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Environmental Protection Technology Series

EVALUATION OF SURFACE MINE RECLAMATION TECHNIQUES
Campbell's Run Watershed, Pennsylvania

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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EVALUATION OF SURFACE MINE RECLAMATION TECHNIQUES
Campbell's Run Watershed Pennsylvania

by

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FOREWORD

When energy and material resources are extracted, processed, and used, these operations usually pollute our environment. The resultant air, land, solid waste and other pollutants may adversely impact our aesthetic and physical well-being. Protection of our environment requires that we recognize and understand the complex environmental impacts of these operations and that corrective approaches be applied.

The Industrial Environmental Research Laboratory - Cincinnati assesses the environmental, social and economic impacts of industrial and energy-related activities and identifies, evaluates, develops and demonstrates alternatives for the protection of the environment.

This report is a product of the above efforts. It describes a study performed to demonstrate the effectiveness of surface mine reclamation upon water quality in streams receiving mine drainage from abandoned underground mines. The results of the study indicated a 43 percent decrease in acid load in the stream. However, this improvement could not be directly attributed to the surface reclamation projects because of residential, commercial, and interstate construction in the study area.

The recommendations have many worthwhile suggestions for those individuals attempting to monitor the effectiveness of reclamation projects. In addition, this report should be of value to state and federal agencies conducting coal mine reclamation projects.

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ABSTRACT

A study was performed to demonstrate the effectiveness of surface reclamation of strip mined land upon water quality in streams receiving mine drainage pollution from abandoned underground mines. The water quality was monitored in three phases, prior to the surface reclamation, during reclamation, and after reclamation. The results were then evaluated to determine any improvement in water quality resulting from the construction of the abatement facilities.

Fifty-two acres (21 hectares) of abandoned strip mined land were regraded and revegetated to reduce infiltration to the spoil zone and to the deep mine complex. The reclamation was completed at a cost of $131,650. The results of the collection and sampling of stream samples over a three year period indicated that the pH and acidity of Campbell's Run had improved and that the acid load had decreased 43% at the mouth of Campbell's Run. However, this improvement could not be directly attributed to the surface reclamation projects. The improvement was determined to be more directly related to the construction of residential and commercial establishments, to the construction of U. S. Interstate 79, and to natural fluctuations in mine pool levels and runoff rates.

This report was submitted by the Department of Environmental Resources, Commonwealth of Pennsylvania, in fulfillment of Grant Number 14010 GCM under the sponsorship of the U.S. Environmental Protection Agency. This report of work, subcontracted to A. C. Ackenheil & Associates, Inc., covers the period November 1970 through October 1975, and work was completed as of October 1975.

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ACKNOWLEDGMENTS

Dr. John Demchalk, Department of Environmental Resources, Commonwealth of Pennsylvania, served as Project Director during this project.

All technical and administrative assistance received during this project, expecially that of Messers. Ronald D. Hill and Elmore C. Grim of the Environmental Protection Agency, is gratefully acknowledged.

I. CONCLUSIONS

Based on the available data, pH, net acid concentration and net acid load have improved throughout the Campbell's Run Watershed since the construction of acid mine drainage abatement facilities designated as Commonwealth of Pennsylvania, Department of Environmental Resources (DER) Project SL 102-3-6.

The net acid load of Campbell's Run at the confluence with Chartiers Creek has decreased from 13,945 lbs/day to 8,009 lbs/day or a 43% improvement from 1971 to 1975.

The Campbell's Run Watershed has undergone extensive urban land development from 1970 to the present day. This development, plus the construction of U. S. Interstate 79 has altered the surface and subsurface drainage characteristics of the area.

The results of the sampling data indicate that a causal relationship between the strip mine reclamation areas and the improvement in the stream water quality of the Campbell's Run Watershed would require extensive sampling far beyond the original scope of this project.

The specific effect of the strip mine reclamation upon water quality improvement could not be accurately quantified because of the ratio between the small drainage areas directly affected by the work areas to the larger drainage areas contributing runoff to the stream sampling stations.

No degradation in stream quality as a direct result of the construction facility was observed.

The reduction in flow at monitoring Station 4 on Campbell's Run is not totally the results of the construction of acid mine drainage facilities, but rather related to the result of the collection and diversion of upstream wastewater to a new treatment facility located downstream of Station 4.

II. RECOMMENDATIONS

All recommendations apply to projects which are expected to demonstrate the effectiveness of the construction of abatement facilities upon receiving stream quality.

Future projects to demonstrate the effectiveness of abatement facilities upon water quality should not be conducted in an area expected to undergo urbanization during the project duration.

Whenever strip mine reclamation is expected to improve streams which receive deep mine discharges, the monitoring project should include sampling at both the deep mine discharge point to be affected and at the receiving stream.

Stream monitoring stations should be instituted as close as possible to the abatement facilities and the affected pollution discharge sources so as to eliminate extraneous background water which reduces the accuracy of the data.

Sampling frequency should be flexible enough to provide sufficient data that yields characteristic relationships between water quality and controlling factors such as precipitation, ground water or mine pool level, temperature, and vegetation. Samples should be collected with sufficient frequency and of sufficient duration (namely, weekly sampling with continuous flow measurement for one water year before and after construction), to insure that their relationships correlate positively and are statistically significant.

Demonstration watersheds should be as small as possible to eliminate or keep to a minimum confusing variables.

III. INTRODUCTION

LOCATION

The Campbell's Run study area is located in Allegheny County, Pennsylvania, approximately five miles southwest of Pittsburgh, Pennsylvania. Campbell's Run is the northernmost major tributary to Chartiers Creek and joins Chartiers Creek at the town of Carnegie, Pennsylvania. It is composed of two major tributaries, both of which are severely degraded by acid mine drainage (AMD). The southernmost fork flows through the heavily developed area along Campbell's Run Road. The northernmost fork drains the region in the vicinity of U. S. Route I-79. This region is, for the most part, sparsely populated. See Figure 1 for the location map of the area.

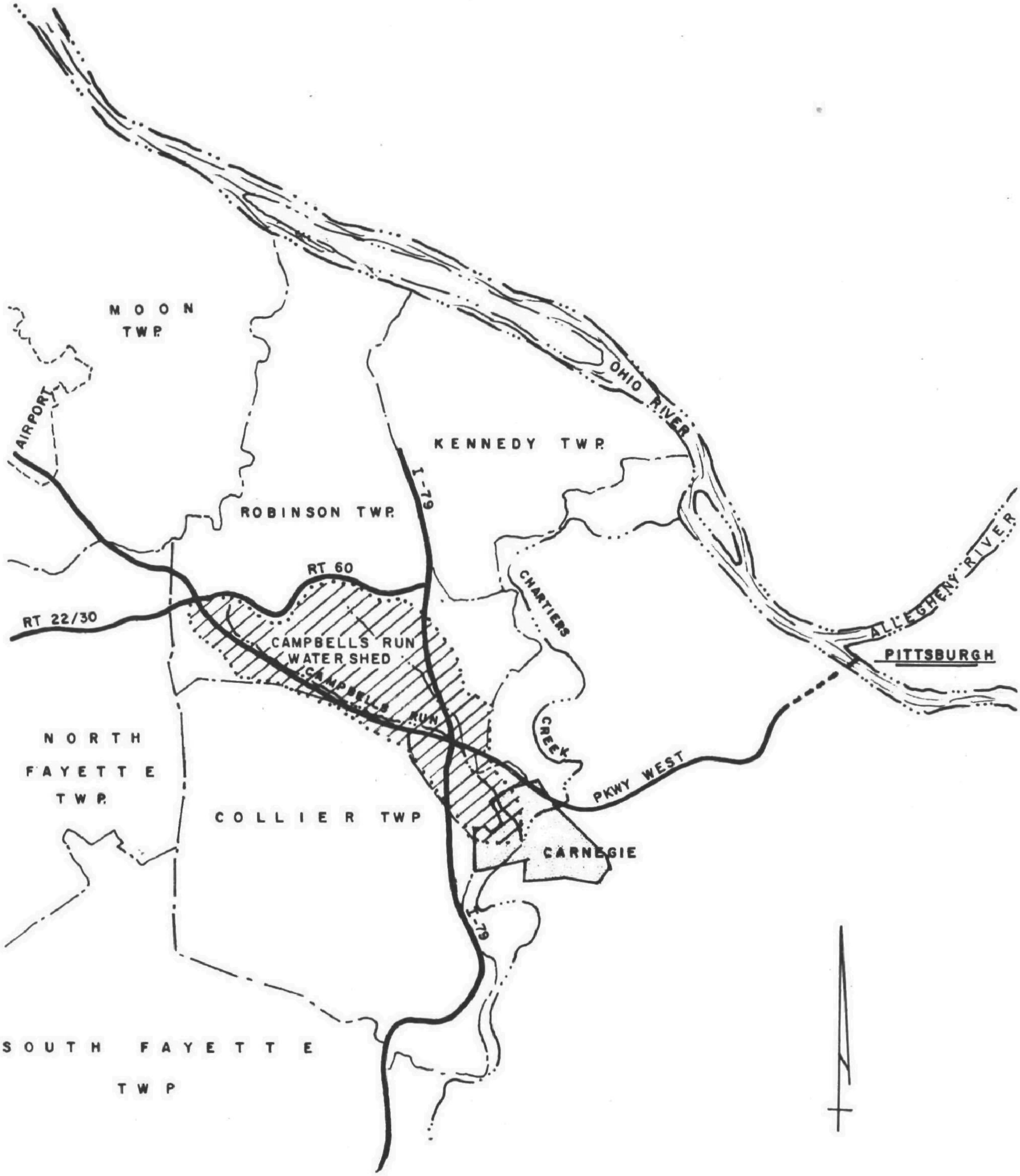
TOPOGRAPHY AND SURFACE DRAINAGE

Campbell's Run is located within the Allegheny Plateaus Physiographic Province. The valley of the main stream is U-shaped with a narrow flood plain averaging about 500 feet (152.4 meters) in width. The gradient of the main stream is approximately 50 feet per mile (9.5 meters per kilometer). The tributary valleys to Campbell's Run are generally V-shaped with steep to moderately steep valley walls and rounded hilltops. The gradient of these streams is between 150 feet and 175 feet per mile (28.4 meters and 33.1 meters per kilometer). The overall relief of the watershed is approximately 500 feet (152.4 meters), rising from a low of 775 feet (236.2 meters) where Campbell's Run enters Chartiers Creek, to a high of approximately 1275 feet (388.6 meters) on the north central portion of the watershed. The area has a local relief which varies from 150 feet to 300 feet (45.7 meters to 91.4 meters).

