I INTRODUCTION

Purpose and Objectives:

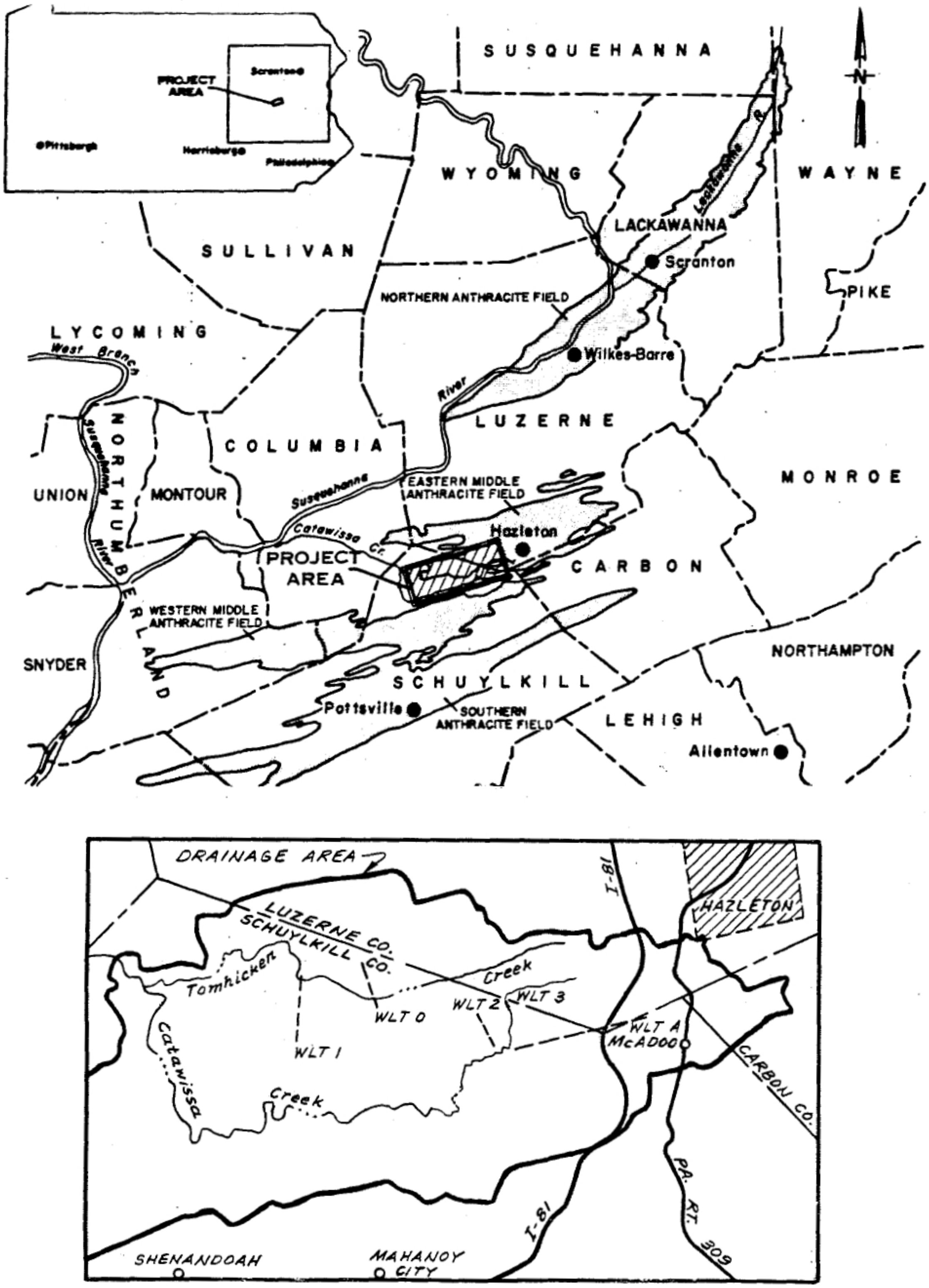
In an on-going effort to eliminate Acid Mine Drainage (AMD) pollution in the Susquehanna River Basin, the Department of Environmental Resources, under the Operation Scarlift Program, has authorized this study.

