COOKS RUN WATERSHED RESTORATION EFFORTS
EAST KEATING TOWNSHIP, CLINTON COUNTY, PENNSYLVANIA[1]

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Abstract

An abandoned surface mine site known as the Fran Camp Run No. 2 Mine, located in Sproul State Forest near Renovo, Pennsylvania, is one of the main sources of pollution to Cooks Run. Cooks Run, designated as a High Quality stream, discharges into the West Branch Susquehanna River approximately three miles downstream of the mine site. Fran Contracting, Inc. began mining operations in 1975, and completed the 46-acre surface reclamation in 1977. Shortly after reclamation, numerous abandoned mine drainage (AMD) seeps appeared below the mine site impacting Camp and Rock Runs, two tributaries to Cooks Run. Prior to being impacted, the Pennsylvania Fish and Boat Commission listed these sections of Camp and Rock Runs as streams supporting the natural reproduction of trout. Many endeavors to abate and treat the AMD were attempted over the years following reclamation, but none of the efforts significantly improved the water quality in Rock, Camp, and Cooks Runs.

Since 2001, the DEP's Bureau of Abandoned Mine Reclamation has been working with Trout Unlimited, governmental agencies, and private industry, with the goal of restoring the water quality in Camp, Rock, and Cooks Runs. Collaborating with these agencies will help minimize costs and maximize restoration efforts. Completed or ongoing work includes the construction of a Fran mine site AMD collection system, construction of a pilot-scale passive treatment system, design of proposed passive treatment systems, on-site drilling, collecting and analyzing numerous spoil, coal, and overburden samples for potential re-mining and alkaline addition, and a rigorous water sampling and monitoring program.

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Cooks Run Watershed Background

Cooks Run flows approximately 12 miles southeast from its headwaters in Cameron County to its confluence with the West Branch Susquehanna River along State Route 120 in Clinton County. Approximately 39 miles of streams drain the watershed to the West Branch. Cooks Run's major tributaries include Crowley Hollow Run, Cole Run, Camp Run, Rock Run, Onion Run, Lick Run, Lebo Branch, and Crawford Branch (Klimkos, 2001).

The Pennsylvania Department of Environmental Resources (DER) [1] previously designated the Cooks Run Watershed as a conservation area. Due to impacts from abandoned mine drainage (AMD) *(Figure 1)*, the designation was changed in 1979 to various classifications. Cooks Run, from its source to Onion Run, is now classified by the PA Code, Title 25 Chapter 93 Water Quality Standards as Exceptional Value (EV). Between Onion Run and Crowley Hollow Run, it is classified as High Quality Cold Water Fishery (HQ-CWF), and from Crowley Hollow Run to its mouth it is classified as Cold Water Fishery (CWF) (Cooks Run TMDL, 2003).

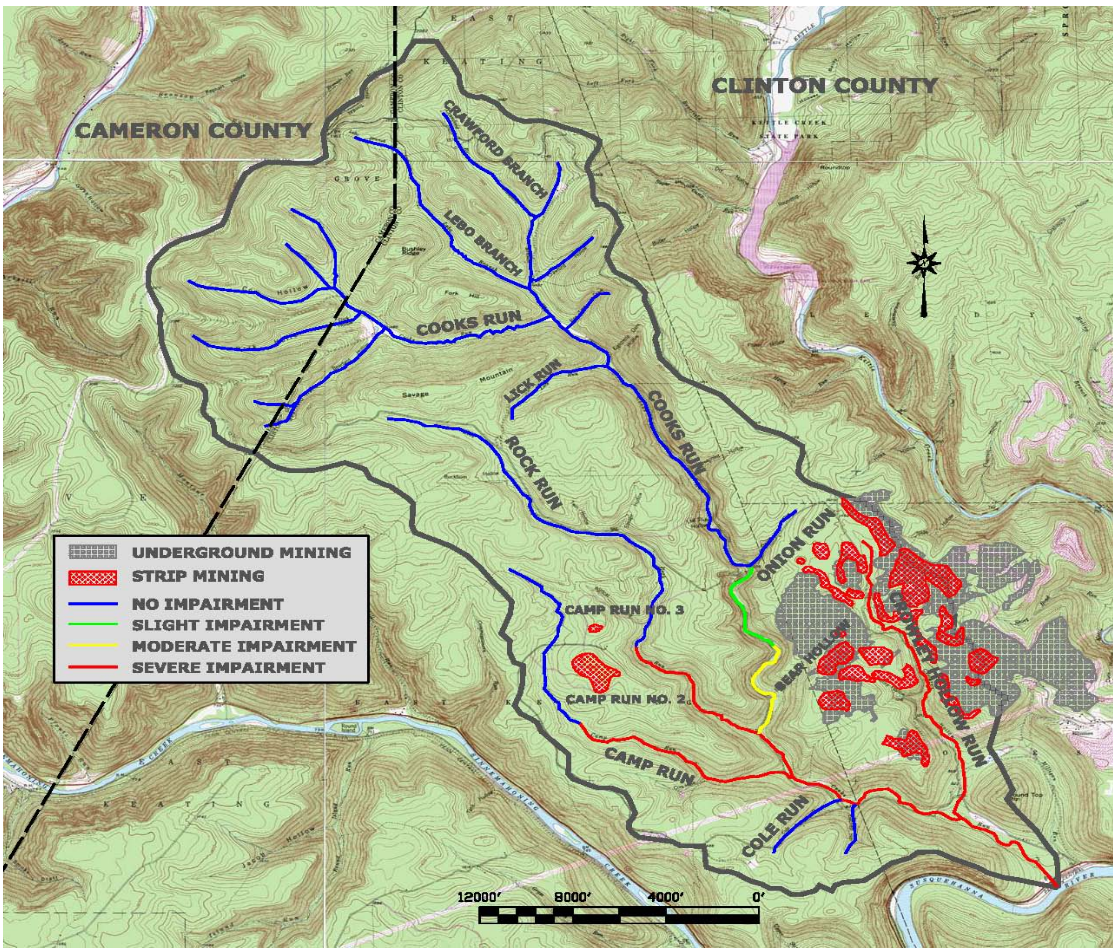

Figure 1. Mining and Impacted Streams in Cooks Run Watershed.

[1] DER is listed for historical accuracy. The 25-year old DER was replaced by two new agencies July 1, 1995. The regulation side of the DER became the Department of Environmental Protection (DEP).

Geology and Mining History

The Pennsylvanian age coals in the Cooks Run Watershed are classified as medium volatile bituminous coal. They are located at the northeastern fringe of the main bituminous coal field (PA TopoGeo, 2000). The gently dipping coal seams are present on isolated hilltops separated from the contiguous bituminous coal field by deep erosion within the plateau.

Five coal seams are known to exist in the watershed. Correlation of the coal seams with the main bituminous coal field is difficult mainly because of the lack of a reliable marker bed. The coal seam correlations used in this paper (from the stratigraphically highest to the stratigraphically lowest) are the Middle Kittanning, Lower Kittanning, Clarion, Brookville, and Mercer.

The Middle Kittanning is not present on some of the hilltops due to erosion, and mining is very limited. The Lower Kittanning is the main coal seam mined. It has been both underground-mined and surface-mined over a large area in the watershed. The underlying Clarion, Brookville, and Mercer coals have not been mined.

Coal mining began in the Cooks Run Watershed in the middle to late 1800s. Mining continued until around 1976.

Underground mining began in the 1870s within the Crowley Hollow area located in the lower portion of the watershed *(Figure 1)*. The Kettle Creek Coal Mining Company mined the Lower Kittanning coal seam until around 1929. Underground mining continued in the watershed until surface mining took over in the 1940s and 1950s. Early surface mining was primarily conducted within the Crowley Hollow area. The most recent surface mining in the watershed was conducted on the Middle and Lower Kittanning coal seams during the 1960s and 1970s (Klimkos, 2001) (Cooks Run TMDL, 2003).

