-	3	3
Dolophilodes distinctus	2	-	-	-	5	0
Ceratopsyche sparna	-	3	3	5	2	1
Ceratopsyche morosa	-	5	2	5	-	6
C. sp.	-	-	-	-	1	5
Hydropsyche betteni	2	-	1	-	-	6
Cheumatopsyche sp.	-	2	-	-	1	5
Diplectrona modesta	-	-	-	-	1	0
Rhyacophila fuscula	4	3	2	2	10	0
R. manistee	6	6	3	2	-	1
Rhyacophila melita	2	1	-	1	-	1
Rhyacophila carolina	-	-	-	-	4	1
Polycentropus sp.	-	-	-	-	1	6
Lepidostoma sp.	-	-	-	-	1	1
Plecoptera (stoneflies)						
Acroneuria abnormis	10	6	10	7	10	0
Acroneuria carolinensis	-	-	-	-	1	0

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Appendix A. continued

TAXA	NUMBERS STATIONS 1	2	3	4	5	BI
Paragnetina media	1	2	3	3	5	1
Paragnetina immarginata	1	-	1	-	-	1
Isogenoides hansoni	-	1	5	7	-	2
Pteronarcys biloba	-	-	-	-	2	0
Strophopteryx fasciata	14	15	20	33	19	3
Taeniopteryx sp.	-	-	1	-	-	2
Sweltsa sp.	3	5	2	1	8	0
Tallaperla sp.	1	-	1	8	20	0
Ostrocerca truncata	2	5	6	12	-	2
Diploperla duplicata	-	1	-	-	-	2
Isoperla marlynia	-	-	-	2	-	4
Isoperla lata	-	-	-	-	3	0
Isoperla orata	-	-	-	-	5	2
Isoperla sibleyi	-	-	-	-	4	0
Diptera (true flies)						
Hexatoma sp.	1	-	-	-	1	3
Tipula sp.	-	-	-	-	4	1
Atherix sp.	1	2	2	1	-	3
Chironomidae	23	9	5	5	4	-
Prosimulium arvum	9	13	10	18	34	2
Prosimulium sp.	16	9	12	9	3	2
Dicranota sp.	-	-	-	-	1	3
Dasyhelea sp.	-	-	-	-	12	5
Bezzia sp.	-	-	-	-	6	1
Megaloptera (Hellgramites)						
Nigronia serricornis	-	1	3	-	1	0
Coleoptera (beetles)						
Psephenus herricki	-	2	1	-	-	4
Odonata (dragonflies)						
Boyeria sp.	-	-	-	-	1	2
Oligochaeta (worms)						
Lumbriculidae	1	-	-	-	2	8
Lumbricina	-	-	-	2	-	6

Appendix E

Benthic Macroinvertebrates of Cranberry Creek Near Cresco, PA Downstream from Blue Ridge Peat Mine, September 23, 1995

BENTHIC MACROINVERTEBRATES

OF

CRANBERRY CREEK NEAR CRESCO, PA

DOWNSTREAM FROM BLUE RIDGE PEAT MINE

SEPTEMBER 23, 1995

Submitted by

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for

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BENTHIC MACROINVERTEBRATES OF CRANBERRY CREEK NEAR CRESCO, PA DOWNSTREAM FROM BLUE RIDGE PEAT MINE, SEPTEMBER 23, 1995

INTRODUCTION

On September 23, 1995, Aquatic Resource Consulting biologist Don Baylor sampled benthic macroinvertebrates of Cranberry Creek on the property of Cranberry Creek Estates in Monroe County, Pennsylvania. The purpose of the sampling was to evaluate water quality to determine whether Cranberry Creek exhibited degradation from upstream disturbance.

SAMPLING STATION

One site (Station B) was sampled on Cranberry Creek approximately halfway between its confluence with a tributary from Hardytown that flows southwest under Route 390 and its confluence with a branch flowing south from the vicinity of Weiler Brush Company (Figure 1). Since no sampling station was available upstream from Blue Ridge Peat Mine on Cranberry Creek, a site (Station A) on an unnamed tributary to Cranberry Creek originating in the same vicinity and lying approximately 3/4 mile east of Station A was used as a reference station. Station A had been sampled for benthic macroinvertebrates on March 19, 1995.

BACKGROUND

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. Species diversity calculations measure the number of taxa present and the evenness of the distribution of individuals among the taxa. Actually, at any given time, varying seasonal cycles and ecological segregation cause undisturbed streams to have a few abundant species and many represented by only a few individuals. Therefore, another statistical calculation - equitability - is used to measure how closely the distribution of abundances in the samples approximate those found in similar size samples from undisturbed streams.

Diversity values in unpolluted streams generally range from 3 to 4; in polluted streams, they often fall below 1. Diversity values, however, are insensitive to moderate pollution. Equitability values, in contrast, are quite sensitive to even slight degradation - generally ranging from 0.6 to 0.8 in clean streams and falling below 0.5 in polluted streams.

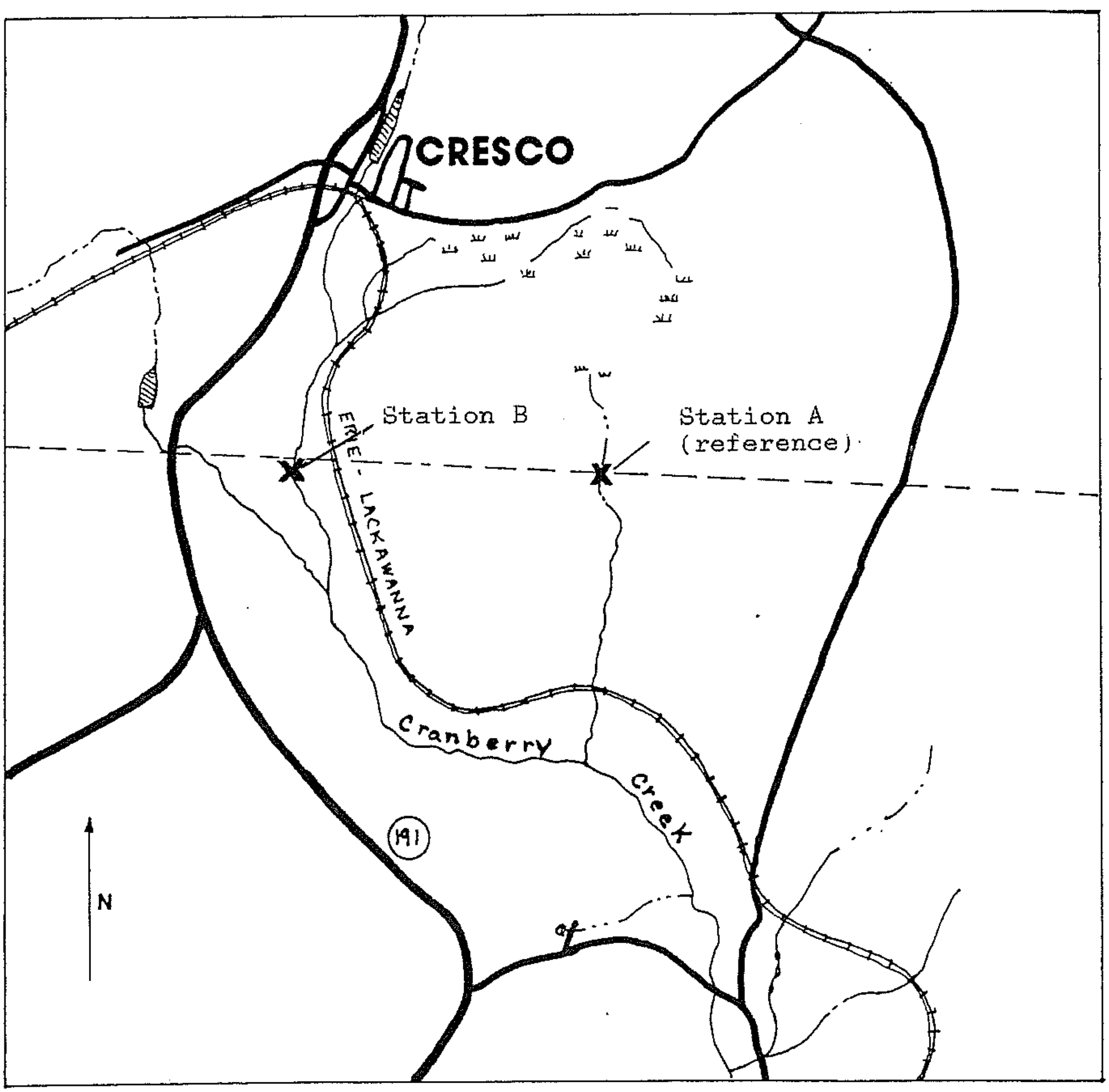


Figure 1. Map of Cranberry Creek and unnamed tributary near Cresco, Monroe County, PA showing stations A and B sampled on March 3, 1995 and September 23, 1995 respectively.

Since many of the aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollutants, a biotic index is also used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated (Table 1).

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

Overall taxanomic richness and total number of Ephemeroptera + Plecoptera + Trichoptera (EPT) taxa are also commonly used to evaluate water quality. EPT taxa richness is used because these three orders are the least tolerant of organic pollution. Impacts other than organic enrichment may cause a reduction in density of benthic macroinvertebrates.

METHODS

Sampling methods followed those recommended by Hilsenhoff (1982) and the Environmental Protection Agency (Weber, 1973). At each station, a riffle area was sampled with a kick screen device of 521 micron nytex. Samples were taken in a riffle area until approximately 100 invertebrates were collected. The substrate was disturbed with a four pronged cultivator tool and by hand to dislodge organisms into the screen. Rocks were also randomly selected and cleaned by hand to dislodge organisms firmly attached. Organisms were picked from the debris in the field, composited for each station, and preserved in Kahle's solutiion for transport to the laboratory.

In the laboratory, organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value if known. Species diversity, equitability, and biotic index were calculated for each station according to Hilsenhoff (1987) and Weber (1973).

RESULTS AND DISCUSSION

Both stations had diversity, equitability, and biotic index values indicative of streams relatively unaffected by organic pollution (Table 2). However, Cranberry Creek at Station B had approximately half the total number of taxa and EPT taxa found at Station A and a much sparser benthic macroinvertebrate population (Table 3). Station A had 37 taxa while Station B on Cranberry Creek had only 18. The most notable difference, however, was the dearth of benthic organisms at Station B. Though kick samples are not strictly quantitative, two kick samples yielded 224 organisms at Station A while numerous kick samples and extensive picking of rocks was required to collect 98 organisms at Station B.

Although each station was sampled in a different season, the samples were taken at times of year - spring and fall - when benthic macroinvertebrate populations are optimum for evaluating water quality. Midsummer is generally not the best sampling time because most species are late spring to summer emergers causing some with one year life cycles to be absent in midsummer. Species present in spring, however, generally emerge, oviposit, and produce at least early instar larvae by fall.

There was significant community loss from the reference Station A to Station B on Cranberry Creek (Table 2). Community Loss Index and the Jaccard Coefficient of Community Similarity were calculated for station comparison. Community Loss Index measures the loss of benthic taxa between stations, and the Jaccard Coefficient measures degree of similarity ranging from 0 to 1.0 - the higher the value the higher the degree of similarity with the reference station. For Station B, the Jaccard Coefficient was 0.21 indicating low degree of similarity to the reference station.

Because of the close proximity of their origins and riparian and gradient similarities, one would expect that, in the absence of degradation, the stations would produce similar invertebrate populations. Many coldwater taxa were present at each station suggesting that disparity of temperature regimes is not entirely the cause. Biotic index and diversity statistics suggest that organic pollution is not the cause. Habitat loss due to severe sedimentation observed during sampling at Station B may be the cause of the disparity in invertebrate populations. Embeddedness - amount of substrate covered with a deposit of fine sediment - was very high in Cranberry Creek in the vicinity of Station B.

Table 3. Number of organisms, number of taxa, diversity, equitability, EPT taxa, biotic index, community loss index, and Jaccard Coefficient of Community Similarity for benthic macroinvertebrate samples from Cranberry Creek, September 23, 1995 compared with an unnamed tributary to Cranberry Creek, March 3, 1995.

	STATION A CRANBERRY CREEK	STATION B UNNAMED TRIBUTARY
Number of Organisms	98	224
Number of Taxa	18	37
EPT Taxa	12	25
Biotic Index	1.42	0.84
Diversity	3.21	4.14
Equitability	0.67	0.61
Community Loss Index	1.56	-
Jaccard Coefficient of Community Similarity	0.21	-

Exposed silt bars were present in many pool areas. Many aquatic macroinvertebrate species inhabit the undersides of rocks and can inhabit interstitial areas up to and beyond 30 centimeters below the water-substrate interface. Where the substrate is severely embedded as in Cranberry Creek at Station B, habitat niches required by many species are greatly reduced, which reduces the overall numbers and severely limits the productivity of the stream. In addition to reducing invertebrate fish food organisms, siltation may severely limit trout reproduction. Trout require clean gravel for redds so that eggs remain well oxygenated during incubation.

