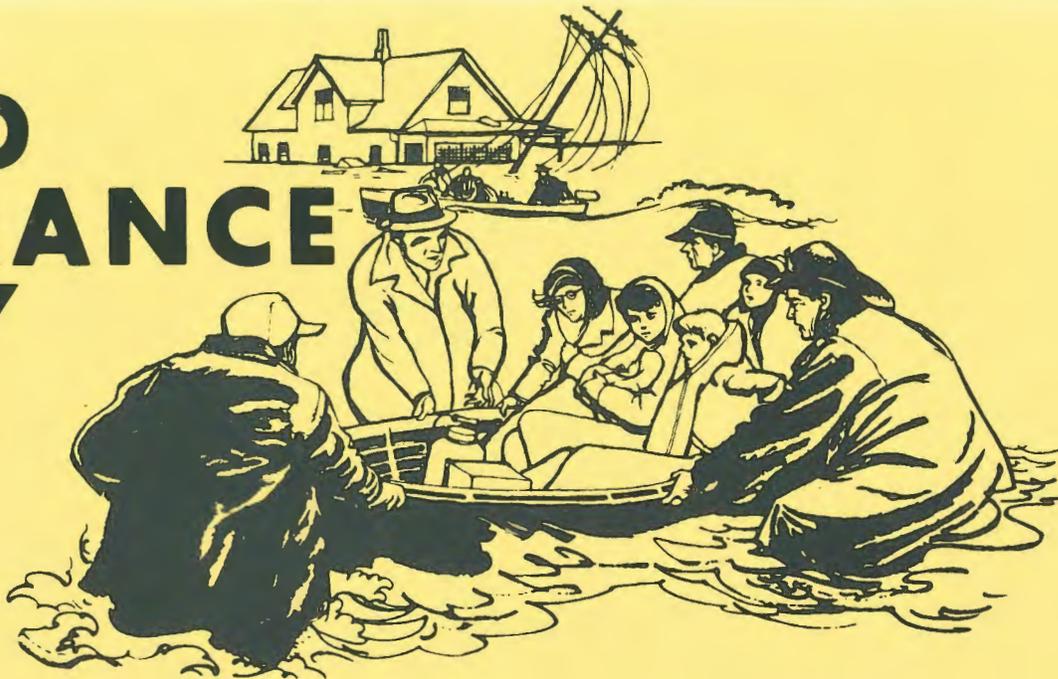


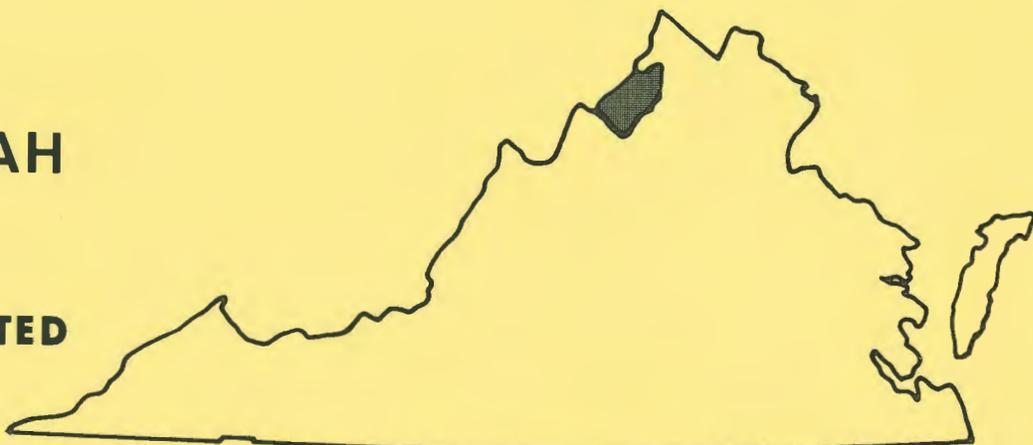
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FLOOD INSURANCE STUDY

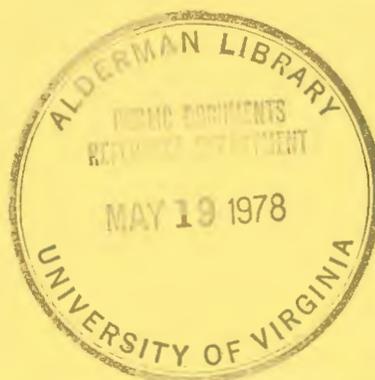


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**SHENANDOAH
COUNTY,
VIRGINIA
(UNINCORPORATED
AREAS)**



FEBRUARY 1978



**U.S. DEPARTMENT of HOUSING & URBAN DEVELOPMENT
FEDERAL INSURANCE ADMINISTRATION**

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PUBLISHED SEPARATELY:	
Flood Insurance Rate Map Index	
Flood Insurance Rate Map	Panels 510147 0001B-0275B

FLOOD INSURANCE STUDY
SHENANDOAH COUNTY, VIRGINIA

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this Flood Insurance Study is to investigate the existence and severity of flood hazards in the unincorporated area of Shenandoah County, Virginia, and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Initial use of this information will be to convert Shenandoah County to the regular program of flood insurance by the Federal Insurance Administration (FIA). Further use of the information will be made by local and regional planners in their efforts to promote sound land use and flood plain development.

1.2 Coordination

Meetings attended by Shenandoah County officials and personnel of the Virginia State Water Control Board, the FIA, and the study contractor were held in March and September of 1975 to identify streams to be studied by detailed and approximate methods.

