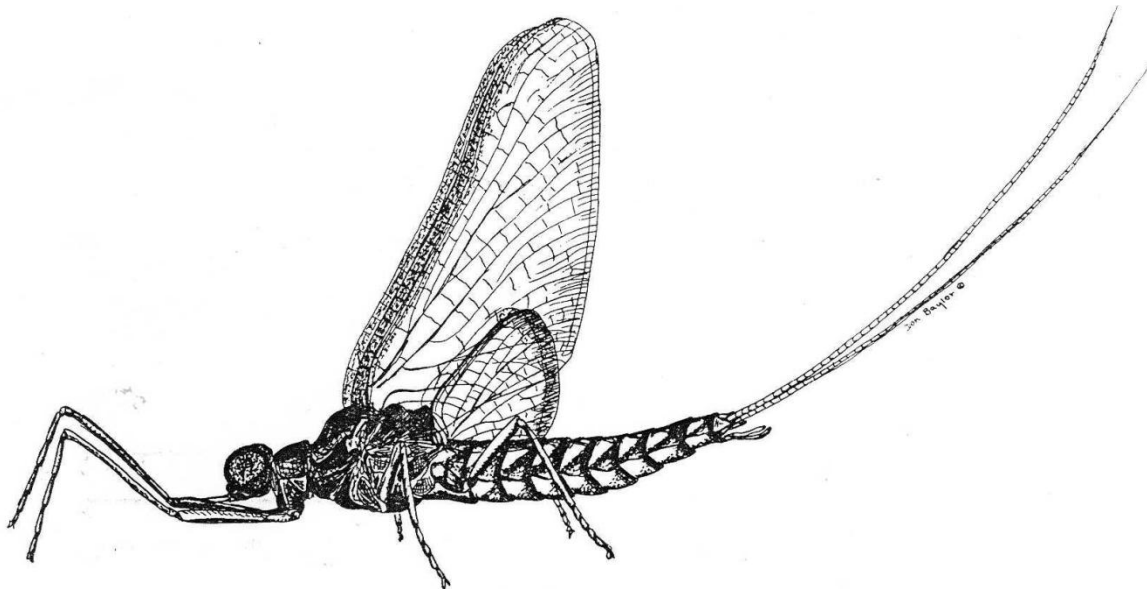


ENVIRONMENTAL QUALITY
OF
PIKE COUNTY STREAMS



DECEMBER 2017

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PIKE COUNTY STREAMS

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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 for one minute. Organisms and debris were composited for each station in a plastic container and preserved in 90% ethyl 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 freestone stream site:

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, 2017 at two baseline stream sites and six 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 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, ten (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 2016 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.

<u>IBI Metrics</u>	<u>Scoring Criteria</u>		
	<u>5</u>	<u>3</u>	<u>1</u>
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

Eight baseline and three non-point study stations were sampled for benthic macroinvertebrates in May, 2017 (Appendix A). Two baseline and six non-point stations were sampled for fish in August, 2017 (Appendix B). Following are descriptions and coordinates for the macroinvertebrate and fish stations:

Macroinvertebrates

Station 02 – Big Bushkill Creek, Lehman Township; 41⁰05'26.43"N-75⁰00'15.59"W

Station 03 – Little Bushkill Creek, Lehman Township; 41⁰05'29.35"N-75⁰00'15.26"W

Station 04 – Toms Creek, Lehman Township; 41⁰09'07.37"N-74⁰57'14.91"W

Station 05 – Hornbeck's Creek, Delaware Township; 41.11'45.0"N/74.54'33.2"W

Station 06 – Dingmans Creek, Delaware Township; 41.13'54.4"N/74.54'39.4"W

Station 07 – Adams Creek, Delaware Township; 41⁰15'40.86"N-74⁰53'23.59"W

Station 08 – Raymondskill Creek, Dingman Township; 41⁰18'13.3"N/74⁰51'18.3"W

Station 18 – East Branch Wallenpaupack Creek, Greene Township;
41.19'17.3"N/75.18'29.8"W

Station 20N – Toms Creek, Lehman Township, 41°08'33.25"N-74°57'44.76"W

Station 24N – Sawkill Creek, Dingman Township, 41.20'01.4"N/74.49'28.9"W.

