RESULTS OF THE INVESTIGATION

The results of the Watershed Investigation indicate that approximately 22.7 miles of streams are being affected by acid mine drainage from abandoned surface and underground mining. These miles are portions of streams that have a pH of less than 5.0, concentrations of net acidity of 14 mg/L or greater during periods of low flow and are not a stable environment for aquatic life. Local history gives evidence that these streams were fished before mines were open in Arnot and Antrim. In addition, 6.5 miles of tributaries are carrying higher concentrations of acid which average 38.6 mg/L or greater and have a pH of 3.8 or less. The names of some of these streams, such as Paint Run and Red Run, suggest that they may have always been naturally acidic. This condition may result from pyritic rock formations in the area as well as organic acids produced from decayed matter, particularly in the swampland headwaters of some streams.

The large area within the Babb Creek Watershed (129 square miles) furnishes large volumes of water that are contaminated by relatively small amounts of acid mine drainage. Roughly 10% of the watershed (8,000 acres) contains strata of workable coal of which about 4,000 acres are estimated to have been deep mined, primarily in the Bloss coal seam. It is drainage from these abandoned deep mines that is polluting the downstream waters of Wilson Creek and the upstream waters of Babb Creek.

Surface mining was concentrated in the Antrim, Anna S and Rattler areas, with approximately 60% of the 815, acres disturbed being located in coal horizons above the abandoned underground mines. Downward percolation of water through these disturbed areas drains into the underground mines and therefore affects the quality of water flowing from the mines, even though most of the abandoned strippings

have been restored.[1]

Mine waste from abandoned underground mines covers an area of approximately 24 acres. This waste is composed of strongly weathered carbonaceous shale, and binder, nearly half of which has burned. Much of the "Red Dog" has been removed for road base material.

Upper Babb Creek receives approximately 31.7% of the A.M.D. flow and 21.8% of the total acid load within the watershed. This includes sources at the Arnot No. 2 Mine, the Klondike Mine and the Bear Run Mine. The mines at Rock Run in the Antrim Complex contribute another 1.4% of total A.M.D. flow and 3.8% of the acid load at a point 3.5 miles further downstream.

Wilson Creek between Antrim and Morris receives by far the most significant portion of acid mine drainage within the watershed. Approximately 62% of the A.M.D. carrying 61.6% of the total acid load originates at the Antrim and Anna S mining complexes, 2 miles north of Morris.

The Rattler Mine is the only significant source of A.M.D. flowing into Stony Fork via Paint Run. Some drainage from reclaimed surface mining undoubtedly finds its way into Paint Run but no channeled discharge large enough to monitor was discovered during the field investigation. Discharges from the Rattler Mine make up approximately 4.8% of the A.M.D. in the watershed and 12.8% of the acid load; however, no detrimental affect on Babb Creek from these sources is apparent due to the neutralization of Paint Run after it flows into Stony Fork. See hydrology data for station Al-l, Appendix C.

[1] Approximately 700 acres (465 acres in the Antrim Mining Complex, 95 acres in the Anna S Complex and 140 acres in the Rattler Complex) have been reclaimed under the conditions of the Surface Mining Conservation and Reclamation Act. The remaining 115+ acres of "Pre-Act" stripping are located throughout the watershed. Most of these unreclaimed strippings are in a process of natural reforestation.

The following table lists the percentages of contribution of acid mining drainage from the six mining complexes in the watershed.

TABLE A

	% FLOW	% NET ACIDITY	% NET ALKY	% TOTAL IRON	% FERROUS IRON	% SULFATE
Arnot #2	10.08	4.87	0	0.82	0.71	6.88
Klondike	10.60	6.13	0	4.77	1.04	11.79
Bear Run	11.06	10.83	0	11.00	10.17	14.10
Antrim*	41.20	40.05	0	22.19	24.17	16.27
Anna S	22.21	25.36	0	30.16	7.06	38.02
Rattler	4.85	12.76	0	31.06	56.85	12.94

*Includes discharges at Rock Run--station C13-2 and C13-3.