During the course of the work, the county officials were contacted to discuss the study report. On April 13, 1977, results of the work were reviewed at the final Consultation and Coordination meeting attended by Shenandoah County officials and personnel of the Virginia State Water Control Board, the FIA, and the study contractor.

1.3 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968, as amended.

The hydrologic and hydraulic analyses for this study were performed by CH2M Hill, Inc., for the Federal Insurance Administration, under Contract No. H-3833. This work, which was completed in April 1977, covered all significant flooding sources in Shenandoah County.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the unincorporated areas of Shenandoah County. The area of study is shown on the Vicinity Map (Figure 1). Excluded from the area of study are all areas within the George Washington National Forest. Also excluded are the incorporated Towns of Edinburg, New Market, Mt. Jackson, Strasburg, Toms Brook and Woodstock.

It was agreed among the FIA, the study contractor, and Shenandoah County officials that floods caused by overflow of the North Fork Shenandoah River in the vicinity of Strasburg and Stony Creek in the vicinity of Edinburg were to be studied in detail.

Flooding along the remainder of the North Fork Shenandoah River and Stony Creek, as well as along Little Stony Creek, Passage Creek and several smaller streams in the county were studied by approximate methods. Approximate methods were used due to the small size of the flood plain and lack of development along these streams.

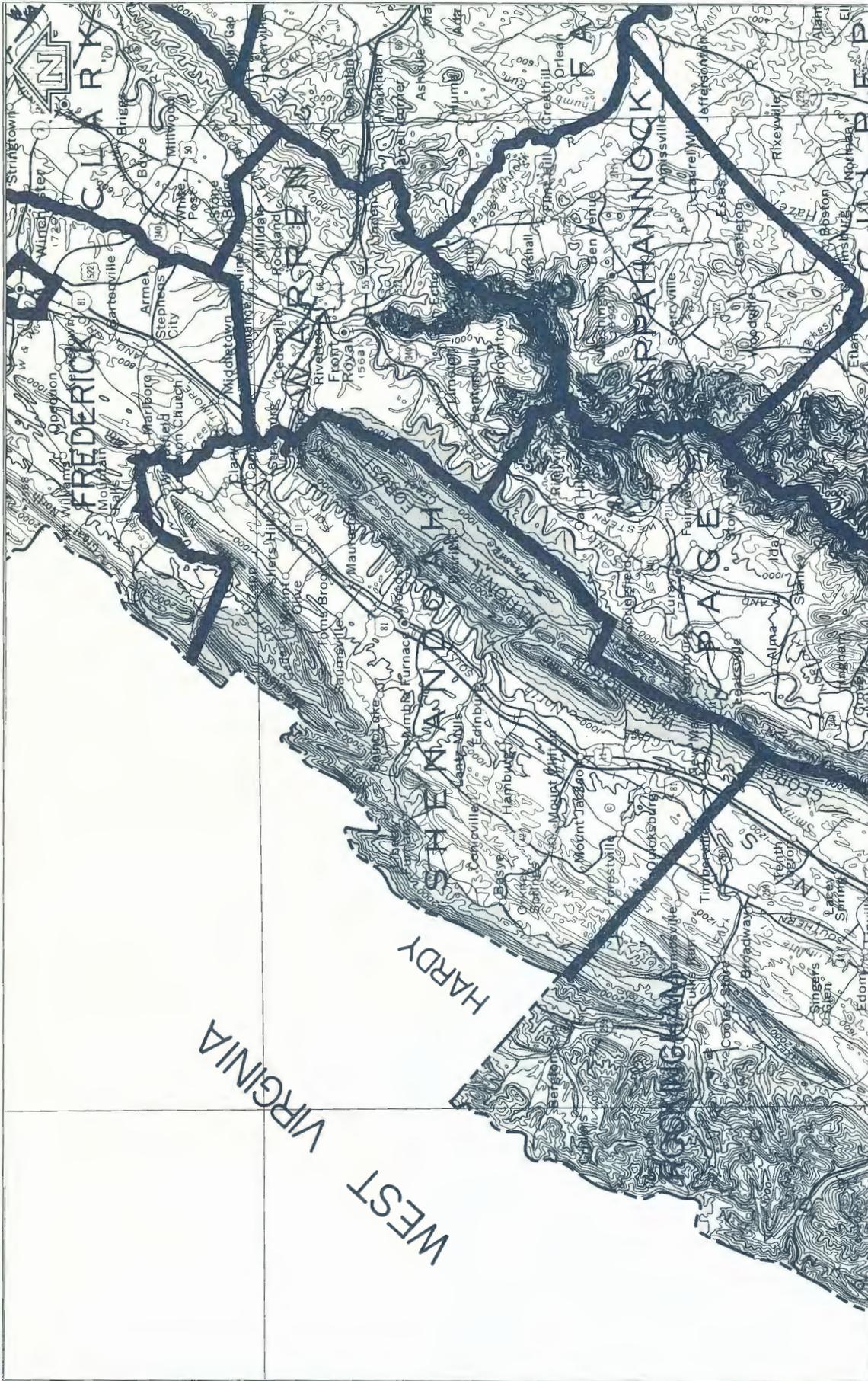
The areas studied in detail were chosen with consideration given to all forecasted development and proposed construction for the next five years (through February 1982).

2.2 Community Description

Shenandoah County is located in the extreme northwestern section of the Shenandoah Valley in northwestern Virginia. The county is bounded on the north by Frederick County, on the south by Rockingham and Page Counties, on the east by Page and Warren Counties and on the west by Hardy County, West Virginia (Reference 1).

