SECTION II

SUBSURFACE INVESTIGATION AND ANALYSIS

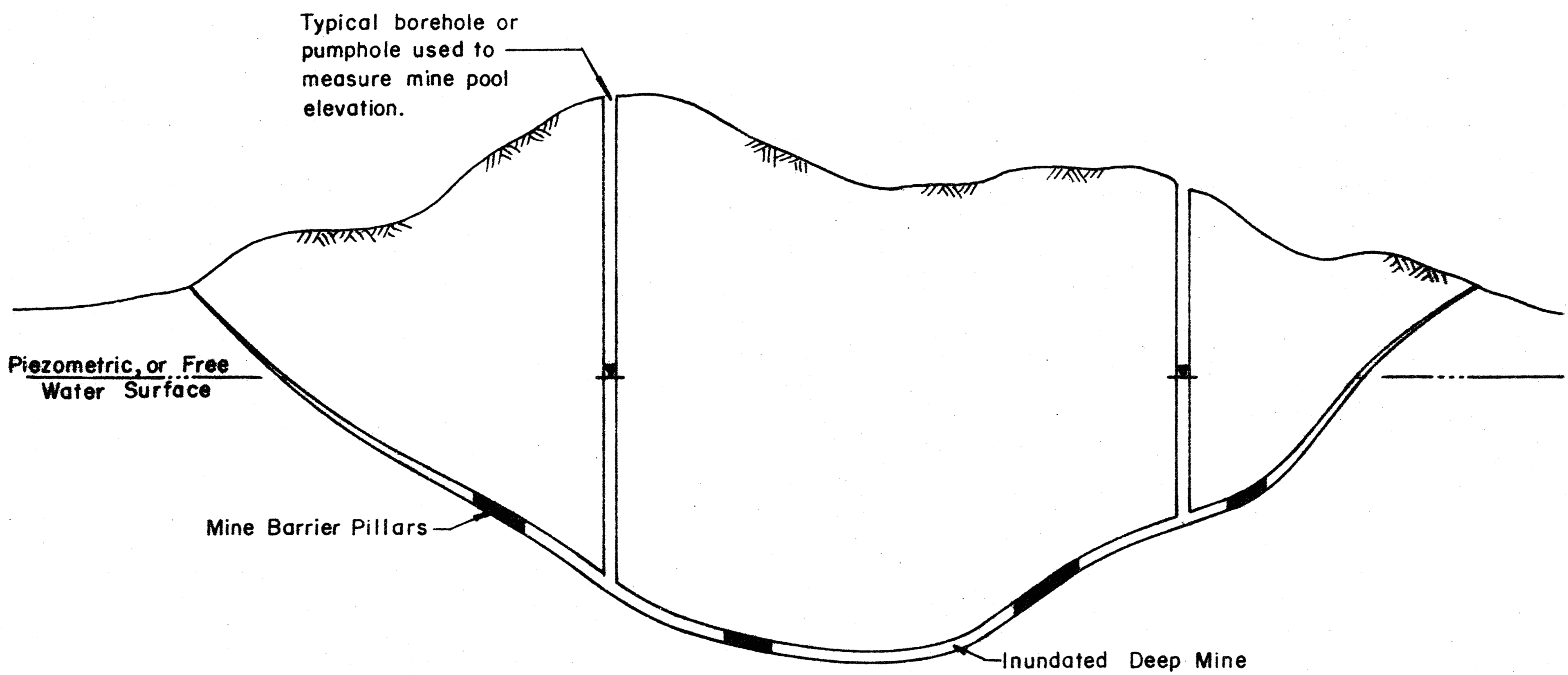
2.0 METHODOLOGY

Determination of a technologically feasible, cost-effective abatement scheme for the Irwin syncline basin demands as thorough an understanding as possible of the subsurface hydrology and the attendant effects on the major acid mine water discharges. Significantly, the analysis is governed by the availability of pertinent data. Flow rates and chemical composition of the major acid mine water discharges, coal structure and climatological data are easily obtained. However, finding sufficiently detailed mapping of the deep mines for the entire basin is complicated by the lapse of time since the mines were abandoned. Works Progress Administration (WPA) maps provide a good starting point and allow fairly accurate delineation of major mine boundaries. Microfilmed deep mine information on file with the U.S. Bureau of Mines is often just a reproduction of the WPA maps or is too minutely detailed for an areal study. As a result, intricate subsurface flow diversion structures or barrier conditions that could have a significant and costly effect on an overall basin abatement scheme remain undetected. Deep mine maps at 1" = 600' and 1200' scales of a sizeable portion of the Irwin syncline basin were eventually located, but it was emphasized by their owners that the information was not for publication.

Conversations with persons familiar with the area's mining history provided an abundance of information pertaining to the sequence of deep mining and its influence on the current basin subsurface hydrology. Related reports provide general background information, but in this particular case, personal contacts were responsible for the consultants knowledge of some of the basin's unique subsurface features such as where a major barrier pillar might be critically severed, the Dillon-Gibbon rock tunnel or the presence of critically situated dams. Where data was sparse or just not available, these personal accounts added another dimension to the interpretation of the subsurface data.

To compliment the flow rate measurements and chemical analyses of the several major AMD discharges, a pool monitoring program was anticipated. Beginning in January, 1974, levels of the mine pool were measured in air shafts, pumpholes and boreholes of the inundated mines where access could be gained with little effort (Reference to a "pool" of water is somewhat misleading. Sometimes misconstrued as a solid body of water, it is actually a measure of the pressure head exerted by the water that has accumulated in the coal seam as shown on Plate 14.) Although this data was not sufficient to provide a comprehensive interpretation of the basin's subsurface hydrologic conditions or the subsurface flow pattern, it provided insight as to the pool behavior and documented the action of the mine pool as the Hutchison mine was flooding. Additional subsurface investigation was subsequently implemented as Operation Scarlift Project SL 103-5-101.5 which entailed the installation of sixteen (16) additional pool monitoring wells (Section 2.3.2). Located at the discretion of the engineer and with DER approval, these additional wells enabled a more confident interpretation of the subsurface conditions when combined with the initial set of pool monitoring sites.

The importance of the pool monitoring program cannot be overemphasized. Primarily, it allowed assessment of the influence of various subsurface flow diversion structures on the hydrology of the basin. Secondly, the basin was undergoing a change that could not be disregarded i.e., the abandonment and subsequent inundation of the Hutchison mine. Constant monitoring of this change allowed assessment of its impact on the behavior of the mine water discharges and the neighboring pool elevations as well as its influence on the development of a final abatement scheme for the basin. Prior to detailing the discharge and pool monitoring data in Sections 2.2 and 2.3 the remainder of this (2.1) section discusses some of the dominant factors affecting the hydrology and subsurface flow pattern of extensively mined and inundated coal seams. Section 2.4 then formulates conclusions pertaining to the relationship between the mine pool and the several major AMD sources.



NO SCALE : Refer to Appendix C for detailed cross sections.

GENERALIZED BASIN CROSS SECTION

PLATE 14

2.1 FACTORS AFFECTING THE ANALYSIS OF THE BASIN SUBSURFACE HYDROLOGY

As the mines of the Irwin syncline basin were worked out and abandoned, they eventually flooded, creating a massive pool estimated by others at 350 billion gallons.[16] In general, the pool fluctuates in response to seasonal variations in precipitation, being highest in early spring and lowest during the summer. Infiltration of precipitation retained by the earth's surface theoretically depends on the permeability characteristics of the overburden and is influenced by the presence of groundwater and groundwater bearing formations. This movement is further augmented by mining practices which have created conditions that allow surface water to enter into active and abandoned mine workings through fissures in the coal beds or in the rock strata, through cave-ins, through strippings and through old mine workings. Rainfall is quickly noticeable in mine workings where sudden inflow of water after intense precipitation often overtaxes the mines' pumping capacity and consequently floods part of an active mine.

Within the flooded mine seam the pool displays lateral movement. The 5' X 5-1/2' tunnel through the Ocean-Keystone barrier pillar was constructed to equalize the water level between these adjacent mines; the purpose of the Dillon-Gibbon rock tunnel is to allow water to flow from the Ocean mine into Marchand. Water seeps through barrier pillars but to varying degrees depending on (a) the barrier's overall structural integrity, (b) its permeability, (c) the hydraulic gradient acting and (d) the cross-sectional area through the barrier. The lateral movement of water is somewhat influenced by the presence of dams constructed during mining. Sections 2.1.2 and 2.1.3 address the significance of these flow diversion structures with respect to the basin analysis.

A final consideration is the long term behavior of the mine pool. Banning No. 4 will eventually flood. Does this alter the development of an abatement scheme? This is better addressed in Section 3.0 which details the proposed basin abatement scheme.

2.1.1 Availability of Recharge Water

By what route does the precipitation captured by the ground surface travel to replenish the pool? How much water is entering the mined out seam and what are the primary sources? How significant are they with respect to the interpretation of the discharge characteristics and to the comprehensive analysis of the basin?

Rainfall that escapes runoff and evapotranspiration lends itself to capture by the earths surface whereupon it may take one of two routes to the mine pool: via percolation through the overburden or via the outcrop where unreclaimed strip mine areas also capture rainfall directly. Surface runoff is also directed to the pool via subsidence areas and via sources of direct inflow such as a. watercourse that traverses an opening to the mine.

Overburden percolation is considered the dominant recharge source. The direct contribution of the strip mined areas is minor. Recharge via subsidence areas, stream loss, storm runoff and sewage disposal are essentially negligible in comparison.

Overburden recharge depends on (a) rainfall, (b) the amount of percolation into the subsurface and (c) rock permeability. The portion of rainfall that lends itself to recharge may first encounter groundwater systems. After infiltrating the overlying soils, the water may be captured in these zones of saturation that typically occur near sandstone and limestone beds. Geologic faults and fractures, aggravated by the use of explosives in mining and subsequent overburden subsidence, have caused a dewatering of most of the overlying water-bearing strata. Thompson reports that based on groundwater records of southwestern Pennsylvania and using an annual precipitation of 40 inches per year, which converts to a water supply of 2.07 gpm/acre, a permeability of 0.0091 feet/day at unit gradient is required to accept the rainfall.(26)

Thompson accounted for the portion of base runoff attributable to rainfall. Base runoff was defined as the part of the streamflow provided largely or entirely by natural groundwater discharge and is considered reasonably indicative of the amount of groundwater available to subsurface flow. Using base-runoff comparisons for the Upper Potomac River Basin, which is adjacent to and considered reasonably analogous to southwestern Pennsylvania, rates of 0.82 and 1.02 cubic feet per second per square mile (cfs/mi^2) were given for two coal basins similar to the Western Pennsylvania area. With an average of 0.92 cfs/mi^2 converted to 0.645 gpm/acre, an average permeability of 0.0028 ft/day at unit gradient would be necessary to accept the flow. Comparing base-runoff to rainfall, Thompson gives 0.645/2.07 = 30% of rainfall as the "approximate amount of water available to enter a mine providing the amount is compatible with the permeabilities that govern input or ingress for the mine."(26)

The concept of permeability was described by Thompson as two inter-related types: granular permeability and rock separation (secondary permeability), i.e. openings along fractures and bedding planes. Permeability depends on depth below ground surface, rock types and fracture characteristics. Throughout the overburden area, however, groundwater may be present under either water-table or artesian conditions depending upon the relative positions of permeable and semi-permeable geologic formations.(26)

The relationship between permeability and depth cannot be defined in absolute terms. However, it is significant to note that a USGS report on groundwater conditions in southwestern Pennsylvania indicates that intergranular permeability is subordinate to secondary permeability, or the permeability of separation planes.(30) This reported generalization, augmented by the extensiveness of mining throughout the basin and the fact that a significant amount of explosives were used, illustrates the disproportionate contribution attributable to overburden recharge. Interestingly, the Pittsburgh seam of the Irwin syncline basin was repeatedly referred to as being one of the "wettest" coal seams by many who have firsthand knowledge.

It is interesting to note that while the rate of overburden recharge generally decreases with overburden depth, the pool in the deeper regions of the basin serves to reduce the distance over which the recharge water must travel to reach the pool. Overburden thickness, which varies from zero to 550 feet, is summarized as follows for the abandoned portion of the basin, i.e. excluding the Banning No. 4 mine. Of a total of 90.83 square miles, nineteen percent (17.28 square miles) has overburden thickness ranging from zero to one hundred feet (100'), 20.2% (18.34 square miles) from 100' to 200' thickness, 26.3% (23.86 square miles) from 200' to 300' depth and 34.5% (31.35 square miles) in excess of 300'. With the depth of water being on the order of zero to 200 feet, the percentage of total area having, say, zero to 200' overburden thickness is increased while the percentage having a thickness exceeding 200' is decreased. Thus, a larger area having high permeability is available to capture water.

A secondary source of recharge is that which originates along the outcrop region of the basin. Stripped extensively prior to the implementation of the more strict surface mining laws in effect today, a majority of the stripped areas were backfilled haphazardly or not at all. Those left unreclaimed capture surface runoff and direct it to mine voids, invariably adding to the pool. Ponds, lakes and other depressions left along the base of highwalls accumulate surface water which percolates back into the deep mines through the soil or through entries into the mine which have been uncovered by the stripping operations. Blockage of natural valleys and drainage channels by strip mine materials cause surface water diversion as well. Inflow from strip mine areas depends on the disturbed topography, local geology, deep mine conditions, surface runoff parameters, and rainfall intensity and duration. Throughout the project area these parameters vary tremendously and are appreciably difficult to accurately evaluate to determine the amount of water that ultimately reaches the mine voids. It is estimated that strip mine area inflow comprises only a small portion of the total recharge water.

A third recharge water category includes those sources which are essentially conveyed directly to the pool. These include core borings from coal exploration and boreholes for water discharge from old workings. Recharge via subsidence areas, direct stream capture and sewage disposal are similar sources, their combined effect being negligible in comparison to overburden recharge. It is an acknowledged but undocumented fact that domestic sewage, commercial and industrial wastewater is conveniently disposed of via holes to the mines. For then-pollution-conscious residents of the older mining areas, this method of disposal was probably an obvious alternative to discharging into nearby watercourses. Some small commercial establishments are known to dispose of their wastewater in this manner. The total recharge volume directly attributable to these sources is estimated to be minimal; it will be remedied to some extent by the Brush Creek interceptor presently under construction.

In addition, streams can convey water to the mines. Three such sites were inadvertently detected by field personnel at the following locations: where Long Run and Shaner Hollow Run cross the outcrop and Hunter's Run crosses the outcrop near Wyano at elevation 915. Their easy discovery was due to a shallow stream where the diversion of water was quite evident. To detect such losses in the total watercourse mileage within the basin would be costly, difficult to remedy, and certainly not cost-effective.

Subsidence areas can capture surface water runoff which is a precipitation-dependent type of recharge source. However in isolated cases, remedial work is justifiable.

In summary, the disproportionate rate of basin recharge attributable to overburden percolation dictates a do-nothing philosophy concerning surface-oriented water recharge sources.

2.1.2 Mine Barrier Pillars

In the deeper regions of the basin where the pool level greatly exceeds the barrier elevation, the effectiveness of the barrier is considerably lessened. The restraint of mine drainage should be more effective per unit width of barrier in deep mines than in shallow mines as influenced by permeability values, however, the presence of higher differential head in the deep mines tends to negate the lower permeabilities.

The extent of subsidence bridging of roof rock above a mined coal will affect the ability of a barrier to restrict seepage. Undisturbed permeability in roof rock may be considered a wedge of unfractured rock above the barrier. A highly permeable bed close to the level of a coal will also decrease the effectiveness of seepage restriction by a barrier, especially in the presence of subsidence fractures.[26]

The condition of the barrier itself also affects transfer of flow. It is reported that barrier effectiveness varies considerably throughout the basin. Several barriers are breached, or severed, others are of minimal thickness, and some are greater than the then legally-required thickness. Comments from individuals concerning the condition of specific barriers are testimony to their varying degree of integrity:

> ". . . . . little or no barrier separates Marchand and Riley, just a shell of coal to keep ventilation of each mine on its own . . . . ."

> ". . . . . a barrier pillar of at least 38 feet and at one point a brick dam of 4 feet separate Riley and the Ocean No. 1 mine . . . . ."

> ". . . . . the barrier pillar between Riley and Adams is just sufficient to maintain separate ventilation and at some points all pillars have been removed.

". . . . . Adams and Ocean No. 1 are separated by a pillar of 50 feet"

". . . . . Ocean No. 1 and Edna No. 2 are separated by an unsevered barrier pillar the entire distance of their common lines . . . . ."

". . . . . a barrier of greater than legal thickness separates Hutchison and Marchand . . . . ."

". . . . . a barrier of greater than legal thickness separates Hutchison and Yough Slope . . . ."

". . . . . the barrier is broken between Hutchison and Magee which is the only section of Hutchison that's broken . . . . ."

". . . . . the barrier of Osborne is intact except for a section near the outcrop along Sewickley Creek at elevation 915 . . . . ."

