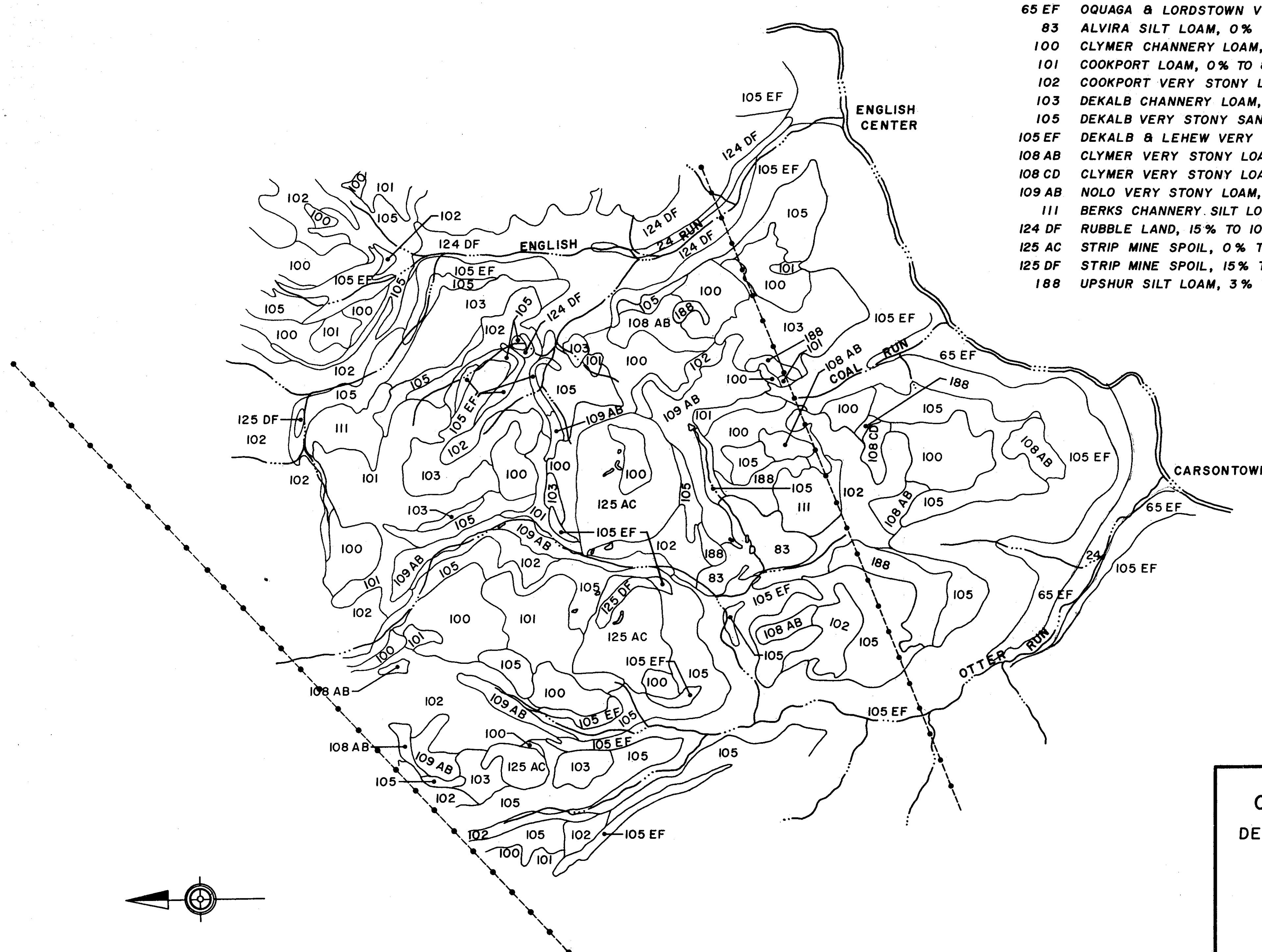
<u>Hydrological Study of Project SL-160</u>

The nature of the hydrological cycle is extremely important to the quality of the water found in the streams and beneath the ground within the watershed. Much of the annual rainfall (38.00 in. @ English Center Rain Gauge, 7-1-70 to 6-30-71) hits the canopy, or forest cover, and thus intercepted, evaporates and is of little further consequence. The remainder of the precipitation, which hits the ground and infiltrates into the soil is of major concern. The volume of rainfall (Table No. 2) affects how much of the infiltration percolates vertically and how much flows laterally, or runs off the surface and contributes directly to stream flow. The nature of the various soil horizons encountered within the watershed (Page 42, Map No. 7) is the most important single factor in determining the duration of the infiltration, lateral flow, and stream emergence process.

Water in the project watershed is unique in that portions of it are typical of land with heavy vegetation cover (i.e., without extreme variations of quality), while still other parts show extreme variations typical of unprotected basins. Strip-mining in the area creates a two-fold alteration of the watershed hydrology, by first, eliminating the forest cover and creating an unprotected basin, and second, by interrupting the natural flow patterns through soil and strata disturbance. The strip-mining area of Buckeye Run is a prime example of such an alteration of watershed hydrology.

Since none of the rainfall in this area is any longer intercepted and evaporated by the canopy (forest cover removed), the amount of precipitation infiltrating the soil is increased substantially. Meanwhile, the infiltrated horizons (soil, gravel, rocks, etc.) have also been substantially altered through mining activity and are unable to cope with increased amounts of water. Although present legislation requires such disturbed lands to be restored and reseeded, much of the damage to the hydrology of the area is irreparable. Remedial action, including such items as diversion ditches, settling basins, and impoundment pools, often is necessary to reduce the erosional effects of rapid water run-off in areas so disturbed by surface mining.



SOIL IDENTIFICATION LEGEND

24	MIXED ALLUVIAL LAND
65 CD	OQUAGA VERY STONY LOAM, 8% TO 25% SLOPES
65 EF	OQUAGA & LORDSTOWN VERY STONY LOAMS, 25% TO 100% SLOPES
83	ALVIRA SILT LOAM, 0% TO 15% SLOPES, MODERATELY ERODED
100	CLYMER CHANNERY LOAM, 0% TO 8% SLOPES, MODERATELY ERODED
101	COOKPORT LOAM, 0% TO 8% SLOPES
102	COOKPORT VERY STONY LOAM, 0% TO 25% SLOPES
103	DEKALB CHANNERY LOAM, 0% TO 15% SLOPES, MODERATELY ERODED
105	DEKALB VERY STONY SANDY LOAM, 0% TO 25% SLOPES
105 EF	DEKALB & LEHEW VERY STONY SANDY LOAMS, 25% TO 100% SLOPES
108 AB	CLYMER VERY STONY LOAM, 0% TO 8% SLOPES
108 CD	CLYMER VERY STONY LOAM, 8% TO 25% SLOPES
109 AB	NOLO VERY STONY LOAM, 0% TO 8% SLOPES
111	BERKS CHANNERY SILT LOAM, 3% TO 15% SLOPES, MODERATELY ERODED
124 DF	RUBBLE LAND, 15% TO 100% SLOPES
125 AC	STRIP MINE SPOIL, 0% TO 15% SLOPES
125 DF	STRIP MINE SPOIL, 15% TO 100% SLOPES
188	UPSHUR SILT LOAM, 3% TO 25% SLOPES

COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF ENVIRONMENTAL RESOURCES

ENGLISH RUN MINE DRAINAGE STUDY

MAP NO. 7 - SOIL HORIZONS

* COURTESY OF U.S.D.A., SOIL CONSERVATION SERVICE

SCALE 1" = 4000'	PREPARED BY
OCT. 1971	ENGLISH ENGINEERING CORP. WILLIAMSPORT, PENNSYLVANIA

Table No. 2 - Monthly Precipitation Data Recorded for English Run and Otter Run Basins

Location	Month	English Center Rainfall-Inches	Otter Run Rainfall-Inches	Variation (Pct.)
1970	July	4.39	4.46 *	1.6
	August	3.27	3.32 *	1.5
	Sept.	3.08	3.13 *	1.6
	Oct.	6.54	6.00	9.0
	Nov.	5.49	4.40	24.8
	Dec.	2.82	3.10	9.9
1971	Jan.	1.80	2.10	16.7
	Feb.	3.26	4.80	47.2
	March	1.80	2.10	16.7
	April	0.65	0.80	23.1
	May	2.01	1.90	5.8
	June	2.89	2.50	15.6
1970-71				
Total		38.00 in.	38.61 in.	(1.6)

* Not recorded: Data estimated.

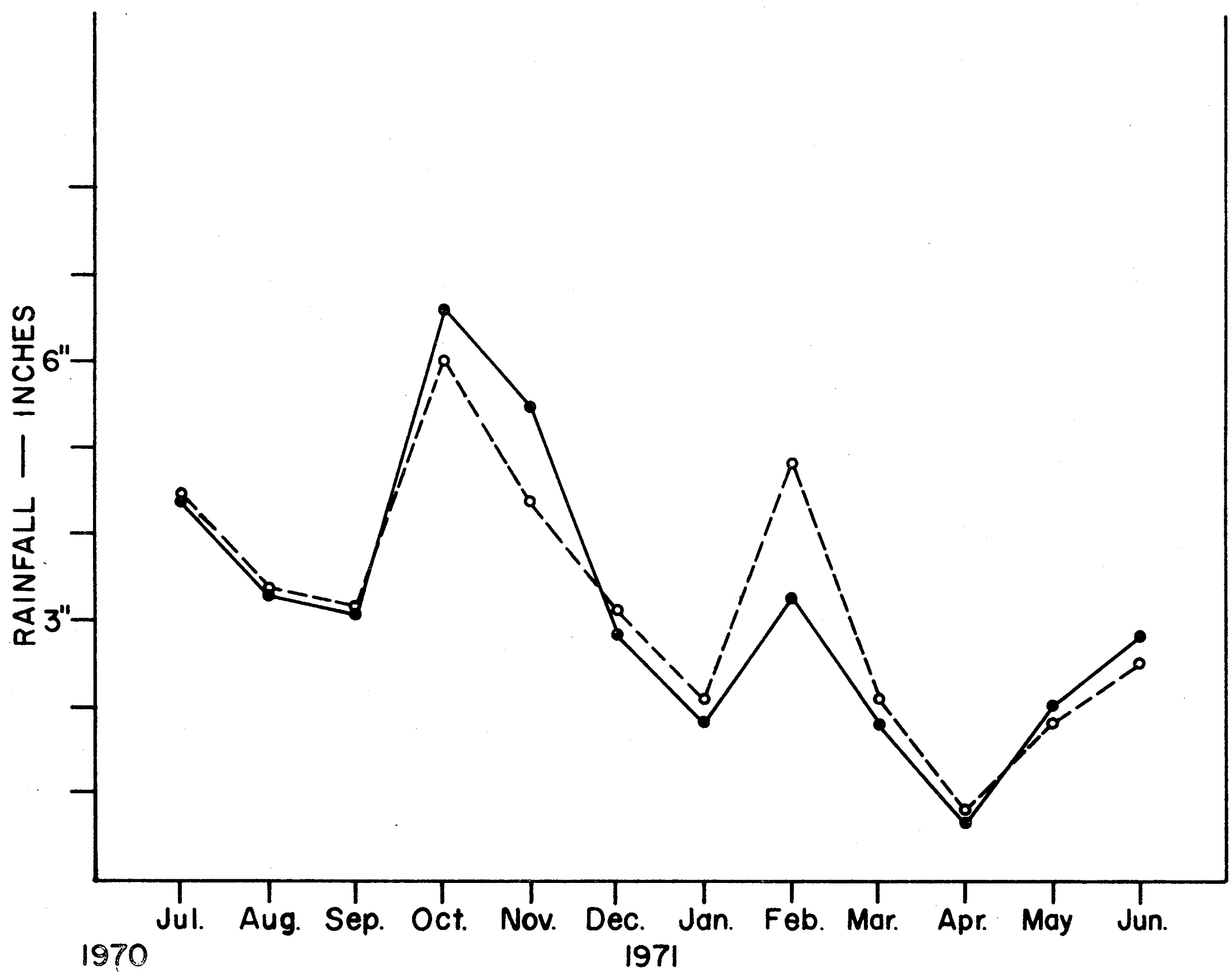
English Center Recording Gage

1970	
Jul.	4.39 in.
Aug.	3.27 in.
Sep.	3.08 in.
Oct.	6.54 in.
Nov.	5.49 in.
Dec.	2.82 in.
1971	
Jan.	1.80 in.
Feb.	3.26 in.
Mar.	1.80 in.
Apr.	0.65 in.
May	2.01 in.
Jun.	2.89 in.
(70–71)	38.00 in

Otter Run Recording Gage

1970	
⊕Jul.	4.46 in.
⊕Aug.	3.32 in.
⊕Sep.	3.13 in.
Oct.	6.00 in.
Nov.	4.40 in.
Dec.	3.10 in.
1971	
Jan.	2.10 in.
Feb.	4.80 in.
Mar.	2.10 in.
Apr.	0.80 in.
May	1.90 in.
Jun.	2.50 in.
(70–71)	38.61 in.

⊕NOTE: First three readings are estimates.



MONTHLY PRECIPITATION READINGS
for
OTTER RUN and ENGLISH RUN BASINS

RECORDED PRECIPITATION READINGS GRAPH NO. 1

The two watersheds of English Run and Otter Run under investigation offer an opportunity to examine and compare twin basins that fairly well parallel each other and due to their adjacency have many similarities, such as; common geologic formations and soils, comparable orientation, equivalent storm patterns, and similar land cover and use except for strip-mining. The smaller English Run basin is approximately two-thirds the size of its Otter Run counterpart and relatively free of surface mining scars or spoil, while the larger Otter Run basin is marked by several abandoned strip-mining areas in addition to one active surface mine.

