CHAPTER VII

COAL MINE DRAINAGE SOURCES

INTRODUCTION

Since January 1971, flow characteristics and water quality data for all sources of mine drainage have been obtained from 152 sampling and gauging stations in the study area of the West Branch Susquehanna River from the headwaters to Cush Cushion Creek at Cherry Tree 15 miles downstream. These drainage sources (deep mines, strip mines and refuse piles) have been identified, mapped and studied to determine their effect on stream quality.

SUMMARY

During the year 1971, the period of data collection, Duman's Dam Treatment Plant was in operation. As the Lancashire No. 15 pool level was lowered, flow from the breakout area diminished until it virtually ceased after February, 1971. The effect of the two (2) Barnes and Tucker treatment plants operating in the study area has been to greatly reduce total deep mine discharge stream pollution and to restore the stream to its relatively innocuous condition (as existed before the 1970 breakout) insofar as its effect on Curwensville Dam is concerned. The average pollutant removal capacity of these plants is indicated in Figure VII-2.

A comparison of summer, 1971 low stream flow loadings produced by the three types of acid sources is shown in Figure VII-1. This data is for all known acid sources on the West Branch and its tributaries upstream from Cherry Tree, Pennsylvania.

The total acid loading rate of 49,000 lbs./day is very close to the figure of 53,500 lbs./day given in the Federal Water Quality Administration report for the same area for the years 1966 through 1968. This is a strong indication that acid-generating processes in the area are remarkably stable. Contrary to previous reports, however, our study indicates that deep mine discharges are not the major pollutant sources under normal circumstances.

It is obvious that under the conditions existing during this sampling period, the major acid contribution of 36,619 lbs./day was made by refuse piles and is quite significant. In marked contrast, strip mines contributed only a minor portion of the total acid mine drainage.

FIGURE VII-l

COMPARISON OF POLLUTION LOAD SOURCES
WEST BRANCH SUSQUEHANNA RIVER (JUNE, 1971)

	ACID		IRON		SULFATES	
	PPD	%	PPD	%	PPD	%
REFUSE PILES	36,619	74.9	2,797	45.9	56,083	50.5
DEEP MINES	12,125	24.8	3,279	53.9	54,077	48.7
STRIP MINES	172	0.3	13	0.2	913	0.8
TOTAL	48,916	100.0	6,089	100.0	11,073	100.0

FIGURE VII-2

POLLUTANT LOADINGS CONTINUOUSLY REMOVED
FROM WEST BRANCH
BY BARNES & TUCKER CO.
MINE DRAINAGE TREATMENT FACILITIES (JAN.-DEC., 1971)

B. & T. CO. #20	AVERAGE FLOW RATE MGD	CHEMICAL ANALYSES ACD. (PPM)	T.Fe	SO_4	pH	POLLUTANT LOADING ACD. (LBS./DAY)	T.Fe	SO_4
MIN.	0.51	102	37	730	2.7			
MAX.	2.59	410	116	1162	3.2			
AVG.	1.66	211	69	978	3.0	2,920	950	13,500
DUMAN'S								
MIN.	5.0	530	450	1900	2.8			
MAX.	10.8	3046	2200	6400	6.3			
AVG.	7.32	2500	1200	4000	4.5	152,600	73,260	244,000
TOTAL DAILY AVERAGE POLLUTANT REMOVAL BY TREATMENT PLANTS =						155,520	74,210	257,500

Resampling of the streams at two large refuse piles approximately one year later (Springfield No. 4 and Sterling No. 6 - May 1972) indicated a much lower acid contribution than was determined in the first sampling. It can be concluded, therefore, that the refuse piles generate varying amounts of acid as a function of time and meteorological conditions.

The geographical distribution of the known acid sources above Cherry Tree is such that under low and base stream flow conditions, 85 percent of the maximum net acid in this reach is introduced directly into the West Branch above Spangler. The remaining 15 percent (from known sources) is the only significant acid loading entering the river stream between Spangler and Cherry Tree. However, at high stream flow rates (greater than 2000 cfs at Bower Station), an unexpected high acid loading from "unknown" diffuse sources below Spangler has been observed which becomes the major pollutant contribution, attaining levels as high as 50,000 lbs./day (See Item 5 - Figure VII-14). This diffuse acid source is believed to be the thousands of tons of acidic refuse rock distributed along the banks of the river and in the river bed, which contact the main stream waters only during periods of turbulence and high water levels.

This unique situation, augmented by the highly restrictive topographic features of the area, makes the complete treatment of the West Branch waters virtually impossible on any reasonable economic basis (see Chapter III for detailed discussion). However, the first 40 miles of the West Branch has sufficient natural alkaline input to be self-neutralizing under all stream flow conditions, and becomes essentially neutral below Bower Station, provided that both Barnes and Tucker treatment plants are neutralizing the flows from Lancashire No. 20 mine and Lancashire No. 15 pool.

BASIC DATA FOR DRAINAGE SOURCES

The basic data for this phase of the work was obtained from measurements and water samples taken from 152 sampling and gauging stations which were installed at all known drainage sources (see Chapter V for details). The sample locations are indicated in Plate 2 (large map in back cover pocket). An index and brief description of each sampling point together with monthly sample records and analyses are presented in Appendix A. Locations of refuse piles and strip mines are also shown on Plate 2. An index map for the refuse piles and individual refuse pile sketches are presented and discussed in Chapter X.

It is important to note that all deep mine discharges from the B Seam mines are strongly acid, whereas all of the D Seam discharges are significantly alkaline. This situation has good potential for increasing the natural neutralizing capacity of the West Branch headwater area. Ways and means for implementing this potential are discussed in Chapters IX and X.

REFUSE PILE SOURCES

All mine refuse piles in the area of the West Branch of the Susquehanna River in the reach from the headwater to Cherry Tree have been located, mapped and studied to determine how much they affect the stream (see Plate 2 and Chapter X).

In order to expedite the work, only the large piles of more than 100,000 cubic yards were selected for study. There are twelve (12) such pile areas and they have been titled in accordance with name of the mine where the refuse originated. These areas are listed in Figure VII-3.

These piles are in or along the natural drainage paths of the streams and tributaries listed on the following page. (See photographs in Figure VII-4). This close proximity to the affected stream precluded the use of the normal weir sampling procedure. Instead, samples were collected and flow measurements made at all inputs upstream of each pile and at the output downstream from each pile. The pollutional loadings from each pile were then obtained by subtracting the sum of the input loads from the output.

One modification of this procedure becomes necessary whenever some of the stream input to a refuse pile system is alkaline. This alkalinity may neutralize some of the acidity produced by the pile, thus reducing the output of acidity. In this case, there will also be a net decrease in alkalinity.

In order to more realistically evaluate the acid contribution from a refuse pile where this condition exists, any decrease in alkalinity has been considered to be an equivalent increase in acidity.

Figure VII-5 was compiled from data obtained in the summer low flow period of 1971.

During this sampling period four (4) areas, all located on the West Branch including Sterling #6, Lancashire #15, Watkins, and Springfield #4, produced 85% and 95% of the total refuse pile acid and iron respectively.

