CHAPTER III

STUDY AREA DESCRIPTION

The study area originally assigned to this project was the West Branch watershed above Cherry Tree, Pennsylvania which involves a drainage area of 43 square miles. The stream pollution survey phase of the study also included representative sampling of the West Branch and its major tributaries as far downstream as Lewisburg, Pennsylvania. As the work progressed, it became apparent that the study area should also include the reach of the West Branch between Cherry Tree and Curwensville Reservoir. It was also necessary to study this lower section of the headwaters area to determine the chemistry of the natural neutralization process that has been effective in the West Branch since 1968.

A further territorial extension was necessary when the project was requested to make a limited survey of the portion of the Allegheny watershed receiving effluent from the Duman treatment plant. This involved sampling in the Duman Lake area and the reach of Elk Creek above and below its juncture with Crooked Run, the actual effluent receiving stream.

The study area is unique in that the underground geology and hydrology of the deep mine pool complex area are major factors in pollutant generation and in potential for future abatement; they are fully as important as the surface features and meterology, all of which have an involved interrelationship in the production and control of mine drainage.

TOPOGRAPHY

The study area is confined to the Appalachian Plateaus province. The headwaters of the West Branch of the Susquehanna River start in the Allegheny Mountain section, continues into the Pittsburgh Plateaus section and then into the Allegheny High Plateau section. The location of the watershed area in these physiographic sections is indicated on Figure III-1. The major topographic feature is the river itself as it travels through the physiographic sections and provinces, and eventually empties into the Chesapeake Bay and the Atlantic Ocean.

In the headwaters area the hilly, surface has altitudes of 1500 to 2100 feet above sea level. This worn plateau is represented by broad flat hilltops with the lower elevations to the north. The streams have cut valleys in the plateau that vary from 300 to 500 feet deep. The valley floor near Carrolltown is 1935± feet above sea level while at Cherry Tree the elevation is 1365± feet (an average

stream slope of 6 ft./1000 ft.). Two highland ridges trend northwest and southwest. The easternmost ridge is Laurel Ridge and western ridge is the Nolo.

There is a major difference in the types of valleys occurring in the headwaters area. Where they cut into the ridges, they are in the youth stage (V-shaped) but at the lower elevations they are in the mature stage (U-shaped). This reflects the stratigraphy of the area; the harder rocks are higher in elevation whereas at the lower elevations, the rocks are softer and erode more rapidly.

Most of the Appalachian Plateau drainage is to the Mississippi via the Monongahela, Allegheny and Ohio Rivers. The West Branch of the Susquehanna River, however, flows into the Atlantic Ocean. It is believed that all the drainage from the plateau in time past flowed northward into the St. Lawrence system to the Atlantic Ocean. Glacial effects eventually blocked this drainage system, and present drainage courses reflect this diversion in their patterns. The West Branch of the Susquehanna indicates the old drainage pattern while, the Allegheny and Ohio show the new pattern.

The headwaters of the West Branch rise southwest of Carrolltown and flow westward to Elmora, northwest to Garman's Mills, then north to Cherry Tree. The tributaries are numerous and are described in detail in Chapter VI. The West Branch starts on the Laurel Hill anticline, flows into the Barnesboro syncline, crosses the low Nolo anticline at its eastern end, and then flows into the Brush Valley syncline. (See Figure III-2).

STRATIGRAPHY

All of the exposed sedimentary rocks in the area are from the Pennsylvanian period (See Figure III-3). These formations in the Pennsylvanian series range from the higher formations in the Conemaugh group to the lower formations in the Allegheny group. A generalized stratigraphic section is shown in Figure III-4. The alluvial deposits of the Quaternary period are the youngest in age. They are composed of gravels, silt, clay and sand unconsolidated in the stream channels.

Pennsylvanian Series

The Conemaugh group of the Pennsylvanian series is made up of numerous deposits of sandstones, shales and limestones. The Gallitzin and Mahoning coal seams in this group are not persistent and are generally thin seams where present.

