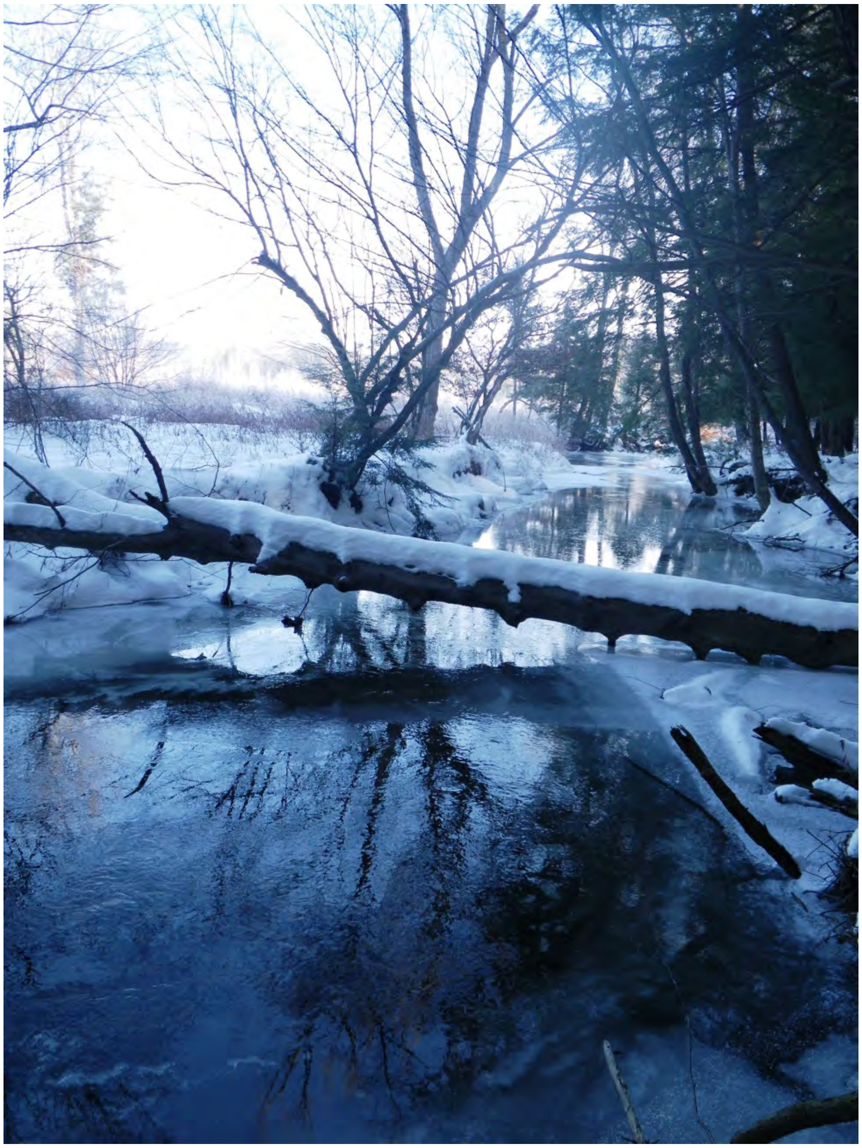
AMD Assessment and Restoration Plan for the Potts Run Watershed, Jordan & Knox Townships, Clearfield County, Pennsylvania

Prepared by Trout Unlimited

December 2014



Assessment Overview

The purpose of this watershed assessment was to investigate the abandoned mine drainage (AMD) pollution that is influencing Potts Run, identify other factors that may be affecting the stream, and develop a restoration plan for the watershed. This report builds off of the *Coldwater Conservation Plan for the Potts Run Watershed, Jordan & Knox Townships, Clearfield County, PA* completed by Trout Unlimited in the fall of 2013. It also includes data and recommendations that were developed by Hedin Environmental as part of a mine drainage snapshot of Potts Run that was completed through Trout Unlimited's AMD Technical Assistance Program for the Knox Township supervisors and finalized in the spring of 2014.

This watershed assessment was completed through a collaborative effort between Trout Unlimited (TU), the Clearfield County Conservation District (CCCD) and Hedin Environmental (HE). Funding for the project was provided by the Coldwater Heritage Partnership, Foundation for Pennsylvania Watersheds, Growing Greener Grant Program (through the TU AMD Technical Assistance Grant Program), and the R.K. Mellon Foundation. Additional support was provided by the Clearfield Creek Watershed Association, DEP Moshannon District Mining Office, DEP Bureau of Abandoned Mine Reclamation, and Pennsylvania Fish and Boat Commission. A special thank you goes to Carl Undercofler for his help with all aspects of this project.

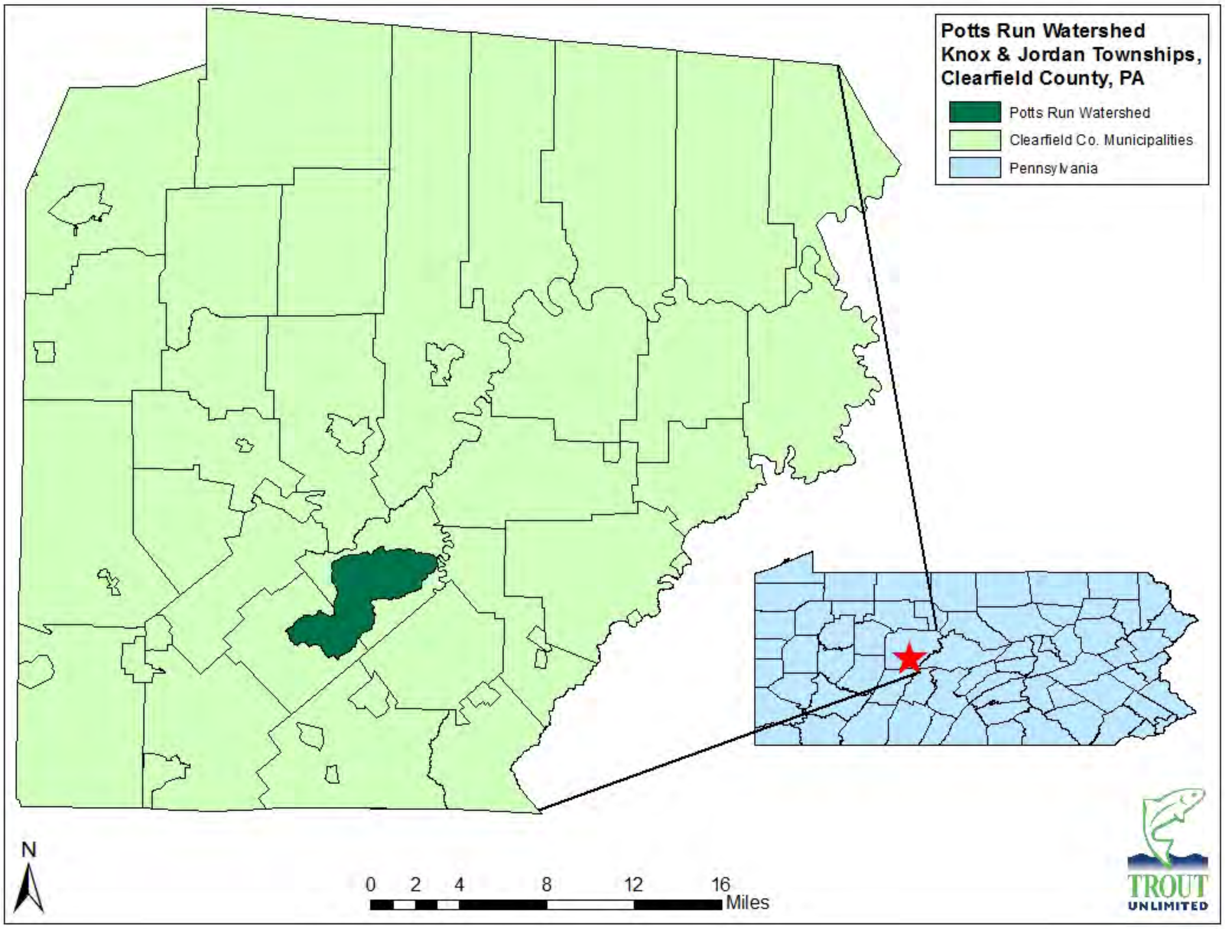
Watershed Background

General Information

The Potts Run watershed encompasses 14.5 square miles in Jordan and Knox Townships, Clearfield County, Pennsylvania (Figure 1). From its source near the village of Ansonville, Potts Run flows approximately 10.7 miles northeast to its confluence with Clearfield Creek, one mile east of the village of Kellytown. Potts Run has fifteen miles of tributaries, including Little Potts Run and thirteen unnamed tributaries. All of the streams within the Potts Run watershed are designated as coldwater fisheries (CWF) according to PA Code, Title 25, Chapter 93 Water Quality Standards, however, 2.7 miles of Potts Run and 0.7 miles of Little Potts Run are listed as impaired due to AMD in the DEP's *2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report*. An additional 0.4-mile section of the unnamed tributary numbered 26197 by the DEP is also impaired due to AMD, although for some reason it is not currently on the impaired waters list. Detailed information about each tributary including the results of water quality sampling and biological monitoring can be found in the aforementioned coldwater conservation plan for Potts Run.

The majority of the Potts Run watershed is forested, with large areas of reclaimed and abandoned surface mining, and a few small pockets of farm land. The area is very rural and contains only a few small villages, including the former mining towns of Ansonsville, Carnwath, Boardman, and Kellytown. According to the 2010 United States Census, the combined population of Jordan and Knox Townships is only 1108, so the actual number of residents in the Potts Run watershed, is even fewer than this. The watershed has a long and interesting history including being at the center of draft resistance and anti-war sentiments in Clearfield County during the Civil War and providing coal to fuel industrial revolution and both world wars (Hughes, 2014).

Figure 1 Watershed Location Map



Mining Information

Deep mining for coal, and to a lesser extent clay, began in the watershed in the late 1800s with the opening of mines in Kellytown, Boardman and Carnwath. By the mid-1950s, the last remaining deep mine was closed and surface mining became the dominant form of natural resource extraction in the watershed. Prior to the passage of the federal Surface Mining Control and Reclamation Act of 1977, it was common practice to abandon mining operations once coal reserves were depleted or mining was no longer economically feasible. This resulted in hundreds of acres of abandoned mine lands (AML) and dozens of AMD discharges in the Potts Run watershed. While re-mining for coal in the upper and middle watershed has led to the remediation of many land and water problems in the Potts Run watershed (Bigatel, 2012), the lower watershed, particularly around the village of Boardman, is still plagued by AMD discharges and dangerous AML features including mine openings, shafts, highwalls and water filled pits. For this reason, much of the information in this report focuses on this area.

At the time of this report, there are no active mining activities taking place in the watershed and only one mine drainage treatment system has been constructed in the watershed. According to the DEP, this passive treatment system is located on a mine site that was last operated by Al Hamilton Contracting and is known as the Carnwath Mine. The treatment system was constructed in 2008 using bond forfeiture funds and consists of a baffled limestone ramp followed by a settling basin, but didn't go online until 2013 when a pipeline was extended from the source to the treatment system (Rosengrant, 2014). Historic mining permits, as well as, additional information about the Carnwath Mine treatment system can be obtained by contacting the DEP's Moshannon District Mining Office (MDMO).

Methods

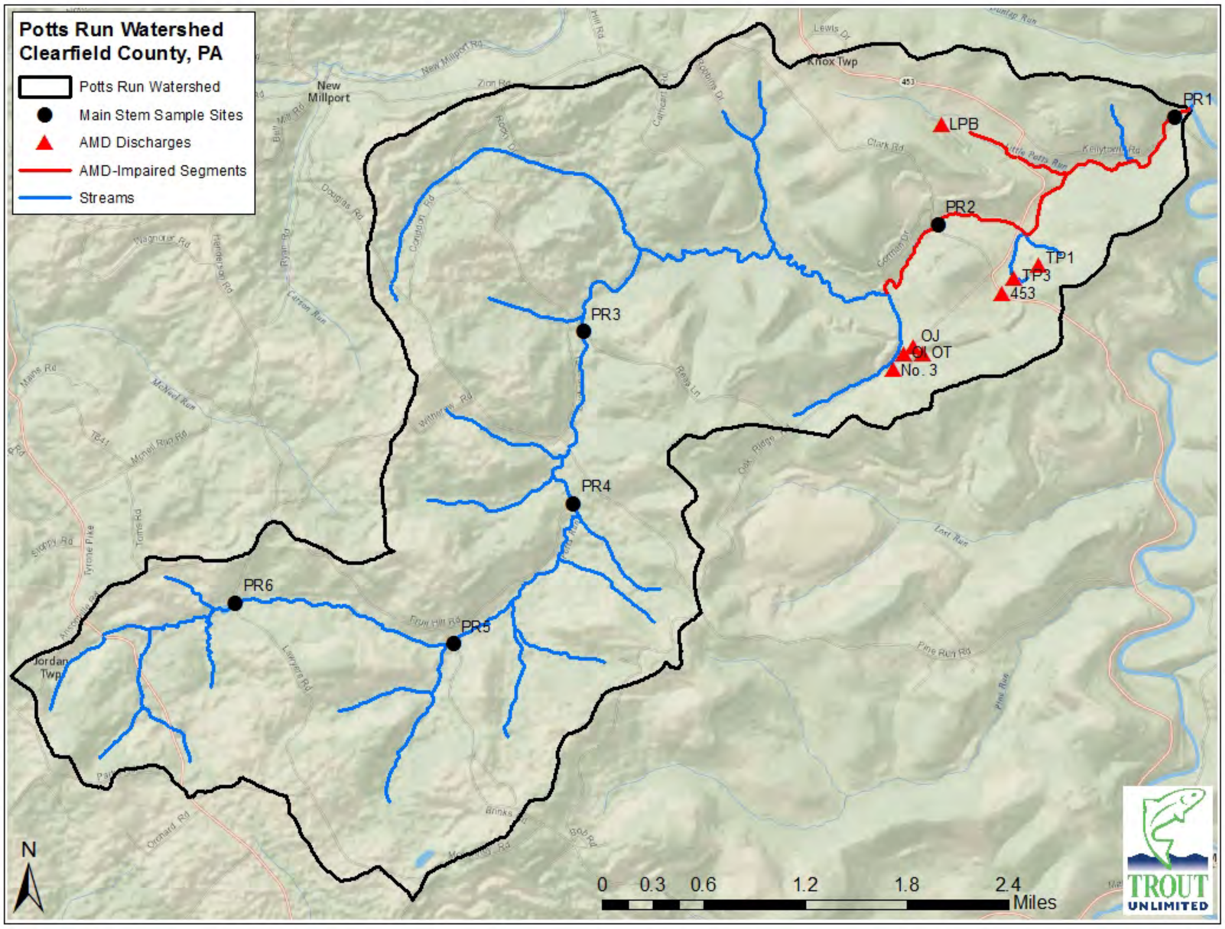
Sample Sites

Sample sites were chosen after stream reconnaissance activities and consultation with the DEP's MDMO. Over a dozen AMD discharges were located in the watershed, however, only eight of these were chosen for long-term study. The others were either very small or not flowing at the time of the study or had marginal water chemistry and were deemed insignificant to the overall water quality of Potts Run. Sample sites were given names/numbers that correspond to local landmarks or other means of identifying them. From downstream to upstream they are Little Potts Beaver (LPB), Twin Pines 3 (TP3), Twin Pines 1 (TP1), Route 453 (453), Oak Twins (OT), Oak Join (OJ), Oak Iron (OI), and Potts Run No. 3 Mine (No. 3). The coordinates and a description of each sampling station can be found in Table 1, while Figure 2 shows their relative locations within the watershed.

