Surface Water Assessments in Centre County Pennsylvania:

The Beech Creek Watershed

Healthy Waters #4100059330

Centre County Conservation District

Centre County chapter of the Pennsylvania Senior Environment Corps at ClearWater

Trout Unlimited-West Branch of the Susquehanna Restoration Coalition

EXECUTIVE SUMMARY

The Centre County Conservation District, Trout Unlimited and the Centre County Pennsylvania Senior Environment Corps (CCPaSEC) conducted the project *Surface Water Assessments in Centre County Pennsylvania: the Beech Creek Watershed* from April 27, 2012 to December 31, 2012. The project was part of a monitoring program established in 2010 by the members of the Centre County Pennsylvania Senior Environment Corps (CCPaSEC), Lock Haven University, the Centre County Conservation District and the Beech Creek Watershed Association.

During the grant period, two CCPaSEC teams monitored nine sites on a monthly basis in the Beech Creek Watershed, a combined monthly travel distance of approximately 160 miles. The sites were located on the following streams: Council Run, Unnamed tributary to Council Run, Hayes Run, Monument Run, Beech Creek, Little Sandy Run, Wolfe Run (2 sites) and Panther Run. The teams, in collaboration with Lock Haven University and the Beech Creek Watershed Association, chose these sites because of their proximity to Marcellus Shale drilling operations. The goal was two fold: to establish baseline water quality data prior to extensive drilling and to note any adverse changes to the landscape that may lead to impairment of water quality. Team members took the following field measurements: pH, DO, temperature, conductivity, salinity and flow. Each month they collected water samples that the District transported to Md. Khalequzzaman, Ph.D., Professor of Geology at Lock Haven University. Dr. Khalequzzaman and his graduate students analyzed the samples and provided detailed reports to CCPaSEC and the District. The Healthy Waters funding enabled us to send water samples three times during the grant period to the DEP laboratory for analysis in Harrisburg. In addition, the financial support allowed the District to contract with Trout Unlimited to conduct macroinvertebrate inventories and to complete habitat assessments at each site. Biologist Dr. Shawn Rummel performed these tasks. These assessments and inventories, coupled with the chemical analyses, constitute the framework for our future conservation endeavors.

The findings in the Healthy Waters Initiative project indicate that, with the exception of Beech Creek, all streams in the study area are healthy. Abandoned mine drainage (AMD) impairs the main stem of Beech Creek, but many tributaries, including those in this study, are untouched by the legacy left by unsafe coal mining. The area is undergoing development. New gas well sites, gas pipelines and service roads are being installed. The fact that there are healthy waters in an AMD impaired watershed underscores the need to protect and preserve these valuable resources. CCPaSEC observers previously documented a roadway erosion and sediment problem in the Council Run Watershed that was mitigated by the District and Anadarko.

Some of the study's sample sites are located deep within the forest and others are situated near small disadvantaged communities. The recommendations for the protection of the streams are based on practical observations of the geographical area. The Centre County Conservation District and the Centre County chapter of the Pennsylvania Senior Environment Corps have made commitments to carry out these recommendations to the best of their abilities. This report will serve as a guide to those individuals who will continue to work to preserve and protect the healthy waters in the Beech Creek watershed.

The Centre County Conservation District is a county agency functioning as the primary local source of assistance to county residents on conservation issues. The District works closely with the Pennsylvania Department of Environmental Protection, local community groups, farmers, landowners, municipalities and developers.

Trout Unlimited is a national organization with more than 140,000 volunteers organized into 400 chapters throughout the United States. TU supports a staff of lawyers, policy experts and scientists in more than 30 offices nationwide. These conservation professionals ensure that TU is at the forefront of fisheries restoration work at the local, state and national levels.

CCPaSEC is a volunteer organization whose mission is to develop and support teams of senior citizens who gather and publish data on the quality of water in the streams of Centre County. They post data for each of the sites on their public website. (http://ccpasec.centreconnect.org/). Members meet monthly for training, quality control instruction and data analysis. The group engages in cooperative projects with ClearWater Conservancy, the Centre County Conservation District, and the PA Department of Environmental Protection.

ACKNOWLEDGEMENTS

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Photos are courtesy of: Terri Davis, Joyce McKay, Ken Johnson, Dan DeLotto, KathiFerrigno, and Ann Donovan

Dr. Md. Khalequzzaman working with CCPaSEC volunteers in the Beech Creek watershed.

PROJECT BACKGROUND

Federal Healthy Waters Program

The federal Healthy Waters Program provided funding for this study, *Surface Water Assessments in Centre County Pennsylvania: the Beech Creek Watershed*. The Healthy Watersheds Initiative (HWI) is an Environmental Protection Agency (EPA) program that intends to protect the nation's healthy watersheds, prevent them from becoming impaired, and accelerate our restoration successes. The purpose of the program is to retain or improve the integrity of our most valuable and least impaired streams and watersheds. It is part of the Environmental Protection Agency's commitment to focus on protecting healthy waters and watersheds, a key action for achieving our clean water goals. Healthy watersheds provide many ecological services as well as economic benefits. A goal is to offer an early warning to the local residents and the Commonwealth of the potential factors that could lead to degradation in the health of the water or the quality of life for the residents. If successfully implemented, the HWI promises to enhance our ability to meet the Clean Water Act Section 101(a) objective of restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters by protecting healthy watersheds as dynamic systems interconnected in the landscape.

Centre County Healthy Waters Project

The Pennsylvania Department of Environmental Protection (DEP) and the Centre County Conservation District executed the Centre County project, Healthy Waters #41000059330, *Surface Water Assessments in Centre County Pennsylvania: The Beech Creek Watershed* on April 27, 2012. The project concluded on December 31, 2012. This project enhanced an existing Centre County Pennsylvania Senior Environmental Corps (CCPaSEC) volunteer monitoring program in the Beech Creek watershed. CCPaSEC is a non-profit, volunteer organization affiliated with the Clear Water Conservancy, located in State College, Pennsylvania, and is supported in part by Nature Abounds, a national non-profit organization.

Beginning in 2009, volunteer monitors from this group have sampled 9 stream sites that are in close proximity to natural gas drilling pads in the Marcellus shale region of northcentral Pennsylvania. Lock Haven University and the Centre County Conservation District collaborated with CCPaSEC and the Beech Creek Watershed Association to establish this program. Both the university and the Centre County Conservation District continue to be active partners in this project. The original goals of this project were to establish baseline date for these streams and to determine if pollutants from natural gas drilling activities were present at the sample sites.

Two teams of CCPaSEC volunteers (Teams 13 and 14) monitored nine (9) sample sites in the Beech Creek watershed (Figure 1). Team 13, led by Dan DeLotto, entered the watershed from the town of Beech Creek to sample the eastern portion of the watershed and Team 14, led by Ken Johnson, entered the watershed from the area of Snowshoe to monitor streams in the western portion of the watershed. The streams sampled as part of this monitoring effort included: Beech Creek, Hayes Run, Council Run,UNT 22700 to Council Run, Monument Run, Panther Run, Wolf Run, and Sandy Run. Each team performed the following field measurements: pH, dissolved oxygen, water temperature, conductivity, and flow. Each month they collected water samples that the Centre County Conservation District transported to Md. Khalequzzaman, Ph.D., Professor of Geology at Lock Haven University. Dr. Khalequzzaman and his graduate students analyzed the samples and provided CCPaSEC and the Centre County Conservation District with a detailed report of the results. Funding from the Healthy Waters Program enabled us to also send water samples to the DEP laboratory in Harrisburg on three separate occasions.

a) b)

Figure 1: a) Members of Team 13, pictured from left to right: Kent Addis, Dan DeLotto, KathiFerrigno, and Dick Shreve. **b)** Members of Team 14, pictured from left to right: Mike Schmidt, Bill Leech, Terri Davis, and Ken Johnson.

OB JECTIVES

In addition to the objectives mentioned above, the main objectives of the Centre County Healthy Waters Project were to:

- Establish baseline chemical, biological, and habitat data for these streams.
- Observe and document potential threats to the integrity of the watershed. Potential threats include changes in land-use, erosion, sedimentation, and changes in chemical, biological, or habitat quality of the waterways.
- Integrate and utilize the Lock Haven University study begun by Dr. Khalequzzaman.
- Help to ensure the protection of healthy, unimpaired streams in an area severely impacted by abandoned mine drainage (AMD). The main stem of Beech Creek is impacted by AMD and monitoring could help to determine improvement or support future remediation efforts.
- Establish, maintain, and share a database of the streams and their supporting data.
- Provide commentary on threats to the watershed's integrity and develop ideas for enhancing the protection of this resource.

- Meet with local planners to discuss the findings of this report.

BEECH CREEK WATERSHED DESCRIPTION

The Beech Creek watershed is located in Centre and Clinton counties in north central Pennsylvania. The watershed drains an area of approximately 171 square miles and includes nearly 300 miles of streams. It covers ten municipalities in both counties; including the boroughs of Beech Creek (Clinton County) and Snow Shoe (Centre County).In Centre County, the watershed is located within Snow Shoe Township, Curtin Township and parts of Liberty Township, Burnside Township and Union Township. In Clinton County, the watershed is located within Beech Creek Township and Noyes Township. Beech Creek is a tributary to Bald Eagle Creek, which flows into the West Branch of the Susquehanna River. Eventually the Susquehanna River flows into the Chesapeake Bay at Harve de Grace, Maryland.

The largest landowner in the Beech Creek watershed is the Commonwealth of Pennsylvania (Figure 2). Approximately 53% of the watershed is public land managed as state game land and state forest land. The Sproul State Forest comprises approximately 48% of the watershed and the Moshannon State Forest covers about 0.2% of the watershed. The Pennsylvania Game Commission manages 5% as State Game Land 100 in the western end of the watershed and a small portion of State Game Land 103. The watershed is located within the boundaries of the Pennsylvania Wilds, a state natural resource management and outdoor recreational tourism and economic revitalization area covering a 13 county region in north central Pennsylvania.

Land use in the Beech Creek watershed is primarily forested (86% of the total area), predominantly with deciduous trees. Other land uses within the watershed include agriculture (6%) quarries and coal mines (5%), and transitional and water features (2%) (Beech Creek CHP 2006-2007). People live in the small communities of Snow Shoe, Clarence, Beech Creek, Monument, and Orviston or in the rural countryside.