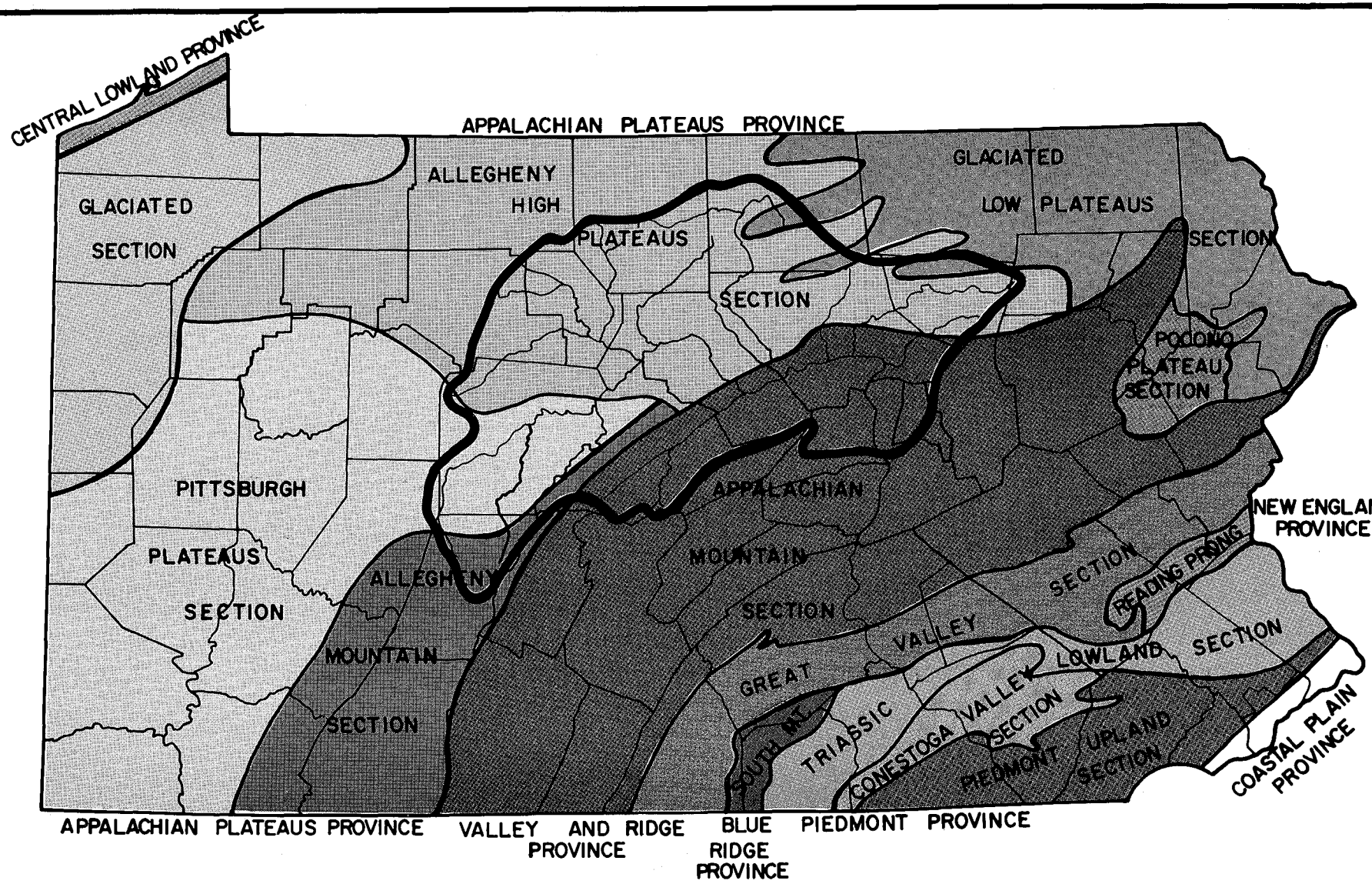


FIGURE III-1

PHYSIOGRAPHIC PROVINCES OF PENNSYLVANIA
SHOWING LOCATION OF WEST BRANCH OF
