

DENTS RUN
MINE DRAINAGE
POLLUTION
ABATEMENT PROJECT

PART OF
O P E R A T I O N S C A R L I F T

COMMONWEALTH OF PENNSYLVANIA

Milton J. Shapp, Governor

Department of Environmental Resources
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PROJECT NO. SL 161

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This report, prepared by outside consultants, has been, reviewed by the Department of Environmental Resources and approved for publication. The contents indicate the conditions that are existing as determined by the consultant, and the consultant's recommendations for correction of the problems. The foregoing does not signify that the contents necessarily reflect the policies, views, or approval of the Department.

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INTRODUCTION

A. DESCRIPTION OF STUDY:

The Department of Environmental Resources, formerly known as the Department of Mines and Mineral Resources of Pennsylvania, has authorized engineering surveys of various watershed areas to locate sources of pollution arising from abandoned deep mines and strip mines.

In December of 1970, the firm of Conable, Sampson, Van Kuren, Huffcut and Gertis was authorized to commence a watershed analysis of Dents Run, Elk County, Pennsylvania. The watershed analysis was initiated with a preliminary chemical analysis of small tributaries contributing to the Dents Run watershed. The polluted tributaries were identified and the contributing sources of pollution were isolated and analyzed. Twenty-five sources of pollution were cataloged and measured. It was calculated that mine sources contributed approximately fifty-six percent of the total average daily acid load.

Aerial photography was used to determine the exact location of the pollution sources and to determine quantities in mine refuse piles.

The study has been divided into three phases:

1. Phase I - The location and identification of pollution sources.

2. Phase II - Measurements of pollution sources for quality and quantity.
3. Phase III - The analysis of all acquired data implementation of the report and recommendation for abatement including projected costs.

The report covers all three phases of the study and further recommends a quick start program to be implemented immediately upon acceptance of the report.

B. PURPOSE:

The purpose of the study is to provide the information and recommendations necessary for the establishment and implementation of a program to abate mine drainage pollution in Dents Run Watershed. The determination of major sources of pollution, establishment of gauging stations, the analysis of all field and laboratory data and the subsequent recommendation on the elimination or practical reduction of pollutants will indicate to the Department of Environmental Resources a method to recreate an environment of economic and environmental benefit for all.

C. DEFINITION OF TERMS:

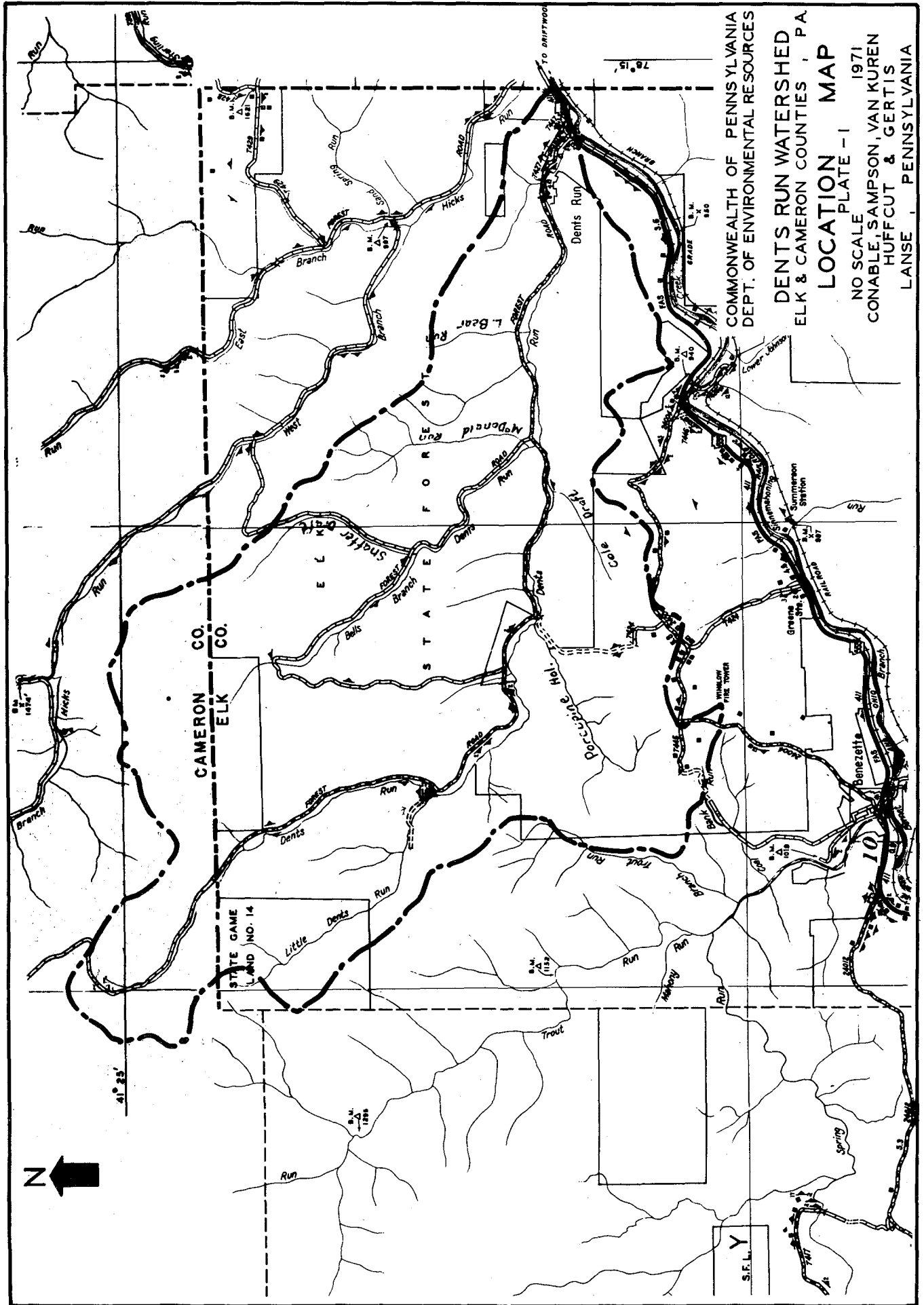
1. Major Source: A discharge of acid mine drainage during maximum flow which produces a daily acid load of at least 400 pounds.
2. Minor Source: A discharge of acid mine drainage during maximum flow which produces a daily acid load of less than 400 pounds.

3. Slugger: A source which produces a large acid load in a short span of time.
4. Slugging Index: The indicator for the potential of a source to produce a large acid load in a short span of time, i.e., a slugging index of two would mean that the acid load from a source during maximum flow was twice that for the average acid loading during the period of sampling.
5. Acid Load: Acid concentration in Lbs/Day determined by laboratory test results in mg/l multiplied by flow at the time of sampling.
6. mg/l: Milligrams per liter - equivalent to parts per million (ppm).
7. Pollution: Acid mine water discharged into Dents Run or a tributary thereto. Expressed quantitatively as acid load in Lbs/Day.
8. Priority Numbers: The priority number assigned to each pollution source is based on the amount of abatement of acid mine drainage for the Dents Run Watershed to be realized if the recommended reclamation project is performed.
9. Syncline: A downfold in a rock mass or the through-like part in a series of folds in a rock mass or strata.
10. Anticline: An upfold in a rock mass or an up-arched part in a series of folds in a rock mass or strata.

