DRAFT

Slippery Rock Creek Watershed

Department of Environmental Protection
Knox Office, District Mining Operations
COMMONWEALTH OF PENNSYLVANIA

PROGRESS REPORT: 2001

Butler County
Pennsylvania
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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Slippery Rock Creek study area is **located** approximately 4 miles *(6.44 km)* south of Interstate 80 in northern Butler County *(See Figure 1)*. The watershed lies 10 miles *(16.10 km)* east of the town of Slippery Rock within Venango, Washington, Marion, and Cherry townships. It is flanked by the communities of Boyers and Eau Claire, and approximately bound by State Routes 38, 58, 308, and 4010 The Slippery Rock watershed has been severely degraded by acid mine drainage. Since watershed remediation efforts under the PA Comprehensive Mine Reclamation *(PA CMRS)* began in 1994, 74 mine drainage sources have been identified with 59 contributing acid loading to the streams. Approximately 90 % of the acid load is released from 35 discharges. Abandoned deep mine complexes and strip operations alike account for 50 % each of the total acid load. The Reclamation/Remediation Plan for the headwaters of the Slippery Rock Creek watershed has been broken down into ten Priority Areas from which interested parties may select a discharge or abandoned clean-up area to remediate. Since 1995, twelve passive treatment systems costing approximately $2,090,800 have been installed and an additional three passive treatment systems have been proposed that will cost approximately $ 863,529. In total, including the currently proposed systems, they will remove 30.35 % of the acid load to the watershed. The progress in the headwaters of Slippery Rock Creek has been accomplished by a team effort that consists of industry, government, landowners, and academic institutions. The Slippery Rock Watershed Coalition "spear-heads" the lines of communication between all interested parties. The majority of the remediation efforts thus far have been completed by Stream Restoration Inc., PA DEP – Knox DMO & BAMR, the PA Game Commission, Kerry Coal Company, Amerikohl Mining Inc., Quality Aggregates Inc., Hedin Environmental and Puryear Excavating.

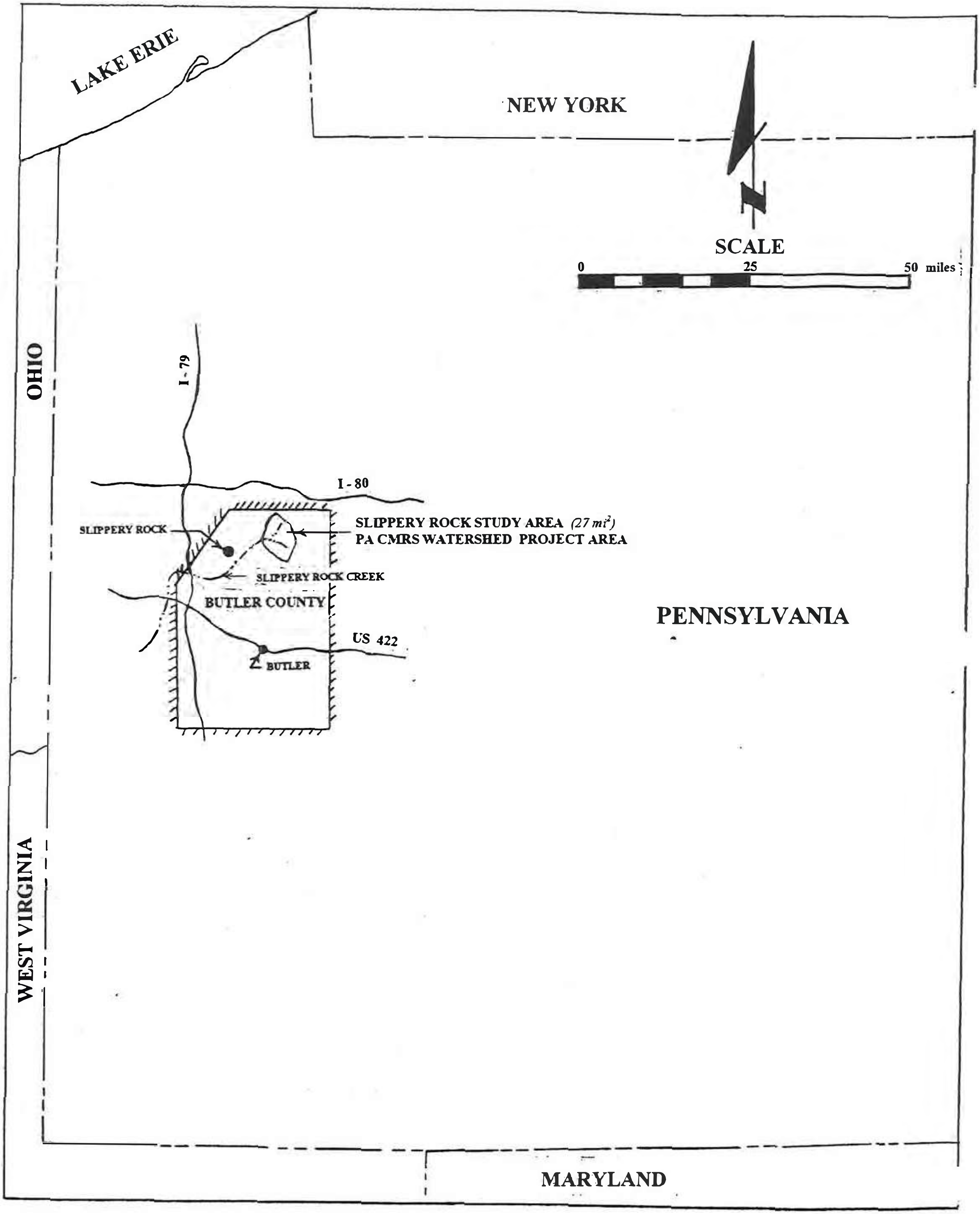


FIGURE 1: VICINITY MAP

INTRODUCTION

PURPOSE

The **purpose** of the 2001 Slippery Rock Progress Report, since the 1998 Pa. CMRS Report, is to:

1. Characterize the acid mine drainage pollution problems in the watershed study area;
2. Provide a cost summary of the acid mine drainage remediation projects completed/ proposed in the watershed;
3. Update the AMD loading reductions that the remediation projects have had on the watershed and develop a loading reduction/performance chart;
4. Provide a hydrologic assessment of the improvements and/or "no-impacts" to the watershed receiving streams;
5. Update the AMD Inventory and Remediation Plan;
6. Develop a prioritized short term "hit list" for AMD remediation projects; and
7. Refine the Remining Section.

It is recommended that this report be used in conjunction with the 1998 Pa. CMRS Report for a complete understanding of the history of remediation efforts that have occurred in the headwaters of Slippery Rock Creek since Operation Scarlift in the early 1970's. The ultimate **goal** of this project is to improve the water quality within the existing ecosystem to allow a wide variety of aquatic/semi-aquatic communities to re-habitate the streams. According to the Pa. Fish and Boat Commission, an ideal water quality to strive for in the ecosystem would be as follows: pH 6-6.5; alkalinity > acidity by 20 mg/l; Iron < 0.5 mg/l; and Aluminum < 0.5 mg/l.

LOCATION AND DESCRIPTION OF STUDY AREA

The Slippery Rock Creek study area is **located** approximately 4 miles *(6.44 km)* south of Interstate 80 in northern Butler County *(See Figure 1)*. The watershed lies 10 miles *(16.10 km)* east of the town of Slippery Rock within Venango, Washington, Marion, and Cherry townships. It is flanked by the communities of Boyers and Eau Claire, and approximately bound by State Routes 38, 58, 308, and 4010. The Slippery Rock Creek study area is bound within the Eau Claire, Hilliards, West Sunbury, and Barkeyville 7.5 minute quadrangles.

The areal extent of the watershed is 27 mi^2 *(70 km^2)* of which 60% drains to the Main Branch of Slippery Rock Creek and 40% to the Seaton Creek/Murrin Run subwatershed. There are approximately 44.4 miles *(71.48 km)* of stream, as measured by planimeter from the USGS topograhic quadrangles, flowing through the watershed area of which 31.4 miles *(50.55 km)* have been impacted by acid mine drainage. Geographic features include shallow to moderate stream gradients (3% ➔ 10%) consisting of flood plain wetlands with forested uplands above the stream corridor. The topographic elevations range from 1500 feet *(457 meters)* above sea level in the highest points near Eau Claire and Parsonville falling to approximately 1200 feet *(365.6 meters)* above sea level at the confluence of Slippery Rock and Seaton Creeks near Boyers. Pa. State Game Lands No. 95 makes up 15% of the watershed area with the remaining 85% belonging to over 500 landowners. An abandoned spur link of the Bessemer and Lake Erie Railroad runs along the flood plain of Slippery Rock Creek from Boyers to Hilliards.

WATERSHED AMD POLLUTIONAL LOADING

Since the CMRS watershed effort in the headwaters of Slippery Rock Creek began in 1994, 74 mine drainage sources have been identified with 59 contributing acid loading to the streams. Approximately 90 % of the acid loading to the streams is released from 35 discharges. Abandoned deep mine complexes and strip operations alike account for 50 % each of the total acid load. Tables 1 and 2 show the magnitude of the acid load on the watershed. The magnitude of the iron and aluminum loading is shown in Table 3.

TABLE 1: MAGNITUDE OF ACID LOAD ON WATERSHED STREAMS

TRIBUTARY	AVERAGE ACID LOAD *(lbs/day)* ♦	PERCENT OF TOTAL ACID LOAD
SEATON CREEK	1059.0	37.3 %
THOMAS TRIBUTARY	600.0	21.1 %
MAIN BR.- SLIPPERY ROCK	374.4	13.2 %
MURRIN RUN	364.0	12.8 %
HILLIARDS BR. - SLIPPERY ROCK	173.0	6.1 %
ACT 43 TRIBUTARY	85.0	3.0 %
ABEL/DRESHMAN TRIBUTARY	71.0	2.5 %
LUCAS TRIBUTARY	65.0	2.3 %
HIGGINS CORNER TRIBUTARY	38.0	1.3 %
PISOR ROAD TRIBUTARY	6.0	0.2 %
BALESTRIERI TRIBUTARY	6.0	0.2 %
TOTAL:	**2841.4**	**100.0 %**

TABLE 2: MAGNITUDE OF ACID LOAD ON SUBWATERSHEDS

SUBWATERSHED	AVERAGE ACID LOAD *(lbs/day)* ♦	PERCENT OF TOTAL ACID LOAD
SEATON CREEK	1195.0	42.0 %
MURRIN RUN	1055.0	37.0 %
SLIPPERY ROCK CREEK	591.4	21.0 %
TOTAL:	**2841.4**	**100.0 %**

TABLE 3: MAGNITUDE OF IRON AND ALUMINUM LOADS ON SUBWATERSHEDS

SUBWATERSHED	*(lbs/day)* AVG. IRON LOAD♦	% OF IRON LOAD	*(lbs/day)* AVG. AL. LOAD ♦	% OF AL. LOAD
SEATON CREEK	306.8	49.3 %	40.8	27.3 %
MURRIN RUN	55.7	9.0 %	86.9	58.1 %
SLIPPERY ROCK CR	259.9	41.7 %	21.8	14.6 %
TOTAL:	**622.4**	**100.0 %**	**149.5**	**100.0 %**

♦ *Average acid, iron, and aluminum load values calculated from 1994 - 1997 water quality and flow data collected by the Knox DMO. Climatological data from the 1970 Scarlift Report was utilized for loading calculations when flow data was unavailable .*

COMPLETED/PROPOSED REMEDIATION PROJECTS

Since 1995, twelve passive treatment systems costing approximately $2,090,800 have been installed and an additional three passive treatment systems have been proposed that will cost approximately $ 863,529. In total, including the currently proposed systems, they will remove 30.35 % of the acid load to the watershed. *(See Tables 4 & 5)*

TABLE 4: COMPLETED PASSIVE TREATMENT PROJECTS *(As of 7/1/2001)*

PROJECT SITE	TYPE OF PROJECT	PROJECT BUILDERS	FUNDING SOURCE	COST
SR 115 *(Argentine)*	Retention Pond/ Wetland	NRCS, Butler County Cons. District, H.R. Stewart, Jr.	CONOCO Fines	$ 31,000.00
SR 114B *(Argentine)*	* ALD/Wetlands	Hedin Environmental, CDS Associates, Jesteadt Excavating	Bond Forfeitures Black Fox Mining	$ 30,000.00
SR 114D *(Argentine)*	* ALD/Wetlands	Hedin Environmental, CDS Associates, Jesteadt Excavating	Bond Forfeitures Black Fox Mining	$ 30,000.00
SR 94$_{\text{(Bertha)}}$ *(Higgins Corner)*	* ALD	Butler County Cons. District & PA Game Commission	CONOCO Fines	$ 30,000.00
SR 85/SR 86 *(Ferris)*	** VFS	Knox DMO, Kerry Coal Co.	Reclamation Agreement	$ 50,000.00
SR 87/ SR 88 *(Ferris)*	** VFS	Knox DMO, Harrisburg BMR, Penn's Corner, & Puryear Excavating	EPA 104(b)(3) grant FY '94/ '95	$ 66,000.00
SR 84 ➔ SR 88 *(Ferris)*	Retention Pond	Knox DMO, Kerry Coal Co.	Reclamation Agreement	$ 35,000.00
SR 101A *(Higgins Cormer)*	*ALD/Wetlands	Hedin/SRI/BAMR	EPA 319 grant	$ 82,000.00
SR 109 *(Argentine)*	**VFS/Wetlands	Puryear/Knox DMO /Penn's Corner/BMR	EPA 104(b)(3) grant FY '96	$ 55,000.00
27F *(DeSale-Ph. I)*	**VFS/Wetlands	Amerikohl/SRI/Knox DMO	WRPA WR-10 grant ME#359478	$ 391,707.00
23F *(DeSale-Ph.II)*	**VFS/Wetlands	Amerikohl/SRI/Knox DMO	Growing Greener Grant #NW90624 ME#3591053	$ 449,342.00
ST38/ST39/ST40/ ST41/ST42 *(Goff Station)*	**VFS/Wetlands	Quality Aggregates/SRI /Knox DMO	Growing Greener Grant #NW9003 + WRAP grant ME#359747	$ 840,751.00
TOTAL:				**$ 2,090,800.00**

* ALD – anoxic limestone drain ** VFS – vertical flow system

TABLE 5: ADDITIONAL PROPOSED PASSIVE TREATMENT PROJECTS

PROJECT SITE	SUBWATERSHED	PROJECT TYPE	PROPOSED BY:	FUNDING	COST
SR 89	Slippery Rock Creek	(Add Alk.) + Comb. of Vert. Flow Systems	Seneca Landfill, Inc./ Youchak, BioMost, Knox DMO, PF&BC, PGC	SMP Off-Site Mitigation Project, SMP 10000103 + *EPA 319* Grant	$ 688,529.00
SR 96	Slippery Rock Creek	ALD + Wetlands	SRI/Jesteadt/PGC/ Knox DMO	GGGrant #NW90647 ME#359746, + EPA 319 GRANT	$ 55,000.00
SR 81	Slippery Rock Creek	ALD + Wetlands	Amerikohl/SRI/Knox DMO/PGC	Growing Greener Grant #NW90647, ME#359746	$ 120,000.00
TOTAL:					**$ 863,529.00**

AMD LOAD REDUCTION ANALYSIS

Based on Knox DMO post construction sampling of the treatment systems, there has been on average an approximate: 30.35 % reduction in the acid loading; 27.27 % reduction in the iron *(Fe)* loading; and a 27.83 % reduction in aluminum loading over the entire watershed from the total 59 mine drainage sources being monitored. This analysis also takes into consideration that the proposed remediation projects will be 100 % efficient along with the actual performance of the completed systems. *(Please See Tables 6, 7, 8 and the "BALL PARK" Estimates Table)*

TABLE 6: POST TREATMENT ACID LOAD REDUCTIONS IN SUBWATERSHEDS

SUBWATERSHED	AVG. ACID LOAD *(lbs/day)*	REDUCED ACID LOAD FROM TREATMENT (AVG.) *(lbs/day)*	POST TREATMENT AVG. ACID LOAD *(lbs/day)*	POST TREATMENT PERCENT REDUCTION (REDUCED AVG. ACID LOAD ÷ AVG. ACID LOAD)
SEATON CREEK	1195.0	286.0	909.0	23.93 %
MURRIN RUN	1055.0	200.0	855.0	18.96 %
SLIPPERY ROCK CREEK	591.4	376.4	215.0	63.65 %
TOTAL WATERSHED:	**2841.4**	**862.4**	**1979.0**	**30.35 %**

TABLE 7: POST TREATMENT IRON LOAD REDUCTIONS IN SUBWATERSHEDS

SUBWATERSHED	AVG. IRON LOAD *(lbs/day)*	REDUCED IRON LOAD FROM TREATMENT (AVG.) *(lbs/day)*	POST TREATMENT AVG. IRON LOAD *(lbs/day)*	POST TREATMENT PERCENT REDUCTION (REDUCED AVG. IRON LOAD ÷ AVG. IRON LOAD)
SEATON CREEK	306.8	22.44	284.36	7.31 %
MURRIN RUN	55.7	9.40	46.30	16.88 %
SLIPPERY ROCK CREEK	259.9	137.86	122.04	53.04 %
TOTAL WATERSHED:	**622.4**	**169.70**	**452.70**	**27.27 %**

TABLE 8: POST TREATMENT ALUMINUM LOAD REDUCTIONS IN SUBWATERSHED

SUBWATERSHED	AVERAGE ALUMINUM LOAD *(lbs/day)*	REDUCED ALUMINUM LOAD FROM TREATMENT (AVG.) *(lbs/day)*	POST TREATMENT AVG. ALUMINUM LOAD *(lbs/day)*	POST TREATMENT PERCENT REDUCTION (REDUCED AVG. ALUM. LOAD ÷ AVG. ALUM. LOAD)
SEATON CREEK	40.8	16.3	24.5	39.95 %
MURRIN RUN	86.9	9.4	77.5	10.82 %
SLIPPERY ROCK CREEK	21.8	15.9	5.9	72.94 %
TOTAL WATERSHED:	**149.5**	**41.6**	**107.9**	**27.83 %**

SLIPPERY ROCK CREEK WATERSHED

AMD LOADING REDUCTION
SLIPPERY ROCK CREEK

TABLE 9: **TOTAL AVERAGE LOADING: ACID=2841.4 lbs/day; Fe=622.4 lbs/day; Al =149.5 lbs/day**

DISCHARGE	ACID			Fe			Al			PROJECT SITE
	ACID LOAD (lbs/day)	POST TREAT-MENT ACID LOAD lbs/day (% EFF.)	% REDUCTION ACID LOAD	Fe LOAD (lbs/day)	POST TREAT-MENT Fe LOAD lbs/day (% EFF.)	% REDUCTION Fe LOAD	Al LOAD (lbs/day)	POST TREAT-MENT Al LOAD (lbs/day) (% EFF.)	% REDUCTION Al LOAD	
SR 114B	15.4	0.0 (100%)	0.54	18.0	3.80 (78.9%)	2.28	0.4	0.0 (100%)	0.27	ARGENTINE (ALD/W)
SR 114D	12.0	0.0 (100%)	0.42	53.6	21.20 (60.5%)	5.21	0.7	0.0 (100%)	0.47	ARGENTINE (ALD/W)
SR 115	0.0	0.0 (NA)	0.00	55.0	23.16 (57.9%)	5.12	0.5	0.0 (100%)	0.33	ARGENTINE (POND)
SR 84	2.0	0.0 (100%)	0.07	0.1	0.00 (100%)	0.02	0.1	0.0 (100%)	0.07	FERRIS (W)
SR 85	17.0	0.0 (100%)	0.60	1.0	0.00 (100%)	0.16	1.4	0.0 (100%)	0.94	FERRIS (VFP/W)
SR 86	115.0	0.0 (100%)	4.05	5.0	0.00 (100%)	0.80	6.1	0.0 (100%)	4.08	FERRIS (VFP/W)
SR 87	10.0	0.0 (100%)	0.35	0.2	0.00 (100%)	0.03	0.6	0.0 (100%)	0.40	FERRIS (VFP/W)
SR 88	15.0	0.0 (100%)	0.53	0.4	0.00 (100%)	0.06	1.1	0.0 (100%)	0.74	FERRIS (VFP/W)
SR 109	3.0	0.0 (100%)	0.11	0.3	0.00 (100%)	0.05	0.1	0.0 (100%)	0.07	ARGENTINE (VFP/W)
SR 101A	37.0	0.0 (100%)	1.30	21.1	3.98 (81.1%)	2.75	0.1	0.0 (100%)	0.07	HIGGINS COR. (ALD/W)
27 F	152.0	0.0 (100%)	5.35	11.6	0.00 (100%)	1.86	5.7	0.0 (100%)	3.80	DESALE - PH. I (VFP/W)
23 F	134.0	0.0 (100%)	4.72	14.0	3.16 (77.4%)	1.74	10.6	0.0 (100%)	7.09	DESALE - PH. II (VFP/W)
ST 38♦	39.0	0.0 (100%)	1.37	3.4	0.00 (100%)	0.55	2.8	0.0 (100%)	1.87	GOFF STATION (VFP/W)
ST 39♦	115.0	0.0 (100%)	4.05	2.8	0.00 (100%)	0.45	5.1	0.0 (100%)	3.41	GOFF STATION (VFP/W)
ST 40♦	17.0	0.0 (100%)	0.60	0.7	0.00 (100%)	0.11	0.5	0.0 (100%)	0.33	GOFF STATION (VFP/W)
ST 41♦	21.0	0.0 (100%)	0.74	1.8	0.00 (100%)	0.29	1.0	0.0 (100%)	0.67	GOFF STATION (VFP/W)
ST 42♦	8.0	0.0 (100%)	0.28	0.7	0.00 (100%)	0.11	0.0	0.0 (100%)	0.00	GOFF STATION (VFP/W)
SR 89♦	136.0	0.0 (100%)	4.79	32.4	0.00 (100%)	5.21	4.6	0.0 (100%)	3.08	HILLIARDS (VFP/W)
SR 81♦	6.0	0.0 (100%)	0.21	0.8	0.00 (100%)	0.13	0.1	0.0 (100%)	0.07	FERRIS (ALD/W)
SR 96♦	8.0	0.0 (100%)	0.28	2.1	0.00 (100%)	0.34	0.1	0.0 (100%)	0.07	HILLIARDS (ALD/W)
TOTALS	**862.4**		**30.36 %**	**♠169.7**		**27.27 %**	**41.6**		**27.83 %**	

♦ Systems under construction/proposed, assumed: 100 % efficiency
♠ Total Fe Load – Post Treatment Fe Load

(W) ----------- Wetland
(ALD/W) --- Anoxic Limestone Drain/Wetland
(VFP/W) --- Vertical Flow Pond/Wetland

HYDROLOGIC ASSESSMENT

General Discussion

In order to evaluate the water quality in the Slippery Rock Creek, a water-monitoring program has been going on since October 1994. Once a year, or as new construction projects come online the program has been reviewed and revised. Currently the water monitoring program consists of 21 discharge and treatment system sample points and 15 stream sample points. Sample locations were selected at strategic points to classify the receiving streams and compare the current water quality with the water quality used to create the stream quality map from the CMRS report. The stream classifications have been color coded on the maps as follows, consistent with the CMRS report.