FIGURE VII-3

MAJOR REFUSE PILES IN THE WEST BRANCH SUSQUEHANNA HEADWATER AREA

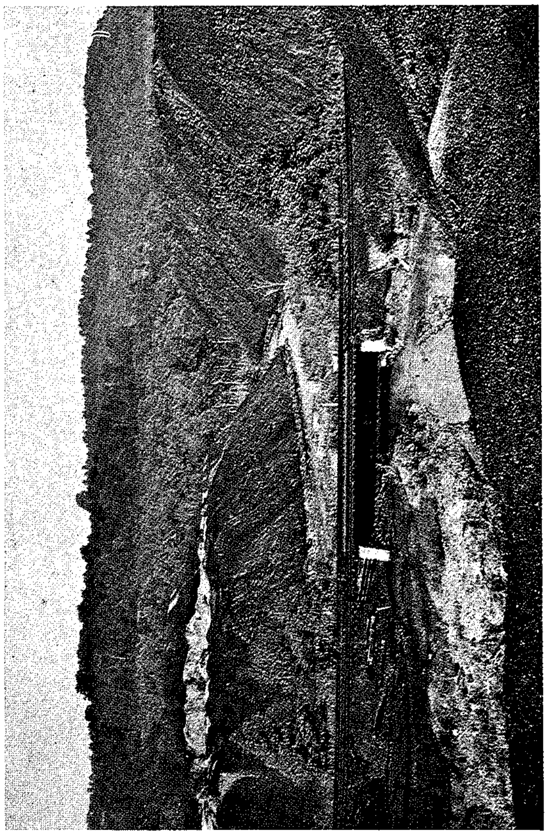
	MINE NAME	COAL SEAM	CONTACTING STREAM	PILE VOLUME (YD^3)	BASE AREA (ACRES)
1.	Lancashire #20	B	West Branch	128,700	4.33
2.	Sterling #6	B	West Branch	659,000	15.32
3.	Ster. #1 & Lan. #14	B	West Branch	620,000	15.73
4.	Lancashire #15	B	West Branch	555,500	17.45
5.	Watkins	B	West Branch	833,300	15.50
6.	Susquehanna #1	D	West Branch	111,100	6.89
7.	Victor #10	B	Fox Run	255,600	18.37
8.	Victor #9	B	Fox Run	513,900	14.29
9.	Springfield #4	B	West Branch	281,500	34.89
10.	Lancashire #9	D	Porter Run	121,900	5.17
11.	Moss Creek	D	Moss Creek	1,215,700	32.83
12.	Victor #17	D	Emeigh Run	312,000	12.19
	TOTAL			5,608,200	192.96

Several of these piles were sampled superficially to get some indication of their coal content. These samples were also subjected to washability (heavy media separation) tests to determine the quality of coal that might be recovered in a pile removal and treatment operation. The results of these tests are presented in Chapter X.

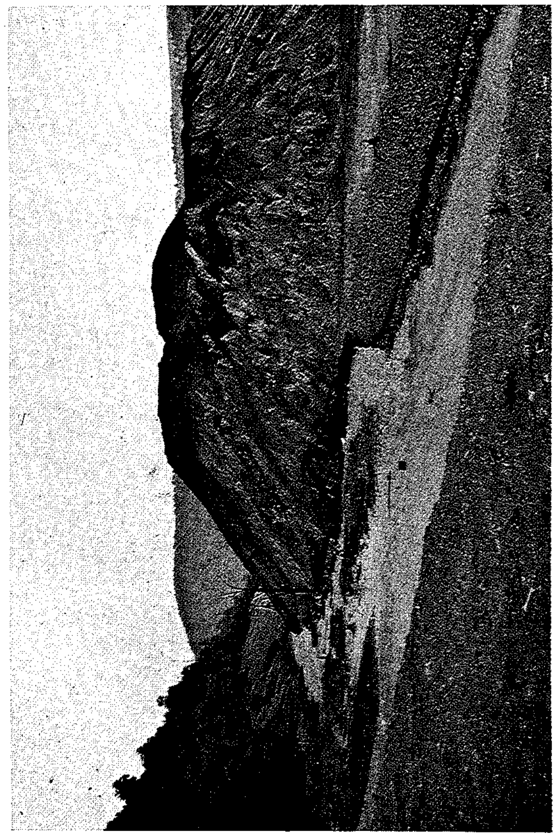
FIGURE VII-4

Lancashire #20 refuse pile southeast of Bakerton

Victor #9 refuse pile at Spangler



Sterling #6 refuse pile at Bakerton



Watkins mine refuse pile at Watkins

FIGURE VII-5

POLLUTION LOAD PRODUCED BY
REFUSE PILES ON WEST BRANCH SUSQUEHANNA RIVER (JUNE, 1971)

REFUSE PILE	CHANGE IN POLLUTANT LOADING-PPD[2] ALK.	ACID	T.Fe	SO_4	ADJUSTED ACIDITY	ACID PRODUCED PPD/ 1000 YD^3	PPD/ ACRE
LANCASHIRE #20	-59	742	1	1,296	801	6.22	185
STERLING #6	-559	4,770	213	6,139	5,329	8.09	348
STER. #1 & LAN. #14	-64	2,421	13	14,811	2,485	4.01	158
LANCASHIRE #15	-1168	11,822	490	15,079	12,990	23.38	744
WATKINS	0	5,522	1,323	11,892	5,522	6.63	356
SUSQUEHANNA #1	NOT POLLUTING		0	0	0	0	0
VICTOR #10	-15	10	-1	53	25	0.10	1
VICTOR #9	-108	2,124	133	8,544	2,232	4.34	156
SPRINGFIELD #4	0	6,600	624	-3,932	6,600	23.45	189
LANCASHIRE #9	NOT POLLUTING		0	0	0	0	0
MOSS CREEK	-522	-5	1.3	2,149	517	0.43	16
VICTOR #17	-118	0	-0.79	52.4	118	0.38	10
TOTAL	-2613	34,006	2,797	56,083	36,619	-----	---

NOTE:

1. Adjusted acidity is the sum of the observed increase in acidity and the acid equivalent of the decrease in alkalinity.

2. The net change in stream pollutant loading downstream from the refuse pile.

DEEP MINE SOURCES

Drainage from deep mine sources discharges onto the surface within the study area primarily through conventional mine openings such as bore holes, drainage courses and old portals. An important feature of these discharges is that they all occur within 25 to 100 feet of the West Branch or one of its tributaries. Hence, for all practical purposes, the pollutant loads are being introduced directly into the headwaters with essentially no chance for impoundment and treatment.

The magnitude of these sources was determined by regular sampling of 76 weirs within the study area. The pollutant loadings computed from monthly source flow measurements and chemical analyses are presented in Figure VII-6. Photographs of several mine discharges are shown in Figures VII-7 and VII-8.

FIGURE VII-6

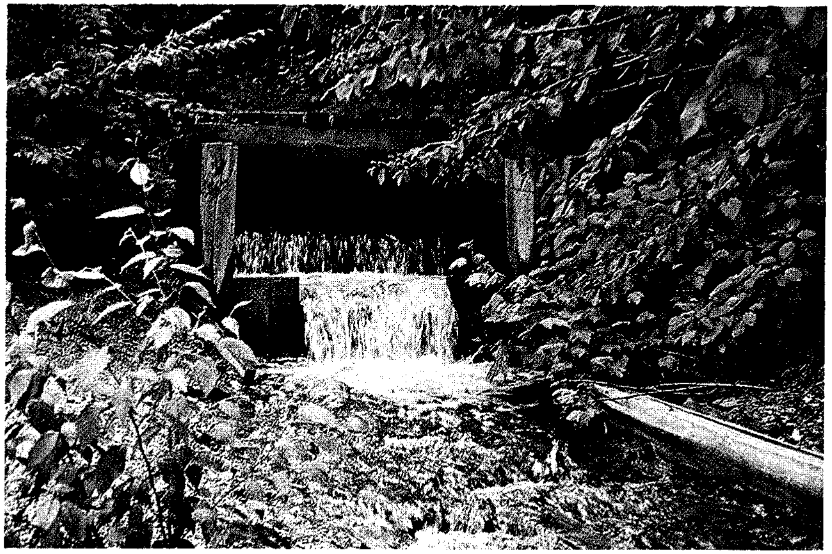
MONTHLY DEEP MINE DRAINAGE DISCHARGE CHARACTERISTICS FOR YEAR 1971

MONTH	FLOW MGD.	ACID LOAD LBS./DAY	IRON LBS./DAY	SULFATES LBS./DAY
January	30.76	50,866	19,310	160,544
February	17.89	30,005	7,176	93,938
March	35.29	49,683	9,005	121,647
April	19.05	16,420	3,368	58,986
May	14.82	11,298	2,697	47,373
June	12.02	12,125	3,279	54,077
July	5.82	9,413	2,497	32,286
August	5.58	10,932	2,868	26,222
September	4.74	12,311	2,111	28,311
October	6.21	12,907	2,903	34,781
November	5.21	10,045	2,848	31,357
December	4.74	10,125	1,857	23,560