The objectives of the study are to quantify the AMD parameters in the study area and to determine the feasibility of AMD abatement by neutralization with limestone. In addition the study includes an analysis of the impact of the proposed neutralization projects on the receiving streams. The methods of treatment are to be based on the results of the Quakake Tunnel Outfall Demonstration Project (SL135-10) of AMD neutralization with limestone media.

Background Information:

The study area is located in the Middle Anthracite Coal Region of Pennsylvania. Abandoned deep coal mines from three coal basins in the study area discharge AMD into the adjacent streams. Although strip mine activities followed deep mining in the study area, the. major source of pollution is the AMD emanating from the deep mines through the portals of drainage tunnels. These tunnels were driven from the lower valleys, adjacent to the coal basins, into the deep coal workings to facilitate the dewatering of the mines by gravity. Accordingly, they are referred to as "Water-Level-Tunnels" (WLT). The general location of the study area is shown in Figure 1. The coal basins, the receiving streams and the limits of the drainage areas are presented in Exhibit A (see pocket).

The water level tunnels, the corresponding coal basins, the receiving streams and their location in the major River Basins are tabulated as follows:



PROJECT LOCATION MAP

FIGURE 1

Source of AMD Discharges		Affected Streams	
Water Level Tunnel	Coal Basin	Receiving Stream	River Basin
Quakake*	Jeansville	Wetzel Creek	Delaware
Audenried	Jeansville	Catawissa Cr.	Susquehanna
WLT #3	South Green Mountain	Catawissa Cr.	Susquehanna
WLT #2	South Green Mountain	Catawissa Cr.	Susquehanna
WLT #1	South Green Mountain	Tomhicken Cr.	Susquehanna
Oneida	North Green Mountain	Tomhicken Cr.	Susquehanna