Station 25N – Vandermark Creek, Milford Township, 41°19'43.34"N/74°47'55.68"W

Fish

Station 05 – Hornbeck's Creek, Delaware Township; 41°11'44.3"N/74°54'33.5"W

Station 12 – Bush Kill Creek, Westfall Township; 41°24'33.4"N/74°44'38.3"W

Station 28N – Westcolang Creek, Lackawaxen Township; 41°30'39.92"N/75°00'22.35"W

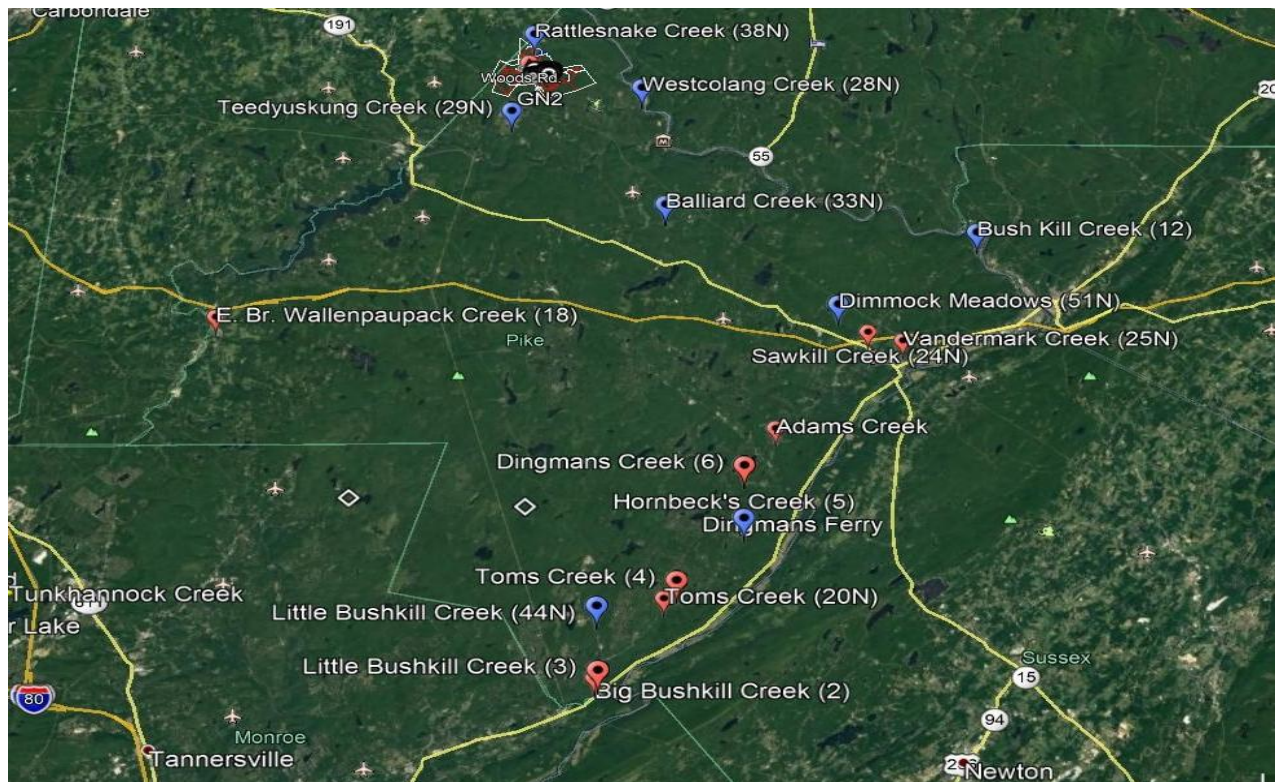
Station 29N – Teedyuskung Creek, Lackawaxen Township; 41°29'16.48:N/75°06'21.1"W

Station 33N – Balliard Creek, Shohola Township; 41°25'10.24"W/74°58'51.81"W

Station 38N – Rattlesnake Creek, Lackawaxen Township; 41°33'04.18"N/75°05'40.2"W

Station 44N – Little Bushkill Creek, Lehman Township; 41°07'56.06"N/75°00'32.4"W

Station 51N – Dimmock Meadows, Milford Township;
41°21'0.0"N/74°21'0.0"N/74°50'50.15"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 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. 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 $\mu\text{mhos/cm}$.

Habitat

All of the stream sites sampled scored in the optimal range for habitat (Table 5, Appendix B). Stations that exceeded the PADEP scoring benchmark of 192 for optimal habitat are shown in green (PA DEP, 2007). 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.).

Habitat scores for Pike County streams over the past six years have averaged 216 and the average has ranged from 200 to 232 units (Ersbak, 2010-2016). Subjective scoring criteria by different field teams have been fairly consistent.

