GEOLOGY

This report is principally concerned with abatement of acid mine drainage from coal mining in the Big Scrubgrass Creek Watershed. The geologic studies have thus been limited to those aspects which would effect the location and distribution of coal-bearing formations within the watershed and the possible formation of acid mine drainage and its subsurface movement.

Very limited geologic information has been published on Venango County and the Big Scrubgrass Creek Watershed. This is probably the result of the general lack of important mineral deposits in the area. The coal has been considered low quality of limited extent which was not economical to mine until recently. Oil reserves in Venango County were developed early. Some of the first attempts to map the geology were associated with the desire to determine the amount of oil potentially recoverable by secondary methods. Coal deposits were studied briefly along with the oil, and this data constitutes the only published source of information. The publications relating to the geology of the area are listed in the References of this report.

Since 1966, applicants for permits to mine coal in Pennsylvania under the Bituminous Coal Open Pit Mining Conservation Act have been required to furnish logs of drill holes showing overburden and coal seams with elevations and thicknesses. Where these permits have been filed, additional data on the stratigraphy can be obtained.

This data was used to supplement field inspections to determine the geology of coal in the Big Scrubgrass Creek Watershed.

The geologic setting is important to a study of mine drainage pollution abatement because it gives insight into the potential sources and character of the pollution as well as possible paths of travel within the watershed. A particular coal seam and its associated over-burden generally will produce a particular type of acid mine drainage. The strike, dip and fracturing of the formations will determine where the pollutants will move beneath the surface.

Regional Structure:

The Big Scrubgrass Creek Watershed lies within the Pittsburgh Plateaus Section of the Appalachian Plateau Physiographic Province. (See Figure 7). The uplands are gently rolling with nearly uniform elevations from ridge to ridge. The extreme western edge of the watershed was affected by the Illinoian and Wisconsin glaciers, (See Figure 8) which left some thin ground moraine and erratics, but did not affect the coal deposits of the area significantly.

The watershed lies in the northwest part of the Appalachian foreland, which lies west and north of the closely folded and faulted Appalachian Mountains. This foreland is a broad, gentle, spoon-shaped synclinorium extending into northwestern West Virginia. The dominant structural feature of this area is a general southward inclination or regional dip. The Appalachian Plateau has

