STREAM QUALITY EVALUATION

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General Discussion

Downstream from the origin and point source of discharge, mine drainage becomes a pollution problem identified with the water quality of rivulets, tributary streams, and the main receiving stream. The degree to which the receiving body of water is affected depends upon many variables including the extent and kinds of mining operations, types and volumes of mine water, availability of alkaline streams, rainfall, and watershed drainage characteristics. Viewed as a water pollution problem, a mine drainage investigation includes a study of stream conditions to help in assessing the magnitude of the problem and evaluate the pollution affect in terms of overall water resources of the area.

With this objective in mind, the water quality in the Slippery Rock Creek Study Area was sampled periodically throughout the 1969 study and tested for pH, acidity, alkalinity, iron and sulfates. Sampling stations were established near the mouths of all the major tributaries as well as at suitable intervals along the main stem to determine the effect of drainage from each sub-watershed and the resulting water quality profile for Slippery Rock Creek. An attempt was also made to characterize stream flow in the Study Area through discharge measurements and time of travel determinations.

Sampling points pertinent to a presentation of the water quality investigation are shown on the Location Map, Figure 12. Stations were designated by numbers and/or names. The numbers 1-29 indicate stream sampling points, while names are used to designate locations which refer to stream flow studies. Specific locations for all stations are referenced to roads and bridges in Table 13.

The criteria used for classifying streams as acid, alkaline, or variable is given below. The colors used to illustrate these conditions on the High Flow (Plate 3) and Low Flow (Plate 4) Schematics are also indicated.

Red = Predominantly Acid = Acidity greater than alkalinity, pH less than 5.0.
Green = Predominantly Alkaline = Net alkalinity greater than 40 ppm, pH greater than 7.5.
Yellow = Variable = Net alkalinity less than 40 ppm, (approximate pH range 5.0 - 7.5).

High and Low Flow Schematic representations of water quality with regard to acid, alkaline, and variable conditions are shown on the foldout maps (4000' = 1") in the envelope attached to this report.

Major Findings

The Study Area as pertains to this project involves about two thirds of the total watershed and 37 miles of the main stream from the headwaters to Rose Point, including 17 major tributaries. Stream study procedures involved acquisition and analysis of data concerning water quality, stream flow and rainfall. The basic data obtained are given in Appendix A, chemical analyses for stream sampling stations 1-29 and Appendix B, monthly precipitation records.

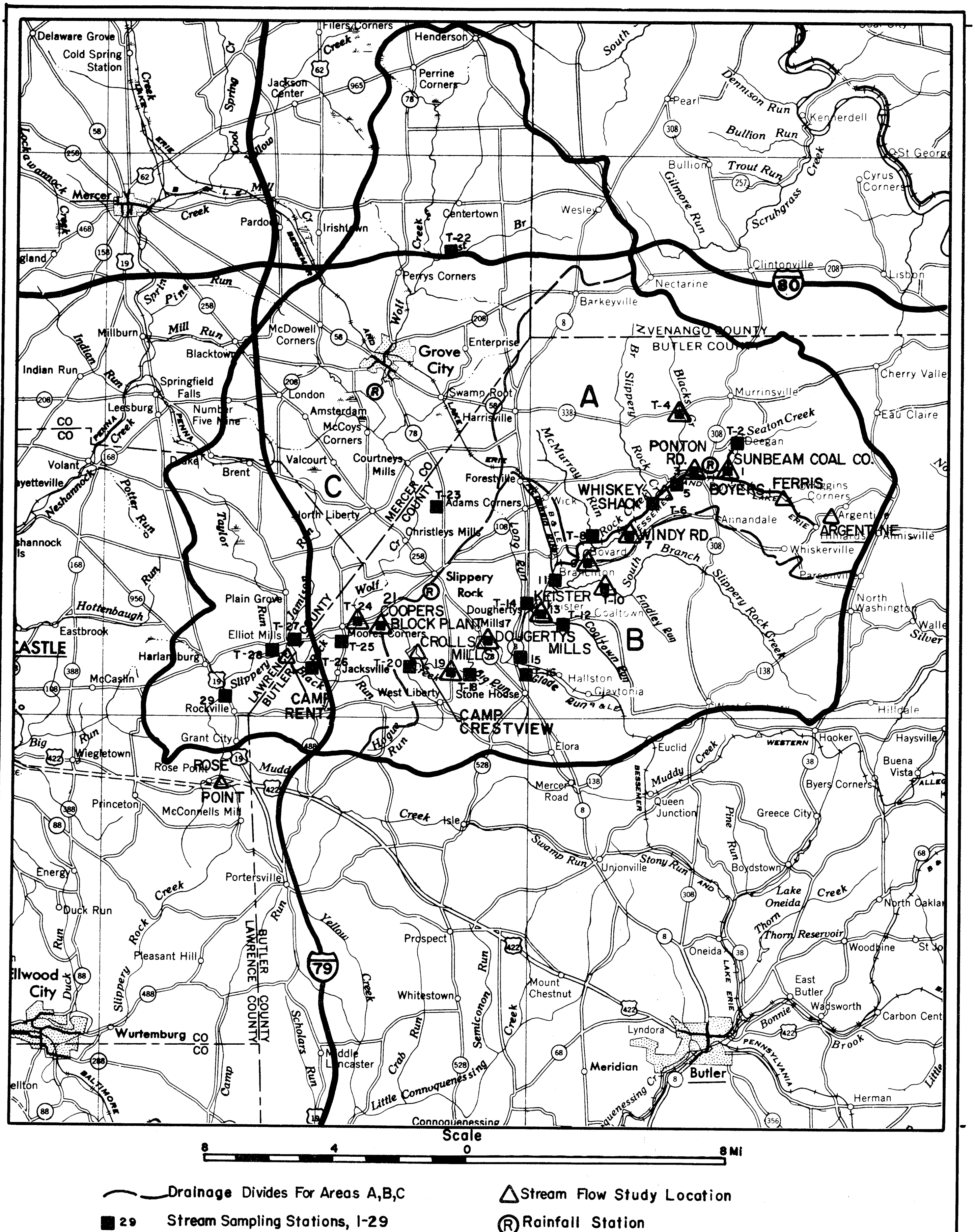
The major findings of the investigation can be summarized as follows:

1. The most severe condition of coal mine drainage is found in the Slippery Rock Creek Headwaters – Seaton Creek Area. Indeed, very little drainage from this region is produced exclusive of contact with, or issuance from mine workings.

2. The main stream was found to be acid for a length of 12 miles from the headwaters to Bovard. Neutralization and a substantial gain in alkalinity, i.e. greater than 40 mg/l, was determined to occur only after the confluence with Wolf Creek.

3. Three tributaries exhibit acid characteristics. Previously mentioned Seaton Creek is consistently acid, while Big Run and Glade Run are predominantly so, but neutral on occasion. North Branch, Blacks Cree, and Hogues Run are generally neutral. The remaining tributaries can be classified as alkaline or variable alkaline – neutral.

4. Base flow for the Slippery Rock Creek Drainage system at Rose Point was determined to be 80 c.f.s. (September 17-19, 1969). Stream flow, relatively constant (approx. 25 c.f.s.) for 14 miles above the confluence with Wolf Creek, is slightly more than doubled (60.5 c.f.s.) with the addition of Wolf Creek. Neutral water quality was found to exist at the Bovard Station during this low flow period.



