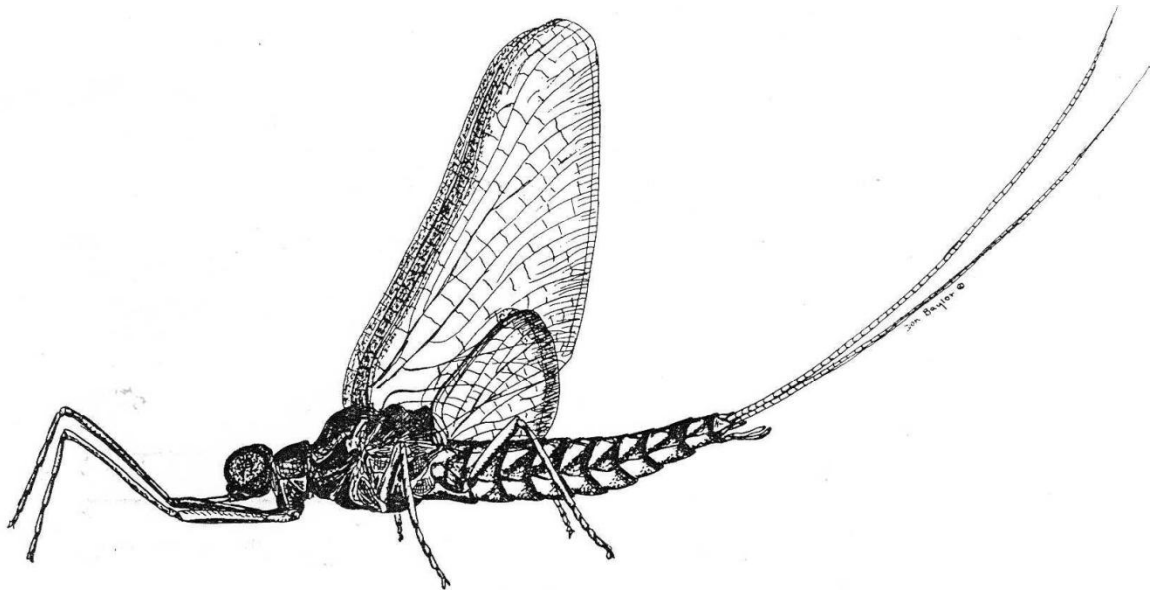
ENVIRONMENTAL QUALITY
OF
PIKE COUNTY STREAMS



DECEMBER 2013

ENVIRONMENTAL QUALITY OF PIKE COUNTY STREAMS

Prepared For

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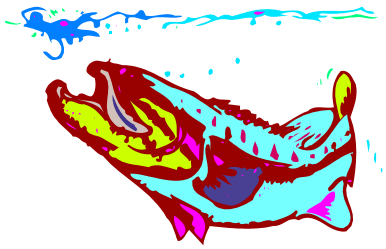

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INTRODUCTION

Biological monitoring of surface waters serves several purposes. It provides an early warning of hazardous changes in water quality, detects episodic events such as pollution spills, evaluates recovery from disturbed conditions, and reveals environmental trends and cycles.

Aquatic macroinvertebrates (primarily insects) and fish are important biological components of freshwater systems. They are the fundamental sensors of any stress that occurs within a stream ecosystem. This stress, which manifests itself in the health of aquatic organisms, can cause subtle or dramatic changes in overall community structure.

Work in bio-monitoring of stream communities has emphasized cost-effective "protocols" that attempt to extract maximum information with the least possible expenditure of time and money. Some of these methods have become standards in the field of bio-monitoring.

The United States Environmental Protection Agency (USEPA) provides several rapid bioassessment procedures for macroinvertebrate and fish populations (Plafkin et al, 1989). The Pennsylvania Department of Environmental Protection (PADEP) has developed its own assessment and listing methodology for integrated water quality monitoring (PADEP, 2007, 2009). Besides providing a means for monitoring temporal trends in aquatic life communities, it also provides a means for evaluating effects among stations.

Pike County has numerous freshwater streams ranging from small headwaters to large rivers. Nearly all of these waterways are classified by the PADEP as "High-Quality" or "Exceptional Value" (PADEP, 1996). The aquatic life communities in these riverine ecosystems have similar characteristics that allow for regional comparisons. However, subtle but recognizable differences do occur between streams of varying size and gradient, and between those waters located above and below impoundments. Consequently, these differences must be noted and considered in any stream comparison or evaluation using the PADEP "Assessment Methodology".

METHODS

Pike County Conservation District (PCCD) personnel sampled fish and benthic macroinvertebrates at baseline and non-point stream sites in Pike County with the assistance of Aquatic Resource Consulting biologists. These sites were established in 1995 as part of the Pike County Water Quality Program network (PCCD, 1995). Additional sites have subsequently been added. In 2012 and 2013 eleven special study sites were surveyed to obtain baseline information. The study was to monitor water quality and determine how sites compared to designated use criteria established for Pennsylvania streams by the Pennsylvania Department of Environmental Protection (PA DEP, 2007, 2009).

Stream Habitat and Water Quality

The Pennsylvania Department of Environmental Protection (PADEP) Flowing Waterbody Field Data and Water Quality Habitat Assessment Forms were filled out for each station (Appendix B). Field measurements included stream temperature, dissolved oxygen, pH, alkalinity and conductivity. Land use and canopy cover at each site were also assessed. Habitat was evaluated at each station using PADEP's Water Quality Network Habitat Assessment forms for streams with a riffle/run prevalence. Twelve habitat parameters were ranked on a scale of 1-20 and combined for a total habitat score. Scores put habitat into categories of "optimal", "sub-optimal", "marginal", and "poor". According to protocols, scores that fall between these category ranges are left to the decision of the investigator for classification.