GEOLOGY

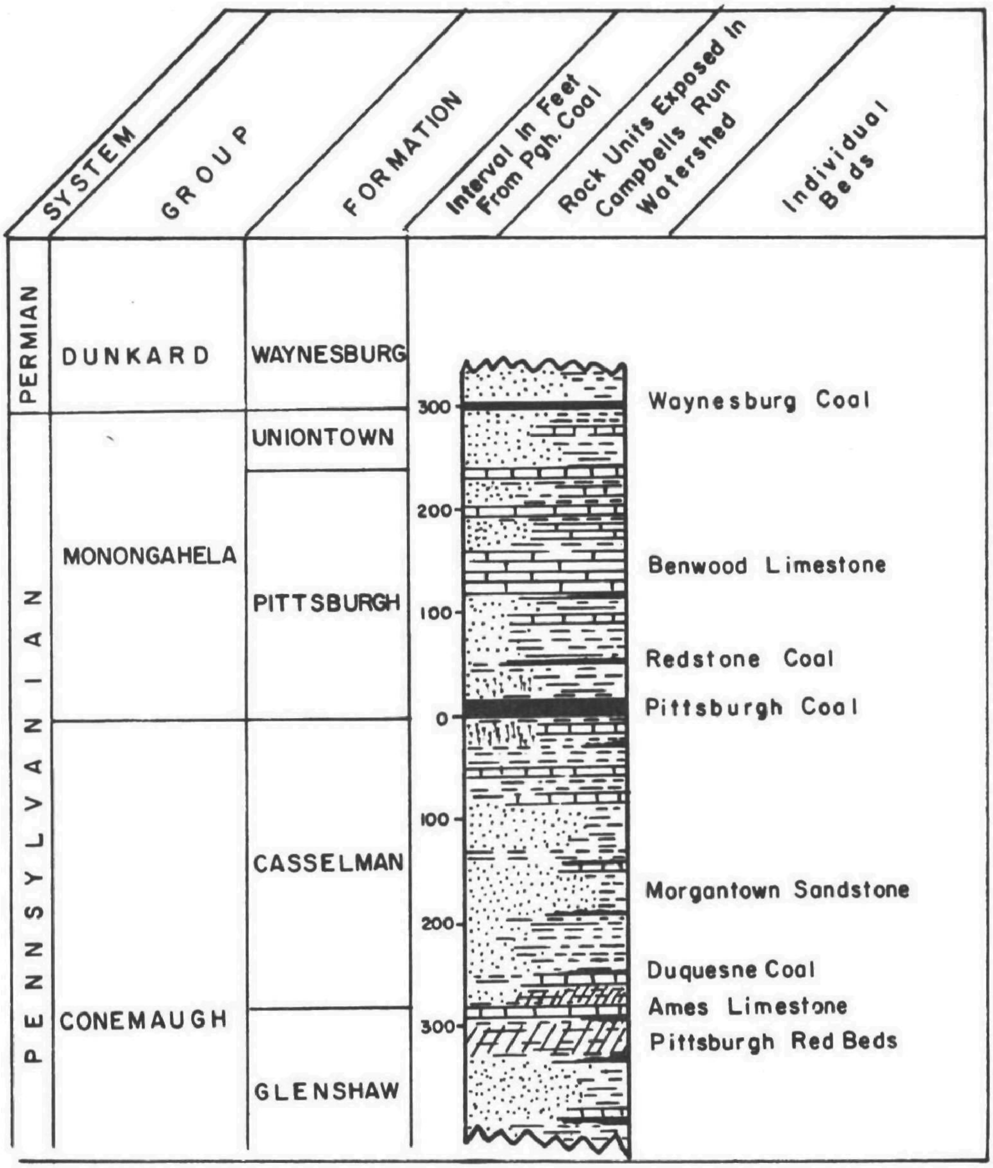
The rocks exposed in the Campbell's Run Watershed area are all of sedimentary origin and of Pennsylvanian age. The structure is composed of gentle to moderately dipping strata.

The rock units exposed in the study area are divided into two groups, the Conemaugh and the Monongahela. Figure 2 is a generalized columnar section showing the rock units exposed in the watershed.



LOCATION MAP SCALE 1" = 2 miles
1 CM = 1.25 Kilometers

Figure 1



GENERALIZED GEOLOGIC SECTION

Figure 2 REFERENCE (7)

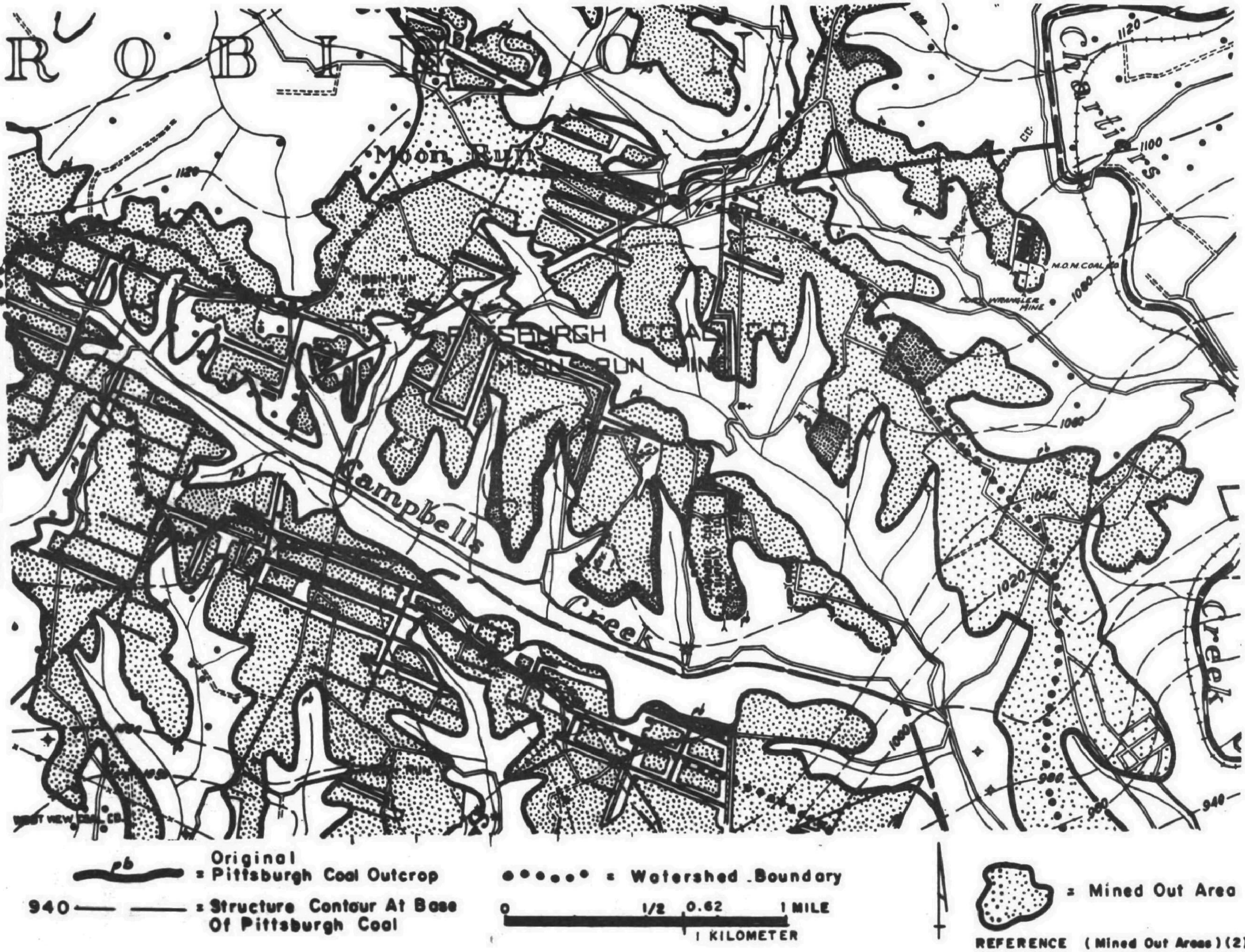
The Conemaugh Group, the lowest unit outcropping in the watershed, is exposed only in the valleys of the main stream and its larger tributaries. The Conemaugh Group is composed of an interbedded series of sandstone, siltstone, shale and limestone. No workable coal seams are found in this group.

The Monongahela Group, which overlies the Conemaugh Group has been totally eroded from the stream valleys and is now exposed only on the hillsides and hilltops The Monongahela Group is composed of interbedded sandstone, shale, limestone and coal. The Pittsburgh Coal seam, which has been extensively mined throughout the study area, is located at the base of the Monongahela Group.

The geologic structure of the Campbell's Run area is influenced by the Ninevah Syncline whose axis is located immediately south of the watershed. The strata in the study area dip southeast toward the synclinal axis. The angle of dip varies from between 10 feet per mile (1.9 meters/kilometer) in the northern portion of the area to 90 feet per mile (17.0 meters/kilometer) in the southern portion.[8]

MINING HISTORY

The Pittsburgh Coal seam has been extensively mined for years throughout the watershed area. The seam is now in its final stages of depletion with the only remaining recoverable reserves being pillars left in-place from earlier mining. Mining operations in the area were done for the most part, under shallow cover, causing localized subsidence and the subsequent disruption of surface and subsurface drainage patterns. Numerous mine openings were improperly sealed allowing water and air to enter the mines compounding the effects of acid mine drainage.[1] The extent of mined out areas in the Campbell's Run Watershed is shown on Figure 3. No active strip or deep mining operations are currently in operation within the watershed boundary. One active strip mine is in operation immediately adjacent to, and east of, the watershed boundary.



DEEP MINE MAP
Figure 3

IV. PURPOSE AND SCOPE

RECLAMATION PROJECTS

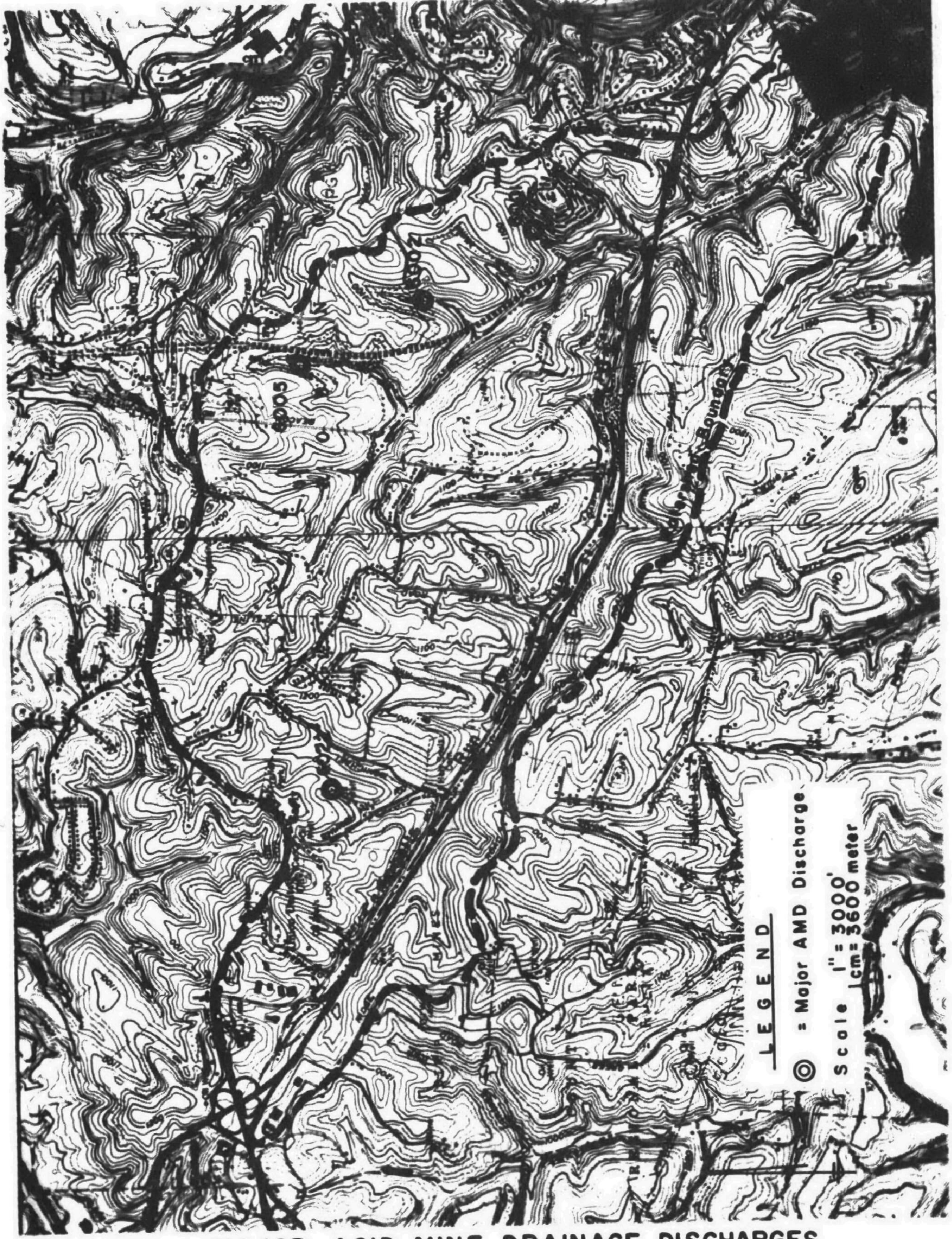
The Chartiers Creek Mine Drainage Pollution Abatement Project,[1] published in 1970, reported that 4 major and 28 minor AMD pollution sources entered Campbell's Run. A major AMD source was defined as one which discharged at least 1000 pounds (553.6 kilograms) per day of net acidity at the time of its maximum measured discharge. The four major sources all originated from deep mines and were found to contribute, on the average 14% of the stream flow and 63% of the acid load of the Campbell's Run Watershed. The locations of these four major sources are shown on Figure 4 and a summary of their characteristics as known in 1970 is presented in Table I. From the information provided in that report, the Commonwealth of Pennsylvania planned the construction of abatement projects under Project Number SL 102-3-4, which were designed to reduce the AMD problems in the watershed. The original scope of these reclamation projects called for the restoration of natural drainage through surface reclamation of strip mined areas and for the sealing of various deep mine openings.