Table 1 Potts Run AMD Discharge Sampling Locations

Sample ID	Description	Latitude	Longitude
LPB	Little Potts Run "Beaver Dam" discharge	40.89069	-78.46915
TP1	Twin Pines Camp discharge 1	40.87875	-78.45812
TP3	Twin Pines Camp discharge 3	40.87762	-78.46086
453	Discharge along SR 453 (Belsena Rd)	40.87624	-78.46218
OT	Oak Ridge Rd "Twin" discharge	40.87106	-78.47099
OJ	Oak Ridge Rd "Join" discharge	40.87165	-78.47217
OI	Oak Ridge Rd "Iron" discharge	40.87105	-78.47320
No. 3	Potts Run No. 3 Mine discharge	40.86975	-78.47440

Figure 2 Potts Run Sampling Locations



In addition to the mine discharges, six long-term sampling points were established along the main stem of Potts Run with additional main stem locations selected for AMD-specific monitoring by Hedin Environmental. The long-term sampling points are all located at or near stream crossings for ease of access. The in-stream sampling points are numbered as follows from the mouth to the headwaters: PR1, PR2, PR3, PR4, PR5, and PR6 (Figure 2). Table 2 provides a description of each main stem sampling location and the types of monitoring that were completed at each site.

Table 2 Potts Run Main Stem Sampling Locations

Sample ID	Description	Latitude	Longitude	Water Chemistry	Bugs	Habitat	Fish
PR1	Potts Run mouth	40.89152	-78.44282	X	X	X	X
PR2	Potts Run near Clark Road bridge	40.88215	-78.46947	X	X	X	X
PR3	Potts Run near Reas Lane bridge	40.87273	-78.50942	X	X	X	X
PR4	Potts Run near Fruit Hill Road bridge	40.85795	-78.51041	X	X	X	X
PR5	Potts Run near Brink Road bridge	40.84585	-78.52377	X	X	X	X
PR6	Potts Run near Lawyers Road culvert	40.84919	-78.54844	X		X	X

Water Quality

Conductivity (umhos), pH (standard units), and water temperature (degrees Celsius) were measured in the field during all sampling activities using an Oakton multi-parameter PCS Testr 35. The meter was calibrated for each parameter and rinsed with distilled water prior to all measurements.

Grab samples were collected according to PA DEP protocols at each of the AMD discharges on a monthly basis while in-stream samples were collected on a quarterly basis from October 2012 to December 2013, with the exception of PR5 and PR6, which were sampled only twice. Additional grab samples were pulled from the discharges and additional in-stream locations during both high and low flow conditions in 2012 and 2014 to assess mine influences near the village of Boardman (see Hedin report). Grab samples consisted of a 500-mL bottle of raw water, one 250-mL bottle of water for metals analyses, and one 250-ml bottle of water for dissolved metals analyses. The samples for dissolved metals analyses were filtered through a 0.45 micrometer membrane using a Nalgene Mityvac hand-operated vacuum pump. All samples for metals analyses were acidified to pH 2 or less with trace metal grade 1 N nitric acid. These samples were submitted to Mahaffey Laboratory, LLC located in Curwensville, Pennsylvania for further analysis. Mahaffey Laboratory, LLC is a DEP-certified laboratory and analyzed the grab samples for pH (standard units), conductivity (umhos), alkalinity (mg/L), acidity (mg/L), total iron (mg/L), total manganese (mg/L), total aluminum (mg/L), sulfates (mg/L), total dissolved solids (mg/L), and total suspended solids (mg/L) using PA DEP standard methods. In addition, the in-stream samples were also analyzed for dissolved iron (mg/L), dissolved aluminum (mg/L), dissolved manganese (mg/L), chloride (mg/L), calcium (mg/L), and magnesium (mg/L).

A Swoffer Current Velocity Meter was used to measure stream flow according to DEP's *Standardized Biological Field Collection and Laboratory Methods*. Width, velocity at 6/10 depth of the water column, and depth of water were measured at intervals across the stream so that not more than 1/10 of the stream velocity was captured per interval. Stream discharge was later calculated by summing the volume of water moving through each interval. Flows from the AMD discharges were measured using standard methods including weirs, the timed-volume method (bucket and stop watch), and the above mentioned velocity meter.

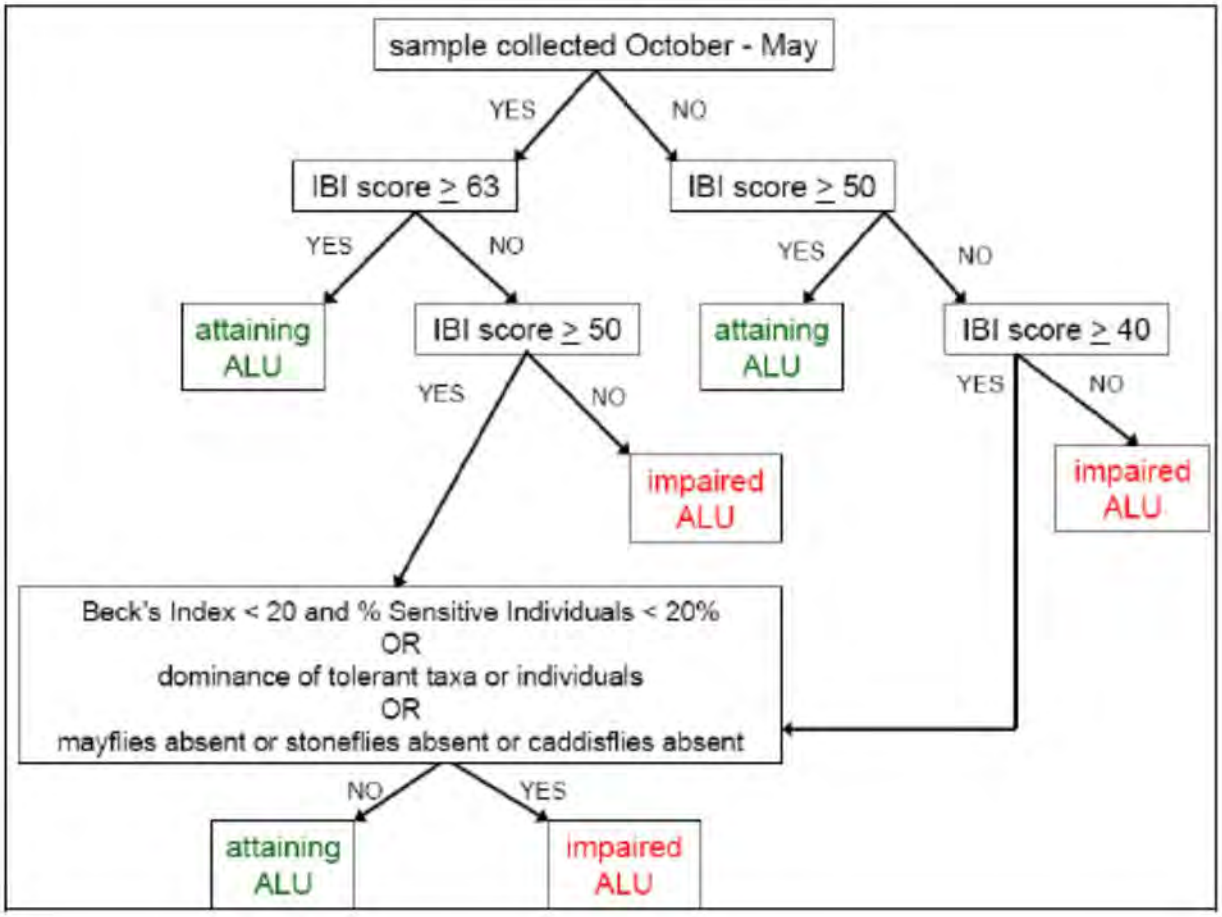
In-stream Habitat Evaluation

Habitat was evaluated for 100 meters at each of the in-stream sample sites using DEP's *Water Quality Network Habitat Assessment* form, which considers the following twelve parameters: in-stream 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 A. 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. Habitat surveys completed with this method are subjective to the observer. This bias was overcome by having the same person perform all of the surveys. Therefore, the results of this study are comparable to one another, but not necessarily comparable to other habitat surveys completed by different observers.

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected at five of the main stem sampling locations in November 2013. Benthic macroinvertebrate collections were performed according to the DEP's Instream Comprehensive Evaluation (ICE) protocol (specifically section C.1.b. Antidegradation Surveys). In short, benthic macroinvertebrate samples consisted of a combination of six D-frame efforts in a 100-meter stream section. These efforts were spread out so as to select the best riffle habitat areas with varying depths. Each effort consisted of an area of one square meter to a depth of at least four inches as substrate allowed and was conducted with a 500-micron mesh, 12-inch diameter D-frame kick net. The six individual efforts were composited and preserved with ethanol for processing in the laboratory. In samples with greater than 200 individuals, subsamples were taken. Individuals were identified by taxonomists certified by the North American Benthological Society to genus or the next highest possible taxonomic level. Samples containing 160 to 240 individuals were evaluated according to the six metrics comprising the DEP's Index of Biotic Integrity (IBI) (Total Taxa Richness, EPT Taxa Richness, Beck's Index V.3, Shannon Diversity, Hilsenhoff Biotic Index, and Percent Sensitive Individuals. Appendix B 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 fishery (Figure 3).

Figure 3 ALU Attainment and Impairment Thresholds for Cold Water Fishes (CWF), Warm Water Fishes (WWF), and Trout Stocked Fishes (TSF) Protected Uses (Department of Environmental Protection, 2009)



Fishery Surveys

Fishery surveys were completed at each of the in-stream sampling locations following PFBC Unassessed Waters protocol. Surveys were conducted during summer low-flow conditions to minimize sampling bias and allow for the capture of young-of-year trout. A sampling site approximately 100 meters in length was selected that included the benthic macroinvertebrate collection site and contained habitat that was representative of the stream. Each sample site ended at a natural impediment to upstream movement to minimize sampling bias. A Smith-Root Model LR-24 backpack electro-fishing unit was used to conduct each survey. Proper current and voltage settings were determined on-site following an evaluation of conductivity. Single pass electrofishing surveys were completed at each site. All fish captured during the electrofishing surveys were identified to species. Each species present for the sample site was given an abundance rating according to the PFBC (< 2 individuals = rare; 2 – 8 individuals = present; 9 – 33 individuals = common; > 33 individuals = abundant). All salmonid species collected were held until the survey was complete and then measured to the nearest millimeter (total length). Brook trout were also categorized by size into 25 mm size classes.

Results/Discussion

Water Chemistry – AMD Discharges

As mentioned above, there are numerous AMD discharges in the Potts Run watershed, but only eight of them were monitored long-term. Table 3 shows the average water chemistry for each of the monitored discharges. The average water chemistry for all eight discharges exceeded Chapter 93 water quality standards for one or more parameters. Chapter 93 Water Quality Standards can be found in Table 4. Additional water chemistry data can be found in Appendix C. Overall, the No. 3 mine discharge accounted for the greatest pollution loading to Potts Run with average loadings of 299 lbs/day acidity, 13.65 lbs/day iron, 6.83 lbs/day manganese, and 22.18 lbs/day aluminum. For this reason, the No. 3 discharge is the number one priority for restoration of Potts Run. Site LPB has the second highest iron and manganese load in the watershed; however, the discharge is alkaline in nature and passes through a natural wetland complex before entering Little Potts Run. Below the wetland, brook trout can be found in Little Potts Run. The third highest loadings in the watershed come from the TP1 discharge; however, this discharge is much smaller than the No. 3 mine discharge, which is located upstream. Treatment of the No. 3 discharge should provide enough buffering capacity to counteract the negative influence of TP1 on Potts Run. If treatment of the No. 3 discharge does not fully restore Potts Run as expected, then the TP1 discharge should become the next priority for treatment. The OT and OJ discharges, though much smaller than the No. 3 discharge, also contain relatively severe chemistry. Due to their close proximity and interconnectedness to the No. 3 mine discharge, they should be treated in conjunction with it, if possible. The other discharges in the watershed are not considered a priority at this time due to the fact that they have relatively little impact on overall water quality in Potts Run, but could be considered for treatment in the future if funding allows.

Table 3 Average Water Chemistry of AMD Discharges

Site ID	Flow (gpm)	Field pH	Lab pH	Cond (uS)	Alk (mg/L)	Acid (mg/L)	Acid Load (lbs/day)	Fe (mg/L)	Fe Load (lbs/day)	Mn (mg/L)	Mn Load (lbs/day)	Al (mg/L)	Al Load (lbs/day)	SO4 (mg/L)
LPB	145	5.66	6.46	528	48	-18	-34	8.80	16.18	4.98	7.71	0.10	0.21	185
TP3	14	5.97	6.26	307	15	5	1	1.23	0.19	0.81	0.13	0.08	0.03	110
TP1	44	3.17	3.76	789	0	46	25	2.15	1.29	6.04	3.13	3.51	1.85	330
453	10	4.69	5.15	610	6	24	2	0.77	0.06	8.26	0.76	0.50	0.06	229
OT	53	2.99	3.50	713	0	72	50	0.89	0.49	6.59	4.70	7.06	4.68	296
OJ	9	3.32	3.91	386	0	42	4	0.18	0.01	3.00	0.25	4.23	0.30	149
OI	3	5.26	6.04	648	16	34	1	18.60	0.42	4.49	0.11	0.26	0.01	253
No. 3	208	3.03	3.03	859	0	130	299	4.77	13.65	3.21	6.83	10.54	22.18	282

Results highlighted in yellow do no meet Chapter 93 water quality criteria.