Blue: Non-Polluted Alkaline, Good Water Quality; Alkalinity > Acidity; pH>6.0; Iron < 1.0 mg/l

Green: Marginal, Acid Sensitive; pH 5.0 – 6.0; Sulfates < 50 mg/l

Yellow: Marginal, Acid Mine Drainage Impacted; pH 5.0 – 6.0; Sulfates > 50 mg/l

Red: Polluted; Acidity > Alkalinity; pH < 5.0; Iron > 1.5 mg/l; Sulfates > 50 mg/l

Major Findings

The major findings of the water-monitoring program for the watershed can be summarized as follows: *(See Stream Quality Map on page 9 for sample point locations)*

1. The Seaton Creek subwatershed, heavily impacted from abandoned deep mines on the Brookville coal seam and surface mines on the Middle Kittanning coal seam, has significantly improved water quality summarized in the following Table 10:

Table 10: Water Quality Improvement at Select Sample Points

SAMPLE PT.		ALK	ACID	Iron	Mn	Al	Sulfate
23		mg/l	Mg/l	mg/l	mg/l	mg/l	mg/l
avg	before 9/00	0	187	9.5	38.9	7.5	877
avg	after 9/00	64	1	2.2	20.9	1.1	818
	% improvement			**77%**	**46%**	**86%**	
25							
avg	before 6/00	0	224	11.8	38.1	14.4	877
avg	after 6/00	18	51	5.3	26.4	4.0	891
	% improvement			**55%**	**31%**	**72%**	
30							
avg	before 1/98	7	46	0.8	14.8	1.4	269
avg	after 1/98	13	1	ND	2.5	ND	109
	% improvement			**~63%**	**83%**	**~65%**	
48							
avg	before 6/00	10	57	1.0	15.7	4.4	445
Avg	after 6/00	20	0	ND	6.3	ND	267
	% improvement			**~70%**	**60%**	**~89%**	

ND – below detection limits of 0.3 mg/l for iron and 0.5 mg/l for aluminum

2. The main branch of Slippery Rock Creek at sample point 64 is impacted by acid mine drainage from abandoned deep mines on the Brookville coal seam. Overall, water quality has improved due to construction of seven passive treatment systems in the watershed. There remains a base flow component to the stream which tends to depress pH and increase acidity and metals concentrations. However, comparing the data set before and after October 1997, pH has been more neutral and average alkalinity exceeds acidity, average metals concentrations have met the instream criteria of 1.5 mg/l for iron, 1.0 and 0.75 mg/l for aluminum.

TABLE 11: Range in pH at Sample Point 64

64	PH
before 10/1/97	3.5 - 6.1
after 10/1/97	4.0 - 6.5

TABLE 12: Average Water Quality Comparison at Sample Point 64

		ALK	ACID	Iron	Mn	Al	Sulfate
64		mg/l	Mg/l	mg/l	mg/l	mg/l	mg/l
avg	before 10/1/97	8	17	1.1	1.0	ND	127
avg	after 10/1/97	12	5	1.2	0.9	ND	136

3. The water quality at sample point 76 shows significant improvement as a result of the construction of two passive treatment systems at Ferris. The following table shows the improvement:

TABLE 13: Water Quality Improvement at Sample Point 76

		ALK	ACID	Iron	Mn	Al	Sulfate
76		mg/l	Mg/l	mg/l	mg/l	mg/l	mg/l
Avg	before 8/97	0	81	4.9	1.7	4.0	266
Avg	after 8/97	49	1	1.3	1.5	ND	298
	% improvement			**73%**	**10%**	**~88%**	

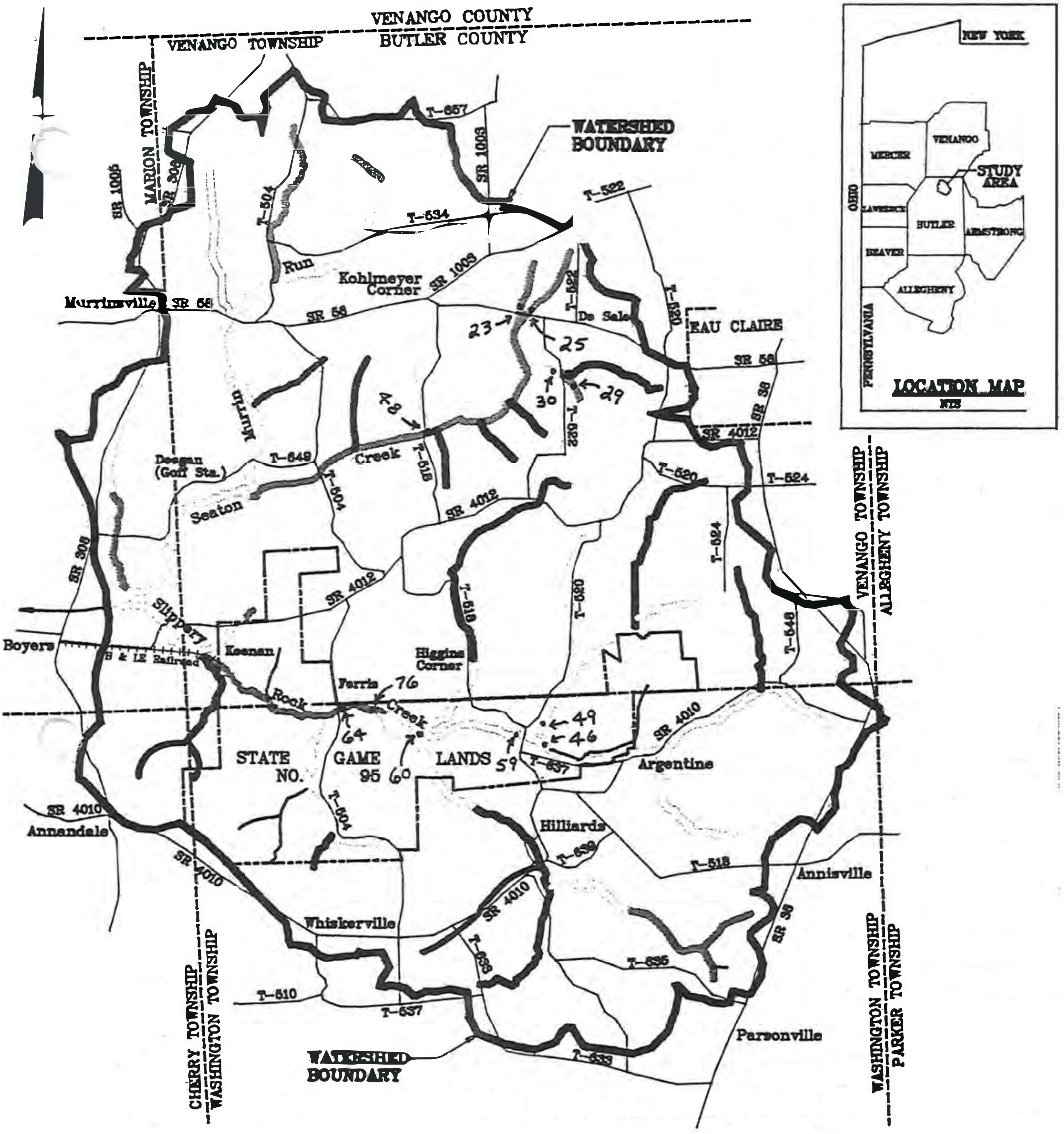
4. Reclamation at the Abel/Dreshman site, using coal ash from the Scrubgrass power plant resulted in a significant improvement in the water quality at sample point 29 and the downstream sample point 30, discussed above. Joe Tarantino and Joe Schueck have written a paper for submission to the 2001 International Ash Utilization Symposium. The paper is attached to this report as Appendix A. The following table, borrowed from the report, summarizes the water quality:

TABLE 14: Water Quality Associated with Coal Ash Reclamation – Sample Point 29

MP-29	Before	During	after	% improvement
# of samples (n)	9	9	11	
Median pH	3.6	3.8	4.8	
Average Net Alkalinity	-117.8	-104.3	-2.8	
Average Iron (total)	1.5	6.4	0.2	87%
Average Manganese (total)	43.3	38.3	9.5	78%
Average Aluminum (total)	2.9	2.7	0.9	69%
Average Sulfates (total)	634.7	624.8	295.6	

5. Water quality at sample points 46, 49, 59 and 60 is typically alkaline with fluctuating metals concentrations. There are no clear trends associated with the passive treatment systems near Argentine. However, removal of metals and the net alkaline nature of discharges once acidic has had a positive influence on the aquatic life in those sections.

6. Headwater streams on Murrin Run, near Murrinsville, on an unnamed tributary to Seaton Creek near Boyers and on an unnamed tributary to Slippery Rock Creek near Parsonville are still polluted by acid mine drainage. These three areas have not been fully considered for reclamation projects for reasons such as landowner issues or severity of the acid mine drainage.



Key to Stream Quality Designations

━ GOOD (pH > 6, acidity < alkalinity, iron < 1.0mg/l)
━ MARGINAL/acid sensitive (pH 5 to 6, sulfates < 50mg/l)
┈ MARGINAL/acid drainage impacted (pH 5 to 6, sulfates > 50mg/l)
━ POLLUTED (pH < 5, acidity > alkalinity, iron > 1.5mg/l)
— UNDESIGNATED

0 .5 1 2

GRAPHIC SCALE
(miles)

STREAM QUALITY MAP

portion of
Slippery Rock Creek Watershed
(27 square miles)
Butler County, Pennsylvania
Scale: 1" = 1 mile Date: 12/94

SAMPLE POINT LOCATIONS: •← ※

UPDATE: AMD INVENTORY

The mining related problems that pollute the headwaters of Slippery Rock Creek are a result of point source discharges from the abandoned surface and deep mine activities. The abandoned deep and surface mining operations account for 50 % each of the total acid load on the watershed. In addition, non-point source discharges occur when rain falls on the unreclaimed surface mines and refuse piles in the study area and flows as surface runoff to the watershed streams.
The Scarlift report estimated 981 acres *(397.30 hectares)* of unreclaimed strip mines and 115,000 yd^3 of abandoned refuse piles where this problem has the potential to occur. The reconnaissance effort that began in October of 1994 by the Knox DMO resulted in identifying 74 discharges on the watershed of point and non-point source origin. After three years of sampling and flow measurements, the loading analysis revealed that the acid mine drainage polluting the headwaters was caused by 59 of the discharges. Table 15 shows the average daily loading analysis in decreasing order from the acid pollution of the 59 discharges.

TABLE 15: AMD DISCHARGE INVENTORY ON HEADWATERS OF SLIPPERY ROCK CREEK WATERSHED PROJECT - PA CMRS

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
▶ST 63E	SEATON CREEK	215	5.7	118.6	54.8	0.5	385	146.1	1.0
7.2	THOMAS TRIBUTARY	15	3.4	1820.9	181.9	176.9	311	30.5	29.5
▶ST 63C	SEATON CREEK	62.8	6.0	103.6	84.8	0.5	143	63.0	0.4
* SR 89	HILLIARDS BR.: SRC	47	3.1	256.6	58.6	8.5	136	32.4	4.6
ST 48	THOMAS TRIBUTARY	27	3.5	439.1	2.7	35.0	125	0.9	9.7
◆ ST 39	MURRIN RUN	203	3.6	57.8	2.7	2.9	115	2.8	5.1
◆ SR 86	MAIN BR.: SRC	98.9	3.3	94.0	4.1	5.0	115	5.0	6.1
◆ 23	SEATON CREEK	134	3.5	178.5	8.7	6.6	111	14.0	10.6
25	SEATON CREEK	69	3.4	220.9	7.5	14.4	106	6.2	11.9
11	MURRIN RUN	152	4.9	54.8	0.6	6.3	100	1.0	11.5
▶ST 63B	SEATON CREEK	40	5.9	193.0	63.5	0.5	93	30.5	0.2
40	LUCAS TRIBUTARY	81.9	4.4	117.7	0.3	8.9	65	0.3	6.9
F116	THOMAS TRIBUTARY	24	4.1	213.0	0.3	30.6	63	0.1	9.1
12.1	ACT 43 TRIBUTARY	10	3.1	515.6	56.3	3.0	57	6.3	0.2
29	ABEL/DRESH TRIBUTARY	59	3.6	127.5	1.6	3.1	52	1.3	1.6
ST 321	THOMAS TRIBUTARY	18	3.4	253.8	5.4	16.9	51	0.8	3.6
SR 102A	MAIN BR.: SRC	21.4	4.8	197.7	86.5	2.5	51	21.1	0.6
▶ST 63A	SEATON CREEK	15	5.9	125.1	85.8	0.5	49	16.7	0.1
◆SR 94 (BERTHA)	MAIN BR.: SRC	13.8	5.8	288.0	157.2	0.5	44	25.0	0.1
SR 91	MAIN BR.: SRC	20.9	5.5	174.0	67.6	0.5	44	17.0	0.1
ST 53	MURRIN RUN	87	6.2	32.6	0.3	3.8	41	0.3	4.4
◆ST 38	MURRIN RUN	35	3.4	106.0	9.3	7.2	39	3.4	2.8
◆SR 101A	MAIN BR.: SRC	22.7	4.9	135.2	78.5	0.5	37	21.1	0.1

(cont.)

		(gpm)		------------- mg/l -------------			----------- lbs/day -----------		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
ST 64	SEATON CREEK	58	5.1	34.4	13.6	0.6	31	7.8	0.4
ST 34	SEATON CREEK	10	3.9	288.0	54.6	4.8	30	1.8	1.0
SR 125B/D	HILLIARDS BR.: SRC	119.8	4.5	20.1	0.3	1.8	29	0.4	2.6
7.4	THOMAS TRIBUTARY	9	3.6	296.3	0.4	39.1	28	0.0	3.4
ST 33	SEATON CREEK	7	3.3	334.3	12.1	18.2	27	1.0	1.5
ST 31	SEATON CREEK	10	3.6	199.8	31.5	4.2	27	3.5	0.5
12.2	ACT 43 TRIBUTARY	13	3.5	159.4	12.0	4.0	24	2.3	0.6
SR 100	HIGGIN CR. TRIBUTARY	15.5	3.0	125.0	5.4	6.1	23	1.0	1.1
◆ 27	SEATON CREEK	6	3.0	421.5	32.3	15.7	23	2.3	1.1
✚10A/10B	SEATON CREEK	6	3.6	558.0	252.0	25.0	23	8.5	0.8
ST 54	MURRIN RUN	76	5.1	12.6	0.6	2.3	23	0.5	2.1
◆ST 41	MURRIN RUN	72	4.2	27.2	1.3	1.3	21	1.8	1.0
ST 59	ABEL/DRESH TRIBUTARY	69	5.0	22.9	0.3	2.3	19	0.2	1.9
◆ SR 85	MAIN BR.: SRC	6.8	3.0	209.8	12.6	15.0	17	1.0	1.4
◆ ST 40	MURRIN RUN	38	3.7	39.3	1.8	1.5	17	0.7	0.5
◆ SR 114B	MAIN BR.: SRC	70.8	5.8	39.3	55.5	0.5	15.4	18.0	0.4
◆ SR 88	MAIN BR.: SRC	12.8	3.4	109.4	4.5	8.0	15	0.4	1.1
SR 98	HIGGINS CR. TRIBUTARY	123.3	4.5	10.1	1.0	0.8	15	1.5	1.1
◆ SR 114D	MAIN BR.: SRC	113.3	6.1	8.7	55.1	0.5	12	53.6	0.7
F95-96	THOMAS TRIBUTARY	2	3.6	622.0	3.2	100.5	11	0.1	2.4
◆ SR 87	MAIN BR.: SRC	12.4	3.4	83.1	2.5	5.2	10	0.2	0.6
7.1	THOMAS TRIBUTARY	11	4.1	63.5	0.3	7.6	9	0.0	0.9
◆ ST 42	MURRIN RUN	37	5.1	5.4	1.7	< 0.5	8	0.7	0.0
* SR 96	HILLIARDS BR.: SRC	18	4.5	36.1	11.8	0.5	8	2.1	0.1
* SR 81	MAIN BR.: SRC	13.3	3.9	35.5	5.2	0.6	6	0.8	0.1
4.1	BALESTRIERI TRIBUTARY	16	5.8	14.9	9.3	0.5	6	1.6	0.1
▶ST 63D	SEATON CREEK	11	5.0	23.7	6.5	0.5	6	1.8	0.1
ST 32	SEATON CREEK	4	6.1	-14.0	38.2	< 0.5	5	1.8	0.8
SR 116A	MAIN BR.: SRC	17.1	5.6	22.4	14.1	0.5	5	2.6	0.1
9B	ACT 43 TRIBUTARY	2.4	5.5	128.0	65.0	0.7	4	1.9	0.0
◆SR 109	PISOR ROAD TRIBUTARY	13.9	4.6	14.8	2.1	0.5	3	0.3	0.1
SR 110	PISOR ROAD TRIBUTARY	26	4.9	10.0	9.9	0.6	3	0.6	0.1
◆SR 84	MAIN BR.: SRC	18.4	4.8	7.0	0.6	0.4	2	0.1	0.1
7.3	THOMAS TRIBUTARY	9	4.7	13.3	0.3	1.4	2	0.0	0.0
SR 116	MAIN BR.: SRC	19.2	5.6	3.5	2.9	0.5	1	0.7	0.1
◆SR 115	MAIN BR.: SRC	278.3	6.1	-18.9	16.1	0.5	0	55.0	0.5
TOTAL:		**2817.7**					**2841.4**	**622.4**	**149.5**

◆ Completed Projects * Proposed Projects ▶ Recently approved GGG3 funding

-Discharge locations can be found on the Reclamation/ Remediation Plan Map - Map 4.