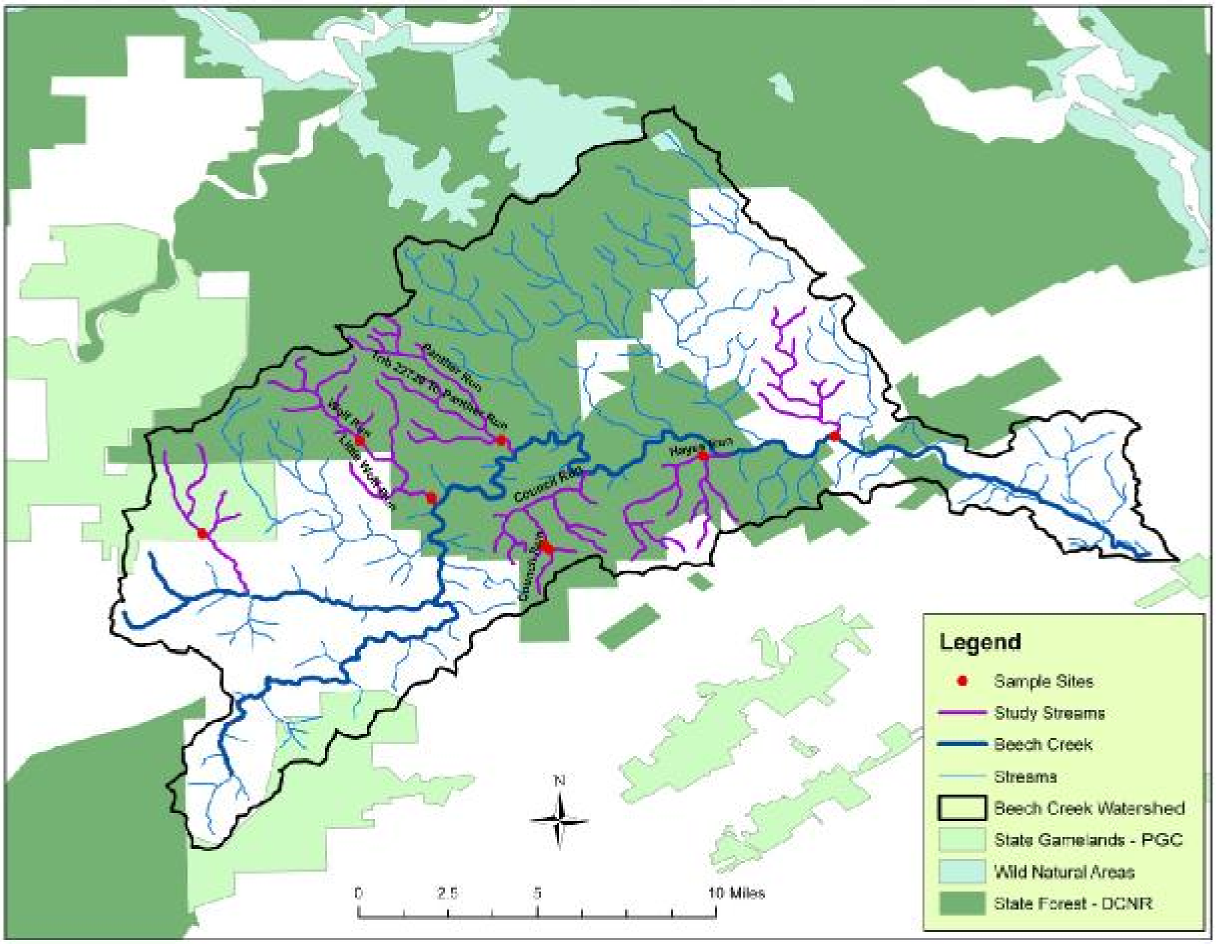

Figure 2: Map of Beech Creek watershed showing land owned by the Commonwealth of Pennsylvania. Streams that were part of this project are highlighted in purple. Sample sites are also indicated on the map.

Natural resources have played a major role within the watershed with coal mining, timber extraction, and clay mining beginning in the watershed in the mid-1800's. The watershed lies in the northeastern tip of the bituminous coal and natural gas fields. Beech Creek is listed by the DEP as impaired by abandoned mine drainage (AMD) from historical mining practices. Over 80 stream miles within the Beech Creek watershed are listed as impaired, primarily by AMD. In addition to AMD impairments, the watershed is also negatively impacted by atmospheric deposition, resulting in net acidic streams. A complete overview and background of the Beech Creek watershed can be found in the Beech Creek Watershed Coldwater Heritage Plan (2006-2007).

METHODS

Description of Sample Sites

CCPaSEC volunteers have been sampling nine (9) sites in the Beech Creek watershed since May 2010 on a monthly basis from February to November. Figure 3 and Table 1 provide the locations of the sample sites. The sample sites are located on the following streams: Beech Creek, Hayes Run, Council Run, UNT 22700 to Council Run, Monument Run, Panther Run, Wolf Run, and Sandy Run. Each sampling effort was completed by two teams of CCPaSEC volunteers. One team, led by Dan DeLotto, sampled the sites located in the eastern portion of the watershed. The sample sites located in the western portion of the watershed were sampled by a team led by Ken Johnson. The teams visited the sample sites on successive days to avoid variation in stream flows due to precipitation events. Several of the sample streams have special designation by the DEP as Exceptional Value (EV) or High Quality Coldwater Fisheries (HQ-CWF) (Figure 4). In addition, several streams and sections of streams are actively managed by the Pennsylvania Fish and Boat Commission (PFBC) (Figure 5). Detailed site descriptions are provided below.

Eastern Sample Sites:

- *Council Run*: Council Run is located in the south central portion of the Beech Creek watershed. Samples were taken just below the bridge on the Orviston/Kato Road. Upstream of the site there is some impairment from aluminum.
- *UNT 22700 to Council Run*: Samples were taken at the mouth of the unnamed tributary that enters Council Run just above the Council Run sample site.
- *Hayes Run*: Hayes Run is an EV stream located in the south central portion of the watershed. Samples were taken at a site approximately ¾ mile upstream from Hayes Run's confluence with Beech Creek, located just outside of the town of Orviston. An abandoned impoundment, which formerly was the Orviston drinking reservoir is located near the sample site. Parking is available at a pull-off and the site is accessible via a well-kept path through the woods. Landowner permission was secured by Dan DeLotto prior to accessing the site.
- *Monument Run*: Monument Run is designated as a HQ-CWF. It is located in the eastern portion of the watershed. Monument Run is a shallow, rocky-bottomed stream with a dense understory of mountain laurel in a mixed hemlock and deciduous forest. The sample site is located in a private yard near the confluence of the stream with Beech Creek. Over the years, residents have built artificial waterfall-like structures that have altered the stream. There is very little riparian buffer in this section of the stream and landowners mow to the edge of the stream.
- *Beech Creek*: The sample site on the main stem of Beech Creek is located just above the dilapidated bridge and just outside the channel created by Monument Run in the town of Monument. AMD impairs the main stem of Beech Creek and the water is red in color due to iron precipitate.

Western Sample Sites:

- *Sandy Run*: The sample site on Sandy Run is located just upstream of the Three Point Sportsman's fish hatchery, near the town of Clarence. Here the water flows along a small sandy beach area. An impoundment built by the Three Point Sportsman's Club creates a lake just below the sample site.
- *Wolf Run*: There are two sample sites located on Wolf Run. The first is located off State Line Road. This sample site is located approximately 100 meters downstream of the bridge on State Line Road. The second sample site is located further downstream. This sample site is located just upstream of the bridge on Panther Road.
- *Panther Run*: Panther Run is listed as an EV stream and supports its designated use for aquatic life. The sample site on Panther Run is the most inaccessible site visited by CCPaSEC volunteers. The site is located off Clubhouse Road.

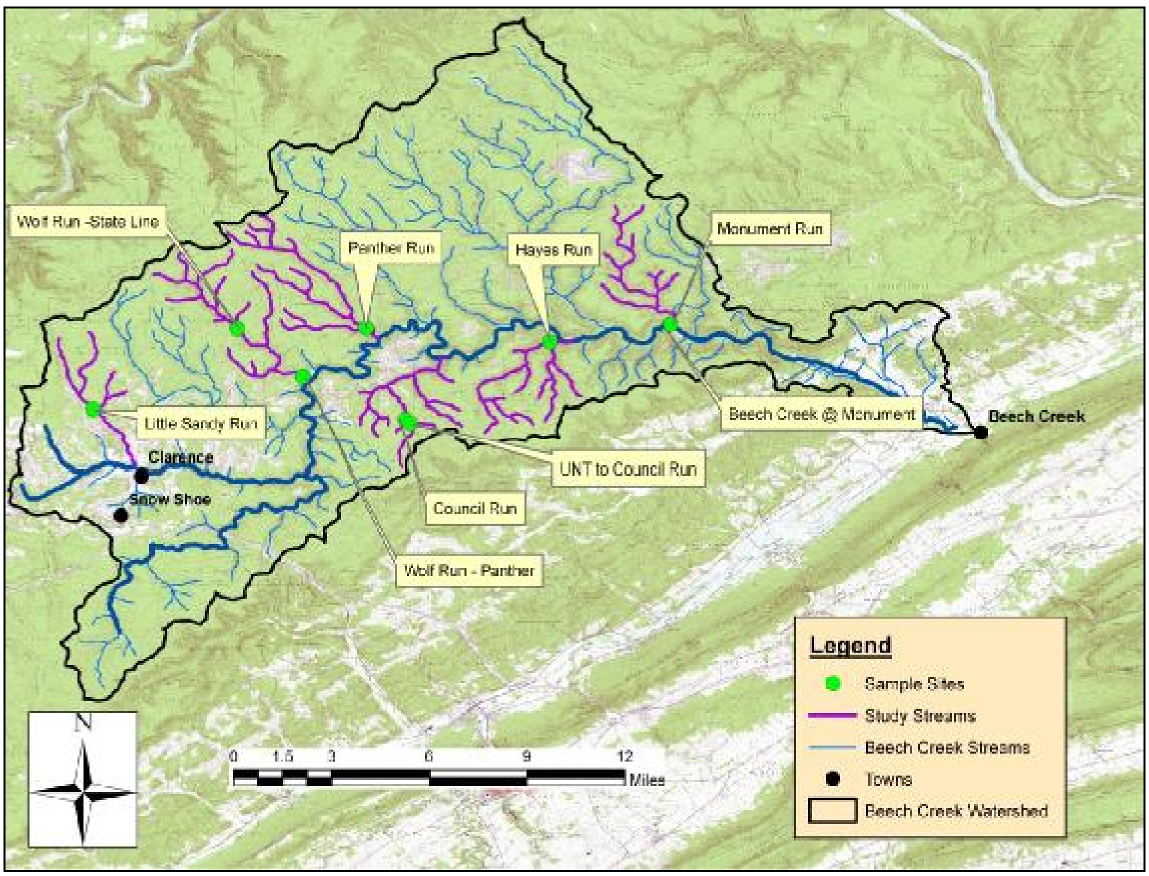

Figure 3: Map of sample locations for the Centre County Healthy Waters Project.

Table 1: Sample site locations and site descriptions for the Centre County Healthy Waters Project.

Site #	Site Description	Latitude (N)	Longitude (W)
1	Wolf Run at Panther Road	41.090079	-77.867958
2	Wolf Run at State Line Road	41.111490	-77.896985
3	Little Sandy Run at Hatchery	41.075765	-77.961007
4	Panther Run at Clubhouse	41.111676	-77.961007
5	Council Run	41.071301	-77.822401
6	UNT 22700 to Council Run	41.069674	-77.820275
7	Hayes Run	41.105375	-77.758125
8	Monument Run	41.113315	-77.704523
9	Beech Creek at Monument	41.113223	-77.704813

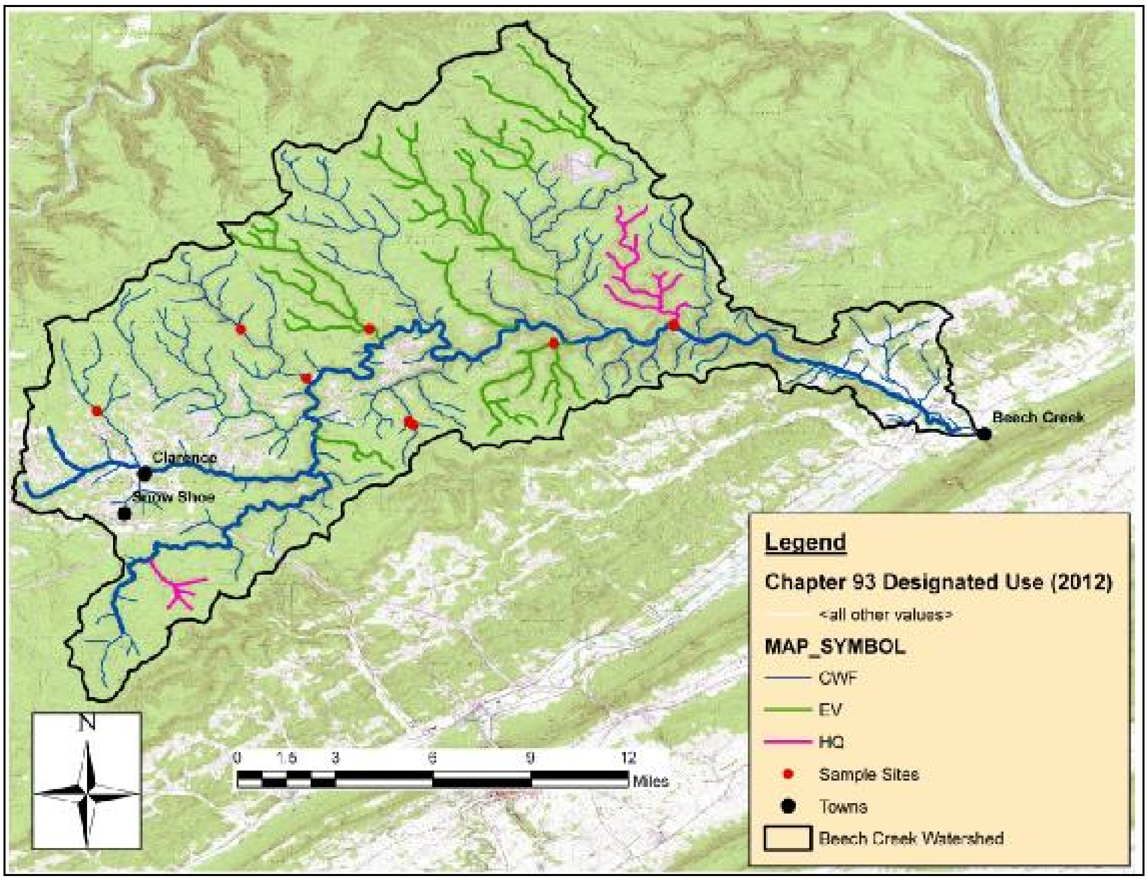

Figure 4: DEP stream designations within the Beech Creek watershed. Sample site locations are indicated on the map.

