II. EXISTING CONDITIONS

WATERSHED CHARACTERISTICS

For the study purposes, each watershed was divided into sub-areas, representing different topographic, mining, or runoff conditions. Limits of these watersheds and sub-area descriptions are shown in FIGURE I.*

Outside the coal measures, the un-mined areas (A and B) are in the upper reaches of the watersheds and are relatively undisturbed forested areas. Due to the absence of mining activities, the existence of tree cover and the relatively steep slopes, the characteristics of the surface water in this area are as follows:

a. The water is of good quality.

b. The "base flow" in the streams is steady and dependable with no losses from streambeds.

e. The "time of concentration" is relatively short resulting in quick response to precipitation runoff.

In Area A, surface runoff and base flow contribute to the flow of the streams that are located outside the coal measures. Upon crossing the coal measures, these streams begin to lose water into the deep mines. Surface runoff from Area B is completely intercepted by downslope strip mine pits and subsidence depressions that are located within the coal basin.

Within the coal measures, the watersheds are divided into three sub-areas. These areas have been exposed to deep and strip mining operations and contain urbanized areas. The upper areas (C and D) are areas where the groundwater table and mine pools are well below surface stream levels. This-combined area extends down slope of the bottom coal outcrop line (limit of coal measures) to about the alignment of Middle Road. Area C contains isolated sub-urban areas and was extensively strip mined and deep mined. Most of the precipitation and runoff in this area is intercepted by strip pits and subsidence depressions and infiltrates into the deep mines. Runoff contribution to stream flow is negligible in

* Pocket

area C. Area D is urban and suburban with extensive abandoned deep mines and limited strip mining operations. Runoff from precipitation over this area is intercepted by strippings where some water losses to the deep mines occur. Consequently, runoff contribution to stream flow in sub-area D is limited. Area E extends approximately from the "Middle Road" to the Susquehanna River, where groundwater and mine pool elevations are near streambed levels. Consequently, there are no significant streambed losses to the deep mines in Area E. Some precipitation and runoff is intercepted and lost in isolated strip mines and mine waste dumps. The stream channels in this area are the recipient of AMD discharges from mine pools and the contaminated groundwater. These discharges consist of major single-point discharges and limited surface seepage areas into the stream channels.

GEOLOGIC CONDITIONS

GENERAL: Basic geologic and mining information was obtained from maps and reports published by State and Federal Agencies. This information and specific geologic and mining conditions were verified during field investigations by an Engineering Geologist from GEO-Technical Services.

The study area watersheds are in the Southeastern part of the Wyoming Valley coal basin which is at the Southern end of the Northern Anthracite Coal Field of Pennsylvania. This coal field is within the Appalachian Mountain Section of the Valley and Ridge Physiographic Province. The coal basin is part of a large synclinorium that trends in a general Northeast-Southwest direction. The basin is rimmed with resistant sandstone ridges to the North and South and is bisected by the Susquehanna River. The River, with a flood plain elevation of 520', is the Northern limit of the study area. The Southern limit of the study area is Penobscot Mountain, that varies from elevation 1,600' to 2,150'. This mountain also represents the Western rim of the Pocono Mountain Plateau area to the East.

Topographic features, the approximate limits of the various rock formations, the general geologic structure and the data related to mine pools and barrier pillars are shown on FIGURE 2, "Geologic Map & Sections" (pocket).

STRATIGRAPHY: The bedrock strata underlying the valley and adjacent mountains consist of sandstone, shale siltstone conglomerate and coal. In statigraphic sequence from the oldest to youngest, the following rock formations are present:

Catskill Formation (Devonian Age): Red, gray and green shale, siltstone and fine to medium sandstone. This rock formation is about 2,000 feet thick and underlies the rolling topography southeast of the watershed limits in the vicinity of Mountain Top and Crystal Lake.

Pocono Formation (Mississippian Age): Gray, hard, massive, sandstone and conglomerate with some siltstone and shale. This resistant rock formation is about 600 feet thick and forms Penobscot Mountain, the outermost and highest. ridges along the southeastern limit of the study area.

Mauch Chunk Formation (Mississippian Age),: Red shale interbedded with some green-gray and brown shale, siltstone and sandstone. This less resistant rock formation is about 1,000 feet thick in the study area and forms the narrow, elevated valley sections between Penobscot Mountain and WilkesBarre Mountain.

Pottsville Formation (Pennsylvanian Age): Light gray to white, medium to coarse grained sandstone and conglomerate. This resistant rock formation is 200 to 300 feet thick in the study area and forms Wilkes-Barre Mountain, the inner, lower rim of ridges on the south side of the Wyoming Valley.

Llewellyn Formation (Pennsylvanian Age): Light and medium gray, fine to coarse grained sandstone and conglomerate, interbedded with light to dark gray shale, siltstone and claystone, black carbonaceous shale and anthracite coal seams. This formation underlies the entire Wyoming Valley floor and lower mountain slopes. The formation is reported to contain at least 26 coal beds ranging in thickness from inches to 27 feet (Hollowell 1971; Ash 1954). The bottom workable coal seam of the Llewellyn Formation is the Red Ash (10' + thick) which outcrops on the mountain slopes at elevation 1,000 to 1,100 feet. The lowest mapped elevation of the Red Ash in the coal basin is 1,500 feet below sea level In the Askam Valley East of Nanticoke (Barton, 1938). In this same area, the upper beds of the Llewellyn Formation outcrop in the Mid-Valley ridge which rises to elevation 813 feet. This represents a maximum formation thickness of at least 2,300 feet. The strata between the coal. beds vary considerably in horizontal and vertical continuity. Lateral changes in thickness and lithology, cross-bedding and channel deposits are common. The coal beds, however, are relatively uniform in thickness and lateral continuity.

OVERBURDEN SOILS: Except for thin, limited areas of recent stream sediments and residual soils, the area is blanketed with a widespread, thin to thick cover of unconsolidated glacial deposits. These glacial deposits from the Pliestocene Period of geologic time, consist of undifferentiated glacial drift, glacial lake deposits and glacial outwash deposits. The present flood plain sediments of the Susquehanna River are underlain by a deep, wide buried valley filled with sediments that were deposited in a glacial lake that stood at a reported elevation of about 560 feet. Glacial outwash deposits and the buried lake sediments extend to a width of about one mile and a maximum depth of about 300 feet below the present flood plain in the vicinity of Buttonwood. These sediments consist of stratified deposits of clay, silt, fine to coarse sand and gravel. The remainder of the valley floor and the mountain slopes is covered with a blanket of unstratified glacial deposits. As a result of extensive surface strip mining in the area, much of the unstratified, glacial drift that blankets the study area has been excavated, mixed with, and covered by strip mine waste rock. Similarly, deep underground mining and coal processing operations have resulted in the glacial drift being covered with large, high culm and breaker waste piles and wide-spread coal silt banks.

STRUCTURE: The bedrock strata underlying the study area are in the Wyoming Valley Coal Basin, which is in the southern half of the large synclinorium that forms the Northern Anthracite Coal Field This syclinal structure trends (strikes) about N50°E and extends a distance of about 60 miles from Forest City on the northeast to Shickshinny on the southwest. The structure is rimmed with resistant sandstone ridges forming a crescent shaped valley with narrow ends and a broad, five mile wide central portion. The deepest part of this structure is in the study area where the coal basin extends to a maximum depth of 1,500 feet below sea level in the vicinity of Askam. From this low point, the bottom of the basin (the Red Ash

Coal Bed) rises on the southwest to about 400 feet below sea level near Glen Lyon and rises on the northeast to about sea level near Pittston. Within this area, the broad, essentially flat bottom coal basin contains several subordinate syclines, anticlines, overthrusts and faults that vary in magnitude, complexity and continuity. Records of deep mine workings in the vicinity of Askam and Warrior Run, reveal thrust faults with vertical displacements of 200 feet to 350 feet respectively (Darton, 1940). Along the southeastern outer rim of the coal basin, exposures of bedrock in strip pits and along Wilkes-Barre Mountain, exhibit a less complex structure. The strata in this area strikes N50° - 70°E and generally dips 300 to 45°NW.