AVAILABLE REMEDIATION PROJECTS

Of the 59 discharges shown in Table 10 that pollute the headwaters of Slippery Rock Creek: **1.** 18 have been addressed with completed remediation projects. **2.** 3 will be addressed by approved Growing Greener Grants, EPA 319 funding, and surface mine permitting off-site stream mitigation. Another 6 discharges from the AMD Inventory are currently being considered from Growing Greener Grant Round 3 funding. Table 16 shows 33 available discharges remaining that need remediation projects prioritized in decreasing acid load order.

TABLE 16: AVAILABLE DISCHARGES IN NEED OF REMEDIATION PROJECTS

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
7.2	THOMAS TRIBUTARY	15	3.4	1820.9	181.9	176.9	311	30.5	29.5
ST 48	THOMAS TRIBUTARY	27	3.5	439.1	2.7	35.0	125	0.9	9.7
♠ SR 86	MAIN BR.: SRC	98.9	3.3	94.0	4.1	5.0	115	5.0	6.1
25	SEATON CREEK	69	3.4	220.9	7.5	14.4	106	6.2	11.9
40	LUCAS TRIBUTARY	81.9	4.4	117.7	0.3	8.9	65	0.3	6.9
F116	THOMAS TRIBUTARY	24	4.1	213.0	0.3	30.6	63	0.1	9.1
♣12.1	ACT 43 TRIBUTARY	10	3.1	515.6	56.3	3.0	57	6.3	0.2
ST 321	THOMAS TRIBUTARY	18	3.4	253.8	5.4	16.9	51	0.8	3.6
SR 102A	MAIN BR.: SRC	21.4	4.8	197.7	86.5	2.5	51	21.1	0.6
SR 91	MAIN BR.: SRC	20.9	5.5	174.0	67.6	0.5	44	17.0	0.1
ST 53	MURRIN RUN	87	6.2	32.6	0.3	3.8	41	0.3	4.4
ST 64	SEATON CREEK	58	5.1	34.4	13.6	0.6	31	7.8	0.4
ST 34	SEATON CREEK	10	3.9	288.0	54.6	4.8	30	1.8	1.0
SR 125B/D	HILLIARDS BR.: SRC	119.8	4.5	20.1	0.3	1.8	29	0.4	2.6
7.4	THOMAS TRIBUTARY	9	3.6	296.3	0.4	39.1	28	0.0	3.4
ST 33	SEATON CREEK	7	3.3	334.3	12.1	18.2	27	1.0	1.5
ST 31	SEATON CREEK	10	3.6	199.8	31.5	4.2	27	3.5	0.5
♣12.2	ACT 43 TRIBUTARY	13	3.5	159.4	12.0	4.0	24	2.3	0.6
SR 100	HIGGIN CR. TRIBUTARY	15.5	3.0	125.0	5.4	6.1	23	1.0	1.1
ST 54	MURRIN RUN	76	5.1	12.6	0.6	2.3	23	0.5	2.1
ST 59	ABEL/DRESH TRIBUTARY	69	5.0	22.9	0.3	2.3	19	0.2	1.9
SR 98	HIGGINS CR. TRIBUTARY	123.3	4.5	10.1	1.0	0.8	15	1.5	1.1
♠SR 114D	MAIN BR.: SRC	113.3	6.1	8.7	55.1	0.5	12	53.6	0.7
F95-96	THOMAS TRIBUTARY	2	3.6	622.0	3.2	100.5	11	0.1	2.4
7.1	THOMAS TRIBUTARY	11	4.1	63.5	0.3	7.6	9	0.0	0.9
4.1	BALESTRIERI TRIBUTARY	16	5.8	14.9	9.3	0.5	6	1.6	0.1
ST 32	SEATON CREEK	4	6.1	-14.0	38.2	< 0.5	5	1.8	0.8
SR 116A	MAIN BR.: SRC	17.1	5.6	22.4	14.1	0.5	5	2.6	0.1
♣ 9B	ACT 43 TRIBUTARY	2.4	5.5	128.0	65.0	0.7	4	1.9	0.0
SR 110	PISOR ROAD TRIBUTARY	26	4.9	10.0	9.9	0.6	3	0.6	0.1
7.3	THOMAS TRIBUTARY	9	4.7	13.3	0.3	1.4	2	0.0	0.0
SR 116	MAIN BR.: SRC	19.2	5.6	3.5	2.9	0.5	1	0.7	0.1
♠SR 115	MAIN BR.: SRC	278.3	6.1	-18.9	16.1	0.5	0	55.0	0.5
TOTAL:	**(34)**	**1488.0**					**1386.0**	**234.9**	**104.8**

♠ NEEDS UPGRADED ♣ BAMR SITE IN PROJECT DEVELOPMENT STAGE

SHORT TERM AMD "HIT LIST"

The most logical approach to addressing the remaining available remediation projects would be from most to least severe in acid loading as shown in Table 16 or to focus on the discharges and abandoned mine land problems of **Priority Area 8 – Thomas** and **Priority Area 5 – DeSale** upstream of the Phase I reclamation completed under WRPA Grant WR10. The largest benefit to the watershed from remediation work would occur in Priority Area 8 - Thomas. It is the next heavy acid and aluminum load hitter in the watershed that has not had any remediation work. However, due to unforeseen circumstances such as landowner cooperation, this approach may not always be feasible in proposing and completing a project. This may be the case in the Thomas, Higgins Corner and upper section of DeSale priority areas. A short term AMD "hit list" of nine available discharges has been developed by the Knox DMO to assist interested agencies and the public into areas of the watershed where upgrades to existing systems are needed to continue treatment and the potential for completing projects are favorable. *(See Table 17)* On seven of the nine available projects in the short term "hit list", there has been conceptual/specific design plans developed and numerous field meetings between BAMR, Knox DMO, PA Game Commission, landowners, and the Slippery Rock Watershed Coalition at the sites. Also included is a table of available gob/refuse pile reclamation projects. *(See Table 18)*

TABLE 17: SHORT TERM AMD "HIT LIST"

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
♠SR 115	MAIN BR.: SRC	278.3	6.1	-18.9	16.1	0.5	0	55.0	0.5
♠SR 114D	MAIN BR.: SRC	113.3	6.1	8.7	55.1	0.5	12	53.6	0.7
♠ SR 86	MAIN BR.: SRC	98.9	3.3	94.0	4.1	5.0	115	5.0	6.1
SR 102A	MAIN BR.: SRC	21.4	4.8	197.7	86.5	2.5	51	21.1	0.6
♣12.1	ACT 43 TRIBUTARY	10	3.1	515.6	56.3	3.0	57	6.3	0.2
♣12.2	ACT 43 TRIBUTARY	13	3.5	159.4	12.0	4.0	24	2.3	0.6
♣ 9B	ACT 43 TRIBUTARY	2.4	5.5	128.0	65.0	0.7	4	1.9	0.0
ST 64	SEATON CREEK	58	5.1	34.4	13.6	0.6	31	7.8	0.4
SR 110	PISOR ROAD TRIBUTARY	26	4.9	10.0	9.9	0.6	3	0.6	0.1
TOTAL:	**(10)**	**627.3**					**320.0**	**162.1**	**10.0**

♠ NEEDS UPGRADED ♣ BAMR SITE IN PROJECT DEVELOPMENT STAGE

TABLE 18: GOB/REFUSE PILE SITE LOCATIONS

SITE LOCATION	**LANDOWNER**	**ESTIMATED VOLUME** *(yd ^{3})*
Argentine Piles	Cook & Mathias	200,000
* Erico Piles	Bessemer & Lake Erie Railroad, Ed Flick	18,000
Tyree Piles	Walter McGarvey	30,000
TOTAL:		**248,000**

* Currently Proposed Growing Greener Round 3 Grant

UPDATE: REMEDIATION PLAN

The **Reclamation/Remediation Plan** was broken down into ten priority areas that would require alkaline addition, passive treatment, and/or discharge abatement This priority order was developed to build on the restoration activities that have been ongoing since 1994. The severity of the loading concentrations from iron and aluminum revealed that passive treatment alone may not always be an option for long term performance efficiency. Although not a detailed engineering proposal, consideration should also be given to implement the conceptual ideas developed in the watershed remediation plan

TABLE 19: SLIPPERY ROCK CREEK WATERSHED REMEDIATION PLAN PRIORITY ORDER/STREAM IMPROVEMENT LENGTHS

PRIORITY AREA	SITE DESIGNATION	TRIBUTARIES	EST. IMPROVE- MENT LENGTH
1	Argentine *Slippery Rock Cr Subw*	Main Br. – Slippery Rock Cr. + Pisor Road Trib.	6.4 mi. *(10.3 km)*
2	Higgins Corner *Slippery Rock Cr Subw*	Main Br. – Slippery Rock Cr. + Higgins Corner Trib.	1.8 mi. *(2.9 km)*
3	Ferris *Slippery Rock Cr Subw*	Main Br. – Slippery Rock Cr. + Whiskerville Trib.	4.9 mi. *(7.90 km)*
4	Hilliards *Slippery Rock Cr Subw*	Hilliards Br. – Slippery Rock Cr.	3.2 mi. *(5.15 km)*
5	De Sale *Seaton Creek Subw*	Seaton Creek + Abel/Dreshman Trib.	4.0 mi. *(6.44 km)*
6	Erico Bridge *Seaton Creek Subw*	Seaton Creek	1.0 mi. *(1.61 km)*
7	Act 43 *Murrin Run Subw*	Murrin Run + Act 43 Trib	2.6 mi. *(4.18 km)*
8	Thomas *Murrin Run Subw*	Thomas Trib. + Balestrieni Trib.	2.7 mi. *(4.35 km)*
9	Goff Station *Murrin Run Subw*	Murrin Run + Seaton Creek	3.2 mi. *(5.15 km)*
10	Lucas *Seaton Creek Subw*	Lucas Trib.	1.6 mi. *(2.57 km)*
TOTAL:			**31.4 mi. *(50.55 km)***

PARTICIPANTS

The progress in the headwaters of Slippery Rock Creek has been accomplished by a team effort that consists of industry, government, landowners, and academic institutions. *(See Table 20)* Although not a dues paying organization, the Slippery Rock Watershed Coalition "spear-heads" the lines of communication between all interested parties. Due to the magnitude of the acid mine drainage problems in the watershed, any and all interested parties are welcome to help the cause.

TABLE 20: SLIPPERY ROCK WATERSHED PARTICIPANTS *(As of 7/01/2001)*

INDUSTRY	ACADEMIC INSTITUTIONS	LANDOWNERS	GOVERNMENT
Amerikohl Mining Inc. Kerry Coal Company Allegheny Minerals Quality Aggregates, Milestone Crushed, Inc. Rosebud Mining Company Ben- Hal Mining Company REC-MIX Chester Engineers Scrubgrass Power Plant Stream Restoration, Inc. BioMost, Inc. CDS Associates Hedin Environmental Fike Associates, Inc. AquaScape Puryear Excavating & Trucking Jesteadt Excavating H.R. Stewart, Jr. Excavating Youchak & Youchak	"The Slippery Rock Watershed Coalition" Slippery Rock University Grove City College Allegheny College Butler County Comm. College The University of Pittsburgh Moniteau School District	- APPROXIMATELY 500 -	PA DEP: DMO, BMR, BAMR, Northwest Regional Office PA Game Commission Penn's Corner Charitable Trust Butler County Cons. District Natural Resources Cons. Service W.P.C.A.M.R. PA DCNR EPA Washington, Venango, Marion & Cherry Townships PA Fish & Boat Commission

UPDATE - PRIORITY AREA 1: ARGENTINE

Seven discharges with an average combined flow of 538.6 gpm contribute a pollutional load to this priority area of: 39.4 lbs/day of acid; 130.8 lbs/day of iron; and 2.0 lbs/day of aluminum to the main branch of Slippery Rock Creek and to a lesser extent the Pisor Road Tributary. *(See Table 21)* These discharges are a result of one of the largest deep mine complexes in the watershed on the Brookville coal seam. It is estimated that the Keystone and Lake Trade deep mine operations produced approximately 4 million tons of coal in this area. Of the seven discharges contributing pollution in this priority area, three have been addressed by passive treatment technology and another is proposed under an EPA 104(b)(3) grant. The water quality of all the discharges in this priority area is amenable to passive treatment. *(See Table 22)*

TABLE 21: PRIORITY AREA 1 - AMD DISCHARGE WATER QUALITY

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
◆SR 114B	MAIN BR.: SRC	70.8	5.8	39.3	55.5	0.5	15.4	18.0	0.4
➡SR 114D	MAIN BR.: SRC	113.3	6.1	8.7	55.1	0.5	12	53.6	0.7
SR 116A	MAIN BR.: SRC	17.1	5.6	22.4	14.1	0.5	5	2.6	0.1
◆SR 109	PISOR ROAD TRIBUTARY	13.9	4.6	14.8	2.1	0.5	3	0.3	0.1
SR 110	PISOR ROAD TRIBUTARY	26	4.9	10.0	9.9	0.6	3	0.6	0.1
SR 116	MAIN BR.: SRC	19.2	5.6	3.5	2.9	0.5	1	0.7	0.1
➡SR 115	MAIN BR.: SRC	278.3	6.1	-18.9	16.1	0.5	0	55.0	0.5
TOTAL:		**538.6**					**39.4**	**130.8**	**2.0**

◆ Completed Projects ➡ Completed in need of Upgrade

TABLE 22: PRIORITY AREA 1 - CONCEPTUAL PASSIVE TREATMENT OPTIONS

PROJECT SITE	TYPE OF PROJECT	PROJECT BUILDERS	FUNDING SOURCE	COST ESTIMATES
◆ SR 114B	ALD/Wetlands + Additional Wetland	Hedin Environmental, CDS Associates, Jesteadt Excavating	Bond Forfeitures *(Black Fox Mining)*	$ 30,000.00
➡ SR 114D	ALD/Wetlands ➡ + Additional Wetland	Hedin Environmental, CDS Associates, Jesteadt Excavating	Bond Forfeitures *(Black Fox Mining)*	$ 30,000.00
SR 116A	ALD/Wetlands	**OPEN**	**OPEN**	$ **OPEN**
◆ SR 109	Vert. Flow System/Retention Pond/Compost Wetland	Knox DMO,BMR, Penn's Corner, Pending Contractor	EPA 104(b)(3) Grant	$ 55,000.00
SR 110	Vert. Flow System/Retention Pond/Compost Wetland	**OPEN**	**OPEN**	**OPEN**
SR 116	ALD/Wetlands	**OPEN**	**OPEN**	**OPEN**
➡ SR 115	Retention Pond/Wetland ➡+ Identical System	NRCS, Butler County Cons. District, H.R. Stewart, Jr.	Conoco Fines	$ 50,000.00
TOTAL:				**•$ 165,000.00**

◆ Completed Projects

➡ Completed Projects in need of upgrade • Remediation cost to date

(cont.)

UPDATE - PRIORITY AREA 1: ARGENTINE *(cont.)*

Approximately 20 acres *(8.10 hectares)* of unreclaimed surface mines were documented to exist within Project Area 22 of the Operation Scarlift Report which will be included in Priority Area 1 - Argentine

As a result of the reconnaissance effort performed by the Knox DMO inspection staff, an estimated 264,000 yd^3 of abandoned gob/refuse piles exist in proximity to Priority Area 1. *(See Table 23)*

TABLE 23: PRIORITY AREA 1 - GOB/REFUSE PILES

SITE LOCATION	LANDOWNER	ESTIMATED VOLUME *(yd^3)*
◆ SR 114 Piles	PA Game Commission	2,000
Argentine Piles	Cook & Mathias	200,000
◆ T-637 Piles	PA Game Commission	18,000
◆ Higgins Piles	PA Game Commission	12,000
Leonard Road Piles (south)	PA Game Commission	2,000
Tyree Piles	Walter McGarvey	30,000
TOTAL:		**264,000**

◆ *Completed gob/refuse pile reclamation projects by Butler County Conservation District on PA State Game Lands No. 95 with the addition of REC-LIME by REC-MIX*

- It should be noted that abatement measures were attempted in this priority area under Operation Scarlift "Quick Start" Project SL-110-1BD. Several feet of grout curtain and deep mine seals were installed. However, the deep mine pool found alternative paths to discharge as acid mine drainage to the receiving streams.

UPDATE - PRIORITY AREA 2: HIGGINS CORNER

Five discharges with an average combined flow of 196.7 gpm contribute a pollutional load to this priority area of: 170 lbs/day of acid; 69.7 lbs/day of iron; and 3.0 lbs/day of aluminum to the main branch of Slippery Rock Creek and to a lesser extent the Higgins Corner Tributary. *(See Table 24)* The discharges are a result of several medium sized deep mines in the watershed on the Brookville coal seam. The Lake Erie #1 and #2 deep mine operations were the largest in this area. Of the five discharges contributing pollution in this priority area, one has been addressed by passive treatment technology and another under an EPA 319 grant. *(See Table 25)*

TABLE 24: PRIORITY AREA 2 - AMD DISCHARGE WATER QUALITY

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
SR 102A	MAIN BR.: SRC	21.4	4.8	197.7	86.5	2.5	51	21.1	0.6
➡SR 94 (BERTHA)	MAIN BR.: SRC	13.8	5.8	288.0	157.2	0.5	44	25.0	0.1
♦SR 101A	MAIN BR.: SRC	22.7	4.9	135.2	78.5	0.5	37	21.1	0.1
SR 100	HIGGIN CR. TRIBUTARY	15.5	3.0	125.0	5.4	6.1	23	1.0	1.1
SR 98	HIGGINS CR. TRIBUTARY	123.3	4.5	10.1	1.0	0.8	15	1.5	1.1
TOTAL:		**196.7**					**170**	**69.7**	**3.0**

♦ Completed Projects ➡ Completed in need of Upgrade

TABLE 25: PRIORITY AREA 2 - CONCEPTUAL PASSIVE TREATMENT OPTIONS

PROJECT SITE	**TYPE OF PROJECT**	**PROJECT BUILDERS**	**FUNDING SOURCE**	**COST ESTIMATES**
SR 102A	Comb. Vert. Flow System/ Compost Wetland/ Retention Pond	**OPEN**	**OPEN**	**OPEN**
➡ SR 94 *(BERTHA)*	ALD/ ➡ + Additional Compost Wetland/ Drop Pond/Vert. Flow Sys.	Butler County Conservation District & PA Game Commission	CONOCO Fines	$ 30,000.00
♦ SR 101A	ALD/Wetlands	Hedin /CDS/BAMR	EPA 319 grant	$ 51,500.00
SR 100	Vert. Flow System/Retention Pond/Compost Wetland	**OPEN**	**OPEN**	**OPEN**
SR 98	Vert. Flow System/Retention Pond/Compost Wetland	**OPEN**	**OPEN**	**OPEN**
TOTAL:				**•$ 81,500.00**

♦ Completed Projects

➡ Completed Projects in need of upgrade • Remediation cost to date

(cont.)

Approximately 12,000 yd^3 of abandoned gob/refuse piles were identified by the Knox DMO inspection staff in proximity to Priority Area 2 - Higgins Corner. *(See Table 26)* Operation Scarlift did not identify any areas of abandoned mine lands in the proximity of Priority Area 2.

TABLE 26: PRIORITY AREA 2 - GOB/REFUSE PILES

SITE LOCATION	LANDOWNER	ESTIMATED VOLUME *(yd^3)*
♦ SR 101/SR 102 Piles	PA Game Commission	10,000
Big Bertha Piles	PA Game Commission	2,000
TOTAL:		**12,000**

♦ *Completed gob/refuse pile reclamation projects by Butler County Conservation District on PA State Game Lands No. 95 with the addition of REC-LIME by REC-MIX.*

- It should be noted that abatement measures were attempted in this priority area under Operation Scarlift Project Area 20. Several feet of grout curtain and deep mine seals were installed that has reduced flows from the mine pool. However, the deep mine pool found alternative paths to discharge as acid mine drainage to the receiving streams.

UPDATE - PRIORITY AREA 3: FERRIS

Seven discharges with an average combined flow of 183.5 gpm contribute a pollutional load to this priority area of: 209 lbs/day of acid; 24.5 lbs/day of iron; and 9.5 lbs/day of aluminum to the main branch of Slippery Rock Creek. *(See Table 27)* The discharges are a result of several medium sized deep mines on the Brookville coal seam. The Keystone #1 and #2 deep mines were the largest in this area. The crop of the Brookville coal has also been extensively surface mined. Of the seven discharges contributing pollution in this priority area, five have been addressed since the **Ferris Treatment Complex** went on-line in August 1997. The water quality of all the discharges in this priority area is amenable to passive treatment. *(See Table 28)*
The Whiskerville tributary is being included in this priority area. A chemical system is currently functioning to treat discharges from the Ponsi Operation *(SMP #10813005)* which was mined by the Lucas Coal Company that flow to this stream. At this time, passive treatment options are not being considered for those discharges.