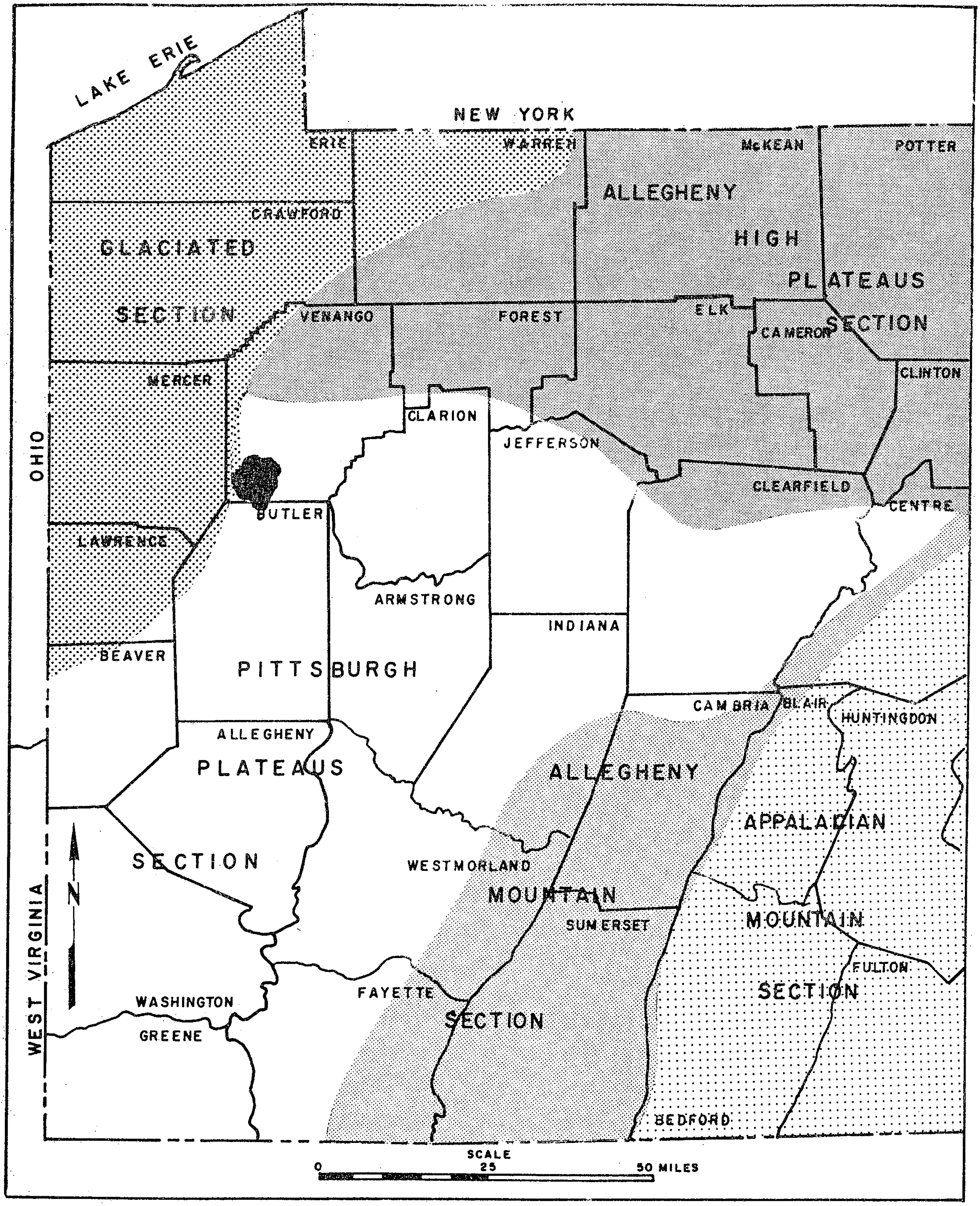


Figure 7. Map of Western Pennsylvania Showing Physiographic Provinces and Location of Big Scrubgrass Creek Watershed.

has been uplifted and eroded several times in the past, and because the uplifting was greater in the north, the erosion has exposed older formations in the northern parts of the area. The narrow stream valleys are deep and steep sided as they have cut through the plateau exposing older formations.

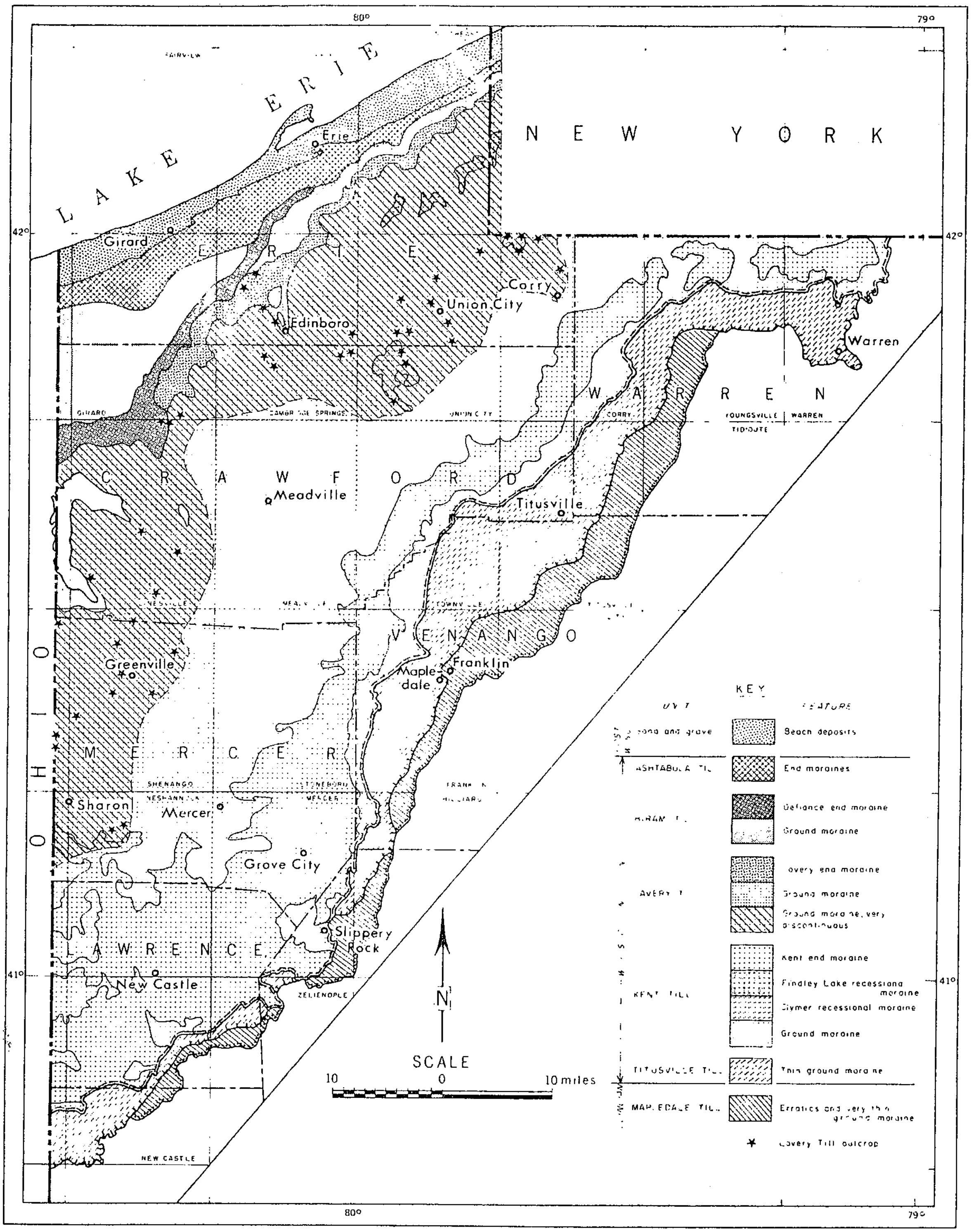


Figure 8. Distribution of glacial drift in Northwestern Pennsylvania (modified from Figure 4 of Bulletin G32, Pennsylvania Topographic and Geologic Survey, Shepps and others, 1959).