TABLE I.

AVERAGE WATER QUALITY CHARACTERISTICS
OF MAJOR ACID MINE DRAINAGE DISCHARGES

	Major Sources (1970 Data)			
	6001	6002	6005	6022
Flow (gpm)	31	45	158	70
pH	2.6	2.6	2.8	3.0
Acidity (mg/1)	776	820	888	600
Iron (mg/1)	46.6	46.5	48.0	16.5
Manganese (mg/1)	3.3	6.4	5.4	2.7
Sulfate (mg/1)	1530	1790	1790	1500
Hardness (mg/1)	912	1010	1218	980
Acid Load (lbs/day)	313	466	1810	550

Reference: (1)



MAJOR ACID MINE DRAINAGE DISCHARGES

Figure 4

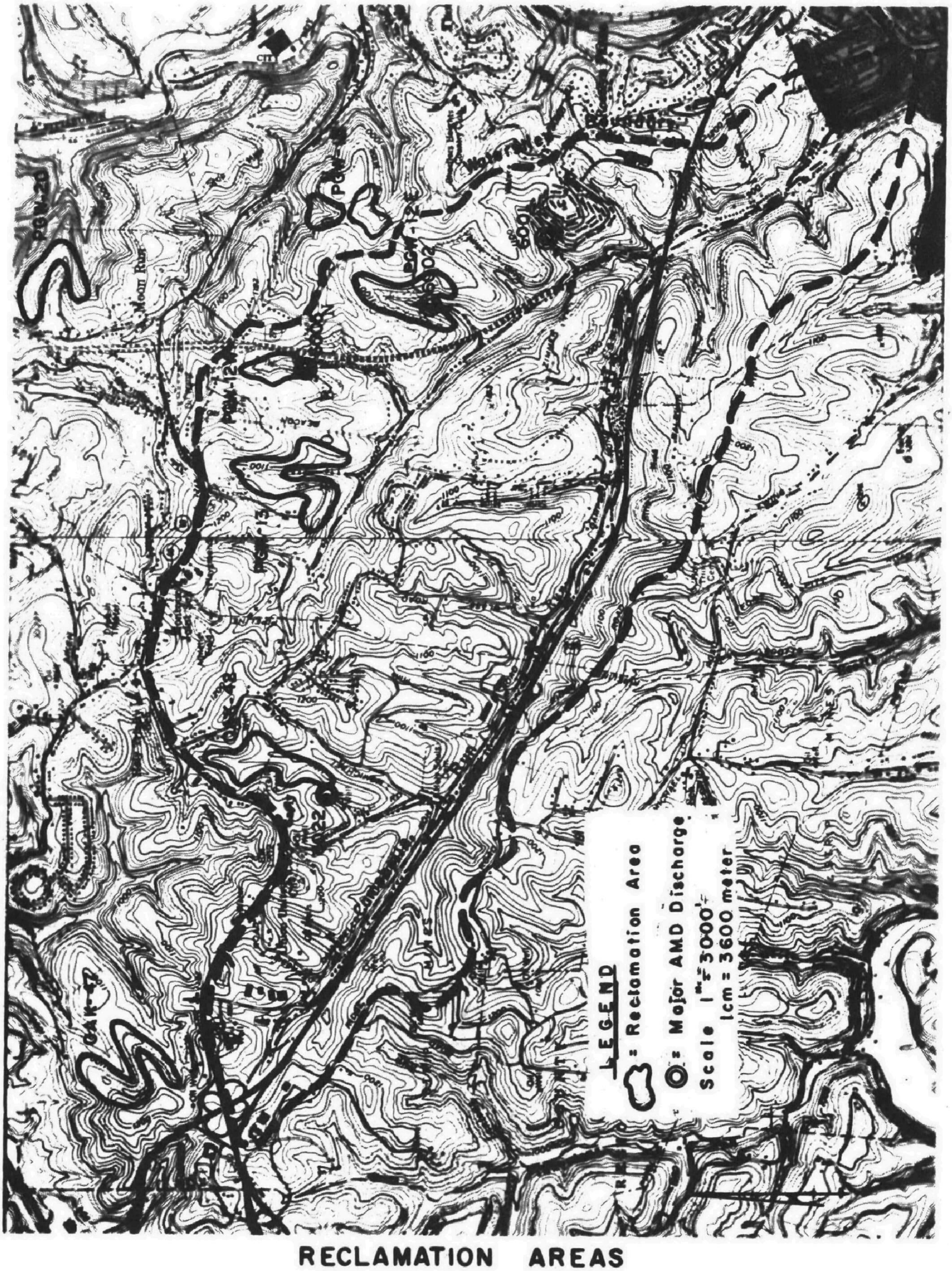
Scope of Abatement Construction: The basic objectives of the surface reclamation projects were to control the infiltration of water into deep mines, to reduce the contact between water and oxidized pyritic spoil material, to increase naturally alkaline runoff, and to provide for reduced erosion and maximum possible vegetative growth. The abatement methods involved in the reclamation projects were numerous. They included surface regrading operations, backfilling of subsidence areas, the installation of diversion ditches, earth channels, bituminous flumes and riprap, as well as soil treatment and seeding. These various methods, when applied selectively to the particular problem areas, were intended to help relieve the water problems arising from deep and strip mining.

Seven work areas were designed and reclaimed in the Campbell's Run area and their locations are shown on Figure 5. Their relationship to the deep mine complex is shown on Figure 6. A total of 52 acres (21 hectares) of strip mined land were reclaimed which restored approximately 230 acres (93 hectares) of land to positive drainage. A description of the work areas and the resultant abatement facilities is discussed below for the seven reclamation areas.

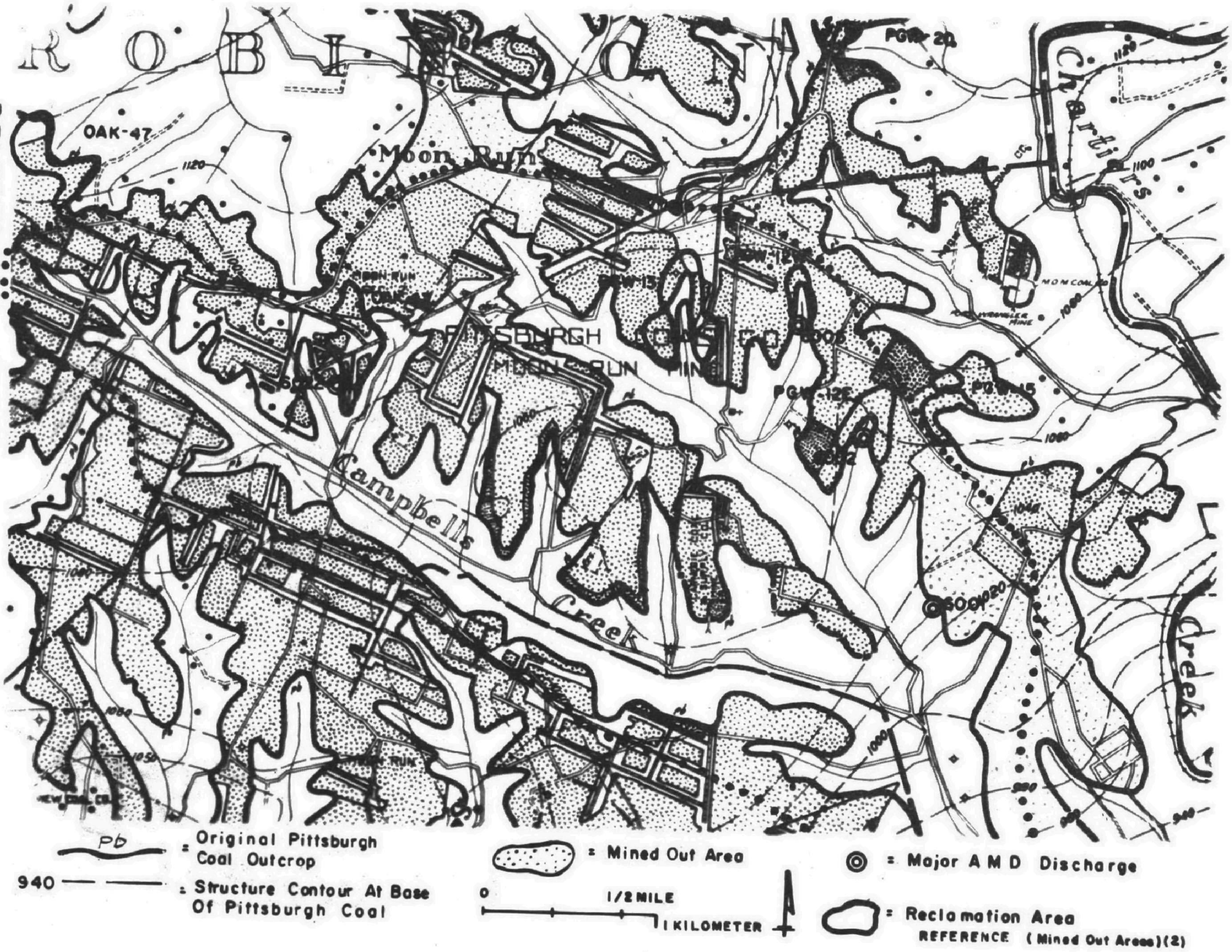
Reclamation areas PGW-12W and PGW-12E were a portion of the 46 acres (19 hectares) of unreclaimed strip mine classified in the Chartiers Creek Report as PGW-12. The original PGW-12 was divided into three areas with two areas becoming PGW-12W and PGW-12E and the remaining 24 acre (10 hectare) section was reclaimed as a consequence of the construction of U. S. Interstate 79. As shown on Figure 6, PGW-12W lies updip of major AMD discharge 6005, and PGW-12E is updip of major discharge 6002. Both reclamation areas were terraced to provide for positive drainage. Flumes were installed on both areas to convey runoff from the undisturbed area above the strip mine to below the strip mine area. The regrading and flume placement plus a vegetative cover were designed to reduce infiltration to the regraded spoil zone and hence to major AMD discharges 6002 and 6005. An added benefit of this project and similar reclamation projects was the neutralization of acid streams with augmented alkaline storm runoff.

Reclamation areas PGW-15 and PGW-20 are beyond the Campbell's Run Watershed boundary yet both strip mined areas were connected to the underground mine complex responsible for deep mine discharges 6001, 6002 and 6005, as shown on Figure 6. These two reclamation areas were regraded and revegetated to reduce infiltration to the adjacent underground mine complex.

Work area OAK 42 consisted of regrading spoils, improving the existing channel and backfilling subsidence areas to reduce infiltration to the deep mine complex contributing to major AMD discharge 6022.



RECLAMATION AREAS
Figure 5



RELATIONSHIP OF WORK AREAS TO DEEP MINES
Figure 6

Work Area OAK 47 lies to the west of the Campbell's Run Watershed. The area consisted of an unreclaimed strip mine with ponded water in the depressions. The area lies updip of the headwaters of Campbell's Run and was believed to be contributing to the quality of the headwaters via a deep mined area as shown on Figure 6. The headwaters received several small AMD seepages from this mine complex. Reclamation of OAK 47 consisted of dewatering the ponded areas, terrace backfilling and regrading to promote drainage away from the highwall, revegetating and constructing an earth channel through the reclaimed area. All of the foregoing methods were designed to minimize infiltration to the deep mine complex which was believed to be conveying subsurface drainage downdip to the Pittsburgh coal outcrop at the headwaters of Campbell's Run.

Reclamation area PGW-13 lies to the west of major source 6005 and was a portion of a 17 acre (6.9 hectare) unreclaimed strip mine associated with two minor AMD sources. (Not shown on Figures). Seven acres (2.8 hectares) were terraced and revegetated to promote positive drainage and to limit infiltration to the adjacent deep mine complex.