TABLE 27: PRIORITY AREA 3 - AMD DISCHARGE WATER QUALITY

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
➡SR 86	MAIN BR.: SRC	98.9	3.3	94.0	4.1	5.0	115	5.0	6.1
SR 91	MAIN BR.: SRC	20.9	5.5	174.0	67.6	0.5	44	17.0	0.1
➡SR 85	MAIN BR.: SRC	6.8	3.0	209.8	12.6	15.0	17	1.0	1.4
◆SR 88	MAIN BR.: SRC	12.8	3.4	109.4	4.5	8.0	15	0.4	1.1
◆SR 87	MAIN BR.: SRC	12.4	3.4	83.1	2.5	5.2	10	0.2	0.6
* SR 81	MAIN BR.: SRC	13.3	3.9	35.5	5.2	0.6	6	0.8	0.1
◆SR 84	MAIN BR.: SRC	18.4	4.8	7.0	0.6	0.4	2	0.1	0.1
TOTAL:		**183.5**					**209**	**24.5**	**9.5**

◆ Completed Projects ➡ Completed in need of Upgrade * Proposed

TABLE 28: PRIORITY AREA 3 - CONCEPTUAL PASSIVE TREATMENT OPTIONS

PROJECT SITE	**TYPE OF PROJECT**	**PROJECT BUILDERS**	**FUNDING SOURCE**	**COST ESTIMATES**
➡ SR 86	Comb Vert. Flow System/ Retention Pond	Kerry Coal Company, Knox DMO	Reclamation Agreement	$ 25,000.00
SR 91	ALD or Vert. Flow System/Retention Pond/ Compost Wetland	**OPEN**	**OPEN**	**OPEN**
➡ SR 85	Comb Vert. Flow System/ Retention Pond	Kerry Coal Company, Knox DMO	Reclamation Agreement	$ 25,000.00
◆ SR 88	Comb Vert. Flow System/ Retention Pond	Puryear-Excavation, Knox DMO, Butler County Cons. Dist., Penn's Corner	EPA 104(b)(3) grant	$ 33,000.00
◆ SR 87	Comb Vert. Flow System/ Retention Pond	Puryear Excavation, Knox DMO, Butler County Cons. Dist., Penn's Corner	EPA 104(b)(3) grant	$ 33,000.00
* SR 81	Comb Vert. Flow System/ Retention Pond/Compost Wetland	Amrikohl/SRI/Knox DMO/PGC	Growing Greener Grant #NW90647, ME#359746	$120,000.00
◆ SR 84	Retention Pond	Kerry Coal Company, Knox DMO	Reclamation Agreement	$ 35,000.00
TOTAL:				**•$271,000.00**

◆ Completed Projects ➡ Completed projects in need of upgrade * Proposed
• Remediation cost to date

(cont.)

UPDATE - PRIORITY AREA 3: FERRIS *(cont.)*

Approximately 240 acres *(97.20 hectares)* of unreclaimed surface mines were documented to exist within Project Areas 18, 19, and 28 of the Operation Scarlift Report which will be included in Priority Area 3 – Ferris. As a result of the reconnaissance effort performed by the Knox DMO inspection staff, an estimated 4,000 yd^3 of abandoned gob/refuse piles exist in proximity to Priority Area 3. *(See Table 29)*

TABLE 29: PRIORITY AREA 3 - GOB/REFUSE PILES

SITE LOCATION	LANDOWNER	ESTIMATED VOLUME *(yd^3)*
♦ Ferris Piles (2)	PA Game Commission	4,000
TOTAL:		**4,000**

♦ *Completed gob/refuse pile reclamation projects by Butler County Conservation District on PA State Game Lands No. 95 with the addition of REC-LIME by REC-MIX.*

Also included within Priority Area 3 is the Sunbeam Tipple Reclamation Project located near Boyers that was completed in the fall of 1996. Reclamation of this site was completed by Kerry Coal Company by blending 175,000 tons of alkaline coal ash to 100,000 tons of coal refuse. Total reclamation of the site was estimated at 21.2 acres *(8.59 hectares)*. A reclamation agreement was reached between Sunbeam Coal Company, Kerry Coal Company, Rockwood Casualty Insurance, and the Knox DMO to complete this project. A portion of the agreement included construction of two phases of the Ferris Treatment Complex by Kerry Coal Company.

- It should be noted that eight deep mine seals were installed in this priority area under Operation Scarlift Project Area 18. Further use of deep mine seals or grout curtains are not needed for this priority area.

UPDATE - PRIORITY AREA 4: HILLIARDS

Three discharges with an average combined flow of 184.8 gpm contribute a pollutional load to this priority area of: 173 lbs/day of acid; 34.9 lbs/day of iron; and 7.3 lbs/day of aluminum to the Hilliards Branch of Slippery Rock Creek. *(See Table 30)* Discharge SR 96 is the result of a large deep mine operation and surface mining of the crop coal on the Brookville seam. Surface mining operations on the Upper Freeport coal seam can be attributed to discharge SR 125B/D. The water quality of discharges SR 96 and SR 125B/D is amenable to passive treatment.

Discharge SR 89 *(Magnum discharge)* is linked to coal refuse from the Amos tipple that was backfilled into an abandoned open cut on the Brookville coal seam under SMP #10820201. An **alkaline addition project** is recommended for discharge SR 89 prior to implementation of passive treatment technology based on the severity of the water quality. Although the refuse is buried under rather steep terrain, there is an estimated 50,000 tons of useable waste coal according to the ACV Power Report for PA State Game Lands No. 95 that was prepared in October of 1995. Mixing of approximately 35,000 tons of coal ash was also included with the proposal. Unfortunately, ACV Power withdrew the proposal for the refuse piles on the Game Lands which included this site. A project of this caliber is recommended to abate or neutralize the Magnum discharge to a quality more amenable to passive treatment. Funding has been received for the SR 89 passive treatment system which is currently in the conceptual stage of design under an EPA 319 grant.

TABLE 30: PRIORITY AREA 4 - AMD DISCHARGE WATER QUALITY

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
* SR 89	HILLIARDS BR.: SRC	47	3.1	256.6	58.6	8.5	136	32.4	4.6
SR 125B/D	HILLIARDS BR.: SRC	119.8	4.5	20.1	0.3	1.8	29	0.4	2.6
*SR 96	HILLIARDS BR.: SRC	18	4.5	36.1	11.8	0.5	8	2.1	0.1
TOTAL:		**184.8**					**173**	**34.9**	**7.3**

* Proposed Projects

TABLE 31: PRIORITY AREA 4 - CONCEPTUAL PASSIVE TREATMENT OPTIONS

PROJECT SITE	**TYPE OF PROJECT**	**PROJECT BUILDERS**	**FUNDING SOURCE**	**COST ESTIMATES**
* SR 89	Alkaline Addition + Comb. Compost Wetlands/Retention Pond/ALD or Vert. Flow Sys.	Seneca Landfill, Inc./Youchak, BioMost, Knox DMO, PF&BC, PGC	SMP Off-Site Mitigation Project SMP 1000103 + EPA 319 Grnat	•$688,529.00
SR 125B/D	Vertical Flow System	**OPEN**	**OPEN**	**OPEN**
* SR 96	ALD + Wetlands	SRI/Jesteadt/PGC/Knox DMO	GG Grant #NW90647 + EPA 319	•$ 55,000.00
TOTAL:				**•$743,529.00**

* Proposed Projects • Remediation cost to date

(cont.)

UPDATE - PRIORITY AREA 4: HILLIARDS *(cont.)*

Approximately 60 acres *(24.30 hectares)* of unreclaimed surface mines were documented to exist within Project Area 24 of the Operation Scarlift Report which will be included in Priority Area 4 - Hilliards. Scarlift also recommended lime injection to neutralize the spoil as part of the reclamation. Blending and mixing alkaline material such as coal ash or Rec-Lime could be considered as an alternative for lime injection

- Deep mine seals or grout curtains are not needed for this priority area.

UPDATE - PRIORITY AREA 5: DE SALE

Six discharges with an average combined flow of 343 gpm contribute a pollutional load to this priority area of: 334 lbs/day of acid; 32.5 lbs/day of iron; and 27.9 lbs/day of aluminum to Seaton Creek and the Abel/Dreshman tributary. *(See Table 32)* The discharges are a result of surface mining activity on the Middle Kittanning coal seam. Stream monitoring points 23 and 25 were included in the discharge water quality since further investigation of the pollutional point sources are needed in this section of the priority area. Based on the severity of the water quality in the headwaters of Seaton Creek, **alkaline addition** is recommended prior to the implementation of passive treatment. Stream monitoring point 29 was also included in the discharge water quality for the Landowner Reclamation Project on the Abel/Dreshman property that was completed by Amerikohl Mining Incorporated. Alkaline coal ash from Scrubgrass Power Plant was blended and mixed to the spoil material and backfilled into the abandoned pits.
The total reclamation of the site was estimated to be 56 acres. *(22.68 hectares)*

Of the six discharges contributing pollution in this priority area, two passive treatment projects have been completed under Growing Greener Grant funding that eliminate AMD loading at stream stations 23, 25 and discharge 27 by Amerikohl Mining Incorporated. Discharge 27 also included an alkaline coal ash reclamation project in conjunction with the passive treatment system. The water quality of all the discharges in this priority area should be amenable to passive treatment technology after up-front alkaline addition is implemented to the discharge areas liberating severe acid mine drainage. *(See Table 33)*

TABLE 32: PRIORITY AREA 5 - AMD DISCHARGE WATER QUALITY

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
◆ 23	SEATON CREEK	134	3.5	178.5	8.7	6.6	111	14.0	10.6
➡25	SEATON CREEK	69	3.4	220.9	7.5	14.4	106	6.2	11.9
◆ 29	ABEL/DRESH TRIBUTARY	59	3.6	127.5	1.6	3.1	52	1.3	1.6
◆ 27	SEATON CREEK	6	3.0	421.5	32.3	15.7	23	2.3	1.1
✚10A/10B	SEATON CREEK	6	3.6	558.0	252.0	25.0	23	8.5	0.8
ST 59	ABEL/DRESH TRIBUTARY	69	5.0	22.9	0.3	2.3	19	0.2	1.9
TOTAL:		**343**					**334**	**32.5**	**27.9**

(cont.)

◆ Completed Projects ➡ Completed Project with additional work needed upstream of stream station 25

✚ Recently approved Growing Greener Round 3 partial funding

UPDATE - PRIORITY AREA 5: DE SALE *(cont.)*

TABLE 33: PRIORITY AREA 5 - CONCEPTUAL PASSIVE TREATMENT OPTIONS

PROJECT SITE	TYPE OF PROJECT	PROJECT BUILDERS	FUNDING SOURCE	COST ESTIMATES
◆ 23	Vert. Flow System/ Retention Pond/Wetland	Amerikohl/SRI/Knox DMO	Growing Greener Grant #NW90624	$ 449,342.00
➡ 25	Alkaline Addition + Comb Vert. Flow System/ Retention Pond/Wetland	**OPEN**	**OPEN**	**OPEN**
29	Alkaline Addition + Comb. Vert. Flow System or Oversized ALD/ Retention Pond/Wetland	**OPEN**	**OPEN**	**OPEN**
◆ 27	Alkaline Addition + Comb Vert. Flow System/ Retention Pond/Wetland	Amerikohl/SRI/Knox DMO	WRPA WR-10 grant + Reclamation Agreement	$ 391,707.00
✚ 10A/10B	Vert. Flow System/ Wetlands	**OPEN**	**OPEN**	$ 166,000.00
ST 59	Comb Vert. Flow System or Oversized ALD/ Retention Pond/Wetland	**OPEN**	**OPEN**	**OPEN**
TOTAL:				**•$1,007,049.00**

◆ Completed Projects

➡ Completed Project with additional work needed upstream of stream station 25

✚ Recently approved Growing Greener Round 3 partial funding

- Remediation cost to date

Approximately 100 acres *(40.50 hectares)* of unreclaimed surface mines were documented to exist within Project Area 14 of the Operation Scarlift Report which will be included in Priority Area 5 - De Sale. Scarlift also recommended lime injection to neutralize the spoil as part of the reclamation. Blending and mixing alkaline material such as coal ash or Rec-Lime could be considered as an alternative for lime injection.

- Deep mine seals or grout curtains are not needed for this priority area.

UPDATE - PRIORITY AREA 6: ERICO BRIDGE

Six discharges with an average combined flow of 401.8 gpm contribute a pollutional load to this priority area of: 707 lbs/day of acid; 265.9 lbs/day of iron; and 2.2 lbs/day of aluminum to Seaton Creek. *(See Table 34)* The acid and iron loading from the discharges in this priority area are the main contributors of pollution to Seaton Creek. Extensive amounts of iron deposition can be seen along the flood plain of Seaton Creek in proximity to the discharges. The discharges are a result of deep mining activity from the Keystone #3 and #4 operations on the Brookville coal seam.

The water quality of all the discharges in this priority area is amenable to passive treatment techniques except for ST 63E and ST 63C. It is highly unlikely that enough space exists to construct adequate-sized wetlands to contain the pollution from ST 63E and ST 63C in proximity to Seaton Creek. A field survey of the available construction area would be needed to verify implementation of such a project. Based on the severity of their iron loading, it appears that at least 10 acres *(4.05 hectares)* of compost wetlands plus additional retention ponds and anoxic limestone drains would be needed to drop the iron and raise the pH above 6.0. *Recently, the PA DEP has approved a Round 3 Growing Greener Grant to Stream Restoration Inc. for $898,679 to construct a passive treatment system to remediate Seaton Creek discharges ST 63A through ST 63E in this priority area. (See Table 35)*

TABLE 34: PRIORITY AREA 6 - AMD DISCHARGE WATER QUALITY

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
▶ST 63E	SEATON CREEK	215	5.7	118.6	54.8	0.5	385	146.1	1.0
▶ST 63C	SEATON CREEK	62.8	6.0	103.6	84.8	0.5	143	63.0	0.4
▶ST 63B	SEATON CREEK	40	5.9	193.0	63.5	0.5	93	30.5	0.2
▶ST 63A	SEATON CREEK	15	5.9	125.1	85.8	0.5	49	16.7	0.1
ST 64	SEATON CREEK	58	5.1	34.4	13.6	0.6	31	7.8	0.4
▶ST 63D	SEATON CREEK	11	5.0	23.7	6.5	0.5	6	1.8	0.1
TOTAL:		**401.8**					**707**	**265.9**	**2.2**

▶ Recently approved Growing Greener Grant Round 3 funding

(cont.)

UPDATE - PRIORITY AREA 6: <u>ERICO BRIDGE</u> *(cont.)*

TABLE 35: PRIORITY AREA 6 - CONCEPTUAL PASSIVE TREATMENT OPTIONS

PROJECT SITE	TYPE OF PROJECT	PROJECT BUILDERS	FUNDING SOURCE	COST ESTIMATES
▶ST 63E	Comb. Compost Wetlands/ Retention Ponds/ALD	SRI/Quality Aggregates/Knox DMO	Growing Greener Round 3 Grant	$ 561,674.37
▶ST 63C	Comb. Compost Wetlands/ Retention Ponds/ALD	SRI/Quality Aggregates/Knox DMO	Growing Greener Round 3 Grant	$ 161,481.38
▶ ST 63B	Comb. Compost Wetlands/ Retention Ponds/ALD	SRI/Quality Aggregates/Knox DMO	Growing Greener Round 3 Grant	$ 105,313.95
▶ST 63A	Comb. Compost Wetlands/ Retention Ponds/ALD	SRI/Quality Aggregates/Knox DMO	Growing Greener Round 3 Grant	$ 42,125.58
ST 64	Comb. Compost Wetlands/ Retention Ponds/ALD	**OPEN**	**OPEN**	**OPEN**
▶ST 63D	Comb. Compost Wetlands/ Retention Ponds/ALD	SRI/Quality Aggregates/Knox DMO	Growing Greener Round 3 Grant	$ 28,083.72
TOTAL:				**• $ 898,679.00**

▶ Recently approved Growing Greener Round 3 funding

- Remediation cost to date

As a result of the reconnaissance effort performed by the Knox DMO inspection staff, an estimated 18,000 yd^3 of abandoned gob/refuse piles exist in proximity to Priority Area 6. *(See Table 36)*

TABLE 36: PRIORITY AREA 6 - GOB/REFUSE PILES

SITE LOCATION	LANDOWNER	ESTIMATED VOLUME *(yd^3)*
▶ Erico Piles	Bessemer & Lake Erie Railroad, Ed Flick	18,000
TOTAL:		**18,000**

▶ Recently approved Growing Greener Round 3 funding

- It should be noted that five deep mine seals and grout curtain were installed in this priority area under Operation Scarlift Project Area 13. However, problems developed as the deep mine pool re-established behind the abatement measures. The deep mine pool found alternative paths around the abatement measures to discharge as acid mine drainage to Seaton Creek. Based on this information, additional attempts to implement deep mine seals and grout curtains are <u>not</u> recommended for this priority area.

UPDATE - PRIORITY AREA 7: ACT 43

Six discharges with an average combined flow of 340.4 gpm contribute a pollutional load to this priority area of: 249 lbs/day of acid; 12.3 lbs/day of iron; and 18.8 lbs/day of aluminum to Murrin Run and the Act 43 tributary. *(See Table 37)* The discharges are a result of surface and deep mining activity on the Middle Kittanning coal seam. Stream monitoring point 11 was included in the discharge water quality since further investigation of the pollutional point sources are needed in this section of the priority area. The water quality of all the discharges in this priority area is amenable to passive treatment.

Of the six discharges contributing pollution in this priority area, three passive treatment projects had been proposed under Act 43 for the 12.2 and 9B discharges on the Ruth Site, SMP #10820121; and the 12.1 discharge on the B&D Site, SMP #10810101 by Amerikohl Mining Incorporated. However, an agreement could not be reached between the PA DEP and Amerikohl Mining Incorporated for the remediation plan. The Bureau of Abandoned Mine Reclamation has made pre-liminary investigations and conceptual design plans for the Ruth and B&D sites. *(See Table 38)*

TABLE 37: PRIORITY AREA 7 - AMD DISCHARGE WATER QUALITY

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
11	MURRIN RUN	152	4.9	54.8	0.6	6.3	100	1.0	11.5
♣12.1	ACT 43 TRIBUTARY	10	3.1	515.6	56.3	3.0	57	6.3	0.2
ST 53	MURRIN RUN	87	6.2	32.6	0.3	3.8	41	0.3	4.4
♣12.2	ACT 43 TRIBUTARY	13	3.5	159.4	12.0	4.0	24	2.3	0.6
ST 54	MURRIN RUN	76	5.1	12.6	0.6	2.3	23	0.5	2.1
♣ 9B	ACT 43 TRIBUTARY	2.4	5.5	128.0	65.0	0.7	4	1.9	0.0
TOTAL:		**340.4**					**249**	**12.3**	**18.8**

♣ BAMR Sites in Project Development Stage

TABLE 38: PRIORITY AREA 7 - CONCEPTUAL PASSIVE TREATMENT OPTIONS

PROJECT SITE	**TYPE OF PROJECT**	**PROJECT BUILDERS**	**FUNDING SOURCE**	**COST ESTIMATES**
11	Comb Vert. Flow System/ Retention Pond/Wetland	**OPEN**	**OPEN**	**OPEN**
♣ 12.1	ALD/Pond/Wetland	BAMR	BAMR	$ 80,000.00
ST 53	Comb. Vert. Flow System/ Retention Pond/Wetland	**OPEN**	**OPEN**	**OPEN**
♣ 12.2	ALD/Pond/Wetland	BAMR	BAMR	$ 125,000.00
ST 54	Comb. Vert. Flow System/ Retention Pond/Wetland	**OPEN**	**OPEN**	**OPEN**
♣ 9B	ALD/Wetlands	Amerikohl Mining/Hedin/CDS	ACT 43	$ 50,000.00
TOTAL:				**$ 255,000.00**

♣ BAMR Site in Project Development Stage w/bond forfeiture cost left on site

UPDATE - PRIORITY AREA 7: ACT 43 *(cont.)*

Approximately 260 acres *(105.30 hectares)* of unreclaimed surface mines were documented to exist within Project Area 8 of the Operation Scarlift Report which will be included in Priority Area 7 - Act 43.

- Deep mine seals or grout curtains are not needed for this priority area.