LOCATION MAP

Fig. 12

Table 13

Stream Sampling Locations
Slippery Rock Creek and Major Tributaries

	Station No.	
	1	SRC-upstream from Seaton Cr. Rt. 10070 Bridge
T	2	Seaton Cr. near mouth
	3	SRC-downstream from Seaton Cr. Ponton's Road-Private-0.5 miles West of Boyers
T	4	Blacks Creek near mouth Rt. T560 Bridge
	5	SRC-Atwells' Crossing - 10070 Bridge
T	6	North Branch of SRC - near mouth - Rt. T535 Bridge
	7	SRC-downstream from North Branch T428 Bridge Windy Road
T	8	McMurray Run near mouth T428 Bridge
	9	SRC-downstream from McMurray Run - 10068 Bridge at Bovard
T	10	South Branch of SRC - T426 Bridge
T	11	McDonald Run near mouth - 10068 Bridge at Branchton
T	12	Coaltown Run near mouth - T526 Bridge
	13	SRC-downstream from Coaltown Run - 10064 Bridge at Keisters
T	14	Long Run near mouth - Camp Bucoco
	15	SRC-downstream from Long Run - T424 Bridge Wadsworth Bridge Rd. at Keisters
T	16	Glade Run near mouth - Culvert Rt. 8
	17	SRC-downstream from Glade Run - Rt. 173 Bridge at Doughertys Mills
T	18	Big Run near mouth - T368 Bridge
	19	SRC-downstream from Big Run - 10101 Bridge at Crolls Mills
T	20	Hogue Run near mouth
	21	SRC-downstream from Hogue Run - T366 Bridge near Cooper Block Plant
T	22	East Branch of Wolf Creek near mouth
T	23	Unnamed tributary to Wolf Creek - Rt. 173 at Armstrong
T	24	Wolf Creek near mouth - Rt. 108 Bridge.
	25	SRC-downstream from Wolf Creek - 488 Bridge near Moores Corners
T	26	Black Run near mouth - T377 Bridge
T	27	Jamison Run near mouth - Rt. 108 Bridge at Elliotts Bridge
T	28	Taylor Run near mouth - Rt. 108 Bridge
	29	SRC-downstream from Taylor Run - Rt. 19 Bridge

SRC = Slippery Rock Creek

5. Stream discharge measurements for October 22-24 showed an increase in flow at Rose Point to 148 c.f.s. coincident with an average rainfall of 1.24" for the area. Water quality analysis at Bovard for this flow revealed acid conditions.

6. Time of travel determinations using a fluorescent dye tracer (Rhodamine BA) indicated low mean velocities for Slippery Rock Creek, i.e. less than 0.5 f.p.s. for discharge of 108 c.f.s. at Rose Point.

7. The average rainfall for the Study Area for the 1969 study period was 37.47 inches, near normal precipitation for this region.

8. The highest average monthly rainfall occurred in April, 4.40 inches; the lowest was 0.40 inches recorded in February.

9. The highest monthly rainfall was measured at the Boyers location, 5.5 inches; for August, the lowest amount of precipitation occurred also at Boyers, 0.2 in February.

10. The distribution of rainfall from station to station was found to vary significantly, while the average rainfall for the area was rather evenly distributed throughout the year April through December. The exceptions were February and March which had little precipitation, 0.40 and 1.10 inches respectively.

The discussion which follows will examine the water quality in Slippery Rock Creek, from the headwaters to Rose Point on the basis of three chemically different reaches, geographically defined as follows:

A - Slippery Rock Creek Headwaters to Bovard including the area, streams, tributaries and the main stem which make up the drainage system to the Bovard Station.

B - Slippery Rock Creek, Bovard to Wolf Creek inclusive of the Watershed downstream of drainage divide A to the confluence with Wolf Creek.

C - Slippery Rock Creek and Wolf Creek from confluence to Rose Point.

Table 14 lists the tributaries associated with these three drainage areas and indicates the general water quality observed for each stream during the study. It can be noted from this table that the study area contains almost fifty miles of acid affected streams.

Stream Quality Profiles

The results of five surveys showing water quality profiles for the main stream with regard to mine drainage chemical parameters are presented in Figures 16 through 20. The following is a brief description of the stream quality found in each of the sub-reach areas.

Area A - Slippery Rock Creek above Bovard drains 68.6 square miles by way of four tributary watersheds, the headwaters and twelve miles of main stream. Of the four tributary streams, one - McMurray Run, was found to be consistently alkaline. North Branch and Blacks Creek were identified as having chemically neutral waters near their points of confluence with the main stream, thereby reducing their beneficial effect to one of dilution, with little in the way of neutralization capacity.

Seaton Creek is the lone acid tributary, joining with the main stem at a point 4.39 miles downstream at Argentine. The chemical quality of Seaton Creek and the Slippery Rock Creek - main stem above Seaton shows nearly identical analysis with average acidities of 50 mg/l. The stream bottoms of both branches are covered with deep deposits of iron sludges as visual evidence of water originating from heavily mined areas. The beginnings of Slippery Rock Creek together with Seaton comprises a drainage area of 26.78 square miles, or about 38.6% of Area A. The resulting water quality for the entire drainage system as measured at Bovard is in the variable range from slightly acid to acid.

The Water Quality Profiles for individual surveys indicate that stream conditions above Bovard were acid in all the test runs.

Area B - The 15.48 miles of stream from Bovard, Station 9 to Station 21, (near Cooper's Block Plant) were classified according to our study results as variable water quality. While alkalinity was predominant in this reach, the buffering capacity was limited and unstable. The sampling point at Station 21, immediately upstream (.36 mi.) of Wolf Creek was established to determine the water quality attributable to watershed and mine drainage conditions prior to the sizable Wolf Creek flow increment. Chemical analysis for this station determined an average alkalinity of 21 ppm, less than the natural background alkalinity present in unaffected parts of the watershed.

