

## Chapter 6

# Utilizing Information from Flood Hazard Studies

### Chapter Overview

Chapter 4 reviewed commonly applied hydrological computational techniques for arriving at estimates of flood flows in streams. These flow estimates are utilized in conducting engineering studies to determine areas subject to floodwater inundation for expected recurrence intervals of interest, the topic of Chapter Five. This chapter describes and illustrates the contents of typical flood hazard studies. Understanding and applying data from these studies are vital in investigating and carrying out the variety of flood damage reduction and resource protection approaches covered in subsequent chapters of this course.

### Sources of Studies

The historical account, in Chapter Three, of this nation's response to flood disasters provides a detailed description of the first efforts, starting in the 1950s, to identify by scientific means areas subject to flooding.<sup>1</sup> They principally involved federal agencies carrying out floodplain mapping in response to their program missions. An overview is provided to transcend to the contents of present-day studies.

#### **TVA, Corps, USGS, SCS, et. al.**

The Tennessee Valley Authority (TVA) was the first federal agency to prepare flood hazard information studies for communities throughout a regional or statewide area. Starting in 1954, and well into the 1980's, TVA produced over 150 reports for some 200 Tennessee River watershed communities. They included historical accounts of past floods and future hypothetical floods termed the "regional" and "maximum probable" floods. The U.S. Army Corps of Engineers (Corps) followed the TVA lead and starting in 1962 and continuing through 1978, prepared around 1,800 floodplain information reports covering 3,500 communities. Similar to TVA reports, data were provided on past floods and projections of future events termed the "regional" and "standard project" floods. During the 1950s and the 1960s, the U.S. Geological Survey (USGS) prepared nearly 70 Hydrologic Investigations Atlases at sites in 17 states. By the early 1970s, the U.S. Soil Conservation Service (SCS), now U.S. Natural Resources Conservation Service, had started to prepare local flood hazard studies. During a decade, the SCS prepared flood hazard maps for nearly 600 rural communities.

By the late 1970s the above agencies had begun to curtail their publication of flood hazard information reports in favor of the rapidly growing Federal Insurance Administration (FIA) flood insurance studies. Their roles had changed from conducting their own studies to carrying out flood insurance studies for the FIA under interagency agreements. Several thousand studies were prepared in this manner. For a more detailed account of these agencies involvement in community flood hazard studies, refer to the previously cited document. Other agencies, states, and special districts carried out a few studies.

Because these flood hazard information reports have been, in almost all instances, superceded by flood insurance studies, and likely no longer used, their contents will not be discussed here. The

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<sup>1</sup> "The Nation's Responses To Flood Disasters: A Historical Account," Association of State Floodplain Managers, 2000.

remainder of this chapter describes and illustrates the myriad of flood insurance study types currently being utilized by flood-prone localities.

### **Flood Insurance Studies**

Congress established the National Flood Insurance Program (NFIP) in enacting the Housing and Urban Development Act of 1968 (Public Law [P.L.] 90-448). The Act created the Federal Insurance Administration (FIA) within the U.S. Department of Housing and Urban Development. Congress tasked the FIA to carry out studies within which flood insurance provisions and appropriate land use regulations would be applied. A more detailed discussion of the NFIP is found in a subsequent chapter.

The FIA was faced with an enormous task of identifying the nation's floodplains on a sound scientific and credible basis. In order to provide some information to localities within a reasonable timeframe, a number of approaches and products were developed and utilized until subsequent detailed studies could be carried out. This national mapping effort started in the early 1970s and continues today as previous studies are updated.

### ***Flood Insurance Study Contents<sup>2</sup>***

#### *Flood Hazard Boundary Maps*

Utilizing flood data and floodplain information from a variety of sources (e.g., soils mapping, actual high water profiles, aerial photographs of previous floods, topographic maps, etc.), the *approximate* outline of the extent of the one-percent-chance (or 100-year) floodplain for specific stream reaches was overlaid on available community maps, usually United States Geological Survey topographic quadrangle maps. In this manner, Flood Hazard Boundary Maps (FHBM) were prepared, without benefit of detailed studies or hydraulic analyses, for nearly all flood prone communities in the nation (over 18,000). Some communities were not mapped initially.

On the FHBM, the Special Flood Hazard Area (SFHA) is designated as a shaded area labeled "Zone A," and no flood elevations are given (see Figure 6-1). These FHBM's were intended for *interim* use in most communities until more detailed studies could be carried out. Where there were little or no development, or expectation of development, in identified flood prone areas, further studies were never carried out. As a result, many of these studies still exist and in use.

#### *Flood Insurance Study Reports*

After this initial mapping effort the FIA started preparing Flood Insurance Studies in the early 1970s. The study is a compilation and presentation of flood risk data for specific watercourses within a locality. The study report and associated maps delineate flood hazard areas and establish flood elevations, thereby serving as a basis for regulating floodplain development and providing flood insurance.

The study report includes:

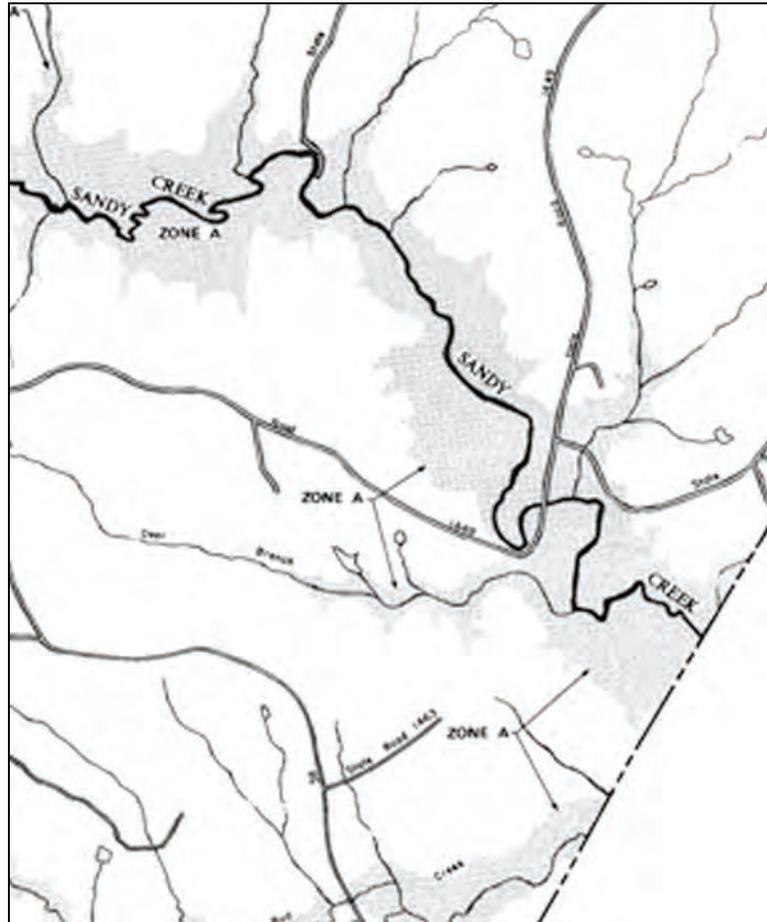
- ∞ A narrative describing the purpose of the study and the study process
- ∞ Tables summarizing various study data
- ∞ Computed flood profiles for floods of various magnitudes

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<sup>2</sup> Much of the following material was extracted from the document "Carrying Out Floodplain Management in Your Locality: Home Study Course for North Carolina Community Officials," November 1997, North Carolina Division of Emergency Management and Federal Emergency Management Agency. The author was principally responsible for preparing this document under employment by FEMA for this purpose.

- ∞ Two types of maps, the Flood Insurance Rate Map (FIRM), and the Flood Boundary and Floodway Map (FBFM)

Each Flood Insurance Study report cover has an outline map of the state in which the study community is located. The location of the community is pinpointed on the outline map.



**Figure 6-1. Flood hazard boundary map.**

### *Report Contents*

Section 1 of a Flood Insurance Study (FIS) report provides an introduction stating the purpose of the FIS, authority and acknowledgments, and coordination. Section 2 provides background information on the community, its flood problems, which areas were studied, and what flood protection measures are in effect.

Section 3 discusses the engineering methods used. Section 3.1 covers *hydrologic analyses*—how much water will flow through the floodplain during peak floods. Section 3.2 describes the *hydraulic analysis*—where the water will go.

Section 4 of the FIS report discusses how the flood map was prepared from the flood data for floodplain management applications. Section 4.1 covers mapping the floodplain boundaries. Section 4.2, if included, describes the floodway study and mapping. Section 4 also includes the Floodway Data Table. How to interpret and use these and other data is discussed below.

Section 5 of the FIS report covers data related to flood insurance. This section may be further subdivided into 5.1, Reach Determinations; 5.2, Flood Hazard Factors; 5.3, Flood Insurance Zones; and 5.4, Flood Insurance Rate Map Descriptions.

Section 6, Other Studies; Section 7, Location of Data; and Section 8, Bibliography and References are self-explanatory. Most riverine Flood Insurance Studies include flood profiles as an exhibit at the end of the document. Coastal studies include a map of transect locations and a table with stillwater and 1 percent annual chance elevations along each transect. A map index and floodplain maps are included as separate exhibits.

*Data Tables*

An excerpt from the City of Kinston, NC Flood Insurance Study report is shown below as Table 6-1.

Table 6-1. City Of Kinston, NC, Flood Discharges (excerpt)					
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mi.)	PEAK DISCHARGES (cfs)			
		10-YEAR	50-YEAR	100-YEAR	500-YEAR
NEUSE RIVER USGS gage at Kinston	2,690.0	19,000	27,900	33,300	54,000
SOUTHWEST CREEK At mouth	67.5	2,520	4,610	5,800	9,410
Below Mill Branch	61.0	2,370	4,360	5,500	8,940
Above Mill Branch	56.7	2,270	4,190	5,280	8,610
Below Strawberry Branch	54.9	2,230	4,120	5,190	8,470
Above Strawberry Branch	50.8	2,130	3,940	4,980	8,130
At NC Highway 58	49.5	2,100	3,890	4,910	8,030

The table summarizes the peak amount of water discharge for various flood frequencies at locations within the study area. The sizes of the drainage areas contributing to the water runoff producing the floods are also shown in the table. The 100-year flood discharge for Southwest Creek at NC Highway 58 is 4,910 cubic feet per second (cfs). This means that 4,910 cubic feet of water will pass this point each second during the peak of the 100-year flood.

Each study report also includes a Floodway Data table, presenting data from the hydraulic analysis. A table from the Columbia County, Florida FIS is reproduced below as Table 6-2. To interpret the floodway data, follow these steps:

1. All numbers shown in the table are those calculated at each floodplain cross section. The first two columns (*Flooding Source*) identify the cross sections used in the FIS and their distance from some reference point, usually the mouth of a river or the point where a stream reaches a river or other stream. The locations of these cross sections are shown on the accompanying flood maps.

- The next three columns (*Floodway*) provide data on the floodway at each cross section. At cross section B, on the Santa Fe River, the floodway is 2,099 feet wide. This information is useful for double-checking the width of the floodway portrayed on the FIRM or FBFM. The cross-sectional area of the floodway below the elevation of the “100-year” flood at this location is 25,132 square feet. The floodway area data is used to determine the velocity of water flow.
- The average or mean velocity of the 100-year flood in the floodway is 0.7 feet per second. Similar data are provided at each of the other cross sections.

Table 6-2. Columbia County, FL, Floodway Data								
FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE <sup>1</sup>	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Suwannee River								
AA	200.74	2,966	47,233	0.6	105.5	105.5	105.4	0.9
AB	202.58	3,077	41,632	0.6	106.1	106.1	107.1	1.0
AC	203.96	4,020	46,730	0.6	106.7	106.7	107.7	1.0
AD	205.26	2,339	33,875	0.8	107.7	107.7	108.6	0.9
AE	206.35	2,667	40,568	0.7	108.2	108.2	109.1	0.9
Santa Fe River								
A	0.742	1,694	23,965	0.7	33.8	33.8	34.8	1.0
B	1.572	2,099	25,132	0.7	34.0	34.0	35.0	1.0
C	3.232	1,217	17,908	0.9	34.5	34.5	35.5	1.0
D	4.522	1,615	28,519	0.6	34.8	34.8	35.8	1.0
E	6.262	1,832	28,188	0.6	35.2	35.2	36.2	1.0
F	7.312	1,883	25,502	0.6	35.5	35.5	36.5	1.0
G	8.332	1,643	22,407	0.7	35.9	35.9	36.8	0.9
H	9.812	1,668	23,330	0.7	36.6	36.6	37.5	0.9
I	11.112	1,615	21,455	0.8	37.2	37.2	38.2	1.0
J	11.842	1,587	18,323	0.9	37.6	37.6	38.6	1.0
K	12.942	1,224	18,240	0.9	38.2	38.2	39.2	1.0
L	13.742	1,368	19,267	1.0	38.6	38.6	39.6	1.0
M	14.912	541	7,946	2.5	39.6	39.6	40.5	0.9
N	15.572	524	6,489	3.0	40.6	40.6	41.5	0.9

<sup>1</sup> Feet above mouth

<sup>2</sup> Total width/width within extraterritorial limits

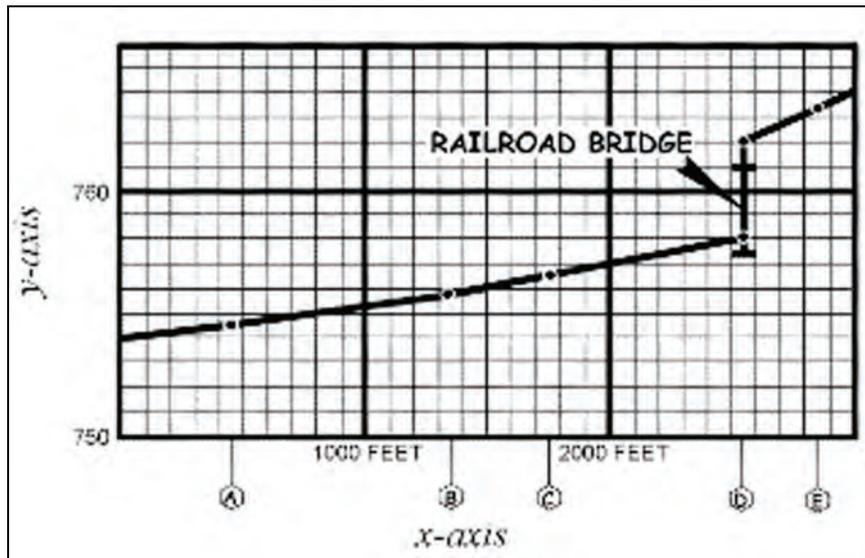
- Three of the last four columns *provide base floodwater surface elevations*. (The 1 percent annual chance or “100-year” flood is referred to as the “base flood” by the FIA.) The main column of interest is the first one, the regulatory flood elevation. The others summarize the increases in the water surface at each cross section from confining flood flows within the floodway. At no cross section is the increase more than 1.0 foot, in accordance with NFIP standards (covered in a later chapter).