Table 4 Chapter 93 Water Quality Standards

Parameter	Criteria Value	Notes
Alkalinity	≥20 mg/L	
Aluminum (Al)	≤0.75 mg/L	Total Recoverable
Chloride	≤250 mg/L	
Iron (Fe)	≤1.5 mg/L	Total Recoverable
Manganese (Mn)	≤1.0 mg/L	Total Recoverable
pH	6.0-9.0 SU	
Sulfate	≤250 mg/L	
TDS	≤750 mg/L	

Water Chemistry – Main Stem of Potts Run

Six in-stream sampling locations were established on the main stem of Potts Run. Table 5 shows the average water chemistry at these locations. Average water quality at all six sites met Chapter 93 criteria with the exception of PR5, which had slightly elevated sulfate levels. Average aluminum, iron, and manganese concentrations are elevated at both in-stream locations below the No. 3 Mine discharge (PR1 and PR2), but still fall within acceptable limits. Otherwise, the stream is net alkaline from headwaters to mouth, and exhibits relatively good average water quality. Additional water chemistry data for these sites can be found in Appendix D.

Table 5 Average In-stream Water Chemistry of Potts Run

Site ID	Flow (gpm)	Field pH	Lab pH	Cond (uS)	Temp (°C)	Alk (mg/L)	Acid (mg/L)	Acid Load (lbs/day)	Fe (mg/L)	Fe Load (lbs/day)	Mn (mg/L)	Mn Load (lbs/day)	Al (mg/L)	Al Load (lbs/day)	SO4 (mg/L)	TSS (mg/L)	TDS (mg/L)	Diss. Fe (mg/L)	Diss. Al (mg/L)	Diss. Mn (mg/L)	Ca (mg/L)	Mg (mg/L)	Chloride (mg/L)
PR1	1864	6.69	7.0	486.3	7.6	46	-26	-340	0.37	10.10	0.43	10.02	0.32	10.19	175	BD	333	BD	BD	0.34	58.82	19.49	10.6
PR2	1441	7.03	7.4	518	6.9	57	-38	-382	0.41	7.14	0.64	8.85	0.49	9.80	187	6.8	336	BD	0.18	0.61	66.88	19.88	10.5
PR3	981	7.30	7.6	643.3	7.0	93	-74	-512	0.24	2.20	0.07	0.74	0.07	0.82	221	6.0	430	BD	BD	0.06	93.44	24.55	9.4
PR4	827	7.50	7.7	700.8	7.4	104	-88	-605	0.23	1.86	0.06	0.58	BD	--	242	BD	476	BD	BD	0.05	105.22	27.23	9.0
PR5	517	7.81	8.2	875.5	8.2	138	-120	-777	0.19	1.13	0.09	0.51	BD	--	309	BD	623	0.07	BD	0.08	128.73	34.49	7.6
PR6	77	7.58	8.1	705.5	8.0	167	-152	-143	0.27	0.26	0.07	0.07	BD	--	175	BD	470	0.08	BD	0.07	102.43	27.46	12.8

Note: BD indicates parameter was below detection limit. Results highlighted in yellow do not meet Chapter 93 water quality criteria.

Habitat

The results from the in-stream habitat assessments are provided in Table 6. Three of the six locations that were evaluated for habitat received total scores in the optimal range, while the other three received scores in the sub-optimal range indicating that habitat throughout the watershed is relatively good. The PR1 sampling location received the highest habitat score, with all parameters scoring in the optimal or sub-optimal range. The PR6 sampling location received the lowest habitat score, due to poor scores for the in-stream cover, epifaunal substrate, velocity/depth regimes, and frequency of riffles parameters. It should be noted that the stream at PR6 flows through a large beaver impoundment/wetland complex that was breached sometime in the last few years. The stream is still trying to establish a new channel through the wetland area, leading to many of the poor scores during the habitat assessment. Only two sampling locations received poor scores for any parameter: PR3 for in-stream cover and PR6 for the above mentioned parameters. All six sampling locations scored below optimal in the embeddedness parameter, while three locations scored below optimal in the sediment deposition parameter. Poor scores for these two parameters are of greater concern because of their ability to influence in-stream benthic macroinvertebrate populations, and in turn, fish populations. See Appendix 1 for a more thorough explanation of these parameters. Several likely sources of sediment to Potts Run were identified during this assessment and development of the coldwater conservation plan including streambank erosion, abandoned mine lands, dirt and gravel roads, and down-cutting of the stream through sediments deposited in formerly impounded areas. Addressing these sources of sediment will improve in-stream habitat in the watershed and should lead to increased populations of macroinvertebrates and fish.

Table 6 Potts Run Habitat Assessment Results

Parameter	**PR1**	**PR2**	**PR3**	**PR4**	**PR5**	**PR6**
Instream Cover (Fish)*	20	8	5	14	9	5
Epifaunal Substrate*	20	16	12	20	8	3
Embeddedness*	13	9	8	9	7	10
Velocity/Depth Regimes	14	17	9	18	7	4
Channel Alteration	20	15	20	18	20	17
Sediment Deposition*	16	19	10	13	15	17
Frequency of Riffles	17	19	9	17	8	2
Channel Flow Status	16	18	13	13	20	20
Condition of Banks	20	19	19	17	20	14
Bank Vegetative Protection	20	20	20	20	20	20
Grazing or Other Disruptive Pressure	20	20	20	20	20	20
Riparian Vegetative Zone Width	20	20	20	20	19	16
Total Score	**216**	**200**	**165**	**199**	**173**	**148**

Optimal
Suboptimal
Marginal
Poor

Macroinvertebrates

Benthic macroinvertebrates were collected at five of the six in-stream sampling sites as outlined in the methods. A macroinvertebrate survey was not completed at PR6 due to the lack of appropriate habitat. 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 Appendix E. Pollution tolerances of the taxa increase 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. PTV values were developed by DEP using primarily organic sources of pollution and do not reflect the tolerance of the organism to acid derived pollution. (I.e. in acidified streams, the IBI score may be inflated due to the presence of acid tolerant genera that have a low PTV for organic pollution.)

Overall, the most abundant families in these samples were Elmidae (Order Coleoptera) Hydropsychidae (Order Trichoptera) and Chironomidae (Order Diptera) (Appendix E). All three of these families are relatively tolerant to anthropogenic pollution with PTVs of 5, 5, and 6, respectively.

The biological metrics calculated for each sample site are provided in Table 7. Detailed descriptions of these metrics are provided in Appendix B. The PR1 and PR4 sampling locations both met attaining life use criteria according to the ALU assessment decision tree found in the methods. PR1 had an IBI score of 65, automatically meeting the criteria for attaining ALU (IBI > 62). Although the IBI score for PR4 was only 52.9, it contained a fairly high percentage of sensitive individuals which show that it is attaining its designated ALU. The PR5 site was close to meeting the ALU criteria (IBI = 56.4) but did not meet the conditions found in the decision tree to be considered as attaining its designated ALU. This stream location should be re-evaluated in the future for ALU attainment, as continuing habitat improvements in the upstream reaches containing the breached beaver impoundment may be enough to change its ALU designation to attaining. One site (PR2) did not contain enough individuals in order for the IBI to be calculated, and the remaining site, PR3, had an IBI score (33.6) that indicates that it is not meeting its designated aquatic life use of CWF. Site PR2 is located directly downstream from the No. 3 mine discharge and there is a great deal of aluminum precipitate on the substrate in this area that may be affecting macroinvertebrates. Site PR3 is located just upstream of the Rea's Lane bridge where the stream is very low gradient and contains a long run and deep pool where sediment from upstream is deposited.

Taxa richness varied among sites, ranging between 16 and 29 taxa. The PR5 sample site contained the greatest number of taxa (29 taxa), followed by PR1 (26 taxa). The PR2 site had the fewest number of taxa observed (16 taxa). The number of taxa belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa) accounted for 41.2% of the total number of individual organisms collected (Appendix E). The presence of EPT taxa in samples is generally an indicator of adequate water chemistry and habitat availability for these organisms.

Table 7 Benthic macroinvertebrate biometric results. See Appendix B for detailed descriptions.

	PR1	**PR2**	**PR3**	**PR4**	**PR5**
Total Taxa Richness	26	16	18	21	29
EPT Taxa Richness	12	6	1	6	8
Beck's Index V.3	20	10	4	11	13
Hilsenhoff Biotic Index	4.24	4.04	5.03	4.22	4.38
Shannon Diversity Index	2.32	2.21	1.91	2.43	2.44
Percent Sensitive Individuals	36.6	33.8	2.6	31.3	16.7
IBI Score	**65**	**N/A**	**33.6**	**52.9**	**56.4**

Note: N/A indicates that the IBI could not be calculated because the sample contained fewer than 200 +/- 40 individuals; therefore the stream at this location does not meet the criteria for ALU attainment.

Fish

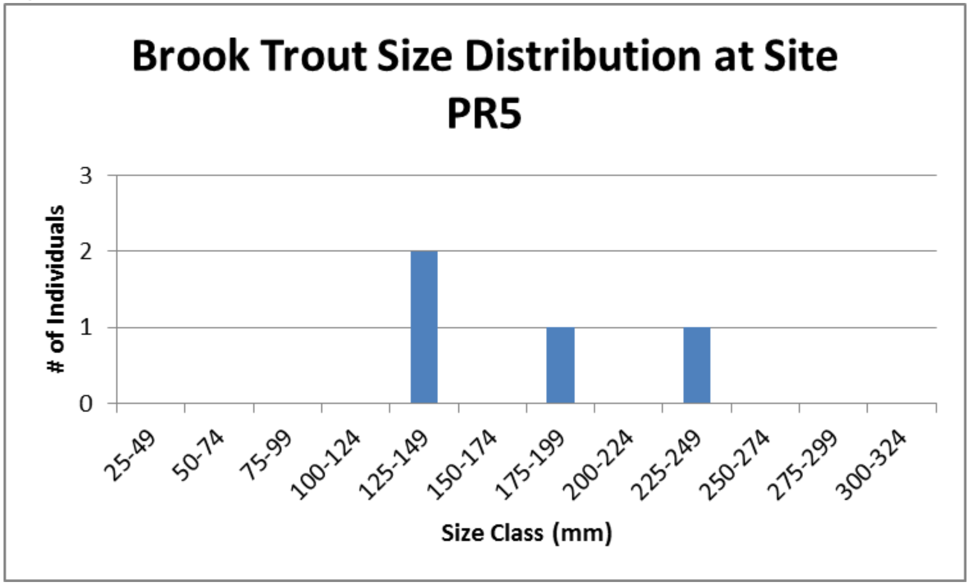
Fishery surveys were completed at all six in-stream sampling locations during August of 2013 and 2014. The species and abundance of fish captured can be found in Table 8. Overall, the most abundant species was the creek chub (*Semotilus acromaculatus*) followed by the blacknose dace (*Rhynichthys atratulus*). Brook trout were found at only one main stem location, PR5, during this study. The size distribution for the trout at this location can be found in Figure 4. However, it should be noted that during development of the Potts Run Coldwater Conservation Plan, brook trout surveys were completed on all of the tributaries to Potts Run, seven of which contained brook trout and are now awaiting final approval by the PFBC for inclusion on the Wild Trout list. Young-of-year brook trout were collected at six of these sites, confirming that reproduction is occurring in the watershed. Additionally, during angler surveys in the spring of 2013 and 2014, numerous brook trout were caught by two different anglers in the section of Potts Run between PR1 and PR2. One brook trout was caught on the main stem of Potts Run between PR2 and PR3 during an unassessed waters survey in August 2012, and visual observations of brook trout have occurred at various times of the year throughout the main stem of Potts Run.

Site PR5 had the highest species richness with six species present, followed by PR3 and PR1, each with five species present. Site PR2 (downstream of the No. 3 mine discharge) had the lowest species richness with only two species present.

Table 8 Fish Abundance and Species Richness at Potts Run Main Stem Sampling Sites

Common Name	Species	PR1	PR2	PR3	PR4	PR5	PR6
Blacknose Dace	*Rhinichthys atratulus*	1	2	15	12	15	
Brook Trout	*Salvelinus fontinalis*					4	
Creek Chub	*Semotilus atromaculatus*	1	9	10	20	30+	22
Green Sunfish	*Lepomis cyanellus*						
Longose Dace	*Rhinichthys cataractae*	1					
Margined Madtom	*Noturus insignis*	2					1
Northern Hogsucker	*Hypentelium nigricans*			1		4	
Pumpkinseed	*Lepomis gibbosus*			4	4	1	
Rock Bass	*Ambloplites rupestris*	2					
Tesselated Darter	*Etheostoma olmstedi*			1	2	1	
White Sucker	*Catostomus commersonii*						1
	Species Richness	**5**	**2**	**5**	**4**	**6**	**3**

Figure 4: Brook Trout Size Distribution at Site PR5



AMD Restoration

As stated above, Hedin Environmental completed an AMD "snapshot" of the Potts Run watershed for the Knox Township Supervisors through TU's AMD Technical Assistance Program. A copy of this report can be found in Appendix F. The findings of the snapshot report agree with the data collected during this assessment and point to the Potts Run No. 3 deep mine discharge as the main contributor of acidity and metal loadings to Potts Run. Treatment of the No. 3 deep mine will restore 0.4 miles of the unnamed tributary (UNT26197) to which it flows, along with the entire 2.7-mile section of Potts Run that is currently listed as impaired.