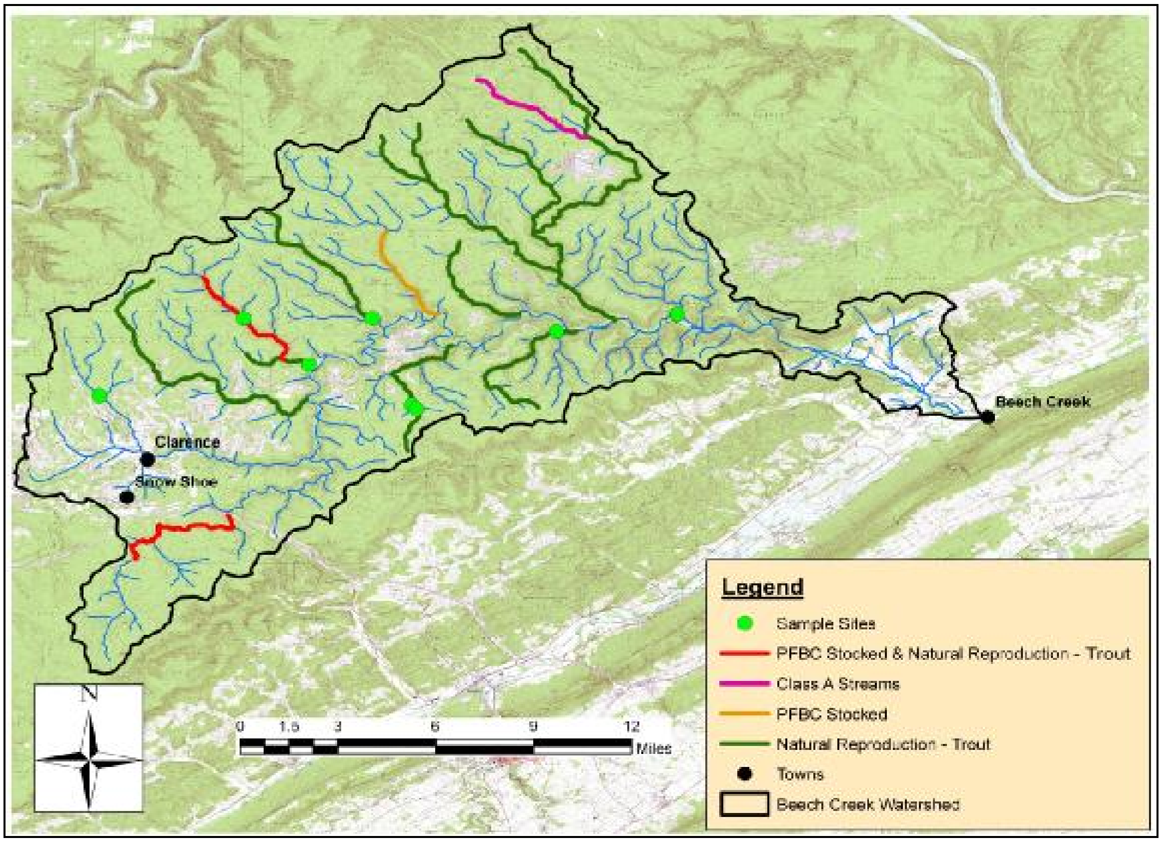

Figure 5: Stream segments within the Beech Creek watershed that are actively managed by the Pennsylvania Fish and Boat Commission (PFBC).

Water Quality Monitoring

In-stream water quality was evaluated in the field on the day of sampling for each of the nine sample sites. A 1000mL plastic bottle was filled with water from the sample site. The bottle was flushed three times in the stream prior to the sample being taken. All field measurements were taken from this sample immediately after the sample was taken.An Oakton multi-parameter Tester 35(model: PCSTestr35) was used to measure the air and water temperature, pH, EC, total dissolved solids (TDS), and salinity. The meter was calibrated for pH and electrical conductivity prior to each sampling event. A standard U.S. 3 point calibration was applied with unexpiredHach or Oakton buffer solutions of 4.01, 7.0, & 10.01 pH. A single point EC calibration was also completed with either Hach or Oakton 1500uS/cm or 1413uS/cm standard solutions prior to each sampling event. This meter also contains a digital thermometer which was calibrated at the beginning of the year with a reliable fishing thermometer.
AHach Colorimeter (model: DR/850) was used solely for dissolved oxygen (DO) measurements. DO measurements were taken at streamside due to the sensitivity of this measurement to temperature. This measurement process requires a vacuum sealed, glass ampul which contains reagents that react with the water drawn into it by the vacuum (Figure 6). After some time and agitation, the water is discolored such that it can be interpreted by the instrument as a DO level. Care was taken to keep the tube containing each stream's water sample free of condensation or

smudges, since it was used to zero the meter. Also the reading chamber and ampul were consistently wiped clean with Q-tips and a cloth to ensure accuracy. In addition, comparisons of DO measurements were made where the ampul was submerged directly into the stream, versus those done on a bottled stream sample as mentioned above. Little difference was found in the results. For either method, the colorimeter cannot be placed in the water, and the ampul would be exposed to ambient air temperature when shaking. The air & water temperature were taken with the Oakton meter almost concurrently with the DO measurement, since a different meter was used. DO results were not compensated for temperature or altitude. These measurements were closely followed by EC, TDS, salinity, and pH in that order.

Figure 6: Photograph of the glass ampule used to obtain dissolved oxygen measurements.

A Flowatch flow meter (model FW450), manufactured by JDC Electronics in Switzerland, was used to measure water velocity at several cross sections in order to calculate the total discharge at each sample site. A stream cross section was selected at each site that had characteristics conducive to making an accurate flow measurement. Steep banks on both sides and a fairly consistent, level steam bed were the ideal. Orange stakes were driven into the bank indicating the chosen cross section's extremes. They were oriented such that the cross section was perpendicular to the stream flow. A 50' Keson "rule on a spool" with a fiberglass, metric, blade was then stretched across the stream between the stakes. Left or right bank origin was documented along with a stream width on our "Stream Flow Calculation Sheet" (see Appendix A). Based on the width of the stream, the number of stream segments or intervals were determined. It was recommended that a minimum of 20 segments per site be used. Though one can straddle at least one of the streams, an attempt was made to conform to this guideline. In those months when the samples were sent to the DEP Laboratory in Harrisburg, a minimum of

18 stream segments were used, with 20 being the norm. For the other seven months, between 5 and 10 stream segments/intervals were used, depending on the water levels. Depth measurements were made at each stream segment/interval using a meter stick attached to a walking stick. Velocities were taken at the corresponding intervals with the aforementioned flow meter. All of dimensions and velocities were recorded by hand at stream side on a "Flow Data Sheet" (see Appendix A). This data was then entered into a Microsoft Excel spread sheet which multiplies each stream segments' width x length x velocity and then sums the individual segment flows to obtain a total discharge measurement for each site.The calculated discharges, along with the field chemical data obtainedin the field were recorded on our "Streamside Worksheet" (see Appendix B) and were later transferred to our official CCPaSEC Excel spread sheet.

In addition to field chemistry measurements, grab samples were also taken for analysis in a laboratory. Lock Haven University and the DEP laboratories collaborated to perform these analyses. Sampling protocols differed slightly between the two laboratories and are outlined below.

*Sampling for Lock Haven University (LHU):*A single 1000 ml grab samplewas taken from each of the nine samples sites on a monthly basis from February to November in 2010, 2011, and 2012. The samples were not normalized in any way, nor were any blanks or duplicates taken. The sample bottles were provided by LHU. Prior to collecting the sample, the bottles were rinsed in the stream 3 times. Care was taken to sample as close to the center of the water column as possible, facing the mouth of the bottle upstream, and keeping the body and any foot turbidity downstream as far from the sample as possible. The samples were immediately placed in a styrofoam cooler with an icepack and kept refrigerated until they could be analyzed in the Lock Haven University's Geology Department. Laboratory.

Sampling for the DEP laboratory in Harrisburg: DEP water quality samples were collected in April, July, and September of 2012 in accordance with DEP protocol. A total of four samples, in addition to the LHU sample, were collected at each of the nine sample sites. Two, 500ml samples and two 125ml samples were collected using bottles provided by the DEP Healthy Waters Program. One of the 125ml samples was fixed with sulfuric acid for phosphate and nitrate analysis and the other was fixed with nitric acid for metals analysis. In both cases, a small pipette of acid was sufficient to normalize the sample. The pH of each normalized sample was tested in the cap of the bottle using a pH test strip so as to not contaminate the sample with the pH test strip. One set of four blank and duplicate samples were included with each of the three sets of samples. A total of 44 samples (including blank and duplicate samples) were collected in each of the three months. These samples were immediately packed in ice and shipped by courier to the DEP lab in Harrisburg, PA. Every effort was made to meet the EPA requirement that the laboratory be able to analyze the samples within 72 hours of collection. All of the samples were shipped from State College within 24 hours of being collected. Although some tests were not performed within the 72 hour requirement, all of the data was determined valid by the DEP. The parameters analyzed in the DEP laboratory and test methods are given in Table 2.

Table 2: Water quality parameters and test methods used by the DEP laboratory in Harrisburg, PA.

Parameter	Test Method	Units
Alkalinity	00410	mg/L
Aluminum	01105A	µg/L
Ammonia-NT	00610A	mg/L
Arsenic T	01002H	µg/L
Barium T	01007A	µg/L
BOD5 INHIB	00314	mg/L
Boron T	01022K	µg/L
Bromide	99020	µg/L
Calcium T	00916A	mg/L
Chloride IC	00940	mg/L
Copper T	01042A	µg/L
Hardness	00900	mg/L
Iron T	01045A	µg/L
Lead T	01051H	µg/L
Lithium T	01132A	µg/L
Magnesium T	00927A	mg/L
Manganese T	01055A	µg/L
Mercury T	719001	µg/L
NO3+NO2-N	00630A	mg/L
OsmoPres	82550	mOsm
pH	00403	pH
Phosphorus T	00665A	mg/L
Selenium T	01147H	µg/L
Sodium T	00929A	mg/L
SPC @ 25^0C	00095	µmhos/cm
Strontium T	01082A	µg/L
Sulfate – IC	00945	mg/L
T Susp Solids	00530	mg/L
TDS 180	70300U	mg/L
Zinc T	01092A	µg/L

In-stream Habitat Evaluation

Habitat was evaluated for 100 meters at eight of the sample sites using DEP's *Water Quality Network Habitat Assessment* form, which considers the following twelve parameters: instream cover, epifaunal substrate, embeddedness, velocity/depth regimes, channel alteration, sediment deposition, frequency of riffles, channel flow status, condition of banks, bank vegetative protection, grazing or other disruptive pressure, and riparian vegetation zone width. These parameters are explained in Appendix C. Habitat was not evaluated on the main stem of Beech Creek (Beech Creek at Monument sample site). Each parameter is given a score (from 0 – 20) based on a visual survey of the sample site. The scores from each parameter are summed to obtain an overall habitat score. The habitat scoring system is as follows: the "optimal" category scores from 240 to 192, “suboptimal” from 180-132, “marginal” from 120 – 72, and “poor” is a site with a combined score less than 60. The gaps between these categories are left to the discretion of the investigator’s best professional judgment.

