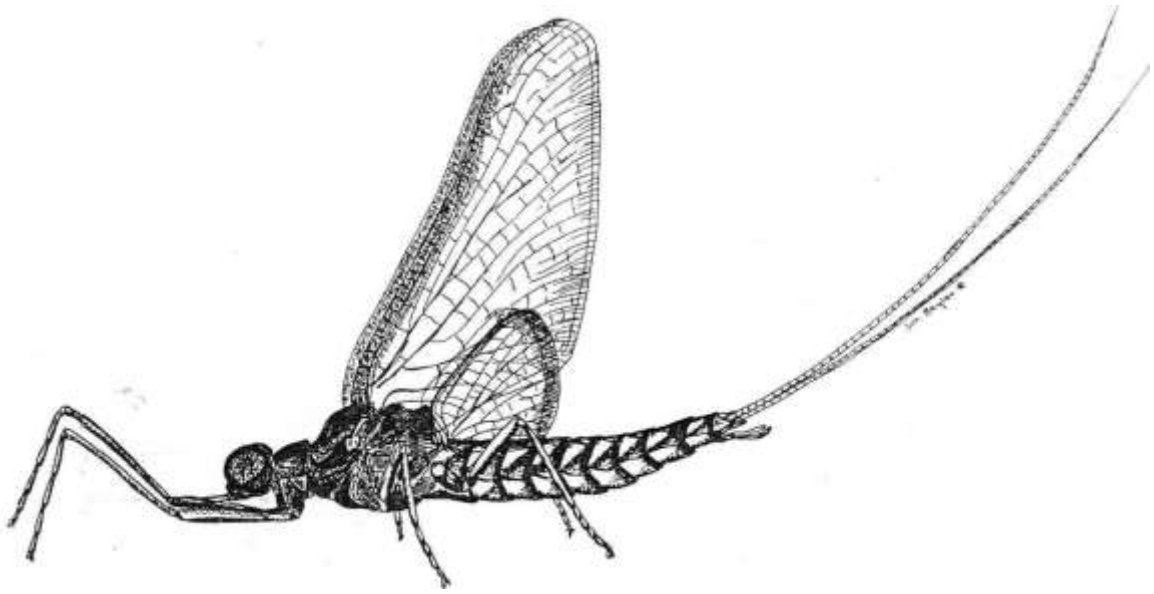
ENVIRONMENTAL QUALITY
OF
PIKE COUNTY STREAMS



DECEMBER 2014

ENVIRONMENTAL QUALITY OF PIKE COUNTY STREAMS

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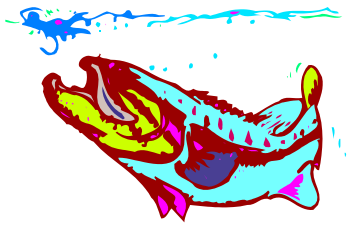

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INTRODUCTION

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 500µm 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 (±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, 2014 at four baseline sites and one non-point sites identified by the Pike County Conservation District and Aquatic Resource Consulting (ARC) – Appendix B. One special study site was also surveyed. 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 300 feet. 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

Ten baseline and eleven non-point stations were sampled for benthic macroinvertebrates in April and May, 2014 and two special study sites were sampled in November, 2014 (Appendix A). Four baseline and one non-point station were sampled for fish in August, 2014 (Appendix B). One special study site was also surveyed. Following are descriptions and co-ordinates for the macroinvertebrate and fish stations:

Macroinvertebrates

Station 02 – Big Bushkill Creek, Lehman Township; 41.090662^0,-75.004328^0

Station 03 – Little Bushkill Creek, Lehman Township; 41.091364^0,-75.003598^0

Station 04 – Toms Creek, Lehman Township; 41.152075^0,-74.954147^0

Station 05 – Hornbeck Creek, Delaware Township; 41.195653^0,-74.909446^0

Station 06 – Dingmans Creek, Delaware Township; 41.231694^0,-74.910548^0

Station 07 – Adams Creek, Delaware Township; 41.261335^0,-74.890436^0

Station 10 – Vandermark Creek, Milford Township; 41.323286^0,-74.795256^0

Station 11 – Cummins Creek, Milford Township, 41.345091^0,-75.761230^0

Station 14 – Shohola Creek, Shohola Township, 41.455904^0,-74.923305^0

Station 18 – E Br Wallenpaupack Creek, Greene Township, 41.321327^0,-75.308891^0

Station 20N – Toms Creek, Lehman Township, 41.142606^0,-74.962511^0

Station 24N – Sawkill Creek, Milford Township, 41.334251^0,-74.824545^0

Station 26N – Rosetown Creek, Westfall Township; 41.354596^0,-74.729050^0

Station 47N/A – Sloat Brook, Dingman Township; 41.329212^0,-74.845133^0

Station 47N/B – Sloat Brook, Dingman Township; 41.328575^0,-74.844403^0

Station 48N/A – Swale Brook, Dingman Township; 41.321310^0,-74.853300^0

Station 48N/B – Swale Brook, Dingman Township; 41.320478^0,-74.852664^0

Station 49N/A – Raymondskill Creek, Dingman Township, 41.303913^0,-74.867259^0

Station 49N/B – Raymondskill Creek, Dingman Township, 41.303845^0,-74.866505^0

Station 50N/B – Pinchot Creek, Milford Township, 41.369160^0,-74.842247^0

Station 51N/B – Dimmock Meadow Creek, Milford Township, 41.349500^0,-74.835900^0

Fish

Station 10 – Vandermark Creek, Milford Township, 41.323286^0,-74.795256^0

Station 11 – Cummins Creek, Milford Township, 41.345091^0,-74.761230^0

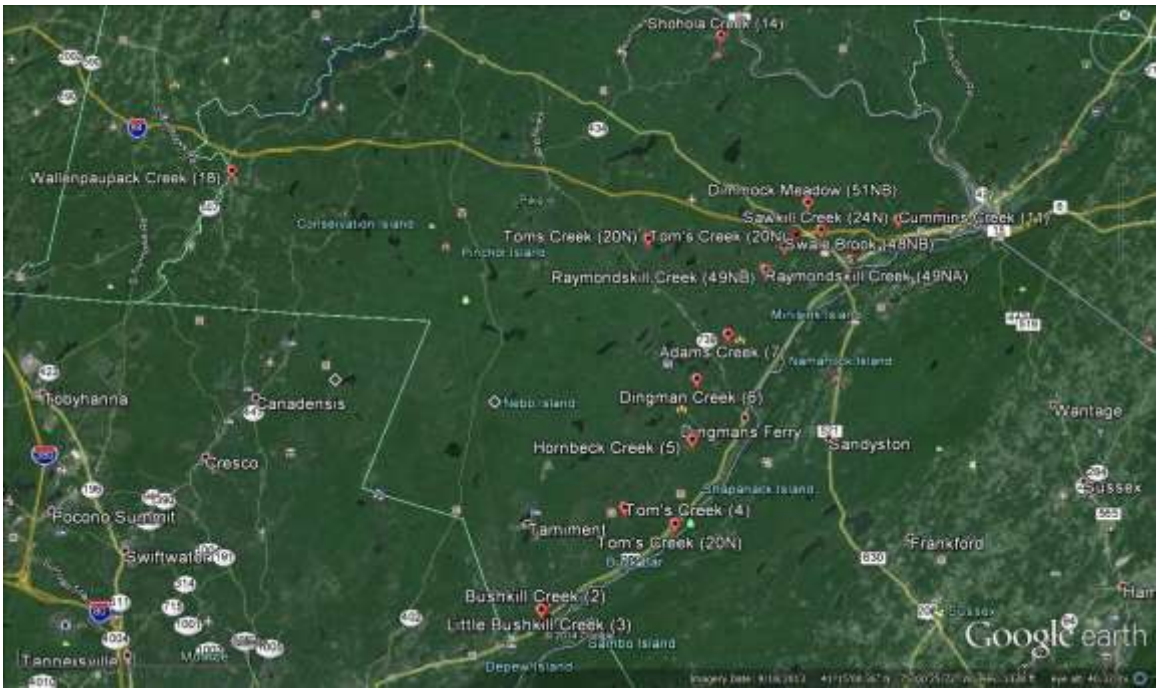
Station 13 – Twin Lakes Creek, Shohola Township, 41.431601^0,-74.888956^0

Station 17 – Wallenpaupack Creek, Greene Township, 41.315489^0,-75.315825^0

Station 25N – Vandermark Creek, Milford Township, 41.328562^0,-74.798802^0

Station 50N – Pinchot Brook, Milford Township, 41.369160^0,-74.842247^0

Station 51N – Dimmock Meadow Creek, Milford Township, 41.349500^0,-74.835900^0



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 slightly alkaline 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. They were highest on Sloat and Swale Brook. 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 µmhos/cm.