### ***Flood Profiles***

Usually, four flood levels are shown on the flood profile fold-out sheets in flood insurance studies: the 10-, 50-, 100-, and 500-year floods (refer to Figure 5-8 in the previous chapter). Only the 100-, and 500-year floods are used for compliance with NFIP standards, but the others are useful for other floodplain management applications, such as septic system design and location, bridge and culvert design, and urban stormwater management.

In addition to the profiles, these sheets contain a plot of the stream bed, the locations of the cross sections used in the FIS (a letter within a hexagon), and stream crossings (depicted as a large “I” to indicate the top of deck and lowest structure component elevations of the bridge). The data are plotted on a grid to facilitate their interpretation. With few exceptions, the large grid squares are one inch long in both the horizontal and vertical direction and are divided into ten squares in both directions. This greatly aids in making measurements.

Refer to the profile shown in Figure 6-2. The bottom or X-axis shows the distance along the river or stream. To be consistent with other data in the flood insurance study report, distance is measured above the mouth of the river or its confluence with another river. The left side or Y-axis shows elevation, almost always referenced to National Geodetic Vertical Datum (NGVD), a national datum based on mean sea level.



**Figure 6-2. Typical stream profile.**

The profile in Figure 6-2 has the following data plotted:

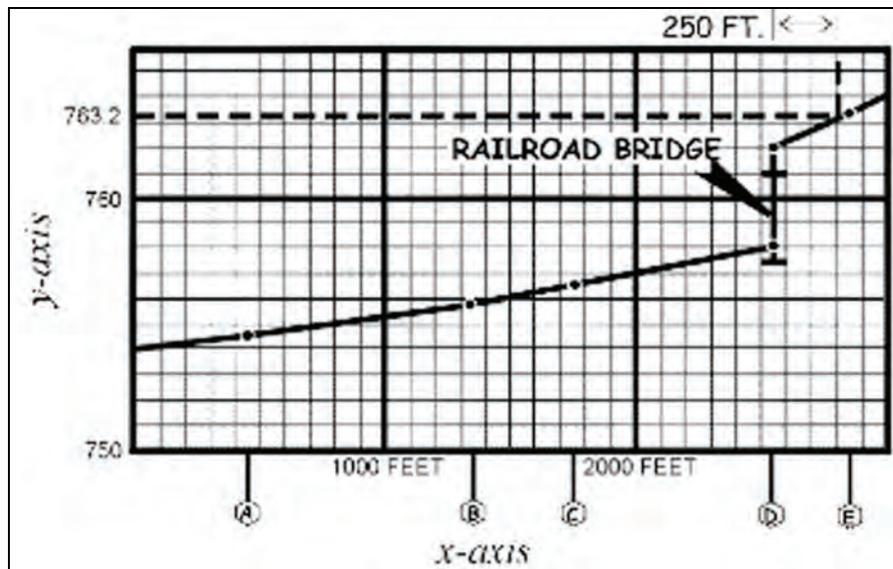
Table 6-3. Stream Profile Data		
Cross section	Feet above mouth	Flood elevation
A	450	754.6
B	1,340	755.8
C	1,760	756.6
D	2,550	758.0 (downstream) 762.0 (upstream)
E	2,850	763.4

When floodwaters reach a bridge or culvert at a stream crossing, several things can happen. All the floodwater can flow through the culvert or under the bridge without backing up or ponding upstream of the crossing. In this instance, the stream profile would not have an appreciable change at the culvert or bridge. If the bridge or culvert is not of adequate size to handle the flood flow, then water can pond upstream. Depending on the elevation of the floodwater relative to the

elevation of the top of the roadway, it may or may not flow over the roadway. In the example shown in Figure 6-2, the railroad crossing of the stream does not have an adequate opening to handle the floodwater, causing it to back up. It continues to do so until it is able to flow over the railway embankment. At cross-section D, representing the railroad bridge, the flood elevation *below* (downstream) of the bridge would be 758.0, and the flood elevation *above* (upstream) of the bridge would be 762.0. In these instances, when reviewing or determining a flood elevation for a site, pay particular attention to whether the site is upstream or downstream of the stream crossing in order to ascertain the applicable elevation.

Figure 6-3 illustrates how to determine flood elevations using plotted data from engineering studies. In this example the profile shown in Figure 6-2 is used to find the flood elevation at a point 250 feet upstream of the railroad bridge by the following steps.

1. Check the horizontal scale at the bottom of the profile. Here each horizontal square (each line on the X-axis) represents 100 feet along the stream. Each vertical square (each line on the Y-axis) represents one foot of elevation.
2. Two hundred and fifty feet upstream of the railroad bridge would be equivalent to two and a half squares to the right of the "I" symbol for the bridge. Mark a vertical line to intersect the profile, as shown in Figure 6-3. At this point, draw a straight line to the left edge of the profile.
3. Read the flood elevation off the left edge of the profile. In this example, it is 3.2 squares above 760 feet, so the flood elevation would be 763.2 (see Figure 6-3). *Note: When profiles are plotted to this scale, always estimate elevations to 1/10<sup>th</sup> of a foot.*



**Figure 6-3. Reading a profile.**

As discussed in Chapter 5, instead of using surveyed cross sections, coastal survey data are called *transects*. The FIS report shows where transects were surveyed, and transect data, including the 100-year stillwater and base flood elevations. The base flood elevation decreases with increasing distance from the shoreline.

### *Flood Prone Area Maps*

There is a direct correlation between the information contained on flood profiles (and in other parts of the flood insurance study report) to that depicted on the various National Flood Insurance Program (NFIP) maps described below. Flood profiles and some types of floodplain maps show the location of surveyed cross sections. Flood elevations have been computed at each of these locations. Using ground elevation data shown on a topographic map, a determination is made as to where the flood elevation would intersect the ground at a particular cross section. These points are plotted on the map. Using other topographic data between the cross sections, floodplain boundary lines are drawn connecting the points (refer to Figure 5-9).

Since the early 1970s, the Federal Insurance Administrator has prepared a variety of flood maps in response to changing program needs and advances in technology. Because each of these flood map types will likely be encountered in practice, they are described here to aid in understanding and applying them.

- ∞ Flood Hazard Boundary Map (FHBM) (also described above)
- ∞ Flood Boundary and Floodway Map (FBFM)
- ∞ Old format Flood Insurance Rate Map (FIRM)
- ∞ New format FIRM
- ∞ Digital FIRM

### *General Map Features*

#### *Map Index*

Many communities, including all counties, are geographically too large to fit on one map panel at a usable scale. The maps for these communities are, therefore, divided into two or more “panels” with unique panel numbers. Whenever a community requires more than one panel, a “Map Index” for both the FIRM and FBFM (and FHBM) is prepared (see Figure 6-4a).

The map index shows the entire community boundary, highlighting prominent features within the community, including major highways, railroads, and streams. The map index shows how the community is divided into the various panels. The map index also depicts the following:

*Title Block.* Includes the community name, county name, community identification number, and panel numbers. It is located at the lower right hand corner of the map when unfolded.

*Community Identification Number.* The community number consists of six digits, in which the first two digits are the same for all communities in a state. Hyde County, NC community identification (CID) number is 370133 (Figure 6-4). Knoxville, TN number is 475434.

*Panels Printed.* FEMA prints only those panels having flood hazard areas; printed panel numbers are indicated on the title block (see Figure 6-4a).

*Panels Not Printed.* Panels that have no flood hazard areas (or floodways on a set of FBFMs) are indicated by an asterisk (see Figure 6-4b). Sometimes the entire panel is in one flood zone and is not printed. The flood zone for that panel is noted directly on the map index.

*Map Index Date.* The date shown on the title block reflects the most recent map revision. As changes occur within a community which result in a change in flood elevations or floodplain delineation, FEMA republishes *only the map index and those map panels* affected. Any revised panels are given a new map effective date, indicating when they were officially revised, and a suffix letter after the panel number to indicate that the panel has been revised. The panel suffix letter is changed (to B, C, etc.) with each revision. A given community could have two or more map panel effective dates. The map index shows the current effective map date for all the FIRM panels *or* that of the most recently revised panel.

*Map Panel Numbers.* Each map panel is assigned a four-digit number that follows the community identification number. The panel numbers for Hyde County are 0025–0830. Panel numbers are based on a standard grid system and frequently occur in increments of 10 or 25. Thus, there are only 48 panels for Hyde County, not 830.

#### *Flood Hazard Boundary Maps (FHBM)*

As discussed before, the Special Flood Hazard Area (SFHA) is designated on the FHBM as a shaded area labeled “Zone A,” and no flood elevations are given (see Figure 6-6). An FHBM title block, map key, and map for Franklin County, NC are shown in Figures 6-5 and 6-6.

*Title Block.* Includes the community name, county name, community identification number, and the panel number (Figure 6-5). Franklin County’s Community Number is 370337. The title block for Panel 6 is shown. The “A” after the panel number indicates this is the original panel and has not been revised.

*Map Dates.* The effective date of the map panel is found on the title block. Further information on initial identification of flood hazard areas and date of map revisions will appear in the map legend.

*Approximate 100-year Flood Zone.* Designated by a blue or gray shaded area and labeled Zone A.

*Map Scale.* The map scale for the panel shown in Figure 6-6 is one inch equals 2,000 feet (found on “Key to Symbols,” Figure 6-5).