Benthic Macroinvertebrate Surveys

Benthic macroinvertebrates were collected according to Pennsylvania Department of Environmental Protection’s (DEP) Instream Comprehensive Evaluation (ICE) protocol (specifically section C.1.b. *Antidegradation Surveys*). A benthic macroinvertebrate sample consisted of a combination of six D-frame efforts in a 100-meter stream section. Sampling effort was distributed to select the best riffle habitat areas with varying depths. Each effort sampled an area of 1 m^2 and a minimum depth of 10.2 cm as the substrate allowed. Sample efforts used a 500 micron mesh, 12 inch diameter D-frame kick net. The six individual samples were composited and preserved in ethanol for processing in the laboratory.

Benthic macroinvertebrates were processed according to semi-qualitative protocols. These protocols require that the sample be deposited into a 3.5 inch deep rectangular pan (14” x 8”) marked in 2” x 2” grids. Four grids are randomly selected and their contents placed into another pan. Organisms from the second pan are sorted from randomly selected 2” x 2” grids until a 200 organism subsample is achieved. If less than 160 identifiable organisms are obtained, additional randomly selected grids from the first pan are added to the subsample until the target of 200 ± 40 organisms is reached. If more than 240 identifiable organisms are subsampled from the original four grids, one randomly selected grid will be removed until the target number of 200 ± 40 organisms is obtained.

Benthic macroinvertebrates were identified to the lowest possible taxonomic level by a North American Bentholigial Society certified taxonomist. In most cases, organisms were identified to genus. Samples were evaluated according to the six metrics comprising the DEP’s Index of Biological Integrity (Total Taxa Richness, EPT Taxa Richness, Beck’s Index V.3, Shannon Diversity, Hillsenhoff Biotic Index, and Percent Sensitive Individuals). Appendix D contains a description of each of these six metrics. These metrics were standardized and used to determine if the stream met the Aquatic Life Use (ALU) threshold for coldwater fishes, warmwater fishes, and trout stocked fishes (Figure 7). Biological metrics are provided for sites containing less than 160 individuals however, an IBI score was not calculated for these sites because sites with less than 160 individuals do not qualify according to DEP.

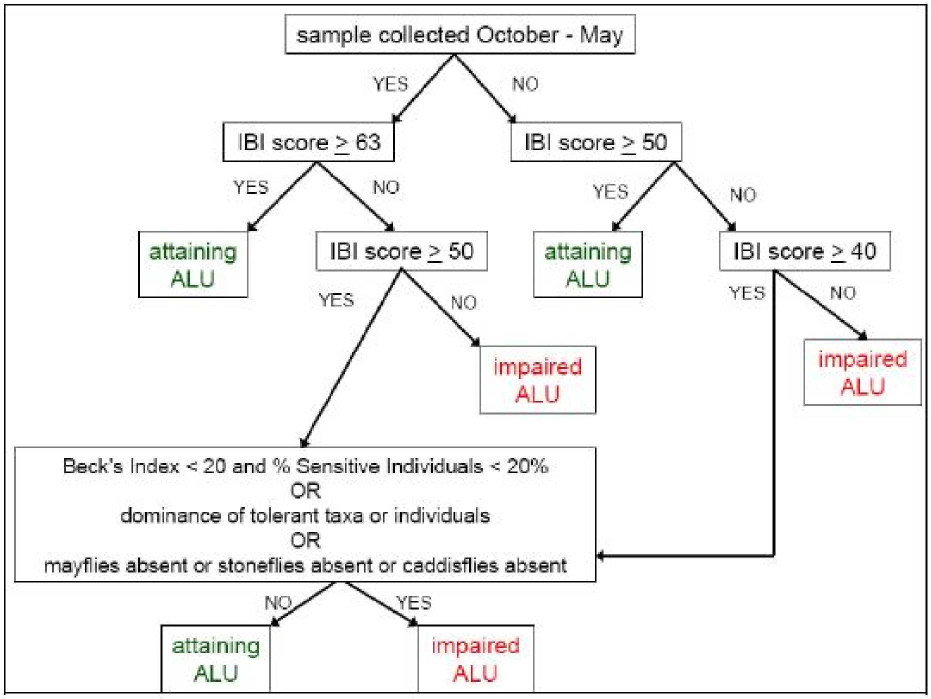

Figure 7: ALU Attainment and Impairment Thresholds for Coldwater Fishes (CWF), Warmwater Fishes (WWF), and Trout Stocked Fishes (TSF) Protected Uses (Department of Environmental Protection, 2009).

RESULTS

Water Quality Monitoring

The complete set of water quality data is available in Appendix E (see CD insert). In addition, data collected by the CCPaSEC may also be accessed online through the CCPaSEC website (http://ccpasec.centreconnect.org). Pennsylvania's water quality standards, which are codified in Chapter 93 and portions of Chapter 92a, are designed to implement the requirements of Sections 5 and 402 of The Clean Streams Law and Section 303 of the Federal Clean Water Act (33 U.S.C.A. § 1313). A summary of the Chapter 93 water quality standards is located in Table 3.

Table 3: Summary of select Pennsylvania Chapter 93 water quality standards.

Parameter	**Chapter 93 Water Quality Standard**
Alkalinity	Min. 20 mg/l as $CaCO_3$, except where natural conditions are less
Aluminum	0.75 mg/l (toxic substance), >0.5 mg/l (no life)
Arsenic	1.0 mg/l
Chloride	Max 250 mg/l
Copper	0.96 mg/l
Dissolved Oxygen	Min. 5.0 mg/l
Iron	30 day avg. 1.5 mg/l as total recoverable; Max 0.3 mg/l as dissolved
Mercury	0.85 mg/l
Manganese	Max 1.0 mg/l total
Nitrite-Nitrate	Max 10 mg/l
pH	pH 6.0-9.0
Selenium	0.922 mg/l
Sulfate	Max. 250 mg/l
Zinc	0.986 mg/l (chronic); 0.978 mg/l (acute)

Water quality results from the field surveys are summarized in Table 4. The only parameter that violated Chapter 93 water quality standards was pH at the sample site on Beech Creek in Monument. The dissolved oxygen was adequate in each of the samples to support biological life in a cold water environment. With the exception of the Beech Creek site (Figure 8), which is polluted by AMD, the conductivities were characteristic of the area.

Laboratory results from the Lock Haven University are summarized in Table 5. DEP water quality data is provided in Table 6(a-d). Water quality data from both LHU and DEP laboratories are available in Appendix E (see CD insert). Overall, water quality was adequate to support aquatic life at each of the sample sites, with the exception of the sample site on the mainstem of Beech Creek. Alkalinity was lower than the 20 mg/l as $CaCO_3$ Chapter 93 standard.

However, this is likely due to the geology underlying the watershed. The watershed is primarily sandstone, which is a naturally acidic geology, with little buffering capacity. No violations to Chapter 93 water quality standards were observed in any of the samples by LHU or DEP laboratories, with the exception of the sample site on Beech Creek in Monument. This site violated Chapter 93 water quality standards for pH, aluminum concentrations, and manganese concentrations. Violations for these parameters are typical for streams impaired by AMD. In addition to AMD in the Beech Creek watershed, atmospheric acid deposition, caused by emissions from coal-fired power plants and automotive emissions, is also an issue throughout the watershed (Beech Creek Coldwater Heritage Plan, 2006-2007). Episodic acidification events from atmospheric acid deposition can cause depressed pH and elevated acid and metal concentrations during high stream flows. This may explain some of the variation in pH and metal concentrations with varying flow rates in streams such as Council Run. However, coupled with the benthic macroinvertebrate survey results, it does not appear that any of the tributaries sampled are experiencing water quality issues severe enough to inhibit biological life. In addition, based on the water chemistry, it would appear (with the exception of the main stem of Beech Creek) that these sample sites could be considered healthy waterways.

Table 4: Mean (standard deviation) water quality results obtained from measurements taken in the field. Samples were collected on monthly basis from February to November 2012 (10 samples total).

	Wolf Run (Panther Rd.)	Wolf Run (State Line Rd.)	Little Sandy Run	Panther Run	Council Run	UNT to Council Run	Hayes Run	Monument Run	Beech Creek
pH	6.7 (0.7)	6.9 (0.5)	6.9 (0.6)	7.3 (0.5)	6.1 (0.7)	6.7 (0.5)	6.8 (0.3)	6.8 (0.28)	4.9 (0.5)
Water Temp (deg C)	12.48 (3.54)	10.8 (2.63)	11.04 (3.69)	11.57 (2.63)	10.76 (3.11)	11.0 (1.57)	11.27 (4.13)	10.82 (3.83)	12.38 (5.59)
DO (mg/l)	11.75 (1.24)	11.71 (1.39)	11.98 (1.73)	11.42 (1.36)	11.16 (1.58)	11.43 (1.28)	12.0 (1.54)	11.42 (1.37)	11.19 (1.82)
Conductivity (uS/cm)	35.18 (15.25)	35.62 (14.52)	48.92 (36.59)	49.59 (29.24)	6.08 (0.76)	53.55 (15.08)	38.56 (5.0)	41.02 (7.62)	190.2 (87.19)
TDS (mg/l)	23.7 (10.36)	24.02 (9.90)	41.06 (28.65)	32.99 (19.42)	40.62 (10.85)	35.8 (9.56)	25.02 (3.15)	28.37 (5.49)	127.68 (57.93)
Salinity (ppm)	20.07 (6.84)	20.06 (6.98)	31.29 (20.32)	26.58 (12.48)	33.54 (9.45)	29.79 (9.97)	21.13 (4.49)	23.18 (5.74)	100.81 (51.51)
Flow (m3/s)	1.02 (2.18)	0.18 (0.16)	0.10 (0.08)	0.19 (0.16)	0.16 (0.15)	0.08 (0.07)	0.15 (0.17)	0.19 (0.17)	6.27 (5.50)

Figure 8: Sample site on the mainstem of Beech Creek at Monument.

Table 5 (next page): Summary of laboratory water chemistry analyses completed at the Lock Haven University Geological laboratory. The total number of samples (n), mean, and standard deviation for each parameter is provided. Parameters violating Chapter 93 water quality standards are highlighted in **red** print.