Elevations in the English Run watershed range from 877 feet at the initial gauging station (station "A") to a high of about 2080 feet above the station. The basin has a northwest orientation. Elevations in the Otter Run watershed above the gauging station (station No. 1) range from 786 feet to 2146 feet. Otter Run also has a northwest orientation and since intervening hills in the approaches to these two areas will cause diffused storm patterns, thereby reducing orographic influences, it is likely that there will be no material difference in precipitation.

English Run is characterized by two large tributaries of about equal area and several smaller tributaries. Otter Run has two headwater tributaries of similar area which form its main stem, one major tributary, and a series of lesser tributaries located along its length.

<u>Otter Run Station No. 1 at Carsontown, Pa.</u>

Location - Lat. 41°24'24", long. 77°20'05", on west bank 112 feet south of bridge spanning Otter Run on L.R. 41021 and 400 feet north of confluence with Little Pine Creek. Datum on gauge is 786.28 feet above mean sea level.

Drainage area - 30.21 square miles (approximately one-half square mile strip-mined)

Establishment - station established and gauge installed August 10, 1970

Discharge Measurements - since establishment eight (8) discharge measurements have been made ranging from a minimum of 1.89 cfs at gauge height 0.13 feet to a maximum of

180.56 cfs at gauge height 1.20 feet (see Table 3) mean velocity of the highest discharge measurement was 3.1 feet per second.

English Run Station "A"' at English Center, Pa.

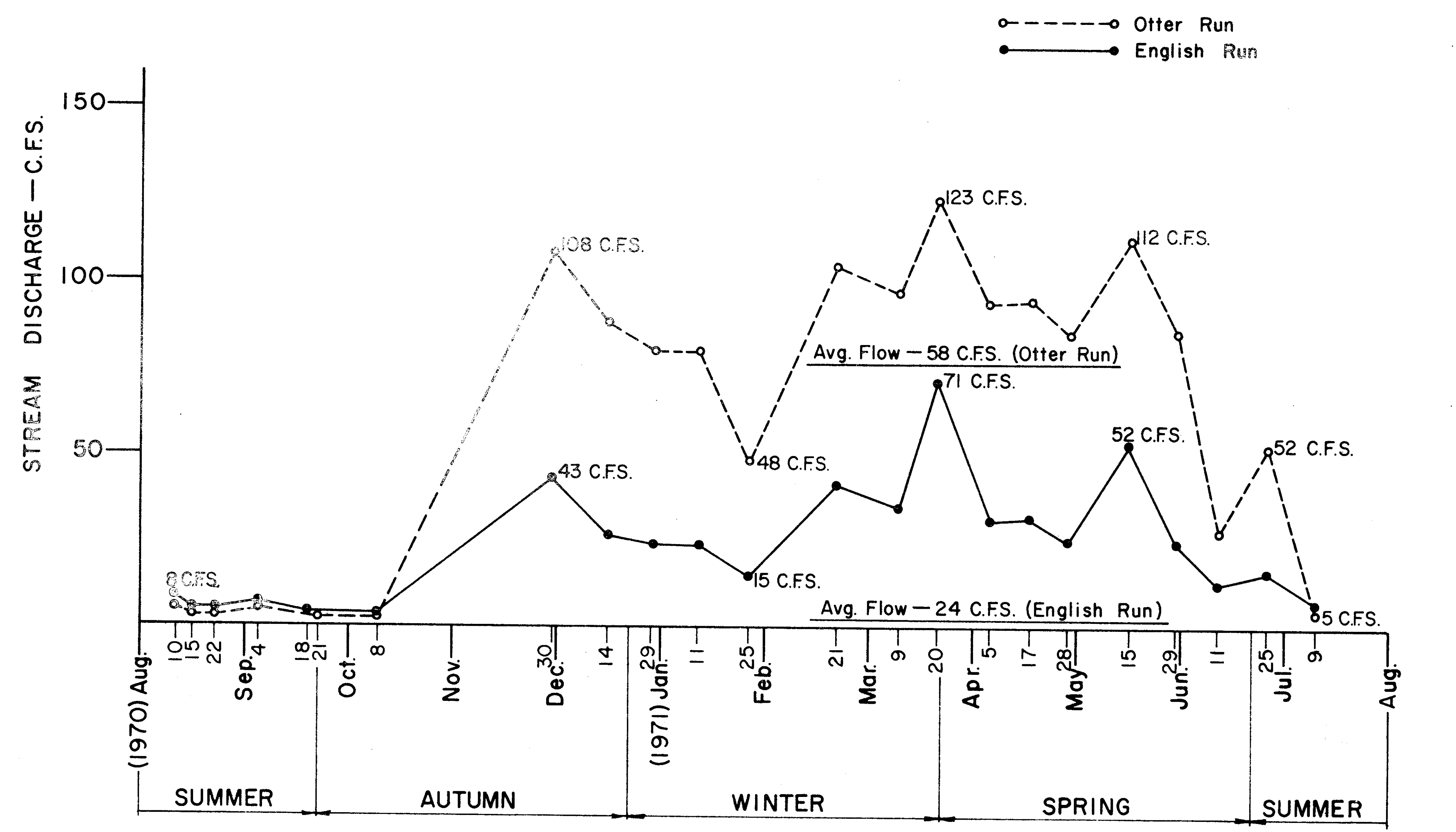
Location - Lat. 41°26'08", long. 77°17'25", on west bank at bridge spanning English Run on T-776 and 350 feet north of confluence with Little Pine Creek. Datum of gauge is 876.79 feet above mean sea level.

Establishment - Station established and gauge installed on August 10, 1970

Discharge Measurements - Since establishment 20 discharge measurements have been made ranging from a minimum of 3.3 cfs at gauge height 0.21 feet to a maximum of 70.9 cfs at gauge height 1.09 feet (see Table 3) mean velocity of highest discharge measurement was 3.7 feet per second.

There was a single recording precipitation gauge located in each of the study basins. The one in the English Run basin, located near gauging station "A" described above, is a permanent installation of the USDC, Department of Environmental Services, while the gauge located in the Otter Run basin, was a temporary installation of nine months duration. The Otter Run gauge was placed in the general area of the strip-mine activity on Buckeye Run and was made available on loan through the courtesy of the aforementioned USDC, Department of Environmental Services. For the nine months, (10-1-70 to 6-30-71) of simultaneous recording the Otter Run gauge indicated 27.70 inches of rainfall to 27.26 inches at the English Run weather station. This approximate 1.6 percent variation was not unexpected because of the differences in elevation, topography, and orientation of the two locations. Graph No. 1 compares the precipitation at these two stations.

