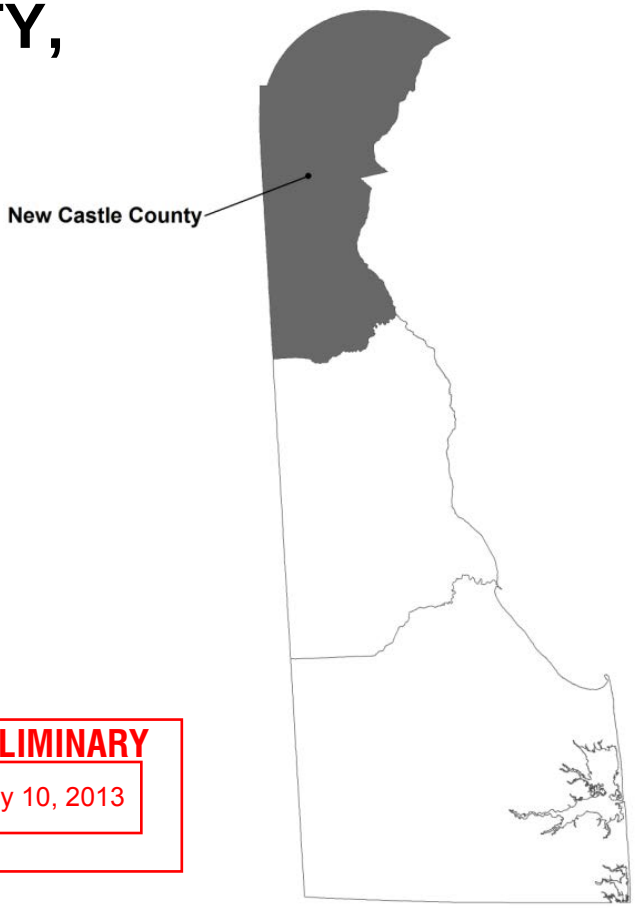
FLOOD INSURANCE STUDY

NEW CASTLE COUNTY, DELAWARE
AND INCORPORATED AREAS



Community Name	Community Number
ARDEN, VILLAGE OF	100052
*AREDENCROFT, VILLAGE OF	100057
ARDENTOWN, VILLAGE OF	100058
*BELLEFONTE, TOWN OF	100021
DELAWARE CITY, CITY OF	100022
ELSMERE, TOWN OF	100023
MIDDLETOWN, TOWN OF	100024
NEW CASTLE, CITY OF	100026
NEW CASTLE COUNTY (UNINCORPORATED AREAS)	105085
NEWARK, CITY OF	100025
NEWPORT, TOWN OF	100054
ODESSA, TOWN OF	100066
TOWNSEND, TOWN OF	100068
WILMINGTON, CITY OF	100028

* No Special Flood Hazard Areas Identified

PRELIMINARY

May 10, 2013

REVISED:

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
10003CV000C

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Initial Countywide FIS Effective Date: April 17, 1996

Revised Countywide FIS Effective Dates:

August 3, 1998	– to update the hydrologic and hydraulic analyses of the Christina River and West Branch Christina River,
October 6, 2000	– to update corporate limits, to add roads and road names, and to incorporate previously issued letters of map revision.
May 5, 2003	– to add Special Flood Hazard Areas, to change Special Flood Hazard Areas, and to reflect the annexation of the Towns of Clayton and Smyrna.
January 17, 2007	– to incorporate previously issues letters of map revision.
TBD	–to incorporate new detailed coastal flood hazard analyses; to update the hydrologic and hydraulic analyses for the Appoquinimink River, Deep Creek, Drawyer Creek, Drawyer Creek Tributary No. 1, Hangmans Creek, Tributary of Drawyer Creek, Belltown Run and tributaries, Mill Creek, Red Clay Creek, and White Clay Creek; and to reflect updated topographic information.

This Preliminary FIS report only includes revised Floodway Data Tables and revised Flood Profiles. The unrevised components will appear in the final FIS report.

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FLOOD INSURANCE STUDY
NEW CASTLE COUNTY, DELAWARE AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of New Castle County, Delaware including the Cities of Delaware City, New Castle, Newark, and Wilmington; the Towns of Bellefonte, Elsmere, Middletown, Newport, Odessa, and Townsend; the Villages of Arden, Ardencroft, and Ardentown; and the unincorporated areas of New Castle County (hereinafter referred to collectively as New Castle County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

Please note that the Towns of Clayton and Smyrna are geographically located in Kent, and New Castle Counties. The Towns of Clayton and Smyrna are shown in their entirety in the Kent County FIS. See the separately published FIS reports and Flood Insurance Rate Maps (FIRMs) for countywide map dates and flood hazard information outside of New Castle County.

Please note that on the effective date of this study, the Town of Bellefonte and the Village of Ardencroft have no mapped Special Flood Hazard Areas (SFHAs). This does not preclude future determinations of SFHAs that could be necessitated by changed conditions affecting the community (i.e. annexation of new lands) or the availability of new scientific or technical data about flood hazards.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The original April 17, 1996 countywide FIS was prepared to include all jurisdictions within New Castle County into a countywide format FIS. Information on the authority and acknowledgments for each jurisdiction with a previously printed FIS report included in this countywide FIS is shown below.

Delaware City, City of: the hydrologic and hydraulic analyses for the FIS report dated August 1976 were prepared by the Delaware River Basin Commission for the

	Federal Emergency Management Agency (FEMA) under Contract No. H-3747. The hydrologic and hydraulic analyses for the FIS report dated March 2, 1982, were performed by Dewberry & Davis for FEMA. The hydrologic and hydraulic analyses for the FIS report dated May 2, 1991, were performed by the U.S. Army Corps of Engineers (USACE), Philadelphia District for FEMA during the preparation of the FIS for the unincorporated areas of New Castle County.
Elsmere, Town of:	the hydrologic and hydraulic analyses for the FIS report dated December 31, 1976, were performed by the U.S. Department of Agriculture, Soil Conservation Service (SCS) for FEMA under Inter-Agency Agreement No. IAA-4-9-72, Project Order No. 5. The hydrologic and hydraulic analyses for the FIS report dated September 18, 1987, were prepared by the USACE, Philadelphia District for FEMA under Inter-Agency Agreement No. EMW-85-E-1822, Project Order No. 1, Amendment No. 4. That work was completed in March 1986.
New Castle, City of:	the hydrologic and hydraulic analyses for the FIS report dated April 3, 1987, were performed by the USACE, Philadelphia District for FEMA under Inter-Agency Agreement No. EMW-85-E-1822, Project Order No. 1, Amendment No. 4. That work was completed in January 1986.
New Castle County (Unincorporated Areas):	the hydrologic and hydraulic analyses for the FIS report dated July 3, 1990, were prepared by the USACE, Philadelphia District for FEMA under Inter-Agency Agreement No. EMW-E-091, Project Order No.4. That work was completed in November 1984.

For the FIS report dated September 4, 1986, the hydrologic and hydraulic analyses for the Christina River were performed by the USACE, Philadelphia District, during the preparation of the FIS for the City of Newark. That work was completed in May 1986.

Newark, City of: the hydrologic and hydraulic analyses for the FIS report dated April 15, 1988, were performed by the USACE, Philadelphia District for FEMA under Inter-Agency Agreement No. EMW-85-E-1822, Project Order No.1, Amendment No. 4. That work was completed in May 1986.

Newport, Town of: the hydrologic and hydraulic analyses for the FIS report dated December 15, 1977, were performed by Dames & Moore for FEMA.

The hydrologic and hydraulic analyses for the FIS report dated April 3, 1987, were performed by the USACE, Philadelphia District for FEMA under Inter-Agency Agreement EMW-85-E-1822, Project Order No. 1, Amendment No. 4. That work was completed in September 1985.

Wilmington, City of: the hydrologic and hydraulic analyses for the FIS report dated November 1976 were performed by the Delaware River Basin Commission for FEMA under Contract No. H--747. That work was completed in March 1976.

The hydrologic and hydraulic analyses for the FIS report dated August 19, 1991, were performed by the USACE, Philadelphia District for FEMA during the preparation of the FIS for the unincorporated areas of New Castle County. That work was completed in October 1989.

There are no previous FIS Reports published for the Town of Middletown; therefore, the previous authority and acknowledgments for this community is not included in this FIS.

There are no previous FISs or Flood insurance Rate Maps (FIRMs) published for Towns of Bellefonte, Odessa, and Townsend; and the Villages of Arden, Ardencroft, and Ardentown; therefore, the previous authority and acknowledgments for these communities are not included in this FIS. These communities will not appear in the Community Map History Table (Section 6.0).

For the April 17, 1996 initial countywide FIS, revised hydrologic and hydraulic analyses for Naaman Creek, South Branch Naaman Creek, and Shellpot Creek were performed by the USACE, Philadelphia District for FEMA under Inter-Agency Agreement Nos. EMW-90-E-3286, Project Order No.7, Task Letter No. 90-7; EMW-91-E-3529, Project Order No.2, Task Letter No. 91-1; and EMW-91-E-3529, Project Order No.2, Task Letter No. 91-2, respectively. That work was completed in February 1991, October 1991, and April 1992, respectively.

Hydrologic and hydraulic analyses for the upper portion of the Christina River, East Branch Christina River, Persimmon Run, Silver Brook, Tributary to West Branch Christina River, West Branch Christina River, and Yorkshire Ditch were performed by the SCS, Dover Delaware. That work was completed in May 1993.

For the August 3, 1998, FIS, the hydrologic and hydraulic analyses were prepared by the USACE, Philadelphia District for FEMA. For the Christina River, the work was completed in September 1994 under Inter-Agency Agreement No. EMW-92-E-3839, Task Letter No. 92-15. For the West Branch Christina River, the work was completed in April 1995 under Inter-Agency Agreement No. EMW-93-E-4119, Task Letter No. 93-6.

For the October 6, 2000, revision, an updated base map was used in the production of the FIRMs and several Letters of Map Revision (LOMRs) were incorporated.

For the January 17, 2007 FIS revision, Base (1-percent-annual-chance) Flood Elevations (BFEs) were added to Back Creek, Belltown Run, Doll Run, Dragon Creek, Dragon Creek Tributary No. 1, Drawyer Creek Tributary No. 1, Duck Creek, Providence Creek, Scott Run, Shallcross Lake, Shallcross Lake Branch, Nos. 1-6, Spring Mill Branch, Tributary to Belltown Run Tributary 1 resulting from the incorporation of LOMRs.

The hydrologic and hydraulic analyses for all or portions of Appoquinimink River, Deep Creek, Drawyer Creek, Drawyer Creek Tributary No. 1, Hangmans Creek, and Tributary of Drawyer Creek for this revision were performed by URS Corporation (URS), for the Delaware Department of Natural Resources and Environmental Control (DNREC), under Order No. 07010106587. This study was completed in November 2011.

The hydrologic and hydraulic analyses for all or portions of Belltown Run and tributaries, Mill Creek, Red Clay Creek, and White Clay Creek for this revision were performed by Duffield Associates, Inc. (Duffield) and Michael Baker Jr., Inc. (Baker) for DNREC, under Project No. 6153.WC. This study included the entire main stem of Red Clay Creek in Delaware, White Clay Creek from

Kirkwood Highway (Route 2) to its confluence with the Christina River, and the entire main stem of Mill Creek within Delaware. Also included was Belltown Run from Salem Church Road to Beck's Pond and Tributary to Belltown Run, and Tributary to Belltown Run Tributary I. This study was completed in January 2013.

The coastal analyses for this revision were performed by Risk Assessment Mapping and Planning Partners (RAMPP) under contract No. HSFEHQ-09-D-0369, Task Order HSFE03-09-J-0002. This study was completed in December 2012.

The final FIRM database for this revision was performed by RAMPP under contract No. HSFEHQ-09-D-0369, Task Orders HSFE03-09-0003 for the riverine floodplain portion and HSFE03-09-J-0002 for the coastal floodplain portion.

Base map information shown on this FIRM was provided in digital format by the Delaware Geospatial Data Exchange. The base map features were compiled at a scale of 1:24,000 from aerial photography dated 2011.

The projection used in preparation of this map was State Plane Delaware zone (FIPS Zone 0700). The Horizontal datum was, North American Datum of 1983 (NAD 83), Geodetic Reference System 1980 (GRS 80) spheroid. Differences in the datum, spheroid, projection or State Plane zones may result in slight positional differences in map features across jurisdictional boundaries. These differences do not affect the accuracy of information shown on this FIRM.

1.3 Coordination

An initial Consultation Coordination Officer's (CCO) meeting is held typically with representatives of FEMA, the community, and the study contractor to explain the nature and purpose of an FIS, and to identify the streams to be studied by detailed methods. A final CCO meeting is held typically with the same representatives to review the results of the study.

The dates of the pre-countywide initial and final CCO meetings held for the communities within New Castle County are shown in Table 1, "Initial and Final CCO Dates."

TABLE 1 – INITIAL AND FINAL CCO DATES

Community Name	Initial CCO Date	Final CCO Date
City of Delaware City	September 27, 1974	October 30, 1975
Town of Elsmere	November 8, 1984	November 4, 1986
City of New Castle	November 8, 1984	May 16, 1986
(Unincorporated Areas)	May 21, 1982	October 24, 1985

TABLE 1 – INITIAL AND FINAL CCO DATES-continued

Community Name	Initial CCO Date	Final CCO Date
City of Newark	November 8, 1984	March 25, 1987
Town of Newport	November 8, 1984	May 16, 1986
City of Wilmington	September 11, 1974	March 24, 1976

For the April 17, 1996, FIS, FEMA notified the unincorporated areas of New Castle County by letters dated January 17, 1992, and June 5, 1992. FEMA notified the Cities of Delaware City, New Castle, Newark, and Wilmington, and the Towns of Elsmere, Middletown, and Newport by letter on July 12, 1993, that a revision to the FIS and FIRM would be prepared. A final CCO meeting was held on June 1, 1994, and was attended by representatives of the USACE, the Villages of Arden and Ardentown, and FEMA.

For the August 3, 1998, FIS, New Castle County was notified by letter on October 27, 1994, that its FIS would be revised using the analyses prepared by the USACE.

For the October 6, 2000, revision, New Castle County was notified by letter on May 14, 1999, that a revision to the FIS and FIRM would be prepared. Final meetings were held on September 6, 2000, for the Town of Odessa; September 16, 2000, for the unincorporated areas of New Castle County, the City of Delaware City, and New Castle, and the Town of Elsmere; and on September 16, 1999, for the Villages of Arden, and Ardentown, the Towns of Middleton and Newport, and the Cities of Newark and Wilmington.

The January 17, 2007 revision update was created in close coordination with New Castle County; a CCO meeting was not required since the county representatives were already familiar with the changes to the FIRM and the next steps in the due process for ordinance adoption.

For this coastal revision, the initial community meeting was held on November 30, 2010 at the New Castle County Government Center and attended by representatives of FEMA, the New Castle County Department of Land Use, DNREC, and RAMPP. For the White Clay Creek et al. study performed by Duffield and Baker, a community meeting was held in November 2012 to review the draft riverine mapping for that study, and was attended by representatives of New Castle County, DNREC, Duffield and Baker. A Flood Risk Review meeting was held on December 6, 2012 at the New Castle City/County Building to review the coastal draft mapping, and was attended by representatives of FEMA, the New Castle County, local communities, DNREC, and RAMPP.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of New Castle County, Delaware.

All or portions of the flooding sources listed in Table 2, "Flooding Sources Studied by Detailed Methods," were studied by detailed methods. Limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Exhibit 2).

TABLE 2 - FLOODING SOURCES STUDIED BY DETAILED METHODS

Appoquinimink River	Pike Creek
Appoquinimink River Tributary 1	Prices Run
Appoquinimink River Tributary 2	Red Clay Creek
Brandywine Creek (Lower Reach)	Shellpot Creek
Brandywine Creek (Upper Reach)	Silver Brook
Christina River	Silverbrook Run
Deep Creek	South Branch Naaman Creek
Derrickson Run	Tributary to Drawyer Creek
Drawyer Creek Tributary 1	Tributary to West Branch Christina River
East Branch Christina River	Tributary to White Clay Creek
Hangmans Creek	West Branch Christina River
Little Mill Creek	West Branch of Derrickson Run
Matson Run	White Clay Creek
Mill Creek	Yorkshire Ditch
Naaman Creek	
Persimmon Run	

The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction through New Castle County.

For this revision, new limited detailed analyses were included for the flooding sources shown in Table 3, "Flooding Sources Studied by Limited Detailed Methods."

TABLE 3 – FLOODING SOURCES STUDIED BY LIMITED DETAILED METHODS

Stream Name	Limits of Study
Appoquinimink River	From the confluence with Delaware River to approximately 0.23 mile upstream of Dogtown Road.
Belltown Run	From Beck's Pond Dam to Salem Church Road .

TABLE 3 – FLOODING SOURCES STUDIED BY LIMITED DETAILED METHODS-continued

Stream Name	Limits of Study
Deep Creek	From the confluence with Appoquinimink River to approximately 0.49 mile upstream of Levels Road (State Route 15)
Drawyer Creek Tributary 1	From approximately 330 feet downstream of Brick Mill Road to approximately 0.24 mile upstream of Summit Bridge Road
Hangmans Creek	From the confluence with Appoquinimink River to approximately 1.48 miles upstream of Taylors Bridge Road
Tributary of Drawyer Creek	From the confluence with Drawyer Creek Tributary No. 1 to approximately 0.57 miles upstream of Summit Bridge Road
Tributary to Belltown Run	From confluence with Belltown Run to 0.30 miles upstream of undefined railroad bridge
Tributary to Belltown Run Tributary 1	From confluence with Tributary to Belltown Run to 0.023 miles upstream of U.S. Highway 40
Unnamed Tributary to Mill Creek	From confluence with Mill Creek to 850 feet upstream of Loblolly Court

For this revision, coastal analyses of the Delaware River and its tributaries has been prepared to establish the frequency-peak elevation relationships for coastal flooding in New Castle County.

This countywide FIS incorporates the determination of Letters of Map Revision shown below in Table 4, "Incorporated Letters of Map Revision."

TABLE 4 – INCORPORATED LETTERS OF MAP REVISION

Case Number	Project Identifier	Effective Date
05-03-0955P	Wiggins Mill Park Flood Study	September 28, 2006
07-03-0213P	Le Grange (DE)	August 24, 2007
07-03-0823P	Spring Mill Branch	October 19, 2007
07-03-1076P	Cool Run Tributary (DE)	October 29, 2007
07-03-0845P	Brookview	December 7, 2007
08-03-0143P	Browntown Truck Route	October 31, 2008

2.2 Community Description

New Castle County, the northernmost of the three counties in Delaware, is located in the heart of the complex of metropolitan area that has come to be known as the Megalopolis Corridor. It is bordered by Chester and Delaware Counties, Pennsylvania to the north; the Townships of Lower Alloways Creek, Oldsman, Elsinboro, Pennsville, Greenwich, Fairfield, and Upper Penns Neck and the Borough of Penns Grove, New Jersey, to the east; the Towns of Clayton and Smyrna and the Unincorporated Areas of Kent County, Delaware to the south; and the Unincorporated Areas of Cecil and Kent Counties, Maryland, to the west. New Castle County has a total land area of 435 square miles. The population of the county was 471,417 in 1996 and increased to 538,479 in 2010.

The climate of New Castle County is characterized by warm summers, when the temperatures can rise above 85 degrees Fahrenheit (°F), and cool winters, when the temperature can fall below 20°F. The annual precipitation in the area averages 42 inches and is fairly evenly distributed throughout the year, although a major portion occurs in the late spring and summer.

2.3 Principal Flood Problems

Flood problems currently exist along the Christina River, White Clay Creek, Red Clay Creek, Mill Creek, Pike Creek, Little Mill Creek, Chestnut Run, Naaman Creek, and South Branch Naaman Creek, and other streams in the unincorporated areas of New Castle County. Inadequate drainage facilities in developing population centers have compounded the problem in urban areas.

The lower portion of the Christina River is also subject to tidal flooding from the Delaware River. This may occur in combination with fluvial flooding. The flood of record for the Christina River basin as a whole occurred during Tropical Storm Agnes on June 22-24, 1972. This storm resulted in flooding at many locations in the basin; however, due to the large size of the basin, other more localized storms resulted in greater damage to certain portions of the basin. Therefore, the flood of record for individual areas varies throughout the basin.

White Clay Creek and Red Clay Creek have been sources of substantial flooding in the past. Damage has been the result of backed-up sewers, flooded roads, and flooded cellars. The Delaware Park Race Track, located along White Clay Creek upstream of the confluence of Red Clay Creek, was damaged in the flood of July 5, 1937. U.S. Geological Survey (USGS) gage No. 01479000, located approximately 3.5 miles east of the City of Newark, was not in operation during that storm; however, a stage of 23.0 feet was obtained from a high-water mark located near the gage. High stages on Mill Creek have produced intense flooding at camps in the Hockessin area. This and other floods damaged several

industries in Yorklyn. Some damage has also occurred along Red Clay Creek in the Stanton area.

The Wilmington Marine Terminal and other industries near the mouth of the Christina River have been flooded by high tides on the Delaware River. The storm of November 25-26, 1950, produced the worst flooding in this area, with depths of up to 3 feet. This storm produced heavy precipitation accompanied by strong winds in the New Jersey and Delaware area. Gusts of up to 70 miles per hour were recorded in Delaware at the New Castle County Airport (Reference 1). The storm produced the highest record tide at the City of New Castle, just south of the City of Wilmington. Homes along the Christina River in the Newark area have had yards and basements flooded on several occasions by fluvial floods.

Two major floods have been documented on Little Mill Creek. The flood of July 8-9, 1952, took place prior to the installation of the USGS gage. The August 9-10, 1967, flood is the flood of record at the gage. That flood, caused by an intense thunderstorm, damaged primarily residential properties in the Elsmere area.

Flooding within the Cities of Delaware City and the City of Wilmington is usually related to hurricane-induced high tides. Fluvial flows are seldom, if ever, a major flood hazard in the area. Because flooding is tidal, most flood damage results from inundation rather than from high velocity flows.

Abnormally high tidal stages of the Delaware Bay and River are caused by a number of factors. Winds from the southeast, which are usually associated with hurricanes, drive water into the bay (Reference 2). Winds from the northeast do not drive water directly into the bay; however, these winds cause water to flow into the bay due to a temporary increase in the ocean tide stage adjacent to the bay entrance.

Storm surge is considered a temporary change in sea level and contributes significantly in the tidal flooding areas. This temporary change is caused by the storm winds acting over an extensive fetch of ocean, creating a mound or swell of water. Storm surge has a frequency that is measured in hours and rarely goes through more than two or three significant cycles during a single storm (Reference 2). The damaging effects from storm surges may penetrate inland far beyond the normal shoreline over low-lying areas.

Waves impinging on shorelines can also cause damage. Waves generated by winds from the east are the largest because the wind from this direction can act over the greatest fetch on the Delaware River, adjacent to the City of Delaware City. Both fetch length and water depth factors are important in the determination of wave height (Reference 3).

Local officials have indicated that the lower end of the City of Delaware City is inundated frequently whenever a good "northeaster" is experienced. The greatest flood readily recalled occurred in September 1944, when water advanced nearly two blocks into the city from the Delaware River (Reference 4).

Because both the Christina River and Brandywine Creek drain relatively large basins at the City of Wilmington, these waterways are subject to flooding from regional, rather than local, storms.

Floods which have caused significant damage along Brandywine Creek occurred in 1920, 1955, 1960, 1971, and 1972. The June 23, 1972, flood caused by Tropical Storm Agnes is the flood of record for the City of Wilmington.

Flooding during Tropical Storm Agnes, primarily in the northeast section of the City of Wilmington, forced more than 100 residents from their homes. Most streets were impassable in the area bounded roughly by Governor Printz Boulevard, Claymont Street, Vandever Avenue, and the Brandywine River (Reference 5). This area is low-lying and portions were inundated to depths of up to 6 feet during Tropical Storm Agnes (Reference 6). Brandywine Creek floodwaters crested at 15.5 feet, 7 feet above flood stage, at the USGS gaging station at stream mile 4.58 of the Brandywine Creek at Rockford Park.

The March 1920 flood, caused by gentle rainfall followed by driving sleet and snow, produced severe flooding in the City of Wilmington. Approximately 40 blocks were inundated, and hundreds of families were driven from their homes.

In the City of Newark, flood problems currently exist along the Christina River and White Clay Creek. Flooding in the area is due primarily to development in the floodplain regions as well as some inadequate drainage facilities.

Flooding in the City of New Castle is usually related to extreme tidal conditions on the Delaware River. The flood of November 1950 was the highest flood recorded at the New Castle tide gage with a height of 8.4 feet. Other major floods occurred in August 1955 and August 1933.

Flood problems currently exist along all the streams in the Town of Elsmere. Flooding in the area is due primarily to development in the floodplain regions as well as some inadequate drainage facilities.

Two major flood events have been well documented on Little Mill Creek in the Town of Elsmere. One, on July 8 and 9, 1952, occurred prior to the installation of the USGS gage No. 01480100, just downstream of the town. The other, on August 9 and 10, 1967, is the flood of record at the gage, during which a discharge of 3,960 cubic feet per second (cfs) was recorded, just below the 50-year flood event. This flood was caused by an intense thunderstorm and damaged primarily residential property in the Town of Elsmere.

Flooding in the Town of Newport is primarily caused by the Christina River. Floods in this area are influenced by tidal action and, for this reason, their duration is difficult to determine. The most severe flood was recorded in June 1972, as Tropical Storm Agnes flooded all drainage centers in the basin. The three most recent major flood events for the Region III domain are Hurricane Isabel (September 2003), extratropical storm Ida (November 2009), and Hurricane Ernesto (August 2012).

2.4 Flood Protection Measures

Presently, there are no major flood control measures that would alter flood flows on the streams studied by detailed methods. Residents of New Castle County depend on the usual warnings issued through radio, television, and local newspapers for information concerning possible flood conditions. Flood warnings and predicted flood peaks are issued by the National Oceanic and Atmospheric Administration Flood Forecasting Centers located at Harrisburg, Pennsylvania, and Trenton, New Jersey.

No flood protection structures exist within Delaware City. The General Comprehensive Development Plan designates much of the areas adjacent to the Delaware River and the Delaware City Branch of the Chesapeake and Delaware Canal for use as agricultural land, open space, or recreation area (Reference 7). Some areas adjacent to the west bank of the branch canal have been designated for residential, commercial, and multifamily residential development.

In the City of New Castle, there is a levee that stretches along the Delaware River for almost the entire length of the city.

FEMA specifies that all levees must have a minimum of 3-foot freeboard against 100-year, or 1-percent-annual-chance, flooding to be considered a safe flood protection structure.

Levees exist in the study area that provide the community with some degree of protection against flooding. However, it has been ascertained that some of these levees may not protect the community from rare events such as the 1-percent-annual-chance flood. The criteria used to evaluate protection against the 1-percent-annual-chance flood are 1) adequate design, including freeboard, 2) structural stability, and 3) proper operation and maintenance. Levees that do not protect against the 1-percent-annual-chance flood are not considered in the hydraulic analysis of the 1-percent-annual-chance floodplain.

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 FIS. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 1-percent annual chance flood (1-percent chance of annual exceedance) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the

risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of this FIS. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting Spartanburg County.

Information on the methods used to determine peak discharge-frequency relationships for the streams studied by detailed methods is shown below.

Pre-countywide Analyses

Each community within New Castle County, except the Towns of Middletown and Odessa and the Villages of Arden and Ardentown, had a previously printed FIS report describing each community's hydrologic analyses. Those analyses not revised in this countywide FIS have been compiled from the previously printed FIS reports and are summarized below.

The hydrologic analysis for the Christina River basin, Little Mill Creek, and White Clay Creek included an evaluation of historic storms and the development of a rainfall-runoff model using the USACE HEC-1 computer program (Reference 8). The HEC-1 program was used in conjunction with recorded precipitation data to model historic flood events (Reference 9). Hypothetical rainfall distributions were developed using National Weather Service Technical Paper No. 40 (Reference 10). The rainfall-runoff model was then used to determine the peak flow and hydrograph for each frequency event at various index locations. The log-Pearson Type III method was used to develop discharge-frequency curves from the historic flood records at each gage location in the basin. A standard project storm was derived using criteria developed by the USACE (Reference 11).

Final discharge-frequency values were computed from composite analyses of streamflow gage records, the rainfall-runoff model, and the USACE Standard Project Flood. Minor adjustments were then made to calibrate the resultant frequency values to reflect gage records (References 11 and 12).

Discharges for Brandywine Creek (Lower Reach) were obtained from the FIS for the City of Wilmington and discharges for Brandywine Creek (Upper Reach) were obtained from the FIS for the Township of Birmingham, Pennsylvania (References 13 and 14). Hydrologic analyses for East Branch Christina River, West Branch Christina River, Belltown Run, and Muddy Run were obtained from the original FIS for the unincorporated areas of New Castle County (Reference 15).

The hydrologic analyses for the portion of Little Mill Creek in the Town of Elsmere, Silverbrook Run, Chestnut Run, and Derrickson Run included an

analysis of the discharge-frequency relationship at the USGS gage No. 01480100, located just downstream from the Town of Elsmere. Hypothetical rainfall distributions were developed using Technical Paper No. 40 of rainfall intensities (Reference 10). These rainfall data were applied to a unit hydrograph that was derived from the August 9 and 10, 1967, flood of record. A rainfall runoff analysis was then performed to determine the peak flow and hydrograph for each frequency relationship. The log-Pearson Type Ill method was used to develop a discharge-frequency relationship for the historical flood records at the same location. Because of the short gage records, the results of this analysis were used for comparative purposes to establish some confidence in the initial evaluation. The discharge-frequency relationship for ungaged areas of the studied streams were developed by application of regional regression techniques appropriate for the area and comparison of results with data developed at the gage.

The hydrologic analysis for West Branch of Derrickson Run was taken from the original FIS for the Town of Elsmere (Reference 20). Peak discharges were determined by valley flood routing of the 2-, 10-, and 1-percent-annual-chance runoff events. Rainfall information was obtained from Technical Paper No. 40 (Reference 10).

Because Matson Run is a tributary to Shellpot Creek, hydrologic analysis of Matson Run was based on a log-Pearson Type III analysis of gage records at the Shellpot Creek gaging station. Peak flood flows for each recurrence interval were adjusted to reflect the drainage area.

For Prices Run, natural flood flow-frequency data were derived from local regionalized frequency curves based on statistical analysis of streamflow records from 15 gages located in the area and operated by the USGS. The analysis of each gage followed the standard log-Pearson Type III statistical technique recommended by the Water Resources Council (Reference 21). Results were regionalized through linear regression analysis of the log-log relationships for peak flow versus drainage area for all gages at each return interval.

Natural (unadjusted) flood flows, determined from the regionalized curves, were used in the analysis of Prices Run.

Countywide Analyses

Information on the methods used to determine peak discharge-frequency relationships for the flooding sources that were restudied or newly studied as part of this countywide FIS is shown below.

For the April 17, 1996, FIS, flood flow frequency for Naaman Creek and South Branch Naaman Creek were developed using the SCS Technical Release No. 55 (TR-55) (Reference 22). TR-55 is a procedure for calculating storm runoff and peak discharges for small watersheds tending toward urbanization. Naaman Creek and South Branch Naaman Creek are ungaged basins with no historical data available for calibration. Therefore, peak discharges calculated using TR-55

were compared to discharges calculated using PC Program USGS-IND and PC Program PSU-IV for Naaman Creek (References 23 and 24). The TR-55 discharges for both flooding sources were compared to a log-Pearson Type III statistical analyses of gages from similar watersheds in the area. Discharges compare favorably to discharges calculated using the other methods.

Flood flow frequency for Shellpot Creek was determined using recorded peak discharge data from USGS gage No. 1-4778 in the USACE HECWRC computer program and in a log-Pearson Type III hydrologic statistical analysis method (References 25-29). Flows were distributed upstream using a drainage area ratio method (Reference 30). Shellpot Creek also has high water mark data available for the July 5, 1989, storm, which was the recent flood of record (Reference 31). This storm reached 1-percent-annual-chance frequency flood levels at various locations throughout the basin. At the gage location, the USGS estimated that this flood reached a peak discharge of 8,040 cfs. Frequency flood flows were adjusted as necessary using this high water mark data.

The hydrologic model for some streams in the Christina River basin, including the upper portion of the Christina River, East Branch Christina River, West Branch Christina River, Tributary to West Branch Christina River, Persimmon Run, Silver Brook, and Yorkshire Ditch, was developed using the SCS Technical Release 20 (TR-20) (Reference 32). A present condition TR-20 model was first developed using current land use/land cover conditions in the watershed. The present condition database was obtained by digitizing data supplied by local planning agencies into a Geographic Information System (GIS) computer. Aerial photography and field investigations were also used to verify the database.

The TR-20 present condition model was calibrated by reproducing flood hydrographs for four historical events at the stream gage at Coochs Bridge. Peak rate of discharge, runoff volume, and hydrograph shape were the parameters used for calibration and verification. In addition, TR-20 simulated flows were favorable compared with statistical discharge-frequency values derived from procedures in the U.S. Water Resources Council *Bulletin No. 17B* (Reference 33).

After calibration, the TR-20 present condition model was run for the 2-, 10-, 2-, 1-, and 0.2-percent-annual-chance events using 24-hour rainfall values from the National Weather Service Technical Paper No. 40 (Reference 34). The resulting flood discharges were then used in WSP-2 to generate water-surface profiles.

For the August 3, 1998, FIS, the discharge-frequency relationship for the Christina River was developed to be consistent with flows previously developed for the April15, 1988, City of Newark FIS, using WRI 78-93 (Reference 35). For the West Branch Christina River, the discharge-frequency relationship was developed using the SCS Technical Report No. 55 (Reference 36).

For the October 6, 2000, revision, the TR-20 present condition model was run for the 1-percent-annual-chance event. The resulting flood discharges were then used in HEC-RAS to generate a water-surface profile for the Unnamed Tributary to Mill Creek.

This Revision

For this revision, discharges for the 10-, 2-, 1-, and 0.2-percent annual chance recurrence intervals for all streams studied by URS with limited detailed methods, which included Appoquinimink River, Deep Creek, Drawyer Creek, Drawyer Creek Tributary No. 1, Hangmans Creek, and Tributary of Drawyer Creek, were determined using USGS regression analyses (Reference 84) developed for the Coastal Plain physiographic province of Delaware.

The Coastal Plain regression equations are as follows:

$$PK10 = 210DRNAREA^{0.709}BSLDEM10M^{0}.289(SOILA+1)^{-0.316}$$
$$PK50 = 353DRNAREA0.712BSLDEM10M^{0.297}(SOILA+1)^{-0.328}$$
$$PK100 = 425DRNAREA0.715BSLDEM10M^{0.303}(SOILA+1)^{-0.332}$$
$$PK500 = 623DRNAREA^{0.720}BSLDEM10M^{0.320}(SOILA+1)^{-0.344}$$

where;

PK10, PK50, PK100, and PK500 are the peak discharges for floods with recurrence intervals of 10 years, 50 years, 100 years, and 500 years;

DRNAREA is the drainage area in square miles;

BSLDEM10M is the mean basin slope determined from a 10-meter DEM in percent, and;

SOILA is a hydrologic soil type A, in percent, high infiltration-rate soils.

Hydrologic Studies of the Red Clay Creek, White Clay Creek, Mill Creek, and Belltown Run and its tributaries were completed under contract to DNREC. The hydrologic studies were part of a detailed study of Red Clay Creek, White Clay Creek, and Mill Creek, and part of a limited detail study for Belltown Run and its tributaries.

The Red Clay Creek and White Clay Creek hydrologic studies were completed by Duffield. Leveraged data from previously completed hydrology studies of the Red Clay Creek and White Clay Creek watersheds was used. Hydrology Discharge-frequency values for the Red Clay Creek and White Clay Creek were computed by Duffield using streamflow gage records. The log-Pearson Type III method was used to develop discharge-frequency curves from the historic flood records and the stream gage locations as described in the U.S. Water Resources Council Bulletin No. 17B (Reference 33).

The Mill Creek hydrologic study was completed by the New Castle County Department of Land Use. For the Mill Creek watershed, a hydrologic model was developed using the SCS Technical Release 20 (TR-20) model (Reference 90). Sub-drainage areas and basin characteristics were derived using the USGS StreamStats program (Reference 93).

Duffield used the USGS StreamStats program to develop the flood frequency discharges for Belltown Run, Tributary to Belltown Run, and Tributary to Belltown Run Tributary I.

A summary of the drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 5, "Summary of Discharges." Discharge data were unavailable for Muddy Run.