Although there is a pond on one branch of Cranberry Creek near Weiler Brush Company above Station B, the dearth of macroinvertebrates and taxa at Station B does not reflect the impact of an impoundment. Impoundments tend to increase downstream macroinvertebrate densities and cause a proliferation of filter-feeding taxa, which is not the condition at Station B.

After sampling was completed on September 23, 1995, at Station B, turbid water was observed flowing down Cranberry Creek a short distance upstream from the station. Although some precipitation occurred early the previous night, any turbidity from rain run-off would not just then have been approaching Station B.

SUMMARY

A considerable loss of overall taxa, EPT taxa, and numbers of organisms at Station B on Cranberry Creek was indicated by comparing a sample taken there on September 23, 1995 to a sample taken from Station A on an unnamed tributary on March 19, 1995. An apparent cause was an observed imbeddedness of the substrate and resultant loss of macroinvertebrate habitat.

Appendix A. Taxa, numbers, and pollution tollerance values (0=least tolerant - 10=most tolerant) for benthic macroinvertebrates collected at Station B on Cranberry Creek southwest of Cresco, Monroe County, PA, September 23 1995.

TAXA	NUMBER	POLLUTION TOLERANCE
Ephemeroptera		
Stenonema ithaca	1	3
Trichoptera		
Chimarra aterrima	24	4
Dolophilodes distinctus	16	0
Diplectrona modesta	3	0
Rhyacophila carolina	1	1
Astenophylax argus	1	-
Frenesia difficilis	2	0
Neophylax sp.	1	3
Plecoptera		
Tallaperla sp.	2	0
Acroneuria carolinensis	23	0
A. abnormis	8	0
Pteronarcys proteus	3	0
Megaloptera		
Nigronia serricornis	1	0
Odonata		
Calopteryx sp.	1	5
Boyeria sp.	4	3
Cordulegaster sp.	2	3
Diptera		
Chironomidae	4	-
Decapoda		
Cambarinae	1	6

Appendix B. Taxa, numbers, and pollution tollerance values (0 = least tolerant-10 = most tolerant) for benthic macroinvertebrates collected in an unnamed tributary to Cranberry Creek southwest of Cresco, Monroe County, PA, March 3, 1995.

TAXA	NUMBER	POLLUTION TOLERANCE
Ephemeroptera (mayflies)		
Stenonema meririvulanum	9	?
S. pudicum	10	2
Stenacron guildersleevei	26	0
Ephemerella dorothea	55	1
Eurylophella funeralis	2	0
Paraleptophlebia mollis	8	1
Ameletus ludens	7	0
Baetis tricaudatus	2	2
Trichoptera (caddisflies)		
Wormaldia moestus	5	0
Ceratopsyche sp.	1	?
Diplectrona modesta	14	0
Rhyacophila carolina	1	1
R. invaria group	5	1
Limniphilidae	2	4
Psilotreta frontalis	1	?
Neophylax concinnus	4	3
Pycnopsyche guttifer	1	4
Polycentropus glacilis		6
Plecoptera (stoneflies)		
Tallaperla sp.	19	0
Eccoptura xanthenes	1	2
Leuctra sp.	3	0
Acroneuria sp.	1	0
Isoperla similis	5	2
Diploperla duplicata	3	?
Remenus bilobatus	5	?
Odonata (dragonflies)		
Stylogomphus sp.	2	0
Boyeria sp.	1	2
Megaloptera (hellgramites)		
Nigronia serricornis	2	0
Sialis sp.	1	4

Appendix B. Taxa, numbers, and pollution tolerance values of macroinvertebrates from an unnamed tributary to Cranberry Creek (continued).

Diptera (true flies)		
Tipula sp.	2	4
Pseudolimnophila sp.	2	?
Chironomidae	1	?
Cnephia dacotensis	15	0
Prosimulium sp.	1	2
Simulium parmassum	2	5
Coleoptera (beetles)		
Hydrocus sp.	2	?
Bivalvia (clams)		
Pisidium sp.	1	?

collected 2 hrs   J. Styk

INVERTEBRATE STATION Cranberry Cr   DATE Sept 23 /1995

P
M
i 50

Ephemeroptera			Trichoptera		
Epeorus			Brachycentrus		
Stenonema ithaca	(3-SC)	1			
			Micrasema		
Stenacron			Chimarra aterrima	(4-FC)	24
Heptagenia			Dolophilodes distinctus	(0FC)	16
Rhithrogena			Hydropsyche sparna		
			H. morosa		
Cinygmula			H. bifida...bronta		
			H. slossonae		
Ephemerella			H. betteni		
			Cheumatopsyche		
			Diplectrona	(0-FC)	3
Paraleptophlebia			Glossossoma		
Habrophlebiodes			Agapetus		
Tricorythodes			Rhyacophila fuscula		
Isonychia			R. carolina	(1-P)	1
Ameletus			Astenophylax argus	(—)	1
			Frenesia difficilis	(0-sh)	2
Siphlonurus			Lepidostoma		
Baetis			Psilotreta		
			Neophylax sp	(3-SC)	1
Pseudocloeon			Pycnopsyche		
Heterocloeon			Hydatophylax		
Centroptilum			Apatania		
Ephemera			Platycentropus		
Litobrancha			Neureclipsis		
Hexagenia			Polycentropus		
Chironomidae		4	Helicopsyche borealis		
			Ceraclea		

Appendix F

Benthic Macroinvertebrates of Unnamed Tributary to Cranberry Creek Near Cresco, PA, March 19, 1995

BENTHIC MACROINVERTEBRATES

OF

UNNAMED TRIBUTARY TO CRANBERRY CREEK

NEAR CRESCO, PA

MARCH 19, 1995

Submitted by

Donald L. Baylor

for

Aquatic Resource Consulting

R.D.#2, Box 2562

Saylorsburg, PA 18353

BENTHIC MACROINVERTEBRATES OF AN UNNAMED TRIBUTARY TO CRANBERY CREEK NEAR CRESCO, PA, MARCH 19, 1995

INTRODUCTION

At the request of Mrs. Susan Price, Aquatic Resource Consulting biologist Don Baylor, assisted by Mr. John Styk, sampled benthic macroinvertebrates of an unnamed tributary to Cranberry Creek on March 19, 1995. The purpose of the sampling was to establish data on the water quality of the tributary.

SAMPLING STATION

The unnamed tributary originates approximately three quarters of a mile southeast of Cresco, in Barrett Township, Monroe County PA, and flows south into Paradise Township before joining Cranberry Creek (Figure 1). The tributary flows for approximately one mile. The station sampled was near the township line, approximately 0.65 miles upstream from its confluence with Cranberry Creek. At the sampling station, the tributary averaged approximately two feet wide.

BACKGROUND

Aquatic macroinvertebrates are preferred indicators of 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. Species diversity calculations measure the number of taxa present and the evenness of the distribution of individuals among the taxa. Actually, at any given time, varying seasonal cycles and ecological segregation cause undisturbed streams to have a few abundant species and many represented by only a few individuals. Therefore, another statistical calculation - equitability - is used to measure how closely the distribution of abundances in the samples approximate those found in similar size samples from undisturbed streams.

Diversity values in unpolluted streams generally range from 3 to 4; in polluted streams, they often fall below 1. Diversity values, however, are insensitive to moderate pollution. Equitability values, in contrast, are quite sensitive to even slight degradation - generally ranging from 0.6 to 0.8 in clean streams and falling below 0.5 in polluted streams.

Since many of the aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollutants, a biotic index is also used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated (Table 1).

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

Overall taxonomic richness and total number of Ephemeroptera + Trichoptera + Plecoptera (EPT) taxa are also commonly used to evaluate water quality. EPT taxa richness is used because these three orders are the least tolerant of organic pollution.

METHODS

Sampling methods followed those recommended by Hilsenhoff (1982) and the Environmental Protection Agency (Weber, 1973). A riffle area was sampled with a kick screen device of 521 micron nytex. Two samples were taken. The substrate was disturbed with a four pronged cultivator tool and by hand to dislodge organisms into the screen. Rocks were also randomly selected and cleaned by hand to dislodge organisms firmly attached. Organisms were picked from the debris in the field, composited for each station, and preserved in Kahle's solutiion for transport to the laboratory.

In the laboratory, organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value if known. Species diversity, equitability, and biotic index were calculated for each station according to Hilsenhoff (1987) and Weber (1973).

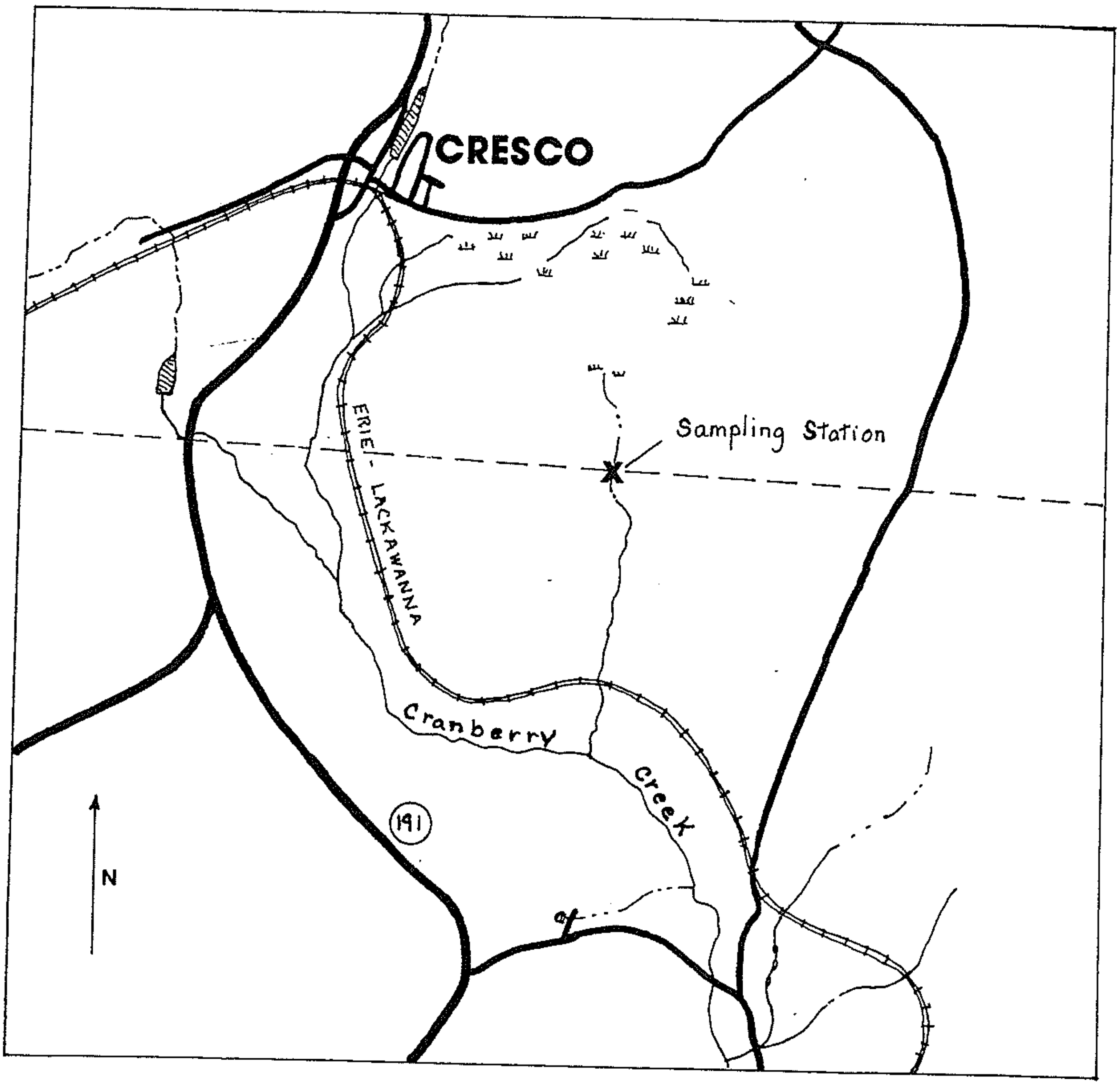


Figure 1. Map of Cranberry Creek, Monroe County, PA, from U.S.G.S. Buck Hill Falls quadrangle, 7.5 minute series, showing the unnamed tributary sampled for benthic macroinvertebrates on March 19, 1995.