PRIORITY AREA 8: THOMAS

Nine discharges with an average combined flow of 131 gpm contribute a pollutional load to this priority area of: 606 lbs/day of acid; 34 lbs/day of iron; and 58.7 lbs/day of aluminum to the Thomas tributary and to a lesser extent the Balestrieri tributary. *(See Table 29)* The discharges are a result of surface mining activity on the Middle Kittanning coal seam. Approximately 39.3 % of the total aluminum load for the watershed originates in this priority area.

Based on the severity of the water quality in the headwaters of the Thomas tributary, **alkaline addition** is recommended prior to the implementation of passive treatment. It should be mentioned that the Vanport limestone blended with the spoil material on SMP #10860119 by Sunbeam Coal Company improved the water quality in the Balestrieri tributary since the Scarlift Report for the Slippery Rock watershed was submitted. Blending alkaline medias such as coal ash or rec-lime to the mine spoils, along with capping the affected area, creates the potential to eliminate or perhaps significantly reduce the acid mine drainage to a point where a passive treatment system can be constructed with a greater confidence level for long term efficiency. The water quality of six of the nine discharges in this priority area should be amenable to passive treatment technology after up-front alkaline addition is implemented to the discharge areas liberating severe acid mine drainage. *(See Table 30)* All projects are "open" for takers in this priority area.

TABLE 29: PRIORITY AREA 8 - AMD DISCHARGE WATER QUALITY

		(gpm)		*mg/l*			*lbs/day*		
DISCHARGE	**TRIBUTARY**	**AVG. FLOW**	**PH**	**NET ACIDITY**	**IRON**	**ALUMINUM**	**ACID LOAD**	**IRON LOAD**	**ALUMINUM LOAD**
7.2	THOMAS TRIBUTARY	15	3.4	1820.9	181.9	176.9	311	30.5	29.5
ST 48	THOMAS TRIBUTARY	27	3.5	439.1	2.7	35.0	125	0.9	9.7
F116	THOMAS TRIBUTARY	24	4.1	213.0	0.3	30.6	63	0.1	9.1
ST 321	THOMAS TRIBUTARY	18	3.4	253.8	5.4	16.9	51	0.8	3.6
7.4	THOMAS TRIBUTARY	9	3.6	296.3	0.4	39.1	28	0.0	3.4
F95-96	THOMAS TRIBUTARY	2	3.6	622.0	3.2	100.5	11	0.1	2.4
7.1	THOMAS TRIBUTARY	11	4.1	63.5	0.3	7.6	9	0.0	0.9
4.1	BALESTRIERI TRIBUTARY	16	5.8	14.9	9.3	0.5	6	1.6	0.1
7.3	THOMAS TRIBUTARY	9	4.7	13.3	0.3	1.4	2	0.0	0.0
TOTAL:		**131**					**606**	**34**	**58.7**

(cont.)

PRIORITY AREA 8: THOMAS *(cont.)*

TABLE 30: PRIORITY AREA 8 - CONCEPTUAL PASSIVE TREATMENT OPTIONS

PROJECT SITE	TYPE OF PROJECT	PROJECT BUILDERS	FUNDING SOURCE	COST ESTIMATES
7.2	Alkaline Addition + Comb Vert. Flow System/ Retention Ponds/Wetlands	OPEN	OPEN	OPEN
ST 48	Alkaline Addition + Comb. Vert. Flow System/ Retention Pond/Wetland	OPEN	OPEN	OPEN
F116	Alkaline Addition + Comb. Vert. Flow System/ Retention Pond/Wetland	OPEN	OPEN	OPEN
ST 321	Alkaline Addition + Comb. Vert. Flow System/ Retention Pond/Wetland	OPEN	OPEN	OPEN
7.4	Alkaline Addition + Comb Vert. Flow System/ Retention Ponds/Wetlands	OPEN	OPEN	OPEN
F95-96	Alkaline Addition + Comb. Vert. Flow System/ Retention Pond/Wetland	OPEN	OPEN	OPEN
7.1	Comb Vert. Flow System/ Retention Pond/Wetland	OPEN	OPEN	OPEN
4.1	Vert. Flow System or ALD /Retention Pond/ Wetland	OPEN	OPEN	OPEN
7.3	Comb Vert. Flow System/ Retention Pond/Wetland	OPEN	OPEN	OPEN
TOTAL:				

Approximately 85 acres *(34.43 hectares)* of unreclaimed surface mines were documented to exist within Project Area 7 of the Operation Scarlift Report which will be included in Priority Area 8 - Thomas

- Deep mine seals or grout curtains are not needed for this priority area.

The Use of FBC Ash for Alkaline Addition at Surface Coal Mines

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KEYWORDS: fluidized bed combustor (FBC) ash, alkaline addition, acid mine drainage, baghouse lime

ABSTRACT

Surface coal mines with an abundance of naturally-occurring carbonate-bearing (alkaline) strata typically produce alkaline water. Sites that contain little or no alkaline strata tend to produce acidic drainage. One approach used in Pennsylvania on some alkaline-deficient sites is to import alkaline material and amend the spoil in order to obtain alkaline drainage. The amount of alkaline material needed is determined by an overburden analysis. Highly alkaline fluidized bed combustor (FBC) coal ash was used to amend the spoils at two surface coal mine sites during mining and reclamation activities. At the first site, which was a reclamation effort, addition of the FBC ash was sufficient to convert acidic groundwater discharges to alkaline discharges. At the second site, a remining operation, groundwater in monitoring wells went from neutral to acidic, despite the addition of the alkaline ash. This paper examines the similarities and differences between the two sites and compares them to an alkaline addition site where baghouse lime was used in an effort to suggest reasons why one site was a success and the other a failure.

INTRODUCTION

Acid mine drainage (AMD) results from the interaction of certain sulfide minerals with oxygen, water, and bacteria. The iron disulfide minerals, pyrite (FeS2), and less commonly marcasite (FeS2), are the principal sulfur bearing minerals in bituminous coal (Davis, 1981; Hawkins, 1984). The following reactions characterize various stages in the complete AMD reaction (Stumm and Morgan, 1981, pp. 470):

$FeS_2 + 3.5\ O_2 + H_20 = Fe^{2+} + 2\ S0_4^{2-} + 2\ H^+$ (Equation 1)
$Fe^{2+} + 0.25\ 0_2 + H^+ = Fe^{3+} + 0.5\ H_20$ (Equation 2)
$FeS_2 + 14\ Fe^{3+} + 8\ H_20 = 15\ Fe^{2+} + 2\ SO_4^{2-} + 16\ H^+$ (Equation 3)

Equation 1 represents the oxidation of the disulfide minerals by oxygen and water. Iron-oxidizing bacteria, notably those of the genus *Thiobacillus*, oxidize Fe^{2+} to Fe^{3+} as described in Equation 2 and become increasingly active as pH is depressed (Kleinmann et al., 1981; Nordstrom, 1982). In Equation 3, dissolved ferric iron (Fe^{3+}) then becomes the oxidizing agent for pyrite, thus increasing AMD production.

It is common to see elevated concentrations of metals, such as manganese and aluminum, associated with AMD. This is not a direct result of pyrite oxidation, but is caused by AMD leaching these cations from other minerals within the spoil, such as clays and siderite, as a secondary reaction.

Surface coal mines with an abundance of naturally-occurring carbonate-bearing (alkaline) strata typically produce alkaline drainage. The carbonate minerals calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) are the main minerals providing alkalinity (Rose and Cravotta, 1998). The carbonate minerals may occur as layers of limestone or dolostone in the overburden above the coal, as cement in sandstone or shale, or as veins cutting the rock. Minerals that produce alkalinity can affect the generation of AMD in two ways. First, if alkaline conditions can be maintained in the pyritic material, the AMD-generating reactions may by inhibited. This is because the bacterial oxidation of Fe^{2+} is minimal in an alkaline environment. Second, once AMD has formed, its interaction with alkaline materials will result in neutralization of the acidity. Using calcite as an example, the initial reaction with an acid solution is:

$CaCO_3 + H^+ = Ca^{2+} + HO_3^-(aq)$ (Equation 4)

Third, Fe^{3+} is not soluble under alkaline conditions, thus the reactions in Equation 3 will not occur, rather, $Fe(OH)_3$ will form.

The overburden analysis (OBA) for proposed surface coal mining operations is an important management tool in Pennsylvania. The strata to be removed during the mining operation are characterized as to thickness, distribution, and acid- or alkalinity-generating capabilities. Acid-base accounting is the most common OBA method, whereby total percent sulfur and neutralization potential (ppt $CaCO_3$) are determined (Perry, 1998). In some cases, where the OBA shows a deficiency of native alkaline material in the overburden, alkaline materials may be brought to the site and incorporated into the backfill in a manner to ensure that final discharges from the site will be net alkaline (Smith and Brady, 1998).

The OBA also provides a mechanism for determining the amount of alkaline material necessary to be incorporated in order to render the site net alkaline. This determination is in the form of *tons of $CaCO_3$ equivalent per 1000 tons of material* to be mined. Various risk factors regarding the site and its setting are evaluated to determine the needed alkaline addition rate, which typically is at least one ton of $CaCO_3$ equivalent per one ton of maximum potential acidity. If material proposed for alkaline addition exhibits less than 100% $CaCO_3$ equivalency, application rates are adjusted to represent 100% $CaCO_3$ (Smith and Brady, 1998).

In order to make an operation economical, it is to the operator's advantage to use low cost (or no cost) alkaline industrial byproducts. For instance, hydrated lime (135% $CaCO_3$ equivalency) is significantly more expensive than its associated byproduct baghouse lime (85% $CaCO_3$ equivalency). Although more baghouse lime would be required than hydrated lime, the difference in cost of the materials makes it advantageous for the operator to import the baghouse lime. In addition to the economic advantages, the re-use of waste alkaline materials that qualify for beneficial use has the added advantage of removing them from the waste stream.

The effects of alkaline addition can be manifested as AMD suppression or AMD neutralization and is dependent upon the placement of the alkaline material in relationship to the acid forming material and the groundwater regime.

Since alkaline addition does not inhibit the transport of water and oxygen into the spoil, oxidation of pyrite will likely occur. On sites where the recharge contacts the alkaline material first, i.e., the water reacts with the alkaline-producing material placed near the surface, the alkaline recharge could then neutralize any AMD as soon as it is formed and/or inhibit or suppress the production of AMD. A slight increase in the concentrations of the sulfates and iron is likely to occur. Secondary leaching of metals such as manganese and aluminum should be minimal simply because there would no longer be AMD available to leach.

Where the recharge first reacts with acid-forming material, sulfate and iron concentrations may increase over time because reactions in equations 2 and 3 can proceed before neutralization occurs. In this case, increases in metals, such as manganese and aluminum, may also occur.

Ideally, the alkaline material would be applied to the site in a manner that alkalinity would be generated at only a slightly greater rate than acidity over a very long period of time following reclamation. This would result in any acidity being neutralized and a net alkaline discharge. If the rate of alkalinity generation is significantly greater than the rate of acid production, then there is a risk that the alkaline material will be depleted long before the acid production has ceased and the discharges would eventually become acid. The rate of alkalinity generation is dependent upon many factors, including the nature of the alkaline material, surface area available for reaction (particle size), placement within the backfill, carbon dioxide (CO_2) concentration, permeability and porosity of the backfill, water table location and fluctuation range, preferred ndwater flow paths, and distribution of the pyritic materials. Presently, the consideration of a material's rate of depletion o solubility is not a factor in determining application rates.

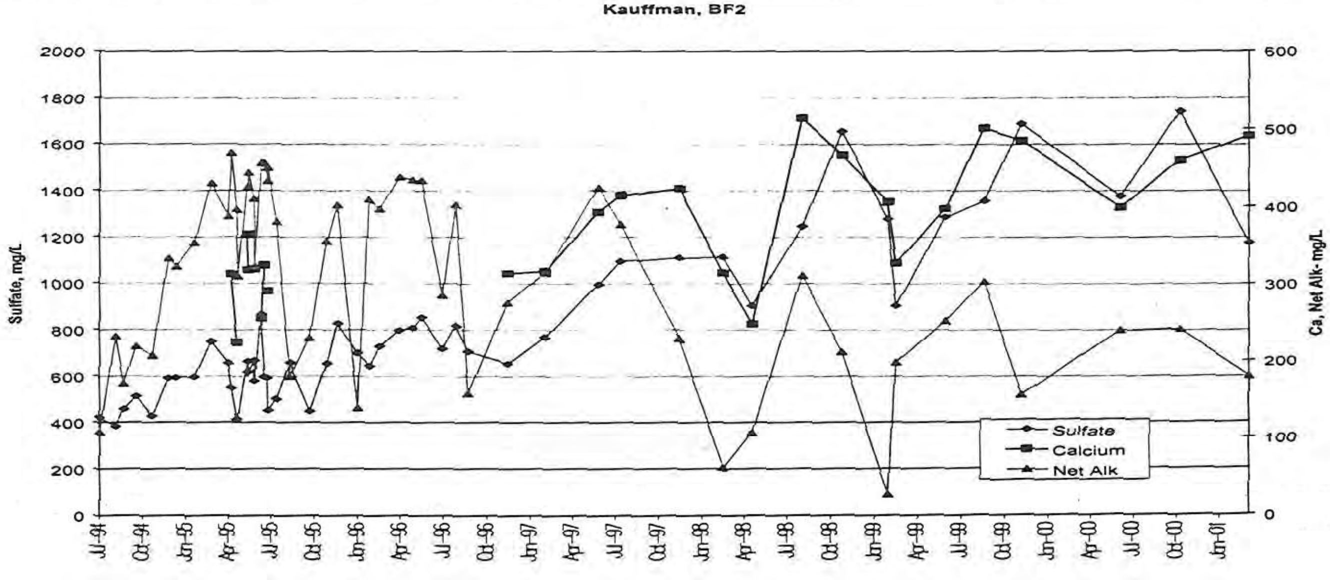
The theory of alkaline addition also assumes that all of the alkaline material, present or added, will eventually dissolve and generate alkalinity. This is a fair assumption because alkaline addition does not necessarily prevent the water within the backfill from contacting the alkaline material. There is also the basic assumption that the neutralization potential will be the same when it is applied in the field as it was when tested in the laboratory. However, these two assumptions may not be valid when considering the use of FBC ash for alkaline addition. Unlike limestone screenings or baghouse lime, when water contacts FBC ash it becomes self-cementing, or pozzolanic. Usually water is added to the ash for conditioning and dust control at the generating station. As discussed in a later section, the result is a reduction in the effective neutralization potential (NP) of the ash as well as a decrease in the availability of the material for dissolution. In fact, the data suggest that the FBC ash may not have the ability to prevent AMD to the degree suggested by its neutralization potential. However, the pozzolanic nature of the ash can benefit the site by restricting groundwater movement through and perhaps isolating the acid forming materials from water and oxygen.

Field Experience

Alkaline Addition Using Baghouse Lime, the Kauffman Site

Baghouse lime, a lime manufacturing byproduct, has been used on several surface coal mine sites for alkaline addition where there is a deficiency of naturally occurring carbonate minerals. The following example illustrates the geochemical responses that may occur at a typical alkaline addition site. At the Kauffman site in Clearfield County baghouse lime was imported as an alkaline material. On one portion of the site, it was applied at a rate of 1212 tons per acre. The rates were set to achieve a net NP of zero, or a one to one ratio of tons of $CaCO_3$ to tons deficiency.

Several wells were installed within the backfill to monitor the effect the alkaline addition was having on the groundwater. The data from monitoring well BF2 is used in this example. (Different application rates were used on various mining phases with a variety of results. Changes observed in BF2 were not uniform across the site.) Mining up gradient of this well began in 1993 before its installation and initial sampling. The up gradient mining apparently influenced the water quality in this area before sampling as evidenced by the initial SO_4 level of 422 mg/L. Figure 1 is a graph from BF2 and includes the concentrations for sulfate, net alkalinity, and calcium. Sulfate is included in the graph as a conservative



ure 1. Response of a monitoring well to the use of baghouse lime for alkaline addition.

indicator of AMD formation. The increases in Ca concentrations provide an indication of the neutralization of the AMD by the baghouse lime. Note that, although on different scales, the changes in concentration of Ca mirror those of SO_4 after October 1996

indicating that sufficient lime is available to neutralize the AMD as the need arises. Figure 2, a scatter plot of Ca and SO4, indicates a reasonably good correlation between the two (R^2=0.6343). Note also that the net alkalinity is gradually decreasing over time while the SO_4 increases from 400 mg/L to 1600 mg/L. Although not shown on Figure 1, Fe and Mn concentrations have also increased over time. This indicates that AMD generation is increasing over time and leaching other minerals before neutralization takes place. According to Hawkins (personal communication, 2001) the acid producing materials were placed at the worst possible level on this site, which is within the zone of the fluctuating water table.

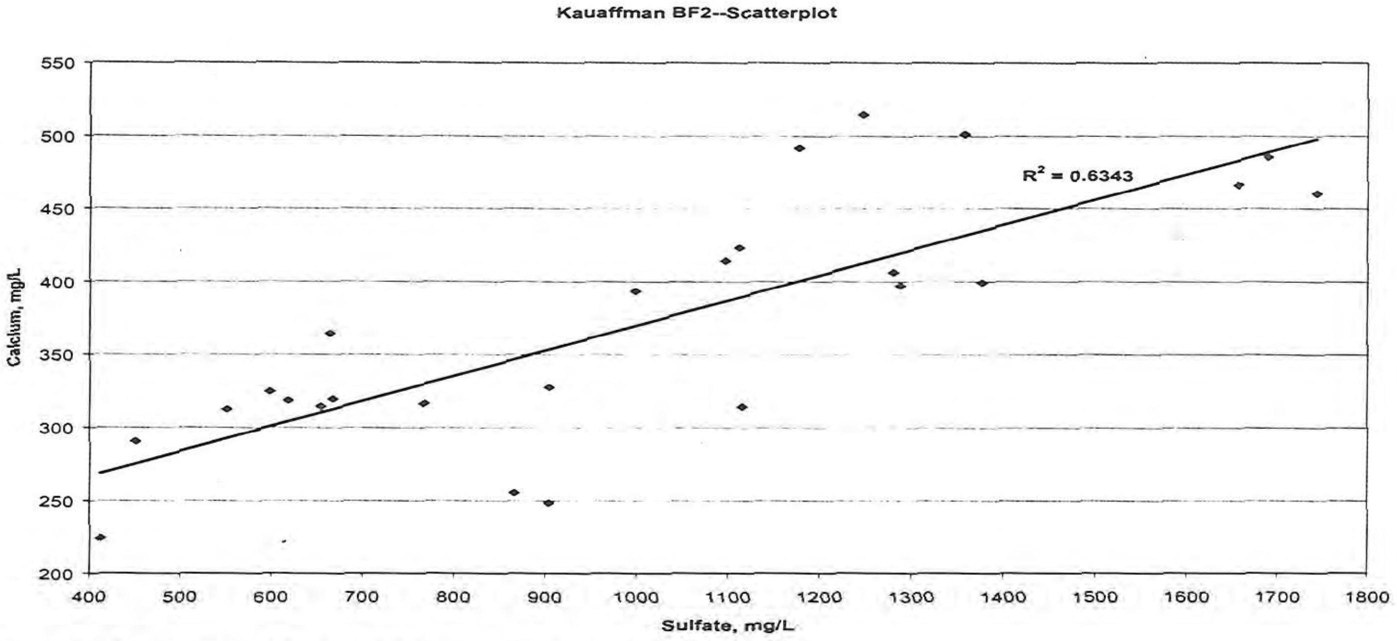


Figure 2. Scatter plot of Ca and SO4 in monitoring well BF2.

In the case of the Kauffman mine site, the use of baghouse lime as an alkaline addition material near monitoring well BF2 appears to be effectively neutralizing the AMD that is produced. The pH of the groundwater has consistently been above 6.0 and the net alkalinity, although lower than initial levels, averages about 200 mg/L. However, the neutralization potential is being converted into alkalinity at a rate in excess of the acidity being generated. Considering the application rate at a ratio of one to one tons CaCO3 to deficiency, it remains to be seen whether the proper balance between neutralization potential and maximum potential acidity has been reached.

The Use of FBC Ash for Alkaline Addition

FBC ash was used as an alkaline amendment on the Abel-Dreshman site in Butler County and on the McDermott site in Cambria County, PA. The chemical responses to the ash placement were significantly different at the monitoring points than the response to the baghouse lime placement on the Kauffman site. The data suggest that the FBC ash may not neutralize AMD production as effectively as baghouse lime, despite adjustments to application rates made to account for the lower NP of the ash. However, the data also suggest that improvements in water chemistry can occur. The pozzolanic nature of the ash is one factor that may affect the ability of the ash to prevent AMD in both a positive and negative way. The pozzolanic character of the ash may help encapsulate the pyritic materials and may reduce permeability of the backfill. However, this same property may also limit the availability of the alkalinity generating components of the ash.