The most persistent and easily identifiable formation in the watershed is the Vanport limestone in the Allegheny Group. It has been quarried in the past, both for crushed stone and agricultural lime. The formation has been mapped in the Billiards 15 minute quadrangle from outcroppings and from gas and oil well logs, and has a southerly dip of approximately 23 feet per mile. This dip is modified locally by a few north or northeasterly trending folds and by numerous minor irregularities and local undulations.

The most prominent fold is the Homewood anticline which, although not clearly defined, extends roughly northeasterly across the watershed on a line which runs down the main valley of Big Scrubgrass Creek. This causes the surface formations including the coals to dip slightly to the south-southeast on the eastern side of the watershed and to the southwest on the western side.

Exposed bedrock in road cuts and mines indicate that the rocks are extensively fractured throughout the watershed which would allow percolation of water in unknown quantities and directions.

<u>Subsurface Stratigraphy:</u>

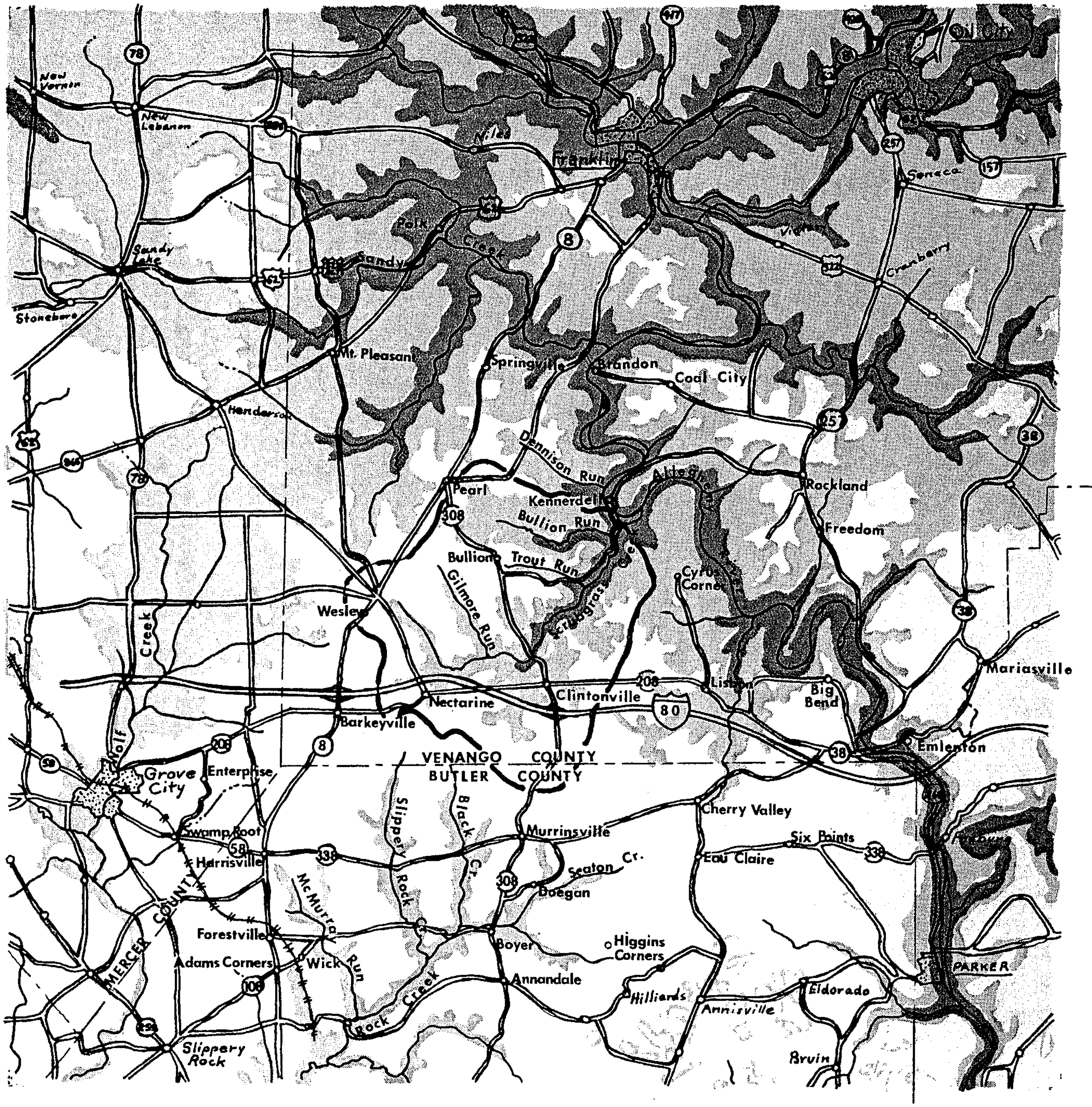
Approximately 600 feet of lower Pennsylvanian to lower Mississippian rock strata are exposed in the Big Scrubgrass Creek Watershed. This includes approximately 300 feet of the Pocono group at the lower elevations, generally below 1220 feet MSL, 200 feet of the Pottsville Group between 1200 and 1400 feet MSL, and approximately 100 feet of the Allegheny

Group. This latter group contains most of the mineable coal in the watershed. (See Figure 9 and Figure 10).