The range of total acid load from deep mines was found to vary widely from about 4.7 tons (July 1971) to 25.4 tons (January 1971) per day. The average acid contribution is approximately 9.8 tons per day for the study area.

A summary listing of deep mine drainage contributions by sub-watershed areas is shown in Figure VII-9.

FIGURE VII-7



Sterling acid mine drainage at Bakerton, Weir #33

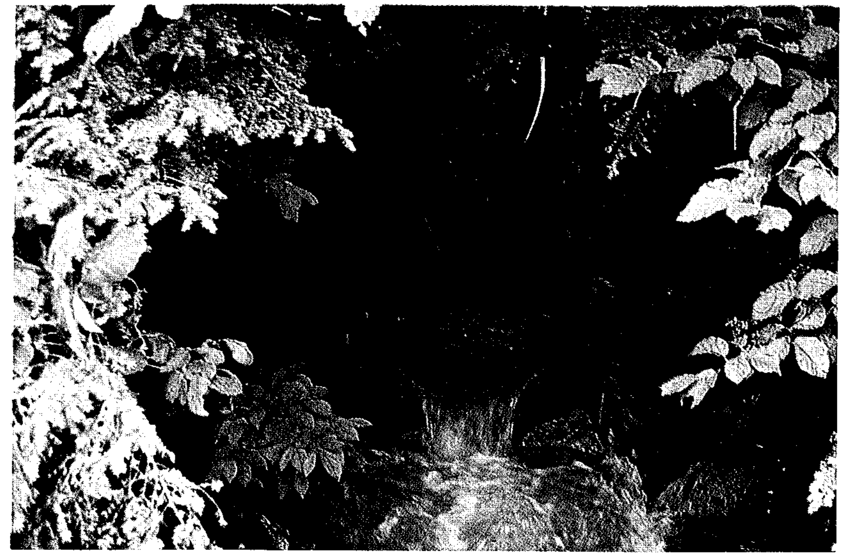
Victor #9 acid mine drainage at Watkins, Weir #40

Victor #9 acid mine drainage at Spangler, Weir #50

Victor #9 acid mine drainage at Spangler, Weir #75

FIGURE VII-8

Pardee #61 alkaline mine drainage, Weir #78



Reed #1 alkaline mine drainage, Weir #36

Pardee #61 alkaline mine drainage, Weir #105

Pennsylvania #22 alkaline mine drainage, Weir #114

FIGURE VII-9

DEEP MINE DRAINAGE DISCHARGE CHARACTERISTICS
IN SUB-WATERSHED AREAS

(AVERAGE VALUES FOR YEAR 1971)

Sub-Watershed Areas	Weir Number Group	Flow (GPM)	Acid (PPD)	Iron (PPD)	Sulfate (PPD)
West Branch Headwaters	1- 22	1,399	3,119	962	14,267
Lesle Run	23- 29	216	491	22	1,220
W.B. Between Lesle & Hoppel	30- 34	651	6,037	1,092	8,162
Hoppel Run	35- 38	318	35	2	1,730
* W.B. Between Hoppel & Fox	39- 50	1,202	8,225	2,479	15,535
Fox Run	51- 75	762	1,671	296	4,857
SUB-TOTAL		4,548	19,578	4,853	45,771
Browns Run	76- 78	1,096	0	57	3,663
W.B. Between Browns & Walnut	79- 83	96	11	9	291
Walnut Run	84- 99	1,685	35	10	6,594
Porter Run	100-104	78	0	0	102
W.B. Between Porter & Moss	105-110	362	14	13	424
Moss Creek	111-128	696	36	19	2,008
W.B. Between Moss & Douglas	129-135	185	1	2	246
Douglas Run	136-151	479	2	29	325
TOTALS	1-151	9,225	19,677	4,992	59,424

* The pollution load in this area includes the Watkin's breakout which produced a continuously decreasing flow during the first four (4) months of 1971 with an "average" acid loading of 2260 ppd, iron 1203 ppd and sulfates 4467 ppd.

This tabulation shows that the acidity generated from the headwaters to Fox Run, a distance of seven miles, constitutes 99.5% of the total deep mine acid discharge for the entire study area..

Deep mine discharges contributing the major acid pollution loads are cataloged according to their mine names.

VICTOR #9 AND VICTOR #10 MINE

Lower Kittanning (B Seam) coal was mined in these operations until April 1950 in the area from Carrolltown to Spangler on the northeast side of West Branch headwaters. Drainage from these workings emanate from two drainage courses (Weirs #15 and #40), a borehole (Weir #50), and a slope entry (Weir #75). The annual average pollutant loads obtained from these weirs were: acidity 7432 ppd, iron 1447 ppd, sulfate 15,170 ppd. Total Average Flow = 1659 GPM.

STERLING #1 AND #6 MINE

Lower Kittanning (B Seam) coal was mined until June 1963 when Sterling #1 ceased operations. This mine complex (#l and #6) is located in an area near Bakerton on the southwest side of the West Branch headwaters. Some of the mine water from these abandoned operations flow underground into the Lancashire #15 pool while the surface discharge consists of a single flow from a drainage drift (Sterling #7). This flow is the present largest single source of acid pollution in the headwaters area and the discharge location is such that the flow could easily be diverted into the Lancashire No. 15 pool for treatment by the Duman plant. This potential is discussed in detail in Chapter X. One rectangular notch weir (#33), was installed at the drift mouth and flow was measured daily April through August, then weekly during the balance of the study period (see photo in Figure VII-7). Daily and weekly flow data are presented in the deep pool pumping records in Appendix C. Monthly chemical analyses are in Appendix A. The annual average of pollutant loads from this source are: acidity 6037 ppd, iron 1092 ppd, and sulfates 8187 ppd. Total Average Flow = 651 GPM.

LANCASHIRE #20 MINE

This is an active mine in the Lower Kittanning (B Seam) coal operated by the Barnes & Tucker Co. It is located south of Carrolltown. The flow from this mine into the West Branch headwaters is a composite of flows from a complex mining system. The "B Seam" in Lancashire #20 is on both sides of the Laurel Hill anticline (see Figure III-2). A mine drainage course on the northwest flank handles the natural drainage on that side and emanates at Carrolltown road l.5 miles west of Carrolltown, the site of the original Lancashire #20 treatment Plant (see photo in Figure VII-16). During the study period (1971), mine drainage from the opposite southeast flank was collected and pumped underground to the drainage course on the northwest flank. Thus, all the drainage from Lancashire No. 20 flowed ultimately into the West Branch headwaters from the drainage course discharge point.