TABLE 5 - SUMMARY OF DISCHARGES
Detailed Streams

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
BACK CREEK	6.35	*	*	10,401	*
BELLTOWN RUN					
Downstream end of Becks Pond	6.45	838	1,420	1,720	2,550
Upstream of Tributary to Belltown Run	4.72	665	1,120	1,360	2,020
Upstream of railroad crossing	3.91	551	929	1,120	1,660
1,800 feet upstream of Route 40	2.57	380	640	771	1,130
1,100 feet downstream of Savannah Drive	1.96	309	519	625	914
1,400 feet upstream of Porter Road	1.08	198	333	400	582
BRANDYWINE CREEK (LOWER REACH)					
At the Delaware-Pennsylvania State Boundary	295.00	13,000	18,600	22,200	34,000
BRANDYWINE CREEK (UPPER REACH)					
At confluence with Christina River	314.00	13,000	21,500	25,600	35,500
CHESTNUT CREEK					
At confluence with Little Mill Creek	1.15	1,300	1,800	2,000	3,300
CHRISTINA RIVER					
Downstream of the confluence of Little Mill Creek	234.00	13,100	22,900	27,600	41,700
Upstream of the confluence of Little Mill Creek	224.50	12,700	22,200	26,700	40,400

*Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued
Detailed Streams

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
CHRISTINA RIVER (continued)					
Upstream of the confluence of White Clay Creek	54.40	5,000	8,500	10,400	15,200
Downstream of the confluence of Belltown Run	37.00	4,000	6,600	8,200	12,200
Upstream of the confluence of Belltown Run	23.80	3,000	5,000	6,400	9,600
At USGS gage No. 01478000 (Coochs Bridge)	20.50	2,400	4,400	5,300	8,800
Upstream of the confluence of West Branch	10.00	1,800	3,100	4,000	6,200
Upstream of Barksdale Road	8.20	1,600	2,700	3,600	5,700
Upstream of State Route 273 (Nottingham Road)	6.70	1,500	2,500	3,300	5,200
Upstream of the confluence of East Branch Christina River	3.84	1,100	1,900	2,500	3,800
At Pennsylvania/Maryland state boundary	1.60	740	1,200	1,500	2,200
DERRICKSON RUN					
At confluence with Little Mill Creek	0.70	1,000	1,400	1,500	2,550
Upstream of CSX Transportation bridge	0.14	450	620	690	1,150
DOLL RUN					
At Lower Twin Lane	1.35	*	*	1,338	*
At Bear Corbitt Road	1.20	*	*	1,095	*
DRAGON CREEK					
At U.S. Route 13	4.63	*	*	2,817	*
Just downstream of State Route 1	3.96	*	*	2,797	*
At McCoy Road	3.72	*	*	2,580	*
DRAGON CREEK TRIBUTARY NO.1					
At confluence with Dragon Creek	0.51	*	*	473	*
DUCK CREEK					
At Smyrna Landing Road	22.56	2,455	5,555	7,400	13,590
Upstream of confluence with Spring Branch	13.50	1,804	4,071	5,401	10,085
EAST BRANCH CHRISTINA RIVER					
At confluence with Christina River	1.94	725	*	1,281	1,939
Approximately 115 feet downstream of Wedgewood Road	*	688	*	1,224	1,948

*Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued
Detailed Streams

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
LITTLE MILL CREEK					
At confluence with the Christina River	9.53	3,700	5,100	5,800	9,500
At USGS gage No. 01480100 (Elsmere)	6.70	3,100	4,300	4,900	8,000
Upstream of the confluence of Chestnut Run	5.50	2,800	3,900	4,400	7,200
MATSON RUN					
At stream mile 0.23	1.30	620	1,050	1,250	1,700
MILL CREEK					
At Route 41	1.05	364	777	1,016	1,672
Swift Park railroad crossing	1.15	280	535	686	1,551
Evanstown Road	1.64	431	794	1,008	2,044
Mill Creek Road	3.73	961	2,010	2,628	4,388
Private Road South of Runnymeade	4.98	1,321	2,694	3,553	6,005
Private Road off of Mill Creek	5.80	1,418	3,192	4,227	7,166
At Mill Creek Road at Graves Road	6.39	1,525	3,485	4,621	7,784
At Stony Batter Road	7.53	1,775	4,130	5,485	9,253
At Dogwood Tributary	8.55	1,975	4,644	6,173	10,410
At Limestone Road	9.82	2,237	5,233	6,947	11,806
At Milltown Road	9.98	2,280	5,258	7,038	11,954
At Kirkwood Highway	10.3	2,370	5,308	7,224	12,255
At Capital Trail	12.3	2,762	6,164	8,350	14,156
At Railroad Crossing	12.5	2,783	6,205	8,407	14,256
At White Clay Creek	13.0	2,848	6,301	8,353	14,201
MUDDY RUN					
Just upstream of State Route 896	5.94	*	*	3,420	*
NAAMAN CREEK					
At confluence with the Delaware River	14.00	3,720	6,160	7,840	11,200
Upstream of the confluence with South Branch Naaman Creek	7.00	1,850	3,150	4,030	6,300
NW TRIBUTARY TO MUDDY RUN					
At confluence with Muddy Run	1.74	*	*	2,090	*
PERSIMMON RUN					
At confluence with the West Branch Christina River	1.86	824	*	1,372	1,855

*Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued
Detailed Streams

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
PIKE CREEK					
At confluence with White Clay Creek	6.30	1,210	2,330	3,010	5,140
At Henderson Road	5.30	1,130	2,230	2,890	4,870
PRICES RUN					
At stream mile 0.50	1.02	550	895	1,175	1,450
RED CLAY CREEK					
Pennsylvania-Delaware State Boundary	28.4	4,300	7,200	8,700	12,700
Downstream of Barley Mill Road	32.9	4,600	7,700	9,400	13,900
At Way Road	33.2	4,600	7,800	9,400	14,000
Between Way Road and Mt. Cuba Road	41.6	4,900	8,400	8,400	10,200
Downstream of Mt. Cuba Road	43.3	4,900	8,400	10,200	15,700
At USGS Wooddale Gage	46.7	4,900	8,400	10,300	15,900
Downstream of Route 48	47.6	4,900	8,500	10,400	16,000
Upstream of Faulkland Road	48.3	5,000	8,500	10,400	16,000
At Route 41	51.3	5,200	8,800	10,700	16,200
Powell Ford Park	52.3	5,300	8,900	10,800	16,300
SCOTT RUN					
Approximately 0.7 mile downstream of Hyetts Corner Road	2.91	*	*	1,699	*
Approximately 710 feet downstream of Hyetts Corner Road	2.01	*	*	1,310	*
SHALLCROSS LAKE BRANCH NO. 1					
At confluence with Shallcross Lake	1.86	*	*	2,200	*
SHALLCROSS LAKE BRANCH NO. 2					
At confluence with Shallcross Lake Branch No. 1	0.18	*	*	200	*
SHALLCROSS LAKE BRANCH NO. 3					
At confluence with Shallcross Lake Branch No. 1	0.20	*	*	420	*
SHALLCROSS LAKE BRANCH NO. 4					
At confluence with Shallcross Lake	0.19	*	*	300	*
SHALLCROSS LAKE BRANCH NO. 5					
At confluence with Shallcross Lake	1.20	*	*	1,200	*

*Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued
Detailed Streams

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
SHALLCROSS LAKE BRANCH NO. 6					
At confluence with Shallcross Lake Branch No.5	0.50	*	*	450	*
SHELLPOT CREEK					
At USGS gage No. 1-4778 approximately 700 feet downstream of Market Street Bridge	7.46	3,480	6,670	8,590	14,900
Approximately 370 feet upstream of Market Street Bridge	6.98	3,331	6,384	8,221	14,260
Approximately 220 feet downstream of Washington Blvd. bridge	5.66	2,900	5,559	7,159	12,418
Approximately 1,840 feet from Baynard Road Bridge	3.65	2,171	4,161	5,359	9,296
Approximately 1,500 feet upstream of Foulk Road Bridge	2.04	1,479	2,834	3,650	6,332
SILVER BROOK					
At confluence with the Christina River	1.26	480	*	610	700
SILVERBROOK RUN					
At confluence with Little Mill Creek	1.31	1,350	1,900	2,100	3,500
At upstream corporate limits of the Town of Elsmere	1.00	1,200	1,700	1,900	3,100
SOUTH BRANCH NAAMAN CREEK					
At confluence with the main stem of Naaman Creek	6.70	1,649	2,799	3,594	5,800
Upstream of confluence of tributary approximately 1,300 feet downstream of Interstate Route 495	5.60	1,420	2,411	3,096	5,160
Upstream of CSX Transportation	4.80	1,240	2,135	2,757	4,790
Upstream of confluence of tributary approximately 1,400 feet downstream of walkway bridge of Harvey Mill Park	2.60	663	2,135	2,757	4,790
Upstream of confluence of tributary approximately 200 feet downstream of Acme parking lot bridge	2.00	507	898	1,173	1,975
SPRING MILL BRANCH					
At the confluence with Shallcross Lake	0.41	*	*	449	*
Upstream of confluence of tributary approximately 1,600 feet downstream of New Castle County boundary	1.0	256	465	611	1,060

*Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued
Detailed Streams

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
TRIBUTARY TO BELLTOWN RUN					
Upstream of Belltown Run	1.67	327	552	667	985
Upstream of Tributary 1 to Belltown Run I	0.87	188	316	380	556
Upstream of Railroad Crossing	0.43	99.1	165	198	287
TRIBUTARY TO BELLTOWN RUN TRIBUTARY 1					
Upstream of Tributary to Belltown Run	0.46	140	136	284	418
TRIBUTARY TO WEST BRANCH CHRISTINA RIVER					
At confluence with the West Branch Christina River	*	785	*	1,168	1,491
TRIBUTARY TO WHITE CLAY CREEK					
At confluence with White Clay Creek	1.62	600	1,200	1,600	2,700
UNNAMED TRIBUTARY TO MILL CREEK					
Upstream of confluence with Mill Creek	0.99	*	*	1,069	*
WEST BRANCH CHRISTINA RIVER					
Upstream of confluence with Christina River	6.48	1,907	2,870	3,376	5,000
Upstream of the confluence of Persimmon Run	4.21	1,446	2,171	2547	4,000
Upstream of the confluence of Tributary to West Branch Christina River Tributary	2.11	690	1,500	1,757	2,700
Approximately 3,900 feet upstream of Brewster Bridge Road	1.22	690	1,022	1,194	1,700
WHITE CLAY CREEK					
Upstream of Pike Creek	82.5	7800	8200	9500	13600
At USGS Gage 01479000	89.1	13,100	14,000	15,300	17,000
Upstream of Pike Creek	104.0	15,900	17,000	19,600	25,100
At Christina River	162.0	24,000	25,600	29,400	34,700
YORKSHIRE DITCH					
At confluence with the Christina River	0.70	530	*	841	1,115

*Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued
Detailed Streams

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
Limited Detail Streams					
APPOQUINIMINK RIVER					
Approximately 0.8 mile upstream of Silver Run Road	35.9	3,201	6,221	7,881	12,451
Approximately 0.4 mile downstream of Old State Road	23.1	2,009	3,813	4,792	7,510
Approximately 1.1 miles downstream of State Highway 13	21.0	1,944	3,707	4,663	7,322
Approximately 0.9 mile downstream of State Highway 13	20.2	1,919	3,667	4,613	7,249
Approximately 0.1 mile upstream of State Highway 1	19.6	1,904	3,642	4,583	7,204
Approximately 0.4 mile downstream of Noxontown Road	17.9	1,859	3,573	4,495	7,078
Approximately 0.1 mile downstream of Noxontown Road	9.9	994	2,015	2,564	4,152
Approximately 0.3 mile upstream of Noxontown Road	9.5	3,234	5,594	6,916	10,577
Approximately 0.6 mile downstream of Summit Bridge Road	7.6	2,171	3,952	4,979	7,627
Approximately 0.5 mile downstream of Summit Bridge Road	5.3	1,377	2,618	3,329	4,743
Approximately 0.5 mile upstream of Summit Bridge Road	4.6	1,156	2,229	2,845	4,007
Approximately 0.6 mile upstream of Grears Cornor Road	3.7	1,900	3,249	3,992	6,010
Approximately 0.2 mile upstream of Dogtown Road	1.7	920	1,565	1,918	2,877
DEEP CREEK					
Approximately 0.1 mile downstream of Silver Lake Road	7.2	882	1,676	2,090	3,244
Approximately 0.3 mile downstream of Summit Bridge Road	6.6	1,005	1,793	2,228	3,407
Approximately 0.1 mile downstream of Summit Bridge Road	3.8	800	1,406	1,736	2,627
Just upstream of Summit Bridge Road	3.3	691	1,212	1,496	2,262

*Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued
Limited Detail Streams

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
DEEP CREEK (continued)					
Approximately 0.8 mile upstream of Summit Bridge Road	2.0	326	606	762	1,188
Approximately 0.5 mile upstream of Level Road	1.3	289	541	681	1,063
Approximately 0.1 mile downstream of Silver Lake Road	7.2	882	1,676	2,090	3,244
Approximately 0.3 mile downstream of Summit Bridge Road	6.6	1,005	1,793	2,228	3,407
Approximately 0.1 mile downstream of Summit Bridge Road	3.8	800	1,406	1,736	2,627
Just upstream of Summit Bridge Road	3.3	691	1,212	1,496	2,262
Approximately 0.8 mile upstream of Summit Bridge Road	2.0	326	606	762	1,188
Approximately 0.5 mile upstream of Level Road	1.3	289	541	681	1,063
HANGMANS RUN					
Approximately 1.0 mile downstream of Taylors Bridge Road	2.9	532	998	1,252	1,932
Just upstream of Taylor's Bridge Road	2.4	513	971	1,221	1,893
Approximately 1.5 miles upstream of Taylors Bridge Road	1.4	412	793	1,001	1,561
TRIBUTARY OF DRAWYER CREEK					
Approximately 0.1 mile upstream of Summit Bridge Road	2.8	635	1,142	1,417	2,155
Approximately 0.6 mile upstream of Summit Bridge Road	0.7	297	531	656	988

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

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 was computed (Section 4.2), selected cross-section locations are also shown on the FIRM (Exhibit 2).

The hydraulic analyses for this countywide FIS were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if the hydraulic structures remain unobstructed, operate properly, and do not fail.

Pre-countywide Analyses

Each community within New Castle County, except the Towns of Bellefonte, Middletown, and Odessa and the Villages of Arden and Ardentown, had a previously printed FIS report describing each community's hydraulic analyses. Those analyses not revised in this countywide FIS have been compiled from the previously printed FIS reports and are summarized below.

Cross sections for the backwater analyses in the first and second revision of the FIS for the unincorporated areas of New Castle County were obtained using photogrammetric methods and field surveys (References 37 and 38). Cross sections for the incorporated communities within New Castle County were obtained by field survey. Cross sections were located at close intervals above and below bridges and culverts in order to compute the significant backwater effects of these structures in the highly urbanized areas. All bridges and culverts were field surveyed to obtain elevation data and structural geometry.

Water-surface elevations (WSELs) of floods of the selected recurrence intervals were computed using the USACE HEC-2 step-backwater computer program (Reference 39). Flood profiles were drawn showing computed WSELs for floods of the selected recurrence intervals.

WSELs for Silverbrook Run and Derrickson Run were determined using the slope/area method.

WSELs of floods of the selected recurrence intervals for Shellpot Creek and the portion of White Clay Creek within the City of Newark were computed using the USACE HEC-2 step-backwater computer program (Reference 39).

Starting WSELs for the Christina River were obtained from the mean annual or 1-year tide on the Delaware River (Reference 17).

Starting WSELs for Red Clay Creek, White Clay Creek, Tributary to White Clay Creek, Mill Creek, Pike Creek, Little Mill Creek, and Chestnut Run were determined by the slope/area method.

Starting WSELs for Brandywine Creek (Lower Reach) were taken from flood elevations determined for each recurrence interval by the tide-frequency analysis at the CONRAIL bridge (stream mile 1.2). Starting WSELs for Brandywine Creek (Upper Reach) were obtained from the FIS for the Township of Birmingham, Pennsylvania (Reference 14).

Starting WSELs for Matson Run were based on WSELs controlled by culvert capacity and high ground elevations. High ground, in this case the roadway of Lea Boulevard, was considered to be a dam and the culvert an outlet structure which conveyed floodwaters under the dam. Starting WSELs for hydraulic computations on Prices Run were taken from the WSELs on Brandywine Creek at the confluence of Prices Run.

Starting WSELs for West Branch of Derrickson Run were obtained from backwater computations at its confluence with Derrickson Run.

Roughness factors (Manning's "n") used in the hydraulic computations were determined by engineering judgment, field inspection of floodplain areas, and using the publication Design of Roadside Drainage Channels (Reference 40).

Countywide Analyses

For the April17, 1996, FIS, cross sections for the upper portion of the Christina River, the East Branch Christina River, the West Branch Christina River, Tributary to West Branch Christina River, Persimmon Run, Silver Brook, and Yorkshire Ditch were derived from three sources: (1) topographic maps at a scale of 1"=200' with a contour interval of 2 feet, (2) SCS field surveys, and (3) flood insurance study HEC-2 cross section data.

WSELs for floods of the selected recurrence intervals for the upper portion of the Christina River, the East Branch Christina River, the West Branch Christina River, Tributary to West Branch Christina River, Persimmon Run, Silver Brook, and Yorkshire Ditch were computed using the SCS WSP-2 water-surface profile computer program (Reference 41). WSP-2 computes water-surface profiles using the standard step method for backwater computations.

Starting WSELs for the upper portion of the Christina River and South Branch Naaman Creek was chosen based on normal depth. Starting WSELs for the West Branch Christina River, the East Branch Christina River, Silver Brook, and Yorkshire Ditch were calculated based on coincident peak discharges at their confluence with the Christina River.

Since the date of the hydraulic analysis, Whitten Road (Walther Road) bridge, which crosses the Christina River, has been replaced. The new structure is located approximately 200 feet upstream of the old structure. The hydraulic

analysis for the Christina River for this countywide FIS does not reflect the bridge replacement.

Starting WSELs for Persimmon Run and Tributary to West Branch Christina River were calculated based on coincident peak discharges at their confluences with West Branch Christina River.

For the August 3, 1998, FIS, WSELs of the selected recurrence intervals for the Christina River and the West Branch Christina River were computed using the USACE HEC-2 standard step-backwater computer program (Reference 39). Starting WSELs for all recurrence intervals were determined by the slope-area method.

For the October 6, 2000, revision, WSELs of the selected recurrence Intervals for the Unnamed Tributary to Mill Creek were computed using the USACE HEC-2 standard step-backwater computer program (Reference 39).

The cross sections for the hydraulic analysis for the Christina River were obtained from the Digital Terrain Model developed for this study (References 42 and 43). For the West Branch Christina River the cross sections were obtained from the Upper Christina River Floodplain Management Study (Reference 44).

Roughness factors (Manning's "n") used in the hydraulic computations for the upper portion of the Christina River, the East Branch Christina River, the West Branch Christina River, Persimmon Run, Silver Brook, Tributary to West Branch Christina River, and Yorkshire Ditch were chosen by engineering judgment and were based on field inspections and aerial photographs (Reference 45).

Hydraulic analyses for Belltown Run and Muddy Run were obtained from the original FIS for the unincorporated areas of New Castle County (Reference 15). No "n" values were available for those streams.

This Revision

Riverine Analysis Performed by URS

For this revision hydraulic analyses performed by URS for streams studied by limited detailed methods, including the Appoquinimink River, Deep Creek, Drawyer Creek, Drawyer Creek Tributary No. 1, Hangmans Creek, and Tributary of Drawyer Creek, were conducted using HEC-RAS 3.1.3 (Reference 85) for steady-state modeling. These models were developed using the Watershed Information System (WISE) software (Reference 86).

Field survey data were collected by URS for the limited detail streams that were part of this study in November 2006. The field survey includes obtaining the physical dimensions of hydraulic and flood control structures. Limited detail study surveys consist of limited detailed field measurements, including invert elevations at structures, top of road elevations, and structure dimensions.

Starting conditions for the hydraulic models were set to normal depth using starting slopes calculated from cross sections, derived from the LiDAR or contour

data or, where applicable, derived from the water surface elevations of existing effective flood elevations.

Riverine Analysis Performed by Duffield

Water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-RAS v4.1 computer program (Reference 92). Starting water surface elevations for were determined using the slope/normal depth method for the Tributary to Belltown Run, Tributary to Belltown Run Tributary I, Mill Creek, Red Clay Creek and White Clay Creek. The downstream starting water surface elevation for Belltown Run was calculated for each of the profiles using the rectangular weir equation to calculate head over the dam for each of the frequency storms analyzed. Data regarding the dam was obtained from the Delaware Dam Safety program dam inventory.

Roughness coefficients (Manning's "n") used in the hydraulic computations were chosen based on field inspection. Table 6, "Manning's "n" Values," provides a listing of roughness coefficients used in the models.

TABLE 6 – MANNING'S "n" VALUES

Stream	Channel "n"	Overbank "n"
Detail Study Streams		
Brandywine Creek (Lower Reach)	0.040-0.045	0.065-0.085
Brandywine Creek (Upper Reach)	0.040-0.045	0.065-0.085
Chestnut Run	0.030-0.070	0.030-0.070
Christina River	0.020-0.045	0.050-0.100
Derrickson Run	0.015-0.050	0.035-0.100
East Branch Christina River	0.045	0.090
Little Mill Creek	0.012-0.065	0.020-0.090
Mill Creek	0.040	0.030-0.100
Naaman Creek	0.040-0.045	0.085-0.100
Persimmon Run	0.021-0.045	0.090
Pike Creek	0.030-0.035	0.035-0.100
Red Clay Creek	0.030-0.035	0.040-0.100
Shellpot Creek	0.011-0.045	0.030-0.125
Silver Brook	0.012-0.045	0.090
Silverbrook Run	0.035-0.060	0.040-0.100
South Branch Naaman Creek	0.0161-0.060	0.085-0.120
Tributary to West Branch Christiana River	0.045	0.090
Tributary to White Clay Creek	0.035	0.085
Unnamed Tributary to Mill Creek	0.030-0.040	0.013-0.080
West Branch Christina River	0.013-0.035	0.035-1.000

TABLE 6 – MANNING'S "n" VALUES-continued

Stream	Channel "n"	Overbank "n"
Detail Study Streams		
West Branch of Derrickson Run	*	*
White Clay Creek	0.035-0.040	0.035-0.060
Yorkshire Ditch	0.032-0.045	0.080-0.100
Appoquinimink River	0.040-0.055	0.100-0.150
Belltown Run	0.030-0.045	0.030-0.070
Deep Creek	0.040-0.055	0.100-0.150
Drawyer Creek Tributary No. 1	0.040-0.055	0.100-0.150
Hangmans Run	0.040-0.055	0.100-0.150
Tributary of Drawyer Creek	0.040-0.055	0.100-0.150
Tributary to Belltown Run	0.030-0.045	0.030-0.070
Tributary to Belltown Run Tributary 1	0.030-0.045	0.030-0.070

*Data not available

For FIRM panels dated July 16, 2004, or later, qualifying bench marks within a given jurisdiction that are cataloged by the National Geodetic Survey (NGS) and entered into the National Spatial Reference System (NSRS) as First or Second Order Vertical and have a vertical stability classification of A, B, or C are shown and labeled on the FIRM with their 6-character NSRS Permanent Identifier.

Bench marks cataloged by the NGS and entered into the NSRS vary widely in vertical stability classification. NSRS vertical stability classifications are as follows:

- Stability A: Monuments of the most reliable nature, expected to hold position/elevation well (e.g., mounted in bedrock)
- Stability B: Monuments which generally hold their position/elevation well (e.g., concrete bridge abutment)
- Stability C: Monuments which may be affected by surface ground movements (e.g., concrete monument below the frost line)
- Stability D: Mark of questionable or unknown vertical stability (e.g., concrete monument above frost line, or steel witness post)

In addition to NSRS bench marks, the FIRM may also show vertical control monuments established by a local jurisdiction; these monuments will be shown on the FIRM with the appropriate designations. Local monuments will only be placed on the FIRM if the community has requested that they be included, and if the monuments meet the aforementioned NSRS inclusion criteria.

To obtain elevation, description, and /or location information for bench marks shown on the FIRM for this jurisdiction, please contact the Information Services

Branch of the NGS at (301) 713-3242, or visit their Web site at www.ngs.noaa.gov.

It is important to note that temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with this FIS and FIRM. Interested individuals may contact FEMA to access this data.

3.3 Coastal Analyses

Pre-countywide Analyses

Tidal elevation-frequency relationships for the Delaware River were prepared by the USACE (References 16 and 17). Elevation versus frequency curves were developed at five gage locations along the Delaware River between Lewes, Delaware and Trenton, New Jersey. These curves were based on a graphical frequency analysis of the adjusted annual peak stages using Weibul plotting positions with high outlier adjustments. The analysis followed procedures outlined in Water Resources Council Bulletin No. 17 A (Reference 18). Elevation versus frequency relationships required for locations between the analyzed gage based on trends show by profile plots of the observed peak stages of historic flood events.

Analysis of wave action (waves caused by wind acting on the water surface) was based on methods and statistics provided by the USACE. Wave heights were computed using forecasting curves for shallow-water waves (Reference 19). Wind velocity from a critical direction was determined from data provided by the USACE (Reference 1).

The Stillwater elevations have been determined for the 10-, 2-, 1-, and 0.2-percent annual chance floods for the flooding sources studied by detailed methods and are summarized in Table 7, "Summary of Stillwater Elevations."

TABLE 7 - SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet NAVD)			
	10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
DELAWARE RIVER				
At the confluence of the Christina River (City of Wilmington)	6.3	8.0	8.8	10.7
At the Town of Newport	6.3	8.0	8.8	10.7
At the City of New Castle	6.2	7.9	8.7	10.6
At Reedy Island	6.1	7.8	8.7	10.6
At the confluence of Smyrna River (downstream of county boundary)	6.0	7.8	8.7	10.5

TABLE 7 - SUMMARY OF STILLWATER ELEVATIONS-continued

FLOODING SOURCE AND LOCATION	ELEVATION (feet NAVD) 10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
SHALLCROSS LAKE				
Along shoreline	*	*	12.4	*
At the confluence of Shallcross Lake	*	*	13.3	*

*Data not available

This Revision

Coastal analysis, considering storm characteristics and the shoreline and bathymetric characteristics of the flooding sources studied, were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along the shoreline. Users of the FIRM should be aware that coastal flood elevations are provided in Table 8, "Summary of Coastal Stillwater Elevations" table in this report. If the elevation on the FIRM is higher than the elevation shown in this table, a wave height, wave runup, and/or wave setup component likely exists, in which case, the higher elevation should be used for construction and/or floodplain management purposes.

Delaware River forms the eastern county boundary and is the primary flooding source in New Castle County. The Delaware River eventually discharge flows into Delaware Bay further downstream of New Castle County. Coastal flooding along the Delaware River impacts the cities of Delaware City, Wilmington, New Castle and portions of the unincorporated areas of New Castle County. These urban areas are located in the northern half of the county and north of Chesapeake and Delaware Canal. Areas south of the Chesapeake and Delaware Canal are primarily suburban and rural and there are large areas of swamp and marshland. The south coastline is comprised of both marshland and a small dune whose elevation varies from two feet to more than seven feet North American Vertical Datum of 1988 (NAVD 88).

An analysis was performed to establish the frequency peak elevation relationships for coastal flooding in New Castle County. The FEMA, Region III office, initiated a study in 2008 to update the coastal storm surge elevations within the states of Virginia, Maryland, and Delaware, and the District of Columbia including the Atlantic Ocean, Chesapeake Bay including its tributaries, and the Delaware Bay. The study replaces outdated coastal storm surge stillwater elevations for all FIS Reports in the study area, including New Castle County, DE, and serves as the basis for updated FIRMs. Study efforts were initiated in 2008 and concluded in 2012.

The storm surge study was conducted for FEMA by the USACE and its project partners under Project HSFE03-06-X-0023, "NFIP Coastal Storm Surge Model

for Region III" and Project HSFE03-09-X-1108, "Phase II Coastal Storm Surge Model for FEMA Region III". The work was performed by the Coastal Processes Branch (HF-C) of the Flood and Storm Protection Division (HF), U.S. Army Engineer Research and Development Center – Coastal & Hydraulics Laboratory (ERDC-CHL).

The end-to-end storm surge modeling system includes the Advanced Circulation Model for Oceanic, Coastal and Estuarine Waters (ADCIRC) for simulation of 2-dimensional hydrodynamics. ADCIRC was dynamically coupled to the unstructured numerical wave model Simulating Waves Nearshore (unSWAN) to calculate the contribution of waves to total storm surge (Reference 87). The resulting model system is typically referred to as SWAN+ADCIRC (Reference 87). A seamless modeling grid was developed to support the storm surge modeling efforts. The modeling system validation consisted of a comprehensive tidal calibration followed by a validation using carefully reconstructed wind and pressure fields from three major flood events for the Region III domain: Hurricane Isabel, Hurricane Ernesto, and extratropical storm Ida. Model skill was accessed by quantitative comparison of model output to wind, wave, water level and high water mark observations.

The tidal surge in Delaware Bay affects the entire 37 miles of New Castle County coastline, and that entire length was modeled for overland wave propagation. The fetch length across the Delaware River ranges from approximately 4.8 miles at the south end of the county to approximately 1.2 miles at the north end. These fetch lengths are long enough to accommodate significant wave generation during the 1% annual chance flood.

The storm-surge elevations for the 10-, 2-, 1-, and .2- percent annual chance floods were determined for Delaware Bay and are shown in Table 8, "Summary of Coastal Stillwater Elevations." The analyses reported herein reflect the stillwater elevations due to tidal and wind setup effects.

TABLE 8 - SUMMARY OF COASTAL STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet NAVD)			
	10-percent chance	2-percent chance	1-percent chance	0.2-percent chance
DELAWARE RIVER				
From south county limit to Chesapeake and Delaware canal	6.9-7.4	7.9-8.4	8.4- 8.8	10.6 -11.1
At Chesapeake and Delaware canal	6.9	7.9	8.4	10.6
From Chesapeake and Delaware canal to north county limit	6.8-7.1	7.6-7.9	8.3- 8.5	10.6 -11.0

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in a report prepared by the National Academy of Sciences (Reference 88). This method is based on three major concepts. First, depth-limited waves in shallow water reach maximum breaking

height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions, such as sand dunes, dikes and seawalls, buildings and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures prescribed in NAS Report. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

The coastal analysis involved transect layout, field reconnaissance, erosion analysis, and overland wave modeling including wave setup, wave height analysis and wave runup.

Wave heights were computed across transects that were located along coastal areas of New Castle County, as illustrated on the FIRMs. The transects were located with consideration given to existing transect locations and to the physical and cultural characteristics of the land so that they would closely represent conditions in the locality.

Each transect was taken perpendicular to the shoreline and extended inland to a point where coastal flooding ceased. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. The stillwater elevations for a 1% annual chance event were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the Zone VE (area with velocity wave action) was computed at each transect. Along the open coast, the Zone VE designation applies to all areas seaward of the landward toe of the primary frontal dune system. The primary frontal due is defined as the point where the ground profile changes from relatively steep to relatively mild.

Dune erosion was taken into account along the Delaware Bay coastline. A review of the geology and shoreline type in New Castle County was made to determine the applicability of standard erosion methods, and FEMA's standard erosion methodology for coastal areas having primary frontal dunes, referred to as the "540 rule," was used (Reference 89). This methodology first evaluates the dune's cross-sectional profile to determine whether the dune has a reservoir of material that is greater or less than 540 square feet. If the reservoir is greater than 540 square feet, the "retreat" erosion method is employed and approximately 540 square feet of the dune is eroded using a standardized eroded profile, as specified in FEMA guidelines. If the reservoir is less than 540 square feet, the "remove" erosion method is employed where the dune is removed for subsequent analysis, again using a standard eroded profile. The storm surge study provided the return period stillwater elevations required for erosion analyses. Each cross-shore transect was analyzed for erosion, when applicable.

Wave height calculations used in this study flood the methodologies described in the FEMA guidance for coastal mapping (Reference 88). Wave setup results in an increased water level at the shoreline due to the breaking of waves and transfer of momentum to the water column during hurricanes and severe storms. For the New Castle County study, wave setup was determined directly from the coupled wave and storm surge model. The total stillwater elevation (SWEL) with wave setup was then used for simulations of inland wave propagation conducted using FEMA's Wave Height Analysis for Flood Insurance Studies (WHAFIS) model Version 4.0 (Reference 90). WHAFIS is a one-dimensional model that was applied to each transect in the study area. The model uses the specified SWEL, the computed wave setup, and the starting wave conditions as input. Simulations of wave transformations were then conducted with WHAFIS taking into account the storm-induced erosion and overland features of each transect. Output from the model includes the combined SWEL and wave height along each cross-shore transect allowing for the establishment of base flood elevations (BFEs) and flood zones from the shoreline to points inland within the study area.

Wave runup is defined as the maximum vertical extent of wave uprush on a beach or structure. FEMA's 2007 Guidelines and Specifications require the 2% wave runup level be computed for the coastal feature being evaluated (cliff, coastal bluff, dune, or structure) (Reference 90). The 2% runup level is the highest 2 percent of wave runup affecting the shoreline during the 1-percent-annual-chance flood event. Each transects defined within the Region III study area was evaluated for the applicability of wave runup, and if necessary, the appropriate runup methodology was selected and applied to each transect. Runup elevations were then compared to WHAFIS results to determine the dominant process affecting BFEs and associated flood hazard levels. Based on wave runup rates, wave overtopping was computed following the FEMA 2007 Guidelines and Specifications.

Computed controlling wave heights at the shoreline range from 4.60 feet at the northern end of the county where the fetch is short to 6.22 feet at the southern end where the fetch is longer. The corresponding wave elevation at the shoreline varies from 11.5 feet NAVD 88 at the northern end to 13.1 feet NAVD 88 at the southern end. Any dunes present along the coast serve to reduce wave height transmitted inland, but the large areas of low-lying marshes which are inundated by the tidal surge allow regeneration of the waves as they proceed inland. In general, the relatively shallow depth of water in the marshes along with the energy dissipating effects of vegetation allows only minor regeneration of the waves.

Figure 1, "Transect Location Map," illustrates the location of each transect. Along each transect, wave envelopes were computed considering the combined effects of changes in ground elevation, vegetation and physical features. Between transects, elevations were interpolated using topographic maps, land-use and land-cover data, and engineering judgment to determine the aerial extent of flooding. The results of the calculations are accurate until local topography, vegetation, or cultural development within the community undergoes major

changes. In Table 9, "Transect Data," the flood hazard zone and base flood elevations for each transect flooding source is provided, along with the 10-, 2-, 1-, and 0.2-percent annual chance stillwater elevations for the respective flooding source.

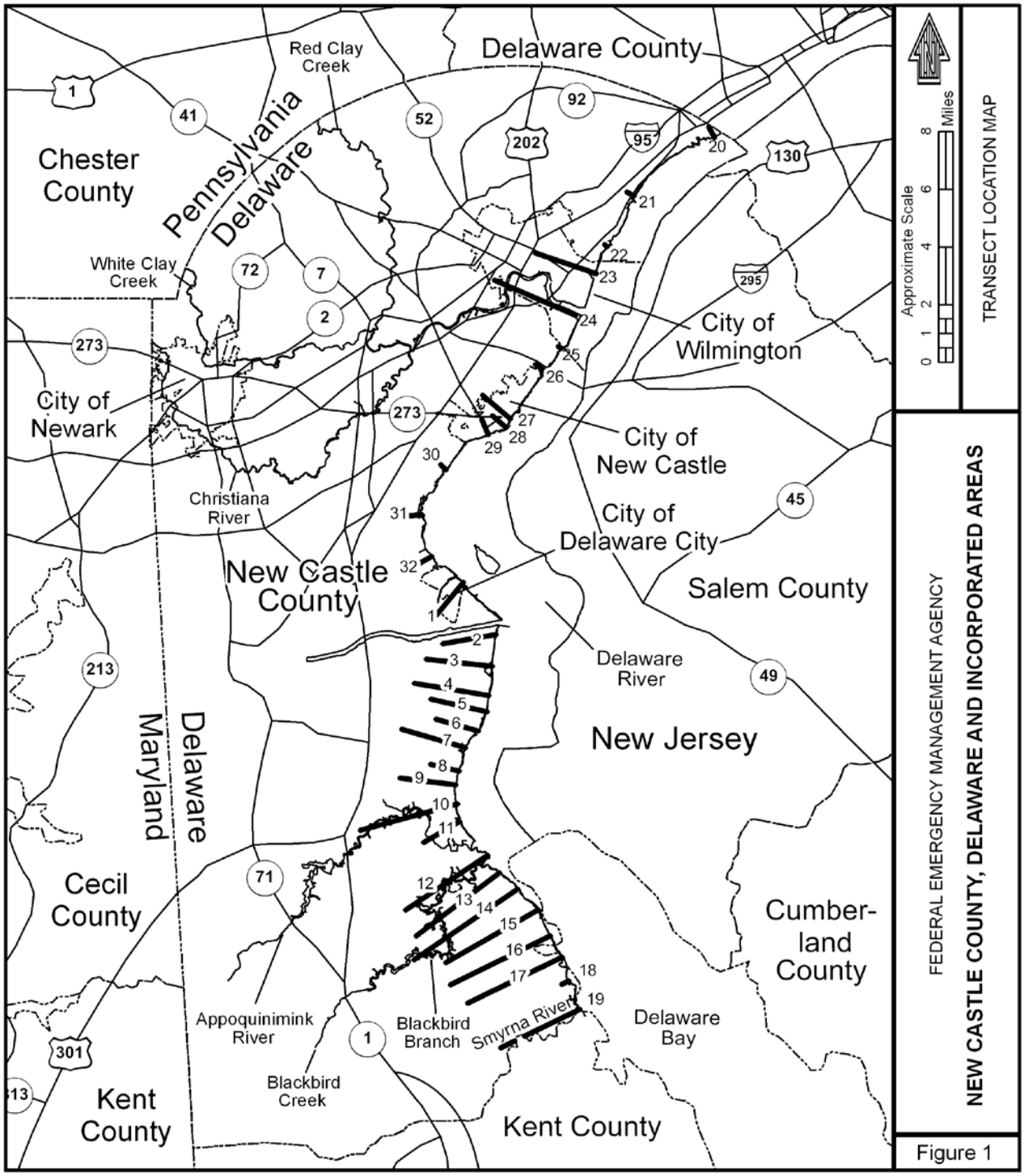

TABLE 9 - TRANSECT DATA

Flood Source	Transect	Coordinates	Starting Wave Conditions for the 1% Annual Chance: Significant Wave Height H_s (ft)	Starting Wave Conditions for the 1% Annual Chance: Peak Wave Period T_p (sec)	Starting Stillwater Elevations (ft NAVD88) Range of Stillwater Elevations (ft NAVD88): 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Delaware River	1	N 39.580992 W 75.587804	4.0	4.3	7.0	8.0	8.5	10.7 10.6 - 10.7
Delaware River	2	N 39.554698 W 75.566865	4.3	3.8	6.9 6.4 - 7.0	8.0 7.2 - 8.0	8.5 7.7 - 8.5	10.6 9.8 - 10.6
Delaware River	3	N 39.538777 W 75.569283	4.3	4.0	7.0 6.6 – 7.0	8.0 7.6 – 8.0	8.5 8.1 - 8.5	10.6 10.1 - 10.6
Delaware River	4	N 39.524128 W 75.571232	4.4	4.0	7.0 6.7 - 7.1	8.0 7.7 - 8.1	8.5 8.2 - 8.6	10.6 10.1 - 10.7
Delaware River	5	N 39.516056 W 75.572416	4.4	4.4	7 6.8 - 7.1	8.1 7.8 - 8.1	8.6 8.2 - 8.6	10.6 10.1 - 11.3
Delaware River	6	N 39.506380 W 75.578332	4.7	4.2	7.1 7.1 - 7.2	8.1 8.1 - 8.2	8.6 8.6 - 8.7	10.7 10.7 - 11.4
Delaware River	7	N 39.497933 W 75.586310	5.1	4.4	7.1 7.1 - 7.2	8.1 8.1 - 8.2	8.6 8.6 - 8.7	10.9 10.9 - 11.2
Delaware River	8	N 39.486107 W 75.590438	5.1	4.5	7.2 7.2 - 7.3	8.2 8.2 - 8.3	8.7 8.6 - 8.7	10.9 10.9 - 11.1
Delaware River	9	N 39.479182 W 75.592509	5.3	4.6	7.2 7.2 - 7.3	8.2 8.2 - 8.3	8.7 8.7 - 8.8	10.9 10.9 - 11.1
Delaware River	10	N 39.469671 W 75.591283	5.2	4.6	7.2 6.2 - 7.3	8.2 7.2 - 8.3	8.7 7.6 - 8.8	10.9 10.1 - 11.1
Delaware River	11	N 39.460855 W 75.589899	5.2	4.7	7.2 6.8 - 7.3	8.2 7.8 - 8.3	8.7 8.1 - 8.8	10.8 10.4 - 10.9
Delaware River	12	N 39.443903 W 75.572152	5.1	4.6	7.1 6.1 - 7.2	8.2 7.2 - 8.2	8.7 7.7 - 8.7	10.7 10.0 - 10.8

TABLE 9 - TRANSECT DATA – continued

Flood Source	Transect	Coordinates	Starting Wave Conditions for the 1% Annual Chance: Significant Wave Height H_s (ft)	Peak Wave Period T_p (sec)	Starting Stillwater Elevations (ft NAVD88) Range of Stillwater Elevations (ft NAVD88): 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Delaware River	13	N 39.434987	5.1	4.7	7.1	8.2	8.7	10.7
		W 75.564512			6.1 - 7.2	7.2 - 8.2	7.6 - 8.7	9.9 - 10.7
Delaware River	14	N 39.426879	5.6	4.7	7.1	8.2	8.7	10.7
		W 75.552925			6.1 - 7.2	7.3 - 8.2	7.7 - 8.7	9.8 - 10.7
Delaware River	15	N 39.416362	5.7	4.7	7.1	8.2	8.7	10.7
		W 75.539891			6.1 - 7.2	7.3 - 8.3	7.7 - 8.7	9.9 - 10.9
Delaware River	16	N 39.403326	5.9	4.8	7.1	8.2	8.7	10.8
		W 75.532049			5.8 - 7.3	6.7 - 8.2	7.1 - 8.7	9.6 - 10.8
Delaware River	17	N 39.392773	6.2	5.0	7.2	8.2	8.7	10.8
		W 75.524412			5.8 - 7.3	6.7 - 8.3	7.1 - 8.7	9.6 - 10.8
Delaware River	18	N 39.380727	6.7	5.3	7.2	8.3	8.7	10.8
		W 75.520028			5.8 - 7.3	6.7 - 8.3	7.1 - 8.8	9.6 - 10.9
Delaware River	19	N 39.366493	6.5	5.3	7.2	8.3	8.8	10.9
		W 75.513115			5.6 - 7.4	6.6 - 8.3	7 - 8.8	9.4 - 11
Delaware River	20	N 39.804845	2.9	3.3	6.9	7.6	8.3	10.9
		W 75.427228						
Delaware River	21	N 39.775306	3.0	3.2	6.9	7.6	8.3	10.9
		W 75.478750						
Delaware River	22	N 39.749992	3.3	3.5	6.9	7.7	8.3	10.9
		W 75.495983				7.6-7.7		
Delaware River	23	N 39.736490	3.3	3.4	6.9	7.7	8.3	10.8
		W 75.503526			6.5 - 6.9	7.3 - 7.7	7.9 - 8.3	10.8 - 11

TABLE 9 - TRANSECT DATA – continued

Flood Source	Transect	Coordinates	Starting Wave Conditions for the 1% Annual Chance: Significant Wave Height H_s (ft)	Starting Wave Conditions for the 1% Annual Chance: Peak Wave Period T_p (sec)	Starting Stillwater Elevations (ft NAVD88) Range of Stillwater Elevations (ft NAVD88): 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Delaware River	24	N 39.715191	3.1	3.4	6.9	7.8	8.3	10.8
		W 75.516077			6.4 - 6.9	7.3 - 7.8	7.9 - 8.3	10.5 - 10.9
Delaware River	25	N 39.698598	3.2	3.5	6.8	7.8	8.3	10.7
		W 75.525220			6.8 - 6.9	7.3 – 7.8		
Delaware River	26	N 39.687027	3.3	3.4	6.8	7.8	8.3	10.8
		W 75.535475			6.8 - 6.9			10.8 - 10.9
Delaware River	27	N 39.663308	3.6	3.4	6.9	7.8	8.3	10.8
		W 75.557948			6.8 - 6.9			
Delaware River	28	N 39.658937	3.6	3.4	6.9	7.8	8.3	10.7
		W 75.560622			6.8 - 6.9		8.3 - 8.4	10.7 - 10.8
Delaware River	29	N 39.655384	4.0	3.6	6.9	7.9	8.4	10.9
		W 75.571925				7.8 – 7.9		
Delaware River	30	N 39.637705	4.9	4.1	6.9	7.9	8.4	10.9
		W 75.599073			6.9 - 7	7.9 - 8.0	8.4 - 8.5	10.9 - 11.1
Delaware River	31	N 39.614655	4.4	4.2	7.0	8.0	8.5	10.8
		W 75.614163			7 - 7.1	7.9 - 8.0		10.8 - 10.9
Delaware River	32	N 39.594045	4.2	3.9	7.0	8.0	8.4	10.7
		W 75.608355						

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The USACE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (Reference 91). The 3-foot wave has been determined to be the minimum size wave capable of causing major damage to conventional wood frame of brick veneer structures. The one exception to the 3-foot wave criteria is where a primary frontal dune exists. The limit the coastal high hazard area then becomes the landward toe of the primary frontal dune or where a 3-foot or greater breaking wave exists, whichever is most landward. The coastal high hazard zone is depicted on the FIRMs as Zone VE, where the delineated flood hazard includes wave heights equal to or greater than three feet. Zone AE is depicted on the FIRMs where the delineated flood hazard includes wave heights less than three feet. A depiction of how the Zones VE and AE are mapped is shown in Figure 2.