RESULTS AND DISCUSSION

The benthic macroinvertebrate community of the unnamed tributary to Cranberry Creek was remarkably diverse for such a small headwater stream. All statistical measures indicated excellent water quality (Table 2). Despite the small size of the tributary, the macroinvertebrate community suggested that flow is maintained year-round. Generally, intermittent streams do not support such a diverse fauna including taxa with up to three year nymphal development periods as exhibited in the tributary sample.

The unnamed tributary samples contained 37 taxa of which 25 were EPT taxa (Tables 2&3). Ephemeroptera (mayflies) constituted 53% of the invertebrates collected, followed by Plecoptera (stoneflies) - 17%; Trichoptera (caddisflies) - 16%; and Diptera (true flies) - 10% (Table 3). There were 10 taxa of Trichoptera, 8 of Ephemeroptera, 7 of Plecoptera, and 6 of Diptera. The diversity index value was very high; 3.0 to 4.0 is the clean stream range, and the tributary had diversity of 4.14. Equitability - 0.67 - was well within the clean stream range of 6.0-8.0, and the biotic index value - 0.84 - was near optimum for clean streams with excellent water quality. The "excellent" range with "little or no organic pollution" is 0.00 to 3.50 (Hilsenhoff 1978).

There was an abundance of very intolerant taxa in the invertebrates collected. Of the 30 taxa for which pollution tolerance values were available, 11 had a tolerance rating of 0 (see Appendix). Only 6 taxa or 9 organisms collected had a tolerance value above 3. Several taxa, such as <u>Wormaldia moestus</u>, <u>Diplectrona</u> <u>modesta</u>, and <u>Tallaperla</u> sp. are known to inhabit streams that remain quite cool through the summer, suggesting an ample contribution of groundwater to the flow of the unnamed tributary, rather than surface run-off.

The macroinvertebrate community of the unnamed tributary to Cranberry Creek would be very sensitive to any degradation in water quality such as organic or thermal pollution. In addition, since the tributary is very small, reductions in flow would be harmflul to the fauna.

RECOMMENDATIONS

The unnamed tributary to Cranberry Creek should be sampled periodically for invertebrates to determine whether changes in water quality or quantity have had an effect on the benthic community.

Table 2. Number of organisms, number of taxa, EPT taxa, diversity, equitability, and biotic index value for samples collected in an unnamed tributary to Cranberry Creek, Monroe County, PA, March 19, 1995.

Number of organisms	224
Number of taxa	37
Number of EPT taxa	25
Diversity	4.14
Equitability	0.67
Biotic index	0.84

Table 3. Numbers of organisms and taxa and percentages of organisms for orders of benthic macroinvertebrates collected in an unnamed tributary to Cranberry Creek, Monroe County, PA, March 19, 1995.

ORDER	NUMBER OF ORGANISMS	NUMBER OF TAXA	PERCENTAGE OF ORGANISMS
Ephemeroptera	119	8	53%
Trichoptera	36	10	16%
Plecoptera	37	7	17%
Diptera	23	6	10%
Others	9	6	4%

Appendix. Taxa, numbers, and pollution tollerance values (0 = least tolerant-10 = most tolerant) for benthic macroinvertebrates collected in an unnamed tributary to Cranberry Creek southwest of Cresco, Monroe County, PA, March 3, 1995.

TAXA	NUMBER	POLLUTION TOLERANCE
Ephemeroptera (mayflies)		
Stenonema meririvulanum	9	?
S. pudicum	10	2
Stenacron guildersleevei	26	0
Ephemerella dorothea	55	1
Eurylophella funeralis	2	0
Paraleptophlebia mollis	8	1
Ameletus ludens	7	0
Baetis tricaudatus	2	2
Trichoptera (caddisflies)		
Wormaldia moestus	5	0
Ceratopsyche sp.	1	?
Diplectrona modesta	14	0
Rhyacophila carolina	1	1
R. invaria group	5	1
Limniphilidae	2	4
Psilotreta frontalis	1	?
Neophylax concinnus	4	3
Pycnopsyche guttifer	1	4
Polycentropus glacilis		6
Plecoptera (stoneflies)		
Tallaperla sp.	19	0
Eccoptura xanthenes	1	2
Leuctra sp.	3	0
Acroneuria sp.	1	0
Isoperla similis	5	2
Diploperla duplicata	3	?
Remenus bilobatus	5	?
Odonata (dragonflies)		
Stylogomphus sp.	2	0
Boyeria sp.	1	2
Megaloptera (hellgramites)		
Nigronia serricornis	2	0
Sialis sp.	1	4

Appendix. Taxa, numbers, and pollution tolerance values of macroinvertebrates from an unnamed tributary to Cranberry Creek (continued).

Diptera (true flies)		
Tipula sp.	2	4
Pseudolimnophila sp.	2	?
Chironomidae	1	?
Cnephia dacotensis	15	0
Prosimulium sp.	1	2
Simulium parmassum	2	5
Coleoptera (beetles)		
Hydrocus sp.	2	?
Bivalvia (clams)		
Pisidium sp.	1	?

REFERENCES

Hilsenhoff, William L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist. 20 (1):31-39

Hilsenhoff, William L. 1982. Using a biotic index to evaluate water quality in streams. Tech. Bull. Wisconsin Dept. Natr. Resour. 132. 22pp.

Weber. Cornelius I., Ed. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA-600/73-001

Appendix G

Cranberry Creek Stream Survey, Barrett Township, Monroe County. PA fish & boat commission February 4, 1993

COMMONWEALTH OF PENNSYLVANIA
February 8, 1993

SUBJECT: Cranberry Creek Stream Survey,
Barrett Township, Monroe County

TO: Rick Shannon, Water Pollution Biologist
Bureau of Dams, Waterways and Wetlands
Department of Environmental Resources

FROM: Ron Tibbott, Hyd. Eng. Tech. RT
Division of Environmental Services
Pennsylvania Fish and Boat Commission

Please find the attached table and topo copy detailing the results of our February 4, 1993 electrofishing on the headwaters of Cranberry Creek. Wild brook and brown trout were collected at both 100 meter Stations 01 and 02, respectively just above and below the confluence with the western tributary originating on SGL 221 and flowing under Route 390 about 3/4 mile south of Cresco.

You will recall that brook trout dominated the sample at Station 01, while - not surprisingly - the downstream Station 02 was more heavily populated with brown trout. Thirteen brook trout ranging from 85 - 160mm and two brown trout of 125 and 255mm were collected at 01; 02 yielded eight brookies of 65 - 220mm with fourteen browns from 60 - 350mm - clearly a healthy fishery.

Based on the documented presence of multiple year classes of both species, the Pennsylvania Fish and Boat Commission would classify this section of Cranberry Creek as supporting naturally reproducing trout populations, thus meeting the Chapter 105 definition of "wild trout streams".

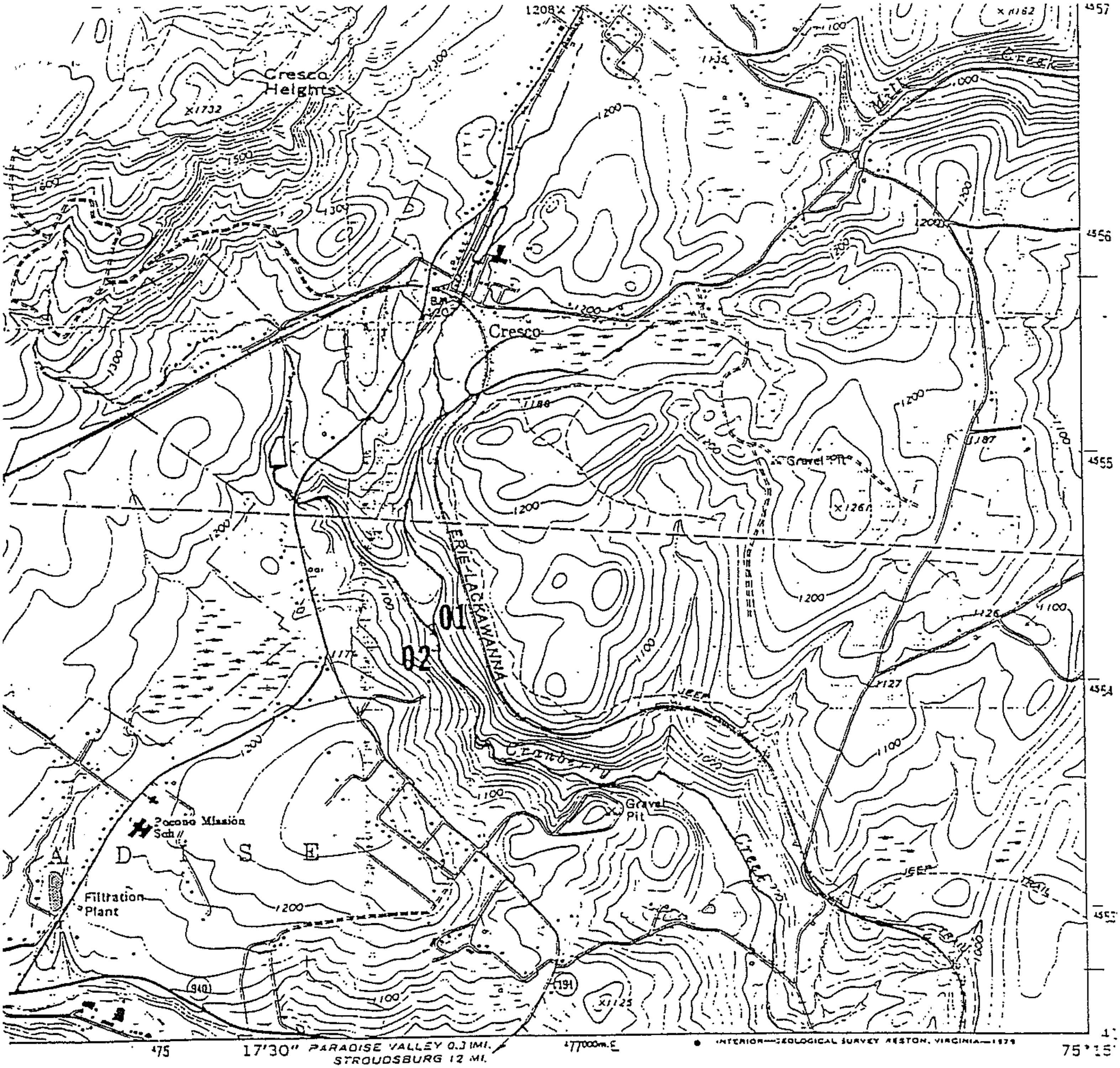
RT:srh

cc: PFBC - W. Snyder, D. Arnold, D. Snyder
Stream File

Attachments

Table 1. Results of quantitative fish sampling at two stations on Cranberry Creek February 4, 1993.

SIZE CLASS	STATION CC01	STATION CC02
Brook Trout		
50 – 74		2
75 – 99	4	2
100 – 124	2	1
125 – 149	4	1
150 – 174	3	
175 – 199		1
200 – 224		1
Brown Trout		
50 – 74		2
125 – 149	1	1
175 – 199		2
200 – 224		2
225 – 249		2
250 – 274	1	4
350 – 374		1
Tot. # Size Classes		
Brook Trout	4	6
Brown Trout	2	7
Tot. # Fish	15	22



1 MILE

6000 7000 FEET

1 KILOMETER

ROAD CLASSIFICATION

Heavy-duty Light-duty

Medium-duty Unimproved dirt

U. S. Route State Route

929

PENNSYLVANIA

QUADRANGLE LOCATION

BUCK HILL FALLS, PA.

N4107.5—W7515/7.5

1966

PHOTOREVISED 1973

AMS 5966 III NE—SERIES V831

STANDARDS

VIRGINIA 22092

AVAILABLE ON REQUEST

Appendix H

Fishery survey of Paradise Creek and Tributaries prepared for Brodhead Watershed Association, 2009

AQUATIC RESOURCE CONSULTING
RR 6, Box 6562 - Saylorsburg, PA 18353 – (570) 992-6443; 992-3558; 685-7171

Fishery Survey of Paradise Creek and Tributaries

*****

Prepared for

*****

Brodhead Watershed Association

Jim Hartzler
Aquatic Biologist
September 2009

Background

In June and July, 2009, Aquatic Resource Consulting conducted a fisheries investigation of streams in the Paradise Creek watershed. The survey was requested by the Brodhead Watershed Association with the cooperation and management of the Paradise Township Supervisors and Ms. Debra Brady, Township Planner and Zoning Officer. Funding was provided by a Growing Greener grant from PA Department of Conservation and Natural Resources. The objective of the investigation was to document the fish communities on the streams, in particular the distribution and abundance of reproducing salmonids – wild brook and brown trout. These two coldwater species are indicators of high water quality because of their extreme sensitivity to low oxygen conditions caused by sewage pollution, sedimentation, and other forms of environmental degradation related to human activity.