Table 14

Characteristics Of Major Tributaries And Sub-Reaches Of Slippery Rock Creek

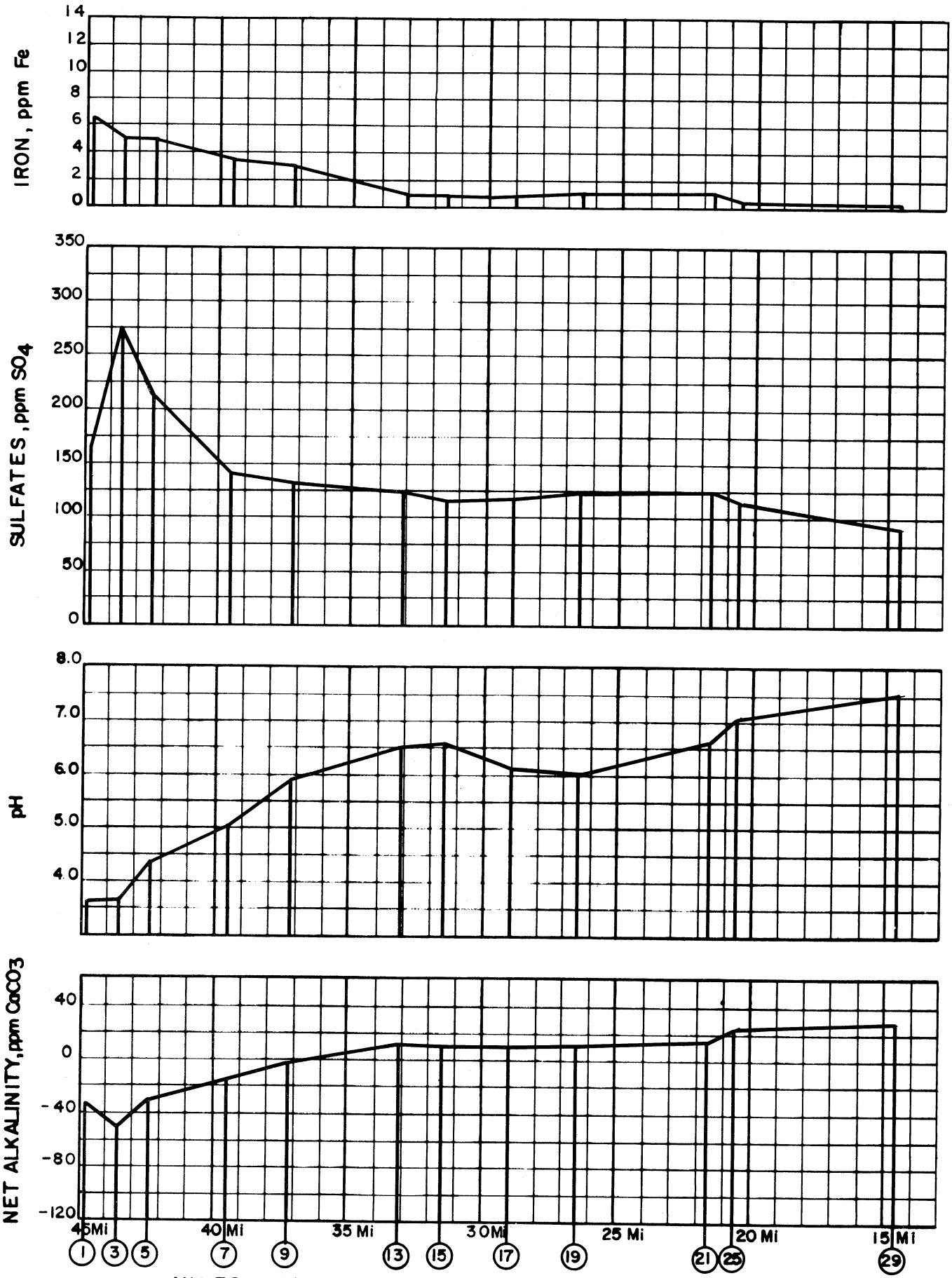
Sub-Reach Drainage Area Of Slippery Rock Creek	Tributary Or Main Stream Reach	Drainage Area Sq. Mile	General Water Quality	Miles Of Acid Affected Stream
A Drainage Area Above Bovard		(68.6)		
	Seaton Creek	10.1	Acid	6.0
	Blacks Creek	8.7	Variable	3.5
	North Branch	15.8	Variable	-
	McMurray Run	12.8	Alkaline	-
	SRC, Bovard to Headwaters	21.2	Acid	14.4
B Drainage Area Above Confluence With Wolf Creek To Bovard		(88.0)		
	South Branch	39.0	Variable	3.1
	McDonald Run	3.8	Alkaline	-
	Coaltown Run	2.9	Variable	-
	Long Run	3.9	Alkaline	-
	Glade Run	7.9	Variable-Acid	4.8
	Big Run	7.2	Variable-Acid	2.7
	Hogue Run	7.7	Alkaline	-
	SRC, Wolf Creek to Bovard	15.6	Variable	10.7
C Drainage Area Wolf Creek And SRC From Confluence With Wolf Creek To Rose Point		(151.1)		
	Wolf Creek	98.9	Alkaline	-
	East Branch Wolf	-	Variable-Acid	4.2
	Black Run	7.3	Alkaline	-
	Jamison Run	12.9	Alkaline	-
	Taylor Run	11.9	Alkaline	-
	SRC, Rose Point to Wolf Creek	20.1	Alkaline	-

Table 15

Locations For Stream Flow Studies
And Results Of Stream Discharge Measurements

Station No.	Station Name	Location	Distance From Mouth Miles	Discharge Cfs 1969 Sept. 17-19	Discharge Cfs 1969 Oct. 22-24
---	Argentine	T 637 Bridge	48.70	-----	-----
---	Ferris	2.65 miles downstream from Argentine	46.05	-----	-----
1	Sunbeam Coal Co.	SRC-upstream from Seaton Creek 10070 Bridge	44.72	3.04	13.20
---	Boyers	0.4 miles upstream from Rt. 308 Bridge	44.05	-----	-----
3	Ponton Road	0.5 miles downstream from Boyers	43.55	6.37	20.40
T 4	Blacks Creek	T 560 Bridge - near mouth of Blacks Creek	-----	1.39	4.17
---	Whiskey Shack	2.5 miles downstream from Boyers	41.18	-----	-----
T 6	North Branch	T 539 Bridge - near mouth of North Branch	-----	2.92	6.46
7	Windy Road	SRC-downstream from North Branch T 428 Bridge	39.51	10.60	34.00
9	Bovard	SRC-downstream from McMurray Run - 10068 Bridge	37.18	15.40	34.10
T10	South Branch	T 426 Bridge - near mouth of South Branch	-----	5.86	22.00
15	Keisters	SRC-downstream from Long Run, T 424 Bridge	31.51	24.60	74.40
17	Doughertys Mills	SRC-downstream from Glade Run, Rt. 173 Bridge	28.99	-----	-----
19	Crolls Mills	SRC-downstream from Big Run, 10101 Bridge	26.46	-----	-----
---	Camp Crestview	SRC, T 372 Bridge	23.69	25.10	86.50
21	Cooper's Block Plant	SRC, T 366 Bridge (Barron Rd.)	21.70	25.80	66.21
T24	Wolf Creek	Rt. 108 Bridge near mouth of Wolf Creek	-----	26.40	41.40
---	Camp Rentz	SRC, T 485 Bridge (McMurray Rd.)	16.95	60.50	117.00
---	Rose Point	800' above Rt. 422 Bridge	11.25	80.00	148.00