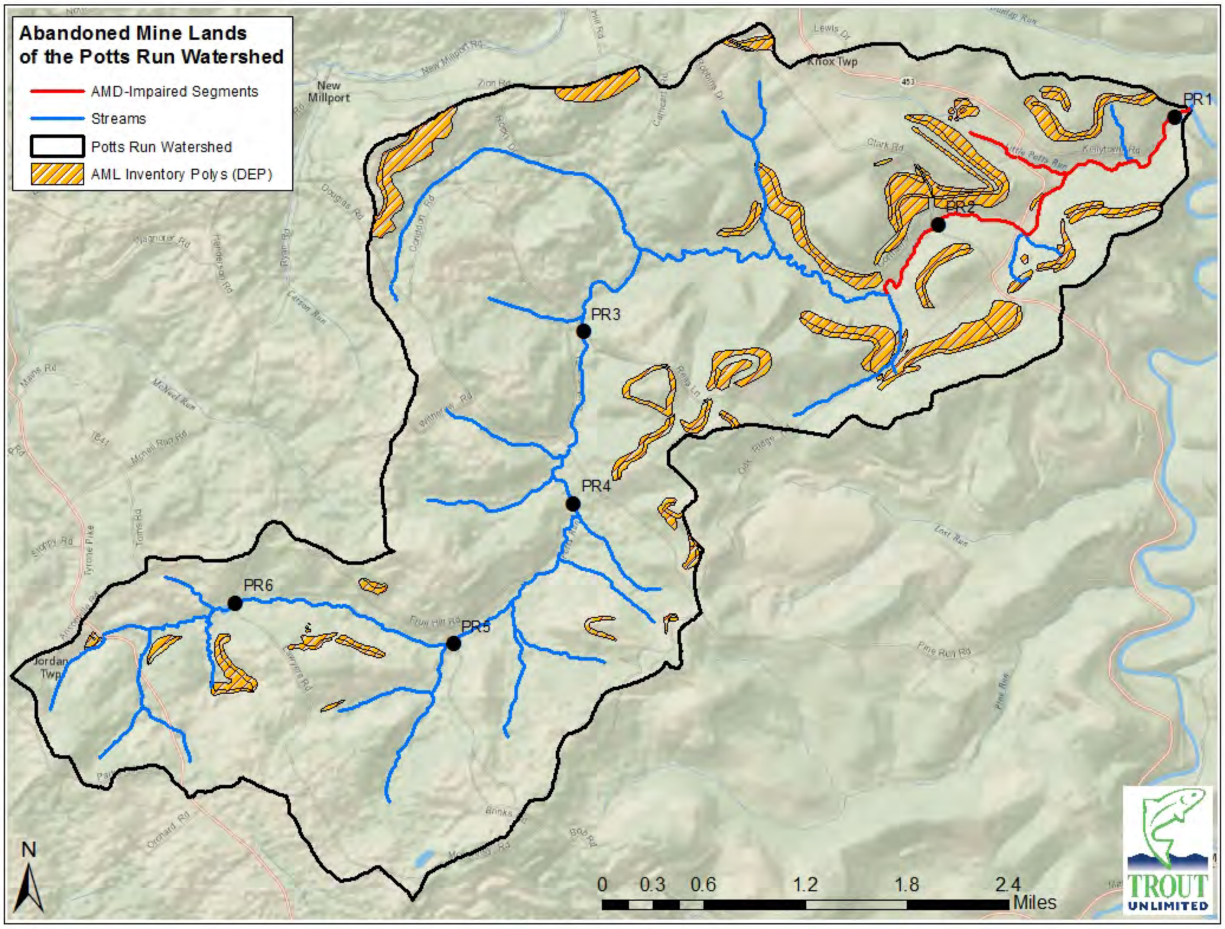
Water quality data indicates that the No. 3 discharge can be treated passively using a vertical flow pond (VFP) system and wetlands/settling basins. Hedin Environmental proposes to build a collection system that will gather the water from the No. 3, OT, and OJ discharges and pipe them to land on the northwest side of Oak Ridge Road for treatment. This area is currently occupied by the No. 3 refuse pile, but it is hoped that this pile can be removed/reclaimed and the area used for construction of the treatment system to avoid disturbing additional ground and impacting wetlands. If this is not possible, the system will be shifted slightly further to the northwest to an upland area that was previously disturbed by clear-cut logging. Please see Figure 3 in the attached report (Appendix F) for a schematic of the proposed treatment system.

Treatment of the No. 3 mine discharge will prevent an average of nearly 300 lbs/day acidity, 14 lbs/day iron, 7 lbs/day manganese, and 22 lbs/day of aluminum from entering UNT26197 and Potts Run, restoring water quality and further enhancing aquatic life in the stream. These improvements in water quality will also aid in the biological recovery of the stream. Macroinvertebrate and fish populations that are downstream of this discharge should begin to recover almost immediately once water quality is improved. Future biological monitoring should show an increase in macroinvertebrate IBI scores, fish abundance, and fish species richness. Please see Appendix F for the full report including cost estimates for the proposed treatment system.

Abandoned Mine Land (AML) Inventory

In addition to the water quality sampling and biological monitoring that took place as part of this assessment, an effort was made to investigate AML areas in the watershed (Figure 5) and determine their reclamation status. Through these efforts, several AML features in the watershed, including abandoned highwalls near the village of Boardman, have been upgraded from Priority 3 (P3) to Priority 2 (P2) status due to their near-vertical nature and close proximity to residences. TU worked with the property owners (heirs of the Potts Run Coal Company) and DEP Bureau of Abandoned Mine Reclamation (BAMR) officials to investigate these highwalls and adjacent coal refuse piles. A reclamation plan for the area is now in the development stages and will complement any water quality improvements that are made through remediation of the No 3. Mine discharge. In the middle and upper portion of the watershed, it appears that several AML features have been reclaimed through remining activities in the past decade or so. Additionally, during the course of this study, BAMR completed a surface reclamation and stream reconstruction project on an abandoned mine site just south of the village of Ansonville in Jordan Township, where the headwaters of Potts Run flowed through an abandoned surface mine. In the future, efforts should be made to work with additional landowners and BAMR, to reclaim additional priority AML areas in the watershed, further improving public safety and enhancing the watershed.

Figure 5 AML Features in the Potts Run Watershed



Additional Recommendations

In addition to the AMD/AML restoration activities mentioned above, it is recommended that additional work be completed that would enhance the in-stream and riparian habitat found within the Potts Run watershed. Data gathered during this study and development of the coldwater conservation plan have indicated that in addition to AMD, sedimentation and elevated summer water temperatures may be contributing to the depressed macroinvertebrate and fish populations found at several of the Potts Run sampling locations. It is recommended that additional projects such as riparian plantings, reclamation of spoil and refuse piles, streambank stabilization projects, dirt and gravel road improvements, and fish habitat enhancement projects be implemented to address these issues.

Also, at this time, there are no public lands located in the Potts Run watershed. The Pennsylvania Game Commission is currently negotiating with a private landowner to acquire 1200 acres near the village of Boardman that would provide access to several miles of Potts Run, as well as, frontage along Clearfield Creek. It is recommended that other environmentally and/or recreationally significant areas be identified in the watershed and a plan developed to provide public access and/or land protection to these areas through easements or acquisitions.

APPENDIX A 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 B Description of Biological Metrics

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 C Water Chemistry of Potts Run AMD Discharges

Site ID	Date	Flow (gpm)	Field pH	Lab pH	Cond (uS)	Temp	Alk (mg/L)	Acid (mg/L)	Acid Load (lbs/day)	Fe (mg/L)	Fe Load (lbs/day)	Mn (mg/L)	Mn Load (lbs/day)	Al (mg/L)	Al Load (lbs/day)	SO4 (mg/L)	TSS (mg/L)	TDS (mg/L)
LPB	06/26/12	--	5.78	6.5	607	--	34	-15	--	4.56	--	5.94	--	0.10	--	244	8.0	426
	12/18/12	--	6.56	6.3	519	5.4	50	-18	--	5.82	--	5.27	--	0.06	--	191	<5.0	343
	02/01/13	268	5.90	6.6	341	3.5	35	-17	-55	5.74	18.49	3.04	9.79	0.12	0.39	114	7.0	194
	12/19/12	53	5.81	6.3	588	9.8	76	-24	-15	18.00	11.45	5.39	3.43	0.16	0.10	193	<5.0	369
	02/28/13	157	5.35	6.6	510	5.5	46	-17	-32	9.87	18.60	5.26	9.91	0.08	0.15	181	12.0	345
	05/30/13	177	5.49	--	550	18.4	Flow and field chem only											
	07/24/13	136	5.42	--	550	17.0												
	12/05/13	81	5.00	--	560	5.8												
TP3	06/26/12	7	5.50	6.5	215	--	22	-4	0	3.77	0.32	0.63	0.05	0.05	0.00	66	<5.0	133
	10/23/12	6	6.24	6.5	349	9.5	16	2	0	0.11	0.01	1.01	0.07	<0.05	--	137	<5.0	218
	11/28/12	6	6.16	6.5	357	2.5	14	5	0	0.13	0.01	0.80	0.05	<0.05	--	146	<5.0	230
	12/18/12	11	5.56	6.0	263	5.5	16	10	1	2.16	0.29	0.85	0.11	0.08	0.01	103	6.0	173
	02/01/13	60	5.78	6.1	172	0.3	8	6	4	0.45	0.32	0.35	0.25	0.14	0.10	61	<5.0	118
	02/28/13	18	6.04	6.2	317	3.0	15	7	2	0.71	0.15	1.10	0.24	<0.05		127	<5.0	207
	03/27/13	13	6.24	6.0	306	3.7	16	10	2	1.31	0.20	0.93	0.15	0.06	0.01	131	<5.0	196
	04/30/13	13	6.03	--	300	10.7	Flow and field chem only											
	05/30/13	10	6.03	--	310	15.7												
	06/27/13	10	5.80	--	330	14.2												
	07/24/13	9	5.75	--	350	13.9												
	08/27/13	8	5.99	--	370	14.4												
	12/05/13	7	6.53	--	350	7.0												
TP1	06/26/12	52	3.32	3.6	921	--	0	49	31	2.67	1.67	6.97	4.35	3.66	2.28	389	<5.0	605
	10/23/12	19	3.31	3.7	797	9.7	0	43	10	2.36	0.54	7.21	1.64	3.69	0.84	360	5.0	559
	11/28/12	19	3.02	3.7	776	3.4	0	50	11	2.12	0.48	6.86	1.56	3.86	0.88	352	<5.0	526
	12/18/12	53	3.32	3.6	722	6.1	0	52	33	1.73	1.10	5.59	3.56	3.23	2.05	315	<5.0	473
	02/01/13	97	3.44	4.1	399	2.3	1	25	29	3.22	3.75	2.83	3.29	1.76	2.05	163	<5.0	263
	02/28/13	35	3.14	3.8	752	3.8	0	49	21	2.01	0.84	6.46	2.71	4.02	1.69	323	<5.0	536
	03/27/13	53	3.36	3.8	759	4.8	0	56	36	1.51	0.96	6.40	4.07	4.23	2.69	364	7.0	536
	04/30/13	53	3.46	3.8	733	11.0	0	47	30	1.58	1.00	6.02	3.83	3.65	2.32	373	<5.0	550
	05/30/13	53	3.44	--	880	15.8	Flow and field chem only											
	06/27/13	35	3.00	--	860	15.3												
	07/24/13	35	3.07	--	910	14.9												
	08/27/13	53	2.89	--	940	15.8												
	12/05/13	19	2.47	--	810	6.7												
453	06/26/12	7	--	4.4	625	--	4	23	2	1.09	0.09	8.14	0.68	0.89	0.07	225	<5.0	407
	10/23/12	3	4.61	4.8	678	9.4	5	23	1	1.00	0.04	12.00	0.43	0.32	0.01	304	6.0	477
	11/28/12	3	4.81	5.4	704	0.5	7	29	1	1.52	0.05	12.80	0.46	0.30	0.01	318	<5.0	492
	12/18/12	3	5.61	5.7	508	6.1	8	24	1	0.90	0.03	6.93	0.25	0.13	0.00	204	<5.0	330
	02/01/13	17	4.89	6.0	428	0.0	9	11	2	0.58	0.12	5.13	1.05	0.10	0.02	156	<5.0	278
	02/28/13	17	4.46	5.0	515	1.7	6	24	5	0.33	0.07	6.66	1.36	0.58	0.12	186	<5.0	393
	03/27/13	5	4.68	5.2	616	2.1	6	29	2	0.51	0.03	7.44	0.45	0.47	0.03	215	7.0	390
	04/30/13	17	4.62	4.7	561	10.8	5	29	6	0.25	0.05	6.97	1.38	1.22	0.24	222	<5.0	389
	05/30/13	8	4.66	--	630	19.5	Flow and field chemistry only											
	06/27/13	49	4.40	--	620	17.6												
	07/24/13	1	4.21	--	690	17.2												
	08/27/13	3	4.16	--	730	18.6												
	12/05/13	1	5.19	--	630	1.7												
OT	06/26/12	41	3.17	3.5	813	--	0	78	38	0.94	0.46	8.70	4.28	6.76	3.33	343	<5.0	548
	10/23/12	13	3.07	3.5	706	9.9	0	70	11	1.39	0.22	6.72	1.05	8.13	1.27	308	13.0	470
	11/28/12	13	3.05	3.5	762	3.5	0	82	13	1.33	0.21	7.27	1.13	9.26	1.44	346	5.0	517
	12/18/12	5	3.20	3.4	757	6.5	0	95	6	1.25	0.08	7.04	0.42	9.03	0.54	333	<5.0	497
	02/01/13	136	2.57	3.6	495	4.0	0	51	83	0.46	0.75	4.42	7.21	4.64	7.57	204	<5.0	196
	02/28/13	81	2.92	3.5	644	5.7	0	73	71	0.68	0.66	6.18	6.01	6.62	6.43	268	<5.0	433
	03/27/13	98	2.91	3.5	626	5.6	0	73	86	0.58	0.68	5.84	6.87	6.12	7.20	271	6.0	399
	04/30/13	136	3.21	3.5	604	7.8	0	55	90	0.51	0.83	6.52	10.66	5.93	9.69	292	<5.0	429
	05/30/13	64	3.34	--	700	11.7	Flow and field chemistry only											
	06/27/13	35	3.30	--	740	11.5												
	07/24/13	23	2.85	--	810	11.8												
	08/27/13	23	2.77	--	800	13.2												
	12/05/13	23	2.45	--	810	7.0												

Appendix C (Continued)