Macroinvertebrate Communities

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 (PADEP, 2009). At each station, six samples were taken from a riffle/run area with a dip net 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. 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 200 (+ or – 40) organisms were obtained. Organisms were identified to genera or the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value (PADEP, 2007) – Appendix A. Metrics for riffle/run freestone streams were calculated for each sub-sample, including Modified Beck's Index (MBI), Ephemeroptera + Plecoptera + Trichoptera taxa richness (EPT), total taxa richness, Shannon diversity index (DI), Hilsenhoff biotic index (BI), percent dominant taxon, and percent intolerant individuals. A description and brief rationale for each of the metrics follow:

1. **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.

2. **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 is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

3. **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.

4. **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 value with increased anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and predominance of a few pollution-tolerant taxa.

5. **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 (Table 1). 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

6. **Percent Intolerant Individuals** is the percentage of individuals in the subsample with pollution tolerance values of five or less. It is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem.

Index of Biotic Integrity Calculation

An overall index is used to integrate information from these various metrics and standardize them into one score for a subsample. The values for any standardized core metric are set to a maximum value of 1.00, with values closer to zero corresponding to increasing deviation from the expected reference condition and progressively higher values corresponding more closely to the biological reference condition. The adjusted standardized metric values for the six core metrics are averaged and multiplied by 100 to produce an index score ranging from 0-100. This number represents the index of biotic integrity (IBI) score for a sample. Table 2 shows a sample of metric standardization equations and index calculations for a stream site:

Table 2. Sample metric standardization and index of biotic integrity calculations for a benthic macroinvertebrate sample

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score Maximum =100
Modified Beck's Index	Observed value/39	34	0.87	0.87
EPT Taxa Richness	Observed Value/23	21	0.91	0.91
Total Taxa Richness	Observed value/35	32	0.91	0.91
Shannon Diversity Index	Observed Value/2.90	2.76	0.95	0.95
Hilsenhoff Biotic Index	10-observed value/ (10-1.78)	3.65	0.77	0.77
Percent Intolerant Individuals	Observed value/92.5	51.9	0.56	0.56
Average of adjusted standardized core metric scores x 100 = IBI score				**83.1**

Pennsylvania DEP Index of Biotic Integrity scoring benchmarks require a score of 80.0 or better to qualify for High Quality (HQ) and Exceptional Value (EV) waters. Scores greater than 62 qualify for Cold Water Fishery (CWF), Trout Stocked Fishery (TSF), and Warm Water Fishery (WWF) use.

Fish Communities

Fish communities were sampled in August, 2013 at two baseline sites and three non-point sites identified by the Pike County Conservation District and Aquatic Resource Consulting (ARC) – Appendix B. Each stream site was sampled with a battery-powered, variable voltage, Smith-Root backpack electrofisher with 6-foot anode probe. Direct-pulsed current at 45 Hz was used to cause electronarcosis in the fish being collected.

Sampling effort was standardized at each site by sampling for a period of 20 minutes or until 300 linear feet of stream had been traversed. As recommended by the PADEP 2007 protocols for sampling fish, the sample reach was at least 10 times the mean width, or a minimum of 100 meters. All fish were collected on the first pass through the sampling area and stored in a 50 gallon live well.

All fish were identified to species and enumerated. Species that could not be identified in the field were preserved in 10% formalin and returned to the laboratory for positive identification. Fish were checked for anomalies, such as discoloration, deformities, eroded fins, excessive mucous, fungus, parasites, poor condition, reddening, tumors and/or ulcers. Exotic or introduced species were noted. Following collection of data, fish were returned to the stream unharmed.

Fish habitat was assessed at each station by measuring stream widths (wetted perimeter) at 50-foot intervals and estimating mean width (Appendix B). Each station was then placed in a standard stream width category for future comparison to other streams in the Pocono region. The categories were as follows: <10 ft.=1, 10-20 ft.=2, 21-40 ft.=3, 41-60 ft.=4, and >60 ft.=5.

For this study, 10 biological characteristics (metrics) were used to assess the fish communities (Lyons et al., 1996 and Karr et al., 1986). They were based on the fish community's taxonomic and trophic (food guild) composition, and the abundance and thermal tolerance of fish (Table 3). These metrics attempt to quantify the quality of the fish community. Comparing values with those expected for the region scores each of these evaluations. Scoring criteria were based on historical data collected from numerous stream sites in Pike County between 1995 and 2004 by Aquatic Resource Consulting. Metric values approximating, deviating slightly from, or deviating greatly from values expected in high quality streams are scored as 5, 3, or 1, respectively. The scores for each metric are tabulated to give a sum ranging from 50 (excellent) to 10 (very poor). This score is known as the index of biotic integrity (IBI).

The IBI serves as an integrated analysis because individual components may differ in their relative sensitivity to various levels of biological condition. A description and brief rationale for each of the 10 IBI metrics used for this study is outlined below.

TABLE 3. Index of biotic integrity (IBI) metrics and the scoring criteria used for each to calculate the IBI scores for Pike County fish populations.