Parameter		Little Sandy Run	Wolf Run (State Line)	Wolf Run (Panther Rd)	Panther Run	UNT to Council Run	Council Run	Hayes Run	Beech Creek	Monument Run
TSS (mg/l)	n	14	12	14	10	15	15	16	16	16
	mean	2.86	3.08	3.86	4.70	5.73	6.73	4.00	3.38	5.13
	st.dev.	6.24	3.68	5.08	5.60	6.94	7.16	5.40	4.43	7.53
Total Hardness as CaCO3 (mg/l)	n	18	14	17	13	18	17	17	17	17
	mean	14.42	11.72	9.71	13.72	24.05	23.46	24.21	76.41	18.44
	st.dev.	6.81	3.80	3.50	8.61	9.43	6.28	12.70	47.36	5.76
Ca Hardness as CaCO3 (mg/l)	n	18	14	18	13	18	17	17	16	16
	mean	6.79	5.47	4.76	5.93	15.02	15.61	12.72	31.34	12.60
	st.dev.	3.11	1.19	1.86	2.76	5.63	3.67	5.24	20.24	5.31
Mg Hardness as CaCO3 (mg/l)	n	18	14	18	13	18	17	17	17	17
	mean	7.68	6.28	4.91	7.76	8.74	8.56	11.53	30.19	5.84
	st.dev.	6.02	3.05	3.14	7.28	5.32	4.11	11.38	19.88	5.10
Barium (mg/l)	n	22	18	21	17	22	22	22	23	22
	mean	1.57	1.06	1.35	1.00	1.62	1.48	1.24	0.95	1.10
	st.dev.	1.05	0.83	0.97	1.14	1.05	1.06	0.55	0.67	0.97
Total Fe (mg/l)	n	22	18	21	18	22	22	22	22	22
	mean	0.05	0.05	0.04	0.04	0.05	0.11	0.06	0.15	0.06
	st.dev.	0.05	0.03	0.03	0.03	0.07	0.15	0.05	0.12	0.05
Mn (mg/l)	n	2	1	2	1	2	2	1	1	1
	mean	0.10	0.40	0.40	0.50	0.15	0.20	0.00	**1.10**	0.10
	st.dev.	0.14	na	0.00	na	0.21	0.28	na	na	na
Bromine (mg/l)	n	12	12	13	13	12	12	12	12	12
	mean	0.03	0.02	0.05	0.04	0.04	0.05	0.07	0.10	0.02
	st.dev.	0.02	0.01	0.03	0.02	0.02	0.07	0.09	0.10	0.02
Sulfate (mg/l)	n	22	18	22	18	22	22	22	22	22
	mean	5.47	5.47	5.79	5.93	9.21	15.16	6.26	79.84	8.26
	st.dev.	1.80	1.81	1.60	4.40	12.03	3.90	1.56	37.33	3.91
Copper (mg/l)	n	22	19	20	18	22	22	22	22	22
	mean	0.05	0.07	0.05	0.04	0.09	0.10	0.08	0.09	0.08

	st.dev.	0.04	0.08	0.04	0.06	0.11	0.08	0.07	0.10	0.05

Table 6: Water quality results from the DEP laboratory in Harrisburg PA. **a)** Water quality results for Council Run, UNT to Council Run, and Hayes Run, **b)** Water quality results for Wolf Run (State Line Road), a duplicate sample for Wolf Run (State Line Road), and Panther Run, **c)** Water quality results for Monument Run, Beech Creek, and Sandy Run, and **d)** Water quality results for Wolf Run (Panther Road) and the blank sample.

a)

Parameter	UNITS	001 Council Run @ K-O Rd April	812 Council Run @ K-O Rd July	823 Council Run @ K-O Rd Sept	002 Tributary to Council Run April	813 Tributary to Council Run July	824 Tributary to Council Run Sept	003 Hayes Run @ Orviston April	814 Hayes Run @ Orviston July	825 Hayes Run @ Orviston Sept
ALKALINITY	mg/L	3.0	7.2	9.4	4.8	17.4	27.2	4.8	7.6	10.6
ALUMINUM	ug/L	<200	<200	<200	<200	<200	<200	<200	<200	<200
AMMONIA-NT	mg/L	<0.02	0.02	<0.02	0.02	<0.02	<0.02	0.02	<0.02	<0.02
ARSENIC T	ug/L	<3.0	<3	<3	<3.0	<3	<3	<3.0	<3	<3
BARIUM T	ug/L	37.000	36	41	31.000	37	42	23.000	29	30
BOD5 INHIB *	mg/L	1.20	1	1.2	0.94	1.1	1.2	0.62	0.7	1.1
BORON T	ug/L	<200	<200	<200	<200	<200	<200	<200	<200	<200
BROMIDE	ug/L	<50.0	<25	<25	<50.0	<25	<25	<50.0	<25	<25
CALCIUM T	mg/L	4.425	6.139	8.26	4.508	8.079	10.9	3.614	4.18	5.294
CHLORIDE IC	mg/L	1.05	1.09	1.68	1.59	1.79	2.88	0.64	0.82	0.93
COPPER T	ug/L	<10	<10	<10	<10	<10	<10	<10	<10	<10
HARDNESS T	mg/L	19	23	34	15	25	33	12	14	18
IRON T	ug/L	29.000	28	28	28.000	38	44	51.000	78	29
LEAD T	ug/L	<1.0	<1	<1	<1.0	<1	<1	<1.0	<1	<1
LITHIIUM T	ug/L	<25	<25	<25	<25	<25	<25	<25	<25	<25
MAGNESIUM T	mg/L	1.889	1.958	3.174	0.961	1.124	1.516	0.827	0.92	1.174
MANGANESE T	ug/L	80.000	53	104	<10.000	<10	<10	<10.000	16	<10
MERCURY T	ug/L	<0.2	<1	<0.2	<0.2	<1	<0.2	<0.2	<1	<0.2
NO3+NO2-N	mg/L	0.17	0.17	0.16	0.13	0.18	0.18	0.12	0.18	0.19
OSMO PRES	mOsm	<1	<1	<1	<1	<1	<1	<1	<1	<1
pH	pH	6.5	7.2	7.2	7.2	7.6	7.9	7.0	7.2	7.3
PHOSPHORUS T	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
SELENIUM T	ug/L	<7	<7	<7	<7	<7	<7	<7	<7	<7
SODIUM T	mg/L	0.686	0.634	0.779	0.914	0.784	1.117	0.458	0.469	0.605
SPC @ 25^0C	umhos/cm	47.80	61.1	88.3	54.60	59.1	79.9	32.60	35.7	42.9
STRONTIUM T	ug/L	21.000	26	36	21.000	34	48	13.000	17	23
SULFATE- IC	mg/L	15.68	16.64	25.42	8.28	7.44	7.97	7.49	6.94	7.25
T SUSP SOLIDS	mg/L	<5	<5	<5	<5	6	10	<5	<5	6
TDS 180	mg/L	54	74	64	48	50	56	50	36	36
ZINC T	ug/L	22.000	19	19	<10.0	<10	<10	<10.0	<10	<10
DISSOLVED O_2	ppm	13.30	8.30	10.30	12.80	9.50	10.30	14.40	10.30	10.90
FLOW	m^3/sec	0.139	0.038	0.010	0.061	0.023	0.005	0.143	0.024	0.011
WATER TEMP	^{0}C	7.20	16.00	12.30	7.00	15.10	12.10	8.10	17.30	14.10

b)

Parameter	UNITS	007 Wolf Run @State Line Bridge April	011 Wolf Run @ State Line Bridge Duplicate April	818 Wolf Run @State Line Bridge July	822 Wolf Run @ State Line Bridge Duplicate July	829 Wolf Run @State Line Bridge Sept	833 Wolf Run @ State Line Bridge Duplicate Sept	008 Panther Run @ Clubhouse Rd April	819 Panther Run @ Clubhouse Rd July	830 Panther Run @ Clubhouse Rd Sept
ALKALINITY	mg/L	1.2	1.0	1.4	1.4	2.6	0.8	1.0	4.8	8.8
ALUMINUM	ug/L	<200	<200	<200	<200	<200	<200	<200	<200	<200
AMMONIA-NT	mg/L	0.03	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ARSENIC T	ug/L	<3.0	<3.0	<3	<3	<3	<3	<3.0	<3	<3
BARIUM T	ug/L	29.000	30.000	28	30	27	<10	34.000	27	28
BOD5 INHIB *	mg/L	3.40	3.00	<0.2	<0.2	1	0.7	3.00	<0.2	1.1
BORON T	ug/L	<200	<200	<200	<200	<200	<200	<200	<200	<200
BROMIDE	ug/L	<50.0	<50.0	<25	<25	<25	<25	<50.0	<25	<25
CALCIUM T	mg/L	1.496	1.481	1.657	1.757	1.936	0.035	1.651	1.904	2.423
CHLORIDE IC	mg/L	1.93	1.96	2.05	1.98	2.64	<0.5	1.48	2.15	3.32
COPPER T	ug/L	<10	<10	<10	<10	<10	<10	<10	<10	<10
HARDNESS T	mg/L	7	7	7	7	8	0	8	8	10
IRON T	ug/L	<20.0	<20.0	20	<20	24	<20	<20.0	27	24
LEAD T	ug/L	<1.0	<1.0	<1	1	<1	<1	<1.0	<1	<1
LITHIIUM T	ug/L	<25	<25	<25	<25	<25	<25	<25	<25	<25
MAGNESIUM T	mg/L	0.690	0.684	0.713	0.752	0.763	<0.01	0.841	0.888	1.013
MANGANESE T	ug/L	<10.00	<10.00	<10	<10	13	<10	25.000	<10	<10
MERCURY T	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
NO3+NO2-N	mg/L	<0.05	<0.05	0.08	0.08	0.09	<0.05	<0.05	0.08	<0.05
OSMO PRES	mOsm	<1	1	<1	<1	<1	<1	<1	<1	<1
pH	pH	6.3	6.3	6.4	6.4	6.8	6.5	6.1	7	7.3
PHOSPHORUS T	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SELENIUM T	ug/L	<7	<7	<7	<7	<7	<7	<7	<7	<7
SODIUM T	mg/L	1.174	1.194	1.187	1.252	1.512	<0.2	0.892	2.508	3.993
SPC @ 25^{0}C	umhos/cm	26.80	25.70	24.8	23.6	29.1	1.19	29.20	31.7	42.8
STRONTIUM T	ug/L	13.000	13.000	14	15	17	<10	16.000	21	29
SULFATE- IC	mg/L	5.86	5.87	5.49	5.52	5.11	<1	7.40	5.69	5.06
T SUSP SOLIDS	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5
TDS 180	mg/L	28	30	34	32	46	10	36	34	48
ZINC T	ug/L	<10.0	<10.0	11	<10	<10	<10	12.000	<10	<10
DISSOLVED O_2	ppm	11.80		n/a		13.00		12.00	10.10	10.10
FLOW	m^3/sec	0.19		0.03		0.02		0.15	0.06	0.04
WATER TEMP	^{0}C	8.60		15.10		19.20		11.60	15.90	12.50

c)