Paradise Creek and the four tributaries sampled – Yankee Run, Tank Creek, Devil's Hole Creek, and Cranberry Creek – are classified by the PA Department of Environmental Protection as either Exception Value or High Quality Coldwater Fisheries.

Methods

The fish community was sampled with a variable voltage DC backpack Smith-Root L-24 electrofishing unit with handheld and trailing electrodes and hand nets. Three consecutive runs were made at each station, with all species collected and enumerated on the first run; during the second and third runs, only trout were netted. Voltage, pulse frequency and duration were adjusted to create electrotaxis (orientation toward the electrode) by small fish. All trout were anesthetized, measured (mm) and weighed (grams), then released unharmed. Population and biomass estimates for trout were made using the depletion removal (Zippin) method.

Sampling Locations

Seven stations in the Paradise Creek watershed were selected for sampling the fish communities (Figure 1):

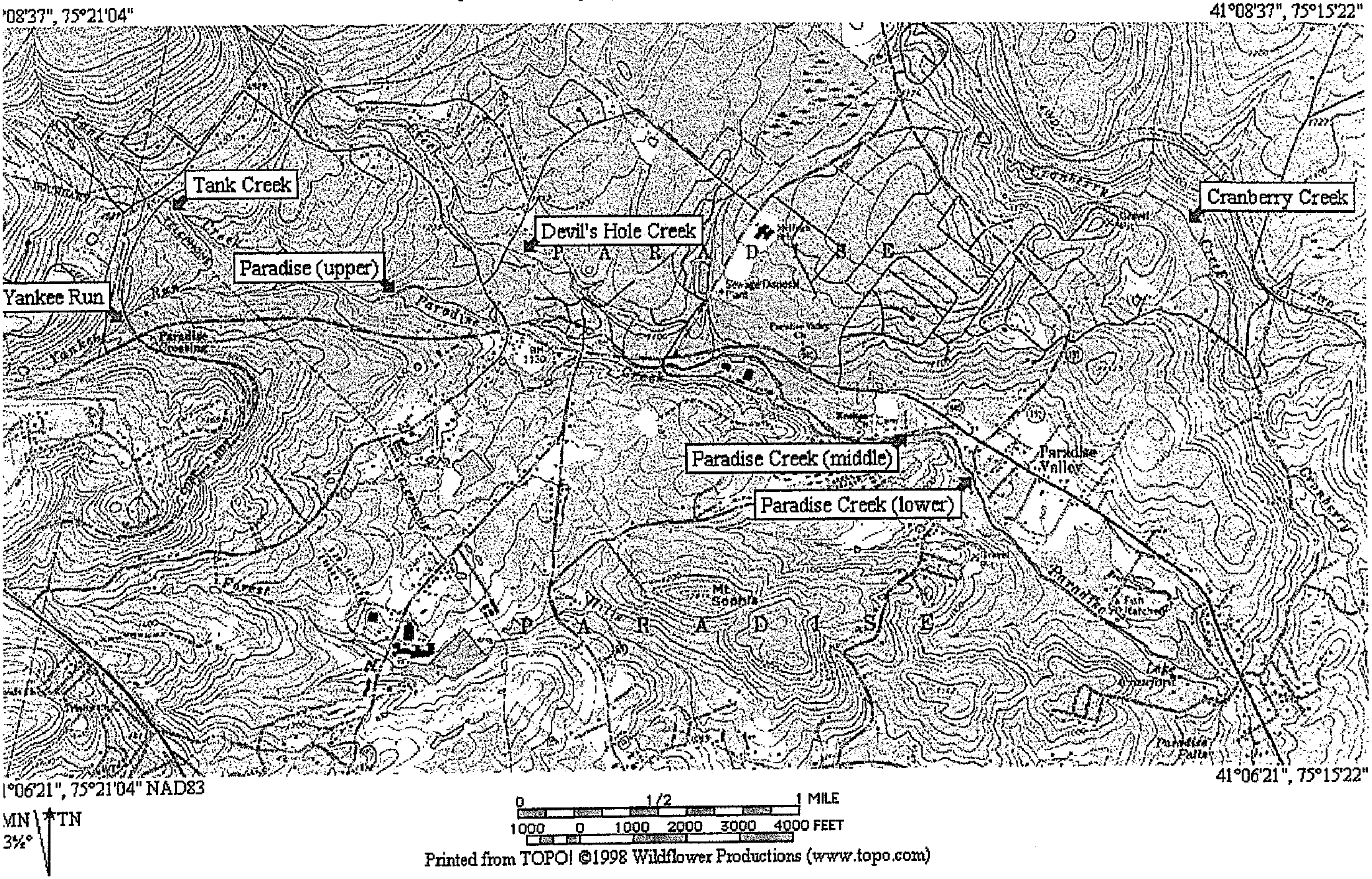
(1) Yankee Run – downstream from Upper Devil's Hole Road and upstream from the railroad culvert pipe.
(2) Tank Creek – downstream from Upper Devil's Hole Road and the railroad culvert pipe on the property of the Kurmes Paradise Creek Preserve.
(3) Devil's Hole Creek – downstream from Koener's Road off Lower Devil's Hole Road, adjacent the Henderson residence.
(4) Cranberry Creek – above and below a wooden footbridge on the property of the Nothstein Cranberry Creek Preserve.
(5) Paradise Creek (upper) – downstream from a steel bridge on access road to Poplar Swamp Club on the property of the Kurmes Paradise Creek Preserve.
(6) Paradise Creek (middle) – adjacent to Paradise Township Park along Keokee Chapel Road.
(7) Paradise Creek (lower) – upstream and downstream of Red Rock Road on the Dietz property.

Results and Discussion

Wild brown trout (***Salmo trutta***) was the predominant fish species at all seven sampling stations on the five streams in the Paradise Creek drainage. Since the fish communities reflected the effects of several different physiographic features, e.g., elevation, slope, flow, temperature, substrate, etc., at the sampling locations, they will be discussed separately, as follows:

1. Headwaters – Tank Creek, Yankee Run, and Devil's Hole Creek;
2. Cranberry Creek – one station, on the Nothstein Preserve.
3. Paradise Creek – three stations, on the Kurmes Preserve, at Paradise Township Park, and on the Dietz Property;

Figure 1. Fish Sampling Stations in Paradise Township in 2009.



Printed from TOPO! ©1998 Wildflower Productions (www.topo.com) he upper Paradise site (Kurmes Preserve) could be considered a headwater site because of its ocation (Figure 1). However, since it was situated downstream from the juncture of Tank reek and Yankee Run, this station was included with the other Paradise Creek stations. The ranberry Creek was considered separately because it joins the Paradise Creek several miles ownstream from the lower Paradise Creek site at a lower elevation, drains a large watershed rea, and has a more moderate gradient than the other streams.

HEADWATERS

Wild brown trout was the exclusive fish species collected in Tank Creek and Devil's ole Creek (Table 1). This species predominated in Yankee Run as well, but one wild brook rout (***Salvelinus fontinalis***) measuring 140 mm (5.5 inches) was also collected at this station. oth species are classified as coldwater taxa intolerant to water pollution, including siltation, hemicals and materials that create low oxygen conditions, such as sewage effluent (Table 2). pawning requirements for both are very demanding – a silt-free, gravel/cobble substrate that is elatively stable, since after fish spawn in the fall, the eggs are covered with gravel and incubate or a 3-4 month period overwinter before hatching in the spring.

Wild brown trout were abundant at all three headwater stations, with fish in the 3-8 inch ize range most numerous (Table 3). It appears that three age classes were represented: young-f-year (0+), yearling (1+), and older (>1+), denoted as small, medium, and large, respectively, n Table 3. Age can be estimated from the length-frequency distribution, a graph displaying the umber of trout according to size, with peaks in the curve representing the average size of a articular age group. As the key in Table 3 indicates, size ranges for age classes in Yankee un, Tank Creek, and Devil's Hole Creek vary somewhat. This is because growth rates differ ue to the ambient thermal regime throughout the year. Temperature is the primary growth egulator. Growth rates for these three streams are typical of other headwater streams in the ocono region. In addition, it is important to note that although few young-of-year brown trout vere collected, the collection efficiency of fish this size (<3 inches) with electrofishing pparatus is poor. Numbers collected undoubtedly would have been higher in late summer, not ecause more young-of-year are present but because at a larger size, they intercept more of the lectrical field and are more vulnerable to capture.

Table 1. Fish species composition at sampling stations on streams in the Paradise Creek drainage in June and July, 2009.
Key: A = Abundant (>20); C = Common (5-20); P = Present (<5); (-) = absent.

SPECIES	**LOCATION**						
	Yankee Run	**Tank Creek**	**Devil's Hole Creek**	**Cranberry Creek**	**Paradise Creek Upper**	**Paradise Creek Middle**	**Paradise Creek Lower**
Brown trout *Salmo trutta*	A	A	A	A	A	A	A
Brook trout *Salvelinus fontinalis*	P	-	-	P	P	-	-
Slimy sculpin *Cottus cognatus*	-	-	-	C	-	-	-
Blacknose dace *Rhinichthys atratulus*	-	-	-	P	-	C	P
White sucker *Catostomus commersoni*	-	-	-	-	-	C	-
American eel *Anguilla rostrata*	-	-	-	P	-	P	P
Longnose dace *Rhinichthys cataractae*	-	-	-	-	-	P	P
Cutlips minnow *Exoglossum maxillingua*	-	-	-	-	-	C	-
Pumpkinseed/bluegill *Lepomis gibbosus/macrochirus*	-	-	-	P	-	P	-
Brown bullhead *Ameiurus nebulosus*	-	-	-	-	P	-	-

Table 2. Classification of fish species collected from streams in the Paradise Creek watershed in June and July, 2009.

Key: Temperature: C = Coldwater; CW = Coolwater; W = Warmwater.
Tolerance (to environmental perturbation): I = Intolerant; M = Intermediate; T = Tolerant.
Trophic Class: TC = Top Carnivore; BI = Benthic Invertivore; GF = Generalist Feeder.

SPECIES	**Temperature**	**Tolerance**	**Trophic Class**
Brown trout *Salmo trutta*	C	I	TC
Brook trout *Salvelinus fontinalis*	C	I	TC
Slimy sculpin *Cottus cognatus*	C	I	BI
Blacknose dace *Rhinichthys atratulus*	CW	T	GF
White sucker *Catostomus commersoni*	CW	T	GF
American eel *Anguilla rostrata*	W	T	TC
Longnose dace *Rhinichthys cataractae*	CW	M	BI
Cutlips minnow *Exoglossum maxillingua*	W	I	BI
Pumpkinseed/bluegill *Lepomis gibbosus/macrochirus*	W	M,T	GF
Brown bullhead *Ameiurus nebulosus*	W	T	GF

Table 3. Number, size, and estimated population and biomass of wild brown trout collected on four tributaries of Paradise Creek in June and July, 2009.

	LOCATION			
	Yankee Run	Tank Creek	Devil's Hole Creek	Cranberry Creek
Stream length (feet)	450	280	270	300
Mean width (feet)	9.4	15.8	21.8	17.3
Area (acres)	0.10	0.10	0.14	0.12
(hectares)	0.039	0.041	0.055	0.048
Number of trout				
*Size: small	2	4	13	11
medium	78	53	74	65
large	1	11	4	33
Total	81	68	91	109
Population estimate				
*Size: small	2	4	20	15
medium	81	54	86	72
large	1	11	4	34
Estimated biomass				
Kg/hectare	75.4	123.9	100.1	151.3
Pounds/acre	67.3	110.6	89.4	135.0

*Key to size: small: <80 mm for Cranberry Creek, Yankee Run and Tank Creek; <90 mm for Devil's Hole Creek.
medium: 80-200 mm for Cranberry Creek; 80-210 mm for Yankee Run; 80-220 mm for Tank Creek; 90-230 mm for Devil's Hole Creek.
large: >200 mm for Cranberry Creek; >210 mm for Yankee Run; >220 mm for Tank Creek; >230 mm for Devil's Hole Creek.