This combined outflow was measured by a 42" rectangular notch weir (#6). Seepage (3.8 GPM) along the cropline was collected by a V-notch weir (#7). The annual average pollutant loads in the raw drainage from this source during 1971 were: acidity 2918 ppd, iron 954 ppd, and sulfates, 13,476 ppd. Total average flow = 1161 GPM.

This flow was one of the major pollutant inputs to the West Branch during 1966 and 1967. During 1971, all of this water was neutralized and clarified in the original Lancashire #20 treatment plant, which went on stream in January, 1968. Effluent from this plant usually contained an excess of alkalinity which produced a beneficial effect on the upper headwaters.

In May 1972, a new Lancashire #20 mine water treatment plant, located adjacent to the Lancashire #20 cleaning plant, came into operation (see photo in Figure VII-16). This plant is treating all of the acid mine water from the southeast flank before it is pumped over to the West Branch side, This treated water also contains excess alkalinity so that the water now flowing from weir (#6) is consistently neutral and requires no further treatment before discharging into the West Branch.

STERLING #3 MINE

Lower Kittanning (B Seam) coal was mined in this operation until 1926. It is located east of Bakerton, on the east side of the West Branch headwaters. Effluent from this mine discharges from four drainage courses, at each of which a sampling weir was installed. The annual average pollution loads obtained from these weirs (#21, #27, #28, and #29) are; acidity 497 ppd, iron 22 ppd and sulfates 1238 ppd. Total Average Flow = 226 GPM.

HEISLEY #2 MINE

Lower Kittanning (B Seam) coal was mined here until September 1926. It is located southeast of Bakerton, on the east side of the West Branch Susquehanna River headwater. Drainage from this mine reaches the surface through three drainage courses at which sampling weirs were installed. The annual average pollution loads measured at these weirs (#19, #20, #22) were; acidity 110 ppd, iron 5 ppd and sulfates 299 ppd. Total Average Flow = 88 GPM.

LANCASHIRE #15 MINE

Barnes and Tucker Company ceased operations at Lancashire #15 (B Seam) Mine on May 10, 1969. The abandoned mine gradually filled with water to an elevation of about 1500 feet in approximately one year. In June 1970, a catastrophic breakout of very acidic water occurred in a secluded swampy area bordering the West Branch near Watkins, Pennsylvania. (See photo in Figure VIII-l). This flow reached a maximum during the period July - October 1970 and was estimated to be between l.5 and 2.0 MGD carrying up to 200,000 lbs./day of acidity. When the Duman treatment plant started up in November 1970, this flow subsided as the Lancashire No. 15 pool level was lowered until it ceased completely in April, 1971. This history is discussed in greater detail in Chapter VIII.

During the first four months of the 1971 study period, acid water from the breakout continuously accumulated in extensive marshy pools, drainage streams from which broke through to the West Branch in several places. Sampling weirs (#43, #44, #45, and #46) were installed at each definite drainage location.

Monthly flow measurements were made at each weir, and samples were taken for chemical analysis. The pollutant loads calculated for these breakout sources are tabulated in Figure VII-10.

FIGURE VII-10

POLLUTANT LOADINGS FROM BREAKOUT SOURCES - 1971

(COMBINED OUTPUT OF WEIRS 43, 44, 45 AND 46)

MONTH	FLOW (GPM)	ACID (PPD)	IRON (PPD)	SULFATES (PPD)
January	545	23,697	13,735	46,914
February	72	3,391	1,846	6,482
March	18	39	11	65
April	18	18	2	42
May	0	0	0	0
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0

As shown above, the pollution load from the breakout decreased to zero rapidly after the Duman treatment plant started operations. The overflow from the deep mine pool ceased completely in May, 1971.

Assuming there is no breakout overflow, five (5) major deep mine areas (Victor #9 and #10, Sterling #7, Lancashire #20, Sterling #3 and Heisley #2) contribute an average total of 16,994 ppd acidity, which is 97.57% of the total (17,417 ppd) deep mine acid load in the study area.

STRIP MINES

Fifty-nine (59) weirs were installed for source sampling and the determination of the flow characteristics of strip mines in the study area. Locations are shown in Plate 2 and sampling data is presented in Appendix A.

The magnitudes of strip mine drainage pollution loads are tabulated in Figure VII-11.

FIGURE VII-11

MONTHLY STRIP MINE DRAINAGE DISCHARGE CHARACTERISTICS

1971	Flow (GPM)	Alk. (PPD)	ACID (PPD)	IRON (PPD)	SULFATE (PPD)
January	2,431	795	457	78	4,676
February	717	346	371	29	2,064
March	2,882	1,089	398	78	3,842
April	1,212	387	245	61	5,180
May	1,244	404	195	33	1,417
June	356	304	172	13	913
July	131	64	113	5	506
August	214	88	99	11	535
September	94	72	101	6	297
October	208	103	93	3	457
November	90	26	104	11	301
December	594	119	59	10	516

The quantity of acid produced each month indicates that strip mines do not discharge any significant amount of acid compared to deep mines or refuse piles.

A summary listing of average strip mine drainage contributions by sub-watershed areas is shown in Figure VII-12.

FIGURE VII-12

STRIP MINE DRAINAGE DISCHARGE CHARACTERISTICS

IN SUB-WATERSHED AREAS

WATERSHED AREA	WEIR NO. GROUP	FLOW (GPM)	ALK (PPD)	ACID (PPD)	IRON (PPD)	SULF. (PPD)
W.B. Headwater	1- 22	30	2	23	42	30
Lesle Run	23- 29	161	29	103	738	161
W.B. Between Lesle & Hoppel	30- 34	14	0	16	47	14
Hoppel Run	35- 38	14	0	10	40	14
W.B. Between Hoppel & Fox	39- 50	4	0	3	10	4
Fox Run	51- 75	113	9	21	244	113
SUB TOTAL		336	40	176	1121	336
Browns Run	76- 78	5	0	1	3	5
W.B. Between Browns & Walnut	79- 83	3	1	3	9	3
Walnut Run	84- 99	28	2	6	40	28
Porter Run	100-104	47	123	0	118	47
W.B. Between Porter & Moss	105-110	31	6	1	13	31
Moss Creek	111-128	129	69	10	224	129
W.B. Between Moss & Douglas	129-135	45	29	1	76	45
Douglas Run	136-151	200	45	2	116	200
W.B. Between Douglas & Peg	152	24	2	0	4	24
TOTALS	1-152	848	317	200	1724	848

Once again the data shows that the major portion (88 percent) of the total acid pollution produced by strip mines is generated in the area upstream from the confluence of the West Branch and Fox Run. This study also indicated that most of the strip mine effluents located below Fox Run were consistently alkaline.

DIFFUSE SOURCES OF ACIDITY BELOW SPANGLER

In Chapter VI, it was mentioned that during periods of heavy rainfall and high flow, a wide range of in-stream pollutant loadings were observed for the West Branch headwater reach from Bakerton to Bower. Figure VI-10 shows that during these periods, large, gradually-increasing, acid loadings are entering the West Branch below Spangler which greatly exceed the quantities coming from known sources in that area. In fact, during a comprehensive stream sampling program conducted in September 1971, acid loadings measured in the stream near Stifflertown showed that the acid content was more than twice as great as that at Spangler. This loading differential, which was confirmed at several points, indicates that under certain meterological conditions, acid loadings of 50,000 lbs./day are generated by unknown diffuse sources below Spangler within a ten mile length of the West Branch. This is greater than the normal average acid loading of 40,000 lbs./day from all known mine drainage sources above Spangler, the area which normally produces about 85% of the total pollutants. (See Figure VII 13).