Crowley Hollow Run is mainly impacted by AMD from the underground mining in the Crowley Hollow area. The "up-dip" underground mining technique was used extensively. This technique facilitates pyrite oxidation by preventing the mine from becoming fully inundated. This AMD also severely impacts the lower approximately 1.1 miles of Cooks Run.

Rock Run and Camp Run are both affected by AMD from Fran Contracting Inc.'s 1975-1976 Camp Run No 2. and Camp Run No. 3 surface-mining operations, located on the ridge between the two Cooks Run tributaries, in the middle portion of the watershed. AMD impacts approximately 1.3 miles and 1.9 miles of the lower reaches of Rock Run and Camp Run respectively. This degradation in turn impacts approximately 2.1 miles of Cooks Run between the mouth of Rock Run and the mouth of Crowley Hollow Run.

Fran Contracting, Inc. Camp Run No. 3 site

The Camp Run No. 3 surface-mined site is approximately 1.7 miles upstream of Rock Run's confluence with Cooks Run. Fran Contracting, Inc. mined the site circa 1976 under MDP 4676SM9, MP1073-5, commencing at an old abandoned highwall and affecting approximately 6 acres. The reclaimed Camp Run No. 3 site did not have any apparent discharges or other issues that would warrant bond forfeiture (Varner, 1983).

Fran Contracting, Inc. Camp Run No. 2 site

Background

The Fran Contracting, Inc. Camp Run No. 2 surface-mined site is located between Rock Run and Camp Run, approximately 1.3 miles upstream of Rock Run's confluence with Cooks Run.

Surface-mining was conducted at the Camp Run No. 2 mine site under MDP 4674SM21, MP1073-3, with approximately 46 acres affected within the permit area. The Mining Permit was issued in May 1975 for mining of the upper bench (split) of the Middle Kittanning coal seam commencing at an old abandoned highwall. However, the Kettle Creek SL-115 Scarlift Report dated December 1972, correlates the old highwall with the Lower Kittanning coal seam (Neilan Engineers, Inc., 1972). According to the mining permit and special conditions, the lower bench of the Middle Kittanning seam and the clay horizon between the benches were not to be mined. Records indicate that there was a pre-existing discharge in this area (Pauly, 1978).

Mining was last conducted in the fall of 1976. Fran Contracting, Inc. completed the 46-acre surface reclamation in 1977. Shortly after reclamation, numerous AMD seeps *(Figure 2)* appeared below the mine site impacting Camp Run and Rock Run.

The Camp Run No. 2 AMD seeps were investigated by DER in September 1978. The resulting November 1978 Geologic Investigation Report found Fran Contracting, Inc. responsible for the degradation to Rock and Camp Runs. The report findings are as follows: the Fran Contracting, Inc. mining was the only mining activity at the time in the Rock and Camp Run recharge area; groundwater flow was controlled by topography and geologic structure; the dip of the strata was 2^o- 5^o to the southeast towards the axis of the Clearfield-McIntyre syncline; major joint sets at N76^oW; 81^oSW and N15^oW; 90^o were strong controls on area stream development, and along with bedding plane fractures, on groundwater flow paths (Voykin, 1978). Water samples from 1980 and 2009 *(Table 1)* show the Camp Run No. 2 AMD water quality.

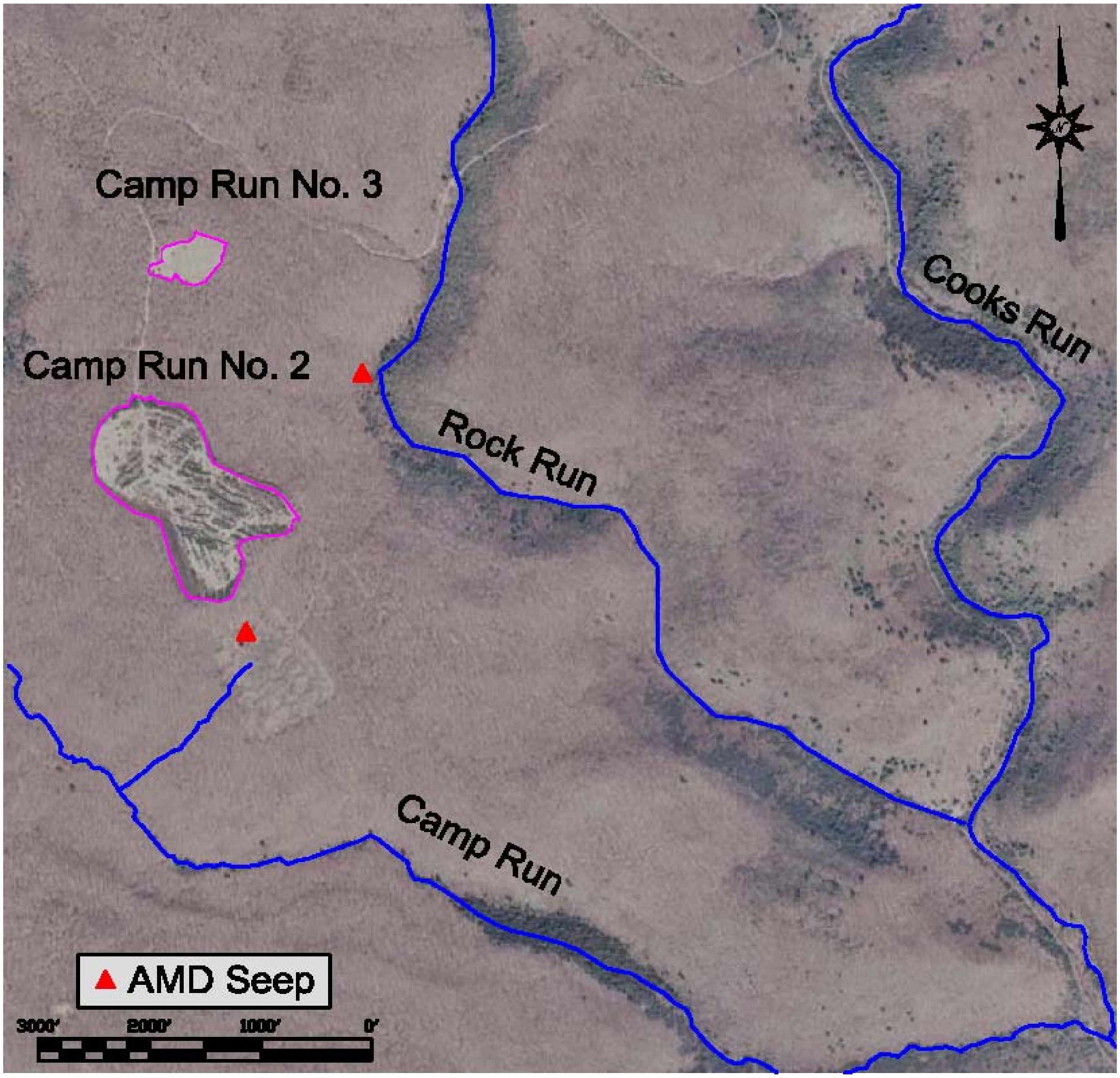

Figure 2. Fran Camp Run No.2 and No. 3 AMD seeps and discharges.

Parameter	1980 Quality (mg/l)	2009 Quality (mg/l)
pH	3.2	2.7
Aluminum	323.8	121.0
Total Iron	31.9	556.6
Ferrous Iron	-	265.0
Manganese	115.8	41.6
Hot Acidity	4050.0	1765.3
Sulfate	4345.0	1989.4

Table 1. Camp Run No. 2 Average AMD Quality parameters from 1980 and 2009.