The estimated biomass of wild brown trout in all three Paradise Creek tributaries far exceeded the 40 pounds/acre (44 kg/hectare) standard of the PA Fish and Boat Commission for Class A wild trout streams. Tank Creek was highest with 110+ pounds/acre, followed by Devil's Hole Creek (89+ pounds/acre), then Yankee Run (67+ pounds/acre). The greater number of larger, heavier trout (>8 inches) in Tank Creek compared to the other two tributaries contributed to this result (Table 3). Physical features, such as water depth and the amount of refuge sites (deadfalls, boulders, pools) can limit the number of larger adult fish that a stream can support.

CRANBERRY CREEK

Cranberry Creek supported a diverse fish community, again dominated by wild brown trout (Table 1). Four wild brook trout were also collected, ranging in size from 128 mm to 168 mm (5.0-6.6 inches). In addition, another fish species, slimy sculpin (***Cottus cognatus***), that is found in only colder, silt-free, unpolluted streams was collected. Its habits of benthic (bottom) foraging for small aquatic macroinvertebrates and spawning on the underside of rocks make it extremely sensitive to sedimentation. Three other species were also found – blacknose dace (***Rhinichthys atratulus***), American eel (***Anguilla rostrata***), and sunfish, either pumpkinseed (***Lepomis gibbosus***) or bluegill (***L. macrochirus***). Blacknose dace, probably the most widespread minnow in the northeastern U.S., is classified as a warmwater species tolerant to environmental disturbance, but often coexists with wild trout if a stream warms sufficiently for dace to spawn. Eels are found in almost every stream system in the Atlantic coast drainage, warm or cold. They are catadromous – spawn in saltwater, but migrate to fresh water where they grow to adulthood – and can ascend to even headwater streams if no obstructions to movement exist, such as steep falls. The sunfish that were taken probably escaped from a pond upstream from the collection site since pumpkinseeds or bluegills rarely spawn in colder, turbulent streams inhabited by wild trout.

More wild brown trout, including more than 30 fish exceeding 8 inches, were collected at the Cranberry Creek stretch than at any other sampling station. All size groups, corresponding to 0+, 1+, and older fish, were well represented in the collection (Table 3). In addition, the estimated biomass (151+ kg/hectare, 135 pounds/acre) was much higher than at the headwater stations. The greater number of adult trout, which comprise a larger percentage of total weight than smaller fish, was responsible. Also, the Cranberry Creek sampling site displayed a more moderate gradient and complex stream features – riffle/run/pool sequences instead of turbulent runs and scour pools – that promote trout growth and survival. However, based upon the length-frequency distribution for wild brown trout at this location, growth is slightly slower than at the other stream locations, perhaps due to cooler summer temperatures.

PARADISE CREEK

Wild brown trout dominated the collections at the three Paradise Creek stations. The middle sampling site at Paradise Township Park supported the most diverse fish community with seven fish species, while only four species were found several hundred yards downstream above and below the bridge on Red Rock Road (Table 1). The upper station, located just below the juncture of Tank Creek and Yankee Run, contained only wild brown trout and one young-of-year brook trout, similar to the electrofishing results from the latter stream. Other species common to both the middle and lower stations on Paradise Creek were blacknose dace, American eel, and longnose dace (***Rhinichthys cataractae***), a closely related species to blacknose dace that grows somewhat larger and prefers torrential flows. Longnose dace are considered less tolerant of warm temperatures and degraded water quality than blacknose although the two species are often sympatric (inhabit the same stream). In addition to several sunfish, cutlips minnow (***Exoglossum maxillingua***), a warmwater species often found in less turbulent reaches of lowland trout streams, were taken at the middle Paradise site. Unlike brook and brown trout, which spawn in the fall when the temperature cools, cutlips minnow, like others in the minnow family, reproduce when water temperature reaches a certain minimum in summer. Hence, temperature is a major factor limiting distribution. One other species, brown bullhead (***Ameiurus nebulosus***), was collected at the upper Paradise Creek station. Like the sunfish found at two other stations on Paradise Creek, the bullhead is classified as a warmwater species. These individuals probably escaped from upstream ponds discharging into the stream. White suckers (***Catostomus commersoni***) were also common at the Paradise Creek Park station but nowhere else. This bottom-feeder is maligned as a "trash fish" that competes with trout, when in fact its tolerance to sediment, warmer temperatures and a host of environmental stresses allow it to survive in streams with both high and low water quality.

Wild brown trout have good reproductive success in Paradise Creek, as evidenced by the numbers of small (young-of-year) fish in collections, particularly at the upper (Kurmes) station. This produces good recruitment of yearling trout and also older, larger fish, particularly at the lower (Dietz) station, where more than 40 wild brown trout over 8 inches long were collected in only 240 linear feet of stream (Table 4). Although only two 0+ trout were found at the lower site, this paucity may be the result of predation by larger trout, not necessarily poor reproduction. Also, torrential flows at this station, just above and below a bridge, reduced collection efficiency.

Estimated biomass for wild brown trout at the lower Paradise Creek site (245+ kg/hectare) was more than five times the PA Fish and Boat Commission's standard (44 kg/hectare, 40 pounds/acre) for Class A wild trout water (Table 4). As expected, this value declined in an upstream direction – approximately 100 kg/hectare (89+ pounds/acre) at the middle (Park) site and 67+ kg/hectare (60+ pounds/acre) at the upper (Kurmes) station. Generally, lowland trout streams support more and larger trout, hence a higher biomass, than headwater reaches because of the larger forage base, such as aquatic macroinvertebrates and other fish, that trout feed on. In addition, growth is slightly faster as you proceed downstream due to slightly warmer temperatures during the growing season – spring through fall.

SUMMARY

An electrofishing survey of the Paradise Creek and four tributaries – Yankee Run, Tank Creek, Devil's Hole Creek, and Cranberry Creek – revealed fish communities dominated by wild brown trout (***Salmo trutta***). Seven stream areas were sampled, three on the main stem of Paradise Creek and one site on each of the tributaries. All fish species were identified, and all wild brown trout collected in three runs were weighed and measured to permit estimation of the total population and biomass. Wild brown trout were the exclusive species on Tank and Devil's Hole Creek, while only wild brook trout (***Salvelinus fontinalis***) and brown trout were found on Yankee Run and the upper headwaters site on Paradise Creek. Slimy sculpin (***Cottus cognatus***), like both salmonid species a coldwater taxa intolerant to warm temperatures, sedimentation and other pollutants, were present only in Cranberry Creek. The middle Paradise Creek station, located within Paradise Township Park, had the most diverse fish population with several minnows (blacknose and longnose dace, cutlips minnow), white suckers, American eels and sunfish (pumpkinseed or bluegill). These species are classified as either cool or warmwater species with varying tolerances to environmental degradation. Several of these taxa were also collected on Cranberry Creek and the lower Paradise Creek site.

Based upon the presence of wild brown trout ranging in size from 35 mm (1.5 inches) to 480 mm (19.0 inches), natural reproduction appears adequate to maintain the population.

Table 4. Number, size, and estimated population and biomass of wild brown trout collected at three stations on Paradise Creek in June and July, 2009.

	LOCATION		
	Upper (Kurmes)	Middle (Park)	Lower (Dietz)
Stream length (feet)	300	250	240
Mean width (feet)	17.6	32.2	24.2
Area (acres)	0.12	0.19	0.13
(hectares)	0.049	0.075	0.054
Number of trout			
*Size: small	31	19	2
medium	65	50	50
large	4	19	45
Total	100	88	97
Population estimate			
*Size: small	37	20	2
medium	66	60	71
large	4	23	47
Estimated biomass			
Kg/hectare	67.3	100.7	245.9
Pounds/acre	60.1	89.9	219.6

*Key to size: small: <80 mm for upper Paradise Creek; <90 mm for middle and lower Paradise Creek.

medium: 80-210 mm for upper Paradise Creek; 90-220 for middle and lower Paradise Creek.

large: >210 mm for upper Paradise Creek; >220 mm for middle and lower Paradise Creek.

Young-of-year (0+ years) trout were present, often abundant, at all sampling stations, but were difficult to collect because of their small size. Yearling trout, those in the 3 to 8 inch size range, were the most abundant group. However, larger adult fish were also numerous at the Cranberry Creek and lower Paradise Creek station. Biomass estimates at the seven sampling stations ranged from 67+ kg/hectare (60+ pounds/acre) at the upper Paradise Creek site to 245+ kg/hectare (219 pounds/acre) at the lower Paradise Creek site. These values exceeded the PA Fish & Boat Commission's standard of 44 kg/hectare (40 pounds/acre) for Class A wild trout waters.

Appendix I

Fish Inventory of Paradise Creek and Tributaries, September 2003 prepared for paradise Township

I

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Fish Inventory of Paradise Creek and Tributaries

September 2003

Prepared for

Paradise Township

Jim Hartzler
Aquatic Biologist
February 2004

BACKGROUND

On September 11 and 12, 2003, Aquatic Resource Consulting (ARC) sampled the fish communities of Paradise Creek and four tributary streams – Butz Run, Indian Run, Forest Hill Run, and Cranberry Creek. The objective was to establish a database to identify the fish species composition of the streams, one important measure of water quality. Paradise Township has developed a comprehensive monitoring program for streams that includes periodic measurements of physical, chemical, and biotic parameters. The information from this electrofishing survey will assist the Township in evaluating each stream's present condition and in assessing possible changes in water quality related to residential, commercial, and industrial development in the Paradise Creek watershed.

ARC conducted electrofishing surveys in 1999, 2000, and 2002 on Paradise Creek and other tributaries, including Swiftwater Creek, Devils Hole Creek, Yankee Run, and Tank Creek. These inventories revealed that most of these streams support reproducing populations of brown trout and often brook trout, two "coldwater" species classified as intolerant to environmental perturbation, such as high water temperatures, sedimentation, pollutants, and habitat degradation. Wild rainbow trout, another salmonid that has a limited distribution in Pennsylvania, were also collected at several locations on Swiftwater Creek.

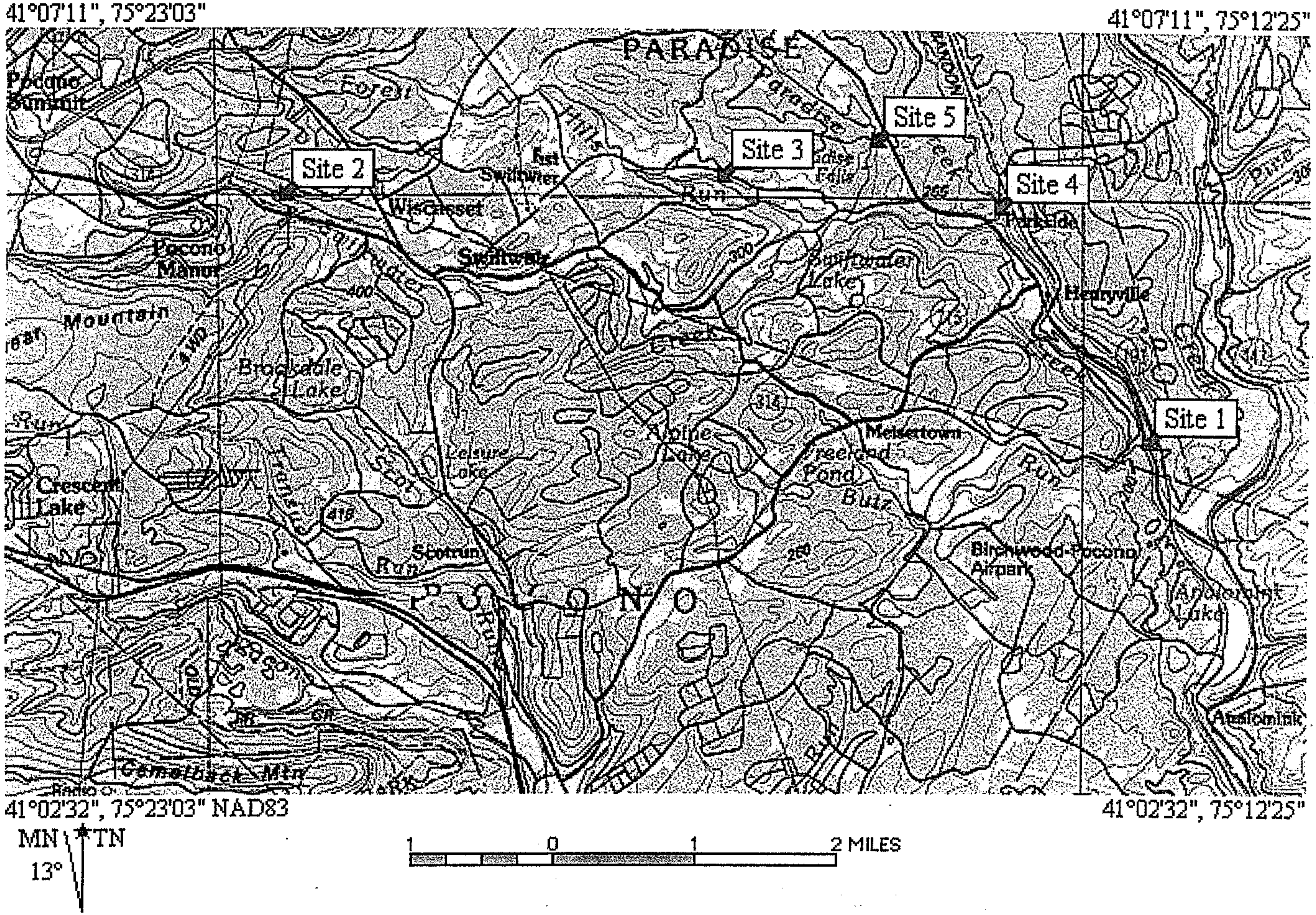
METHODS

Fish communities were sampled by electrofishing with a Coffelt BP1C 300 watt backpack variable voltage (0-600 V) unit with handheld electrodes and nets. Collections were made in an upstream direction, and two or three consecutive runs were made at each station to permit statistical estimates of total abundance (numbers) and biomass (weight per unit area) of wild trout. All trout were netted, anesthetized, weighed and measured. Relative abundance of other fish species was estimated.