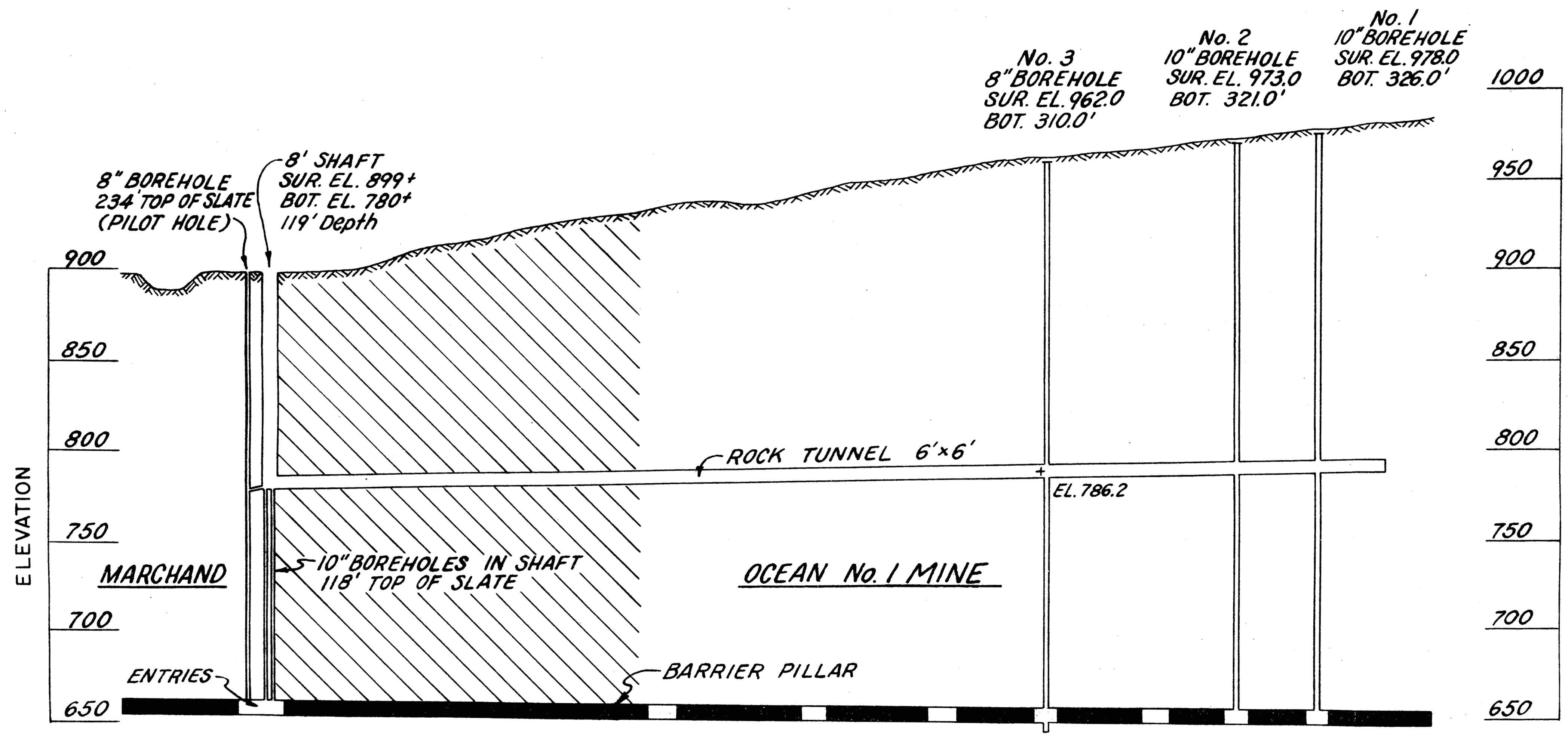
". . . . . barrier between Ocean No. 2 (easterly extension of Ocean mine)and Edna No. 2 is still intact and about 40 to 50 feet wide . . . nothing drains into Ocean . . . . ."

The widely variable influence of barrier pillars on the subsurface hydrology is demonstrated by the mine pool monitoring program to be discussed in Section 2.3. The basic governing factors are the overall structural integrity of the barrier, the local stratigraphy and hydraulic gradient, the cross-sectional area through the barrier and the barrier permeability.

2.1.3 Dams, Coal Reserves and Drainage Tunnels

A common practice in mining was the construction of dams. A main reason for their use was to prevent water from flowing into the mine workings when an extremely wet formation had been penetrated, thus reducing pumping costs. In the initial phase of this study it was learned that dams had been constructed in the vicinity of the Irwin discharge, in the lower third dip haulways of the South Side mine. (Refer to Section 1.4) Their significance with respect to the development of an abatement scheme could not be disregarded.

Throughout the basin there are only a few large coal reserves which primarily serve as support for the population centers and for public institutions such as schools, hospitals, and cemeteries. Coal was also left under railroad corridors where overburden was shallow. Examination of the original tracings of the Delmont and Export mines shows that almost all of the coal remains beneath the abandoned railroad grade of the Penn Central Railroad Company (absorbed by ConRail)



(No Horizontal Scale)

DRAINAGE TUNNEL AND BOREHOLES BETWEEN MARCHAND AND OCEAN MINE

SEWICKLEY TWP. WESTMORELAND CO.

OPERATION SCARLIFT PROJECT No. SL 103-5	· COMMONWEALTH OF PENNSYLVANIA · DEPARTMENT OF ENVIRONMENTAL RESOURCES	DRAWN B.M.C. CHECKED R.C.O. SCALE As Shown	IRWIN SYNCLINE BASIN MINE DRAINAGE POLLUTION ABATEMENT PROJECT DILLON-GIBBON TRACT ROCK TUNNEL	PLATE 15 DRAWING NO.

PS CONTRACT NO.

ATLAS LITHO CO., PGH., PA. 1020 CLEARPRINT

between Export and the easternmost outcrop line. It was the option of the mining company to extract 60% of this reserve, the remaining 40% left in the form of ribs, stumps and pillars. Within the Delmont mine this coal was left intact and the few hallways that did traverse the reserve were sealed with dams as shown on Plate 33. Within the Export mine only the Mellon mains cut through the reserve and there are no dams indicated. See Plate 32. Numerous haulways traverse the railroad corridor that passes through Irwin to Adamsburg. The obvious reason is the greater overburden depth and higher degree of consolidation as compared to the Export-Delmont vicinity. However, there is supposedly a coal reserve west of Biddle for about one mile.

The water level in the various mines was maintained by an intricate maze of barrier pillars and tunnels. One such device was a 5' x 5 1/2' tunnel driven through the barrier pillar separating the Keystone and Ocean mines at elevation 640. It served to equalize the water level between these mines and at one time was used to drain Keystone.[16]

Another interesting subsurface installation is the Dillon-Gibbon rock tunnel. It was constructed in 1942 by the Westmoreland Coal Company above the barrier between the Ocean and Marchand mines to lower the water level in the Ocean-Keystone mines complex which had built up to a dangerously high level. The Hutchison mine was active and its northern barrier pillar was forced to retain the pool of water that had accumulated in these adjacent mines. Installation of the tunnel was successful in maintaining the Ocean-Keystone mine water level but because of "yellowboy" accumulation in the eight (8) and ten (10) inch boreholes it often plugged and had to be reamed out. This is illustrated in the graph of water levels, Plate 13. The tunnel is illustrated in Plate 15.

2.2 MAJOR DISCHARGES

The seven major acid mine water discharges in the Irwin syncline basin average a combined total flow of approximately 20.8 million gallons per day, spewing an average combined total iron and net acid load of 9 1/3 tons and 16 1/2 tons per day respectively. Monitored on a monthly basis from July, 1973, to October, 1975, the results of chemical sampling analyses for the Export, Delmont, Coal Run, Irwin, Marchand, Upper Guffey and Lower Guffey Station discharges plus the corresponding flow rates are contained in Appendix A .

The Delmont discharge was originally studied in Operation Scarlift Project SL 146-l from November, 1971 to December, 1972. As referred to herein, the Delmont discharge includes the "DEL/EX" discharge, or Source 1104/1106 as it was called in SL 146-l and Source 1021 as identified in that report, located near the "DEL/EX" source. Recognizing the similarity in chemical composition between the Export and Delmont discharges, the latter was added to the SL 103-5 flow discharge measuring schedule in May, 1974, the intent being to simultaneously collect data for the design of a treatment facility to accommodate both discharges if needed in the final abatement plan.

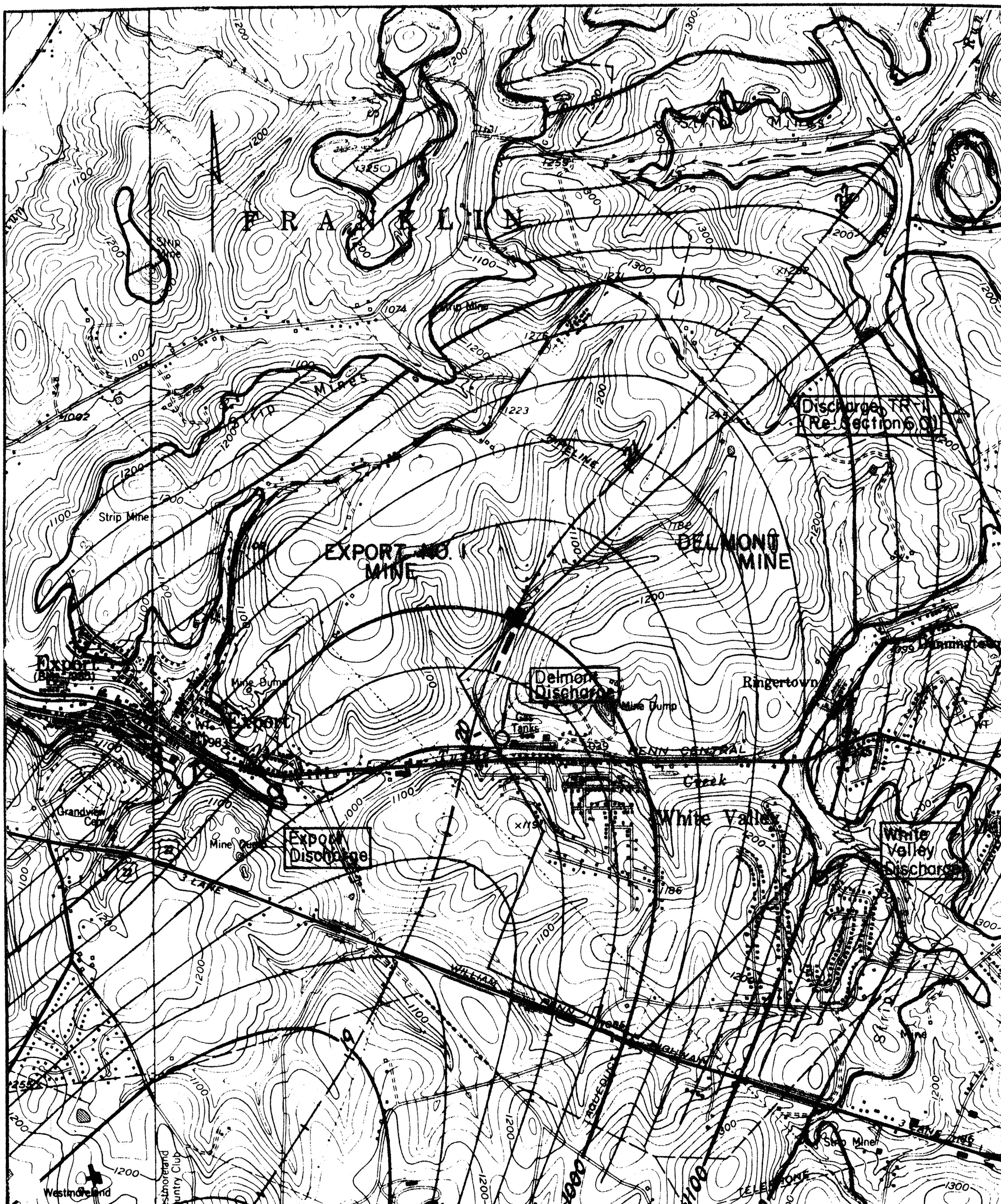
Although the Appendix cites monthly flow rate measurements, the average, maximum and minimum flow rates are based on about 50 readings. Numerous intermediate readings were obtained because of the dynamic nature of the pool, i.e. its responsiveness to precipitation compounded by the abandonment and inundation of the Hutchison mine.

2.2.1 Export Discharge

The Export discharge is located along the outcrop line near Export, Pa. as shown on Plate 16. At elevation 980.3' it is an outlet for the No. 1 Export mine lower main haulways. A four foot rectangular weir was originally installed to monitor the flow but was removed because it increased the local mine pool elevation just enough to force out acid mine drainage along the outcrop nearby. The weir was replaced with a 36 inch pipe. Because of the shallow slope of the receiving watercourse the end of this pipe was blocked to form a rectangular weir for measuring the flow. Section 2.4.l examines the origin of this discharge in more detail.

The following table summarizes the discharge water quality analysis contained in Appendix A for the Export discharge.

Parameter	Maximum	Minimum	Average
Flow (MGD)	3.60	0.14	1.14
pH	3.2	2.4	2.9
Acidity (mg/l)	800	100	439
Alkalinity (mg/l)	0	0	0
Net acid load *(lbs./day)	9600	732	4172



LOCATION MAP
EXPORT AND DELMONT DISCHARGES

DRAWN W.J.M. DATE SCALE 1" = 2000'

COMMONWEALTH OF PENNSYLVANIA
DEPT. OF ENVIRONMENTAL RESOURCES

PLATE 16

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Parameter	Maximum	Minimum	Average
Total iron (mg/l)	56	13	27
Total iron load (lbs./day)	466	107	257
Ferrous iron (mg/l)	17	0	6
Average % ferrous of total iron	-	-	22
Sulfates (mg/l)	1000	350	711

*Negative value indicates net alkaline condition.

2.2.2 Delmont

Located about 3/4 mile east of the Export discharge, this source was monitored previously under Operation Scarlift Project SL 146-l which dealt primarily with the Delmont mine complex. Discharging at surface elevation 1010'±, it is an artesian discharge forced out through two 8-inch pumpholes from the Delmont mine. Section 2.4.l will also discuss .this discharge in detail. Essentially, water that is generated within the mine is retained by the Delmont-Export barrier pillar and a coal reserve beneath the east-west oriented railroad corridor on Plate 16.

Parameter	Maximum	Minimum	Average
Flow (MGD)	2.12	.004	l.13
pH	4.9	2.9	3.4
Acidity (mg/l)	400	48	140
Alkalinity (mg/l)	10	0	1
Net acid load *(lbs./day)	3679	5	1310
Total iron (mg/l)	53	3	30
Total iron load (lbs./day)	613	2	283
Ferrous iron (mg/l)	38	0	21
Average % ferrous of total iron	-	-	70
Sulfates (mg/l)	800	300	539

*Negative value indicates net alkaline condition.

2.2.3 White Valley

Operation Scarlift Project SL 146 addressed the White Valley discharge, located east of the Delmont discharge and lying along the outcrop line as shown on Plate 16. It is a gravity type discharge flowing from an 18" inch pipe into the headwaters of Turtle Creek. Its chemical composition is comparable to that of the Delmont discharge but the flow, averaging about 200,000 gallons per day, is small by comparison.

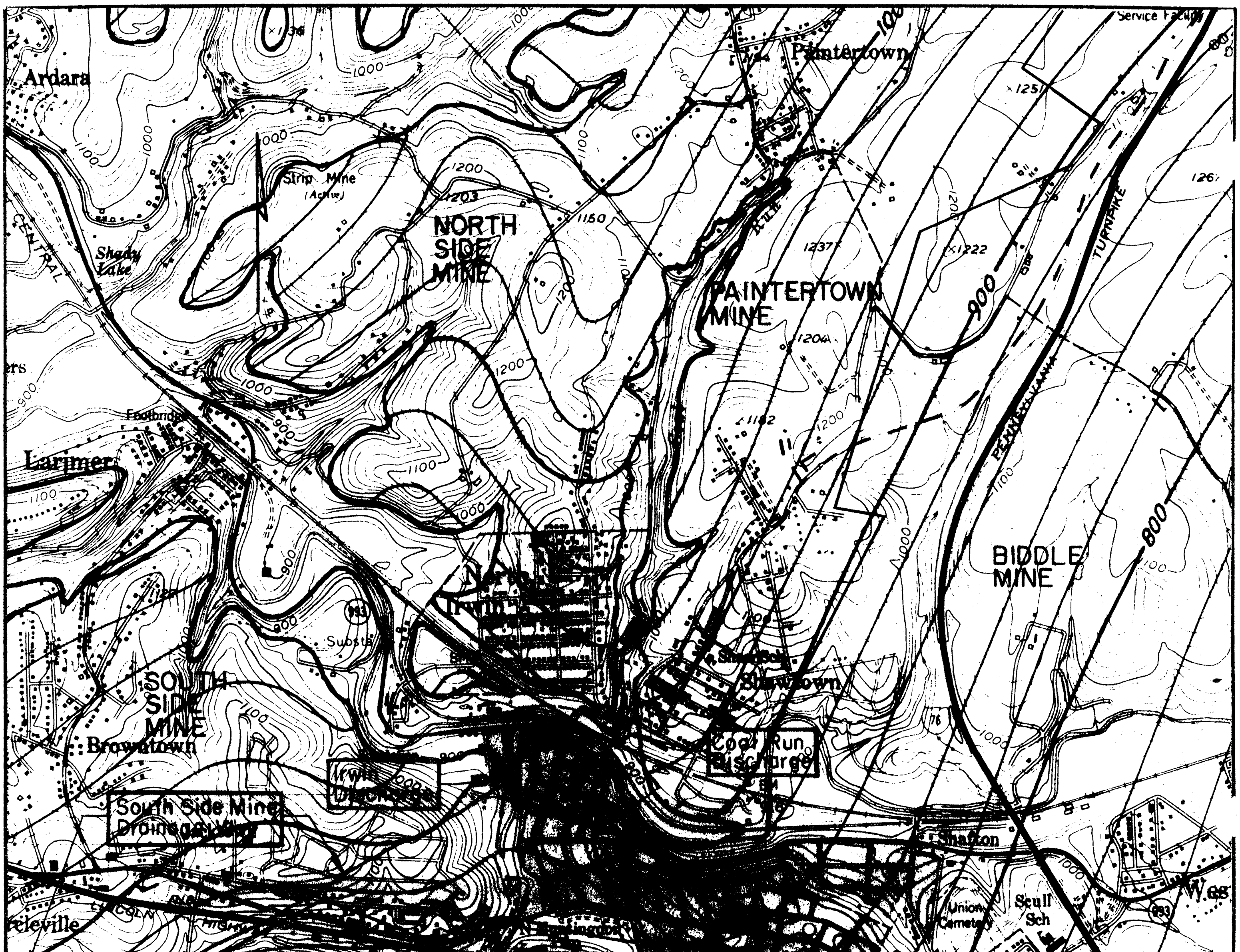
The consultant was requested to include this AMD source in the SL 103-5 analysis. As can best be determined, it drains a small isolated section of the eastern flank of the basin. Presumably the water accumulates next to the east side of the Delmont mine barrier.