IBI Metrics	Scoring Criteria 5	3	1
1. Number of Intolerant Species	>2	1-2	0
2. Percent of Individuals that are Tolerant	<11%	11-35%	>35%
3. Percent of Individuals that are Top Carnivores	>19%	8-19%	<8%
4. Percent of Individuals that are Coolwater or Coldwater	>83%	43-83%	<43%
5. Percent of Salmonid Individuals that are Brook Trout	>2%	1-2%	<1%
6. Percent of Individuals that are Insectivores	>56%	44-56%	<44%
7. Percent of Individuals that are Pioneering Species	<21%	21-56%	>56%
8. Catch per 20 Minute Effort	>142	96-142	<96
9. Percent of Individuals that are Lithophilic Spawners	>89%	72-89%	<72%
10. Number of YOY Trout Caught Per 20 Minute Effort	>11	1-11	<1

1. Number intolerant species - recognizes those fish that are sensitive to degradation resulting from siltation and oxygen depletion because they feed and reproduce in benthic (stream bottom) habitats.

2. Percent of individuals that are tolerant species - measures those fish species present that are tolerant to a variety of chemical and physical pollutants, and which tend to dominate a fish community that is degraded.

3. Percent of individuals that are top carnivore species - measures that portion of the fish community that feed on other fish. The dominant carnivores in coldwater streams are pollution sensitive adult salmonids (trout).

4. Percent of individuals that are stenothermal coolwater and coldwater species - measures that portion of the fish community that is intolerant to warm water conditions. Stenothermal fish species are often associated with high water quality.

5. Percent of salmonid individuals that are brook trout - Brook trout are often associated with high-quality, cold water streams. They are pollution sensitive to chemicals, elevated water temperatures, and siltation.

6. Percent of individuals that are insectivores - measures that portion of the fish community that feed on insects. The percent of insectivores, which are the dominant trophic guild in clean waters, increases as the physical and chemical habitat improves.

7. Percent of individuals as pioneering species - measures the proportion of the fish community represented by species which dominate in fluctuating environments such as variable flow regimes, chronic shifts in stream temperature, shifting habitats, and pulses of chemical pollutants.

8. Catch per 20 minute effort - measures the density of the fish community, which varies with region and stream size. Generally, the number of fish increases with improving stream conditions.

9. Percent lithophilic spawners - is an estimate of the suitability of the habitat for reproduction by fish species that build nests in sand, gravel and cobble substrates. These fish provide no parental care of their young after the eggs are laid and fertilized. Generally, as environmental degradation increases the number of lithophils decreases.

10. Catch of young-of-year trout per 20 minute effort – measures the capacity of a stream to reproduce trout species. Generally, the number of young-of-year trout increases with improving stream conditions.

Sampling Stations

Three baseline and twenty-two non-point stations were sampled for benthic macroinvertebrates in May, 2013 and two sites were sampled in November, 2013 (Appendix A). Two baseline and three non-point stations were sampled for fish in August, 2013 (Appendix B). Following are descriptions and co-ordinates for the macroinvertebrate and fish stations:

<u>Macroinvertebrates</u>

Station 09 – Sawkill Creek, Milford Township; 41.19’02.6”N/74.47’59.6”W

Station 11 – Cummins Creek, Milford Township, $41^0$25’10.24”N/$74^0$58’51.81”W

Station 15 – Lackawaxen River, Lackawaxen Township, 41.28’34.0”N/74.02’07.0”W

Station 20N – Toms Creek, Lehman Township, $41^0$19’22.7”N/$74^0$47’43.9”W

Station 22N – Dingmans Creek, Delaware Township; 41.17’47.7”N/74.45’27.62”W

Station 23N – Dwarfskill Creek, Dingman Township, $41^0$24’33.4”N/$74^0$44’38.3”W

Station 27N – Walker Lake Creek, Shohola Township; 41.25’58.36”N/74.53’17.57”W

Station 28N – Westcolang Creek, Lackawaxen Township;41.30’39.92”N/75.00’22.35”W.

Station 29N –Teedyuskung Creek, Lackawaxen Township,41.29’16.48”N/75.06’21.1”W.

Station 30N – Kleinhans Creek, Palmyra Township, 41.22’15.58”N/75.15’07.02”W.

Station 38N – Rattlesnake Creek, Lackawaxen Township, 41.33’04.18”N/75.05’40.2”W

Station 39N – Big Bushkill Creek, Porter Township, 41.14’35.49”N/75.05’58.09”W.

Station 43N – Lackawaxen River, Lackawaxen Township, 41.25’10.1”N/74.58’53.0”W

Station 44N – Little Bushkill Creek, Lehman Township, 41.07’56.6”N/75.00’32.4”W

Station 45NA – Lackawaxen River, Lackawaxen Township; 41.29’6.64”N/75.01’38.2”W

Station 45NB – Lackawaxen River, Lackawaxen Township;41.29’12.7”N/75.01’35.2”W

Station 47NA – Sloat Brook, Dingman Township; $41^0$19’44.4”N/$74^0$50’43.3”W

Station 47NB – Sloat Brook, Dingman Township; $41^0$19’42.3”N/$74^0$50’40.1”W

Station 48N/A – Swale Brook, Dingman Township; $41^0$19’17.9”N/$74^0$51’13.9”W

Station 48N/B – Swale Brook, Dingman Township; $41^0$19’12.4”N/$74^0$51’09.8”W

Station 49N/A – Raymondskill Creek, Dingman Township, $41^0$18’15.17”N/$74^0$52’4.8”W