Benthic Macroinvertebrates

Appendix A shows the taxa, numbers, and pollution tolerance values for the benthic macroinvertebrates from 8 baseline and 3 non-point stream sites in Pike County for 2017. 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 eleven stations sampled in 2017, six had IBI scores high enough to qualify for special protection HQ and EV waters (Table 6). The remaining five met the PADEP benchmark for the supporting use categories of CWF, TSF, and WWF. Station 7, Adams Creek and Station's 4 and 20N, Tom's Creek had the highest IBI scores of 90.9, 94.6 and 91.7, respectively. Big Bushkill Creek (2) had the lowest score of 71.8.

Four of the 11 stations surveyed in 2017 showed significantly higher IBI scores than over the past 10 years. They included Tom's Creek (04), Adams Creek (07), East Branch Wallenpaupack Creek (18), and Tom's Creek (20N). The remaining sites showed no

significant change or had too few years sampled to make a statistical analysis.

Table 4. Physical and chemical field data from eleven Pike County stream sites (May, 2017) – Pennsylvania Department of Environmental Protection 2009.

PARAMETER	STA. 02 Big Bushkill	STA. 03 Little Bushkill	STA. 04 Toms	STA. 05 Hornbeck 's	STA. 06 Dingman's	STA. 07 Adams
Sample Date	5/3/17	5/3/17	5/3/17	5/6/17	5/6/17	5/9/17
Temperature (°C)	14.0	13.1	12.7	13.5	12.5	12.3
Dissolved Oxygen (mg/l)	11.71	10.85	11.36	11.03	11.06	11.23
pH	7.76	8.07	7.63	7.09	7.26	7.2
Conductivity (µmhos/cm)	51.8	42.7	115.1	102.7	61.0	72.1
Alkalinity (mg/l)	15.0	15.0	15.0	15.0	15.0	15.0
PARAMETER	STA. 08 Raymondskill	STA 18 East Branch Wallenpaupack	STA. 20N Toms	STA.24N Sawkill	STA.25N Vandermark	
Sample Date	5/9/17	5/30/17	5/3/17	5/9/17	5/9/17	
Temperature (°C)	10.8	14.0	11.9	8.8	8.5	
Dissolved Oxygen (mg/l)	11.7	10.56	11.83	12.67	12.45	
pH	7.12	7.81	7.69	7.32	6.97	
Conductivity (µmhos/cm)	92.5	45.7	118.3	75.5	55.4	
Alkalinity (mg/l)	15.0	10.0	15.0	15.0	10.0	

Table 5. Habitat assessment of nineteen sampling stations on Pike County streams (2017) - Pennsylvania Department of Environmental Protection. 2009.

HABITAT PARAMETER	STA. 02 Big Bushkill 5/3/17	STA. 03 Little Bushkill 5/3/17	STA. 04 Toms 5/3/17	STA. 05 Hornbeck's 5/16/17	STA. 06 Dingman's 5/16/17	STA. 07 Adams 5/9/17
1. Instream Cover	18	18	17	15	20	19
2. Epifaunal Substrate	19	19	18	13	19	20
3. Embeddedness	17	17	19	17	20	19
4. Velocity/Depth Regimes	19	16	16	17	18	19
5. Channel Alteration	11	19	17	20	20	20
6. Sediment Deposition	18	18	18	16	19	18
7. Frequency of Riffles	18	19	16	17	20	20
8. Channel Flow Status	18	18	20	19	20	20
9. Condition of Banks	19	19	19	20	20	19
10. Bank Vegetative Protection	16	18	18	17	16	20
11. Grazing or Other Disruptive Pressure	19	20	20	20	20	20
12. Riparian Vegetative Zone Width	15	20	15	20	20	19
TOTAL SCORE	207	221	213	211	232	243

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

Table 5. (cont.).

HABITAT PARAMETER	STA. 08 Raymondskill 5/9/17	STA 18 East Branch Wallenpaupack 5/30/17	STA. 20N Toms 5/3/17	STA.24N Sawkill 5/9/17	STA.25N Vandermark 5/9/17	STA. 5 Hornbeck's 8/30/17
1. Instream Cover	18	13	17	18	17	9
2. Epifaunal Substrate	15	16	18	18	18	10
3. Embeddedness	18	16	19	18	18	16
4. Velocity/Depth Regimes	16	15	18	18	18	15
5. Channel Alteration	19	14	20	19	18	20
6. Sediment Deposition	16	16	18	19	18	17
7. Frequency of Riffles	15	19	17	16	19	14
8. Channel Flow Status	20	19	19	18	20	16
9. Condition of Banks	20	19	18	19	17	19
10. Bank Vegetative Protection	20	19	17	20	16	19
11. Grazing or Other Disruptive Pressure	19	16	20	20	17	20
12. Riparian Vegetative Zone Width	18	11	20	20	15	20
TOTAL SCORE	214	193	221	222	211	195

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

Table 5. (cont.).