D. DESCRIPTION OF THE DENTS RUN WATERSHED:

1. Location and Description of Area: The area of concern comprises approximately 25.5 square miles located in Benezette Township, Elk County and is bordered on the west by Jay Township, on the north by Shippen Township and on the east by Gibson Township in Cameron County and on the south by Girard and Goshen Townships in Clearfield County. It is located approximately 12 miles southeast of St. Mary's and 23 miles north of Clearfield and encompasses a major portion of the northeast area of the township. Dents Run is a tributary to the Sinnemahoning Creek (Bennetts Branch) and located entirely in the Susquehanna River Basin. The elevation of Dents Run at the Bennetts Branch Railroad Station is 925.8 feet with the elevation of the headwaters at 2,240 feet. Plate 1 is a location map of the general area.

2. Topography: The Dents Run Watershed lies entirely within the Allegheny Plateau. The principal streams have eroded the region forming deeply cut valleys with very steep slopes. Smaller tributary streams generally formed by runoff have given similar characteristics to the smaller upland ranges. The hills are round topped and generally range from approximately 1,500 feet near Dents Run to 2,320 feet at the head lands of the watershed near Jordan Hollow.



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DENTS RUN WATERSHED
 ELK & CAMERON COUNTIES, PA

LOCATION MAP
 PLATE - I

NO SCALE
 1971
 CONABLE, SAMPSON, VAN KUREN
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 LANSE - PENNSYLVANIA

Dents Run flows in a generally southeast direction commencing at a point near the southwest corner of Cameron County and terminating approximately 9.5 miles southeast at the Village of Dents Run at Bennetts Branch.

The principal features of the topography of the project area are outlined on the Benezette Quadrangle Map.

3. Surface Drainage: The Dents Run drainage basin is an irregularly shaped area that is 5 miles wide at its widest point and approximately 9.5 miles long from its headwaters to the confluence with Bennetts Branch.

The area is drained by Dents Run, Little Dents Run and the tributaries Dark Hollow, Bell Draft, Shaffer Draft, McDonald Run, Little Bear Run, Porcupine Hollow and Cole Draft.

Original drainage pattern still exist throughout most of the vast area of this watershed except in the area of Porcupine Hollow.

Porcupine Hollow is heavily polluted by drainage from deep mine openings contributing flows from 1 GPM to 60 GPM. The water contributed from these deep mines has entered the pollution sources from crevices, sub-surface mine subsidence, percolation and some abandoned strip mine activity. These disrupted drainage channels have contributed to flows through existing mine refuse piles.

4. Geology:

a. Introduction:

Dents Run is located in the Appalachian Plateau Province of Pennsylvania and is 35 to 40 miles south of the furthest advance of the Pleistocene ice sheets. Gently dipping rock formations of Devonian, Mississippian and Pennsylvania age underlie the study area. The dominant rock types that occur within the area are sandstones, shales and siltstones with minor amounts of conglomerates, coals and underclays.

The total thickness of the rocks which outcrop in the drainage basin is about 1,250 feet. Some deep mining was performed from the early 1900's until World War II but strip mining has become the dominant means of mining for the last 25 years.

b. Stratigraphy:

The rocks underlying the study area consist of the "coal measures" and several other Paleozoic formations. It must be realized that a precise stratigraphic (rock) section is impossible to construct because of the thickness variations of some of the rock units, i.e., a sandstone may grade laterally into a shale within a few hundred feet. However, a generalized stratigraphic section (Figure 1) was constructed below to represent the approximate thickness and rock types found in the Dents Run area. In addition, a geologic cross-section (Figure 2) through the area was developed along the geologic section line as shown on Plate 2.

GENERALIZED STRATIGRAPHIC SECTION

SERIES	FORMATION	MEMBER	SECTION	CHARACTER OF MEMBER
PENNSYLVANIA	MIDDLE AND LOWER ALLEGHENY FORMATION	SHALE WITH SOME THIN BEDDED SANDSTONE AND SILTSTONE LOWER KITTANNING COAL (B' COAL OR DAGS) INTERBEDDED SANDSTONE AND SHALE FERRIFEROUS (FERRUGINOUS) LIMESTONE SHALE (HARD AND SOFT LAYERS)	60' - 80' 2' - 5.2' 18' - 20' 4' - 8' 35' - 45'	
	POTTSVILLE FORMATION	CLARION COAL (A COAL OR CLERMONT) HOMEWOOD SANDSTONE - PREDOMINANTLY A SANDSTONE WITH SOME INTERBEDDED SHALE UNDERCLAY AND SHALE (MERCER?) MIDDLE ALTON COAL (MERCER?) LOWER ALTON COAL (MERCER?) SANDSTONE WITH SOME SHALE AND SILTSTONE CONCENTRATED NEAR THE BASE GRAY SHALE LOWER MERCER COAL LOWER MERCER UNDERCLAY CONGLOMERATING SANDSTONE - COARSE AND MEDIUM GRAINED SANDSTONE	3' - 4.1/2' 40' - 60' 8' - 20' 8' - 20' 10' - 12' 1/2 - 2 1/2' 10' - 15' 0.1' - 1 1/2' 5' - 8' 3.5' - 40'	
MISSISSIPPIAN AGE	POCONO FORMATION	BURGOON SANDSTONE - SANDSTONE (MORE CONGLOMERATIC NEAR BASE) PATTON SHALE AND SILTSTONE - RED TO OLIVE GREEN SHALE AND SILTSTONE SANDSTONE - WHITE, COARSE GRAINED	60 55' 90'	
DEVONIAN	OSWAYO FORMATION	SILTSTONE AND SHALE WITH SMALLER AMOUNTS OF INTERBEDDED SANDSTONE SHALE, SILTSTONE AND SANDSTONE IN NEARLY EQUAL AMOUNTS, EXCEPT MORE OF THE SANDSTONE IS CONCENTRATED IN THE BOTTOM HALF OF THIS FORMATION. RED, OLIVE AND TAN ARE THE COLORS MOST CHARACTERISTIC OF THE FORMATION.	210' 323'	
	CATSKILL FORMATION	ONLY THE UPPER PORTION OF THIS FORMATION APPEARS IN THE AREA. IT IS DOMINANTLY A RED SHALE WITH SOME INTERBEDDED RED SANDSTONE AND SILTSTONE	200'±	



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DEPT. OF ENVIRONMENTAL RESOURCES
WATERSHED ANALYSIS S.-181
DENTS RUN WATERSHED
ELK & CAMERON COUNTIES, PENNA.
GENERALIZED STRATIGRAPHIC SECTION
1971
PLANS PREPARED BY
CONABLE, SAMPISON, YANKUREN
HUFFCUT & GERTIS
CONSULTING ENGINEERS LAND SURVEYORS
LANSE, PENNSYLVANIA