Station 49N/B – Raymondskill Creek, Dingman Township, $41^0$18’13.6”N/$74^0$51’56.8”W

Station 50N – Pinchot Creek, Milford Township, $41^0$21’23.6”N/$74^0$51’1.45”W

Station 51N – Dimmock Meadow Creek, Milford Township, $41^0$21’0.0”N/$74^0$50’15.0”W

Station 53N – Deep Brook, Westfall Township,$41^0$20’43”N/$74^0$47’29”W

Fish

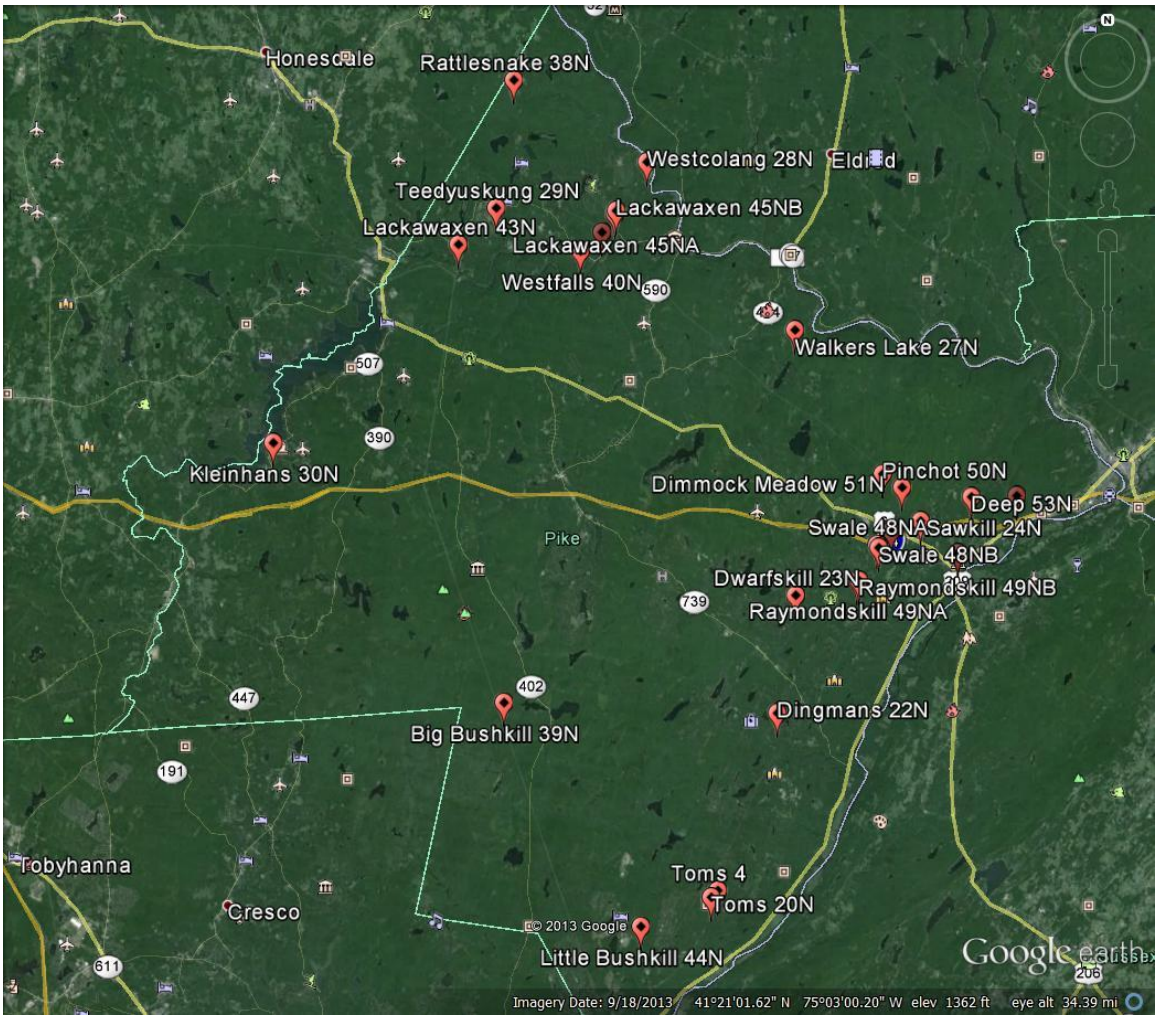
Station 4 – Tom’s Creek, Lehman Township, $41^0$9’0.0”N/$74^0$57’30.0”W

Station 11 – Cummins Creek, Milford Township, $41^0$20’45.0”N/$74^0$45’40.0”W

Station 24N – Sawkill Creek, Milford Township, $41^0$20’0.0”N/$74^0$49’30.0”W

Station 40N – Westfalls Creek, Westfall Township, $41^0$28’0.0”N/$75^0$3’0”W

Station 51N – Dimmock Meadow Creek, $41^0$21’0.0”N/$74^0$50’15”W



RESULTS AND DISCUSSION

Physical – Chemical Field Data

Physical and chemical parameters measured were similar at both baseline and non-point stream sites surveyed (Table 4, Appendix B). Temperature and dissolved oxygen levels were considered adequate for stream life at the time of sampling. All streams were considered slightly acidic to neutral with low buffering capability (alkalinity).