This table does not include run-off from mine waste deposits at some complexes. There are three such deposits in the watershed that are potential sources of acid drainage during periods of heavy rainfall. These deposits are located at the Anna S Mine, the Klondike Mine and the Bear Run Mine. Analysis of water samples taken as run-off after a period of heavy rainfall is listed in Table B. The samples show that these deposits have relatively heavy concentrations of acid and ferric iron; however, it is difficult to determine their impact on the water quality of receiving streams because the volume of run-off is almost impossible to measure. An attempt was made to observe change in water quality on Wilson Creek just below the mine waste deposit for the Anna S but water analysis results were inconclusive. (See stations B1-13a and BI-13c-Appendix C.) Table B shows the results of the mine waste run-off analysis.

TABLE B

	ACIDITY	ALKALINITY	TOTAL IRON
Anna S	275 mg/L	0 mg/L	4.0 mg/L
Klondike	260 mg/L	0 mg/L	1.20 mg/L
Bear Run	260 mg/L	0 mg/L	0.85 mg/L

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DESCRIPTION OF 12-MONTH SAMPLING STATIONS

The 12-month sampling stations have been divided into the following categories:

1. Source Sites: Includes the sites that contribute A.M.D. to the watershed. These sites include deep mine, drifts, mine waste, and strip mined areas.

2. Affected Streams: Streams and tributaries into which source sites empty.

3. Control Stations: Streams that have been used as quality control streams. Selection of these sites are in areas that should represent general unaffected waters in the surrounding area. Water-analysis from these control sites, excluding stations Cl-lB and Cl-1C, has also been used to establish criteria for stream vitality. See page 32.

SOURCE SITES

SITE	ELEVATION FEET	DESCRIPTION	NET AV. ACIDITY LBS./DAY
A2-2	1725.50	Mine Drift, ("B") vein, Rattler Mine	446.8
A2-3	1717.17	Mine Drift, ("B") vein, Rattler Mine	473.9
A2-4	1738.74	Mine Drift, ("B") vein, Rattler Mine	392.0
A2-10	1781.23	A.M.D. north of reclaimed stripping (possible deep mine contribution)	101.4
A3-4	1852.24	Mine Drift, ("B") vein, Rattler "Annex"	13.5
B1-5	1669.15	"Hunter" Mine Drift, ("B") vein, Anna S Mine	1554.4
B1-20	1682.66	Main Entry, ("B") vein, Anna S Mine	1039.3
B1-22	1672.83	Mitchell Mine Drift, ("B") vein, Anna S Mine	199.6
B1-23	1674.90	Mitchell Mine Drift, ("B") vein, Anna S Mine	29.2
B1-31	1681.47	Pre-Act Stripping, ("B") vein, Anna S Mine	17.6
B1-14	1650.38	Main Entry, ("B") vein, Antrim #1 Mine	3768.6
B1-16	1704.28	Mine Drift, ("B") vein, Switchback-Antrim	274.5
B1-24	1702.39	Mine Drift, ("B") vein, Cope Mine	9.2
B1-25	1715.09	Surface Water passing through spoil	13.0
C13-2	1703.30	Mine Drift, ("B") vein, Young & VanOrder Mine (Rock Run)	362.4
C13-3	1685.01	Stripped Mine Drift with open highwall, Birchstill ("B") vein	67.5
C1-14	1726.59	Mine Drift with air seal, ("B") vein, Bear Run Mine	997.8
C1-15	1726.20	Mine Drift with air seal, ("B") vein, Bear Run Mine	16.3
C1-16	1749.33	Stripped Mine Drift with open highwall, ("B") vein, Bear Run Mine	194.8

SITE	ELEVATION FEET	DESCRIPTION	NET AV. ACIDITY LBS./DAY
C1-17	1813.90	"Brown's Drift", ("B") vein, Bear Run Mine	40.4
C7-2	1724.64	Main Entry, ("B") vein, Klondike Mine	564.7
C9-2	1751.54	"Davis Drift", ("B") vein, Klondike Mine	122.2
C8-4	1709.73	Open Deep Mine Watercourse, ("B") vein, Arnot #2 Mine	48.7
C8-5	1716.14	Mine Drift, ("B") vein, Arnot #2 Mine	122.3
C8-8	1721.16	"Monkey Drift", Watercourse, Arnot #2 Mine	422.9
C8-7	1707.36	Mine Drift, ("B") vein, Arnot #1 Mine	1.2*
C8-9	1696.31	Main Entry, ("B") vein, Arnot #1 Mine	63.6*