Site 1-Reclamation on the Abel-Dreshman Site

Site description and history

A permit to mine 55.5 acres of coal on an 81-acre tract in Venango Twp., Butler County was issued in June 1980. The first mining cut was being taken in July 1980 and mining continued intermittently until June 1982. The mining occurred on two contiguous parcels, one parcel owned by an individual named Abel, the other owned by an individual named Dreshman.

The first indication of AMD production occurred during routine sampling in July 1982 when the sediment pond and a toe of spoil discharge on the Dreshman parcel were found to be characteristic of AMD. Additional samples were collected in August and December 1982. Observations of depressed pH, elevated acidity, iron, manganese, aluminum and sulfates were consistent with the production of AMD. The mining operation also contaminated two private water supplies with AMD. This contamination was also first noticed in 1982.

In March 1983, bond forfeiture was recommended. Approximately 65 of the 74.5 bonded acres had been affected. A water impounded pit having approximate dimensions of 150 ft. L x 60 ft. W x 40 ft. highwall height existed on the Abel parcel and a pit of 75 ft. L x 50 ft. W x 40 ft. highwall height remained on the Dreshman parcel.

Another operator proposed taking over the mine. As part of the re-permitting application an OBA was conducted at the site. The results of the testing of the two overburden holes along with the presence of AMD at the site supported the Department's claim that continued mining at the site would likely produce AMD. Since the permittee was unable to demonstrate that AMD pollution would not occur from the continued mining operations, the repermitting application was denied.

Alkalinity requirements from the OBA

The mass weighted acid base accounting results showed that the site was alkaline deficient with a strong hood of AMD production (see Perry, 1998; Smith and Brady, 1998, for in depth discussion on acid base accounting):

Overburden	Highwall	Net Neutralization Potential			Tons $CaCO_3$/acre needed to provide		%
Hole	Cover	tons/1000 tons	tons/acre		6 ton/1000 ton excess	12 ton/1000 ton excess	SS
#	Height	Thresholds			Thresholds		
		without	with	without	with	without	
OB-1	56	-2.33	-227	-215	780	1320	56.5%
OB-2	46	-9.27	-612	-740	1090	1696	91.1%

The use of thresholds when evaluating acid base accounting OBA data was discussed in Brady and Hornberger, 1990. The thresholds used were 0.5 % Sulfur and a NP of 30 tons/1000 tons $CaCO_3$ equivalent with the zone having a fizz with a 20% HCl solution.

As part of a reclamation agreement, Amerikohl Mining Inc. reclaimed the site. The proposal included importing fly ash as an alkaline material to blend with the spoil. The application rates were to be determined from the OBA. From September 1997 until September 1998, fly ash was admixed with the spoil and the entire site reclaimed to approximate original contour. The Dreshman parcel was reclaimed first and was completed in May 1998, and then the Abel parcel was reclaimed. Although the original proposal was to add 200,000 tons of Scrubgrass Generating Project FBC ash, or approximately 4,000 tons/acre, to the site, only 83,600 tons were ally applied/mixed at the site. The ash had a reported 600 tons per 1000 tons of $CaCO_3$ equivalency. Therefore, approximately 1003 tons of 100% $CaCO_3$ equivalent per acre were added at the site. This amount would provide a little more than an average 6 ton/1000 ton excess using thresholds across the site. In order to evaluate the success of the alkaline addition, springs designated as MP-29A (Dreshman parcel), and MP-29B (Abel parcel) were monitored by the Department.

Fly ash placement

The Abel-Dreshman site consists of two parcels. Placement of the ash was slightly different on the two areas. Water was added at the plant to condition the ash for dust control. Sufficient water was added to bring the ash up to a moisture content of about 21%. The ash was brought to the site in bottom dump tanker trucks. The ash was dumped adjacent to the pits. Spoil was then pushed with a dozer, mixing spoil with the ash as it was pushed into the pit. The ratio of ash to spoil was commonly 1:1. Mixing and spreading of the ash often occurred within minutes of the arrival of the ash on the site. On both parcels, the floor of the existing pits was covered with a layer of the ash, approximately 2 to 3 feet thick. The primary difference in backfilling the two parcels was that much of the ash was spread in layers on the Abel site (due to non-availability of equipment and breakdowns) whereas it was thoroughly mixed with the spoil on the Dreshman site. A layer of ash, 1 to 2 feet thick, was placed and compacted on both parcels before placement of the final topsoil material.

Monitoring point response to the ash placement

Ash placement occurred on the Dreshman parcel from September 1997 until May 1998 and on the Abel parcel from May 1998 until September 1998. Tables 1 and 2 display summaries of changes to some of the water quality parameters for monitoring points MP-29A (Dreshman parcel) and MP-29B (Abel parcel) respectively.

MP-29A # of samples (n)	PreFlyash Application 18	During Flyash Application 9	Post Flyash Application 14	% Improvement
Median pH	3.35	3.87	6.2	99.8%
Average Net Alkalinity mg/L	-190.3	-200.0	-8.6	95.5%
Average Iron (total) mg/L	2.9	14.9	0.4	87.7%
Average Manganese (total) mg/L	59.4	75.2	22.7	61.8%
Average Aluminum (total) mg/L	3.3	3.1	0.8	75.1%
Average Sulfates (total) mg/L	990.8	926.6	752.0	24.1%
Average Flow (gpm)	31.2	27.8	6	81%

Table 1. Summary of water quality changes resulting from FBC ash addition for MP-29A from the Dreshman parcel.

As can be seen from Table 1, MP-29A shows significant improvement in quality when comparing the pre- and during- fly ash placement chemistry to the post-placement chemistry. The decrease in sulfate concentrations indicates a decrease in or suppression of AMD production from the site. Compare this to the Kauffman site where sulfate concentrations near BF2 continue to increase over time, indicating a continual increase in AMD production. In addition, there has been sufficient alkalinity generation to neutralize any AMD that is formed, resulting in a slightly net alkaline discharge. Also of significance is the reduction in flow from an average of 31.2 gpm before ash placement to an average flow of 6 gpm following completion of the project. The improvement in water chemistry combined with the reduction in flow results in a significant reduction in pollutional loading from the site.

Table 2 provides a summary of the results from sampling MP 29-B. The quality of the MP-29B discharge was much better than that of the MP-29A discharge before the application of the fly ash. However, the quality of MP-29B did not improve near as much as MP-29A as a result of the ash placement, but there are similarities. In both cases, there was an improvement in net alkalinity. The net alkalinity at MP-29B is now near zero mg/L whereas it was –41 mg/L before the ash placement. The average flow of the discharge at MP-29B also decreased significantly, from 27.8 to 9.8 gpm, similar to that of MP-29A. The primary difference in application of the FBC ash is that mixing of the ash with the spoil on the Abel parcel was less thorough than it was on the Dreshman property.

MP-29B # of samples (n)	Pre Flyash Application 18	During Flyash Application 9	Post Flyash Application 14	% Improvement
Median pH	4.4	4.7	4.7	48.3%
Average Net Alkalinity mg/L	-41.2	-16.2	-2.2	94.7%
Average Iron (total) mg/L	0.6	0.1	0.2	69.3%
Average Manganese (total) mg/L	18.9	6.8	4.8	74.4%
Average Aluminum (total) mg/L	3.1	1.8	1.1	66.6%
Average Sulfates (total) mg/L	292.8	194.3	202.8	30.7%
Average Flow (gpm)	28.7	18.5	9.8	66%

Table 2. Summary of water quality changes resulting from FBC ash addition for MP-29B from the Abel parcel.

The graph shown in Figure 3 depicts the change in pH and net alkalinity of both monitoring points in response to the placement of the ash. Sulfate concentrations also dropped, indicating a decrease in or suppression of AMD production, not just neutralization. Both sites reported significant decreases in manganese and aluminum concentrations at the discharge locations, further signifying AMD abatement. In addition, some of the reduction may be attributed to encapsulation of the pyritic minerals within the self-cementing ash. Schueck, et. al, 1996 noted similar reduction in concentrations of typical AMD-related metals when a FBC grout was injected into pyrite-rich piles of buried pit cleanings.

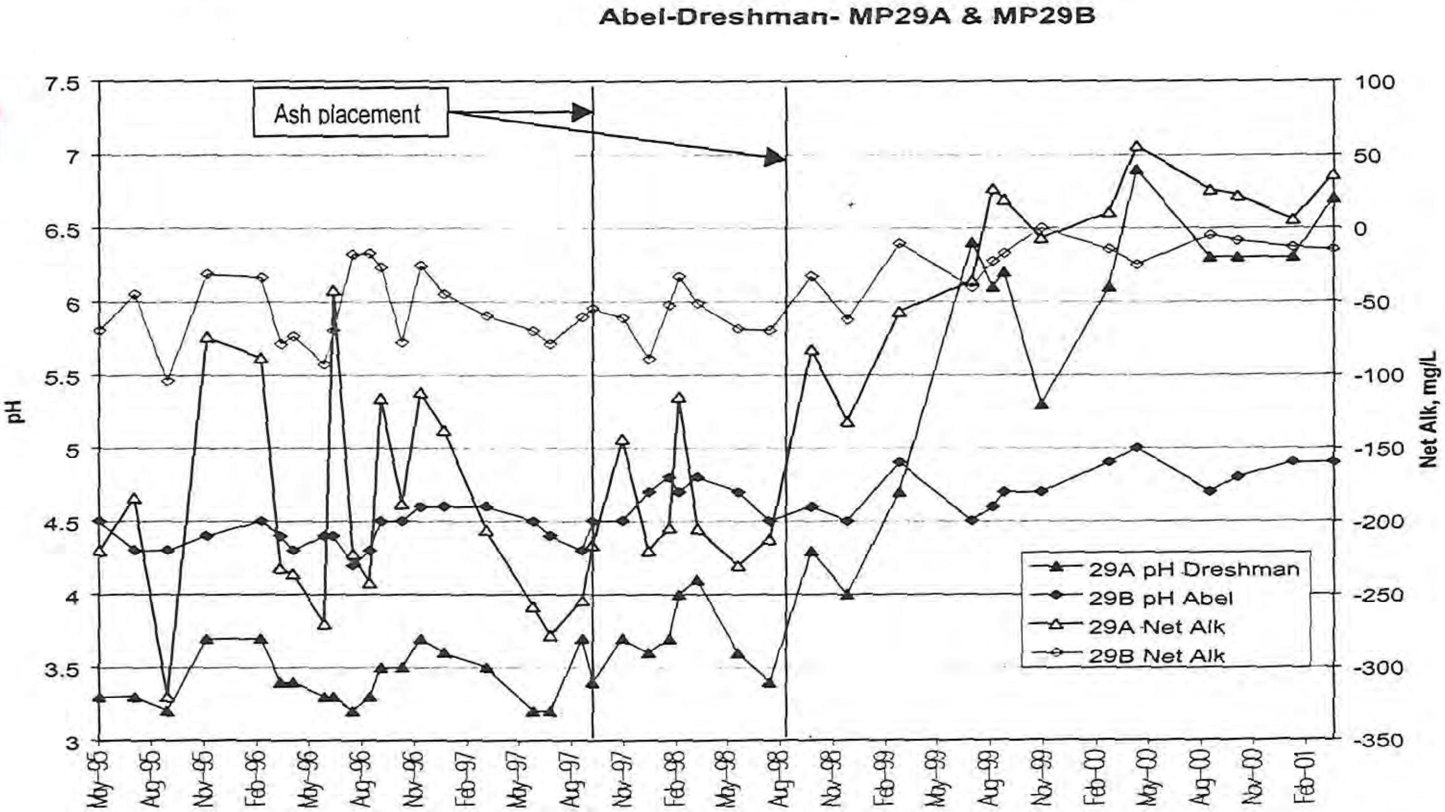


Figure 3. Changes in pH and net alkalinity for MP-29A and MP-29B in response to reclamation of the Abel-Dreshman site with FBC ash.

Site 2-Alkaline Addition on the McDermott Operation

Site description and history

In July 1995, Laurel Land Development submitted an application to mine on the McDermott property located in Jackson Twp., Cambria County. The original application was to mine 25.5 acres of Lower Kittanning coal, 28.8 acres of Middle Kittanning coal, and 8.6 acres of Lower Freeport (more likely Upper Kittanning) coal. After the permit had been issued and activated it was amended to increase the acres of Lower Kittanning mining to 26.5 and the acres of Middle Kittanning mining to 32.1, as well as to add 10.8 acres of Worthington Sandstone removal. A small portion of the site had been previously surface mined on the Lower Kittanning seam. In addition, two small room-and-pillar mines were also present on the Lower Kittanning. Because of pre-existing discharges, the McDermott operation was permitted as a Subchapter F site (Rahall type mining).

As part of the permitting requirements, an OBA was completed. The overburden data were evaluated using thresholds of 30 NP with a positive fizz rating and using 0.5% total sulfur. Numerous overburden holes were drilled on the site. Table 3 summarizes the site overburden data in terms of site NP both before and after ash addition. Based on the OBA, the Department determined that 320 tons of $CaCO_3$/acre were required for mining of both the Middle and Lower Kittanning seams. That amount of $CaCO_3$ was needed to reach a site net NP of 0, the minimum the Department will typically accept on remining sites. The ash to be used exhibited a NP that ranged from 150 to 250, and the applicant proposed an application rate of 2060 tons of fly ash per acre. Assuming a typical NP for the ash of about 200 tons/thousand tons, this alkaline addition rate would raise the overall site net NP to 0.88 tons/1000 tons. Originally, the ash came from the Colver Generating Station. However, the bulk of the ash placed at the site is from the Cambria Cogeneration Plant.

Net Neutralization Potential		Net Neutralization Potential After Alkaline Addition	
-3.07	-320	4.2	440
tons/1000 tons	tons/acre	tons/1000 tons	tons/acre

Table 3. Net neutralization potential for the McDermott operation before and after ash placement.

The permit was issued on January 18, 1996 and mining commenced in the eastern portion of the mine site. Shortly after mining began, water quality problems began to manifest themselves. In response to concerns raised by the Department, the permittee agreed to increase the ash addition rate to 3200 tons per acre. In late 1999, the operator proposed adding ash to the site at a rate of 4500 tons per acre in conjunction with a request to also mine sandstone. The ash addition rate at the site has varied with time, as has the NP of the ash, which has generally decreased with time. Records kept by the ash suppliers show that the average ash placement rate over the course of the operation has been approximately 3800 tons per acre. Again, assuming an average NP of 200, the ash added to the site has been sufficient to bring the overall site net NP to 4.2.

Similar to the ash from the Scrubgrass plant, moisture is added at the silo before loading to bring the natural moisture up to about 21%. Also similar to the Abel-Dreshman site, a layer of ash, two to three feet thick, was placed on the pit floor before backfilling. However, it was observed that blending of the ash with the spoil was not nearly as complete at the McDermott operation. Also, in terms of the overall site net NP, the amount of ash added to the McDermott site, especially early on, was significantly less than that added to the Abel-Dreshman site. Delivery of the ash to the site was based upon availability at the plant. Because the ash did not arrive on a consistent basis, there were periods of time where the ash was stockpiled for several months before being used and other periods of time where no ash was available to mix with the spoil. Similar to the Abel-Dreshman site, a layer of ash was applied to some areas of the surface before final backfilling.

itoring point response to the ash placement

The response of the various monitoring wells on the site show that groundwater degradation occurred shortly after mining began, despite the addition of the alkaline ash. Monitoring well MW-2 is located in the Kittanning Sandstone, below the Lower Kittanning crop line. The response in MW-2 is characteristic of the other monitoring points on the site. As can be seen in Figure 4, the pH dropped from 5.6 before mining to the low 3's after mining began. Net alkalinity dropped from near zero to about –350 mg/L in a corresponding time frame. Thus, the FBC ash is not providing the needed alkalinity to neutralize or prevent the AMD being generated. MW-2 also exhibits high concentrations of iron, manganese and aluminum that were not present before mining, Figure 5. This is an indication that AMD is being generated at the site and is leaching other metals. It is also noteworthy that the water quality was poorest when the active mining was closest to this monitoring well (1996-1998). Water quality improved somewhat after the recharge area was backfilled and reclaimed. This may be attributable in part to reduced permeability of the near surface backfill material resulting from the placement of a layer of ash on the spoil before applying topsoil.

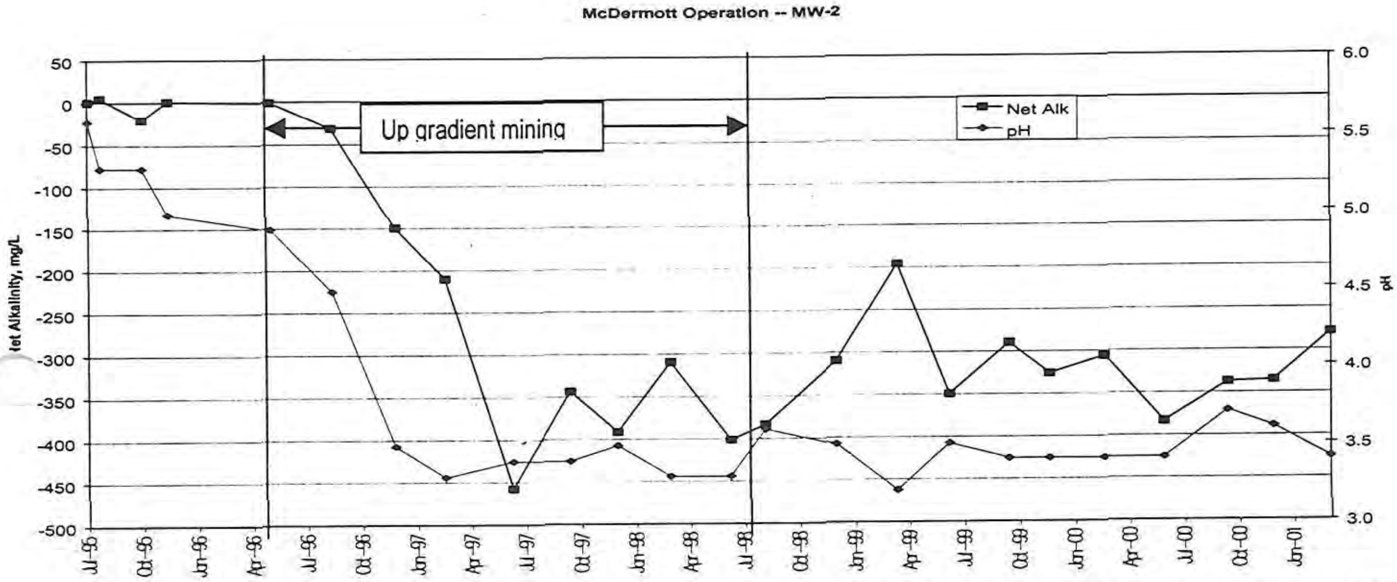
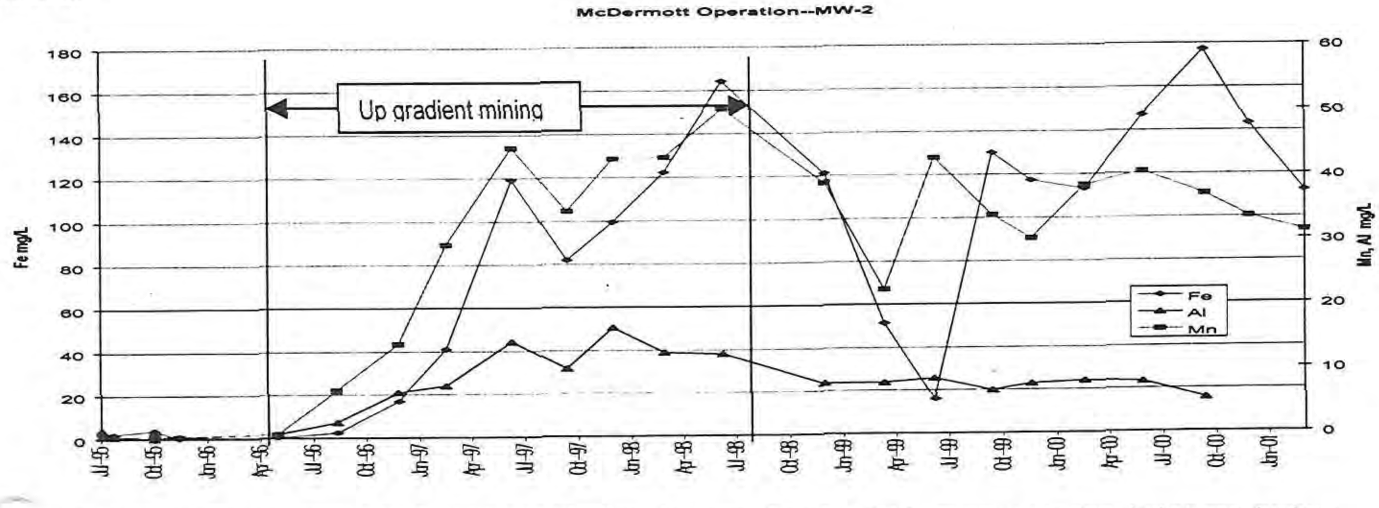


Figure4 Decrease in pH and net alkalinity on the McDermott operation despite the addition of FBC ash as alkaline addition material



ure 5 Iron, manganese and aluminum concentrations increased on the McDermott operation, but showed minor improvement following the completion of reclamation.