HABITAT PARAMETER	STA. 12 Bush Kill 8/30/17	STA. 28N Westcolang 8/30/17	STA. 29N Teedyuskung 8/23/17	STA. 33N Balliard 8/23/17	STA. 38N Rattlesnake 8/23/17	STA. 44N Little Bushkill 8/30/17	STA. 51N Dimmock Meadows 8/30/17
1. Instream Cover	19	18	19	18	17	18	19
2. Epifaunal Substrate	20	17	18	17	18	18	18
3. Embeddedness	18	17	17	17	18	18	17
4. Velocity/Depth Regimes	19	17	17	17	16	18	15
5. Channel Alteration	19	20	18	18	20	20	20
6. Sediment Deposition	19	19	18	19	18	18	17
7. Frequency of Riffles	20	17	18	19	17	19	18
8. Channel Flow Status	18	16	16	17	18	17	16
9. Condition of Banks	19	19	14	18	19	19	20
10. Bank Vegetative Protection	19	19	16	18	19	20	19
11. Grazing or Other Disruptive Pressure	20	20	20	20	20	20	20
12. Riparian Vegetative Zone Width	18	20	20	20	20	20	20
TOTAL SCORE	228	219	211	218	220	225	219

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

Table 6. Metric scores for eleven benthic macroinvertebrate samples from Pike County stream sites (May, 2017).

METRIC	STA. 02 Big Bushkill	STA. 03 Little Bushkill	STA. 04 Toms	STA. 05 Hornbeck's	STA. 06 Dingman's	STA. 07 Adams
Total Taxa Richness	22	29	29	30	24	29
Diversity Index	2.49	2.67	2.85	2.73	2.56	2.82
EPT Taxa Richness	15	17	22	18	16	20
Hilsenhoff Biotic Index	3.47	3.38	1.86	3.46	3.61	2.35
Percent Intolerant Individuals	40.2	44.6	77.5	3.7	40.2	67.0
Modified Beck's Index	26%	28%	38%	18%	25%	31%
Index of Biotic Integrity	71.8	79.7	94.6	74.7	73.2	90.9

METRIC	STA. 08 Raymondskill	STA 18 East Branch Wallenpaupack	STA. 20N Toms	STA.24N Sawkill	STA.25N Vandermark	
Total Taxa Richness	33	29	28	27	22	
Diversity Index	2.57	2.85	21.9	2.6	2.33	
EPT Taxa Richness	19	21	19	21	16	
Hilsenhoff Biotic Index	4.55	3.43	1.7	2.85	2.08	
Percent Intolerant Individuals	26.2	47.1	91.1	49.5	80.4	
Modified Beck's Index	22%	28%	42%	34%	36%	
Index of Biotic Integrity	73.6	82.9	91.7	84.8	86.0	

FISH

Eight 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 7 – Appendix B). The streams surveyed fell into one of five width categories ranging from 1 (<10 feet) to 5 (>60 feet). Of the eight (8) stream stations, one had no upstream impoundments, three had one, and four had more than three.

Trout species were present at five of the eight stream sites surveyed. Brook and brown trout were collected from Dimmock Meadows (51N), brook trout from Teedyusking Creek (29N) and Little Bushkill Creek (44N), brown trout from Bush Kill (Millrift) Creek (12) and rainbow trout from Westcolang Creek (28N) - Table 7.

Largemouth bass were collected from Hornbeck's Creek (05). They were probably migrants from the upstream impoundment.

Table 7. Stream fish communities sampled for width category, impoundments in watershed, and game fish present in Pike County, PA (August, 2017)

STREAM SAMPLED	SITE ID	WIDTH CATEGORY	IMPOUNDMENTS ABOVE SAMPLE SITE	GAME FISH PRESENT
Hornbeck's Creek	05	2	1	Largemouth bass
Bush Kill Creek	12	2	1	Brown trout
Westcolang Creek	28N	2	>3	Rainbow trout
Teedyuskung Creek	29N	2	0	Brook trout
Balliard Creek	33N	3	>3	
Rattlesnake Creek	38N	2	>3	
Little Bushkill Creek	44N	3	>3	Brook trout
Dimmock Meadows	51N	2	1	Brook trout and 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 are less tolerant to thermal stress and sedimentation than brown trout and are usually associated with springs and headwater regions of watersheds. Brook trout also require high concentrations of dissolved oxygen to survive. Therefore, brook trout are usually associated with clean water conditions and are fairly intolerant to organic pollutants.