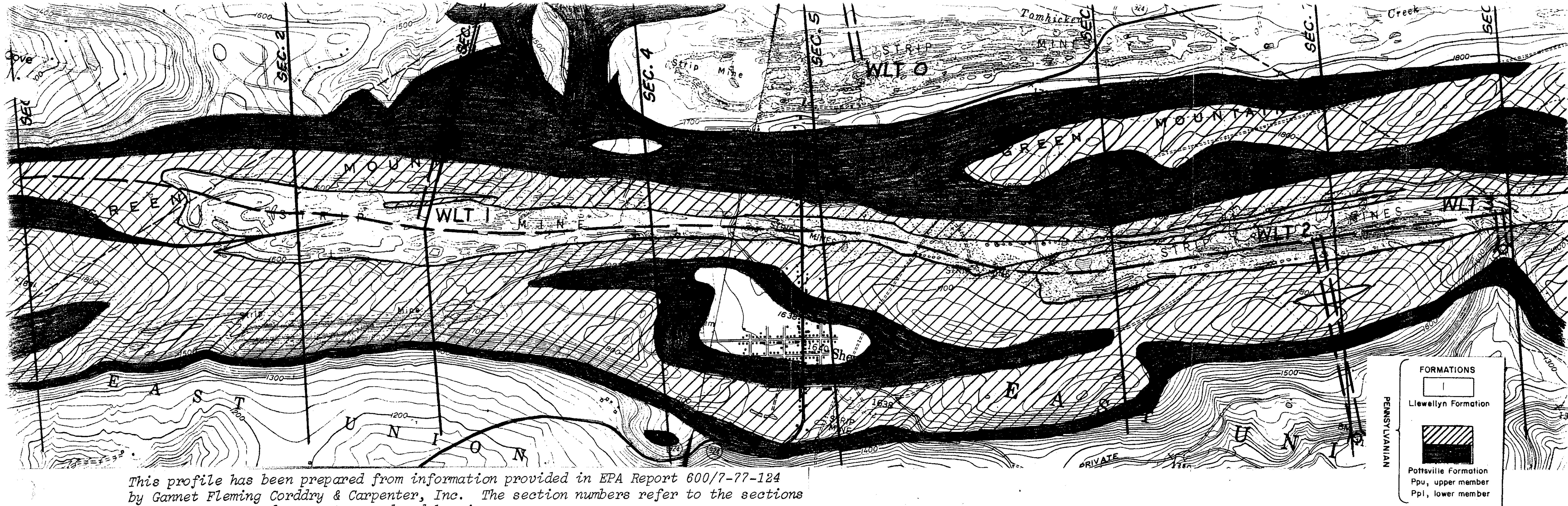
* *Outside the study area limits*

The Oneida and WLT #1 discharge into the Tomhicken Creek, a tributary of the Catawissa Creek. Consequently, discharges from the five study area tunnels have caused AMD pollution in the Catawissa Creek, from its headwaters west of MacAdoo, to its confluence with the North Branch of the Susquehanna River at Catawissa. Approximately 44 miles of stream, including 7 miles of the Tomhicken Creek, are being affected, by the tunnel discharges.

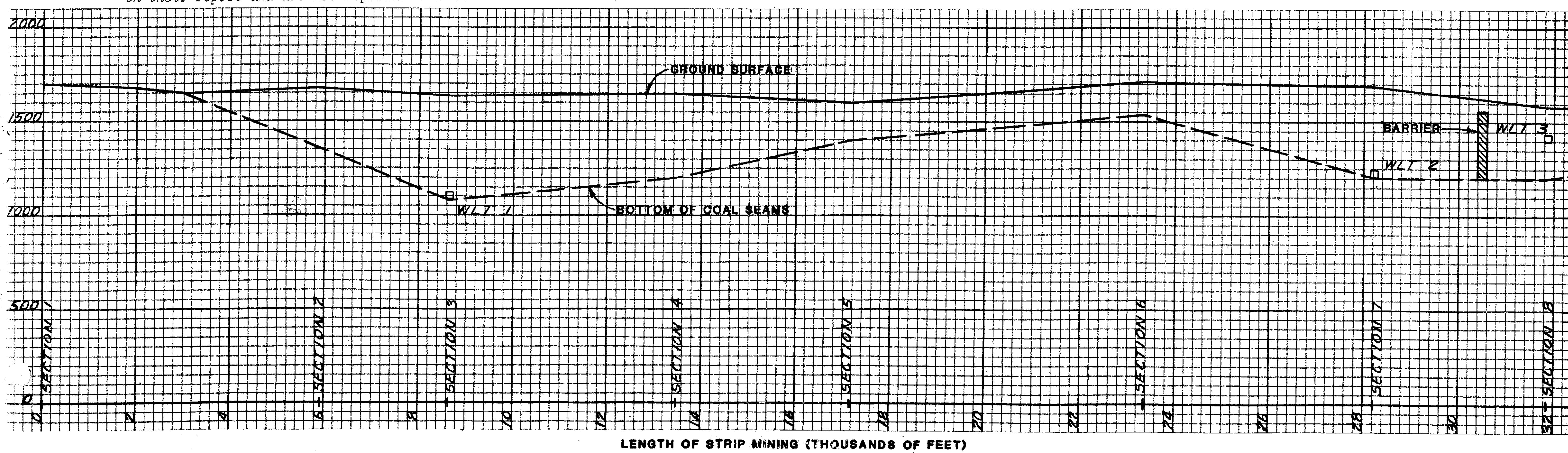
The three previously mentioned coal basins are geologically similar in nature. Folds or wrinkles in the earth's crust occurring during the Appalachian Orogeny formed "canoe shaped" basins that contain the anthracite coal seams of the Post-Pottsville formations. The coal basins are underlain by the resistant sandstone and conglomerate beds of the Pottsville formation that also forms the resistant ridges surrounding the basins. The adjacent Mauch Chunk formation has been eroded to form the deep valleys north and south of-the basins through which the Tomhicken and Catawissa Creeks flow.