Demonstration Project: As an outgrowth of the planned construction of abatement projects, a program was devised to gauge the effectiveness of the reclamation projects in improving stream quality. The plan of this operation was as follows:

Choose stream sampling stations in the study area originally composed of Miller's Run and Campbell's Run Watersheds.

Obtain periodic stream samples and flow measurements for three periods or phases; Phase I prior to construction, Phase II during construction, and Phase III after construction.

Collect the samples and analyze them for pH, acidity, alkalinity, total iron, manganese, aluminum, and sulfates.

Calculate the pollutant load passing the sample stations.

Evaluate all available data to determine the effect of the reclamation projects upon stream quality.

Quantities and Costs: The seven areas were reclaimed for a total bid price of $131,650 and the quantities and unit prices for all the work areas are described in Table II.

TABLE II.

SCHEDULE OF TOTAL QUANTITIES AND PRICES FOR RECLAMATION AREAS

Item Description	Completed Quantity	Unit Price	Total Amount
Clearing and Grubbing	52 Acres	$450.00/Ac.	$23,400.00
Regrading	148,000 C.Y.	Lump Sum	$66,000.00
Backfill Sinkholes	60 C.Y.	$ 2.50/C.Y.	$ 150.00
Flume	2,160 L.F.	$ 7.50/L.F.	$16,200.00
Headwall or Endwall	16	$300.00/Ea.	$ 4,800.00
Diversion Ditch	3,400 L.F.	$ .50/L.F.	$ 1,700.00
Riprap	70 S.Y.	$ 15.00/S.Y.	$ 1,050.00
Soil Treatment & Seeding	52 Acres	$350.00/Ac.	$18,200.00
Anti-Pollution Measures	Job	Lump Sum	$ 150.00
		Total Amount:	$131,650.00

Metric Equivalents:	Acre	=	0.4047 Hectare
	Cubic Yard	=	0.7646 Cubic Meter
	Lineal Foot	=	3.048 Decimeter
	Square Yard	=	0.8361 Square Meter

STUDY METHODS

Deletion of Miller's Run Area: In addition to Campbell's Run, the demonstration project was to encompass Miller's Run, another major Chartiers Creek tributary. Fifteen stream sampling stations were selected, of which ten were located in Miller's Run Watershed and the remaining five in the Campbell's Run Watershed. Samples at the ten Miller's Run stations were collected for the preconstruction phase of the project; however, the difficulty in obtaining the property easements necessary for abatement construction in the Miller's Run area prompted the postponement of the monitoring program. Finally, the Miller's Run portion was officially deleted from the demonstration project in June, 1974.

The reclamation projects for the Campbell's Run area were completed and for the purposes of this report, the water monitoring program and the subsequent evaluation of results will be limited to the Campbells Run area.

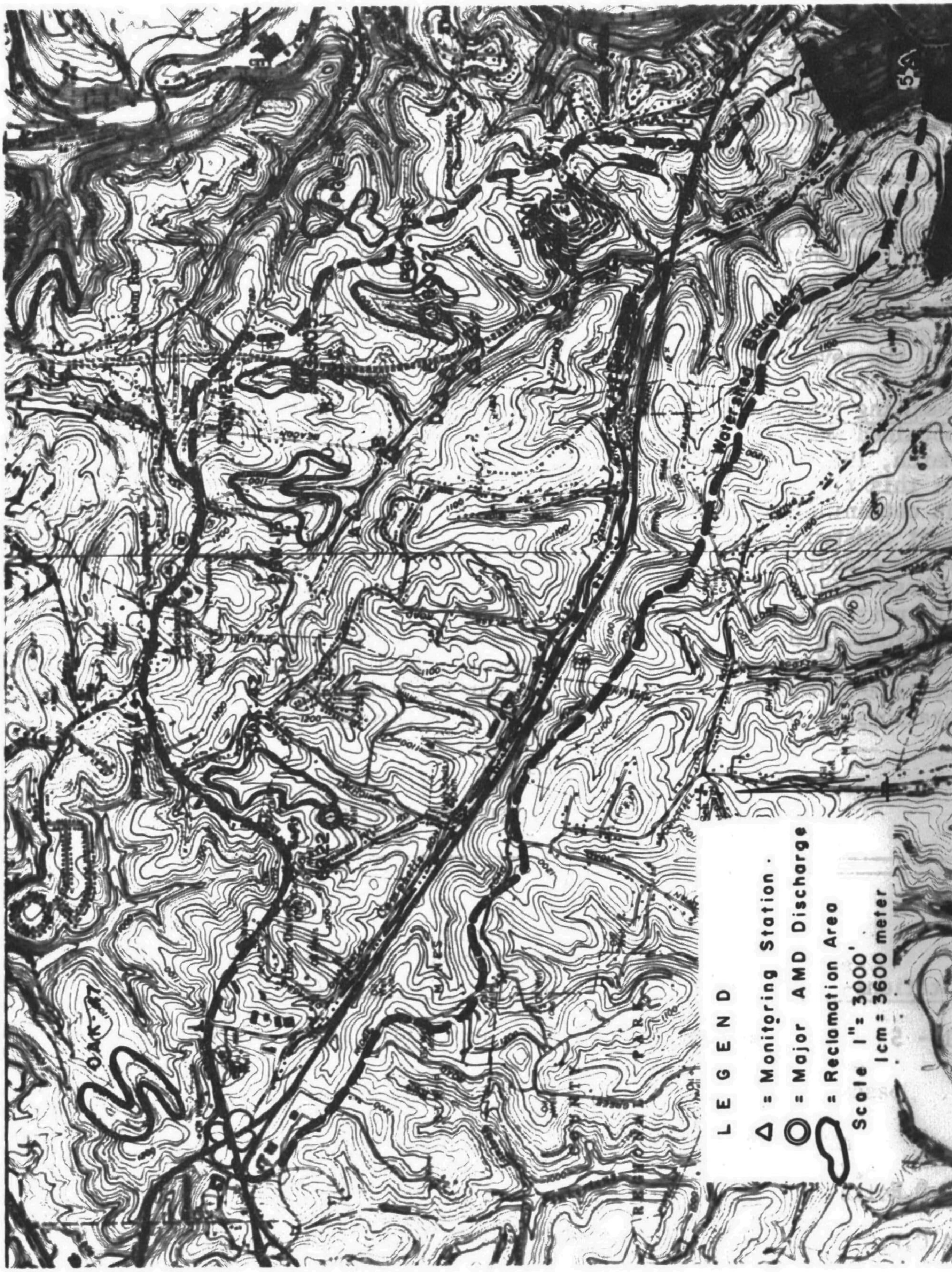
Stations 1 Through 5, Campbell's Run: The Chartiers Creek Report[1] indicated four major AMD deep mine discharges in the Campbell's Run Watershed. The reclamation projects originally planned for Campbell's Run were predicted to affect, either directly or indirectly, the four major AMD sources and the resultant water quality of the receiving streams. To monitor any improvement, five stream sampling stations, numbered 1 through 5 were selected for Campbell's Run and its major unnamed tributary. These five stations were sampled periodically during the first two phases, i.e., preconstruction and during construction. When the construction was completed in September, 1974, seven additional stations, labeled A through G were added, resulting in a total of twelve postconstruction gauging stations. The twelve stations are shown on Figure 7 together with their relationship to the four major AMD discharges and the seven reclamation areas.

Sampling Schedule: Phase I samples and discharge measurements were obtained weekly at stations 1 through 5 for the fifteen month period, March, 1971 through May, 1972; and once a month until October, 1972. At this time the entire project was postponed due to delays encountered in obtaining property easements necessary for the commencement of abatement construction. Consequently, sampling activity ceased for one year and resumed again in November, 1973 with the beginning of construction, (Phase II). Samples were collected once per month during construction. The post-construction monitoring (Phase III), included seven additional stations, A through G, which were intended to provide more reliable analysis of stream quality. The complete sampling schedule for the project is shown in Table III. The water quality data for each of the stations is included in Appendix B of this report.

TABLE III.

SAMPLING SCHEDULE

Stations	Phase I Before Construction 3/71 - 10/72	Phase II During Construction 11/73 - 8/74	Phase III After Construction 9/74 - 8/75
1 - 5	Once Per Week 3/71 - 5/72 Once Per Month 6/72 - 10/72	Once Per Month	Twice Per Month
B,D,E			Once Per Month
A,C,F,G			Once Per Quarter



STREAM MONITORING STATIONS
Figure 7

Testing Procedures: All samples were analyzed in the laboratory for pH, acidity, alkalinity, total iron, manganese and aluminum. A summary of the testing procedures is included in Appendix A of this report. All test results were multiplied by the corresponding discharge rates and the resultant mean material loads were compared by months, quarters and years to measure any changes in water quality.

Analysis of Results: For simplicity, net acid load was used as the primary variable to determine if any change in water quality resulted from the reclamation projects. To effectively compare mean acid loads requires analysis of consistent data. This was accomplished by narrowing the data to that of two corresponding water years, September, 1971 through August, 1972, and September, 1974 through August, 1975. The data from the former of these water years represents the base line data before construction, while the latter water year data represents the corresponding period for one year immediately following reclamation.

Moreover, the comparison of preconstruction water quality with post-construction water quality necessitated isolating the effect of the reclamation projects from natural occurrences. This was done because natural occurrences such as precipitation, groundwater, temperature, and degree of vegetation were much more capable of changing water quality than were the reclamation projects. For these reasons, the ratio of monthly mean acid load in pounds per day to total monthly precipitation was calculated and the results from Phase I and Phase III compared.

V. DISCUSSION OF RESULTS

PRESENTATION OF DATA

Goals of Analysis: The intent of the abatement work and monitoring program in the Campbell's Run area was to enable an evaluation of the effectiveness of surface reclamation methods in reducing acid mine drainage, through monitoring water quality before, during, and after reclamation.

Analysis Considerations: Several variables which affected acid load were listed and studied for significance. Some of the variables were natural phenomenon, such as rainfall, snowfall, snow melt, temperature, vegetation and groundwater levels. The other variables were man made, such as residential and commercial construction, sanitary sewage collection and treatment, and mine drainage abatement facilities.

Of all the above variables, stream flow was found to be the most significant factor affecting the acid load in Campbell's Run, while the reclamation projects were judged to be the least significant.