Parameter	UNITS	004 Monument Run April	815 Monument Run July	826 Monument Run Sept	005 Beech Creek @ Monument April	816 Beech Creek @ Monument July	827 Beech Creek @ Monument Sept	006 Little Sandy Run Hatchery April	817 Little Sandy Run Hatchery July	828 Little Sandy Run Hatchery Sept
ALKALINITY	mg/L	9.0	9.8	13.6	0.0	0	0	1.4	1.4	2
ALUMINUM	ug/L	<200	<200	<200	862.000	1197	1557	<200	<200	<200
AMMONIA-NT	mg/L	0.02	<0.02	<0.02	0.03	0.03	<0.02	0.03	<0.02	<0.02
ARSENIC T	ug/L	<3.0	<3	<3	<3.0	<3	<3	<3.0	<3	<3
BARIUM T	ug/L	27.000	31	32	31.000	36	33	36.000	30	27
BOD5 INHIB *	mg/L	0.59	1.3	2	0.96	0.3	0.5	3.10	<0.2	1.1
BORON T	ug/L	<200	<200	<200	<200	<200	<200	<200	<200	<200
BROMIDE	ug/L	<50.0	<25	<25	<50.0	<25	<25	<50.0	<25	<25
CALCIUM T	mg/L	4.082	5.179	6.446	10.800	21.5	29.7	1.557	1.582	1.682
CHLORIDE IC	mg/L	0.51	0.68	1.29	3.39	4.16	5.4	2.39	2.05	3.27
COPPER T	ug/L	<10	<10	<10	<10	<10	<10	<10	<10	<10
HARDNESS T	mg/L	14	17	21	54	104	143	8	8	9
IRON T	ug/L	73.000	72	147	300.000	203	533	23.000	43	231
LEAD T	ug/L	<1.0	<1	<1	<1.0	1.02	1.1	<1.0	<1	<1
LITHIIUM T	ug/L	<25	<25	<25	<25	<25	<25	<25	<25	<25
MAGNESIUM T	mg/L	0.892	1.09	1.218	6.490	12.3	16.6	0.964	0.997	1.109
MANGANESE T	ug/L	10.000	10	10	1109.000	2269	3124	22.000	16	33
MERCURY T	ug/L	<0.2	<1	0.2	<0.2	<1	<0.2	<0.2	<00.2	<0.2
NO3+NO2-N	mg/L	0.16	0.16	0.2	0.15	0.19	0.09	0.06	0.11	0.09
OSMO PRES	mOsm	<1	<1	<1	2	2	<1	1	<1	<1
pH	pH	7.0	7.3	7.4	4.9	4.4	4.2	6.3	6.4	6.7
PHOSPHORUS T	mg/L	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SELENIUM T	ug/L	<7	<7	<7	<7	<7	<7	<7	<7	<7
SODIUM T	mg/L	0.493	0.716	1.377	2.902	4.468	5.217	1.388	1.069	1.515
SPC @ 25^{0}C	umhos/cm	36.00	42.2	51	159.70	280	382	30.70	28.3	31.4
STRONTIUM T	ug/L	19.000	33	41	49.000	114	169	18.000	17	17
SULFATE- IC	mg/L	8.54	7.84	7.58	62.21	121	185	6.89	6.39	5.47
T SUSP SOLIDS	mg/L	<5	6	<5	<5	<5	<5	<5	<5	<5
TDS 180	mg/L	46	70	38	118	196	248	32	50	56
ZINC T	ug/L	<10.0	<10	25	67.000	95	106	13.000	<10	12
DISSOLVED O_2	ppm	13.50	10.50	9.40	11.90	8.10	9.80	13.30	9.40	10.60
FLOW	m^3/sec	0.223	0.044	0.030	6.909	1.529	0.793	0.09	0.03	0.05
WATER TEMP	^{0}C	9.20	17.00	14.40	12.70	22.00	17.50	7.60	17.90	11.20

d)

Parameter	UNITS	009 Wolf Run @ Panther Rd April	820 Wolf Run @ Panther Rd July	831 Wolf Run @ Panther Rd Sept	010 Blank April	821 Blank July	832 Blank Sept
ALKALINITY	mg/L	2.4	1.4	3	0.8	0.6	3
ALUMINUM	ug/L	<200	<200	<200	<200	<200	<200
AMMONIA-NT	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ARSENIC T	ug/L	<3.0	<3	<3	<3.0	<3	<3
BARIUM T	ug/L	26.000	28	25	<10	<10	29
BOD5 INHIB *	mg/L	1.90	<0.2	1.1	1.40	<0.2	0.9
BORON T	ug/L	<200	<200	<200	<200	<200	<200
BROMIDE	ug/L	<50.0	<25	<25	<50.0	<25	<25
CALCIUM T	mg/L	1.531	1.591	1.824	<0.03	<0.03	2.025
CHLORIDE IC	mg/L	2.89	1.4	1.96	<0.50	<0.5	2.61
COPPER T	ug/L	<10	<10	<10	<10	<10	<10
HARDNESS T	mg/L	7	7	8	0	0	8
IRON T	ug/L	<20.0	<20	<20	<20.0	<20	22
LEAD T	ug/L	<1.0	1	<1	<1.0	<1	<1
LITHIIUM T	ug/L	<25	<25	<25	<25	<25	<25
MAGNESIUM T	mg/L	0.788	0.764	0.83	<0.01	<0.01	0.791
MANGANESE T	ug/L	<10.00	<10	<10	<10.00	<10	11
MERCURY T	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
NO3+NO2-N	mg/L	0.05	0.07	<0.05	<0.05	<0.05	0.06
OSMO PRES	mOsm	<1	<1	<1	1	<1	<1
pH	pH	6.6	6.5	6.8	6.1	5.9	6.8
PHOSPHORUS T	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SELENIUM T	ug/L	<7	<7	<7	<7	<7	<7
SODIUM T	mg/L	1.908	1.012	1.272	<0.2	<0.2	1.52
SPC @ 25^{0}C	umhos/cm	30.10	25.1	28.4	<1.0	1.09	29.2
STRONTIUM T	ug/L	16.000	14	16	<10	<10	18
SULFATE- IC	mg/L	5.86	6.32	5.65	<1.00	<1	4.93
T SUSP SOLIDS	mg/L	<5	<5	<5	<5	<5	<5
TDS 180	mg/L	34	30	36	6	12	36
ZINC T	ug/L	<10.0	<10	<10	<10.0	<10	12
DISSOLVED O_2	ppm	13.50	12.40	10.90			
FLOW	m^3/sec	0.46	0.05	0.03			
WATER TEMP	^{0}C	11.00	18.30	7.20			

In-stream Habitat Evaluation

Total habitat scores and individual scores for each habitat parameter are provided in Table 7 and should be referenced throughout this section. Overall, the habitat at the eight sites was generally optimal. Little Sandy Run, UNT to Council Run, and Monument Run were the exceptions to this, all scoring in the suboptimal range for total habitat score. An explanation of the habitat at each site is provided below.

Table 7: Total habitat scores and individual scores for each habitat parameter for each of the eight survey sites.

Habitat Parameter	Wolf Run (Panther Rd)	Wolf Run (State Line Rd)	Little Sandy Run	Panther Run	Council Run	UNT to Council Run	Hayes Run	Monument Run
Instream Cover	20	19	11	20	18	16	19	15
Epifaunal substrate	20	20	10	20	19	15	20	10
Embeddedness	16	15	12	19	16	14	19	11
Velocity/Depth Regimes	16	15	10	16	15	14	19	15
Channel Alteration	15	14	13	20	15	15	20	9
Sediment Deposition	19	18	8	18	18	16	19	15
Frequency of Riffles	20	20	10	19	20	20	20	18
Channel Flow Status	20	20	19	20	19	16	17	17
Condition of Banks	18	17	11	19	15	14	16	15
Bank Vegetative Protection	20	20	20	20	20	12	15	17
Grazing or Other Disruptive Pressure	16	18	10	20	20	12	16	3
Riparian Zone Width	20	20	18	20	20	11	20	8
TOTAL HABITAT SCORE	**220**	**216**	**152**	**231**	**215**	**175**	**220**	**153**

OPTIMAL
SUBOPTIMAL
MARGINAL
POOR

Wolf Run (Panther Road)

The survey site on Wolf Run at Panther Road (Figure 9) received a total habitat score of 220 out of a possible 240, which places the habitat at this location in the optimal category. The site received optimal scores for 11 of the 12 parameters. The site received a suboptimal score for channel alteration due to the presence of a bridge crossing on Panther Road. Habitat does not appear to be a limiting factor for aquatic life in this section of Wolf Run.

Figure 9: Sample site on Wolf Run at Panther Road bridge crossing.

Wolf Run (State Line Road)

The survey site on Wolf Run at State Line Road (Figure 10) is located upstream of the Wolf Run site at Panther Road. At this location, the site received a total habitat score of 216 out of a possible 240, which places the habitat at this location in the optimal category. The site scored within the optimal range for all parameters with the exception of embeddedness, velocity/depth regimes, and channel alteration. The lower scores for these parameters were primarily due the bridge crossing located upstream of the survey site. The bridge crossing has caused some channel alteration and some sediment deposition on the stream's substrate (embededdness). In addition, the site lacked deep pool habitat, which is crucial for several life stages of brook trout. It appeared that habitat did improve upstream and downstream of the bridge's influence. However, habitat in these areas was not evaluated.

Figure 10: Sample site on Wolf Run at State Line Road.

Little Sandy Run

The survey site on Little Sandy Run (Figure 11) was located just upstream of the Three Point Sportsman fish hatchery. The habitat at this site received a total score of 152 out of a possible 240, which placed the habitat at this location in the suboptimal category. The major habitat issue at this site is a small impoundment. The impoundment is causing increased sediment deposition and embeddedness as well as creating a large pool that lacks riffle habitat. In addition, very little riparian buffer exists in this area of the stream, adding to erosion and sedimentation issues. Habitat is likely a limiting factor for aquatic life in this section of Little Sandy Run.

Figure 11: Sample site on Little Sandy Run. The site was located upstream of the Three Points Sportsman's fish hatchery.

Panther Run

The survey site on Panther Run (Figure 12) received an optimal total habitat score (231 out of 240). The survey site was located in a remote location that was completely forested. The site received optimal scores for each of the 12 habitat parameters evaluated. It is unlikely that habitat is a limiting factor for aquatic life on Panther Run.

Figure 12: Sample site on Panther Run.

Council Run

The survey site on Council Run (Figure 13) received a total habitat score of 215 out of a possible 240, which placed the habitat at this location in the optimal category. The site scored in the optimal range for nine of the 12 habitat parameters evaluated. The site received scores in the suboptimal range for channel alteration, velocity/depth regimes, and condition of banks. The presence of a bridge crossing within the surveyed section was the primary cause for the lower scores for channel alteration and condition of banks. The site lacked substantial pool habitat, which lowered the score for velocity/depth regimes. Infrequent, moderate erosion was also noted at the site. Overall, habitat is not likely limiting aquatic life in Council Run.

Figure 13: Sample site on Council Run.

UNT to Council Run

Just upstream of the survey site on Council Run, an unnamed tributary enters Council Run. The survey site was located at the mouth of the unnamed tributary (Figure 14). The official number of the tributary is UNT 22700, according to PA DEP. This survey site received a total habitat score of 175 out of a possible 240, which placed the habitat at this location in the suboptimal category. The site lacked significant pool habitat. In addition, a dirt and gravel road located along the stream's right bank has had a significant influence on the habitat quality of the stream in this location. The presence of the road has caused some channel alteration and removed a large portion of the riparian buffer along the right bank of the stream.

Figure 14: Sample site at the mouth of UNT 22700. The UNT can be seen entering Council Run on the left.

Hayes Run

The survey site on Hayes Run (Figure 15) received a total habitat score of 220 out of a possible 240, which placed the habitat at this location in the optimal category. The site received optimal scores for 11 of the 13 parameters. The site received a suboptimal score for bank vegetative protection because of a mowed path that is parallel to the stream in this location. Overall, habitat does not appear to be a limiting factor for aquatic life in this section of Hayes Run.

Figure 15: Sample site on Hayes Run.

Monument Run

The survey site on Monument Run (Figure 16) received a total habitat score of 153 out of a possible 240, which placed the habitat at this location in the suboptimal category. Human disturbance in the form of mowing and channel alteration has influenced the habitat at this site. The site lacked a riparian buffer and was mowed up to the stream channel. The majority of the stream at this location has been channelized. It does appear that habitat quality may improve upstream of the survey site, although this area was not evaluated as part of this project.

Figure 16: Sample site on Monument Run.

Benthic Macroinvertebrate Surveys

Benthic macroinvertebrates were collected at each of the eight sample sites as outlined in the methods. A full list of the taxa collected, their abundance, and the pollution tolerance value (PTV) (based on PA DEP data) for each site is provided in Table 9. Pollution tolerance of the taxa increases as the PTV increases. For example, taxa with a PTV of 6 are more tolerant to anthropogenic pollution than taxa with a PTV of 2.