The stream discharges (see Graph No. 2, page 47) of the two watersheds and their selective sediment loads (see Table No. 3, Page 49) reveal some interesting facts. During periods of low flow, English Run sustains a substantially higher volume than Otter Run, while during similar periods of high flow, the reverse is true. This would seem to indicate that the smaller English Run basin, with good vegetative cover, slows storm runoff and increases flow during dry periods. On the other hand, the larger



SEASONAL DISCHARGES for OTTER RUN and ENGLISH RUN

SEASONAL
STREAM DISCHARGES
GRAPH NO. 2

Otter Run basin, beset with fairly extensive strip-mined areas, has inferior retardation qualities and cannot slow down storm run-off or increase seasonal flow in dry periods as can its English Run counterpart. Peak discharge comparison indicated that Otter Run is perhaps 80 percent high as compared to English Run. Consideration is given to the effect of difference in drainage area size. Presumably differences in other factors such as basin shape, channel and local slopes, land cover and use, soil type and condition, and precipitation account for the disparity. However, strip-mining effects several of these factors to a large degree, usually with the tendency to increase peak runoff.

To further analyze runoff characteristics of the two basins, the lag from mode of precipitation to time of peak flow was computed for several storms. Generally only one heavy rainstorm occurred during the storm events selected and antecedent and trailingoff precipitation was minor. Consequently, there was little or no difference between the mode and mass of precipitation. For each of the selected storms, the lag time for Otter Run was shorter than that for English Run. The inference again being that retardation qualities of the Otter Run watershed are inferior to those on English Run basin. Further, the shorter lag time for Otter Run substantiates its higher peak flow characteristic, for the two hydrologic characteristics and the factors governing them usually occur together.

One method of controlling undesirable runoff characteristics of a watershed is to impound water throughout the basin at selected intervals. The United States Department of Agriculture through its Soil Conservation Service has performed a field survey of the Otter Run and English Run watersheds and selected favorable impoundment sites. Twenty of these sites fall within the boundaries of study project SL-160 (Page 59, Map No. 8). Although these dams and their impoundments are multi-purpose, see principal use, Table 4, Column 7, their primary function(s) in this instance would be sediment control, flood retardation, and/or flow augmentation. In addition, several selected sites would be effective in treating mine acid by dilution and retention. The approximate construction costs of these AMD treatment dams have been estimated and placed upon Page 59, Map No. 8, to further

Table No. 3 - Sediment Loads for Maximum and Minimum Flows at Water Sampling Stations

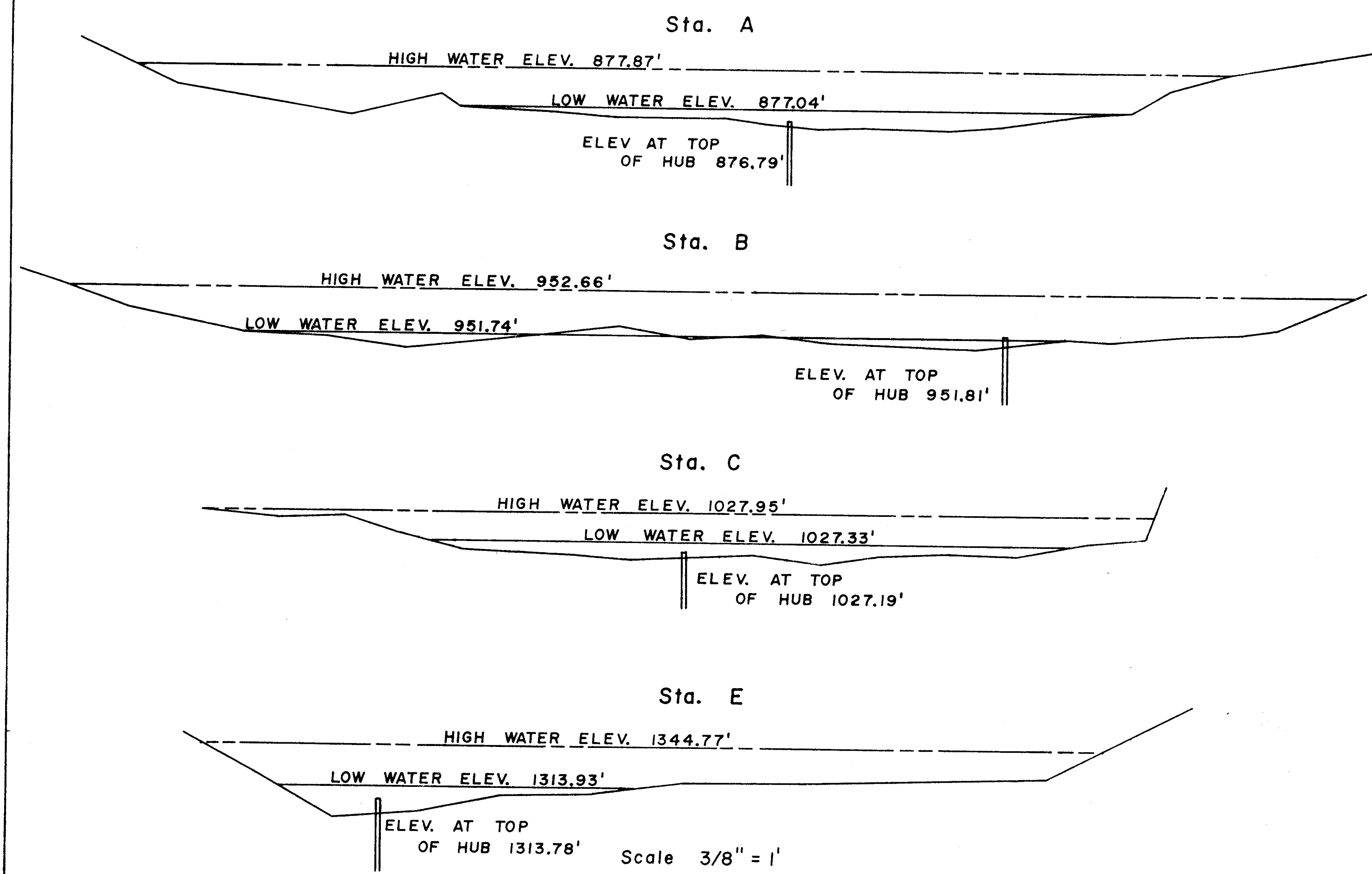
STATION	Date	Flow CFS Hi	Flow CFS Lo	Water CF/Day x10^3	Water Lb/Day x10^6	Fe PPM	SO4 PPM	Total PPM	Sediment Load lb/Day	Acidity PPM	Acid Load lb/Day	Water Temp $^\circ$F	Depth to hub Ft.
English Run													
A	3-20-71	70.9		6126	382	0.1	38.0	38.1	14,563	12.0	4587	38°	1.08'
	9-18-70		3.3	285	18	0.4	36.0	36.4	648	-	-	-	0.21'
B	3-20-71	92.5		7992	499	0.3	24.0	24.3	12,118	2.0	997	38°	0.85'
	9-18-70		4.5	389	24	0.35	44.0	44.35	4,587	-	-	-	0.09'
C	12-14-70	39.5		3413	213	0.4	20.0	20.4	4,344	6.0	1278	39°	0.76'
	9-18-70		4.23	365	23	0.4	28.0	28.4	646	-	-	-	0.14'
D	3-20-71	34.5		2980	186	0.35	32.0	32.35	6,017	-	-	38°	1.26'
	9-18-70		0.85	73	5	0.10	44.0	44.10	202	-	-	-	0.15'
E	3-20-71	66.2		5721	357	0.10	20.0	20.1	7,176	-	-	37 1/2°	0.99'
	9-18-70		4.35	376	23	0.70	28.0	28.7	673	-	-	-	0.15'
F	3-20-71	17.7		1529	95	0.55	40.0	40.55	3,870	10	954	37°	0.65'
	9-18-70		1.9	164	10	0.45	28.0	28.45	291	-	-	-	0.13'
G	3-20-71	34.6		2989	187	0.50	36.0	36.5	6,809	14	2612	38°	0.92'
	9-18-70		2.24	193	12	0.25	36.0	36.25	438	-	-	-	0.17'
H	3-20-71	9.6		829	52	0.30	22.0	22.3	1,154	-	-	38°	0.55'
	9-18-70		0.35	30	2	0.45	48.0	48.45	91	-	-	-	0.13'
I	3-20-71	11.2		968	60	0.35	24.0	24.35	1,470	4	241	36°	0.50'
	9-18-70		0.63	54	3	0.55	325.0	325.55	1,105	-	-	-	0.09'
J	3-20-71	6.9		596	37	0.60	38.0	38.6	1,436	-	-	36 1/2°	0.69'
	10-8-70		0.19	16	1	0.35	48.0	48.35	49	-	-	54°	0.05'
K	3-20-71	4.6		397	25	0.40	36.0	36.40	903	-	-	37°	0.40'
	8-22-70		0.41	35	2	0.15	34.0	34.15	75	-	-	-	0.07'
Otter Run													
1	11-30-70	108.6		9380	585	0.75	28.0	28.75	16,827	6	3512	-	1.20'
	9-21-70		1.89	163	10	0.35	80.0	80.35	819	4	41	-	0.13'