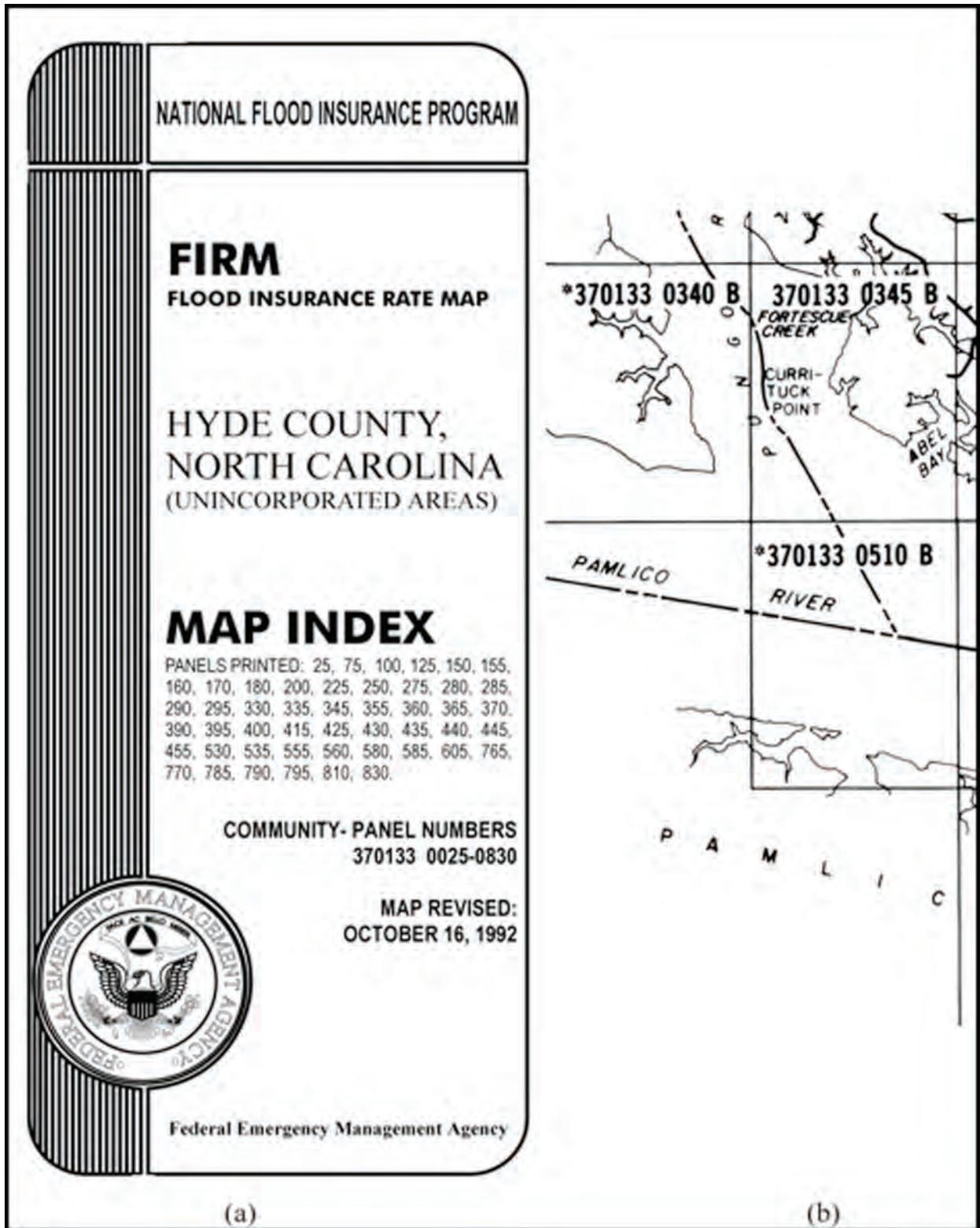
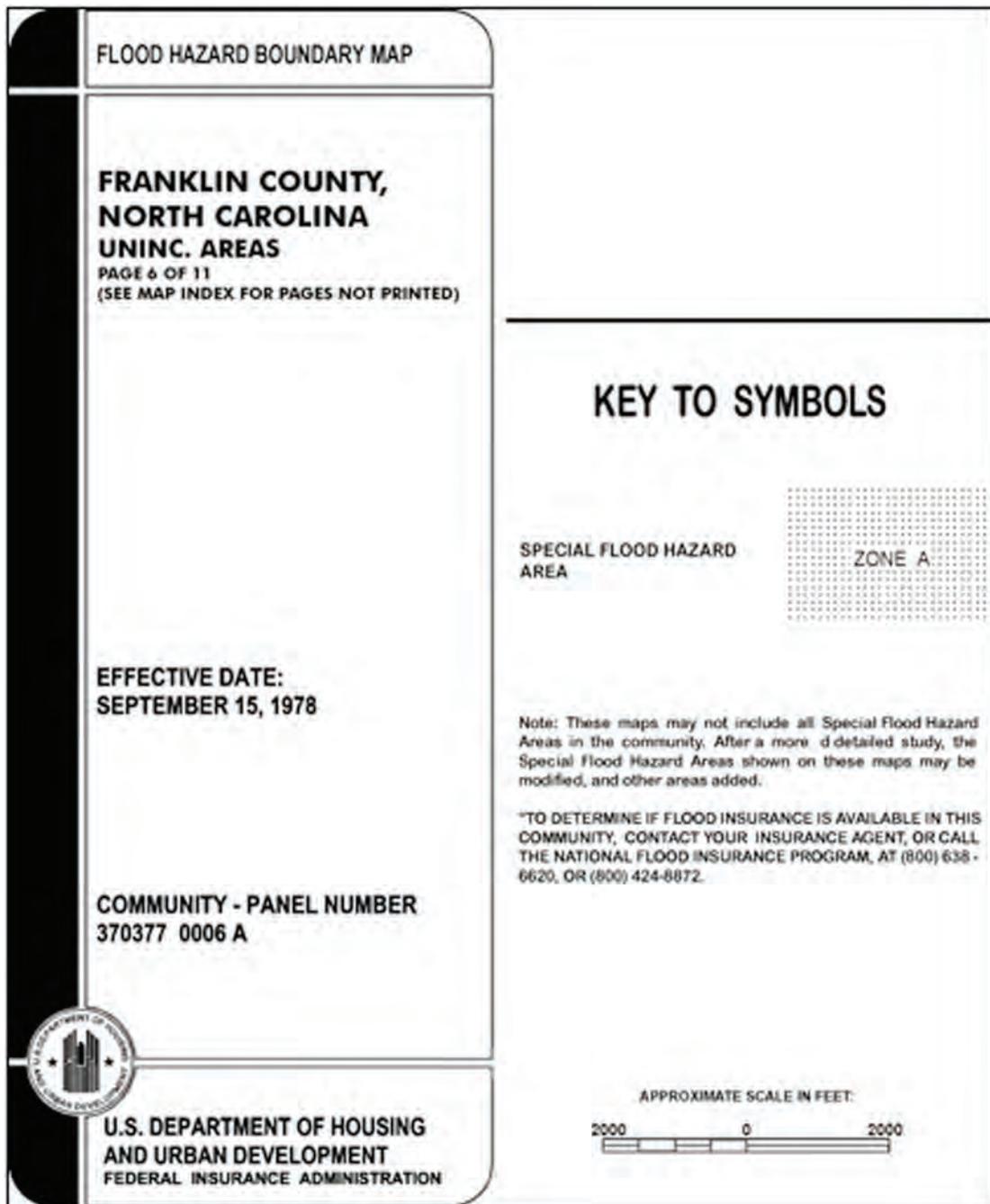


Figure 6-4. FIRM map index.



**Figure 6-5. Title block and key to FHBMs.**

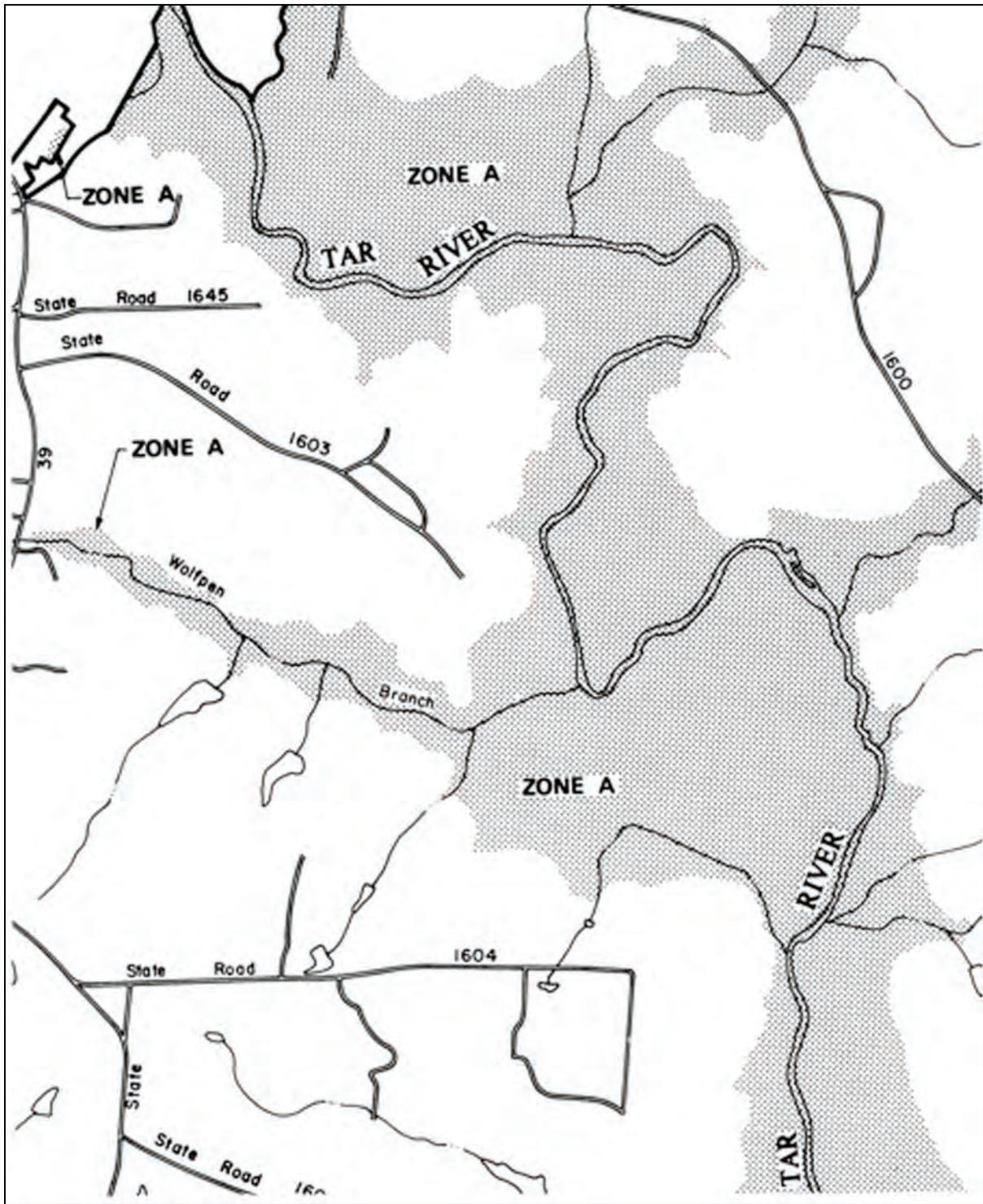


Figure 6-6. Flood hazard boundary map (FHB).

*Flood Insurance Rate Map (FIRM)—Old Format*

The Flood Insurance Rate Map (Figures 6-7 and 6-8) is used mainly by lenders, insurance agents, real estate agents, appraisers, property owners, and private citizens to determine:

- ∞ Whether a specific property is located within the floodplain
- ∞ The flood insurance zone that applies to the property
- ∞ The approximate base flood elevation (BFE) at the site

*Title Block.* Includes the community name and county name, community identification number, and the panel number (see Figure 6-7).

*Map Dates.* The effective date of the map panel appears on the title block. Other dates that may be listed in the map key (or legend) include:

- ∞ Initial Identification—date when the flood hazards in the mapped community were first identified [FHBM], and any revisions prior to issuance of a FIRM.
- ∞ Flood Insurance Rate Map Effective—date the community was converted to the regular program of the NFIP which normally corresponds to the date of the initial FIRM.
- ∞ Flood Insurance Rate Map Revision—dates of subsequent revisions to the FIRM, if any, and a brief description of the reasons for the revisions.

*Map Scale.* Shown on the “Key to Map.” Different scales may have been used for a single community with more than one map panel.

*100-Year Floodplain.* Denoted by dark-shaded areas (Insurance Zones A, A1–A30, AE, AO, AH, V, V1–V30, VE). In Figure 6-8, most of the floodplain is designated Zone A13.

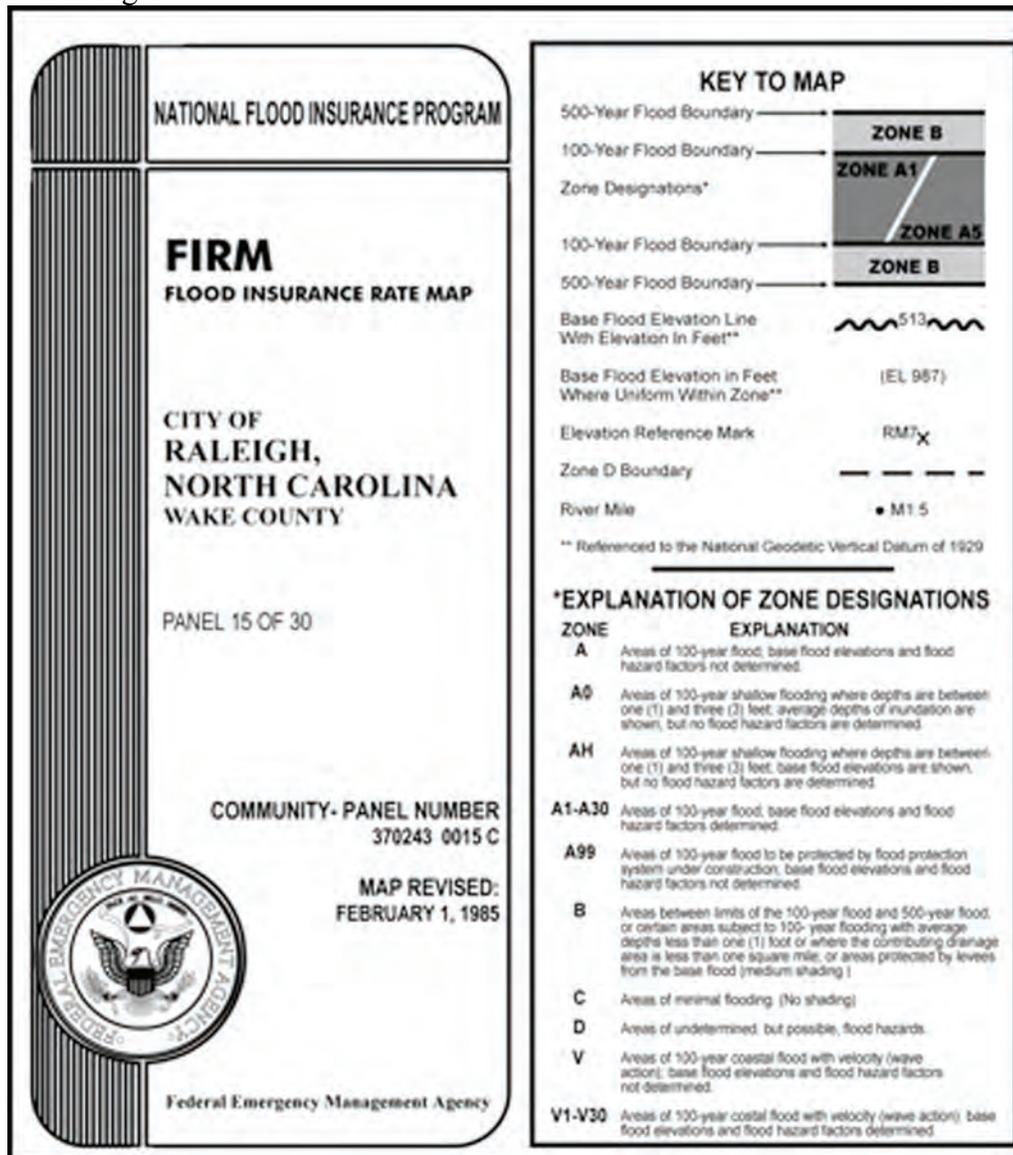
*500-Year Floodplain.* Designated by the lighter-shaded areas (Insurance Zone B). Newer studies include a shaded Zone X. No 500-year flood elevations are shown on the map, but are contained in the FIS.