Previous Remediation Efforts

Several on-site endeavors to abate the AMD were attempted. In early 1981 Fran Contracting, Inc. completed construction of an AMD collection ditch below an AMD kill-zone at the headwaters of an unnamed tributary to Camp Run. The ditch discharged into chemical treatment ponds, and an automatic liming device treated the collected AMD. In August 1981, a Sodium Lauryl Sulfate (an anionic surfactant used in many cleaning and hygiene products) detergent was applied on the site to kill iron-oxidizing bacteria. In addition, five (5) tons per acre of lime was spread over the site to add alkalinity to percolating water in an attempt to neutralize AMD-generating chemical reactions. In May 1982, Fran Contracting Inc. injected lime slurry into the reclaimed area via eight (8) drill holes on the southwestern corner, and seven (7) drill holes on the southeastern corner of the permit area. Drill holes ranged in depth from 16 to 29 feet, depending on the depth of the pit floor. All of these abatement attempts were unsuccessful, and the site was subsequently abandoned. Bonds totaling $9,940.00 were forfeited in 1983 and collected in 1986.

AMD also enters Rock Run via as many as a dozen different AMD seeps and springs along a three-quarter mile reach within a steep hollow below the Camp Run No. 2 site. The observed discharges are seeps with little or no visible flow and some springs with flow rates of 1 to 2 gallons per minute (gpm). Some of the AMD degradation to Rock Run is via base flow directly into the steam channel. The AMD contains elevated levels of iron, aluminum, manganese, and other metals. The pH is about 2.5 and the acidity concentration is over 2,000 mg/L (Henry, 1989).

During the late 1980s and early 1990s the DER's Bureau of Mining and Reclamation (BMR) drilled injection and monitoring wells on areas of the site where geophysical studies indicated concentrations of acid-producing material were buried. During that period, fly ash slurry was injected into the "hot" areas via the injection wells in an attempt to encapsulate and/or neutralize the material's acid-producing abilities. Water sampling over a period of time indicated some improvement to the discharging water quality, but not significant enough to improve the quality of water in Rock and Camp Runs.

Passive Treatment Evaluation

In 2001, the Allegheny Mountain Chapter of Trout Unlimited (TU) raised funds and received a Department of Environmental Protection (DEP) Grant to evaluate and initiate passive treatment options at the Camp Run No. 2 site.

Bench-scale sulfate reducing bioreactors (SRBR) consisting of five 50-gallon containers of varying mixtures of organic substrate, including manure, shredded wood, alfalfa/hay, and fine limestone, were constructed near the site. Each container of varying organic substrate mixture was dosed with AMD collected from the Camp Run No. 2 site. Treated discharge water quality was monitored from August to December 2001. In January 2002, each container was evaluated to determine the amount of plugging and short-circuiting in the substrate. The best organic substrate mixture was chosen for use in the design of a pilot-scale SRBR system, which was constructed near the discharge, to treat one gallon per minute of Camp Run No. 2 AMD. The pilot system effluent water quality monitoring was conducted between September 2002 and September 2003 *(Table 2)*.

Parameter	**Influent Quality** (mg/l)	**Effluent Quality** (mg/l)
pH	2.4	6.4
Aluminum	271	0.5
Total Iron	300	134.4
Ferrous Iron	54.7	101.8
Manganese	34.1	42.4
Hot Acidity	2580	0
Sulfate	2421	1511
Alkalinity	0	841.5
Calcium	62.6	686.0

Table 2. Pilot-scale System - Average water quality parameters from 2002 and 2003.

After one year of the Pilot System operation, preliminary design was initiated for a full-scale treatment system. The design included an AMD collection system and a passive treatment SRBR system to be constructed on the Camp Run No. 2 site, as well as a high-alkaline limestone upflow pond (LUP) passive treatment system to be constructed along an easily accessible un-impacted section of Rock Run along Cole Run Road *(Figure 3)*.

The intent of the LUP system was to add alkalinity to Rock Run to neutralize the Camp Run No. 2 AMD that is discharging approximately 2,000 ft. downstream of that area. However, subsequent cubitainor tests conducted on Rock Run water indicated that the proposed high-alkaline LUP would not produce sufficient alkalinity to buffer the acid loading in Rock Run that is caused by the Camp Run No. 2 AMD. Using high-alkaline slag instead of limestone could produce sufficient alkalinity, but the high pH of the effluent would most likely be hazardous to the aquatic life in the un-impacted reach of Rock Run between the LUP system and the AMD seepage area approximately 2,000 feet downstream. In addition, dosing Rock Run with alkalinity would likely benefit Cooks Run, but metals would settle out in Rock Run thus not providing remediation for Rock Run.

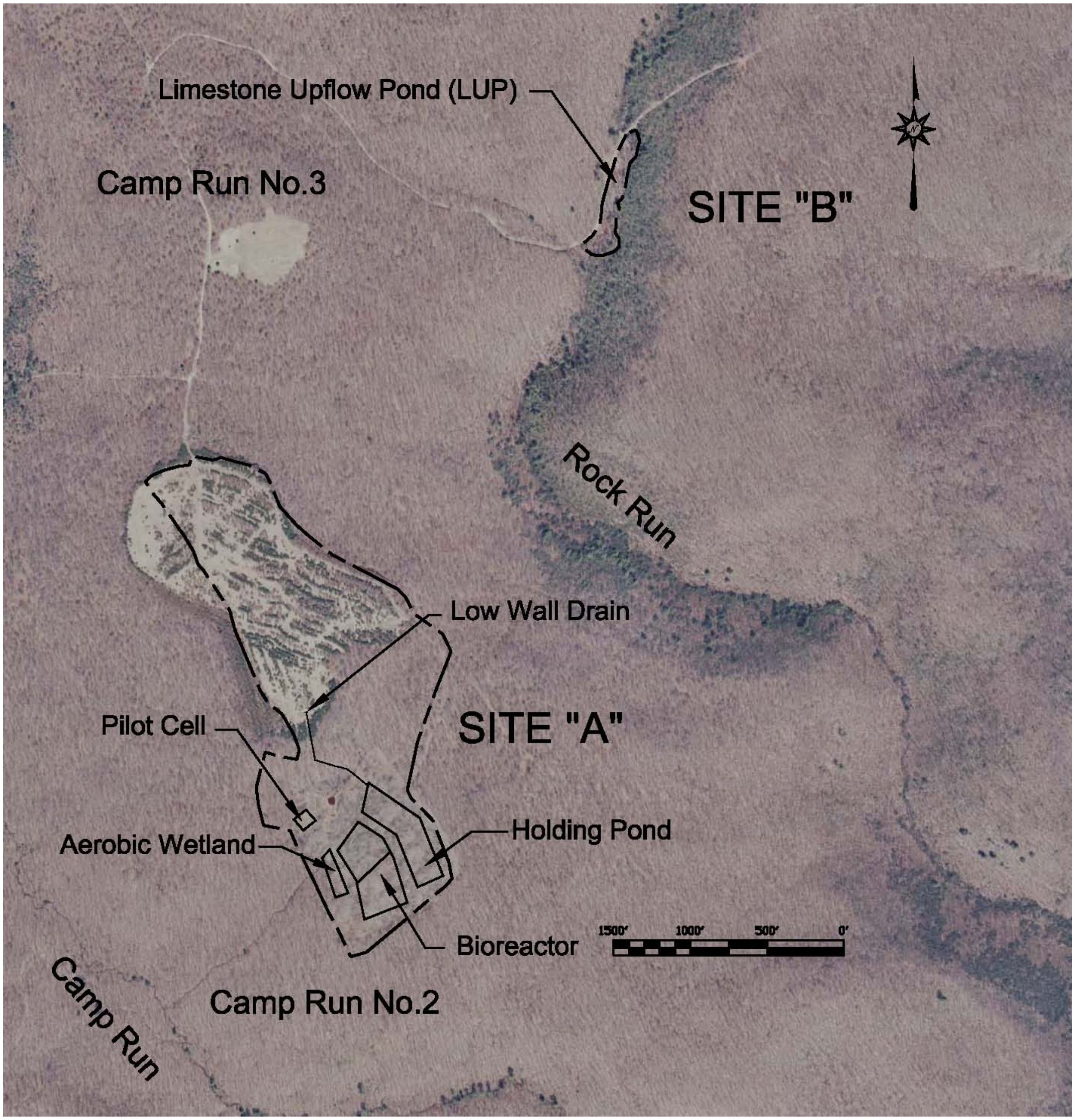

Figure 3. Sulfate Reducing Bioreactor System (Site "A") and Limestone Pond (Site "B").