Table No. 3 - Sediment Loads for Maximum and Minimum Flows at Water Sampling Stations

STATION	Date	Flow CFS Hi	Flow CFS Lo	Water CF/Day $x10^3$	Water Lb/Day $x10^6$	Fe PPM	SO4 PPM	Total PPM	Sediment Load lb/Day	Acidity PPM	Acid Load lb/Day	Water Temp °F	Depth to hub Ft.
2	2-9-71	60.3		5206	325	0.35	24.0	24.35	7,910	6	1949	32°	1.08'
	9-21-70		6.32	546	34	0.40	86.0	86.40	2,944	6	204	-	0.10'
3	4-12-71	77.1		6662	416	0.45	22.0	22.45	9,333	2	831	-	1.20'
	9-21-70		11.2	970	61	0.45	86.0	86.45	5,234	-	-	-	0.25'
4	2-9-71	92.3		7978	498	0.30	28.0	28.30	14,088	-	-	32 1/2°	1.13'
	9-21-70		18.3	1581	99	0.25	104.0	104.25	10,286	-	-	-	0.30'
5	3-17-71	167.5		14468	903	0.10	32.0	32.1	28,979	8	7222	38°	0.88'
	9-21-70		6.3	544	34	0.10	100.0	100.1	3,400	-	-	-	0.10'
6	3-17-71	174.5		15074	941	0.30	48.0	48.3	45,432	12	11288	39°	1.12'
	8-22-70		13.6	1174	73	0.10	128.0	128.1	9,386	14	1026	-	0.33'
7	3-1-71	105.7		9133	570	1.40	38.0	39.40	22,455	8	4559	40°	1.33'
	9-21-70		12.2	1050	66	0.55	34.0	34.55	2,263	-	-	-	0.40'
8	4-12-71	52.2		4506	281	0.10	36.0	36.10	10,152	-	-	-	0.80'
	8-10-70		3.9	340	21	0.10	68.0	68.10	1,443	2	42	-	0.12'
9	3-17-71	128.8		11127	694	0.30	80	80.30	55,757	36	24997	39°	1.05'
	8-22-70		10.4	897	56	0.35	360.0	360.35	20,166	66	3694	-	0.08'

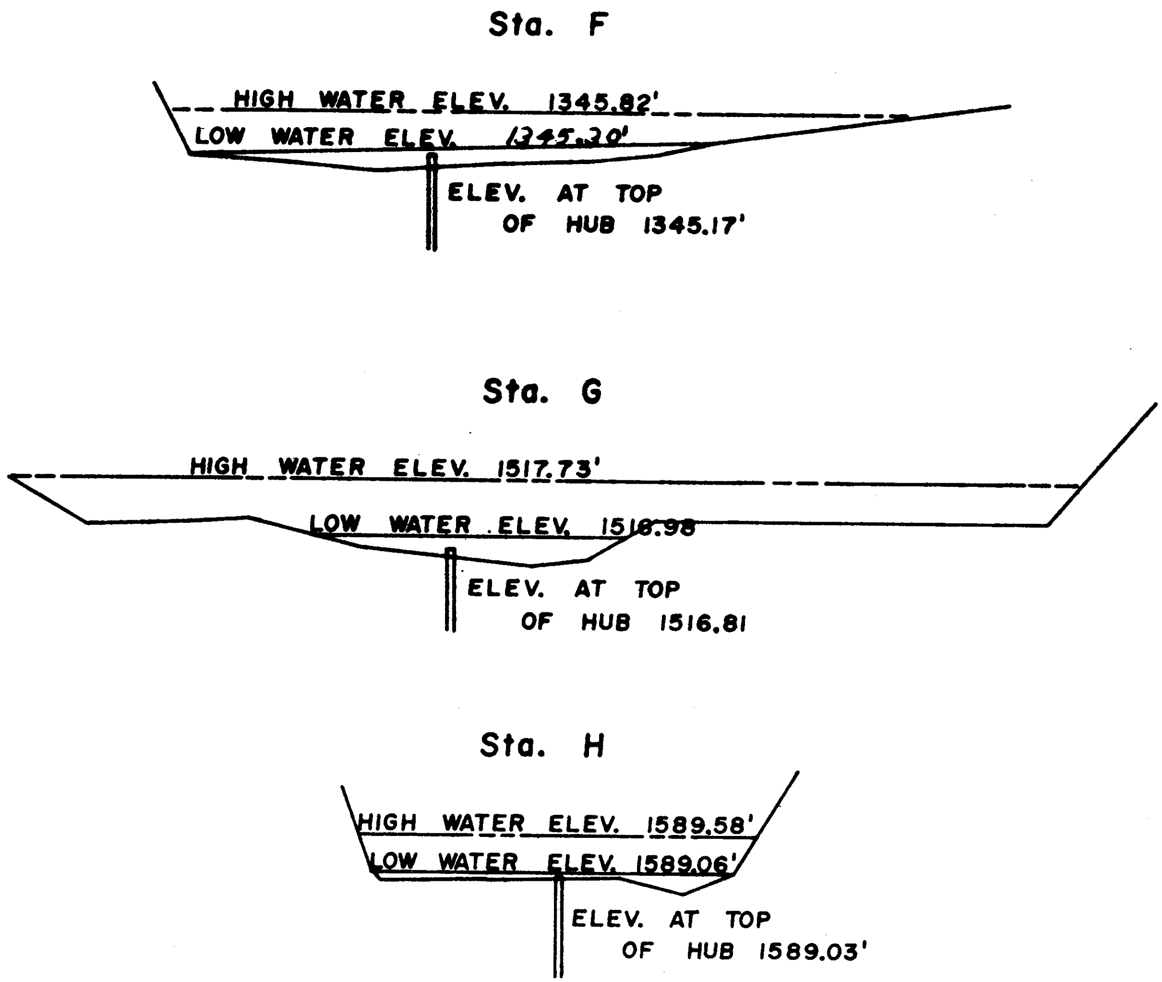
identify these particular dams and impoundment basins.