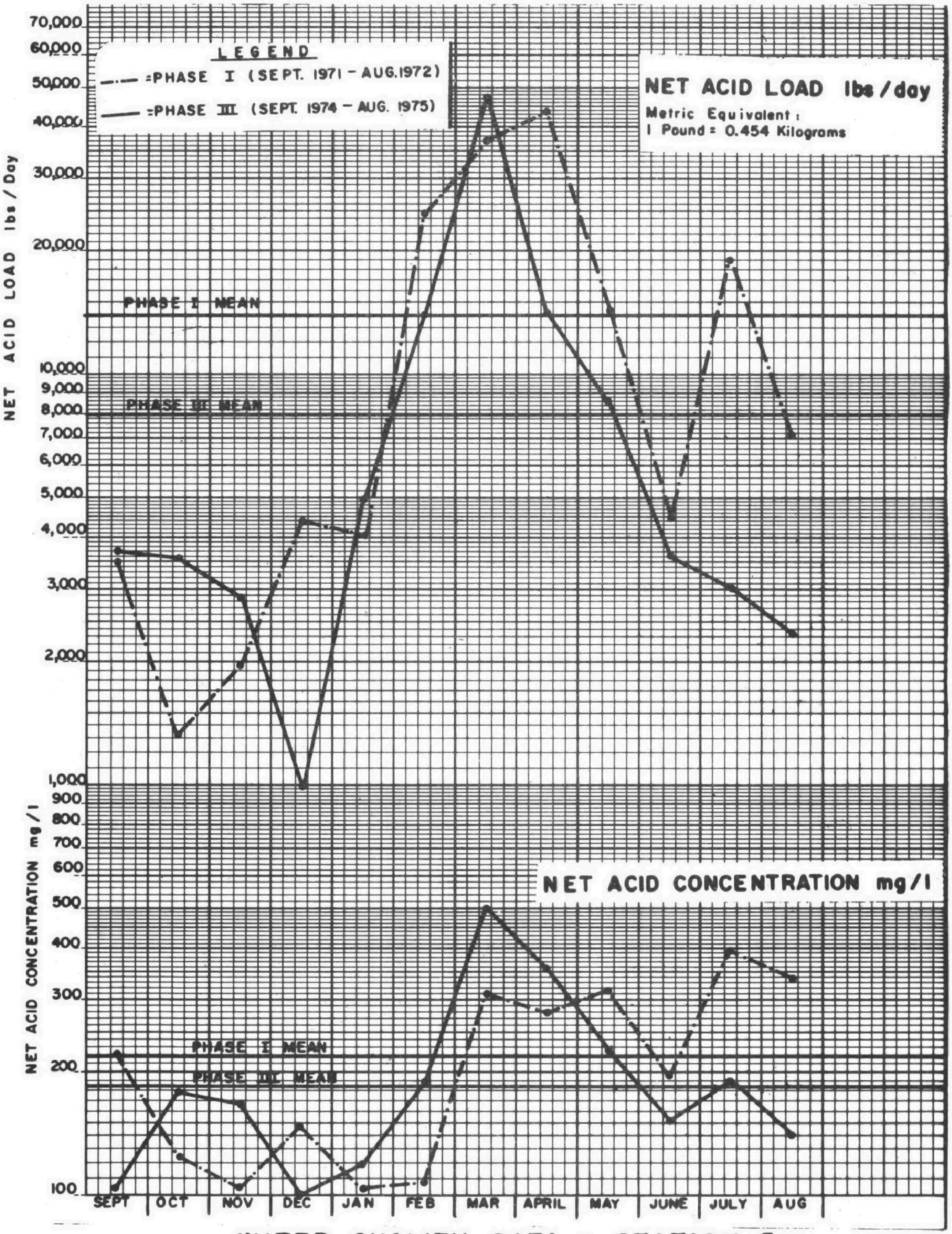
The reclamation areas (52 acres or 21 hectares) had only a small affect upon water quality because:

The amount of restored surface drainage area was small compared to the total watershed (230 acres vs. 3,600 acres or 93 hectares vs. 1460 hectares of watershed).

Augmented storm runoff to Campbell's Run was a benefit of only 4 of the 7 reclamation areas.

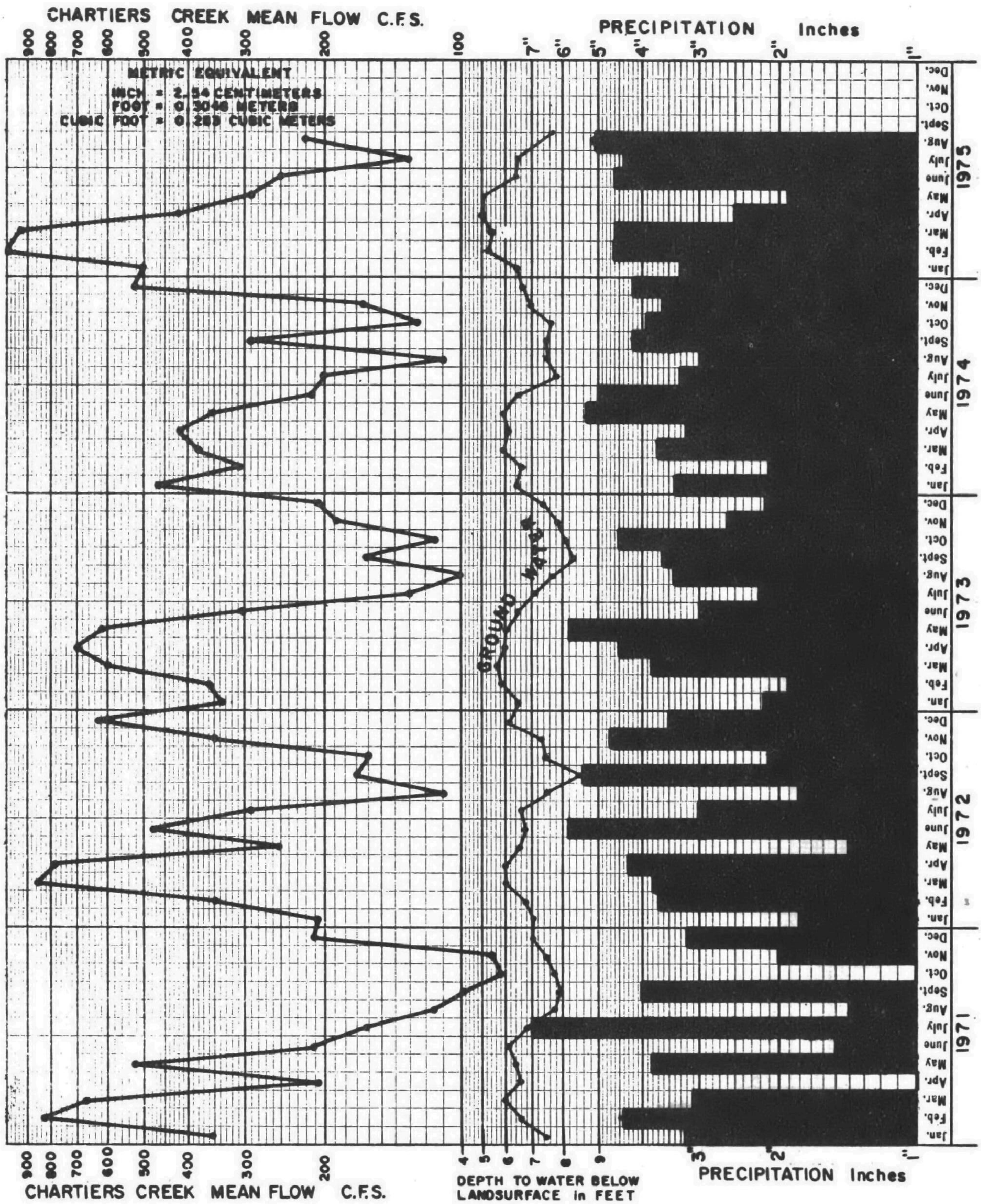
The work areas changed a very small amount of subsurface flow when comparing their area to the area of the deep mine complex.

Some assumptions have been made as to certain causal relationships between variables other than the reclamation projects to acid load. The basis for these assumptions were derived from an evaluation of the graphs shown on Figures 8 and 9, from water quality data shown in the Appendix, and from statistical tests of correlation between variables. These assumptions are provided as follows:



WATER QUALITY DATA - STATION 5

Figure 8



SUMMARY OF STREAMFLOW, GROUNDWATER and PRECIPITATION
REFERENCES (4, 6, 7)

Figure 9

1. The acid concentration of mine effluents varies directly with the depth of the mine pool.

2. When the groundwater level is higher than the yearly average, mine water constitutes a greater proportionate part of stream flow than during the period when groundwater is lower than the yearly average.

3. The greatest daily fluctuations in water quality occur in late fall and early winter when groundwater and mine discharges are lower than normal and the lack of vegetation promotes storm runoff.

An example of items 1 and 2 occurred in March, 1975. According to Figure 9, groundwater was near its peak for the water year cycle and from Appendix B, the March, 1975 samples correspond to the peak flow or near peak flow for Stations 1 through 5. Thus, the combination of near-peak groundwater levels (assuming near-peak mine pool levels and corresponding higher than average acid concentration) coupled with the maximum measured flow of March, 1975, yielded the peak monthly acid load for Phase III.

The effect of item 3 can be illustrated by water quality at Station 5 for December, 1974. In this case groundwater (and the assumed mine pool level) was closer to the yearly average but the December, 1974 samples were obtained at Station 5 concurrently with the maximum monthly flow for Phase III. The assumption is that the moderate acid concentration of the mine effluent was effectively neutralized by higher than average watershed runoff. In this case the neutralization capacity of the augmented runoff was sufficient to render the water net alkaline at Station 5.

Physical changes in the study area that alter water infiltration rates and drainage patterns, and rob water that would normally influence acid mine drainage are variables that must be considered. Since the study program began, several areas have been sewered, extensive residential and commercial developments have been constructed and a major four lane highway (I-79) with two major interchanges now intersects the area.

Ultimately, any specific determination of water quality improvement must be considered in the light of the highly variable conditions which influence that quality at the time of each sample collection.

EFFECTIVENESS OF THE PROJECT

For the purpose of this report, conclusions were made regarding changes and trends in water quality over the duration of the demonstration project. As shown in Table IV, the tendency is toward the reduction in flow, which in turn reduces acid load. More significantly, the ratio of acid load to precipitation is also reduced while acid concentration has decreased slightly. This estimated reduction shows a general improvement between Phase I sampling and Phase III sampling.

TABLE IV.

ACID LOAD PRODUCTION RATES

	Mean Flow (gpm)	Average Net Acid Concentration (mg/1)	Average Net Acid Load (lbs/day)	Acid Load[2] Production Rate (lbs/day/in)	Improvement
STATION 1					
Phase I[1]	1,230	629	9,292	2,244	40%
Phase III	792	457	4,347	1,345	
STATION 2					
Phase I	1,318	481	7,614	2,267	20%
Phase III	966	470	5,453	1,809	
STATION 3					
Phase I	1,619	664	12,911	4,067	56%
Phase III	1,070	448	5,757	1,809	
STATION 4					
Phase I	1,280	223	3,397	1,085	63%
Phase III	648	145	1,128	405	
STATION 5					
Phase I	5,278	220	13,945	4,655	42%
Phase III	3,624	184	8,009	2,682	

[1]Phase I data on this table applies to the months, September, 1971 - August, 1972 inclusive
Phase III data is from September, 1974 - August, 1975 inclusive

[2]Acid load production rate was determined by dividing the mean monthly net acid load by the total monthly precipitation for each month, then determining the mean for Phases I and III. Precipitation data is from the National Climatic Center, Pittsburgh International Airport WSO.

Metric Equivalents:			
	Gallon	=	3.785 Liters
	Pound	=	0.454 Kilograms
	Inch	=	2.54 Centimeters