From past experience with constructed AMD collection systems, both the flow rate and water chemistry often differ from the original discharge. The DEP's Bureau of Abandoned Mine Reclamation (BAMR) decided to complete the project in two phases. Phase 1 would involve AMD water collection and monitoring, a chemical treatment evaluation, and a re-mining and alkaline addition evaluation. Phase 2 would involve AMD remediation.

AMD Collection System

The AMD collection system includes a low-wall drain and pipeline, subsurface drain laterals, and a holding pond (Pond 1) *(Figure 4)*. During excavation of the holding pond, the Contractor encountered seepage in the bottom of the holding pond along the northern embankment cut. This was an indication that some AMD was not being collected by the AMD collection system.

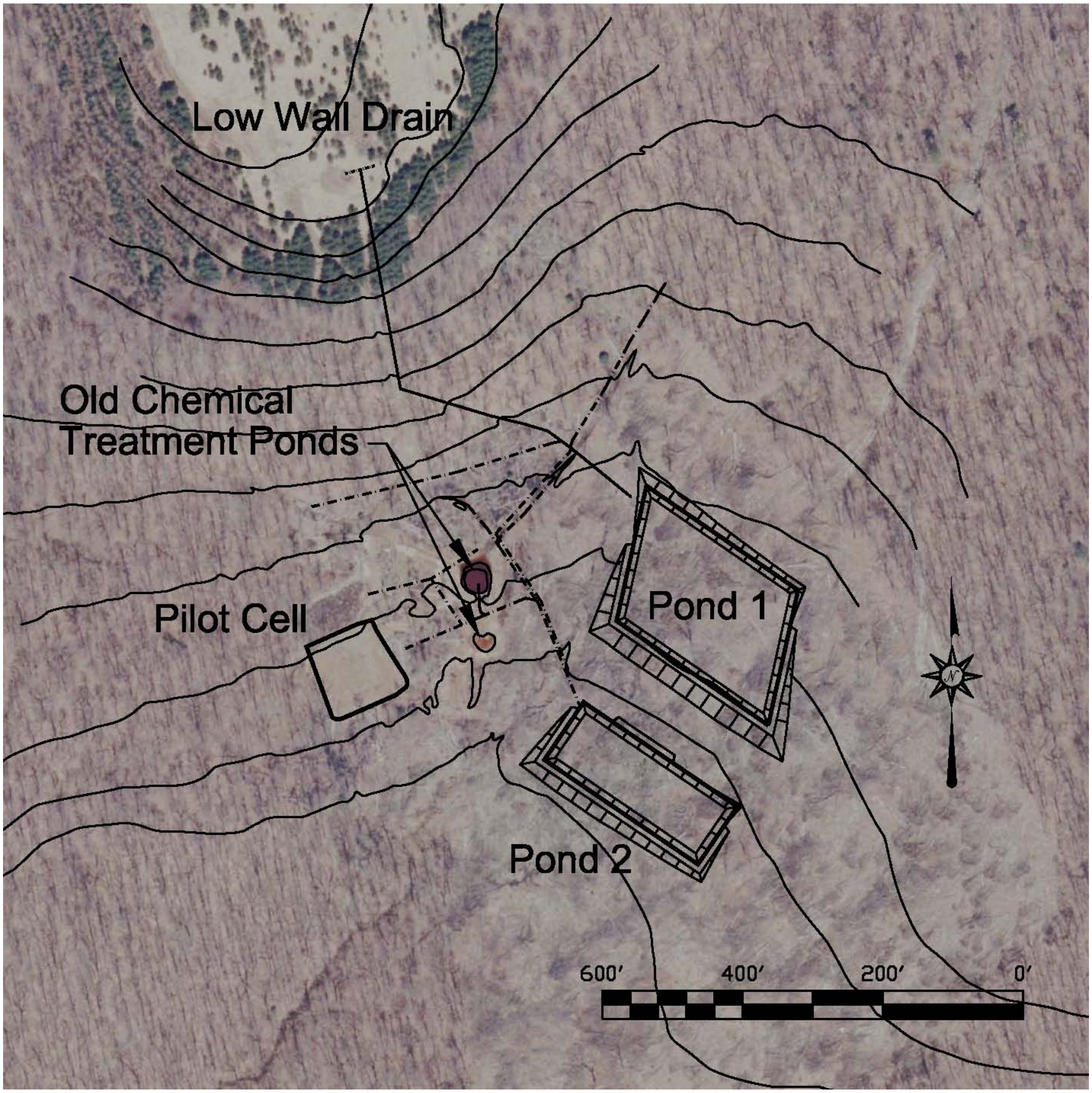

Figure 4. Camp Run No. 2 AMD Collection System.

After a few weeks in operation it became apparent that the low-wall mine drain and the two lateral subsurface drains were not collecting the entire discharge as intended. In late August

2009, an additional approximately 2,000 linear feet of subsurface drains and an additional collection pond (Pond 2) were installed in an effort to collect as much AMD as practical *(Figure 4)*. During this construction, the existing chemical treatment ponds were breached and drained. This work completes all that can be feasibly done under the Phase 1 contract to intercept and collect the AMD at the Camp Run No. 2 mine site.

Chemical Treatment Evaluation

A chemical treatment option was evaluated for the Camp Run No. 2 AMD discharge during the construction of the AMD collection system. Since electricity is not available at the remote site, an automatic caustic soda dip system would likely be the most practical chemical treatment option for consideration.

Titrations with twenty percent (20%) solution of Sodium Hydroxide (NaOH) were completed to determine the amount of chemical needed to remove metals and pH acidity. Titrations continued until the mixture reached pH 11, to simulate different levels of treatment for increased acidity removal.

Cold acidity titrations were performed in the field using a twenty percent (20%) solution of Sodium Hydroxide (NaOH) to define treatment acidity and chemical consumption at various pH endpoints, including pH 7.1 and 10 *(Table 3)*. The field testing revealed that chemical requirements needed to achieve a treatment pH of 7.1 would be 6.75 ml of 20% NaOH per liter of raw AMD. Treatment to a 7.1 pH would neutralize 1,687.5 mg/L of acidity. Chemical requirements to achieve a treatment pH of 10.0 would require 11.0 ml of 20% NaOH per liter of AMD and neutralize 2,750 mg/L of acidity as $CaCO_3$. Using a chemical cost of $1.30 per gallon of caustic soda, it would cost approximately $3,800 and $6,200 to annually treat one (1) gallon per minute of the discharge to pH levels of 7.1 and 10.0 respectively. Additional costs would be incurred for AMD collection and conveyance, pond construction, and perpetual sludge management.