Pocono Group - The Pocono Group is present in the watershed along the lower valleys. In ascending order, the group contains the Cuyahoga shale, the Shenango sandstone, the Hempfield shale and the Burgoon sandstone. Upper members of the group are not present in the watershed. This group contains no minerals of importance.

Pottsville Group - The Pottsville Group outcrops extensively on the upper valleys and lower hilltops of the watershed. This group includes, in ascending order, the Lower Connoquenessing sandstone, the Quakertown shale, the Upper Connoquenessing sandstone, the Mercer shales, and the Homewood sandstone. The most significant member of this group is the Mercer formation which contains several thin seams of coal. One of these coal seams, probably the middle seam commonly known as the Upper Mercer seam, lies at about 1350 feet MSL and has been mined in the northeastern part of the watershed. Generally, however, this coal lies too deep and is too thin to be economically important.

Allegheny Group - The base of the Allegheny Group is the Brookville coal seam which is the most extensive in the Big Scrubgrass Creek Watershed. It outcrops at about 14.70 feet MSL in the extreme northern part of the watershed and dips in a general southerly direction to an elevation of about 1330 feet MSL at the southern watershed boundary. Where this coal has been identified, it ranges in thickness



PENNSYLVANIAN

APPALACHIAN PLATEAU

Conemaugh Formation

Cyclic sequences of red and gray shales and siltstones with thin limestones and coals; massive Mahoning Sandstone commonly present at base; Ames Limestone present in middle of sections; Brush Creek Limestone in lower part of section.

Allegheny Group

Cyclic sequences of sandstone, shale, limestone and coal; numerous commercial coals; limestones thicken westward; Vanport Limestone in lower part of section; includes Freeport, Kittanning, and Clarion Formations.

Pottsville Group

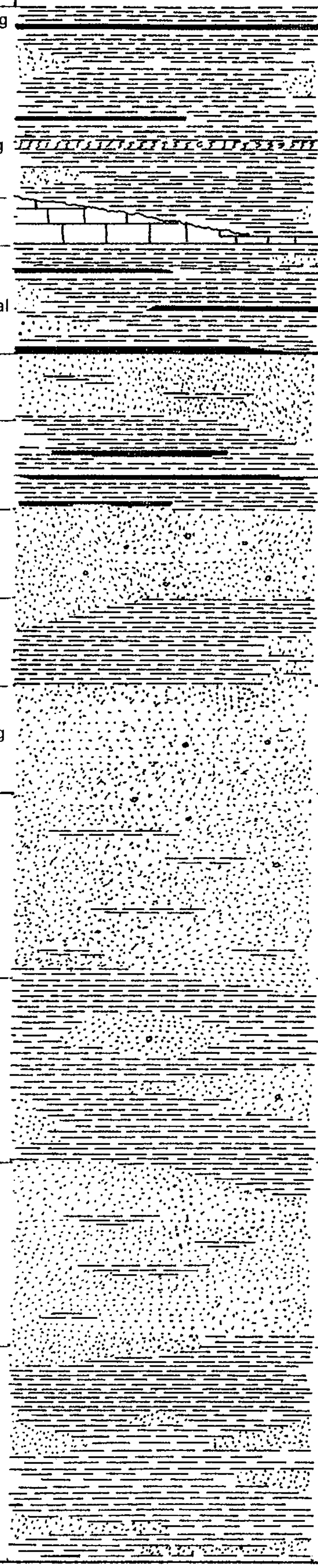
Predominantly sandstones and conglomerates with thin shales and coals; some coals mineable locally.

MISSISSIPPIAN

Pocono Group

Predominantly gray, hard, massive, cross-bedded conglomerate and sandstone with some shale; includes in the Appalachian Plateau Burgoon, Shenango, Cuyahoga, Cussewago, Corry, and Knapp Formations; includes part of "Oswayo" of M. L. Fuller in Potter and Tioga counties.

FIGURE 9 Bedrock Geologic Map of the Big Scrubgrass Creek Watershed - From Geologic Map of Pennsylvania, Pennsylvania Topographic and Geologic Survey, 1960



		Formation	Description
PENNSYLVANIAN SERIES	ALLEGHENY GROUP	Middle Kittanning Coal Lower Kittanning Coal Lower Kittanning Clay	Brownish shales and sandstones containing coal and clay layers. Present only in the southern part of the watershed. Up to 100 feet thick. Lower Kittanning coal is not persistant and is only mined in certain locations. Middle Kittanning coal occurs only on hilltops.
		Vanport Limestone	0 to 20 feet thick. Dark gray fossiliferous limestone key bed in the southern portion of the watershed.
		Scrubgrass Coal Lower Clarion Coal Brookville Coal	40 to 60 feet of shale in which occur variable beds of coal and clay. The coals are thin and some beds are absent in parts of the watershed. Brookville coal most persistant, locally up to 4 feet thick.
	POTTSVILLE GROUP	Homewood Sandstone	10 to 40 feet thick, gray, medium-grained sandstone, Shaly in places.
		Mercer Shales and Coals	40 feet thick, brown to black shale with irregular layers of coal, clay and siderite concretions.
		Upper Connoquenessing Sandstone	40 to 60 feet thick, coarse-grained massive gray sandstone.
		Quakertown Shale	1 to 40 feet thick dark brown to black shale.
		Lower Connoquenessing Sandstone	40 to 60 feet thick coarse-grained massive sandstone.
MISSISSIPPIAN SERIES	POCONO GROUP	Burgoon Sandstone	75 to 100 feet thick, medium to coarse-grained gray to greenish sandstone in platy layers interbedded with soft gray or greenish shales.
		Hempfield Shale	75 to 100 feet thick, contains a few sandstone lenses which are quite thick in places.
		Shenango Sandstone	75 to 90 feet thick contains subordinate shale layers generally stratified in thin platy layers.
		Cuyahoga Shale	Up to 200 feet thick. Only about 46 feet exposed at the mouth of Big Scrubgrass Creek. Interbedded with thin layers of fine grained sandstone.