Habitat

Seventeen of the twenty-one 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 or marginal category are shown in blue and red, respectively (PA DEP, 2007). The sites with sub-optimal habitat were Station 10 on Vandermark Creek, 47NA on Sloat Brook and 49NB on Raymondskill Creek. Rosetown Creek, Station 26N, was the only site with marginal habitat. 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-one Pike County stream sites (May, 2014) – Pennsylvania Department of Environmental Protection. 2009.

PARAMETER	STA. 2 Bushkill	STA. 3 Little Bushkill	STA.4 Tom's	STA. 5 Hornbeck	STA. 6 Dingmans	STA. 7 Adams
Sample Date	14-May	14-May	21-May	23-April	23-April	25-April
Temperature (°C)	15.2	15.3	12.4	10.5	10.8	8.3
Dissolved Oxygen (mg/l)	10.13	10.05	10.46	10.91	10.65	11.15
pH	7.48	7.11	7.28	6.96	7.0	7.11
Conductivity (µmhos/cm)	55.4	51.4	118.4	99.4	59.9	67.8
Alkalinity (mg/l)	12.5	12.5	-	15	10	10
PARAMETER	STA.10 Vandermark	STA 11 Cummins	STA. 14 Shohola	STA.18 E. Br. Wallenpaupck	STA.20N Tom's	STA.24N Sawkill
Sample Date	12-May	12-May	28-May	13-May	21-May	12-May
Temperature (°C)	11.7	10.6	20.3	17.8	12.5	14.2
Dissolved Oxygen (mg/l)	10.89	11.06	8.36	8.93	10.41	10.31
pH	7.18	7.25	6.98	7.59	7.3	7.52
Conductivity (µmhos/cm)	110.2	68.9	75.6	48.7	126.6	114.6
Alkalinity (mg/l)	12.5	7.5	-	7.5	-	12.5
PARAMETER	STA.26N Rosetown	ST.47NA Sloat (above)	ST.47NB Sloat (below)	STA.48NA Swale (above)	STA.48NB Swale (below)	ST.49NA Raymondskill (above)
Sample Date	25-April	28-April	28-April	28-April	28-April	28-April
Temperature (°C)	8.2	9.1	8.8	10.1	9.5	11.6
Dissolved Oxygen (mg/l)	11.7	11.14	11.47	11.04	11.12	10.72
pH	6.83	7.12	7.46	6.52	6.55	7.07
Conductivity (µmhos/cm)	27.7	141.5	211.3	232.7	235.1	145.3
Alkalinity (mg/l)	-	12.5	7.5	6.0	6.0	7.5

Table 4. (cont.).

PARAMETER	ST.49NB Raymondskill (below)	ST.50NB Pinchot	ST.51NB Dimmock Meadows			
Sample Date	28-April	19-May	19-May			
Temperature (°C)	11.5	13.9	12.9			
Dissolved Oxygen (mg/l)	10.96	9.93	10.25			
pH	7.14	6.58	6.63			
Conductivity (µmhos/cm)	145.2	19.8	22			
Alkalinity (mg/l)	11	7.5	7.5			

Table 5. Habitat assessment of twenty-one sampling stations on Pike County streams (2014) - Pennsylvania Department of Environmental Protection. 2009.

HABITAT PARAMETER	STA. 2 Bushkill	STA. 3 Little Bushkill	STA.4 Tom's	STA. 5 Hornbeck	STA. 6 Dingmans	STA. 7 Adams
1. Instream Cover	20	19	20	6	19	16
2. Epifaunal Substrate	20	19	20	18	19	19
3. Embeddedness	20	17	20	14	19	17
4. Velocity/Depth Regimes	19	19	20	12	15	19
5. Channel Alteration	20	20	20	20	20	19
6. Sediment Deposition	16	17	15	16	18	7
7. Frequency of Riffles	19	20	18	19	20	19
8. Channel Flow Status	19	19	19	17	18	19
9. Condition of Banks	19	12	19	20	12	18
10. Bank Vegetative Protection	20	15	19	14	12	15
11. Grazing or Other Disruptive Pressure	19	20	19	20	20	20
12. Riparian Vegetative Zone Width	18	20	19	20	19	20
TOTAL SCORE	229	218	228	196	211	208
Score ranges: Optimal 240-192, Suboptimal 180-132, Marginal 120-72, Poor <60						

Table 5. (cont.).