Site ID	Date	Flow (gpm)	Field pH	Lab pH	Cond (uS)	Temp	Alk (mg/L)	Acid (mg/L)	Acid Load (lbs/day)	Fe (mg/L)	Fe Load (lbs/day)	Mn (mg/L)	Mn Load (lbs/day)	Al (mg/L)	Al Load (lbs/day)	SO4 (mg/L)	TSS (mg/L)	TDS (mg/L)
OJ	06/26/12	7	3.59	4.0	333	--	0	32	3	0.06	0.01	2.52	0.21	2.70	0.23	121	<5.0	200
	10/23/12	3	3.47	3.9	587	9.6	0	58	2	0.26	0.01	5.02	0.18	8.14	0.29	253	<5.0	394
	11/28/12	3	3.56	3.5	568	7.3	0	67	2	0.26	0.01	5.20	0.16	8.25	0.25	253	<5.0	384
	12/18/12	4	3.52	3.8	514	8.0	0	65	3	0.17	0.01	4.26	0.18	7.21	0.30	228	<5.0	348
	02/01/13	16	2.91	4.0	292	6.5	0	29	6	0.13	0.02	2.19	0.42	2.73	0.52	111	<5.0	175
	02/28/13	11	3.10	4.0	219	5.8	0	31	4	<0.05	--	1.62	0.21	1.65	0.22	72	<5.0	123
	03/27/13	13	3.13	4.0	209	5.5	0	29	5	0.17	0.03	1.45	0.23	1.58	0.25	70	<5.0	102
	04/30/13	19	3.62	4.1	220	7.8	1	28	6	<0.05	--	1.72	0.39	1.54	0.35	84	<5.0	127
	05/30/13	12	3.70	--	200	10.1	Flow and field chemistry only											
	06/27/13	10	3.42	--	360	10.0												
	07/24/13	9	3.26	--	380	10.9												
	08/27/13	7	3.23	--	540	11.4												
	12/05/13	4	2.71	--	590	8.3												
OI	10/23/12	1	5.33	6.1	726	12.9	16	52	0	32.20	0.19	6.99	0.04	0.11	0.00	349	<5.0	582
	11/28/12	1	6.04	6.1	751	8.5	12	64	0	35.50	0.21	7.58	0.05	0.11	0.00	371	10.0	559
	12/18/12	3	5.67	6.0	575	6.5	22	23	1	15.00	0.54	3.42	0.12	0.09	0.00	233	<5.0	381
	02/01/13	3	4.68	6.2	457	2.1	13	21	1	9.18	0.33	2.78	0.10	0.52	0.02	175	6.0	298
	02/28/13	3	5.05	6.0	857	2.8	16	26	1	12.90	0.46	3.55	0.13	0.30	0.01	202	11.0	523
	03/27/13	3	5.05	5.8	667	3.7	17	34	1	14.20	0.51	3.73	0.13	0.36	0.01	214	11.0	413
	04/30/13	5	5.20	6.1	451	10.2	17	20	1	11.19	0.70	3.35	0.21	0.33	0.02	230	<5.0	320
	05/30/13	8	5.38	--	520	16.4	Flow and field chem only											
	06/27/13	3	5.20	--	570	15.4												
	07/24/13	1	5.31	--	660	15.3												
	08/27/13	3	5.39	--	720	15.4												
	12/05/13	1	4.78	--	820	8.6												
No. 3	06/26/12	278	2.74	3.0	871	--	0	116	387	4.68	15.61	2.77	9.24	8.70	29.02	228	<5.0	483
	10/23/12	46	2.71	3.0	930	10.0	0	151	84	3.98	2.22	4.10	2.28	14.30	7.96	343	<5.0	522
	11/28/12	25	2.52	3.0	988	7.7	0	149	45	3.95	1.20	4.25	1.29	13.50	4.10	345	6.0	531
	12/18/12	9	2.70	3.0	774	8.1	0	125	13	3.13	0.34	3.15	0.34	10.20	1.10	250	<5.0	424
	02/01/13	238	2.31	3.1	689	6.9	0	108	309	6.36	18.17	2.74	7.83	8.90	25.43	244	<5.0	381
	02/28/13	364	2.47	3.1	778	8.9	0	124	542	5.64	24.64	2.66	11.62	8.27	36.12	235	74.0	379
	03/27/13	364	2.45	3.0	722	8.9	0	124	542	5.08	22.19	2.53	11.05	8.63	37.70	242	<5.0	387
	04/30/13	556	2.81	3.1	691	9.6	0	115	767	5.74	38.30	2.64	17.62	8.64	57.66	270	<5.0	409
	05/30/13	320	2.94	--	830	10.2	Flow and field chem only											
	06/27/13	320	2.66	--	880	10.2												
	07/24/13	130	2.48	--	940	10.1												
	08/27/13	46	2.42	--	1020	10.4												
	12/05/13	3	1.94	3.0	1060	9.8	0	155	6	4.40	0.17	4.04	0.15	13.68	0.52	378	6.0	599

Appendix D Water Chemistry of Potts Run In-stream Sampling Locations

Site ID	Date	Flow (gpm)	Field pH	Lab pH	Cond (uS)	Temp (°C)	Alk (mg/L)	Acid (mg/L)	Acid Load (lbs/day)	Fe (mg/L)	Fe Load (lbs/day)	Mn (mg/L)	Mn Load (lbs/day)	Al (mg/L)	Al Load (lbs/day)	SO4 (mg/L)	TSS (mg/L)	TDS (mg/L)	Diss. Fe (mg/L)	Diss. Al (mg/L)	Diss. Mn (mg/L)	Ca (mg/L)	Mg (mg/L)	Chloride (mg/L)
PR1	10/23/12	893	6.67	7.7	583	9.0	57	-41	-439	<0.05	--	0.14	1.50	0.05	0.54	227	<5.0	400	<0.05	<0.05	0.14	81.30	26.00	8.8
	03/27/13	4547	5.91	6.3	349	2.6	28	-4	-218	0.38	20.73	0.46	25.10	0.58	31.65	108	<5.0	198	<0.05	<0.05	0.45	34.50	12.10	13.5
	08/13/13	1128	6.91	6.8	489	17.4	48	-25	-339	0.66	8.94	0.61	8.26	0.57	7.72	181	6.0	357	<0.05	0.06	0.27	56.99	20.60	9.7
	11/13/13	887	7.28	7.2	524	1.5	51	-34	-362	0.06	0.64	0.49	5.22	0.08	0.85	185	<5.0	375	<0.05	<0.05	0.50	62.49	19.25	10.5
PR2	10/23/12	580	7.07	7.8	607	9.4	64	-49	-341	0.23	1.60	0.81	5.64	0.28	1.95	254	7.0	406	<0.05	0.28	0.81	84.90	25.20	13.4
	03/27/13	3660	6.15	6.4	346	2.5	32	-7	-307	0.41	18.01	0.39	17.13	0.61	26.79	110	10.0	198	0.06	<0.05	0.38	37.00	12.10	11.6
	08/15/13	922	7.60	7.9	581	14.3	66	-48	-531	0.47	5.20	0.77	8.52	0.69	7.64	205	5.0	378	<0.05	0.08	0.73	69.82	21.92	7.6
	11/13/13	603	7.28	7.3	538	1.5	67	-48	-347	0.52	3.76	0.57	4.12	0.39	2.82	179	5.0	362	<0.05	<0.05	0.51	75.80	20.28	9.2
PR3	10/23/12	374	7.31	8.0	727	9.6	105	-91	-408	0.22	0.99	0.05	0.22	<0.05	--	269	6.0	497	<0.05	<0.05	0.05	119.00	29.60	8.4
	03/27/13	2613	6.63	6.5	396	2.4	49	-20	-627	0.15	4.70	0.06	1.88	0.06	1.88	122	6.0	224	0.08	<0.05	0.06	48.40	14.00	12.3
	08/15/13	368	7.72	8.2	762	14.4	120	-104	-460	0.32	1.41	0.10	0.44	0.08	0.35	255	<5.0	515	<0.05	<0.05	0.07	101.58	28.71	7.7
	11/13/13	568	7.55	7.7	688	1.7	99	-81	-552	0.25	1.70	0.06	0.41	<0.05	--	237	<5.0	482	<0.05	<0.05	0.06	104.78	25.90	9.1
PR4	10/23/12	365	7.70	8.1	781	10.3	114	-102	-447	0.29	1.27	0.05	0.22	<0.05	--	290	<5.0	553	<0.05	<0.05	0.04	132.00	32.00	7.7
	03/27/13	2010	6.69	6.6	435	2.6	51	-30	-724	0.14	3.38	0.06	1.45	0.05	1.21	133	<5.0	260	0.06	<0.05	0.06	50.90	14.70	13.2
	08/15/13	552	7.75	8.3	843	14.7	138	-124	-821	0.24	1.59	0.05	0.33	<0.05	--	288	<5.0	570	<0.05	<0.05	0.03	122.39	33.78	7.1
	11/13/13	381	7.85	7.9	744	2.0	111	-94	-430	0.26	1.19	0.07	0.32	<0.05	--	257	<5.0	521	<0.05	<0.05	0.06	115.58	28.44	8.0
PR5	08/15/13	744	7.60	8.3	927	14.3	148	-132	-1179	0.18	1.61	0.08	0.71	<0.05	--	328	<5.0	642	<0.05	<0.05	0.07	134.06	37.50	7.0
	11/13/13	290	8.01	8.0	824	2.1	128	-108	-375	0.19	0.66	0.09	0.31	<0.05	--	290	<5.0	604	0.07	<0.05	0.09	123.39	31.47	8.1
PR6	08/15/13	93	7.29	8.2	784	13.2	185	-169	-189	0.35	0.39	0.09	0.10	<0.05	--	204	<5.0	509	0.08	<0.05	0.09	111.25	32.63	10.1
	11/13/13	60	7.86	8.0	627	2.7	149	-134	-96	0.19	0.14	0.05	0.04	<0.05	--	146	<5.0	430	<0.05	<0.05	0.05	93.61	22.29	15.5

Appendix E Macroinvertebrate Data for the Potts Run Watershed

Order	Family	PA Taxon	PA PTV	PR1	PR2	PR3	PR4	PR5
		Oligochaeta	10	2		2	3	1
		Hydracarina	7	1	1	8	12	8
Coleoptera	Elmidae	Optioservus	4	7	7	84	53	88
		Oulimnius	5			2	14	5
		Stenelmis	5	1			2	12
		Dubiraphia	6			3		1
Diptera	Ceratopogonidae	Ceratopogonidae	6		1			1
		Dasyhelea	6		3			
	Chironomidae	Chironomidae	6	65	26	46	36	15
	Empididae	Hemerodromia	6	8		8	6	6
	Simuliidae	Prosimulium	2	1			9	3
	Tipulidae	Dicranota	3		2			4
		Hexatoma	2					3
		Tipula	4	1		1		
		Antocha	3	2		4	7	4
	Athericidae	Atherix	2				1	
Ephemeroptera	Ameletidae	Ameletus	0			1	1	
	Baetidae	Baetis	6	8				
	Ephemerellidae	Eurylophella	4	1				1
	Heptageniidae	Epeorus	0				1	
		Maccaffertium	3	7				
	Caenidae	Caenis	7			1		1
Megaloptera	Corydalidae	Nigronia	2			1		2
	Sialidae	Sialis	6					
Odonata	Gomphidae	Gomphidae	4	1		4	5	
	Calopterygidae	Calopteryx	6					1
	Aeschnidae	Boyeria	2					1
Plecoptera	Capniidae	Allocapnia	3	21	2		3	2
	Chloroperlidae	Chloroperlidae	0	2				
		Sweltsa	0	1				
	Leuctridae	Leuctra	0	2	4			
	Perlidae	Acroneuria	0					2
		Agnetina	2					4
	Perlodidae	Isoperla	2					9
	Taeniopterygidae	Taeniopteryx	2	36	5		38	5
		Taeniopterygidae	2	3	3		12	
Trichoptera	Hydropsychidae	Ceratopsyche	5	49	3	3	6	31
		Cheumatopsyche	6		1	51	19	17
		Diplectrona	0	2	6			
		Hydropsyche	5	4	2	10	2	7
	Limnephilidae	Limnephilidae	4					3
	Philopotamidae	Chimarra	4	2				
		Dolophilodes	0	7				
	Polycentropodidae	Polycentropus	6	1				
	Psychomyiidae	Psychomyia	2				1	
	Rhyacophilidae	Rhyacophila	1	3	1			
	Glossosomatidae	Glossosoma	0					1
	Phryganeidae	Oligostomis	5					
		Nematoda	9			3		1
	Tetrastemmatidae	Prostoma	6		1	2	2	
				238	**68**	**234**	**233**	**239**

Appendix F Potts Run AMD Snapshot Report by Hedin Environmental

Potts Run Restoration Plan, Existing AMD and Treatment Opportunities

Technical Report Provided by Hedin Environmental through the Trout Unlimited AMD Technical Assistance Program

June 2014

Background

This Trout Unlimited (TU) Technical Assistance project addresses acid mine drainage (AMD) pollution in the Potts Run watershed. Initially, the assistance involved the establishment of monitoring points in the Potts Run watershed that would be sampled by TU staff. This work was completed in June 2012. However, as TU investigated restoration options it became clear that both PA DEP and a private mining company were planning to work in the watershed. For this reason, the scope of the project was expanded to include technical assistance in coordinating an effort to consolidate and add urgency to the various reclamation efforts. The monitoring effort was expanded to include a full round of sampling under higher flow spring conditions and the preparation of a restoration plan. That plan is being prepared by TU and will include the AMD assessment and treatment recommendations from this report.

Potts Run Watershed

Potts Run is a tributary to Clearfield Creek in southern Clearfield County (Figure 1). Designated a cold water fishery, the lower 2.7 miles is listed as impaired due to AMD. Several abandoned unreclaimed surface and deep mines in the Brookville, Clarion and Lower Kittanning coals exist in the watershed. Recent observations have indicated that aquatic life is returning to the watershed but impairment remains in the lower reach.