AFFECTED STREAM MONITORING SITES

SITE	ELEVATION FEET	DESCRIPTION	NET AV. ACIDITY LBS./DAY
A1-1	935	Mouth of Stony Fork	8861.0*
A2-1	1080	Mouth of Paint Run	3037.0
A2-13	1570	Mouth of Paint Run Tributary	179.7
A3-1	1140	Mouth of Black Run	203.3
B1-1	1010	Mouth of Wilson Creek	4090.0
B1-4b	1140	Mouth of Basswood Run	3012.0
B1-7	1180	Mouth of Wilson Run	30.3
B1-8	1210	Mouth of Bridge Run	3620.0
C1-1	855	Mouth of Babb Creek	9587.6*
C1-4a	1035	Babb Creek at Morris	1152.0
C1-7a	1165	Babb Creek Upstream from Mouth of Rock Run	525.0
C1-19	1450	Mouth of Rattlesnake Run	8.2
C7-1	1360	Mouth of Lick Creek	1374.3
C8-1	1630	Lick Creek Downstream from Mouth of South Creek	264.1
C9-1	1535	Mouth of Red Run	476.2
C13-1	1160	Mouth of Rock Run	1042.4

CONTROL STATIONS

SITE	ELEVATION FEET	DESCRIPTION	NET AV. ALKALINITY LBS./DAY
A1-4a	1145	Stony Fork Upstream from Mouth of Black Run	6877.4
A2-6	1695	Headwaters of Paint Run	154.5**
B1-12c	1315	Wilson Creek Downstream from Mouth of Sand Run (Duncan Township)	2760.0
C1-1a	860	Pine Creek Upstream from Mouth of Babb Creek	75466.0
C1-1c	845	Pine Creek Downstream from Mouth of Babb Creek	105304.0
C1-20	1685	Headwaters of Babb Creek	1407.9
C1-21a	1360	Babb Creek Upstream from Mouth of Lick Creek	1577.0
C10-1	1440	Mouth of Sand Run (Bloss Township)	393.9
C12-1	1185	Mouth of Nickle Run	69.1

*Net Alkalinity
**Net Acidity

The following sites are possible sources of acid mine drainage and water samples have been taken periodically. Because of negligible flows, and at some sites no flow at all, permanent monitoring stations were not established.