This spectacular difference between observed normal and abnormal conditions is more apparent from a study of the alkali-acid material balance for the West Branch headwaters that has been developed in Figure VII-14. Several important observations can be made for each item in this figure:

Item 1 - During periods of high flow (in the 5% frequency of occurrence range), acid loadings from sources above Spangler can increase by a factor of about four (4) when stream flow increases by a factor of ten (10).

Item 2 - Natural alkalinity input to the upper West Branch also increases by a factor of about 4 above Spangler.

Item 3 - Residual net acidity in the stream at Spangler increases by a factor of four (4).

Item 5 - Unknown acid sources can generate from zero to 50,000 lbs. of acidity per day in the area between Spangler and Stifflertown (See Figure VII-16 for stream-mile locations for towns mentioned). The abnormal maximum acid loadings occur at locations where stream flows attain a magnitude of 475 cfs or 308 MGD, thus making treatment a formidable problem.

Item 6 - Maximum acid loading in the West Branch headwaters observed during 1971 was 131,000 lbs./day, a 9-fold increase over basic flow conditions.

FIGURE VII-13

ACID SOURCES AND POLLUTION LOAD GENERATION IN THE WEST BRANCH SUSQUEHANNA HEADWATERS ABOVE SPANGLER, PENNSYLVANIA

(DATA FOR THE PERIOD JUNE, 1971)

SAMPLING POINTS	ACID SOURCE	POLLUTANT LOADING (LBS./DAY) ALK.	ACID	T.Fe	SO_4	ACID LOADING DISTRIBUTION (%)
A. WEST BRANCH ABOVE WATKINS (NEAR BREAKOUT)						
	Refuse	0	27,127	2,040	49,217	74.8
	Deep	48	8,986	2,539	30,680	24.8
	Strip	0	158	6	400	0.4
# 1-#46	Totals	48	36,271	4,585	80,297	100.0
B. WEST BRANCH BETWEEN WATKINS AND FOX RUN						
	Deep	0	1,689	337	3,026	100.0
	Strip	14	0	1	21	0.0
#47-#50	Totals	14	1,689	338	3,047	100.0
C. FOX RUN (TOTAL DRAINAGE AREA)						
	Refuse	0	2,257	132	8,597	61.8
	Deep	22	1,385	303	4,188	37.9
	Strip	2	10	0	82	0.3
#51-#75	Totals	24	3,652	435	12,867	100.0
STUDY AREA DISTRIBUTION						
A. (# 1-#46)	Combined Sources	48	36,271		80,297	74.15
B. (#47-#50)	Combined Sources	14	1,689		3,047	3.45
C. (#51-#75)	Combined Sources	24	3,652		12,867	7.47
TOTALS (ABOVE SPANGLER)		86	41,612		96,211	85.07
D. (SPANGLER TO CHERRY TREE)	Combined Sources	8,514	7,304		14,883	14.93
TOTALS		8,600	48,916		111,094	100.00

FIGURE VII-14

ACID-ALKALI MATERIAL BALANCE IN THE WEST BRANCH
ABOVE BOWER STATION VS. STREAMFLOW RATES

(DATA FOR YEAR 1971)

		LOW AND MEDIAN FLOW (5 CFS @ WATKINS)	HIGH FLOW (50 CFS @ WATKINS)
1.	TOTAL KNOWN ACID GENERATED FROM ALL SOURCES ABOVE SPANGLER - LBS./DAY	40,000	140,000
2.	NATURAL ALKALINITY IN WEST BRANCH ABOVE SPANGLER - LBS./DAY	26,000	93,000
3.	RESIDUAL ACID IN STREAM AT SPANGLER - LBS./DAY	14,000	57,000
4.	KNOWN ACID GENERATED BETWEEN SPANGLER AND CHERRY TREE - LBS./DAY	8,000	24,000
*5.	UNKNOWN DIFFUSE ACID SOURCES BETWEEN SPANGLER AND CHERRY TREE - LBS./DAY	VERY MINOR	50,000
6.	MAXIMUM ACID LOADING IN WEST BRANCH BETWEEN SPANGLER AND BOWER STATION - LBS./DAY	18,000 (AT GARMANTOWN)	131,000 (AT STIFFLERTOWN)
7.	NATURAL ALKALINITY ADDED BY TRIBUTARIES BETWEEN SPANGLER AND BOWER STATION - LBS./DAY	29,000	210,000
8.	NET ALKALINITY AT BOWER STATION	9,000	79,000
9.	% OF NET MAXIMUM ACID (6) AT SPANGLER	78%	44%
10.	pH AT CHERRY TREE	4.3	3.9
11.	pH AT MCGEES MILLS	7.2	4.4
12.	pH AT BOWER STATION	7.6	6.0

Item 7 - Natural alkalinity entering the West Branch between Spangler and Bower Station increased 7-fold during the September 1971 period. This was roughly proportional to the increase in flow volume, and provided an excess of alkalinity which neutralized the 9-fold acid increase within the West Branch before the mixed waters reached Bower Station. The West Branch headwater watershed capability of generating compensating loadings of alkalinity to neutralize maximum acid loadings from all present sources is a most important characteristic. This natural treatment capability is so immediately interlocked with the pollutant-producing sources (by virtue of local terrain characteristics) that direct neutralization takes place within a stream reach of about twenty-five miles. The result of this local interaction is that the West Branch at Bower Station remains at a pH of six or higher under all flow conditions, which is sufficient to maintain the normal game fish population in Curwensville Reservoir.

It is important to note that this natural neutralizing capacity is marginal, and is easily exceeded if major acid flows from deep mine pools break into the stream.

Item 9 - The percentage of net maximum stream acidity to be found at Spangler is 78% of the total under base flow conditions, but may be only 44% at high flow. This indicates one of the problems involved in attempting to locate an effective stream treatment plant in the Spangler Area.

Item 10 - 12 These pH indications are included to show that under base flow conditions, water quality at Bower Station is as good as any treatment plant could provide. At high flow, with a 9-fold increase in stream acid loading, the natural neutralizing system is taxed (see pH drop at McGees Mills from 7.2 to 4.4). However, at Bower the pH is up to 6, and an excess of alkalinity is present. This water is not detrimental to Curwensville Reservoir.

The data in Figure VII-14 is based upon observations made during the 1971 study period. To confirm the existence of the diffuse acid source and the self-neutralizing capacity of the stream at high flow conditions, two additional samplings of the West Branch were carried out in June, 1972 during the week of the major flood (Agnes). Raw data for these samplings are included on the stream analyses tables in Appendix B and are summarized in Figures VI-13 and 14 in Chapter VI. A graphical presentation of this data is shown in Figure VI-10 (Chapter VI). The same high flow characteristics as discussed above were again observed and confirmed in both cases, but were of a lower order of magnitude. Since these high flow stream loading characteristics are of great importance in the consideration of any West Branch treatment facility, additional monitoring of high flow water quality in the study area should be carried out.

SOURCE OF DIFFUSE ACIDITY

One of the most perplexing problems encountered was to determine the actual source of the high acid loadings that were originating between Spangler and Stifflertown only during periods of high flow. The major known acid source in that area was Springfield No. 4 refuse pile at Spangler whose maximum contribution could probably not exceed 24,000 lbs./day, all of which would be produced at a single point source. The features of the diffuse acid source are the following:

1. The acidity loading rate ranged from 10,000 to 50,000 lbs./day.

2. The loading gradually increased from Spangler to a point between Garmantown and Stifflertown, then gradually decreased.