NOTE: SRC = Slippery Rock Creek

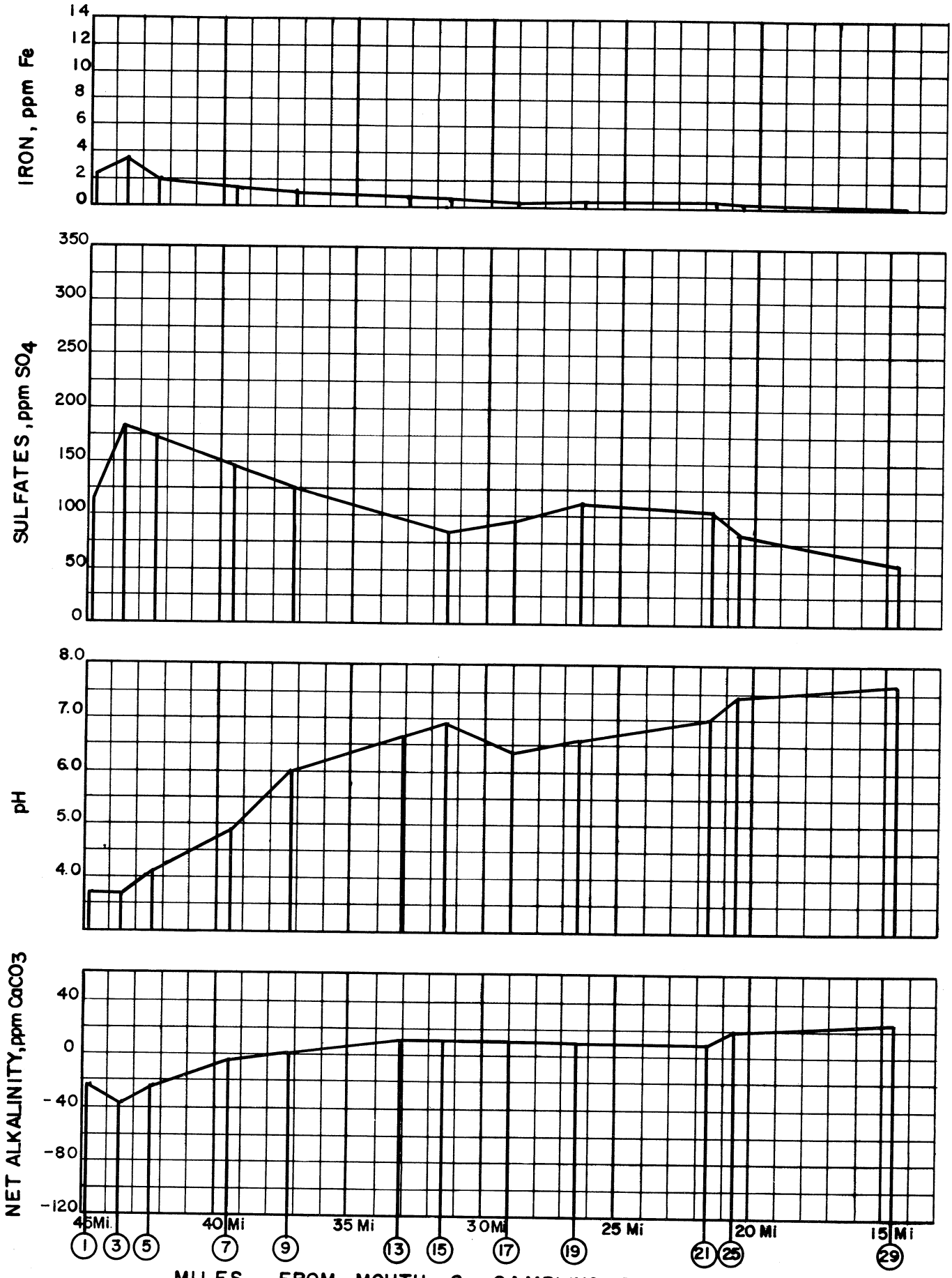


JANUARY 29, 1969

WATER QUALITY PROFILE - SLIPPERY ROCK CREEK

SLIPPERY ROCK CREEK WATERSHED

FIG. 16

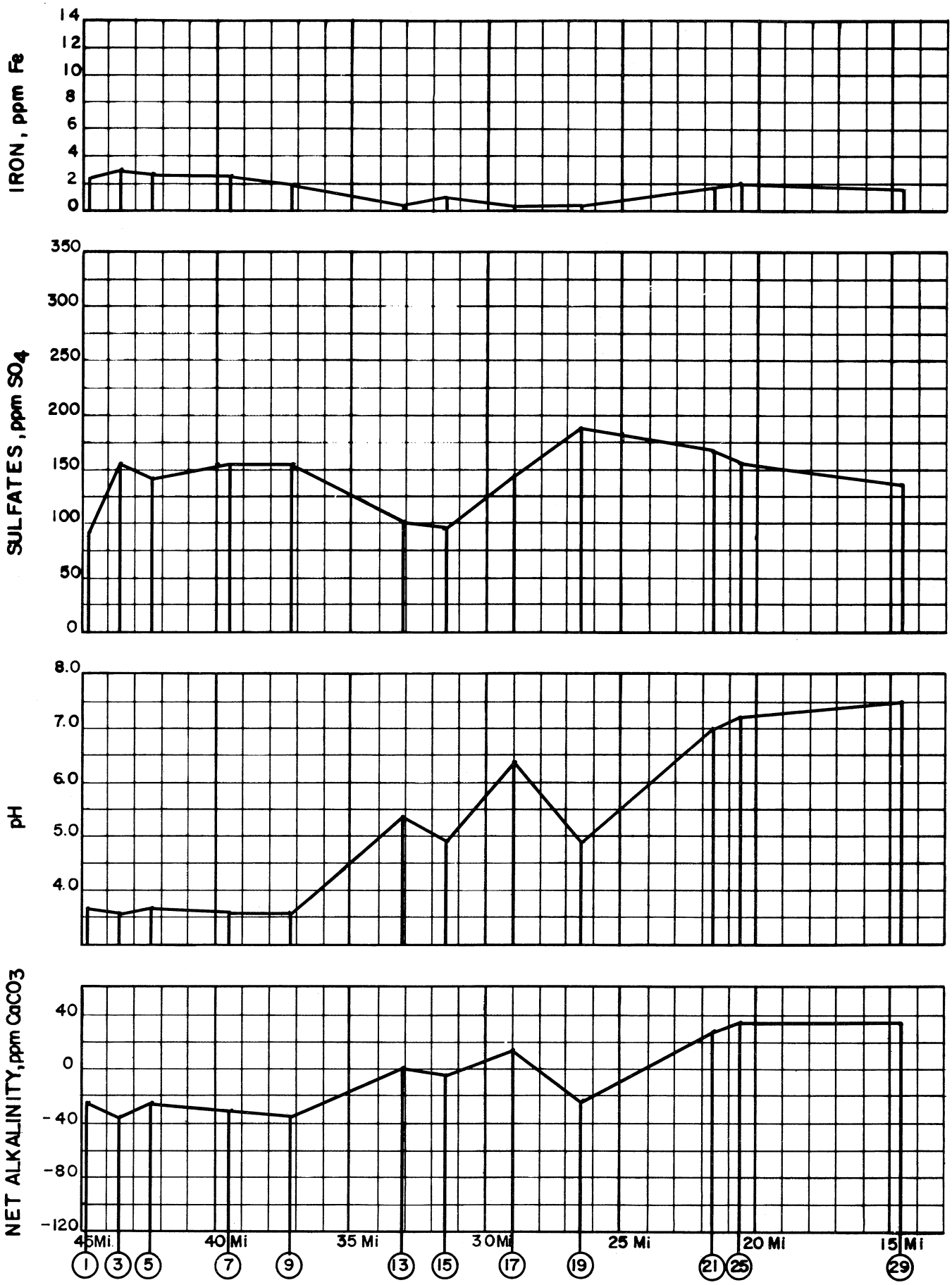


MAY 15, 1969

WATER QUALITY PROFILE - SLIPPERY ROCK CREEK

SLIPPERY ROCK CREEK WATERSHED

FIG. 17

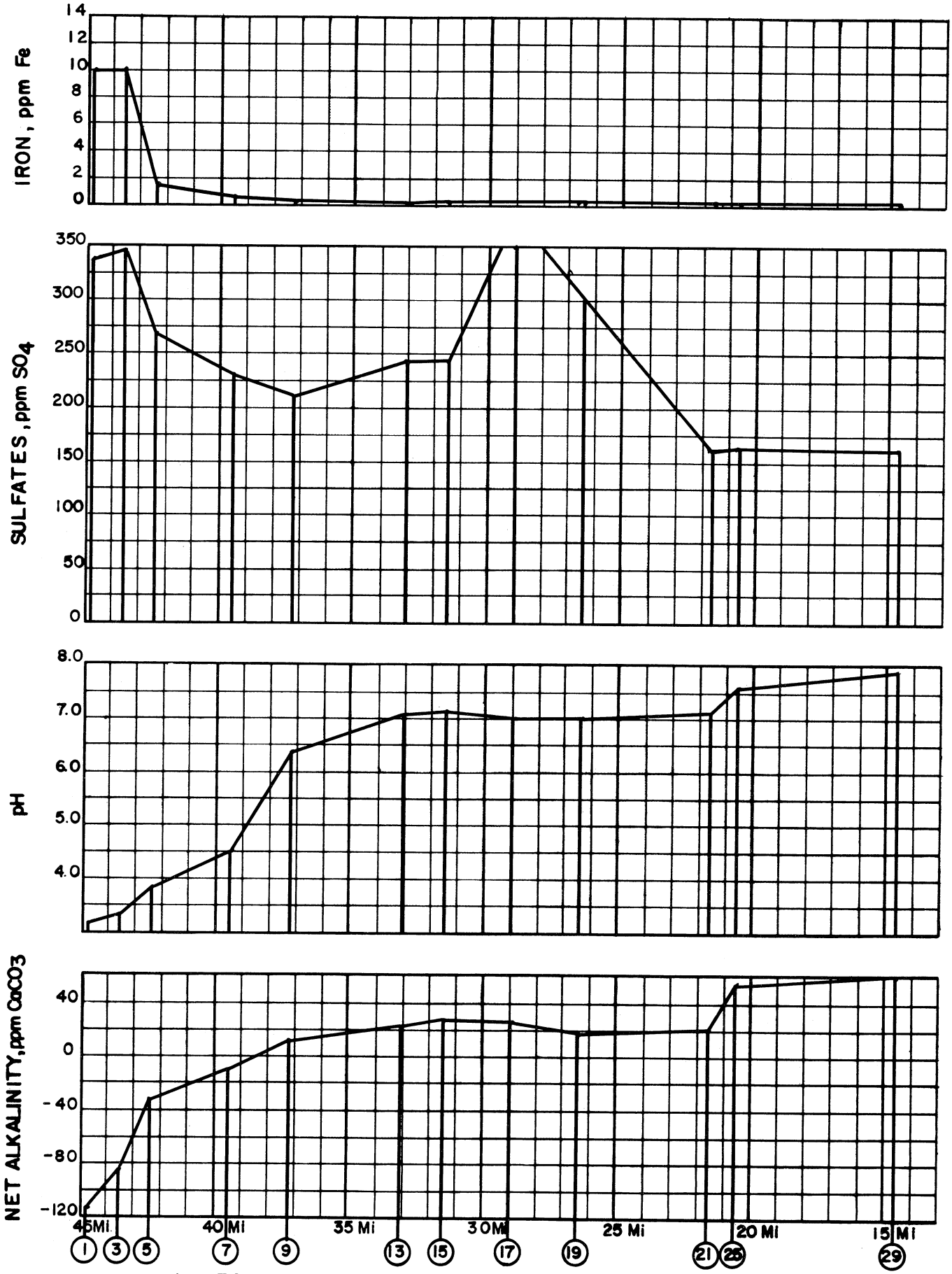


AUGUST 20, 1969

WATER QUALITY PROFILE - SLIPPERY ROCK CREEK

SLIPPERY ROCK CREEK WATERSHED

FIG. 18

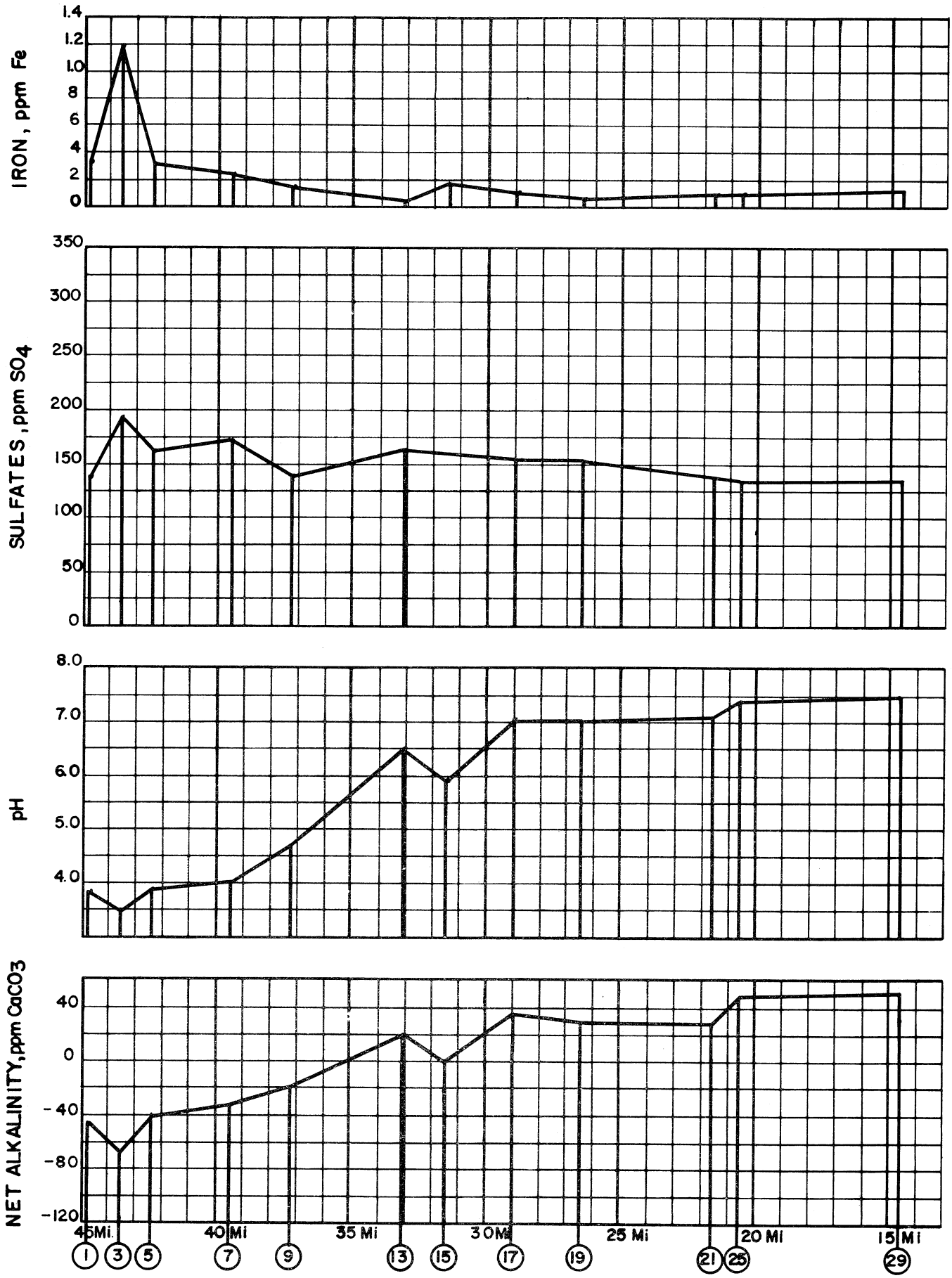


SEPTEMBER 24, 1969

WATER QUALITY PROFILE - SLIPPERY ROCK CREEK

SLIPPERY ROCK CREEK WATERSHED

FIG. 19



MILES FROM MOUTH & SAMPLING STATIONS

OCTOBER 22, 1969

WATER QUALITY PROFILE - SLIPPERY ROCK CREEK

SLIPPERY ROCK CREEK WATERSHED

FIG. 20

The significance of our streamflow studies as related to water quality and mine drainage is limited to a consideration of base flow and conditions resulting from a moderate increase in discharge due to rainfall and runoff. The graphs in Figure 21 were prepared to show the results of the two flow measurements in Slippery Rock Creek and the related water quality. These observations illustrate graphically the shift in acid load downstream caused by runoff and roughly a two fold increase in stream discharge.