GENERALIZED STRATIGRAPHIC SECTION

<u>Map Symbol and Formation Name</u>	<u>Thickness</u>	<u>Rock Types and Descriptions</u>
Pa Middle and Lower Allegheny Formation (Penn. Age)	60' - 80'	Shale with some thin bedded sandstone and siltstone
	2' - 5' ⁺ ₋	<u>Lower Kittanning Coal</u> (B Coal) or Dagus
	18' - 20'	Interbedded sandstone and shale
	4' - 8'	Ferriferous (ferruginous) limestone
	3' - 4½' ⁺ ₋	Clarion Coal (A ¹ Coal or Clermont)
<hr/>		
Pp Pottsville Formation (Penn. Age)	40' - 60'	Homewood Sandstone - predominantly a sandstone with some interbedded shale
	1' - 2' ⁺ ₋	<u>Upper Alton Coal</u> (Mercer)
	8' - 10'	Underclay and Shale
	1' - 3' ⁺ ₋	<u>Middle Alton Coal</u> (Mercer)
	10' - 12'	Underclay and Shale
	½' - 2' ⁺ ₋	<u>Lower Alton Coal</u> (Mercer)
	40' - 50'	Sandstone with some shale and siltstone concentrated near the base
	10' - 15'	Gray Shale
	0' - 1' ⁺ ₋	<u>Lower Mercer Coal</u>
	5' - 6'	Lower Mercer Underclay
35' - 40'	Connoquenessing sandstone - conglomeratic sandstone to coarse and medium grained sandstone	

GENERALIZED STRATIGRAPHIC SECTIONS

(Continued)

<u>Map Symbol and Formation Name</u>	<u>Thickness</u>	<u>Rock Types and Descriptions</u>
Mp Pocono Formation (Miss. Age)	60'	Burgoon Sandstone - Conglomeratic to coarse grained sandstone (more conglomeratic near base)
	55'	Patton Shale and Siltstone - red to olive green shale and siltstone
	90'	Sandstone - white, coarse, grained
	210'	Siltstone and shale with smaller amounts of interbedded sandstone
<hr/>		
Doo Oswayo Formation (Dev. Age)	323'	Shale, siltstone and sandstone in nearly equal amounts, except more of the sandstone is concentrated in the bottom half of this formation. Red, olive and tan are the colors most charastic of the formation.
<hr/>		
Dck Catskill Formation (Dev. Age)	200' [±]	Only the upper portion of this formation appears in the area. It is dominantly a red shale with some interbedded red sandstone and siltstone.
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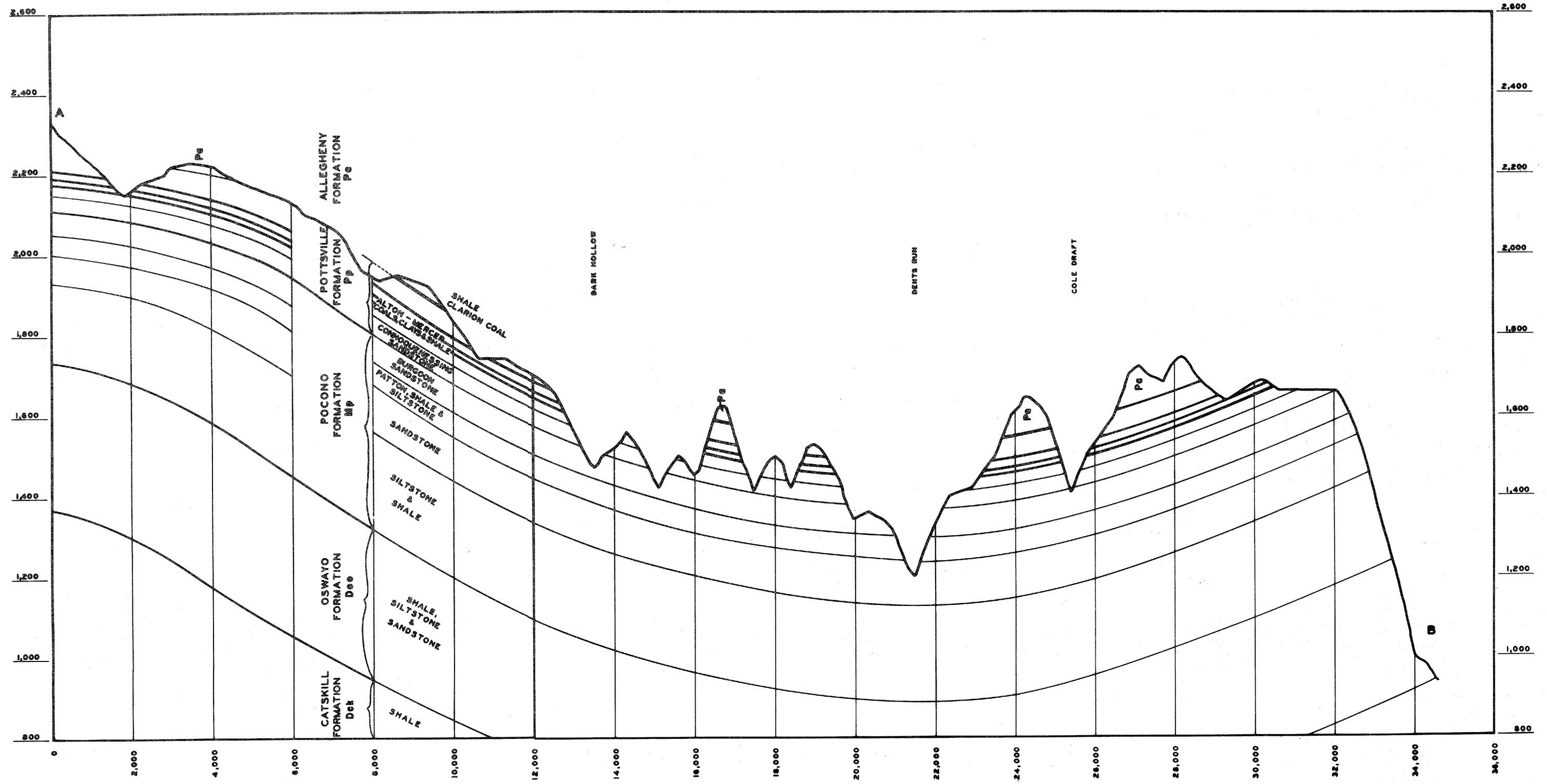
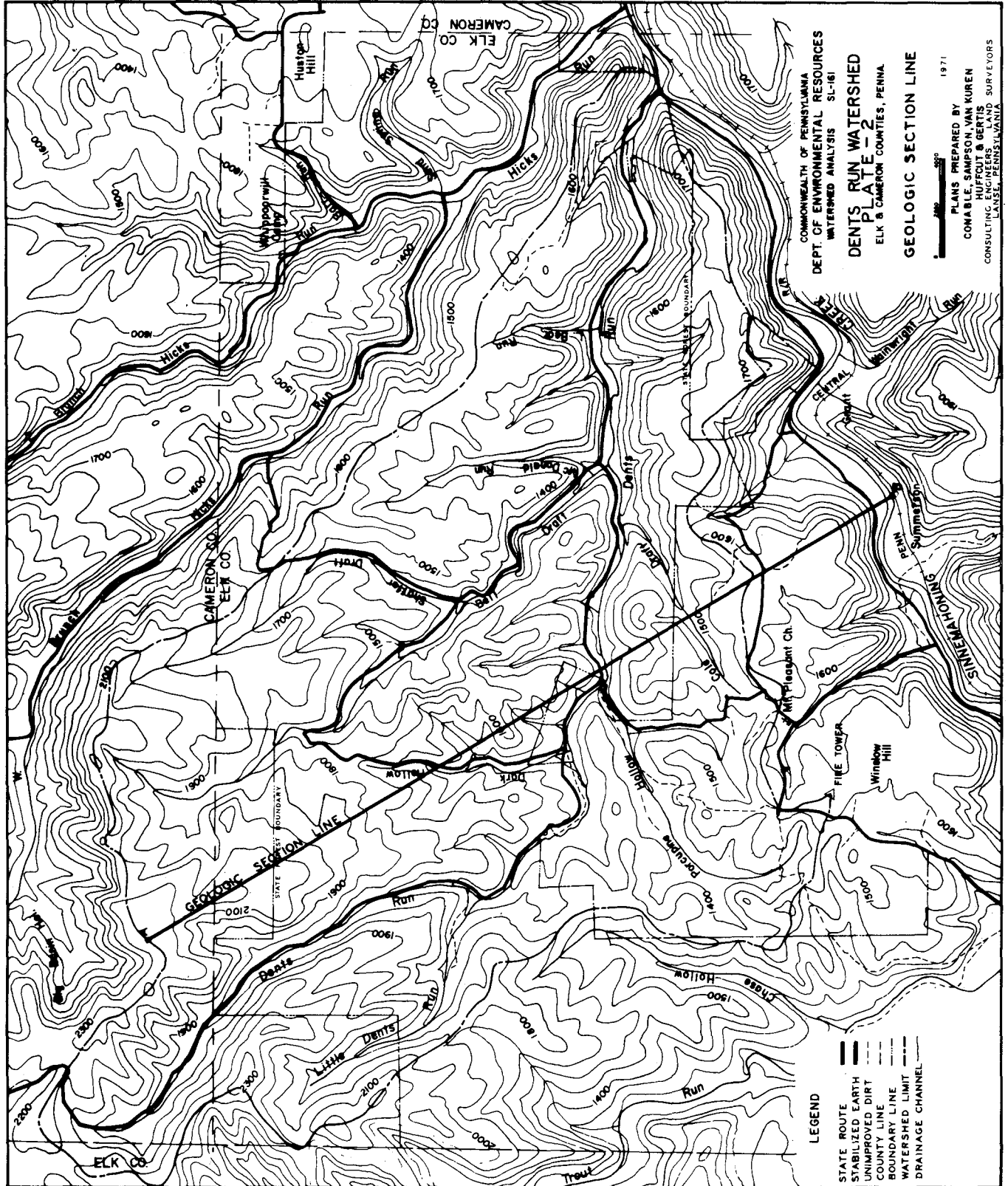