Coal deposits within the basins have been mined for the past 90 years giving rise to the existing drainage conditions[1]. Original deep mine workings were kept dry by pumping and through the use of surface water diversion ditches. About the turn of the century when deeper mining took place, water level tunnels were driven in an effort to reduce pumping cost. The exact degree of interconnection between deep mine workings, within the same basin, is not known. This lack of knowledge is inherent to the South Green Mountain Coal Basin and hampers the correlation between precipitation and AMD discharges from water level tunnels, 1 through 3. Nevertheless, the degree of interconnection within the coal basin increases near the surface where recent strip mining and subsidence has greatly altered the local topography and drainage patterns. Precipitation within the basin infiltrates or collects and flows into the deep mines, and through interconnecting tunnels to the discharge points. Each of the tunnel discharges varies in terms of water quality and rate of flow, resulting in variabilities that complicate analysis and treatment. A geologic profile of the South Green Mountain Coal Basin, showing the relative locations and pool elevations of the water level tunnels, is presented in Figure 2. The profile was prepared from information presented by Gannett-Fleming Corddry and Carpenter, Inc. [2] in the 1979 report on the Catawissa Creek Mine Drainage Abatement for EPA (EPA-60017-77-124).

Studies [3,4] were conducted by the Department to gain insight into two potential methods of abating acid mine drainage discharges within the three previously mentioned coal basins. The feasibility of sealing the tunnel portals in order to inundate the mine workings, thereby reducing the oxidation of acid forming pyrites was studied. These proposals, although technically feasible, proved to be too costly. Shortly thereafter, a study was initiated at the Quakake Water Level Tunnel to test the viability of various prototype limestone neutralization methods[4]. Limestone barriers, fluidized downflow and upflow beds, and revolving drums were used to treat a. portion of the Quakake discharge successfully. Limestone treatment has inherent advantages, including low reagent cost, safer handling characteristics and the elimination of problems that may result from "overtreatment".



This profile has been prepared from information provided in EPA Report 600/7-77-124 by Gannet Fleming Corddry & Carpenter, Inc. The section numbers refer to the sections in their report and are not reproduced herein.



LENGTH OF STRIP MINING (THOUSANDS OF FEET)

SOUTH GREENRIDGE MOUNTAIN COAL BASIN

FIGURE 2

Scope of Study:

The study consisted of collection and evaluation of data and the determination of various treatment schemes, utilizing limestone neutralization techniques that were tested at the Quakake Water Level. Tunnel Demonstration Project. The study included evaluation of the proposed treatment on the receiving streams.

A weekly water sampling program was initiated at the portals of the five tunnels and at selected locations in the receiving streams. Weekly flow measurements were to be made at all sampling points. Continuous stage-discharge recorders were installed at, or below the tunnel portals.

Laboratory test results were correlated with flow rates from the tunnels, receiving streams and with precipitation data, obtained for a 12-month period.

On the basis of the collection and evaluation of the water quality and the hydrologic analysis in the study area sub-watersheds, suitable treatment methods for AMD abatement by neutralization with limestone media were evaluated. Feasible treatment schemes and cost estimates were developed and are summarized in this report.

II – FIELD INVESTIGATIONS

Reconnaissance Survey:

Site visits to the tunnel portals were made to determine the configuration of weir construction and the location of still wells for continuous recorders. The condition at the tunnel portals are depicted in the photographs in Appendix A. The tunnel portals and immediate downstream areas were surveyed by aerial photogrametry for the evaluation of abatement schemes that can be applicable for each site.

Monitoring Program:

In June of 1978, a year-long sampling and flow monitoring program was initiated by the Department. Water quality samples from each of the polluting tunnel discharges and from various locations along receiving streams were collected on a weekly basis. Samples were then shipped to a nearby State laboratory for analysis. Concurrent with the sampling program, weirs were constructed at the tunnel portals. Each weir was equipped with a Stevens Type-F continuous recorder installation. Weekly staff gage readings and current meter measurements of flow were provided at each of the continuous recorder sites, for later determination of stage-discharge relationships. In addition to the continuous flow recording stations, other stream stations were established in the Sugarloaf, Tomhicken and Catawissa Creeks. The locations of the monitoring stations are presented in Exhibit A and the type of records obtained at each station is summarized in Table I.