Conductivity readings at each site were generally low suggesting limited concentrations of dissolved or filterable solids such as minerals, metals, or man-made wastes. The mean value of the world's rivers contain an average of 120 parts per million (ppm) of total dissolved solids (Cole, 1983). A comparable conductivity would equal 240 umhos/cm.

Habitat

Twenty-three of the twenty-five stream sites scored in the optimal range for habitat (Table 5, Appendix B). Stations that exceeded the PADEP scoring benchmark of 192 for

optimal habitat is shown in green and those that fell in the suboptimal category are shown in blue (PA DEP, 2007). The sites with sub-optimal habitat were Station 30N on Kleinhans Creek and 48NB on Swale Brook. Diverse habitat is considered a necessary component to healthy stream conditions. Habitat can be degraded by human activities within a watershed. However, natural events may also degrade habitat at certain times (i.e. floods, dewatering due to drought, pest infestations, etc.).

Table 4. Physical and chemical field data from twenty-five Pike County stream sites (May, 2013) – Pennsylvania Department of Environmental Protection. 2009.

PARAMETER	STA.9 Sawkill	STA. 11 Cummins	STA.15 Lackawaxen	STA.20N Toms	STA.22N Dingmans	STA.23N Dwarfskill
Sample Date	5/13/13	5/13/13	5/15/13	5/3/13	5/3/13	5/21/13
Temperature (^{0}C)	10.1	8.6	11.7	13.9	14.6	16
Dissolved Oxygen (mg/l)	10.35	10.58	11.25	10.16	9.61	9.15
ph	6.9	6.7	7	7	6.8	7
Conductivity (umhos/cm)	133.6	59.1	83.1	114.6	74.4	147.1
Alakalinity (mg/l)	12	4	20	16	8	12
PARAMETER	STA.27N Walker Lake	STA.28N Westcolang	STA.29N Teedyuskung	STA.30N Kleinhans	STA.38N Rattlesnake	STA.39N Big Bushkill
Sample Date	4/30/13	5/24/13	5/24/13	4/30/13	5/24/13	5/3/13
Temperature (^{0}C)	12.8	16.7	12.5	9.9	13.9	16.7
Dissolved Oxygen (mg/l)	9.3	8.79	10.7	97	10.45	9.9
ph	6.5	6.8		7	6.7	6.75
Conductivity (umhos/cm)	62.5	103.5	194.9	142.4	34.7	50.6
Alakalinity (mg/l)	12			16	8	4
PARAMETER	STA.43N Lackawaxen	STA.44N Little Bushkill	ST.45NA Lackawaxen	ST.45NB Lackawaxen	STA.47NA Sloat	STA.47NB Sloat
Sample Date	5/15/13	5/3/13	5/15/13	5/15/13	4/29/13	4/29/13
Temperature (^{0}C)	13.4	16	7.1	10.9	9.2	9.4
Dissolved Oxygen (mg/l)	10.77	10.13	11.09	10.98	9.74	10.95
ph	7.3	6.5	6.7	6.7		6.7
Conductivity (umhos/cm)	84	39.8	82.8	84.5	287.4	288.6
Alakalinity (mg/l)	28	6	18	8		18

Table 4. (cont.).

PARAMETER	STA.48NA Swale	ST.48NB Swale	ST.49NA Raymondskill	ST.49NB Raymondskill	STA.50N Pinchot	STA.51N Dimmock Meadows
Sample Date	4/29/13	4/29/13	5/21/13	5/21/13	5/22/13	5/22/13
Temperature (^{0}C)	10.5	10.7	15.5	15.4	15	15.4
Dissolved Oxygen (mg/l)	9.03	9.04	9.16	8.46	8.17	8.6
ph	6.7	7	6.9	6.8	6.8	6.5
Conductivity (umhos/cm)	180.8	192.2	123.6	123.3	34.3	30.4
Alakalinity (mg/l)	36	20	8	6	8	4
PARAMETER	STA.53N Deep					
Sample Date	5/13/13					
Temperature (^{0}C)	8.4					
Dissolved Oxygen (mg/l)	11.85					
Ph	6.6					
Conductivity (umhos/cm)	31.9					
Alakalinity (mg/l)	8					

Table 5. Habitat assessment of twenty-five sampling stations on Pike County streams (2013) - Pennsylvania Department of Environmental Protection. 2009.

HABITAT PARAMETER	STA. 9 Sawkill	STA. 11 Cummins	STA.15 Lackawaxen	STA. 20N Toms	STA. 22N Dingmans	STA. 23N Dwarfskill
1. Instream Cover	19	16	18	17	17	16
2. Epifaunal Substrate	19	16	19	19	18	17
3. Embeddedness	14	16	19	18	16	17
4. Velocity/Depth Regimes	18	17	18	19	19	18
5. Channel Alteration	19	20	20	20	20	19
6. Sediment Deposition	15	17	18	17	16	17
7. Frequency of Riffles	20	19	19	19	20	20
8. Channel Flow Status	17	15	20	19	19	20
9. Condition of Banks	13	15	19	19	20	18
10. Bank Vegetative Protection	15	16	19	18	19	18
11. Grazing or Other Disruptive Pressure	20	20	20	20	20	20
12. Riparian Vegetative Zone Width	15	20	16	20	20	13
TOTAL SCORE	204	197	225	225	224	215
Score ranges: Optimal 240-192, Suboptimal 180-132, Marginal 120-72, Poor <60						

Table 5. (cont.).