A2-5

A2-14

A2-15

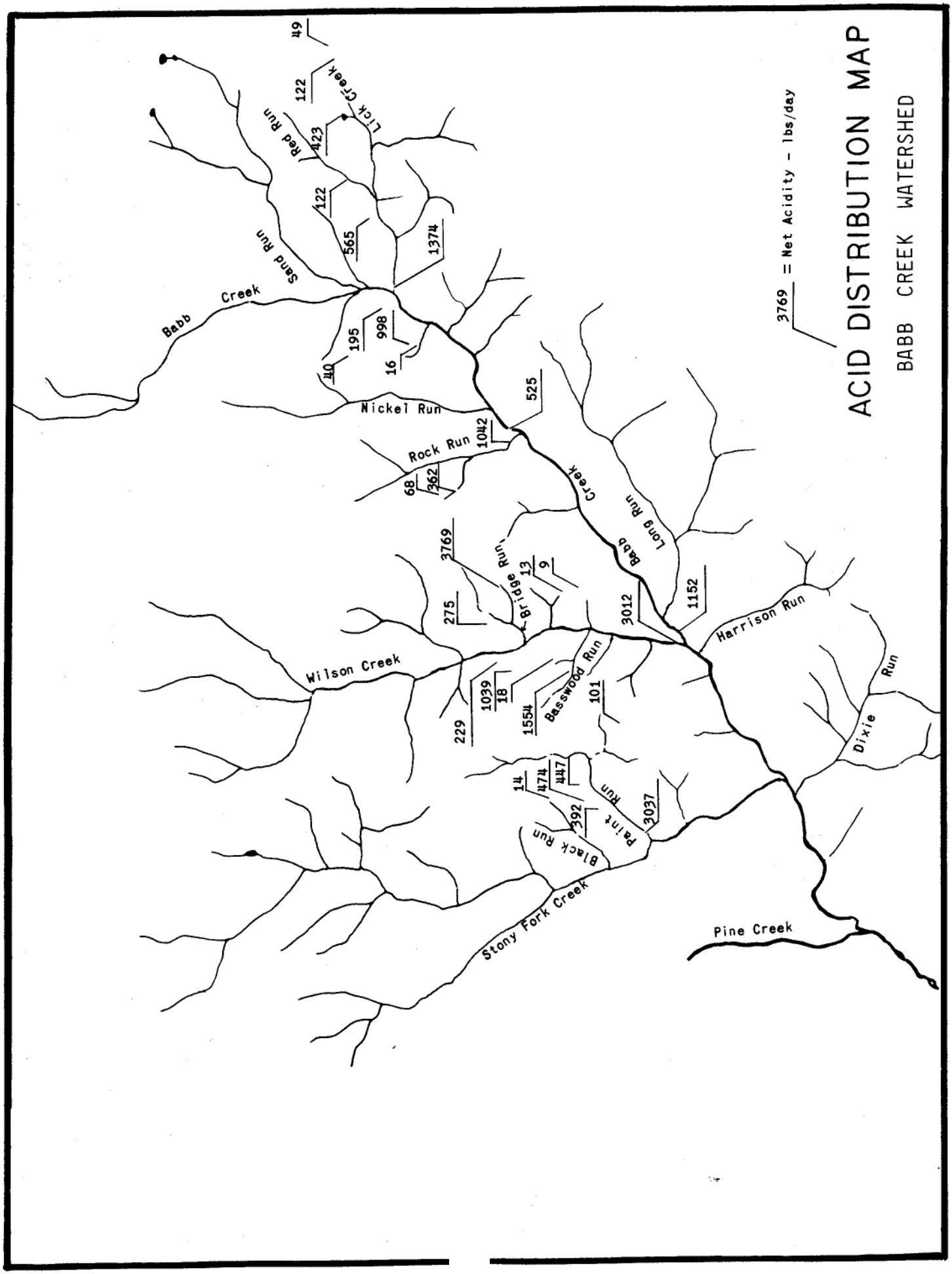
B1-13a

B1-13c

For complete location description and water analysis data see Appendix A and Appendix C respectively.

Figure V, page 26, is an acid distribution map showing net acid loading for the 12-month sampling stations. For a complete location description and a water analysis/loading inventory, see Appendix A and Appendix C respectively.

FIGURE V


ACID DISTRIBUTION MAP
BABB CREEK WATERSHED
3769 = Net Acidity - lbs/day
Babb Creek
Sand Run
Red Run
Lick Creek
Nickel Run
Rock Run
Long Run
Bridge Run
Basswood Run
Paint Run
Black Run
Wilson Creek
Stony Fork Creek
Harrison Run
Dixie Run
Pine Creek
49
122
423
122
565
1374
195
998
40
16
525
1042
68
362
3769
275
13
9
3012
1152
1039
18
1554
229
101
14
474
447
392
3037

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ESTIMATES OF DEEP-MINED AREAS USING SELECTED FLOW DATA

Mine maps of the six deep-mine complexes are indispensable for accurately determining both the area mined and the expected hydraulic head pressure, in the event hydraulic seals are feasible. In this respect, maps for the Antrim and Rock Run Mines, as well as several smaller mines, are very inadequate. To compensate for this, average monthly flows from A.M.D. Discharge Points have been used to estimate the acreage of the deep mine watersheds where mine maps are incomplete or unavailable. To check the accuracy of these estimates, flows from deep mines of the known area are also projected using the same computation.

"Run-off per Acre" is calculated from the twelve-month average run-off figures (cross sectional stream flow measurements) at three selected locations. This average stream flow measurement for each sub-watershed is then divided by the sub-watershed land area to obtain the Sub-watershed "Run-off per Acre" Constant. The three locations are:

A1-1 - The mouth of Stony Fork Creek for the "A" Sub-watershed.
B1-1 - The mouth of Wilson Creek for the "B" Sub-watershed.
C1-4a - Babb Creek at Morris for the "C" Sub-watershed.