Flow reduction in response to ash placement

Hellier, 1998 documented the ability of a layer of FBC ash placed beneath the topsoil to greatly inhibit infiltration o the Upper Three Runs site in Clearfield County. On this site, 55-gallon drums were cut in half and buried in the spoil to monitor infiltration of precipitation. On the areas not treated with ash, the drums filled with water on a regular basis in response to precipitation. In contrast, the drums buried beneath the areas where the ash blanket was applied remained dry. It was noted earlier that the flow rates at MP-29A and MP-29B on the Abel-Dreshman site were diminished by 66 to 81% following reclamation in this fashion. For monitoring point MP-29A, the average acid load before reclamation was 72.4 lbs/day. Considering the improvement in chemistry alone, the average post reclamation acid loading was 11.2 lbs/day. However, when the reduction in flow is considered, the loading is a mere 2.2 lbs/day. Diminished flows following reclamation are also noted on the McDermott operation. MD-12 is a spring whose recharge area is the part of the McDermott operation. The measured flows from MD-12 are indicated in the graph, Figure 6. Reclamation using the FBC ash up gradient of the spring was completed in 1997. Note the apparent reduction in flows measured at the spring following reclamation activities. Flow reduction is a significant factor when calculating pollutional loadings.

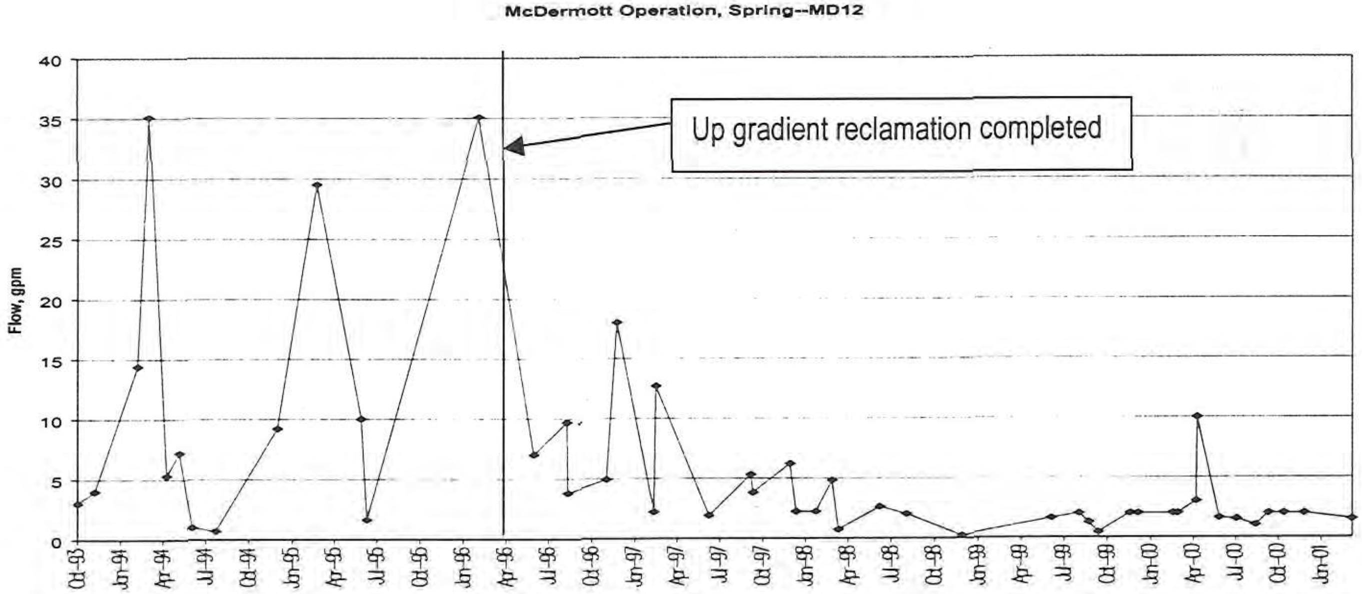


Figure 6. Flow rates measured at a down gradient spring on the McDermott operation. Note the apparent reduction in flows following up gradient reclamation.

FBC Ash for Alkaline Addition

The primary requirement for a material to be used as an approved material for alkaline addition is whether the material has significant neutralization potential. The amount of material that must be imported to the site is based upon its $CaCO_3$ equivalency. FBC ash typically has a $CaCO_3$ equivalency of between 15 and 30%. Thus for every ton of $CaCO_3$ per acre that would be needed, 5 tons of 20% $CaCO_3$ equivalent ash would need to be imported to ensure sufficient alkalinity is present to neutralize AMD. The data from the Kauffman site clearly demonstrates that baghouse lime can and does neutralize AMD in the vicinity of well BF2; however, the Department has observed alkaline addition sites using lime at rates similar to the Kauffman site where AMD did occur. On the Abel-Dreshman site, the monitoring data indicate a reduction or abatement of AMD generation. The increase in net alkalinity also suggests that neutralization is occurring as well. The FBC ash used on the McDermott operation had significantly less NP than that used on the Abel-Dreshman site. The overall site net NP achieved on the McDermott was significantly less than that achieved on the Abel-Dreshman site. Other significant differences observed include the length of time before mixing occurred and a much less thorough blending with the spoil. On the McDermott operation the net alkalinity dropped substantially, indicating little if any neutralization of AMD is t ng place. Further, the only observation where the AMD parameters decreased in concentration was after final amation where a layer of compacted ash was placed beneath the topsoil. The McDermott site remains active as of this writing, so the final water quality may differ from that presented here; however, at this point in the operation it seems unlikely that it would turn net alkaline.

FBC ash exhibits a characteristic unlike that of many other alkaline amendments such as baghouse lime. FBC ash is pozzolanic: it reacts with water to form a low-strength cement. This characteristic reduces the availability of the potentially alkalinity generating components and the effect is that the neutralization potential of material is reduced. This pozzolanic action also prevents the free infiltration of ground water through the FBC itself, therefore reducing the alkalinity generation by reduction of the reactive surface area available to ground water. Thus, the FBC ash may not generate alkalinity at the same level as the equivalent amount of NP added in the form of lime. However, the fact that the ash forms low-strength cement has the advantage of being able to encapsulate some of the pyrite, thus rendering it unavailable to oxidize to form AMD.

Samples of ash that had been stockpiled on the site for a period of seven months were collected from the McDermott Operation. The ash had agglomerated into clumps that visually ranged in size from that of coarse sand to medium gravel. A sample was dried and crushed to minus 60 sieve and tested for neutralization. The NP reported for this sample was 235 tons/1000 tons. A second sample was tested for NP in the same condition as it existed on the stockpile (without drying and crushing). The NP reported for this sample was 177 tons/1000 tons, or a 25% reduction in NP. The following discussion details why NP of FBC fly ash is reduced once it is exposed to additional moisture.

The combustion process

In the combustion process of a fluidized bed combustor, limestone is added to the circulating bed of finely ground fuel primarily for the purpose of off gas pollution control. The combustor is operated above the omposition temperature for limestone thus forming "lime", calcium oxide. In turn, the lime reacts with the SOx produced from the oxidization of sulfide minerals to form anhydrite, CaSO4. Normally the ratio of limestone to sulfur in the fuel is maintained so that there is excess lime available to handle fluctuations in the sulfur content. The consequences of this approach are that there is always excess free lime in the ash.

Reactions in the ash

The mineralogy of the ash is typically:

$CaCO_3 \rightarrow CaO + CO_2$ lime (Equation 5)

Pyrite [and marcasite] $\rightarrow Fe_2O_3 + SO_2$ (Equation 6)

$CaO + SO_2 \rightarrow CaSO_4$ anhydrite (Equation 7)

Clay $\rightarrow$ dehydroxylated clay + H_2O (Equation 8)

Any quartz in the system will process through the FBC chemically and mineralogically unaffected. If combustion conditions within the reactor are sub-stiochiometric, carbon, in the form of char, could be present. Fines, collected above the unit, may contain dust from the limestone addition.

Mineralogical changes with weathering

For the purpose of this discussion, two forms of weathering are exposure to the natural elements in an ompacted form and treatment with moisture for dust control purposes or deliberately to ensure chemical reactions. FBC ash, in an unconsolidated form, exposed to moisture and atmospheric carbon dioxide will result in the formation of secondary mineralization that will consume alkalinity. Furthermore, the calcium is present in a form that is the most water-soluble form for calcium in the ash mixture and therefore has the ability to be washed from the ash. In the presence of moisture (or water in ash-grout composites), several chemical reactions that consume calcium into the secondary mineral phases will also contribute to the removal of alkalinity from the system and hence contribute to the lowering of NP.

Several chemical reactions spontaneously occur within the FBC ash upon the addition of moisture and exposure to the atmosphere. Initially, the lime will begin to absorb both atmospheric moisture and carbon dioxide:

$CaO + CO_2 \rightarrow CaCO_3$ limestone (Equation 9)

$CaO + H2O \rightarrow Ca(OH)_2$ slaked lime (Equation 10)

The initial reaction will remove lime from the chemical reaction pathway and begin to reduce NP. The second reaction establishes the controlling pH of the system at 12.4. Slaked lime is singularly the most soluble form of calcium in the ash.

A third reaction with the anhydrite and water contributes to the short term mechanical properties of ash:

$CaSO_4 + H_2O \rightarrow CaSO_4\,2H_2O$ gypsum (Equation 11)

This reaction is similar to the "plaster of Paris" reaction that everyone is familiar with.

The fourth reaction is the most well know and contributes the most to the early term mechanical properties:

$6Ca^{2+} + 2Al(OH)^{4-} + 3SO_4^{2-} + 4OH^{-} + 32H_2O \rightarrow Ca_6Al_2(SO_4)3(OH)12.32H_2O$

(Equation 12)

In a simplistic manner the above reaction can be written:

3Ca + 3 gypsum +26 water → ettringite (Equation 13)

where the gypsum is derived from the ash and the tri-calcium aluminate is derived from the slaked lime and the aluminosilicate from the dehydroxylated clay. Ettringite forms in the elevated pH range established by the slaked lime. As can be recognized, the ettringite reaction consumes calcium ions from the mix thus further reducing NP.

Discussion on the use of ash for alkaline addition

AMD was produced when mining occurred but was neutralized by the baghouse lime on the Kauffman site in the vicinity of monitoring well BF2. Figure 2 depicts a strong correlation between concentrations of SO_4 and Ca ($R^2=0.6343$). It is reasonable to assume that the baghouse lime was providing the necessary alkalinity for the neutralization reactions to occur. Figures 7 and 8 depict how calcium concentrations vary with changing sulfate concentrations on the Abel-Dreshman site and Figure 9 presents this same information for the McDermott operation. By itself, this information would lend itself to the conclusion that the FBC ash was providing alkalinity for neutralization purposes. However, this conclusion is questionable when the data for Mg is considered.

Before the application of the FBC ash, the Ca and Mg concentrations at MP-29A from the Dreshman parcel averaged 162 mg/L and 133 mg/L, respectively. The Ca and Mg concentrations from the Abel parcel, MP-29B averaged 72 mg/L and 50 mg/L respectively. This indicates the presence of carbonate material on the site, perhaps dolomitic shale. Shale with an NP of 14 was noted in the overburden holes completed on the Dreshman parcel. Ca and Mg concentrations were less than 10 mg/L initially on the McDermott operation; however, the Johnstown Limestone formation is present and was mined. Mg concentrations are also plotted on Figures 7,8, and 9. Note that when Ca concentrations increase or decrease, Mg concentrations follow suit. On the Abel-Dreshman site, the Ca and Mg concentrations are actually lower f wing the FBC ash application than before the application. Following the application of the ash, there was only a slight i..ease in Ca:Mg ratio, from 1.2:1 to 1.5:1 on the Dreshman parcel and from 1.42:1 to 1.46:1 on the Abel parcel. At the McDermott operation, the Ca:Mg ratio decreased from 2.7:1 to 2.2:1 following mining. Scatter plots for the Abel-Dreshman monitoring point MP-29A, Figure 10, and for the McDermott operation, monitoring well MW-2, Figure 11, show little scatter and a strong linear relationship when comparing Ca concentrations to those of Mg.