In addition to the water quality and flow data gathered, precipitation data was also collected. A continuous recording rain gage was installed in the vicinity of Water Level Tunnel 2 at the Blue Knob Rod and Gun Club. The collected rainfall data was used to establish precipitation-discharge relationships at the discharge points. Stream flow data collected during the 1978-1979 monitoring program are presented in Appendix B.

TABLE I

CATAWISSA CREEK MONITORING STATIONS

STATION NO.	
CC-1	Sample only
CC-2	Sample and Flow Measurement with Meter
CC-3	Sample and Flow Measurement with Meter
CC-4*	Sample and Flow Measurement with Meter
CC-5*	Sample and Flow Measurement with Meter
WLT-A	Sample and Maintain Flow Recorder
WLT-3	Sample and Maintain Flow Recorder
WLT-2	Sample and Maintain Flow Recorder
CC-6	Sample Only
CC-7	Sample and Flow Measurement with Meter - flow measurement is to be taken 100' upstream of bridge. Reference point is to be established on bridge.
CC-8	Same as CC-7
CC-9	Sample Only
TC-1	Same as CC-7
TC-2	Sample Only
TC-3	Sample Only
TC-4	Sample and Flow Measurement with Meter
WLT-1	Sample and Maintain Flow Recorder
S-1	Sample and Flow Measurement with Meter
S-2	Sample Only
WLT-0	Sample and Maintain Flow Recorder

All the above stations were monitored on a weekly basis.

* *The combined flows of CC4 and CC5 were monitored by a continuous stage recorder.*

Limitation of Data:

Throughout the monitoring period, various problems were encountered which account for missing data. Frequent incidents of vandalism occurred, destroying data and equipment at several of the stations. Water level recorders sustained rifle fire damage, weirs were deliberately blocked, etc. Various climatological factors such as high flows, frozen monitors and frozen current meters resulted in data gaps. Difficult access to some of the monitoring sites and the limited number of personnel assigned for the collection of data necessitated more than one day of measurements for each sampling period. Consequently, during periods of runoff from precipitation, data collected in a single day at some of the stations cannot be related to records obtained at other stations within the same sampling period.

Previous Investigations:

Data collected during the previously cited studies were examined to gain insight into past flow and quality conditions. Monthly tabulations of discharges and water quality emanating from water level tunnels 1, 2, and 3 are presented in Appendix C. These tables were excerpted from the mine sealing study on the South Green Mountain Basin entitled "Catawissa Creek Mine Drainage Abatement Project," (2) prepared by Gannett Fleming Corddry and Carpenter, Inc. A range of values for the Audenried Tunnel was excerpted from a second study entitled "Mine Drainage Abatement Measures for the Jeansville Basin" (3). No previous water quality records are available for the Oneida Tunnel discharge.

Pollution Sources:

The major pollution sources in the study area, identified in the present and previous studies, are delineated as follows:

Audenried Tunnel, the largest single AMD discharge into Catawissa Creek, is located approximately four miles west of the town of McAdoo. "The tunnel was driven through rock strata from the Gamma Coal Vein in the Audenried Mine at an elevation of approximately +1207 (near McAdoo), in a westerly direction for about 16,150 feet to a point outside of the Jeansville Basin on the Catawissa Creek Watershed at an elevation of +1178[(2)]". The tunnel discharges into a deep narrow draw and flows through a large box culvert, under a haul road, before entering the Catawissa Creek, approximately 830 feet downstream from the portal opening.