SUSQUEHANNA RIVER WATERSHED

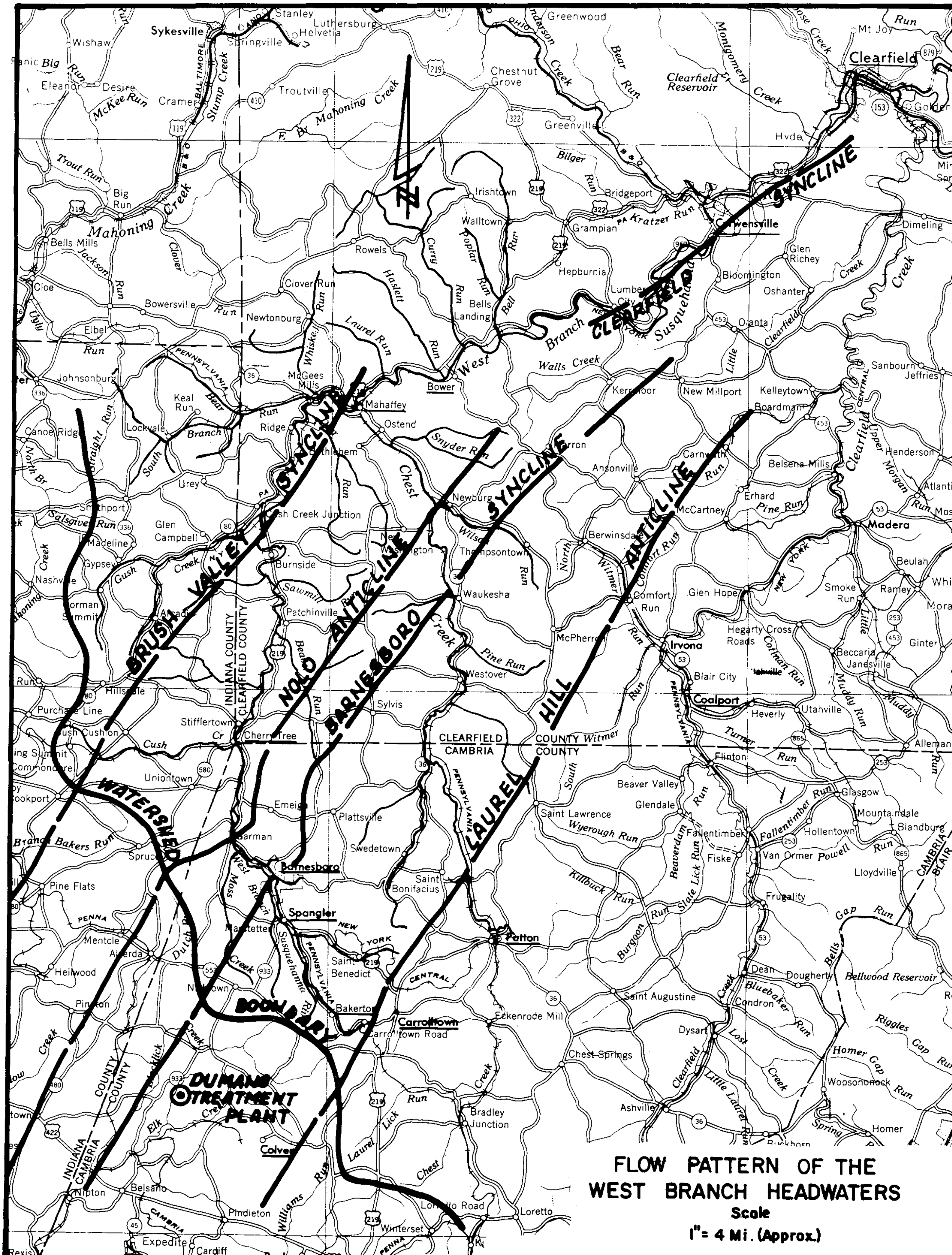
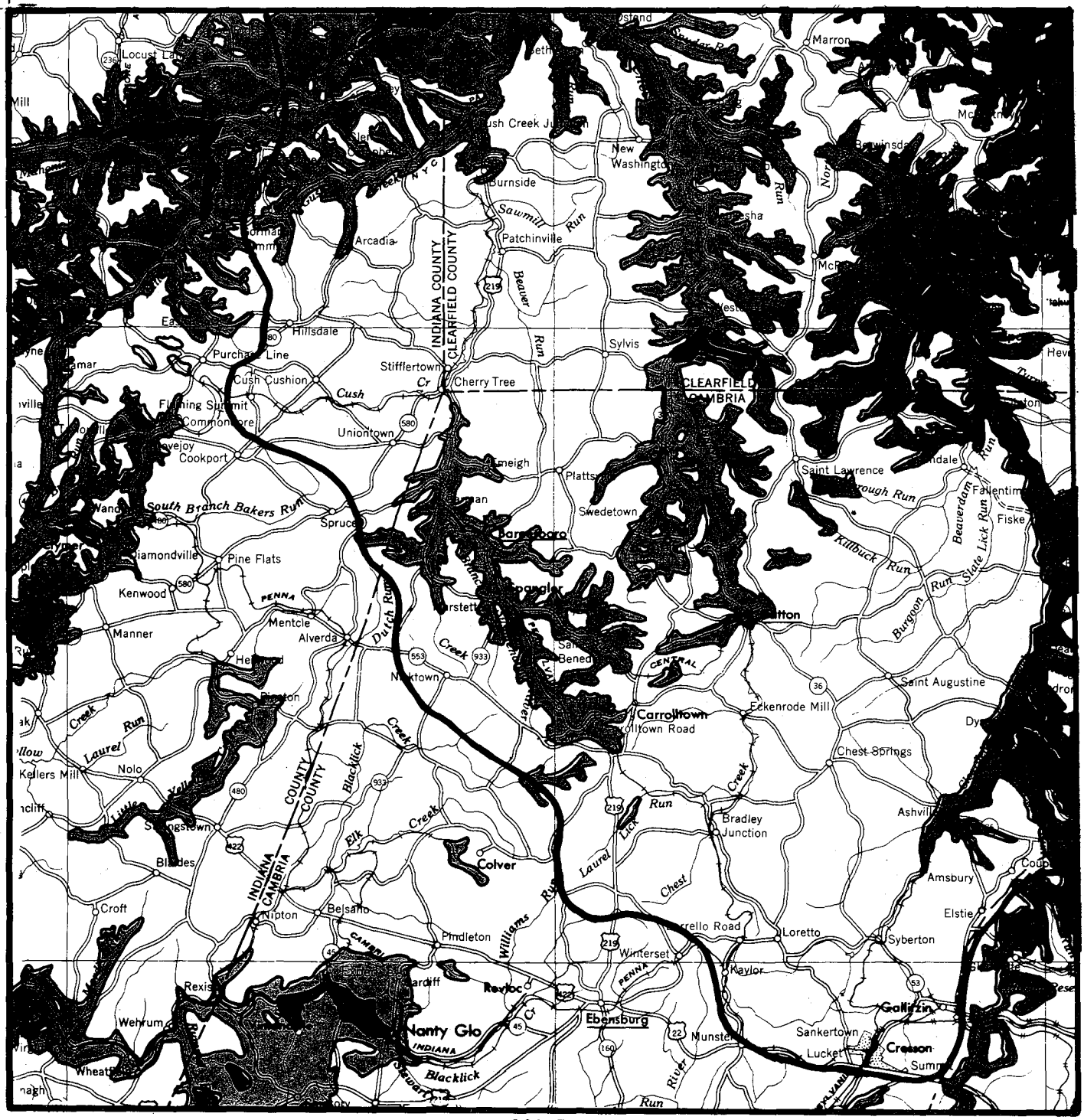