HABITAT PARAMETER	STA.10 Vandermark	STA 11 Cummins	STA. 14 Shohola	STA.18 E. Br. Wallenpaupck	STA.20N Tom's	STA.24N Sawkill
1. Instream Cover	14	19	18	19	19	19
2. Epifaunal Substrate	19	19	19	16	20	18
3. Embeddedness	18	18	19	19	20	20
4. Velocity/Depth Regimes	15	19	20	16	20	20
5. Channel Alteration	19	20	20	20	20	20
6. Sediment Deposition	11	18	17	18	14	18
7. Frequency of Riffles	20	20	20	17	19	18
8. Channel Flow Status	14	19	20	20	17	18
9. Condition of Banks	9	19	18	20	10	17
10. Bank Vegetative Protection	8	19	19	17	15	20
11. Grazing or Other Disruptive Pressure	11	20	20	20	20	20
12. Riparian Vegetative Zone Width	12	20	18	20	20	20
TOTAL SCORE	170	230	228	222	214	228

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

Table 5. (cont.).

HABITAT PARAMETER	STA.26N Rosetown	ST.47NA Sloat (above)	ST.47NB Sloat (below)	STA.48NA Swale (above)	STA.48NB Swale (below)	STA.49NA Raymondskill (above)
1. Instream Cover	13	18	16	11	15	19
2. Epifaunal Substrate	16	11	20	18	20	17
3. Embeddedness	12	11	10	13	15	18
4. Velocity/Depth Regimes	11	12	14	11	11	15
5. Channel Alteration	15	19	13	20	18	19
6. Sediment Deposition	9	11	11	18	16	17
7. Frequency of Riffles	19	7	19	19	20	16
8. Channel Flow Status	10	19	19	19	19	16
9. Condition of Banks	4	19	19	15	19	17
10. Bank Vegetative Protection	6	19	19	10	14	14
11. Grazing or Other Disruptive Pressure	10	19	16	19	19	20
12. Riparian Vegetative Zone Width	5	20	20	19	19	19
TOTAL SCORE	130	185	196	192	205	207

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

Table 5. (cont.).

HABITAT PARAMETER	ST.49NB Raymondskill (below)	ST.50NB Pinchot	ST.51NB Dimmock Meadows		
1. Instream Cover	17	16	20		
2. Epifaunal Substrate	11	16	20		
3. Embeddedness	17	16	20		
4. Velocity/Depth Regimes	11	15	19		
5. Channel Alteration	13	18	20		
6. Sediment Deposition	19	20	20		
7. Frequency of Riffles	8	17	20		
8. Channel Flow Status	17	20	20		
9. Condition of Banks	14	20	15		
10. Bank Vegetative Protection	16	18	18		
11. Grazing or Other Disruptive Pressure	18	20	20		
12. Riparian Vegetative Zone Width	16	18	20		
TOTAL SCORE	177	214	231		

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 ten baseline and eleven non-point stream sites in Pike County for 2014. 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-one stations sampled, thirteen had IBI scores high enough to qualify for special protection HQ and EV waters (Tables 6 and 7). Six met the PADEP benchmark for the supporting use categories of CWF, TSF, and WWF and two failed to meet either of the two use categories. Station 51N/B on Dimmock Meadow Creek had the highest IBI score of 99.6 in the spring and 99.2 in the fall. Sloat Brook, above and below the special study site, had the lowest scores of 42.4 and 38.4, respectively. Comparison of upstream and downstream stations at the special study sites revealed little difference in biotic integrity except for Sloat Brook. In 2014 this special study site showed noticeable change in its biotic integrity from that seen in 2013. Its use category designation dropped from CWF/TSF/WWF to no protected use. The IBI dropped 35% and 47% above and below the special study site, respectively. On the other special study sites the IBI was slightly better in 2014 than in 2013. The special study sites of Swale Brook and Dimmock Meadow Creek had IBI scores that met the PADEP criteria for EV and HQ stream designation (Ersbak, 2012). The special study sites at Raymondskill Creek met the protected use category above for HQ/EV protection and below for CWF/TSF/WWF. Pinchot Brook met the protected use category for CWF/TSF/WWF in the spring and for HQ/EV status in the fall.