*Base Flood Elevation (BFE).* The water surface elevation of the base flood (100-year flood) at that point of the stream, denoted in whole numbers by wavy lines running across the floodplain; or, where the BFE is uniform within a zone, denoted in parentheses below the zone designation. Symbols are shown in Figure 6-7. *Coastal AE and A1-A30 Zones within the area of 100-year tidal flooding, as well as AH Zones and some lake A Zones, have the base flood elevation noted in parentheses beneath the zone designations.* BFEs in riverine A Zones are indicated by a squiggly line across the floodplain, with the BFE at that point shown as a whole number.

*Zone Break Line (or Gutter Line).* The thin white line separates different flood insurance rate zones within the 100-year floodplain. Symbol shown in Figure 6-7. Can you find the zone break line shown in Figure 6-8?

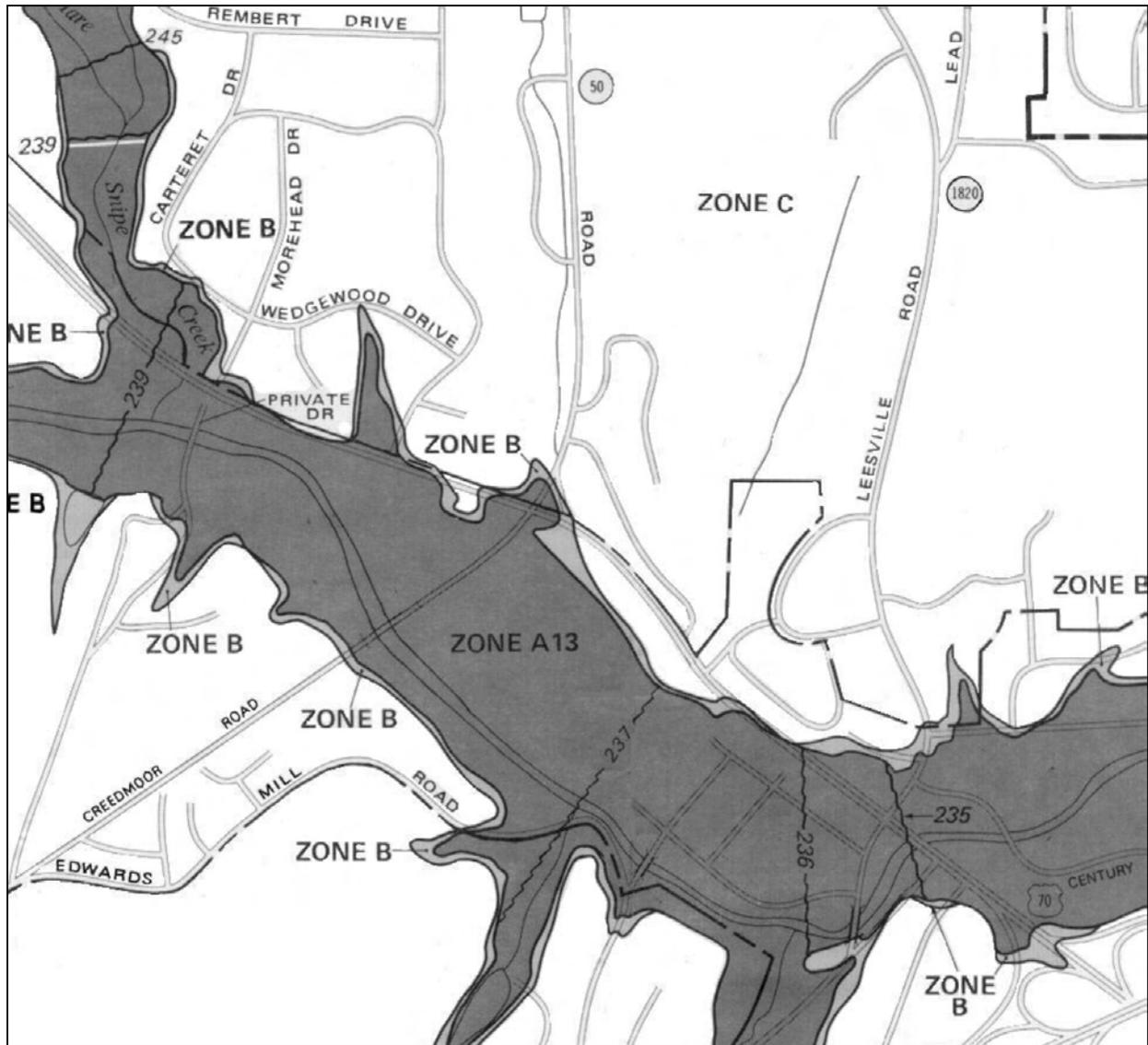
*Approximate Floodplain Areas.* 100-year floodplain areas using approximate methods. No base flood elevations are shown in approximate floodplain areas. These areas are classified as “unnumbered” A Zones. None are shown in Figure 6-8.

*Elevation Reference Marks.* Benchmarks with known, recorded elevations, which are used by surveyors to determine unknown elevations at nearby locations. None are shown in Figure 6-8. Symbol shown in Figure 6-7.



**Figure 6-7. Title block and key to old format FIRM.**

Coastal Barrier Resource System Units. Designated by diagonal line patterns (three of them) that overlay other designations. An example is shown in Figure 6-19.



**Figure 6-8. Old Format FIRM**

*Flood Boundary and Floodway Map (FBFM)*

The Flood Boundary and Floodway Map (Figures 6-9 and 6-10) is used by community officials for administration of floodplain management ordinances. The same area is shown in Figures 6-7 and 6-8 to facilitate comparison of features on the FIRM and FBFM maps.

The FBFM shows how the floodplain is divided into floodway and flood fringe where streams are studied in detail. The FBFM also shows general floodplain areas where floodplains have been

studied by approximate methods. If a map panel area does not include any detailed study streams or floodways, a FBFM will not be printed; only a FIRM panel will be printed. The FBFM shows the location of stream cross sections which can be used in conjunction with the floodway data table (e.g., Table 6-2) to make a more exact determination of the base flood elevation (BFE) for a site. *Note that no BFEs or flood zone names are shown on the FBFM.*

*Title Block.* Includes the community name, county name, panel number, community number, and the map date (see Figure 6-9). *Caution!* The FBFM panel numbers may be different from the FIRM panel numbers. The FIRM and FBFM panels shown in Figures 6-7 and 6-9, for the same floodplain area, have different panel numbers.

*Map Scale.* Shown on the map key (Figure 6-9).

*Floodway.* The non-shaded areas adjacent to and including a stream or channel between the heavy dashed lines.

*Flood Fringe (Floodway Fringe).* Shaded areas outside of the floodway but still within the 100-year floodplain. The flood fringe may be developed in the future provided all new structures are elevated or floodproofed to the BFE. Areas of 100-year tidal flooding have the flood elevation noted in parentheses beneath the zone designations.

*500-Year Floodplain.* Lighter shaded areas adjacent to, but outside of the 100-year floodplain.

*Approximate Floodplain Areas.* 100-year floodplain areas determined using approximate methods. The limits of the approximate floodplain on the FBFM are shown as dashed lines outside of the detailed study areas (not to be confused with the dashed lines marking the floodway boundaries).

*Cross-Section Line.* These lines represent the location of the surveyed cross sections used in the computer model of the stream for calculating 100-year flood elevations. They are individually labeled with a letter or letter combination put in a hexagon at either end of the cross section. These labels are also used on the profiles and floodway data tables. These cross sections can be used to relate a specific point on the FBFM to the flood profile and floodway data table.

*Elevation Reference Marks.* Benchmarks with known, recorded elevations, which are used by surveyors to determine unknown elevations at nearby locations. None are shown on Figure 6-10. Symbol is shown in Figure 6-9.

**NATIONAL FLOOD INSURANCE PROGRAM**

**FLOODWAY  
FLOOD BOUNDARY AND  
FLOODWAY MAP**

**CITY OF  
RALEIGH,  
NORTH CAROLINA  
WAKE COUNTY**

**PANEL 25 OF 40**

**COMMUNITY-PANEL NUMBER  
370243 0025  
MAP REVISED:  
JUNE 18, 1987**

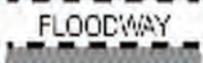


**Federal Emergency Management Agency**

**KEY TO MAP**

500-Year Flood Boundary → 

100-Year Flood Boundary → 

FLOODWAY FRINGE → 

100-Year Flood Boundary → 

500-Year Flood Boundary → 

Approximate 100-year Flood Boundary → 

Cross Section Line → 

Elevation Reference Mark → RM7<sub>x</sub>

River Mile → ●M1.5

**NOTES TO USER**

This map is for use in administering the National Flood Insurance Program; it does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size, or all planimetric features outside Special Flood Hazard Areas.

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydrologic considerations with regard to requirements of the Federal Emergency Management Agency.

Floodway widths in some areas may be too narrow to show to scale. Refer to Floodway Data Table where floodway width is shown at 1/20 inch.

Corporate limits shown are current as of the date of this map. The user should contact appropriate community officials to determine if corporate limits have changed subsequent to the issuance of this map.

For adjoining panels, see separately printed Map Index.

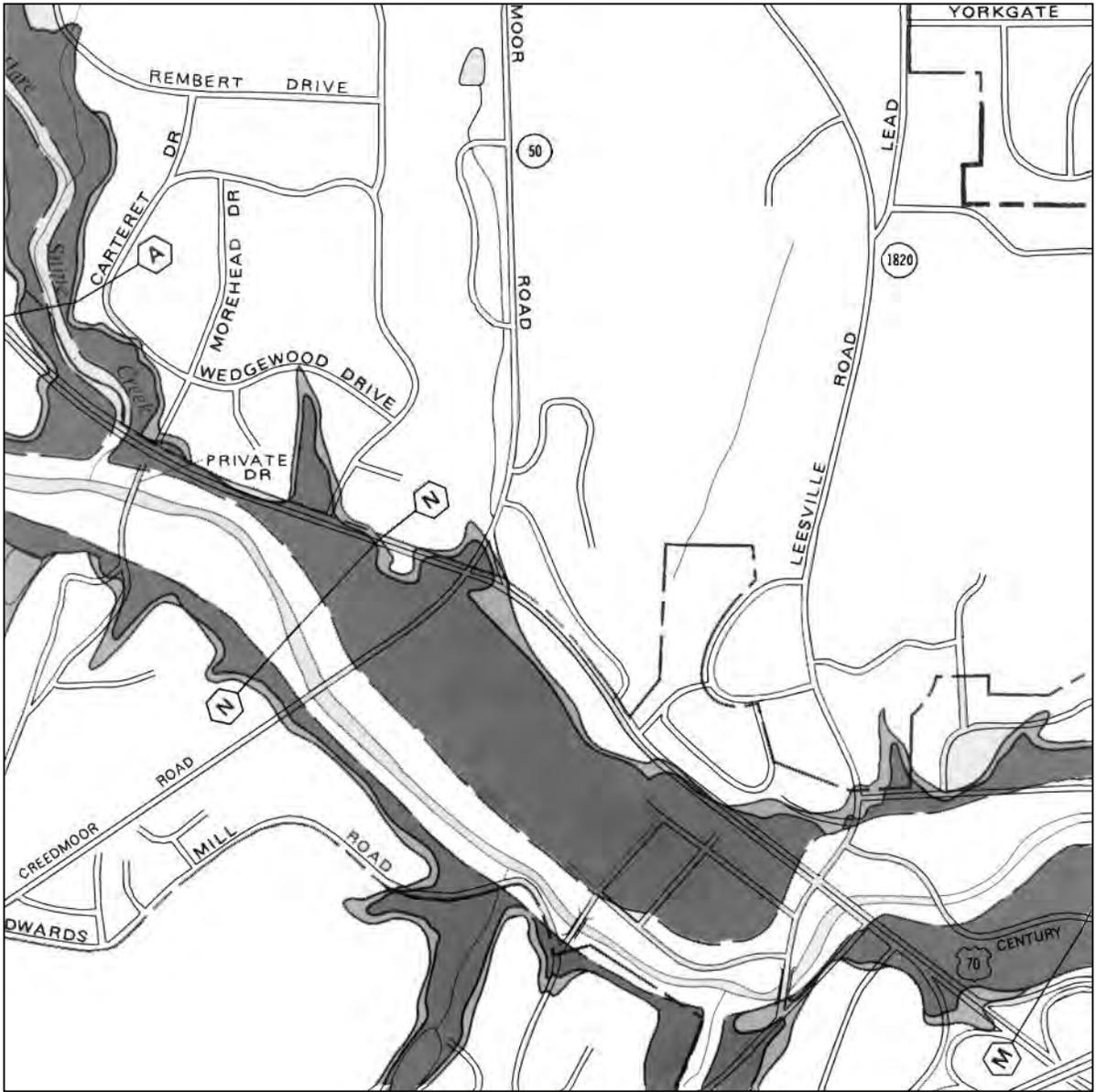
FLOOD BOUNDARY AND FLOODWAY MAP EFFECTIVE:  
AUGUST 15, 1978

FLOOD BOUNDARY AND FLOODWAY MAP REVISIONS:

Map revised February 1, 1985  
to change floodway, cross sections, flood boundaries, revise corporate limits, add streets and street names, and to reflect new FEMA title block.