FLOW PATTERN OF THE
WEST BRANCH HEADWATERS
Scale
1" = 4 Mi. (Approx.)
CLEARFIELD SYNCLINE
BRUSH VALLEY SYNCLINE
NOLO ANTICLINE
BARNESBORO SYNCLINE
LAUREL HILL ANTICLINE
WATERSHED BOUNDARY
DUMAN TREATMENT PLANT
INDIANA COUNTY
CLEARFIELD COUNTY
CLEARFIELD COUNTY
CAMBRIA COUNTY
INDIANA COUNTY
CAMBRIA COUNTY
CAMBRIA
BLAIR
N
Sykesville
Stanley
Luthersburg
Helvetia
Greenwood
Mt Joy
Clearfield
Clearfield Reservoir
Chestnut Grove
Troutville
Greenville
Wishaw
Desire
Cramer
Eleanor
Big Run
Bells Mills
Cloe
Bowersville
Newtonburg
Clover Run
Rowels
Irishtown
Walltown
Grampian
Bridgeport
Curwensville
Hepburnia
Lumber City
Bloomington
Glen Richey
Oshanter
Dimeling
Olanta
Bells Landing
Bower
Johnsonburg
Keal Run
McGees Mills
Mahaffey
Ostend
Kerrmoor
New Millport
Kelleytown
Boardman
Sanbourn
Jeffries
Lockvale
Ridge
Bethlehem
Urey
Canoe Ridge
Smithport
Glen Campbell
Madeline
Gypsey
Nashville
Burnside
Newburg
Ansonville
Carnwath
Belsena Mills
Henderson
McCartney
Erhard
Madera
Berwinsdale
Thompsontown
Waukesha
Patchinville
Comfort Run
Glen Hope
Smoke Run
Ramey
Beulah
McPherron
Irvona
Hegarty Cross Roads
Blair City
Beccaria
Janesville
Ginter
Coalport
Heverly
Utahville
Westover
Sylvis
Stifflertown
Cherry Tree
Hillsdale
Purchase Line
Cush Cushion
Uniontown
Flinton
Allemans
Beaver Valley
Glendale
Saint Lawrence
Glasgow
Mountaindale
Blandburg
Emeigh
Plattsville
Barman
Swedetown
Fallentimber
Fiske
Hollentown
Van Ormer
Lloydville
Spruce
Pine Flats
Barnesboro
Saint Bonifacius
Frugality
Spangler
Patton
Mentcle
Alverda
Heilwood
Nicktown
Saint Benedict
Bakerton
Carrolltown
Carrolltown Road
Eckenrode Mill
Dean
Dougherty
Saint Augustine
Condron
Dysart
Chest Springs
Bellwood Reservoir
Pinkton
Wopsononock
Ashville
Bradley Junction
Colver
Nipton
Belsano
Pindleton
Loretto
Winterset
Homer
Expedite
Cardiff
Reyloc
Rexis
Mahoning Creek
West Branch Susquehanna River
Chest Creek
Clearfield Creek
Anderson Creek
Bear Run
Montgomery Creek
Stump Creek
Trout Run
Walls Creek
Little Clearfield Creek
Muddy Run
Beaverdam Run
Slate Lick Run
Killbuck Run
Burgoon Run
Blacklick Creek
Elk Creek
Laurel Run
Williams Run
Little Laurel Run
Riggles Gap Run
Homer Gap Run
Bells Gap Run
Cush Creek
Sawmill Run
Pine Run
Snyder Run
Bilger Run
Kratzer Run
Haslett Run
Whiskey Run
Laurel Run
Curry Run
Poplar Run
Witmer Run
Comfort Run
Cofman Run
Turner Run
Powell Run
Lost Creek
Bluebaker Run
Fallentimber Run
Bakers Run
Dutch Run
Moss Creek
Salsgiver Run
Straight Run
Ugly Run
Elbel Run
Jackson Run
Clover Run
Bear Run
South Branch
Upper Morgan Run