Sampling locations (see Figure 1) were as follows (GPS coordinates of starting point in parentheses).

(1) Butz Run – begin at old logging road just upstream from juncture with Paradise Creek, off Sylvan Cascade Rd. (41 04.683N, 75 13.733W).

Figure 1. Location of electrofishing stations, 2003.



(2) Indian Run – begin approximately 100 yards upstream from juncture with Swifwater Creek, just off Rt. 314 near power line (41 06.133N, 75 20.842W).
(3) Forest Hill Run – begin approximately 50 yards below footbridge on Steven's property, off Donaldson Rd. (41 06.262N, 75 17.189W).
(4) Cranberry Creek – begin approximately 150 yards upstream from Browns Hill Rd., off Rt. 191 (41 06.140N, 75 14.985W).
(5) Paradise Creek – begin approximately 150 yards downstream from Paradise Lutheran Falls Road bridge (41 06.544N, 75 16.021W).

RESULTS AND DISCUSSION

Fish Species Composition

Brown trout was the predominant fish species at the Paradise Creek station and in all four tributaries (Table 1). This salmonid is the most adaptable of the three species with reproducing populations in Pennsylvania – brook, brown, and rainbow trout – because of its higher temperature tolerance and less demanding spawning requirements. The total weight of wild brown trout exceeded that of any other species at all the sampling locations except perhaps on Paradise Creek, where white suckers were abundant. Numerically, brown trout also ranked first except on Indian Run where both wild brook trout and slimy sculpin were more numerous.

American eel were found at all stations but on Indian Run. This catadromous species ascends most streams tributary to the Delaware River as young-of-year (0+ age) "elvers" after migrating from spawning areas in the Sargasso Sea near Bermuda. After reaching adulthood in 3-5 years, the mature eels migrate downstream in the fall months. Although classified as a "warmwater" species, American eels can be found in many trout streams in the Pocono region, including some higher elevation headwater brook trout streams.

Two small, closely related minnow species – longnose and blacknose dace – were collected at most of the electrofishing sites (Table 1). Cutlips minnow, another member of the Cyprinidae (minnow) family that prefers slightly higher temperatures, was found in Butz Run and Paradise Creek. All these fish require water temperatures in the 70's to spawn and have a widespread distribution in Pocono area streams. Blacknose dace are probably the most numerous minnow in the region because of their broad tolerance to temperature and generalist feeding habits (Table 2). Whereas blacknose dace commonly school in quiet pools and backwater areas of streams, longnose dace are solitary and prefer torrential flows (riffles and runs). Both species were absent on Indian Run, and blacknose dace were not found at the Forest Hills Run site.

Table 1. Relative abundance of fish species collected in tributaries of Paradise Creek in September, 2003.

Occurrence: A = Abundant (>20 individuals); C = Common (5-20); R = Rare (<5); (--) = Absent.

SPECIES	Butz Run	Indian Run	Forest Hill Run	Cranberry Creek	Paradise Creek
Brown trout *Salmo trutta*	A	A	A	A	A
American eel *Anguilla rostrata*	C	--	C	R	C
Longnose dace *Rhinichthys cataractae*	R	--	R	C	R
Blacknose dace *Rhinichthys atratulus*	C	--	--	C	C
Cutlips minnow *Exoglossum maxillingua*	C	--	--	--	C
Slimy sculpin *Cottus cognatus*	--	A	--	C	--
Brook trout *Salvelinus fontinalis*	--	A	--	R	--
White sucker *Catostomus commersoni*	--	--	--	--	A
Margined madtom *Noturus insignus*	R	--	--	--	--
Brown bullhead *Ameiurus nebulosus*	--	--	--	--	R
Bluegill *Lepomis macrochirus*	--	R	--	--	--

Table 2. Classification of fish species collected in tributaries to the Paradise Creek in September, 2003.

SPECIES	**Distribution**	**Temp.**	**Trophic Class**	**Tolerance**
Brown trout *Salmo trutta*	S	C	TC	I
American eel *Anguilla rostrata*	S,L	W	TC	T
Longnose dace *Rhinichthys cataractae*	B,S	CW	BI	M
Blacknose dace *Rhinichthys atratulus*	B,S	CW	GF	T
Cutlips minnow *Exoglossum maxillingua*	S,L	W	BI	I
Slimy sculpin *Cottus cognatus*	B,S	C	BI	I
Brook trout *Salvelinus fontinalis*	B,S,L	C	TC	I
White sucker *Catostomus commersoni*	S,L	CW	GF	T
Margined madtom *Noturus insignus*	S	W	BI	M
Brown bullhead *Ameiurus nebulosus*	S,L	W	GF	T
Bluegill *Lepomis macrochirus*	S,L	W	GF	M,T

KEY

Distribution: B = brooks (flowing waters <5 m wide); S = streams (flowing waters 5-10 m wide); R = rivers (flowing waters >10 m wide); L = lakes (ponds & reservoirs).

Temp. class : C = coldwater (<22 C); W = warmwater (>24 C); CW = coolwater (inhabits both types).

Trophic Class: TC = top carnivore (feeds on fish and insects); BI = benthic invertivore (feeds on aquatic insects); GF = generalist feeder (omnivore, i.e., feeds on available plants and animals).

Tolerance (to environmental perturbation): I = Intolerant; T = Tolerant: M = Intermediate.

Slimy sculpin and brook trout, two "coldwater" species with very demanding spawning requirements, were collected only in Indian Run and Cranberry Creek. Spawning females of sculpin deposit adhesive eggs on the underside of boulders and large cobble in early spring. Brook trout require upwelling groundwater (springs) where a nest is excavated in suitable sized silt-free gravel and cobble in late fall; fry hatch the following spring after a four-month incubation period. Both species are benthic invertivores, i.e., feed primarily on aquatic macroinvertebrates.

Four other fish species were sampled, each at only one stream location: White sucker and brown bullhead in Paradise Creek, margined madtom in Butz Run, and bluegill in Indian Run. Both white sucker and brown bullhead are bottom feeders that prefer deep pools with a silty substrate, features more commonly found in warmer, low gradient streams. However, suckers spawn in early spring when temperatures approach 40 degrees F and are often associated with trout in cold, undegraded streams. Distribution of margined madtom, like bullhead a member of the catfish family, is limited to warmer Pocono streams. The presence of bluegill (sunfish) in cooler Pocono streams can often be attributed to individual fish that have escaped from upstream impoundments. Distribution of most members of the sunfish group is restricted to lakes and ponds; spawning in streams is rare.

Salmonids

Numbers and biomass (weight per unit area of stream) of wild brown trout varied widely in the five waterways sampled. These differences, along with the fish species composition, were useful in characterizing the water quality and habitat features of each stream (see next section). Brown trout, although adaptable to a wide range of temperatures and stream conditions, cannot tolerate high water temperatures (>75 degrees F) for extended periods and have very specific requirements in order to survive, grow, and reproduce. Hence, there is a greater focus on this species because their presence is indicative of fairly high water quality and habitat in the resident stream.

Successful reproduction defines whether a wild trout population exists. Young-of-year (0+ age) brown trout were present in Paradise Creek and all four tributaries, evidence for successful spawning in the fall of 2002 (Table 3). These fingerlings measured less than 110 mm (4.3 inches) and were most abundant at the Cranberry Creek and Butz Run electrofishing sites and least numerous in Paradise Creek. [Bear in mind that the total area sampled differed among sites, with the Cranberry and Paradise Creek areas being much larger than the other three]. Adult brown trout apparently found suitable spawning substrate, generally a mix of gravel and cobble at the tails of pools or heads of riffle areas, in all the streams. High natural mortality of eggs, fry and

Table 3. Summary of electrofishing data for wild brown trout in tributaries of Paradise Creek in September, 2003.

	LOCATION				
	Butz Run	Indian Run	Forest Hill Run	Cranberry Creek	Paradise Creek
Sampling - length (feet)	285	260	215	300	330
width (feet)	13	13	15	28	32
area (hectares)	0.035	0.031	0.031	0.079	0.097
(acres)	0.086	0.077	0.076	0.195	0.238
Number of trout collected					
<110 mm (4.3 in.)	32	18	16	50	4
110-199 mm (4.3-7.9 in.)	4	12	24	25	18
>=200 mm (>=7.9 in.)	2	4	22	27	41
Total	38	34	62	102	63
Population estimate					
<110 mm (4.3 in.)	50	21	16	65	4
>=110 mm (>=4.3 in.)	6	17	46	59	62
Total estimated biomass					
kg./hectare	18.5	26.6	139.4	83.5	74.0
pounds/acre	16.5	23.8	124.5	74.6	66.0
Coefficient of condition (k)					
<110 mm (<4.3 in.)	0.86	0.90	0.96	0.93	1.03
110-199 mm (4.3-7.9 in.)	0.95	0.94	0.99	0.98	0.97
>=200 mm (>=7.9 in.)	1.01	1.07	0.97	1.01	0.93

fingerlings may explain the lower numbers on some streams. Since no previous data are available for comparison, the abundance or scarcity of young-of-year trout may represent normal conditions. Additional sampling on other areas of the same stream or in other years would give a more precise picture of reproduction and mortality.

Abundance of adult, legal-size (>200 mm, or >7.9 inches) brown trout also varied among the streams. Lárger fish were most numerous in Paradise Creek, Cranberry Creek, and Forest Hill Run, while Butz Run and Indian Run, the smallest (narrowest) waterways, held the least. Larger trout require suitable refuge areas provided by undercut banks, boulders, overhanging roots, and deep pools, where they can escape predators and swift currents, particularly during storm events. Total area provided by these features is generally more limited in small tributaries.

Numbers of fish in balanced populations normally declines as fish grow due to mortality, and on most of the streams sampled this was the case (Table 3). Each size group (<110 mm, 110-199 mm, >200 mm) represents a specific age class, e.g., 0+, 1+, 2+ years, etc. Mortality thins the ranks, so that fingerlings are usually much more numerous than yearlings, which in turn are more abundant than legal-size trout. Paradise Creek displayed the worst balance, with numbers of young-of-year fish depleted while catchable-size trout were very abundant. These proportions can change yearly depending upon a myriad of factors – spawning success, stream discharge, and mortality (both natural and fishing, even cannibalism. However, streams with stable trout populations show the least year-to-year fluctuation.

Estimated biomass of wild trout on four of the five stream areas sampled exceeded 40 kg/hectare, the PA Fish & Boat Commission's standard for Class A waterways (Table 3). Only the weight of trout on Butz Run fell below this level. [The biomass of trout in Indian Run totaled 47.6 kg/hectare when the weight of wild brook trout was included.] Forest Hill Run clearly supported the highest weight per unit area of stream – almost 140 kg/hectare. Large numbers of legal-size trout in Cranberry and Paradise Creeks also sent biomass levels far above the standard. Indian Run was unique because the stream ecosystem supported an almost equal number and weight of both wild brook and brown trout – sympatric populations.