As the text will show, the Export and Delmont discharges warrant their respective abatement projects, which are detailed in Section 3.0. The cost in each case for the recommended abatement scheme is significantly lower than would be incurred for a treatment facility. Although the White Valley discharge is not that easily adaptable to collection and treatment Section 3.2.2 gives some suggestions for possible abatement action.

2.2.4 Coal Run

On Plate 17 the Coal Run watercourse is shown to join Brush Creek after flowing through a stone culvert beneath Legislative Route 64209 and the Pennsylvania Railroad corridor. About one-third of the way inside this culvert from the north end, two very deteriorated twelve inch pipes protrude from the east wall. These pipes become clogged with iron oxide formations resulting in very erratic flow rates. The cause of this clogging and unclogging action will be shown to be attributable primarily to the fluctuations of the mine pool and the presence of the Paintertown mine barrier. The pipes are at elevation 875'±. General water quality is summarized as follows:

Parameter	Maximum	Minimum	Average
Flow (MGD)	3.0	0.32	0.97
pH	6.5	5.4	5.9
Acidity (mg/l)	300	0	57
Alkalinity (mg/l)	132	36	91
Net acid load *(lbs./day)	949	-1066	-275
Total iron (mg/l)	36	0	22
Total iron load (lbs./day)	487	0	178
Ferrous iron (mg/l)	32	0	19



LOCATION MAP
IRWIN AND COAL RUN DISCHARGES

DRAWN W.J.M. DATE ______ SCALE 1" = 2000'

COMMONWEALTH OF PENNSYLVANIA
DEPT. OF ENVIRONMENTAL RESOURCES

PLATE 17

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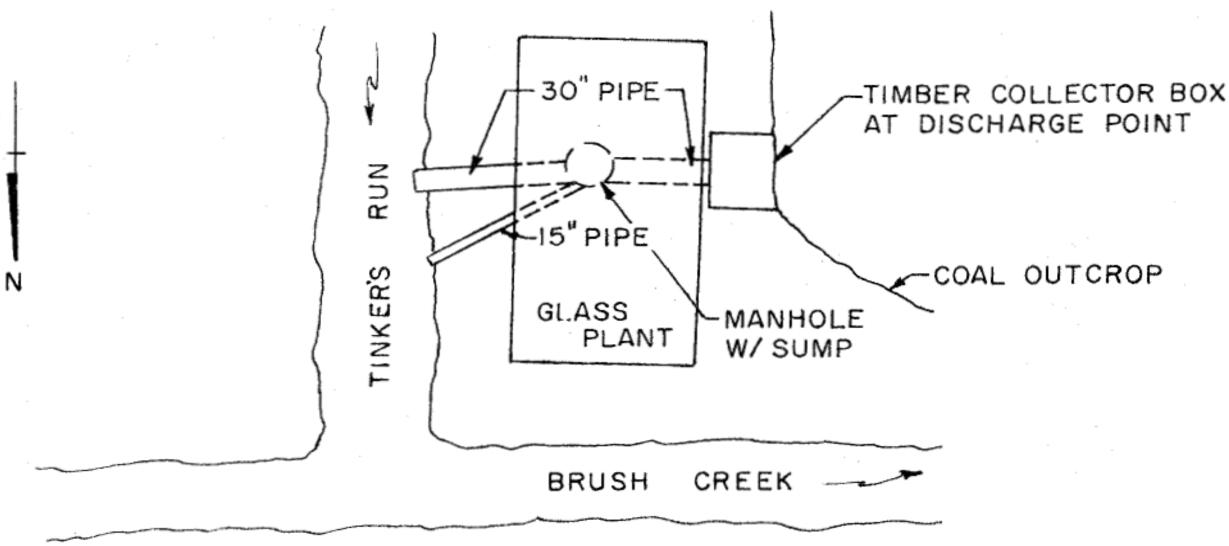
Parameter	Maximum	Minimum	Average
Average %ferrous of total iron	-	-	86
Sulfates (mg/l)	750	225	461

*Negative value indicates net alkaline condition.

2.2.5 Irwin

This is the most voluminous and pollution laden acid mine drainage source within the study limits. Situated along the outcrop line behind a light industrial building in Irwin, Pa., it flows from the old South Side mine drainageway. The tremendous flow rates exhibited by this source did not begin until the Biddle and McCullough mines stopped pumping in April of 1955 as noted in Section l.4 Plate 17 shows the location of the discharge adjacent to Tinker's Run. As the AMD exits the mine it is conveyed beneath the building via a six foot wide timber box which flows into a 30" pipe. Somewhere within the building this 30" pipe, empties into a sump from which a 30" pipe and a 15" pipe direct the water to Tinker's Run as shown below.



The timber box was not discovered until four months after the study began. Until that time the discharge was measured using stream gaging techniques in Tinker's Run upstream of the 30" pipe (Upper Irwin discharge) and downstream of the 15" pipe (Lower Irwin discharge). Discovery of the timber box allowed more expeditious measurement of the discharge using stream gaging techniques. To permit intermediate flow measurements a depth - discharge relationship was developed. (See Plate 21, Section 2.3.1). Another advantage of measuring the AMD flow rate in the box was the elimination of any additional effluent via the sump, thus more accurate flow readings resulted. Section 2.4.2 addresses the subsurface and hydrogeologic factors causing the Irwin discharge to fluctuate synchronously with seasonal variations in precipitation and attendant pool fluctuation. General water quality is summarized as follows:

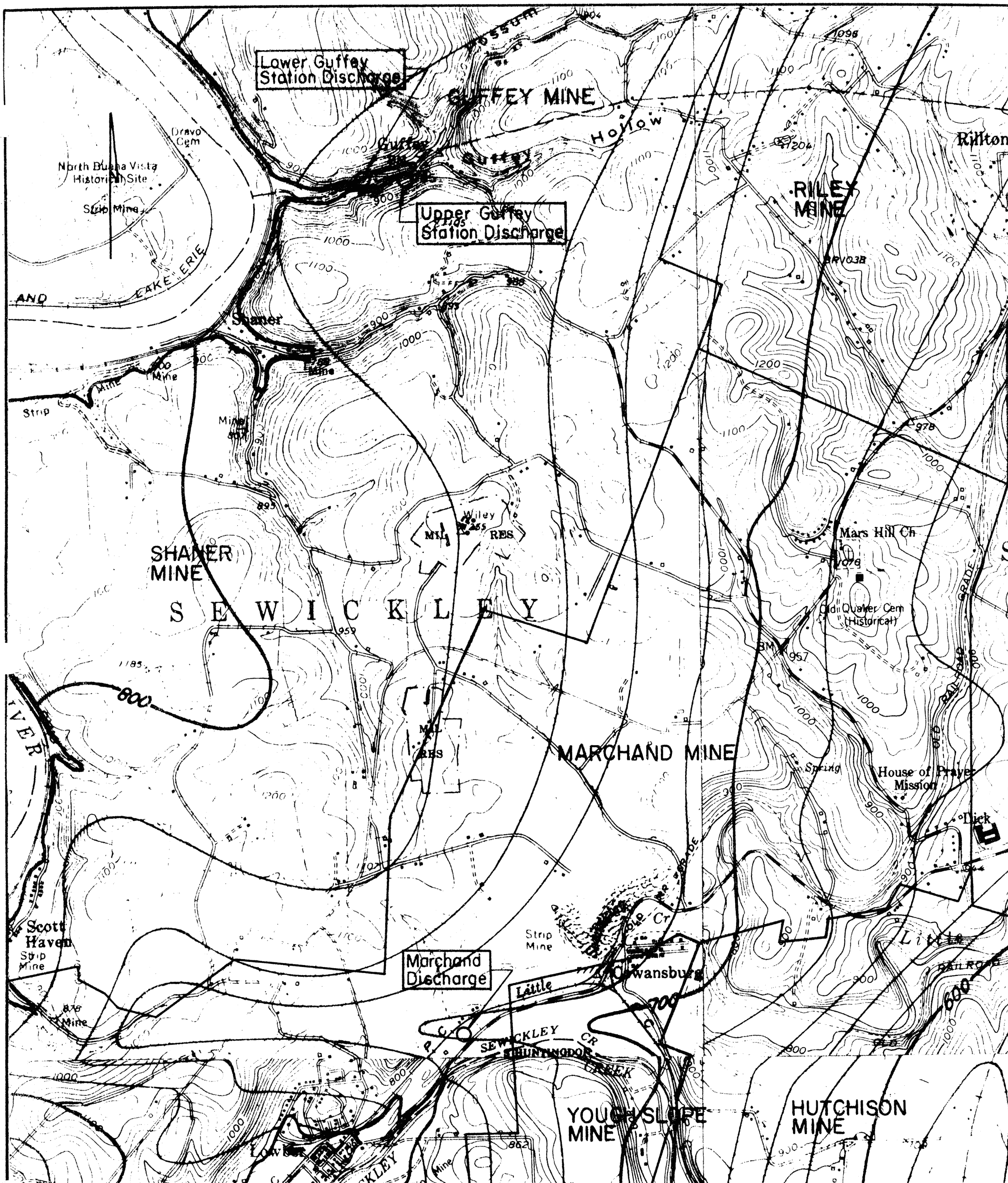
Parameter	Maximum	Minimum	Average
Flow (MGD)	23.63	3.22	11.16
pH	5.9	2.6	4.0
Acidity (mg/l)	500	100	290
Alkalinity (mg/l)	72	0	10
Net acid load *(lbs./day)	45202	6900	26040
Total iron (mg/l)	195	49	126
Total iron (lbs./day)	15962	2871	11718
Ferrous iron (mg/l)	165	36	109
Average % ferrous of total iron	-	-	87
Sulfates (mg/l)	2352	775	1164

*Negative value indicates net alkaline condition.

2.2.6 Marchand

Located in Sewickley Township, this is an artesian discharge at elevation 764' ± which flows from the main slope entry of the Marchand mine. As alluded to in Section l.4, this AMD source began just after the Dillon-Gibbon rock tunnel was completed. Over the years, the acid mine water has been detained in ponds located on the west side of Legislative Route 64104 in an effort to allow as much iron as possible to settle out before reaching the receiving stream, Big Sewickley Creek. These ponds were reportedly constructed by the Pennsylvania Department of Health shortly after the discharge began. Overflow from the ponds then flows beneath the road to the creek via two or three pipe culverts. Although the iron was being effectively removed, these ponds were drained by unknown persons during the course of SL 103-5, and the discharged water now flows directly into Big Sewickley Creek.

The following table summarizes various parameters constituting the pollution load for the Marchand discharge. Appendix A will also show that the flow rate from this source hardly varied during the study.



LOCATION MAP
MARCHAND, UPPER & LOWER GUFFEY STA.

DRAWN W.J.M. DATE SCALE 1" = 2000'

COMMONWEALTH OF PENNSYLVANIA
DEPT. OF ENVIRONMENTAL RESOURCES

PLATE 18

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Parameter	Maximum	Minimum	Average
Flow (MGD)	3.84	2.10	2.76
pH	6.3	4.8	5.7
Acidity (mg/l)	605	50	293
Alkalinity (mg/l)	400	0	185
Net acid load *(lbs./day)	9808	-7681	2482
Total iron (mg/l)	311	72	196
Total iron (lbs/day)	6934	1419	4504
Ferrous iron (mg/l)	270	0	163
Average % ferrous of total iron	-	-	83
Sulfates (mg/l)	3500	1575	2425

2.2.7 Upper Guffey Station

The Upper Guffey Station discharge is reportedly the outlet end of a drainageway excavated below the coal for the purpose of allowing further coal recovery in the Shaner mine which is downdip of Guffey. Thus the discharge acts as a gravity type source. The orientation of the drainageway can only be estimated from available mine maps. Section 2.4.3 will elaborate on the origin of this discharge.

An elevation of 785' is constantly attributed to this outfall as a result of a benchmark of the same elevation on a small bridge carrying L.R. 64102 over Guffey Hollow Run. The coal contours indicate that the elevation must be less than 780. It is approximated at 778'±.

Appendix A data is summarized below. It should be noted that, on the average, the discharge is alkaline although at times it is predominantly acidic.

Parameter	Maximum	Minimum	Average
Flow (MGD)	3.75	.96	2.07
pH	6.4	5.4	5.8
Acidity (mg/l)	300	0	106
Alkalinity (mg/l)	194	0	127
Net acid load *(lbs./day)	3819	-3271	-363

Parameter	Maximum	Minimum	Average
Total iron (mg/l)	110	1	58
Total iron load (lbs./day)	2185	6	1001
Ferrous iron (mg/l)	90	0	55
Average % ferrous of total iron	-	-	95
Sulfates (mg/l)	1450	350	1050

*Negative value indicates net alkaline condition.

2.2.8 Lower Guffey Station

The origin of this discharge is nebulous. It is located as shown on Plate 18, about 50 yards downstream of the Upper Guffey discharge. Lower Guffey discharges along the embankment on the south side of Legislative Route 64102, however, it actually originates on the north side of the road. As noted previously, only WPA maps are available for this area. Conversations with local residents reveal that the discharge began when water had accumulated sufficiently in the mine to simply blow out at this location in the outcrop. Thus, in contrast to original thinking, this source is unrelated to the Upper Guffey discharge as will be discussed in Section 2.4.3.

Parameter	Maximum	Minimum	Average
Flow (MGD)	2.20	.88	1.55
pH	6.4	5.3	5.9
Acidity (mg/l)	400	0	91
Alkalinity (mg/l)	204	0	115
Net acid load *(lbs./day)	4364	-2593	-310
Total iron (mg/l)	300	0	55
Total iron load (lbs./day)	3730	0	710
Ferrous iron (mg/l)	62	0	39
Average % ferrous of total iron	-	-	71
Sulfates (mg/l)	900	325	621

*Negative value indicates not alkaline condition.

2.3 MINE POOL MONITORING DATA

Mine pool elevation measurements were initially gathered at accessible air shafts, boreholes and pumpholes of the abandoned mines beginning in January, 1974. It is sufficient to say that comprehensive interpretation of the basin subsurface hydrology could not be confirmed based solely on these measurements and discharge data from the seven major acid mine drainage sources.

2.3.1 Initial Observations

Mine pool elevations are summarized in Appendix B. The initial set of pool monitoring sites included: McCullough shaft, Ocean No. 1 mine borehole, Edna No. 2 mine pumphole, Hutchison mine pumphole, Biddle mine air shaft, Jimtown man shaft, Yough Slope air shaft, air shaft second north of the Marchand mine, Osborne mine pumphole, South Side mine air shaft, the Dillon-Gibbon rock tunnel (Ocean and Marchand mines) and the Adams mine air shaft. Data for the Smithton, Port Royal, Buddtown and Fitzhenry monitoring sites were provided by the Republic Steel Corporation. They also monitor the Hutchison, Yough Slope and Osborne sites to insure safe conditions in their Banning No. 4 mine.