FIGURE III-2



LEGEND

- CONEMAUGH GROUP
- ALLEGHENY GROUP
- POTTSVILLE GROUP

BEDROCK GEOLOGIC MAP OF PORTION OF WATERSHED OF WEST BRANCH SUSQUEHANNA RIVER

FIGURE III-3

The Allegheny group is only partially exposed in the flanks of the anticlines and synclines where streams have eroded the overlying strata. This group has three members; Freeport, Kittanning, and the Clarion. The Kittanning formation has the lowest exposed sedimentary rocks. The Allegheny group interval is approximately 300 feet thick ranging in descending order from the Upper Freeport (E) coal seam to the base of the Brookville fire clay. The Brookville (A) coal and the Clarion (A') coal have never been correlated and many discrepancies occur in this part of the columnar section.

The Freeport member as defined in this report extends from the top of the Upper Freeport coal to the base of the Lower Freeport clay. In this formation there are two coal seams: Upper (E) seam and Lower (D) seam. The interval between the two coal seams is approximately forty feet. The interval variation suggests facies changes with sandstone (Butler) lenses interbedded with shale and siltstone. Clay with some limestone variable underlies the coal. This limestone is important in the generation of alkaline mine water from these seams. The Lower Freeport (D) coal seam is persistent throughout the area and has been extensively developed. This seam ranks next to the Lower Kittanning (B) seam in economic importance in the area. The Upper Freeport (E) coal seam is not as persistent in its occurrence as the Lower Freeport; however, it has had successful development in localized areas.

The Kittanning formation has three coal seams: Upper Kittanning (C') seam, Middle Kittanning (C) seam and Lower Kittanning (B) seam. The Upper Kittanning (C') and Middle Kittanning (C) coal seams have had only limited development in the area due to variation in seam thickness. The Lower Kittanning (B) coal seam is by far the most important economically in the entire watershed area.

The Clarion member has two coal seams: Clarion (A') seam and Brookville (A) seam. As previously stated, correlation in this zone is lacking and many discrepancies occur. The Clarion coal is very thin and absent in many places. The base of the Allegheny formation and the Clarion member is the underclay of the Brookville coal. No evidence of the Vanport limestone is found in this area.