Time of travel studies for Slippery Rock Creek were only partially successful. Table 22 shows the sub-reaches which were used in the study and summarizes the information obtained. It was determined that the time required for a water soluble substance to reach Bovard from Argentine (11.52 miles) would be about 2.4 days with a discharge of 24 c.f.s. at Bovard. Accurate data on the time of passage from Bovard to Crolls Mills could not be obtained due to the very low dye concentration pick up. However, estimating from the time required for detectable dye to arrive at the Crolls Mills Station, the travel time for this 10.72 mile reach is about 5 days. Travel time for the subreach from Crolls Mills to Rose Point was 2.17 days with a Rose Point discharge of 108 c.f.s. The overall travel time from Argentine to Rose Point then could be estimated at 10 days for a stream flow of 108 c.f.s. at Rose Point.

Mean velocities for five sub-reaches in the main stream are shown in Figure 23. The low range (0.3 - 0.5 f.p.s.) of velocities indicates considerable stagnation and pooling in various stretches. In the upper reaches, or the acid zone the response of these sluggish places to rainfall and runoff would be to shift the acid load downstream, a condition which was actually observed in the September and October surveys.

Daily precipitation records for three stations in the Study Area, Slippery Rock, Grove City, and Boyers are included in the basic data section in Appendix B. The average rainfall by months is shown graphically in Figure 24. With regard to stream quality, generalizations concerning the effect of rainfall and runoff cannot be readily made. Intensity and duration of rainfall are certainly important factors which need to be considered.

Characteristics for this drainage area (Table 14) show that only two tributaries, Big Run and Glade Run contribute acid water to Slippery Rock Creek. Other tributaries in this section - Hogue Run, Long Run, Coaltown Run, and South Branch were found to have a water quality varying from low to fairly stable alkaline content. The only exception is McDonald Run which was found to contain substantial alkalinity throughout the sampling and testing period.

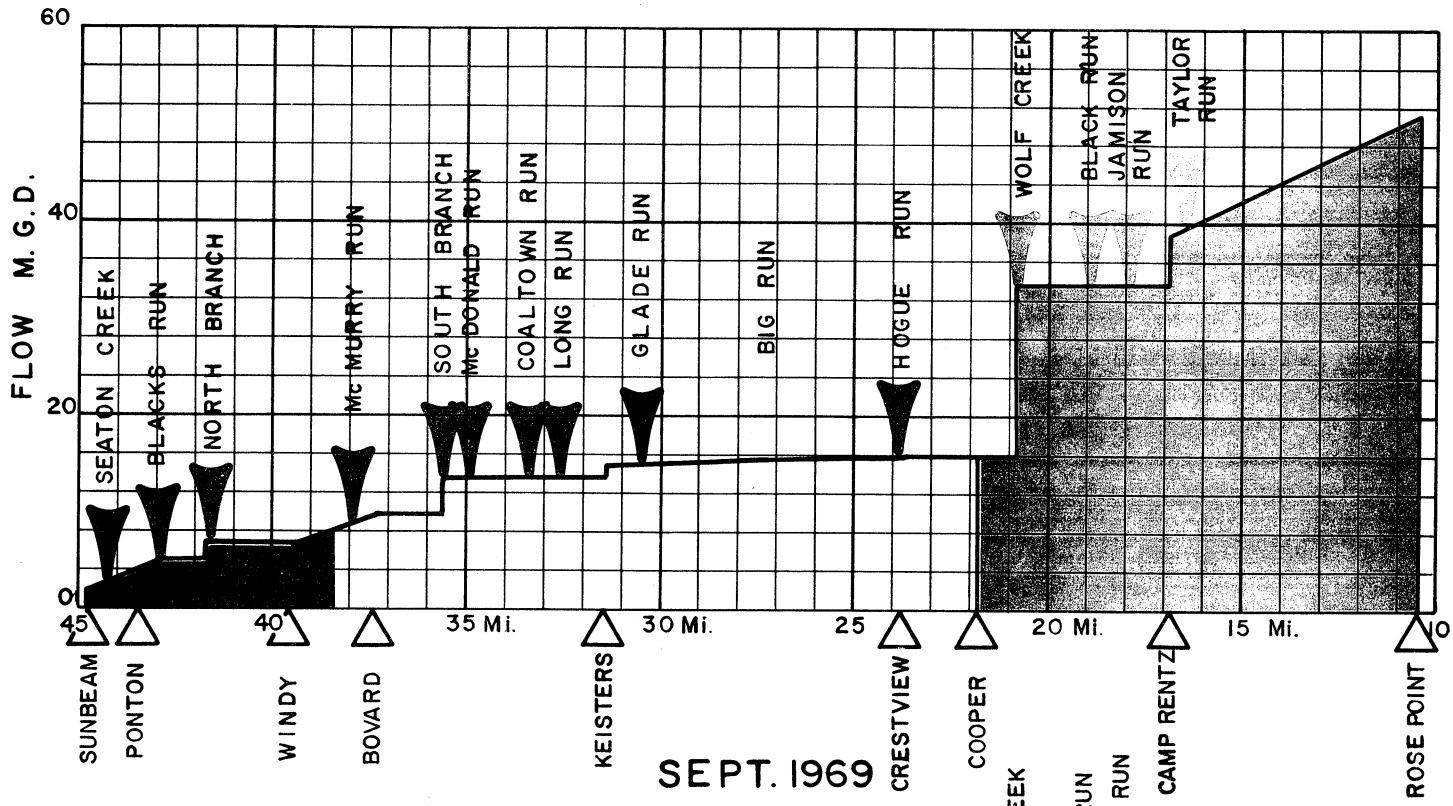
Area C - Wolf Creek and the remaining reach of Slippery Rock Creek to Rose Point as a drainage unit makes up almost 50% of the Study Area. Changes in the main stream to an alkaline type of water below Wolf Creek can be attributed to the natural recovery of Slippery Rock Creek to a variable quality above this point and the influence of alkalinity from Wolf Creek.