Growth rates of wild brown trout, based upon the length-frequency distribution (LFD) of fish, were similar among four of the streams sampled. Only Indian Run deviated somewhat with lower values than in Paradise Creek and the other tributaries. The LFD plots the number of trout collected in each size group; peaks in the graph represent the average size of a specific age group. For example, for Cranberry Creek these peaks occur at 80-90 mm, 170 mm, and 260 mm, corresponding to 0+, 1+, and 2+

year-old brown trout (Figure 2). Columns (points) to the left or right of the average represent fish of that age group that are smaller or larger, respectively. Cranberry Creek was chosen for graphing because more trout were collected there. If only a few larger trout are collected, such as in Butz Run, there aren't adequate numbers to create peaks, and estimation of growth using the LFD method is not recommended. More accurate aging of trout is possible by the microscopic examination of boney parts (scales, otoliths, fin rays) for annuli (annual rings).

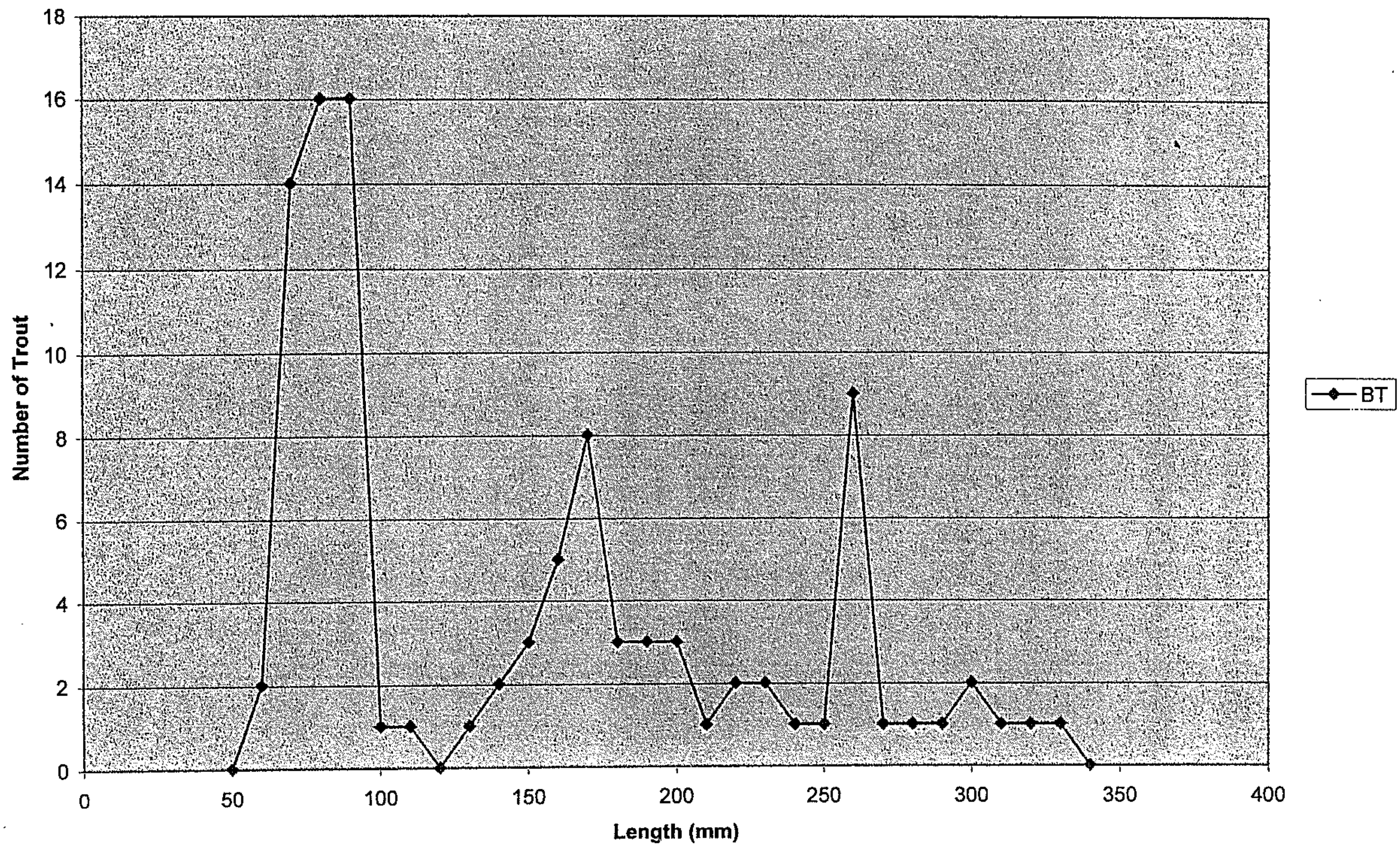
The condition of individual trout at the five locations sampled was generally good. Condition factor (K) is a statistical measure of a fish's weight in relative to its length; more robust fish have a higher condition. K for wild trout usually falls within the 0.90-1.10 range. Almost all size groups of wild brown trout on the five stream electrofished had values in this range (Table 3). Diseased or starving fish can exhibit low K values, and competition among fish for food and space can affect condition as well as high metabolism caused by elevated water temperatures. The lowest coefficient of condition recorded was for fingerling (mostly young-of-year) trout in Butz Run. Condition of the same size group in Indian Run was below the average K value calculated for trout in the other streams.

Stream Characterization

Each stream ecosystem, and stream area within that waterway, has a host of physical, chemical, and biotic features that regulates the number and species of fish found there. Water analysis is often used to measure water quality. However, water chemistry can change momentarily, whereas fish species composition usually remains fairly stable. Furthermore, each taxa can be classified using a number of criteria, including preferred temperature regime, habitat requirements, foraging strategy, and tolerance to environmental disturbance (Table 2). Hence, an assessment of the fish community can be used as a benchmark to measure and monitor changes in water quality. Following is a brief description or characterization of the five stream areas on the Paradise Creek watershed sampled in 2003 based upon the electrofishing results.

Paradise Creek – The "main stream" had the highest species diversity as expected since three of the other streams electrofished are smaller tributaries. This finding can be attributed to the more complex and diverse habitat features – variable depth, width, velocity, substrate, instream debris, etc. – offered by this larger stream. Paradise Creek supports a mix of cold, warm, and coolwater taxa with wide tolerances to environmental stress and feeding habits ranging from carnivores to omnivores to exploit the available forage. Wild brown trout predominated in collections, which had an abundance of legal-size fish (>200 mm) but few young-of-year (0+ age).

Figure 2. **Length-frequency Distribution of Brown Trout in Cranberry Creek, 2003**



Cranberry Creek – Biomass estimates for wild brown trout in this large tributary to the Paradise Creek were slightly higher than in the main stream. More fingerling trout were found here than at any other electrofishing station, indicative of excellent spawning conditions – suitable substrate, stable temperatures and flows. In addition, the wild trout population in this stream displayed the best balance among size (age) groups. The presence of brook trout and slimy sculpin and absence of several warmwater species found in the main stream suggests slightly cooler temperatures in summer.

Butz Run – Clearly, the fish species composition in this tributary that discharges into the lower Paradise Creek reflected the warmer temperature regime. Upstream impoundments may have a significant effect on water temperature and quality. Most taxa collected are classified as warm or coolwater, with brown trout the only coldwater species. The presence of numerous young-of-year indicated excellent reproductive success but adult trout were rare. Due to the sampling site's close proximity to the main stream, it's possible resident adults in Paradise Creek ascend Butz Run to spawn, then return to the main stream.

Indian Run – Located at the highest elevation in the watershed of the five electrofishing sites, this small tributary had only four fish species but probably the highest quality habitat and coolest summer temperatures. All taxa except the single bluegill, which probably escaped from a pond at the source, were coldwater species. Biomass estimates for wild brook trout (21.0 kg/hectare) were comparable to weight of brown trout (26.6 kg/hectare). Slimy sculpin, whose distribution is limited to only the coldest, least-degraded, sediment-free Pocono streams, were abundant.

Forest Hills Run – With its relatively steep gradient and boulder strewn, silt-free channel, this stream was a study in contrasts. Only three fish species were collected – one classified as coldwater, one warmwater, and one coolwater. Yet the wild brown trout biomass, almost 140 kg/hectare, far exceeded the estimated weight at the other stations and was well above the state standard for Class A wild trout waterways. The high productivity may be attributable to excellent habitat features, such as refuge provided larger trout by boulders and plunge pools, or possibly are a consequence of nutrient enrichment from upstream sewage discharges that "feed" the food chain (algae, aquatic macroinvertebrates).

SUMMARY

Electrofishing surveys of Paradise Creek and four tributaries revealed a diverse mix of fish species, reflecting the influence of water temperature, width, depth, sediment load, substrate composition, and habitat features on relative abundance. Eleven taxa were collected at the five stations, with the highest number taken on Paradise Creek (7) and the least on Indian Run (4) and Forest Hill Run (3). Wild brown trout predominated at each sampling site. American eel, longnose dace, and blacknose dace were the next most common species collected. Distribution of wild brook trout and slimy sculpin, two other "coldwater" species with demanding spawning requirements and an even lower tolerance to environmental degradation than brown trout, was limited to Indian Run and Cranberry Creek. Butz Run had the highest number of warmwater species.

Water quality at the five stream areas can be characterized as very good/excellent, based upon the abundance and biomass of brown trout. Fingerling (0+ years) brown trout were found at all five stations, indicative of successful reproduction in the fall of 2002. Total estimated biomass of trout on each stream showed extreme variation as did the relative number of fish in size groups that corresponded to age classes. Forest Hill Run had the highest weight per unit area, nearly 140 kg/hectare (125 pounds/acre), while Butz Run displayed the lowest – 18+ kg/hectare (17 pounds/acre). All the streams except Butz Run had values exceeding the Pa Fish & Boat Commission's standard for Class A Wild Trout Waters. On Indian Run, weight of wild brook trout nearly equaled that of brown trout. Legal-size brown trout (>200 mm, or 7.8 inches) were abundant on the largest streams – Paradise Creek, Cranberry Creek, and Forest Hill Run – but relatively scarce on the smallest, Butz Run and Indian Run. Average condition factors of different size (age) groups of brown trout were generally within normal ranges.

Appendix J

Water Analysis of Streams in the Brodhead Drainage, October 2003 prepared for the Brodhead Protective Association

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Water Analysis of Streams in the Brodhead Drainage

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October 2003

Prepared for

Brodhead Protective Association

Jim Hartzler
Aquatic Biologist
August 2004

BACKGROUND

On 9 October 2003, Aquatic Resource Consulting collected water samples for analysis and sampled aquatic macroinvertebrates at streams in the Brodhead Creek drainage in Monroe County, PA. The survey was requested by the Brodhead Protective Association, a consortium of private hunting and fishing clubs in the Pocono region with a long history of stream management and stewardship. The purpose of the investigation was twofold: (1) To assess the water quality at several locations on the Brodhead Creek and its tributaries – Paradise Creek, Forest Hills Run, and Cranberry Creek; and (2) to monitor changes that may have occurred since a previous survey in 1985. This report includes results for the water analysis; the benthic macroinvertebrate survey was reported separately.