Trout reproduction was evident by the presence of young-of-year (YOY) fish at Bush Kill (Millrift) Creek and Dimmock Meadows Creek. Nineteen YOY brown trout were collected in Bush Kill Creek and one in Dimmock Meadows (Appendix B). Twelve YOY brook trout were found in Dimmock Meadows.

A total of 17 species of fish were collected from the eight streams surveyed in August of 2017 (Table 8). Blacknose dace were the dominant forage fish. The American eel (*Anguilla rostrata*), which is a catadromous fish (living in fresh water and spawning in salt water), was found at Bush Kill Creek (12), Westcolang Creek (28N), Rattlesnake Creek (38N) and Balliard Creek (33N). Sea lamprey, which is an anadromous fish (living in salt water and spawning in freshwater) was also collected in Rattlesnake Creek. Hornbeck's Creek (05) and Rattlesnake Creek (38N) had the greatest diversity of fish with 7 species present.

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 eight (8) stream sites surveyed ranged from fourteen (at Balliard Creek and Rattlesnake Creek to forty-four at Dimmock Meadows Creek – Table 9. Only Bush Kill (Millrift) Creek and Dimmock Meadows Creek had IBI indices considered good (≥ 23) and scores approximating those found in high quality streams of the region. Three of the stream sites had IBI scores that deviated significantly from previous years sampled (Ersbak, 1995-2016). They included Westcolang Creek (28N), Balliard Creek (33N), and Rattlesnake Creek (38N).

It is noteworthy, that of the 445 individual fish sampled, no external deformities (tumors, ulcers, etc.) indicative of stress resulting from chemical or physical pollutants were observed.

Table 8. Fish species collected from seven stream sites in Pike County, PA (August, 2017).

		8/30/17	8/30/17	8/30/17	8/23/17	8/23/17	8/23/17	8/30/17	8/30/17
Scientific Name	Common Name	Hornbeck's 05	Bush Kill 12	Westcolang 28N	Tedyuskung 29N	Balliard 33N	Rattlesnake 38N	Little Bushkill 44N	Dimmock Meadow 51N
<i>Anguilla rostrata</i>	American eel		11	1		4	5		
<i>Catostomus commersoni</i>	white sucker						1		
<i>Petromyzon marinus</i>	sea lamprey						3		
<i>Lepomis auritus</i>	red breasted sunfish	1							
<i>Rhinichthys atratulus</i>	blacknose dace	24	44	69	42	38	9	35	2
<i>Rhinichthys cataractae</i>	longnose dace		1			4			
<i>Salmo trutta</i>	brown trout		22						3
<i>Salvelinus fontinalis</i>	brook trout				6			1	21
<i>Oncorhynchus mykiss</i>	Rainbow trout			1					
<i>Esox niger</i>	Chain pickerel	2							
<i>Micropterus salmoides</i>	largemouth bass	4							
<i>Exoglossum maxillingua</i>	cutlips minnow					2	3		
<i>Semotilus atromaculatus</i>	creek chub						21	5	
<i>Luxilus cornutus</i>	common shiner	17			1	1	1		
<i>Etheostoma olmstedii</i>	tessellated darter								
<i>Lepomis macrochirus</i>	bluegill	22							
<i>Lepomis gibbosus</i>	pumpkinseed				3				
<i>Noturus insignis</i>	marginated madtom					3		5	
<i>Semotilus corporalis</i>	fallfish	4						2	
TOTAL		74	78	71	52	52	44	48	26

TABLE 9. Index of biotic integrity (IBI) test scores at 8 stream sites in Pike County, Pennsylvania (August, 2017).