Cross-sections of the various streams within the two watersheds have been plotted and the high and low flow marks placed on each one (See figure No. 6). These sections were taken at the various gauging stations and due to the difficulty in obtaining good definition for the required scale no attempt was made to present these high and low flows in plan view or schematically.



STREAM CROSS-SECTIONS

ENGLISH RUN
STREAM CROSS-SECTIONS
FIGURE NO. 6 SHEET 1
SCALE AS NOTED

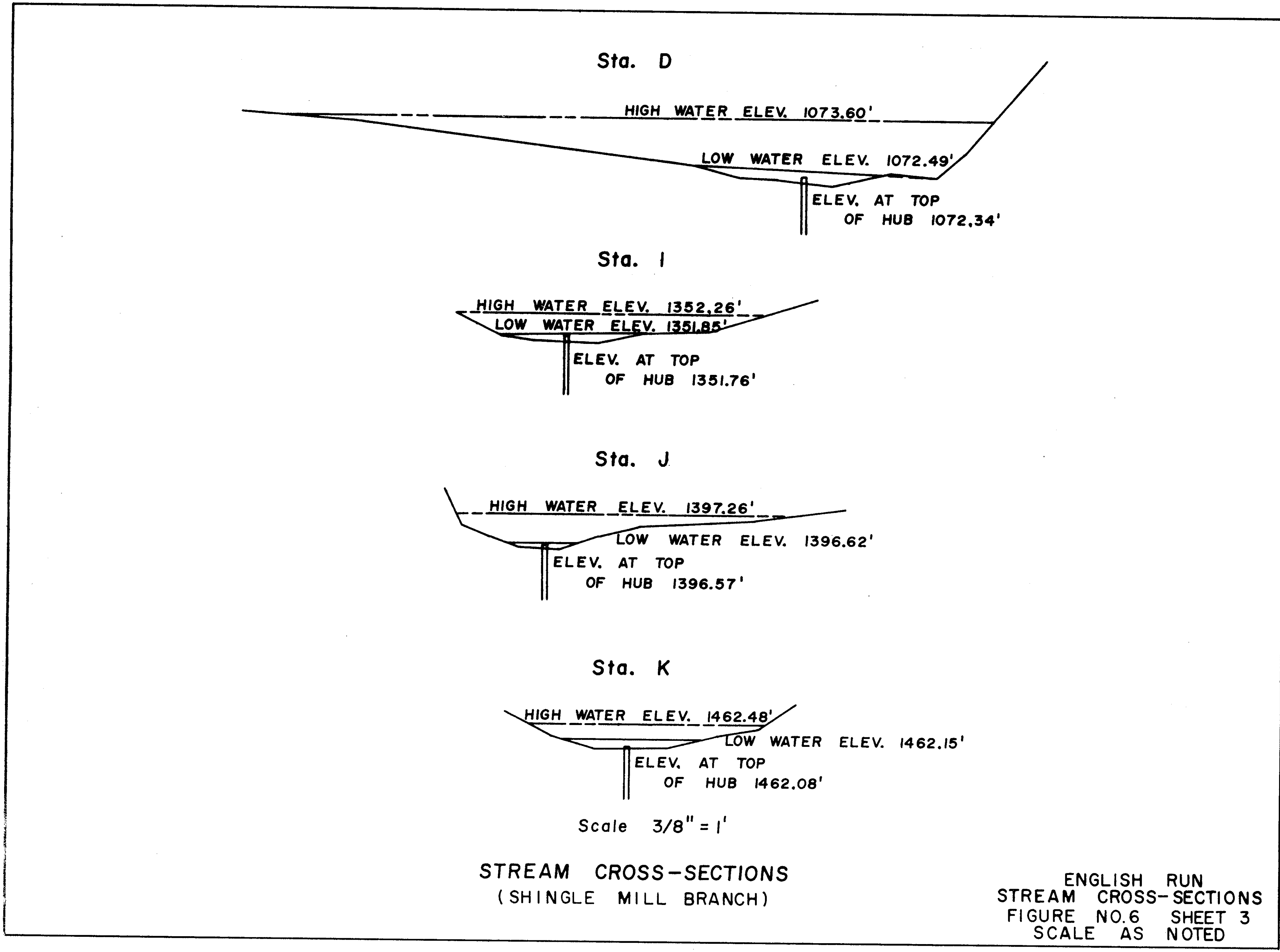


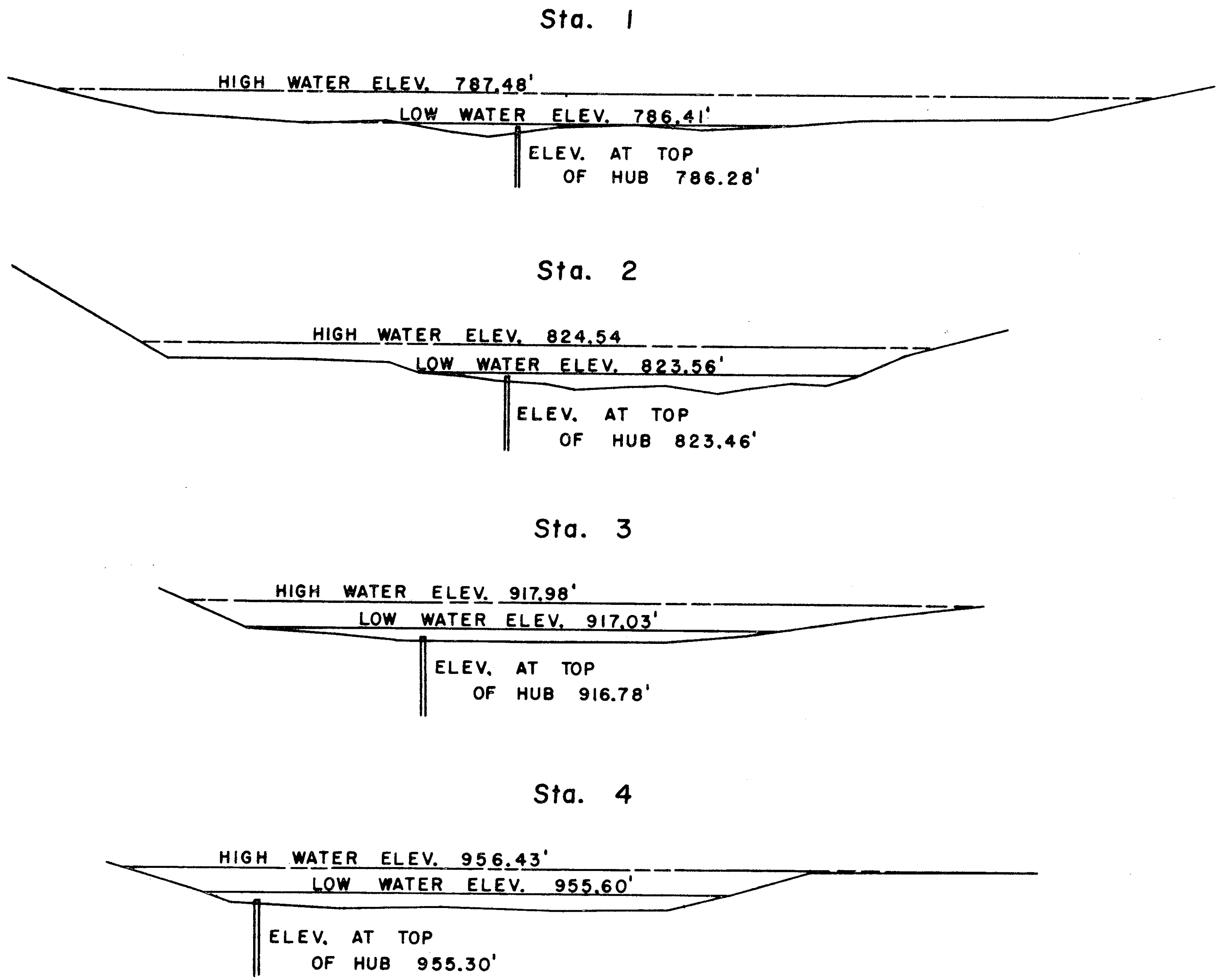
Scale 3/8" = 1'