Post-storm field visits and laboratory tests have confirmed that wave heights as small as 1.5 feet can cause significant damage to structures when constructed without consideration to the coastal hazards. Additional flood hazards associated with coastal waves include floating debris, high velocity flow, erosion, and scour which can cause damage to Zone AE-type construction in these coastal areas. To help community officials and property owners recognize this increased potential for damage due to wave action in the AE zone, FEMA issued guidance in December 2008 on identifying and mapping the 1.5-foot wave height line, referred to as the Limit of Moderate Wave Action (LiMWA). While FEMA does not impose floodplain management requirements based on the LiMWA, the LiMWA is provided to help communicate the higher risk that exists in that area. Consequently, it is important to be aware of the area between this inland limit and the Zone VE boundary as it still poses a high risk, though not as high of a risk as Zone VE (see Figure 2, "Transect Schematic").

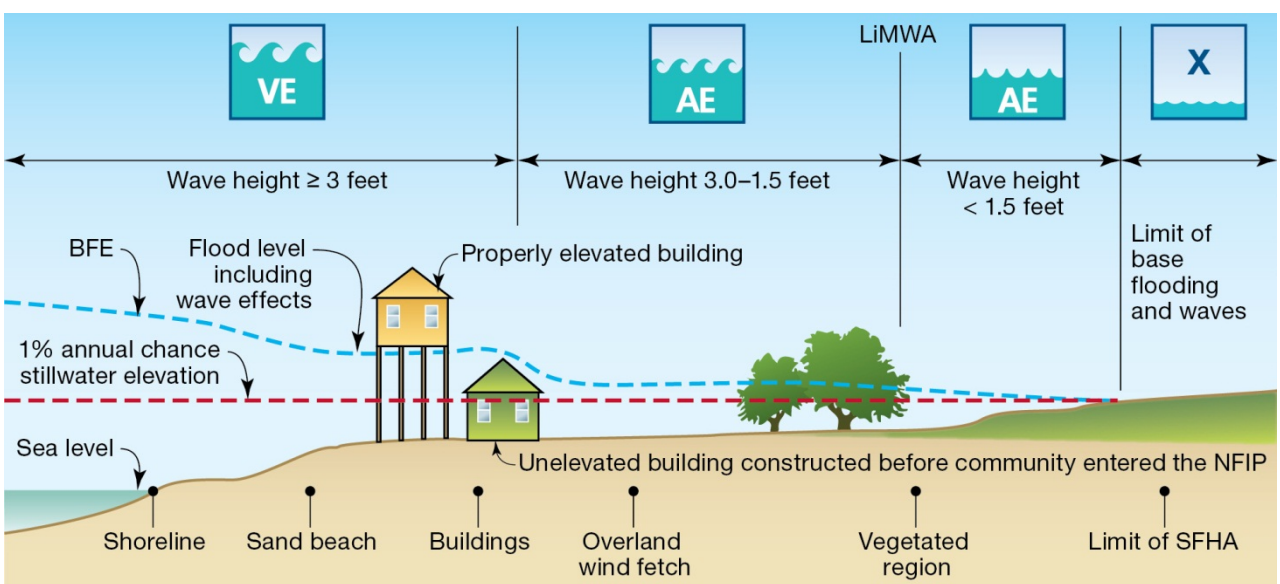

FIGURE 2: TRANSECT SCHEMATIC

3.4 Vertical Datum

All FISs and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FISs and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD 29). With the finalization of the North American Vertical Datum of 1988 (NAVD 88), many FIS reports and FIRMs are being prepared using NAVD 88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD 88. Structure and ground elevations in the county must, therefore, be referenced to NAVD 88. It is important to note that adjacent counties may be referenced to NGVD 29. This may result in differences in BFEs across the county boundaries between the counties.

For information regarding conversion between the NGVD 29 and NAVD 88, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3242

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 1-percent annual chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations; delineations of the 1- and 0.2-percent annual chance floodplains; and 1-percent annual chance floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, and Floodway Data Tables and Summary of Stillwater Elevations Table. Users should reference the data presented in the FIS as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance flood is employed to indicate additional areas of flood risk in the community. For the streams studied in detail, the 1-percent and 0.2-percent annual chance floodplains have been delineated using the flood elevations determined at each cross section.

Countywide Analyses

Between cross sections, the boundaries were interpolated using topographic maps and according to the WSEL (References 37, 46, 47, 48, 49, 50, 51, and 52).

For Delaware City, boundaries were interpolated between cross sections using topographic maps supplemented by topographic contour data furnished by New Castle County (References 47 and 53).

For the City of New Castle and the unincorporated areas of New Castle County, boundaries were interpolated between cross sections using topographic maps supplemented with field surveys and with topographic contour data (References 46, 47, and 53).

For the Town of Newport, boundaries were interpolated between cross sections using topographic maps and aerial photographs (References 37, 39, and 40).

For the City of Newark, the boundaries were interpolated between cross sections using topographic maps and aerial photographs (References 46, 54, and 55).

For the flooding sources studied by approximate methods, the boundaries of the

1-percent-annual-chance floodplain were delineated using the previously printed FIS reports for the unincorporated areas of New Castle County; the Cities of Delaware City, Newark, New Castle, Wilmington; and the Towns of Elsmere and Newport (References 56, 57, 58, 59, 13, 20, and 60).

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2).

This Revision

For this revision, flood boundaries for the Appoquinimink River, Deep Creek, Drawyer Creek, Drawyer Creek Tributary No. 1, Hangmans Creek, and Tributary of Drawyer Creek were interpolated using the WISE computer software (Reference 86).

New floodplain boundaries were also developed and mapped for Belltown Run, Tributary to Belltown Run, Tributary to Belltown Run Tributary I, Mill Creek, Red Clay Creek and White Clay Creek.

HEC-GeoRAS version 4.3.93 (Reference 95) was used to generate draft floodplain boundaries from the HEC-RAS models for Mill Creek, Belltown Run and its Tributaries. The generated floodplain boundaries were then manually revised by an engineer in areas where additional information indicated changes were appropriate.

The floodplain boundaries for Red Clay Creek and White Clay Creek were created by manually depicting the boundaries based on the HEC-RAS model profiles for each creek.

The sources of topography used for delineating the flood zones varied for each of the streams. New Castle County 2-foot contour topographic data developed from LiDAR data collected in 2007 was used to delineate flood zones for the Appoquinimink River, Deep Creek, Drawyer Creek, Drawyer Creek Tributary No. 1, Hangmans Creek, and Tributary of Drawyer Creek (Reference 96).

LiDAR (Reference 97) was also the primary source of topography for Mill Creek, and was supplemented with field-surveyed cross sections. A total of 24 stream cross-sections were surveyed. Additionally, a stream section immediately upstream or downstream of each of the 27 structures was surveyed.

Aerial survey was the primary source of topography for Red Clay Creek. This was supplemented with a field-survey of 121 bathymetric cross sections.

Aerial survey was the primary source of topography for White Clay Creek. LiDAR topographic data, acquired from the State of Delaware, was used as a supplemental topography as needed. Additionally, 131 bathymetric cross sections were developed from soundings collected along cross-stream transects of White Clay Creek.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM. On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations, but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent annual chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent annual chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as a minimum standard that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections in Table 10, "Floodway Data." The computed floodways are shown on the FIRM (Exhibit 2). In cases where the floodway and 1-percent annual chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

No floodways have been computed for Appoquinimink River Tributary 1, Appoquinimink River Tributary 2, Becks Pond, Belltown Run, the East Branch Christina River, Muddy Run, Persimmon Run, Silver Brook, Sunset Lake, Tributary to West Branch Christina River, Unnamed Tributary to Mill Creek, or Yorkshire Ditch.

No floodways have been computed for streams studied by limited detail methods.

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 10 for certain downstream cross sections of the Christina River, Mill Creek, Pike Creek, Red Clay Creek, South Branch Naaman Creek, Tributary to White Clay Creek, the West Branch Christina River, and White Clay Creek are lower than the regulatory flood elevations in that area, which must take into account the 1-percent-annual-chance flooding due to backwater from other sources.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage, and heightens potential flood hazards by further increasing velocities. A listing of stream velocities at selected cross sections is provided in Table 10, "Floodway Data." To reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

The area between the floodway and 1-percent annual chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent annual chance flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 3, "Floodway Schematic."

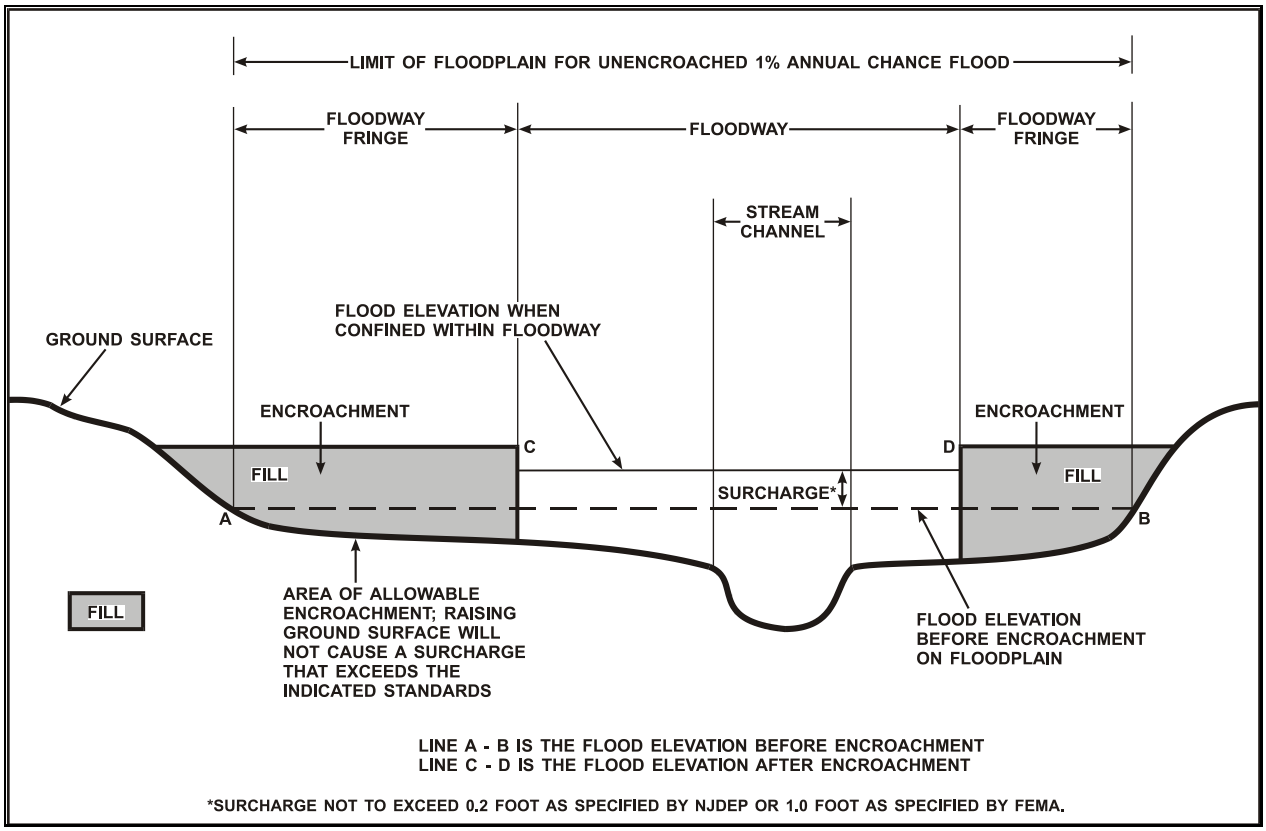

FIGURE 3: FLOODWAY SCHEMATIC

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Brandywine Creek (Lower Reach)								
A	1.62[1]	447	6,132	4.3	13.6	13.6	14.6	1.0
B	2.31[1]	168	2,689	9.7	15.5	15.5	16.5	1.0
C	2.94[1]	230	3,292	8.0	27.1	27.1	27.3	0.2
D	3.40[1]	142	2,122	12.3	38.3	38.3	39.3	1.0
Chestnut Run								
A	665[2]	190	661	3.0	76.8	76.8	77.6	0.8
B	1,865[2]	162	299	6.7	82.7	82.7	82.7	0.0
C	3,020[2]	121	548	3.6	89.4	89.4	90.4	1.0
D	4,550[2]	81	291	6.9	96.6	96.6	96.7	0.1
Christina River								
A	14,855[3]	616	6,636	4.0	8.8	8.3[4]	8.3	0.0
B	18,970[3]	345	3,999	6.7	9.6	9.6	9.6	0.0
C	33,490[3]	1,299	12,579	0.8	12.9	12.9	13.9	1.0
D	39,545[3]	1,275	11,743	0.9	13.3	13.3	14.2	0.9
E	43,300[3]	685	7,482	1.3	13.5	13.5	14.5	1.0
F	45,710[3]	825	9,460	1.0	13.8	13.8	14.7	0.9
G	48,870[3]	700	7,542	1.3	14.1	14.1	15.0	0.9
H	52,165[3]	775	9,248	1.0	14.5	14.5	15.4	0.9
I	56,750[3]	587	6,787	1.4	15.6	15.6	16.4	0.8
J	58,500[3]	753	9,130	1.0	15.7	15.7	16.4	0.7
K	61,700[3]	672	5,291	1.7	16.6	16.6	17.1	0.5
L	63,850[3]	868	5,714	1.6	17.0	17.0	17.5	0.5
M	66,990[3]	700	5,665	1.6	17.8	17.8	18.2	0.4
N	68,320[3]	390	2,397	3.7	18.1	18.1	18.4	0.3
O	71,390[3]	458	2,786	3.2	20.7	20.7	21.1	0.4

[1] Miles above confluence with Christina River
[2] Feet above confluence with Little Mill Creek
[3] Feet above the City of Wilmington corporate limits
[4] Elevation computed without consideration of backwater effects from Delaware River

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

BRANDYWINE CREEK (LOWER REACH) – CHESTNUT RUN – CHRISTINA RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Christina River - continued								
P	74,630	475	4,072	2.0	23.1	23.1	24.0	0.9
Q	76,280	450	3,930	2.1	23.9	23.9	24.7	0.8
R	80,720	663	4,449	1.4	25.4	25.4	26.3	0.9
S	81,800	542	3,344	1.9	26.4	26.4	27.2	0.8
T	87,800	650	3,222	1.7	29.8	29.8	30.6	0.8
U	91,725	668	2,763	1.9	33.2	33.2	34.2	1.0
V	94,360	98	695	7.6	38.1	38.1	38.6	0.5
W	96,470	434	3,262	1.6	42.1	42.1	42.8	0.7
X	97,460	336	1,807	2.9	42.2	42.2	43.2	1.0
Y	99,635	161	723	7.3	47.7	47.7	47.8	0.1
Z	102,280	136	1,052	5.0	63.4	63.4	63.4	0.0
AA	104,590	219	1,783	3.0	68.7	68.7	69.2	0.5
AB	106,235	145	486	10.9	73.7	73.7	73.7	0.0
AC	109,220	393	1,759	3.0	81.8	81.8	81.9	0.1
AD	110,740	370	1,574	3.4	84.5	84.5	84.7	0.2
AE	113,320	291	1,358	2.9	89.8	89.8	90.4	0.6
AF	115,740	417	2,467	1.6	96.0	96.0	96.4	0.4
AG	122,000	407	2,156	1.9	109.4	109.4	109.5	0.1
AH	123,165	343	1,236	3.2	109.9	109.9	110.8	0.9
AI	124,150	185	886	4.1	113.5	113.5	114.0	0.5
AJ	126,265	193	684	5.3	120.5	120.5	120.7	0.2
AK	128,500	130	768	4.7	128.8	128.8	129.8	1.0
AL	129,427	184	1,090	3.0	132.9	132.9	133.8	0.9
AM	130,899	164	715	4.3	137.9	137.9	138.7	0.8
AN	132,566	120	521	5.9	144.0	144.0	144.5	0.5

[1] Distance in feet above the City of Wilmington corporate limits

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

CHRISTINA RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Christina River - continued								
AO	133,731[1]	160	686	4.5	150.1	150.1	150.4	0.3
AP	135,527[1]	109	531	5.1	155.0	155.0	155.4	0.4
Derrickson Run								
A	920[2]	120	743	2.1	70.5	70.5	71.4	0.9
B	1,890[2]	89	442	3.5	75.5	75.5	76.1	0.6
C	2,490[2]	110	542	2.9	78.8	78.8	79.0	0.2
D	3,810[2]	78	136	5.1	94.5	94.5	94.5	0.0
Little Mill Creek								
A	2,090[3]	1,698	10,817	0.5	9.0	9.0	9.0	0.0
B	4,690[3]	260	1,301	4.5	10.9	10.9	11.5	0.6
C	6,690[3]	149	814	7.1	15.1	15.1	16.1	1.0
D	9,100[3]	180	615	9.4	26.2	26.2	26.2	0.0
E	10,530[3]	212	820	6.0	58.5	58.5	58.5	0.0
F	11,715[3]	264	1,507	3.3	63.1	63.1	63.1	0.0
G	14,475[3]	320	1,019	4.8	66.1	66.1	66.2	0.1
H	17,050[3]	742	5,395	0.9	74.2	74.2	75.2	1.0
I	18,300[3]	314	1,299	3.8	75.0	75.0	76.0	1.0
J	20,765[3]	264	753	5.8	83.6	83.6	83.6	0.0
K	21,690[3]	286	1,858	2.4	87.3	87.3	87.9	0.6
Matson Run								
A	0.34[4]	50	360	3.5	62.0	62.0	62.0	0.0

[1] Distance in feet above City of Wilmington corporate limits
[2] Distance in feet above confluence with Little Mill Creek
[3] Distance in feet above confluence with Christina River
[4] Miles above confluence with Shellpot Creek

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

CHRISTINA RIVER – DERRICKSON RUN – LITTLE MILL CREEK – MATSON RUN

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Mill Creek								
A	633	331	2,224	3.0	19.4	14.5[2]	14.6	0.1
B	1,363	422	4,106	1.6	19.4	19.2[2]	20.2	1.0
C	2,645	243	1,641	4.1	19.5	19.5	20.3	0.8
D	3,471	375	2,566	2.6	20.5	20.5	21.4	0.9
E	5,376	300	3,779	1.7	34.0	34.0	34.1	0.1
F	6,927	232	1,832	3.5	35.9	35.9	36.4	0.5
G	9,499	300	1,251	4.7	49.5	49.5	49.7	0.2
H	11,725	145	814	7.2	72.4	72.4	72.5	0.1
I	14,294	129	1,070	5.4	91.8	91.8	92.3	0.5
J	17,606	207	1,168	4.9	106.5	106.5	106.7	0.2
K	18,636	108	889	6.4	111.9	111.9	112.8	0.9
L	19,511	69	567	10.0	115.1	115.1	115.4	0.3
M	21,179	96	613	9.3	126.4	126.4	127.2	0.8
N	23,593	47	388	12.9	150.0	150.0	150.3	0.3
O	25,207	84	760	5.8	166.6	166.6	166.7	0.1
P	27,252	224	971	4.6	172.5	172.5	173.3	0.8
Q	28,820	248	1,234	3.6	178.7	178.7	179.4	0.7
R	29,882	120	767	5.8	183.2	183.2	184.0	0.8
S	31,094	96	593	6.3	190.3	190.3	190.8	0.5
T	33,199	264	1,052	3.6	198.4	198.4	199.3	0.9
U	34,314	75	432	7.9	204.0	204.0	204.7	0.7
V	35,964	152	712	4.0	215.5	215.5	216.4	0.9
W	37,604	225	1,609	1.5	225.5	225.5	226.2	0.7
X	38,729	60	377	6.5	226.9	226.9	227.5	0.6
Y	40,395	87	447	5.5	230.6	230.6	231.3	0.7
Z	41,690	391	1,248	1.7	233.3	233.3	234.0	0.7

[1] Distance in feet above confluence with White Clay Creek
[2] Elevation computed without consideration of backwater effects from White Clay Creek

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

MILL CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Mill Creek – continued								
AA	44,327[1]	45	201	43	243.9	243.9	244.9	1.0
AB	45,792[1]	53	185	47	251.1	251.1	251.4	0.3
AC	46,871[1]	68	226	35	257.2	257.2	258.1	0.9
AD	49,990[1]	23	109	73	290.8	290.8	291.1	0.3
AE	51,077[1]	45	170	47	303.1	303.1	304.0	0.9
Naaman Creek								
A	1,000[2]	457	1,725	4.5	11.1	11.1	11.7	0.6
B	2,950[2]	196	1,884	4.2	15.9	15.9	16.3	0.4
C	3,880[2]	82	536	14.6	27.9	27.9	27.9	0.0
D	5,175[2]	86	742	5.4	35.2	35.2	35.2	0.0
Pike Creek								
A	600[1]	190	599	5.0	32.9	29.8[3]	30.7	0.9
B	1,960[1]	140	519	5.8	36.8	36.8	37.4	0.6
C	2,290[1]	250	903	3.3	40.4	40.4	40.4	0.0
D	2,860[1]	170	469	6.4	42.1	42.1	42.1	0.0
E	4,210[1]	121	596	5.1	52.8	52.8	52.8	0.0
F	5,460[1]	140	450	6.7	58.3	58.3	58.3	0.0
G	6,760[1]	120	424	7.1	66.4	66.4	66.4	0.0
H	9,160[1]	105	377	7.7	84.3	84.3	84.3	0.0
I	10,370[1]	140	389	7.4	94.8	94.8	94.8	0.0
J	13,620[1]	140	401	7.2	115.6	115.6	115.6	0.0
K	15,100[1]	205	544	5.3	124.6	124.6	124.8	0.2
L	16,140[1]	139	341	7.3	130.8	130.8	130.8	0.0
M	17,220[1]	133	336	7.4	140.3	140.3	140.4	0.1

[1] Distance in feet above confluence with White Clay Creek
[2] Distance in feet above confluence with Delaware River
[3] Elevation computed without consideration of backwater effects from White Clay Creek

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

MILL CREEK – NAAMAN CREEK – PIKE CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Pike Creek – continued								
N	18,840	165	661	3.8	152.5	152.5	153.0	0.5
O	20,840	80	260	9.5	163.7	163.7	163.7	0.0
P	21,870	175	457	5.4	172.0	172.0	172.4	0.4
Red Clay Creek								
A	632	220	1,135	9.5	16.4	12.8[2]	13.2	0.4
B	1,436	330	2,937	3.7	17.0	17.0	17.3	0.3
C	5,006	260	1,645	6.6	23.0	23.0	23.5	0.5
D	7,056	330	2,806	3.9	25.0	25.0	25.6	0.6
E	8,912	197	1,411	7.6	27.3	27.3	28.2	0.9
F	10,247	252	1,731	6.2	39.2	39.2	39.9	0.7
G	11,039	269	2,078	5.2	43.8	43.8	44.6	0.8
H	12,219	148	1,077	9.9	44.8	44.8	45.7	0.9
I	12,787	104	1,161	9.2	48.6	48.6	49.4	0.8
J	13,883	185	1,609	6.7	54.1	54.1	54.6	0.5
K	15,393	169	1,744	6.0	60.7	60.7	60.8	0.1
L	16,271	253	3,498	3.0	64.5	64.5	65.4	0.9
M	17,605	141	1,171	8.9	67.4	67.4	67.9	0.5
N	19,524	161	1,714	6.1	75.8	75.8	76.5	0.7
O	19,915	171	2,658	3.9	82.1	82.1	82.6	0.5
P	22,113	145	1,291	8.1	84.7	84.7	85.2	0.5
Q	23,287	145	1,351	7.7	87.0	87.0	87.8	0.8
R	24,399	241	2,196	4.7	89.6	89.6	90.6	1.0
S	25,775	295	2,150	4.8	91.3	91.3	92.0	0.7
T	29,640	316	1,941	5.3	98.5	98.5	99.3	0.8
U	32,787	153	2,202	4.6	110.7	110.7	111.3	0.6

[1] Distance in feet above confluence with White Clay Creek
[2] Elevation computed without consideration of backwater effects from White Clay Creek

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

PIKE CREEK – RED CLAY CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Red Clay Creek - continued								
V	3,4480	340	3,255	3.1	111.3	111.3	112.2	0.9
W	36,080	196	1,771	5.8	114.6	114.6	115.3	0.7
X	38,530	380	2,986	3.4	117.7	117.7	118.7	1.0
Y	40,284	173	1,554	6.6	119.3	119.3	120.1	0.8
Z	42,099	111	1,326	7.7	125.7	125.7	126.4	0.7
AA	45,351	410	4,016	2.5	135.9	135.9	136.5	0.6
AB	47,692	124	1,220	7.7	139.3	139.3	140.2	0.9
AC	49,594	198	1,910	4.9	144.4	144.4	145.3	0.9
AD	51,907	332	3,405	2.8	150.1	150.1	150.9	0.8
AE	54,470	396	2,142	4.1	151.9	151.9	152.8	0.9
AF	56,512	200	1,291	6.7	159.4	159.4	160.4	1.0
AG	58,598	199	1,295	6.7	169.1	169.1	170.0	0.9
AH	60,884	441	2,347	3.7	176.8	176.8	177.4	0.6
AI	62,180	172	1,512	5.8	181.1	181.1	182.0	0.9
AJ	62,960	284	1,889	4.6	182.1	182.1	183.0	0.9
AK	64,596	228	2,010	4.3	188.3	188.3	188.8	0.5
AL	65,842	170	1,465	5.9	189.9	189.9	190.3	0.4

[1] Distance in feet above confluence with White Clay Creek

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

RED CLAY CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Shellpot Creek								
A	7,560	800	9,027	1.1	15.6	15.6	16.5	0.9
B	9,120	375	3,171	3.1	20.2	20.2	20.5	0.3
C	11,100	256	2,696	3.7	24.9	24.9	25.3	0.4
D	12,240	180	1,418	6.1	26.8	26.8	27.4	0.6
E	13,715	250	1,072	7.7	43.3	43.3	43.9	0.6
F	14,400	135	985	8.3	50.4	50.4	51.2	0.8
G	15,780	280	1,305	5.5	67.5	67.5	67.7	0.2
H	17,250	250	1,056	6.8	89.5	89.5	89.7	0.2
I	20,160	102	615	11.6	168.8	168.8	168.9	0.1
J	22,200	212	1,118	6.4	206.6	206.6	207.2	0.6
K	23,190	194	739	9.7	221.7	221.7	221.8	0.1
L	25,100	120	614	11.7	241.4	241.4	242.0	0.6
M	28,030	350	1,854	2.9	260.2	260.2	261.1	0.9
N	29,280	259	651	8.2	269.1	269.1	269.2	0.1
O	30,950	300	829	6.5	289.6	289.6	289.9	0.3
P	32,000	230	821	4.4	294.2	294.2	295.0	0.8
Q	34,890	120	515	7.1	319.1	319.1	319.4	0.3
R	36,280	154	764	4.8	328.3	328.3	328.7	0.4
S	37,760	455	1,727	2.1	342.3	342.3	343.0	0.7
T	39,700	240	925	3.9	367.1	367.1	367.8	0.7

[1] Distance in feet above confluence with Delaware River

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

SHELLPOT CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Silverbrook Run								
A	200[1]	95	310	6.8	44.8	44.8	44.8	0.0
B	1,000[1]	98	318	6.6	60.1	60.1	60.1	0.0
C	1,930[1]	38	254	7.9	85.5	85.5	85.5	0.0
D	3,500[1]	110	509	3.7	96.6	96.6	97.4	0.8
South Branch Naaman Creek								
A	80[2]	42	345	10.4	33.7	32.9[3]	32.9	0.0
B	1,200[2]	173	1,297	2.8	37.0	37.0	37.0	0.0
C	2,400[2]	56	255	12.1	51.1	51.1	51.1	0.0
D	3,500[2]	160	775	5.7	71.3	71.3	71.3	0.0
E	5,440[2]	83	652	5.0	77.8	77.8	78.3	0.5
F	6,200[2]	59	453	6.8	80.0	80.0	80.1	0.1
G	8,800[2]	50	246	12.6	82.8	82.8	82.8	0.0
H	9,720[2]	60	351	8.8	85.4	85.4	85.4	0.0
I	10,840[2]	100	437	7.1	92.6	92.6	92.9	0.3
J	12,680[2]	173	404	7.7	121.3	121.3	121.3	0.0
K	14,400[2]	78	263	10.5	160.1	160.1	160.6	0.5
L	17,760[2]	66	595	4.6	240.3	240.3	241.1	0.8
M	20,800[2]	96	479	5.8	284.2	284.2	284.2	0.0
N	23,800[2]	35	172	6.8	290.5	290.5	290.5	0.0
O	25,680[2]	163	288	4.1	299.5	299.5	299.9	0.4
P	27,240[2]	60	140	8.4	316.9	316.9	316.9	0.0
Q	28,840[2]	42	98	6.2	357.6	357.6	357.7	0.1

[1] Distance in feet above confluence with Little Mill Creek
[2] Distance in feet above confluence with Naaman Creek
[3] Elevations computed without consideration of backwater effects from Naaman Creek

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

SILVERBROOK RUN – SOUTH BRANCH NAAMAN CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Tributary to White Clay Creek								
A	3,655[1]	495	1,745	0.9	12.3	5.0[3]	5.7	0.7
B	5,870[1]	350	2,208	0.7	17.9	8.6[3]	9.4	0.8
C	7,060[1]	193	855	1.7	18.9	8.7[3]	9.6	0.9
D	7,965[1]	143	406	3.6	18.9	12.1[3]	12.5	0.4
West Branch Christina River								
A	635[2]	110	445	7.6	85.8	84.8[4]	85.3	0.5
B	760[2]	96	654	5.2	88.3	88.3	89.2	0.9
C	2,205[2]	210	1,115	3.0	90.7	90.7	91.7	1.0
D	3,745[2]	141	669	5.0	93.7	93.7	94.3	0.6
E	4,060[2]	164	676	5.0	94.6	94.6	95.0	0.4
F	4,540[2]	229	1,203	2.1	97.2	97.2	97.8	0.6
G	5,540[2]	118	712	3.2	98.0	98.0	98.6	0.6
H	5,880[2]	204	762	2.9	100.3	100.3	100.3	0.0
I	6,350[2]	435	1,675	1.3	102.6	102.6	102.6	0.0
J	7,150[2]	118	452	4.9	103.3	103.3	103.4	0.1
K	7,380[2]	169	820	2.7	105.1	105.1	105.1	0.0
L	8,106[2]	144	694	2.5	105.4	105.4	105.8	0.4

[1] Distance in feet above confluence with White Clay Creek
[2] Distance in feet above confluence with Christina River
[3] Elevations computed without consideration of backwater effects from White Clay Creek
[4] Elevations computed without consideration of backwater effects from Christina River

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

TRIBUTARY TO WHITE CLAY CREEK – WEST BRANCH CHRISTINA RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
White Clay Creek								
A	6,765	1,069	7,519	3.3	12.3	9.7[2]	10.6	0.9
B	13,959	2,433	22,430	1.1	16.4	16.4	17.4	1.0
C	18,012	781	7,186	2.7	20.8	20.8	21.7	0.9
D	25,077	715	3,335	5.1	24.0	24.0	25.0	1.0
E	26,825	635	5,364	3.2	28.5	28.5	29.1	0.6
F	29,495	603	6,055	2.8	33.0	33.0	33.7	0.7
G	31,715	338	3,162	5.0	34.1	34.1	34.8	0.7
H	34,375	310	3,192	5.0	38.3	38.3	39.1	0.8
I	36,034	348	3,600	4.4	39.8	39.8	40.7	0.9
J	37,810	680	4,925	3.2	41.4	41.4	42.2	0.8
K	39,221	712	6,855	2.3	45.3	45.3	46.2	0.9
L	40,810	385	3,823	4.2	46.5	46.5	47.5	1.0
M	42,475	332	2,825	5.6	47.8	47.8	48.7	0.9
N	45,029	187	1,687	9.4	52.5	52.5	53.3	0.8
O	47,484	180	1,704	7.9	59.4	59.4	59.4	0.0
P	52,114	180	2,150	5.9	67.7	67.7	68.6	0.9
Q	52,924	200	1,842	6.8	69.3	69.3	69.9	0.6
R	55,429	351	2,718	4.6	72.9	72.9	73.5	0.6
S	60,189	455	3,674	3.4	85.7	85.7	86.4	0.7
T	62,449	179	1,441	8.3	88.2	88.2	88.8	0.6
U	64,889	216	2,107	5.6	92.9	92.9	93.7	0.8
V	69,289	432	3,186	3.7	102.9	102.9	103.6	0.7
W	70,829	728	5,533	2.2	104.5	104.5	105.3	0.8
X	74,554	803	5,367	2.2	109.8	109.8	110.7	0.9
Y	76,184	641	2,862	4.2	112.0	112.0	113.0	1.0
Z	77,869	207	1,429	8.3	116.8	116.8	116.8	0.0

[1] Distance in feet above confluence with Christina River
[2] Elevation computed without consideration of backwater effects from Christina River

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

FLOODWAY DATA

WHITE CLAY CREEK

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS report by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base (1-percent-annual-chance) flood elevations BFEs or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS report by detailed methods. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to areas of 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone AR

Zone AR is the flood insurance risk zone that corresponds to an area of special flood hazard formerly protected from the base flood event by a flood-control system that was subsequently decertified. Zone AR indicates that the former flood-control system is being restored to provide protection from the 1-percent-annual-chance or greater flood event.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 1-percent-annual-chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No BFEs or depths are shown within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no BFEs are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile (sq. mi.), and areas protected from the base flood by levees. No BFEs or depths are shown within this zone.

Zone X (Future Base Flood)

Zone X (Future Base Flood) is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined based on future-conditions hydrology. No BFEs or base flood depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The current FIRM presents flooding information for the entire geographic area of New Castle County. Historical map dates up to and including the initial countywide FIS prepared for each community are presented in Table 11, “Community Map History.

7.0 OTHER STUDIES

Information pertaining to revised and unrevised flood hazards for each jurisdiction within New Castle County has been compiled into this FIS. Therefore, this FIS supersedes all previously printed FIS reports, and FIRMs for all of the incorporated and unincorporated jurisdictions within New Castle County.

Other studies prepared include the Metropolitan Christina River Basin Study and the Delaware River Basin Study (References 12 and 17). Technical data contained in several USACE Flood Plain Information reports are superseded by information in this FIS (References 75-82). The differences in the 10-, 2-, and 1-percent-annual-chance tide frequency elevations are due to an updated tide frequency analysis for the Delaware River. Differences in the elevations are all within 0.5 foot. The major difference in the 0.2-percent-annual-chance tide frequency elevation was due to the previous use of the Standard Project Tide as the 0.2-percent-annual-chance tide frequency. It has since been determined that on the Delaware River, the 0.2-percent-annual-chance tide frequency stages are lower than the Standard Project Tide. Consequently, differences in the 0.2-percent-annual-chance tide frequency elevations exist.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting Federal Insurance and Mitigation Division, FEMA Region III, One Independence Mall, Sixth Floor, 615 Chestnut Street, Philadelphia, PA 19106-4404.