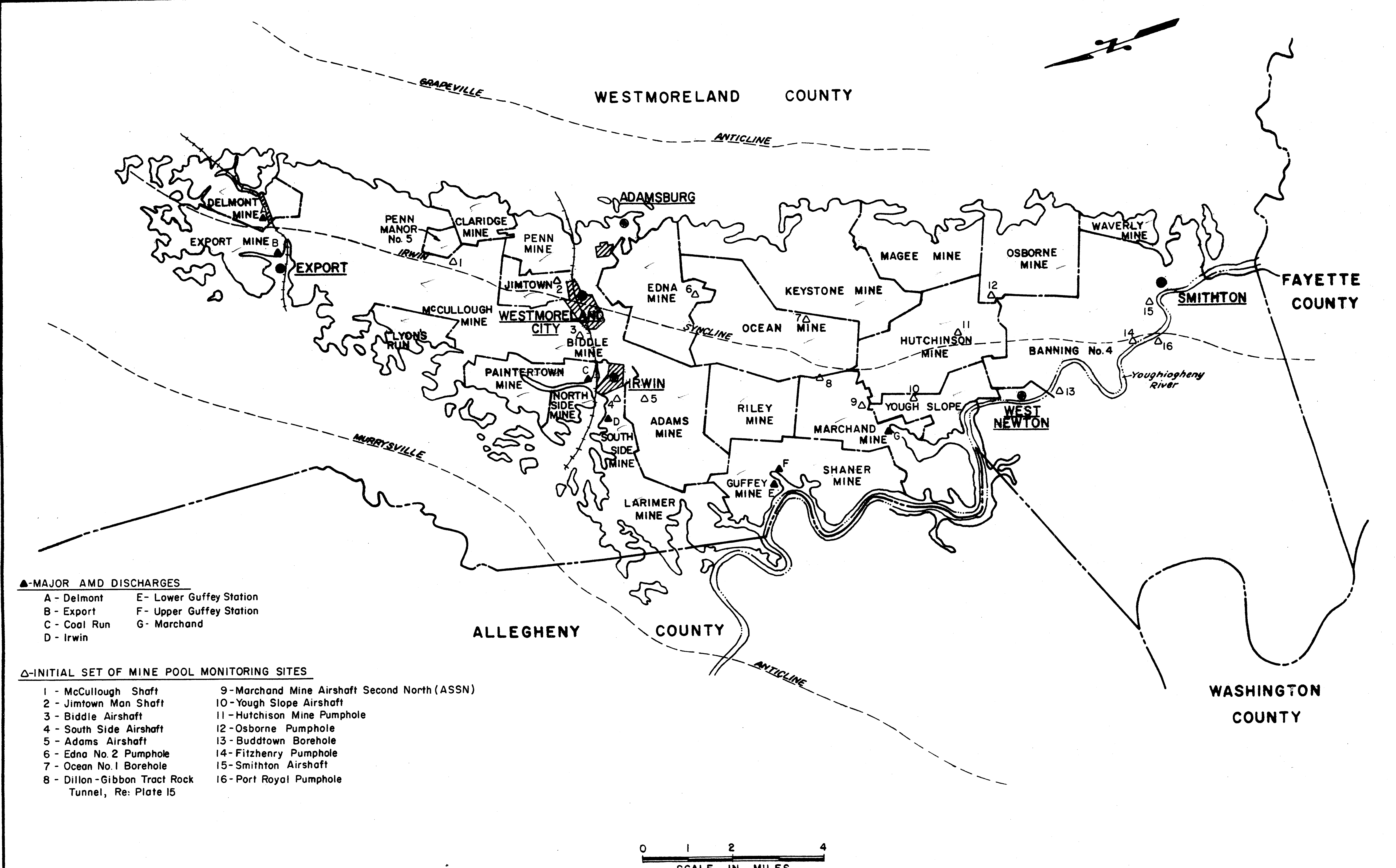
These sites, in addition to the major discharges and the mine boundaries, are shown on Plate 19. Their locations are similarly marked on the Composite Map and the U.S.G.S. maps in Appendix D.

Based on the data from these initial points and the AMD discharges the behavior of the Irwin syncline basin could be summarized as follows:

1. A northerly projection of the average mine pool level of 924'± as measured at the McCullough shaft indicated that the pool could be interfering with the Export and/or Delmont discharges. No accessible pool monitoring locations existed in the Export-Delmont region to confirm or dismiss this possibility.

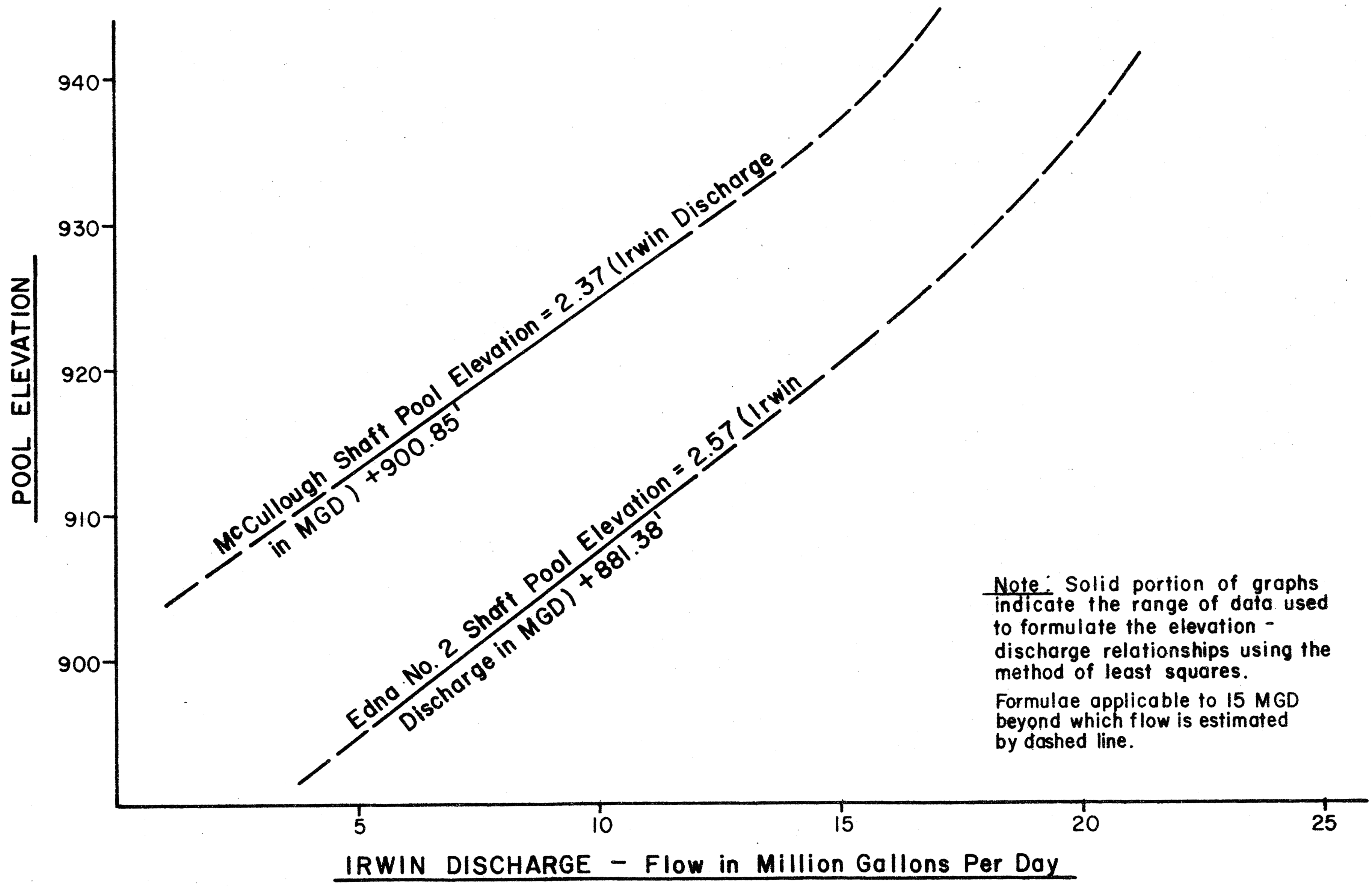
2. There was insufficient subsurface information to establish or deny any relationship between the Delmont discharge and the artesian discharge along L.R. 64044. (Re: Thorn Run Watershed, Section 6.0)

3. As measured at the McCullough shaft, Edna No. 2 pumphole and the Ocean No. 1 borehole, the Irwin discharge and the mine pool were quite responsive to seasonal variations in precipitation. The fluctuations displayed by the Irwin discharge were sufficiently synchronous with those of the mine pool elevations measured at Edna No. 2 and McCullough shaft to permit the development of a stage-discharge relationship as shown on Plate 20. A gage depth-discharge relationship was also developed for ease of measuring the Irwin discharge as shown on Plate 21.

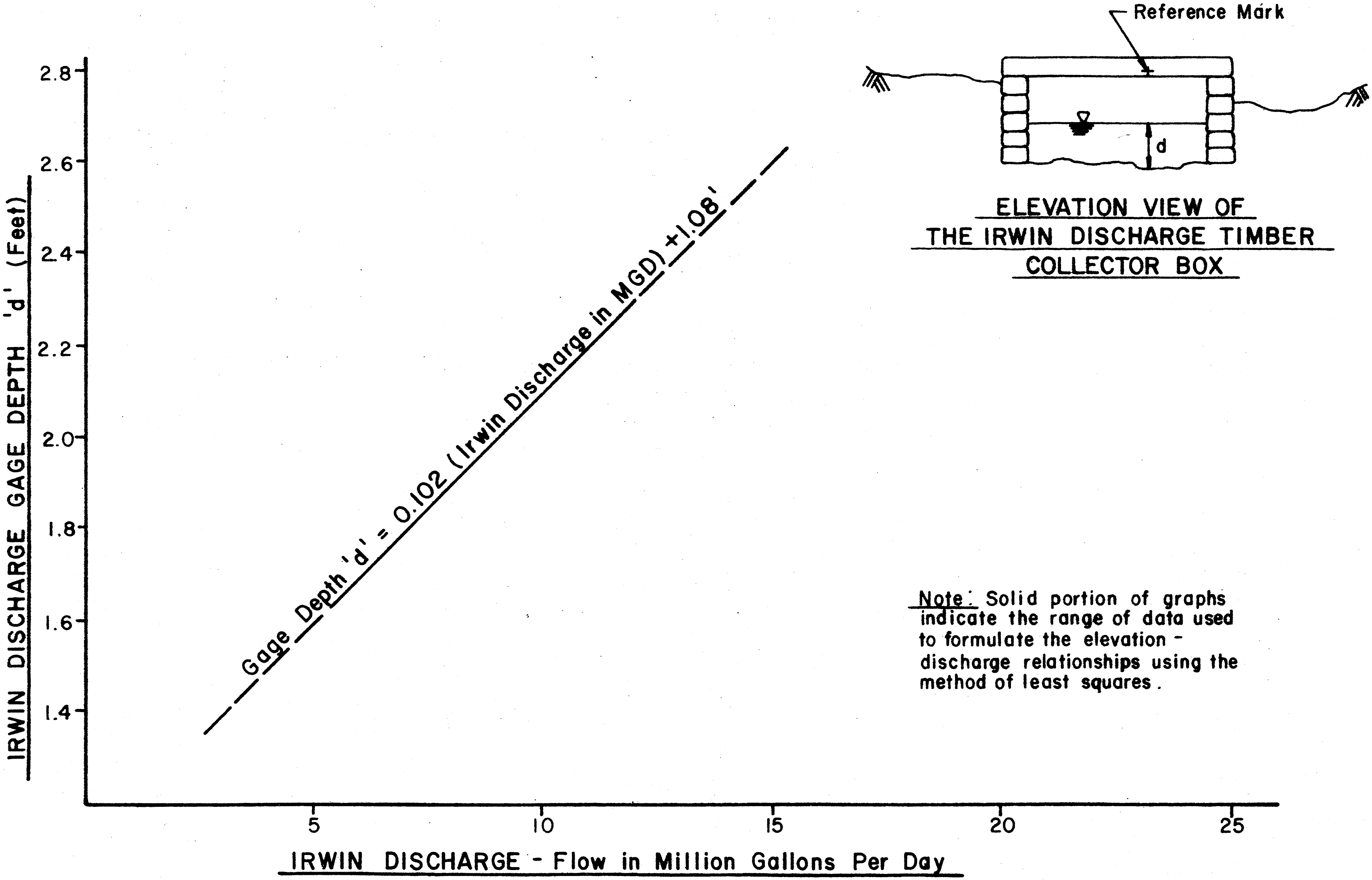


OPERATION SCARLIFT PROJECT No. SL 103-5	· COMMONWEALTH OF PENNSYLVANIA · DEPARTMENT OF ENVIRONMENTAL RESOURCES	DRAWN B.M.C. CHECKED R.C.O. SCALE As Shown	IRWIN SYNCLINE BASIN MINE DRAINAGE POLLUTION ABATEMENT PROJECT INITIAL POOL MONITORING SITES	PLATE 19 DRAWING NO.

PS CONTRACT NO.



OPERATION SCARLIFT PROJECT No. SL103-5	**COMMONWEALTH OF PENNSYLVANIA** **DEPARTMENT OF ENVIRONMENTAL RESOURCES**	DRAWN W.J.M. CHECKED R.C.O. SCALE AS SHOWN	PLATE 20



ELEVATION VIEW OF
THE IRWIN DISCHARGE TIMBER
COLLECTOR BOX

OPERATION SCARLIFT PROJECT No. SL 103-5	·COMMONWEALTH OF PENNSYLVANIA· DEPARTMENT OF ENVIRONMENTAL RESOURCES	DRAWN W.J.M. CHECKED R.C.O. SCALE AS SHOWN	PLATE 21

On the other hand, mine pool monitoring sites surrounding the Irwin and Coal Run discharges remained constant: Adams shaft at 900'± Biddle shaft at 888'±, South Side air shaft at 887'± and Jimtown at 898'±. And during this period the Coal Run discharge flowed erratically as the pipes would clog and unclog.

As noted in Section 1.4, this area of the basin was mined in a sequence that required the construction of dams in the Lower 3rd dip mains of the South Side mine to force water out at the South Side drain, i.e., Irwin discharge, to permit mining to continue in the Biddle mine. Later, the dams were supposedly breached to allow the Adams mine to operate. Eventually, all of these mines were abandoned and allowed to flood causing the pool to rise enough to create the voluminous Irwin discharge. In summary the dynamic nature of the discharges, the inconsistent behavior of the mine pool elevations, combined with the uncertainty of the influence of the mine barriers and dams (re: South Side, 3rd dip mains) prevented conclusive evaluation of the subsurface conditions in this region.

4. The Marchand, Upper Guffey Station and Lower Guffey Station discharge flow rates changed minimally during the inundation of the Hutchison mine and the eventual rise of its pool to be coincident with the Osborne pool at about elevation 800'±. With the exception of both Ocean boreholes (at the Dillon-Gibbon rock tunnel and near Herminie), the monitored pool elevations in this vicinity of the basin remained constant or were erratic. Marchand mine air shaft second north (ASSN) was constant at 767'±, Yough Slope constant at 765'±, Adams air shaft constant at 900'±, while the Marchand side of the Dillon-Gibbon tract was very erratic, averaging 888'± with a range from 874 to 894. (The Ocean borehole seasonally fluctuated, averaging 863'±) Along the left flank, the shallow structure of the coal seam, the constant flow rate of the discharges, the stable pool surface as illustrated by most of the monitoring data and the presence of mine barrier pillars of questionable condition prevented a conclusive evaluation of the subsurface hydrology and flow pattern in this region also.

The Hutchison mine deserves a closer look. Prior to abandonment, its barriers were forced to retain the pool that spread throughout the basin similar to the role that Banning No. 4 has recently assumed. Being surrounded by abandoned flooded mines while operating, Hutchison had a severe water drainage problem traceable to four principal sources: (1) water flow through the north barrier, (2) flow from the abandoned Magee mine to the east, (3) water drainage from the mined out areas at the north end of the mine and (4) water at the working face.