FIGURE - 2 GEOLOGIC CROSS SECTION



The main stream beds of Dents Run and Bell Draft are almost entirely confined to the Pocono formation, except in the lower two or three miles, where they traverse the Catskill and Oswayo formations. Several of the smaller tributaries in the downstream area of Dents Run also traverse the Pocono rocks.

Many of the other tributaries, including Porcupine Run, traverse the upper portion of the Pottsville formation which contains some coal seams. Some of the upper most portions of these tributaries find their origin in the coal strippings and old mine workings. Most of these are in the Allegheny formation.

During a field investigation of the study area, the Clarion coal seam and associated rocks were found to contain an extremely large amount of pyrite and marcasite. These iron sulfide minerals occur as lenses one to three inches thick and up to five feet long in the coal seams. In the overlying sandstones and shales, they occur in the form of concretions and segregations. Finely disseminated pyrite and marcasite are probably scattered throughout this rock sequence but are much more difficult to detect because of their fine grain size.

The spoil piles which contain the broken and shattered pyritic rocks present a tremendous increase in exposure of the surface area of these rocks. Oxygen in the air and

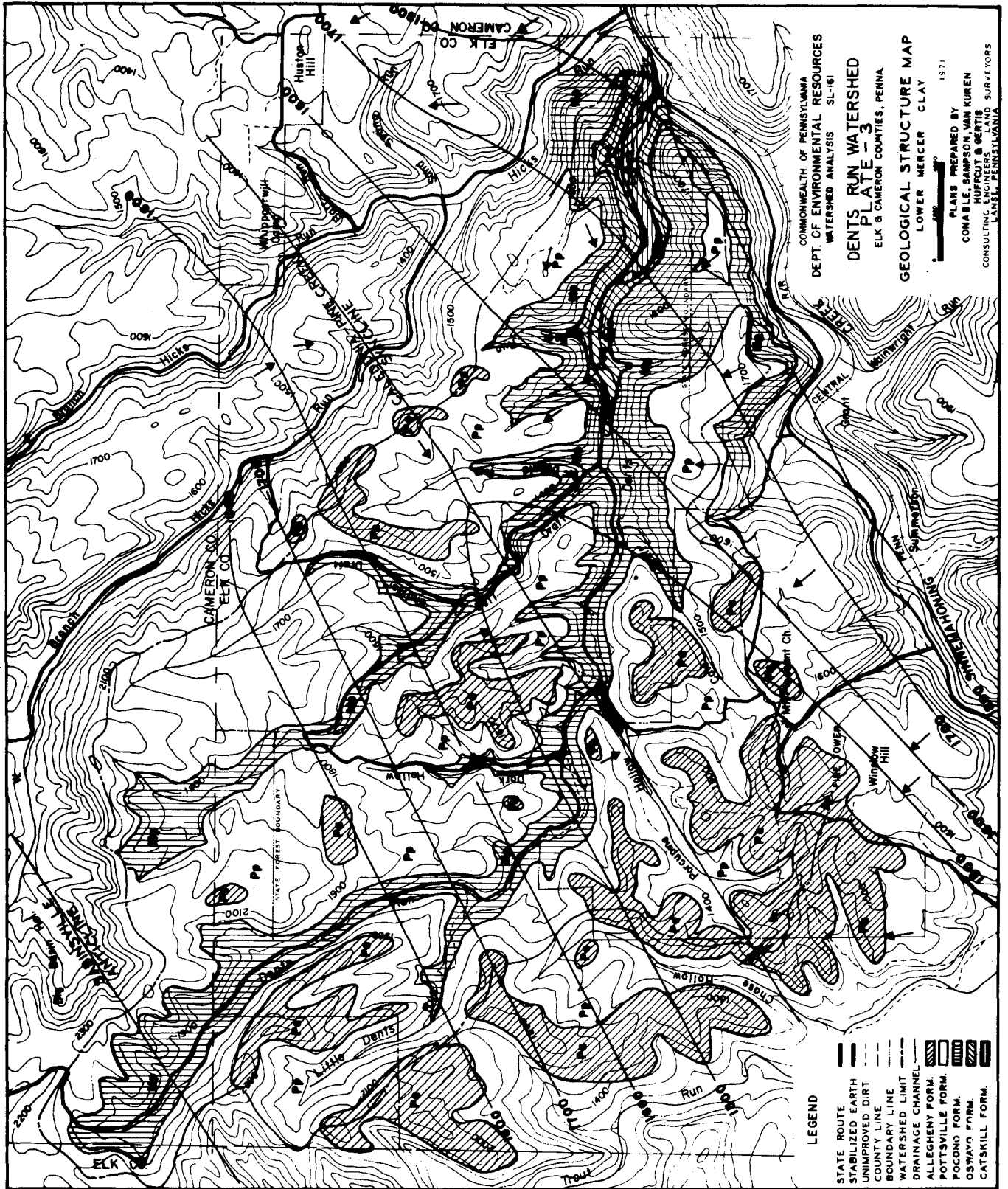
oxygenated waters percolating through the spoil piles cause the minerals to decompose into iron sulfate and sulfuric acid.