COMMUNITY NAME	INITIAL NFIP MAP DATE	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	INITIAL FIRM DATE	FIRM REVISIONS DATE
Delaware City, City of	April 5, 1974	December 19, 1975	February 16, 1977	September 2, 1982 May 2, 1991 April 16, 1993
Elsmere, Town of	June 5, 1970	January 31, 1975	December 31, 1976	September 18, 1987
Middletown, Town of	August 2, 1974	December 12, 1975	January 7, 1977	
New Castle, City	December 7, 1973	July 1, 1974	December 26, 1975	April 3, 1987
New Castle County (Unincorporated Areas)	December 7, 1971	None	December 7, 1971	July 1, 1974 December 26, 1975 September 4, 1986 July 3, 1990
Newark, City of	June 5, 1970	None	December 7, 1971	July 1, 1974 December 26, 1975 April 15, 1988
Newport, Town of	December 20, 1974	December 12, 1975	June 15, 1978	April 3, 1987
Wilmington, City of	May 31, 1974	December 26, 1975	May 2, 1977	August 19, 1991

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

9.0 BIBLIOGRAPHY AND REFERENCES

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4. Personal communication with city officials, Delaware City, Delaware, September 27, 1974.
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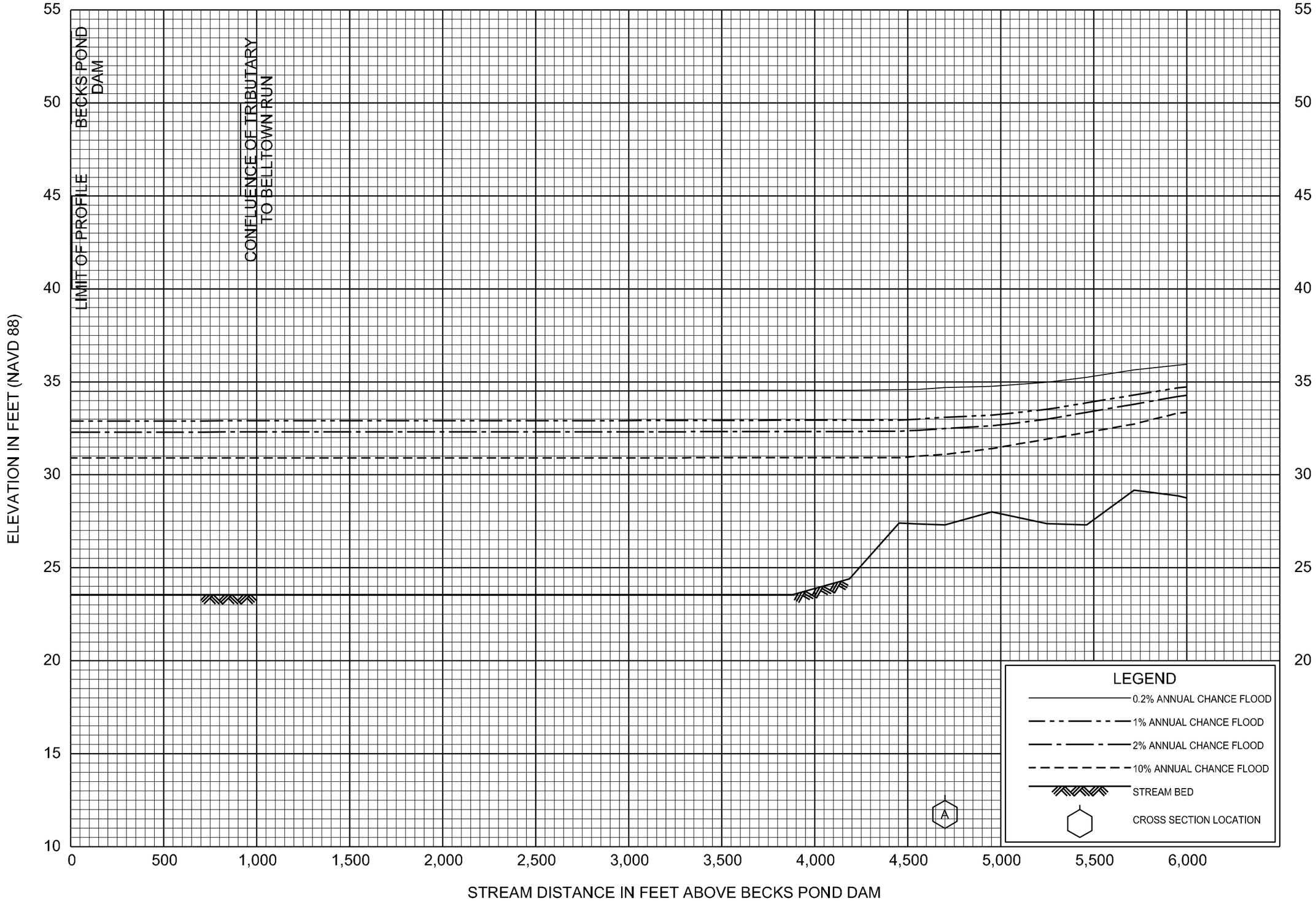


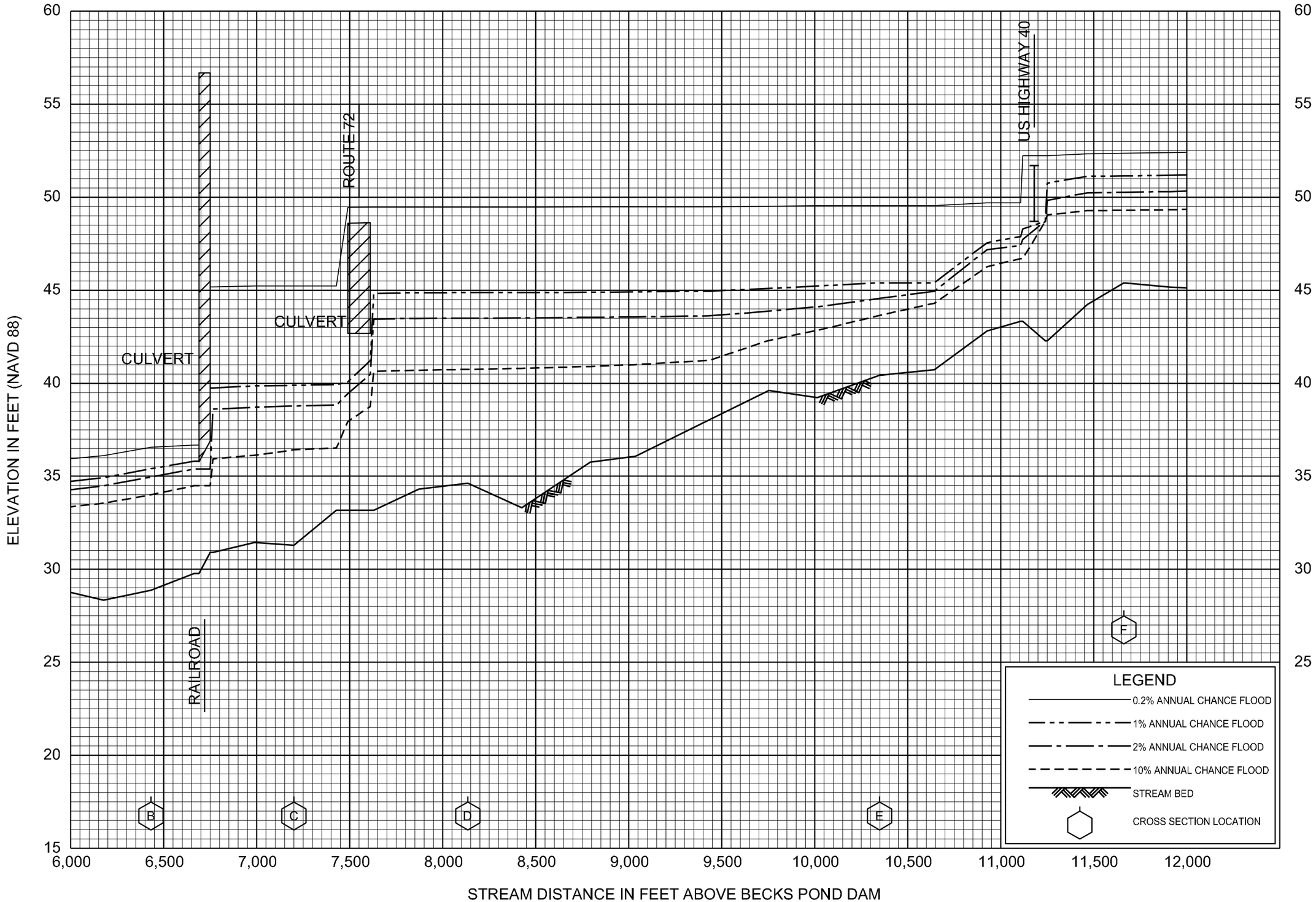
FLOOD PROFILES

BELLTOWN RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

02P(a)



FLOOD PROFILES

BELLTOWN RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS

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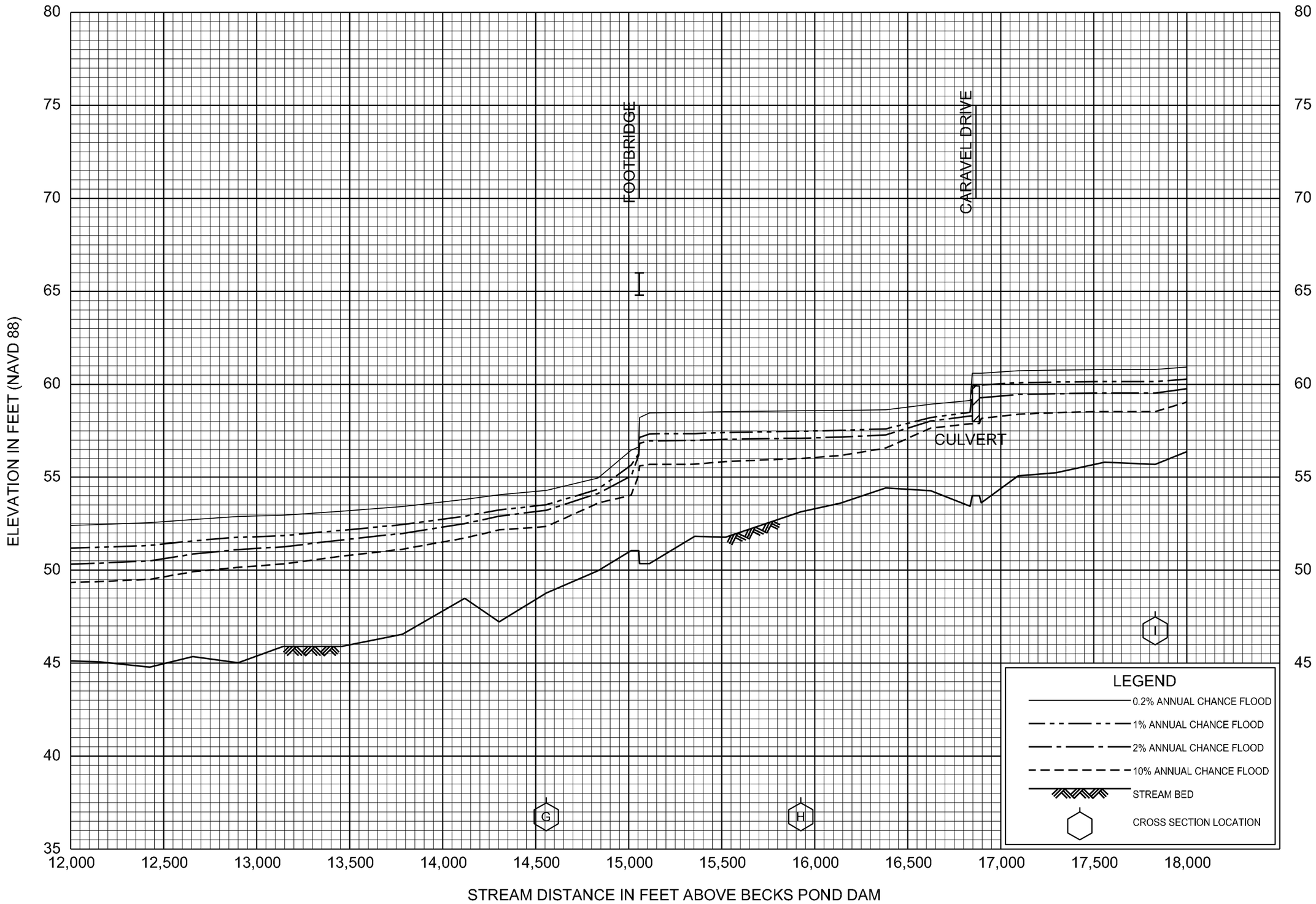

FLOOD PROFILES

BELLTOWN RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

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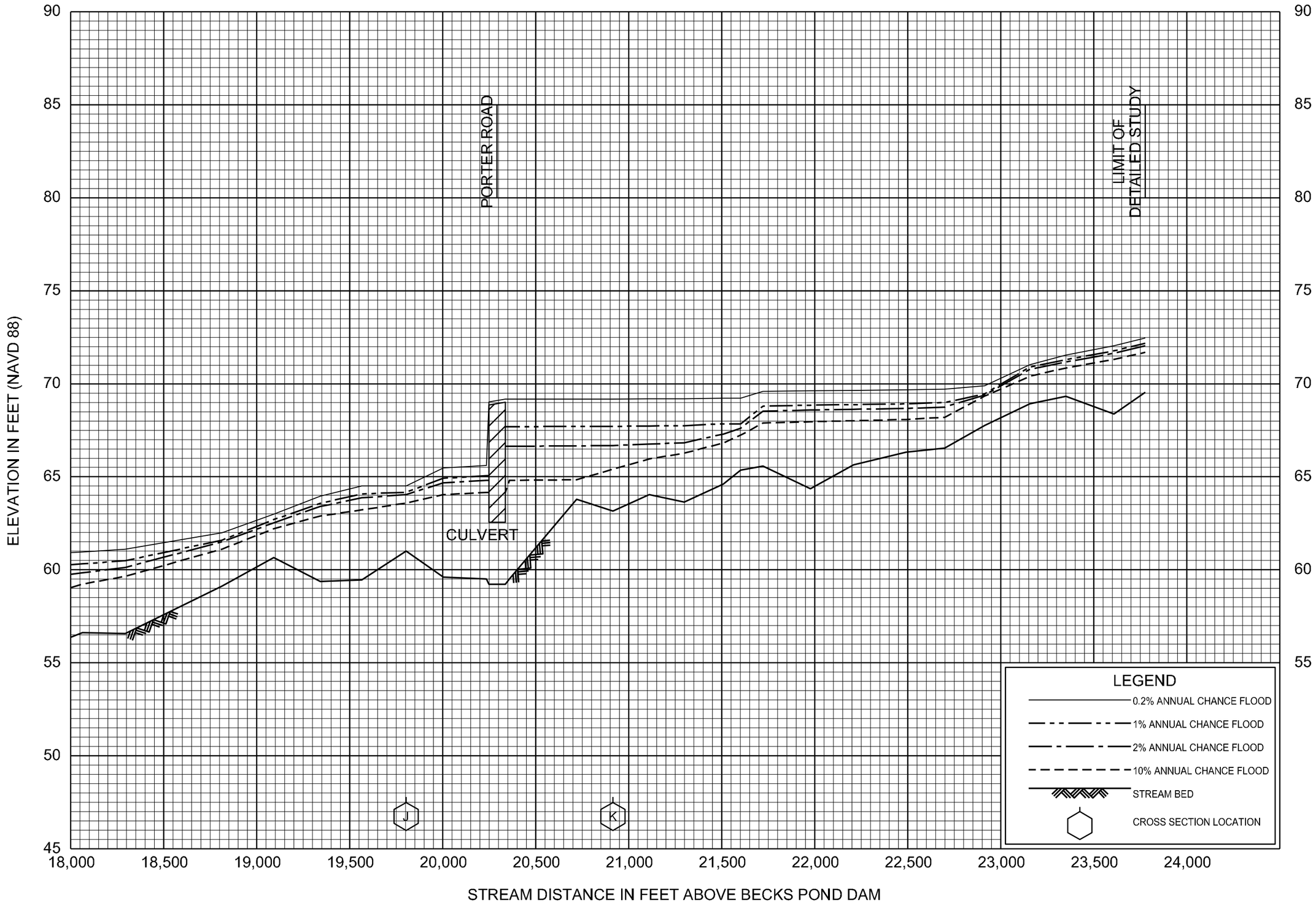

FLOOD PROFILES

BELLTOWN RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

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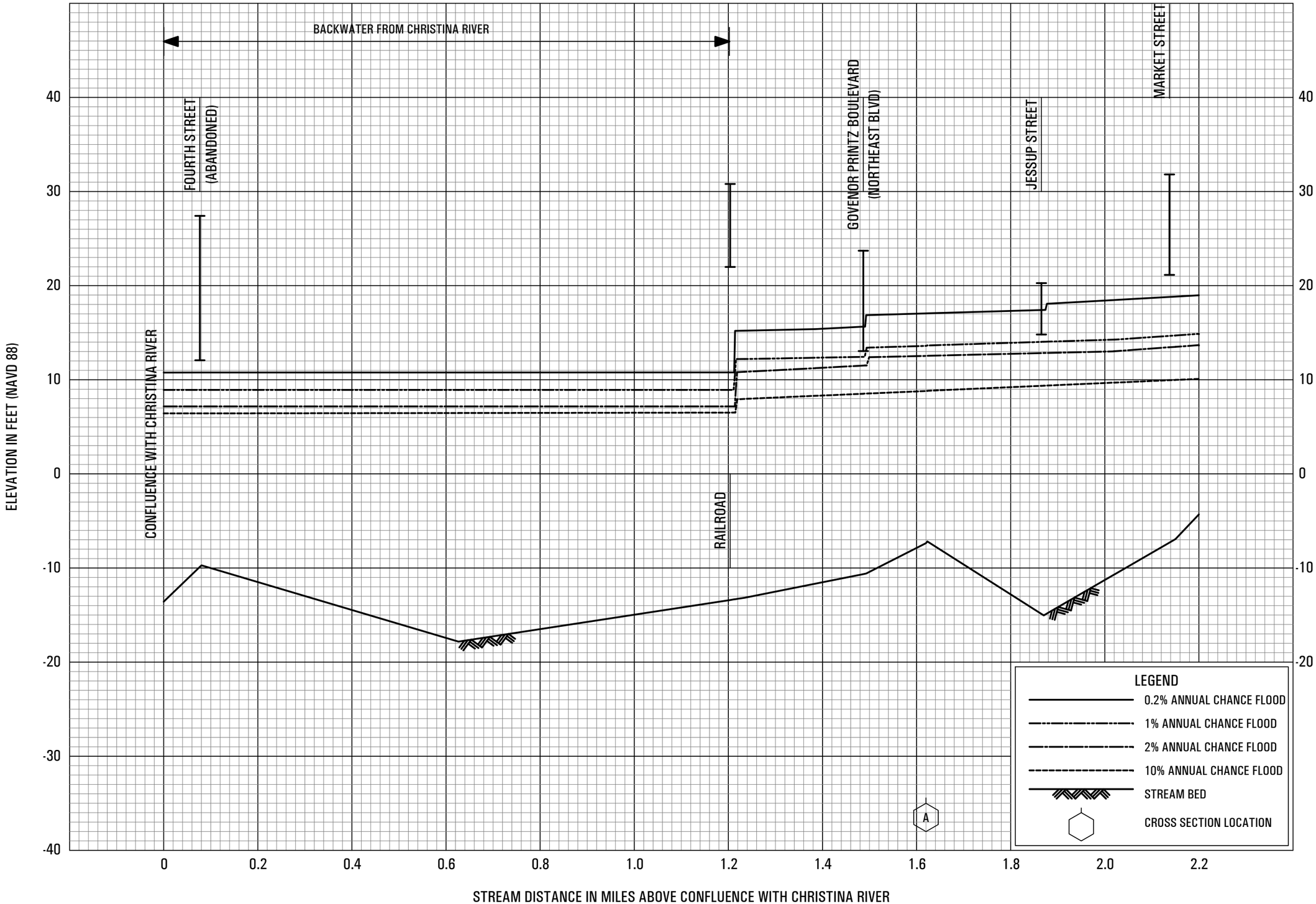


FLOOD PROFILES

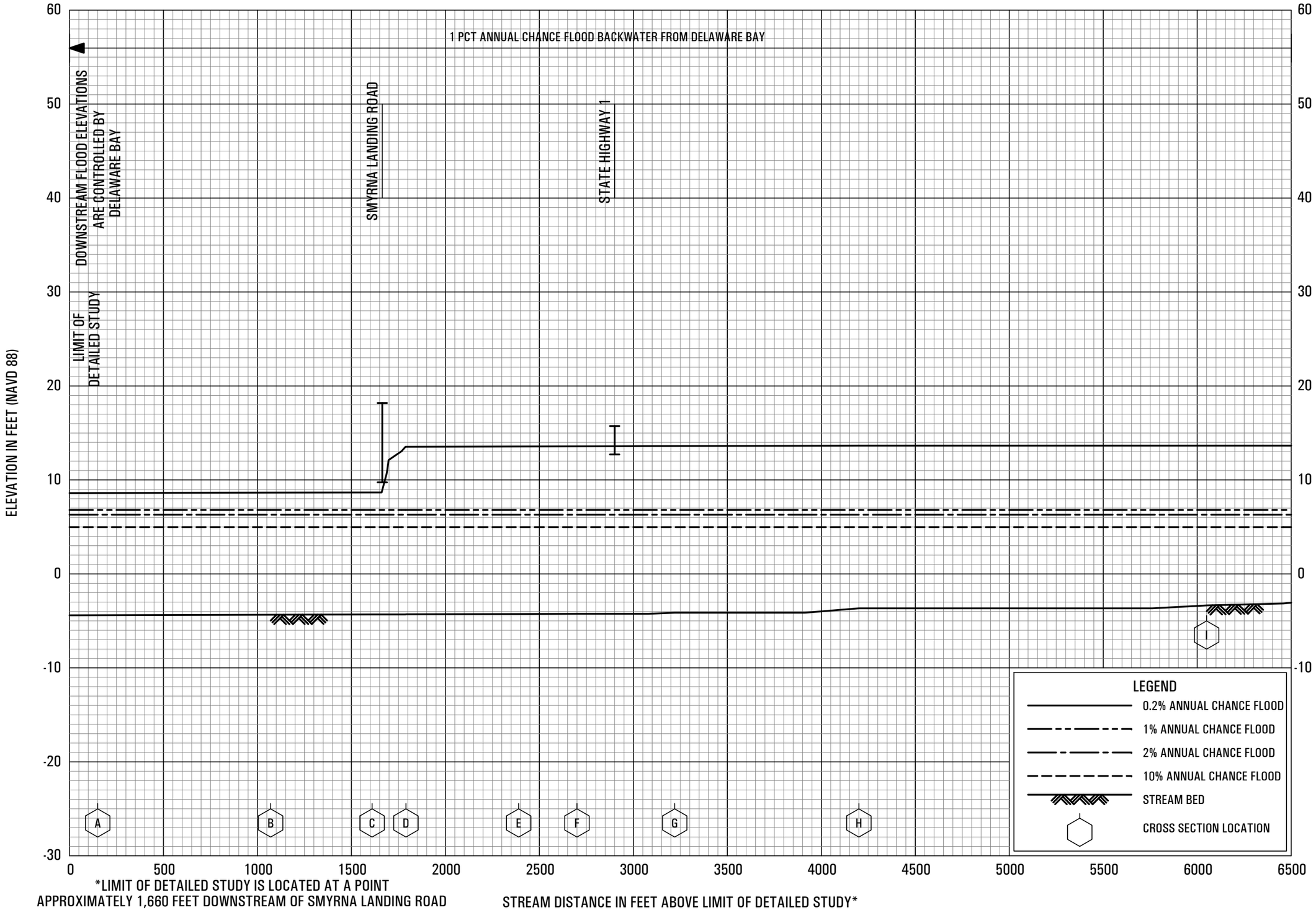
BRANDYWINE CREEK (LOWER REACH)

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUTNY, DE

AND INCORPORATED AREAS

03P



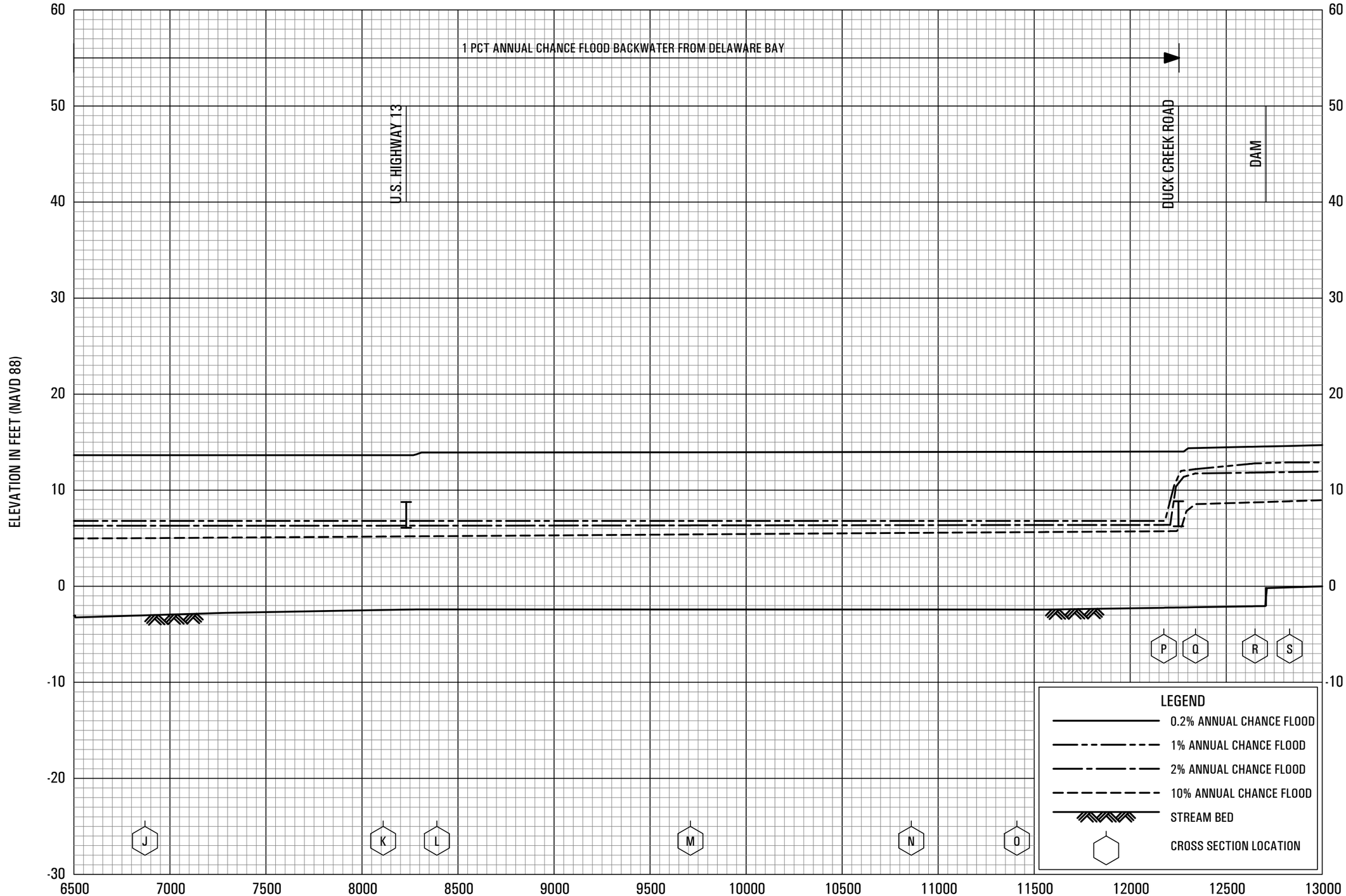
FLOOD PROFILES

DUCK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



*LIMIT OF DETAILED STUDY IS LOCATED AT A POINT APPROXIMATELY 1,660 FEET DOWNSTREAM OF SMYRNA LANDING ROAD

STREAM DISTANCE IN FEET ABOVE LIMIT OF DETAILED STUDY*

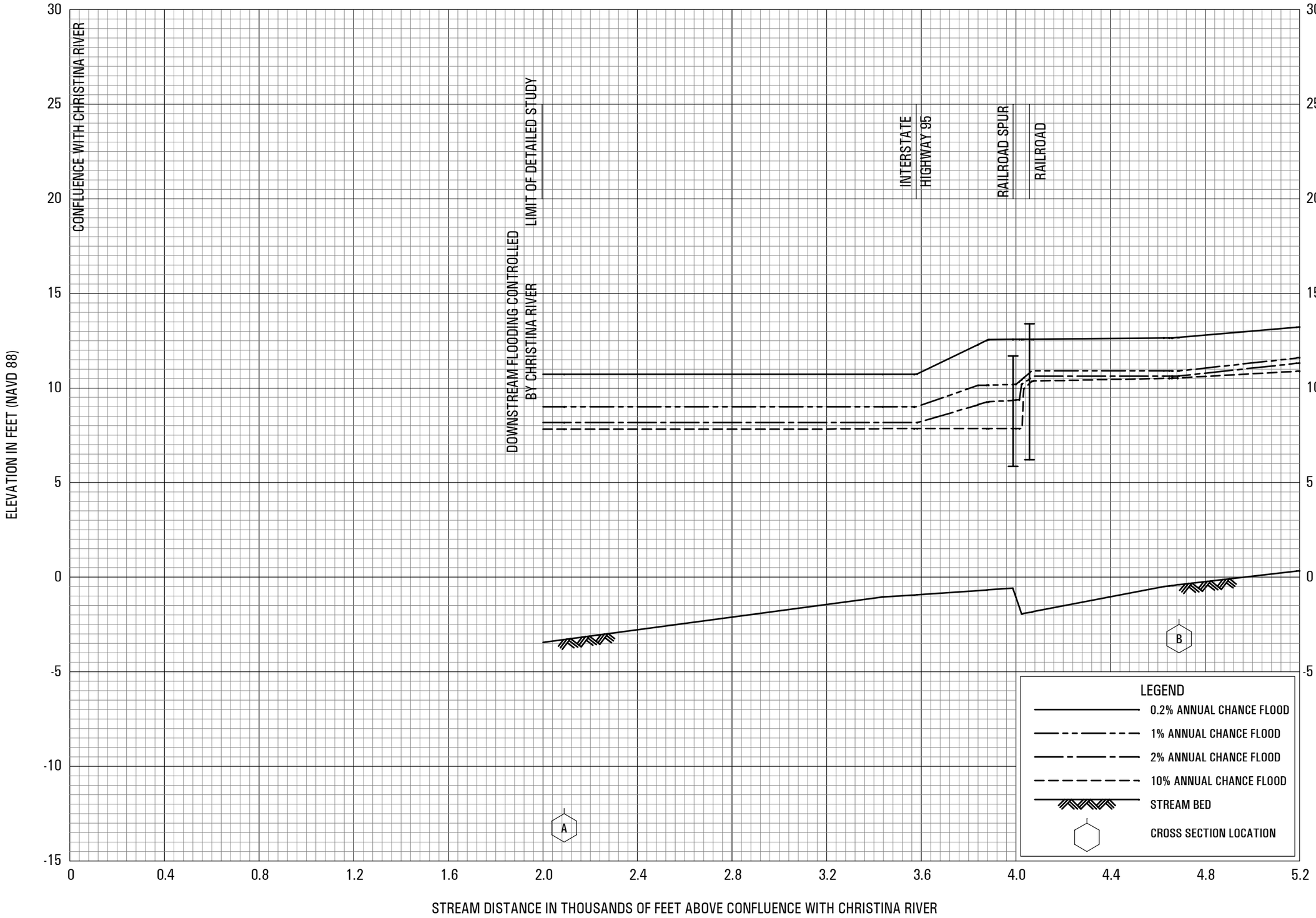
FLOOD PROFILES

DUCK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



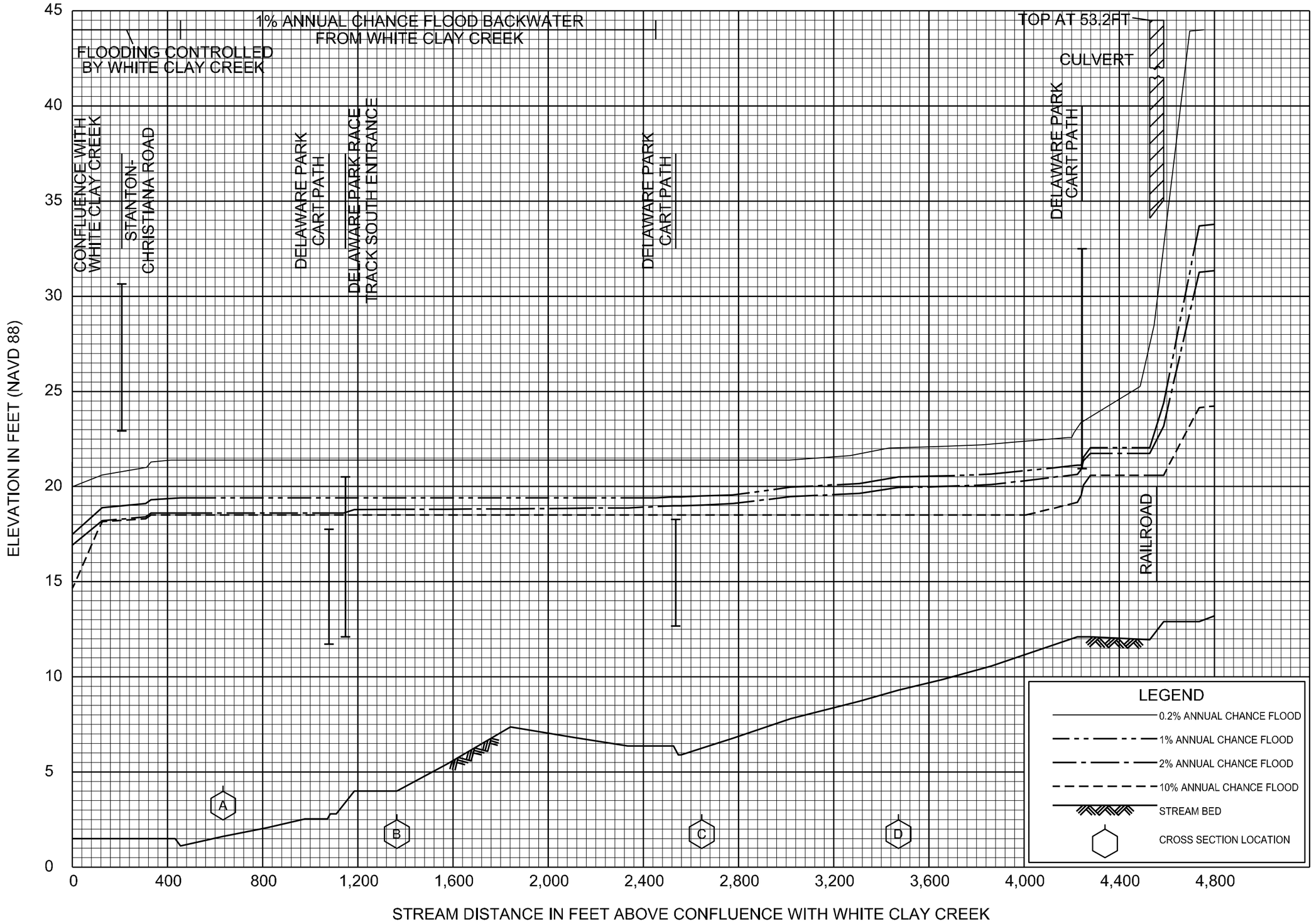
FLOOD PROFILES

LITTLE MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE, DE

(AND INCORPORATED AREAS)