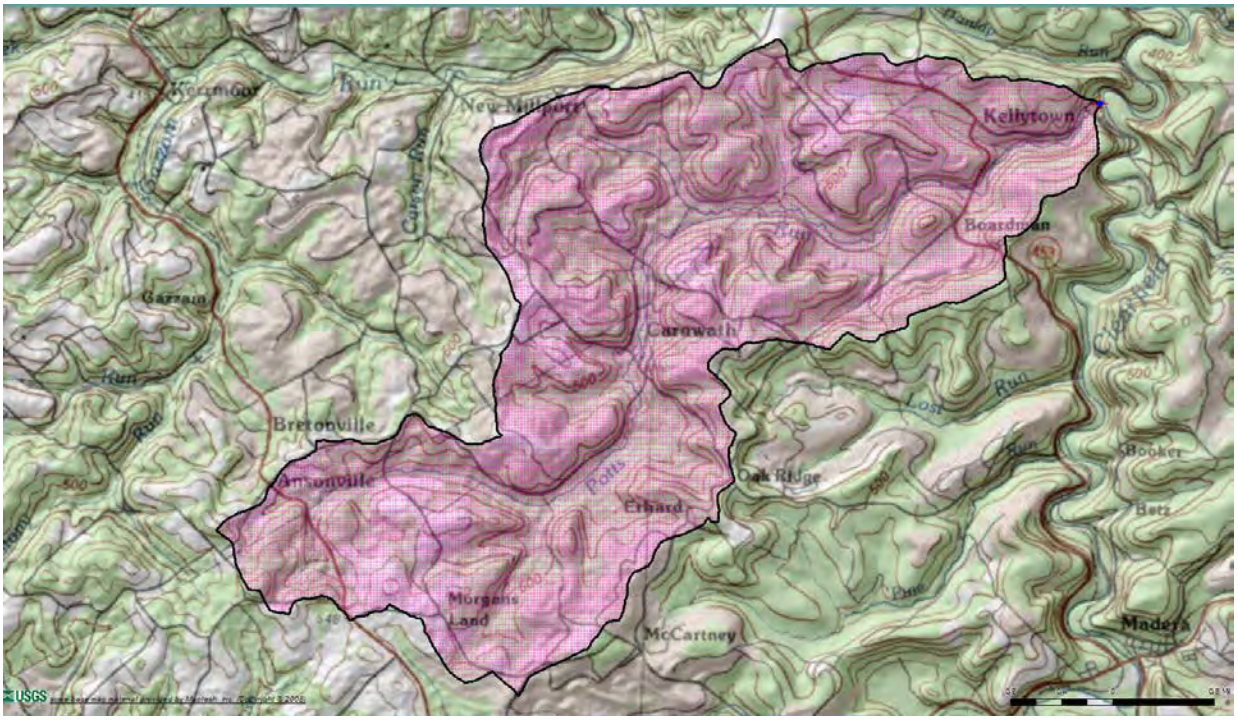


Figure 1. Potts Run Watershed

Water Quality Sampling Results

At least ten AMD discharges have been identified in the watershed. To determine the relative impact of these discharges, Hedin Environmental (HE) staff assisted TU with the establishment of a monitoring plan by performing a watershed snapshot on June 26, 2012, during low flow conditions. The snapshot focused on the lower third of the watershed where there is visible impairment (staining) by AMD. Following this snapshot, monitoring was conducted by Trout Unlimited and local watershed volunteers. Then on April 2, 2014 a second snapshot was conducted under flow conditions. Figure 2 shows the locations of the samples. Table 1 compares the flow conditions of the two snapshots.

Table 1. Comparison of snapshot flow conditions (gpm).

Sampling Point ID	**6/26/12**	**4/2/14**
Potts Run above Oak Ridge Tributary	1,198	11,025
Oak Twin Discharge	41	167
Oak Join Discharge	7	2.5
No. 3 Mine Discharge	278	743
Oak Ridge Tributary	350	1,331
Twin Pines 1 Discharge	52	64
453 Discharge	7	17
Potts Run Above Little Potts Run	1,481	12,350
Little Potts Run Mouth	171	968

In-stream water quality data show that Potts Run is net alkaline throughout the study area under both low and high flow conditions (Table 2). The alkaline condition allows the stream to assimilate AMD inputs but the presence of AMD in the watershed is evidenced by elevated sulfate and metal concentrations. With circumneutral in-stream pH the iron and aluminum measured are likely particulate (samples were not filtered before acidification) and not as directly toxic as occurs when these metals are dissolved. The segment with the worst water quality is downstream of the Oak Ridge tributary. Despite the AMD inputs, the alkaline water quality suggests that the stream is capable of recovery with only moderate improvement.

Table 2. In-stream conditions during the two flow sampling event, June 26, 2012

Sample ID	**Flow**	**pH**	**Alk**	**Acid**	**Fe**	**Mn**	**Al**	**SO4**
	gpm		**mg/L $CaCO_3$**		**----- mg/L -----**			
Low Flow Event, June 26, 2012								
Potts Run above Oak Ridge Tributary	1,198	7.7	78	-59	0.5	0.4	0.1	196
Potts Run below Oak Ridge Tributary	1,400	7.0	44	-22	1.2	1.1	1.8	206
Potts Run above Little Potts Run	1,481	7.4	38	-19	0.3	1.0	0.4	208
Little Potts Run Mouth	171	7.1	25	-6	0.1	0.1	0.0	197
High Flow Event, April 2, 2014								
Potts Run above Oak Ridge Tributary	11,025	7.3	29	4	0.3	0.1	0.2	72
Potts Run below Oak Ridge Tributary	12,356	6.9	21	10	0.6	0.3	0.7	82
Potts Run above Little Potts Run	12,350	7.1	19	6	0.5	0.4	0.7	84
Little Potts Run Mouth	968	7.1	18	9	0.3	0.5	0.2	73

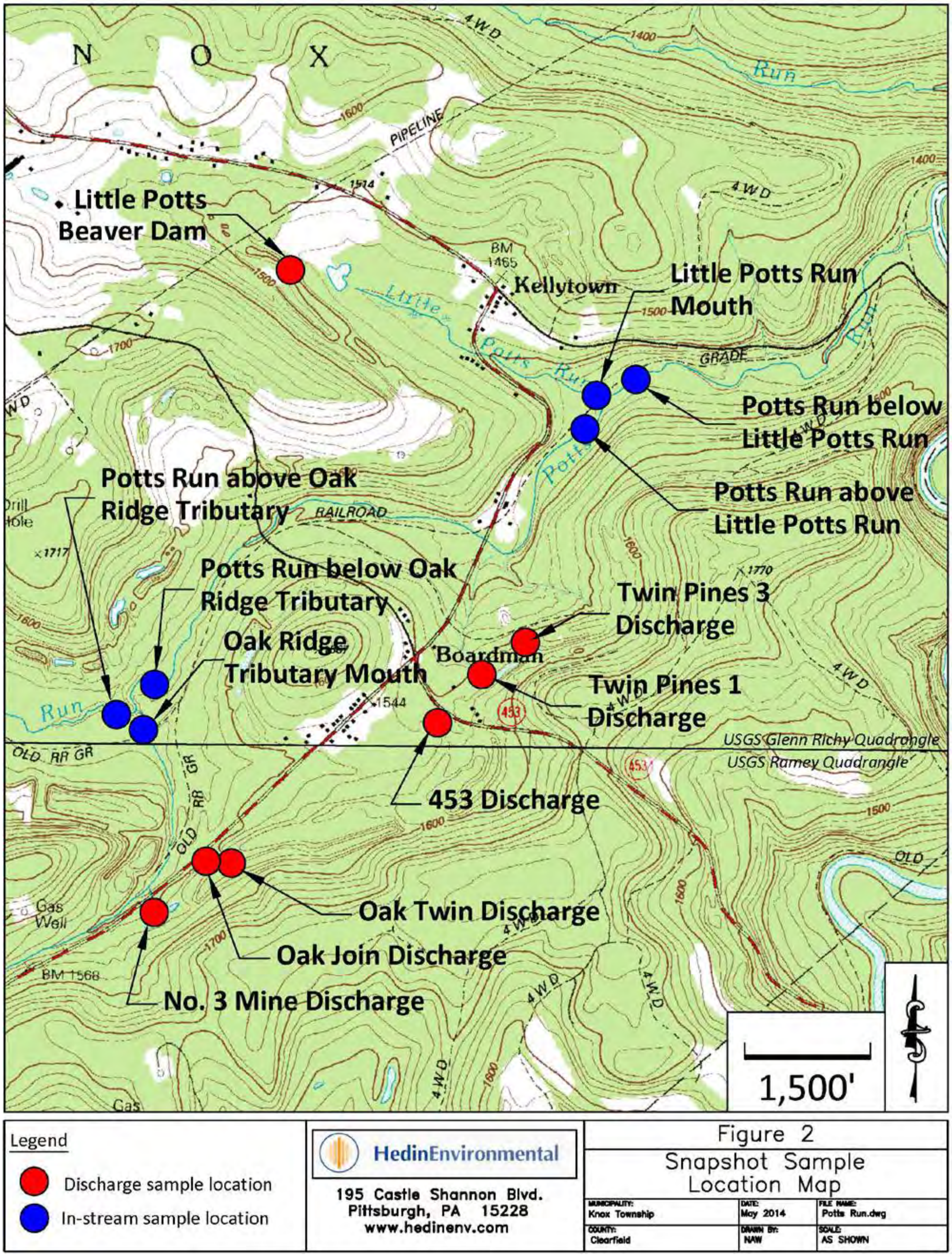


Figure 2. Sampling points in the Potts Run watershed.

Flow from the Oak Ridge tributary degrades a portion of Potts Run immediately below the confluence where iron, aluminum and manganese all exceed in-stream limits. Table 3 shows the chemistry of Potts Run and the AMD-polluted Oak Ridge tributary. The strongly alkaline condition of Potts Run above the Oak Ridge tributary allows the pollution loading to be assimilated fairly quickly with iron and aluminum falling to levels similar to the upstream condition at the Potts Run above Little Potts station. Likewise, Little Potts Run was found to be net alkaline at the mouth but with slightly elevated metals concentrations. Comparing water quality between high and low flow conditions shows that pH is higher and acidity lower under low flow conditions but metals concentrations are higher. This is largely due to a combination of higher upstream alkalinity concentration under low flow and the Potts Run upstream to Oak Ridge tributary flow ratio which was 8:1 under high flow but only 3:1 under low flow.

Table 3. Snapshot in-stream water quality summary.

Site	**Potts Run Upstream**		**Oak Ridge Trib**		**Potts Run Below Oak Ridge Trib**		**Potts Run Above Little Potts Run**		**Little Potts Run Mouth**	
Flow	11,025	1,198	1,331	350	12,350	1,400	12,350	1,481	968	171
pH	7.3	7.7	3.3	3.1	6.9	7.0	7.1	7.4	7.1	7.1
Alk.	29	78	0	0	21	44	19	38	18	25
Acid*	-27	-76	61	95	-15	-30	-14	-33	-16	-25
Fe	0.3	0.5	2.9	4.0	0.6	1.2	0.5	0.3	0.3	0.1
Mn	0.1	0.4	2.0	3.9	0.3	1.1	0.4	1.0	0.5	0.1
Al	0.2	0.1	4.9	7.4	0.7	1.8	0.7	0.4	0.2	ND
SO4	72	196	176	231	82	206	84	208	73	197

**Acidity value calculated from pH, metals and alkalinity concentrations.*
Units: flow gpm, pH S.U., all others mg/L. ND = below detection

Flow rates and concentrations were multiplied to calculate loadings for both days (Table 4). The Oak Ridge tributary produced large loads of acidity and Al and lesser loads of Fe and Mn. Al and Fe form solids in the alkaline circumneutral waters in Potts Run and their loadings are not conservative. Mn and sulfate do not form solids under these conditions and their loadings are useful for tracking inputs to the stream. Table 5 shows the summed loading of Potts Run upstream and the Oak Ridge tributary as a percentage of the loading measured at Potts Run above Little Potts Run. Sulfate and manganese are essentially fully accounted for (within the expected error of measurements) while iron and aluminum are over accounted (i.e. >100% capture) as expected. These data indicate that there are no other significant sources of AMD in the watershed other than the Oak Ridge tributary.

Table 4. Snapshot in-stream loading summary.

Site	**Potts Run Upstream**		**Oak Ridge Trib**		**Potts Run Below Oak Ridge Trib**		**Potts Run Above Little Potts Run**		**Little Potts Run Mouth**	
Flow	11,025	1,198	1,331	350	12,350	1,400	12,350	1,481	968	171
Alk.	3,837	1,121	0	0	3,114	739	2,816	675	209	51
Acid*	-3,621	-1,089	972	399	-2,283	-507	-2,021	-593	-183	-50
Fe	33.1	6.9	45.5	16.8	83.0	19.3	77.1	4.8	2.9	0.2
Mn	17.2	5.0	32.6	16.5	48.9	18.1	62.2	18.1	5.9	0.2
Al	22.5	2.0	77.6	31.0	106.8	29.6	97.8	7.5	1.7	0.0
SO4	9,526	2,818	2,811	970	12,158	3,461	12,449	3,697	848	404

**Acidity value calculated from pH, metals and alkalinity concentrations.*
Units: flow gpm, all others are pounds per day

Table 5. Loadings as percentage of loading at Potts Run above Little Potts Run

Site	**Potts Run Upstream**		**Oak Ridge Trib**		**Potts Run Below**	
Date	04/02/14	06/26/12	04/02/14	06/26/12	04/02/14	06/26/12
Flow	89%	81%	11%	24%	100%	105%
Alkalinity	136%	166%	0%	0%	136%	166%
Acidity	179%	184%	-48%	-67%	131%	116%
Fe	43%	144%	59%	350%	102%	494%
Mn	28%	28%	52%	91%	80%	119%
Al	23%	27%	79%	415%	102%	442%
SO4	77%	76%	23%	26%	99%	102%

Oak Ridge Tributary

The Oak Ridge tributary accounts for nearly all of the AMD pollution in the lower part of the watershed. The stream is shown as Coder Run in historic mine maps but this name is not shown on the USGS Ramey, PA quadrangle. The PA DEP name for this stream is unnamed tributary (UNT) 26197. There are two main AMD discharges in the Oak Ridge tributary watershed as well as several small seeps. Both surface and deep mining on multiple seams are present in the watershed. The entry to the Potts Run No. 3 deep mine in the Lower Kittanning is located along Oak Ridge Road (SR 2015) southwest of the village of Boardman and the associated refuse pile can be found opposite the entry.

Data collected for the Oak Ridge tributary AMD sources during the two watershed snapshots are shown in Table 6. All three discharges are acidic with depressed pH and elevated concentrations of manganese and aluminum. Only the No. 3 Mine discharge contains significant iron concentrations.

Table 6. Flow and water chemistry for Oak Ridge Tributary (mouth) and three AMD Discharges.

