INTRODUCTION

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The Questions

1. Have the major acid mine discharges from the Shaw Mines Complex changed during the period of observation 1967-1983, i.e., have acid, iron and sulfate concentrations and loads decreased, increased or remained about the same?

2. If there are changes in the water quality of these discharges, can these changes be related to Pa. DER reclamation projects or to strip mining and daylighting operations?

Background Summary

The Shaw Mines Complex (SMC) is located in southern Somerset County, one mile southwest of Meyersdale, PA, at the eastern edge of the Allegheny Plateau Physiographic Province. The Complex is a structural coal basin occupying nearly 5000 acres at the center of the Berlin Syncline. The basin is composed of coal measures of Pennsylvanian Age in the Monongahela Group. The basin is 4.5 miles long at its axis and 2.3 miles at its center, with the crop of the Pittsburg coal defining the boundaries of the basin. In the Shaw Mines Complex, the Pittsburg or "Big Vein" is 6-12 feet thick and has been deep-mined throughout its entire extent. See map of Deep Mines-Pittsburg Coal in pocket.

The extensive network of Pittsburg deep mines acts as a ground-water underdrain for the SMC. Ground water recharge to the coal basin ultimately drains to the Pittsburg workings via large fracture zones created by roof sagging and collapse in the deep mines. Once the water reaches the deep mines, it flows downdip and discharges from old headings and entries to the Casselman River or one of the Casselman's tributaries.

There are only three principal locations of acid mine drainage (AMD) input to the Casselman River: Shaw Mines Run (Station 3), Weir No. 11 (Station 11), and Coal Run (Station 13) (see Geologic Base map in pocket).

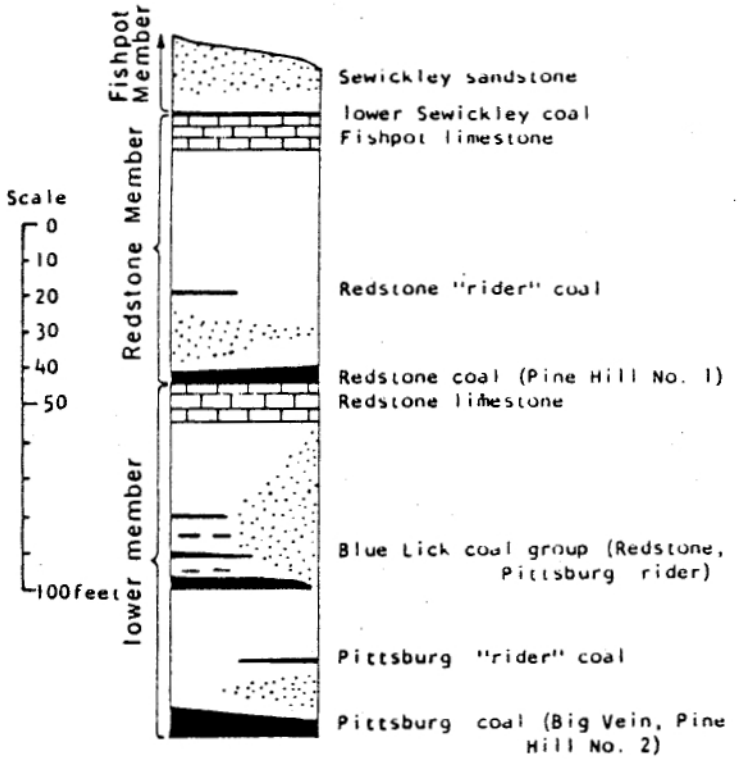
The drainage characteristics of the deep mine system are complicated by the installation of air seals in deep mine portals by WPA in the late 1930's, strip mining (daylighting) of the Pittsburg deep mines and coals above the Pittsburg, and Pa. Dept. of Environmental Resources (DER) reclamation projects built in the early 1970's. Records of water quality sampling collected at sporadic intervals by the Pa. DER from 1967-1983 serve as the data base for this project.