FIGURE 10. Generalized stratigraphic column in Big Scrubgrass Creek Watershed
Vertical scale: 1 inch=80 feet

from 12 to more than 48 inches. The Brookville coal seam is the principal seam being mined in the Big Scrubgrass Creek Watershed.

Several other coal seams in the Allegheny Group occur in the watershed. The following table shows the principal members of the Allegheny Group in the Big Scrubgrass Creek Watershed and their relationship to the Vanport limestone.

TABLE 5

NAME OF MEMBER	AVERAGE INTERVAL TO TOP OF VANPORT LIMESTONE-FEET
Middle Kittanning Coal	80 to 90
Lower Kittanning Coal	40 to 50
Lower Kittanning Clay	35
Vanport Limestone	15 to 30
Scrubgrass (Upper Clarion) Coal	30 to 45
Brookville Coal	55 to 65

All of these coals are probably mined at some location in the watershed, although the Scrubgrass seam is not specifically identified with any of the mine sites.

Mining History:

The first mining in the Big Scrubgrass Creek Watershed were small deep mines operated by individuals and families. Deep mining continued into the middle 1960’s from small mines in the Kittanning seams in the extreme lower end of the watershed. A search of records of the U. S. Bureau of Mines and the Pennsylvania Department of Environmental Resources uncovered no records for the deep mines in this watershed. There are no active deep mines in the watershed at the present time.

A number of apparent mine openings are recorded in strip mine permit applications for areas in the watershed. Field checks revealed additional small drift mine openings. Most of these were owned and operated by the land owners strictly for family field supplies and were in the same seams which were later strip mined. The later stripping operations have completely disturbed and eliminated many of these small workings. Additional deep mines may exist in the watershed which were not located from mine records or field inspections.

Strip mining began in the 1930's in the watershed, although the only records of this mining are the remains found in the field. The first written records of mining in the watershed began in 1945 when the Bituminous Coal Open Pit Mining Conservation Act required permits for all strip mining in Pennsylvania. Since that time, approximately 2200 acres of strip mining has been done in the watershed. The coal seams identified in the permit applications include the Brookville, Clarion, Middle Kittanning and Lower Kittanning. Most of the mining has been in the Brookville seam with some mining in the Middle Kittanning seam at the extreme southern edge of the watershed. An estimated 6 million tons of Brookville and 800,000 tons of Middle Kittanning coal have been mined from the watershed.

Plate II located in the rear of the report indicates the probable extent of the Middle Kittanning coal and the Brookville coal in the watershed based on extension of the Vanport limestone maps adjusted from available drill hole data from mining permits and field inspection of mines. This indicates that the Brookville seam underlies approximately

13,200 acres with approximately 43 million tons of coal reserves still unmined in the watershed.

The Soil Conservation Service began a study of erosion from strip mines in the Big Scrubgrass Creek Watershed as part of the Penn Soil Resource Conservation and Development Project in 1967. As a part of this project they identified 54 strip mine sites within the watershed. The SCS identification system was adopted for this report, and six additional sites which were not included in the SCS report have been added.

The watershed was divided up into seven subwatersheds for analysis purposes. Figure 29 is a map of the watershed showing the subwatershed divisions used in this report. Each of these subwatersheds has a separate section in this report including a map showing all the strip mine sites and all known deep mine areas.

Strip mine permit applications from the early 1950's indicate the presence of small acid seeps at a few points throughout the watershed, although most of the permanent streams were alkaline. As strip mining continued the number of acid water samples found in the watershed increased, particularly in the Trout Run and Gilmore Run Subwatersheds. Much of this early strip mining was done without adequate backfilling, regrading or revegetagion. Most of the Pollution in the watershed comes from spoil piles that have not been properly regraded and revegetated. Although the degree of regrading and reclamation is fairly uniform throughout the watershed, there is almost no acid mine drainage in the tributary streams to the south and east of the main stream. Apparently the coal and overburden in this part of the watershed either has a lower sulfur content or there is more alkaline material associated with it. With three minor exceptions, all tributary streams in this part of the watershed were found to have an average net alkalinity.

Some of the newer mines to the north and west of the main stream were regraded but not properly revegetated. These areas are still producing acid mine drainage. In all cases where adequate vegetative cover has been established no acid mine drainage is found. (See Figures 1 and 25).

The earliest attempts at strip mine reclamation almost always involved planting trees on spoil piles with no regrading. Where soils were good and erosion was not too severe, these trees have survived and after many years have begun to provide adequate control of acid formation. However, where the stand of trees was thin or the slopes were very steep, these areas have still not stabilized and in some areas of the watershed, tree-covered mine spoil piles are still important sources of acid mine drainage pollution. (See Figure 13).