Site	**Oak Twin Discharge**		**Oak Join Discharge**		**No. 3 Mine**		**Oak Ridge Trib**	
Date	04/02/14	06/26/12	04/02/14	06/26/12	04/02/14	06/26/12	04/02/14	06/26/12
Flow	167	41	3	7	743	278	1,331	350
pH	3.5	3.5	4.0	4.0	3.1	3.0	3.3	3.1
Alkalinity	0	0	0	0	0	0	0	0
Acidity*	59	71	17	25	102	112	61	95
Fe	0.5	0.9	0.1	0.1	6.5	4.7	2.9	4.0
Mn	5.6	8.7	1.7	2.5	2.5	2.8	2.0	3.9
Al	5.9	6.8	1.6	2.7	8.3	8.7	4.9	7.4
Sulfate	268	343	93	121	252	228	176	231

**Acidity value calculated from pH, metals and alkalinity concentrations.*
Units: flow gpm, pH S.U., all others mg/L.

Contaminant loadings within the Oak Ridge tributary subwatershed were calculated to determine the proportion that is accounted for by the three known discharges and to assess the potential for loading reduction to the tributary and Potts Run (Table 7). The three identified AMD discharges account for all of the acidity, sulfate, and metals measured at the tributary mouth. There are no unidentified significant sources of AMD in the subwatershed.

Table 7. Flow (gpm) and loadings (lb/day) summaries for AMD sources in the Oak Ridge tributary subwatershed. Capture calculated from Sum/Mouth.

Site	**Sum of Discharges**		**Oak Ridge Trib mouth**		**Capture**	
Date	04/02/14	06/26/12	04/02/14	06/26/12	04/02/14	06/26/12
Flow	913	326	1,331	350	**69%**	**93%**
Acidity*	1,030	410	972	399	**106%**	**103%**
Fe	58.9	16.1	46	17	**129%**	**96%**
Mn	33.7	13.7	33	16	**103%**	**83%**
Al	85.9	32.6	78	31	**111%**	**105%**
Sulfate	2,787	940	2,811	970	**99%**	**97%**

**Acidity value calculated from pH, metals and alkalinity concentrations.*

Potts Run No. 3 Deep Mine

The snapshots revealed that the majority of the AMD impairment can be traced to a single discharge from the Potts Run No. 3 deep mine. The Potts Run No. 3 deep mine worked the Lower Kittanning coal on the southeast side of Oak Ridge Road. The mine entry and associated refuse pile are located along Oak Ridge Road about half a mile southwest of SR 453. Subsequent surface mining has removed the mine entry and much of the crop coal on the Lower Kittanning seam as well as the higher Clarion and Brookville seams. It appears that the surface mining has obstructed the original drainage structures of the deep mine and as a result the mine discharges primarily through a breakout in the roof of the mine. Mine maps suggest the breakout is associated with a ventilation shaft but this is difficult to confirm due to extensive surface disturbance. This flow of water has been identified as the “No. 3 Mine” discharge. Two other discharges are located in the vicinity of the No. 3 Mine discharge. One, identified as the “Oak Twin” discharge appears to discharge from open strip pits near the original No. 3 mine haulage entry and may be related to the No. 3 mine discharge. The other is a small toe of spoil seepage along Oak Ridge Road between the Oak Twin and No. 3 Mine discharges. In the past, the Oak Twin and Oak Join discharges were monitored at a single point but recent monitoring separated the two in order to determine if they are of similar chemistry. The water quality of these discharges is shown in table 8. The dominance of the No. 3 discharge accounts for 77% of the flow and 88% of the acidity loading.

Figure 8. Average water quality of discharges from the Oak Ridge No. 3 deep mine (December 2012 to April 2014)

Sample ID	**Flow**	**pH**	**Alk**	**Acid**	**Fe**	**Mn**	**Al**	**Sulfate**	**Acidity**
	gpm		mg/L $CaCO_3$		mg/L	mg/L	mg/L	mg/L	ppd
No. 3 Mine Discharge	321	3.0	0	131	7.1	3.2	10.3	281	512
PR-3 Discharge*	97	3.6	0	69	0.8	6.8	6.8	288	73

**Combined Oak Twin and Oak Join discharges*

Table 9 shows the loading of Potts Run above the discharge, the No. 3 mine discharge, and Potts Run above Little Potts Run. Also shown in table 9 is the proportion of the change in loading from upstream to downstream that can be attributed to the No. 3 mine discharge. Although the water quality of the No. 3 mine discharge is not severe, it accounts for three quarters of the change in acidity observed at the Potts Run above Little Potts Run site (about 1.7 miles downstream). Iron and aluminum precipitate in the alkaline waters of Potts Run and settles as solids in the streambed. As a result, the sum of iron and aluminum loading inputs is greater than the loading measured in-stream. Manganese and sulfate remain largely in solution and are better indicators for quantifying inputs. The No. 3 mine discharge accounts for much of the change in water quality between the two in-stream points.

Table 9. Contaminant loadings calculated from the June 26, 2012 (low flow) watershed snapshot

Description	**Flow gpm**	**Alk ppd**	**Acid ppd**	**Fe ppd**	**Mn ppd**	**Al ppd**	**SO4 ppd**
Potts Run above	1,198	1,121	-848	7	5	2	2,818
No. 3 Mine Discharge	278	-387	387	16	9	29	761
SUM	1,476	734	-461	23	14	31	3,578
Potts Run above Little Potts Run	1,481	675	-338	5	18	8	3,697
% Capture	100%	109%	137%	469%	78%	413%	97%
Change upstream to downstream	283	-446	511	-2	13	6	879
No. 3 Mine Discharge contribution	98%	87%	76%	-743%	70%	527%	87%

Restoration Potential

Potts Run impairment is entirely due to the inflow of AMD from the Oak Ridge tributary where the No. 3 Mine discharge is the primary source of contamination. Remediation of the No. 3 Mine discharge will significantly improve water quality in the lower 2.7 miles of Potts Run. Completely eliminating the deep mine through remining would be extremely expensive due to the high overburden to coal ratios. Remining to remove a portion of the remaining coal and reclaim the land has been proposed but was stalled in the permitting process. Reclamation of P2 features has been proposed and is being considered by DEP's Bureau of Abandoned Mine Reclamation (BAMR). Reclamation of the open strip mine pits along the outcrop would be beneficial however, since the discharge emanates from a deep mine, surface reclamation will not completely eliminate the discharge though it would likely reduce the volume of flow and potentially improve the quality.

Regardless of the ultimate reclamation or remining actions, a discharge will persist at this site and will require treatment for full restoration of Potts Run. Treatment of the discharge can be accomplished with passive technology. Water chemistry determines treatment technology selection. The flow chart attached to this report's appendix was used as a guide. Loading calculations, combined with expected contaminant removal rates, were used to calculate the sizes of treatment units. The site mapping developed for the project was used to evaluate whether there was sufficient land for a passive option.

Because of their close proximity, the Oak Twin and Oak Join discharges should be combined with the No. 3 Mine discharge for treatment. Historically, the Oak Twin and Oak Join discharges were monitored at a single point (PR-3) but more recent monitoring separated them. The water quality is very similar so to take advantage of the historical data, the recent monitoring data was recombined to a single point. The average characteristics of the discharges are shown in Table 10 as well as the calculated characteristics of the mixed discharges.

The discharge is acidic with moderate concentrations of Fe, Al, and Mn. The passive treatment technology most appropriate for this chemistry is a vertical flow pond (VFP) system. A vertical flow pond contains a 2-3 feet deep bed of limestone aggregate overlain with 1-2 feet of organic substrate that is overlain by 1-3 feet of water. Water enters on the surface and flows downward to an underdrain that discharges to a polishing pond or wetland. VFPs neutralize acidity and remove any dissolved Al and a portion of the Fe. Subsequent ponds/wetlands precipitate the remaining Fe and a portion of the Mn.

The VFP technology has been utilized on dozens of sites in Pennsylvania. The Anna S passive treatment system in Tioga County has successfully treated water with similar chemistry and loading for nearly 10 years. Table 7 compares the Potts Run AMD mixture to the average Anna S treatment system influent and effluent between 2004 and 2013.

Table 10. Comparison of the Potts Run AMD to Anna S passive system influent

Site	**flow**	**pH**	**Alk**	**Acid**	**Fe**	**Mn**	**Al**	**Acid**
	gpm		**mg/L**	**$CaCO_3$**	**----**	**mg/L**	**----**	**ppd**
PR-3*	97	3.6	0	69	0.8	6.8	6.8	73
No 3. Mine	321	3.0	0	131	7.1	3.2	10.3	512
Mixed**	418	3.2	0	112	5.4	4.2	9.2	587
Anna S passive system influent	263	3.1	0	140	4.8	6.1	8.6	445
Anna S passive system effluent	na	7.4	134	-102	<1	4	<1	-312

**Sum of Oak Twin and Oak Join discharges*
***Sum of No. 3 Mine, Oak Twin, and Oak Join discharges*

The size of the treatment system is determined from a targeted loading condition and the expected contaminant removal rate. Where continual and reliable treatment is required to promote stream restoration, the design loading should be higher flow conditions. A highly effective approach is to design for the 90th percentile loading rate. A 90th percentile loading is a loading rate that is not exceeded 90% of the time. Contaminant removal rates are typically measured as grams of removal per square meter of treatment area per day ((g/m^2)/d). VFPs are designed based on an expected acidity removal rate of 30-40 g/m^2/d. Table 11 shows the 90th percentile acidity loadings for the Oak Ridge tributary AMD and the calculated surface area for the VFP(s).

The effluent from a VFP treating water of this chemistry will be alkaline but will also contain iron that should be removed before discharge to the stream. Wetlands can effectively remove iron from the VFP effluent. Like VFPs, treatment wetlands are sized based on a loading rate per unit area but rather than using acidity loading, wetlands are sized based on iron loading rate. A loading rate of 10 (g/m^2)/d) is recommended. To determine the size of the wetland, the VFP effluent iron loading must be estimated. The low iron concentration of the discharge means that much of the iron will be removed by the VFP. The Anna S VFPs decrease Fe from 7 to 4 mg/L. Using an effluent iron concentration of 4 mg/L and the 90th percentile flow rate of 913 gpm, the effluent loading would be 19,903 g/day under these conditions. A wetland with an area of at least 1,990 m^2 is needed to remove this iron.

Table 11. Component sizing calculations for the combined No. 3 Mine, Oak Twin and Oak Join discharges

Component and Assumptions	**Value**
Vertical Flow Ponds	
90th percentile flow rate	913 gpm
90th percentile acidity loading	569,131 g/day
Design VFP acidity loading rate	40 (g/m^2)/day
Required VFP area (total)	14,228 m^2
Ponds/wetlands	
90th percentile iron loading*	19,903 g/day
Design wetland iron loading rate	10 (g/m^2)/day
Required pond/wetland area (total)	1,990 m^2

**See text*

A conceptual layout of four vertical flow ponds and one wetland has been developed that is shown in Figure 3. The system is located in land to the northwest of Oak Ridge Road. Much of the system is located within the footprint of an existing refuse pile. The concept plan assumes that the refuse will be removed. The system contains a total of 14,228 m^2 of vertical flow pond. The vertical flow pond acreage is divided into four VFPs arranged in parallel. This design allows major maintenance on one VFP while retaining treatment from the other three. The wetland was enlarged to 3,800 m^2 to provide additional wildlife habitat and to make beneficial use of the land occupied by the refuse pile.

Construction costs are summarized in Table 12. The estimate is based on known costs for major materials (limestone, mushroom compost), an excavation cost of $5.50/CY, and estimates of other costs. The total cost to build the passive system itemized in Table 11 is estimated at $1.75 million.

Table 12. Passive treatment system construction cost estimate

Item	**Basis**	**cost**
Mob/demob	Estimate	$20,000
Erosion and sediment controls	Estimate	$20,000
Collection and delivery system	Estimate	$40,000
Earthwork	24,000 CY @ $5.50/CY	$132,000
Limestone	12,000 tons @ $30/ton	$360,000
Limestone amended mushroom compost	10,000 CY @ $26/CY	$260,000
VFP Plumbing	Estimate	$90,000
Channels	400 ft @ $40/ft	$16,000
Install materials	Estimate	$450,000
Wetland planting	1 acres @ $10,000/acre	$10,000
Subtotal		$1,398,000
Engineering	10%	$139,800
Contingency	15%	$209,700
Total		**$1,747,500**

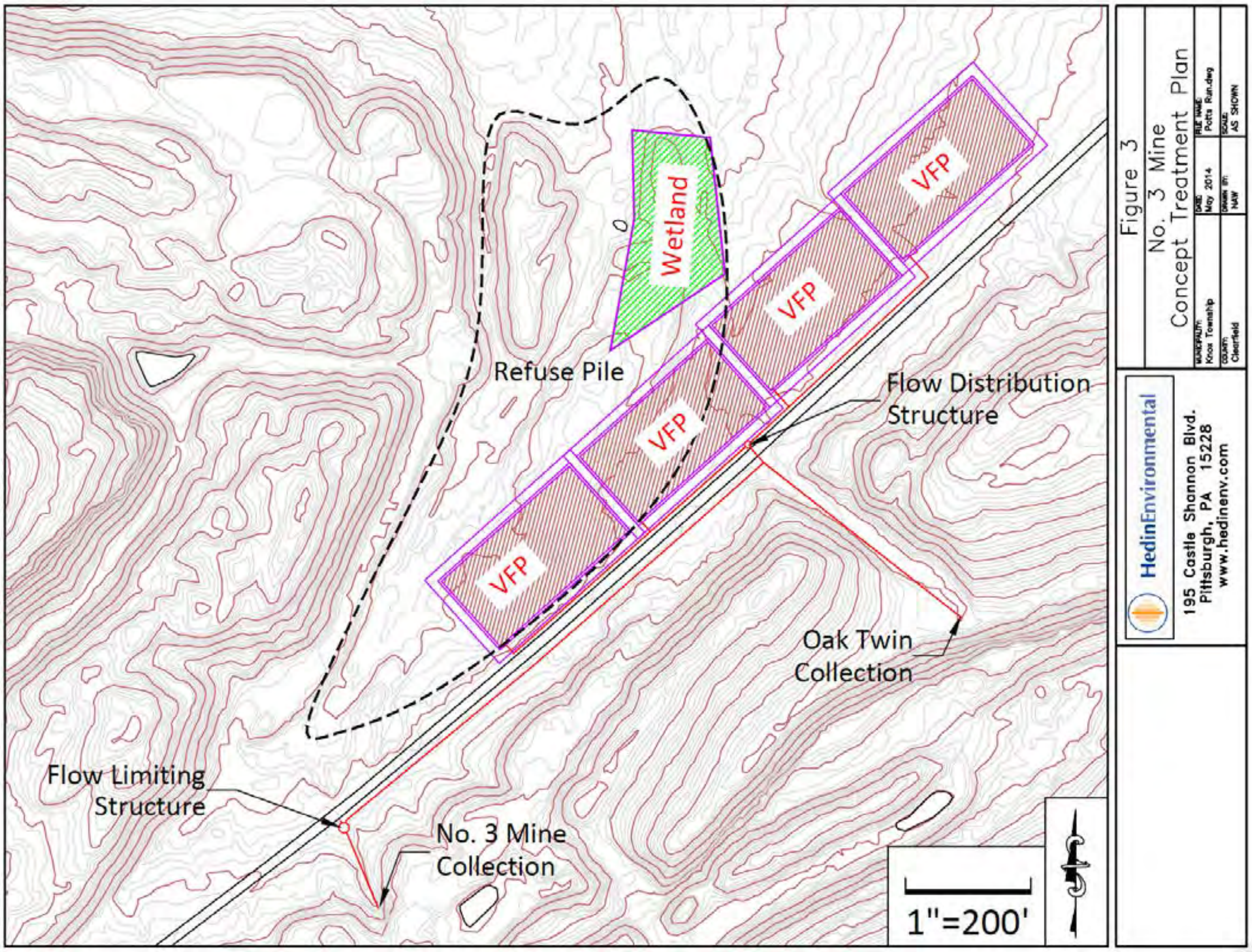


Figure 3. Concept layout for a passive treatment system sized according to Table 11.