HABITAT PARAMETER	STA.27N Walker Lake	STA.28N Westcolang	STA.29N Teedyusku ng	STA.30N Kleinhans	STA.38N Rattlesnake	STA.39N Big Bushkill
1. Instream Cover	15	19	17	15	20	13
2. Epifaunal Substrate	16	20	19	12	20	16
3. Embeddedness	13	20	18	9	17	15
4. Velocity/Depth Regimes	16	17	18	13	18	16
5. Channel Alteration	20	20	19	20	20	20
6. Sediment Deposition	16	19	16	8	18	16
7. Frequency of Riffles	19	20	20	15	19	16
8. Channel Flow Status	16	20	17	15	20	19
9. Condition of Banks	20	20	18	15	19	19
10. Bank Vegetative Protection	18	17	16	18	19	19
11. Grazing or Other Disruptive Pressure	20	20	20	20	20	20
12. Riparian Vegetative Zone Width	20	17	17	20	20	15
TOTAL SCORE	209	229	215	180	230	204

Score ranges: Optimal 240-192, Suboptimal 180-132, Marginal 120-72, Poor <60

Table 5. (cont.).

HABITAT PARAMETER	STA.43N Lackawaxen	STA.44N Little Bushkill	ST.45NA Lackawaxen	ST.45NB Lackawaxen	STA.47NA Sloat	STA.47NB Sloat
1. Instream Cover	19	19	16	19	14	18
2. Epifaunal Substrate	19	19	17	16	13	15
3. Embeddedness	19	19	14	18	15	19
4. Velocity/Depth Regimes	19	19	15	16	16	16
5. Channel Alteration	20	20	18	19	20	20
6. Sediment Deposition	19	18	15	16	14	20
7. Frequency of Riffles	19	19	16	18	19	20
8. Channel Flow Status	19	18	19	19	19	16
9. Condition of Banks	19	18	19	19	15	14
10. Bank Vegetative Protection	19	19	19	19	18	14
11. Grazing or Other Disruptive Pressure	20	20	20	20	20	19
12. Riparian Vegetative Zone Width	20	20	18	17	20	20
TOTAL SCORE	231	228	206	216	203	211

Score ranges: Optimal 240-192, Suboptimal 180-132, Marginal 120-72, Poor <60

Table 5. (cont.).

HABITAT PARAMETER	ST.48NA Swale	ST.48NB Swale	ST.49NA Raymondskill	ST.49NB Raymondskill	STA.50N Pinchot	STA.51N Dimmock Meadows
1. Instream Cover	17	11	17	17	17	19
2. Epifaunal Substrate	17	8	17	18	18	19
3. Embeddedness	18	10	17	18	17	19
4. Velocity/Depth Regimes	18	15	18	18	17	19
5. Channel Alteration	20	20	19	15	20	20
6. Sediment Deposition	17	11	15	16	16	19
7. Frequency of Riffles	18	15	16	17	19	20
8. Channel Flow Status	20	14	17	19	19	19
9. Condition of Banks	19	15	18	16	20	19
10. Bank Vegetative Protection	19	18	18	19	20	19
11. Grazing or Other Disruptive Pressure	20	20	17	16	20	20
12. Riparian Vegetative Zone Width	20	20	19	14	20	20
TOTAL SCORE	223	177	208	203	223	232

Score ranges: Optimal 240-192, Suboptimal 180-132, Marginal 120-72, Poor <60

Table 5. (cont.).

HABITAT PARAMETER	STA.53N Deep					
1. Instream Cover	18					
2. Epifaunal Substrate	18					
3. Embeddedness	15					
4. Velocity/Depth Regimes	18					
5. Channel Alteration	16					
6. Sediment Deposition	15					
7. Frequency of Riffles	19					
8. Channel Flow Status	19					
9. Condition of Banks	19					
10. Bank Vegetative Protection	19					
11. Grazing or Other Disruptive Pressure	20					
12. Riparian Vegetative Zone Width	15					
TOTAL SCORE	211					

Score ranges: Optimal 240-192, Suboptimal 180-132, Marginal 120-72, Poor <60

Benthic Macroinvertebrates

Appendix A shows the taxa, numbers, and pollution tolerance values for the benthic macroinvertebrates from three baseline and twenty-two non-point stream sites in Pike County for 2013. Table 6 shows the raw metric values and the adjusted standardized index of biotic integrity (IBI) score for each sample. Stations that exceeded the PADEP scoring benchmark of ≥80 for EV (exceptional value), HQ (high quality) protected use are highlighted in blue, those exceeding the benchmark of ≥63 for CWF (cold water fishery), TSF (trout stocked fishery), and WWF (warm water fishery) protected use are highlighted in green. Stations that failed to meet either of the two benchmarks are highlighted in red.

Of the twenty-five stations sampled, twelve had IBI scores high enough to qualify for special protection HQ and EV waters (Tables 6 and 7). Nine met the PADEP benchmark for the supporting use categories of CWF, TSF, and WWF and three failed to meet either

of the two use categories. Station 9 on Sawkill Creek had the highest IBI score of 90.8 and Dingmans Creek the lowest score of 55.1. Comparison of upstream and downstream stations at the special study sites revealed some difference in biotic integrity. Sloat Brook in 2013 showed no change in its use category designation. However, on Swale Brook and Raymondskill Creek there was a change in designation with the downstream site having a lower rating than the upstream site. The Lackawaxen River in 2013 showed no change in its use category designation between sites. In the fall of 2012 and spring and fall of 2013, the special study sites of Cummins Creek, Deep Brook, Pinchot Creek, and Dimmock Meadow Creek had IBI scores that met the PADEP criteria for EV and HQ stream designation (Ersbak, 2012).