Map Revised June 18, 1987  
to change floodway, cross sections, flood boundaries, revise extrajurisdictional limits, add streets and street names, streams and stream names, and to change map panel layout.

Figure 6-9. Title block and key to FBFM.



**Figure 6-10. Flood boundary and floodway map (FBFM).**

*Flood Insurance Rate Map (FIRM)—New Format*

Generally since 1989, new FIRMs (Figures 6-11, 6-12, and 6-13) combine the data that were shown separately on the old format FBFMs and FIRMs. Therefore, the new FIRMs are used by community officials and local administrators for floodplain management purposes, by lenders to determine the need for flood insurance, by insurance agents to rate policy applications, and by land surveyors, appraisers, engineers, etc.

*Title Block.* See Figure 6-11. Includes the community name, county name (Hoke), community identification number (370397), and the panel number (0090 B). “B” means the panel has been revised once.

*Map Dates.* Several dates may be listed, including:

- ∞ Initial Identification—date of first Flood Hazard Boundary Map.
- ∞ Flood Insurance Rate Map Effective—date community was converted to the Regular Phase of the NFIP that normally corresponds to the date of initial FIRM if no revisions have been made. The date of conversion to the Regular Phase is also the date that determines whether structures are pre-FIRM or post-FIRM.
- ∞ Flood Insurance Rate Map Revision—date of subsequent revisions to the FIRM (March 2, 1989 for Panel 90).

*100-Year Floodplain.* Designated by the dark shaded areas (Insurance Zones A, AE, A99, AO, AH, V, VE, and V99). *Coastal AE and A1-A30 Zones within the areas of 100-year tidal flooding, as well as AH or lake AE Zones, have the flood elevation noted in parentheses beneath the zone designations* (See Figure 6-13).

*Floodway.* The crosshatched areas adjacent to a stream.

*Base Flood Elevation.* The water surface elevation of the base flood at that point of the stream or within a zone (denoted in whole numbers). Several “wavy” BFE lines are shown in Figure 6-12.

*Zone Break Line (or Gutter Line).* Thin white lines separate different flood insurance rate zones within the 100-year floodplain on new format FIRMs. Symbol shown in Figure 6-11. Can you find the zone break line shown in Figure 6-12?

*Approximate Floodplain Areas.* 100-year floodplain areas determined using approximate methods. No base flood elevations will be shown in approximate floodplain areas. These areas are classified as unnumbered A Zones. Such an area is shown in Figure 6-12 above a zone break line. That area is usually labeled “Limit of Detailed Study.”

*Elevation Reference Marks.* Benchmarks with known, recorded elevations, which are used by surveyors to determine unknown elevations at nearby locations. There is a reference mark in Figure 6-12. Can you find it?

*Cross-Section Line.* These lines with hexagonal labels represent the surveyed cross sections used in the computer model of the stream in calculating 100-year flood elevations. These cross sections can be used to relate a specific point on the FIRM to the flood profile and/or floodway data table. There are a number of cross-section lines shown in Figure 6-12.

*500-Year Floodplain.* Designated by a light-shaded area. In old format, the 500-year floodplain was designated as Zone B. It is designated as a *shaded* Zone X on the new FIRMs.

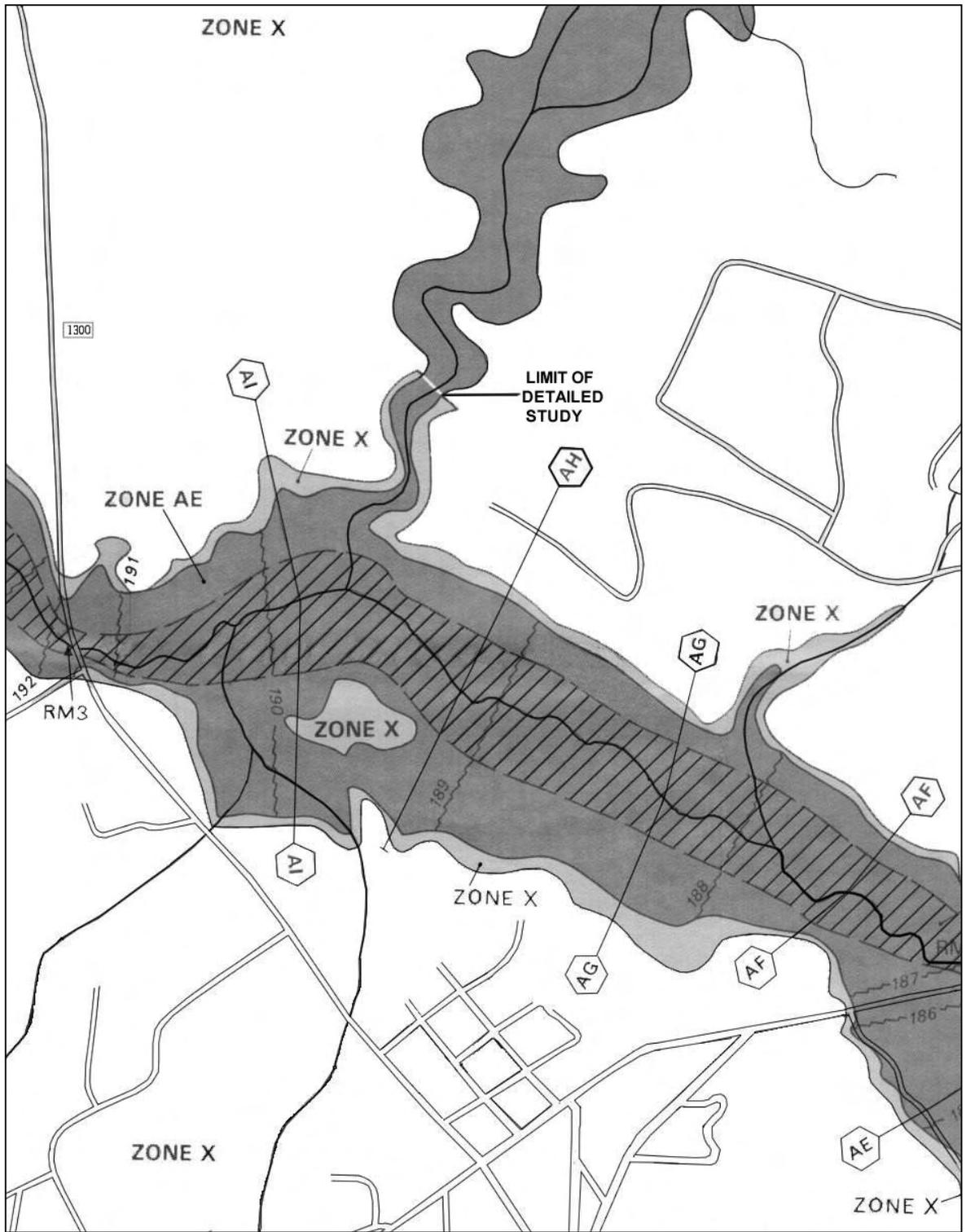
*Minimally Floodprone Areas.* Designated as *unshaded* Zone X. These zones correspond to the Zone C on the old FIRM format.

*Coastal Barrier Resource System Units.* Designated by diagonal line patterns (three types) that overlay other designations. An example is shown in Figure 6-19.

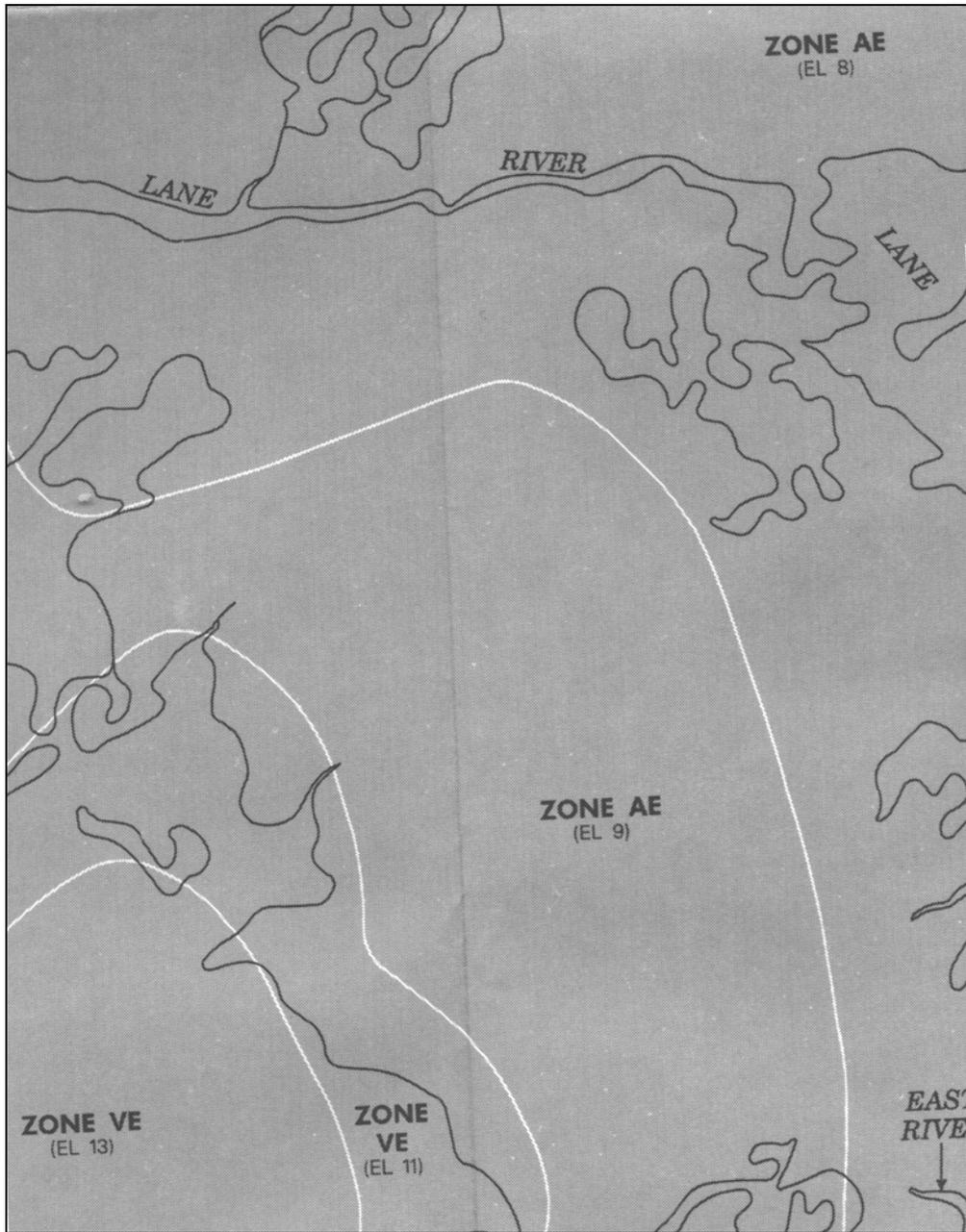
#### *Countywide FIRMS*

Countywide FIRM maps show flood information for all geographic areas of the county, including unincorporated areas and other jurisdictions such as villages, towns, cities, etc. Previously, maps were prepared for each separate jurisdiction, i.e., county FIRMs only showed the flood hazards identified in the unincorporated areas of the county and did not show any flood information inside the corporate limits of a municipality. Now all the identified flood hazard areas within the boundaries of the county are shown on one set of countywide maps.

*Title Block.* Figure 6-14 shows the title block of a countywide FIRM panel for Richmond County, NC. A list of communities in the county is included on the title block for each panel, along with a panel location map. The community identification numbers (CIDs) in this example are 370200 for the City of Hamlet, 370201 for the City of Rockingham, and 370348 for the unincorporated areas of Richmond County. The CID for a municipality applies to the area within the corporate limits and also to the area of extraterritorial jurisdiction (ETJ). If an unincorporated county area is annexed or included in the ETJ, all references to that area must subsequently use the municipality's CID.



**Figure 6-12. New Format FIRM (riverine).**



**Figure 6-13. New format FIRM (coastal).**

*Map Number.* Each countywide map panel is identified on the title block by a number starting with a *five-digit* code unique to the county, followed by the letter “C” which stands for “countywide” mapping. It ends with a four-digit panel number, plus a suffix letter if the panel has been revised. In Figure 6-14, the code for Richmond County maps is 37153C; note that this is *not* the same as the community identification number for unincorporated Richmond County. The map number in this example ends with a suffix C, indicating that this may be the third revision of FIRMs for one or more municipalities and/or the unincorporated county. The initial countywide FIRM often has a “C” suffix, used as a convenient starting point for each of the new panels.

*Map Effective Date.* The effective date for a particular panel is shown on the title block. The date of the initial FIRM for each community is shown on the FIRM index map (not illustrated here). The initial FIRM date is used to determine whether a structure is pre- or post-FIRM for insurance rating purposes.

*Legend.* The legend for a countywide FIRM (Figure 6-14) is the same as for a new format FIRM.

Figure 6-15 shows a portion of the countywide FIRM for Richmond County indicating the corporate limits and ETJ of the City of Rockingham, as well as unincorporated county areas. Note the community identification number (370201) for the City of Rockingham and unincorporated Richmond County below the name on the map segment.

#### *Digital Flood Data and Mapping*

Along with a rapid change in technology, FEMA now provides flood data and maps in a number of digital forms that are available at its web site.