NaOH Titration Measurements					
Treatment pH	**Acidity Removed** (mg/L as CaCO3)	**Titration** mL 20% NaOH (**w/v**) [1] / L Raw	**Titration** gallons of 20% (**w/w**) [2] NaOH per gal Raw	**Titration** Annual Gallons of 20% (**w/w**) NaOH needed assuming 1 gpm flow	**Titration** Annual Cost for 20% (**w/w**) NaOH assuming cost $1.30 per gallon and 1 gpm
2.82	0			0	$0
3.02	125	0.50	0.00041	215	$280
3.29	250	1.00	0.00082	431	$560
3.43	375	1.50	0.00123	646	$840
3.57	500	2.00	0.00164	862	$1,121
4.08	625	2.50	0.00205	1,077	$1,401
4.37	750	3.00	0.00246	1,293	$1,681
4.53	875	3.50	0.00287	1,508	$1,961
4.79	1062.5	4.25	0.003485	1,832	$2,381
5.37	1187.5	4.75	0.003895	2,047	$2,661
5.71	1250	5.00	0.0041	2,155	$2,801
6.16	1375	5.50	0.00451	2,370	$3,082
6.6	1500	6.00	0.00492	2,586	$3,362
7.1	1687.5	6.75	0.005535	2,909	$3,782
7.43	1875	7.50	0.00615	3,232	$4,202
7.57	2005.625	8.02	0.00657845	3,458	$4,495
7.89	2187.5	8.75	0.007175	3,771	$4,903
8.55	2375	9.50	0.00779	4,094	$5,323
9.2	2500	10.00	0.0082	4,310	$5,603
9.75	2625	10.50	0.00861	4,525	$5,883
10	2750	11.00	0.00902	4,741	$6,163
10.45	2875	11.50	0.00943	4,956	$6,443
11	3000	12.00	0.00984	5,172	$6,723

[1] (w/v) – weight to volume ratio   [2] (w/w) – weight to weight ratio

Table 3. Chemical treatment evaluation of the Camp Run No. 2 discharge.

Watershed Water Quality Monitoring

In September 2009, water samples and flow measurements of the AMD collection system outlet and watershed streams were conducted to provide a "snapshot" of the AMD pollution loading conditions.

Results of the sampling "snapshot" *(Figure 5 and Table 4)* indicate that approximately forty percent (40%) of the Camp Run No. 2 AMD acidity loading impairs Camp Run, and approximately sixty percent (60%) impairs Rock Run. Furthermore, the Camp Run No. 2 AMD collection system does not appear to be intercepting all of the acidity loading entering Camp Run. That pollution loading is likely entering Camp Run via fractures in the vicinity of the site.

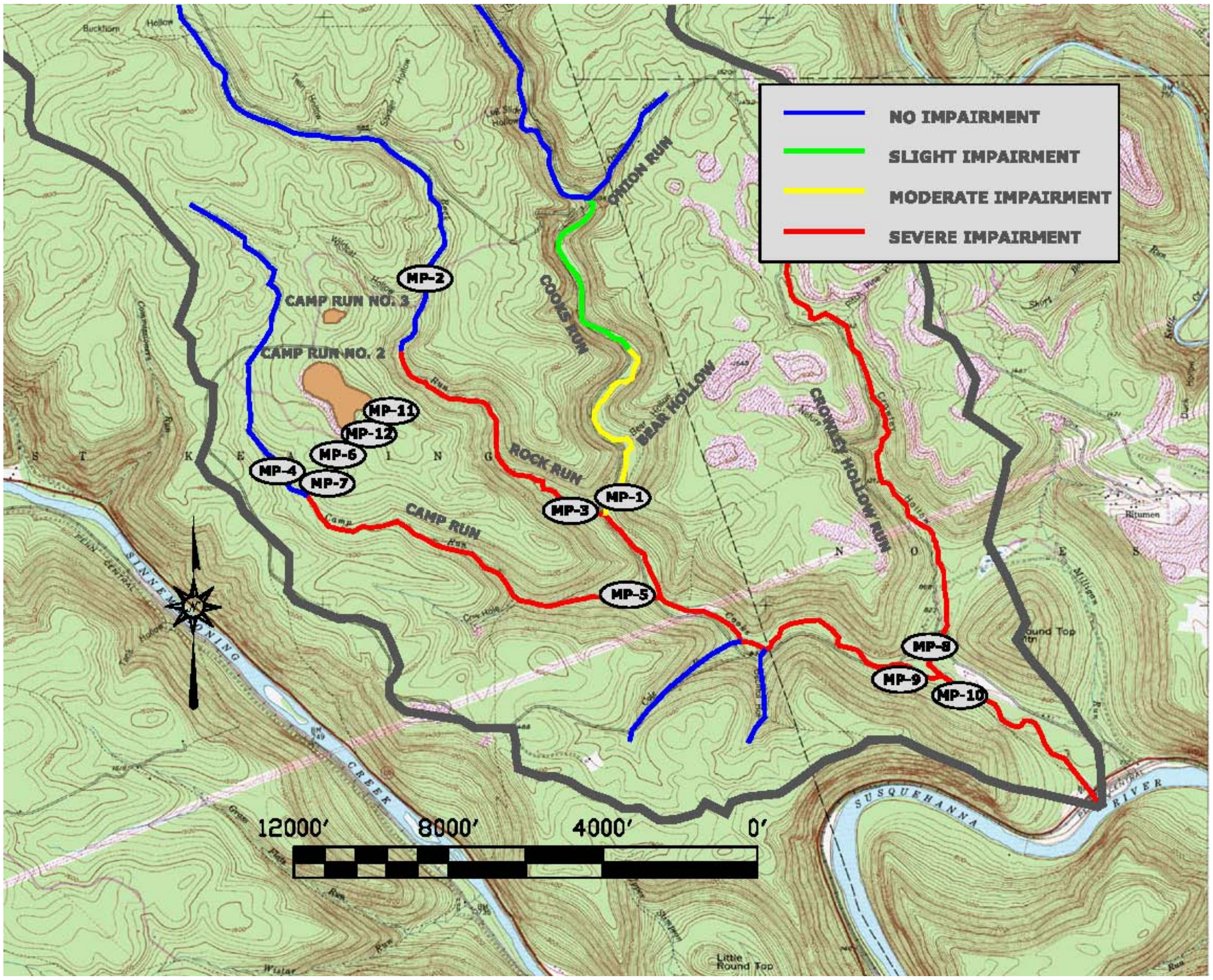

Figure 5. Cooks Run Watershed "Snapshot" Sample Points Location Map.

Cooks Run Watershed Water Quality						
(Water Quality and Flow Rates from 09/30/2009 "snapshot" sampling)						
Sample Location	**pH**	**Flow** (gpm)	**Acidity** (lb/day as $CaCO_3$)	**Fe** (lb/day)	**Mn** (lb/day)	**Al** (lb/day)
Cooks Run upstream of Rock Run **(MP-1)**	**7.1**	2458	-29.5	5.1	2.5	3.0
Rock Run upstream of AMD **(MP-2)**	**6.8**	381	0.9	0.1	0.0	0.5
Rock Run at mouth **(MP-3)**	**4.5**	889	209.4	0.6	7.8	18.8
Camp Run upstream of Fran Tributary Mouth (FTM) **(MP-4)**	**6.0**	283	16.3	0.1	0.1	0.3
Camp Run at mouth **(MP-5)**	**4.0**	415	142.7	0.8	7.3	13.2
Fran AMD Tributary near source **(MP-6)**	**2.7**	5.1	42.6	1.9	2.5	4.8
Fran Tributary Mouth **(MP-7)**	**2.8**	22.2	113.4	3.8	6.2	12.9
Crowley Hollow Run mouth **(MP-8)**	**2.7**	447	2098.7	293.9	48.0	112.3
Cooks upstream of Crowley **(MP-9)**	**6.0**	3587	301.8	3.5	12.9	18.1
Cooks Run downstream of Crowley **(MP-10)**	**3.6**	4034[1]	1590.4	125.6	42.7	90.2
Fran Pond 1 Out **(MP-11)**	**2.8**	8.0	77.3	1.0	4.2	9.9
Fran Pond 2 Inlet Flume **(MP-12)**	**2.3**	2.5	57.2	9.6	1.1	3.9

Table 4. Water Quality in Cooks Run Watershed ([1] Flow for MP-10 is the summation of flows for MP-8 and MP-9, which would affect the loading calculations).