Shenandoah County was formed from Frederick County in 1772. It was then named Dunmore County in honor of the last Colonial Governor of Virginia. In 1778 the county was renamed for the Shenandoah River. The Town of Woodstock was established as the county seat in 1752.

The county has a land area of 507 square miles. In 1970 the population of Shenandoah County was 22,852 and the Division of State Planning and Community Affairs has projected that the 1980 population will be 24,000. The climate is temperate with cold, but not severe winters and moderate summers. Temperatures average 32.5



DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
 Federal Insurance Administration

SHENANDOAH COUNTY, VA
 (UNINCORPORATED AREAS)

APPROXIMATE SCALE



VICINITY MAP

FIGURE 1

degrees Fahrenheit in February and 73 degrees Fahrenheit in July. Precipitation is evenly distributed throughout the year and averages 32.8 inches annually. Snowfall normally occurs during the months of February and March and averages a total of 26.5 inches annually (References 1 and 2).

Shenandoah County is well known for its poultry production. It also produces cattle, calves, hogs, apples and peaches. Although Shenandoah County is an agricultural county, more people are employed in manufacturing than farming. Much of the manufacturing, however, is related to the farming industry (Reference 3).

Shenandoah County lies in the Valley and Ridge Province of Virginia. The topography is steep to gently rolling and well drained. Elevations vary from 1,200 feet (National Geodetic Vertical Datum of 1929 (NGVD), formerly referred to as Sea Level Datum of 1929), in the valley to approximately 2,500 feet NGVD in the Massanutten Mountains and North Mountains. There are three major divisions of soils in the county. These are the Shenandoah Mountain Division, the Limestone and Shale Division, and the Massanutten Mountains Division. Most of the limestone and shale soils are found in the central portion of the county and have high productive potential for farming. The mountain soils are of little or no value for agricultural purposes (Reference 1).

Shenandoah County lies within the Potomac River Drainage Basin. North Fork Shenandoah River, the major drainage for the county, originates near the southern boundary and meanders through the county in a northeasterly direction. Other major watersheds are Stony Creek, Passage Creek, Cedar Creek and Smith Creek which all flow into the North Fork Shenandoah River.

Flood plain development along North Fork Shenandoah River and Stony Creek, the streams studied in detail, is mainly residential with some commercial development. There is also a high school and a sewage disposal plant located along the North Fork Shenandoah River near Strasburg.

2.3 Principle Flood Problems

According to streamflow records, the largest floods on North Fork Shenandoah River occurred in 1942 and 1936. Peak discharges for these floods are respectively estimated to be 100,000 cubic feet per second (cfs) and 89,000 cfs. Both of these discharges are greater than the 100-year flood computed at the gage. Smaller floods

occurred in 1955 and 1972. These discharges were recorded as 36,100 cfs and 35,700 cfs, respectively, approximately one mile downstream from Strasburg. Both of these floods are estimated to be between the 10-year and 50-year recurrence intervals (References 4 and 5).

Floods on Stony Creek were recorded in 1959 and 1972 with discharges of 6,900 cfs and 6,850 cfs, respectively. Both of these floods are estimated between the 10-year and 50-year recurrence intervals. Based on accounts of local residents it is estimated that there was a flood in 1942 which exceeded both of these floods in magnitude. Gaging records of nearby streams indicate that there was probably a significant flood on Stony Creek in 1936. Both the 1942 flood and 1936 flood occurred before the gaging station was in operation; therefore, no attempt is made to estimate corresponding discharges.

2.4 Flood Protection Measures

Flood plain management measures in Shenandoah County are described in the Virginia Uniform Statewide Building Code. This building code was adopted and is enforced by Shenandoah County. The code states that, where a structure is located in the 100-year flood plain, the lowest floor must be built at or above the 100-year flood elevation, except for nonresidential structures which may be flood proofed to that level (Reference 6).

There are presently no flood control structures on any of the streams studied in detail which would have an effect on base flood water-surface elevations.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Floods having recurrence intervals of 10, 50, 100, and 500 years have been selected as having special significance for flood plain management and for flood insurance premium rates. The analyses reported here reflect current conditions in the drainage areas of the streams.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each stream studied in detail in the county.

A gaging station on the North Fork Shenandoah River approximately 1 mile downstream from Strasburg was the principal source of data for defining discharge-frequency relationships for the river. This gage has been operated by the U. S. Geological Survey (USGS) since March 1925 (References 4 and 5). Values of the 10-, 50-, 100-, and 500-year peak discharges were obtained from a log-Pearson Type III distribution of annual peak flow data (Reference 7).

Peak discharges for Stony Creek were also obtained from a log-Pearson Type III distribution of annual peak flow data. The source of data for this analysis was provided by a gaging station near Columbia Furnace, Virginia, upstream of the study limits. This gage has been in operation since 1947 (References 4 and 5). Discharges for the downstream locations were adjusted based on drainage area.

Values of the 10-, 50-, 100-, and 500-year peak discharges were determined for the streams studied in detail. Drainage area peak discharge relationships for this stream are listed in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

<u>FLOODING SOURCE AND LOCATION</u>	<u>DRAINAGE AREA (sq. miles)</u>	<u>PEAK DISCHARGES (cfs)</u>			
		<u>10-YEAR</u>	<u>50-YEAR</u>	<u>100-YEAR</u>	<u>500-YEAR</u>
NORTH FORK SHENANDOAH RIVER					
Cross Section A	769	31,000	64,000	84,000	153,000
STONY CREEK					
Cross Section A	116	7,100	14,500	18,000	32,000
Cross Section F	109	6,900	13,500	17,000	30,000
Cross Section K	91	6,200	12,500	15,500	27,000
Diversion Dam	84	5,900	11,900	14,700	25,700

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the streams studied in detail in the county were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these streams.