The unexposed stratigraphic section of Pennsylvanian series is the Pottsville group. This group is divided into three members: Homewood sandstone, Mercer and Connoquenessing sandstone. The Homewood sandstone is massive, coarse grained to conglomeritic, light brown in color. This sandstone is often confused with the Clarion sandstone and locally may be replaced by shale.

The Mercer is the interval between the Homewood sandstone and Connoquenessing sandstone. This interval is usually composed of shale coal and clay. The coal is very thin when found and not of any economic value.

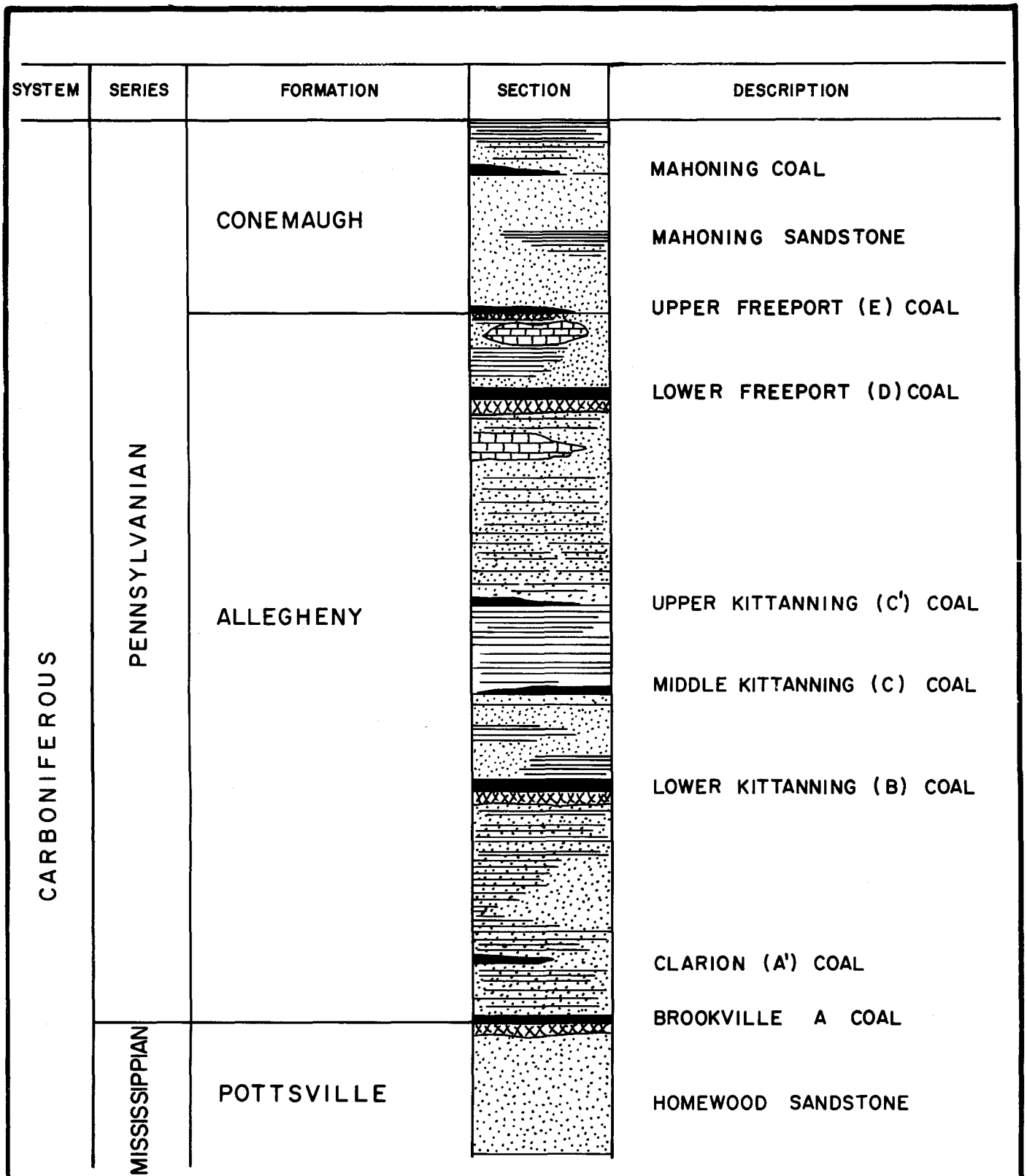


FIGURE III-4

GENERALIZED STRATIGRAPHIC SECTION

The Connoquenessing sandstone is the lowest member of the Pottsville group of the Pennsylvanian series. This sandstone overlies an unconformity with the Mississippian series. The Connoquenessing sandstone is fine grained and is often recognized as a sandy shale because of its high shale content.