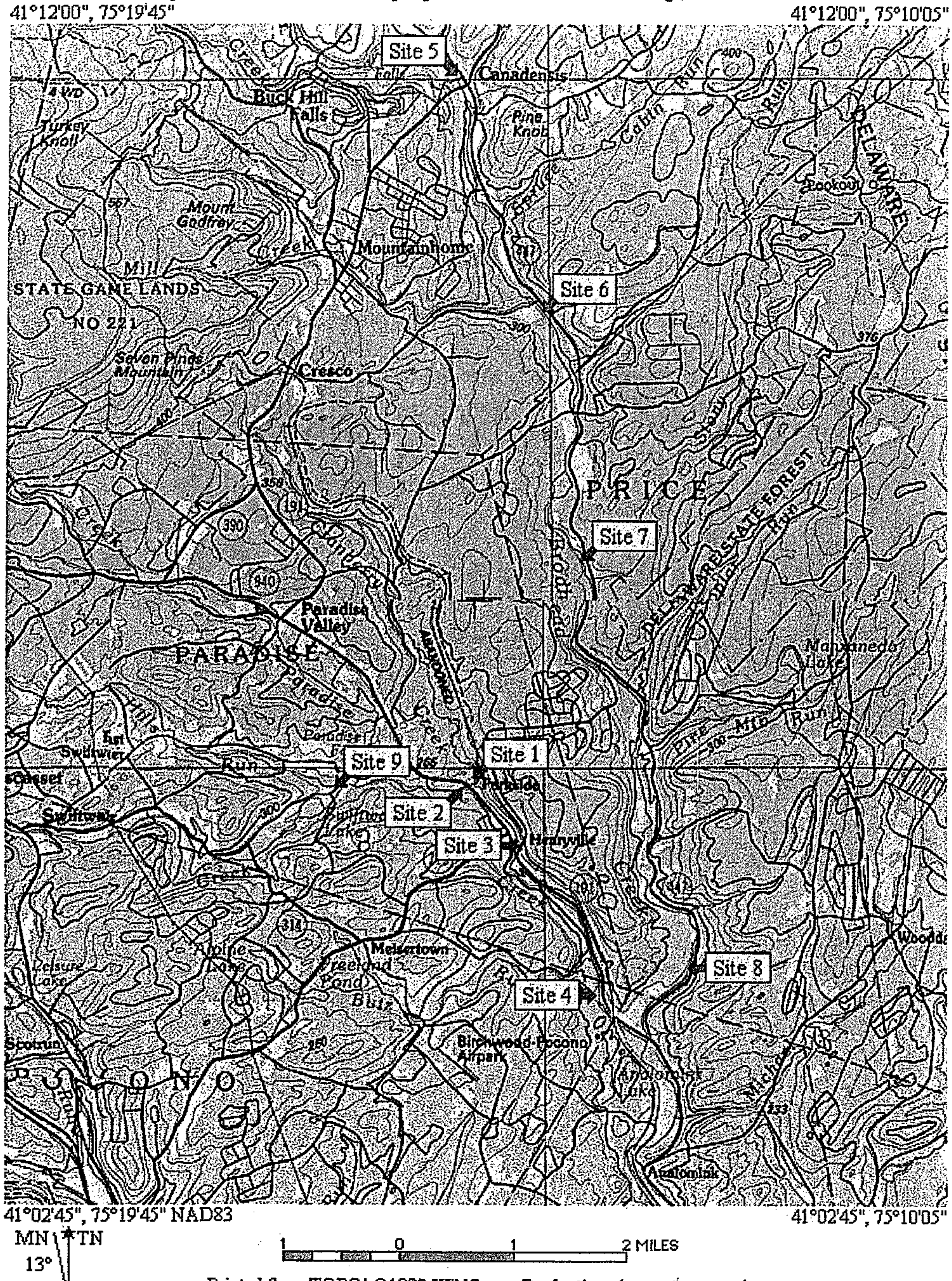
Eight stations were sampled for the 1985 survey, including one site on Swiftwater Creek, three on Paradise Creek, and four on the Brodhead Creek. In 2003, the Swiftwater station was dropped and two were added, one on Forest Hills Run and another on Cranberry Creek. All these streams are classified as High Quality Coldwater Fisheries by the PA Department of Environmental Protection. Discharges are permitted on HQ waters that allow degradation, but regulations are established to prevent pollution. On the sampling date in 1985, the streams displayed high water quality, with low fecal bacteria counts, relatively low nutrient (nitrate and phosphate) levels, and an acid-base balance near neutrality (pH = 7.0).

METHODS

Water samples were collected on 9 October 2003 at nine stations on the Brodhead Creek and tributaries, located as follows (Figure 1):

1. Cranberry Creek – approximately 100 yards upstream from juncture with Paradise Creek off Browns Hill Road.
2. Paradise Creek – approximately 50 yards upstream from Rt. 191 and Browns Hill Road.
3. Paradise Creek – approximately 100 yards upstream from Rt. 191, just above Bridge Pool.

Figure 1. Location of water sampling sites on Brodhead Creek drainage, 9 October 2003.



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4. Paradise Creek – approximately 100 yards upstream from the tunnel and railroad overpass on Rt. 191.
5. Brodhead Creek – in Canadensis, behind the Moravian Church off Rt. 447.
6. Brodhead Creek – approximately 150 yards downstream from the bridge just below the juncture with Mill Creek off Rt. 447.
7. Brodhead Creek – approximately 300 yards upstream from the confluence with Stony Run off Rt. 447.
8. Brodhead Creek – approximately 0.8 miles upstream from the juncture with Paradise Creek off Rt. 447.
9. Forest Hills Run – approximately 100 yards upstream from the juncture with Swiftwater Creek.

Stations 2 through 8 were identical to those sampled in 1985; stations 1 and 9 were new.

Water samples were collected, placed on ice and transported immediately to Prosser Laboratories (Effort, PA 18330) for analysis of the following parameters:

fecal coliform bacteria	total dissolved solids
biochemical oxygen demand (BOD-5)	pH
nitrite + nitrate nitrogen	alkalinity
total phosphorus	acidity
total suspended solids	

Following is the rationale describing the importance of each of these parameters for evaluating water quality.

Fecal coliform bacteria (FC) – Fecal coliform bacteria are found in the gut of all warm-blooded animals and are the predominant organism in the human intestinal tract, where they aid in digestion. Most are anaerobes – they grow best in the absence of oxygen and cannot survive for long periods in air – which can be associated with pathogenic bacteria. High FC counts often indicate the presence of sewage, which explains their use as indicators of water quality. Water with fecal counts exceeding 200/100 ml of water is considered unsuitable for recreational use where there is direct contact, such as swimming. FC counts of 20 or less are desirable.

Biochemical oxygen demand (BOD-5) – BOD-5 measures the five-day consumption of oxygen by a specific volume of water inoculated with bacteria.

Hence, this test indirectly estimates the amount of readily oxidized organic matter in the water. Water containing large quantities of organic waste, such as sewage, generally has a BOD-5 greater than 5 mg/l, while in undegraded streams, values are generally less than 2 mg/l.

Nitrite + nitrate as nitrogen (NN) – Nitrate is the most oxidized form of nitrogen in the natural environmental. Nitrite, much less stable and readily changed to nitrate, is rarely found except in grossly polluted conditions. Soils and water naturally contain varying levels of nitrate. However, because nitrate is an end product of sewage treatment and also a primary constituent of fertilizer, waters with high nitrate levels are indicative of an excessive influx of organic waste, such as sewage, or fertilizer from surface runoff. Nitrates are a primary plant nutrient that, in slow moving or standing waters, can cause the excessive growth of algae and aquatic plants. In some cases, the processes of plant respiration and decay can lead to fish kills because of dissolved oxygen depletion.

Total phosphorus – In lotic ecosystems (streams and rivers), phosphorus is found mostly as orthophosphate, the form most usable by plants. Phosphorus is also the plant nutrient most often considered limiting to primary (plant) production in water bodies. Uptake or adsorption is quite rapid so that most of the phosphorus in natural systems is tied up in living tissue, either plant or animal. For this reason, soils and water normally contain very low concentrations of phosphorus. However, discharges from industrial processes, sewage treatment plants and septic systems, and fertilizer in surface runoff can elevate levels. The recommended maximum level for streams is 0.1 mg/l.

Total suspended solids (TSS) – Suspended solids in water includes both inorganic components (soil particles) and organic materials (algae, detritus, and decaying plants and animals). Both are naturally found in streams with high water quality. However, excessive runoff from disturbed soils can increase the influx of clay, silt, and sand particles. The resulting sediment can damage the aquatic macroinvertebrate and fish community directly by suffocation or indirectly by smothering of spawning beds and refuge habitat in streams.

Total dissolved solids (TDS) – The soil types and subsoil geology of a region largely determine the total concentration of dissolved minerals in stream water, known as total dissolved solids (TDS). Areas with underground limestone deposits usually have streams with a high TDS because groundwater readily dissolves calcium carbonate, whereas streams draining land with sandstone geology, such as the Pocono region, commonly display a relatively low TDS. Discharges from sewage treatment plants and industrial processes can raise dissolved solid concentrations dramatically, sometimes damaging the aquatic biota. Hence, TDS can be a useful measure of water quality.

pH, alkalinity, acidity - pH is the negative logarithm of the hydrogen ion concentration. A pH of 7.0 is neutral, with values below being acid and those above, alkaline or basic. pH in most natural waters falls in the range 4-9, however the most common and desirable range for aquatic life is 6.5-8. Values outside this range can be toxic and can limit the survival and distribution of certain species of macroinvertebrates and fish. Alkaline minerals in water, primarily bicarbonates and carbonates, act to buffer or prevent wide fluctuations in pH. Waters with a more alkaline pH (>7.0) tend to be more productive of plants and fish. Acid precipitation has destroyed the aquatic biota in some higher elevation lakes and streams that drain poorly buffered watersheds in the Northeast. However, more alkaline lowland streams have not been adversely affected.

RESULTS

Water analysis revealed no evidence of stream degradation on the sampling date at any of the nine sites in the Brodhead drainage. The highest fecal bacteria count (120 organisms/100 ml), reported at station 5 (Canadensis) on the Brodhead Creek, was well below the maximum standard (200/100 ml) for recreational waters (Table 1). In fact, five of the nine sites had FC counts < 20. BOD-5 values were all measured as <2.0 mg/l, indicative of low levels of oxidizable solids in dissolved or suspended form. In addition, four of the nine stations – Cranberry Creek and three of the sites on the Brodhead Creek – had nitrate and total phosphorus levels reported as not detectable (below 0.2 mg/l and 0.1 mg/l, respectively). Suspended solids were also less than 1.0 mg/l except at the Henryville site (#3) on the Paradise Creek. Dissolved solids, which were measured primarily to establish a baseline for future comparison, were lowest on the Brodhead Creek, intermediate in value on Cranberry Creek and the Paradise Creek stations, and highest on Forest Hills Run. Forest Hills Run also had the highest pH reading (7.4) and alkalinity (22). The remaining stations had pH values near neutrality (range: 6.9-7.2). The Brodhead Creek samples displayed the lowest alkalinity. Acidity was the least variable of all parameters, measuring 2.0 or 3.0 at all stations.

Little change in water quality was observed when the 2003 values were compared to those recorded 18 years previously (Table 1). In 1985, acid precipitation was a concern, although pH, alkalinity, and acidity values measured at that time were considered normal for streams in the Pocono region. Acidity has remained

Table 1. Water analysis at nine locations in the Brodhead Creek drainage on 8 September 1985 and on 9 October 2003. Results measured in mg/l except fecal coliform bacteria (number/100 ml) and pH (units). NS = not sampled. ND = not detectable. Phosphorus* - orthophosphate was measured in 1985, total phosphorus in 2003.

	LOCATION								
	1	2	3	4	5	6	7	8	9
	Cranberry Cr.	Paradise Cr. (Paretta)	Paradise Cr. (Henryville)	Paradise Cr. (Forest & Stream)	Brodhead Cr. (Canadensis)	Brodhead Cr. (Parkside)	Brodhead Cr. (Hunting & Fish.)	Brodhead Cr. (Forest & Stream)	Forest Hills Run
PARAMETER									
fecal coliform									
1985	NS	10	40	40	50	60	40	30	NS
2003	40	<20	<20	20	120	<20	<20	<20	20
BOD-5									
2003	<2	<2	<2	<2	<2	<2	<2	<2	<2
NO2+NO3 - N									
1985	NS	0.52	0.49	0.43	0.43	0.36	0.33	0.27	NS
2003	ND	0.45	0.39	0.37	0.21	ND	ND	ND	0.47
phosphorus*									
1985	NS	0.06	0.02	0.04	0.06	0.04	<0.01	0.02	NS
2003	ND	ND	ND	ND	ND	ND	ND	ND	ND
TSS									
2003	ND	ND	2.8	ND	ND	ND	ND	ND	ND
TDS									
2003	46	65	60	59	28	28	35	29	91
pH									
1985	NS	6.9	6.9	6.9	6.8	6.8	6.8	6.9	NS
2003	7.0	7.1	7.0	7.2	7.0	7.0	6.9	7.1	7.4
alkalinity									
1985	NS	15	16	16	10	14	12	12	NS
2003	9	12	13	13	6	5	8	8	22
acidity									
1985	NS	2	4	3	3	2	3	4	NS
2003	3	2	3	2	3	3	3	3	2

essentially the same, alkalinity declined slightly since 1985, but pH was actually somewhat higher in 2003 at the seven sites where samples were taken in both years. None of.these changes would be considered significant. Fecal bacteria counts were higher at all stations in 1985, than in 2003, but were still quite low. Nitrate levels were lower in 2003 at all stations. Measurable levels (>0.01 mg/l) of orthophosphate were reported in 1985 at six of seven sites. Total phosphorus, which includes all forms of suspended and dissolved phosphorus, including orthophosphate, was below 0.10 mg/l at the same stations in 2003.

In summary, despite increased residential development in the Brodhead watershed and higher sewage discharges from municipal, school, and commercial treatment plants since 1985, particularly in the Paradise drainage, the water quality on the Cranberry Creek, Paradise Creek, Brodhead Creek, and Forest Hills Run remains high. Periodic assessment by laboratory analysis is recommended to monitor potential changes related to these activities. The limitations of water analysis should be noted, i.e., that the sampling measures one moment in time and may not be representative of stream conditions at all times, especially during drought conditions (low flows) and flood events (high flows).