Cross section data for each stream studied in detail were obtained from field surveys. Structural geometry for bridges on Interstate 81 crossing Stony Creek and State Route 648 crossing North Fork Shenandoah River was provided by the Virginia Department of Highways.

All other bridges, culverts and structures within the detailed study area were surveyed to obtain elevation data and structural geometry.

Roughness coefficients (Manning's "n") for each of these streams were estimated by field inspection at each cross section. Values of Manning's "n" for the North Fork Shenandoah River ranged from 0.055 to 0.065 for the channel and from 0.070 to 0.120 for the overbanks and for Stony Creek ranged from 0.055 to 0.065 for the channel and from 0.050 to 0.130 for the overbanks.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 3). Water-surface elevations of floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 8). Starting water-surface elevations for the streams studied in detail were computed using the slope-area method.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD); elevation reference marks used in the study are shown on the maps.

The hydraulic analyses for this study are based upon unobstructed flow. The flood elevations on the profiles are valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Approximate flood elevations for North Fork Shenandoah River, Stony Creek, Mill Creek, Crooked Run, Swover Creek, Smith Creek, Cedar Creek, Narrow Passage Creek, and Pughs Run were taken from USGS Maps of Flood Prone Areas (Reference 9). All other approximate elevations were determined by combinations of the following: correlation considering size of drainage area, slope vegetative cover and hydrologic conditions with other streams studied by detailed methods within the region; field reconnaissance; and engineering judgment.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage state and local governments to adopt sound flood plain management programs. Each Flood Insurance Study, therefore, includes a flood boundary

map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FIA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100 and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections the boundaries were interpolated using USGS 7.5 minute quadrangle maps (Reference 10) with 20 foot contour interval. In cases where the 100 and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown.

Flood boundaries for those streams studied by approximate methods were delineated using USGS 7.5-minute quadrangle maps 20 foot contour interval (Reference 10).

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 3). Small areas within the flood boundaries may lie above the flood elevations and, therefore, may not be subject to flooding; owing to limitations of the map scale or lack of detailed topographic data, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of the FIA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this report are presented to local

agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plains. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 2).

As shown on the Flood Boundary and Floodway Map (Exhibit 3), the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FIA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHF's) and flood insurance zone designations for each flooding source affecting Shenandoah County.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

<u>Average Difference Between 10- and 100-Year Floods</u>	<u>Variation</u>
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	WITH FLOODWAY (NGVD)	WITHOUT FLOODWAY (NGVD)	DIFFERENCE (FT.)
North Fork Shenandoah River							
A	6,300 ¹	685	18,969	4.4	538.0	537.2	0.8
B	8,300 ¹	925	22,520	3.7	538.8	537.9	0.9
C	10,250 ¹	1,526	28,769	2.9	539.4	538.4	1.0
D	15,085 ¹	1,315	23,603	3.6	541.8	540.9	0.9
E	15,835 ¹	1,056	21,139	4.0	541.9	541.0	0.9
Stony Creek							
A	150 ²	129	1,920	9.4	773.6	772.6	1.0
B	800 ²	98	1,531	11.8	776.5	775.7	0.8
C	1,500 ²	104 ³	1,396	12.9	778.9	778.5	0.4
D	2,496 ²	137	1,975	9.1	786.0	785.2	0.8
E	2,960 ²	130 ³	2,042	8.8	789.4	788.4	1.0
F	10,200 ²	142	1,950	8.7	815.9	814.9	1.0
G	10,570 ²	119	1,803	9.4	816.8	815.9	0.9
H	12,035 ²	167	2,378	7.1	821.1	820.4	0.7
I	12,560 ²	158	2,328	7.3	822.3	821.3	1.0

¹FEET ABOVE U.S. ROUTE 55
²FEET ABOVE MOUTH

³THIS WIDTH EXTENDS BEYOND THE CORPORATE LIMITS

TABLE 2

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

SHENANDOAH COUNTY, VA
(UNINCORPORATED AREAS)

FLOODWAY DATA

NORTH FORK SHENANDOAH RIVER AND STONY CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE ¹	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	WITH FLOODWAY (NGVD)	WITHOUT FLOODWAY (NGVD)	DIFFERENCE (FT.)
Stony Creek (continued)							
J	13,060	154	2,133	8.0	823.3	822.3	1.0
K	18,260	140	1,710	9.1	841.5	840.7	0.8
L	18,960	236	2,711	5.7	845.3	844.5	0.8
M	19,310	125	1,686	9.2	845.8	845.2	0.6
N	22,121	603	3,812	3.9	858.9	858.0	0.9
O	22,821	713	3,250	4.5	861.3	860.4	0.9
P	23,937	996	4,869	3.0	868.0	867.2	0.8