GROUNDWATER AND MINE POOLS: Sub-surface water in the study area is encountered under normal water table conditions, and as confined water that exhibits artesian pressure and flow conditions. Normal water table conditions are found in the unconsolidated flood plain sediments and shallow bedrock along and adjacent to the Susquehanna River. Normal water table conditions are also found in the upper reaches of the tributary watersheds, beyond the limits of the coal measures. Confined water under artesian pressure and flow conditions is found along the narrow elevated valleys between Penobscot Mountain and Wilkes-Barre Mountain, such as the artesian well in the elevated valley at Sugar Notch. The pronounced water gap breaches in WilkesBarre Mountain indicate zones of highly fractured and/or faulted bedrock, which in turn, suggests narrow highly pervious zones that facilitate rapid groundwater movement toward the coal measures, and a reduction in the artesian pressure conditions. Such pervious pressure relief zones represent high recharge areas of clean groundwater that contribute to, and become contaminated by coal bearing strata and the deep mine pools underlying the study area. Confined water under variable water pressure conditions is also found in the deep mined areas where the breached and unbreached mine barrier pillars interact with mined and unmined strata to create isolated and interconnected mine pools at different elevations. Rapid percolation and leakage of precipitation in strip mine areas and direct loss off surface streams into the strip pits and underground mines results in rapid, large fluctuation of the mine pool levels. Pressure relief wells have been drilled through confining strata at critical locations of these mine pools to minimize fluctuation and to maintain lower mine pool levels. These relief wells have reduced mine pool flooding problems in the study area and are expected to minimize related subsidence problems and reduce the acid concentration of mine drainage by shortcutting the mine pool flow path contact with acid producing pyrites exposed in the deep mining operations (Hollowell., 1971).

HYDROLOGIC CONDITIONS

Surface runoff in the study area has undergone significant changes due to the mining activities. These changes are demonstrated by records of the USGS Station on Solomon Creek (S-4), available since 1940. These records also show the amount of mine water previously discharged by the deep mine pumps, upstream of the station. The rate of pumping from the operating deep mines, generally reflects the rate of surface water losses and groundwater recharge into these mines. Deep mining and pumping of mine water in the study area stopped in September 1967. The USGS records from Station S-4 vividly demonstrate the Solomon Creek watershed losses into the deep mines since the pumping was stopped. Previous attempts to reduce such surface water losses is depicted by the remains of stone paved channels, wooden and concrete flumes. These flumes were constructed directly in the streambeds, or as diversion channels adjacent to the streambeds. The most recent flume was constructed of concrete and is located in Leuder Creek, a tributary of Nanticoke Creek. The location of these structures, surface water loss areas and AMD discharge points are shown in FIGURES 3, 4 and 5 (pages 13,14, 15) for Solomon, Warrior and Nanticoke Creeks respectively.

Analysis of the long term records indicate that the mean annual surface runoff losses into the deep mines, in the Solomon Creek watershed, are 18.9 percent of the 40.3 inches mean annual precipitation. Derivation of the relationship between precipitation, runoff and losses into the deep mines is presented in Appendix B and is summarized as follows:

WATER LOSSES IN SOLOMON CREEK WATERSHED

PERIOD	VALUE IN INCHES				LOSSES AS % OF	
	PRECIP-ITATION	TOTAL RUNOFF (RUNOFF + LOSSES)	LOSSES INTO DEEP MINES	SURFACE RUNOFF	TOTAL RUNOFF	PRECIP-ITATION
1968 - 1973 (6 YEARS)	40.30*	19.89*	7.63*	12.26*	38.4%*	18.9%*
STUDY PERIOD 8/01/73-7/31/74	39.87	20.41	7.25	13.16	35.5%	18.2%
1972 FLOOD 6/16/72-6/30/72	6.82	5.93	3.37	2.56	56.8%	49.4%

* *Mean Annual for the indicated Period*

Expressing the losses into the deep mines as percent of the total runoff, for each period shown in the summary, above, indicates, that the maximum ratio between losses and total runoff occurred during the 1972 flood. These findings indicate that the rate of surface water losses into the deep mines increases with an increase in the rate of surface runoff.

Derivation of the relationship between precipitation runoff and water losses in the Warrior and Nanticoke Watersheds is presented in Section III of this report and is summarized below:

WATER LOSSES IN WARRIOR AND NANTICOKE CREEK WATERSHEDS

PERIOD	VALUE IN INCHES				LOSSES AS % OF	
	PRECIP-ITATION	TOTAL RUNOFF (RUNOFF + LOSSES)	LOSSES INTO DEEP MINES	SURFACE RUNOFF	TOTAL RUNOFF	PRECIP-ITATION
STUDY PERIOD 8/01/73-7/31/74	39.87	13.90*	20.41**	6.51	68.1%	34.9%

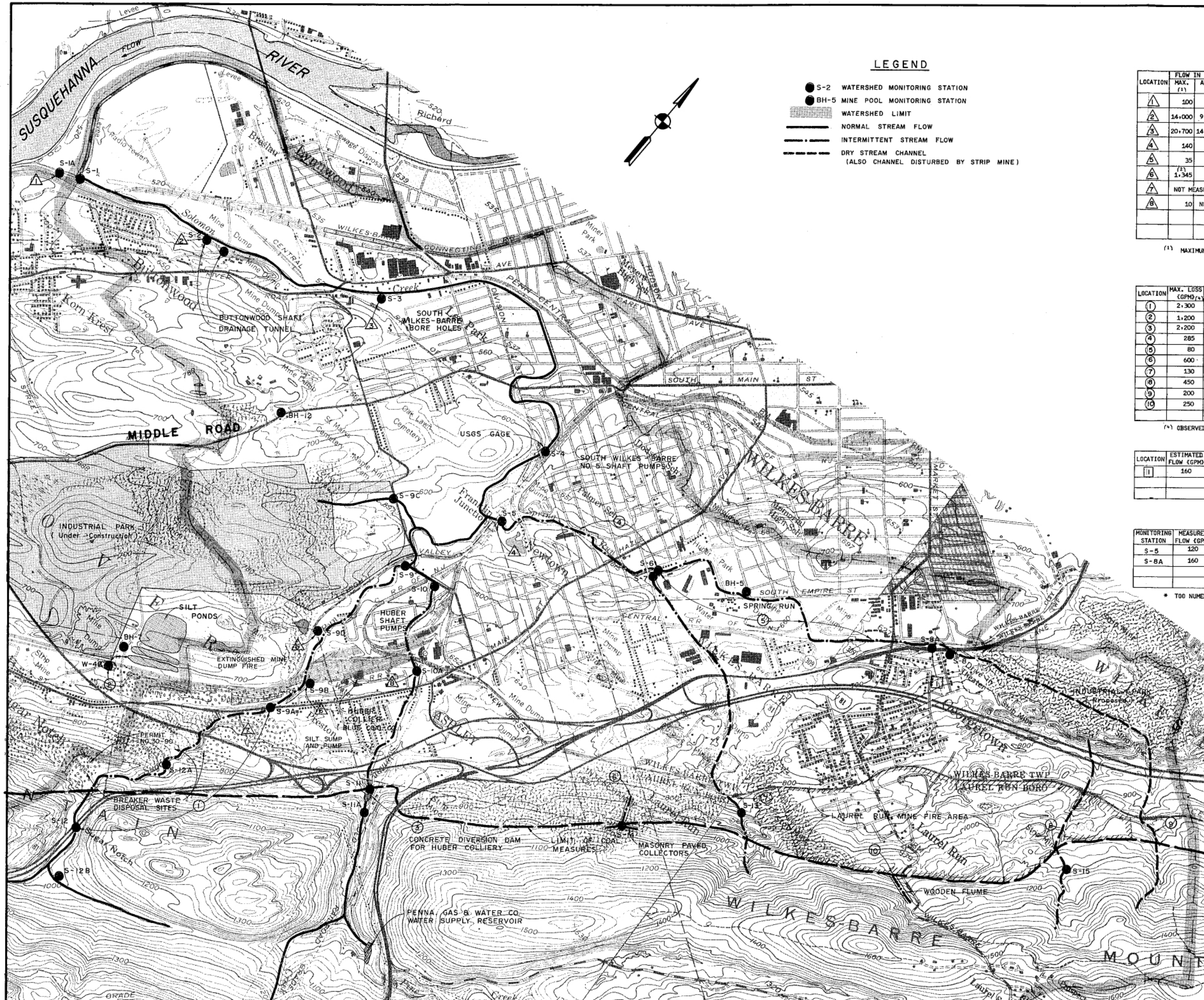
* *Excluding Blue Coal Co. Diversion from Solomon Creek. (see Fig.4 [1]).*
** *Adopted from Solomon Creek Watershed.*

<u>AND POLLUTION SOURCES,</u>

The major AMD discharge points in the study area are the South Wilkes-Barre boreholes (three 36" diameter holes), the Buttonwood Tunnel in the Solomon Creek watershed, shown in FIGURE 3, and the Askam borehole (36" diameter hole) in the Nanticoke Creek watershed, shown in FIGURE 5.