The Oneida Tunnel is the second largest source of pollution within the Catawissa Creek Watershed. It is the sole drainage tunnel of the North Green Mountain Basin, from which it was driven in a northerly direction to a discharge point on the Sugarloaf Creek at an elevation of +510 feet. Like Audenried, the Oneida Tunnel discharges into a deep narrow draw approximately 670 feet from the left bank of Sugarloaf Creek, a tributary of Tomhicken Creek. The portal opening is currently in a collapsed condition. Recreational lakes were recently constructed above and below the Oneida discharge which is located within the Valley of Lakes, a planned residential development. The potential for development exists within the vicinity of the discharge.

Water level tunnels 1, 2 and 3 all drain the South Green Mountain Mine complexes. "Tunnel No. 1 was driven approximately 7000 feet from the Tomhicken Creek, at elevation + 1082 feet, to intercept the workings at an elevation of +1086 feet[(2)]". Tunnel No. 2 was driven approximately 4100 feet to the north from Catawissa Creek to intercept a second low point in the mine workings at an elevation of + 1175 feet (2), This tunnel discharges into an existing raceway type structure, under a haul road, to a marsh area, then to the Catawissa Creek, approximately 1200 feet south of the tunnel opening. Both tunnels 1 and 2 exhibit a characteristic known as "mine breathing," which is an indication of surface inter-connections. "Tunnel No. 3 was driven 840 feet in a northward direction from Catawissa Creek to a third point within the workings at elevation +1413. Tunnel No. 3, unlike any of the other discharges, exhibits a higher iron content as can be seen by the "yellow boy" formation, above and below the portal.

Comparison Between Collected Data:

Average monthly flow and water quality of tunnel discharges during the 1978-1979 sampling period are presented in Appendix C along with data collected from previous studies (1969 thru 1971). Comparison between the data collected during the previous and current study periods shows a general improvement in water quality and a decrease in flow from the pollution sources over approximately a 9-year period. Precipitation records indicate that although the 1978-1979 was the wettest sampling period, the discharges emanating from the tunnels were smaller than those recorded during the previous sampling periods. A summary of monthly precipitation (in inches) from the Tamaqua 4N Dam climatological station located 5 miles southeast of the study area, is presented in Table 2. The change in water quality with time is indicated in Table 3.

TABLE 2

PRECIPITATION, IN INCHES, FOR THE INDICATED PERIODS

TAMAQUA 4N DAM

Month	1969/1970	1970/1971	1978/1979	Normal
June	2.98	3.39	4.02	3.70
July	8.77	8.57	2.98	5.05
August	4.78	2.08	5.74	4.24
September	2.32	2.73	2.58	3.95
October	2.24	5.59	4.50	3.54
November	5.02	7.14	2.84	4.51
December	4.75	1.24	4.03	3.71
January	.45	2.05	11.42	3.09
February	3.85	N.A.	3.87	2.90
March	2.55	3.18	3.48	3.74
April	4.20	4.56	4.93	4.02
May	3.39	3.49	6.51	4.77
TOTAL	45.30	44.02*	56.90	47.22

* *Length of Study = 11 Months*

TABLE 3

ANNUAL AVERAGE VALUES

Source	Year	Flow (cfs)	pH	Acidity (mg/l)	Fe (mg/l)	SO_4 (mg/l)
Tunnel 1 -	1969	11.1	3.7 - 4.0	67	0.4	85
	1970	13.7	3.9 - 4.2	63	0.4	75
	1979	5.4	4.0 - 4.9	36	0.3	64
Tunnel 2 -	1969	4.8*	3.4 - 3.8	87	0.7	107
	1970	3.9*	3.5 - 3.8	88	1.0	115
	1979	1.5	3.8 - 4.1	64	0.6	83
Tunnel 3 -	1969	12.3*	3.9 - 6.3	49	0.8	88
	1970	1.9*	3.2 - 3.9	75	3.9	84
	1979	1.3	3.4 - 4.4	39	1.8	52
Audenried	1970	26.7	3.2 - 3.5	349	4.5	505
Tunnel	1979	15.7	3.2 - 4.1	195	2.2	282

Annual Precipitation

1969 - 45.3 inches
1970 - 44.0 inches
1979 - 56.9 inches

* *Before and after Reconstruction of the Catawissa Creek streambed (See Reference 2).*