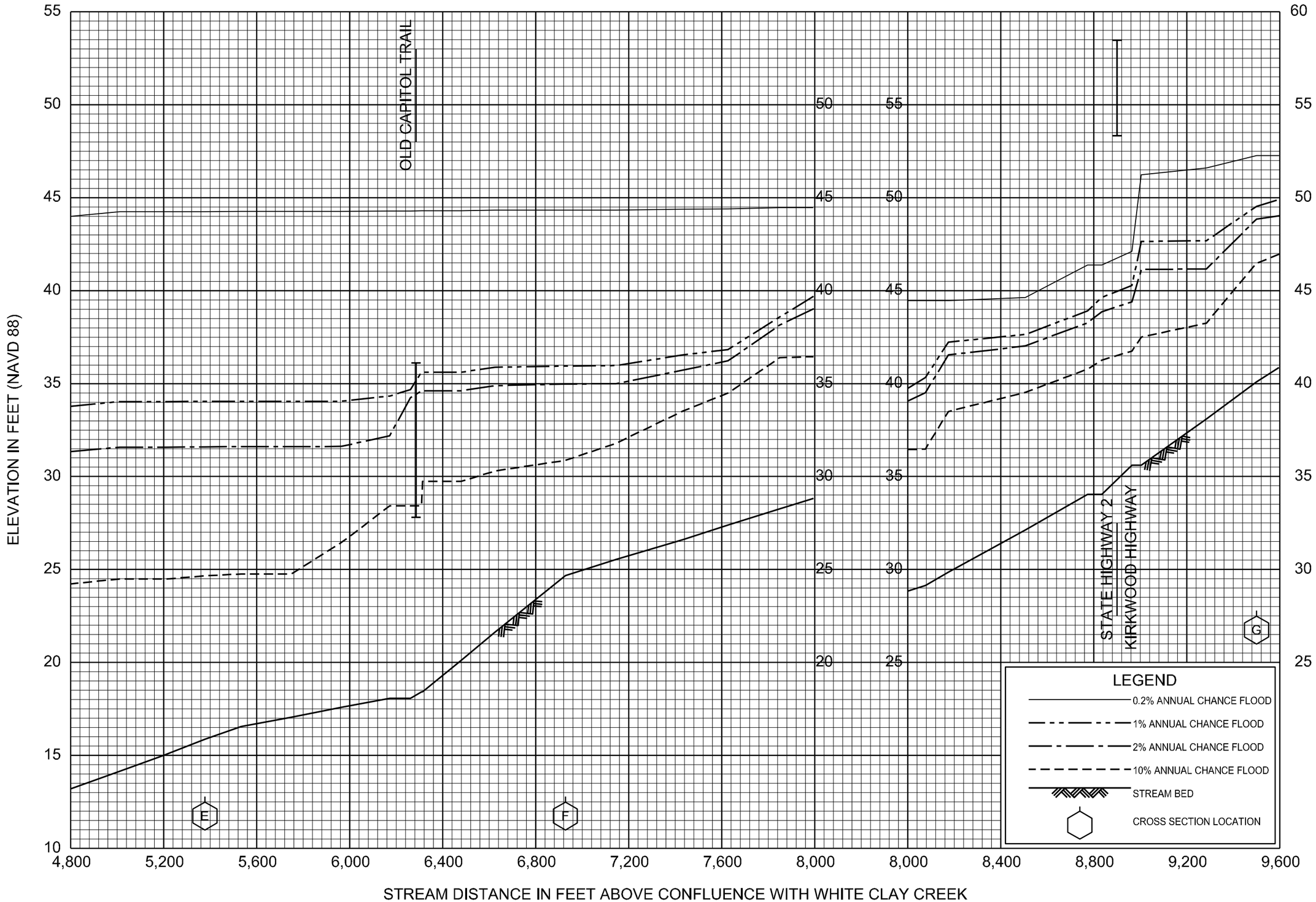


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

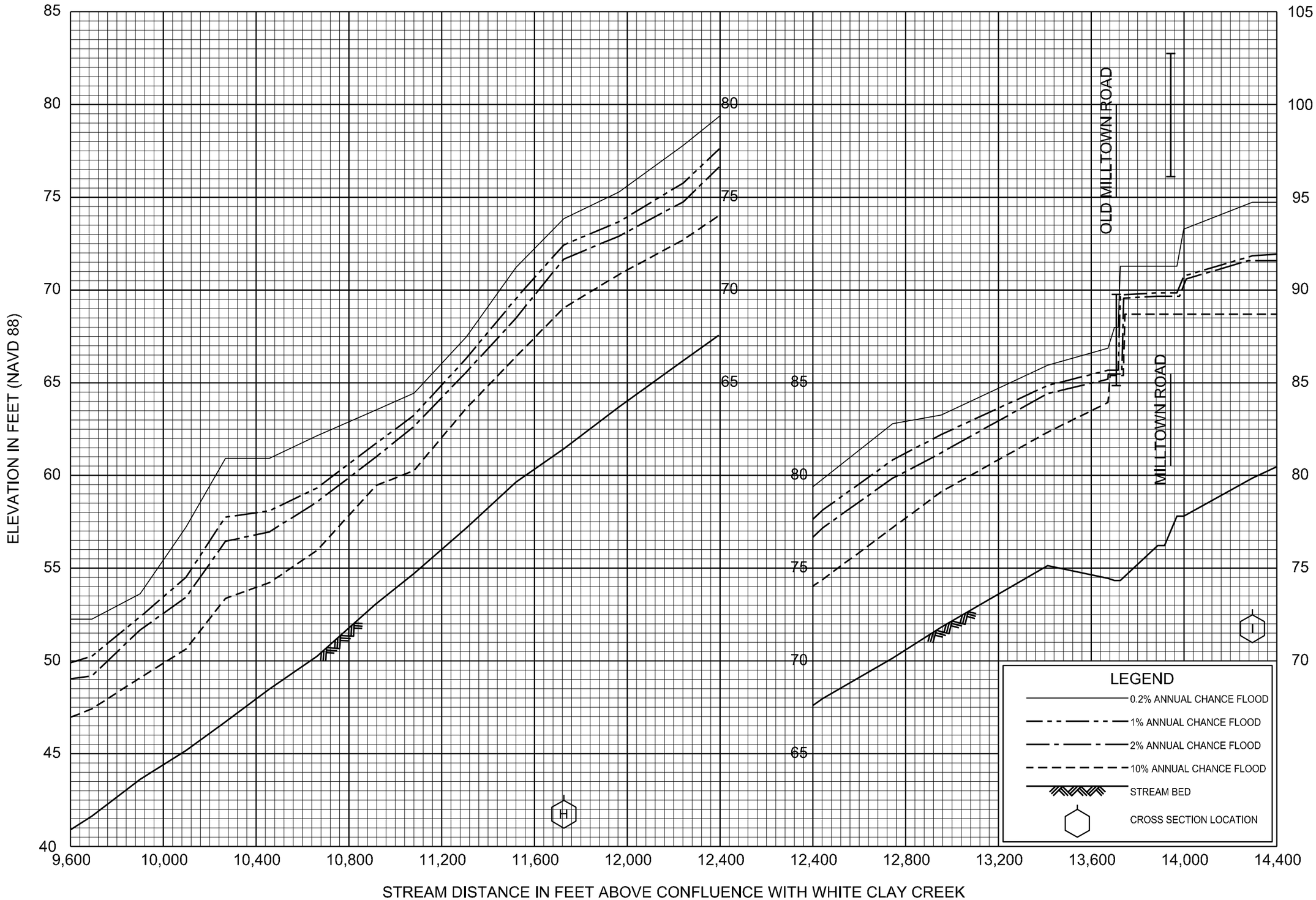


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

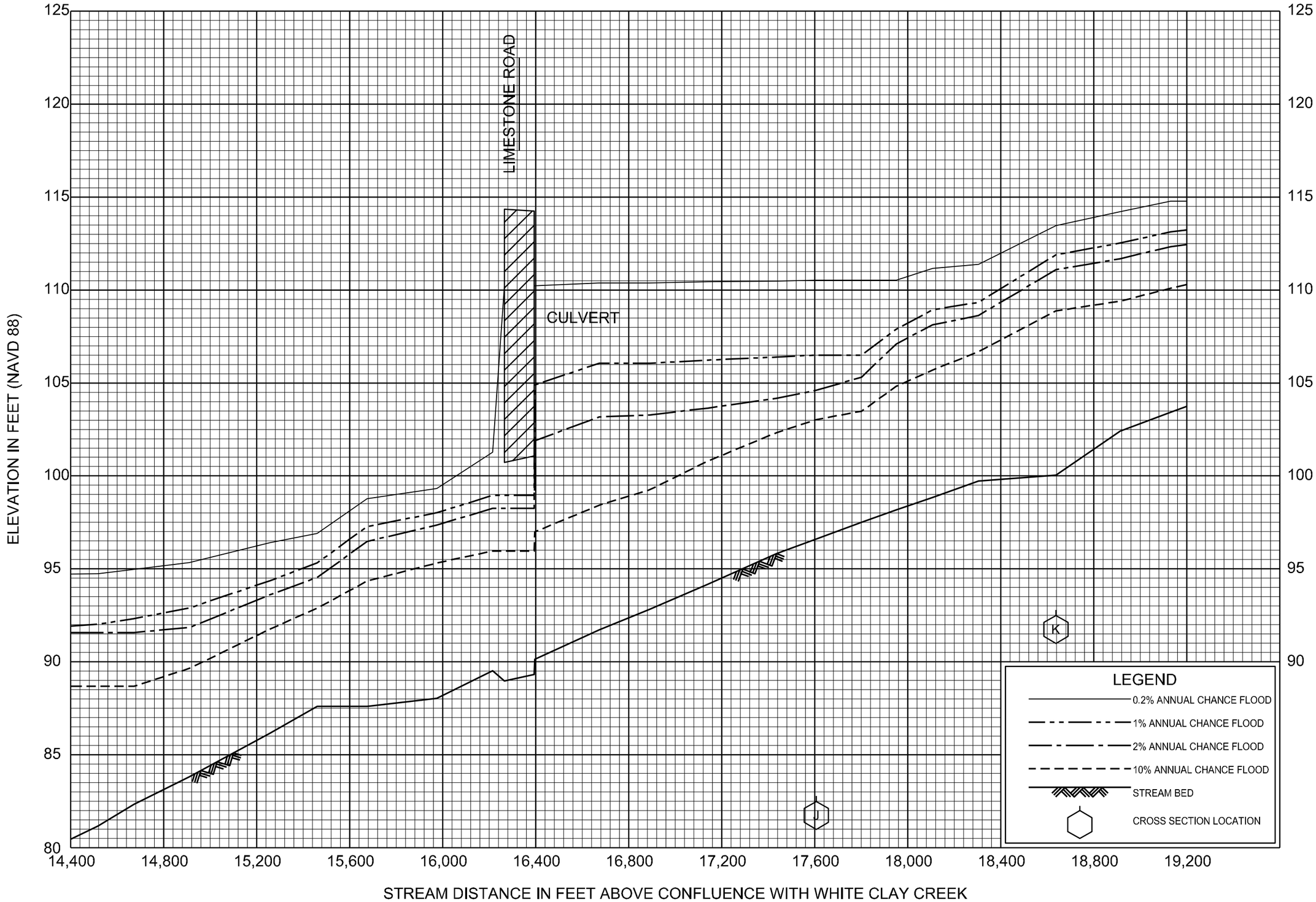


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

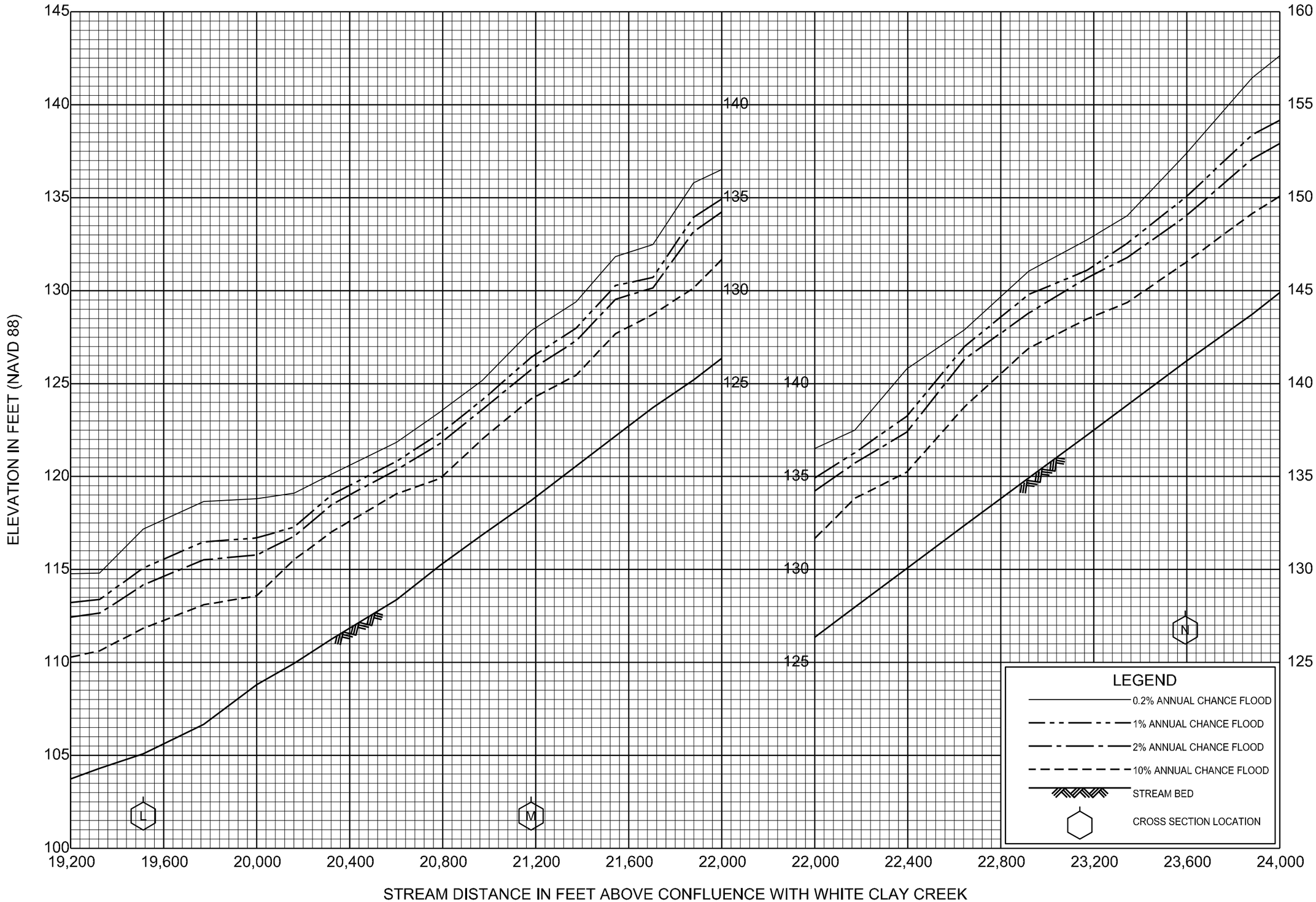


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

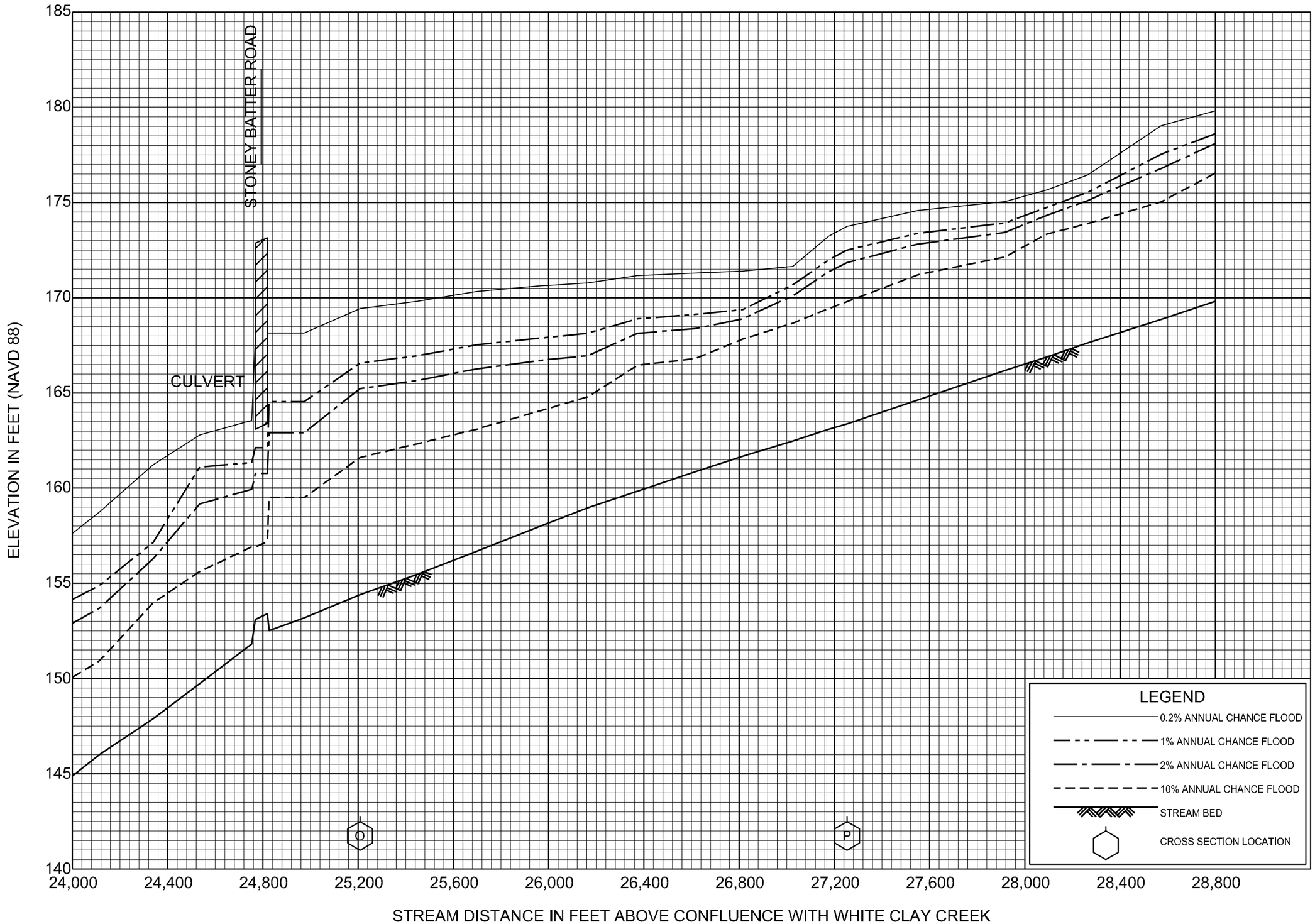


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

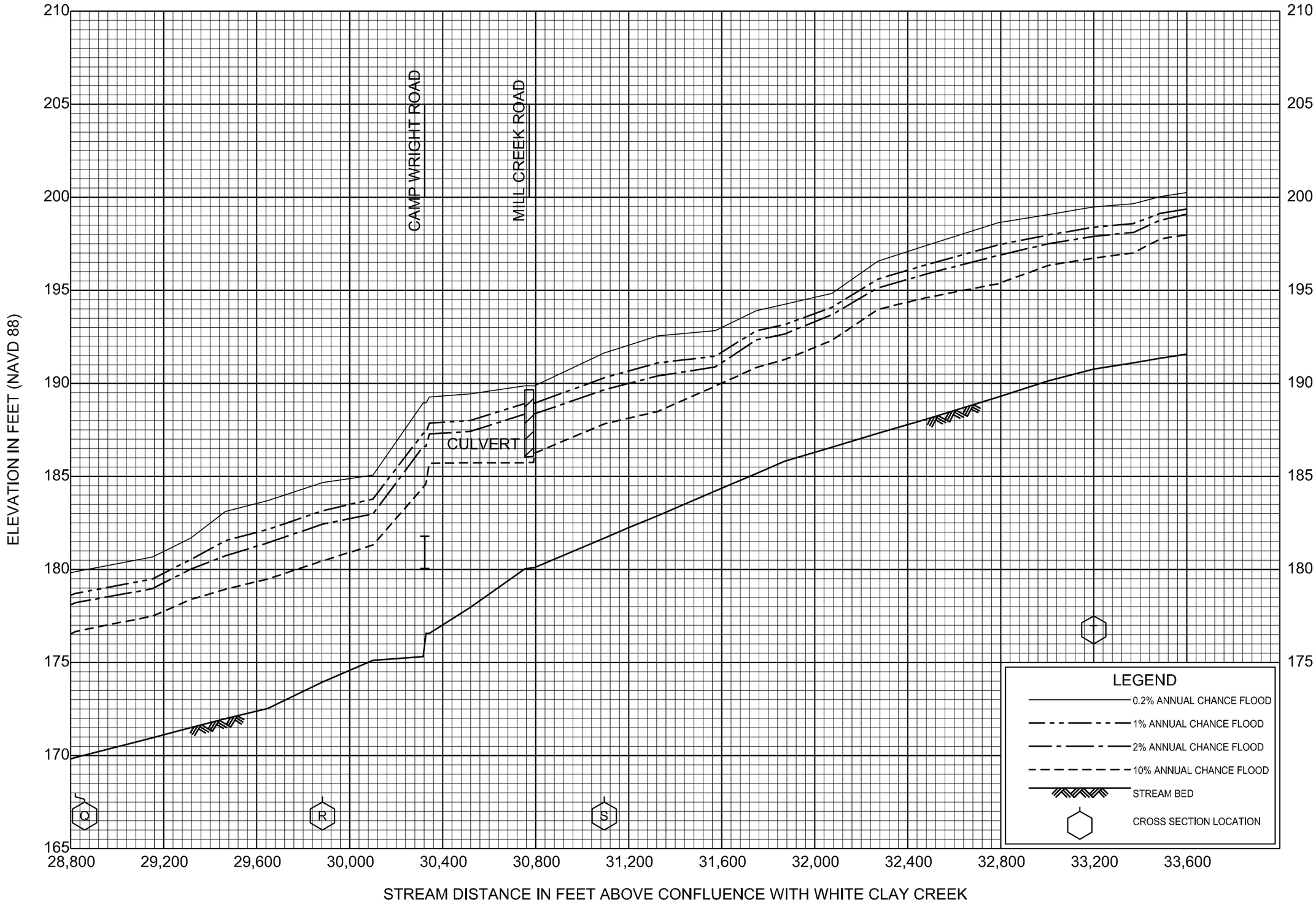


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

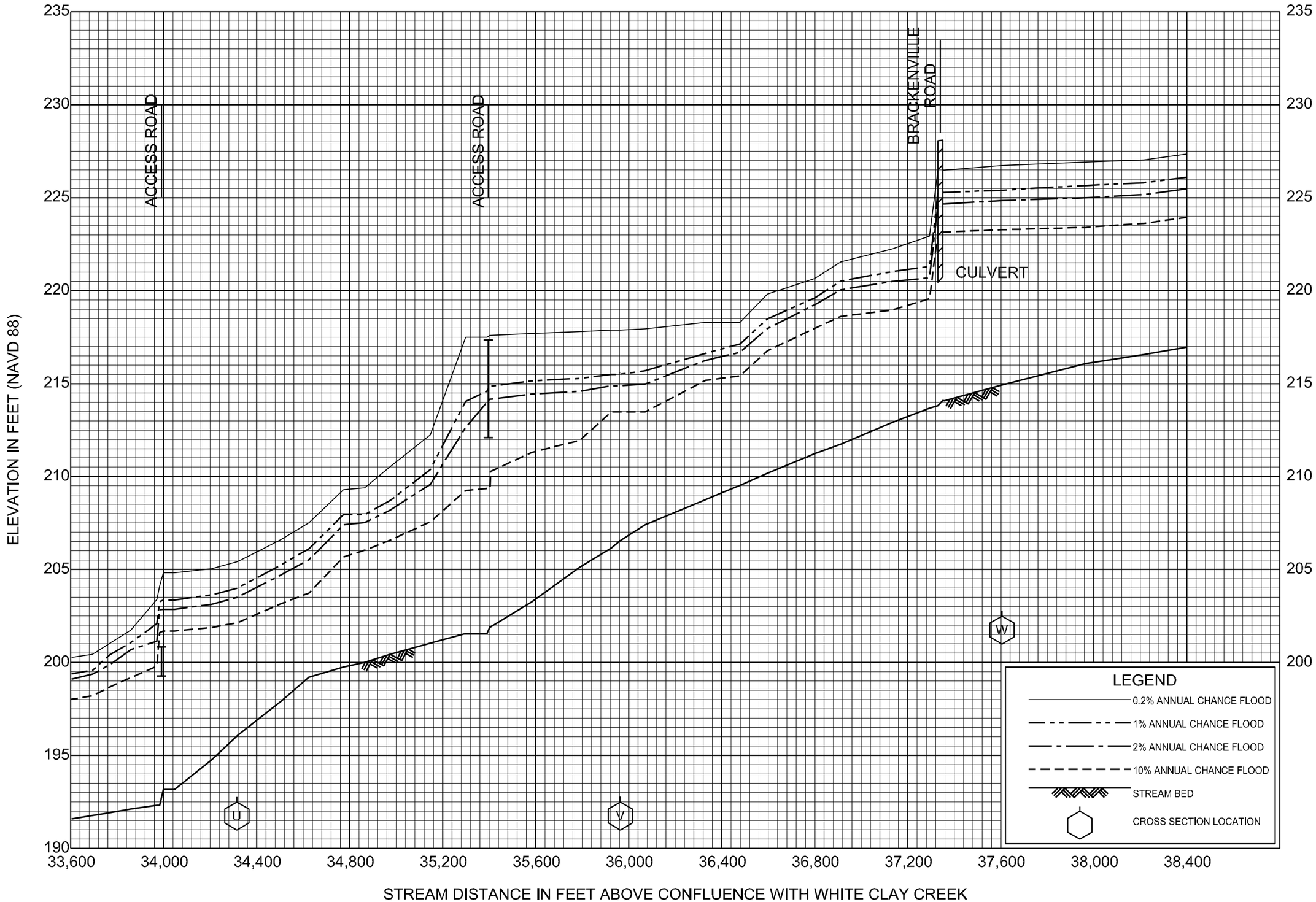


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

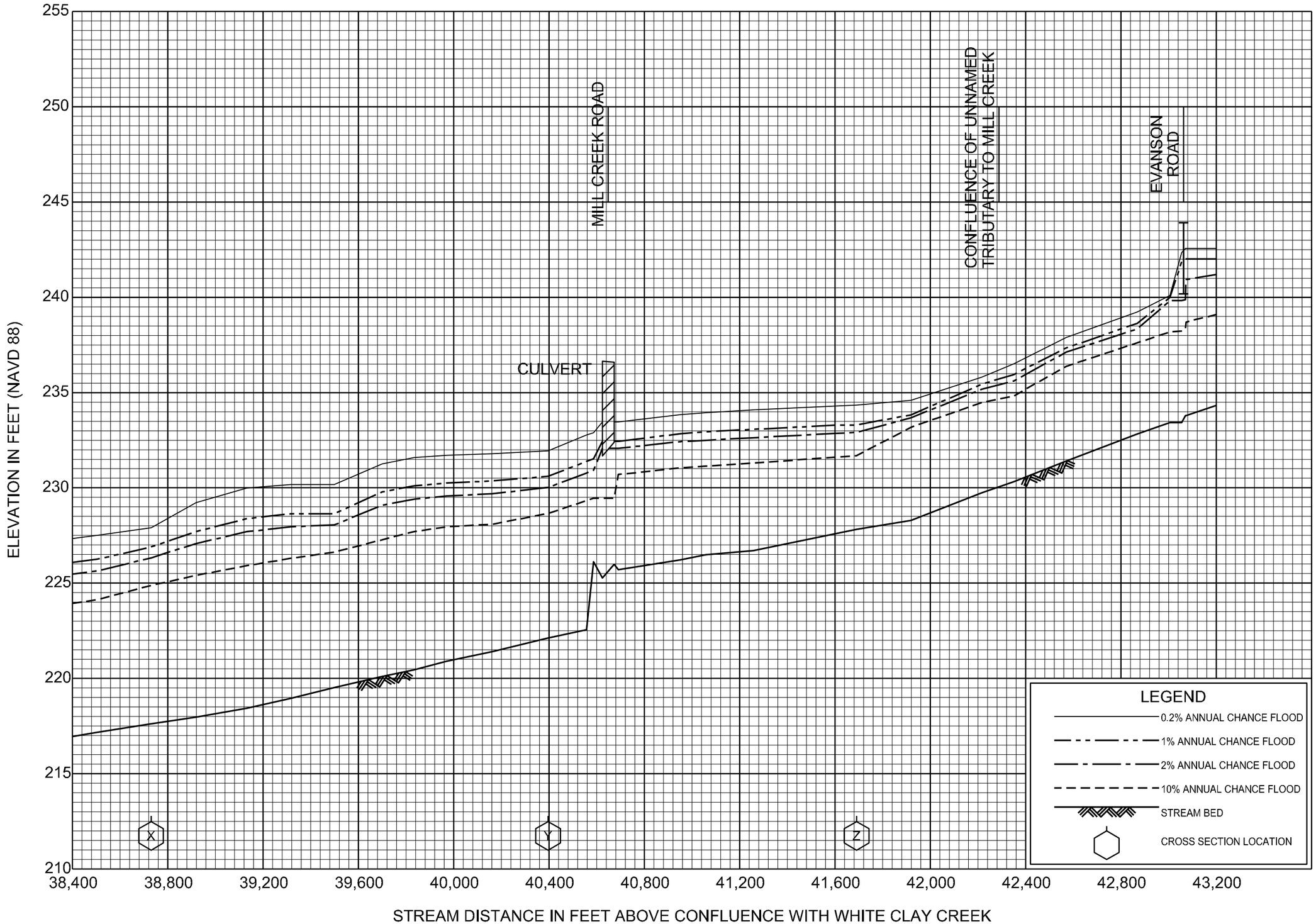


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

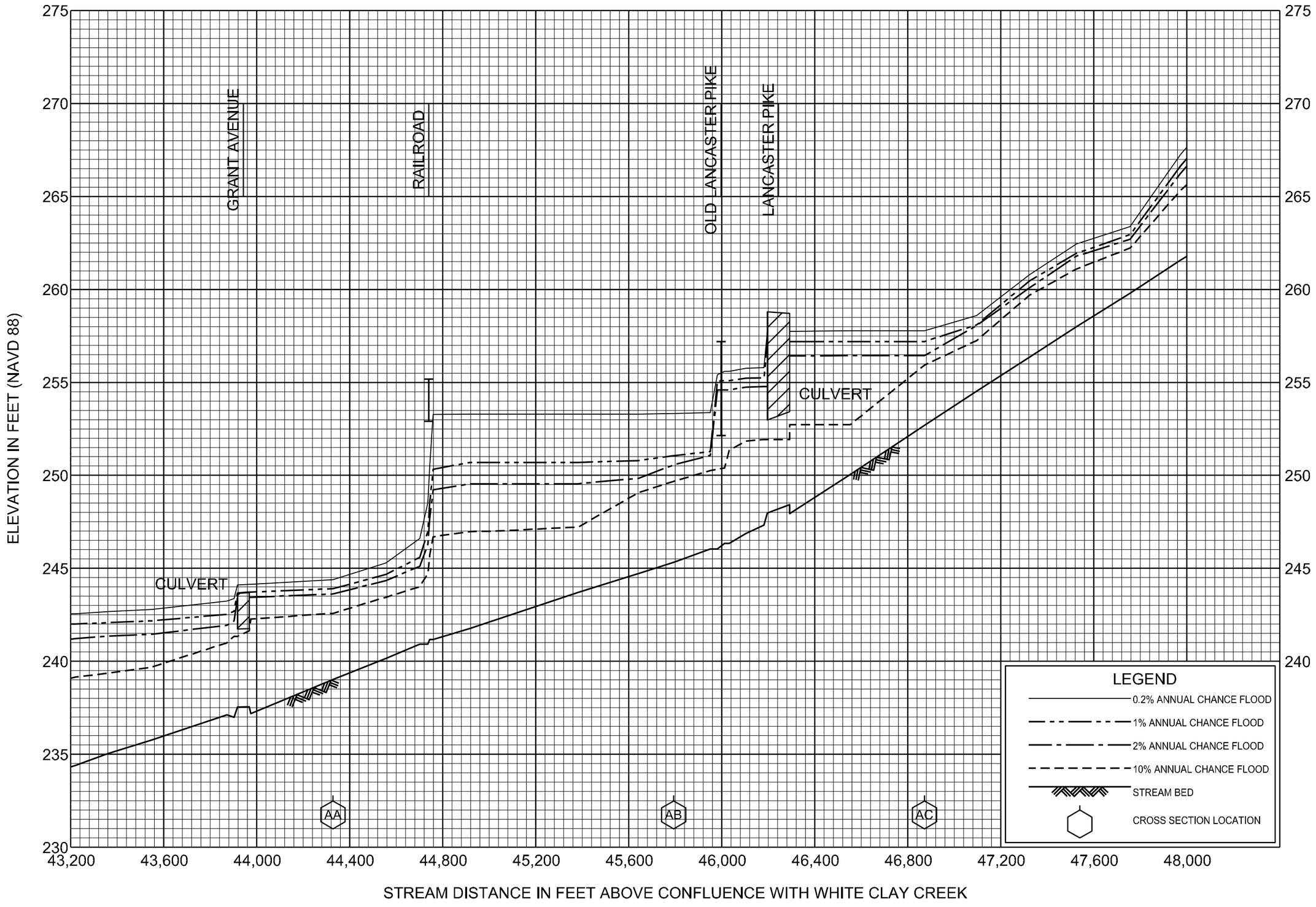


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS



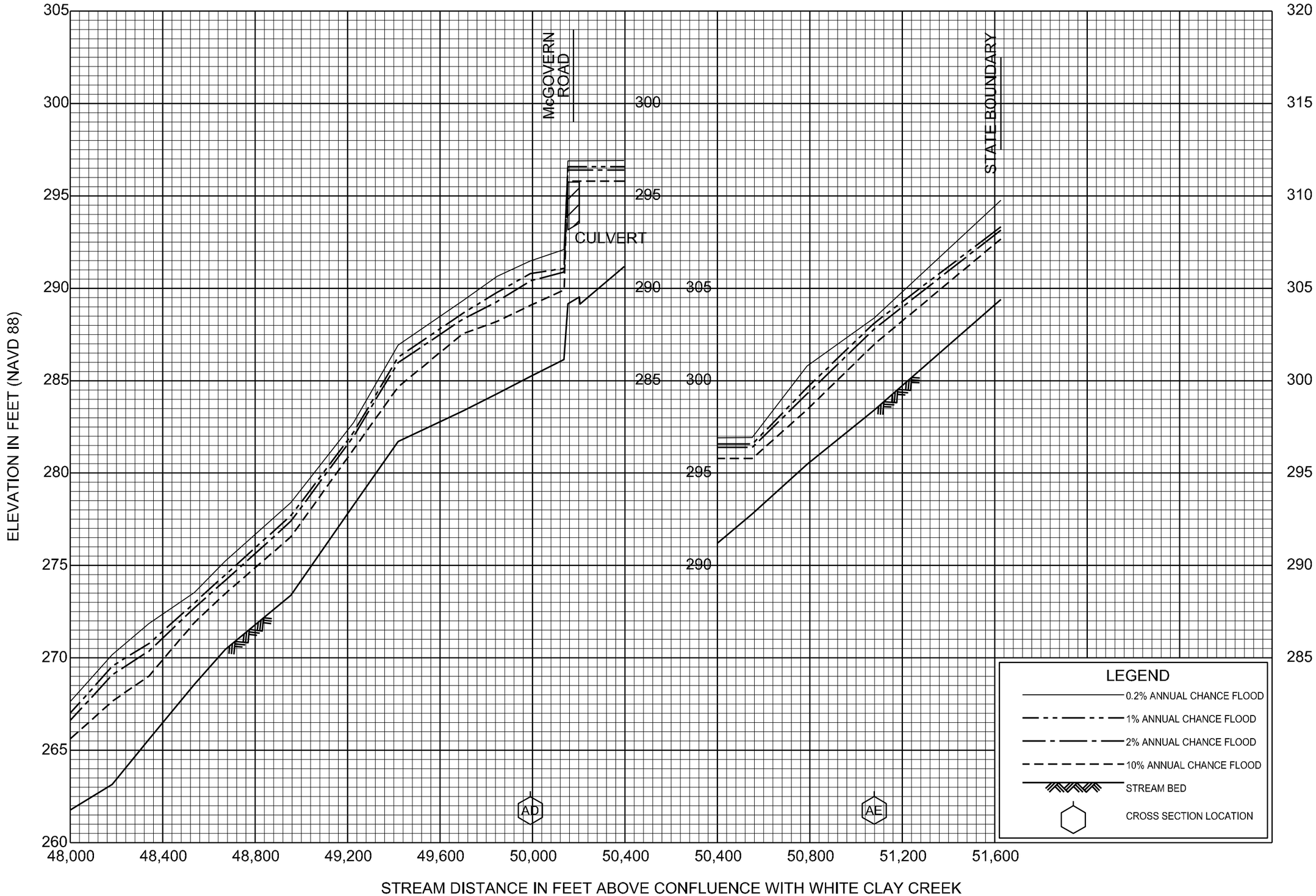
FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

51P(a)