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 05

Hornbeck's Creek

IBI Metrics	Metric Value	Test Score
IS	0	1
TOL	33	3
CARN	9	3
STENO	45	3
ST	0	1
I	38	1
P	33	3
CPE	74	1
L	63	1
YOY	0	1

IBI Score = 18

STATION 12

Bush Kill Creek

Metric Value	Test Score
0	1
57	1
29	5
29	1
43	3
44	3
71	5
78	1
86	3
19	5

28

STATION 28N

Westcolang Creek

Metric Value	Test Score
1	3
98	1
2	1
3	1
0	1
3	1
99	1
71	1
99	5
0	1

16

STATION 29N

Teedyuskung Creek

IBI Metrics	Metric Value	Test Score
IS	1	3
TOL	81	1
CARN	12	3
STENO	12	1
ST	100	5
I	20	1
P	81	1
CPE	52	1
L	14	1
YOY	0	1

IBI Score = 18

STATION 33N

Balliard Creek

Metric Value	Test Score
2	3
73	1
0	1
12	1
0	1
23	1
81	1
52	1
83	3
0	1

14

STATION 38N

Rattlesnake Creek

Metric Value	Test Score
1	3
72	1
0	1
19	1
0	1
14	1
82	1
37	1
82	3
0	1

14

STATION 44N
Little Bushkill
Creek

IBI Metrics	Metric Value	Test Score
IS	2	3
TOL	84	1
CARN	2	1
STENO	14	1
ST	100	5
I	19	1
P	84	1
CPE	48	1
L	90	5
YOY	0	1

IBI Score = 20

STATION 51N
Dimmock Meadow
Creek

Metric Value	Test Score
1	3
8	5
93	5
93	5
13	5
93	5
8	5
26	1
100	5
13	5

44

RECOMMENDATIONS

PCCD should continue its monitoring program of streams and rivers in the County. The cyclical rotation schedule of sites to be surveyed should be reviewed, and a revised schedule of sampling established, if necessary.

Based on historical data it is suggested the following be included in the 2018 sampling rotation for macroinvertebrate and fish populations:

Macroinvertebrates

- Big Bushkill 39N
- Saw 19N
- Wallenpaupack 17
- Lackawaxen 15
- Shohola 14
- West Falls 41N
- Pond Eddy 36N
- Shohola 35N
- Blooming Grove 32N

Fish

- Walker Lake 27
- West Falls 41
- Shohola 34
- Blooming Grove 32
- Little Bushkill 37

The significantly lower IBI score for the fish populations on Westcolang Creek (28N), Balliard Creek (33N), and Rattlesnake Creek (38N) is concerning. These sites should be sampled again within the next couple years to see if this low score was an anomaly or represents a decline in water quality.

Further testing should be considered for other new or existing stream sites threatened by environmental impacts or significant land use changes. Proposed large development projects should be considered in scheduling additional special study sites in the County's water quality monitoring program.

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Appendix A.

Taxa, numbers, and pollution tolerance values for the benthic macroinvertebrates from seventeen stream sites in Pike County for 2017.

TAXON	POL.											
ORDER	POL.	02	03	04	05	06	07	08	18	20N	24N	25N
GENERA/SPECIES	TOL.											
AMPHIPODA (freshwater shrimp)												
<i>Gammarus spp.</i>	4				7			1				
BIVALVIA (clams)												
<i>Pisidium spp.</i>	8		1			2		12				
COLEOPTERA (beetles)												
<i>Stenelmis spp.</i>	5	15	22		13	33	4	12	4			
<i>Promoresia spp.</i>	2				24		1		1			
<i>Microcylloepus spp.</i>	2										1	
<i>Optioservus spp.</i>	4		1		1			3				1
<i>Peltodytes spp.</i>	5		2									
<i>Psephenus herricki</i>	4	10	21	16	52	15	24	15	21	11	49	
DECAPODA (crayfish)												
<i>Cambarus spp.</i>	6									1		
DIPTERA (true flies)												
Chironomidae	8	53	47	13	24	46	8	85	46		37	32
<i>Blepharicera spp.</i>	0	1	4			1				3	2	10
<i>Tipula spp.</i>	4									1		
<i>Hexatoma spp.</i>	2			3			2			5	5	13
<i>Dicranota spp.</i>	3						2					
<i>Atherix spp.</i>	2				1			1				
<i>Antocha spp.</i>	3	1	3						4		1	
<i>Prosimulium spp.</i>	2			20						111		69
<i>Simulium spp.</i>	6	1		3				6		2		
EPHEMEROPTERA (mayflies)												
<i>Epeorus spp.</i>	0	4	16	37		2	3	3	5	20	26	20
<i>Mccaffertium spp.</i>	3		4		1	3	2	9	3		3	
<i>Stenacron spp.</i>	4				2							
<i>Heptagenia spp.</i>	4					3						
<i>Ephemerella spp.</i>	1	20	36	33	11	5	43	7	15	23	11	2
<i>Eurylophella spp.</i>	4											
<i>Drunella spp.</i>	1	20	8	1	5	5		5	12	3	5	
<i>Seratella spp.</i>	2	6	5	10					14		3	
<i>Habrophlebiodes spp.</i>	6						4					
<i>Leucrocuta spp.</i>	1					2						
<i>Paraleptophlebia spp.</i>	1		7	6		1	10	1	1	7	19	8
<i>Heterocloen spp.</i>	2											
<i>Cinygmula spp.</i>	1			5						4		20
<i>Nixe spp.</i>	2											