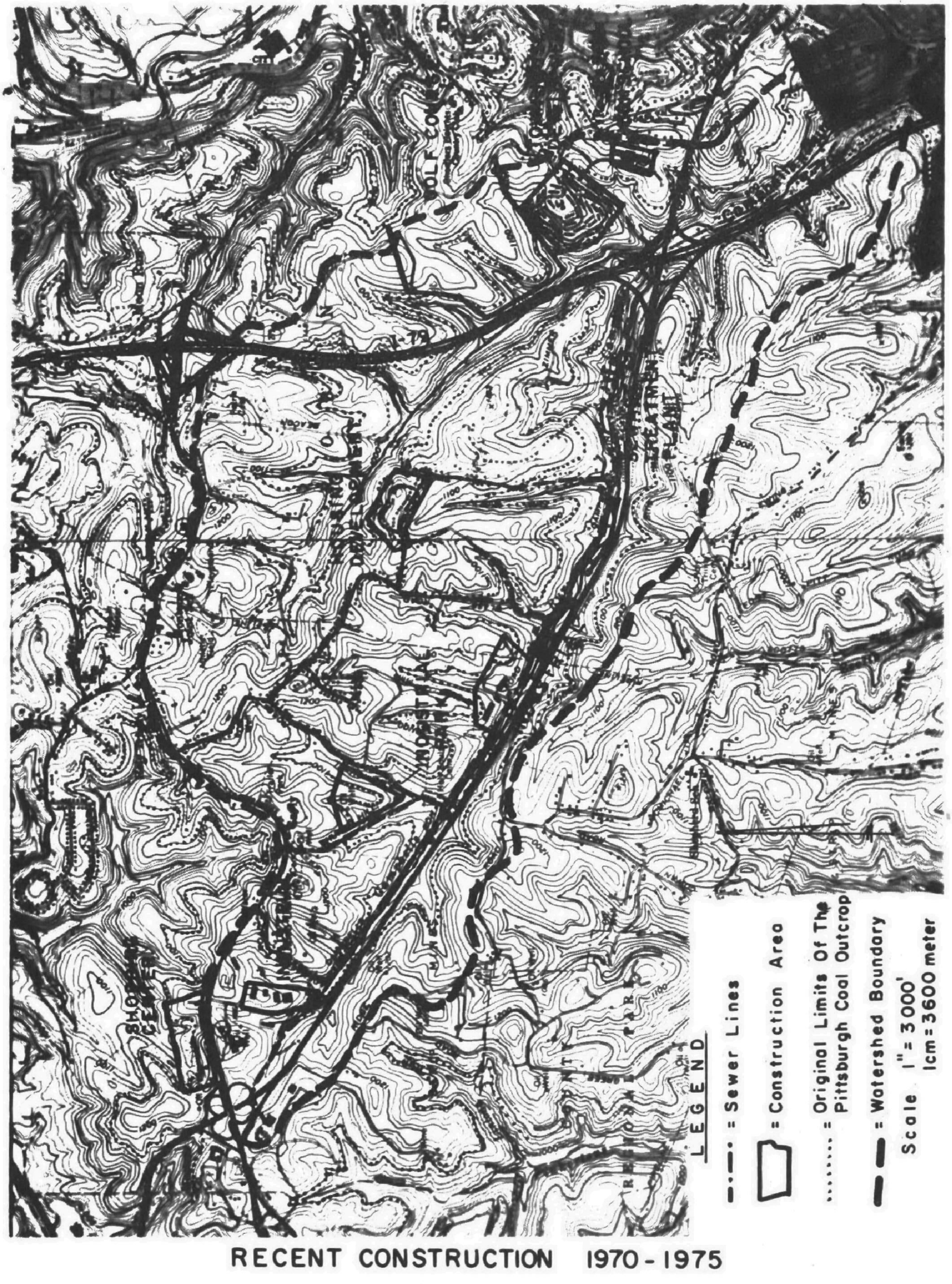
There is a noticable difference between the concentrations of dissolved metals from Phase 1 and Phase 3. The Phase 3 results show higher concentrations than those of Phase 1 because Phase 1 samples were not ingested with acid to maintain the solubility of the dissolved metals. Metals in non-acidified samples are subject to alterations in chemical structure due to organic material and other interfering elements and compounds, thus yielding lower concentrations of dissolved metals. Beginning in January, 1974, a separate sample was collected for metal tests and acidified in the field. This method would yield a higher dissolved metal content than if the sample were allowed to sit before being tested without additional acid. The practice of acidifying a sample to preserve the dissolved metal content was not a uniform practice of the Environmental Protection Agency (EPA) until 1972 in their Cincinnati Laboratory.[3]

FACTORS INFLUENCING WATER QUALITY

Recent Construction: Since the beginning of the Campbell's Run project, the area has experienced a rapid growth in population and industry, coupled with an extensive amount of new construction. In numerous cases, this construction has come in contact with the deep mines of the area. This quite often compounds the problem of AMD, since it allows easier entry and exit for water from the deep mines. In the Campbell's Run Watershed, as much as three miles of coal outcrop may have been disturbed by new construction in the past few years. Figure 10 shows the extent of this recent construction.

Numerous industrial and residential buildings have also been built along the valleys in close proximity to the coal outcrop. The exact effect of these structures on the AMD problem of the area is unknown. Any construction activity, however, which intersects the deep mines can be expected to change the potential of AMD pollution. The Campbell's Run area has, in the past few years been the site of a comprehensive sewer installation project.[5] In many instances, these sewer lines have been laid on the sites of abandoned strip mines and have cut across lines of coal outcrop. All of the above construction features have increased the likelihood of disturbing the surface and subsurface drainage patterns of the area.

The section of U. S. Interstate 79 through the study area was completed in 1973 during the period in which the demonstration project was dormant. Interstate 79 was built through the valley of the unnamed tributary to Campbell's Run on which are located sampling stations 1, 2 and 3 and which receives major AMD sources 6001, 6002 and 6005. The highway construction cut and fill limits encroached upon abandoned deep mines, original and existing Pittsburgh coal outcrops and dissected an unreclaimed strip mine (formerly PGW-12, See Figure 5).[1] The ensuing alterations to subsurface drainage were assumed to significantly affect the discharge rates and water quality of both the mine effluents and the receiving tributary. One observed effect of the highway construction was to consolidate and increase the discharge rates of major AMD sources



RECENT CONSTRUCTION 1970-1975

Figure 10

6002 and 6005. The average discharges were noted to increase from 45 gallons per minute to 91 gallons per minute for source 6002 and from 158 gallons per minute to 193 gallons per minute for source 6005. To sufficiently assess the causes of water quality changes caused by I-79 construction would require detailed analysis of Pennsylvania Department of Transportation design and as-built specifications, and was considered beyond the scope of this project. Nevertheless, the highway construction project must be considered a significant factor in evaluating the demonstration project.

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5. Newell, James, Robinson Township Official, Interview on July 2, 1975.

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7. U. S. Geological Survey, Water Resources Data for Pennsylvania, Data from Chartiers Creek Streamflow Gauge at Crafton, Pennsylvania, Water Years 1972-1975, and at Carnegie, Pennsylvania Water Year 1971

8. Wagner, Walter R., and Others, Geology of The Pittsburgh Area, General Geology Report G-59, Pennsylvania Geological Survey, 1970

APPENDIX A

SUMMARY OF LABORATORY TESTING PROCEDURES

pH: Determined in the laboratory on a Beckman Chem-Mate Model 72 pH meter.

Acidity: Determined in the laboratory according to Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971, Section 201, Page 370. All samples were titrated hot in order to enhance oxidation and hydrolysis of acid producing components.

Alkalinity: Determined in the laboratory according to Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971, Section 102, Page 52. All samples were titrated cold.

Sulfates: Determined in the laboratory according to the Hach Turbidimetric Method in "Hach DR Colorimeter Methods Manual," 9th Edition, 1973, Page 137. A calibration curve was generated in order to obtain sample sulfate concentrations.

Total Iron: Determined in the laboratory according to two methods. Initially, a Hach 1,10-Pehnanthroline Method in "Hach DR Colorimeter Methods Manual," 9th Edition, 1973, p. 137 was used. Later, total iron was determined according to an atomic absorption method in EPA "Manual of Methods for Chemical Analysis of Water and Wastes," 1974, p. 78.

Manganese: Determined in the laboratory according to two methods. Initially, a Hach Cold Periodate Oxidation Method in "Hach DR Colorimeter Methods Manual, 9th Edition, 1973, p. 70 was used. Later, manganese was determined according to an atomic absorption method in EPA "Manual of Methods for Chemical Analysis of Water and Wastes," 1974, p. 78.

Aluminum: Determined in the laboratory according to two methods. Initially a Hach Eriochrome Cyanine R Method in "Hach DR Colorimeter Methods Manual," 9th Edition, 1973, was used. Later, aluminum was determined according to an atomic absorption method in EPA "Manual of Methods for Chemical Analysis of Water and Wastes," 1974, p. 78.

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

The tables on the following pages summarize the water quality data for the three phases of the Campbell's Run Demonstration Project: Phase 1, before construction; Phase 2, during construction; and Phase 3, after construction.

For those instances where weekly samples were collected, (refer to Table III), only the monthly means of the weekly samples are presented.

All concentrations except pH are expressed in milligrams per liter and material loads are expressed in pounds per day (one pound per day equals .454 kilograms per day). Mean concentrations are arithmetic averages except for pH which is a logarithmic average. All mean constituent loads are the product of the mean flow and mean concentration.

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 1 - BEFORE CONSTRUCTION

STATION NO. 1

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
9-71	2.4	302	2307	8367	----	----	41	149	1020	3700	9	33	4	14
10-71	2.2	109	534	699	----	----	31	41	2360	3090	4	5	4	5
11-71	2.5	330	443	1756	----	----	37	147	940	3720	4	16	2	8
12-71	2.5	461	374	2071	----	----	28	155	780	4320	18	100	4	22
1-72	2.7	436	331	1773	----	----	9	47	700	3660	4	21	3	16
2-72	2.5	4804	258	14885	----	----	7	404	700	40390	2	115	2	115
3-72	2.8	1919	434	10002	----	----	29	668	780	17980	24	553	5	115
4-72	2.8	3582	523	22499	----	----	32	1337	910	39150	22	946	6	258
5-72	2.5	970	576	6710	----	----	35	408	830	9670	28	326	5	58
6-72	2.7	591	492	3492	----	----	70	256	1000	7100	10	71	4	28
7-72	2.1	874	694	7285	----	----	43	451	920	9660	24	252	6	63
8-72	2.4	385	578	2673	----	----	24	111	1170	5410	30	139	4	19
Mean	2.5	1230	629	9292	----	----	32	473	1010	14920	15	222	4	59

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 2 - DURING CONSTRUCTION

STATION NO. 1

		Flow	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
Date	pH	(gpm)	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
11-73	3.1	858	166	1710	----	----	62	639	670	6900	16	165	4	41
12-73	3.0	1092	240	3148	----	----	83	1088	780	10230	13	170	4	52
1-74	3.1	1281	435	6692	----	----	43	662	1260	19380	28	431	7	108
2-74	3.3	514	365	2253	----	----	36	222	1000	6170	24	148	4	25
3-74	3.0	1145	480	6601	----	----	41	564	1100	15130	29	399	4	55
4-74	3.2	828	400	3978	----	----	44	438	1230	12230	25	249	5	50
5-74	3.3	878	460	4850	----	----	31	327	1100	11600	18	190	6	63
6-74	3.3	424	420	2139	----	----	21	107	1140	5800	19	97	6	31
7-74	3.2	424	314	1603	----	----	34	174	1060	5410	8	41	6	31
8-74	3.3	220	440	1162	----	----	24	63	1060	2800	5	13	8	21
Mean:	3.2	766	372	3422	----	----	42	386	1040	9570	19	175	5	16

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 3 - AFTER CONSTRUCTION

STATION NO. 1

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
9-74	3.6	728	242	2116	----	----	24	210	820	7170	6	52	5	44
10-74	3.2	378	392	1780	----	----	30	136	1000	4540	10	45	6	27
11-74	3.2	343	338	1615	----	----	20	82	990	4080	8	33	6	25
12-74	4.4	1524	147	2690	----	----	12	220	560	10250	8	146	3	55
1-75	2.9	935	276	3099	----	----	39	438	1000	11230	23	258	4	45
2-75	3.2	1664	342	6835	----	----	38	759	950	18980	23	460	2	40
3-75	3.0	1842	987	21894	----	----	100	2218	1820	40370	138	3061	2	44
4-75	3.1	672	680	5488	----	----	49	395	1510	12190	68	549	2	16
5-75	3.0	642	550	4241	----	----	55	424	1200	9250	44	339	5	38
6-75	3.0	440	464	2452	----	----	51	270	1110	5860	38	201	8	42
7-75	3.0	187	556	1249	----	----	46	103	1260	2830	37	83	8	18
8-75	2.8	156	506	948	----	----	42	79	1300	2440	18	34	7	13
Mean	3.1	792	457	4347	----	----	42	399	1020	9740	35	333	5	48

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 1 - BEFORE CONSTRUCTION

STATION NO. 2

		Flow	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
Date	pH	(gpm)	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
9-71	2.4	329	655	2588	----	----	46	182	1050	4150	9	37	4	16
10-71	2.4	133	478	764	----	----	36	58	2720	4340	6	10	5	8
11-71	2.4	443	390	2075	----	----	37	197	890	4740	3	16	3	16
12-71	2.5	464	312	1739	----	----	24	134	720	4010	14	78	5	28
1-72	2.6	406	327	1594	----	----	13	63	750	3660	4	20	3	15
2-72	2.6	5161	292	18099	----	----	16	992	770	47730	4	248	4	248
3-72	2.5	2487	445	13291	----	----	24	717	780	23297	24	717	7	209
4-72	2.6	3402	475	19407	----	----	34	1389	930	38000	27	1103	6	245
5-72	2.4	998	575	6892	----	----	31	372	850	10200	31	372	4	48
6-72	2.4	654	516	4053	----	----	40	707	1000	7850	14	110	4	31
7-72	2.2	905	710	7717	----	----	48	522	880	9560	24	261	4	44
8-72	2.2	439	592	3121	----	----	31	163	1200	6330	28	148	4	21
Mean:	2.4	1318	481	7614	----	----	36	570	1040	16540	10	253	4	63