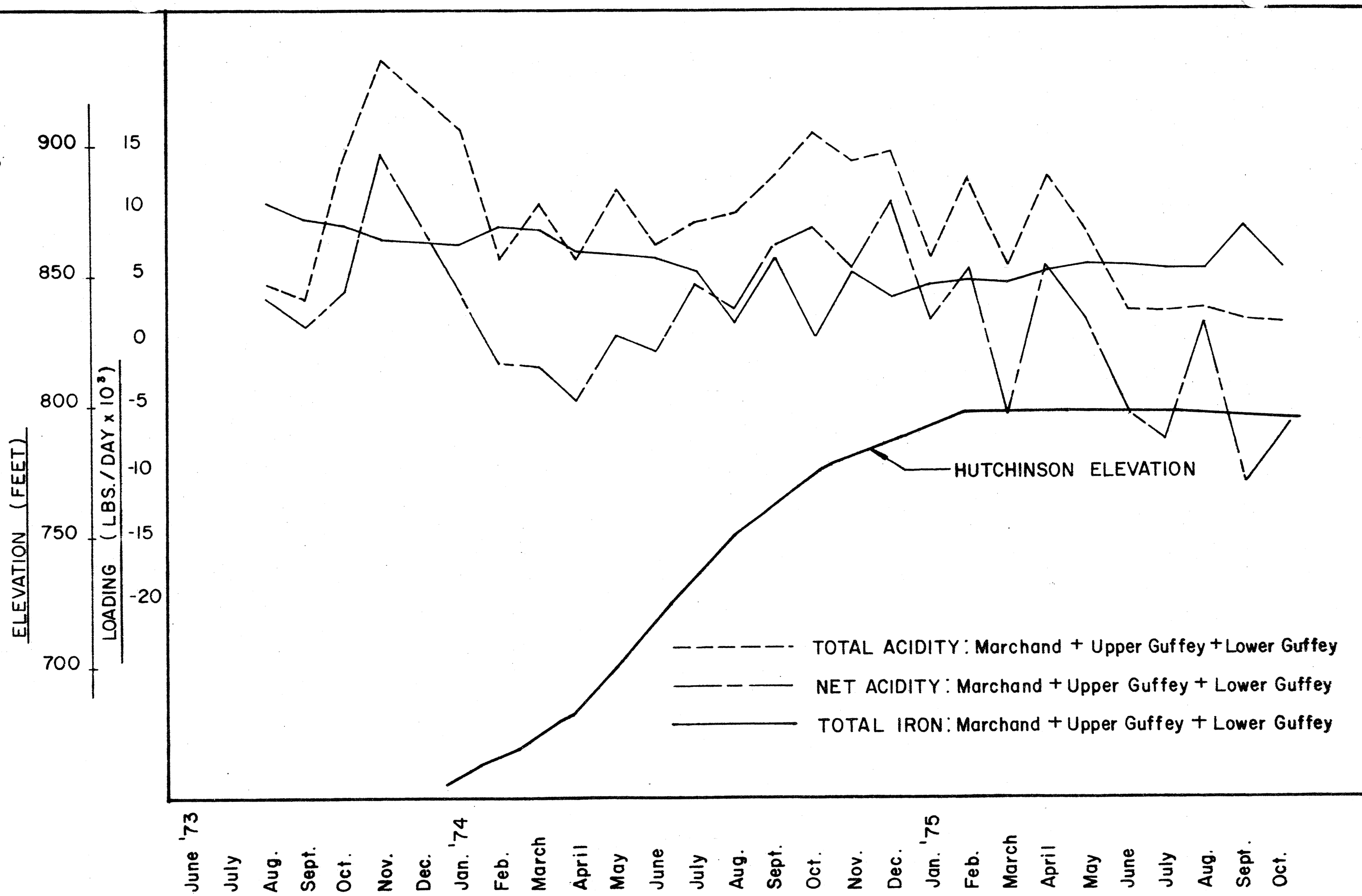
The last two sources were insignificant in comparison with the others. Water from the north barrier pillar (minimum of only 96 feet thick was forced to retain a pool equivalent to 95 feet of hydrostatic pressure) and from the Magee mine was collected in drainage ditches, conveyed to a sump and pumped to the surface via four 16-inch, 4200 GPM pumps. During periods of low flow, minimum pumping time was 30 pump-hours per day and the annual average was 40 pump-hours per day. During high flow periods all four pumps were barely adequate.[(16)] From the central portion of the mine, water was discharged from four outlets across from the main tipple into Big Sewickley Creek, one of which is the pool monitoring site used herein. Water pumped from the northern exhausted portion outletted at the 25 Butt borehole, located along Little Sewickley Creek. (This discharge was to be included in the Irwin Syncline Basin study but was eliminated from consideration since the mine stopped pumping. Located at surface elevation 839'±, it is capped and offers no possibility of discharge.) An average of 850,000 gallons per day was pumped at this site.

Upon abandonment, the mine became quickly inundated. During the first few months, the water level rose about three feet per week and averaged 0.5 feet per week overall until it levelled off at about elevation 795'-800'. See Plate 13. In Operation Scarlift Report SL 103, "Youghiogheny River Basin Mine Drainage Pollution Abatement Project," the effect of abandoning the mine was predicted. An investigation of the hydrogeologic, mining, and mine drainage conditions of the Hutchison mine was conducted in February, 1968 by W. Gross and G. Emerich of the Pennsylvania Department of Health. They concluded that ...

> ... "if the Hutchison mine boreholes, portals and openings were sealed upon abandonment of mining, this mine will flood. There will be no discharge from this mine except for re-establishing natural ground water discharges. The flooded Hutchison mine would become a part of the flooded mine complex consisting of the Marchand, Ocean, Keystone Coal and Coke, and Magee Mines. These mines will continue to overflow at the Guffey overflow and the Marchand overflow. The water quality from these overflows will improve as the water in the mines reaches equilibrium ..."

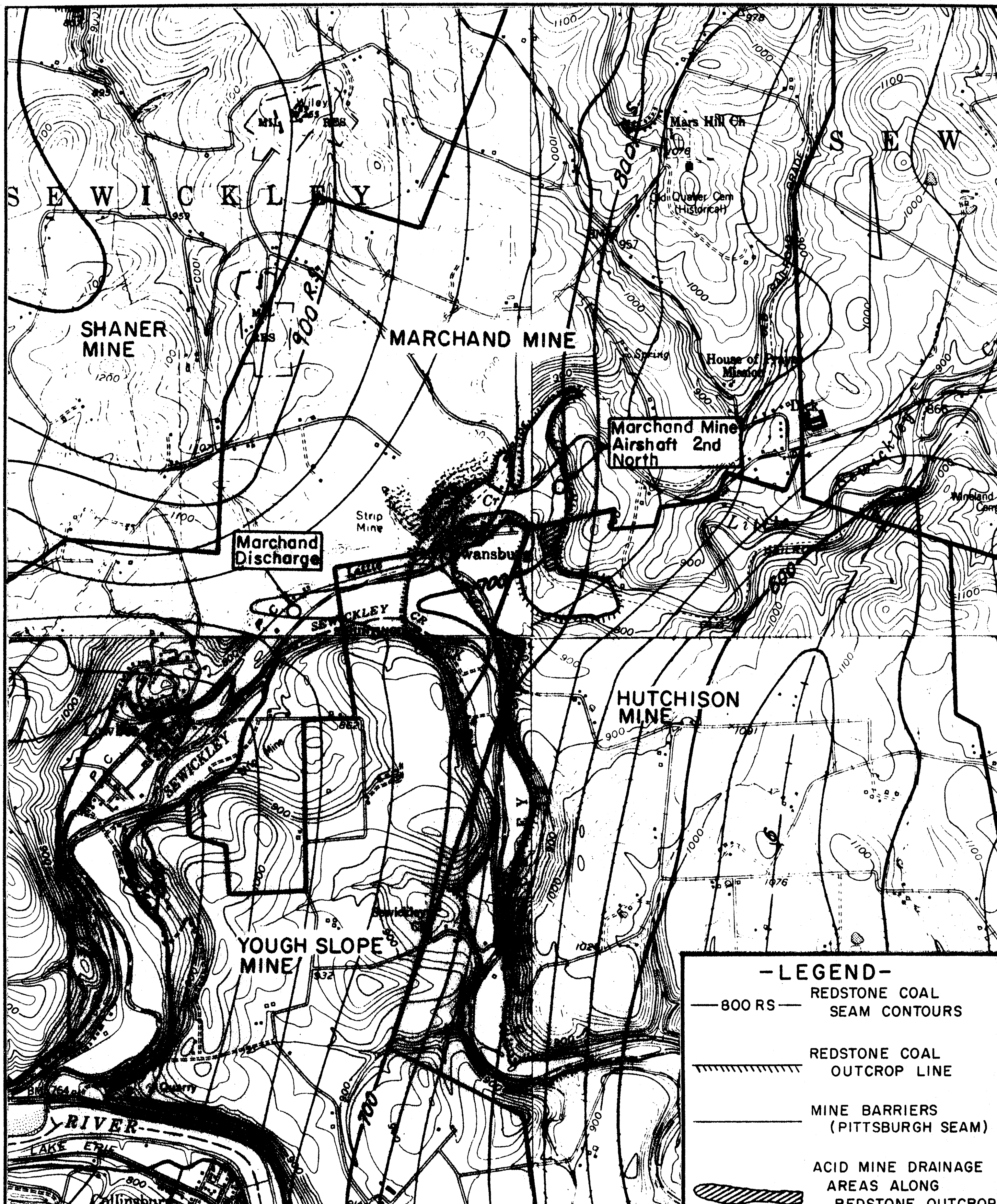
While pre-abandonment data is not available for Hutchison, the combined total acid load for the Marchand, Upper Guffey and Lower Guffey Station discharges is illustrated in Plate 22, superimposed on the rising water elevations within the Hutchison mine. Bearing out the predictions of Gross and Emerich, the total acid load has dropped from an average of about 10,000 pounds per day to approximately 2000 pounds per day based on Appendix A. It should be noted that the samples and flow measurements were taken during the normal low acid-producing season, and that additional monitoring is necessary to fully verify these predictions.

The Hutchison mine pool eventually leveled off at elevation 800'±. As this occurred in the early spring of 1975, acid mine water began to discharge from the Redstone Coal Seam at the locations shown on Plate 23.



POLLUTIONS LOADS - Marchand & Upper and Lower Guffey

OPERATION SCARLIFT PROJECT No. SL103-5	· COMMONWEALTH OF PENNSYLVANIA · DEPARTMENT OF ENVIRONMENTAL RESOURCES	DRAWN W.J.M. CHECKED R.C.O. SCALE AS SHOWN	PLATE 22



REDSTONE SEAM AMD DISCHARGES

DRAWN W.J.M. DATE SCALE 1" = 2000'

COMMONWEALTH OF PENNSYLVANIA
DEPT. OF ENVIRONMENTAL RESOURCES

PLATE 23

ATLAS LITHO CO., PGH., PA. 1020 CLEARPRINT

This is an indication of the extent of fracture of the intervening strata between the Pittsburgh and Redstone coal seams.

The most perplexing of the mine pool measurements were those from the Dillon-Gibbon rock tunnel. On the ocean side, the mine pool registered elevations from 841' to 886', and as expected, it was consistently about five feet lower than those recorded at the Ocean No. 1 borehole near Herminie. On the Marchand side of the tunnel, the only safe location to monitor the pool was the 8" borehole next to the shaft (re: Plate 15). The ground surrounding the shaft was caved and the borehole could just be reached. Water was pooled in the shaft area. The water elevation measurements in the 8" borehole were about equal to the elevation of the pooled water in the shaft. Appendix B shows elevations on the order of 874 to 894, and always much higher than the Ocean side measurements. Aware that the tunnel periodically plugged on the Marchand side as shown on Plate 13, the independent readings of the two sides of the tunnel implied that the tunnel and/or boreholes could be plugged at any number of combinations of locations. It was therefore proposed by the consultant to ream out the boreholes on both sides of the rock tunnel. This idea was abandoned for these reasons:

A Cleaning the boreholes would not insure an operable tunnel.

B If the tunnel was in fact inoperable, restoring the flow might endanger the active operations at Banning No. 4.

C Since additional information was needed for other areas throughout the basin, new holes could be installed more safely, particularly in the area of the Marchand shaft.

2.3.2 <u>Operation Scarlift Project SL 103-5-101.5</u>

Additional monitoring sites were needed throughout the basin if a thorough understanding of the subsurface flow was to be gained. In October, 1975 sixteen (16) monitoring wells were installed as Operation Scarlift Project Number SL 103-5-101.5. These new wells are shown on the Composite Map, the USGS maps of Appendix D and typically throughout the report as MW-7 (monitoring well No. 7 under SL 103-5-101.5).

In the Export-Delmont region monitoring well numbers 1 through 5 (i.e. MW l, l-A, l-B, 2, 3, 3-A, 4 and 5) permitted the consultant to assess this area in detail. The artesian flow of the Delmont discharge was an indication that the barrier pillar between the Export and Delmont mines, acting jointly with the coal reserve under the east-west railroad corridor, was confining water in the Delmont mine.

The limit of this body of water to the northeast was questionable in that it could have been associated with the TR-1 artesian discharge at elevation 1140'± along Legislative Route 64044 (See Section 6.0) which is the largest AMD discharge in the Thorn Run Watershed, a small subbasin of the Beaver Run Reservoir. The Thorn Run watershed is to be analyzed in conjunction with the Irwin syncline basin as will be detailed in Section 6.0. The new wells in the Delmont mine allowed a more comprehensive abatement plan to be developed for this area.

Monitoring wells l, l-A, l-B and 5 were for establishing the conditions responsible for the Export discharge. Water that is generated in the overburden, along the outcrop, and via direct sources from the Thorn Run watershed (See Section 6.0) is collected in the Export mine lower mains and discharged via the outlet at elevation 980.3. However, as noted earlier, the coal reserve under the railroad is severed only by the Mellon mains in which no dams were constructed as can best be determined from available mine maps. Depending on the rate of recharge to the Export mine, the railroad reserve could conceivably help to retain water in the area of the discharge. In addition, the average pool elevation at McCullough shaft five (5) miles south of Export, was 924'±. Based on the fact that the pool is similarly inclined but at a lesser slope than the synclinal axis, it is also conceivable that the fringe of the pool extended into the area of the Export discharge (elevation 980'±). If this is occurring, less water would be allowed to drain via the Mellon mains, and more would be forced out at the discharge.

Monitoring well 6 was to relate the fluctuation of the mine pool in the Paintertown mine with the discharge rate of the Coal Run source. Well 7 was for establishing the limit of the pool beyond the Irwin discharge, and 7-A was for investigating the dams in the lower third dip haulways of the South Side mine and to examine why the Adams, South Side & Biddle pool monitoring points remained at constant elevations. On the western flank, wells 8, 8-A, 9 and 9-A were placed to establish pool conditions in the vicinity of the Guffey discharges, and the MW-10 was installed as the alternative to reaming the Dillon-Gibbon rock tunnel borehole on the Marchand side.

To expedite the installation of these wells, they were located within roadway right-of-way limits. In this way, private property releases and temporary right of way easements for construction were eliminated in lieu of obtaining highway occupancy permits from the state and local municipalities. In addition to trying to locate a suitable mine void to intercept with each well, the void had to also be overlain by a portion of roadway where (1) sufficient shoulder area was available (2) no underground utilities were present and (3) sufficient clearance from overhead wires could be maintained.

Locating a well on the surface with the intention of intercepting a mine void did not guarantee that a void would be encountered. The biggest factor was the scale of available mapping and the lack of unchanged surface controls (such as roadway intersections) on the 600' and 1200' scale mine maps that could be aligned with similar existing topographic features. Many of the roadways shown on the early maps have been reconstructed and realigned in several areas. Barring this difficulty, a well in the center of a main haulway was the best attempt to intercept a mine void, however, a solid coal mass was intercepted more frequently than expected.

Another problem with the new monitoring well installations was groundwater intrusion. Based on water well installation records for the area, groundwater-bearing formations were identified and avoided when placing monitoring well installations. However, because the limited availability of water well records did not permit identification of all water-bearing formations, and because budgetary restrictions prohibited an elaborate groundwater investigation, the absence of undocumented formations could not be guaranteed. The result was that several of the new monitoring wells intercepted groundwater-bearing formations.

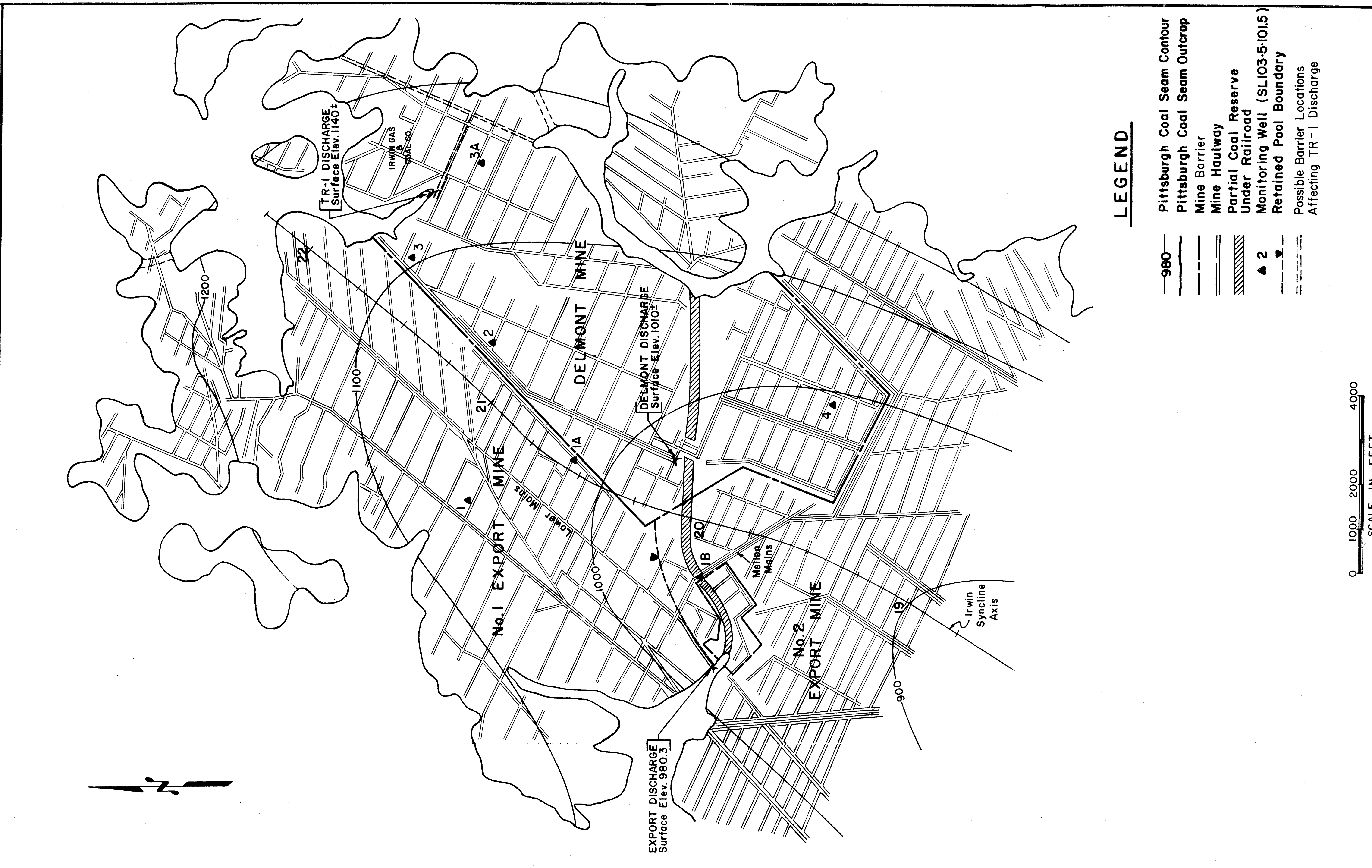
2.4 COMPREHENSIVE BASIN ANALYSIS

With the pool monitoring wells installed under Operation Scarlift Project SL 103-5-101.5, a more conclusive evaluation of the subsurface hydrologic conditions was permitted. Although it was intended to terminate each well in a mine void, several intercepted solid coal.