c. Geologic Structure:

The dominating structure throughout the area is the Caledonia Pine Creek Syncline (Plate 3). It is oriented in a northeast-southwest direction and plunges very slightly to the southwest. The limbs or flanks of the syncline dip at about 1° to 3° toward its center. Locally, dip angles can be as great as 4° or 5° . The Caledonia-Pine Creek syncline is slightly asymmetrical and seems to strongly influence the drainage in the Dents Run area. Its center nearly coincides with Porcupine Hollow.

Another major structure, the Sabinsville anticline, is located in the extreme northwestern portion of the study area. It also has a northeast-southwest trend and its southeastern flank dips at a very gentle angle toward the adjacent tributaries in the northwestern portion of Dents Run. Structure contours and dip direction arrows as seen on Plate 3 give more specific information for individual areas in the drainage basin.

It is interesting to note that many of the streams or segments of their tributaries northwest of the axis of the Caledonia Pine Creek syncline have a distinct trend parallel to the



regional dip. This seems to suggest that they are partially controlled by the underlying geologic structure, i.e., the southeastern regional dip and the associated joints that are parallel to it. It would be reasonable to expect that some of the subsurface drainage would also be deflected in this same direction by the joints and the dip of semi-impermeable beds in the rock sequence. Joints and north-westerly dipping beds southeast of Porcupine Hollow would also deflect the sub-surface drainage toward the center of the syncline. Porcupine Hollow, therefore, seems to serve as a collecting area for much of the sub-surface drainage from the rock sequence on either side of the hollow.

Small scale structures such as minor faults, local rolls, small flexures or folds, joints and fractures characterize the structure of the Appalachian Plateau. Some of these structures are responsible for local deviations in the regional dip and can also greatly influence local surface and sub-surface drainage conditions.

The study area is located beyond the general margin of the wrench fault zones of the Clearfield-Philipsburg area. However, some small faults having a displacement of a few inches to several feet are probably present within the area. They are extremely difficult to locate and map in heavily wooded areas such as Dents Run. Local rolls are

very small warps or bends in the generally flat-lying coal seams and underclays. They can be caused by ancient stream channel erosion of part of the sequence when it was deposited or by differential compaction of underlying and adjacent sediments. As a result, in the areas of local rolls, the coal and associated rocks appear to sag downward. Another cause of local variations in the dip is due to the fact that the regional structure is not always "smooth-flowing" but is periodically slightly crumpled or folded.

This results in local dip reversals and variation in the amount of dip from outcrop to outcrop. An example of this type of structure can be seen in the Catskill formation about 0.8 of a mile upstream from the mouth of Dents Run.

Joints are relatively smooth, well-defined linear breaks in the rocks. Normally, they are very steeply inclined to the bedding planes and occur as a repeating series of breaks along preferred directions. Very frequently these directions are nearly parallel to the dip and strike of the bedrock. Well developed joints can be easily seen along the road cuts in the lower portion of Wilmer Road and in the highwalls of the strip mines. Fractures are irregular, non-repeating cracks in the bedrock. They are naturally occurring in the bedrock of the study area. However, subsidence due to deep mining activity will cause excessive fracture development in the rocks immediately overlying the collapsed or partially collapsed mine.

d. Mining History:

Early mining activity in the Dents Run Area began in the latter quarter of the 1800's. It consisted of excavating small pits and short drifts which reached into the hillside from the outcropping coal.

In the early 1900's, extensive underground mining was developed in the area. The "room and pillar" method of mining was used to extract the coal.

Since the early 1940's, to the present time, the mining activity in the area has consisted of strip mining. This method of mining is highly efficient, practically recovering all of the coal but is usually restricted to coal with a rock cover of 50 to 100 feet thick.

In the study area, the Clarion and Lower Kittanning are the seams that have been extensively stripped. The Mercer (Alton) and a rider of the Clarion have only been stripped in a few selected areas. Strip mining has been largely confined to areas south of Dents Run, predominately in the Porcupine Hollow area. Some deep mining has occurred in this same area. Deep mining and some stripping operations have occurred in a small section north of Dents Run in the area east of Dark Hollow. There has been some attempt to seal this deep mine.

E. SURFACE - SUB-SURFACE WATER COMPLEX:

1. Surface Drainage: Surface drainage in some sub-regional tributary areas remains in an undisturbed state. The water tested at the sampling station respective to these areas was noted to be relatively pollution free. These areas have been noted and further described in other areas of this report.