3. A few stream samples indicated that calcium, magnesium, and aluminum loadings were higher during high flow periods.

4. Initial high flows contained the highest loadings, which decreased as the high flow persisted for a period of 24 hours or longer.

These features are strong indications that the acidity is coming from oxidized refuse material which commonly produces leachates high in acid, Ca, Mg and Al. The uniform acid addition can only be originating from refuse evenly distributed in or along the banks of the stream. The short duration of the loading (essentially a slugging effect) can be attributed to accumulated acid salts either on stream bank particles or in stream bed sediments buried under yellow boy deposits. These salts are dissolved in the main stream waters only during periods of high water levels and strong turbulence.

The logical source of widely distributed refuse sediments would be the numerous refuse piles bordering or within the West Branch in the area above Spangler where stream velocities do not permit any appreciable amount of sedimentation. Photographs of several of these piles in Figure VII-4 show the high degree of stream erosion these piles are constantly undergoing. Since the vegetative cover in the headwater area provides good erosion protection to the surface soils, it is logical to expect that the major sediment loadings in the upper West Branch are refuse particles. Drainage area sediment yield data for Pennsylvania streams (4) indicate an average deposition rate of 250 tons/year/square mile of drainage area. West Branch stream morphology is such that the reach between Spangler and Stifflertown would be the natural deposition basin for sediments from upstream.

To test the rationale of the proposition that refuse sediments are the diffuse acid source, estimates of accumulated refuse sediment volumes and sediment deposition rates were made for the area below Spangler. Estimate calculations are presented in Figure VII-15. From the data and assumptions used, it appears logical to expect that diffuse acidic refuse deposits could be responsible for the large, high flow, acid slugs observed in the West Branch during this study.

MINE WATER TREATMENT PLANTS

Four treatment plants are located in the study area, all of which are processing strong acid waters from deep mine pools. Photographs of these plants are shown in Figure VII-16. The Barnes and Tucker Company operates the Duman and Lancashire No. 20 plants. Flows and analyses of mine waters treated by these plants are shown in Figure VII-2. The Lancashire No. 20 plant is now treating about 3 MGD, with the neutralized and clarified water running into the West Branch headwaters. These treated waters contain a slight excess of alkalinity which helps to neutralize some acid in the stream. The Duman plant is treating 8 to 10 MGD of extremely acid water from Lancashire No. 15 pool. The Duman operation is located in the Allegheny River watershed, hence the effluent from this plant never enters the West Branch. A full discussion of this facility is presented in Chapter VIII.

The two flows now being treated by these plants are those which in the past have been the cause of overloading the West Branch self-neutralizing capacity. With these two flows now under control, the West Branch is capable of self-regulation in the reach above Curwensville Reservoir.

The original Lancashire No. 20 plant located on the Carrolltown road (see reference in previous discussion under Deep Mine Sources) is the standard lime neutralizationsettling pond type which was in full operation during the 1971 study period. This has since been replaced by the new Lancashire No. 20 plant which utilizes the latest

FIGURE VII-15
CALCULATIONS OF POTENTIAL WEST BRANCH ACID SLUGGING EFFECT FROM REFUSE EROSION DEPOSITS ON STREAM BANKS AND IN STREAM BED

BASIC DATA AND ASSUMPTIONS (FOR STREAM REACH TO STIFFLERTOWN)

Stream Miles Involved: 10 Miles
Average Width of Stream: 10 Ft.
Assumed Avg. Depth of Refuse Sediments: 0.4 Ft.
Avg. Refuse Pile Erosion Rate (Total): 250 Tons/yr./mi.^{2} drainage area
W.B. Drainage Area Above Spangler: 20 sq. mi. (Incl. Fox Run)
Acid Generation Capacity of Refuse: 45-90 lbs. acid/ton/year
Bulk Density of Refuse: 85 lbs./ft.^{3}
Avg. Sediment Yield for Local Rivers: 250 tons/yr./sq. mi. drainage area

POTENTIAL "IN-STREAM" ACID GENERATION CAPACITY FOR REACH
Total Refuse In-Stream:

4 ft.^{3}/ft. x 85 lbs./ft.^{3} = 340 lbs. Refuse Sediments/Ft. Stream Length

$\frac{340 \text{ lbs./.ft. x 5,280 ft./mile x 10}}{2000 \text{ lbs./ton}}$ = 8,976 tons Refuse in or Beside Stream Bed

Total Annual Acid Generating Capacity (Use Low Acid Figure)

8,976 tons x 45 lbs. acid/ton/yr. = 403,920 lbs. acidity/year

Potential Acid Slug Magnitude During High Stream Flow (Assume six even periods)

$\frac{403{,}920 \text{ lbs./yr.}}{6}$ = 67,320 lbs. acid/slug (calculated)

Actual Observed Acid Slug From "Diffuse Sources"

50,000 lbs. acid/slug (actual)

CONTINUOUS REFUSE LOADING RATE-FOR REACH
Total Estimated Ref se Erosion Rate:
250 tons/yr./mi. x 20 mi.^{2} = 5,000 tons/yr.

Acid Generation Potential of Annual Refuse Addition
5,000 TYP x 45 lbs. acid/ton = 225,000 lbs./yr.

Total Estimated Refuse Tonnage above Spangler: 4,000,000 tons

Total Refuse Eroded Per Year: $\frac{5{,}000 \times 100}{4{,}000{,}000}$ = 0.12%/yr.

lime feeding and mixing equipment, and an automated Hydra hydraulic rake sludge removal system (see photos of Hydra equipment in Chapter VIII). Maximum design capacity of the plant is 3,500 GPM (5 MGD).

The treated water from this operation still flows through the old Lancashire No. 20 pond system, where a final polishing treatment can be applied, if necessary. Since lime feeding facilities are still available at this site, it is suggested that this equipment be maintained in stand-by condition for emergency neutralization service for the West Branch headwaters. A controlled alkaline flow of 3 to 4 MGD from this plant could provide major control of any future break-out from the deep mine pools.

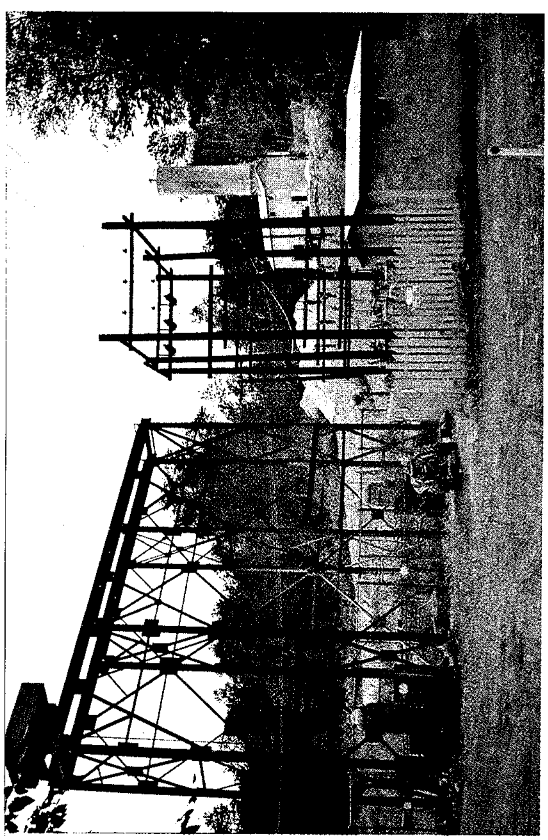
Eastern Associated Coal Corporation operates a treatment plant for its operating mine discharge at Cover Y Portal (see photo in Figure VII-16 and location map in Figure VIII-3). This plant discharges almost directly into Elk Creek (Allegheny watershed) and is not a factor in contamination of the West Branch. It is included only because of its possible conjoint effect with the Duman plant effluent on the water quality in Elk Creek. This subject is discussed in detail in Chapter VIII.