Figure 11. Remains of a deep mine operation in the Southwest Tributaries area south of the Village of Nectarine. The portal has been obliterated by later strip mining on the hillside. Runoff from gob piles on the surface is a source of stream pollution.

Figure 12. View of Mine Site No. 13 in the Gilmore Run Subwatershed. Many areas such as this mine on the upper end of the Gilmore Run Subwatershed were left completely unreclaimed, allowing them to become major sources of acid mine drainage.

Figure 13. View of Mine Site No. 4 in the Bullion Run Subwatershed. This area of acid mine drainage on the Bullion Run Subwatershed originates from an area of mine spoil which was not regraded but has a good stand of white birch trees which were planted in 1966, and which have not produced an adequate vegetative cover to control acid formation.

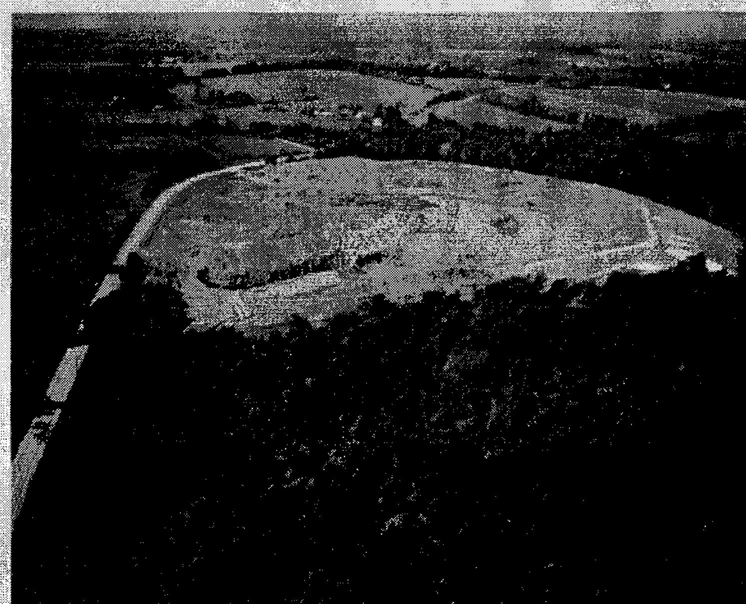


Figure 14. View of new strip mining on Site No. 3 in the Bullion Run Subwatershed. This mine in the Bullion Run Subwatershed has been reopened and is being reclaimed in accordance with the newest regulations. These areas should not be sources of future pollution to the stream.

HYDROLOGY

General Climate:

The winters in the Big Scrubgrass Creek Watershed are moderately cold and the summers are warm and humid. The mean annual temperature is about 49°F with an average of 140 days between killing frosts.

The average annual precipitation on the watershed is about 40 inches with an average of 50 inches of snowfall and 22 inches of rainfall during the growing season.

Precipitation:

No United States Weather Bureau rain gaging stations exist within the Big Scrubgrass Creek Watershed. However, three stations are located within a 12 mile radius of the watershed and their locations are shown on the map in Figure 15. During the first twelve months of the project period two rain gages were maintained in the watershed from which 24 hour rainfall totals were measured. The locations of these project rain gages are shown in Figure 17. Figure 16 shows the monthly totals measured at these project gages compared with weighted averages for the nearby Weather Bureau stations and the long-term monthly averages in the area. A more detailed discussion of precipitation is included in Appendix C of this report.

Soils:

The rainfall-runoff relationship on a watershed is dependent upon the types of soil and the topography. The soils in the Big Scrubgrass Creek Watershed are classified into four groups or associations. All of the soils in these associations either have restrictive horizons or occur on steep slopes so that they produce a high percentage of runoff from storm rainfall.