Table 6. Metric scores for twenty-five benthic macroinvertebrate samples from Pike County stream sites (May, 2013).

METRIC	STA. 9 Sawkill	STA. 11 Cummins	STA.15 Lackawaxen	STA. 20N Toms	STA. 22N Dingmans	STA 23N Dwarfskill
Total Taxa Richness	27	26	22	26	22	30
Diversity Index	2.6	2.5	2.45	2.06	1.87	2.7
EPT Taxa Richness	20	19	11	20	12	19
Hilsenhoff Biotic Index	2.3	1.6	3.6	3.1	4.9	2.4
Percent Intolerant Individuals	67%	85%	28%	56%	25%	64%
Modified Beck's Index	35	41	19	37	16	28
Index of Biotic Integrity	90.8	94.4	62.0	83.3	55.1	88.0

METRIC	STA.27N Walker Lake	STA.28N Westcolang	STA.29N Teedyuskung	STA.30N Kleinhans	STA.38N Rattlesnake	STA.39N Big Bushkill
Total Taxa Richness	24	23	23	20	30	24
Diversity Index	2.12	2.25	2.35	2.41	2.80	2.47
EPT Taxa Richness	18	14	16	15	20	13
Hilsenhoff Biotic Index	1.6	1.6	2.0	3.1	2.4	5.3
Percent Intolerant Individuals	78%	73%	69%	53%	74%	31%
Modified Beck's Index	29	24	28	27	27	10
Index of Biotic Integrity	85.1	78.7	81.6	73.8	90.2	58.1

Table 6. (cont.).

METRIC	STA.43N Lackawaxen	ST. 44N Little Bushkill	ST.45NA Lackawaxen	ST.45NB Lackawaxen	ST.47NA Sloat	STA.47NB Sloat
Total Taxa Richness	29	32	42	20	14	20
Diversity Index	2.49	2.48	2.85	2.7	1.86	2.7
EPT Taxa Richness	20	20	26	13	8	13
Hilsenhoff Biotic Index	52	47.4	4.16	2.23	1.62	2.23
Percent Intolerant Individuals	32%	35%	34%	64%	89%	64%
Modified Beck's Index	21	29	25	23	14	23
Index of Biotic Integrity	79.3	81.2	79.6	72.1	64.4	72.1

METRIC	ST.48NA Swale	ST.48NB Swale	ST.49NA Raymondskill	ST.49NB Raymondskill	STA.50N Pinchot	STA.51N Dimmock Meadow
Total Taxa Richness	26	20	33	31	30	24
Diversity Index	2.0	1.54	2.92	2.75	2.66	2.05
EPT Taxa Richness	18	14	20	19	17	17
Hilsenhoff Biotic Index	2.35	1.52	2.95	4.25	2.36	1.51
Percent Intolerant Individuals	71%	91%	54%	32%	75%	90%
Modified Beck's Index	27	27	32	23	26	33
Index of Biotic Integrity	81.9	76.5	89.1	76.5	87.5	86.8

METRIC	STA.53N Deep
Total Taxa Richness	28
Diversity Index	2.51
EPT Taxa Richness	20
Hilsenhoff Biotic Index	2.26
Percent Intolerant Individuals	76%
Modified Beck's Index	28
Index of Biotic Integrity	88.6

Table 7. Metric scores for two benthic macroinvertebrate samples from Pike County stream sites (November, 2013).

METRIC	STA.50N Pinchot	STA.51N Dimmock Meadow				
Total Taxa Richness	28	32				
Diversity Index	2.62	1.67				
EPT Taxa Richness	21	24				
Hilsenhoff Biotic Index	2.91	3.03				
Percent Intolerant Individuals	65%	77%				
Modified Beck's Index	28	43				
Index of Biotic Integrity	85.7	98.1				

FISH

Five stream fish communities in Pike County were assessed by electrofishing techniques. Each survey site was categorized into habitat categories based on stream width (wetted perimeter) to allow for comparative assessments of biotic integrity among streams (Table 8 – Appendix B). The streams surveyed fell into one of five width categories ranging from 1 (<10 feet) to 5 (>60 feet). Four of the five stream sites evaluated were classified as 2 (widths 10-20 feet) and one was classified as 3 (widths 20-30) feet. Of the 5 stream stations, three had no upstream impoundment and two had more than three.

Table 8. Stream fish communities sampled for width category, impoundments in watershed and game fish present in Pike County, PA (August, 2013)

STREAM SAMPLED	SITE ID	WIDTH CATEGORY	IMPOUNDMENTS ABOVE SAMPLE SITE	GAME FISH PRESENT
Cummins Creek	11	2	0	Brown trout
Sawkill Creek	24N	3	>3	Brown trout
West Falls Creek	40N	2	>3	Brown trout
Dimmock Meadow Creek	51N	2	0	Brook & brown trout
Tom's Creek	4	2	0	Brown trout

Trout species were present at all five of the stream sites surveyed. Brook and brown trout were collected from one of the five sites – Dimmock Meadow Creek (Table 8).