Table 6. Metric scores for twenty-one benthic macroinvertebrate samples from Pike County stream sites (May, 2014).

METRIC	STA. 2 Bushkill	STA. 3 Little Bushkill	STA. 4 Tom's	STA. 5 Hornbeck	STA. 6 Dingmans	STA 7 Adams
Total Taxa Richness	27	29	34	26	23	32
Diversity Index	2.55	2.96	3.09	2.8	2.36	3.03
EPT Taxa Richness	18	21	24	15	15	19
Hilsenhoff Biotic Index	2.5	1.9	2.8	33.7	3	3
Percent Intolerant Individuals	61	69	62	53	57	52
Modified Beck's Index	25	38	42	23	28	34
Index of Biotic Integrity	82.8	90.3	93.7	76.8	76.5	88.9

METRIC	STA.10 Vandermark	STA.11 Cummins	STA.14 Shohola	STA.18 E. Br. Wallenpauck	STA.20N Tom's	STA.24N Sawkill
Total Taxa Richness	20	26	32	25	26	30
Diversity Index	2.02	2.66	3.01	2.41	2.49	2.78
EPT Taxa Richness	14	20	22	15	20	20
Hilsenhoff Biotic Index	2.3	2.2	3.0	3.9	1.9	2.7
Percent Intolerant Individuals	71	65	64	39	73	58
Modified Beck's Index	29	42	33	24	37	33
Index of Biotic Integrity	79.0	90.8	91.0	70.6	91.4	88.8

METRIC	ST. 26N Rosetown	ST.47NA Sloat Above	ST.47NB Sloat Below	ST.48NA Swale Above	STA.48NB Swale Below	ST.49NA Raymondskill Above
Total Taxa Richness	21	13	10	26	29	27
Diversity Index	2.18	1.71	1.38	2.16	2.13	2.73
EPT Taxa Richness	15	5	5	18	16	17
Hilsenhoff Biotic Index	1.6	4.9	4.6	2.2	2.1	3.40
Percent Intolerant Individuals	78	26	34	72	75	50
Modified Beck's Index	32	13	7	33	31	24
Index of Biotic Integrity	82.6	42.2	38.4	86.1	85.5	78.3

Table 6 (cont.)

METRIC	ST.49NB Raymondskill Below	ST.50NB Pinchot	STA.51NB Dimmock Meadows			
Total Taxa Richness	32	25	33			
Diversity Index	2.60	2.69	2.8			
EPT Taxa Richness	19	15	21			
Hilsenhoff Biotic Index	3.6	2.8	1.8			
Percent Intolerant Individuals	46	62	85			
Modified Beck's Index	23	22	45			
Index of Biotic Integrity	80.3	78.2	99.6			

Table 7. Metric scores for two benthic macroinvertebrate samples from Pike County stream sites (November, 2014).

METRIC	STA.50NB Pinchot	STA.51NB Dimmock Meadow				
Total Taxa Richness	28	35				
Diversity Index	2.73	3.05				
EPT Taxa Richness	20	25				
Hilsenhoff Biotic Index	2.5	1.7				
Percent Intolerant Individuals	69	80				
Modified Beck's Index	30	44				
Index of Biotic Integrity	88.9	99.2				

FISH

Six 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). Five of the six stream sites evaluated were classified as 2 (widths 10-20 feet) and one was classified as 3 (widths 20-30 feet). Of the 6 stream stations, three had no upstream impoundment and three had more than three.

Trout species were present at all six of the stream sites surveyed. Brook and brown trout were collected from three of the six sites, including Vandermark Creek, Twin Lakes Creek and Dimmock Meadows Creek (Table 8).

Table 8. Stream fish communities sampled for width category, impoundments in watershed, and game fish present in Pike County, PA (August, 2014)

STREAM SAMPLED	SITE ID	WIDTH CATEGORY	IMPOUNDMENTS ABOVE SAMPLE SITE	GAME FISH PRESENT
Vandermark Creek	10	2	0	Brook & brown trout
Cummins Creek	11	2	0	Brown trout
Twin Lakes Creek	13	2	>3	Brook & Brown trout
Wallenpaupack Creek	17	3	>3	Brown trout
Vandermark Creek	25N	2	>3	Brook trout
Dimmick Meadows Creek	51N	2	0	Brook & Brown trout

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 six fish sites showed healthy adult and young-of-year trout populations (Table 9). It appears reproductive success was not affected in the special study area on Dimmock Meadows Creek. Pinchot Creek, another special study area, was not sampled in 2014 due to poor sampling conditions.