¹FEET ABOVE MOUTH

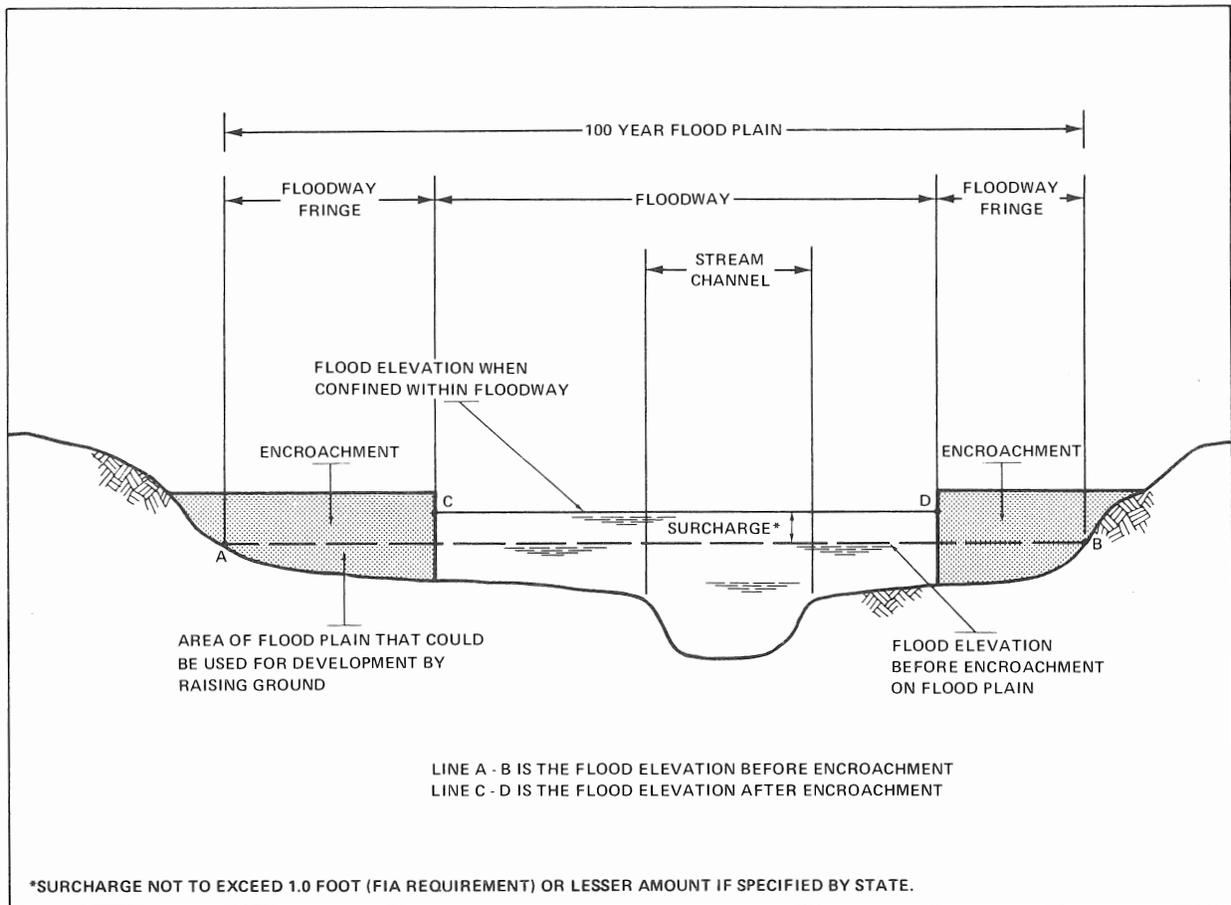
TABLE 2

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

SHENANDOAH COUNTY, VA
(UNINCORPORATED AREAS)

FLOODWAY DATA

STONY CREEK



FLOODWAY SCHEMATIC

Figure 2

Five reaches meeting the above criteria were required for flooding sources in Shenandoah County. These included one on North Fork Shenandoah River and four on Stony Creek. The locations of these reaches are shown on the Flood Profiles (Exhibit 1).

5.2 Flood Hazard Factors

The FHF is the FIA device used to correlate flood information with insurance rate tables. Correlations between property damages from floods and their FHF's are used to set actuarial insurance premium rate tables based upon FHF's from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot, and shown as a three-digit code. For

example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHF's, the entire area of study was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A: Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods, no base flood elevations shown or FHF's determined.

Zones A4, A9, A10, A20: Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones assigned according to FHF's.

Zone B: Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; or, areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

Table 3, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHF's, flood insurance zones, and base flood elevations for each flooding source studied in detail in the county.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Shenandoah County is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of

FLOODING SOURCE	PANEL ¹	ELEVATION DIFFERENCE ² BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION ³ (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
North Fork Shenandoah River	125	-10.3	-2.4	+8.2	100	A20	Varies
Stony Creek	200	- 4.8	-0.8	+4.0	050	A10	Varies
	200	- 5.2	-1.1	+4.5	050	A10	Varies
	200	- 4.3	-1.3	+3.2	045	A9	Varies
	200	- 2.2	-0.6	+1.8	020	A4	Varies

¹FLOOD INSURANCE RATE MAP PANEL

²WEIGHTED AVERAGE

³ROUNDED TO NEAREST FOOT - SEE MAP

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

SHENANDOAH COUNTY, VA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

NORTH FORK SHENANDOAH RIVER AND STONY CREEK

TABLE 3

flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the FIA.

6.0 OTHER STUDIES

There are no conflicts between the data presented in this report and the data presented in the Flood Insurance Study for Frederick County, Virginia (Reference 11).

No other published reports dealing with flood problems within the study area were found.

This study is authoritative for purposes of the Flood Insurance Program and the data presented here either supersede or are compatible with previous determinations.