Coal Stratigraphy

The generalized stratigraphic section of the Monongahela Group of Somerset County (Flint, 1965, pg. 93, see pg. I-3) shows six distinct coals and rider seams. The occurrence and relative position of these is consistent with our own field observations, but misconceptions and ambiguities in coal terminology developed by local coal operators over the years has led to many inconsistencies in the coal mapping available for this area.

The primary area of confusion surrounds the nomenclature of the first minable coal above the easily recognized Pittsburg or Big Vein coal. In areas to the north and west of the Shaw Mines Complex the first minable coal above the Pittsburg is the four-foot thick Redstone coal. However, in the Shaw Mines area a multi-bench coal, known as the Blue Lick, occurs between the Pittsburg and the true Redstone coal. The Blue Lick coal group contains a discrete four-foot thick seam of minable coal at its base; hence, the name "four-foot coal" is locally common for the Blue Lick. Coal miners with experience in areas north and west of Shaw Mines, where the Blue Lick is missing from a thinner Monongahela sequence, have incorrectly labelled the Blue Lick

coal as the Redstone in the Shaw Mines area because of its position above the Pittsburg coal. Additional confusion arises from the Blue Lick coal's variable thickness and stratigraphic separation above the Pittsburg coal.



Generalized section of the Monongahela Group of southern Somerset County.

We have mapped the cropline of the base of the Pittsburg coal because of its prominent stratigraphic expression and its controlling influence on groundwater flow in the deep mines. The true Redstone coal occurs 85 to 90 feet above the Pittsburg, and an average of 30 feet above the Blue Lick. We have mapped the outcrop of the true Redstone coal, even though many of the mines above the Big Vein are probably worked into the Blue Lick or a split seam of Pittsburg coal. In the Coal Run Stream valley, the Morantown coal outcrops 40-60 feet below the base of the Pittsburg, and has been deep-mined to a limited extent. No other Morantown mines have been noted anywhere else in SMC.

In summary, the stratigraphic interval between the mapped croplines of the Pittsburg and Redstone coals includes nearly all of the coal mining activity in the Shaw mines area (see Geologic Base map).

Mining History

The first record of commercial mining in the SMC is contained in Franklin and Platt's 1877 Pa. Second Survey Report HHH. Franklin and Platt note the location of six large commercial mines on the Pittsburg coal that were operating prior to 1877. These mines were spread almost uniformly over the coal basin, with main headings located in the vicinity of the sampling points numbered 8, 11, 12, 16, 24 and 30 (see Geologic Base map, in pocket).

These six deep mines accounted for most of the coal mined in the SMC. The deep mines expanded and remained active through World War I, but largescale production had ceased by the Depression. Most of the deep mines included mining on the Pittsburg Rider and Redstone via shafts driven upward from Pittsburg workings. In many mines, pillars were pulled in retreat when the maximum areal extent of the mines had been achieved.

From the Depression until the mid-1960's, coal production in the SMC was limited to small crop stripping and pillar-pulling operations. In the mid1960's, Sanner Bros. Coal Co. began extensive strip mining in the SMC. Though other coal companies have operated strip mines in the SMC, the bulk of the mining from the mid-1960's to the present has been done by Sanner Bros. Coal Co. (name changed to Action Coal Co. in 1982).

The Geologic Base map shows a time chronology of Sanner Bros.-Action Coal activities in the SMC. The earliest mining occurred in the Shaw Mines Run drainage basin. Sanner Bros. stripped the Pittsburg, Blue Lick, and Redstone Coals on the north side of Shaw Mines Run from Shaw Mines to the village of Summit Mills from 1962 to 1970.

From 1970 to 1978 Sanner Bros. strip-mining operations were concentrated on the hilltop southwest of the village of Shaw Mines and along the south branch of Shaw Mines Run. The Pittsburg, Blue Lick, Redstone and Sewickley were mined in this area.

The Pittsburg, Blue Lick and Redstone were stripped in the northern and central portions of Saylor's Hill from 1975-1979.