STREAM CROSS-SECTIONS

(PINE RUN TRIBUTARY)

ENGLISH RUN
STREAM CROSS-SECTIONS
FIGURE NO. 6 SHEET 2
SCALE AS NOTED

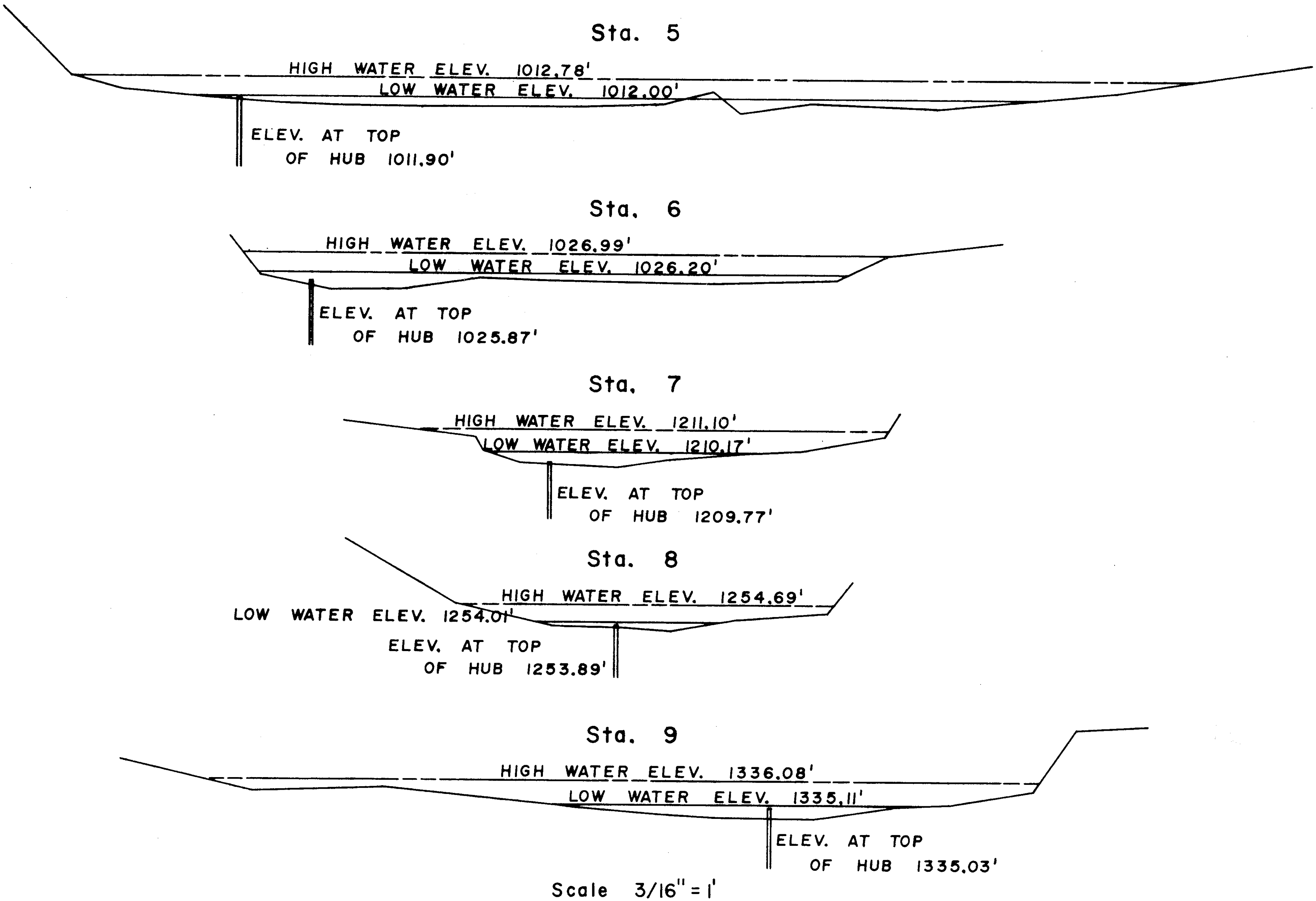

Sta. D
HIGH WATER ELEV. 1073.60'
LOW WATER ELEV. 1072.49'
ELEV. AT TOP OF HUB 1072.34'
Sta. I
HIGH WATER ELEV. 1352.26'
LOW WATER ELEV. 1351.85'
ELEV. AT TOP OF HUB 1351.76'
Sta. J
HIGH WATER ELEV. 1397.26'
LOW WATER ELEV. 1396.62'
ELEV. AT TOP OF HUB 1396.57'
Sta. K
HIGH WATER ELEV. 1462.48'
LOW WATER ELEV. 1462.15'
ELEV. AT TOP OF HUB 1462.08'
Scale 3/8" = 1'
STREAM CROSS-SECTIONS
(SHINGLE MILL BRANCH)
ENGLISH RUN
STREAM CROSS-SECTIONS
FIGURE NO.6 SHEET 3
SCALE AS NOTED



Scale 3/16" = 1'