2.4.1 Export-Delmont Area

The Export discharge is an outlet for water collected in the No. l. Export mine lower main haulway as illustrated on Plate 24. A major portion of the recharge is attributable to overburden inflow. Based on estimates by officials of the Hutchison mine, l.27 MGD of the total 3.44 MGD pumped to operate that mine in the late sixties was attributed to recharge from the overburden immediately above their mine boundaries with the remainder originating in adjacent flooded mines.[11] Spanning 3500 acres, or about 5.47 square miles, the rate of overburden recharge in the Hutchison mine was then about 232,000 GPD/mi^2. Referring to Section 2.1.1, Thompson end Miller report base flow estimates of 0.92 cfs/mi^2 (595,000 GPD/mi.^{2}). In the Export mine, two square miles of overburden drain via the lower mains. Using a rate of 400,000 GPD/mi.^{2} the overburden in this case generates approximately 0.8 MGD, conservatively about two thirds of the Export discharge average flow rate of 1.1 MGD.

All of the monitoring wells installed in the Export-Delmont region under SL 103-5-101.5 are located on Plate D-2 of Appendix D. Plate 25 is a condensed profile along the synclinal axis from McCullough shaft northward. Monitoring well 1 (MW l), which intercepted solid coal, penetrated a local limestone formation at about 140' above the seam. The water elevation was initially 1137', end then averaged 1132' as indicated on Plate 25 (As defined on Plate 25 initial water levels were those encountered during the drilling process. These are not the same as the zero-hour readings cited in Appendix B which were taken upon completion of the entire well apparatus). This limestone lense was also encountered during the installation of MW 2 end MW 5 thus showing the lense to be parallel to the synclinal axis as shown on Plate 25. Monitoring wells l-A and l-B also terminated in solid coal end had average water elevations of 1032' and 981' respectively. MW l-B was planned to intercept the Mellon mains that traverse the east-west railroad corridor reserve. As noted in Section 2.1.3, the reserve within the Delmont mine is undisturbed for the most part, but it was the option of the mining company to extract a maximum of 60% of the coal. This may occur elsewhere, however, mine maps show that only the Mellon mains slice the railroad reserve in the Export mine. While there may be other severance points, the effectiveness of the railroad reserve between the Delmont mine barrier and the coal outcrop line near Export cannot be totally discounted. The consistent elevation of 981'± in MW l-B approximates the Export discharge elevation (980.3) indicating a common groundwater situation. It is concluded that the rail-road reserve retains a smell pool of water having a boundary of 981± as shown on Plate 24. Conceding that an incalculable amount of pooled water does pass through the reserve, the fringe of this confined pool outlets via the Export discharge. The remaining third of the Export average discharge is attributed to inflow via the Thorn Run Watershed. See Section 6.0.



PS CONTRACT NO.

OPERATION SCARLIFT
PROJECT No. SL 103-5

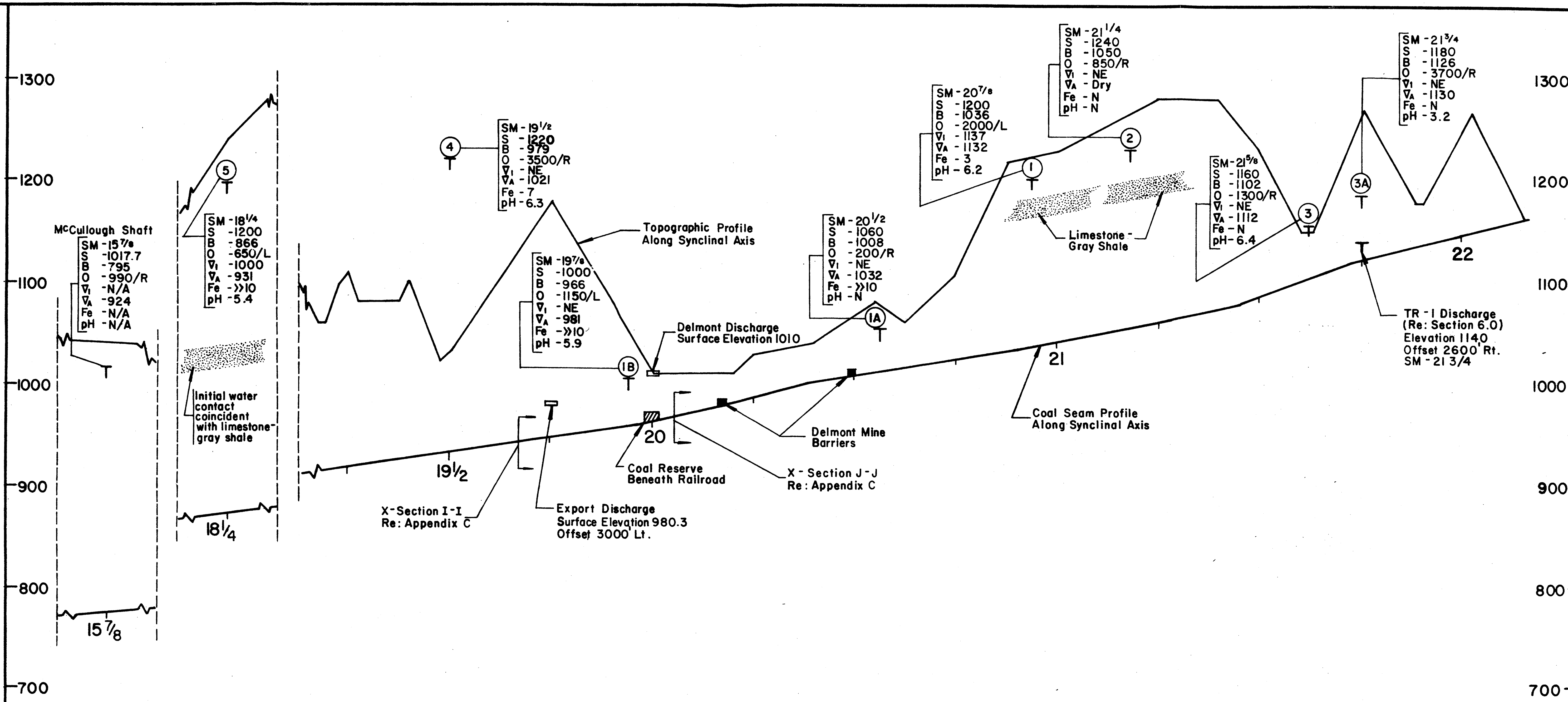
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

DRAWN B.M.C.
CHECKED R.C.O.
SCALE As Shown

IRWIN SYNCLINE BASIN MINE DRAINAGE
POLLUTION ABATEMENT PROJECT
- MINE MAP -
EXPORT AND DELMONT DISCHARGES

PLATE 24
DRAWING NO.

ATLAS LITHO CO., PGH., PA. 1020 CLEARPRINT



LEGEND

Mine Pool Monitoring Site, i.e. McCullough Shaft (Re: Section 2.3.1) or
Operation Scarlift Project SL 103-5-101.5 Monitoring Well Number (Re: Section 2.3.2)

SM	- 8 1/8	- Syncline axis mile location
S	- 960	- Surface elevation of pool monitoring instrument
B	- 650	- Bottom elevation of pool monitoring instrument
O	- 4200/L	- Offset from syncline axis, left (L) or right (R)
∇_I	- 762	- Initial water level encountered during drilling of SL 103-5-101.5 monitoring wells (NE - None Encountered)
∇_A	- 773	- Average water level during pool monitoring program (Re: Appendix B)
Fe	- 8	- Iron Content (ppm) at well bottom. Only monitoring wells installed under SL 103-5-101.5 tested (N - no measurement)
pH	- 6.6	- pH value at well bottom. Only monitoring wells installed under SL 103-5-101.5 tested (N - no measurement)

OPERATION SCARLIFT PROJECT No. SL 103-5	COMMONWEALTH OF PENNSYLVANIA · DEPARTMENT OF ENVIRONMENTAL RESOURCES	DRAWN W.J.M. CHECKED R.C.O. SCALE Horiz. 1" = 1320' Vert. 1" = 100'	IRWIN SYNCLINE BASIN MINE DRAINAGE POLLUTION ABATEMENT PROJECT CONDENSED PROFILE - EXPORT & DELMONT VICINITY	PLATE 25 DRAWING NO.

PS CONTRACT NO.

ATLAS LITHO CO., PGH., PA. 1020 CLEARPRINT

Appendix B contains a summary of all mine pool elevation measurements. An average pool elevation of 924'± was exhibited at the McCullough shaft. MW 5 terminated in a void and registered water elevations from eight to ten feet higher than McCullough, averaging 931'±. These monitoring points are located at syncline axis miles 15 7/8 and 18 1/4 respectively. Projecting the average water elevations northward, the pool boundary intersects the coal seam at syncline axis mile (SAM) 19 5/8± at approximate elevation 935±. McCullough reached a maximum of 939'±. A corresponding maximum for MW 5 is estimated at 948'±. A projection of these elevations place the pool edge for maximum flow conditions at elevation 954±, intersecting the basin axis at SAM 19 7/8. It can be concluded that the pool does not affect the Export discharge even during maximum flow conditions.

The artesian Delmont discharge is at surface elevation 1010'±. Monitoring wells 2 and 3 in the Delmont mine encountered undisturbed coal while 3A terminated in a void. After an initial accumulation of water in MW 2 subsequent readings indicated a dry hole. Presumably the initial water column of 50'± burst what little coal surrounded the well bottom. A water depth of 15'± accumulated in MW 3 after an initial dry condition. In MW 3-A a foot of water accumulated after an initially dry, void situation was encountered. As shown on Plate 24, the artesian discharge TR-1 adjacent to L.R. 64044 and to which the Delmont discharge is possibly linked, is at surface elevation 1140'±, higher than the water level reached in any of the monitoring wells. According to a previous report on the Thorn Run Watershed by J. B. Brunot in August, 1965 (See Section 1.6), discharge TR-1 is from twin headings that outlet at the surface. At that time, one was open and the old mine workings could be looked into while the other was covered and a "considerable amount of highly acid water "seeped" through the earth to flow openly into Thorn Run." In essence the TR-1 discharge is recharged through the outcrop and the overburden in the small area of old workings to the northeast. The report by Brunot recommended that "a dam in each heading, notched into the sides, roof and floor of the heading to prevent water from flowing out" be built to "divert the water into abandoned mine headings and hence, away from Thorn Run." The WPA maps indicate that the boundary between the Irwin Gas and Coal Company mine and the Delmont mine is in this area. A barrier between the mines could be the cause of this discharge, however, its existence or effectiveness has not been verified. Section 3.2.1 will address recommendations in more detail.

In summary the Export discharge is recharged via the outcrop, the overburden, and some direct inflow sources within the Thorn Run watershed which are collected and discharged via the No. 1 Export mine lower mains. A small pool is retained by the east-west railroad reserve with its fringe also outletting via the Export discharge. It has also been demonstrated that the northernmost limit of the major basin pool does not affect the Export discharge even during maximum flow conditions. In the Delmont mine, MW 4, even though it intercepted solid coal, is a good indicator of the conditions governing the Delmont discharge: The 1021 average elevation in MW 4 is a measure of the confined pool elevation in this lower section of the Delmont mine. It is certainly possible that the pool elevation in the section of the mine north of the railroad reserve is equal to or somewhat greater than the confined pool elevation. Recharged via the overburden and the outcrop, the pool within the Delmont mine is therefore estimated to extend to approximately SAM 21.

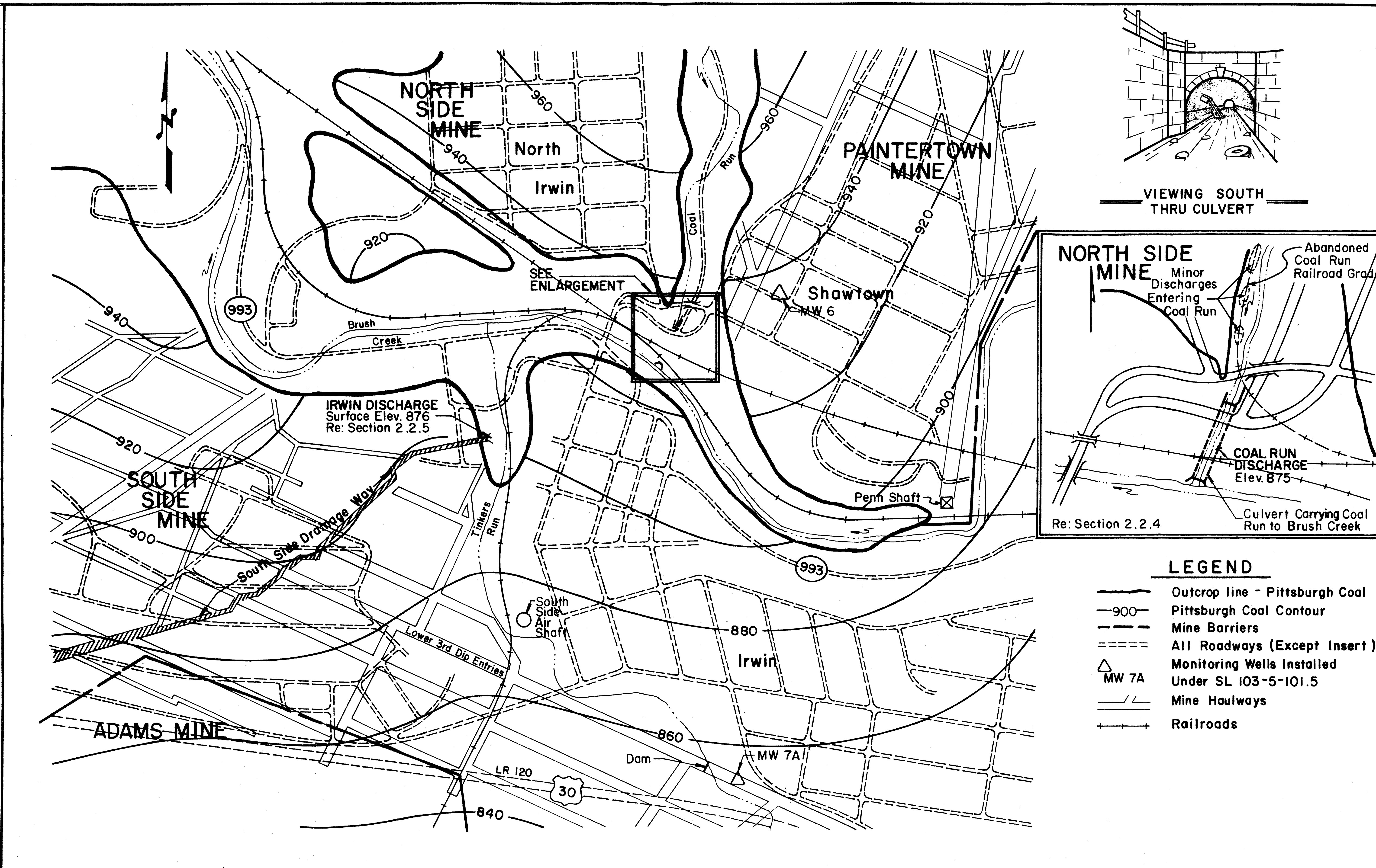
2.4.2 Irwin - Coal Run

Based on the data available prior to the implementation of Operation Scarlift Project SL 103-5-101.5, the conclusions pertaining to this vicinity of the basin were summarized in Item 3 of Section 2.3.l, Initial Observations. To reiterate, the Coal Run discharge flowed erratically while the Irwin discharge demonstrated seasonal fluctuations. At the same time, the pool elevation at monitoring sites closest to these discharges remained static (Adams, Biddle, South Side and Jimtown), but at those further away (Edna No. 2, Ocean No. l, and McCullough) the pool fluctuated in the typically seasonal fashion. Knowledge of dams built in the past expressly to force water out at the Irwin discharge compounded interpretation of this data, because it had not been confirmed that these dams were removed as reported. Therefore, in addition to establishing the relationships between the discharges and the mine pool, it was deemed necessary to positively determine if these dams were intact and if they significantly influenced the subsurface hydrology.

Plates D-3 and D-4 of Appendix D and Plate 26 show the location of the major discharges, mine barriers and mine pool monitoring locations in this area. Plate 27 is a condensed profile along the synclinal axis.