STRUCTURAL GEOLOGY

Deposition was in conformable horizontal layers. This can still be seen in association with later folding that has a northeast trend. The four geological structures that are relative to the West Branch in this area are: the Laurel hill anticline, the Barnesboro syncline, the Nolo anticline and the Brush Valley syncline. (See Figure III-2).

Laurel Hill anticline, although it is not outstanding in this area, is a structure which is well defined in the Appalachian Plateau. This is the more visible west of the Allegheny mountains. Structurally, this anticline is normal with equal dips on both sides.

In the study area, the axis of the Barnesboro syncline pitches southwestward from Barnesboro and also pitches almost northward for about three miles before it again resumes its normal trend (northeast-southwest). This broad crest in the syncline is where the West Branch of the Susquehanna River crosses the structure at Barnesboro, Pennsylvania.

The Nolo anticline has an axis trend (northeast-southwest) pitching toward the northeast. The river crosses the anticline near Garman's Mills. This sharp fold continues to pitch northeast for about four and one-half miles into Clearfield County where it is not prominent. The dips are steeper on the west side of the fold than on the east side.

The Brush Valley syncline, the westernmost structure in this area effecting the West Branch of the Susquehanna River, becomes the trough that carries the water out of the area. This syncline is located in Indiana and Clearfield Counties.

RELEVANCE TO THE DEEP MINE DRAINAGE PROBLEM

The deep mine acid water problem is directly related to the geologic structure. Abandoned coal mine workings act as natural sinks and water courses for percolating ground water. This water flows through the open workings and caved ground, reacting with air and pyrite to form and dissolve acid salts such as ferrous and aluminum sulfates. These acidic waters follow the sloping coal seam bottom

downward and ultimately form a collective pool within the trough or syncline. The structural relief between the Barnesboro syncline and the Laurel Hill Anticline is 650 feet on the Lower Kittanning coal seam (B-Seam). The structural relief on the west between the Nolo Anticline and the Barnesboro Syncline is about 250 feet. Therefore, there is a large hydraulic head factor involved which will greatly enhance the pool formation process.

If the ground water is not removed by pumping at the same rate at which it is being generated, the pool level will gradually rise back up the slope until it finds a point at which it can break out at the surface. The conditions involved and their relationship to the geological structure are shown schematically on Plate 7.

When large volumes of highly acid water break out suddenly, they swamp the surface streams with tremendous acid loads. In the case of the Watkins breakout in 1970, the amount of acid being added to the West Branch by the breakout flow was about 200,000 pounds per day (sulfuric acid equivalent). This daily dosage of acid is usually sufficient to annihilate all aquatic life throughout the full course of the river within a very short time.

RAINFALL

Rainfall data for the study area was provided through the courtesy of the Northern Cambria Water Company in Spangler, Pennsylvania which maintains daily records of precipitation measured at their chlorination station on the road between Spangler and Nicktown. Data for the year 1971 are presented in Appendix D. Additional records for the months of May and June, 1972 are also included to augment the data obtained for the high flow acid slug study made during the Agnes flood period in June, 1972. Total rainfall during sampling period (January to December, 1971) was 39.2 inches which is about normal for the study area.

STREAM FLOW IN THE UPPER WEST BRANCH

The characteristic topography of the study area in conjunction with the unique location of most of the mine drainage sources create a situation in which precipitation and run-off become major controlling factors in any abatement considerations. This necessitated a thorough review of rainfall and stream flow records for the study area to determine the frequency and magnitude of acid water flows, which data would be essential to the sizing of any effective impoundment basins and total treatment plants. Fortunately, continuous annual U.S.G.S. Survey Report records are available for stream flow at Bower Station since 1914. Data for stream flow rate frequency for the period 1914 to 1963 has been compiled in graph form in Figure VI-1 in Chapter VI.