The tunnel and the boreholes were deliberately constructed to control the rise of water levels in the respective mine pools.

[1] *Succeeding-pages*



AMD DISCHARGES

LOCATION	FLOW IN GPM		AVERAGE AMD DISCHARGES									REMARKS
	MAX. (1)	AVG.	pH (3)	ACIDITY PPM	ACIDITY #/DAY	ALKALINITY PPM	ALKALINITY #/DAY	IRON PPM	IRON #/DAY	SULFATE PPM	SULFATE #/DAY	
△1	100	50	5.6	259	155	206	124	178	107	2,004	1,200	FLOW FROM HILLSIDE SEEPAGE AREA
△2	14,000	9,300	4.1	293	32,700	17	1,900	154	17,200	1,335	140,000	FLOW FROM BUTTONWOOD DRAINAGE TUNNEL, S-2
△3	20,700	14,100	3.2	639	108,266	0	0	319	54,100	1,855	314,100	FLOW FROM 3 BOREHOLES AT SOUTH WILKES-BARRE, S-3
△4	140	30	4.3	94	34	0	0	14	5	458	165	SEEPAGE FLOWS INTO STREAM CHANNEL
△5	35	13	2.9	910	330	0	0	39	14	2,076	750	SEEPAGE FLOW FROM WATER STORAGE POND
△6	(2) 1,345	930	4.1	73	808	2	24	71	780	281	3,100	SILT SUMP OVERFLOW AT HUBER COLLIERY (3)
△7	NOT MEASURED: SEE TESTS FOR S-12 & S-9A											SEEPS ALONG EDGE OF BREAKER WASTE DUMP
△8	10	NOT SAMPLED: ASSUMED SIMILAR TO △6										FLOW VIA 24" Φ PIPE FROM HUBER COLLIERY

(1) MAXIMUM FLOW OBSERVED (2) SUSPENDED SOLIDS - 2810 mg/l (3) LABORATORY pH

SURFACE WATER LOSSES

LOCATION	MAX. LOSS (GPM) (4)	DATE	EST. ANNUAL LOSS (MG) (5)	REMARKS
(1)	2,300	3/22/74	400	"CLEAN" STREAM FLOW LOST IN CREEK BED
(2)	1,200	2/05/74	(6)	SILT POND OVERFLOW OF HUBER COLLIERY WASH WATER INTO PIT
(3)	2,200	9/21/74	225	ENTIRE "CLEAN" STREAM FLOW DIVERTED TO HUBER COLLIERY
(4)	285	7/16/74	58	SEWAGE AND RUNOFF LOST IN STREAM CHANNEL
(5)	80	11/26/73	74	SEWAGE AND RUNOFF LOST IN STREAM CHANNEL
(6)	600	3/21/74	44	"CLEAN" STREAM FLOW LOST IN STRIP PIT
(7)	130	3/21/74	82	"CLEAN" STREAM FLOW LOST IN STRIP PIT
(8)	450	3/21/74	62	"CLEAN" STREAM FLOW LOST IN STRIP PIT
(9)	200	4/17/74	62	"CLEAN" STREAM FLOW LOST IN LOW PONDED AREA @ R.R.
(10)	250	3/21/74	51	"CLEAN" STREAM FLOW LOST IN STRIP PIT

(4) OBSERVED LOSS (5) FOR SAMPLING PERIOD (6) DISCHARGE POINT FOR 3

RAW SEWAGE DISCHARGES

LOCATION	ESTIMATED FLOW (GPM)	DATE	REMARKS
1	160	3/21/74	INTO STREAM CHANNEL FROM STORM SEWERS

TESTS OF SEWAGE PARAMETERS IN STREAMS

MONITORING STATION	MEASURED FLOW (GPM)	DATE	COLIFORM PER 100ML	BOD mg/l	NH_3-N mg/l	REMARKS
S-5	120	3/21/74	TNTC*	1	1.75	SOURCE NOT LOCATED
S-8A	160	3/21/74	TNTC*	4	1.26	STORM SEWER SOURCE

* TOO NUMEROUS TO COUNT

NOTES

1. BASE MAP IS U.S.G.S. 7½ MIN. QUADRANGLE (WILKES-BARRE EAST AND WILKES-BARRE WEST).
2. SUB-DRAINAGE AREAS FOR PRIMARY WATERSHED MONITORING STATIONS LISTED ON FIGURE NO. 1.
3. FLOW AND WATER QUALITY RECORDS FOR THE INDICATED MONITORING STATIONS ARE PRESENTED IN APPENDIX A.

SCALE IN FEET
1000 0 1000 2000

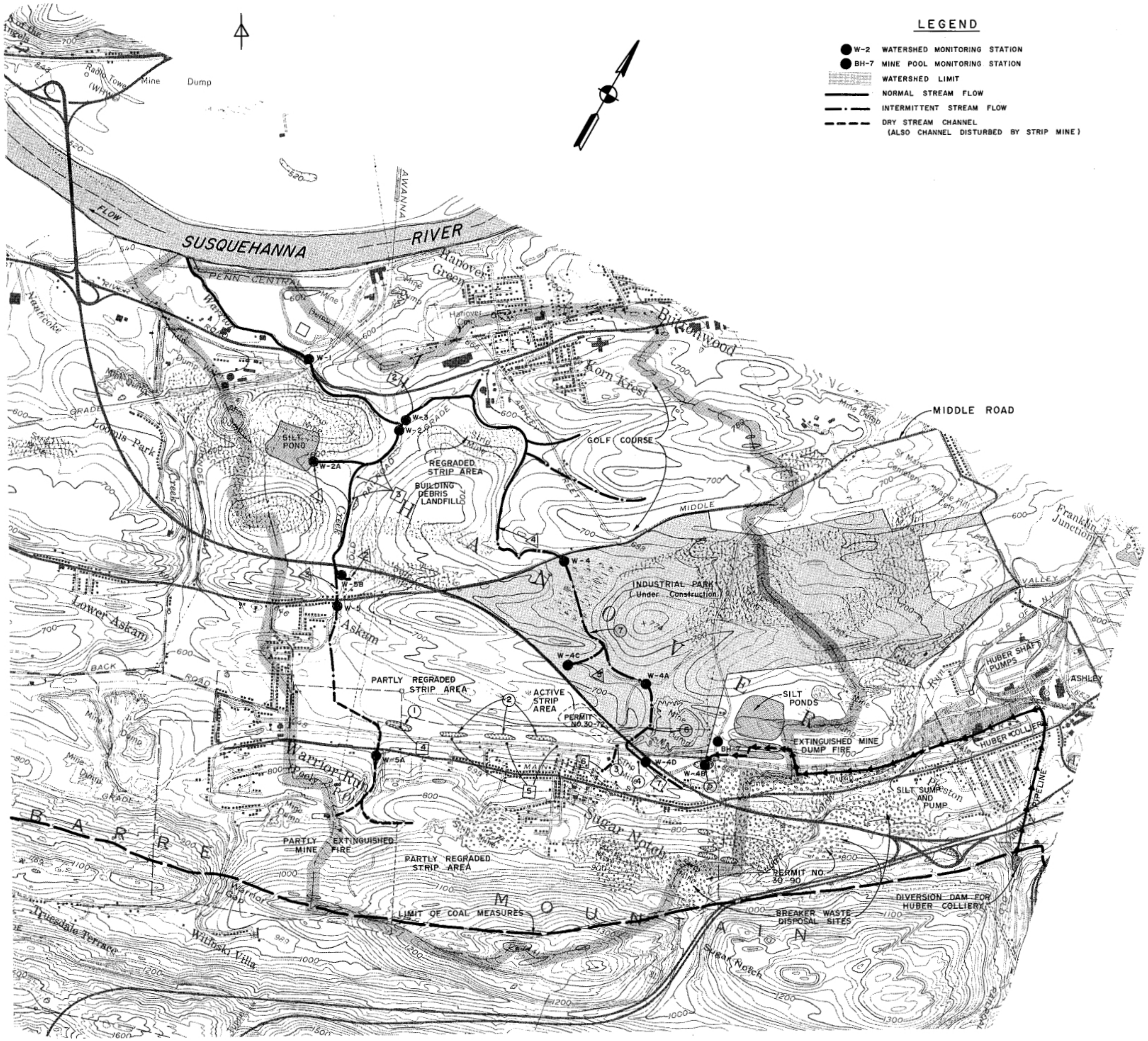
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

AMD ABATEMENT STUDY

NANTICOKE, WARRIOR AND SOLOMON CREEKS
PROJECT NO. SL 181-3
HANOVER & WILKES BARRE TWPS. LUZERNE CO. PENNA.