Scanned or Raster FIRMs are available nationwide. They are available for viewing and/or ordering on-line from FEMA’s Flood Map Store. The home page for the store is: <http://store.msc.fema.gov>. Perhaps the easiest way to view the map images is to search by using “Product Catalog.” Choose “FEMA Issued Flood Maps.” This lets the user specify the state, county, and community. (For countywide FIRMs, choose the “Uninc. And Inc. Areas” option. Other options may take the user to older map editions.) Then click on “Get FEMA Issued Flood Maps” to get a panel-by-panel list of maps. Clicking the green magnifying glass button for each panel allows the user to view the map on-line. Some searching may be required to locate the area of interest. The index map, usually the last panel in the listing, may aid in the search. FIRMettes can be created using the on-line tool “Make a FIRMette.” A FIRMette is a “clip” of a scanned FIRM image using the F-MIT application. This user-defined portion of the map image is at the same scale as the FIRM and contains a map title block, north arrow, and scale bar.

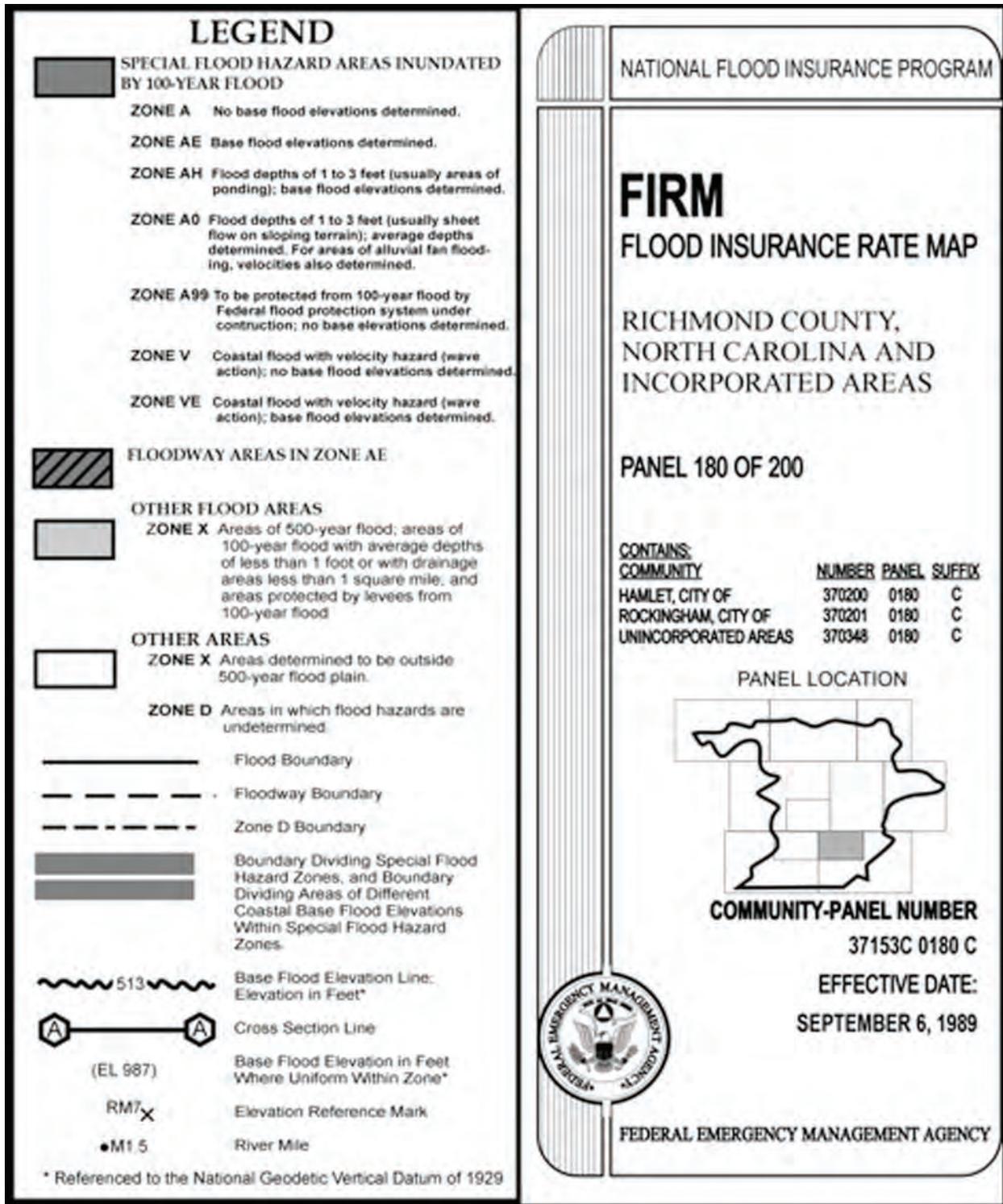
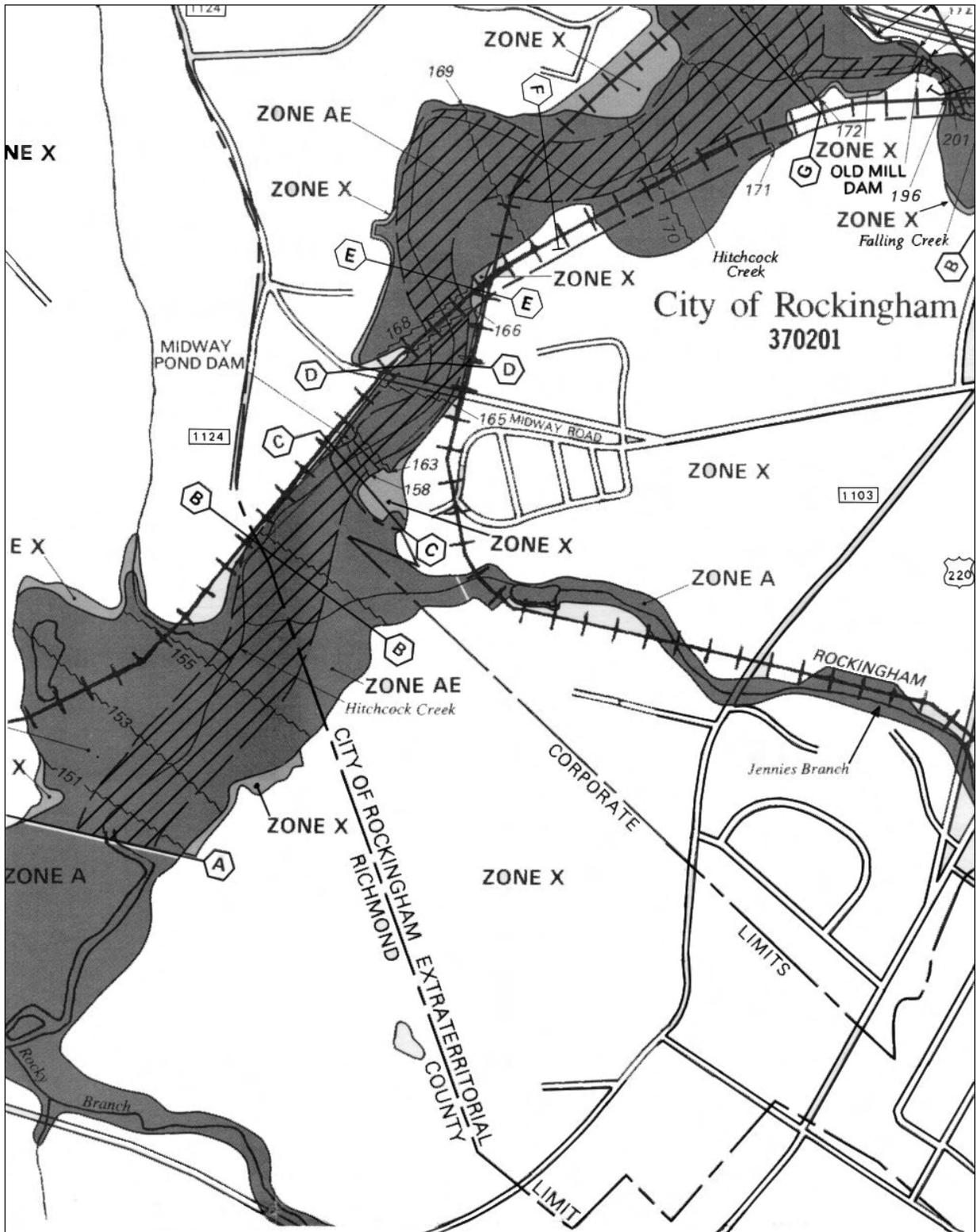
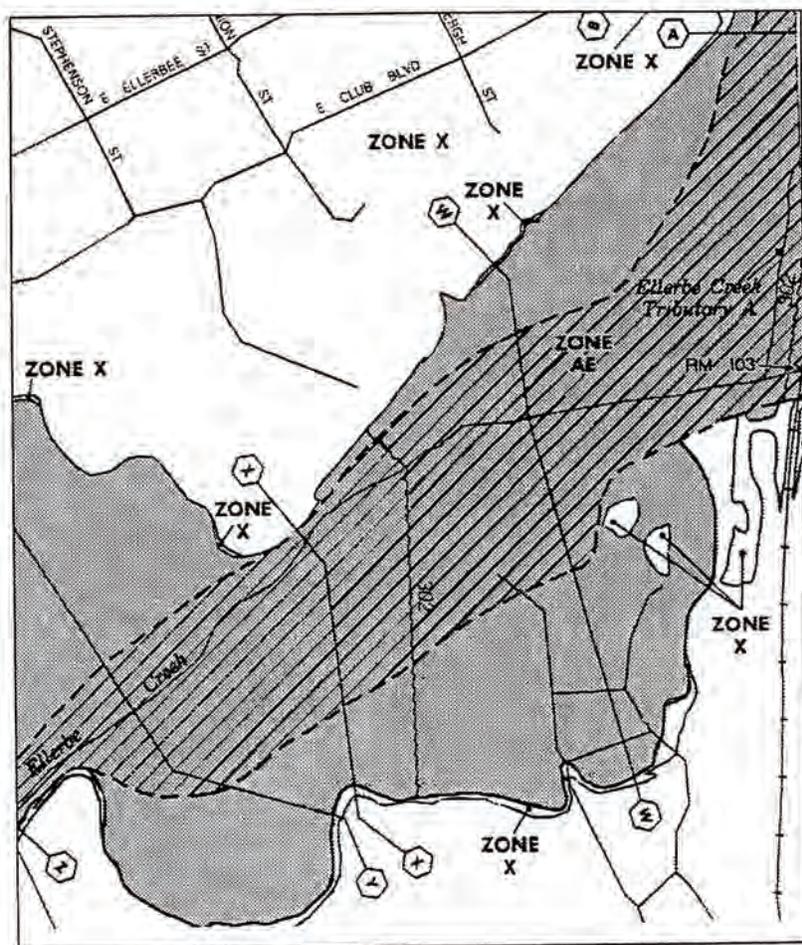


Figure 6-14. Title block and legend of countywide FIRM panel.



**Figure 6-15. Countywide FIRM.**

DFIRM Database. The web site [http://fema.gov/fhm/dfm\\_ovrw.shtm](http://fema.gov/fhm/dfm_ovrw.shtm) provides an overview of the database. It comprises Geographic Information System (GIS) data that make up a Digital Flood Insurance Rate Map (DFIRM). A DFIRM includes the digital data used in the hard copy map production process. This includes base map information, graphics, text, and other geographic and graphic data. The DFIRM is generally produced in a countywide format, where all flood data for the county and incorporated communities are shown on one set of maps. It can be used in a manner similar to other flood maps. An example of a hard copy paper DFIRM is shown in Figure 6-16

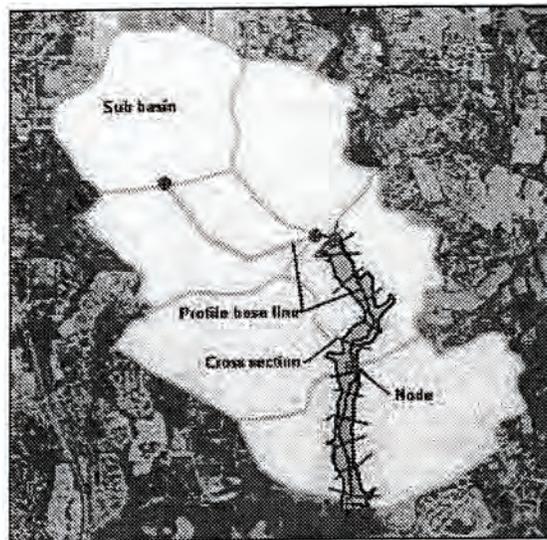


**Figure 6-16. An example of a hard copy paper DFIRM.**

On-line viewing of available DFIRM Database data is provided from the Flood Map Store's web page. As described above, use "Product Catalog" and choose "DFIRM Databases." Then go through the same iterations as above for the community of interest.

FEMA has developed an Enhanced DFIRM Database, accessed by clicking on that topic at [http://www.fema.gov/plan/prevent/fhm/dfm\\_ovrw.shtm](http://www.fema.gov/plan/prevent/fhm/dfm_ovrw.shtm). It was designed to store the backup engineering data as well as all the mapping data that is in the Standard DFIRM Database. In addition to all of the elements in the Standard DFIRM Database, the Enhanced version contains pertinent back-up engineering data needed by FEMA mapping partners for flood studies, map revisions, or map maintenance. It includes information needed for core NFIP functions such as insurance rating, and compliance monitoring. It includes sufficient data to allow users to

reproduce the flood profile and water surfaces. Additionally, it stores original products and intermediate products of high value and/or wide applicability. It does not include all intermediate data developed in the course of conducting the flood study. Some of the Enhanced DFIRM Database features may be stored in GIS mapping layers or related tables but not shown on the paper FIRM product. The amount of data that will be captured digitally and stored in the Enhanced DFIRM Database will vary for each flood study. In general, the production of any digital map will result in a complete Standard DFIRM Database. However, most studies will also have some additional data that will be stored in the Enhanced DFIRM Database. Even studies where existing effective flood hazard analyses are used to produce updated digital maps may include easily accessible elements of the Enhanced DFIRM Database. Some of the data items in the Enhanced Database are illustrated in Figure 6-17.