"A" SUB-WATERSHED (STONY FORK CREEK) - TOTAL LAND AREA = 24,045 ACRES

STATION	AVERAGE FLOW	RUN-OFF PER ACRE[1] (gal/ac/day)		ESTIMATED DEEP-MINED AREA[2]
A1-1	42,423 mg/day	1764.33		
		RATTLER MINE		
A2-2	103,000 gal/day	1764.33		58.38 ac
A2-3	73,000 gal/day	1764.33		41.38 ac
A2-4	39,000 gal/day	1764.33		22.10 ac
	Total Estimated Area - Rattler			121.86 ac
	Mapped Area - Rattler		101.23 ac	
A-3	32,000 gal/day	1764.33		18.14 ac
	Total Estimated Area - Rattler Annex			18.14 ac
	Mapped Area - Rattler Annex		3.50 ac	

(1) Sub-watershed "Run-off per Acre" Constant = $\frac{\text{Av. Sub-watershed Flow (gal/day)}}{\text{Sub-watershed Land Area (acres)}}$

(2) "Estimated Deep-Mined Area" for each mine drainage source = $\frac{\text{Av. Flow at Mine Drainage Source (gal/day)}}{\text{Sub-watershed "Run-off per Acre" Constant (gal/ac/day)}}$

"B" SUB-WATERSHED (WILSON CREEK) - TOTAL LAND AREA = 14,464 ACRES

STATION	AVERAGE FLOW	RUN-OFF PER ACRE[1] (gal/ac/day)		ESTIMATED DEEP-MINED AREA[2]
B1-1	24.864 mg/day	1719.03		
		ANNA S MINE		
B1-5	561,000 gal/day	1719.03		326.35 ac
B1-20	601,000 gal/day	1719.03		349.62 ac
B1-31	56,000 gal/day	1719.03		32.58 ac
A2-10	58,000 gal/day	1764.33		32.87 ac
	Total Estimated Area - Anna S Mine			742.59 ac
	Mapped Area - Anna S Mine		813.65 ac	
		MITCHELL MINE		
B1-22	162,000 gal/day	1719.03		94.24 ac
B1-23	22,000 gal/day	1719.03		12.80 ac
	Total Estimated Area - Mitchell Mine			107.04 ac
	Mine Map Not Available - Land Area		30.00 ac	
		ANTRIM MINE		
B1-14	2,341,000 gal/day	1719.03		1361.81 ac
B1-16	158,000 gal/day	1719.03		91.91 ac
	Total Estimated Area - Antrim Mine			1453.72 ac
	Mapped Area - Backswitch Section of Antrim Mine (B1-16)		102.04 ac	
		PERCY COPE MINE		
B1-24	18,000 gal/day	1719.03		10.48 ac
	Total Estimated Area - Cope Mine			10.48 ac
	Mapped Area - Cope Mine Map Not Available			

"C" SUB-WATERSHED - BABB CREEK UPSTREAM FROM MORRIS
TOTAL LAND AREA = 37,606.4 ACRES

C1-4a	66.762 mg/day	1775.28		
		YOUNG & VANORDER MINE		
C13-2	65,000 gal/day	1775.28		36.61 ac
	Total Estimated Area - Young & VanOrder Mine			36.61 ac
	Mapped Area - Young & VanOrder Mine Map Not Available			

(1) Sub-watershed "Run-off per Acre" Constant = $\frac{\text{Av. Sub-watershed Flow (gal/day)}}{\text{Sub-watershed Land Area (acres)}}$

(2) "Estimated Deep-Mined Area" for each mine drainage source = $\frac{\text{Av. Flow at Mine Drainage Source (gal/day)}}{\text{Sub-watershed "Run-off per Acre" Constant (gal/ac/day)}}$

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MILES OF POSSIBLE STREAM IMPROVEMENT

"Miles of Possible Stream Improvement" represents the miles of Babb Creek and its tributaries affected by each mining complex within a representative sub-watershed. In sub-watersheds where more than one mine complex affects the water quality of the same stream "Miles of Possible Stream Improvement" is measured from the point in the stream where an A.M.D. discharge enters, to the next point of discharge downstream.

"Total Miles of Possible Stream Improvement" is the sum of all miles of stream that will be improved if abatement procedures are successful at all mining complexes within a sub-watershed.

"C" SUB-WATERSHED

	MILES OF POSSIBLE STREAM IMPROVEMENT
ARNOT #2 COMPLEX(1)	
Lick Creek to Red Run	2.1 miles
KLONDIKE COMPLEX	
Red Run to Lick Creek	0.9 miles
Lick Creek to Babb Creek	1.5 miles
Babb Creek to Bear Run Mine Influx	0.4 miles
BEAR RUN COMPLEX	
Rattlesnake Run to Babb Creek	1.1 miles
Babb Creek to Rock Run	3.5 miles
ROCK RUN MINES(Antrim Complex)	
Rock Run to Babb Creek	0.8 miles
Babb Creek to Cut-off Point at Morris	5.2 miles
MILES OF POSSIBLE STREAM IMPROVEMENT	15.5 miles

(1)Water quality improvement may be achieved at the headwaters of Johnson Creek if the A.M.D. discharge at station C8-4 (Arnot #2 Mine) is successfully abated. The next mine water influx on Johnson Creek flows from the Arnot #3 Mine, 0.5+ miles downstream.