From 1978 to the present, Sanner-Action stripping operations were concentrated in the Coal Run watershed. The Pittsburg, Blue Lick, Redstone and, to a limited extent, the Morantown have been stripped in this watershed.

Mine Reclamation

The earliest attempt at controlling acid discharges at SMC dates back to the 1930's when the WPA constructed air seals in deep mine portals. Many of the air seals are still intact. These air seals have proved to be ineffective at excluding air from the mines, and hence limiting the formation of AMD.

From November 1969 to July 1973, five DER acid mine drainage (AMD) abatement projects (SL 118-1 through SL 118-5) were implemented at SMC. Though we have found no written records describing the intent or conceptual justification of these projects, conversations with DER staff indicate that four of these projects totalling over 3.8 million dollars were designed around a single abatement concept: DER project planners believed the water quality of the Pittsburg deep mine outfalls could be improved by flooding the entire deep mine complex.

Project SL 118-1 was the lone reclamation attempt which did not entail mine flooding. In this project 20,000 dollars were spent to regrade mine-subsided terrain and to install a tar paper flume for rerouted surface drainage on the Albert Hay property. This project was destroyed by stripping in 1978.

Projects SL 118-2 through SL 118-5 incorporated a series of highwall clay seals, box cuts lined with clay, double-bulkhead mine seals and a grout curtain attempting to flood the Pittsburg mine workings. Our complete understanding of these projects suffers from a lack of documentation. Records dealing with the actual field installation and completion of these projects are nonexistent. To date no rigorous attempt has been made to evaluate the effects of these projects on water quality at SMC.

The project descriptions are based on information gained from DER personnel and the contractors who built them. After reviewing the project descriptions, locations and geologic structure, it is unclear how they would accomplish mine flooding since they are not in obvious positions of damming flow in the deep mines.

Project SL 118-2 - Valley Clay Seal - A five-foot high, by 50 to 100-foot wide pad of locally quarried clay was used to seal the Pittsburg crop in the valley at the south end of the grout curtain (see map of Deep Mines). Highwall box cuts were made at an elevation of 2190 feet along the valley walls to form a base for clay packing. Work began in June 1970 and was completed in July 1971.

Project SL 118-3 - Box Cuts - Two box cuts were installed over a distance of 4100 linear feet (see Geologic Map). The box cuts were excavated to the Pittsburg underclay then clay was packed to an unrecorded height and depth before the cuts were backfilled. Work began in October 1969 and was completed in November 1971.

Project SL 118-4 - Grout Curtain - Air rotary drill holes from 4-5/8 to 6 inches in diameter were drilled to the Pittsburg coal on five to ten foot centers along 3500 linear feet of proposed grout curtain (see Geologic Map for location). Shale aggregate (size 2B) was vibrated into drill holes penetrating Pittsburg mine voids. Fly ash, cement grout, and AM9 chemical grout were

pumped into these holes in an attempt to seal the Pittsburg mine voids. Conversations with DER personnel and people who worked on the job cast doubt on the completeness of the grout curtain. Few of the monitoring wells drilled to check water levels on both sides of the grout curtain were found in our 1981 field reconnaissance. Work began in December 1971 and was finished in July 1973.

Project SL 118-5 - Double Bulkhead Mine Seals - Five double-bulkhead seals constructed of stone aggregate and cement grout were installed in drift openings in the head waters of the south branch of Shaw Mines Run. These seals were stripped out in 1978. Work began on the seals in March 1972 and was finished in December 1972 (see Geologic Map).

Water Sampling Records

A program of water sampling was started by DER in the SMC in 1967. From 1967 to 1972, 41 stations, including the present Meiser and Earl sampling points 3, 6, 7 and 13, were sampled at weekly to monthly intervals. The samples were analyzed for acidity, alkalinity, ferrous iron, total iron, pH and sulfates by Seewald Laboratories. Flows were recorded sporadically at all stations with the exception of Stations 6 and 7 on the Casselman where no flows were measured.