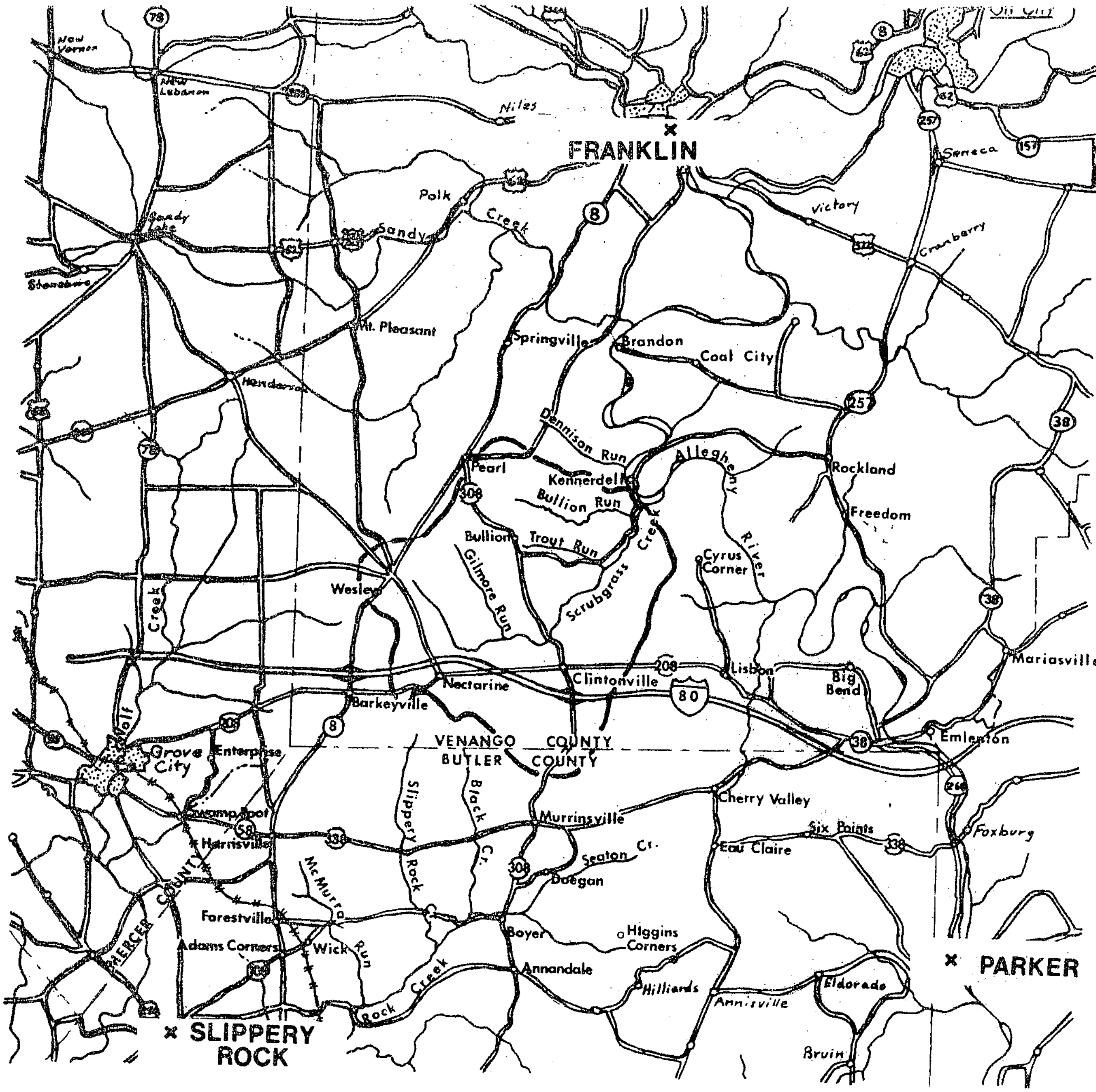
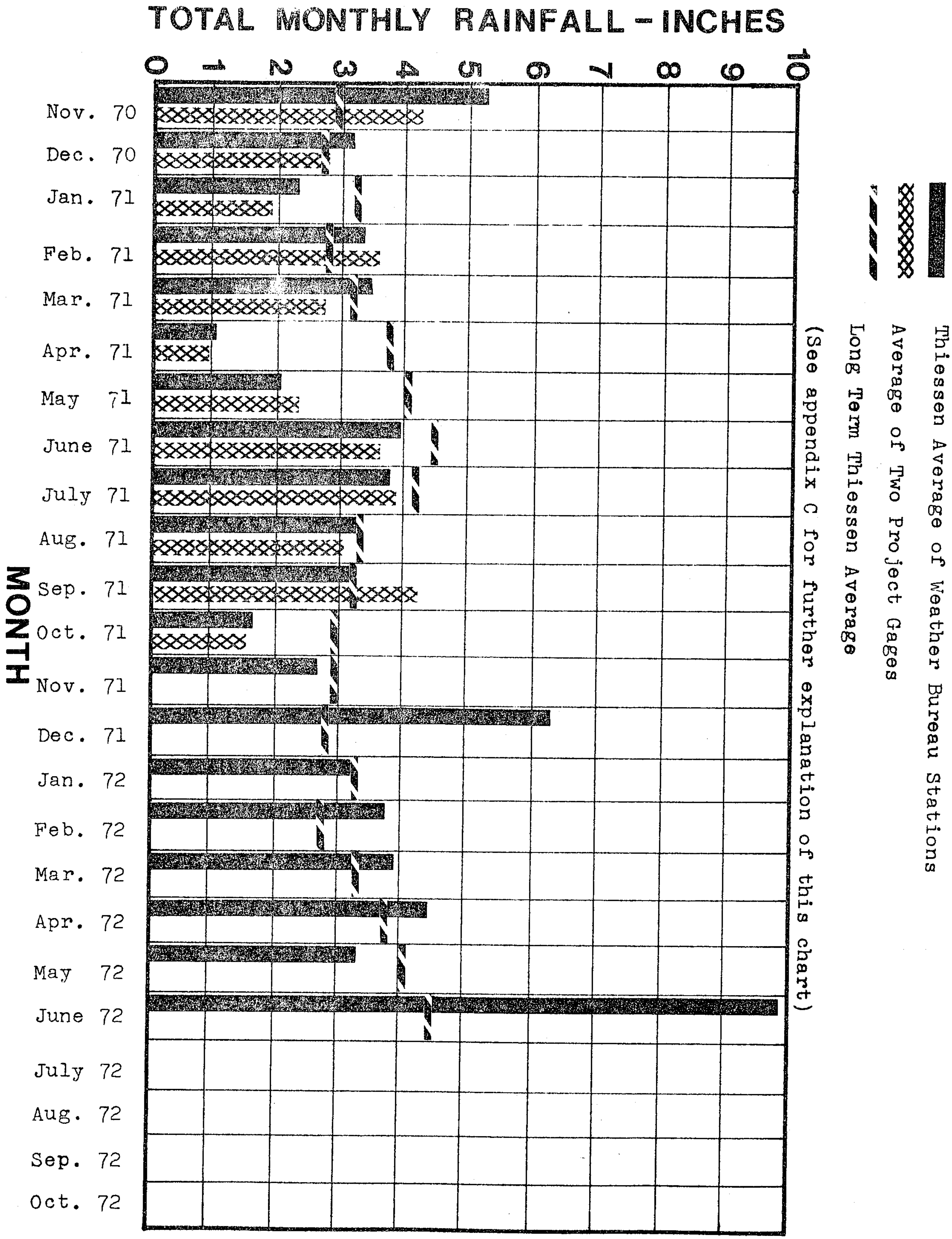