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 2--DURING CONSTRUCTION

STATION NO. 2

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
11-73	2.9	1232	201	2974	----	----	3	4	660	9760	13	192	4	59
12-73	3.1	726	238	2075	----	----	1	9	780	6800	20	174	4	35
1-74	3.2	1430	440	7557	----	----	46	790	1270	21800	28	481	8	137
2-74	3.3	744	330	2949	----	----	37	331	1040	9290	25	223	4	36
3-74	3.0	974	430	5030	----	----	40	468	1130	13220	26	304	5	58
4-74	3.3	691	440	3652	----	----	46	382	1230	10200	23	191	5	42
5-74	3.2	771	430	3982	----	----	31	287	1100	10180	19	176	6	56
6-74	3.2	469	440	2478	----	----	34	192	1190	6700	23	130	6	34
7-74	3.3	559	312	2095	----	----	40	268	1060	7120	7	47	6	40
8-74	3.3	359	310	1337	----	----	30	129	1010	4350	4	17	6	26
Mean	3.2	796	357	3413	----	----	30	287	1050	10040	19	182	5	18

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 3 - AFTER CONSTRUCTION

STATION NO. 2

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
9-74	3.6	831	243	2425	----	----	22	220	780	7780	5	50	5	50
10-74	3.2	390	398	1864	----	----	32	150	990	4640	11	52	5	23
11-74	3.2	388	357	1664	----	----	22	102	980	4570	10	47	6	28
12-74	4.4	1986	128	3053	----	----	10	238	530	12640	8	191	2	48
1-75	2.8	851	294	3005	----	----	41	419	980	10020	22	225	4	41
2-75	3.1	1751	346	7276	----	----	38	799	960	20190	22	463	4	84
3-75	2.9	2386	974	27910	----	----	90	2579	1700	48710	122	3496	3	86
4-75	3.1	927	729	8116	----	----	73	813	1560	17370	80	891	2	22
5-75	3.0	828	564	5608	----	----	70	696	1260	12530	46	457	2	20
6-75	3.0	573	510	3510	----	----	42	289	1100	7570	36	248	8	55
7-75	3.0	352	574	2427	----	----	42	178	1260	5330	46	194	8	34
8-75	2.8	324	526	2047	----	----	40	156	1220	4750	17	66	6	23
Mean	3.1	966	470	5453	----	----	57	661	1110	12880	35	406	4	46

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 1 - BEFORE CONSTRUCTION

STATION NO. 3

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
9-71	2.3	374	630	2830	----	----	36	162	1110	4980	11	49	5	22
10-71	2.2	167	578	1159	----	----	43	86	1040	2086	5	10	4	8
11-71	2.1	496	684	4074	----	----	58	346	1000	5960	17	101	2	12
12-71	2.2	574	520	3585	----	----	48	331	910	6270	30	207	2	14
1-72	2.2	672	672	5423	----	----	35	282	950	7670	47	379	2	16
2-72	2.2	5570	414	27694	----	----	27	1806	670	44820	24	1606	3	201
3-72	2.5	2683	632	20364	----	----	36	1160	850	27390	40	1289	6	193
4-72	2.4	4882	795	46612	----	----	47	2756	1130	66250	50	2932	5	293
5-72	2.2	1041	1046	13077	----	----	46	575	1000	12500	55	688	4	50
6-72	2.2	1460	602	10556	----	----	80	1403	1000	17530	17	298	3	53
7-72	2.1	1010	718	8709	----	----	40	485	950	11520	29	352	5	61
8-27	2.2	499	672	4027	----	----	35	210	1130	6770	30	180	7	42
Mean:	2.2	1619	664	12911	----	----	46	856	980	19060	30	583	4	78

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 2 --DURING CONSTRUCTION

STATION NO. 3

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
11-73	2.9	1516	214	3896	----	----	0.4	7	670	12200	13	237	4	73
12-73	2.9	795	300	2864	----	----	0.8	8	660	6300	24	229	4	38
1-74	3.2	1409	435	7361	----	----	42	711	1 290	21830	26	440	8	135
2-74	3.3	808	365	3542	----	----	32	310	1040	10100	24	233	5	48
3-74	3.2	1085	415	5408	----	----	40	521	1130	14720	28	365	6	78
4-74	3.3	686	450	3707	----	----	50	412	1230	10130	29	239	5	41
5-74	3.2	828	430	4276	----	----	28	278	1020	10140	19	189	5	50
6-74	3.3	564	460	3116	----	----	28	190	1000	6770	14	95	5	34
7-74	3.4	645	295	2285	----	----	40	310	920	7130	8	62	5	39
8-74	3.4	402	338	1632	----	----	25	121	920	4440	7	34	6	29
Mean	3.2	874	370	3884	----	----	29	304	990	10500	19	220	5	52

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 3 - AFTER CONSTRUCTION

STATION NO. 3

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
9-74	3.4	974	262	3065	----	----	22	257	780	9120	9	105	5	58
10-74	3.2	362	409	1778	----	----	27	117	940	4090	42	183	4	17
11-74	3.3	440	354	1871	----	----	22	116	940	4970	8	42	5	26
12-74	4.4	2140	122	3136	----	----	11	283	520	13360	9	231	2	51
1-75	2.9	972	282	3292	----	----	39	455	980	11440	22	257	3	35
2-75	3.1	1944	333	7775	----	----	38	887	940	21950	23	537	4	93
3-75	2.9	2636	940	29758	----	----	92	2912	1680	53180	114	3609	2	63
4-75	3.2	1076	694	8968	----	----	72	930	1320	17060	66	853	1	13
5-75	3.0	922	547	6057	----	----	68	753	1180	13070	42	465	2	22
6-75	3.1	636	468	3575	----	----	44	336	1080	8250	34	260	6	46
7-75	3.1	368	501	2214	----	----	32	141	1140	5038	32	141	8	35
8-75	2.9	367	470	2072	----	----	36	159	1120	4940	17	75	6	26
Mean	3.1	1070	448	5757	----	----	42	540	1050	13490	35	450	4	51

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 1 - BEFORE CONSTRUCTION

STATION NO. 4

Date	pH	Flow (gpm)	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
			Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
9-71	3.9	568	196	1337	----	----	11	75	420	2860	1	6	1	7
10-71	3.7	91	207	226	4	4	6	7	1340	1460	1.6	2	3	3
11-71	3.5	284	177	604	12	41	15	51	450	1540	2	6	2	7
12-71	3.9	416	145	724	4	20	8	40	450	2250	9	45	2	10
1-72	3.7	376	192	867	----	----	10	45	560	2530	8	36	1	4
2-72	3.7	5416	122	7936	4	260	6	390	450	29270	2	130	1	65
3-72	3.2	2208	264	7001	----	----	13	345	500	13260	6	159	6	159
4-72	3.2	2932	282	9930	----	----	19	669	650	22890	5	176	3	106
5-72	2.8	1190	303	4330	----	----	15	214	530	7580	9	129	1	14
6-72	3.4	775	148	1378	----	----	40	372	550	5120	4	37	1	9
7-72	2.8	735	330	2913	----	----	18	159	510	4500	4	35	2	18
8-72	2.9	371	306	1363	----	----	13	58	600	2670	8	36	4	18
Mean	3.2	1280	223	3428	2	31	15	231	580	8920	5	77	2	31

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 2 - DURING CONSTRUCTION

STATION NO. 4

Date	pH	Flow (gpm)	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
			Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
11-73	5.0	576	70	484	26	180	1	4	420	2900	6	42	3	21
12-73	5.3	595	108	772	10	71	1	6	520	3720	4	29	3	21
1-74	4.4	3395	150	6116	----	----	15	612	680	27720	4	163	4	163
2-74	4.1	720	175	1513	----	----	20	173	700	6050	7	60	2	17
3-74	3.7	769	185	1709	----	----	18	166	700	6460	5	46	2	18
4-74	4.1	609	170	1243	----	----	18	132	700	5120	4	29	2	15
5-74	4.5	444	210	1120	----	----	15	80	680	3626	4	21	2	11
6-74	4.6	242	200	581	----	----	12	35	650	1890	6	17	2	6
7-74	4.6	248	162	482	----	----	18	54	590	1760	3	9	2	6
8-74	5.2	223	96	257	4	11	9	24	620	1660	0.8	2	2	5
Mean	4.3	782	153	1437	13	122	13	122	630	5920	4	38	2	19

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 3 - AFTER CONSTRUCTION

STATION NO. 4

Date	pH	Flow (gpm)	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
			Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
9-74	5.1	558	100	670	26	174	6	40	520	3480	1	7	2	13
10-74	3.9	341	188	770	----	----	12	49	700	2 870	2	8	2	8
11-74	4.8	264	128	406	6	19	8	25	560	1 780	2	6	2	6
12-74	5.9	1543	20	368	32	590	6	110	340	6 260	2	37	1	18
1-75	3.8	710	116	989	----	----	20	170	690	5880	4	34	2	17
2-75	3.7	928	176	1962	----	----	21	234	660	7 360	5	56	2	22
3-75	3.1	1574	425	8034	----	----	50	945	1020	19280	18	340	2	38
4-75	3.7	604	256	1857	----	----	47	341	790	5 730	7	51	0	0
5-75	3.8	583	164	1148	----	----	42	294	620	4 341	5	35	0	0
6-75	4.5	338	90	365	2	8	12	49	520	2 110	6	24	2	8
7-75	4.1	244	149	437	----	----	16	47	610	1790	3	9	2	6
8-75	4.2	92	119	132	----	----	12	13	600	660	2	2	2	2
Mean	3.8	648	161	1253	16	125	21	163	640	4980	5	70	2	16

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 1 - BEFORE CONSTRUCTION

STATION NO. 5

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
9-71	4.1	1301	228	3562	6	94	12	188	600	9370	0.5	8	3	47
10-71	4.0	876	141	1483	15	158	6	63	540	5681	0.2	2	3	32
11-71	3.9	1555	118	2204	14	261	6	112	530	9900	0.1	2	2	37
12-71	4.1	2468	147	4357	----	----	6	178	530	15710	4	118	2	59
1-72	4.1	3300	108	4280	6	238	5	198	540	21400	2	79	4	158
2-72	3.7	19162	112	25775	4	920	5	1151	450	103560	1	230	2	460
3-72	3.4	10014	310	37282	----	----	17	2044	600	72160	8	962	8	962
4-72	3.2	13113	279	43938	----	----	21	3307	700	110240	10	1575	9	1417
5-72	3.0	3822	315	14459	----	----	15	688	580	26620	22	1010	3	138
6-72	3.7	1895	198	4506	----	----	30	683	80	1820	1.5	34	2	46
7-72	2.7	4030	396	19166	----	----	20	968	640	30980	8	387	2	97
8-72	3.1	1800	334	7220	----	----	14	303	620	13400	3	65	4	86
Mean	3.3	5278	224	14199	4	254	13	824	530	33600	5	317	4	254

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 2 - DURING CONSTRUCTION

STATION NO. 5

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
11-73	4.8	4104	63	3105	30	1479	1	30	550	27110	6	296	4	197
12-73	5.2	3784	105	4772	8	364	1	32	600	27270	5	227	3	136
1-74	4.4	6681	175	14042	----	----	18	1444	710	56970	8	642	4	321
2-74	4.2	2938	185	6528	----	----	22	776	720	25400	8	282	2	70
3-74	3.6	3388	250	10172	----	----	25	1017	820	33360	10	407	2	81
4-74	4.1	3658	190	8347	----	----	22	966	840	36900	7	308	3	132
5-74	4.5	3270	190	7462	----	----	15	589	760	29850	5	196	3	118
6-74	5.4	1765	180	3816	10	212	13	276	760	16110	7	148	5	106
7-74	4.7	1494	121	2171	1	18	5	90	640	11480	3	54	2	36
8-74	5.1	1602	70	1347	6	115	7	135	700	13470	1	19	2	38
Mean	4.3	3268	153	6005	11	432	13	510	710	27870	6	235	3	118