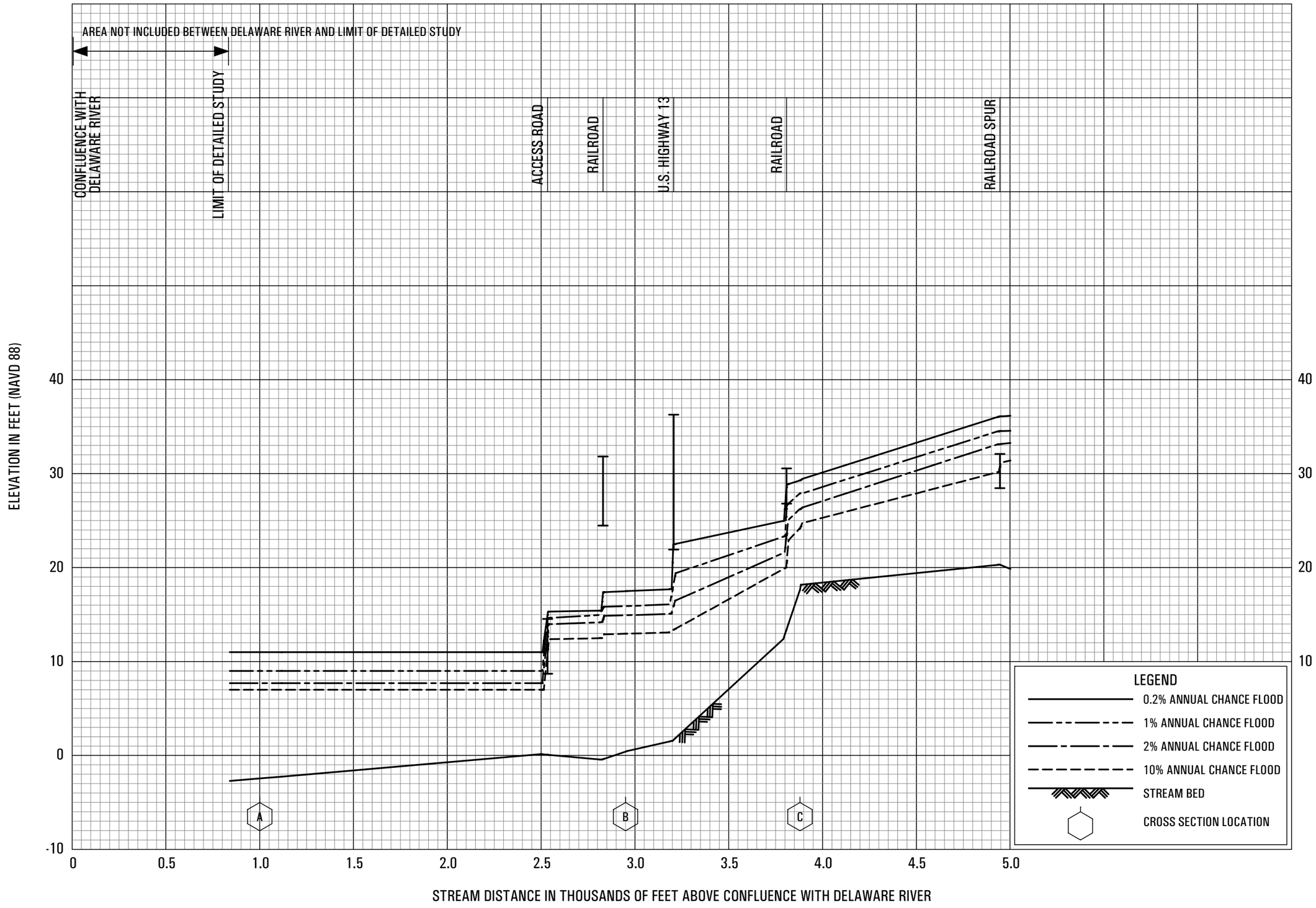


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS



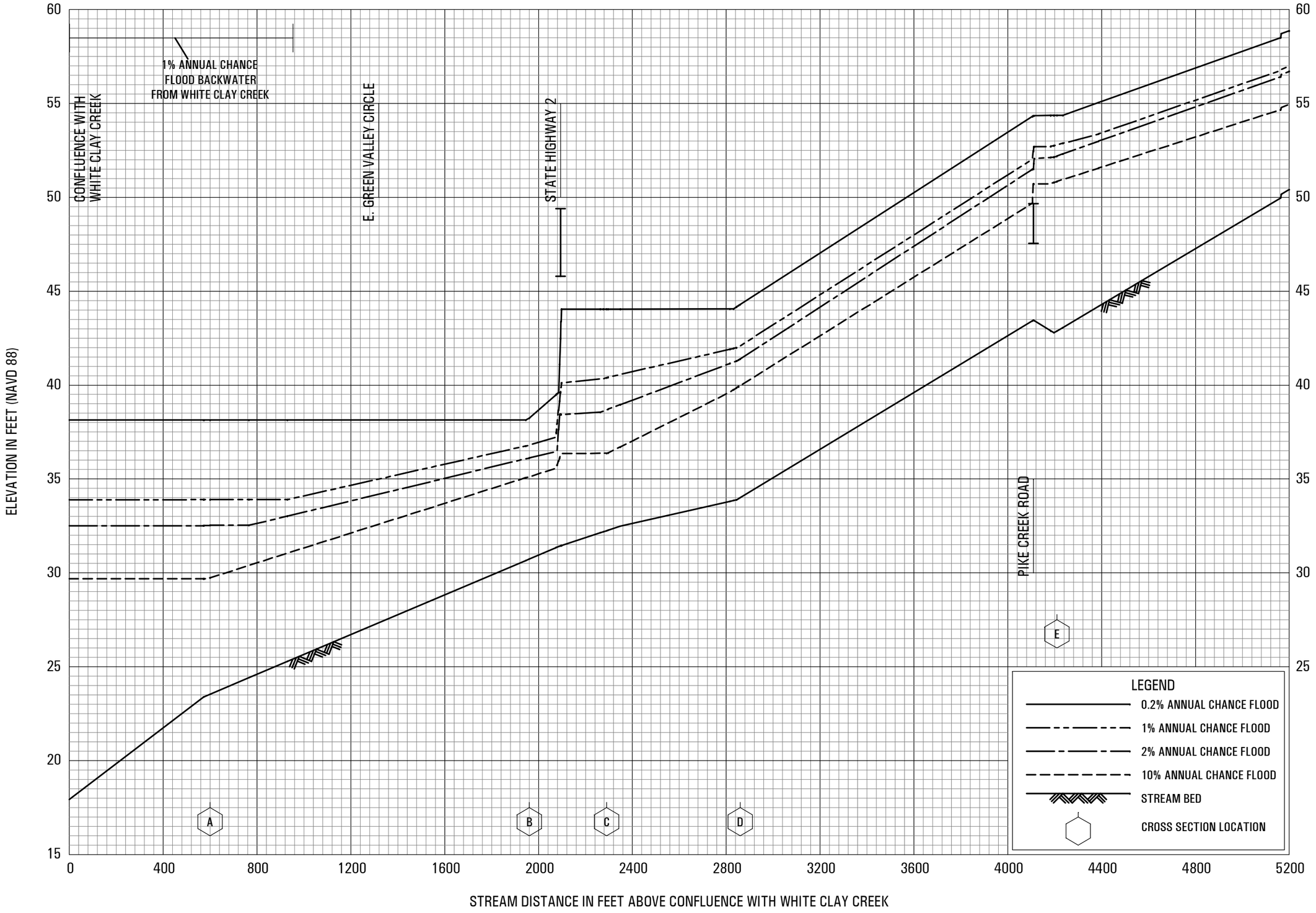
FLOOD PROFILES

NAAMAN CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



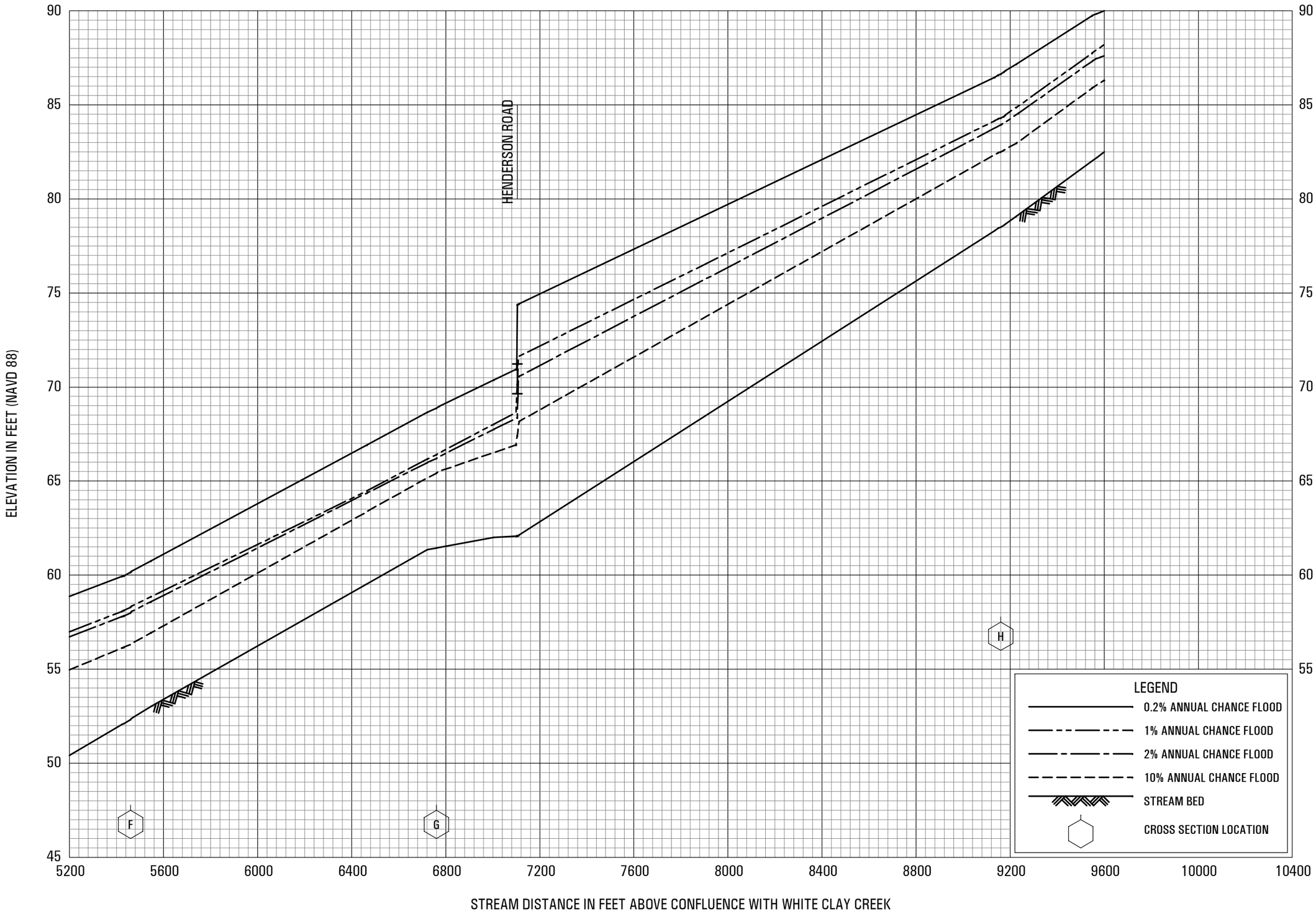
FLOOD PROFILES

PIKE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



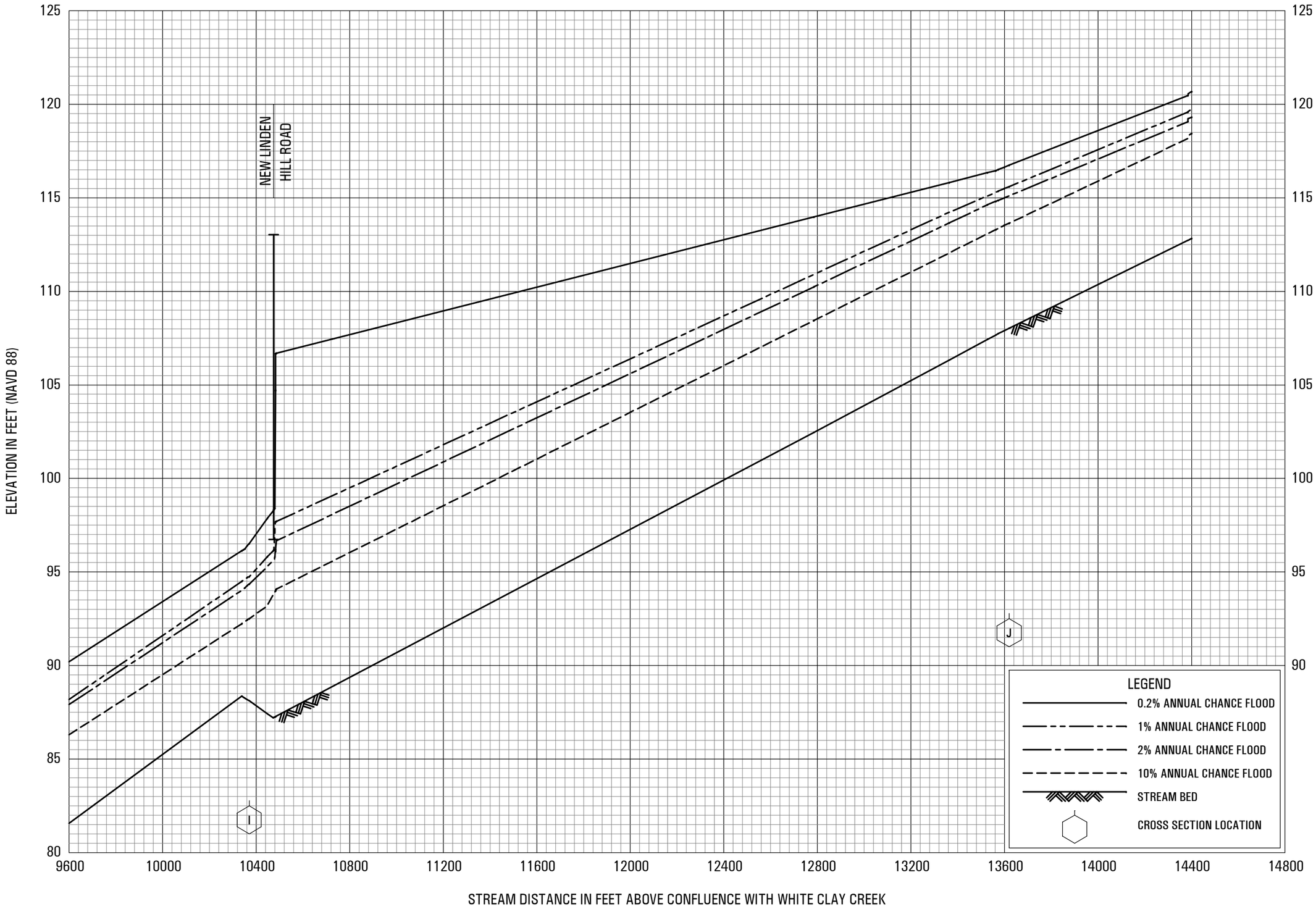
FLOOD PROFILES

PIKE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



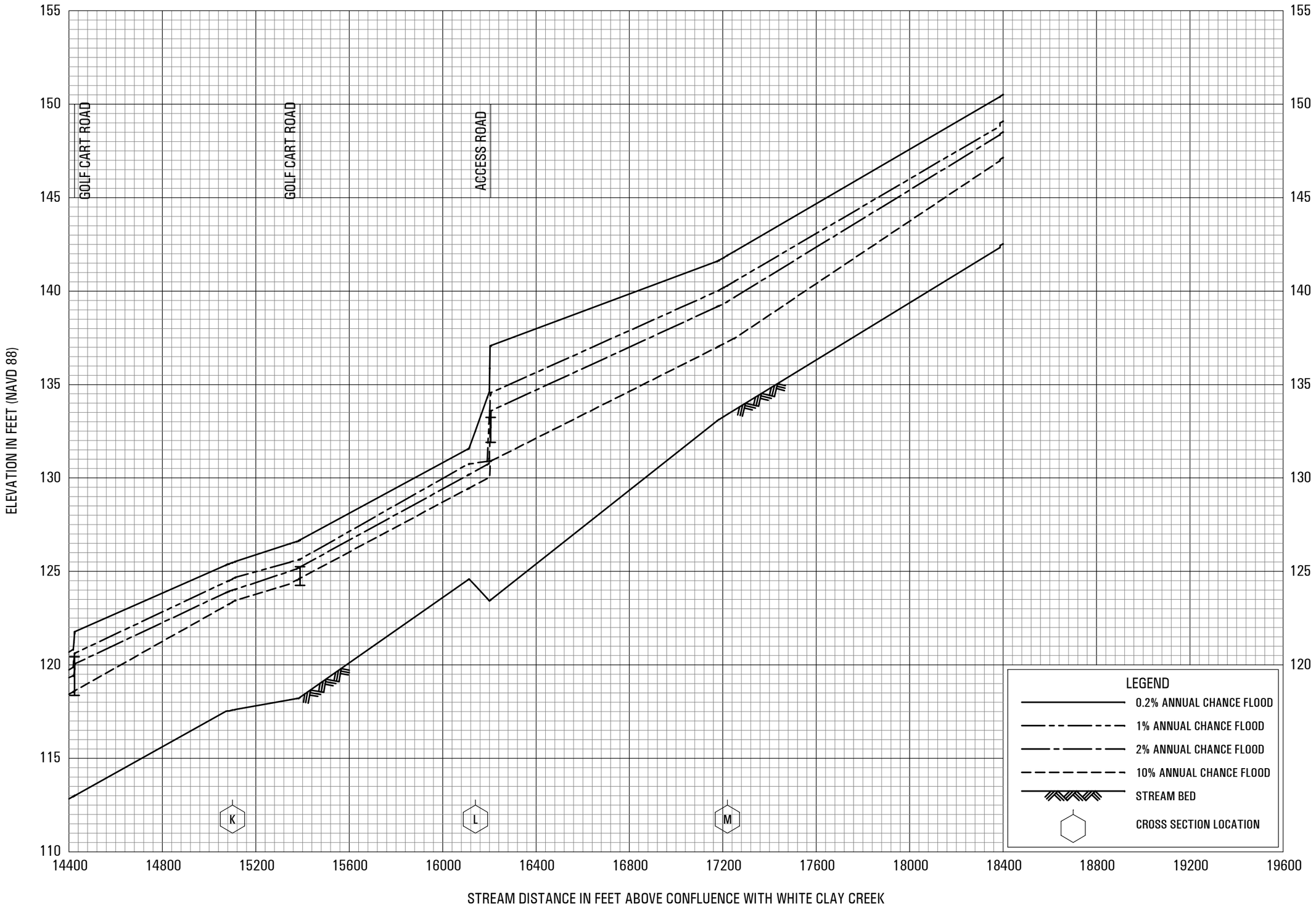
FLOOD PROFILES

PIKE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



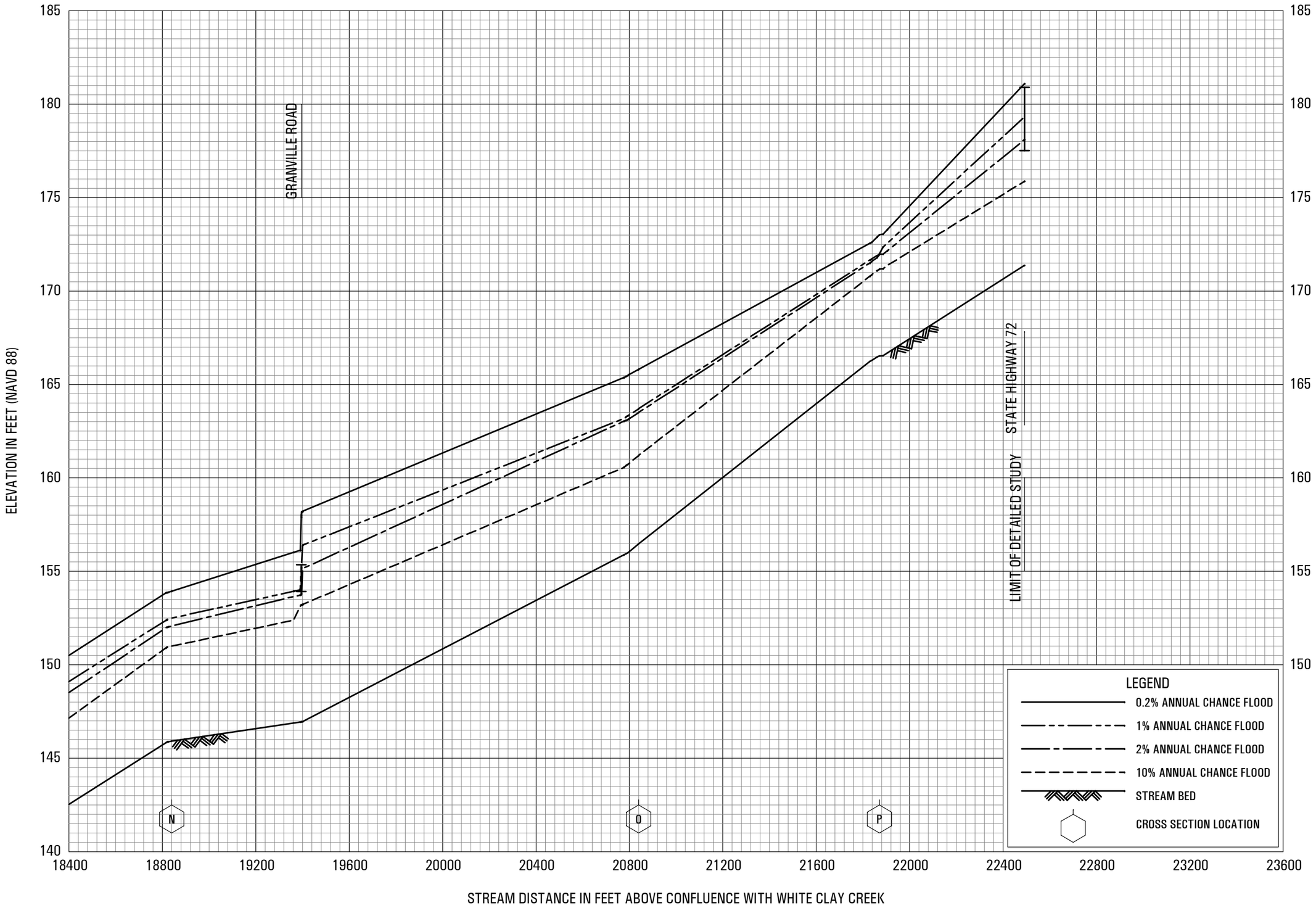
FLOOD PROFILES

PIKE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



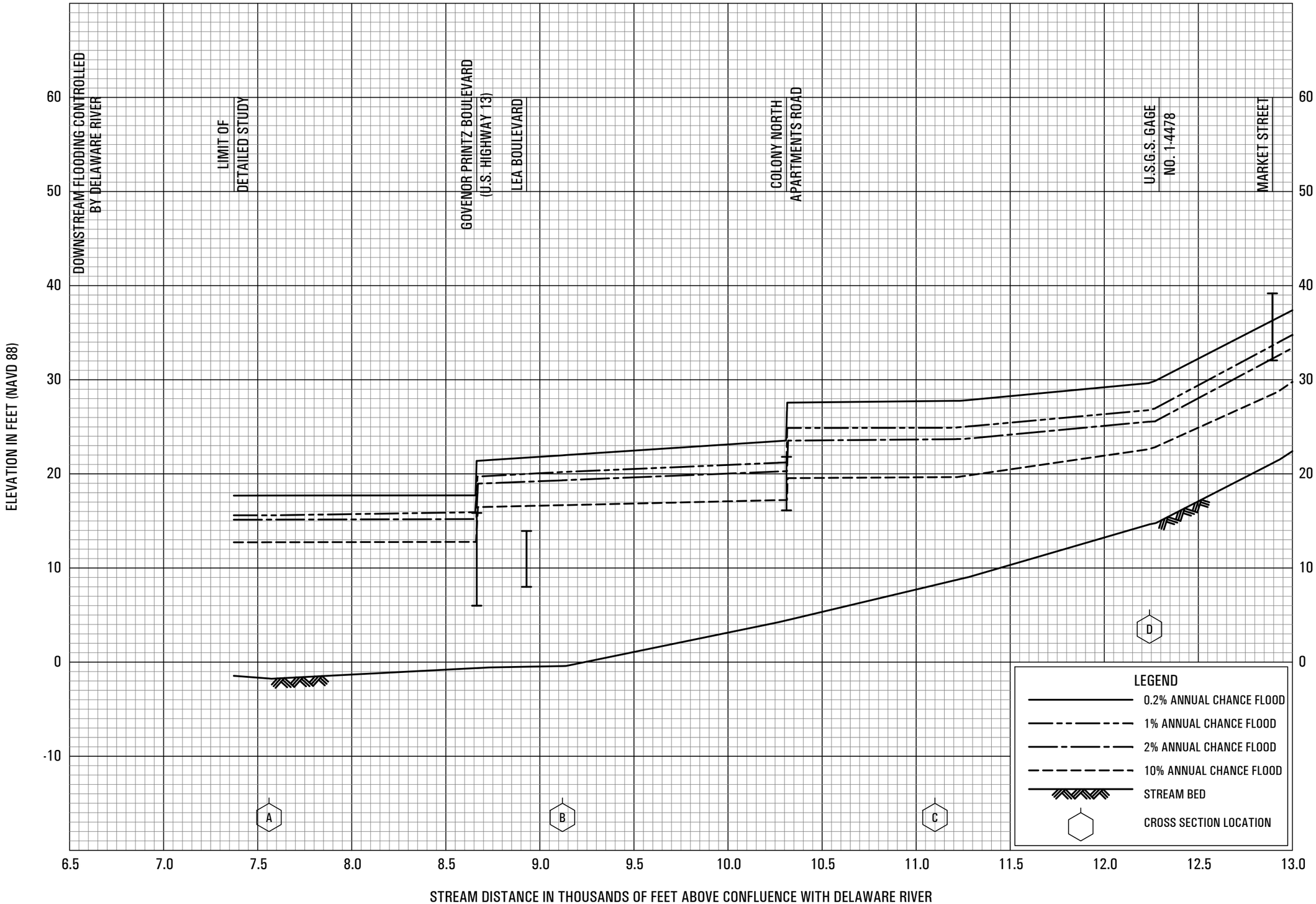
FLOOD PROFILES

PIKE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



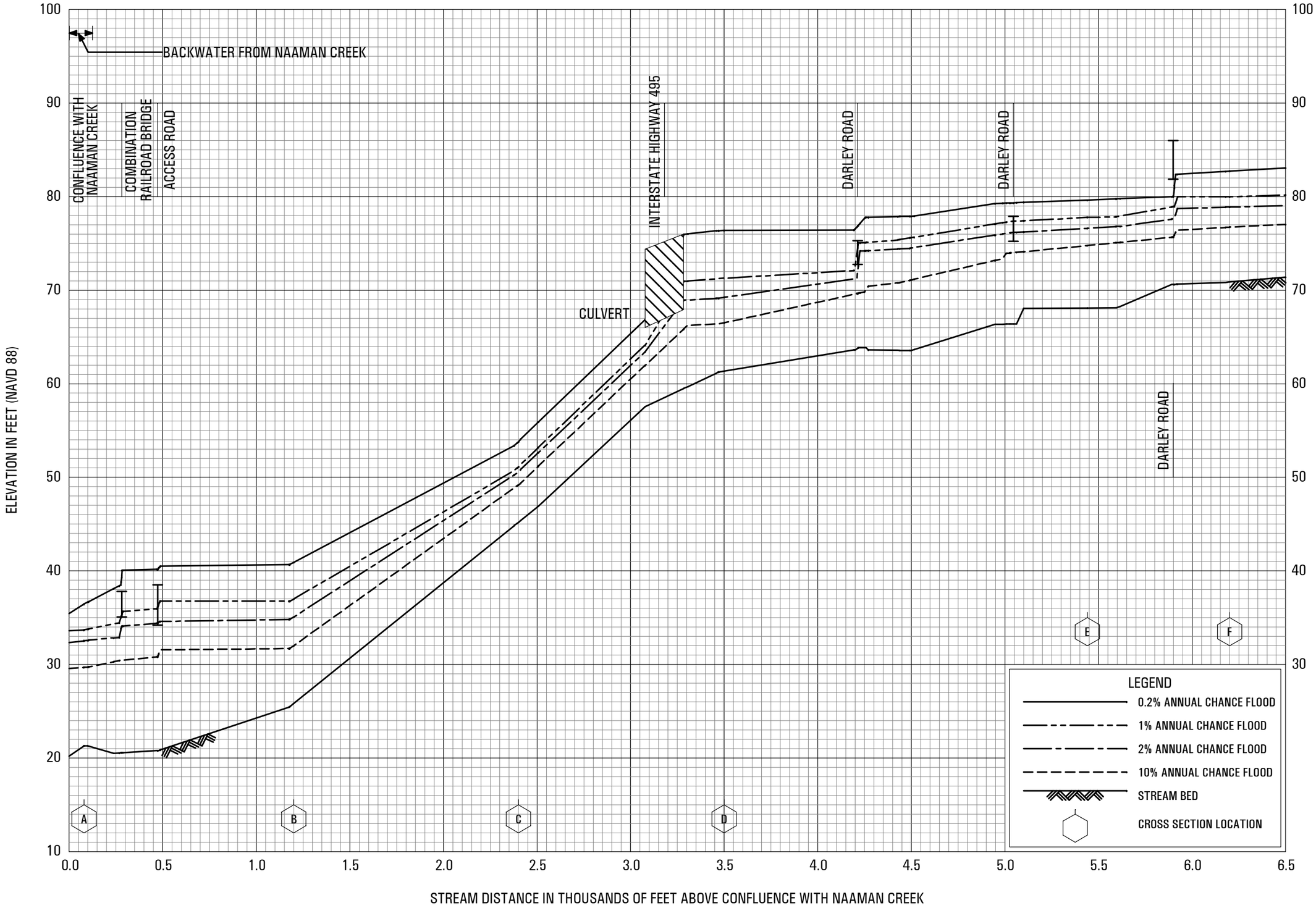
FLOOD PROFILES

SHELLPOT CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS



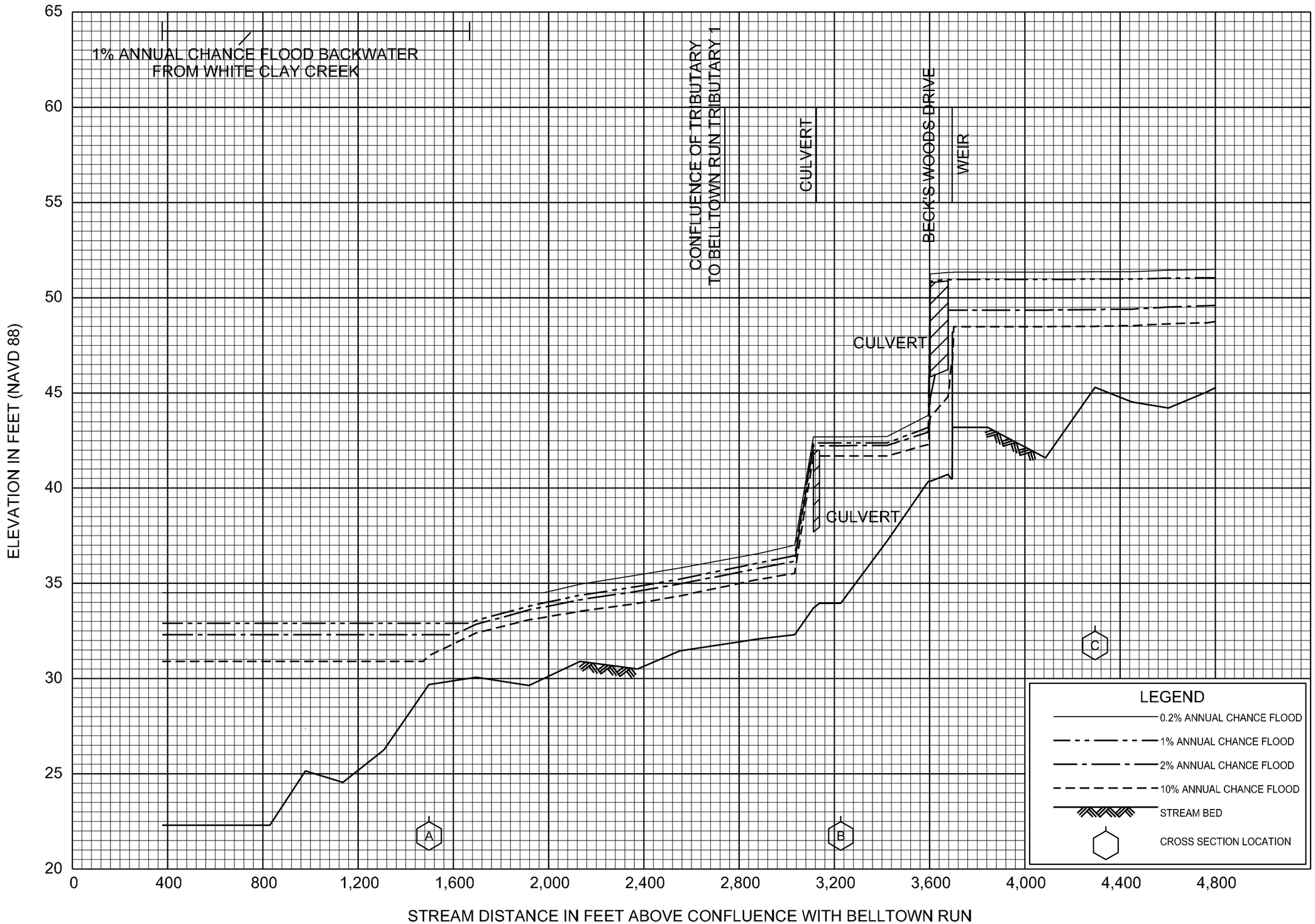
FLOOD PROFILES

SOUTH BRANCH NAAMAN CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE, DE

AND INCORPORATED AREAS

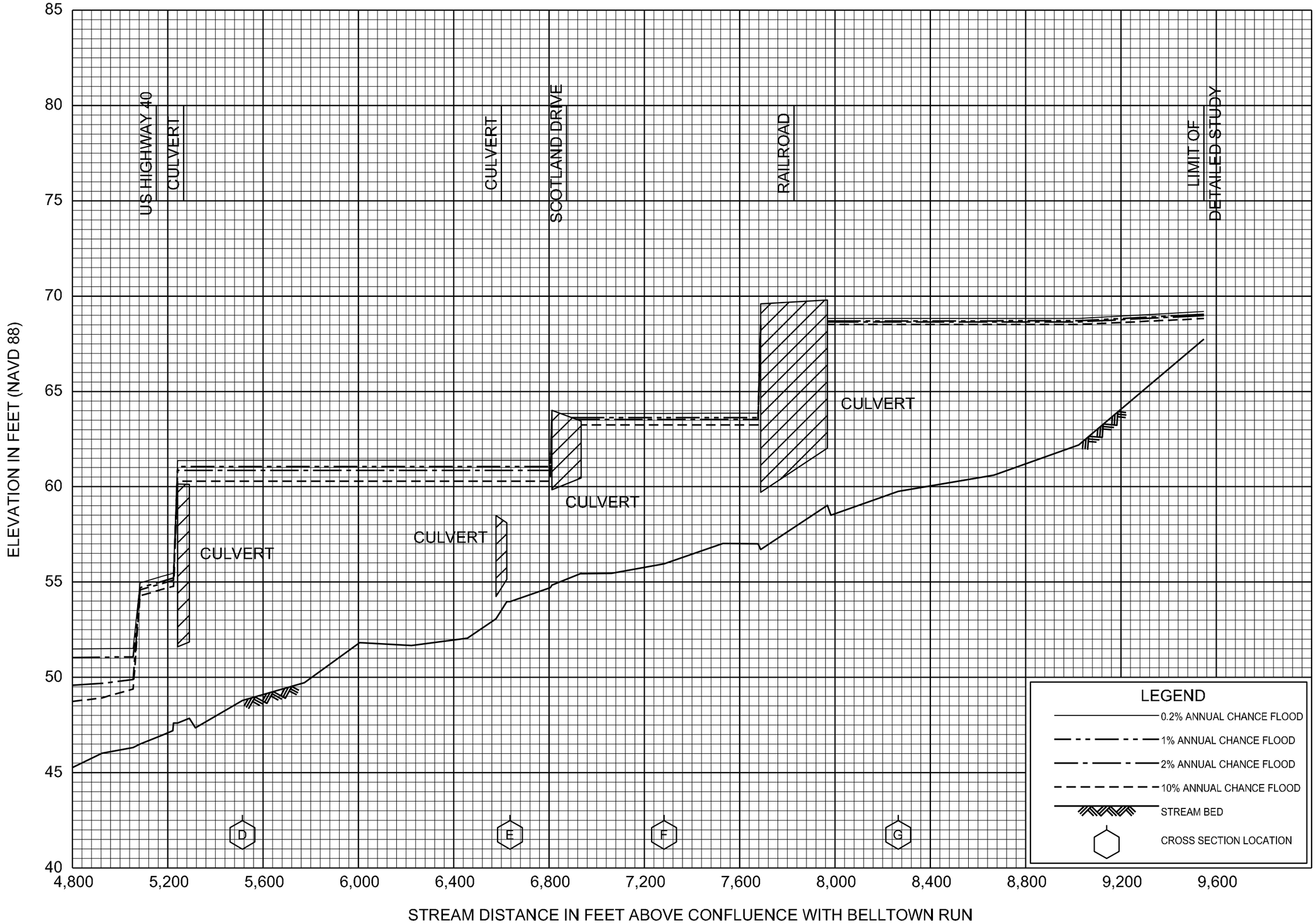


FLOOD PROFILES

TRIBUTARY TO BELLTOWN RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

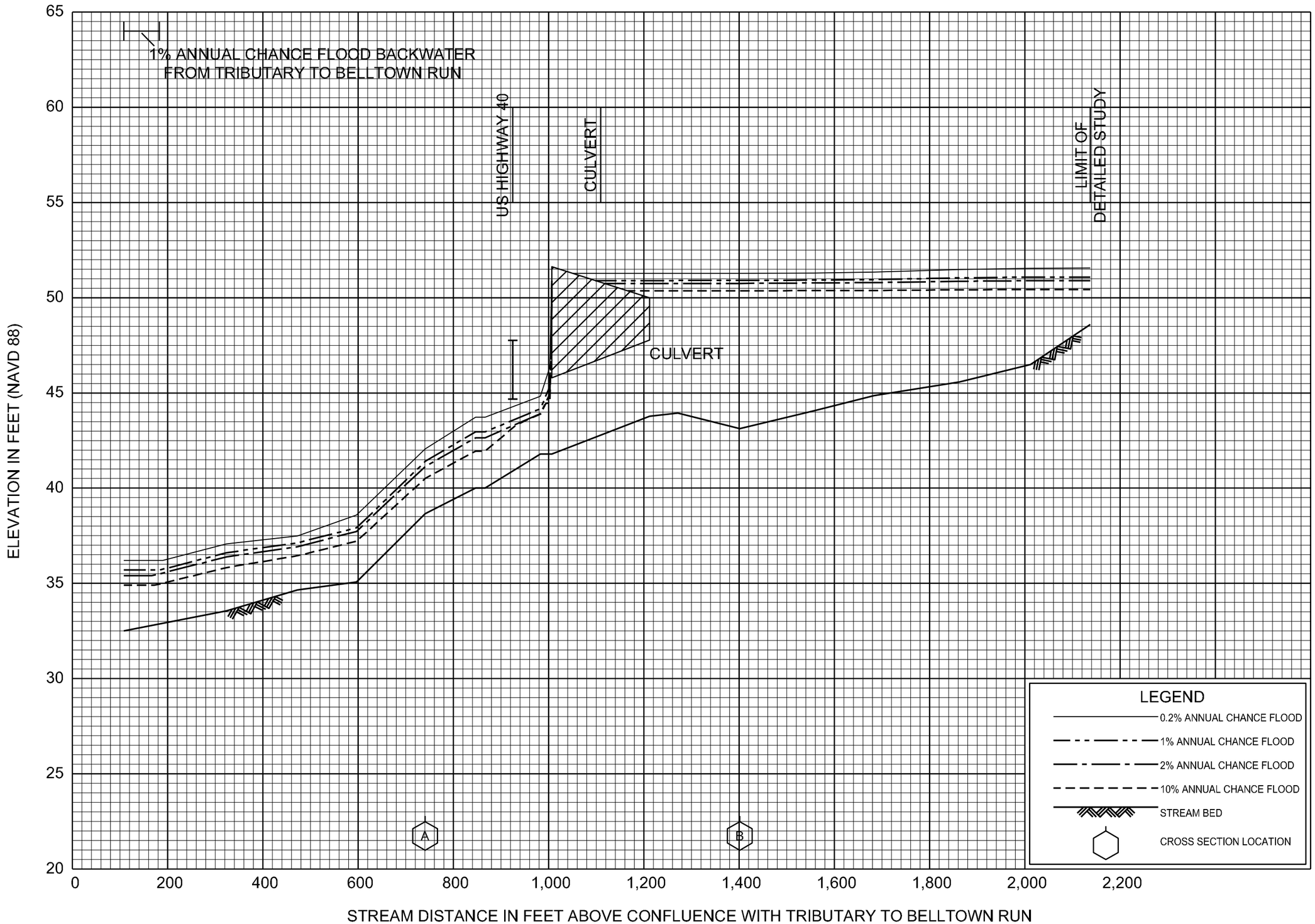


FLOOD PROFILES

TRIBUTARY TO BELLTOWN RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS



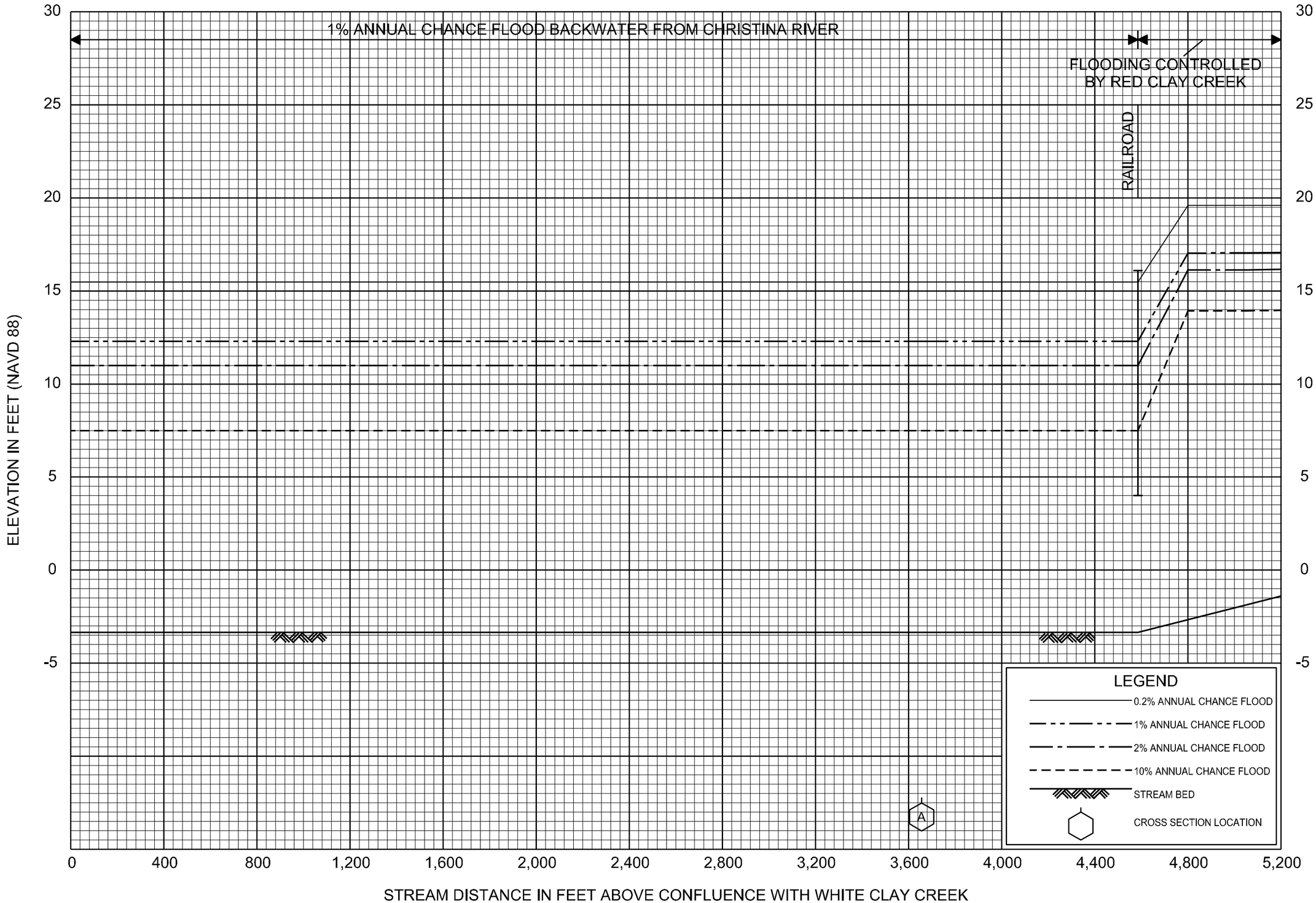
FLOOD PROFILES

TRIBUTARY TO BELLTOWN RUN TRIBUTARY 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