A total of 16 species of fish were collected from the six streams surveyed in August of 2014 (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 four of the six sites. Blacknose dace (*Rhinichthys atratulus*) were the dominant forage fish at four 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. Slimy Sculpin, a pollution intolerant coldwater fish, was found at both sites on Vandermark Creek. Wallenpaupack Creek was most diverse with 12 of the 16 species present.

Table 9. Fish species collected from six stream sites in Pike County, PA (August, 2014).

Scientific Name	Common Name	Vandermark 10	Cummins 11	Twin Lakes 13	Wallenpaupack 17	Vandermark 25N	Dimmock Meadows 51N
Anguilla rostrata	American eel	12		2			
Catostomus commersoni	white sucker				1		
Rhinichthys atratulus	blacknose dace			2	14	3	3
Rhinichthys cataractae	longnose dace	2					
Salmo trutta	brown trout	59	109	23	48		11
Salvelinus fontinalis	brook trout	5		11		59	33
Umbra pygmaea	Eastern mudminnow				24		
Exoglossum maxillingua	cutlips minnow				37		
Semotilus corporalis	fall fish				8		
Esox niger	chain pickerel				3		
Micropterus salmoides	largemouth bass				1		
Luxilus cornutus	common shiner				3		
Etheostoma olmstedi	tessellated darter				6		
Lepomis gibbosus	pumpkinseed				1		
Noturus insignis	margined madtom	1			2		
Cottus cognatus	slimy sculpin	3				92	
	TOTAL	**82**	**109**	**38**	**148**	**154**	**45**

Fish species were classified for calculation of an index of biotic integrity at each station surveyed (Table 10). 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 6 stream sites surveyed ranged from 36 at Cummins and Wallenpaupack Creek to 46 at Vandermark Creek – Table 10. 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, 1995-2014).

TABLE 10. Index of biotic integrity (IBI) test scores at 6 stream sites in Pike County, Pennsylvania (August, 2014).

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 10 VANDERMARK CREEK

IBI Metrics	Metric Value	Test Score
IS	3	5
TOL	0%	5
CARN	78%	5
STENO	10%	1
ST	8%	5
I	100%	5
P	17%	5
CPE	82	1
L	82%	3
YOY	63	5
IBI Score =		**40**

STATION 11 CUMMINS CREEK

Metric Value	Test Score
0	1
0	5
100%	5
0	1
0	1
100%	5
0	5
109	3
100%	5
60	5
	36

STATION 13 TWIN LAKES CREEK

Metric Value	Test Score
1	3
5%	5
89%	5
34%	1
29%	5
95%	5
11%	5
30	1
95%	5
7	3
	38

STATION 17 WALLENPAUPACK CREEK

IBI Metrics	Metric Value	Test Score
IS	2	3
TOL	9%	5
CARN	35%	5
STENO	17%	1
ST	0%	1
I	46%	3
P	14%	5
CPE	148	5
L	75%	3
YOY	38	5
IBI Score =		**36**

STATION 25N VANDERMARK CREEK

Metric Value	Test Score
3	5
2%	5
38%	5
100%	5
100%	5
98%	5
2%	5
154	5
40%	1
56	5
	46

STATION 51N DIMMOCK MEADOWS CREEK

Metric Value	Test Score
2	3
7%	5
93%	5
80%	3
73%	5
93%	5
7%	5
45	1
100%	5
11	3
	40

It is noteworthy, that of the 570 individual fish sampled, no external deformities (tumors, ulcers, etc.) indicative of stress resulting from chemical pollutants was observed.

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 at Sloat Brook (47NA and 47NB) should be monitored for one more year to determine what, if any, impacts are occurring to the stream macroinvertebrate community and water quality.

The special study stream site at Pinchot Brook (50N) should be monitored for one more year to determine what, if any, impacts are occurring to the stream fish community and water quality.

Further testing should be considered for other new or existing stream sites threatened or reportedly impaired from environmental impacts.

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Appendix A.

Taxa, numbers, and pollution tolerance values for the benthic macroinvertebrates from twenty-one stream sites in Pike County for 2014.

Appendix B
Pennsylvania Department of Environmental Protection flowing waterbody data sheets and water quality network habitat assessment for 21 stations sampled at baseline, non-point, and special study stream sites in Pike County in May, 2014.