From 1973 to 1981, DER concentrated their regular sampling on only five stations, Meiser and Earl numbers 3, 6, 7, 9 and 13. Samples were taken at one- to three-month intervals. Once again, flows were recorded sporadically with the exception of Stations 6 and 7, where no flows were measured. Station 11 was sampled at one- to three-month intervals from 1972 through 1975. Analytical work from 1973 through 1983 was divided among three laboratories: Buchart-Horn (October 1973-June 1975 and July 1977-April 1978), Greene

(September 1975-June 1977), and DER Hawk Run (May 1978-June 1981). The list of parameters analyzed remained the same as in the previous sampling period.

From July to September 1981, Meiser and Earl sampled 78 stations in a field reconnaissance of the SMC. Reconnaissance was organized by starting at the regional drainage (Casselman River) and tracing tributary systems back into the uplands. A profile of the Casselman from W. Salisbury to the Elk Lick confluence "consumed" 33 samples. Profile samples were taken from the river above and below the confluence of each large tributary and from each tributary at its mouth. Field measurements of pH, conductivity, and temperature were recorded for each sample.

The remaining 45 samples were taken from point sources contributing to tributary systems. Hundreds (literally) of conductivity measurements were used as a screening tool to prevent over-sampling. Point sources sampled included mine openings, field drains, mine seals, seeps and springs. After initial field reconnaissance, aerial photographs (PennDOT, 1980) and two-foot contour maps (L.R. Kimball, 1968) of the Shaw Mines Complex were examined to find areas needing further reconnaissance. All mapped drift openings and areas of subsidence were checked for drainage.

Once flow and chemical data for the 78 samples were compiled and organized by watershed, a point-by-point review by all people involved in field reconnaissance was used to pick a monitoring network (see "Sampling Point Field Inventory" for listing of locations and status for the 78 stations). Criteria considered in monitoring point selection were: flow, drainage density, chemistry, proximity to active or proposed mining, access, and historical record (see "Sampling Point Field Inventory" for a point-by-point explanation of the rationale involved in selecting the final 35-station monitoring network).

Monthly monitoring of the 35-station network was performed by Meiser and Earl from February 1982 to December 1982. Flows were measured at all stations. In addition to the standard mine-drainage parameters, samples were analyzed for aluminum and magnesium. The Department is currently continuing monitoring of the 35-station network.

SAMPLING POINT FIELD
INVENTORY

Project Map Designation	Location and Status	Approximate Discharge - in gpm	Type of Flow Measuring Device *
1	WPA weir No. 1 on S. branch of Shaw Mines Run - V-notch not intact	15	VE/BS
2	W branch of Shaw Mines Run	200	VE/PF
3	Weir on Main branch of Shaw Mines Run	740	PRW
4	Casselman downstream of Elk Lick confluence	--	FM
5	Elk Lick at Casselman confluence	--	FM
6	Casselman at Boynton Bridge	--	FM
7	Casselman at Broadway Bridge	--	FM
8	Headwaters of Saylor's Hill Run	5	VE/PF
9	Weir on Saylor's Hill Run in W. Meyersdale	9	PVW
10	Casselman at Shaw Mines	--	FM
11	WPA weir No. 11 - mine seal - V-notch intact	230	PVW
12	Mine Seal discharge on N side of Shaw Mines Run - seal destroyed	78	BS
13	Weir on lower reach of Coal Run	22	PVW
14	Lower reach of S branch Shaw Mines Run	40	VE/PF
15	Mouth of Piney Creek	--	FM
16	Mine seal on South side of Shaw Mines Run V-notch not intact	8	VE/BS
17	Mine seal on North side of Shaw Mines Run Seal destroyed	15	BS
18	Southern tributary to Elk Lick	1000	VE/FM
19	Casselman downstream of Weir 11 discharge	--	FM
20	Casselman upstream of Weir 11 discharge	--	FM
21	Casselman at 3rd bridge below Boynton	--	FM
22	Unnamed tributary to Casselman -NE of Boynton	2	VE/BS
23	Casselman at 2nd bridge below Boynton	--	FM
24	Unnamed Northern tributary to Coal Run	40	VE/PF
25	WPA weir No. 25 on South side of Coal Run - mine seal - V-notch not intact	3	VE/BS
26	Casselman at W. Salisbury Bridge	--	FM
27	West branch of Coal Run	30	VE/PF
28	North branch of Coal Run	60	VE/PF
29	Mine seal on South side of Coal Run No V-notch	10	VE/BS
30	Mine seal on North branch Coal Run V-notch intact	36	PVW
31	Mine seal NE of the village of Coal Run V-notch intact	34	PVW
32	Mine seal on North branch of Coal Run Stand pipe destroyed	3	BS
33	Mine seal on North branch of Coal Run V-notch intact	6	PVW
34	Headwaters of Southern most tributary to Elk Lick	5	BS
35	Mine seal on West branch of Coal Run - V-notch intact - WPA No. 37	12	PVW