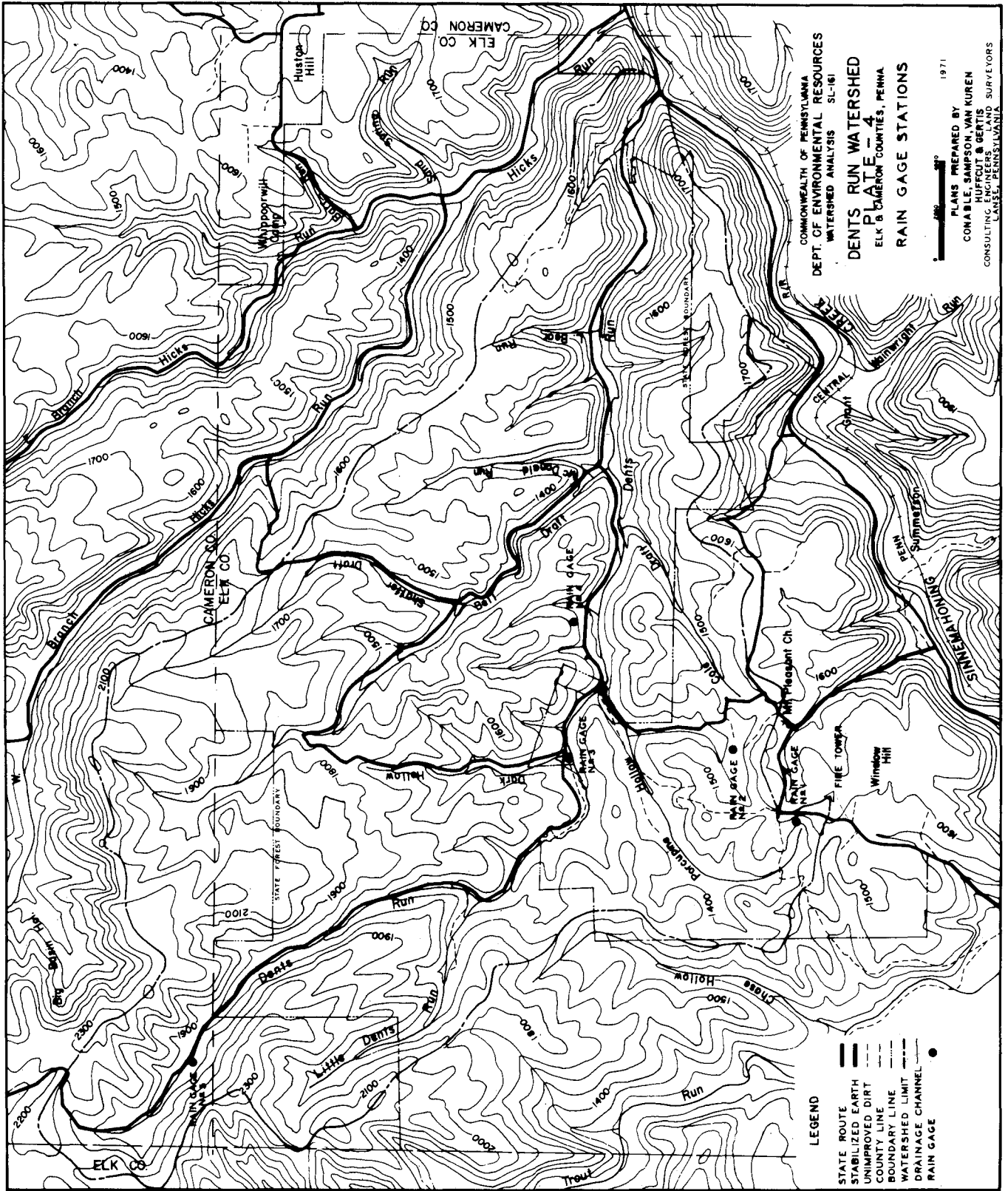
The surface drainage in other sub-regional tributary areas has been altered by extensive strip mining, some of which is inactive at this time and some active sites. Although the overland flow has been altered, the main tributaries are still the recipients of the sub-regional surface drainage. At present, the surface drainage in these areas does flow over some oxidized iron sulfide minerals in the mine refuse piles contributing to the formation of acid mine drainage.

2. Sub-Surface Drainage: The nature of the Caledonia-Pine Creek Syncline and the location, which nearly coincides with the run on Porcupine Hollow, is probably the strongest influence on the pollution content and major sources within the watershed. The underlying geologic structure would lead us to believe that certain sub-surface drainage will follow the semi-impervious layers which will contribute to the pollution at its outlet point. As stated before, the Porcupine Hollow area appears to serve as the collection point for sub-surface drainage.

3. Rainfall Correlation: In an attempt to correlate rainfall, surface drainage and sub-surface drainage, a period of rainfall and stream testing was initiated on a 24 hour basis with flow measurement taken at selected sampling stations and point rainfall stations within a given watershed area. Rain Gage Stations are shown on Plate 4.

The following chart represents rainfall in inches for a 24 hour period from September 11, 1971 to September 24, 1971:

DATE	RAINFALL IN INCHES - 24 HOUR PERIOD					REMARKS
	GAGE NUMBER 1	2	3	4	5	
9/12 to 9/13	1.210	1.200	1.380	1.325	1.225	
9/13 to 9/14	.325	.425	.275	.325	.400	
9/14 to 9/15	0	0	0	0		
9/15 to 9/16	0	0	T	T		
9/16 to 9/17	.725	.740	.810	.825	.875	
9/17 to 9/18	0	T	T	T	0	
9/18 to 9/20	.950	1.050	1.008	1.104	1.303	48 hrs
9/20 to 9/21	.110	1.300	.100	.105	.335	
9/21 to 9/22	0	0	0	0	0	
9/22 to 9/23	0	0	0	0	0	
9/23 to 9/24	0	0	0	0	0	



In establishing rainfall correlation, the area of each sub-regional watershed was calculated and the theoretical runoff for each was determined using the McMath (Empirical Approach) formula of $Q = Aci \sqrt[5]{sla}$ for 5, 10 and 50 year storm frequencies wherein:

i (5 year storm) = 3.4" for 20 minute storm

i (10 year storm) = 3.9" for 20 minute storm

i (50 year storm) = 5.1" for 20 minute storm

c = 0.70 (assumed)

A = area

S = average slope in feet per thousand

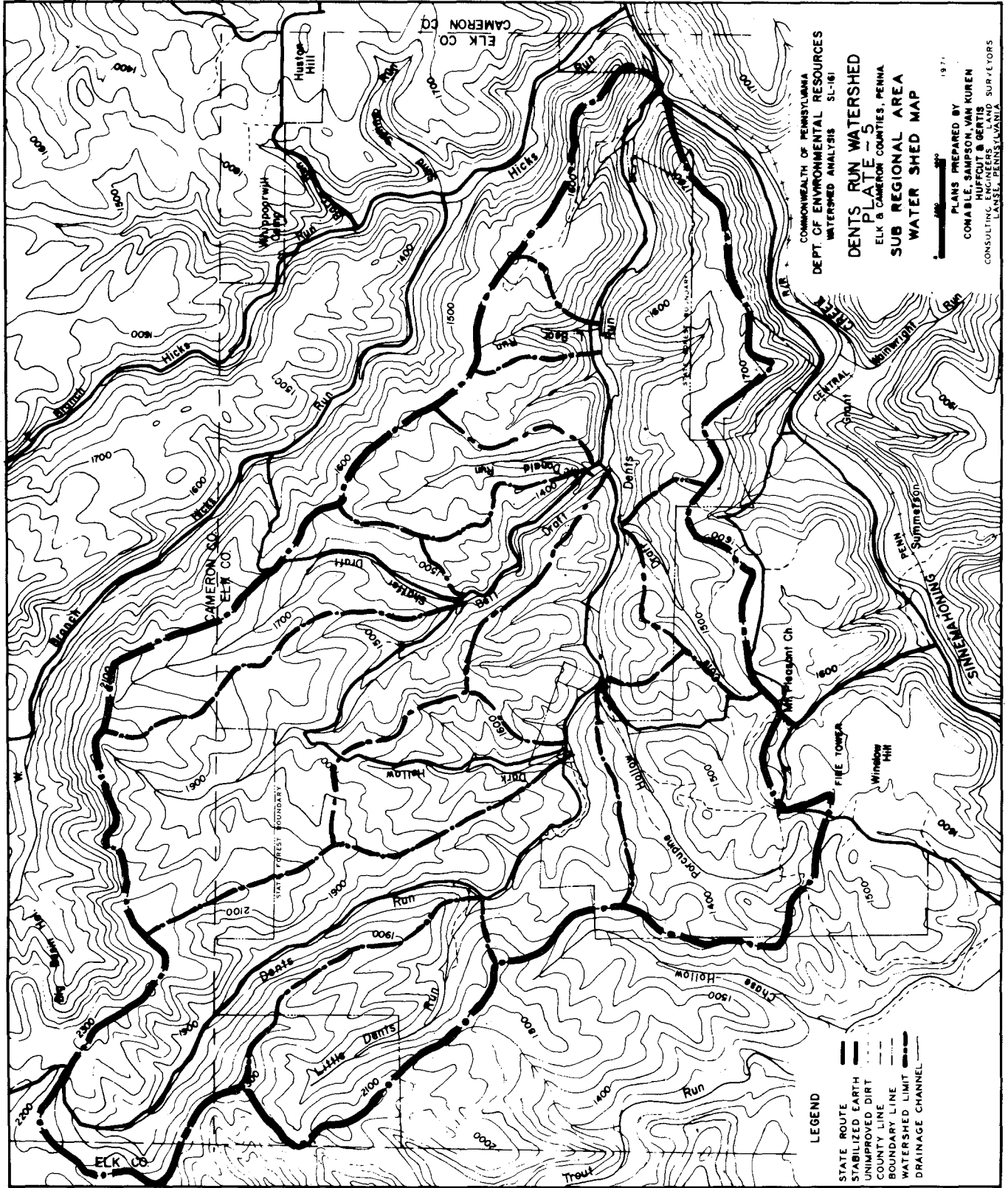
The period of September 12, 1971 through September 24, 1971 was selected for measurement and comparison purposes since this was the only period during the span of the study in which adequate rainfall conditions existed for this purpose. Measured increases in flows resulting from storms corresponded closely to the theoretical runoff quantities for each sub-regional area with the only appreciable variation occurring in the Porcupine Hollow sub-region. This can be accounted for by the fact that a relatively large percentage of the Porcupine Hollow area is barren due to strip mining and the assumed value for C of 0.70 is too low for this area.