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

PHASE 3 - AFTER CONSTRUCTION

STATION NO. 5

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
9-74	5.2	2932	113	3979	8	282	10	352	610	21480	2	70	4	141
10-74	4.5	1655	182	3618	2	40	10	199	710	14110	2	40	2	40
11-74	4.5	1410	168	2845	1	17	9	152	680	11520	3	51	2	34
12-74	6.5	8616	16	1656	39	4035	6	621	350	36220	3	310	1	104
1-75	4.0	3466	120	4995	----	----	21	874	760	31640	8	333	2	83
2-75	3.7	6189	190	14122	----	----	24	1784	750	55750	10	743	2	149
3-75	3.1	7972	498	47680	----	----	57	5457	1140	109150	42	4021	2	192
4-75	3.6	3324	356	14212	----	----	54	2156	900	35930	20	798	0	0
5-75	3.6	3213	225	8682	----	----	51	1968	700	27010	10	386	0	0
6-75	4.3	1998	151	3623	----	----	16	384	580	13920	8	192	4	96
7-75	3.9	1336	190	3049	----	----	18	289	750	12030	6	96	4	64
8-75	4.2	1376	142	2347	----	----	13	215	750	12390	3	50	3	50
Mean	3.8	3624	196	8531	12	522	24	1045	720	31340	10	435	2	87

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

STATION NO. A - SAMPLED ONCE PER QUARTER DURING PHASE 3

Date	pH	Flow (gpm)	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
			Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
PHASE 2 - DURING CONSTRUCTION														
5-74	4.3	208	200	500	----	----	21	52	1350	3370	4	11	6	16
6-74	4.6	122	230	337	----	----	13	19	925	1355	2	3	7	10
Mean	4.4	165	215	426	----	----	17	34	1140	2260	3	6	6	12
PHASE 3 - AFTER CONSTRUCTION														
9-74	4.6	207	148	368	2	5	12	30	700	1740	4	10	2	5
12-74	6.8	360	51	220	29	125	4	17	560	2421	4	17	3	13
3-75	2.9	608	717	5231	----	----	77	562	1520	11090	48	350	6	44
6-75	4.2	146	231	405	----	----	20	35	820	1440	9	16	6	10
Mean	3.5	330	287	1137	8	32	28	111	900	3570	16	63	4	16

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

STATION NO. B - SAMPLED ONCE PER MONTH DURING PHASE 3

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
PHASE 2 - DURING CONSTRUCTION														
5-74	3.5	400	330	1585	----	----	21	101	1100	5284	12	58	8	40
6-74	3.6	193	320	742	----	----	16	37	1100	2550	10	23	7	17
Mean	3.5	296	325	1155	----	----	18	64	1100	3910	11	39	8	28
PHASE 3 - AFTER CONSTRUCTION														
9-74	4.2	494	154	914	----	----	12	71	760	4510	6	37	6	36
10-74	3.3	218	375	982	----	----	26	68	1040	2720	9	24	7	18
11-74	3.6	259	302	939	----	----	18	56	960	2990	5	16	6	19
12-74	5.0	524	83	522	4	25	7	44	650	4090	4	25	4	25
1-75	3.2	419	235	1183	----	----	31	156	980	4930	15	75	5	25
2-75	3.2	817	327	3205	----	----	41	402	1020	10000	30	244	3	29
3-75	2.9	818	705	6920	----	----	72	707	1520	14920	62	609	7	69
4-75	3.2	357	602	2581	----	----	68	292	1520	6520	62	266	2	9
5-75	3.3	328	388	1528	----	----	61	240	1150	4530	26	102	5	20
6-75	3.4	211	330	836	----	----	25	63	980	2480	24	61	7	18
7-75	3.2	169	364	739	----	----	26	53	1200	2440	20	41	12	24
8-75	3.0	188	423	955	----	----	25	56	1080	2440	8	19	7	16
Mean	3.3	400	357	1715	0	0	34	168	1070	5116	23	106	6	29

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

STATION NO. C - (MAJOR POLLUTION SOURCE 6005) SAMPLED ONCE PER QUARTER DURING PHASE 3

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
PHASE 2 - DURING CONSTRUCTION														
5-74	2.9	150	770	1387	----	----	55	99	1410	2540	88	159	5	9
6-74	3.0	180	710	682	----	----	51	49	1410	1360	74	71	5	5
Mean	2.9	115	740	1022	----	----	53	73	1410	1950	81	112	5	7
PHASE 3 - AFTER CONSTRUCTION														
9-74	2.8	145	644	1121	----	----	48	84	1160	2020	50	87	5	9
12-74	3.1	108	549	712	----	----	40	39	1010	1310	48	62	2	3
3-75	2.8	400	2236	10733	----	----	191	917	3200	15360	446	2141	5	24
6-75	3.0	120	1130	1628	----	----	56	81	1750	2520	180	259	6	9
Mean	2.9	193	1140	2642	----	----	81	209	1780	4130	181	420	4	9

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

STATION NO. D - SAMPLED ONCE PER MONTH DURING PHASE 3

Date	pH	Flow (gpm)	Acidity Conc.	Acidity Load	Alkalinity Conc.	Alkalinity Load	Aluminum Conc.	Aluminum Load	Sulfate Conc.	Sulfate Load	Iron Conc.	Iron Load	Manganese Conc.	Manganese Load
PHASE 2 - DURING CONSTRUCTION														
5-74	3.2	577	430	2980	----	----	32	222	1100	7620	26	180	7	49
6-74	3.3	289	400	1388	----	----	29	101	1140	3960	19	66	7	24
Mean	3.2	433	420	2184	----	----	30	156	1120	5820	22	114	7	36
PHASE 3 - AFTER CONSTRUCTION														
9-74	3.7	699	240	2015	----	----	21	176	760	6380	7	61	5	42
10-74	3.1	505	473	2869	----	----	33	200	1020	6190	14	85	6	36
11-74	3.2	412	394	1950	----	----	22	109	1010	5000	7	35	6	30
12-74	4.7	932	193	2160	1	11	9	101	620	6940	8	90	3	34
1-75	3.0	460	307	1696	----	----	42	232	1100	6080	22	122	4	22
2-75	3.0	1244	352	5255	----	----	42	627	1020	15230	30	448	4	60
3-75	2.9	1473	1173	20734	----	----	109	1927	2100	37120	191	3376	3	53
4-75	3.1	592	844	6001	----	----	32	227	1800	12800	95	675	1	7
5-75	3.2	605	596	4330	----	----	78	567	1280	9300	55	400	2	14
6-75	3.2	464	535	2981	----	----	29	162	1080	6020	36	201	6	33
7-75	3.0	195	560	1311	----	----	39	91	1400	3280	38	89	9	21
8-75	2.8	179	472	1015	----	----	39	84	1250	2690	18	37	7	15
Mean	3.1	647	512	3978	0	0	41	319	1200	9320	43	334	5	39

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

STATION NO. E - SAMPLED ONCE PER MONTH DURING PHASE 3

Date	pH	Flow (gpm)	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
			Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
PHASE 2 - DURING CONSTRUCTION														
5-74	3.4	52	560	350	----	----	39	24	1140	710	9	8	3	2
6-75	3.4	29	470	164	----	----	36	13	1190	410	12	4	5	2
Mean	3.4	40	520	250	----	----	38	18	1160	560	11	5	4	2
PHASE 3 - AFTER CONSTRUCTION														
9-74	4.3	37	370	164	----	----	26	12	1010	450	2	1	5	2
10-74	3.3	21	571	144	----	----	36	9	1250	315	7	2	7	2
11-74	3.1	6	558	40	----	----	28	2	1120	80	4	0	6	0
12-74	4.7	34	224	91	2	1	10	4	750	310	3	1	3	1
1-75	3.0	60	364	262	----	----	31	22	1190	860	11	8	5	4
2-75	3.0	64	457	351	----	----	55	42	1180	910	16	12	5	4
3-75	2.9	108	645	836	----	----	68	88	1400	1810	26	34	1	1
4-75	3.2	36	658	284	----	----	22	10	1400	600	24	10	1	0
5-75	3.2	46	490	271	----	----	82	45	1150	635	12	7	3	2
6-75	3.2	22	434	115	----	----	33	9	1050	280	4	1	5	1
7-75	3.6	4	454	22	----	----	32	2	1250	60	1.8	0	8	0
8-75	4.0	2	324	8	----	----	33	1	1150	30	1.6	0	5	0
Mean	3.2	37	462	205	0	0	38	17	1160	520	9	4	4	2

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

STATION NO. F - (MAJOR POLLUTION SOURCE 6002) SAMPLED ONCE PER QUARTER DURING PHASE 3

Date	pH	Flow (gpm)	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
			Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
PHASE 2 - DURING CONSTRUCTION														
5-74	2.8	57	820	561	----	----	54	37	1290	880	75	51	5	3
6-74	2.8	37	860	382	----	----	62	28	1490	660	86	38	5	2
Mean	2.8	47	840	474	----	----	58	33	1390	780	78	44	5	3
PHASE 3 - AFTER CONSTRUCTION														
9-74	2.9	47	458	259	----	----	36	20	850	480	24	14	5	3
12-74	3.2	110	319	421	----	----	21	28	560	740	26	34	2	3
3-75	2.6	158	1551	2941	----	----	134	254	2200	4170	178	337	2	4
6-75	2.8	48	1367	793	----	----	62	36	1750	1010	156	90	4	2
Mean	2.8	91	924	1010	----	----	63	69	1340	1460	96	105	3	3

APPENDIX B

LABORATORY ANALYSIS AND MATERIAL LOAD SUMMARY

STATION NO. G - SAMPLED ONCE PER QUARTER DURING PHASE 3

Date	pH	Flow (gpm)	Acidity		Alkalinity		Aluminum		Sulfate		Iron		Manganese	
			Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
PHASE 2 - DURING CONSTRUCTION														
5-74	3.3	75	300	270	----	----	24	22	700	630	19	17	2	2
6-74	3.5	95	170	194	----	----	12	14	360	410	6	6	1	1
Mean	3.4	85	235	240	----	----	18	18	530	540	12	12	2	2
PHASE 3 - AFTER CONSTRUCTION														
9-74	2.8	206	432	1069	----	----	31	77	780	1930	42	104	2	5
12-74	5.8	156	46	86	10	19	7	13	440	820	9	17	1	2
3-75	3.0	200	416	998	----	----	43	103	850	2040	31	74	2	5
6-75	3.8	80	190	182	----	----	17	16	350	340	15	14	1	1
Mean	3.2	160	271	521	2	4	24	40	610	1170	24	46	2	4

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-76-111	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Evaluation of Surface Mine Reclamation Techniques - Campbell's Run Watershed, Pennsylvania		5. REPORT DATE June 1976 (Issuing Date) 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Murray T. Dougherty and Hans H. Holzen		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS A.C. Ackenheil & Associates, Inc. 1000 Banksville Road Pittsburgh, Pennsylvania 15216		10. PROGRAM ELEMENT NO. EHE 623 11. CONTRACT/GRANT NO. Grant 14010 GCM
12. SPONSORING AGENCY NAME AND ADDRESS Industrial Environmental Research Laboratory Office Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Final-Nov. 1970 - Oct. 1975 14. SPONSORING AGENCY CODE EPA - ORD

15. SUPPLEMENTARY NOTES

16. ABSTRACT

A study was performed to demonstrate the effectiveness of surface reclamation of strip mined land upon water quality in streams receiving mine drainage pollution from abandoned underground mines. The water quality was monitored in three phases, prior to the surface reclamation, during reclamation, and after reclamation. The results were then evaluated to determine any improvement in water quality resulting from the construction of the abatement facilities.

Fifty-two acres (21 hectares) of abandoned strip mined land were regraded and revegetated to reduce infiltration to the spoil zone and to the deep mine complex. The reclamation was completed at a cost of $131,650. The results of the collection and sampling of stream samples over a three year period indicated that the pH and acidity of Campbell's Run had improved and that the acid load had decreased 43% at the mouth of Campbells Run. However, this improvement could not be directly attributed to the surface reclamation projects. The improvement was determined to be more directly related to the construction of residential and commercial establishments, to the construction of U. S. Interstate 79, and to natural fluctuations in mine pool levels and runoff rates.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Mining* Reclamation* Water Quality Coal Mining Underground Mining Surface Mining	Acid Mine Drainage* Pennsylvania Campbell's Run	08H, 08G

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