STREAM CROSS-SECTIONS

OTTER RUN
STREAM CROSS-SECTIONS
FIGURE NO. 6 SHEET 4
SCALE AS NOTED



STREAM CROSS-SECTIONS

OTTER RUN
STREAM CROSS-SECTIONS
FIGURE NO.6 SHEET 5
SCALE AS NOTED

Table 4: Data For Selected Impoundment Sites

Stream	Site #	Col. 1 WS (Ac)	Col. 2 PP (Ac)	Col. 3 PP Depth (FT)	Col. 4 Vol. (Ac-FT)	Col. 5 PP (MSL)	Col. 6 Dam Length	Col. 7 Principal Use	Col. 8 Estd. Cost (M-Dams)
ENGLISH RUN	1	352	19	38	239	1660	1200	R, WH	
	2	252	15	45	265	1560	1000	R, WH	
	3	773	30	40	485	1560	850	A, R, WH	
	4	473	9	30	110	1600	550	WH	
	5	829	17	40	264	1600	900	A, S, M	$292,320
	6	452	20	40	323	1650	1100	A, S, M	$357,280
	7	1494	9	35	129	1540	500	A, S, M	$142,100
	8	1722	37	60	882	1500	900	A, S, M	$438,480
	9	233	29	40	470	1580	1250	A, R, WH	
	10	92	21	30	254	1590	1100	WH	
	11	102	7	22	65	1540	350	A, S, M	$ 62,524
	12	96	7	30	88	1540	700	S, M	$170,520
	13	5907	46	85	1561	1040	850	S, F, R, WH	
OTTER RUN	11	748	44	53	934	1560	1300	A, F, M	$559,468
	12	725	38	50	753	1580	1300	A, F, R, WH	
	13	1200	51	42	848	1500	700	A, F, R, WH	
	14	1634	17	40	279	1420	700	S, M	$227,360
	15	634	25	40	397	1440	1350	S, M	$438,480
	16	207	23	30	275	1590	1000	S, M	$243,600
	17	14192	88	78	688	900	1000	S, F, R, WH	

Table No. 4

Principal Use Legend

A - Flow Augmentation

F - Flood Retardation

R - Recreation

WH - Wildlife Habitat

WS - Water Supply

S - Sediment Control

M - Mine Acid Treatment

Table No. 4 & Map No. 8

Site Legend Description

Column 1 - Watershed area in acres. To determine watershed size in square miles divide watershed area in acres by 640.

Column 2 - Size of Permanent Pool in acres.

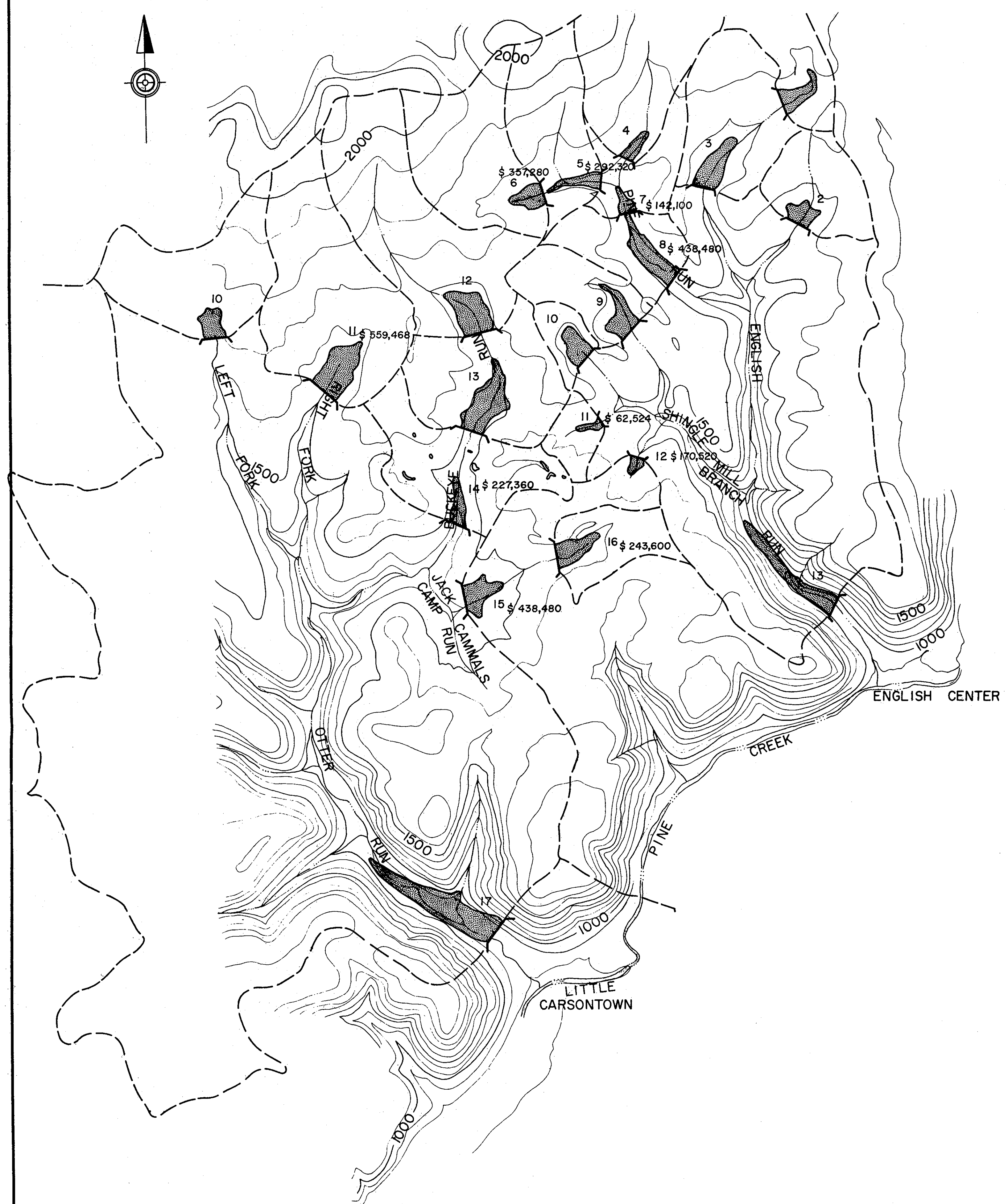
Column 5 - MSL (Mean Sea Level Elevation of Permanent Pool.)

Column 4 - Volume stored at permanent pool expressed in acre-feet.

Column 3 - Pool depth in feet from permanent pool elevation (MSL) to bottom of dam fill.

Column 6 - Length of Embankment needed.

Column 7 - Principal Uses.



(SEE PAGE 58 FOR SITE LEGEND DESCRIPTION)

COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF ENVIRONMENTAL RESOURCES

ENGLISH RUN

MINE DRAINAGE STUDY

MAP NO. 8-WATER IMPOUNDMENT AREAS

* COURTESY OF U.S.D.A. SOIL CONSERVATION SERVICE

SCALE 1" = 4000'	PREPARED BY ENGLISH ENGINEERING CORP. WILLIAMSPORT, PENNSYLVANIA
OCT. 1971	