Overall, the most abundant taxa of benthic macroinvertebrates were the family Chironomidae (Order Diptera), *Leuctra spp.* (Order Plecoptera), and *Baetis spp.* (Order Ephemeroptera) (Table7). The biological metrics calculated for each site are provided in Table 8. Detailed descriptions of these metrics are provided in Appendix D. Each of the eight sample sites met the criteria of 160-240 individual benthic macroinvertebrates captured; therefore an IBI score could be calculated for each site (see Table 8).Based on the IBI scores, each site met or exceeded the threshold for meeting it aquatic life use attainment (IBI > 63), with the exception of Little Sandy Run. However, the site on Little Sandy Run was extremely close to meeting the threshold for aquatic life use attainment and it is recommended that the site be reevaluated in the future, perhaps upstream of the small impoundment.

In addition to adequate IBI scores, several other biometrics indicate that these streams are healthy. Most of the sites are dominated (>50%) by individuals that are known to be sensitive to anthropogenic pollution (Table 8). Typically, the individuals that are most sensitive to anthropogenic pollution below to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These orders are known as EPT taxa and the presence of individuals belonging to these orders are typically a strong indicator of good water quality.

Table 8: Biometrics calculated based on the benthic macroinvertebrate data collected at each sample site.

	Wolf Run (Panther Road)	**Wolf Run (State Line Road)**	**Panther Run**	**Little Sandy Run**	**Hayes Run**	**Monument Run**	**Council Run**	**UNT to Council Run**
Total Taxa Richness	23	25	25	19	27	29	26	20
EPT Taxa Richness (PTV 0-4)	11	12	14	9	15	16	15	13
Beck's Index, V3	24	25	30	14	29	36	31	29
Hilsenhoff Biotic Index	4.71	3.51	3.12	3.44	2.46	2.91	2.14	2.11
Shannon Diversity	2.16	2.54	2.71	2.27	2.8	2.66	2.65	2.26
% Sensitive Individuals (PTV 0-3)	43.4	48.5	52.1	62.0	66.3	59.4	74.1	70.0
IBI Score	63.9	71.8	78.3	62.6	84.4	86.3	86.1	77.4

Table 9: List of taxa and abundance of benthic macroinvertebrates collected at each sample site.

Family	PA Taxon	PTV (PA DEP)	Wolf Run (Panther Rd)	Wolf Run (State Line Road)	Panther Run	Little Sandy Run	Hayes Run	Monument Run	Council Run	UNT to Council Run	Total
	Diploperla	2				3					3
	Remenus	2					1				1
	Oligochaeta	10	64	1	5	13		1	3		87
	Hydracarina	7		1			2				3
Gammaridae	Gammarus	4	8								8
Cambaridae	Cambaridae	6	1	1							2
Asellidae	Caecidotea	6				1					1
Elmidae	Oulimnius	5	2	4	30	30	23	25	8	33	155
Elmidae	Promoresia	2			1			1	2	2	6
Elmidae	Stenelmis	5		1							1
Ceratopogonidae	Ceratopogonidae	6	4			3	3	1	1		12
Ceratopogonidae	Dasyhelea	6	2								2
Chironomidae	Chironomidae	6	33	66	28	31	20	29	17	10	234
Empididae	Chelifera	6	1		1			1		1	4
Empididae	Neoplasta	6			1				1		2
Simuliidae	Prosimulium	2						4			4
Simuliidae	Simulium	6		6		14					20
Tipulidae	Antocha	3		6	6		1	5		3	21
Tipulidae	Dicranota	3				1	1	1	1		4
Tipulidae	Hexatoma	2	2	2		3	5	3	3		18
Ameletidae	Ameletus	0									0
Baetidae	Acerpenna	6		8		2					10
Baetidae	Baetis	6	1	30	30		22	28	23	24	158
Baetidae	Diphetor	6					2	2	1	2	7
Ephemerellidae	Drunella	1					1	2			3
Ephemerellidae	Ephemerella	1		18	13		25	40	31	23	150
Heptageniidae	Cinygmula	1		19	18		24	2	13	43	119
Heptageniidae	Epeorus	0		10	26		23	17	52	57	185
Heptageniidae	Heptagenia	4		1					1		2
Heptageniidae	Maccaffertium	3			3	19	3	1			26
Heptageniidae	Stenacron	4				1					1
Leptophlebiidae	Habrophlebia	4	1								1
Leptophlebiidae	Paraleptophlebia	1		10	4		14	10		9	47
Gomphidae	Gomphidae	4	1		1						2
Gomphidae	Lanthus	5		2			2		3		7
Chloroperlidae	Chloroperlidae	0	8								8
Chloroperlidae	Haploperla	0	2		4	1		1	6	1	15
Chloroperlidae	Sweltsa	0	1	4					5	1	11
Leuctridae	Leuctra	0	46	25	16	42	11	15	9	4	168
Nemouridae	Amphinemura	3	19	8	4	42	4	6	13	1	97
Nemouridae	Ostrocerca	2	1						2		3
Peltoperlidae	Tallaperla	0						1			1
Perlidae	Acroneuria	0	2		2			1			5
Perlodidae	Isoperla	2		4	2			4	8	7	25
Perlodidae	Malirekus	2						1	2	1	4
Pteronarcyidae	Pteronarcys	0		2	2		3	3		2	12
Hydropsychidae	Ceratopsyche	5			16	1		1			18
Hydropsychidae	Cheumatopsyche	6			1		6				7
Hydropsychidae	Diplectrona	0	11	4	15	4	19	5	5	6	69
Lepidostomatidae	Lepidostoma	1	1		1		1		3		6
Philopotamidae	Dolophilodes	0					5				5
Philopotamidae	Philopotamidae	3				1					1
Philopotamidae	Wormaldia	0							1		1
Polycentropodidae	Polycentropus	6		2							2
Rhyacophilidae	Rhyacophila	1	1	4	6	4	17	6	10	2	50
Uenoidae	Neophylax	3					1				1
	Nematoda	9	2								2
	Turbellaria	9					1				1
			214	239	236	216	240	217	224	232	1818

DISCUSSION/RECOMMENDATIONS

Although remote in nature, the Beech Creek Watershed is no stranger to human impact. For many years, the area supplied the nation with coal, mined from deep within the earth. Coal extraction levied a heavy toll on this watershed. To this day, a century after much of the mining took place, streams remain polluted from the residual effects of acid mine drainage. DEP considers the main stem of Beech Creek a “dead” stream because it does not support life. In 1977, President Jimmy Carter signed the Surface Mine and Reclamation Act, which resulted in safe, more environmentally friendly mining methods carried on throughout the United States. However, the legislation came too late for the Beech Creek watershed. The main stem and several tributaries are still devoid of fish and mancroinvertebrates. AMD is the single largest pollutant in this watershed.

Acid deposition is another concern in this area. Emissions from distant coal burning power plants contribute acid pollution to the streams and forests in the form of acid rain.

A relatively recent threat to the watershed is the development of the natural gas industry (Figure 17). Significant gas deposits are located in deep pockets in the Marcellus shale under the earth. Shallow gas wells have existed in this area for a long time, but it is only in the last five years that technology has made it possible to extract valuable gas from Marcellus shale deposits. There is some moderate Marcellus activity in the Beech Creek watershed, although the initial flurry felt in 2009-2010 has subsided. It is relatively easy to form apprehension about the gas industry because of the memory of coal mining, the other extraction industry. Our recommendations to address the Marcellus issues and other potential threats to water quality are:

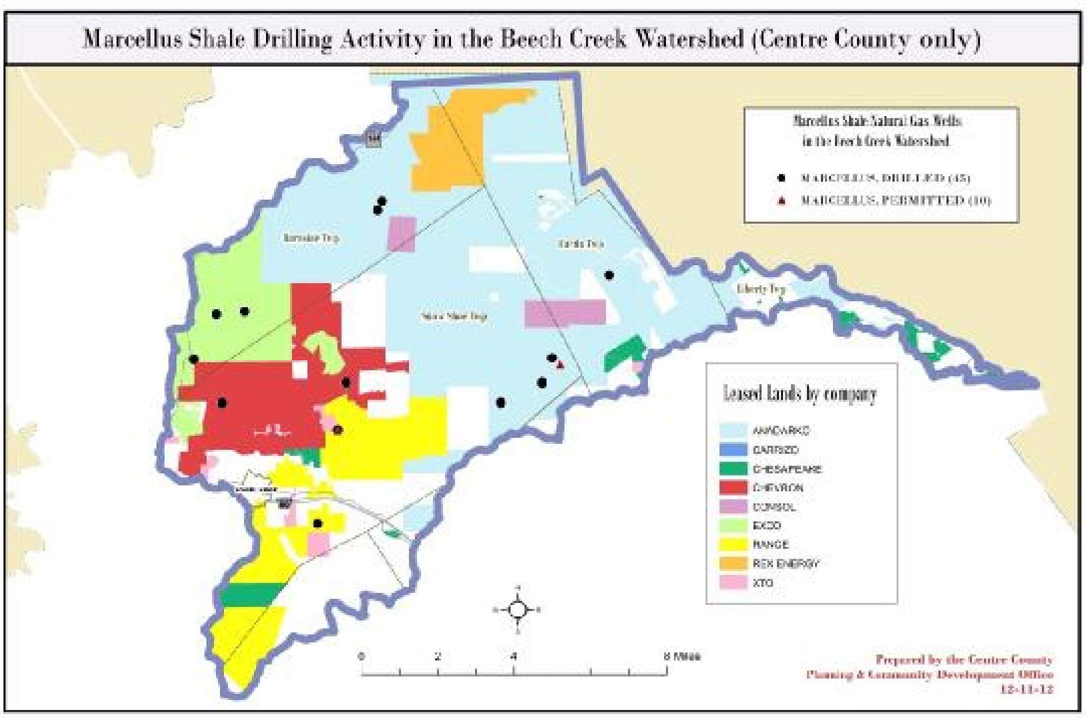

Figure 17: Marcellus shale drilling activity in the Beech Creek watershed (Centre County only).

1. Continue to work with DEP to ensure that gas-drilling companies are complying with state rules and regulations. Follow current legislative activity. Write to your local and state officials to lobby for safe drilling practices. Keep abreast of and help to influence state and federal policy concerning gas extraction.

2. Strengthen your relationships with the gas companies working in the Beech Creek watershed.

In addition to the potential dangers of pollution from hydro fracking and methane migration, the erosion and sediment issues that originate from the construction of roads and pipelines could be problematic. Increased traffic and heavy vehicles can be detrimental to older existing roads that are not suitable for such activity. Several years ago, CCPaSEC members brought an erosion and sediment problem in the Council Run Watershed to the District's attention. The bridge over Council Run on the Orviston-Kato Road had fallen into disrepair because of the heavy truck traffic. Visible sediment was entering Council Run. CCCD contacted Snowshoe Township who told us that the gas company, Anadarko, was maintaining the township road at this time. The District then contacted Anadarko and representatives from the township, from Anadarko, the District and CCPaSEC team members met on site. Within a few months, Anadarko built a new bridge, regraded the road, and installed sediment barriers. We addressed the problem and reached a solution because we created an open line of communication.

3. Develop a relationship with local government.

Pennsylvania has a Dirt and Gravel Road program that is available to townships and boroughs who want to improve their unpaved roads. In order to qualify for the funding Road Masters and/or other maintenance personnel must participate in a training course. Then they must apply to the Conservation District for the grant. We plan to make the local government officials aware of this program and encourage their participation. Improving unpaved roads will curtail erosion and sediment issues.

CCPaSEC plans to visit each township and borough in the watershed to make a presentation about their monitoring work in the watershed. Their presentation will express appreciation of the area and encourage protection of the natural resources. It is important to establish rapport with the local governments---you are visitors to their home territory but you have a shared interest in the area. They are essential partners in getting things done.

4. Encourage residents to serve on the Centre County Marcellus Gas Task Force

The mission of the Centre County Natural Gas Task Force is to address public and private sector impacts and opportunities of natural gas drilling in Centre County. Public officials and private citizens make up the group that is led by the Centre County office of Planning and Development. It is important that there is representation from the Beech Creek Watershed on this committee.