EXISTING CONDITIONS
SOLOMON CREEK WATERSHED

DATE	PREPARED BY	FIGURE No.
DEC. 1974	GEO-Technical Services CONSULTING ENGINEERS & GEOLOGISTS HARRISBURG, PENNA.	3



AMD DISCHARGES

LOCATION	FLOW IN GPM		AVERAGE AMD PARAMETERS									REMARKS
	MAX. (1)	AVG.	pH	ACIDITY PPM	ACIDITY #/DAY	ALKALINITY PPM	ALKALINITY #/DAY	IRON PPM	IRON #/DAY	SULFATE PPM	SULFATE #/DAY	
△1	<1	(2)	2.9	420	–	0	–	145	–	(3)	–	SEEPAGE FROM SILT POND
△2	75	50	6.5	43	26	275	165	2	1	288	173	BUBBLING OUT OF GROUND
△3	20	20	(3) QUALITY ASSUMED SIMILAR TO △2									FOUR SEEPS AT 5 GPM
△4	25	(3)										YELLOWBOY IN DISCHARGE AREA
△5	25	25	7.0	0	0	180	54	1.7	0.5	300	90	YELLOWBOY IN DISCHARGE AREA

(1) MAXIMUM FLOW OBSERVED (2) 1 SAMPLE (3) NOT TESTED

SURFACE WATER LOSSES

LOCATION	MAX. LOSS (GPM)	DATE	EST. ANNUAL LOSS (MG) (4)	REMARKS
①	50	10/29/74	25	RAW SEWAGE FLOW INTO STRIP PIT
②	30	10/29/74	15	THREE SEWAGE AND STORM DRAINS FLOW INTO STRIP PITS
③	10	7/26/73	5	SEWAGE AND STORM RUNOFF LOST IN LOW AREA
④	10	10/29/74	5	SEWAGE AND STORM RUNOFF LOST IN STRIP POND
⑤	1,200	2/05/74	225 (5)	SILT POND OVERFLOW INTO PIT AND DEEP MINE
⑥	60	6/26/74	21	HIGHWAY SUB-DRAIN FLOW AND RUNOFF LOST IN CREEK BED
⑦	25	5/30/74	13	SEEPAGE FLOW AND RUNOFF LOST IN CREEK BED

(4) FOR SAMPLE PERIOD (5) INCLUDING POND LOSSES

RAW SEWAGE DISCHARGES

LOCATION	ESTIMATED FLOW (GPM)	DATE	REMARKS
[1]	50	4/29/74	INTO STREAM FROM CONCRETE STRUCTURE ON NORTH SIDE OF CREEK
[2]	5	7/25/73	INTO STREAM FROM 4" PVC PIPE BEHIND TRAILER COURT
[3]	3 @ 10	5/30/74	INTO STREAM FROM STREAM BANK ARTESIAN DISCHARGES
[4]	50	10/29/74	INTO STRIP PIT FROM BROKEN (?) SEWER LINE
[5]	3 @ 10	10/29/74	INTO GROUND SURFACE AND STRIP PITS FROM STORM SEWERS
[6]	10	7/26/73	INTO DITCH AND DEPRESSIONS FROM 18" VCP BEHIND HOUSES
[7]	10	10/29/74	INTO STRIP PIT POND FROM CONCRETE BOX OVERFLOW

TESTS OF SEWAGE PARAMETERS IN STREAMS

MONITORING STATION	MEASURED FLOW (GPM)	DATE	COLIFORM PER 100ML	BOD mg/l	NH_3-N mg/l	REMARKS
W-2	310	3/22/74	TNTC*	2	0.60	SOME UPSTREAM SOURCES LOCATED
W-3	450	3/22/74	TNTC*	7	0.32	SOME UPSTREAM SOURCES LOCATED

* TOO NUMEROUS TO COUNT

NOTES

1. BASE MAP IS U.S.G.S. 7½ MIN. QUADRANGLE (WILKES-BARRE WEST).
2. SUB-DRAINAGE AREAS FOR PRIMARY WATERSHED MONITORING STATIONS LISTED ON FIGURE NO. 1.
3. FLOW AND WATER QUALITY RECORDS FOR THE INDICATED MONITORING STATIONS ARE PRESENTED IN APPENDIX A.

SCALE IN FEET
1000 0 1000 2000

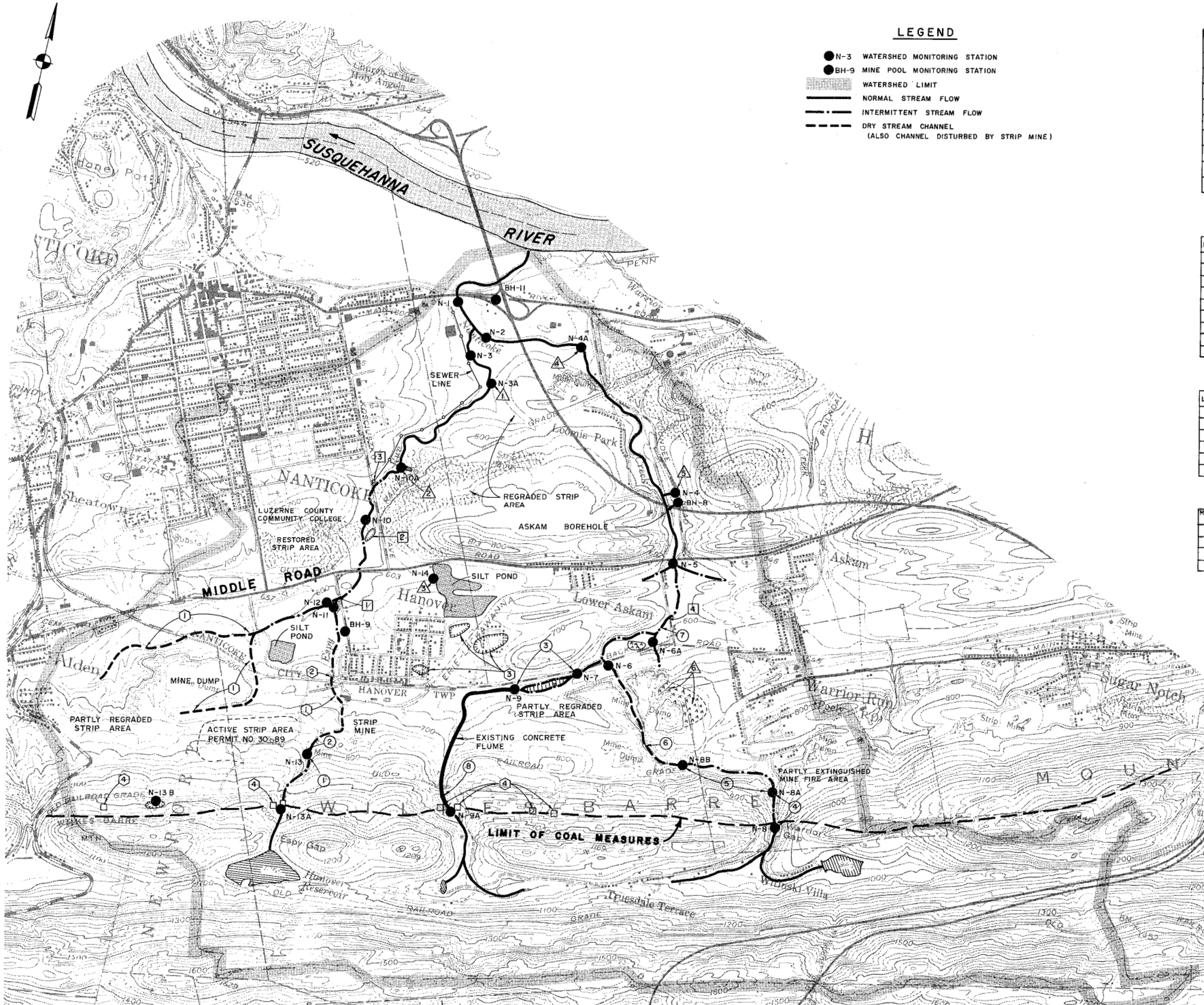
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

AMD ABATEMENT STUDY

NANTICOKE, WARRIOR AND SOLOMON CREEKS
PROJECT NO. SL 181-3
HANOVER & WILKES BARRE TWPS. LUZERNE CO. PENNA.