Trout are an important sport fish in the region, are temperature sensitive and prefer streams where thermal conditions seldom exceed 65 degrees Fahrenheit (Scott and Crossman, 1979). Impoundments with surface water releases tend to discharge warm water during the summer months, which is considered detrimental to the natural survival and production of trout. Sedimentation of streams is also detrimental to the survival of trout, as they require a clean substrate to incubate their eggs. Brook trout can tolerate less thermal stress and sedimentation than brown trout and are usually associated with springs and headwater regions of watersheds. They also require high concentrations of dissolved oxygen to survive. Therefore, they are usually associated with clean water conditions and are fairly intolerant to organic pollutants. All five fish sites showed healthy adult and young-of-year trout populations (Table 9). Further study is needed to determine if reproductive success was affected in these special study areas during the fall of 2013.

A total of 6 species of fish were collected from the five streams surveyed in August of 2013 (Table 9). Brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*) were the two trout species present. A healthy, reproducing population of trout (>20 specimens) was collected at all five sites. Blacknose dace (*Rhinichthys atratulus*) were the dominant forage fish at three of the survey sites. American eel (*Anguilla rostrata*), which is a catadromous fish (living in fresh water and spawning in salt water), was found at 2 stream sites.

Fish species were classified for calculation of an index of biotic integrity at each station surveyed (Table 9). These categories included pollution tolerance, trophic position (carnivore, omnivore or insectivore), thermal tolerance (stenothermal vs. eurythermal), adaptability to changing conditions (pioneer), spawning requirements (lithophil), and salmonid reproductive capacity (presence of young-of-year) - Lyons et al., 1996, Scott and Crossman, 1979; Plafkin et al., 1989; and Cooper, 1983.

The index of biotic integrity for the 5 stream sites surveyed ranged from 32 at Sawkill Creek to 44 at Dimmock Meadow - Table 9. All of the sites had IBI indices that are considered good ($\geq$24) and scores approximating those found in high quality streams of the region. All of these stream sites have consistently rated high in their fish population's biotic integrity (Ersbak, 1995-2009). Two special study sites, Dimmock Meadow and Cummins Creek, exhibited the highest indices of biotic integrity for fish.

It is noteworthy, that of the 400 individual fish sampled, no external deformities (tumors, ulcers, etc.) indicative of stress resulting from chemical pollutants was observed.

Table 9. Fish species collected from five stream sites in Pike County, PA (August, 2013).

Scientific Name	Common Name	Toms 4	Cummins 11	Sawkill 24N	West Falls 40N	Dimmock Meadows 51N
Anguilla rostrata	American eel	1			4	
Catostomus commersoni	white sucker			1		
Rhinichthys atratulus	blacknose dace	19		90	17	
Salmo trutta	brown trout	56	91	47	27	20
Salvelinus fontinalis	brook trout					25
Semotilus atromaculatus	creek chub	2				
	TOTAL	**78**	**91**	**138**	**48**	**45**

TABLE 10. Index of biotic integrity (IBI) test scores at 5 stream sites in Pike County, Pennsylvania (August, 2013).

IS	Number of intolerant species
TOL	% of individuals that are tolerant species
CARN	% of individuals that are top carnivore species
STENO	% of individuals that are stenothermal coolwater & coldwater species
ST	% of salmonid individuals that are brook trout
I	% of individuals that are insectivores
P	% of individuals that are pioneering species
CPE	Catch per 20 minute effort
L	% of individuals that are lithophilic spawners
YOY	Number of young-of-year trout

INDEX OF BIOTIC INTEGRITY

	STATION 4 TOM'S CREEK		**STATION 11** CUMMINS CREEK		**STATION 24N** SAWKILL CREEK	
IBI Metrics	Metric Value	Test Score	Metric Value	Test Score	Metric Value	Test Score
IS	1	3	1	3	1	3
TOL	1%	5	0%	5	35%	3
CARN	73%	5	100%	5	34%	5
STENO	99%	5	100%	5	100%	5
ST	0%	1	0%	1	0%	1
I	76%	5	100%	5	34%	1
P	72%	1	0%	5	65%	1
CPE	78	1	91	1	138	3
L	99%	5	100%	5	100%	5
YOY	27	5	44	5	21	5
IBI Score =		**36**		**40**		**32**

TABLE 10. (cont.)

	STATION 40N WEST FALLS CREEK		STATION 51N DIMMOCK MEADOW CREEK	
IBI Metrics	Metric Value	Test Score	Metric Value	Test Score
IS	1	3	2	3
TOL	35%	3	0%	5
CARN	65%	5	100%	5
STENO	92%	5	100%	5
ST	0%	1	44%	5
I	65%	5	100%	5
P	44%	3	0%	5
CPE	48	1	30	1
L	92%	5	100%	5
YOY	11	3	24	5
IBI Score =		**34**		**44**

RECOMMENDATIONS

It is recommended that the PCCD continue its monitoring program of streams and rivers in the county. The cyclical rotation of sites surveyed should remain compliant with that established by the PCCD in 2010.

The special study stream sites should continue to be monitored for one more year to determine what, if any, impacts are occurring to the stream biota and water quality. Particular attention should be given to the fish stream sites surveyed in 2013. Sedimentation may have affected the fall reproductive success of the lithophilic species residing therein and this may be confirmed or denied with another survey in 2014.

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Appendix A.

Taxa, numbers, and pollution tolerance values for the benthic macroinvertebrates from twenty-five stream sites in Pike County for 2013.

Appendix B
Pennsylvania Department of Environmental Protection flowing waterbody data sheets and water quality network habitat assessment for 25 stations sampled at baseline, non-point, and special study stream sites in Pike County in May, 2013.