DEEP MINE ALKALINE DISCHARGES

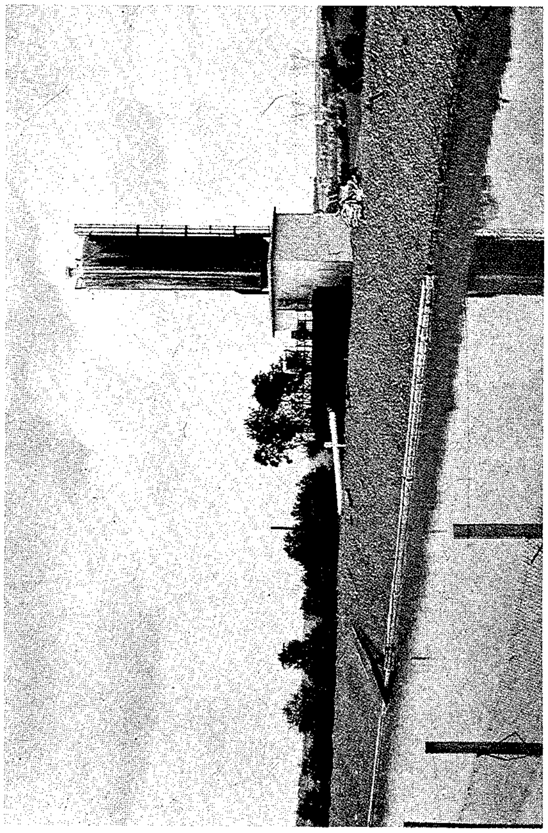
One of the major efforts in this project has been the study of the alkalinity production capacity of the West Branch watershed within the study area. Previous sections of this report have cited the alkalinity contributions of direct surface run-off and West Branch tributaries (see Chapter VI and Figure VII-14). A large potential source of alkalinity is from the limestones and calcareous shales adjacent to the D coal seam. Several flows from this seam discharge on the surface in the study area. Flows and loadings of these discharges are shown in Figure VII-17. With one exception (Reed No. l), all of these flows are consistently alkaline, with total flows ranging from an average of 3 MGD to a maximum of about 10 MGD. However, the total alkalinity loading provided by these flows is quite small, less than 10% of the total acidity produced in the area.

The real natural neutralizing potential of the D-seam lies in diverting large volumes of acid water from the B-seam into the D-seam. Data obtained in our study indicates that during the period of the breakout, about 1 MGD of Lancashire No. 15 acid water was naturally diverted into the D-seam and discharged at Pardee #61 portal (Weir #78) with an alkalinity of 150 ppm and a pH of 7.5. Ways and means of taking advantage of this natural neutralization capacity are discussed in detail in Chapter X.

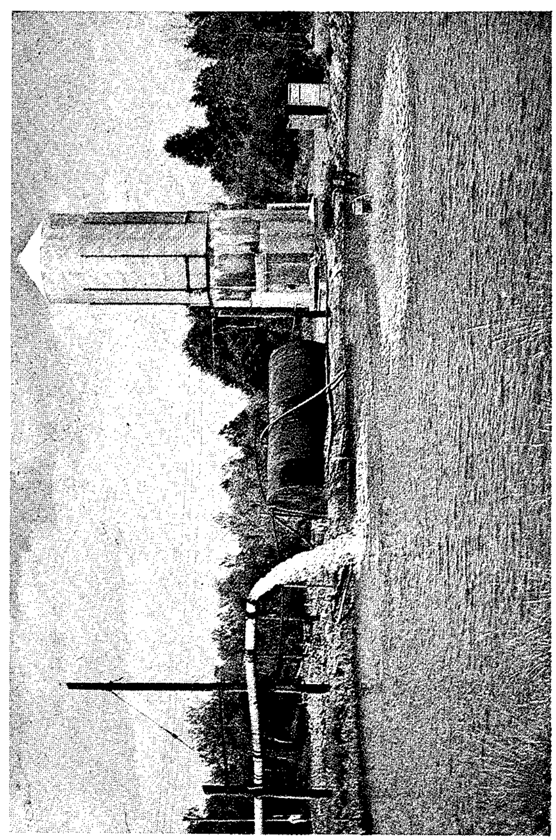
FIGURE VII-16



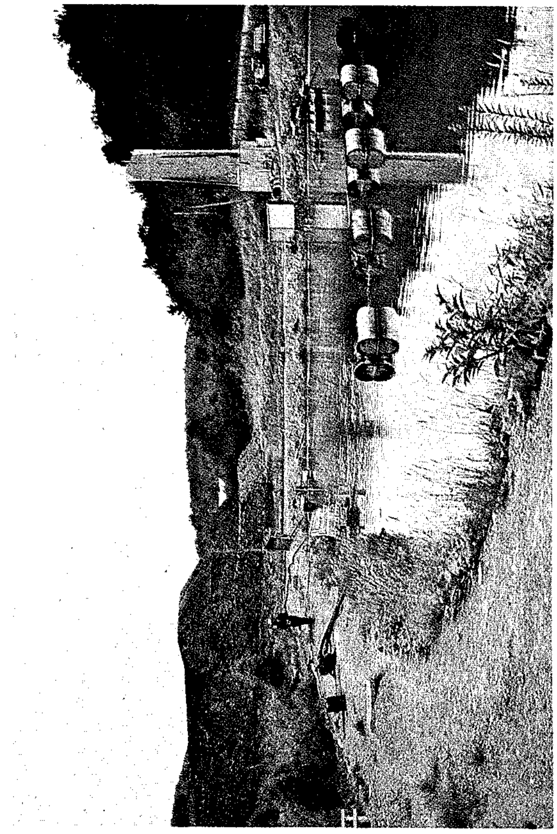
Barnes & Tucker Duman's Dam treatment plant



B. & T. Lancashire #20 new treatment plant



Eastern Associated Colver Y Portal treatment plant



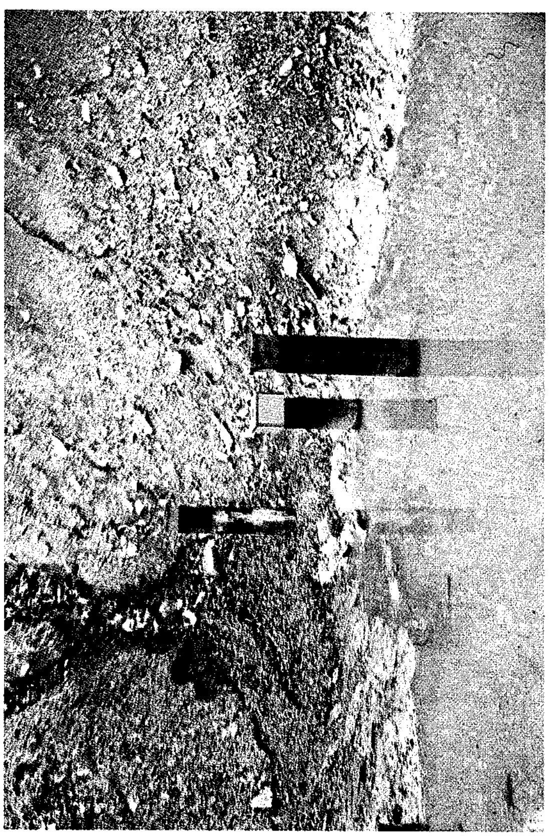
B. & T. Lancashire #20 old treatment plant