EXISTING CONDITIONS
WARRIOR CREEK WATERSHED

DATE	PREPARED BY	FIGURE No
DEC. 1974	GEO-Technical Services CONSULTING ENGINEERS & GEOLOGISTS HARRISBURG, PENNA	4



AMD DISCHARGES

LOCATION	FLOW IN GPM MAX. (1)	FLOW IN GPM AVG.	pH (3)	ACIDITY PPM	ACIDITY #/DAY	ALKALINITY PPM	ALKALINITY #/DAY	IRON PPM	IRON #/DAY	SULFATE PPM	SULFATE #/DAY	REMARKS
△1	50	(2)	6.3	92	55	490	294	3.4	2	700	420	FLOW FROM PARTLY REGRADED STRIP AREA
△2	20	(2)	6.4	16	4	304	73	4.6	1	700	168	FLOW FROM STRIP POND
△3	10	(2)	3.4	32	4	0	0	38	5	365	44	SEEPAGE FROM SILT POND
△4	220	(2)	4.8	104	275	0	0	16	42	775	2050	STREAM RECHARGES BETWEEN N-2 AND N-4A ON 7/17/74
△5	8,500	2540	3.7	579	17660	0	0	344	10500	1904	58100	FLOW FROM ASKAM BOREHOLE, N-4
△6	50	40	2.4	2252	1082	0	0	129	62	3442	11000	FLOW FROM BASE OF MINE DUMP

(1) MAXIMUM FLOW OBSERVED (2) SAMPLED ONCE (3) LABORATORY pH

SURFACE WATER LOSSES

LOCATION	MAX. LOSS (GPM)	DATE	EST. LOSS (MG) (4)	REMARKS
(1)	100	2/05/74	28	"CLEAN" STREAM FLOW LOST IN CREEK BED
(2)	190	3/20/74	123	"CLEAN" STREAM FLOW LOST IN STRIP PIT
(3)	40	9/26/73	21	"CLEAN" FLUME FLOW LOST IN RESERVOIR
(4)	410	11/28/73	95	"CLEAN" FLOW LOST IN CREEK BED
(5)	275	1/08/74	200	"CLEAN" FLOW LOST IN STRIP CREEK BED
(6)	410	3/20/74	25	"CLEAN" FLOW LOST AT BLOCKED CULVERT INLET
(7)	75	5/30/74	45	STREAM FLOW LOST IN CREEK BED
(8)	220	5/30/74	73	STREAM FLOW LOST IN BROKEN FLUME SECTIONS

(4) FOR SAMPLING PERIOD

RAW SEWAGE DISCHARGES

LOCATION	ESTIMATED FLOW (GPM)	DATE	REMARKS
[1]	75	5/25/74	INTO STREAM FROM 18" DRAIN UNDER BRIDGE
[2]	20	5/25/74	STRIP PIT WITH PONDED RAW SEWAGE
[3]	10	5/25/74	INTO STREAM VIA 24" PIPE FROM CONCRETE STRUCTURE
[4]	10	5/25/74	INTO STREAM FROM 8" VCP ON EAST SIDE OF BRIDGE

TESTS OF SEWAGE PARAMETERS IN STREAMS

MONITORING STATION	MEASURED FLOW (GPM)	DATE	COLIFORM PER 100ML	BOD mg/l	NH_3-N mg/l	REMARKS
N-2	8,630	3/20/74	1	6	9.00	7,900 GPM AMD FROM ASKAM BOREHOLE
N-3	370	3/20/74	TNTC*	1	1.65	SOME UPSTREAM SOURCES LOCATED

* TOO NUMEROUS TO COUNT

MISCELLANEOUS OBSERVATIONS

(1) NO BASE FLOW. ORIGINAL STREAM CHANNEL DESTROYED BY STRIPPING OPERATION.

(2) NO BASE FLOW. ORIGINAL STREAM CHANNEL FILLED WITH WASTE MATERIAL FOR HOME SITES.

(3) ALL SURFACE RUNOFF DIVERTED AND LOST IN SUBSIDENCE DEPRESSIONS.

(4) OPEN "AIRSHAFTS" REPRESENT SAFETY HAZARDS. SOME DIVERT RUNOFF TO DEEP MINES.

NOTES

1. BASE MAP IS U.S.G.S. 7½ MIN. QUADRANGLE (WILKES-BARRE WEST).
2. SUB-DRAINAGE AREAS FOR PRIMARY WATERSHED MONITORING STATIONS LISTED ON FIGURE NO. I.
3. FLOW AND WATER QUALITY RECORDS FOR THE INDICATED MONITORING STATIONS ARE PRESENTED IN APPENDIX A.

SCALE IN FEET

1000 0 1000 2000

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

AMD ABATEMENT STUDY

NANTICOKE, WARRIOR AND SOLOMON CREEKS
PROJECT NO. SL 181-3
HANOVER & WILKES BARRE TWPS. LUZERNE CO. PENNA.

EXISTING CONDITIONS
NANTICOKE CREEK WATERSHED

DATE	PREPARED BY	FIGURE No.
DEC. 1974	GEO-Technical Services CONSULTING ENGINEERS & GEOLOGISTS HARRISBURG, PENNA.	5

This resulted in the reduction of frequent basement flooding and possibly subsidence, in communities located on both sides of the Susquehanna River.

The mine pool relief points changed the previous direction of mine pools flow, resulting in a considerable diversion and concentration of mine pool discharges into the study area streams. The major discharge outlets are further described below:

BUTTONWOOD TUNNEL: Review of published and unpublished reports indicated that the AMD discharges from the Tunnel are attributed to interconnected mine pools located north of the Susquehanna River. These mine pools are identified as the North-West Mine Pool Complex and are shown on the Geologic Map, FIGURE 2 (pocket). Previous studies related the recharge of these mine pools to surface runoff losses in watersheds located outside the study area. Since the Tunnel discharges are within the study area, whereas the recharge sources are outside of the study area; recommended abatement measures for this discharge source are not within the scope of this study. Analysis of available records of mine pool fluctuations and correlation of these records with the flow in the Susquehanna River strongly indicate that the predominant recharge of the North-West mine pools can be attributed to River losses into the deep mines. The analysis is presented in PART III of this report. The concentration of AMD parameters and the Tunnel discharges measured on the sampling dates are presented in Appendix A, Monitoring Station S-2. The range of AMD concentration emanating from this discharge source is presented in TABLE II (page 23).

SOUTH WILKES-BARRE BOREHOLES: The source of discharge from the three boreholes is attributed to the South-East Mine Pool Complex and is predominantly governed by the recharge and fluctuations of the lower pools in this complex. The limits of the lower pools in the South-East Mine Pool Complex are shown on the Geologic Map, FIGURE 2 (pocket). Analysis of mine pool. fluctuations, rate of discharge from the boreholes and the precipitation over the applicable portion of the watershed is presented in PART III of this report. This analysis indicates that approximately 70 percent of the discharges from the boreholes can be attributed to surface water losses in the Mill Creek watershed, adjacent to the present study area. At This writing, the Department authorized the study of the Mill Creek watershed. Location of major surface water losses in this adjacent watershed and recommended means to reduce such losses are to be included in the newly authorized study.

The concentration of AMD parameters in the South Wilkes-Barre boreholes and the discharges measured on the sampling dates are presented in Appendix A, Monitoring Station S-3. The range of AMD .concentration and load, emanating from this discharge source is presented in TABLE II (page 23) and TABLE X (page 49).

During this study period, the Department sponsored the following two separate improvements within and adjacent to the study area., related to the South-East Mine Pool Complex:

a. The casings of the three South Wilkes-Barre Boreholes were cut to elevation 527.50, resulting in lowering the discharge points by approximately 9 feet. This improvement further reduced the levels of the lower mine pools. During the construction of this improvement (between January and April, 1974) the discharge channel into the Solomon Creek was relocated and accurate flow measurements could not be made.

b. A 42 inch diameter borehole, known as the "Plains Borehole", was drilled into the Henry Prospect Mine Pool. The borehole was originally drilled to shorten the flow path and time of travel in the South-East Mine Pool Complex, thereby reducing the present concentration of AMD discharges into the River from the South Wilkes-Barre boreholes. A reduction in the rise of mine pool levels in the vicinity of the Plains borehole was also anticipated. The outlet of the borehole casing is at elevation 531.75. The date of completion of the borehole and the "Rating Curves" of the South Wilkes-Barre boreholes are shown in FIGURE 8 (pocket). Upon completion of the Plains borehole, it became evident that the Henry Prospect Mine Pool is related to the South-East Mine Pool Complex when the pools are above elevation 535±. At the approximate elevation 535', the South-East Mine Pool overflows into the Henry Prospect Pool. The present top elevation of the South Wilkes-Barre boreholes has substantially lowered the SouthEast Mine Pool levels and diminished the possibility off future overflow into the Henry Prospect Pool.