Data indicates that the under-clay and lower coal seam below the pit floor are fractured and pit water is leaking down through and following the strata below it *(Figure 6)*. According to the background information in the mining permit files, the southeastern knob on the Camp Run No. 2 site is highly fractured. The mine foreman remembered that no blasting was required during the mining operations due to the highly jointed overburden (Voykin, 1978). Surface geophysical surveys by DER/BMR show high terrain conductivity along the two down-dip southeastern lobes of the mine indicating higher concentrations of AMD (Schueck, 1990). A very low frequency (VLF) survey completed in November 2009 indicates a high degree of bedrock fracturing on and adjacent to the site in that area. Because of the generally southeastward dip, the high degree of fracturing at the southeastern end of the site, the geophysical data, and the AMD discharges in that area, major groundwater flow paths to both Rock Run and Camp Run are believed to originate at the southeastern end of the site and enter Camp and Rock Runs via surface seeps and base flow.

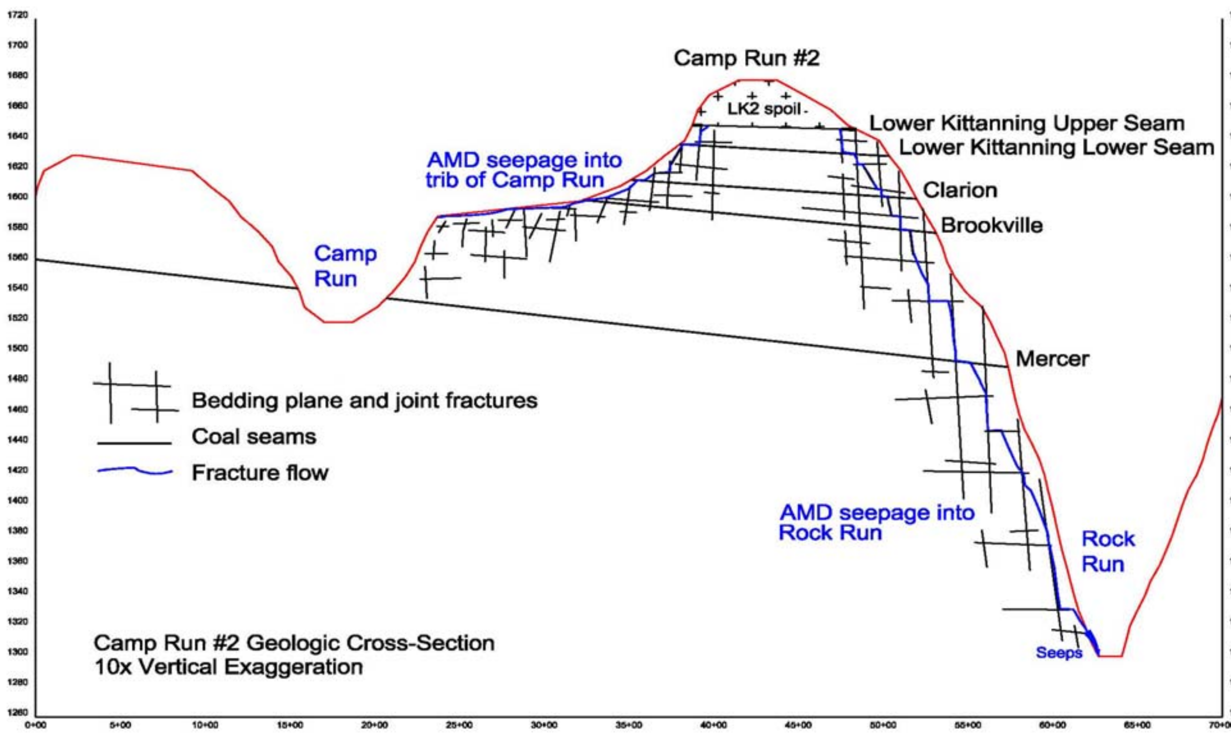

Figure 6. Geological Cross Section across Camp Run No. 2 mine site.

<u>Preliminary Re-mining and Alkaline Addition Evaluation</u>

In April 2009, during the construction of the AMD collection system, fourteen (14) exploratory drill holes were completed on the Camp Run No. 2 site in order to evaluate both the potential for re-mining the upper two coal seams, and for alkaline addition. Three (3) of these drill-holes were converted to water-monitoring wells *(Figure 7)*. Water samples were collected and analyzed *(Table 5)*. Cores were collected and the samples were tested for overburden and coal quality. The overburden analyses included the preparation of rock samples and acid-base accounting tests (Total Sulfur and Neutralization Potential). The coal analyses included the preparation of coal samples and tests for total moisture, ash, sulfur, British Thermal Unit (BTU) per pound (lb.), lbs. of sulfur per million BTU, and BTU (moisture and ash free) on "as received" and "dry" bases. The recovery rates through the Camp Run No. 2 mine spoils were very low in most holes.

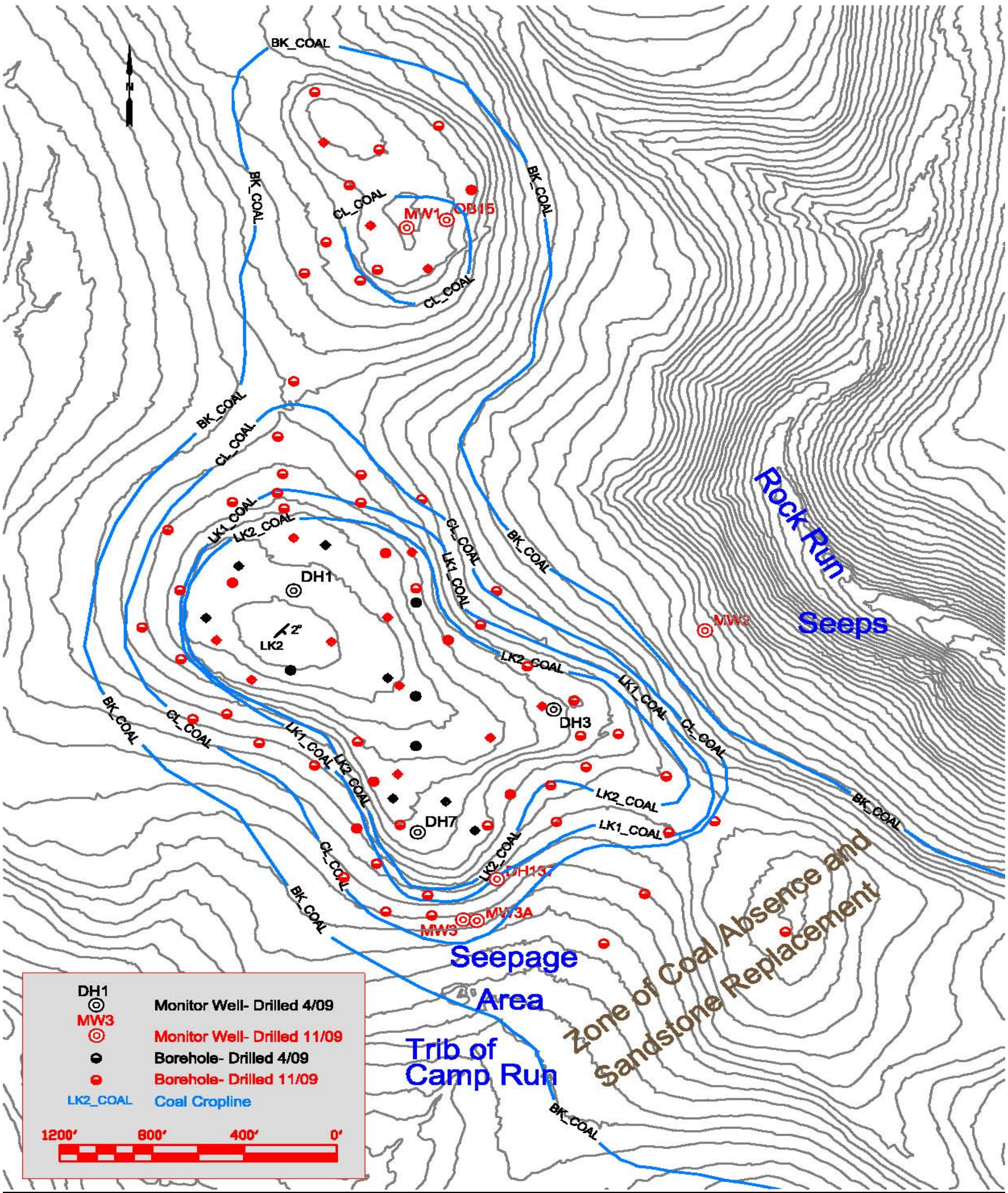

Figure 7. Exploratory Drilling - Drill Hole Location Map and Projected coal crop-lines.