"B" SUB-WATERSHED

	MILES OF POSSIBLE STREAM IMPROVEMENT
ANTRIM COMPLEX	
South Fork of Bridge Run to Wilson Creek	0.6 miles
Wilson Creek to Anna S Mine Influx	0.5 miles
ANNA S COMPLEX	
Wilson Creek to Babb Creek at Morris	1.7 miles
Basswood Creek to Wilson Creek	0.9 miles
Miles of Possible Stream Improvement in "B" Sub-watershed[1]	3.7 miles
Miles of Possible Stream Improvement in "C" Sub-watershed[1] (Babb Creek at Morris to Cut-off Point at Blackwell)	5.4 miles
MILES OF POSSIBLE STREAM IMPROVEMENT	9.1 miles

"A" SUB-WATERSHED

RATTLER COMPLEX	
Paint Run to Stony Fork	1.7 miles
Stony Fork to Babb Creek[2]	2.2 miles
MILES OF POSSIBLE STREAM IMPROVEMENT	3.9 miles
TOTAL MILES OF POSSIBLE STREAM IMPROVEMENT	28.5 miles

[1] Babb Creek at Morris has been designated the cut-off point for stream improvement in the "C" Sub-watershed. Because of the high acid loads of the Antrim and Anna S Mines, the cut-off point for the "B" Sub-watershed was designated further downstream on Babb Creek at Blackwell.

[2] The affects of A.M.D. from Paint Run flowing through the final 2.2 miles of Stony Fork are uncertain. Water quality data indicates the stream is a viable environment for aquatic life. See

"Criteria for Stream Water Quality in the

Babb Creek Watershed", page 32 . Also see hydrology data for Al-1, Appendix C.

CRITERIA FOR STREAM WATER QUALITY IN THE BABB CREEK WATERSHED

The following is a table of water analysis averages at control stations located on streams that either do not receive A.M.D. or on streams that do, but at points further downstream. Water analysis for the six control stations has been averaged to provide a reference for water quality which should be obtained if the abatement plan is to be successful.

STATION	FLOW MG/DAY	pH	ACIDITY mg/L	ALKALINITY mg/L	TOTAL FE mg/L	FERROUS mg/L	SULFATE mg/L
A1-4a	21.561	7.0	2.3	55	0.16	0.10	67
A2-6	2.707	5.2	11.8	7	0.30	0.17	58
B1-12c	13.857	7.0	6.0	38	0.17	0.07	47
C1-20	7.243	6.9	4.3	37	0.32	0.20	54
C10-1	10.717	6.2	5.0	13	0.33	0.08	48
C12-1	3.267	6.0	8.7	10	0.14	0.07	52
Average		6.4	6.35	26.7	0.24	0.12	54

The above averages indicate a ,"stream standard" that should support aquatic life. It is known that trout live upstream from stations Al-4a, B1-12c, C10-1 and C12-1. The averages fall within the stream standard set by the D.E.R., Bureau of Water Quality Management listed below:

pH -Not less than 6.0 and not more than 8.5.

Total Iron -Not more than 1.5 mg/L.

Sulfate -Not more than 250 mg/L or natural levels, whichever is greater.

Temperature -Not more than 58^0 F.

In a study published by the Fourth Symposium on Coal Mine Drainage Research1972, results indicate young brook trout have a greater susceptibility to disease, injury and winter mortality in concentrations of ferric hydroxides greater than 6 mg/L. They also found that the safe concentration for reproduction and growth "of fish and water shrimp" to be less than 3 mg/L.[1]

Other standards may show that much lower concentrations of ferric hydroxide have chronic effects on aquatic life, but it can be seen that the above stream sample average for total iron is well below the concentration found detrimental by the study sited above.

[1]Sykora, Jan, E. J. Smith, M. A. Shappiro and M. Synak, "Chronic Effect of Ferric Hydroxide on Certain Species of Aquatic Animals", University of Pittsburgh, Pittsburgh, Pennsylvania, 1972.