THE ASKAM BOREHOLE: The source of AMD discharges from this borehole is attributed to the upper pools of the South-East Mine Pool Complex. The recharge of these mine pools is related to surface water losses within the coal measures and to groundwater from outside of the coal measures, in the Nanticoke and Warrior Creek watersheds. The limits of these mine pools are shown on the Geologic Map, FIGURE 2 (pocket). Analysis of the mine pool fluctuations, the rate of borehole discharges and the precipitation over the applicable portion of the watersheds are presented in PART III of this report. The analysis indicates that approximately twenty percent of the total annual borehole discharge is attributed to the groundwater recharge and the base flow contribution, upstream of the coal measures. Inflow from these water sources is subsequently lost from streambeds within the coal measures. During periods of runoff from precipitation, the flow per square mile of the watershed outside of the coal measures is considerably larger than the flow per square mile within the coal measures of the Nanticoke and Warrior watersheds. Analysis indicates that during runoff periods, 40.0 percent of. the mine pool discharges are attributed to inflow from only 22.5 percent of the watershed area located above the coal measures. The clean watershed inflow Is subsequently lost from streambeds into the deep mines within the coal measures. Consequently the prevention of streambed losses in the coal measures and the partial interception of groundwater recharge into the coal basin are expected to reduce the annual discharge from the Askam borehole at least forty percent.

The Askam borehole is the only major AMD source with periods of zero discharge to the surface. Zoro discharges occur when the water level in the upper mine pools drops below elevation 573.2 feet. Fluctuations in the levels of these upper mine pools were recorded below elevation 573.2 feet. These fluctuations indicate the existence of inflow into the mine pools as well as outflow from the mine pools, when there are no discharges from the Askam borehole. Analysis, presented in PART III of this report, indicates that 1.2 million gallons per day (MGD) rate of inflow is required to maintain these pools at elevation 573.2 feet. Maintaining the upper pools at the aforementioned elevation implies that the rate of outflow is similar to that of the inflow. Since the Askam borehole is not discharging below the aforementioned elevation, the outflow from these upper mine pools is through barrier pillar breaches or other discharge points that existed prior to the drilling of the Askam borehole. This concealed outflow recharges the lower mine pools, discharges directly into the Susquehanna River, or can be attributed to a combination of both of the above mentioned flow directions. On the basis of these findings, when the mine pools are above elevation 573.2', the outflow consists of the measured borehole discharges and additional concealed discharges of at least 1.2 MGD, flowing into the lower mine pools.

FIELD OBSERVATIONS

In the extensive urban areas located between the Middle Road and the Susquehanna River, a large part of the runoff is collected by existing storm sewer systems and discharged into the streams. A summary of observed streambed losses, land uses and other AMD related conditions within each watershed is described below:

SOLOMON CREEK WATERSHED: Existing conditions within this watershed are presented in FIGURE 3 (Page 1.3). Flow records and observations made during the study period Indicate the following prevailing conditions in the watershed streams:

Laurel Run - Tributary to Spring Run: No base flow from a drainage area of 1.5 sq. mi. Intermittent flow was observed and lost immediately downstream of Station S-13 and S-14. The area east of S-13 is within the Laurel Run Mine Fire Area. Low flow storm runoff is slightly acid from contact with mine waste material. Peak storm runoff has not been observed to date. (See records for Station S-7, Appendix A).

Spring Run - Tributary to Solomon Creek: No base flow from a drainage area of 1.5 sq. mi. upstream of Station S-8. Intermittent flow was observed and lost immediately downstream of Station 5-15. The area west of S-15 is within the Laurel Run Mine Fire Area. Station S-8A with a drainage area of 0.2 sq. mi. provides the base flow in Spring Run and has a high sewage content.

Streambed losses as high as 285 GPM have been observed between Station S-6 at Blackman Street and a point above Station S-5 where Spring Run crosses Gilligan Street. Station S-5 is just inside the stream recharge area. Groundwater with high AMD parameters enters the stream as seepage, approximately 100 to 200 feet above S-5.

Ashley Run - Tributary to Solomon Creek: No observed base flow from a I.0 sq. mi. drainage area. Flow contribution is primarily from the storm sewer system of Ashley Boro. Discharge points were not monitored; however, it is suspected that some storm runoff is lost to the deep mines through breaks in the storm sewer system caused by subsidence.

Sugar Notch Run - Tributary to Solomon Creek: Sugar-Notch Run has a drainage area of 1.1 sq. mi. outside of the coal measures. Part of the streams base flow is attributed to the artesian well at Station S-12B. An estimated 75% of the annual flow is lost when the stream enters the mined area. Losses as high as 2,300 GPM were recorded between Stations S-12 and S-9A.

During periods of high stream flow, large direct losses of water were observed entering wide (1 - 4") open vertical cracks in the stream channel bedrock. The observed loss area Is located 100 to 200 feet downstream of the double arch railroad culvert directly North of Station S-12.

When stream flow is low, the water that reaches Station S-9A Is severely degraded in quality. (See records for S-12 and S-9A).

The stream receives periodic AMD doses as high as 1,345 GPM due to periodic silt sump overflows when the Huber Colliery is in operation. (See S-9 and S-9B records).

The stream receives AMD seepage from a storage pond constructed with coal waste materials near Station S-9D. The maximum recorded flow of this highly acid discharge was 35 GPM.

Solomon Creek - Main Stem: Solomon Creek has a drainage area of 6.9 sq. mi outside of the coal measures.

The Blue Coal Company diverts an estimated 270 million gallons of water per year at Station S-11. An illustration of the frequency, magnitude and duration of this stream diversion between October 16-25, 1973, is shown in the Hydrograph of Solomon Creek, FIGURE 6 (Page 22). The water is used in the coal processing operation, then pumped to silt settling basins west of Huber Colliery and eventually discharged into an abandoned mine shaft at Station W-4B. Accidental spills of coal processing water with a high concentration of suspended solids were observed at a silt sump located at Station S-9B (See FIGURE 3 (page 13). The extent of stream contamination due to these spills is reflected in the water quality test data of Station S-9 (See Appendix A). On September 18, 1973, an accidental spill of 1345 GPM for at least one hour was recorded. Laboratory tests on this water revealed 2810 ppm of suspended solids and 290 ppm of acidity.

At a point above Station S-11A, the Pennsylvania Gas and Water Co. diverts an estimated 100 MG per year for domestic water supply. It is presumed that the bulk of this water is discharged into the Susquehanna River as treated sewage effluent.

Unaccounted for increases in flow have been recorded between Station S-4 and the combined flow of the upstream stations. However, the quality of the water at Station S-4 indicates that the increased flow is stream recharge that cannot be attributed to acid mine water discharges.

The major AMD loads contributed to Solomon Creek are from the following mine pool discharge points:

South Wilkes-Barre Boreholes - Station S-3, which had recorded AMD discharges as high as 20,700 GPM.

Buttonwood Tunnel - Station S-2, which had recorded AMD discharges as high as 14,000 GPM.

The seepage Area at Station S-1A had recorded AMD discharges as high as 100 GPM.

Water quality records for Solomon Creek are given in the Appendix and summarized in TABLE II (Page 23).

WARRIOR CREEK WATERSHED: Existing conditions within the watershed are presented in FIGURE 4 (Page 14). Flow records and observations made during the study period indicate the following prevailing conditions in the watershed streams:

The drainage area of Warrior Creek is predominantly within the coal measures.

There is no significant base flow in either branch of the stream until the streams pass Middle Road (Stations W-4 and W-5).

The largest AMD discharge in the watershed is at Station W-5B north of Askam where as much as 75 GPM of mine water bubbled out of the ground.