* - VE - Visual estimate; BS - Calibrated bucket-stopwatch; PF - Portable cut-throat flume; FM - Hydraulic flow meter; PVW - Permanent V-notch weir; PRW - Permanent rectangular weir.

Project Map Designation	Location and Status	Approximate Discharge - in gpm	Type of Flow Measuring Device *
36	Flaugherty Run at mouth	--	FM
37	Mine seal discharge on N side of Saylor's Hill - no V-notch	3	BS
38	Mine seal discharge on N side of Saylor's Hill - no V-notch	2	VE/BS
39	Miller Run at mouth	5	VE/PF
40	Seep along Casselman North of Shaw Mines	2	VE/BS
41	WPA weir No. 4 - mine seal North of Shaw Mines - no V-notch	1	VE
42	Seep along Casselman North of Shaw Mines	2	VE/BS
43	Seep along Casselman North of Shaw Mines	4	VE/BS
44	Unnamed Northern tributary to Shaw Mines Run	3	VE/PF
45	Shaw Mines Run at mouth	1000	VE/FM
46	David Yoder's Spring	1	VE/BS
47	Mine seal on South side of Shaw Mines Run No V-notch	3	VE/BS
48	Elk Lick at Summit Mills Bridge	--	FM
49	Tipple pile seep East of Shaw Mines	3	VE/BS
50	Weir 11 discharge just before it enters the Casselman	200	VE/BS
51	E side tributary to Casselman	6	VE/BS
52	E side tributary to Casselman	4	VE/BS
53	Casselman downstream from Boynton	--	FM
54	E side tributary to Casselman	4	VE/BS
55	Casselman downstream of Boynton	--	FM
56	Boynton Drive-in Creek	5	VE/FM
57	Casselman downstream of Boynton	--	FM
58	Coal Run at mouth	--	FM
59	Casselman upstream of Piney Creek	--	FM
60	Casselman upstream of Boynton	--	FM
61	Casselman at railroad bridge upstream of Boynton	--	FM
62	Northern tributary to Coal Run	2	VE
63	Mine seal North of Coal Run - no V-notch	5	VE/BS
64	Mine seal North of Coal Run - WPA No. 36 V-notch intact	8	PVW
65	Mine seal North of Coal Run - WPA No. 35 V-notch intact	9	PVW
66	Mine seal North of Coal Run - WPA No. 34 Stand pipe is destroyed	1	VE/BS
67	Mine seal North of Coal Run - WPA No. 32 No V-notch - stand pipe broken	1	VE/BS
68	Mine seal North of Coal Run - WPA No. 41 V-notch	6	PVW

* - VE - Visual estimate; BS - Calibrated bucket-stopwatch; PF - Portable cut-throat flume; FM - Hydraulic flow meter; PVW - Permanent V-notch weir; PRW - Permanent rectangular weir.