FIGURE VII-17

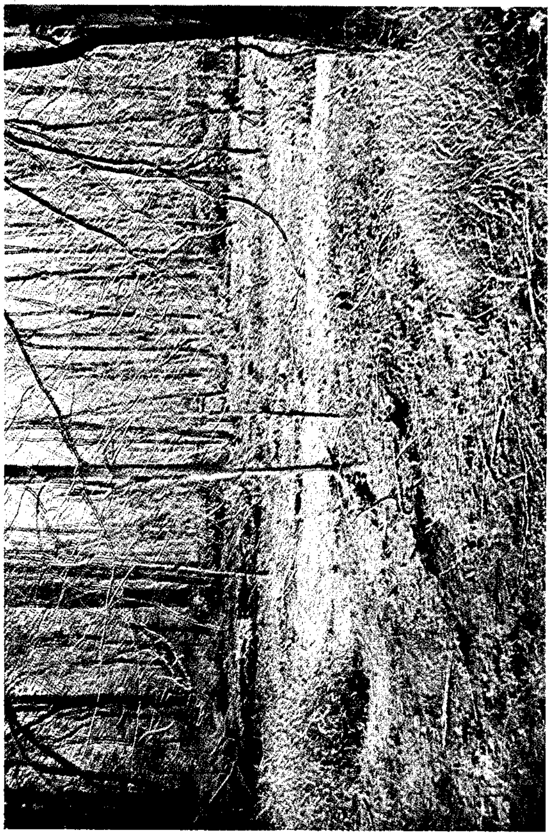
ALKALINE DRAINAGE FROM D SEAM DEEP MINES

SAMPLE POINT		MINE SOURCE	FLOW GPM	CHEMICAL LOADINGS ALK.	ACID	T.Fe	SO_4	pH
				P P D				
36	Avg.	Reed #1 &	302	40	35	2	1,723	5.4
	Max.	Sterling #10	880	84	84	4.2	4,963	5.6
78	Avg.	Pardee #61	1076	1716	0	57	3,642	7.1
	Max.		3924	2354	0	235	14,456	7.0
82	Avg.	Pardee #61	24	32	0	0.1	51	7.2
	Max.		82	102	0	0.3	186	7.1
83	Avg.	Pardee #61	62	97	0	0.1	122	7.0
	Max.		174	292	0	0.2	340	7.5
105	Avg.	Pardee #61	106	75	0	5	110	7.7
	Max.		694	383	0	52	483	7.5
113	Avg.	Pardee #61	28	47	0	1	84	7.4
	Max.		123	204	0	3	382	7.5
114	Avg.	Penna. #22	582	1065	0	14	1,730	7.6
	Max.		925	1709	0	19	2,664	7.7
TOTALS - AVERAGE			2180 (3.14 MGD)	3072				
MAXIMUM			6802 (9.79 MGD)	5128				

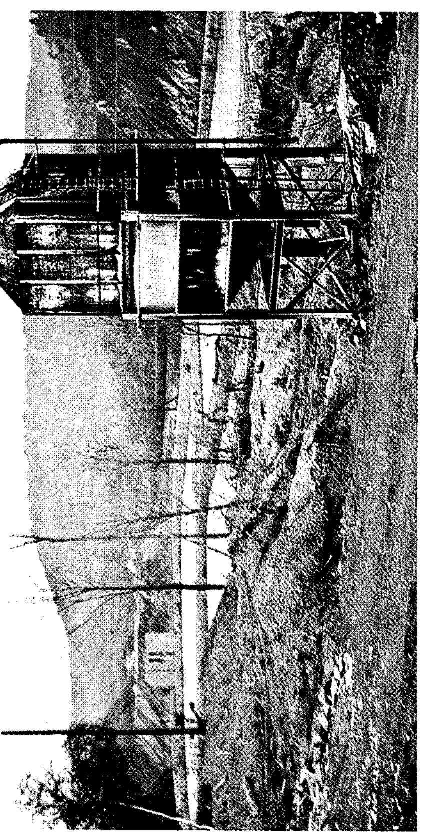
FIGURE VIII-1



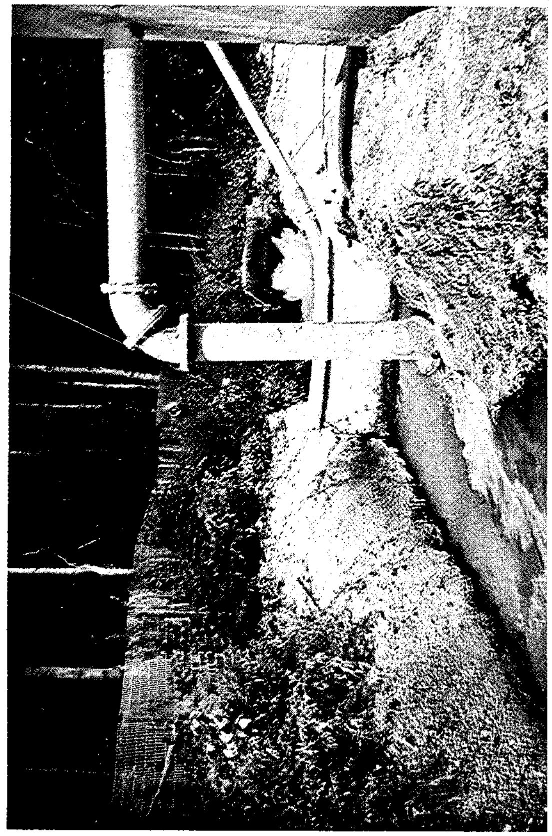
Maberry borehole - Lancashire #15



Breakout area near Watkins



Maberry borehole emergency treatment facility



Raw pool water pumping at Duman's plant

DESCRIPTION OF UNIT OPERATIONS

a. Pumps

Two 3500 gpm, constant speed Worthington vertical turbine deep well pumps, Model No. 15-H-277, 5-stage, 1760 RPM, provide the capability of delivering a total of 10 MGD of raw water from the mine pool bottom at a depth of 460 feet at 1700' elevation. Each pump has a rated capacity of 2,500 GPM at 500 ft. total dynamic head at 1750 rpm and 80% efficiency. At the 1440 ft. pool operating level, the working dynamic head is 260 feet. This pumping capacity has been adequate for pool level control since the start of pumping operations on October 31, 1970. Pumping records for the year 1971 are included in Appendix C. This data is reproduced in graphical form in Figure VIII-6.

Available data indicates that in one year of operation (from March 1971 through February 1972) the pool level was lowered approximately forty feet at an average pumping rate of approximately 8.7 million gallons per day. It also indicates that maintenance of the pool level at elevation 1480 (low enough to prevent flow from the breakout) required a pumping rate of approximately 7.7 MGD. At this rate, with one pump operating full time, the second pump operated at an average of eleven hours per day.

The pumps have demonstrated that they are capable of controlling pool level at any elevation down to about 1430 feet, so that adequate storage capacity is available in the event of a power failure or other breakdown. A photograph of the pumping station is shown in Figure VII-16 in Chapter VII.

b. Transmission Lines

Two 20" transite pipelines transfer the acid water from the top of the boreholes up a grade for open discharge into the transfer ditch which starts at an elevation of about 40 feet above the pumps and the treatment ponds. The raw mine water has a strong blue coloration and a strong odor of hydrogen sulfide. All raw water (influent) samples were taken at this pump discharge point.