The effects of the rainfall were immediately apparent in increased stream flow readings. Stream flow readings decreased beginning almost immediately after cessation of rainfall but required approximately seven days subsequent to the end of a heavy rainfall to return to flow levels prior to the storm. Similar results were apparent in discharges from abandoned deep mines. In all cases, flow during dry periods or periods of little rainfall were below average daily discharge but increased appreciably during and immediately following heavy rains stabilizing to below average within two to seven days upon cessation of heavy rainfall. Minimum flows from mine openings 101 and 102 were 64% of average flows and maximum flows were 293% of average flows. For mine openings 103 and 108 and 109, the respective minimum and maximum discharges were 73% and 116%, 61% and 275% and 85% and 139% of average discharges.

F. DESCRIPTION OF SUB-REGIONAL AREA WATERSHED TRIBUTARIES: 1.

Location Map - Plate 5.

2. Dents Run - Headwaters to Confluence with Little Dents Run: This area is a heavily wooded, mountainous area which is subdivided into seven minor drainage areas. This watershed area comprises approximately 2,105 acres of land with the major stream flow in a southeasterly direction.



Sampling Station Number 16 was set up to determine the quality of water disbursed by this watershed area. This watershed again appears to be in a natural, undisturbed condition with only a few hunting camps in evidence. An artesian well, which was noted as a possible pollution source, was labeled Sampling Station 16A and was periodically sampled and tested. It was mutually agreed between the Department of Environmental Resources and the firm of Conable, Sampson, Van Kuren, Huffcut and Gertis that because of the lack of pollution evidence in the chemical analysis that sampling points 16 and 16A be discontinued on a regular basis. There is evidence of an old abandoned narrow gauge railroad in this area located on the west side of Dents Run. An investigation into this area uncovered no evidence of previous mining activity.

3. Little Dents Run: Little Dents Run comprises approximately 1,220 acres of heavily wooded, mountainous topography subdivided into six minor drainage areas. The predominant direction of flow is in a southeasterly direction to intercept the main channel of Dents Run.

In February of 1971, Sampling Station Number 17 was set up to determine the quality of water collected by this watershed.

After a thorough investigation of this watershed area, it was determined that because of its undisturbed condition

and the complete lack of past and present mining history no further sampling at this point would be necessary. The chemical analysis confirmed this decision.

4. Shaffer Draft: The Shaffer Draft Watershed area is a tributary to Bell Draft and comprises approximately 1,035 acres of heavily wooded land of high relief. The major stream flow is in the southeasterly and southerly direction. This area falls entirely within the State Forest boundaries. One gas well, N884, is located in the watershed and is no longer active having been plugged and abandoned. Some gas distribution lines do traverse this area.

Sampling Station No. 8 was set up to monitor the quality of drainage from this watershed. Initial samples indicated an absence of pollution and weekly sampling was discontinued.

5. Mc Donald Run: The Mc Donald Run Watershed area contains approximately 715 acres and is a tributary to Bell Draft just upstream from the junction of Bell Draft with Dents Run. The flow is generally southerly and terrain is similar to that in Shaffer Draft. No visible evidence of pollution contribution exists within this watershed which was borne out by the initial chemical samples obtained at Sampling Station No. 7 and weekly sampling was discontinued.

6. Bell Draft: Bell Draft is the stream into which Shaffer Draft and Mc Donald Run discharge and, in addition, contains 2,820 acres of watershed area with the general direction of flow being southeasterly to its confluence with Dents Run. In its lower reaches, the terrain is in short relief with the stream flowing through a relatively narrow valley. Progressing upstream to the northwest, the watershed broadens and side slopes become less steep. The area is heavily wooded with some meadows having heavy ground cover of ferns and high grass. No visible pollution sources were found within this watershed which finding was correlated by chemical analysis of the flow at Sampling Station No. 6. Weekly sampling was, therefore, discontinued.
7. Dark Hollow: Dark Hollow is a smaller drainage area of approximately 851 acres with a broad valley bottom and less mountainous terrain. The slopes are less wooded in this area and the valley bottom is covered with a dense grass. This appears to be relatively unspoiled as far as pollution sources are concerned. There is evidence of one deep mine in this area with a refuse pile of about 100 cubic yards. Natural revegetation of the refuse pile is occurring and samples of pocketed runoff water in the area indicated that this refuse pile is not a source of pollution. The Consolidated Gas Company has two gas wells in this area labeled N697 and N657. Both wells are inactive and have

been plugged and abandoned. A 12" distribution line does traverse the head lands of this watershed and is shown on the map of Gas Wells and Distribution Lines in the Appendix.

Sampling Points 13 and 14 were established to determine the quality of this watershed. There was again a lack of any indication of major or minor pollution sources in this watershed. It was mutually agreed that Sampling Stations 13 and 14 be removed from the list of weekly samples and that they be tested very infrequently.