AND INCORPORATED AREAS

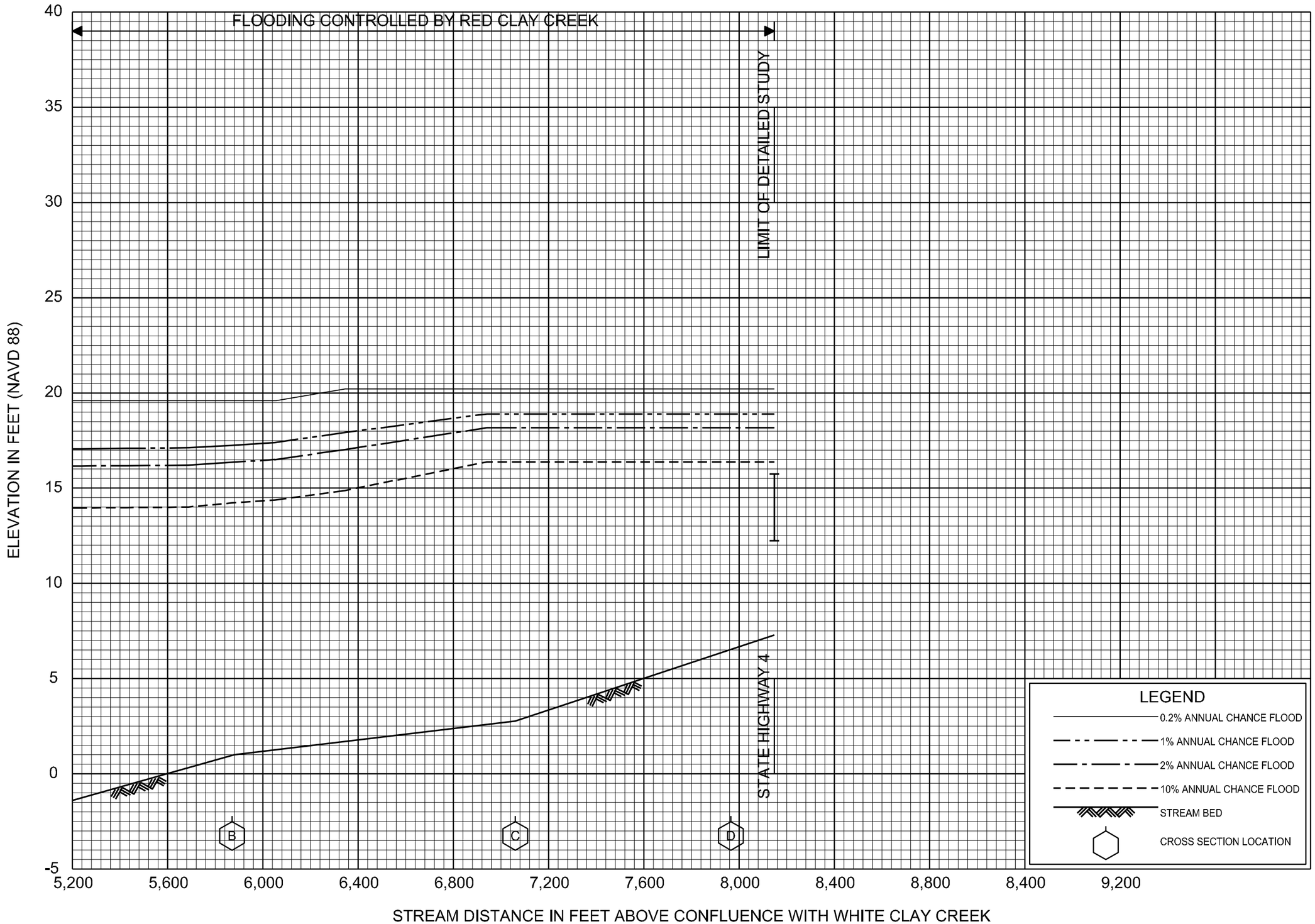


FLOOD PROFILES

TRIBUTARY TO WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

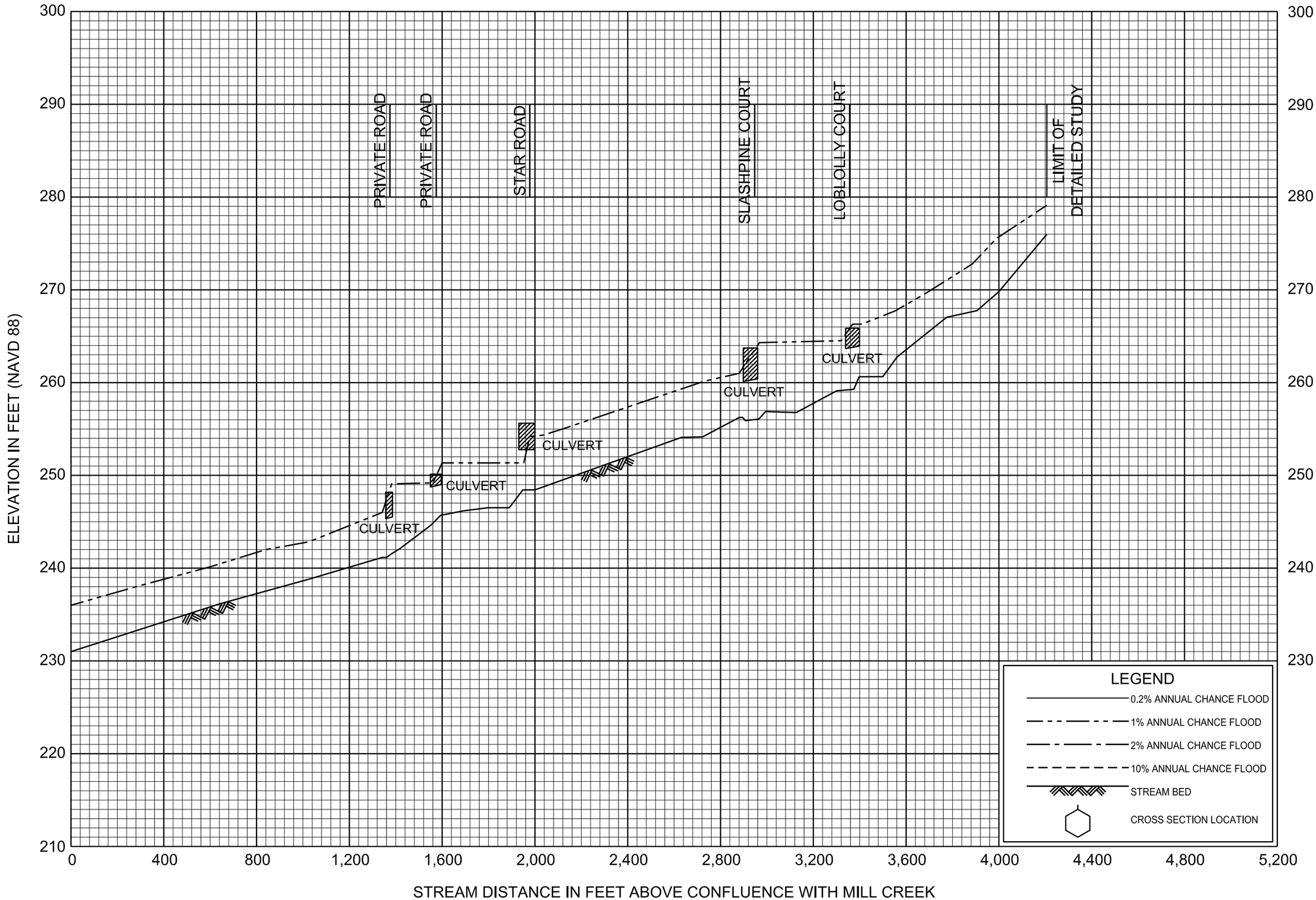


FLOOD PROFILES

TRIBUTARY TO WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

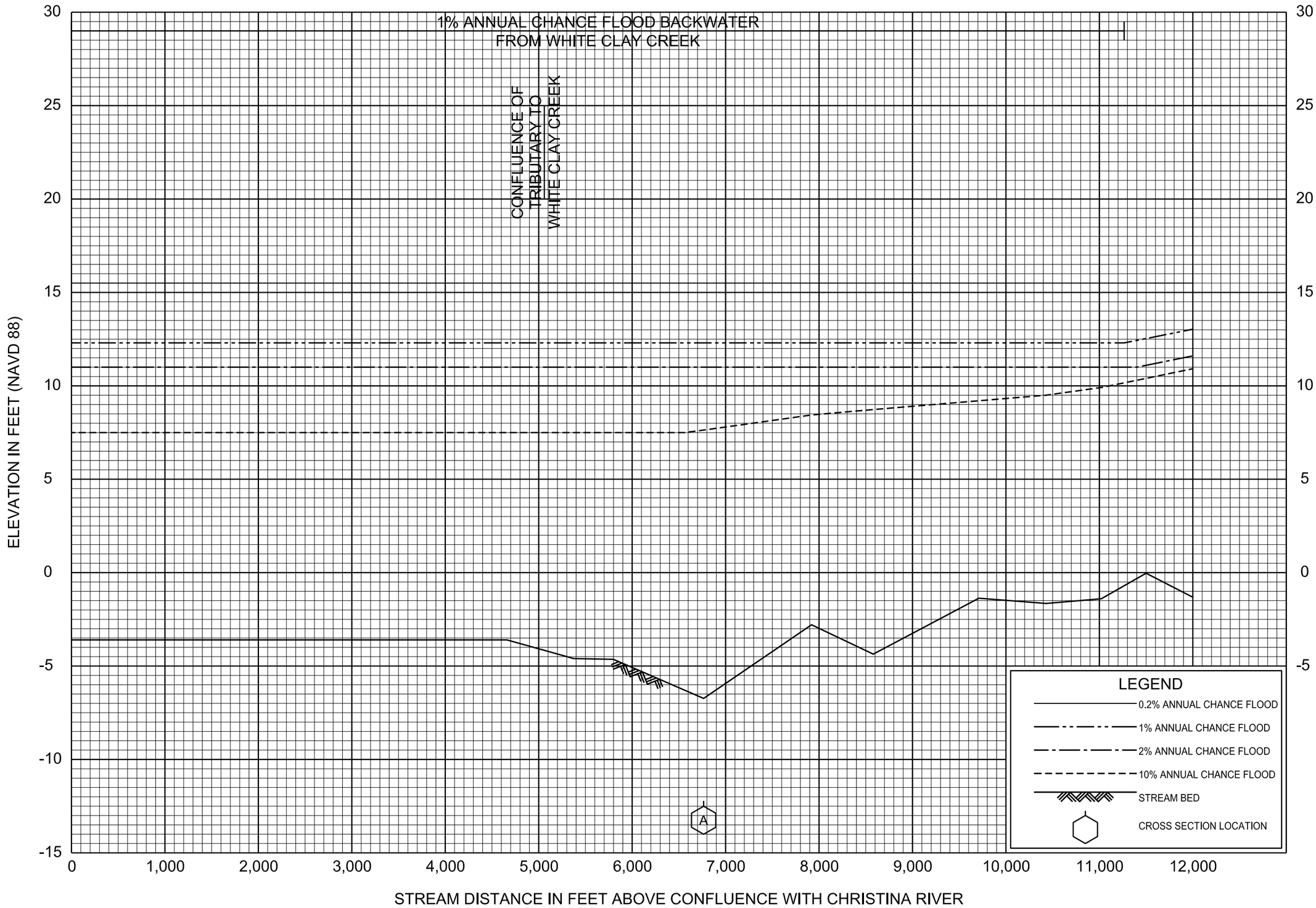


FLOOD PROFILES

UNNAMED TRIBUTARY TO MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

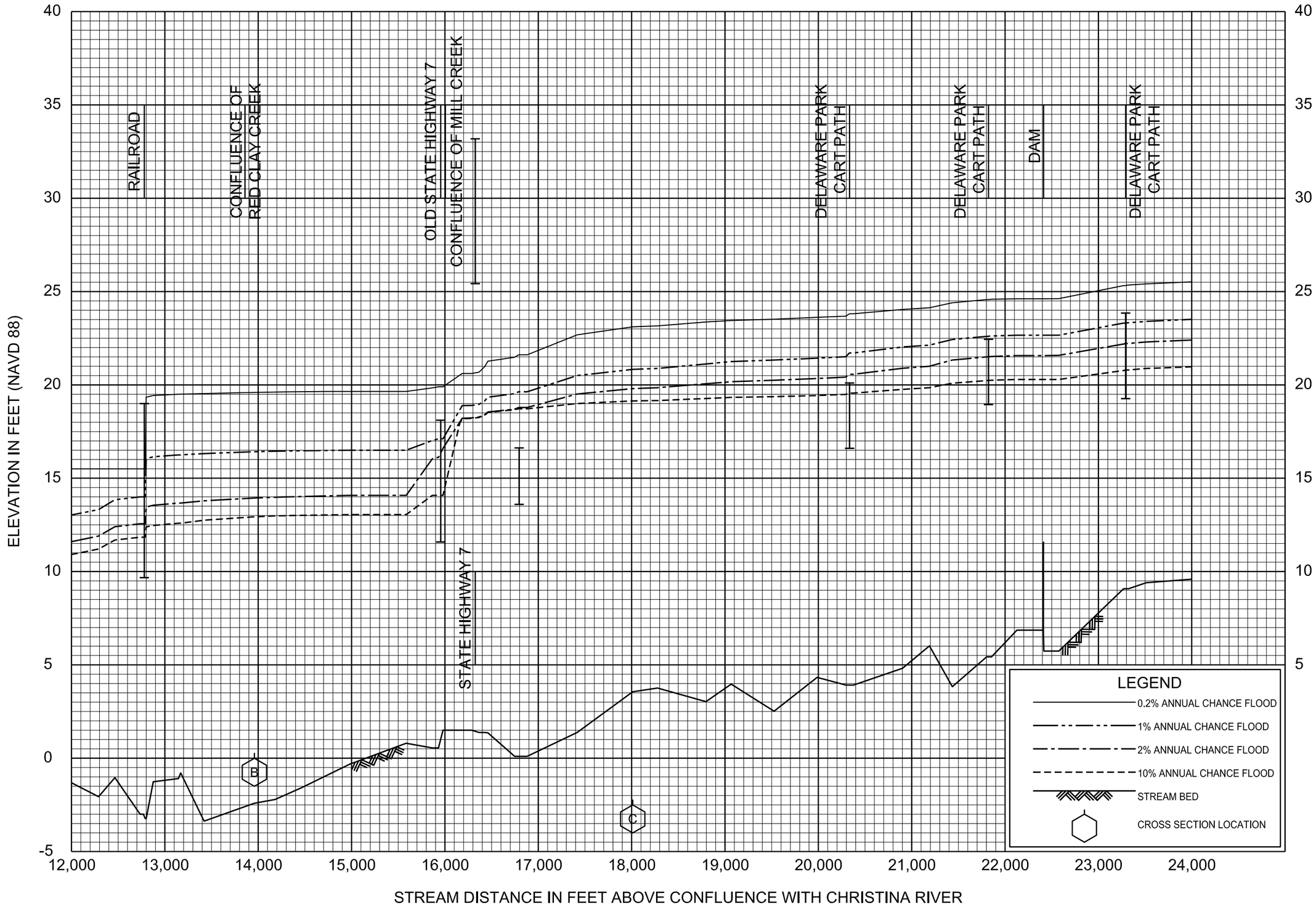


FLOOD PROFILES

WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

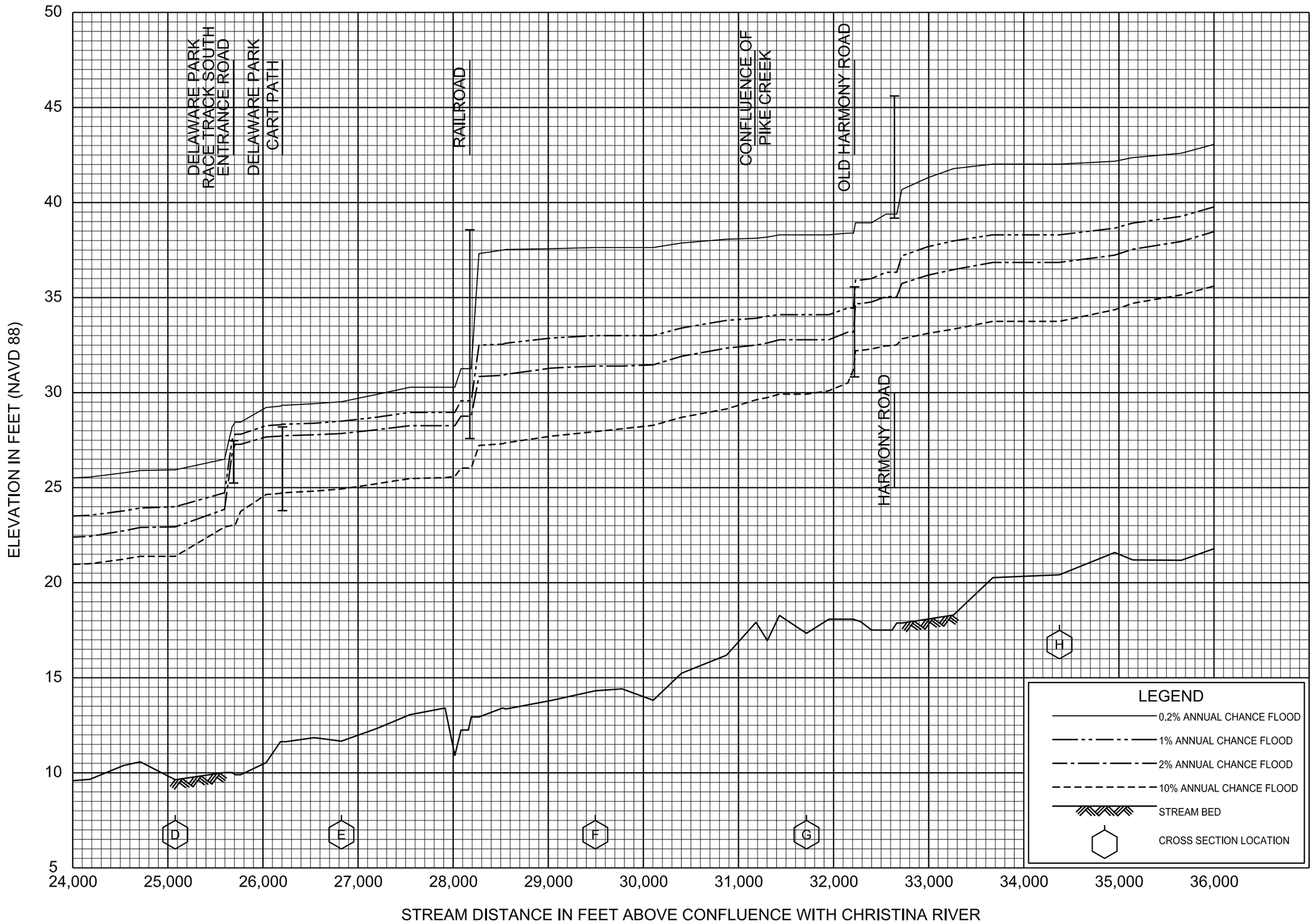


FLOOD PROFILES

WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

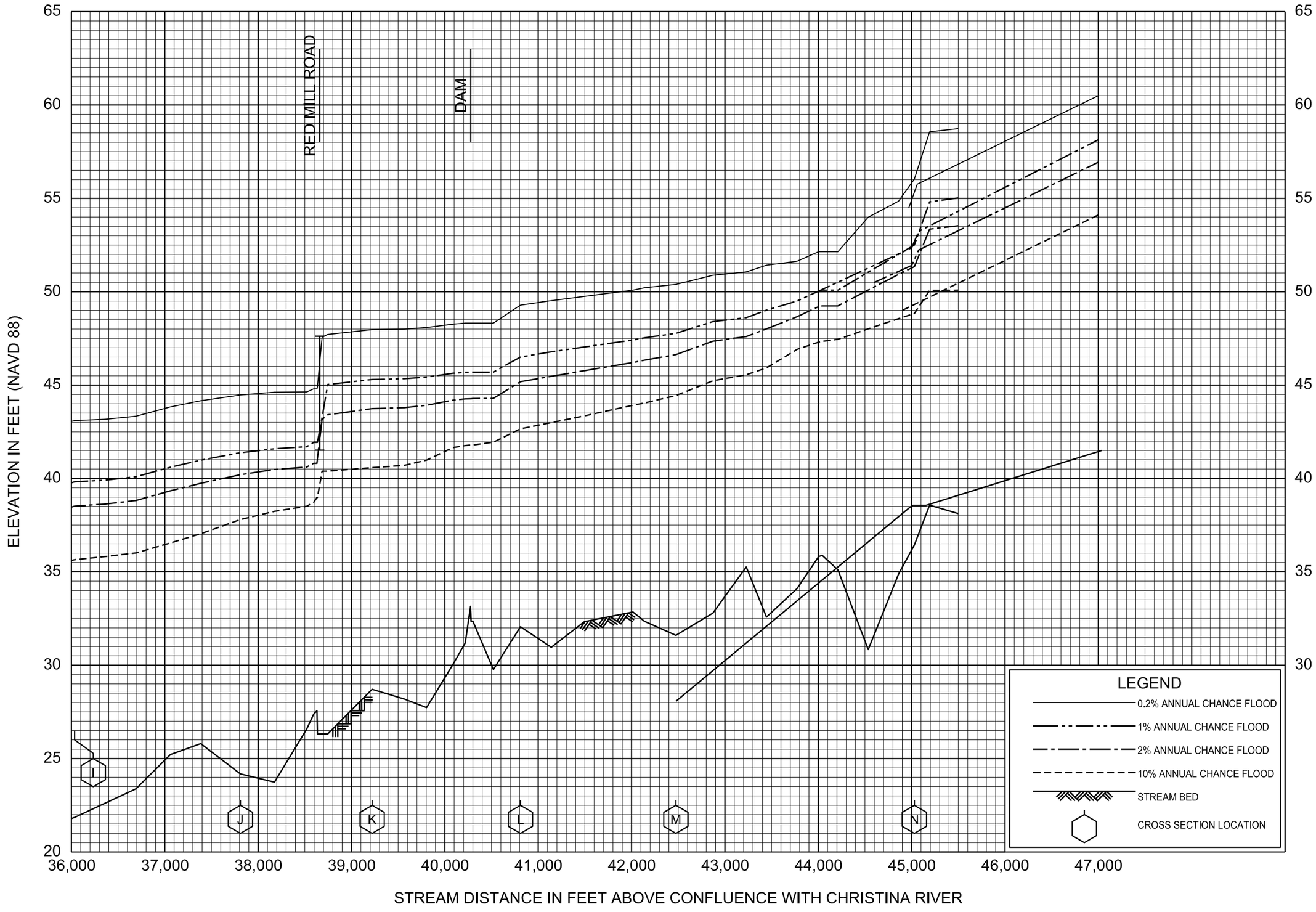


FLOOD PROFILES

WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

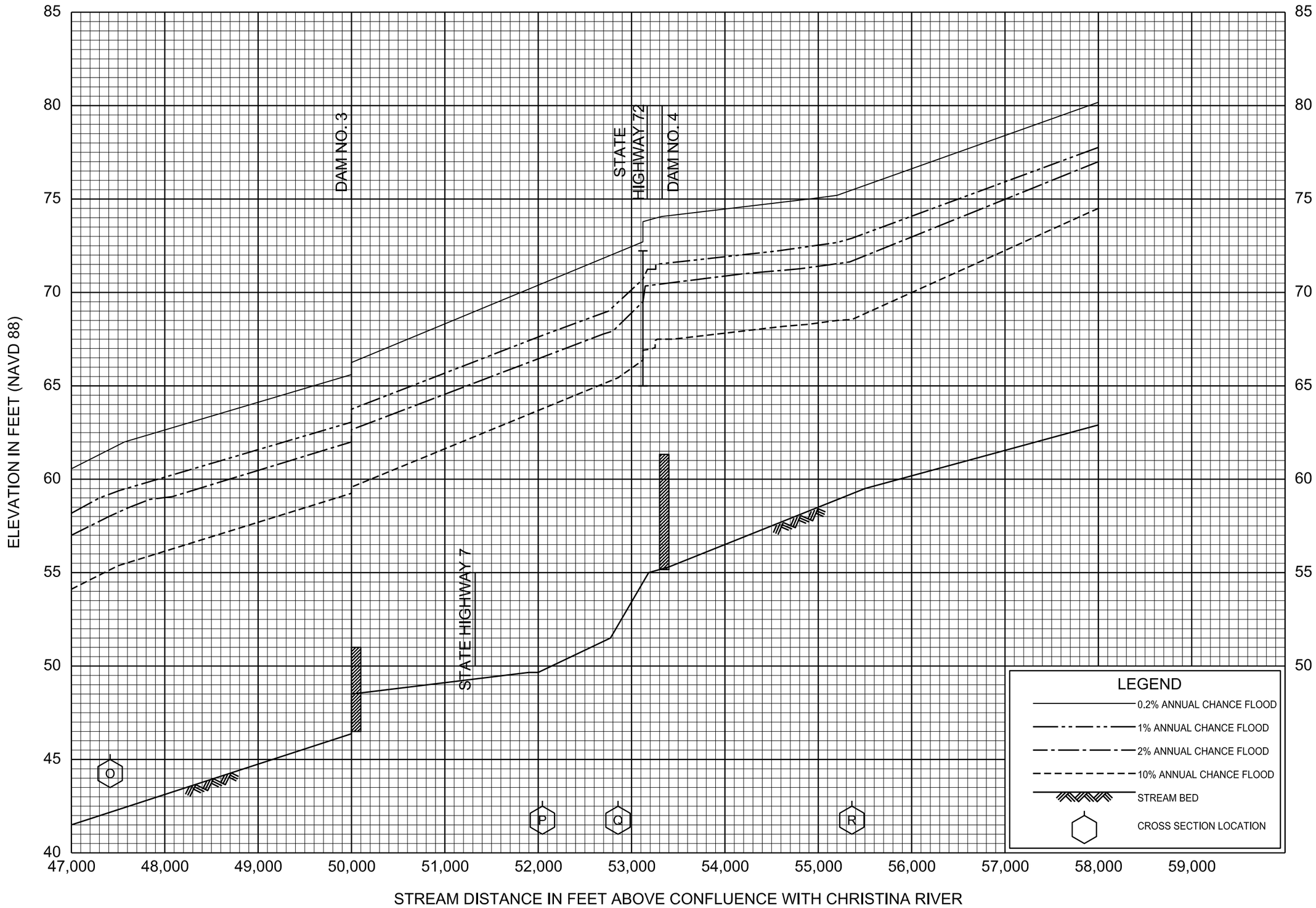


FLOOD PROFILES

WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

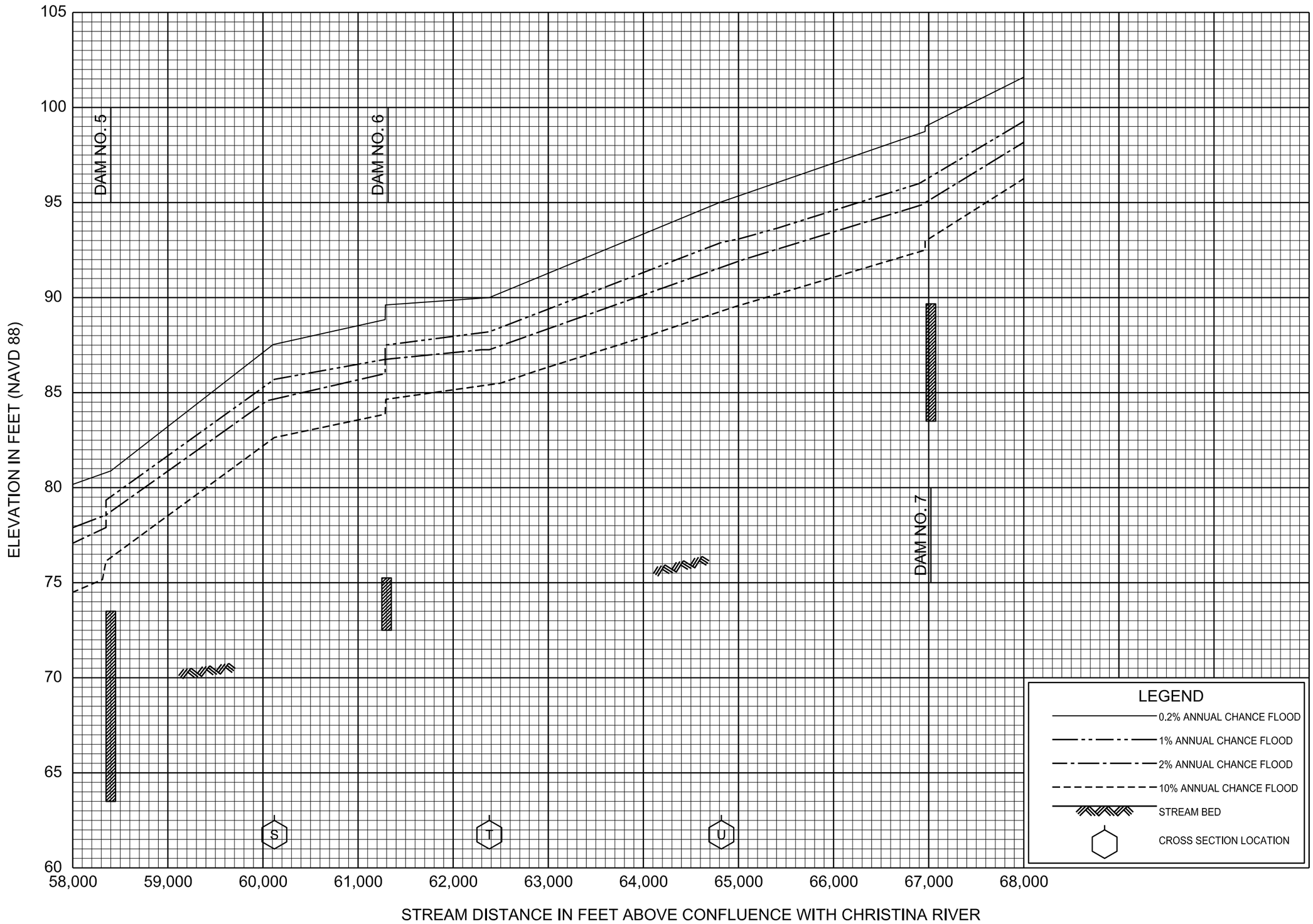


FLOOD PROFILES

WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

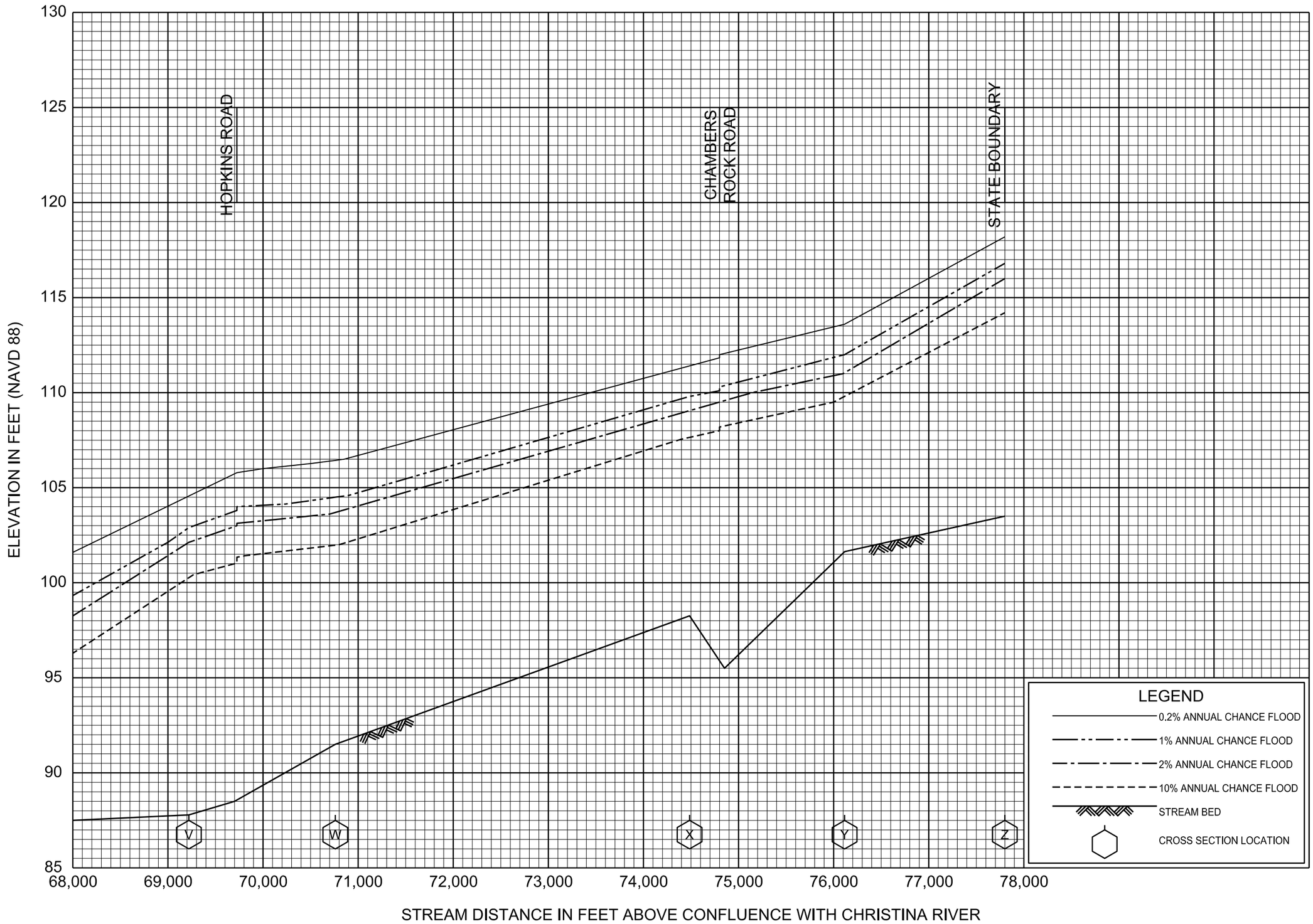


FLOOD PROFILES

WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

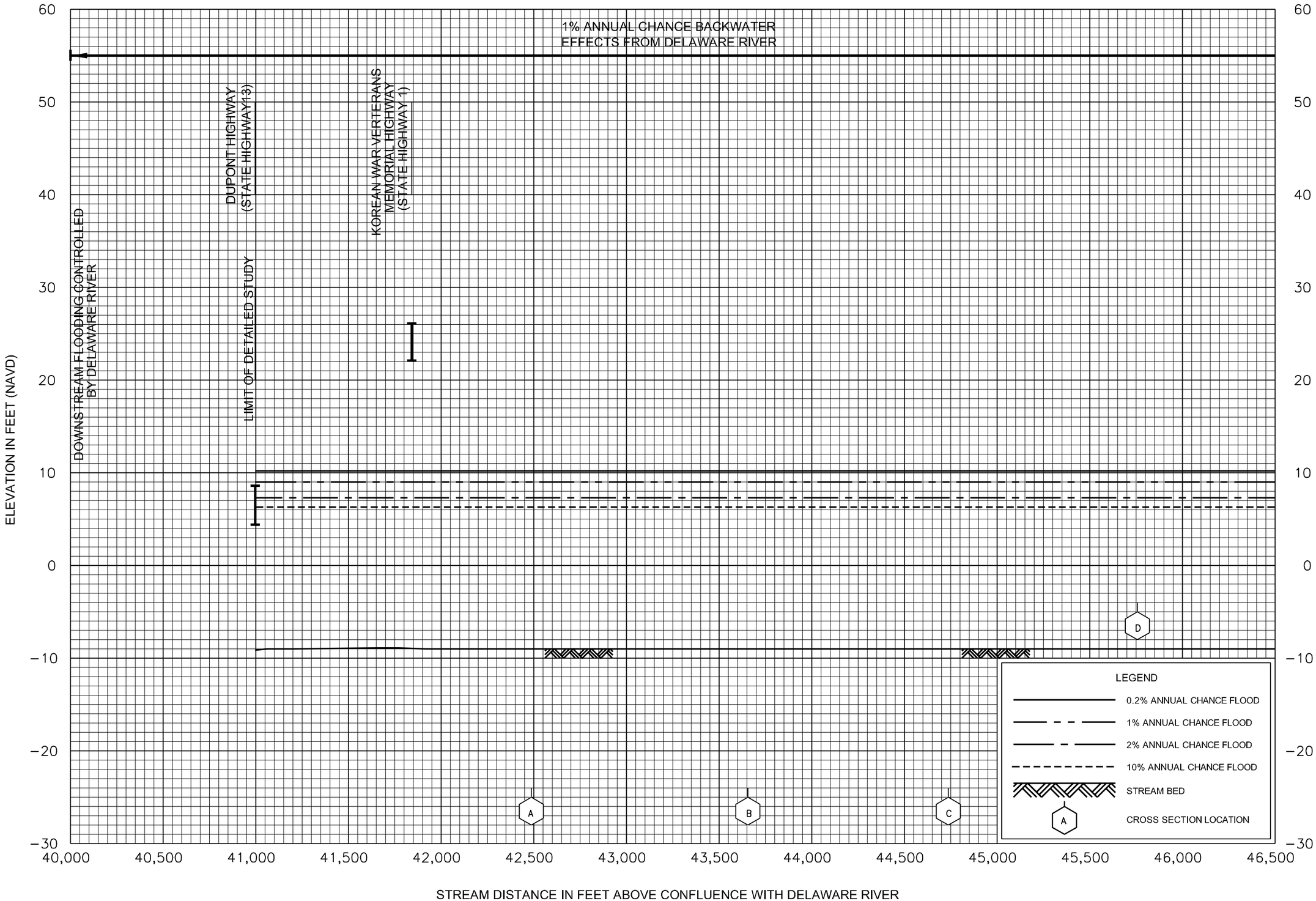


FLOOD PROFILES

WHITE CLAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS



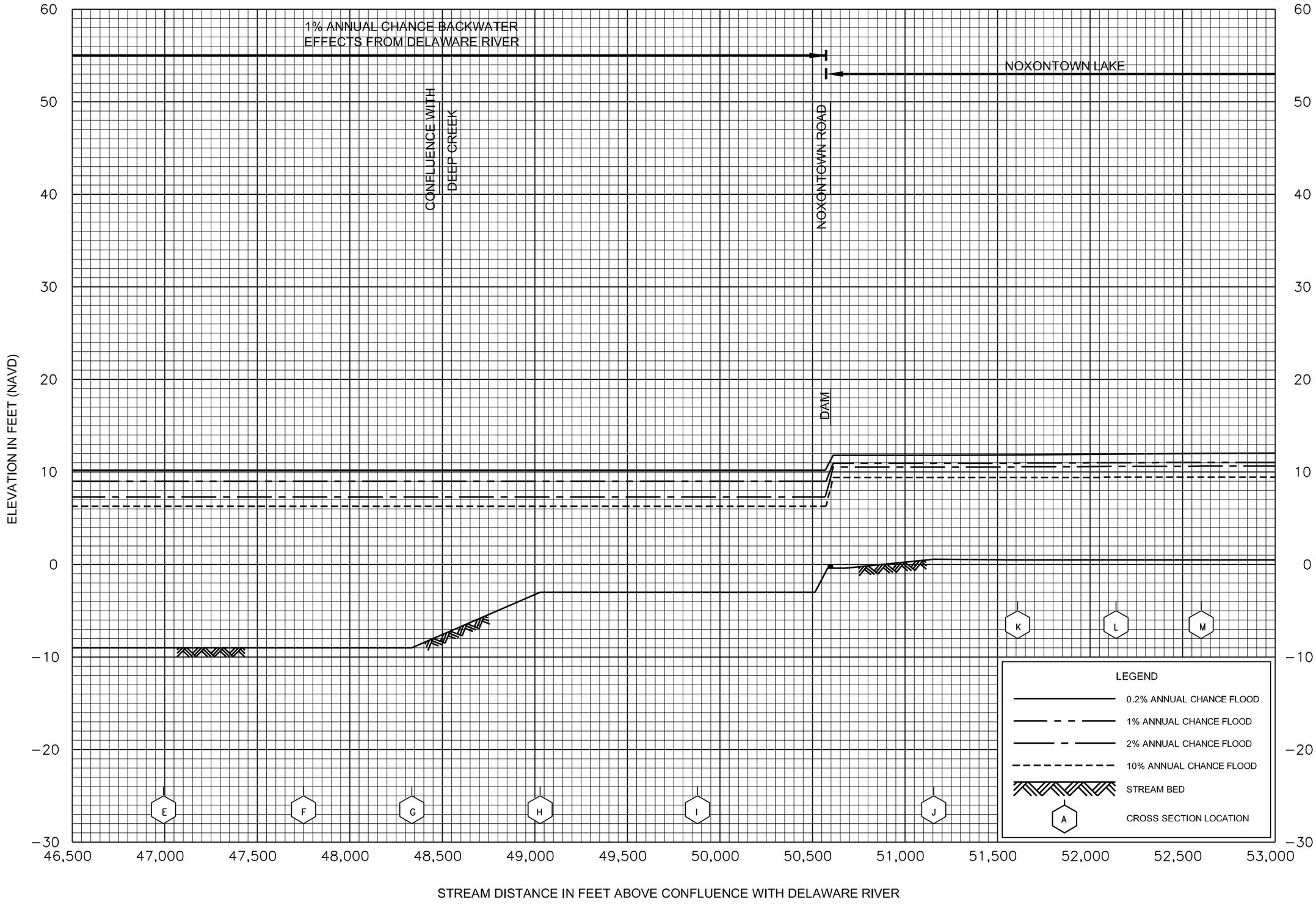
FLOOD PROFILES

APPOQUINIMINK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

104P

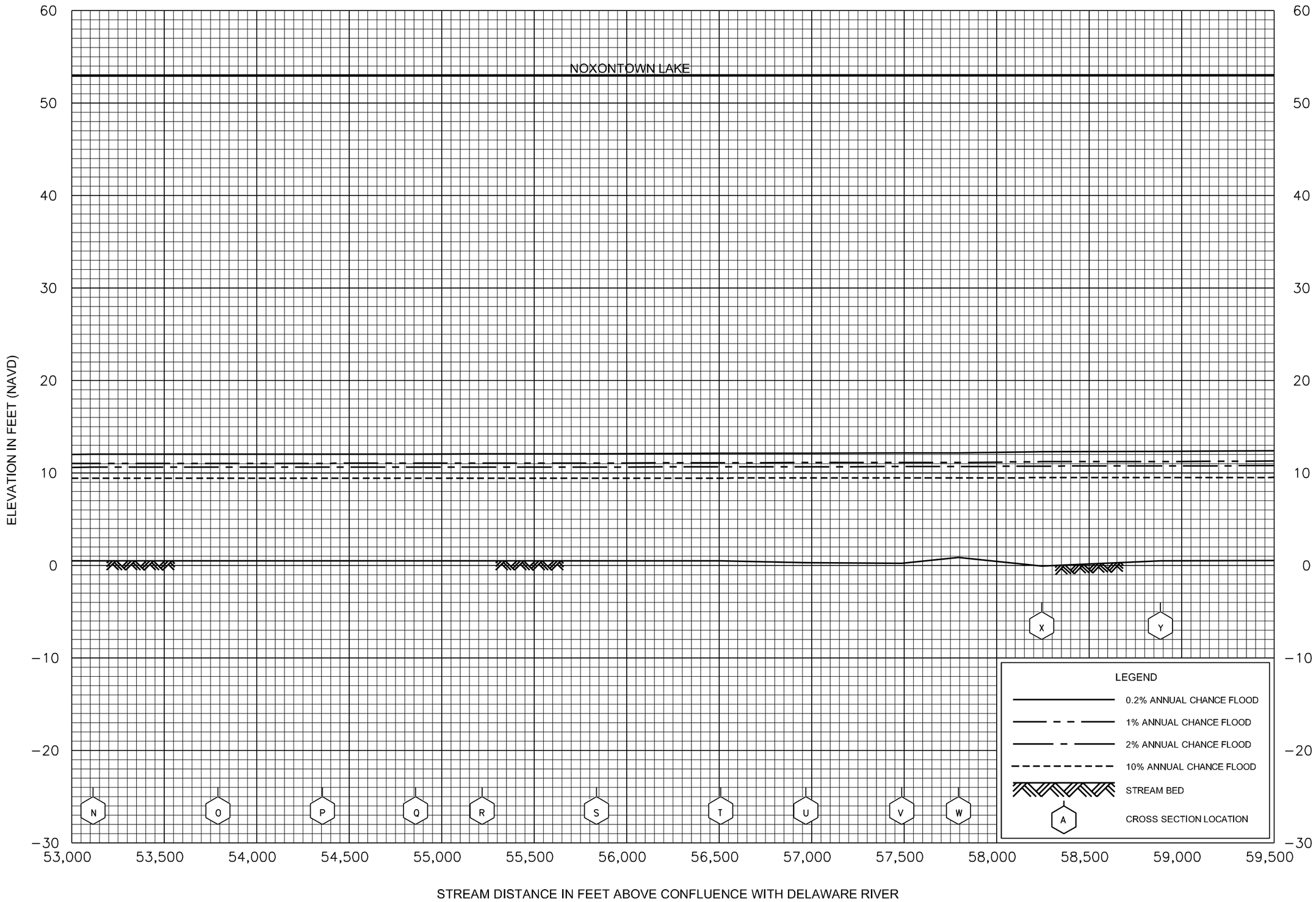