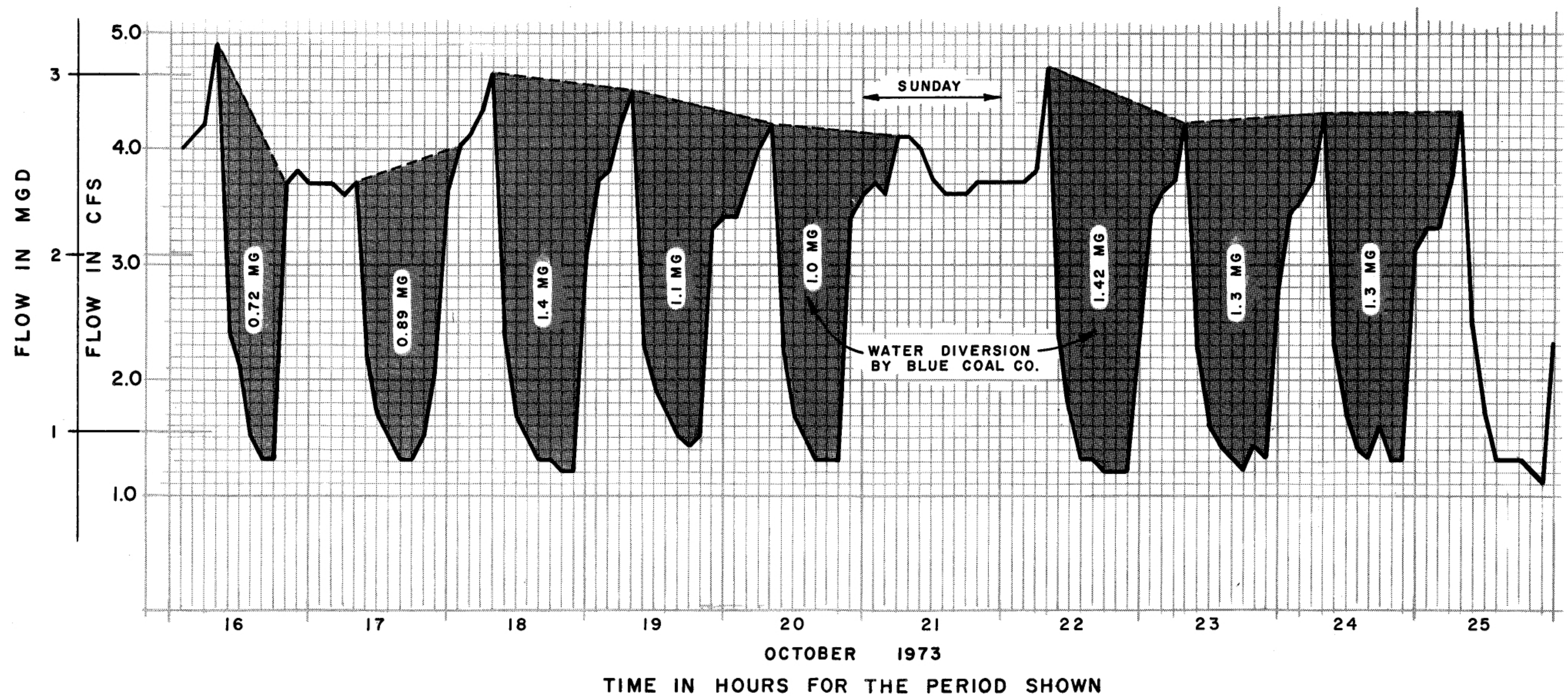
Downstream of Middle Road at Stations W-2 and W-3, the stream water is alkaline. Some of the alkalinity can be attributed to raw sewage discharges.

Average water quality for Warrior Creek is presented in TABLE III (Page 24).

NOTES

1. THIS HYDROGRAPH IS BASED ON BI-HOURLY RECORDS AT THE U.S.G.S. GAGING STATION.

2. THIS FIGURE DEMONSTRATES THE MAGNITUDE OF WATER DIVERSION FROM THE SOLOMON CREEK WATERSHED BY THE BLUE COAL CO. THE DIVERTED WATER IS USED BY THE COLLIERY, THEN PUMPED INTO DESILTING PONDS AND ULTIMATELY DISCHARGED INTO THE DEEP MINES IN THE WARRIOR CREEK WATERSHED. TOTAL DIVERSION FOR THE PERIOD SHOWN IS 9.13 M.G.



HYDROGRAPH OF SOLOMON CREEK
FIGURE NO. 6

TABLE II

SOLOMON CREEK WATERSHED

SUMMARY OF WATER QUALITY RECORDS

MONITORING STATION			SOURCE OF WATER	pH		CONCENTRATION IN ppm			
NO.	D. A.{1} {SQ.MI.}	SUB-AREA{2}		FIELD TEST	LAB. TEST	ACID	ALK.	TOTAL IRON	SULFATE
S-11A	6.81	A	MAIN STEM	6.8	6.2	3	5	0.2	31
S-12	1.05	A	SUGAR NOTCH	6.3	5.7	3	5	0.3	33
S-9A	1.74	C	SUGAR NOTCH	4.6	4.4	14	2	1.2	75
S-9D	0.23	C	UNNAMED TRIB. TO SUGAR NOTCH	4.2	3.9	356	0	26.2	814
S-9B	NA	D	SILT SUMP	7.3	5.4	76	1	51.5	278
S-9	2.33	D	SUGAR NOTCH	4.2	3.7	60	0	36.7	265
S-10	8.33	D	MAIN STEM	6.1	5.8	15	8	2.5	57
S-9C	0.27	D/E	UNNAMED TRIB. TO MAIN STEM	6.6	6.0	5	4	0.3	169
S-8	1.45	C/D	TRIB. TO SPRING RUN	RUNOFF ONLY FROM DRIVE-IN THEATER					
S-8A	0.20	D	TRIB. TO SPRING RUN	6.6	6.0	57	55	0.9	88
S-7	1.53	D	TRIB. TO SPRING RUN	5.9	5.5	3	2	0.2	36
S-6	4.00	D	SPRING RUN	6.0	5.5	17	22	2.3	128
S-5	4.43	E	SPRING RUN	5.6	4.7	7	2	1.4	42
S-4	15.70	E	MAIN STEM	5.5	4.7	6	5	0.9	67
S-3	NA	E	BOREHOLES AMD	5.4	3.3	608	0	304	1,767
S-2	NA	E	BUTTONWOOD TUNNEL	5.7	4.3	293	17	154.2	1,385
S-1	18.20	E	MAIN STEM AT MOUTH	5.2	2.6	542	0	243.1	1,675
S-1A	NA	E	MINE POOL SEEPAGE INTO SUSQ. RIVER	6.8	5.6	259	204	176.9	1,991

{1} DRAINAGE AREA (WHEN APPLICABLE)
{2} FOR LOCATION OF SUB-AREAS, SEE FIGURE 1

TABLE III

WARRIOR CREEK WATERSHED
SUMMARY OF WATER QUALITY RECORDS

MONITORING STATION			STREAM OR TRIBUTARY	pH		CONCENTRATION IN ppm			
NO.	D.A.(1) (SQ.MI.)	SUB-AREA(2)		FIELD TEST	LAB. TEST	ACID	ALK.	TOTAL IRON	SULFATE
W-5	1.00	D/E	WEST BRANCH	8.2	7.4	8	72	13.0	70
W-2	1.51	E	WEST BRANCH	7.7	7.1	4	164	2.0	238
W-4A	1.00	C/D	EAST BRANCH	←←←←←←←← NO FLOW (DRY) →→→→→→→→					
W-4	1.63	E	EAST BRANCH	8.1	7.3	5	6	0.6	46
W-3	2.69	E	EAST BRANCH	8.3	7.5	5	134	2.9	177
W-1	4.32	E	MAIN STEM	6.7	6.0	16	259	1.9	190

(1) DRAINAGE AREA

(2) FOR LOCATION OF SUB-AREAS, SEE FIGURE 1

NANTICOKE CREEK WATERSHED: Existing conditions within this watershed are presented in FIGURE 5 (Page 15). Flow records and observations made during the study period indicate the following prevailing conditions in the watershed streams:

Espy Run - Tributary to Nanticoke Creek: The entire runoff and base flow in the drainage area. above Station N-13 is lost in a strip pit downstream of this Station.

Water with high AMD parameters has been recorded at Stations N-11 and N-12. The source of this contaminated water appears to be seepage from ponded areas in the adjacent strippings and mine waste piles. To date, the maximum recorded flow at both stations was 23 GPM.

There is considerable reduction in acidity between the aforementioned stations and monitoring Station N-I0. This reduction is attributed to observed discharges of raw sewage, as high as 75 GPM, from a pipe under the bridge at Station N-il. Measured reduction in stream flow between Stations N-11 and N-10 is attributed to water losses from the streambed into the deep mines.

Between Stations N-10 and N-3, Espy Run receives both AMD and sewage from several sources.

Leuder Creek Flume: This concrete flume is in relatively good condition. However, some flow losses occur through broken sections at the upstream end and some water bypasses or flows under the upper sections. The highest recorded loss is 200 GPM.