8. Porcupine Hollow: Porcupine Hollow lies in the extreme southwest portion of the Dents Run Watershed and contains approximately 1,668 acres. The flow into Dents Run is in a northeasterly direction and Porcupine Hollow discharges into Dents Run about midway between Dark Hollow and Cole Draft. Porcupine Hollow contributes approximately 24% of the average daily flow in Dents Run but is responsible for 94% of the pollution. The terrain varies from grassy meadows to heavily wooded, steeply sided slopes, ten abandoned deep mine openings are present with six of them discharging appreciably measurable flows of severe pollutants. In addition, extensive strip mining has been conducted in the area with a total of approximately 425 acres having been strip mined and of this total approximately 200 acres are actively strip mined at this time. Some of the older strip mine areas have been exposed to revegetation of varying degrees of success but the regrading

of some of the old strip mines was done in such a manner as to leave high banks, low banks and benches which collect surface water which is ultimately discharged as a polluting agent. Sampling Stations 21, 23, 24 and 25 were established in Porcupine Hollow for the purpose of obtaining chemical analyses and stream flow measurements. Stations 23 and 25 were on Porcupine Run, a small tributary to Porcupine Hollow. Station 24 was on Porcupine Hollow upstream from the intersection of Porcupine Run and Station 21 was on Porcupine Hollow downstream from the intersection of Porcupine Run just prior to the confluence of Porcupine Hollow with Dents Run.

9. Cole Draft: Cole Draft flows in a northeasterly direction discharging into Dents Run upstream from Bell Draft and drains an area of approximately 582 acres. Sampling Station 28, at the confluence of Cole Draft with Dents Run, was established for chemical analysis and flow measurements. The terrain is generally heavily wooded with steep side slopes. Approximately 90 acres of the upper reaches are old strip mine areas where some attempt has been made at revegetation but without appreciable success. Chemical analysis at Station 28 reveals moderate to heavy pollution of this stream with flows varying from less than 20,000 gallons per day to over 2 million gallons per day. The apparent source of pollution is the strip mine workings. No deep mine evidence was found in this watershed.

10. Little Bear Run: Little Bear Run contains approximately 337 acres of densely wooded, extremely steeply graded watershed discharging into Dents Run downstream from Bell Draft. Little Bear Run flows almost due south and there is no visible evidence of mine activity, past or present, and the results obtained at Sampling Point 3 which was established for this area revealed water of acceptable quality and sampling on a regular basis was discontinued.

G. METHODS OF STUDY

1. Collection of Sample:

- a. Samples were collected weekly at all sources and weir locations in plastic bottles provided by the testing laboratory. Weir locations and sampling points are shown on Plate 6 at beginning of Appendix D.
- b. All samples were analyzed in the laboratories of Seewald Laboratories of Williamsport, Pennsylvania.
- c. The field study was carried out by a two man team during the months of March through September, 1971.

2. Engineering Investigation:

- a. An on-site investigation was made by two principals of the firm to determine the location of pollution sources and determine the condition of associated strip mine, deep mine opening, subsidence.

- b. Aerial photography was taken to determine volumes of mine refuse pile and areas of strip mine activity and disrupted drainage patterns.
 - c. Deep mine maps and strip mine maps were obtained where possible to pinpoint sources of pollution and to give us the information needed to establish structure contours. These structure contours are necessary to determine the direction of sub-surface flow for the deep mines.
 - d. Sampling station and weirs were constructed in the streams to measure high and low flows throughout the sampling period as well as a laboratory analysis of the samples.
 - e. Agencies and individuals were contacted for any maps or information on the abandoned deep mines.
3. Laboratory Analysis:
- a. pH - This was analyzed by the glass electrode method as described in Standard Methods for the Examination of Water and Waste Water (12th Edition).
 - b. Acidity - This test was performed in accordance with ASTM Standards as modified by FWPCA. A 50 ml sample is boiled for two minutes. The sample is titrated with a 0.2 (N/50) normal sodium hydroxide solution using a phenolphthalein indicator to a pink color and end point of pH, as measured continuously by a temperature compensated pH meter. The results are expressed as mg/l of calcium carbonate as acidity.

- c. Alkalinity - This test is determined in the laboratory by titrating a 50 ml sample with .02 normal sulfuric acid down to an end point of pH 4.5. The results are expressed as mg/l of calcium carbonate as alkalinity.

- d Sulfates - The barium sulfate turbidimetric method is used to determine the concentration of sulfate ions in the acid mine water. Barium sulfate is precipitated under controlled conditions which stabilize the suspension. The suspension is placed in a light-cell and the results are read as milligram per liter of sulfate on a photometer.

- e. Iron - The iron content is determined by the phenanroline method. An orange color develops in the presence of iron. The concentration of iron is measured in milligram per liter.

H. SOURCES OF INFORMATION

The information necessary to study the Dents Run Watershed was acquired from various sources.

Information relative to climate conditions and precipitation was acquired by field data and from the Department of Commerce, U. S. Weather Bureau.

Past studies and recommendations were acquired from the U. S. Army Corps of Engineers.

Coal Mine Maps were acquired from John Hess, P.E., Pennsylvania Department of Forest and Waters, Pennsylvania Game Commission, U. S. Bureau of Mines, P & N Coal Company.

Surveys were acquired from field data and aerial photography taken by Conable, Sampson, Van Kuren, Huffcut & Gertis.

Information was also obtained from people who live and work in this area.

J. RESULTS OF STREAM FLOW ANALYSIS

Field data and laboratory analysis yield the following daily maximum, minimum and average values:

<u>1. DENTS RUN:</u>	<u>MAXIMUM</u>	<u>MINIMUM</u>	<u>AVERAGE</u>
Flow-Gals/Dday	17,902.0000	909,000	4,382,600
pH	3.8	2.9	
Acid Load-Lbs/Day	9,785	1,230	3,386
Iron-Lbs/Day	343	7	101
Sulfate-Lbs/Day	31,468	4,147	12,663
<u>2. PORCUPINE HOLLOW:</u>	<u>MAXIMUM</u>	<u>MINIMUM</u>	<u>AVERAGE</u>
Flow-Gals/Day	2,090,000	339,000	849,300
pH	3.0	2.5	
Acid Load=Lbs/Day	10,860	1,748	4,083
Iron-Lbs/Day	1,220	121	488
Sulfate-Lbs/Day	30,503	1,418	12,248

<u>3. Porcupine Run:</u> (Station 23)	<u>MAXIMUM</u>	<u>MINIMUM</u>	<u>AVERAGE</u>
Flow-Gals./Day	856,000	42,000	220,500
pH	3.7	2.9	
Acid Load-Lbs/Day	1,130	3	186
Iron-Lbs/Day	113	.1	11
Sulfates-Lbs/Day	4,523	20	904

<u>4. Cole Draft:</u> (Station 28)	<u>MAXIMUM</u>	<u>MINIMUM</u>	<u>AVERAGE</u>
Flow-Gals/Day	2,181,000	14,000	313,100
pH	6.4	3.8	
Acid Load-Lbs/Day	760	17	187
Iron-Lbs/Day	14	.01	2.2
Sulfates-Lbs/Day	7,093	115	1,238

5. Dents Run upstream from confluence with Porcupine Hollow and Porcupine Run (Station 20).

<u>Dents Run:</u>	<u>MAXIMUM</u>	<u>MINIMUM</u>	<u>AVERAGE</u>
Flow-Gals/Day	9,591,000	212,000	1,816,000
pH	6.6	4.9	
Alkalinity-Lbs/Day	797	7(0)	195
Iron-Lbs/Day	23	.1	5
Sulfates-Lbs/Day	4,799	88	717

Individual readings from which the above was developed appear on the Data Sheets in Appendix E.