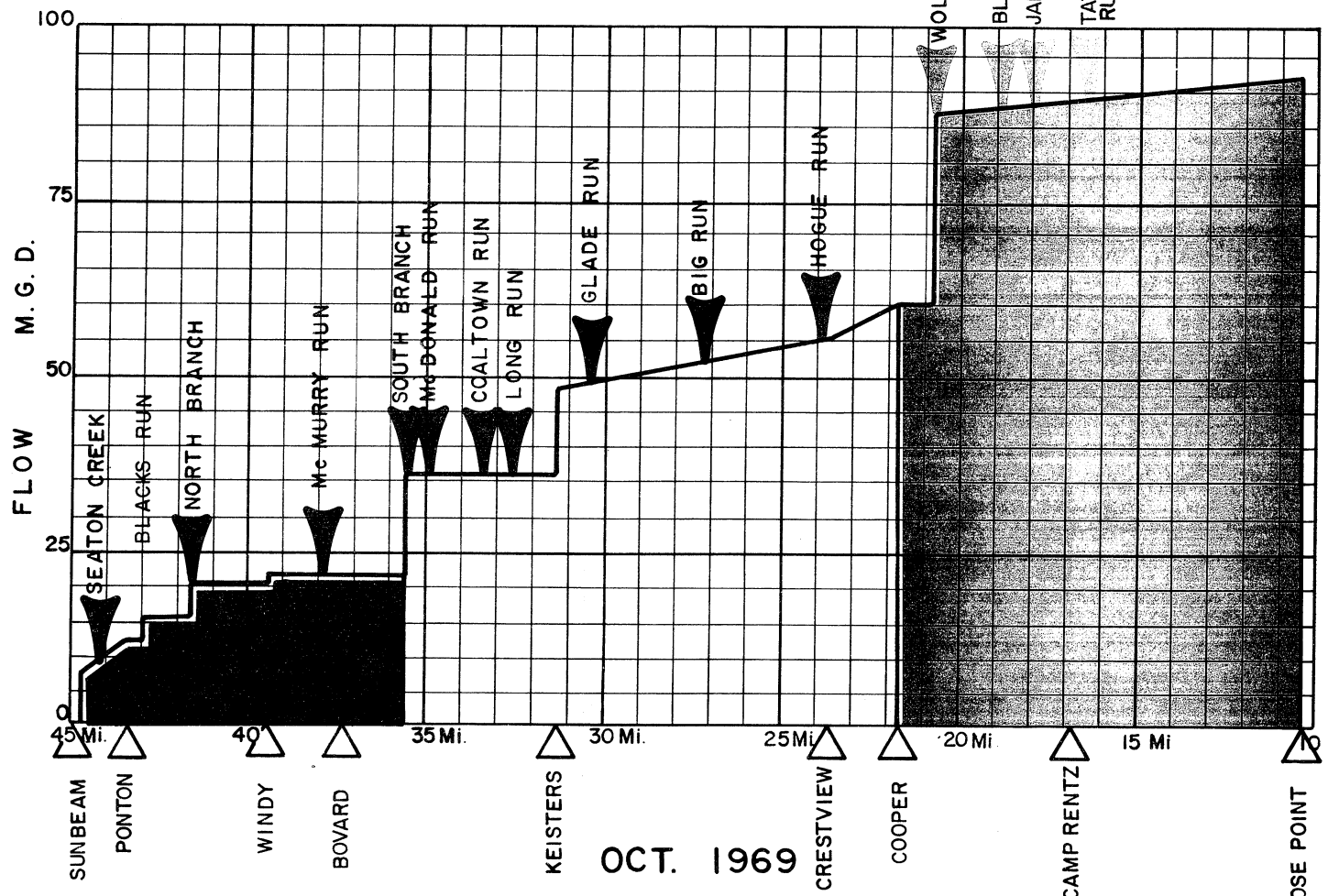
Two secondary streams on Wolf Creek were also sampled to determine the collective effect of mine drainage in the East Wolf Creek Area and the Redmond Area. The East Branch is located 16.54 miles from the mouth of Wolf Creek, above Grove City. Water quality (Station T22) was found to be variable to slightly acid. A small unnamed tributary entering Wolf Creek 5.6 miles from the mouth was also tested (Station T23) to determine if adverse water quality existed due to mine drainage. Results showed this stream to be predominantly alkaline.

Below Wolf Creek three alkaline flows, Taylor Run, Jamison Run and Black Run are added to Slippery Rock Creek prior to the Rose Point Station. Water quality in this reach of the main stem has sufficiently recovered in buffering capacity to be classified as predominantly alkaline.

Streamflow

The results of two stream discharge measurements are shown in Table 15. Flow at Rose Point was determined to be 80 c.f.s. (September 19) and 148 c.f.s. (October 24). Both of these are less than the mean annual discharge for the drainage area. The second measurement was made over a three day period concurrent with 1.24 inches of rainfall for the area. Travel time studies were conducted in the period following (October 26 - November 14), during which stream flows were receding. A record of stream stage was kept throughout the time of travel studies so that a near approximation of discharge could be made.