TAXON	POL.	02	03	04	05	06	07	08	18	20N	24N	25N
ORDER	POL.											
GENERA/SPECIES	TOL.											
EPHEMEROPTERA (mayflies)												
<i>Rithrogena spp.</i>	3								1			
<i>Plauditus spp.</i>	4							3				
<i>Isonychia spp.</i>	3		4	3	3	3	1	15	9	1		
<i>Ameletus spp.</i>	0											
<i>Baetis spp.</i>	6				6		7	2	11		4	
Baetidae	6											
<i>Acerpenna spp.</i>	6											
<i>Acentrella spp.</i>	4	19	11	2	3			3	6	2	2	
GASTROPODA (snails)												
<i>Ferrissia spp.</i>	7							2				
Physinae	8							1				
HIRUDINEA (leeches)												
<i>Myzobdella spp.</i>	7		1			1						
MEGALOPTERA (hellgramites)												
<i>Sialis spp.</i>	6						1	2				
<i>Corydalus spp.</i>	4		1		1			7				
<i>Nigronia spp.</i>	2			2	2		3	1		3		2
ODONATA (dragon flies)												
<i>Boyeria spp.</i>	2		1									
<i>Argia spp.</i>	6				3	1						
Gomphidae	4				1		4		2			
<i>Ophiogomphus spp.</i>	1								1			
<i>Lanthus spp.</i>	5			2	1	1		2		2		
OLIGOCHAETA (worms)	10	2	2			11			2			
PLECOPTERA (stoneflies)												
<i>Leuctra spp.</i>	0		1	3	5	34	8	5	13	3	8	9
<i>Amphinemura spp.</i>	3			4	3	5	4			8		2
<i>Pteronarcys spp.</i>	0			2			2				1	
<i>Acroneuria spp.</i>	0	12	6	12	8	15	20	8	5	8	7	1
<i>Paragnetina spp.</i>	1		1	2	1			1	12	1	3	
<i>Agneta spp.</i>	1	5	1	1							8	3
<i>Perlesta spp.</i>	4	2										
<i>Suwallia/Sweltsa spp.</i>	0		1	2			1			4	4	5
<i>Isoperla spp.</i>	2	1		4			8	1	1	1	1	2
TRICHOPTERA (caddisflies)												
<i>Chimarra spp.</i>	4				4	10	8	12	2			
<i>Dolophilodes spp.</i>	0	2	2				16		4	1	3	1
<i>Neophylax spp.</i>	3		1								1	
<i>Hydropsyche spp.</i>	5			3	9		2					

TAXON ORDER GENERA/SPECIES	POL. TOL.											
		02	03	04	05	06	07	08	18	20N	24N	25N
TRICHOPTERA (caddisflies)												
<i>Ceratopsyche spp.</i>	5	5	4	8	2	3	3	1	7	2	5	5
<i>Cheumatopsyche spp.</i>	6	4	10				1	1	9		2	
<i>Heliopsyche spp.</i>	3			2								
<i>Diplectrona spp.</i>	0			4		10	4			5		2
<i>Macrostemum spp.</i>	6							1				
<i>Rhyacophila spp.</i>	1	4		8	14	2	4		3	3	2	1
<i>Lepidostoma spp.</i>	1									1		
<i>Glossosoma spp.</i>	0											
<i>Psilotreta spp.</i>	0	1		2								5
<i>Psychomyia spp.</i>	2				1			2				
<i>Lype spp.</i>	2											
<i>Agapetus spp.</i>	5	6										
<i>Micrasema spp.</i>	2							1	1			
<i>Polycentropus spp.</i>	6				1	6		1	4		1	
<i>Pycnopsyche spp.</i>	4				4							1
TOTAL		233	253	242	235	238	220	253	269	252	229	227

METRICS	02	03	04	05	06	07	08	18	20N	24N	25N
Total Taxa Richness	22	29	29	30	24	29	33	29	28	27	22
Shannon Diversity Index	2.49	2.67	2.85	2.73	2.56	2.82	2.57	2.85	21.9	2.6	2.33
EPT Taxa Richness	15	17	22	18	16	20	19	21	19	21	16
Hilsenhoff Biotic Index	3.47	3.38	1.86	3.46	3.61	2.35	4.55	3.43	1.7	2.85	2.08
Percent Intolerant Individuals	40.2	44.6	77.5	3.7	40.2	67.0	26.2	47.1	91.1	49.5	80.4
Modified Beck's Index	26%	28%	38%	18%	25%	31%	22%	28%	42%	34%	36%
Index of Biotic Integrity	71.8	79.7	94.6	74.7	73.2	90.9	73.6	82.9	91.7	84.8	86.0

Appendix B

Taxa, numbers, and site description for the eight electrofishing stream sites in Pike County for 2017.