5. CCPaSEC and CCCD should seek to educate and involve residents of the watershed in addressing Acid Mine Drainage.

At this time, Acid Mine Drainage remains the major source of pollution in the Beech Creek watershed. CCPaSEC and the District will continue to work with the Beech Creek Watershed Association, the West Branch of the Susquehanna Restoration Coalition and the Department of Environmental Protection to address the residual effects of the coal mining industry in this and other areas. The Beech Creek Watershed Association commissioned an *AcidMine Drainage Restoration Plan* from HedinEnvironmental in 2006. This study identifies acid discharges in the Beech Creek Watershed and makes recommendations for treatment, either active or passive. Acid Mine remediation is very expensive and limited funding is available through DEP grants or the Bureau of Abandoned Mine Reclamation. The Beech Creek Watershed Association should expand its membership recruitment efforts in the watershed and continue to seek funding for stream reclamation.

6. CCPaSEC and CCCD should work with the Department of Conservation and Natural Resources and the local municipalities to combat illegal dumping in the watershed.

We frequently find illegal dumpsites in rural areas and the Beech Creek Watershed is no exception (Figure 18). It is all too easy for citizens to dispose of garbage by dumping it over a hill or at the end of a secluded road and this trash is a potential pollution concern. For many years various groups have held annual clean ups. One year a DCNR/ BCWA sponsored Clean Up near the town of Beech Creek netted approximately 900 tires. During the last several years, the Beech Creek Watershed Association and the Clinton County Solid Waste Authority in Wayne Township have worked collaboratively on this issue. Each year during the Pennsylvania Clean Up they have placed dumpsters in the towns of Monument and Orviston. For an entire week end residents may dispose of unwanted items, free of charge.

Figure 18: An example of illegal dumping in the Beech Creek watershed. A 1956 Dodge Lancer is pictured along the bank of Panther Run.

Because these towns are remote and very poor it is unlikely those residents could pay for collection and unlikely that more than one company would travel the distance to service these towns. Townships might look into other funding sources and contact a single company that could provide collection at a reduced rate.CCPaSEC volunteers and CCCD could work with the municipalities to find a more permanent solution.

7. CCPaSEC and CCCD can work with the townships, DCNR, the counties and Pennsylvania Wilds to promote recreational tourism in the area.

In the fall of 2007 Claudia Albertin and Glenn Vernon, of *albertinvernon*compiled the*BrickTown Trail Feasibility Study*. The Beech Creek Watershed Association, in partnership with the Centre and Clinton County Planning Commissions, the Centre and Clinton County Conservation Districts and the Penn State Center for Watershed Stewardship sponsored this project. The study explores the development of a 24-mile trail from Curtin Village and Eagle Ironworks to the town of Orviston. The document is a wonderful collection of information about this area, revealing the rich history of the Brick Towns. At the present time BCWA has not been able to proceed with the Trail construction because of lack of funding.

Organizations should promote fishing in the watershed. In 2009 the Penn State Center for Watershed Stewardship completed the *Beech Creek Watershed Coldwater Conservation Plan* with funding from the ColdWater Heritage program. This Plan documents the unimpaired waters in the Beech Creek Watershed. Most of these streams are EV or HQ. PA Fish and Boat Commission and Trout Unlimited have verified the presence of native brook trout in these streams.

All terrain vehicles and snowmobiles are popular forms of recreation in the Beech Creek watershed. Environmental stewardship among the users of these vehicles is important and should be encouraged.

The landscape in this area is dotted with isolated cabins and there has been some new construction on privately owned land. CCCD and CCPaSEC can make suggestions to the governing bodies about pro-active planning for future development. They should make sure that water and sewage for existing and new cabins are up to current standards. They could pass a riparian buffer ordinance to ensure that buffers along streams remain in place.

8. In meeting with the individual municipalities CCPaSEC and CCCD should emphasize pride in the area and encourage environmental stewardship.

One of the CCPaSEC team leaders, Ken Johnson, wrote “Few people in State College or PSU have visited the Pennsylvania Wilds and neither realize nor appreciate what is there...those waters represent an irreplaceable resource that first need to be recognized for its importance, both present and future and second to be cherished by the community.”

CCPaSEC, the CCCD, the Beech Creek Watershed Association, and the WBSRC should collaborate with the Pennsylvania Wilds to develop a public awareness campaign about the area. As part of this campaign we could publish a series of short photo essays and organize driving and hiking tours, particularly in the early fall and spring.

9. CCPaSEC and CCCD should petition to have the streams upgraded to HQ and/or EV.

Streams that have this designation are afforded more protection than streams that carry the CWF designation. Upgrading these streams would provide them with the best possible protection under current Pennsylvania law. CCPaSEC, TU, and the Center for Watershed Stewardship have already collected most of the data necessary for this process. CCPaSEC and CCCD should take the lead in the stream upgrade process.

10.CCPaSEC volunteer teams should continue to monitor in the Beech Creek watershed.

The CCPaSEC teams should continue to collaborate with Md. Khalequzzaman, PhD., Associate Professor and Chair of the Department of Geology and Physics at Lock Haven University to establish baseline data for these and other streams in the watershed that are in close proximity to Marcellus drilling. The presence of the volunteer monitors indicates to the companies that someone is interested in what is happening in these remote places. While on the quest to identify changes in water chemistry they can also monitor other aspects of the watershed, looking for erosion issues on the roads and other changes in the landscape as demonstrated by CCPaSEC team 13's observation and reporting of erosion and sediment problems at Council Run on the Orviston-Kato Road.CCPaSEC is limited to volunteers over the age of 55, but they could help expand volunteer monitoring activities by training members of other interested organizations or individuals and suggest survey equipment.

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APPENDIX A: Stream Flow Calculation worksheet used by CCPaSEC volunteers.

Flow Data Sheet

Site: Council Run @ K-O Rd. Date:_________________ Run Width = _______m Interval = ______m

Depths in meters: ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Velocities in m/s: ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Site: Tributary to Council Run @ K-O Rd. Date:_________________ Run Width = _______m Interval = ______m

Depths in meters: ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Velocities in m/s: ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Appendix B: Streamside worksheet used by CCPaSEC volunteers to record field data

.

STREAMSIDE WORKSHEET

SITE 1: Council Run @ K-O Rd. Flow: ______ m^3/s DATE:___________ TIME:__________

AIR TEMP:_______°C WATER TEMP:_____°C pH:_____ EC:______ TDS:_____ SAL:_____ DO:___

SITE 2: Tributary to Council Run Flow: _______ m^3/s DATE:___________ TIME:__________

AIR TEMP:_______°C WATER TEMP:_____°C pH:_____ EC:______ TDS:_____ SAL:_____ DO:___

SITE 3: Hayes Run @ Orviston Flow: _______ m^3/s DATE:___________ TIME:__________

AIR TEMP:_______°C WATER TEMP:_____°C pH:_____ EC:______ TDS:_____ SAL:_____ DO:___

SITE 4: Monument Run Flow: _______ m^3/s DATE:___________ TIME:__________

AIR TEMP:_______°C WATER TEMP:_____°C pH:_____ EC:______ TDS:_____ SAL:_____ DO:___

SITE 5: Beech Creek @Monument Flow: _______ m^3/s DATE:___________ TIME:___________

AIR TEMP:_______°C WATER TEMP:_____°C pH:_____ EC:______ TDS:_____ SAL:_____ DO:___

APPENDIX C: Description of habitat parameters.

Instream Fish Cover
Evaluates the percent makeup of the substrate (boulders, cobble, other rock material) and submerged objects (logs, undercut banks) that provide refuge for fish.

Epifaunal Substrate
Evaluates riffle quality, i.e., areal extent relative to stream width and dominant substrate materials that are present. (In the absence of well-defined riffles, this parameter evaluates whatever substrate is available for aquatic invertebrate colonization.)

Embeddedness
Estimates the percent (vertical depth) of the substrate interstitial spaces filled with fine sediments. (**Pool substrate characterization:** evaluates the dominant type of substrate materials, i.e., gravel, mud, root mats, etc. that are more commonly found in glide/pool habitats.)

Velocity/Depth Regime
Evaluates the presence/absence of four velocity/depth regimes - fast-deep, fast-shallow, slow-deep and slow-shallow. (Generally, shallow is <0.5m and slow is <0.3m/sec. (*Pool variability:* describes the presence and dominance of several pool depth regimes.)

The next four parameters evaluate a larger area surrounding the sampled riffle. As a rule of thumb, this expanded area is the stream length defined by how far upstream and downstream the investigator can see from the sample point.

Channel Alteration
Primarily evaluates the extent of channelization or dredging but can include any other forms of channel disruptions that would be detrimental to the habitat.

Sediment Deposition
Estimates the extent of sediment effects in the formation of islands, point bars and pool deposition.

Riffle Frequency (pool/riffle or run/bend ratio)
Estimates the frequency of riffle occurrence based on stream width. *(Channel sinuosity:* the degree of sinuosity to total length of the study segment.)

Channel Flow Status
Estimates the areal extent of exposed substrates due to water level or flow conditions. The next four parameters evaluate an even greater area. This area is usually defined as the length of stream that was electroshocked for fish (or an approximate 100-meter stream reach when no fish were sampled). It can also take into consideration upstream land-use activities in the watershed.

Condition of Banks
Evaluates the extent of bank failure or signs of erosion.

Bank Vegetative Protection
Estimates the extent of stream bank that is covered by plant growth providing stability through well-developed root systems.

Grazing or Other Disruptive Pressures
Evaluates disruptions to surrounding land vegetation due to common human activities, such as crop harvesting, lawn care, excavations, fill, construction projects and other intrusive activities.

Riparian Vegetative Zone Width
Estimates the width of protective buffer strips or riparian zones. This is a rating of the buffer strip with the least width.

APPENDIX D: Description of biological metrics that were used in this project.

Total Abundance

The total abundance is the total number of organisms collected in a sample or sub-sample.

Dominant Taxa Abundance

This metric is the total number of individual organisms collected in a sample or sub-subsample that belong to the taxa containing the greatest numbers of individuals.

Taxa Richness

This is a count of the total number of taxa in a sample or sub-sample. This metric is expected to decrease with increasing anthropogenic stress to a stream ecosystem, reflecting loss of taxa and increasing dominance of a few pollution-tolerant taxa.

% EPT Taxa

This metric is the percentage of the sample that is comprised of the number of taxa belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). Common names for these orders are mayflies, stoneflies, and caddisflies, respectively. The aquatic life stages of these three insect orders are generally considered sensitive to, or intolerant of, pollution (Lenat and Penrose 1996). This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of taxa from these largely pollution-sensitive orders.

Shannon Diversity Index

The Shannon Diversity Index is a community composition metric that takes into account both taxonomic richness and evenness of individuals across taxa of a sample or sub-sample. In general, this metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and increasing dominance of a few pollution-tolerant taxa.

Hilsenhoff Biotic Index

This community composition and tolerance metric is calculated as an average of the number of individuals in a sample or sub-sample, weighted by pollution tolerance values. The Hilsenhoff Biotic Index was developed by William Hilsenhoff (Hilsenhoff 1977, 1987; Klemm et al. 1990) and generally increases with increasing ecosystem stress, reflecting dominance of pollution-tolerant organisms. Pollution tolerance values used to calculate this metric are largely based on organic nutrient pollution. Therefore, care should be given when interpreting this metric for stream ecosystems that are largely impacted by acidic pollution from abandoned mine drainage or acid deposition.

Beck's Biotic Index

This metric combines taxonomic richness and pollution tolerance. It is a weighted count of taxa with PTVs of 0, 1, or 2. It is based on the work of William H. Beck in 1955. The metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive taxa.

Percent (%) Sensitive Individuals

This community composition and tolerance metric is the percentage of individuals with PTVs of 0 to 3 in a sample or sub-sample and is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive organisms.

APPENDIX E (SEE CD INSERT): Water quality data from the field, LHU laboratory, and DEP laboratory. The file is a Microsoft Excel worksheet containing separate tabs for each data set.