STREAM FLOW & WATER QUALITY PROFILE

SLIPPERY ROCK CREEK WATERSHED

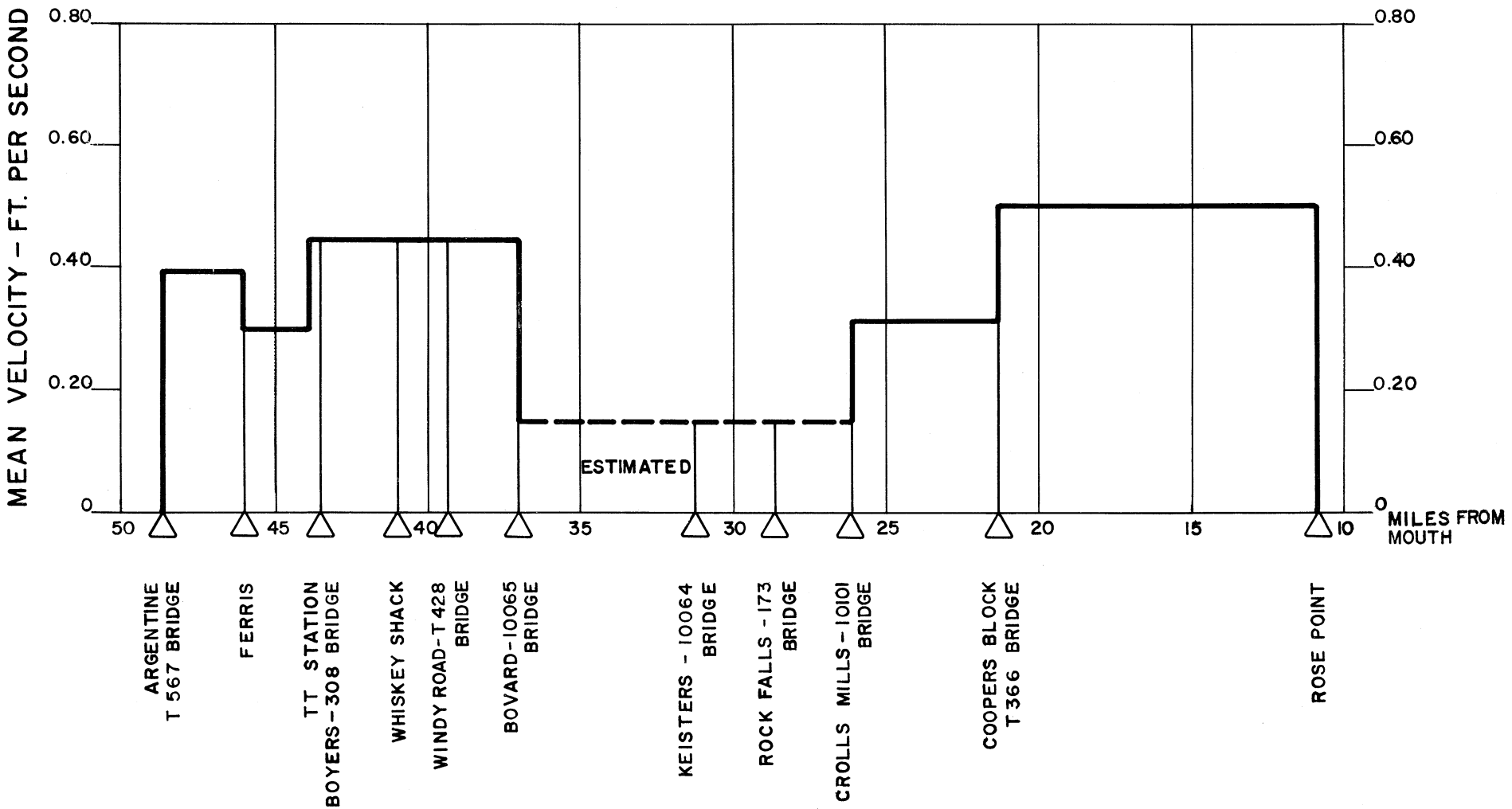
FIG.21

Table 22

Travel Time Of Rhodamine BA Dye Tracer
For Slippery Rock Creek October 26 To November 14, 1969

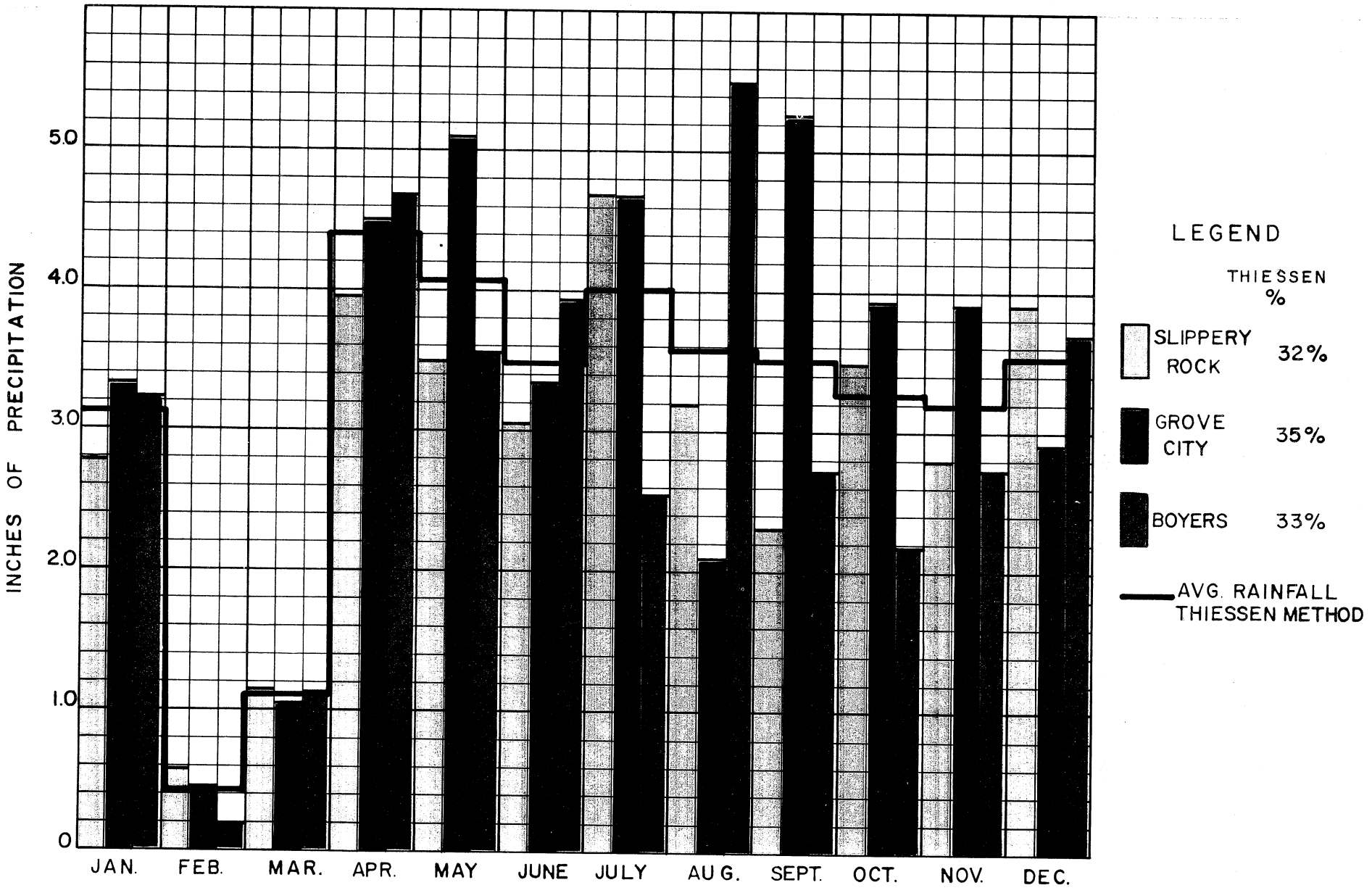
Station (For Locations See Table 15)	Miles Above Mouth	Discharge (Cfs)	Elapsed Time (Hours & Minutes) After Dye Dose	
			Time Of 1st Arrival	Time Of Peak Concentration
Argentine	48.70	------	Starting Point	--------
Ferris	46.05	------	8:20	10:15
Ferris	46.05	------	Starting Point	--------
Sunbeam Coal Co.	44.72	8.40	-----	--------
Boyers	44.05	------	10:40	12:05
Boyers	44.05	------	Starting Point	--------
Ponton Road	43.55	12.8	-----	--------
Whiskey Shack	41.18	------	11:00	13:15
Boyers	44.05	------	Starting Point	--------
Windy Road	39.51	23.0	-----	--------
Bovard	37.18	24.0	17:15	21:45
Bovard	37.18	24.0	Starting Point	--------
Keisters	31.51	43.0	-----	--------
Dougherty's Mills	28.99	------	80:00*	**
Crolls Mills	26.46	------	120:00*	**
Crolls Mills	26.46	------	Starting Point	--------
Camp Crestview	23.69	46.0	------	--------
Cooper's Block Plant	21.70	------	17:50	21:45
Cooper's Block Plant	21.70	60.0	Starting Point	--------
Camp Rentz	16.95	98.2	------	--------
Rose Point	11.25	108.0	25:00	30:30

* Dye dectable at very low concentrations
**Dye concentrations too low for peak determination



MEAN RATE OF STREAM FLOW
FOR
SLIPPERY ROCK CREEK
WITH
108 cfs DISCHARGE AT ROSE POINT

FIG. 23



TOTAL MONTHLY RAINFALL – 1969

SLIPPERY ROCK CREEK WATERSHED

FIG. 24