**Figure 6-17. Graphic image of some data items in an enhanced DFIRM database.**

### ***Coastal High Hazard Areas***

Waves pack a lot of power. They are much more destructive than standing or slow-moving water and that power increases exponentially with their height. For the purposes of the NFIP, the flood study identifies the “coastal high hazard area” as that part of the coastal floodplain where the wave heights during the base flood will be three feet or more. As illustrated in Figure 6-18, these areas are designated as “V Zones” where the “V” stands for “velocity wave action.” They are analogous to riverine floodways. V Zones are subject to more stringent regulatory requirements and a different flood insurance rate structure due to increased degree of risk.

The three-foot wave height threshold was selected because it was found to be the smallest wave with enough power to break a wall panel away from a floor to which it has been nailed. Coastal flood areas with wave heights of less than three feet are mapped as AE or A# Zones with the BFE indicated in parentheses.

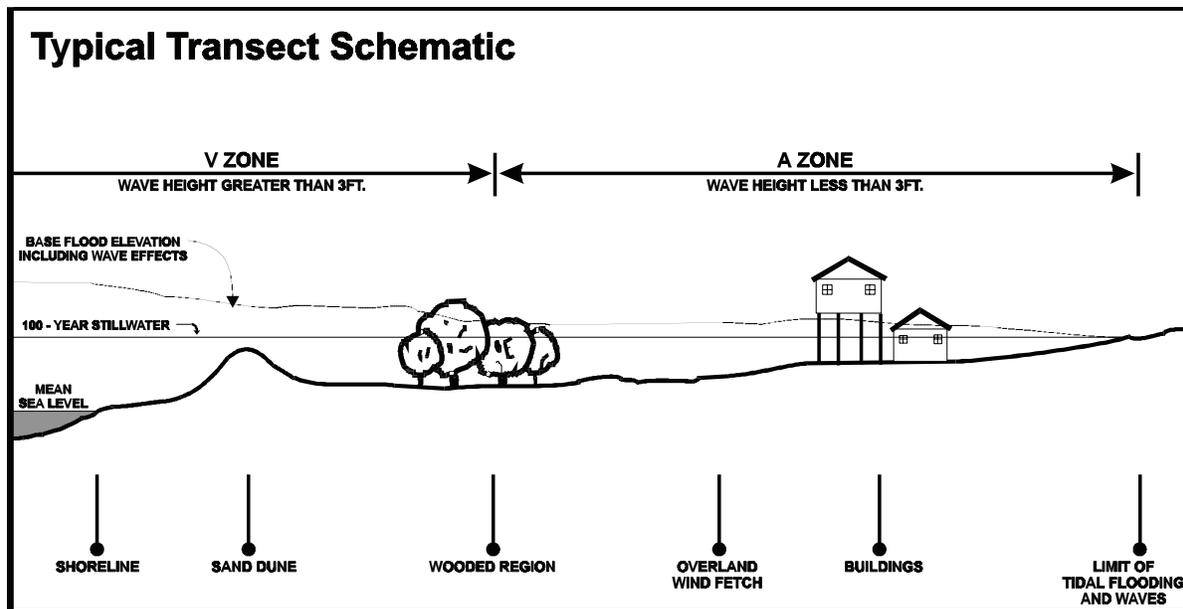


Figure 6-18. Typical transect schematic.

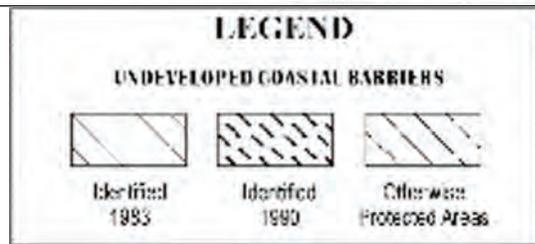
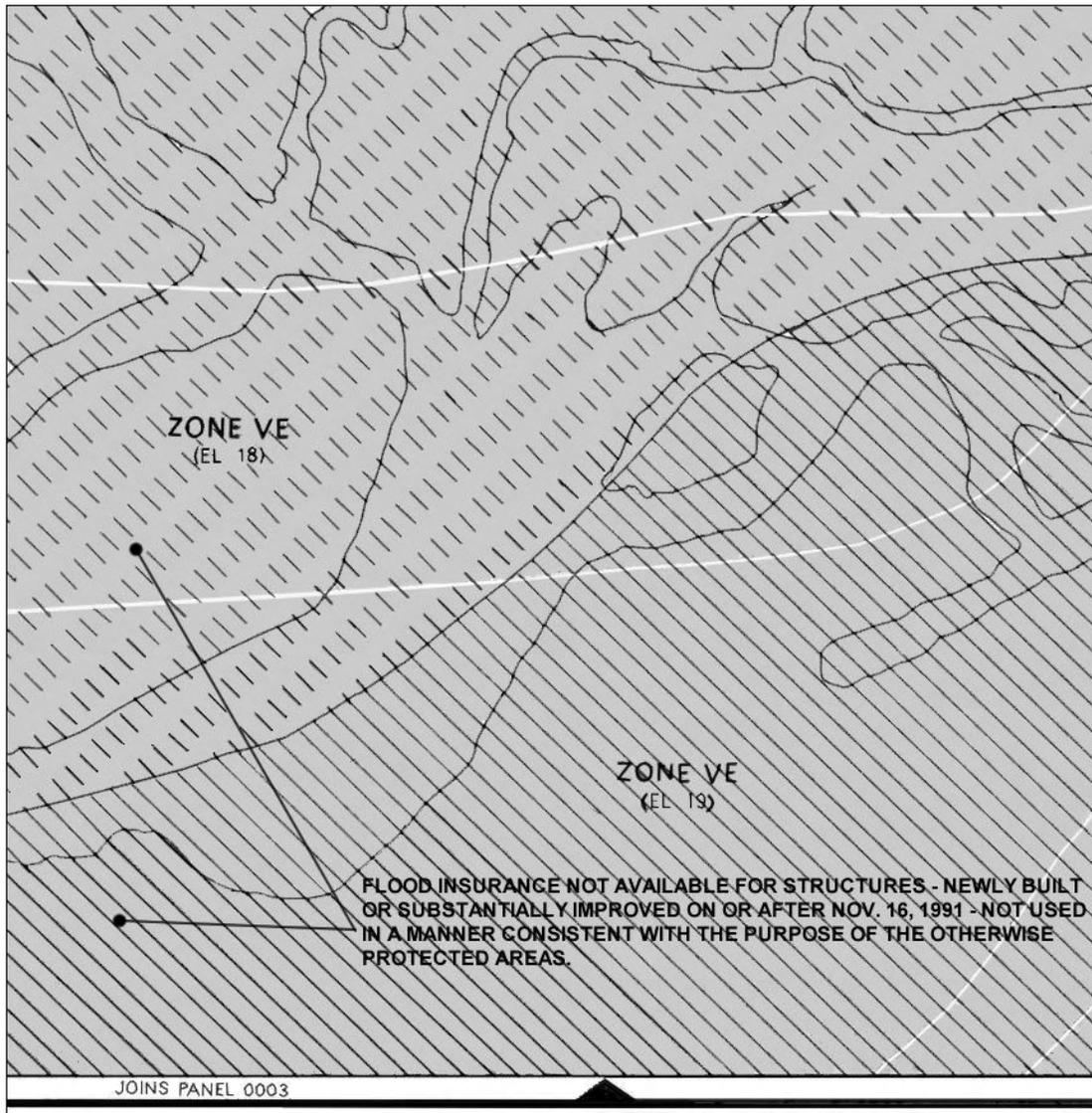
### Special Map Features

Stream or river floodways and coastal high hazard areas are extremely hazardous for human occupancy because of water depths and velocities. These hazards have been quantified by the Flood Insurance Study for the community, and floodways are designated on the flood maps.

The floodway has already been discussed a number of times. In coastal studies, those coastal high hazard areas subject to flooding *and* wave action of three feet or more (discussed earlier) are designated as V or VE Zones. *The number in parentheses after or below the zone designation is the base flood elevation.* (Refer to Figure 6-13.)

Undeveloped portions of coastal barrier islands in the Coastal Barrier Resources System and other areas (e.g., coastal mainland, along the shore of the Great Lakes, along bays, inlets, or estuaries) have been identified and included on applicable map panels. Otherwise Protected Areas (OPA) are also shown. These are primarily open space areas owned by federal or state governments or private conservation organizations. Congress, via the Coastal Barrier Resources Act of 1982 and the Coastal Barrier Improvement Act of 1990, established this system. These areas are identified because, as required by the above acts, no new flood insurance coverage may be provided after specified dates for new or substantially improved structures in any unit in the system. In addition, any other federal programs that may have the effect of encouraging development in these identified areas are restricted by the acts. This includes limitations on funding for permanent reconstruction after a disaster.

An example of an identified undeveloped coastal barrier is shown on the FIRM in Figure 6-19. In this instance, identification was made for one area in 1983 and another in 1990.



**Figure 6-19. Identified undeveloped coastal barrier.**

## Flood Insurance Zones

Flood risk areas are divided into zones on the FIRM. The zones that appear on a particular map will depend on local conditions and the date when the map was issued. Table 6-4 summarizes zone terminology. This terminology will be discussed in more detail in a subsequent chapter on the National Flood Insurance Program.

<b>Table 6-4. Flood Insurance Rate Map Zones</b>	
<b>Zone A</b>	<p>The 100-year or base floodplain. There are seven types of A Zones:</p> <p><b>A</b> Mapped by approximate method, i.e., base flood elevation (BFE) not provided. Often called unnumbered A Zone or approximate A Zone.</p> <p><b>A# (A1-A30)</b> Numbered A Zones (e.g., A7 or A14) where the FIRM shows a BFE in relation to NGVD (old FIRM format).</p> <p><b>AE</b> BFEs are provided. AE Zone delineations are used on new FIRMs instead of A# Zones.</p> <p><b>AO</b> Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths are determined. For areas of alluvial fan flooding, velocities are also determined.</p> <p><b>AH</b> Flood depths of 1 to 3 feet (usually areas of ponding); with BFEs.</p> <p><b>AR</b> SFHAs that result from decertification of a flood protection system that is in the process of being restored to provide a 100-year or greater level of flood protection.</p> <p><b>A99</b> To be protected from 100-year flood by a federal flood protection system under construction; no BFEs determined.</p>
<b>Zone B</b>	Areas of 500-year flood; areas subject to the 100-year flood with average depths of less than 1 foot or with contributing drainage area less than 1 square mile; and areas protected by levees from the base flood.
<b>Zone C</b>	Area of minimal flood hazard, outside the 500-year floodplain. B and C Zones may have ponding and local drainage problems that don't warrant a detailed study or designation as base floodplain.
<b>Zone D</b>	Area of undetermined but possible flood hazard.
<b>Zone V</b>	Coastal flood with velocity hazard (wave action). Zones V, V#, and VE correspond to the A Zone designations.
<b>Zone X</b>	Newer FIRMs show Zones B and C as Zone X. <i>Shaded</i> X Zones are equivalent to B Zones and <i>unshaded</i> X Zones match C Zones.

## Reconciling Report Data, Profiles, and Maps

The preceding materials described the data that are developed and used in preparing a Flood Insurance Study (FIS) report for a community. Each set of data is used for calculations needed to produce additional data for the FIS. The data contained in the FIS report is consistent with that found on the accompanying profiles and maps.

For example, the base flood water surface elevations at each identified cross section can be found in the floodway data table, read from the flood profiles, and interpolated from the flood maps. Within the limits of map accuracy, one should obtain the same answer regardless of which source is used.

In the same way, the distances between cross sections, or their distance from some reference, can be found using any or all of the above data sources. Again, the answers should be approximately the same.

The elevations of the computed profiles contained in the FIS report are used with ground elevation data to determine the limits of the various zones shown on the flood maps. Again, flood elevations can be determined at any location along the studied stream using either the flood profiles or the flood maps. *All the data fit one another.*

Just a reminder—due to the limited detail and large scale of the base maps used for most FIRMs (i.e., United States Geological Survey quadrangles) much interpolation between contour lines is done in mapping the floodplain boundaries. This is why there are so many discrepancies when actual ground elevations are surveyed. The FIRMs are just the best available graphic representations of the BFEs. The BFE takes precedence if there is a discrepancy between the surveyed ground location of the BFE and the floodplain boundary shown on the maps.

## Ground Sites and Flood Maps

The following material focuses on utilizing the above described flood maps to determine if a site of interest, or any part of it, is located within an identified flood hazard area

To locate the site on the map, follow these steps:

1. If the community has more than one map panel, use the map index to determine which panel to use.
2. Locate the site on the index using map landmarks, such as highways, streets, and streams.
3. Locate the map panel for the area containing the site. If there is an asterisk on the panel number, either no flood hazard has been identified in that area or it is entirely one flood zone and the panel was not printed. Be sure the map panel is the most recent one by comparing its suffix letter with the suffix letter for that panel on the current map index. Remember, in many communities different panels will have different effective dates due to revisions that do not affect the whole community.
4. Locate the site as accurately as possible on the map. Use a detailed street or road map to correctly identify the property boundaries, if necessary. Obtain the distance on the ground between the site and one or more identifiable points (centerline of a road or street, a bridge,

or some other feature on the map). Locate these identifiable points on the flood map. Using the map scale and the measured ground distance from these points, plot the site on the map.