To verify the existence of the dams in the lower 3rd dip mains of the South Side mine, MW 7-A was aligned with this main haulway and was positioned downdip of the dams. However, MW 7-A intercepted solid coal and after an initial water elevation of 906'±, averaged 919'±. That this average elevation exceeds the consistent elevations of the nearby pool monitoring sites (Biddle, Adams, South Side and Jimtown; all in the 887-900 range) is attributed to its terminating in solid coal and probable penetration of a small water-bearing formation. Monitoring well 6 was installed near the Coal Run discharge to measure the pool fluctuation within the Paintertown mine and establish a correlation with the main pool. However, it too terminated in undisturbed coal and apparently traversed a water-bearing formation, because it registers an extremely high average water elevation. Monitoring well 7 was situated to determine the extent of the mine pool north of Adams mine and to the west of the Irwin discharge. Solid coal was intercepted and inordinately high readings resulted.

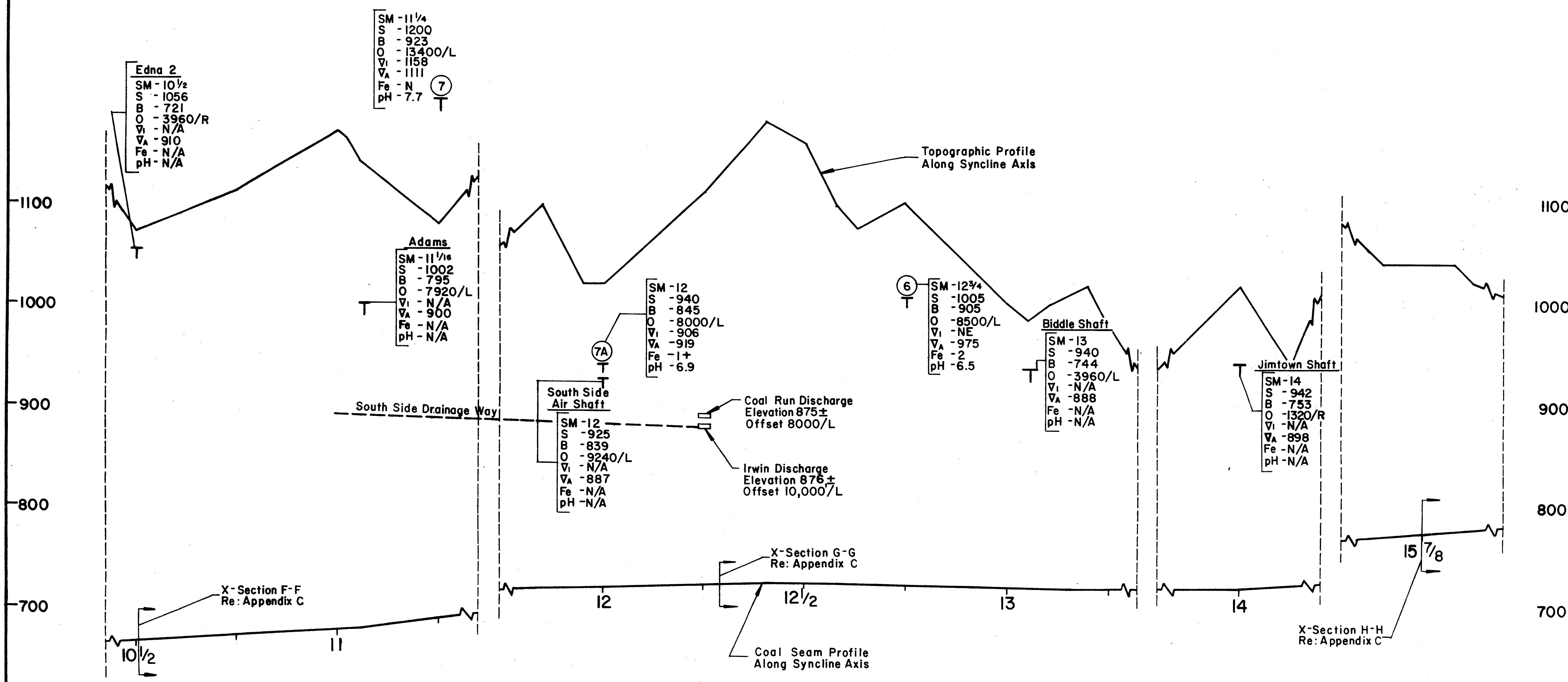
The behavior of the mine pool as it interacts with the Irwin discharge is considered analogous to water table drawdown as water is pumped from an aquifer. As measured at the Edna No. 2 pumphole, the pool fluctuates within a band of elevations from 893' to 926'. Moving radially closer towards the Irwin and Coal Run discharges, the fluctuation in the mine pool is dissipated as the pool "rushes" toward these outlets. Thus in the immediate vicinity of these relief points, the pool surface tends to be constant year-round. Going south from the Irwin discharge (at elevation 876'), the South Side air shaft averaged 887'± and the Adams air shaft averaged 900'±



OPERATION SCARLIFT PROJECT No. SL 103-5	· COMMONWEALTH OF PENNSYLVANIA · DEPARTMENT OF ENVIRONMENTAL RESOURCES	DRAWN B.M.C. CHECKED R.C.O. SCALE 1" = 600'	IRWIN SYNCLINE BASIN MINE DRAINAGE POLLUTION ABATEMENT PROJECT MINE MAP IRWIN AND COAL RUN AREA	PLATE 26 DRAWING NO.

PS CONTRACT NO.

ATLAS LITHO CO. PGH. PA. 1030 CLEARPRINT



LEGEND

Mine Pool Monitoring Site, i.e. McCullough Shaft (Re: Section 2.3.1) or
Operation Scarlift Project SL 103-5-101.5 Monitoring Well Number (Re: Section 2.3.2)

(5)

SM	- 8 1/8	- Syncline axis mile location
S	- 960	- Surface elevation of pool monitoring instrument
B	- 650	- Bottom elevation of pool monitoring instrument
O	- 4200/L	- Offset from syncline axis, left (L) or right (R)
∇_I	- 762	- Initial water level encountered during drilling of SL 103-5-101.5 monitoring wells (NE - None Encountered)
∇_A	- 773	- Average water level during pool monitoring program (Re: Appendix B)
Fe	- 8	- Iron Content (ppm) at well bottom. Only monitoring wells installed under SL 103-5-101.5 tested (N - no measurement)
pH	- 6.6	- pH value at well bottom. Only monitoring wells installed under SL 103-5-101.5 tested (N - no measurement)

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thus forming a parabolic-like water surface similar to a drawdown curve. To the east, beginning at Coal Run (elevation 875'), Riddle shaft averaged 888' and Jimtown averaged 898'±, fixing the direction of the depression cone surface. When maximum pool elevations are reached in the main portion of the mine pool, say at Edna No. 2, a greater hydrostatic pressure is exerted and more acid mine drainage is forced out at the discharges. Near the discharges, the differences in mine pool elevation between minimum and maximum flows are less. The result is that the pool appears constant at South Side, Biddle and Adams. In addition, the dams in the lower third dip main haulways of the South Side mine are relegated to the status of a mine barrier pillar under an analogously deep mine pool in that water flows around and through them. Thus they do not influence the pool behavior.

Pool recharge of the Irwin and Coal Run discharges is partially accomplished by overburden and outcrop inflow from the unflooded part of the coal seam (i.e. the area updip of the pool boundary to the west and west-northwest of the Irwin discharge). It is estimated that about twenty-five percent (25%) of the average Irwin discharge flow rate originates in this area. (Based on approximately seven square miles of contributing overburden area and 400,000 gallons per day per square mile as the average overburden recharge rate). Water generated in the overburden makes up most of this 25% which flows downdip to join the pool, eventually outletting at Irwin.

The erratic flow from the Coal Run discharge at elevation 875'± is judged to be caused by the interference of the Paintertown mine barrier pillar with the relatively stable, drawn down pool surface extending from the discharge through Biddle (888) to Jimtown at 898. The mine barrier pillar that encloses the Coal Run discharge parallels the coal contours and thus creates a "step" in pool elevation. Since the pool just exceeds the outlet elevation, any further dampening near the discharge causes the water in the Paintertown mine to become almost static. This provides an ideal situation for forming the ferric hydroxide, or "yellowboy," that clogs the 12" outlet pipes by presumably allowing sufficient air to interact with the pyrites in the coal near the inlet within the mine. As the pool increases above the clogged outlet, sufficient pressure builds, eventually forcing the clogged conduit open. It should also be noted that the slope of the protruding pipes suggests that they are angled up into the Paintertown mine, however, the exact elevation of the invert relative to the pool surface is not known.

2.4.3 Marchand, Upper Guffey Station and Lower Guffey Station Discharges

Item 4 of Section 2.3.1 cited the difficulty with evaluating the subsurface hydrology of this area of the basin based solely on the discharge and mine pool monitoring data collected prior to SL 103-5-101.5. Reiterating, as the Hutchison mine flooded, these three discharges maintained the same magnitude of flow. As measured at the Yough Slope shaft and the second north air shaft of the Marchand mine, the pool was static. In the Marchand side of the Dillon-Gibbon rock tunnel the water elevation fluctuated erratically, but at both Ocean mine measuring sites, the pool fluctuated in the typically seasonal fashion. The deep mine sections under consideration are isolated in Plates 28 and 29.

In the previous section, the relationship between the mine pool and the Irwin and Coal Run discharges was found to be analogous to a well drawdown situation. With increasing distance from the discharges, the pool surface fluctuates within a wider range of elevations. The drawdown concept is easily visualized: the average piezometric surface approximates concentric contours around the discharges. On the contrary, the subsurface flow pattern in the Guffey Station-Marchand analysis is more irregular for several reasons. The conditions of the barrier pillars as alluded to in Section 2.1.2 became significant, for example the severed Adams-Riley and Riley-Marchand barriers. The shallow coal structure along the west flank, the Dillon-Gibbon rock tunnel, and the presence of three outlets all factor into generating a complex pool surface. Combining the data from the new monitoring wells with an analysis of the history of the basin hydrology, the subsurface flow pattern in this area can be deciphered.

An estimate of the mine pool elevation in the Riley mine is instrumental in illustrating the transition of the mine pool surface that occurs throughout the Adams, Riley, Marchand, Ocean, Hutchison and Guffey mine region. Referring to Plate 13 in Section 1.4, as more mines were being abandoned in the late 1930's a common pool began to accumulate. The flow of water into the active Hutchison mine was minimized by equalizing the water level in the Keystone and Ocean mines (via the 5' x 5 1/2' tunnel) and pumping from the Marchand mine. It eventually became necessary to provide relief for the Keystone-Ocean pool which was rising to a dangerously high level and was forcing more water into Hutchison. This was accomplished by constructing the Dillon-Gibbon rock tunnel after which the Marchand discharge started. As a result, the pool in all of the flooded mines leveled off during the 1940's. During this stable period, the water level in Marchand as measured at the Marchand air shaft second north was 764'±, identical to the main slope entry surface elevation. Concurrently, the pool elevation in the Riley mine averaged approximately 778'±, a difference of about 14 feet.

When the Biddle, Adams and South Side mines were allowed to flood in 1955, the Adams, Edna, McCullough, Biddle and South Side mines near Irwin flooded to elevations higher than the South Side drainageway of elevation 876'± (thus the Irwin discharge began) and then leveled off. See Plate 1.3. At the same time, the Ocean-Keystone pool (kept level by the 5 x 5-1/2" tunnel) rose to elevation 850'± and then receded. This demonstrates that the vast basin pool reached an equilibrious state between inflow and outflow. The pool was relieved via the Irwin discharge to the north, and to the south, the Ocean-Keystone pool found relief via the Dillon-Gibbon rock tunnel and the Marchand discharge. The difference in the maximum elevations reached in the two areas is due to the tilt of the basin. This is basically the state of the subsurface flow pattern in existence today, although the pool has generally risen as illustrated by the pool elevations collected during Operation Scarlift SL 103-5.

As the Ocean-Keystone pool peaked at 850'± in the spring of 1956, the Riley mine pool rose to a maximum elevation of 810'±, but the Marchand air shaft second north remained at elevation 764'±, a difference of 46'. Subsequent readings in Riley, after the basin pool assumed equilibrium, indicate that it leveled off at approximately 792'±, twenty-eight feet (28') greater than Marchand. (Riley mine pool readings: 796.0' on December 5, 1956, and 792.5' in October, 1957.) Inasmuch as Adams leveled off at 880'±, the difference of 88' between Adams & Riley versus the 28' difference between Riley and Marchand is indicative of the severed barrier, conditions augmented by the tilt of the basin. Plate 13 indicates that the pool, as measured at the Edna and Ocean mines, has risen an average of approximately 20 feet since the late 1950's. It is estimated that a corresponding increase has accrued in the Riley mine, but due to the condition of the barriers it is estimated at less than 20 feet. The present pool elevation in Riley is approximated at 805'±. (The 20' increase in pool surface could be attributable to several factors: (1) generally higher groundwater conditions, (2) a redistribution of the pool within these two mines and (3) increases in wastewater disposal to the mines accompanying population growth as well as commercial and industrial development.) The elevations in the Marchand borehole of the Dillon-Gibbon tract have been justifiably disregarded since they are quite erratic, as illustrated on Plate 13, due to clogging of the borehole documented in Section 2.3.1.

It is proposed that the Marchand discharge exhibits a drawdown effect on the basin pool. As is the case for groundwater systems in general, the pool surface is parallel to the synclinal axis plunge. In this case, however, the phenomenon is augmented by the conditions of the transverse mine barriers. Consider the Edna-Ocean-Hutchison mine pool. Their common barriers are generally intact. The pool surface drops from 910'± to 800'±, but the basin is similarly sloped. Thus the depth of water averages about 200' along this deepest part of the basin and the water surface itself parallels the axis plunge.

	Edna No. 2	Ocean No. 1	Ocean(D/G)	Hutchison
Average pool elevation	910	868	863	800
Coal elevation	721	653	650	585
Depth of water	189	215	213	215

Now examine the Adams-Riley-Marchand series of minesin the proper perspective, i.e., that relief is being provided at each end via the Irwin and Marchand discharges. The Edna No. 2

	(Edna No.2)	Adams	Riley	(Ocean,D/G)	MW#10	Marchand ASSN
Average pool elevation	(910)	900	805	(863)	773	767
Coal elevation	(721)	795	669	(650)	650	706
Depth of water	(189)	105	136	(213)	123	61

elevations are included to illustrate the pool surface and depth change in a transverse direction (perpendicular to the syncline axis) along the drawdown surface. Going south from Adams, the difference in pool surface elevation changes by 95', then it changes by 32' from Riley to the Marchand mine (MW 10), then 6' between MW #10 and the Marchand ASSN, and finally by 3' to the Marchand discharge elevation (764). The Ocean (D/G) elevations are included to indicate the variation in pool surface among the Adams-Ocean-Riley and Riley-Ocean-Marchand mines. In essence, the pool surface simultaneously varies in the transverse and longitudinal directions. The effects of the barriers are evident in this case, particularly those surrounding the Ocean mine. Water is generally confined within the Ocean mine with the exception of the outlet provided by the Dillon-Gibbon rock tunnel. (The elevation of 773'± in MW 10 vs. the Marchand readings in the Dillon-Gibbon borehole indicates the Marchand borehole is plugged above the tunnel).

In essence, going radially from the Marchand discharge a parabolically increasing water surface is fixed. To the north, the pool surface rises to 767'± (ASSN) and then to 773'± (MW #10) before encountering the Riley barrier. To the southeast the Yough Slope shaft averages a constant 765'±. (Further south the pool elevation falls to 732 at Buddtown primarily because of the overall basin plunge and its nearness to the active Banning No. 4 mine). The Hutchison mine leveled off at elevation 800'±, meeting the piezometric surface established by the interaction of the surrounding abandoned mines (Yough Slope, Osborne, Ocean-Keystone and Marchand) and the nearby, internal discharge locations, i.e. the Marchand discharge and the Banning No. 4 mine. In summary, a piezometric map of mine pool elevations would show concentric contours around the Marchand discharge.

As noted in Section 2.2.7, the Upper Guffey Station discharge was supposedly constructed as a drainageway to permit more coal recovery in the Shaner mine. The orientation of this drainageway is approximated on Plate 28. Available mapping shows the drainageway terminating at point 'A' and oriented such that its extension would intersect the outcrop in the vicinity of the Upper Guffey Station discharge. Twelve hundred scale (1" = 1200') deep mine maps show the drainageway extending much further in the east-northeast direction than do the WPA maps. Based on the pool elevations of 805' and 773' within the Riley and Marchand mines respectively, it is proposed that the pool intersects the drainageway somewhere along its length. The average of these elevations is 789', some 11 feet higher than the drainageway outlet at 778. (The portion of the discharge flow attributable to this action is incalculable as is that part attributed to the other haulway that parallels L.R. 64204 to the north-northeast).

Data from monitoring well 9 tends to support this proposal. After a. zero-hour reading of 780'±, MW 9 averaged 776'±, elevations that are considered valid because the well terminated in a void. The 776' average is two feet lower than the Upper Guffey outlet of 778'. The pool could not discharge via the drainageway based on these exact elevations. They should be viewed, however, as approximations to illustrate that the pool does intersect the drainageway at some appropriate elevation; i.e. higher than 778. The exact elevations involved are not known but allowing that the coal contours are not precise, the local structure is extremely shallow, and the elevations associated with the monitoring well and the discharge are of comparable accuracy, the concept of the pool intersecting the drainageway and discharging at Upper Guffey Station becomes increasingly acceptable.