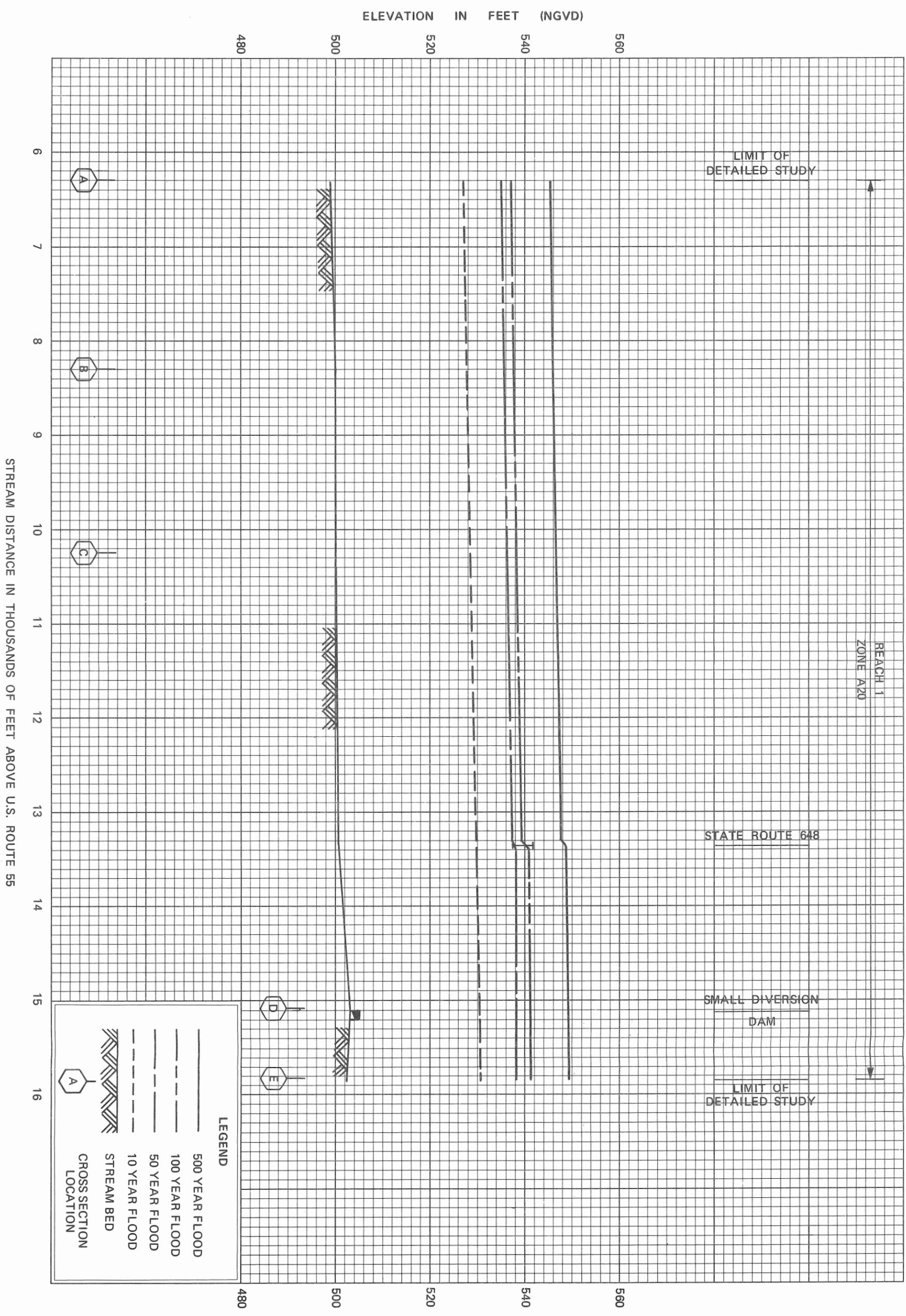
7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the office of the Federal Insurance Administration, Regional Director, Curtis Building, Sixth and Walnut Streets, Philadelphia, Pennsylvania 19106.