MONITORING WELLS											
MP No.	**COAL(s)**	**DATE**	**pH**	**Acidity**	**Iron (T)**	**Iron (Fe^{+}**	**Mn (T)**	**Al (T)**	**Sulfate**	**TDS**	**SpC**
MW1	Clarion spoil	11/18/09	**2.3**	5567	>300	812	12.6	404	4340		
		1/20/10	**2.4**	4864	1630		13.6	437	4145	8258	4230
OB15	Clarion spoil &	11/18/09	**3.4**	2258	>300	422	7.2	239	1943		
	Brookville	1/20/10	**3.0**	1603	361		8.2	211	1331	2756	1914
DH3	LK2	1/20/10	**2.1**	6034	1650		34.7	418	5240	10654	6180
DH1	LK1	4/14/09	**2.3**	6087		375			6574		5820
		1/20/10	**2.1**	8984	2940		31.5	648	7325	15386	7730
DH7	LK1	4/14/09	**2.3**	2687		54			2066		3900
		1/20/10	**2.3**	2176	1480		38.4	350	1957	3686	3440
DH137	Clarion	11/18/09	**2.3**	2449	278	36	17.6	203	2093		
		1/20/10	**2.1**	5412	337		19.4	259	5039	9128	6030
MW3	Clarion	11/18/09	**3.5**	2234	>300	855	38.8	91	3003		
		1/20/10	**3.5**	2365	1330		60.2	68	3408	5516	3810
MW3A	Brookville	11/18/09	**4.3**	2398	>300	1220	55.8	8	3776		
		1/20/10	**3.8**	2588	1600		67.2	27	4008	6462	4350
MW2	Mercer	11/18/09	**3.1**	1186	>300	259	66.2	52	1920		
	91 ft.[1] 14 min.	1/21/10	**3.0**	1047	475		68.9	71	1689	3244	2760
	161ft. [1] 45 min.	1/21/10	**3.1**	1080	535		65.3	56	2012	3474	2870
	161ft. [1] 75 min.	1/21/10	**3.2**	1072	492		61.4	46	2105	3396	2850

[1] Depth of pump in monitoring well and purge time in minutes.
Note: All results in mg/L, except pH (pH units) and SpC (*u*mhos/cm). Alkalinity = 0 for all samples.
Note: Coal correlation top to bottom; #1 = LK2, #2 = LK1, #3 = Clarion, #4 = Brookville, #5 = Mercer.

Table 5. Exploratory Drilling - Monitoring Well Water Quality Sampling Data

For the purpose of the April 2009 exploratory drilling evaluation, the Camp Run No. 2 upper coal seam mined by Fran Contracting, Inc. is correlated with the upper split of the Lower Kittanning (LK2), and the lower seam, which was not mined due to the special conditions in the Mine Drainage Permit, with the lower split of the Lower Kittanning (LK1).

Computer Aided Design (CAD) mining software was used to generate the LK2 crop-line and cross sections from the boreholes. The remaining recoverable reserve for the LK2 was estimated. A twenty-five (25) foot crop-line barrier was required to be left intact, as per the special conditions of the Camp Run No. 2 Mine Drainage Permit issued to Fran Contracting, Inc. The LK1 crop-line was estimated taking into account the generalized dip and inter-burden between the LK2 and LK1. The volume to remove the existing mine spoil and in-situ rock overlying the LK2 was calculated using CAD earthwork software. The volume of inter-burden between the LK2 and LK1 was calculated using the average thickness *(Table 6)*.

PRELIMINARY INFERRED COAL RESERVE				
Coal Seam	**Area** (Ac.)	**Average Thickness** (in.)	**Overburden Volume** (CY)	**Coal Tonnage**
Upper Split of Lower Kittanning Coal **(LK2)**	6.3	18	1,338,323	14,218
Lower Split of Lower Kittanning Coal **(LK1)**	50.8	17	938,488	108,529
TOTALS	--	--	2,321,811	122,747

- Assumptions: Coal Density = 1,770 Tons/Acre-foot; Pit Recovery = 85 %
- Stripping Ratio = 2,321,811 cubic yards/ 122,747 tons = 18.9:1

Table 6. Preliminary Overburden and Coal quantities - April 2009 drilling.

The preliminary coal analyses *(Table 7)* included the preparation of coal samples and the tests for total moisture, ash, sulfur, BTU/lb., lbs. sulfur/million BTU, and BTU (moisture and ash free) on "as received" and "dry" bases.

PRELIMINARY COAL ANALYSIS					
Coal Seam	**Number of Samples**	**Percent Moisture**	**Percent Ash**	**Percent Sulfur**	**BTU**
Upper Split of Lower Kittanning Coal **(LK2)**	2 Trench	6.6 – 8.7	2.3 – 6	0.63	12,542 – 13,836
Lower Split of Lower Kittanning Coal **(LK1)**	5 Core	1.1 – 2.4	17 – 26.2	0.57 – 2.5	10,929 – 12,153

Table 7. Preliminary Coal Analysis - April 2009 drilling.

Acid-base accounting was performed on the spoil materials as a way to define the alkaline addition requirement that could be used during a re-mining effort. There is an inherent difficulty in applying acid base accounting techniques to reclaimed mine spoils. The difficulty lies in the fact that reclaimed spoils lack lateral stratigraphic continuity between drill holes. It may not be a reasonable assumption that sulfur values obtained from a certain section of a drill hole represent the mass of sulfur within that section between drill holes. The heterogeneous nature of reclaimed spoil is an inherent source of uncertainty in any calculated alkaline requirement. Nevertheless, a traditional acid-base accounting analysis was performed to provide a target for alkaline addition. The preliminary overburden analysis included the preparation of the rock samples, and acid-base accounting tests (i.e., Total Sulfur and Neutralization Potential). The overburden analysis revealed *(Table 8)* that in order to neutralize the Fran Contracting Inc.'s Camp Run No. 2 mine spoil (Upper Split of the Lower Kittanning LK2) and the in-situ inter-burden between the LK2 and LK1, 2,700 tons/acre of 100% Calcium Carbonate ($CaCO_3$) equivalent (CCE) will need to be incorporated into the backfill. The required amount of 85% Calcium Carbonate ($CaCO_3$) = 50.8 acres x 2,700 tons/acre x 1.15 = 157,734 tons.