FISH FIELD COLLECTION DATA SHEET

PIKE COUNTY WATER QUALITY SURVEY

Stream/River – Little Bushkill Creek Township - Lehman DEP Water Use Classification HQCWF

Site I.D. #44N Date – 8/30/2017

Location – starting 150 yards upstream of road bridge

Sampling duration – 20 minutes Sampling Distance – 273 feet

Sampling area (ft2) – 7,996 Mean Stream Width – 29 feet

Weather /Comments - sunny

Temperature – 15.5 Celsius Dissolved oxygen – 9.62 ppm pH – 7.25 Alkalinity - 15

Gear used - Backpack Electroshocker Habitat rating - 225

Voltage – 250 Stream Width Category - 3

Scientific Name	Common Name	Number	Number of
Genus/Species		Collected	Anomalies
<i>Salvelinus fontinalis</i>	Brook trout (juvenile/adult)	1	
<i>Semotilus atromaculitis</i>	Creek Chub	5	
<i>Noturus insignis</i>	Margined madtom	5	
<i>Salvelinus fontinalis</i>	Fallfish	2	
<i>Rhinichthys atratulus</i>	Blacknose dace	35	

TOTAL 48

Anomalies = deformities, eroded fins, excessive mucous, fungus, reddening, tumors, and ulcers.

FISH FIELD COLLECTION DATA SHEET

PIKE COUNTY WATER QUALITY SURVEY

Stream/River – Rattlesnake Creek Township – Lackawaxen DEP Water Use Classification HQCWF

Site I.D. #38N Date – 8/23/2017

Location – starting 200 yards upstream of road bridge

Sampling duration – 23 minutes Sampling Distance – 250 feet

Sampling area (ft2) – 4,937 Mean Stream Width – 19.8 feet

Weather /Comments – rain night before – water clear

Temperature – Dissolved oxygen – pH – Alkalinity -

Gear used - Backpack Electroshocker Habitat rating - 220

Voltage - 250 Stream Width Category - 2

Scientific Name	Common Name	Number	Number of
Genus/Species		Collected	Anomalies
<i>Rhinichthys atratulus</i>	Blacknose dace	9	
<i>Noturus insignis</i>	Margined madtom	1	
<i>Semotilus atromaculitis</i>	Creek chub	21	
<i>Exoglossum maxillingua</i>	Cutlips minnow	3	
<i>Noturus insignis</i>	Margined madtom	1	
<i>Anguilla rostrata</i>	American eel	5	
<i>Petromyzon marinus</i>	Sea lamprey	3	
<i>Catostomus commersoni</i>	White sucker	1	

TOTAL 44

Anomalies = deformities, eroded fins, excessive mucous, fungus, reddening, tumors, and ulcers.

FISH FIELD COLLECTION DATA SHEET

PIKE COUNTY WATER QUALITY SURVEY

Stream/River – Westcolang Creek Township – Lackawaxen DEP Water Use Classification HQCWF

Site I.D. #28N Date – 8/30/2017

Location – 25 yards upstream of road bridge

Sampling duration – 20 minutes Sampling Distance – 200 feet

Sampling area (ft²) – 2,880 Mean Stream Width – 14.4 feet

Weather /Comments – sunny

Temperature – 16.2 Celsius Dissolved oxygen – 9.10 pH – 7.0 Alkalinity - 10

Gear used - Backpack Electroshocker Habitat rating - 219

Voltage - 300 Stream Width Category - 2

Scientific Name	Common Name	Number	Number of
Genus/Species		Collected	Anomalies
<i>Oncorhynchus mykiss</i>	Rainbow trout (juvenile/adult)	1	
<i>Anguilla rostrata</i>	American eel	1	
<i>Rhinichthys atratulus</i>	Blacknose dace	69	

TOTAL 71

Anomalies = deformities, eroded fins, excessive mucous, fungus, reddening, tumors, and ulcers.