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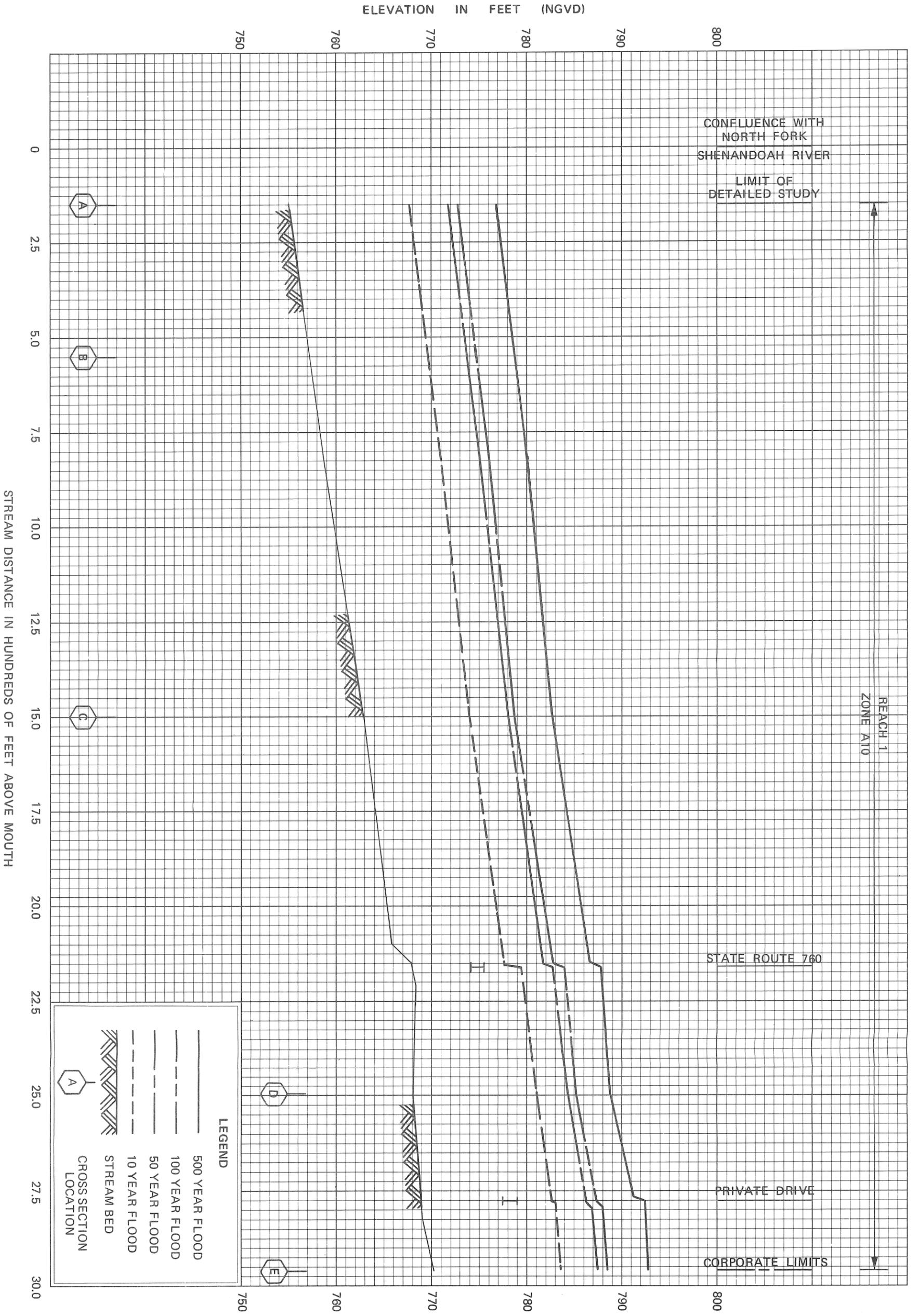


DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

SHENANDOAH COUNTY, VA
(UNINCORPORATED AREAS)

FLOOD PROFILES

NORTH FORK SHENANDOAH RIVER



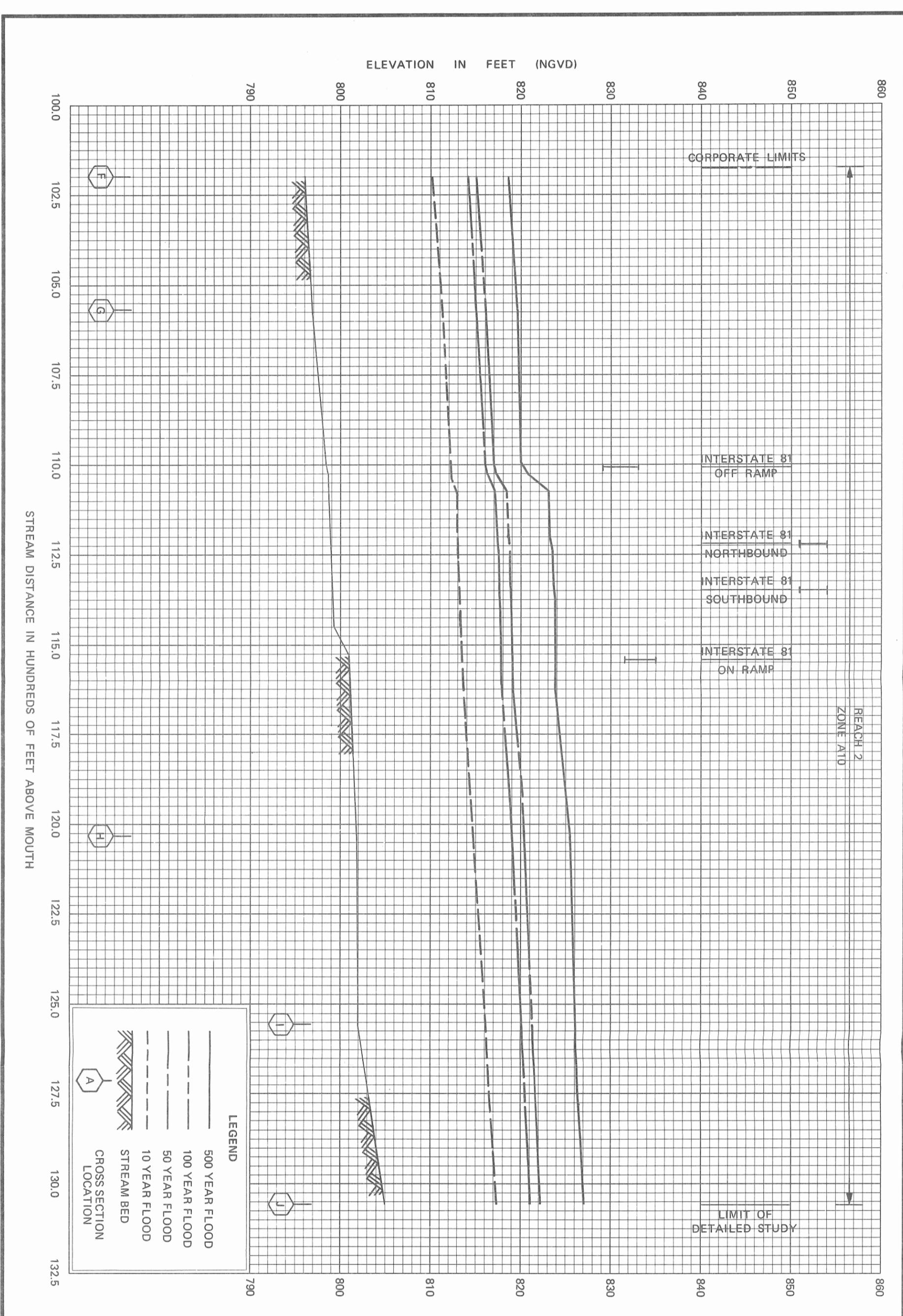
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