FIGURE III-5

RECORDS OF MAXIMUM FLOWS AT BOWER STATION
WEST BRANCH SUSQUEHANNA RIVER
CFS

	1966	1967	1968	1969	1970	1971	1972
January	2,100	1,160	3,000	4,040	3,480	3,130	
February	8,210	1,480	2,530	1,810	3,660	14,000	
March	1,980	6,460	2,190	728	2,840	4,020	
April	3,480	1,350	1,010	2,870	7,330	1,180	
May	3,810	2,250	3,390	1,010	2,490	1,360	
June	284	301	1,070	445	942	548	(5,200)
July	112	820	583	617	537	435	
August	160	748	265	1,690	3,880	1,840	
September	208	3,820	500	241	1,840	(2,400)	
October	332	1,310	111	346	925		
November	1,200	1,300	1,910	839	2,280		
December	2,770	943	2,900	2,910	3,440		

NOTES:

1. DATA FROM ANNUAL WATER RESOURCES REPORTS - U.S. GEOLOGICAL SURVEY

2. UNDERLINED VALUES INDICATE STREAM FLOWS AT WHICH ACID CONTROL MEASURES WOULD BE ECONOMICALLY UNREALISTIC

3. VALUES INDICATED IN (-) WERE MEASUREMENTS BY GWIN, DOBSON & FOREMAN, INC.

The high flow stream sampling conducted in September, 1971 when the flow at Bower Station was 2,400 cfs indicated the development of a large acid slug between Spangler and McGees Mills under these flow conditions. It was necessary, therefore, to determine the frequency at which flows of this order of magnitude could be expected. The curve in Figure VI-1 shows flows of 2000 cfs or higher occurring at the 5% frequency level over a 50-year period. In order to check this figure against more recent data, the maximum flows recorded for each month for the years 1966 through 1971 were compiled from recent U.S.G.S. records and are tabulated in Figure III-5. It can be seen from this data that flows greater than 2000 cfs occur several times each year, and in many cases the flows exceed 5000 cfs.

CRITICAL FLOW VERSUS IMPOUNDMENT CAPACITY

Since essentially all mine drainage sources discharge directly into the West Branch, any effective stream restoration abatement treatment must process the full stream flow at whatever treatment locations might be selected. The flow at any point on the West Branch can be reasonably estimated on a proportional drainage area basis. The drainage areas for various critical locations on the Upper West Branch are shown in Figure III-6.

FIGURE III-6

DRAINAGE AREAS vs. STREAM POINTS - UPPER WEST BRANCH

STREAM POINT	DRAINAGE AREA (Sq. Miles)	% OF TOTAL AREA AT BOWER STATION	CRITICAL FLOW RATE	
			CFS	MGD
BAKERTON	4.0	1.27	25	16
WATKINS	7.6	2.41	48	31
SPANGLER	19.3	6.12	122	79
NORTH BARNESBORO	25.8	8.19	164	106
GARMANTOWN	34.0	10.79	216	139
CHERRY TREE	42.3	13.43	269	173
STIFFLERTOWN	61.6	19.5	390	252
MCGEES MILLS	140	44.4	888	573
BOWER STATION	315	100.0	2000	1290

Short duration high flows are conventionally controlled by impoundment dams to protect treatment plants from overload conditions. To explore the feasibility of this technique, the data for critical flow duration periods was first obtained from U.S.G.S. Survey reports for 1965 through 1970. This is summarized in Figure III-7. This data shows that since 1965, critical flows occurred during 12 three consecutive day periods, 2 four-day, 1 six-day and 1 eight consecutive day period.

FIGURE III-7

DURATION OF CRITICAL FLOW PERIODS
IN UPPER WEST BRANCH (1965-1970)

	NUMBER OF CRITICAL FLOW PERIODS 1/				
CONSECUTIVE DAYS DURATION	2 DAYS	3 DAYS	4 DAYS	6 DAYS	8 DAYS
YEAR					
1965-66	-	4	-	-	-
1966-67	3	-	1	-	1
1967-68	2	-	1	1	-
1968-69	2	2	-	-	-
1969-70	-	6	-	-	-

1. Critical flow is defined as 2,000 cfs or greater at Bower Station.

Calculations based upon this data, the critical flow values for various points from Figure III-6 and the design criteria specified for peak discharge capacity for flood control dams on Pennsylvania streams 10/ prove that impoundment dam facilities necessary for any reasonable size of treatment plant would require much greater acreages of reservoir area than are available at any point in the Upper West Branch flood plain. Because of this unfortunate geological condition, it becomes quite evident that any West Branch treatment plant would have to be designed to handle maximum full stream flow at any point if complete immediate downstream protection is to be provided.