If it cannot be determined whether the site is in or out of the floodplain, then additional information and/or investigations will be needed. In this instance, ground elevation and lowest floor elevations of any structures will be needed for the site, likely requiring the services of a surveyor. A field visit and measurements on the ground may also be required. The actual site elevations are compared to the base flood elevation, read from the FIS flood profiles, for that location.

For coastal, lake, reservoir, and shallow flooding studies, the same procedures apply. In these instances the BFE is printed in parentheses below the flood zone designation for that location and can be used without any interpretation.

If the site is near the floodway boundary, the same process as described above will need to be used to determine if any portion of the site is within the floodway. In this instance, as discussed in Chapter 5, measuring from identifiable land features located on both the ground and the map will be required. As before, scaling these distances on the map will help determine location of the site in relation to the floodway boundary. Because the floodway boundary *is not* based on a flood elevation, measuring in the field and on the map is the *only* way to locate the site in relation to the floodway. If the site is at a surveyed cross-section, floodway width data from the floodway data table may be used to supplement the field and map measurements. Remember the width listed in the table is the distance from the floodway line on one side of the stream to the floodway line on the other side of the stream. This is very important if the stream channel is the community boundary, so only a portion of the floodway is shown on the community's FIRM. If the width measured on the map at that site is not comparable to that shown in the table, the table data are to be used. The proportional width of the floodway can be used to determine the floodway boundary on the ground.

If a site of interest is located in a coastal high hazard area (Zone V), this determination can be made by scaling on the FIRM from one or more identifiable features (streets, roads, etc.) to the zone boundary, and then by measuring the scaled distances from these features on the ground to establish the boundary location.

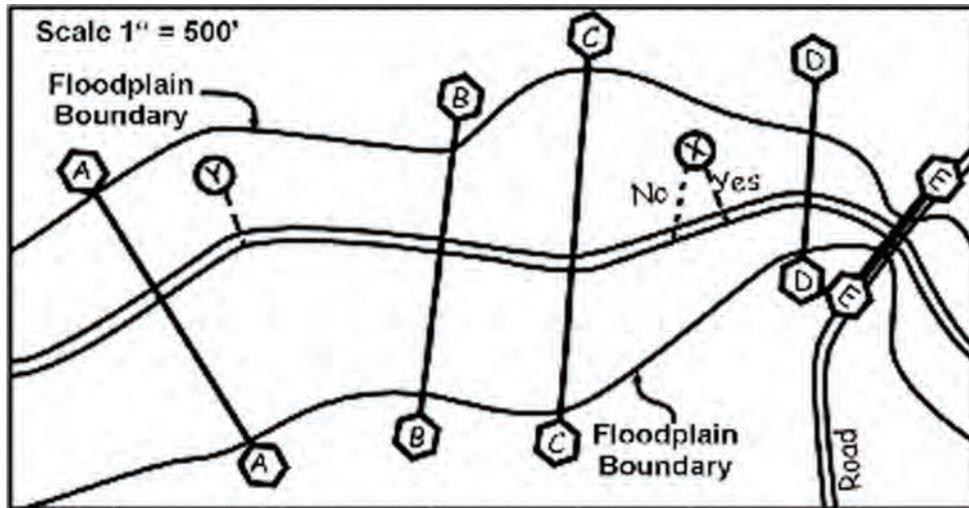
## Determining Stream Distance

Flood profile sheets in the Flood Insurance Study are used to calculate flood elevations at the development site. The scale on a flood profile is expressed in terms of stream distance in either feet or miles above the mouth of the stream or other reference. Once a site has been located on the flood map (as described above), the next step is to determine the site's position relative to the flood profile. Figure 6-20 illustrates this procedure. In the example, a site, marked by an "x," is located between cross sections C and D.

Find the letter designation for the nearest upstream and downstream cross sections on the Flood Boundary and Floodway Map (FBFM) or the new format Flood Insurance Rate Map (FIRM). Locate these same cross-section letters on one of the flood profiles in the FIS. To determine the site's location relative to the profile, use one of the two procedures outlined below, depending on whether the distance is expressed in feet or miles.

Draw a line from the site *perpendicular* to the center of the stream, as is shown in the Figure 6-20. (Another line has also been drawn from the site to the centerline of the stream at another location. Notice it is not perpendicular to the stream and must not be used in these calculations.)

From the point where the perpendicular line intersects the center of the stream, measure the distance to the nearest cross section—scale the distance along the center of the stream, following all bends and curves. (*It would be worthwhile to measure distances to both cross sections to check accuracy.*) In this instance, the site is about 500 feet upstream of cross section C and 250 feet downstream of cross section D. The cross-section lettering system starts downstream, usually with the letter “A” and goes upstream. Cross section A is downstream of cross section B; B is upstream of A, etc.) In the same manner, site “y” can be located in relation to the flood profile. It is about 600 feet downstream of cross section B and 300 feet upstream of cross section A. Keep these numbers in mind. They will be used shortly.

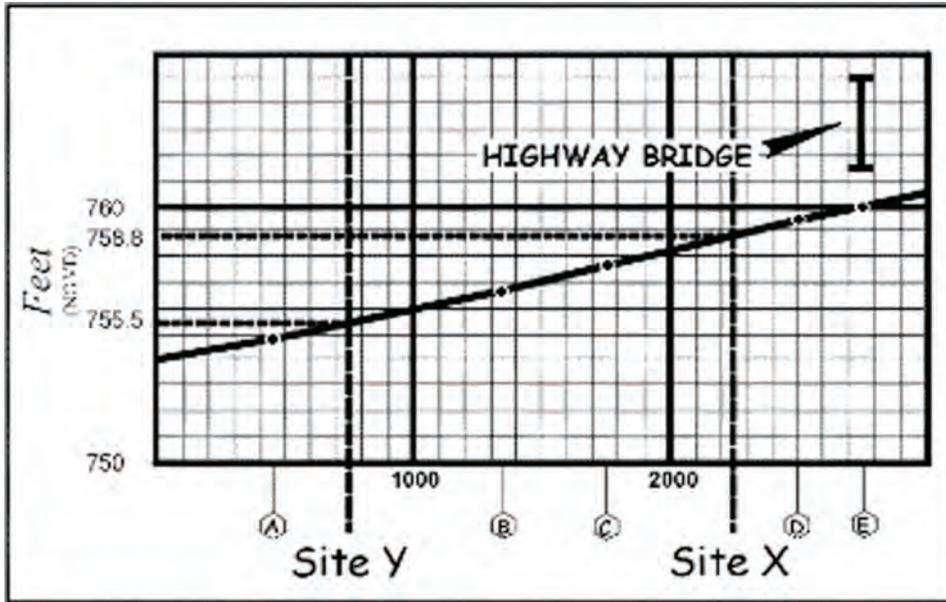


**Figure 6-20. Measuring stream distance from site to cross section.**

Where flood profiles are plotted using a scale in miles, it will be necessary to convert flood map measurements from feet to miles. One mile equals 5,280 feet. Making this conversion, site “x” shown on Figure 6-20 is located about 0.1 mile (rounded) upstream of cross section C (500 divided by 5280). It would be located about 0.05 miles (rounded) downstream of cross section D (250 divided by 5280). Site “y” is located about 0.11 mile downstream of cross section B and about 0.06 miles upstream of cross section A. Keep these numbers in mind, also.

### **Flood Elevations from Map Data**

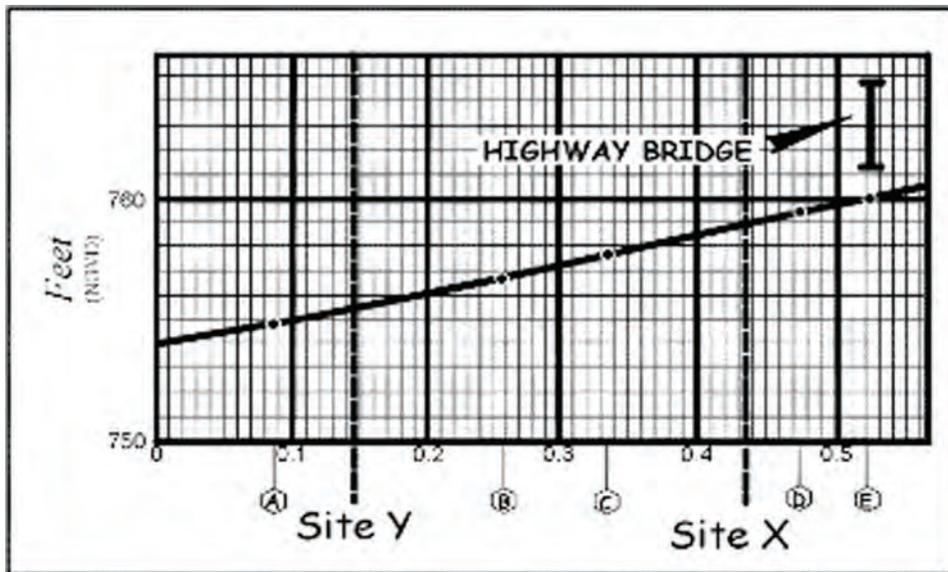
To obtain flood elevations for a development site, the measurements of site distance (in feet or miles) from stream cross sections are transferred to a flood profile sheet. For example, for site “x” on Figure 6-21, measure 500 feet upstream (to the right) of cross section C on the grid. (This distance was determined from Figure 6-20.) Draw a vertical line on the grid until it intersects the plotted profile. Read the flood elevation for this site at the left edge of the grid as 758.8 feet (NGVD). If the distance is measured 250 feet downstream (to the left) of cross section D on the grid, the same vertical line would be drawn on the grid. Measuring from both directions on the flood map and on the flood profile is a check for accuracy in obtaining data from these sources. Likewise, the flood elevation for site “y” can be determined by plotting the location on the flood profile, measured from cross sections upstream and downstream of the site. The flood elevation for site “y” would be 755.5 feet (NGVD).



**Figure 6-21. Typical flood profile—stream distance in feet.**

Figure 6-22 illustrates how to transfer the converted measurements made from Figure 6-20 when flood profiles are plotted in stream miles. For site “x” on the figure, measure 0.1 mile upstream (to the right) of cross section C. Again, draw a vertical line on the grid until it intersects the plotted profile. Read the flood elevation for this site at the left edge of the grid as 758.8 feet (NGVD). If the distance is measured 0.05 miles downstream of cross section D on the grid, the same vertical line would be drawn. As before, the flood elevation for site “y” can be determined by plotting the location on the flood profile, measured in miles from cross sections upstream and downstream of the site. A flood elevation of 755.5 feet (NGVD), as before, should be obtained.

The horizontal scale depicted in Figures 6-21 and 6-22 (1 inch = 0.1 mile) is rarely found in FIS flood profiles. It is used here as a learning exercise. Typically, the scales used in plotting computed flood profiles are 1 inch = 0.5 mile or 1 inch = 1 mile.



**Figure 6-22. Typical flood profile—stream distance in miles.**

The flood profiles in the Flood Insurance Study should always be used to determine BFE instead of interpolating between base flood elevation lines on the FIRM. *The profiles will provide a more accurate estimate of the elevation because there may not be a straight-line relationship between “even-foot” base flood elevations shown on FIRMs. Remember that it is the elevations computed at surveyed cross sections that are connected with straight lines to produce the flood profiles.*

## Chapter Homework Assignment

Note: An engineer's scale will be needed.

1. Using the Kinston, NC Flood Insurance Study report and the Flood Boundary and Floodway Map, find answers to the following:
  - a. A structure is located fifty feet west of the intersection of Williams Street and Snow Hill Road.
    - i. The property is in which of the following? (check those that apply)  
\_\_\_ floodway, \_\_\_ 100 year floodplain, \_\_\_ 500 year floodplain,  
\_\_\_ above the 500 year floodplain.
    - ii. What is the 100-year flood elevation at this site? \_\_\_\_\_
    - iii. What is the closest cross-section? \_\_\_\_\_
    - iv. The closest elevation reference mark? \_\_\_\_\_ What is its elevation?  
\_\_\_\_\_
    - v. What is the stream distance of the structure site above the mouth of the stream? \_\_\_\_\_
  - b. What is the width of the floodway at cross-section C on Briery Run?  
(Determine using two methods and compare the results)  
Method \_\_\_\_\_, Distance \_\_\_\_\_  
Method \_\_\_\_\_, Distance \_\_\_\_\_
  - c. What is the mean velocity of flow in the floodway of Briery Run at cross-section B? \_\_\_\_\_ What is the increase in the Base (100-year) flood from confining the flow of that flood within the floodway? \_\_\_\_\_
  - d. On Jerico Run
    - i. What is the drainage area at cross-section C? \_\_\_\_\_ 100-year discharge? \_\_\_\_\_
    - ii. What is the drainage area at cross-section D? \_\_\_\_\_ 100-year discharge? \_\_\_\_\_
    - iii. What is the drainage area of the tributary? \_\_\_\_\_
  - e. A proposed development site is located along the south side of Highway 1590, 100 feet west of the intersection of Highway 58.
    - i. What stream distance would be assigned to the site? \_\_\_\_\_
    - ii. Is it in a floodplain? \_\_\_\_\_
    - iii. If so, what would be the estimated 100-year flood elevation? \_\_\_\_\_
    - iv. How much higher is this elevation than the 10-year flood? \_\_\_\_\_
    - v. How much higher is the 500-year elevation? \_\_\_\_\_
    - vi. How far back from Highway 1590 could development occur and stay out of the floodway? \_\_\_\_\_
    - vii. How far would a surveyor have to go to find a known ground elevation in order to determine the ground elevation at the development site? \_\_\_\_\_