FIGURE 15. Map of Big Scrubgrass Creek Watershed and surrounding area showing the location of the closest U. S. Weather Bureau Rainfall Recording Stations.

× **PARKER** - Weather Station Location



TOTAL MONTHLY RAINFALL - INCHES
0
1
2
3
4
5
6
7
8
9
10
MONTH
Nov. 70
Dec. 70
Jan. 71
Feb. 71
Mar. 71
Apr. 71
May 71
June 71
July 71
Aug. 71
Sep. 71
Oct. 71
Nov. 71
Dec. 71
Jan. 72
Feb. 72
Mar. 72
Apr. 72
May 72
June 72
July 72
Aug. 72
Sep. 72
Oct. 72
Thiessen Average of Weather Bureau Stations
Average of Two Project Gages
Long Term Thiessen Average
(See appendix C for further explanation of this chart)

FIGURE 16

Runoff:

The average annual runoff from the watershed is slightly in excess of 20 inches as determined from records of stream flow at USGS stream gaging stations on other nearby watersheds. No records of runoff are available for the Big Scrubgrass Creek except for those obtained during this project. Flow estimates made during the project period at the mouth of Big Scrubgrass Creek indicate an annual runoff of 24.34 inches which agrees closely with the nearby USGS gage records.

The topography and soils on the watershed are a combination which would tend to produce storm runoff hydrographs with quick high peaks and a rapid rise and fall of the water levels in the streams. On the tributaries this would cause the periodic flow measurements to be generally lower than the mean flow for the period. Fluctuations on the main stream should be less pronounced making periodic measurements be a good estimate of the long-term runoff averages.

A more detailed discussion of hydrology is included with the precipitation data in Appendix C of this report.

FORMATION OF ACID MINE DRAINAGE

The necessary ingredients for the formation of acid mine drainage are a sulfur mineral, a source of oxygen and a source of water. In much of Pennsylvania, iron pyrite (FeS_2), which provides the sulfur source, is commonly associated with coal bearing strata. Oxygen is a major component of the atmosphere and it is also found to a lesser degree in soil air and dissolved in percolating water. Water occurs as vapor in the atmosphere and within the soil and also as a liquid in precipitation and percolating groundwater.

The acid formation is basically a surface phenomona where oxygen, water and pyrite can come in contact with each other. The initial oxidation reaction is shown in the following chemical equation:

$$2FeS_2 + 2H_2O + 7O_2 \rightarrow 2FeSO_4 + 2H_2SO_4$$

Both the ferrous sulfate and sulfuric acid which are formed in the above reaction are highly soluable and are thus readily carried from the mine dissolved in both ground water and surface water. The ferrous sulfate usually undergoes further oxidation producing ferric sulfate by the following reaction:

$$4FeSO_4 + O_2 + 2H_2SO_4 \rightarrow 2Fe_2(SO_4)_3 + 2H_2O$$

At pH levels above 2.6 the ferric sulfate becomes unstable and reacts with water producing ferric hydroxide and additional sulfuric acid by the following reaction:

$$Fe_2(SO_4)_3 + 6H_2O \rightarrow 2Fe(OH)_3 + 3H_2SO_4$$

The ferric hydroxide is insoluable at the higher pH levels and deposits on the stream bottoms as a red coating commonly called "Yellowboy."

These reactions are affected by temperature and the presence or absence of other minerals and certain bacteria to some extent. Other compounds of generally lesser importance are found in all mine drainage water. Where limestone is present the sulfuric acid will react forming a neutral salt as illustrated by the following chemical equation:

$$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + CO_2 + H_2O$$

This reaction causes an increase in the pH level of the water but does not change the sulfate ion content. Such neutralization occurs naturally at some places in the Big Scrubgrass Creek Watershed causing streams which have a neutral or alkaline quality but which still contain iron and sulfates.

Iron pyrite is found in the coal and the sandstone overburden on many mines in the Big Scrubgrass Creek Watershed producing acid mine drainage from exposed coal waste and spoil piles on unreclaimed strip mines and from some abandoned deep mine workings. The recommended reclamation measures are aimed at prevention of the acid formation at these sources to produce clean streams in the watershed and elimination of acid discharge to the Allegheny River.