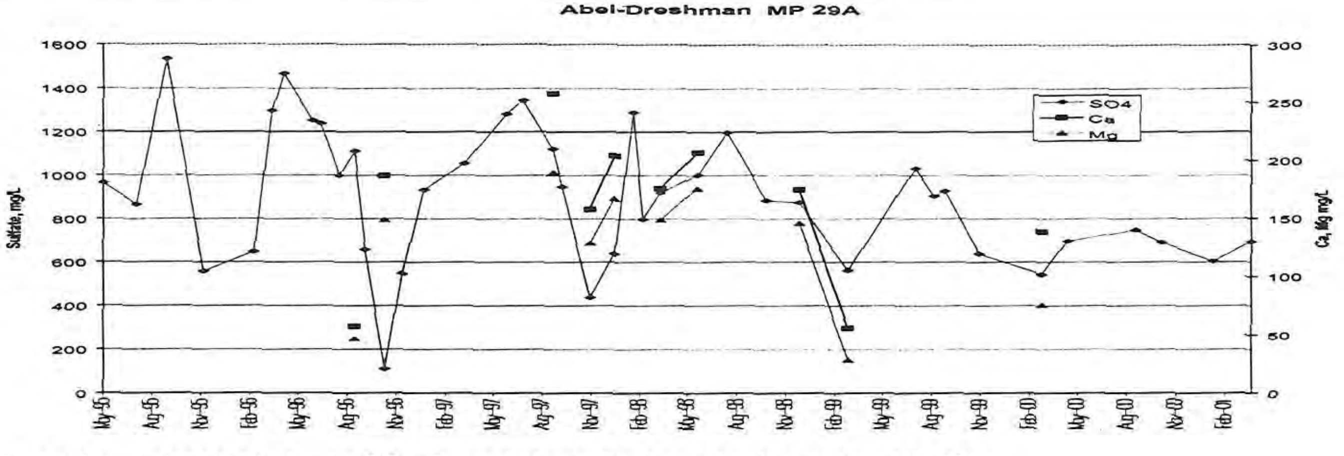


Figure 7. Relationship between SO_4, Ca and Mg on the Abel Dreshman site, MP 29A

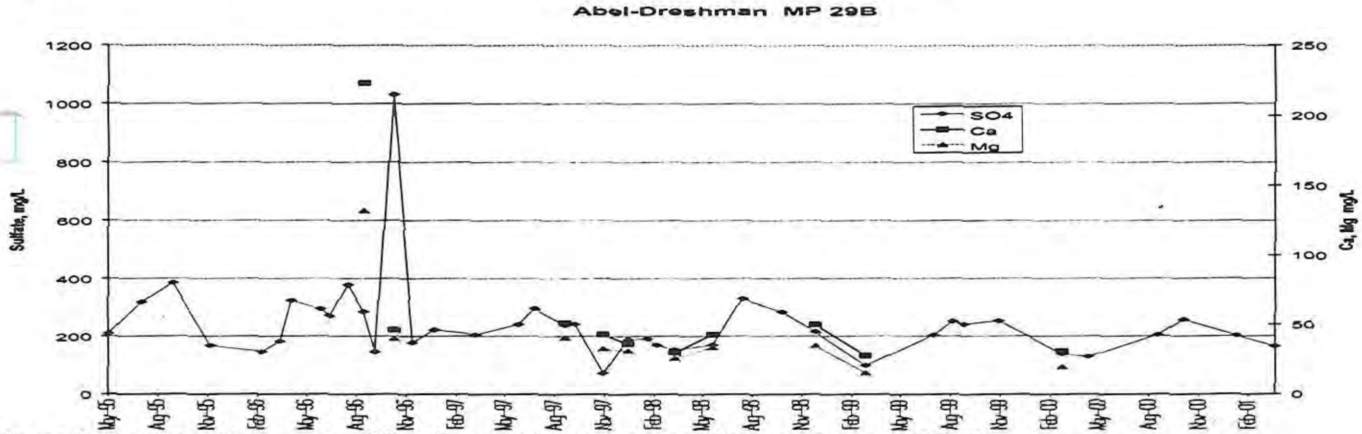


Figure 8. Relationship between SO_4, Ca and Mg on the Abel Dreshman site, MP 29B

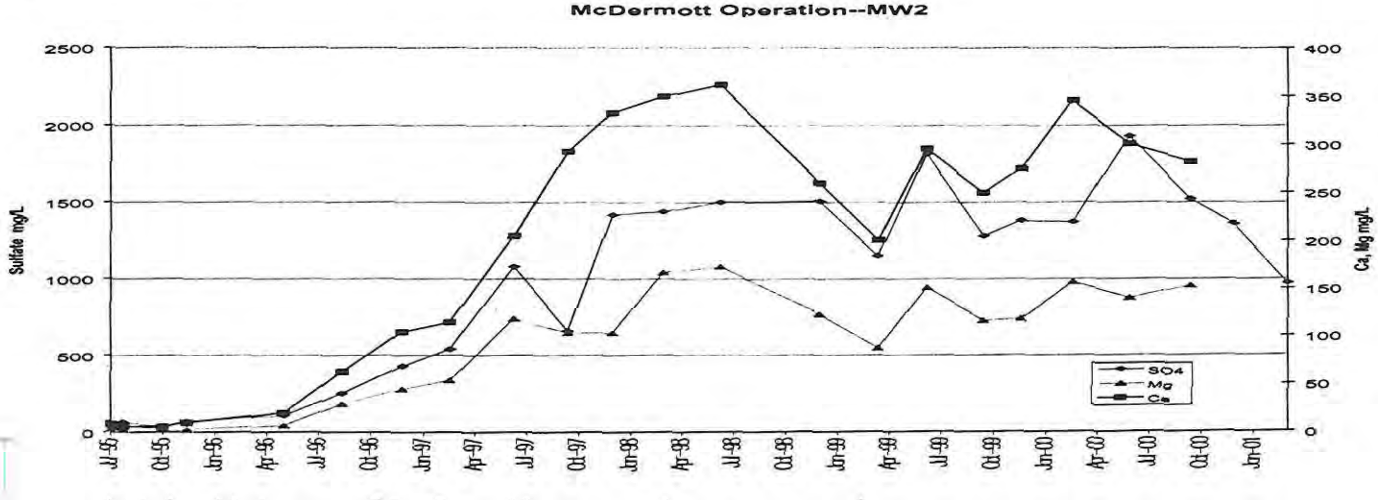


Figure 9. *Relationship between SO_4, Ca and Mg on the McDermott operation*

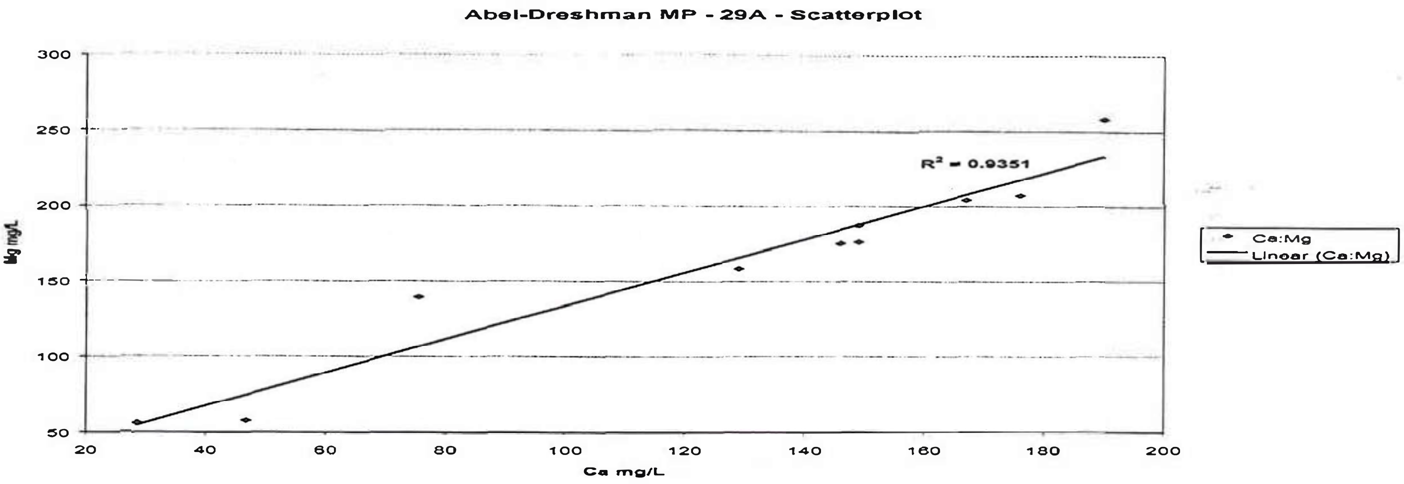


Figure 10. Scatter plot of Ca and Mg from Abel Dreshman MP-29A

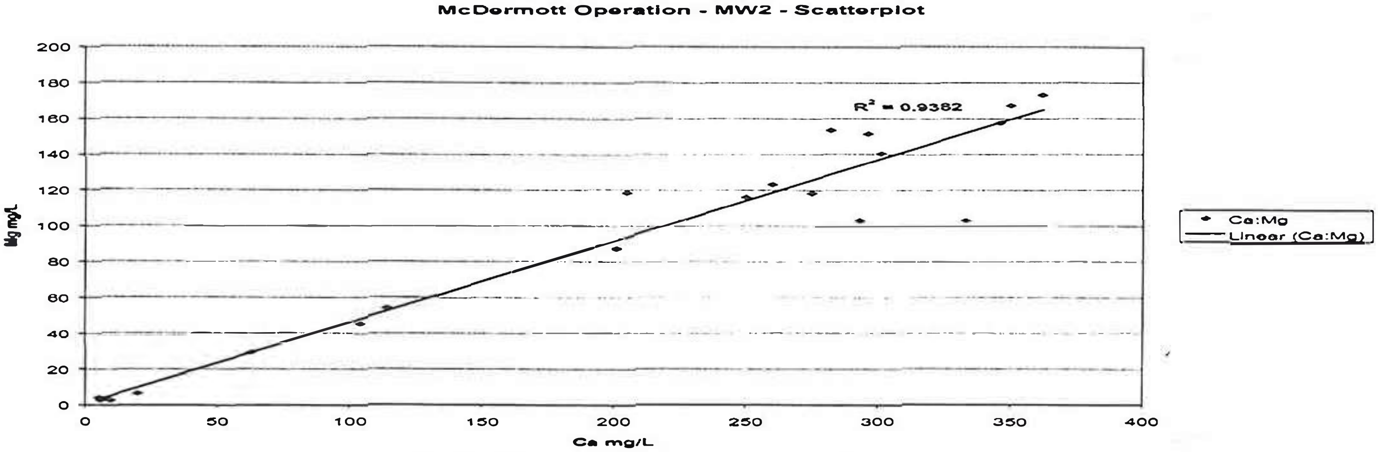


Figure 11. Scatter plot of Ca and Mg from the McDermott operation, MW-2

FBC ash contains approximately 30% CaO and less than 1% MgO, based on the analysis of the ash from several sources. Thus if the ash was the source of the alkalinity for neutralization, the strong linear relationship between the two should not be observed. FBC ash was used as a grout to encapsulate pyritic materials on the Fran Contracting site in Clinton County in 1992 and 1993 (Schueck, et. al, 1996). A large quantity of FBC ash grout was injected near monitoring well L25 in July 1993 and in September 1993 a near surface pod of dry FBC ash was placed near the well. The grout consisted of only FBC ash and water. Figure 12 shows the relationship between Ca and Mg before and after the grout injection in L25. The initial peak in Ca was most likely from the supernatent (washing out of CaO) associated with the grout. Figure 13 is a scatter plot showing the relationship between Ca and Mg for well L25. There is no relationship as the tremendous amount of scatter demonstrates.

There is strong correlation between Ca and Mg on the Abel-Dreshman (R^2=0.9351) and the McDermott operations (R^2=0.8264) and a lack of correlation (R^2 = 0.0238) on the Fran Contracting site (where the measured response was directly attributed to FBC ash placement). Considering this, it appears that the alkalinity for neutralization on these sites is derived primarily from the naturally occurring carbonate minerals present and not from the FBC ash. If the fly ash were providing the alkalinity, then the Mg concentrations should not rise and fall with those of Ca. However, considering the slight increase in the Ca:Mg ratio of the Dreshman parcel and the post-ash application increases in Ca on the Fran Contracting site, it is likely that the FBC ash is providing some degree of neutralization capability to the sites.

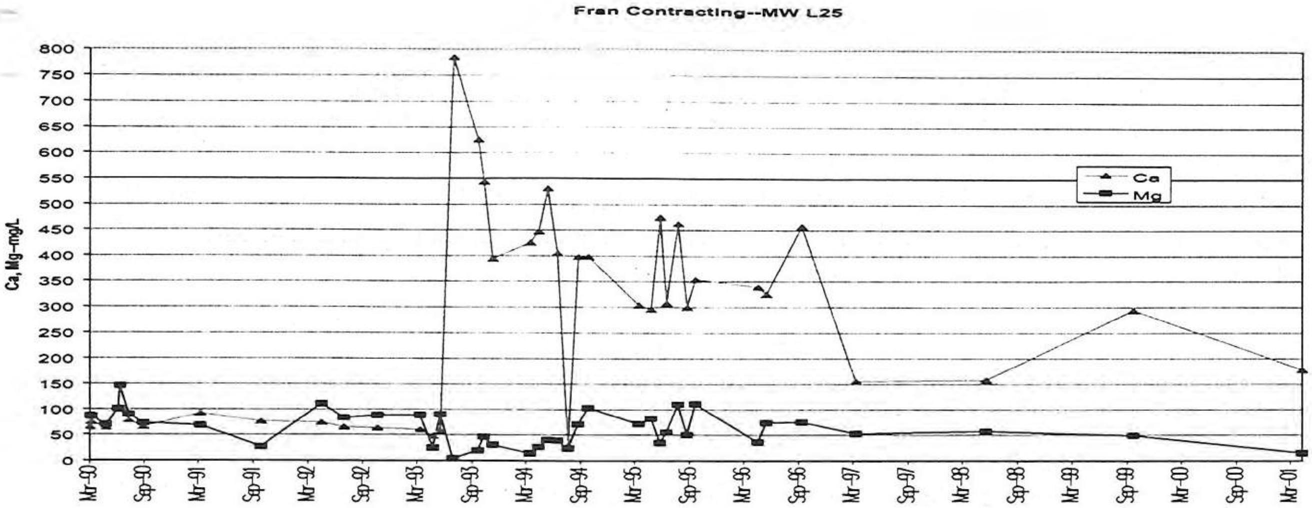


Figure 12. Relationship between Ca and Mg before and after FBC grout injection near the monitoring well

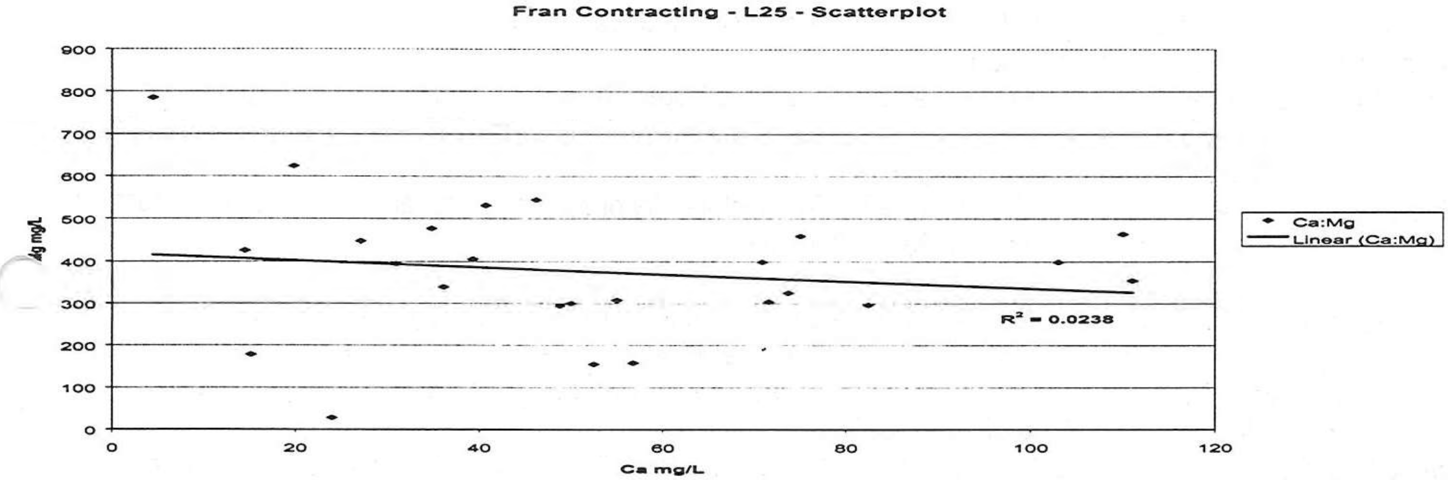


Figure 13. Scatter plot of Ca and Mg for monitoring well L25. Note the lack of relationship present.

Conclusions

Considering the information provided from the various sites studied in this paper, it appears that the ability of FBC ash to neutralize or prevent AMD may not be as easily correlated to the results of NP test results as is the case with baghouse lime. The pozzolanic nature of the ash is one factor that may account for its apparent lesser ability to prevent or neutralize AMD, as compared to limestone. However, mine sites can benefit in other ways from the FBC ash. Because the ash is pozzolanic, or self-cementing, the ash should be applied as cement. There are three primary applications. First, placing a layer of ash on the pit floor can limit AMD generation where the pavement is pyritic. The second is that the pyrite-rich materials encountered or transported to a site can be encapsulated with the FBC ash. This prevents their contact with oxygen and water, thus limiting AMD generation. The third is providing a shallow subsurface, compacted layer of the ash, limiting infiltration.

Timing of these processes is critical; however, especially where moisture is added to the ash at the generating station for dust control. As soon as moisture is added to the ash, the pozzolanic reactions begin. In order to gain full benefit from the cementitious nature of the ash, immediate placement upon arrival at the site is best. If the generating station could d dry ash onto the trucks, the operators would have greater flexibility in placing the material in order for the application to be effective.

It is also possible that, when ash is used as an alkaline additive, the amount needed to offset the site maximum potential acidity, as defined by an OBA, is greater than that suggested by the NP of the ash. Additional ash placement sites need to be examined to determine if the conclusions drawn here are general or are only specific to the three sites examined in this paper. Also, more work needs to be done to determine just how much the effective NP is reduced with time as a result of the pozzolanic nature of the FBC ash.

Although not a topic of this paper, the data from the Kauffman site suggests that additional alkaline addition sites should be studied to determine the best way to incorporate the alkaline materials into the backfill and to determine if material solubility should be a factor in determining the application rates.

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With the continued tightening of the air quality particulate regulations as imposed by the EPA, Coal fired power plants are utilizing more and more electrostatic precipitators to clean the air by removing the flyash.

Coal combustion ash from fluidized bed combustion facilities is an alkaline waste product with pozzolonic properties.

In order to evaluate the effectiveness of the alkaline residual waste ash reclamation with CFB ash and monitoring of an abandoned forfeited site in Butler County was undertaken.

Mining History

The application was submitted December 18, 1979 to mine 81 acres in Venango Twp., Butler County. The application proposed mining 55.5 acres of Middle Kittanning coal. The application did not contain an overburden analysis. The permit was issued on June 17, 1980 to Chernicky Coal Company. The first mining cut was being taken in July 1980 and mining continued intermittently till June 1982. In March 1983 bond forfeiture was recommended. Approximately 65 of the 74.5 bonded acres were affected. On March 1984, a water impounded pit of approximate dimensions of 150 ft. L x 60 ft. W x 40 ft. highwall height existed on the 02-0 and a pit of 75 ft. L x 50 ft. W x 40 ft. highwall height remained on the 01-1 mining permit. Another operator proposing to take over the mine started pumping and treating the impounded water on the 02-0 permit in June 1984

The first indication of a potential for AMD production occurred during routine sampling in July of 1982 when the sediment Pond on the 01-1 mining permit and a spoil discharge had:

COLL ID#	Description	DATE	Flow	pH	ALK	HOT A	Fe Tot	Mn Tot	Al Tot	SO4	NET ALK
4226 033	Sed. Pond 01-1	7/29/1982		3.3	0	359	5.5	91.7	25.3	1300	-359
4226 034	Spoil Discharge	7/29/1982	5	5.4	17	105	33.1	43.6	0.81	900	-88

Additional samples indicating the production of AMD having depressed pH, elevated acidity, iron, manganese, aluminum and sulfates were collected in August and December1982. Starting in August 1980, shortly after the replacement of the Charles Dreshman's original shallow well (CD-8) and Henry Dreshman's spring (CD-7) there was evidence of groundwater contamination to the replacement water supplies.

COLL ID#	Description	DATE	pH	ALK	HOT A	Fe Tot	Mn Tot	Al Tot	SO4
	CD-8 original shallow well	**10/15/1979**	**6**	**11**	**2**	**0.05**	**0.35**		**12**
	CD-8 original shallow well	**5/23/1980**	**4.1**	**1**	**26**	**0.40**	**0.21**		**13**
	Charles Dreshman replacement well	**8/1/1980**	**6.0**			**1.00**			
	Charles Dreshman replacement well	**3/14/1982**	**6.1**			**5.00**			
4226 128	**Charles Dreshman replacement well**	**2/7/83**	**6.1**	**69**	**0**	**15.00**	**6.46**	**0.12**	**550**
4221 219	**Charles Dreshman replacement well**	**5/23/83**	**6.4**	**73**	**0**	**20.20**	**8.00**	**0.11**	**740**
4217 344	**Charles Dreshman replacement well**	**7/18/84**	**5.6**	**57**	**114**	**53.50**	**35.50**	**0.07**	**>500**
	Henry Dreshman spring (CD-7)	**10/15/79**	**5.7**	**6**	**2**	**0.05**	**0.05**		**19**

	Henry Dreshman spring (CD-7)	5/23/80	5.8	1.6	24	0.05	0.05		23
	Henry Dreshman 1st replacement well	11/8/82	5.5	0	6	18.00			
4226 129	Henry Dreshman 2nd replacement well	2/7/83	6.1	61	0	12.40	8.41	0.11	750
5221 223	Henry Dreshman 2nd replacement well	5/23/83	6.0	63	2	44.90	10.12	0.35	950
4217 345	Henry Dreshman 2nd replacement well	7/18/84	5.7	63	149	72.20	37.80	0.07	>500

The large increase in sulfates, iron and manganese indicates the production of AMD.

As part of the re-permitting application an overburden analysis was conducted at the site. The results of the testing of the two overburden holes along with the presence of AMD at the site supported the Department's claim that continued mining at the site would likely produce AMD. Since the permmittee was unable to demonstrate that AMD pollution to the Waters of the Commonwealth would not occur from the continued mining operations, the repermit application was denied June 7, 1984.

Overburden Analysis

The mass weighted acid base accounting results showed that the site was alkaline deficient with a strong likelyhood of AMD production, should mining continue:

Overburden	Highwall	Net Neutralization Potential			Tons $CaCO_3$/acre needed to provide		%
Hole	Cover	tons/1000 tons	tons/acre		6 ton/1000 ton excess	12 ton/1000 ton excess	SS
#	Height	Thresholds			Thresholds		
		without	with	without	with	without	
OB-1	56	-2.33	-227	-215	780	1320	[illegible]
OB-2	46	-9.27	-612	-740	1090	1696	91.1%

The use of thresholds when evaluating acid base accounting OBA data was discussed in ____________________ The thresholds used were 0.5 % Sulfur and a NP of 30 tons/1000 tons $CaCO_3$ equivalent with the zone having a fizz.

From September 1997 till September 1998 as part of a reclamation agreement with Amerikohl Mining Inc. Flyash was admixed with the spoil and the entire site reclaimed to AOC. Although originally it was proposed to add 200,000 tons of Scrubgrass Generating Project CFB ash or approximately 4,000 tons/acre to the site only 83,600 tons were actually applied/mixed at the site. The ash has approximately 600 tons per 1000 tons of $CaCO_3$ equivalent. Therefore approximately 1003 tons of 100% $CaCO_3$ equivalent were added to each of the 50 acres at the site. This amount would provide a little more than a 6 ton/1000 ton excess with thresholds across the site.

In order to monitor the success of the alkaline addition, monitoring of springs 29, 29A, and 29B were conducted by the Department.

Monitoring Results

As can be seen on the attached table and graphs, comparing the period of prior to flyash mixing and backfilling (prior to September 1997 – 1998) to the period following the application of flyash shows, that there has been a marked decrease in metals and sulfate concentrations at monitoring points 29 , 29A and 29B. The Pre-application of flyash period from July 1996 – July 1997as compared to the period following the application of flyash (after September 1998).

The data also show a significant increase in pH and net alkalinity at these points from pre-application to post application of the flyash.

MP-29	Pre-Flyash Application	During Flyash Application	Post Flyash Application
# of samples (n)	9	9	11
Median pH	3.6	3.8	4.8
Average Net Alkalinity	-117.8	-104.3	-2.8
Std. Deviation Net Alkalinity	39.5	58.1	11.8
Average Iron (total)	1.5	6.4	0.2
Std. Deviation Iron (total)	0.6	11.2	0.2
Average Manganese (total)	43.3	38.3	9.5
Std. Deviation Manganese (total)	18.2	18.8	4.1
Average Aluminum (total)	2.9	2.7	0.9
Std. Deviation Aluminum (total)	0.5	2.1	0.5
Average Sulfates (total)	634.7	624.8	295.6
Std. Deviation Sulfates (total)	237.1	258.7	75.2

MP-29A	Pre-Flyash Application	During Flyash Application	Post Flyash Application
# of samples (n)	9	9	11
Median pH	3.5	3.7	6.1
Average Net Alkalinity	-185.3	-207.3	-35.2
Std. Deviation Net Alkalinity	56.9	50.6	80.7
Average Iron (total)	2.1	15.1	0.8
Std. Deviation Iron (total)	1.5	13.7	1.2
Average Manganese (total)	44.6	76.3	32.7
Std. Deviation Manganese (total)	25.5	19.7	23.1
Average Aluminum (total)	3.5	3.1	1.3
Std. Deviation Aluminum (total)	1.0	2.1	1.5
Average Sulfates (total)	835.6	942.7	817.2
Std. Deviation Sulfates (total)	377.5	292.6	202.0

MP-29B	Pre-Flyash Application	During Flyash Application	Post Flyash Application
# of samples (n)	9	9	11
Median pH	4.5	4.7	4.7
Average Net Alkalinity	-36.3	-18.7	-5.0
Std. Deviation Net Alkalinity	17.1	16.2	8.0
Average Iron (total)	1.1	0.1	0.2
Std. Deviation Iron (total)	1.7	0.1	0.3
Average Manganese (total)	27.7	7.0	5.9
Std. Deviation Manganese (total)	37.0	3.3	2.5
Average Aluminum (total)	2.5	1.8	1.4
Std. Deviation Aluminum (total)	0.6	0.8	0.7
Average Sulfates (total)	335.1	190.6	213.1
Std. Deviation Sulfates (total)	289.7	63.7	69.5

COMMONWEALTH OF PENNSYLVANIA
Department of Environmental Protection
District Mining Operations
September 18, 1998

Knox District Office **814-797-1191**

SUBJECT: "Revised" Reclamation/Remediation Plan
PA Comprehensive Mine Reclamation Strategy
Slippery Rock Watershed Project

TO: Javed I. Mirza
District Mining Manager
Knox District Office

FROM: Roger D. Bowman
Mining Engineer/Project Officer
Knox Technical Section

RdB

THROUGH: Lorraine Odenthal
Chief, Technical Section & Permitting
Knox District Office

Enclosed is the "revised" edition of the Reclamation/Remediation Plan for the Slippery Rock Watershed Project as per the recommendations that you and Lori suggested. I have submitted this file to BMR over the LAN to fulfill our final requirements for Slippery Rock Creek under the EPA 104(b)(3) grant for 1994. The file name is Sliprokr.doc.