Losses occur in the reservoir and streambed downstream of the flume. Flows as high as 900 GPM were recorded in the flume with only 450 GPM passing Station N-7, downstream of the reservoir.

Nanticoke Creek - Main Stem: Loss of the entire runoff from the drainage area upstream of coal measures (Station N-8) has been recorded at Station N-6.

Highly acid discharges of up to 50 GPM from the base of the Truesdale Mine Waste-Dump have been recorded at Station N--6A.

In general, low stream. flow from a 3.5 sq. mi. drainage area and high AMD parameters was recorded at Station N-5.

The largest AMD discharge in the watershed emanates from the 36 inch diameter Askam borehole at Station N-4. Discharges as high as 8,500 GPM have been recorded.

The average water quality in the Nanticoke Creek is presented in TABLE IV.

TABLE IV

NANTICOKE CREEK WATERSHED

SUMMARY OF WATER QUALITY RECORDS

MONITORING STATION			STREAM OR TRIBUTARY	pH		CONCENTRATION IN ppm			
NO.	D.A.{1} (SQ.MI.)	SUB-AREA{2}		FIELD TEST	LAB. TEST	ACID	ALK.	TOTAL IRON	SULFATE
N-8	1.30	A	EAST BRANCH	6.5	5.9	5	11	0.3	50
N-8A	1.34	C	EAST BRANCH	8.0	7.0	2	2	0.1	20
N-8B	1.70	C	EAST BRANCH	8.1	7.0	2	10	0.4	37
N-6	2.94	C/D	EAST BRANCH	6.4	5.5	1	5	0.2	14
N-9A	0.61	A	LEUDER CREEK AT FLUME	7.7	6.6	4	15	0.3	38
N-9	0.89	A	IN FLUME	7.9	6.8	4	13	0.4	23
N-7	1.01	C/D	LEUDER CREEK	7.4	6.4	2	14	0.3	34
N-5	3.50	D	MAIN STEM	4.9	3.9	18	0	2.2	42
N-4	NA	E	36" BOREHOLE	6.5	4.9	571	1	339	1.878
N-13A	0.30	A	ESPY RUN	7.0	6.0	5	10	0.1	25
N-13	0.40	C	ESPY RUN	7.4	6.3	4	11	0.1	24
N-11	1.11	D	ESPY RUN	5.4	4.9	24	1	1.2	81
N-12	0.86	C	UNNAMED TRIB.	5.2	4.7	36	0	0.7	176
N-10	2.47	D	ESPY RUN	7.3	6.6	48	86	1.8	63
N-3	3.14	E	ESPY RUN	6.6	6.1	23	80	2.4	152
N-1	7.47	E	MAIN STEM	5.3	3.6	336	3	248	1,639
N-2	7.39	E	MAIN STEM	5.2	3.4	365	0	259	1,304

{1} DRAINAGE AREA, WHEN APPLICABLE
{2} FOR LOCATION OF SUB-AREAS, SEE FIGURE 1

OTHER MAJOR PROBLEMS IN THE STUDY AREA

SUBSIDENCE: Subsidence caused by caving of abandoned deep mines is a serious problem in the study area. In addition to causing major property damage, subsidence can aggrevate the AMD problem by creating areas of high surface water infiltration. Concurrent with this study, a study is being conducted by others relating to the possibility of correlating mine pool fluctuations with subsidence. Since one method of AMD abatement in the study area is to lower the present mine pool elevations, the relationship and possible effect of such lowering on subsidence within the study area can be evaluated when more information is available.

FLOODING: Despite water losses from streambeds and strip mines, some urban areas at the lower part of the study area are subject to flooding. Records indicate that flooding in the study area occured in 1924, 1933, 1935, 1945, 1950, 1955, 1958 and 1972. As a result of the 1955 flood damages (Hurricane Diane), a survey was conducted by the. former Pennsylvania Department of Forests and Waters to assess flood damages and to propose remedial measures

At the present time, D.E.R. is conducting a study of flooding conditions in the Solomon Creek area.

It should be noted that the reclamation of two abandoned strip mines in the near future is expected to increase the runoff and flood potential in two study area watersheds. Approximately 700 acres of reclamation, paving and buildings for the Hanover Township Industrial Park will increase runoff and flow in Solomon and Warrior Creeks.

An area of approximately 350 acres is presently being proposed for an industrial park by the Wilkes-Barre Chamber of Commerce at the Zayre Strippings. The completion of this industrial park would increase the present runoff into Spring Run, a tributary to Solomon Creek.

Conversion of strippings and spoil banks to higher and better use would reduce the present surface water losses into the deep mines as well as enhance the aesthetic and economic environment in the study area. Consequently, the dual purpose achieved by improved land use in the area is beneficial to the local people as well as to the Commonwealth.

In contrast to the aforementioned benefits, the potential increase in surface runoff due to future reclamation of strippings, would require compensating measures to prevent additional future flood damages. Such compensation can be achieved by constructing flood control reservoirs, upstream of the Coal Measures, and by small storm retention ponds and channel improvements within and downstream of areas designated for stripping reclamation.

MINE FIRES: Both active and extinguished fires in deep mines and mine waste piles are located within the project area as shown in FIGURES 3 and 4 (Pages 13 and 14). The active deep mine fire at the former community of Laurel Run has required the razing of 150 homes because of gas fumes and cave-ins.

A description of this mine fire is given by Hollowell*. The major features are summarized as follows:

a. The fire is in the abandoned working of the Red Ash Mine and has been burning since 1915.
b. The surficial area of the mine is 367 acres.
c. When the fire threatened to spread to adjacent mines, sand seals were constructed by the Pennsylvania Department of Mines to halt the spreading eastward and westward.
d. The fire was stopped from spreading northward toward Wilkes Barre when the Huber Mine was abandoned and filled with water.

Obviously, this problem must be considered if any permanent lowering of the mine pools is contemplated. The possibility that successful AMD abatement measures may result in spreading this mine fire should be taken into consideration in the design of abatement measures for this area.

* Hydrology, Glacial Geology and Environmental Geology of the Wyoming-Lackawanna Valley; J.R. Hollowell, USGS, 1973

SEWAGE: Surface water with odor and color characteristics of raw sewage is found at several locations within the watersheds. Special test results presented in Appendix A also suggest the presence of sewage. The observed reduction in acid concentration in the previously indicated stretches of streams and the alkalinity in the Warrior Creek can be partially attributed to the discharges of raw sewage in the study area. The eventual elimination of raw sewage discharges in the study area would reduce organic pollution, as well as the present level of alkalinity.

The primary locations where raw sewage is seen or suspected are summarized as follows:

a. Station S-8A on Spring Run.

b. Both branches of the Warrior Creek below Middle Road.

c. The stream reach of Espy Run between Stations N-10 and N-3.

It should be noted that at the present time, the communities of Sugar Notch and Warrior Run are unsewered.

LAND USE: Mining activity in the past has degraded the general environmental quality and has placed severe land use restrictions on portions of the study area. Waste dumps, where little vegetation will root, and strip mining scars are generally considered less than desirable landscapes. Additionally, the steep ground surface associated with these features, limits economical land usage for residential, industrial or agricultural purposes. Opportunities to economically up-grade the land use characteristics in conjunction with AMD abatement projects can stimulate local interests to actively participate in land reclamation projects.

Information gathered to date indicates that local housing and recreation development authorities are actively looking for project sites where land reclamation is economically feasible.

Due to the past and present mining activities, land suitable for recreation purposes is limited to the unmined upstream parts of the study area in the Solomon and Nanticoke watersheds. These areas, located upstream of the lower Coal Outcrop, are wooded and the water in the streams is unpolluted. Therefore, they are also suitable for water oriented recreation activities. Although the access to these areas from local communities is presently limited, the numerous existing discontinued railroad beds near abandoned strip mines can provide the necessary additional access to these areas. Land reclamation of such strippings in selected areas can also provide suitable and accessible recreational facilities for the local communities.

MULTI-PURPOSE APPROACH TO AREA PROBLEMS

The aforementioned problems and their relationship to AMD abatement, strongly suggest the desirability for a multi-purpose approach to the solution of AMD abatement in the study area. Such an approach would help to promote active participation by the local people in the abatement of AMD pollution. Local sponsorship of land reclamation, restoration and reconstruction of leaking sewer lines and the prevention or reduction of flood hazards, could justify certain pollution abatement measures that otherwise may not be feasible under a single-purpose approach to AMD abatement.