Operation and Maintenance

Passive treatment systems require maintenance in order to function reliably and sustainably. Maintenance tasks are divided into minor and major categories. Minor maintenance includes sampling, inspections and vegetation control. These tasks occur on either a short interval or an as-needed basis and do not include replacement of treatment infrastructure. Major maintenance tasks involve replacement or repair of treatment infrastructure and occur on infrequent intervals, generally 5 years or longer. Activities and cost estimates are shown in Table 13. These costs are for the 90th percentile system.

Table 13. Long-term O&M activities for the passive treatment system

Activity	Basis	Interval (years)	Cost/event
System inspection	4 hr @ $35/hr, semi-annually	0.50	$140
Inspection and Sampling	6 hour @ $35/hr and 8 sampling stations @ $30/sample,	0.50	$450
Vegetation control	clear brush and clean channels	5	$2,000
Replace organic substrate	7,500 CY new material @ $35/CY	12-13	$262,500
Clean limestone	12,000 tons @ $5/ton	25	$60,000
Total Discounted Value	5% net discount rate, 40 years		$326,579

The single largest maintenance cost for VFPs is replacement of the organic substrate. This major maintenance task involves placement of new organic substrate in the VFPs. This activity maintains good treatment and protects the limestone underdrain from fouling with metals. Because the maintenance is performed <u>before</u> treatment problems arise, the existing organic substrate is depleted but still viable. As a result, the existing organic substrate can be placed on top of the new material to take advantage of the remaining treatment capacity of the material and also to avoid the cost of disposal. In addition, the viability of the old material allows for a reduction in the amount of new material installed.

Replacement of organic substrate was completed in 2013 for the Hunters Drift VFP system after 8 years of treatment. A total of 3,406 CY of spent mushroom compost was amended with 2,979 tons of limestone fines and added to four VFPs at a cost of $186,000 (including 10% engineering) or $35/CY of substrate. This cost was used to develop the substrate replacement cost for the Potts Run system. The proposed organic substrate layer in the system will be twice as thick as that of the Hunters Drift system. The extra compost and the fact that Potts Run AMD is half as severe as Hunters Drift, results in less frequent substrate replacement (every 12-13 years).

A cost to clean the limestone underdrain is included in Table 13. This activity has never occurred at a VFP system (to HE's knowledge). If the aggregate required cleaning, it is anticipated that this activity would occur in conjunction with the replacement of organic substrate. The cost estimate is based on an established cost of $5/ton to clean aggregate in drainable limestone beds.

The present value of the maintenance costs over 40 years assuming a net discount rate (after inflation) of 5.0% is $326,579. No significant recapitalization costs are anticipated. (Major maintenance on the organic substrate and limestone aggregate could be considered recapitalization. The financial analysis is the same so the financial outcome does not change.) The total cost for the passive system, including construction plus 40 years of O&M, is estimated at $2,074,000.

The passive treatment system would discharge neutral pH water with 100-150 mg/L alkalinity and less than 1 mg/L Al and Fe. Minimal Mn removal should be anticipated, but the concentrations in the raw AMD are less than 4 mg/L which is unlikely to prevent fishery restoration.

Alternative Partial Treatment Passive System

Many streams in north central Pennsylvania are severely polluted by AMD and when treatment systems are built it is advisable to size them as large as possible so that they introduce extra alkalinity into the stream. Potts Run is only mildly impaired by AMD and has substantial buffering capacity. For this reason, the conservative sizing rationale based on 90th percentile loading conditions may not be necessary to restore and protect the in-stream chemistry of Potts Run below the No. 3 deep mine inflow. Table 15 provides a calculation of the benefits of a treatment system designed for the median (50th percentile) flow conditions. This system is approximately one-half the size of the 90th percentile system. Flows above the median would be bypassed around the VFPs and combined with treated water in a mixing/settling pond before discharging to the stream. The excess alkalinity produced by the treatment system would neutralize the acidity of bypass water. Metals contained in the bypass (mainly aluminum) would form a solid and be retained in the pond through settling. This approach has several advantages:

- <u>Reduced thermal impacts</u> – A smaller treatment system will have shorter residence time and thus will minimize effluent temperatures. In the absence of AMD impairment, thermal impacts are a significant threat to trout populations in Potts Run.
- <u>Smaller footprint</u> – The system could potentially be built entirely on the footprint of the existing refuse pile with minimal disturbance to native ground.
- <u>Reduced cost</u> – The construction cost of a treatment system is related to its size so a smaller system will cost less.

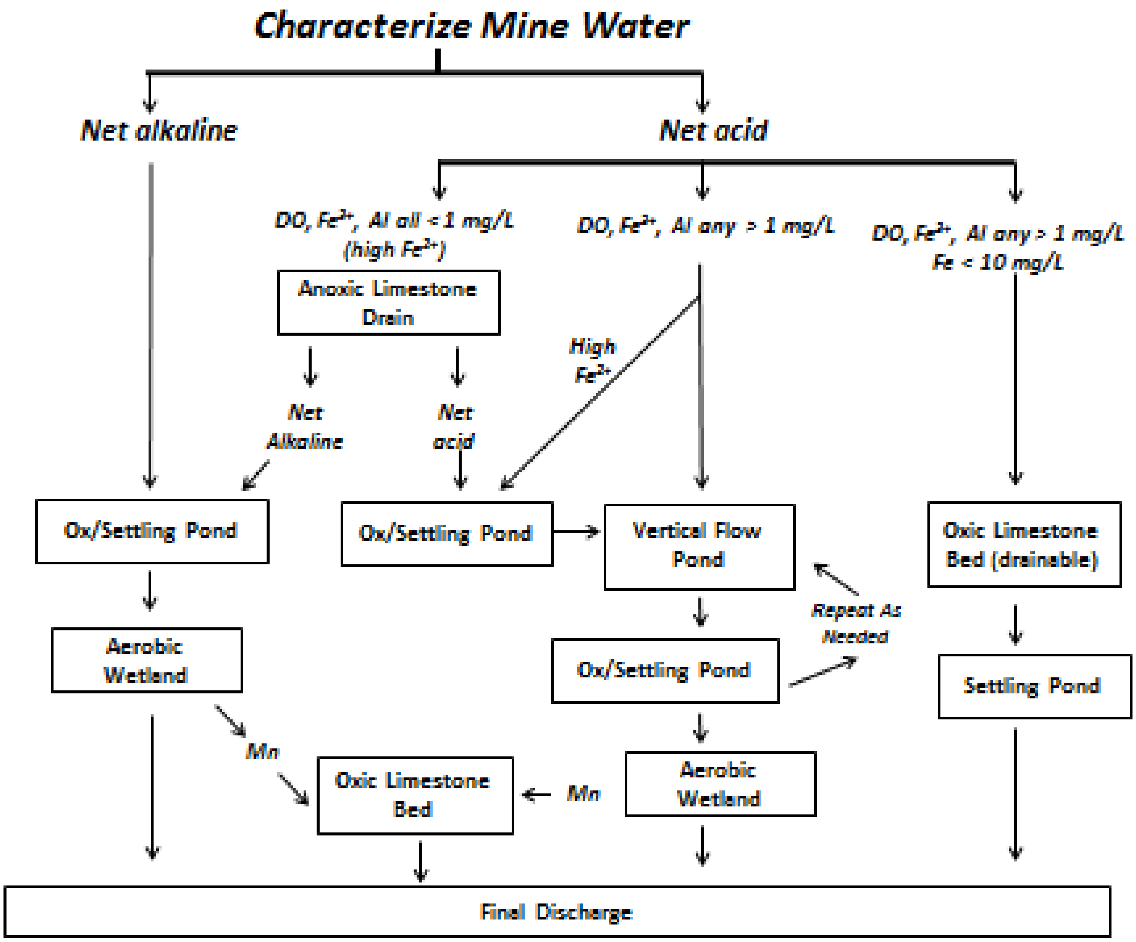
Table 15 shows the calculated effluent from a treatment system designed for median flow conditions or 390 gpm. The table calculates the impact of the passive system on the summed AMD loadings measured between 2005 and 2014. On days when the flow is less than 390 gpm, all of the water is treated and the final discharge has a predicted net acidity of -138 mg/L (net alkalinity). On days when the flow is greater than 390 gpm, flow in excess of 390 gpm is bypassed around the VFPs (protecting their integrity) and mixed with the alkaline VFP effluents in a pond designed for mixing and settling solids. The calculations indicate that the system only produces a net acidic final discharge once. This occurred during a very high flow event in November 2011 and the predicted final effluent contained 71 mg/L acidity. It is likely that on this day the flow rate of Potts Run was also very high and this theoretical acidic effluent would have been neutralized and diluted by the high stream flow and alkalinity loading.

The system designed for median flow conditions is approximately one-half the size of the 90th percentile system. At this conceptual level, it is reasonable to assume the costs would scale directly to the size of the system. The estimated cost to install the median flow system is $880,000. Assuming that O&M costs are also one-half, the total 40-year present value cost for the median flow system is approximately $1,050,000.

Anticipated Stream Improvements

Treatment of the Oak Ridge Tributary AMD should restore 2.7 miles of Potts Run between the tributary inflow and confluence with Clearfield Creek. The 90th percentile treatment system will assure alkaline conditions and concentrations of Al and Fe below the in-stream limits for a cold water fishery on all days. The 50th percentile treatment system would produce an alkaline low-metal influent under all but the highest flow conditions. This is considered sufficient to restore the cold water fishery below the Oak Ridge Tributary.

The DEP Draft Guidance for the Set-Aside Program provides a method for evaluating the economic feasibility of an AMD treatment project by comparing the restoration benefits to the project costs. The comparison is done over a 40 year period at a 5% discount rate. The Set-Aside document provides a fishery value for cold water native trout streams of $56.95 per fisherman day and an expectation of 500 days per mile per year. The calculated fishery value of restoring 2.7 miles of lower Potts Run is $76,883/yr. The 40-year present value of this benefit is $1,319,233. This benefit is smaller than the cost of the 90th percentile system (B/C = 0.64) and larger than the cost of the median flow passive system (B/C = 1.26). Based on the benefit cost analysis, installation of smaller median flow passive system is economically justified as long as the fishery benefits are realized.



Design flow chart used to select appropriate passive treatment technologies

Table 15. Calculated performance of a passive system designed for median flow conditions but receiving all AMD flow. Actual measured flow and chemistry values 2005-2013 are used for reference.

	Mine Drainage Flow and Chemistry					**Treatment System**					
Date	**Flow**	**Acid**	**Fe**	**Mn**	**Al**	**Treat**	**Bypass**	**VFP effluent**	**Bypass**	**Mixture**	**Pond effluent**
	gpm	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**gpm**		**Acid, lb/day**			**mg/L**
12/13/2005	200	68	5	5	10	200	0	-330	0	-330	-138
1/12/2006	679	128	9	4	9	390	289	-644	367	-277	-34
2/16/2006	783	101	6	4	9	390	393	-644	484	-160	-17
3/15/2006	458	110	4	4	8	390	68	-644	73	-571	-104
4/24/2006	447	104	5	4	9	390	57	-644	65	-578	-108
5/26/2006	518	111	6	4	9	390	128	-644	153	-491	-79
6/29/2006	297	117	5	3	4	297	0	-491	0	-491	-138
7/28/2006	179	123	5	5	10	179	0	-295	0	-295	-138
8/31/2006	93	105	3	6	10	93	0	-154	0	-154	-138
9/26/2006	103	135	7	6	12	103	0	-170	0	-170	-138
10/27/2006	200	111	5	5	10	200	0	-330	0	-330	-138
11/22/2007	1433	154	17	5	14	390	1,043	-644	1861	1217	71
6/26/2012	326	109	4	4	8	326	0	-538	0	-538	-138
10/23/2012	62	130	3	5	13	62	0	-103	0	-103	-138
11/28/2012	41	123	3	5	12	41	0	-67	0	-67	-138
12/18/2012	17	104	2	4	9	17	0	-29	0	-29	-138
2/1/2013	390	85	4	3	7	390	0	-644	0	-644	-138
2/28/2013	456	113	5	3	8	390	66	-644	71	-573	-105
3/27/2013	475	111	4	3	8	390	85	-644	90	-554	-97
4/30/2013	711	101	5	3	8	390	321	-644	347	-297	-35
4/2/2014	913	119	5	3	8	390	523	-644	566	-78	-7

Assumptions: maximum flow treated is 390 gpm; VFP discharge contains 150 mg/L alkalinity, 3 mg/L Fe, and 3 mg/L Mn

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