Monitoring well 8 apparently intercepted a localized pool. The depth of water in this well maintained a constant depth of 7± feet after intersecting a void, averaging 933±. MW 9A intercepted solid coal and averaged an excessively high average water elevation of 898, probably striking a perched aquifer. The pool surface in this area can't possibly be this high or the water would be discharging along Shaner Hollow where it has been observed that a small watercourse disappears and apparently enters the abandoned mines.

As noted in Section 2.2.8 the Lower Guffey Station discharge began when water had accumulated sufficiently in the Guffey mine to burst from the outcrop at this location. Monitoring well 8-A encountered a void. It averaged a water elevation of 800± which is an indication of the depth of water acting on this discharge. Recharge appears to be via the outcrop and overburden to the northwest. The origin of the discharge cannot be documented.

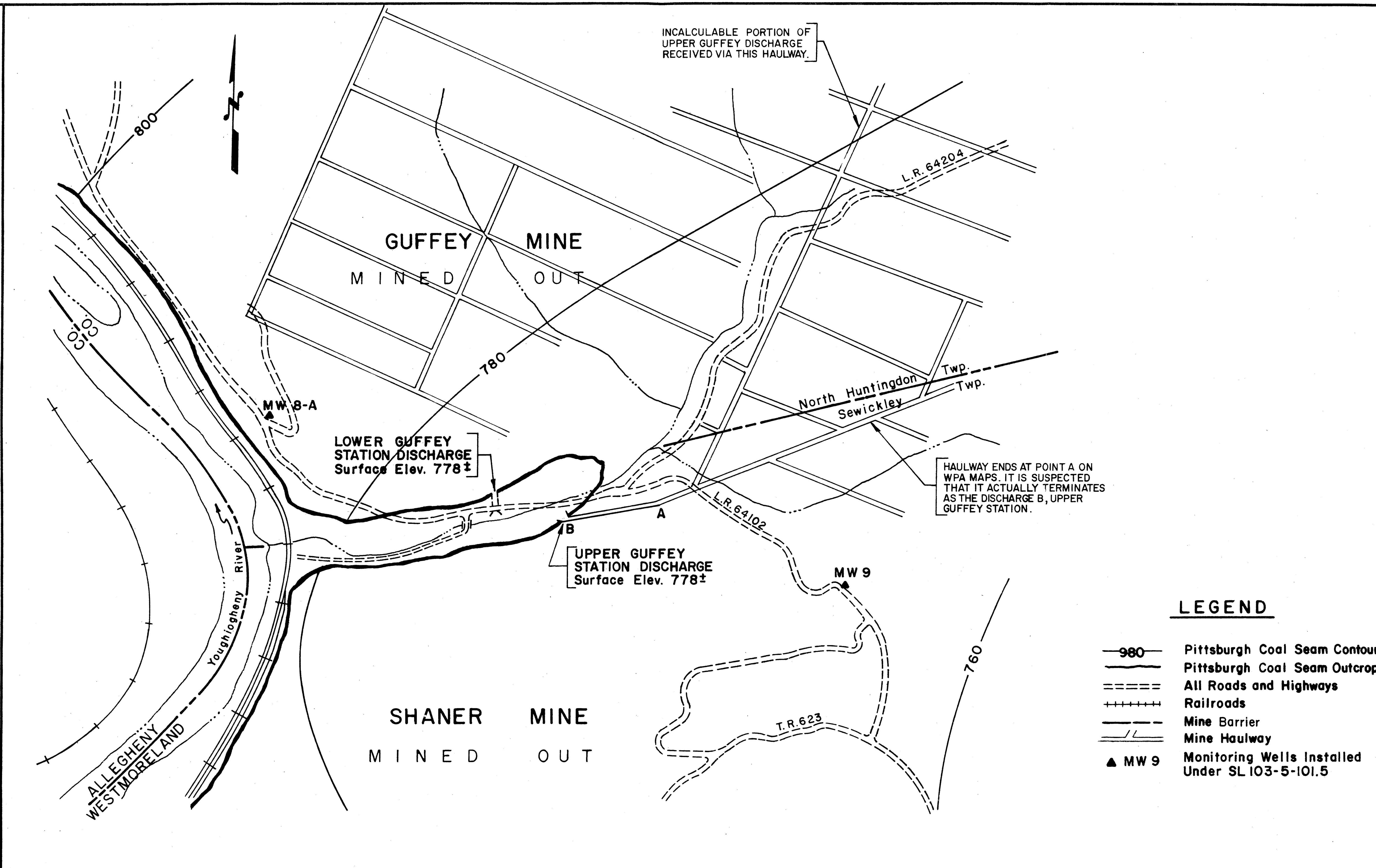

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PLATE 28

DRAWING NO.

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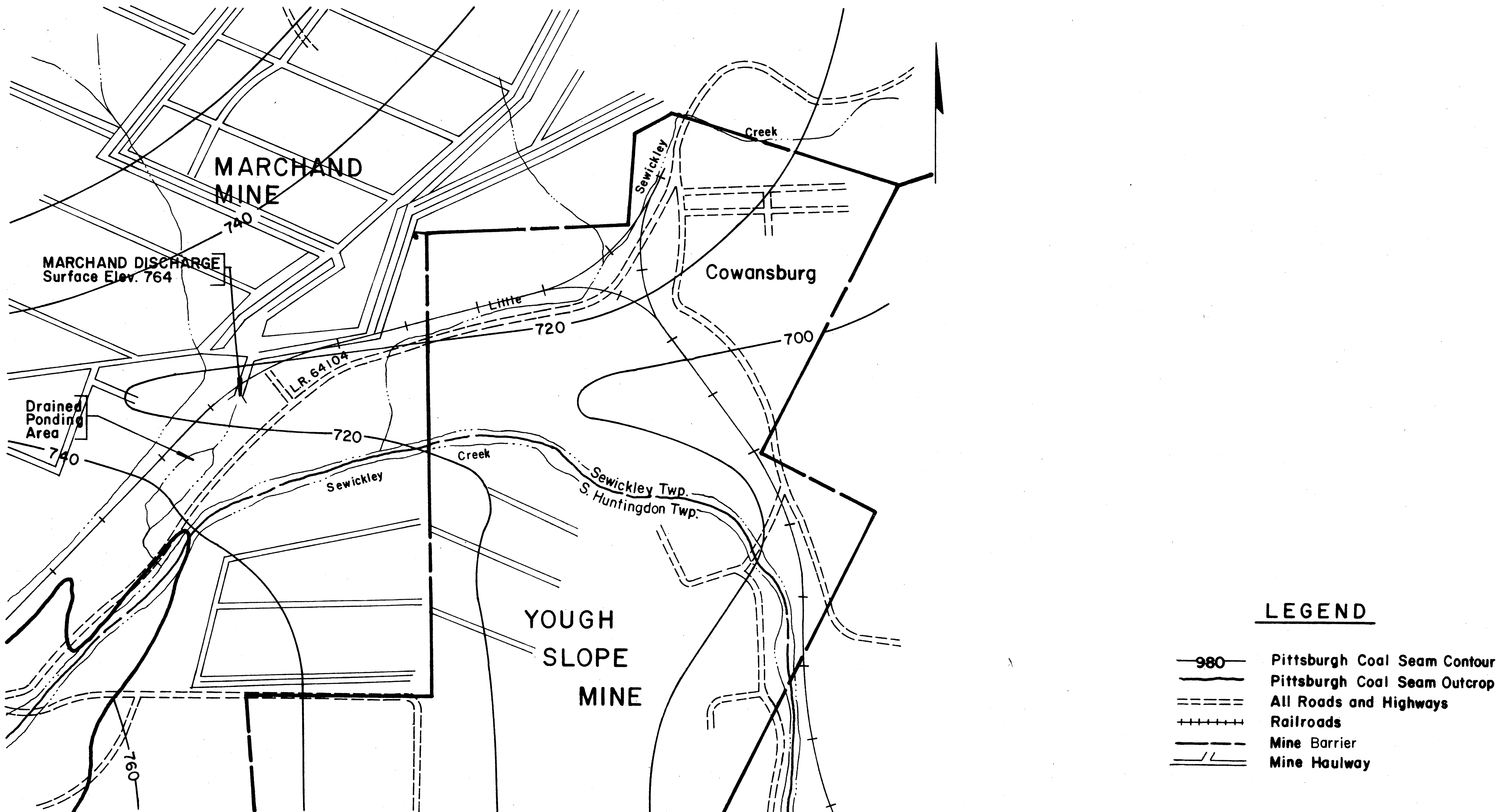

OPERATION SCARLIFT PROJECT No. SL 103-5	· COMMONWEALTH OF PENNSYLVANIA · DEPARTMENT OF ENVIRONMENTAL RESOURCES	DRAWN W.J.M. CHECKED R.C.O. SCALE 1" = 600'	IRWIN SYNCLINE BASIN MINE DRAINAGE POLLUTION ABATEMENT PROJECT MINE MAP MARCHAND DISCHARGE

PLATE 29

DRAWING NO.

PS CONTRACT NO.

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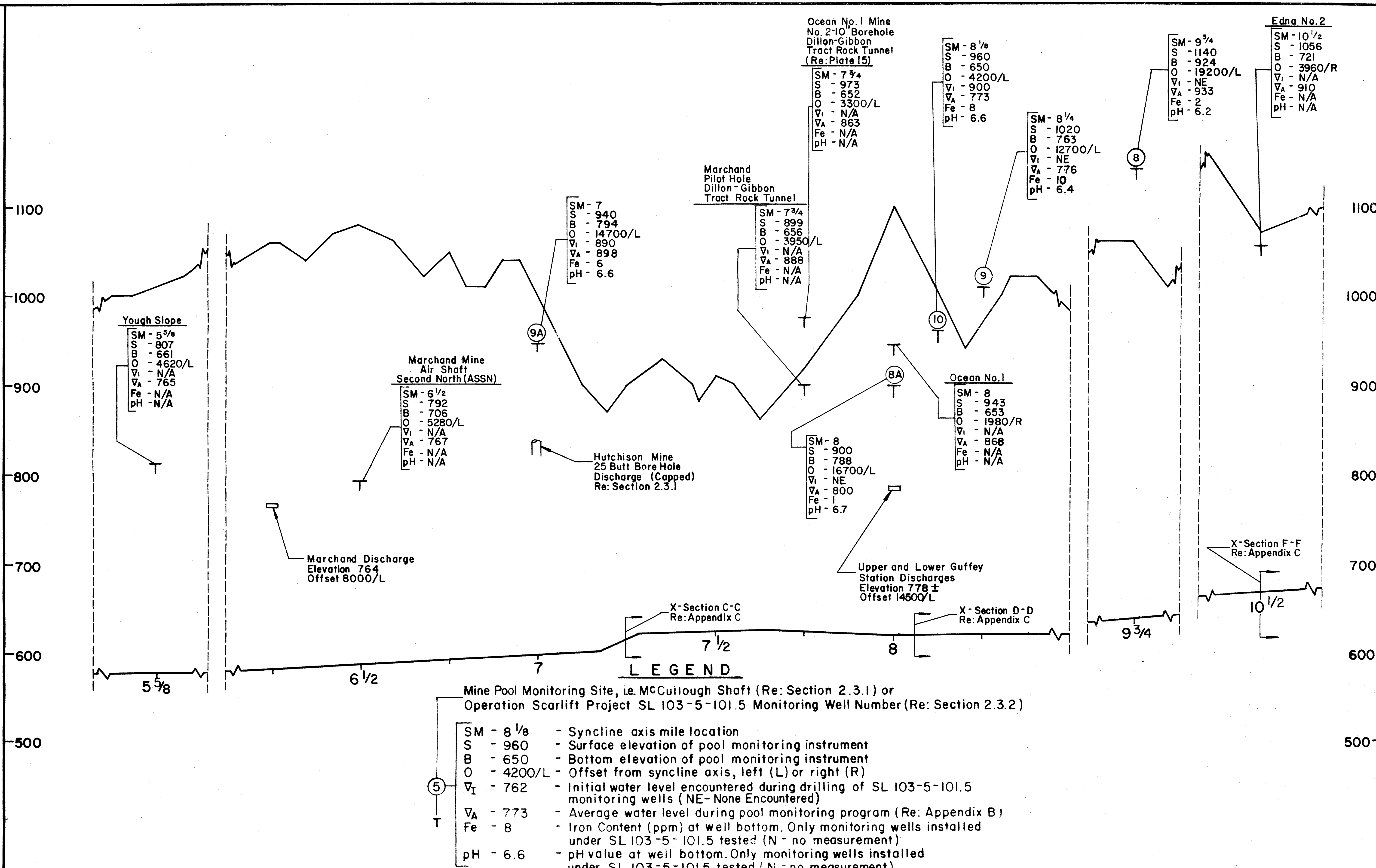

OPERATION SCARLIFT PROJECT No. SL 103-5	COMMONWEALTH OF PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES	DRAWN W.J.M. CHECKED R.C.O. SCALE Horiz. 1" = 1320' Vert. 1" = 100'	IRWIN SYNCLINE BASIN MINE DRAINAGE POLLUTION ABATEMENT PROJECT CONDENSED PROFILE LOWER BASIN AREA (SAM 6-11)	PLATE 30 DRAWING NO.

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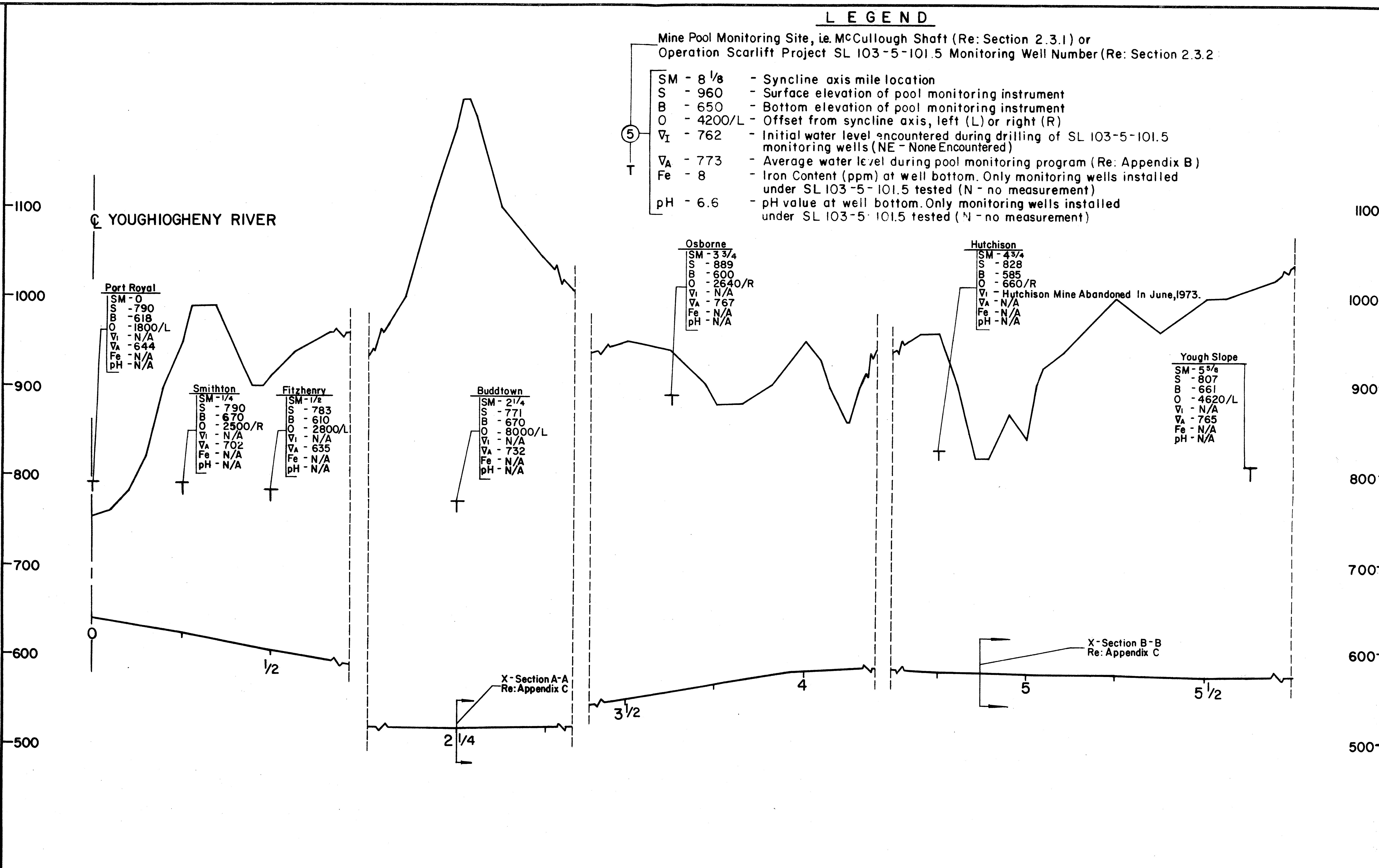

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IRWIN SYNCLINE BASIN MINE DRAINAGE POLLUTION ABATEMENT PROJECT
CONDENSED PROFILE
LOWER BASIN AREA (SAM 0-6)

PLATE 31
DRAWING NO.

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