PRELIMINARY OVERBURDEN ANALYSIS			
Drillhole	**Calculated Deficiency** (Tons/Acre) (% Sulfur ≥ 0.5; NP[2] ≥ 30 w/Fizz)	**Alkaline Addition[1]** (Tons) To achieve NNP[3] ≥12 tons per thousand tons excess	**Acreage Adjusted Alkaline Addition Rate[1]** (Tons/Acre) To achieve NNP[3] ≥12 tons per thousand tons excess
DH 1	4044	5715	3740
DH 2	321	1703	1066
DH 3	4586	5563	2691
DH 4	468	2626	1126
DH 5	2780	5136	3326
DH 6	1992	4332	2662
DH 7	1006	2685	2244
DH 8	1474	2266	2266
DH 9	1544	2321	1625
DH 10	0	572	520
DH 11	779	1387	750
DH 12	2103	2609	1547
DH 13	1965	2450	1315
DH 14	1643	3442	2946
Median	1594	2618	1935
Third Quartile	2075	4110	2684

[1] Assumes 100% $CaCO_3$ Equivalent Alkaline Material
[2] NP = Neutralization Potential
[3] NNP = Net Neutralization Potential

Table 8. Preliminary Results from DEP's Overburden Analysis System

BAMR staff determined that additional exploration was needed to accurately define the geology and remaining Camp Run No. 2 coal reserve on the LK2 crop-line, the crop-line of the LK1, which will directly influence the recoverable reserve, and the additional coal quality, which will better define marketability.

Additional Exploration and Ongoing Re-Mining and Alkaline Addition Evaluations

BAMR completed a more extensive exploratory drilling project on November 17, 2009 that included both reclaimed mine lands and un-mined areas. Seventy-five (75) holes *(Figure 7)* totaling 3,687 feet were drilled to obtain the additional hydrological and geological information. The areas drilled were the Camp Run No. 2 mine site, the Camp Run No. 3 mine site to the north, and the saddle and hilltop southeast of the Camp Run No. 2 site. Several drill holes were converted to monitoring wells.

Several of the drill holes in the saddle between the Camp Run No. 2 site and the hilltop to the southeast did not encounter the Clarion coal as expected. The coal is replaced by brown sand and sandstone likely through fluvial erosion and channel sand deposition. An alternate explanation is structural; faulting due to tectonic forces. However, no faults have been mapped in the Cooks Run Watershed.

A total of forty-four (44) coal samples were analyzed for the November 2009 exploratory drilling evaluation *(Table 9)*.

In January 2010, pump tests were conducted and water samples were collected in the six (6) water-monitoring wells (MW1, MW2, MW3, MW3A, OB15, and DH137). The analyses revealed similar water quality characteristics to that of the Rock Run and Camp Run AMD seeps *(Table 5)*. Water quality chemistry from monitoring well MW2, located between the Camp Run No. 2 site and Rock Run, indicates AMD influence from the Fran Camp Run No. 2 site due to subsurface flow through fractures. Water quality chemistry from monitoring wells MW1 and OB15, located on the Camp Run No. 3 site, indicates probable AMD influence on Rock Run from the Camp Run No. 3 site due to subsurface flow through fractures.

PRELIMINARY COAL ANALYSIS						
Coal Seam	**Average Thickness**	**Number of Samples[1]**	**Percent Moisture**	**Percent Ash**	**Percent Sulfur**	**BTU**
Upper Split of Lower Kittanning Coal (LK2) Remaining crop left at Camp Run No. 2	20 inches	3 Dust	7.0 – 30.5	9.6 – 18.9	0.33-1.0	6,502 – 11,664
Lower Split of Lower Kittanning Coal (LK1)	17 inches	5 Dust 4 Core	3.0 – 8.0	20.4 – 21.4	0.47 - 0.78	9,641 – 11,584
Upper Split of Clarion Coal	Streak to 8 inches	2 Core	1.8 – 2.1	12.9 – 31.1	1.2 – 1.7	10,169 – 13,186
Middle Split of Clarion Coal	13 inches	2 Dust 4 Core	2.5 – 5.8	20.7 - 26	0.5 – 1.3	10,403 – 11,777
Lower Split of Clarion Coal	13 inches	4 Dust 4 Core	2.0 - 4.2	16.0 – 29.0	0.9 – 2.5	9,616 – 12,681
Brookville Coal	15 inches	6 Dust 1 Core	1.5 – 4.1	31.0 – 36.2	2.8 – 5.7	8,837 – 10,086

[1] Some of the samples were combined to create nine (9) additional composite samples.

Table 9. Preliminary Coal Analysis - November 2009 drilling.

Summary

The primary restoration goal for the Cooks Run Watershed is to restore Rock Run, Camp Run, and Cooks Run to resources capable of supporting trout and natural trout reproduction. After reviewing the data, it is presumed that the majority of the acid-forming material affecting Camp Run and Rock Run is contained within the mine spoils at the Fran Contracting, Inc. Camp Run No. 2 and Camp Run No. 3 surface-mined sites. This acid-forming material is leaching acidic AMD that percolates through the fractured formations, with some of that AMD entering Rock Run as baseflow, some entering Camp Run as baseflow, and some collected by the AMD collection system constructed at the Camp Run No. 2 site. Active or passive treatment at the Camp Run No. 2 site would likely only partially remediate Camp Run, and would do nothing to remediate Rock Run. Active or passive treatment at the Cole Run Bridge site along Rock Run would likely benefit Cooks Run, but would do nothing to remediate Rock Run. Additionally, most treatment systems require perpetual, long-term, often costly, operation and maintenance.

The preliminary overburden analyses revealed that in order to neutralize the Camp Run No. 2 mine spoil (Upper Split of the Lower Kittanning LK2) and the in-situ inter-burden between the LK2 and LK1 approximately two thousand seven hundred (2,700) tons per acre of 100% calcium carbonate ($CaCO_3$) equivalent (CCE) would be have to be incorporated into the backfill. Typical alkaline addition material is 85% CCE. This translates to approximately 157,734 tons of 85% CCE material for the Camp Run No. 2 site. Using an estimated average cost of $22 per ton of alkaline material, it would cost a coal operator $3,470,148 for alkaline addition at the Camp Run No. 2 site. A generalized coal requirement for power plants is greater than 11,700 BTU/lb., less than 2.2 % Sulfur, and less than 15% ash. The average spot market price per ton for this quality is approximately $60 per ton. Assuming a coal operator could market the poor quality LK2 and LK1 coal for $25 per ton, re-mining the Camp Run No. 2 site would generate gross revenues of $3,068,675.

The preliminary re-mining and alkaline addition analyses support further investigation. The stripping ratio is within economic industry standards, but due to the coal quality, remoteness of the site, and potential liability for the pre-existing AMD, it is highly unlikely a coal company would mine this site without an economic incentive and liability protection.

BAMR will continue the evaluation of the re-mining and alkaline addition alternatives. This will include completing the calculations for the amount of alkaline material required to neutralize the acid-forming material, which is dependent upon which coal seam or coal seams will be mined. The additional November 2009 exploratory drilling efforts generally indicate that all of the coal is of poor quality. A favorable stripping ratio should be obtainable on all of the coal seams from the Lower Kittanning to the Brookville. The individual coal seam re-mining feasibility will be dependent on the results of the final overburden analysis.

BAMR plans to conduct additional exploratory drilling in order to accurately locate the crop-line of the Brookville coal, obtain some additional overburden and coal for analysis, and install additional water-monitoring wells. The re-mining evaluation will also include consideration of a pit floor mine drainage collection system, a pit floor impermeable liner, and a potential post re-mining AMD treatment system, in case any post re-mining drainage still requires some treatment.

BAMR will continue to collect and analyze water samples from the watershed and the monitoring wells on a regular basis, in conjunction with the ongoing evaluation of the re-mining and alkaline addition options.

After the re-mining and alkaline addition evaluations are completed, BAMR will make a determination as to the viability of implementing these options. Based on the information evaluated to date, re-mining and alkaline addition appear to be the most viable remediation options. If AMD remediation efforts at the Camp Run No. 2 and No. 3 mine sites are implemented and are successful, BAMR can focus continued restoration efforts on the remainder of the watershed.

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