SHENANDOAH COUNTY, VA
(UNINCORPORATED AREAS)

FLOOD PROFILES

STONY CREEK

02P



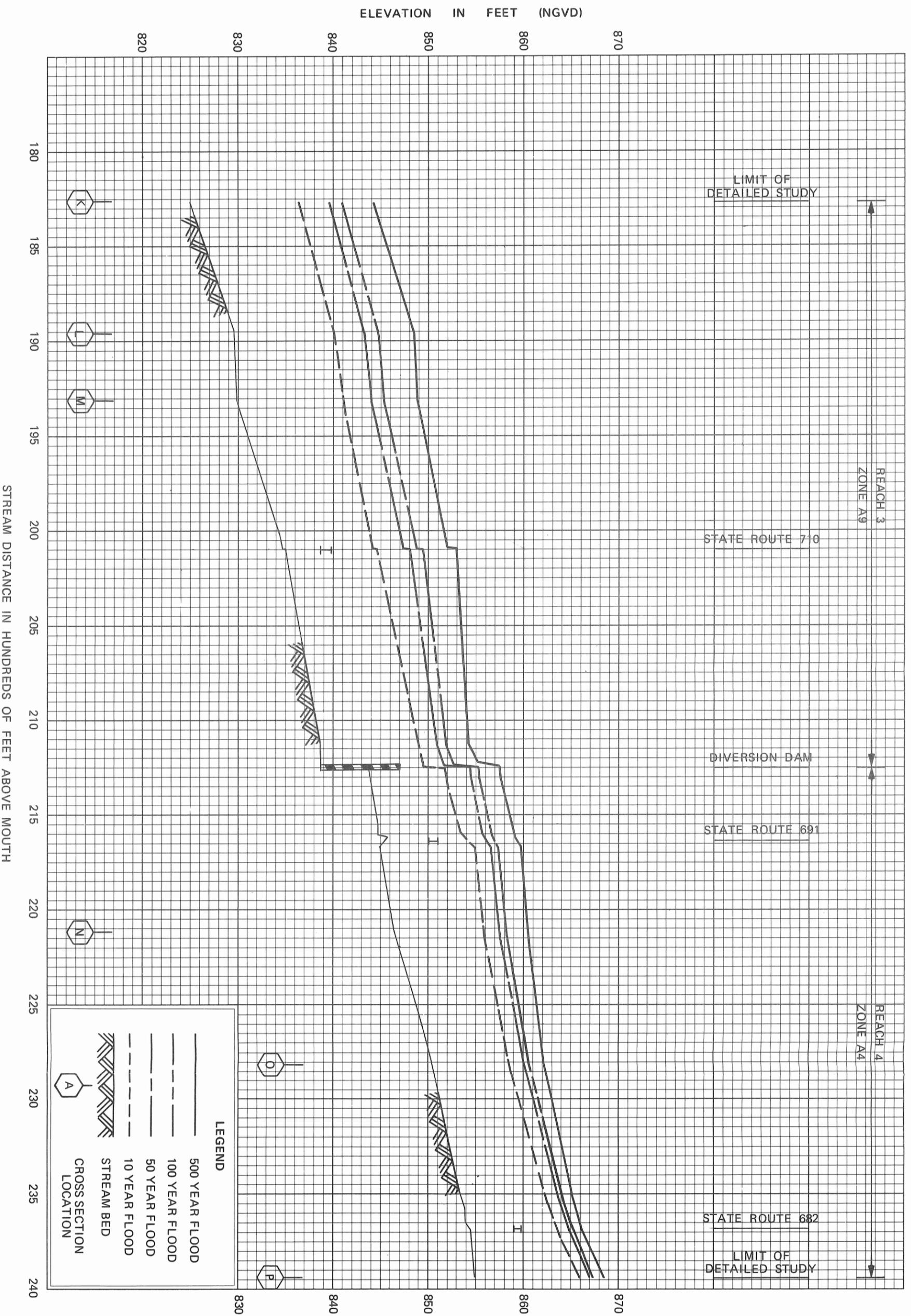
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

SHENANDOAH COUNTY, VA
(UNINCORPORATED AREAS)

FLOOD PROFILES

STONY CREEK

03P



LEGEND	
	500 YEAR FLOOD
	100 YEAR FLOOD
	50 YEAR FLOOD
	10 YEAR FLOOD
	STREAM BED
	CROSS SECTION LOCATION

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FLOOD PROFILES
STONY CREEK

04P