Project Map Designation	Location and Status	Approximate Discharge - in gpm	Type of Flow Measuring Device *
69	Mine seal South of Coal Run - WPA No. 28 or 29 - no V-notch	2	VE/BS
70	Mine seal South of Coal Run - WPA No. 26 or 27 - no V-notch	2	VE/BS
71	Mine seal South of Coal Run - no V-notch	5	VE/BS
72	Mine seal North of Coal Run - no V-notch	10	VE/BS
73	Mine seal North of Coal Run - WPA No. 38 - No V-notch	7	VE/BS
74	Mine seal North of Coal Run - WPA No. 40 - No V-notch, stand pipe crushed	5	VE/BS
75	Mine seal discharge North of Coal Run - No V-notch	30	VE/FM
76	Mine seal on N branch of Coal Run - no V-notch	6	VE/BS
77	Mine seal on N branch of Coal Run - top of stand pipe broken - no V-notch	6	VE/BS
78	Elam Bender Spring at head of the N branch of Coal Run	2	VE

* - VE - Visual estimate; BS - Calibrated bucket-stopwatch; PF - Portable cut-throat flume; FM - Hydraulic flow meter; PVW - Permanent V-notch weir; PRW - Permanent rectangular weir.

SHAW MINES COMPLEX

MONITORING POINT SUMMARY

Rationale for Sampling

Monitoring Point No. (Project Map Designation)	
1	Headwaters of a large drainage (W. branch of Shaw Mines Run) - DER chemistry data 1967-1973
2	Representative sample of water in the two western tributaries of Shaw Mines Run - DER chemistry data 1967-1973
3	Provides a mainstream measure of Shaw Mines Run before Casselman confluence for loading computations - DER chemistry data 1967-1973
4	Records the quality of the Casselman after leaving the Complex
5	Allows evaluation of the effect of the Elk Lick drainage on the Casselman
6	Records quality of Casselman before entrance of Coal Run - DER chemistry data 1967-1981
7	Records quality of Casselman after all mine drainage from the Complex has reached the river - DER chemistry data 1967-1981
8	Headwaters of a drainage that has been daylighted
9	Provides a mainstream measure of "Saylor's Hill Run" before Casselman confluence for loading computations
10	Records quality of Casselman before entrance of Shaw Mines Run - DER chemistry data 1980
11	Largest mine seal flow in the study area. Appears to be draining a huge area - DER chemistry data 1972-1973
12	Large mine seal draining old strippings and deep mines - DER chemistry data 1980
13	Provides a mainstream measure of Coal Run before Casselman confluence for loading computations - DER chemistry data 1967-1981
14	Representative sample of S. branch of Shaw Mines Run - DER chemistry data 1967-1973

Monitoring Point No. (Project Map Designation)	
15	Allows evaluation of the effect of Piney Creek on the Casselman - DER chemistry data 1967-1981
16	Records quality of a mine seal drainage in a stripped mined watershed
17	Records quality of a mine seal in an area that has been stripped recently
18	Allows assessment of the impact of mining (proposed and active) on tributaries of Elk Lick Creek.
19	Records quality of Casselman after entrance of Weir 11 discharge
20	Records quality of Casselman before Weir 11 discharge
21	Allows evaluation of the recovery of the Casselman approximately halfway between Coal Run and Weir 11
22	Representative sample of a Casselman tributary draining a large area - DER chemistry data 1980
23	Allows assessment of the impact of Coal Run on the Casselman - DER chemistry data 1980
24	Reprsentative sample of N. tributary to Coal Run
25	Records quality of a mine seal in a watershed recently stripped and unreclaimed
26	Records quality of Casselman before it enters the Shaw Mines Complex
27	Representative sample of W. branch of Coal Run
28	Representative sample of W. branch of Coal Run. Active mining in watershed
29	Mine seal draining a large area. One of only a few flows on the S. side of Coal Run
30	Mine seal draining a recently stripped area. More stripping planned in the area
31	Mine seal draining a recently stripped area. More stripping planned in the area - DER chemistry data 1967-1973
32	Mine seal draining in an undisturbed area to be stripped in the near future

Monitoring Point No. (Project Map Designation)	
33	Mine seal draining an active strip job
34	Field drain below a strip mine reclaimed in 1981
35	Mine seal draining an old reclaimed strip mine - DER chemistry data 1967-1973