FLOOD PROFILES

APPOQUINIMINK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

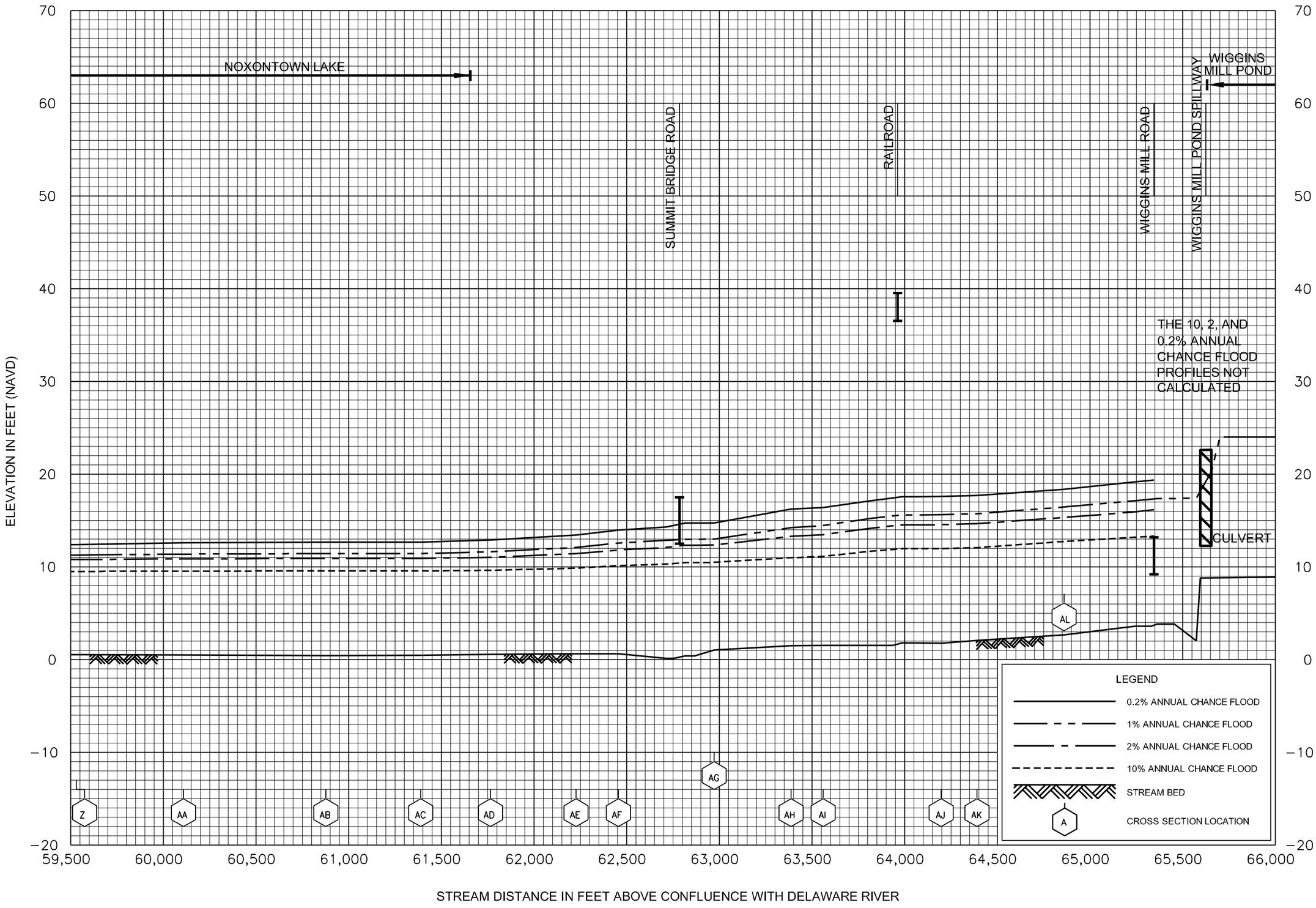


FLOOD PROFILES

APPOQUINIMINK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

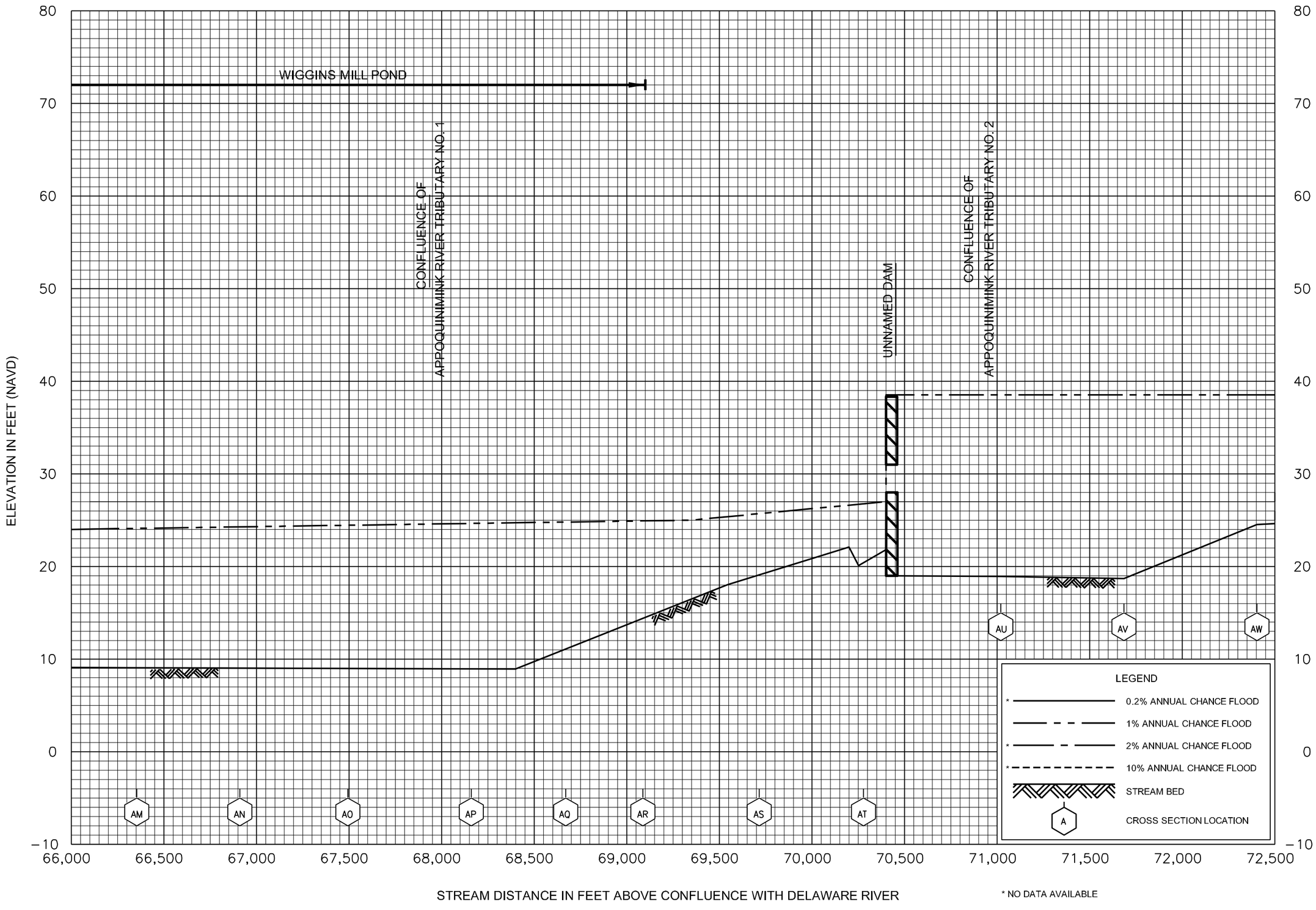


FLOOD PROFILES

APPOQUINIMINK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

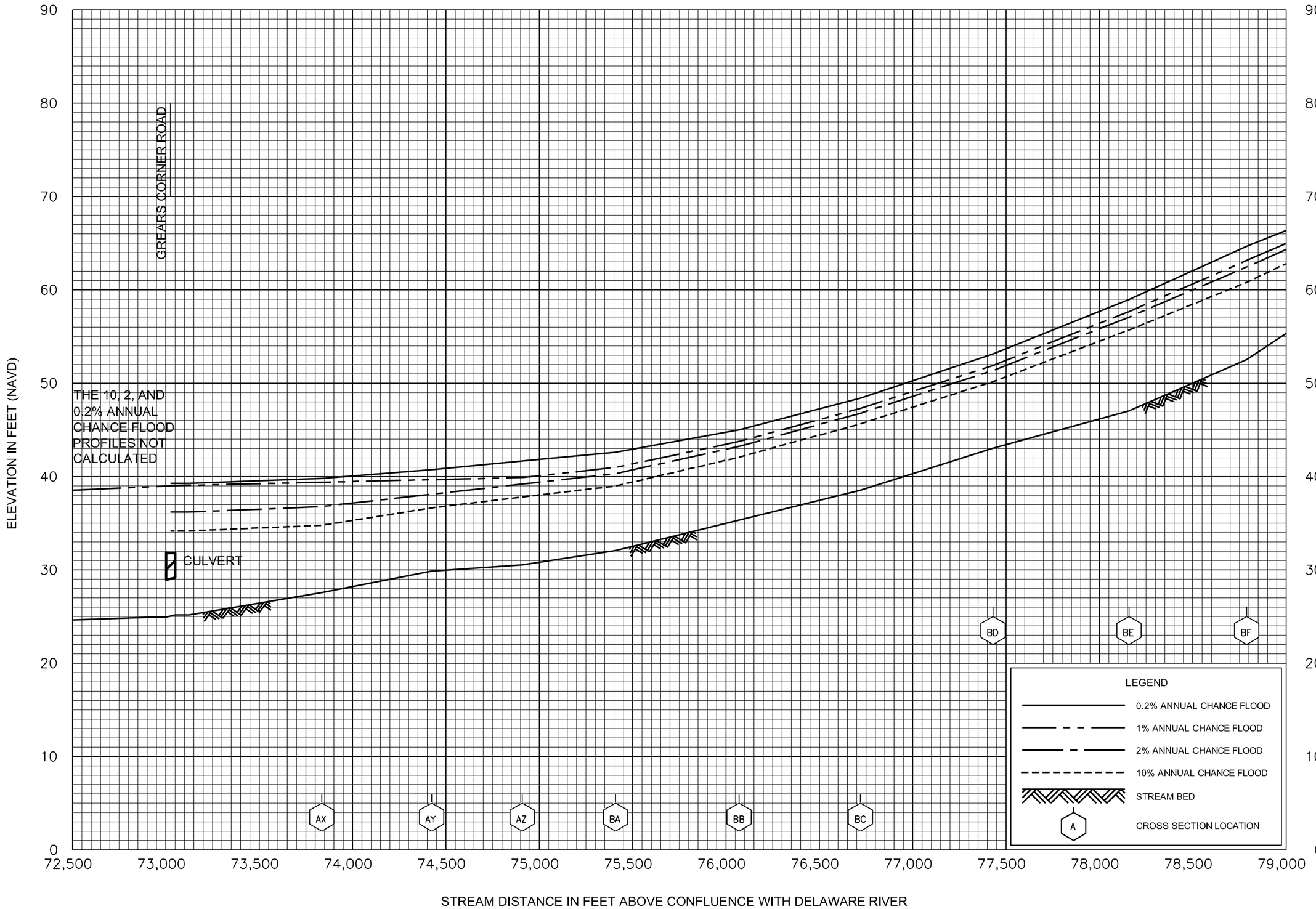


FLOOD PROFILES

APPOQUINIMINK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

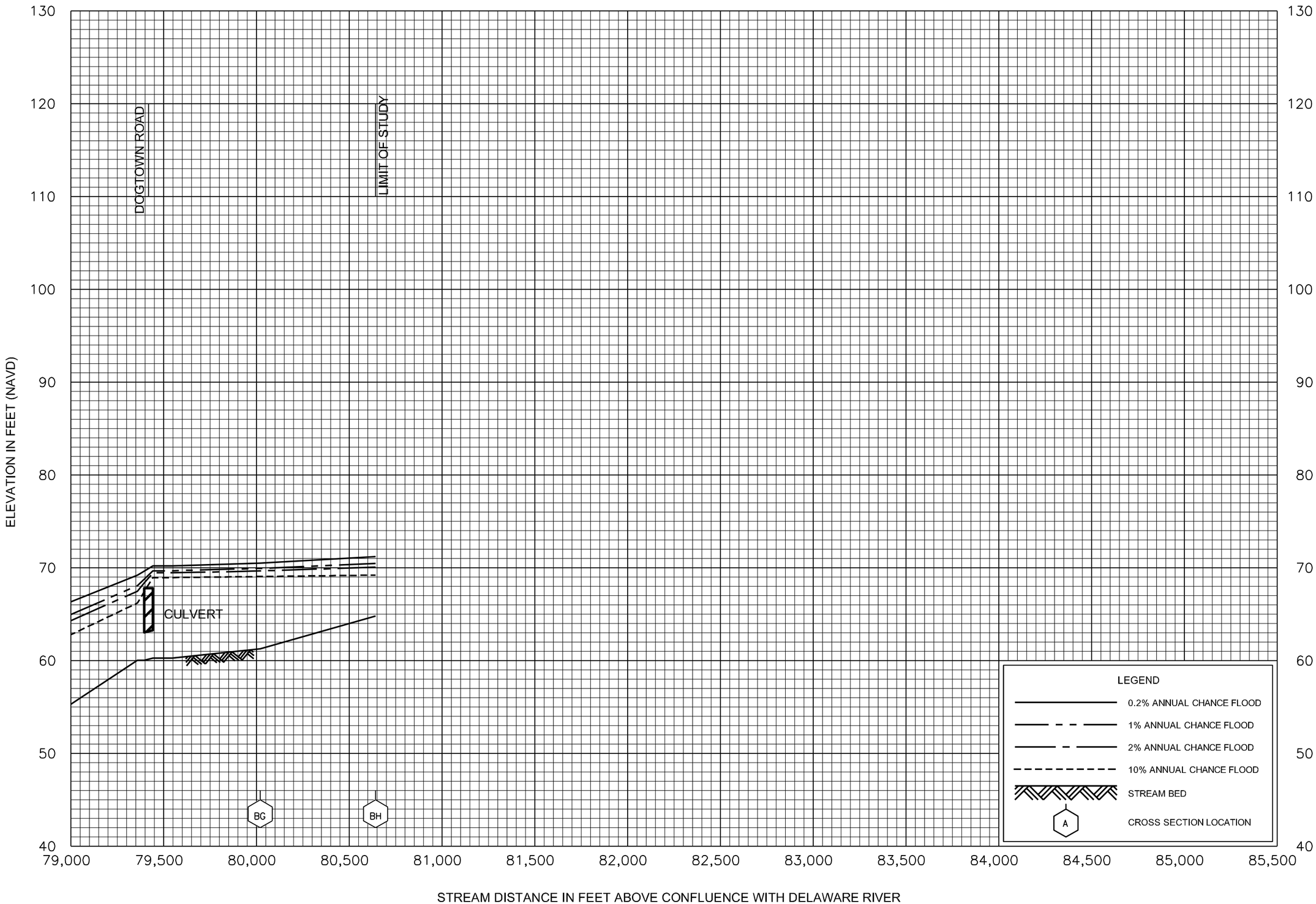


FLOOD PROFILES

APPOQUINIMINK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS



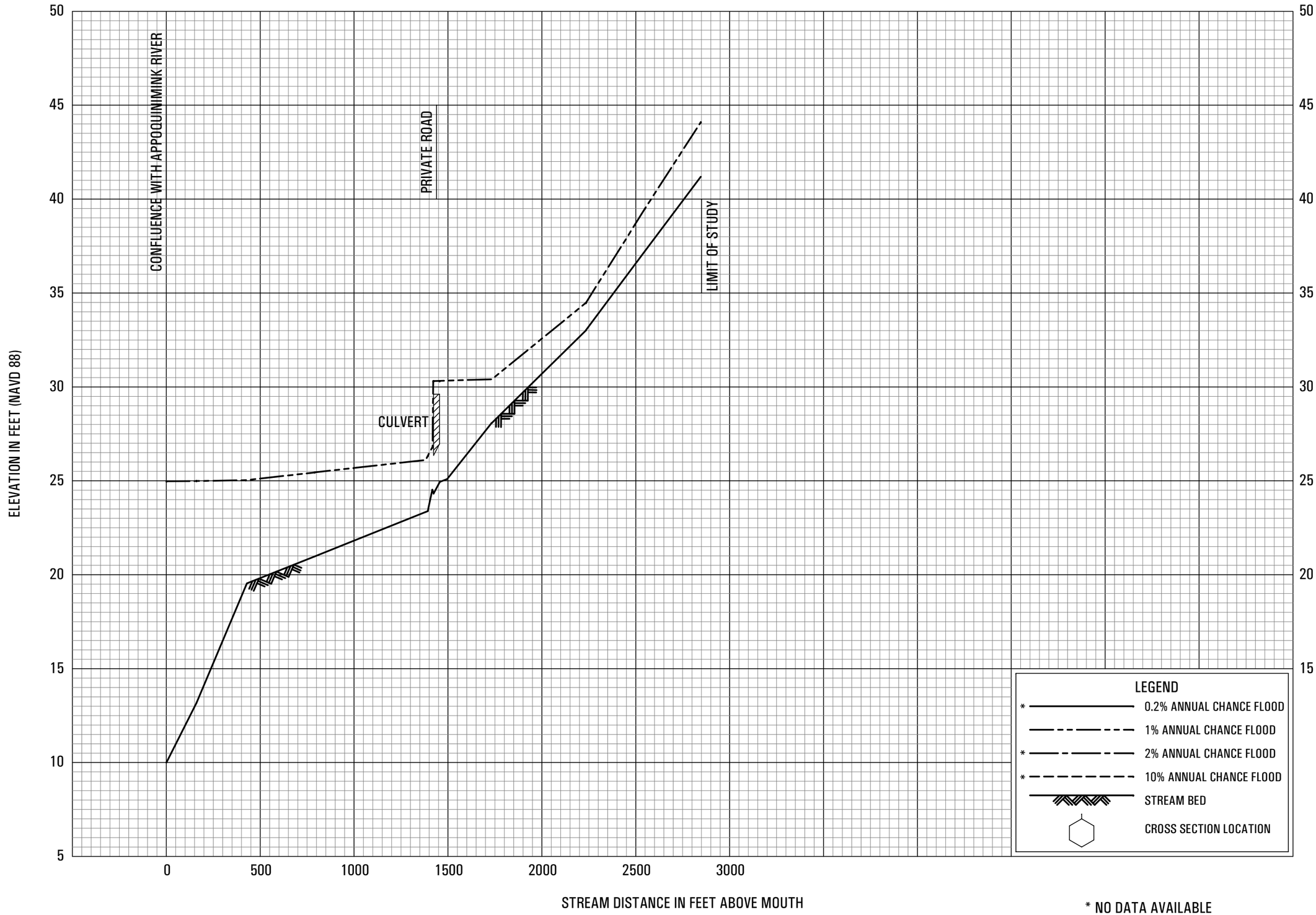
FLOOD PROFILES

APPOQUINIMINK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

110P



* NO DATA AVAILABLE

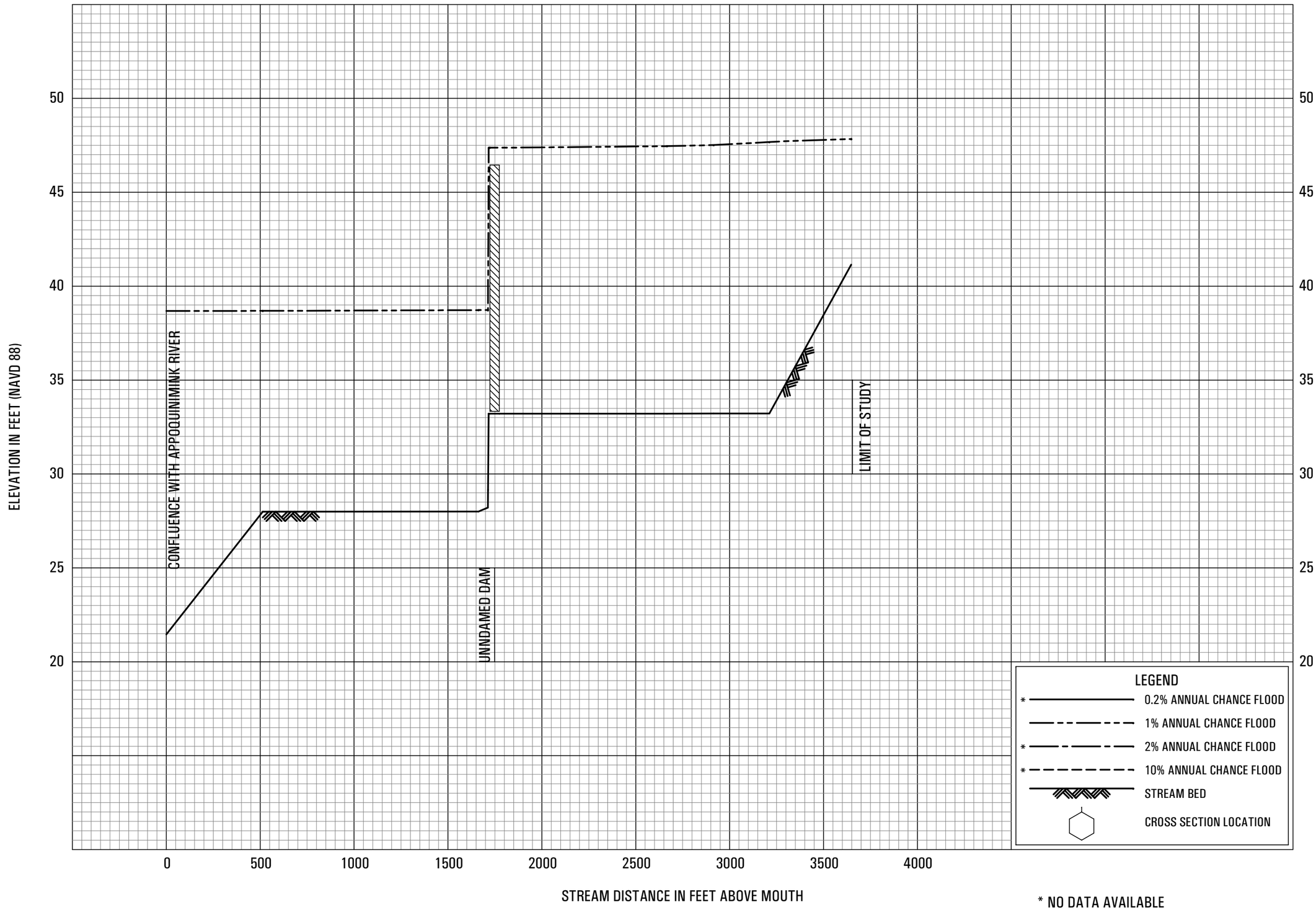
FLOOD PROFILES

APPOQUINIMINK RIVER TRIBUTARY NO. 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

(AND INCORPORATED AREAS)



* NO DATA AVAILABLE

FLOOD PROFILES

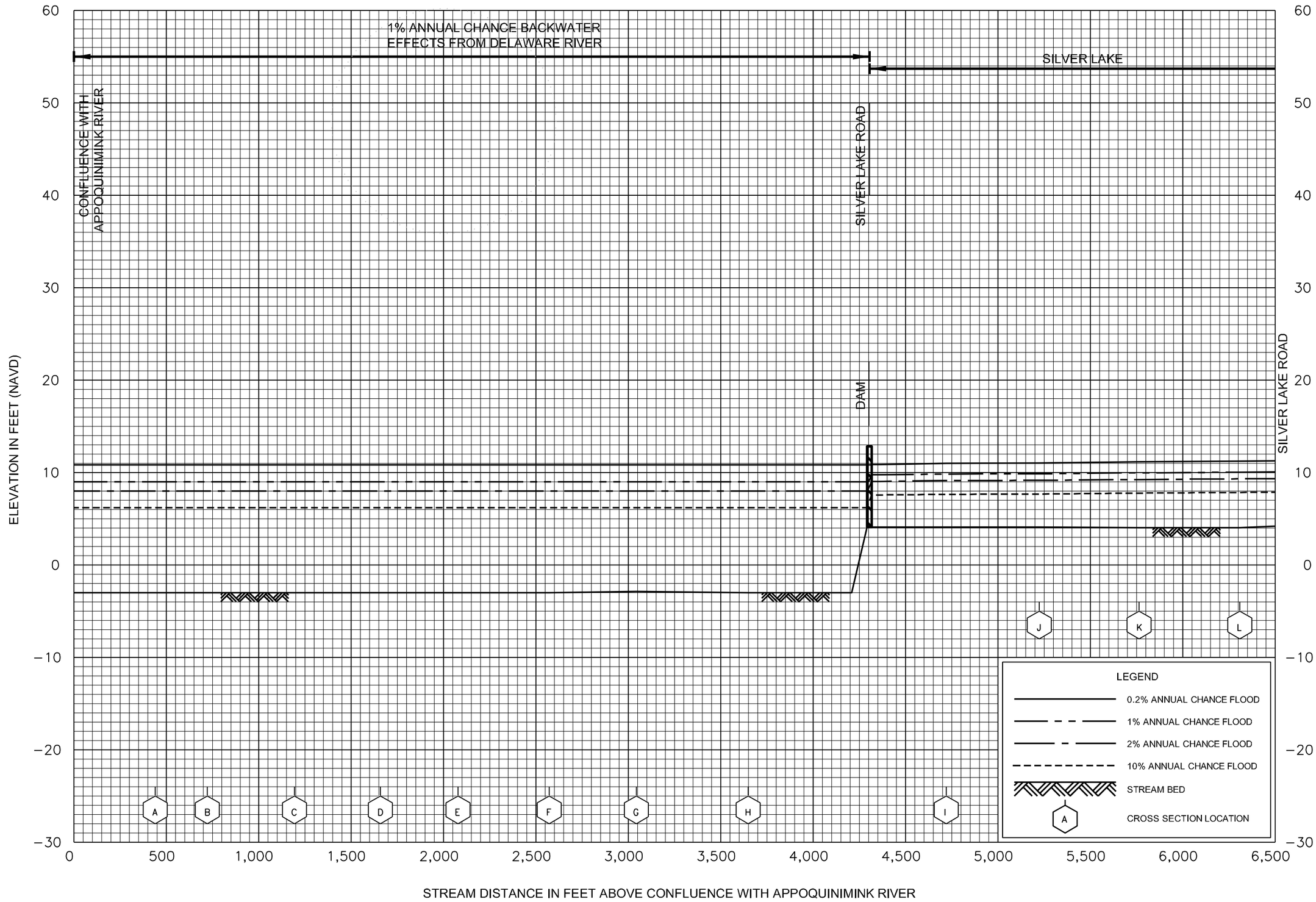
APPOQUINIMINK RIVER TRIBUTARY NO. 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE

(AND INCORPORATED AREAS)

116P

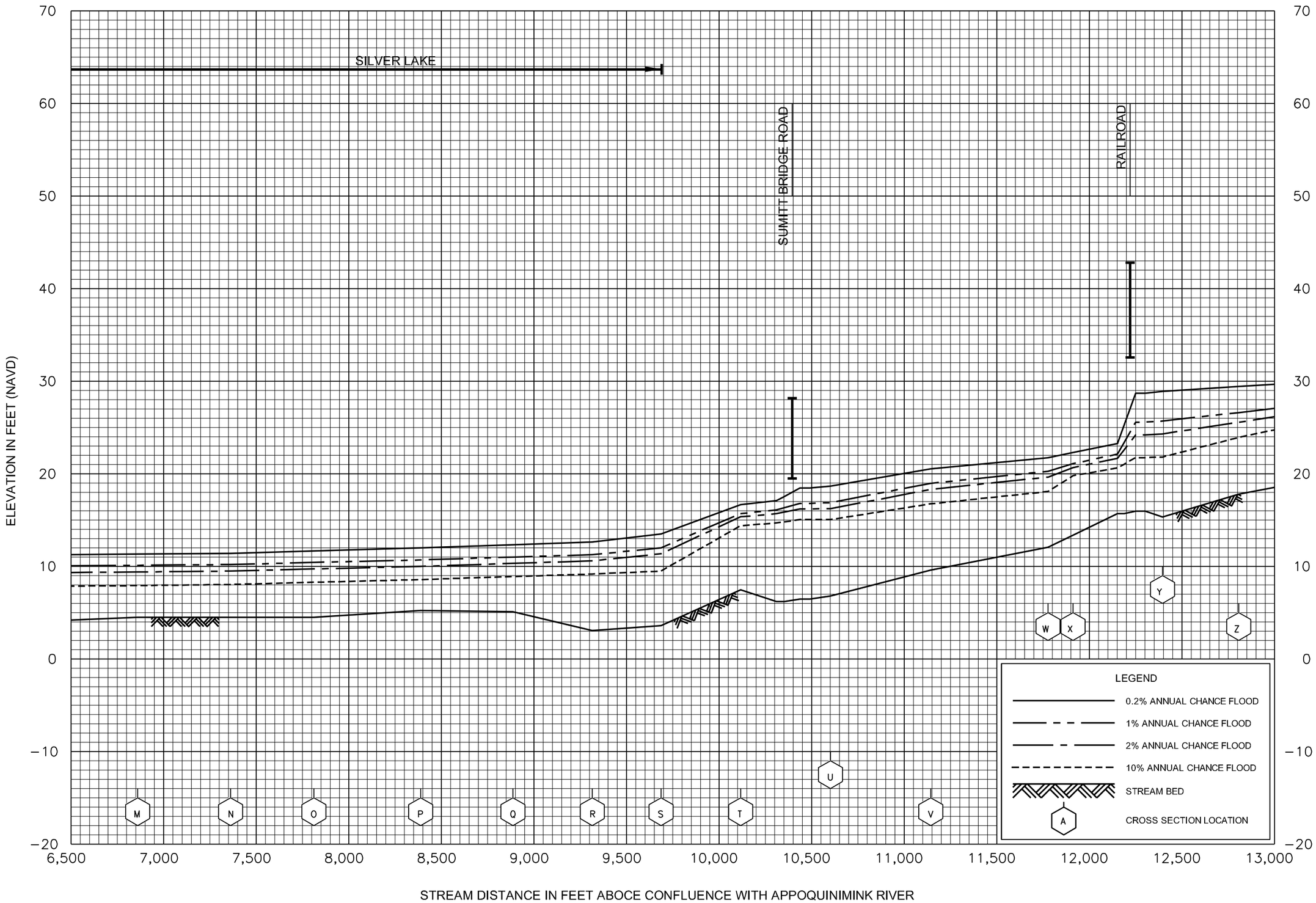


FLOOD PROFILES

DEEP CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS



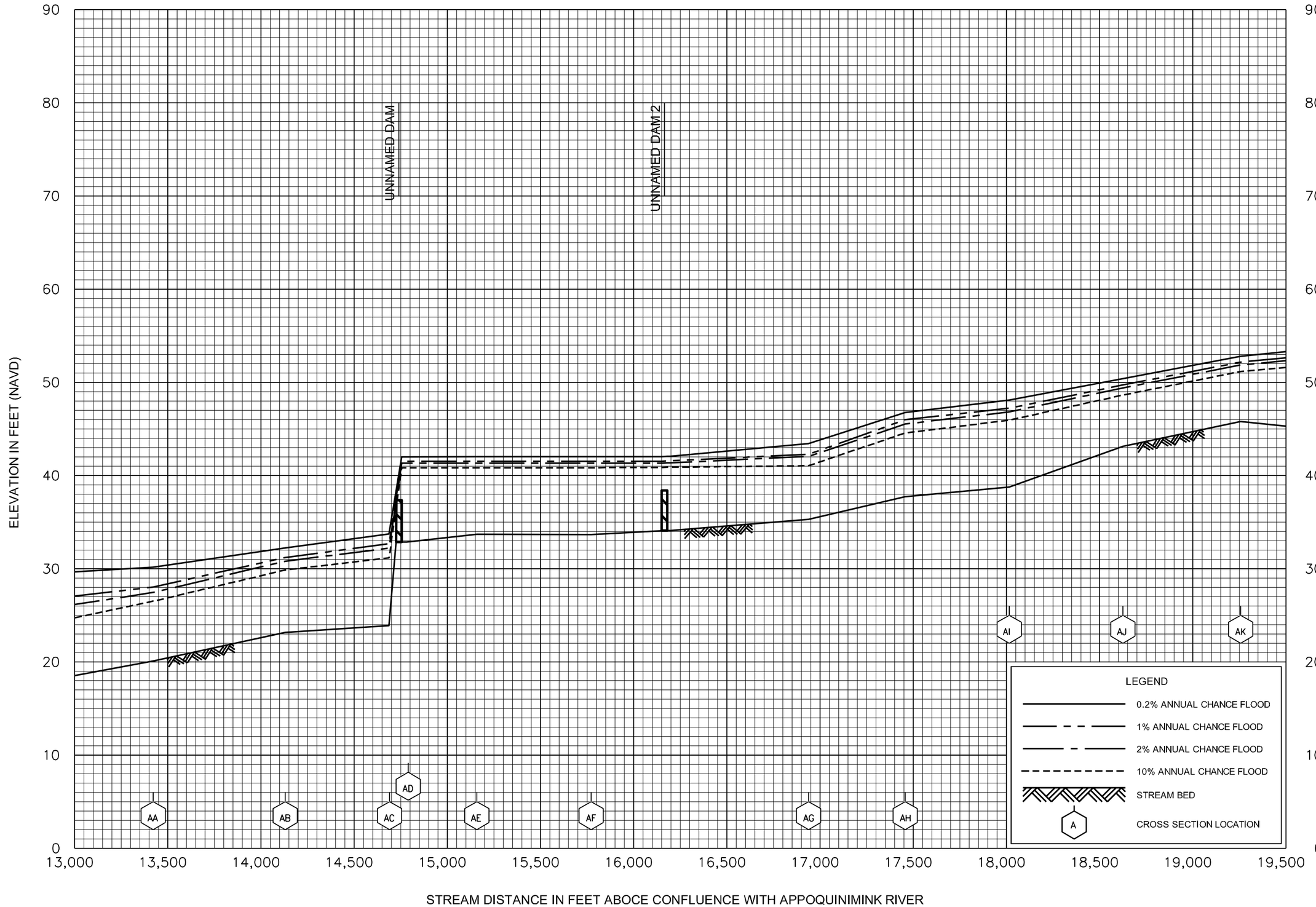
FLOOD PROFILES

DEEP CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

118P

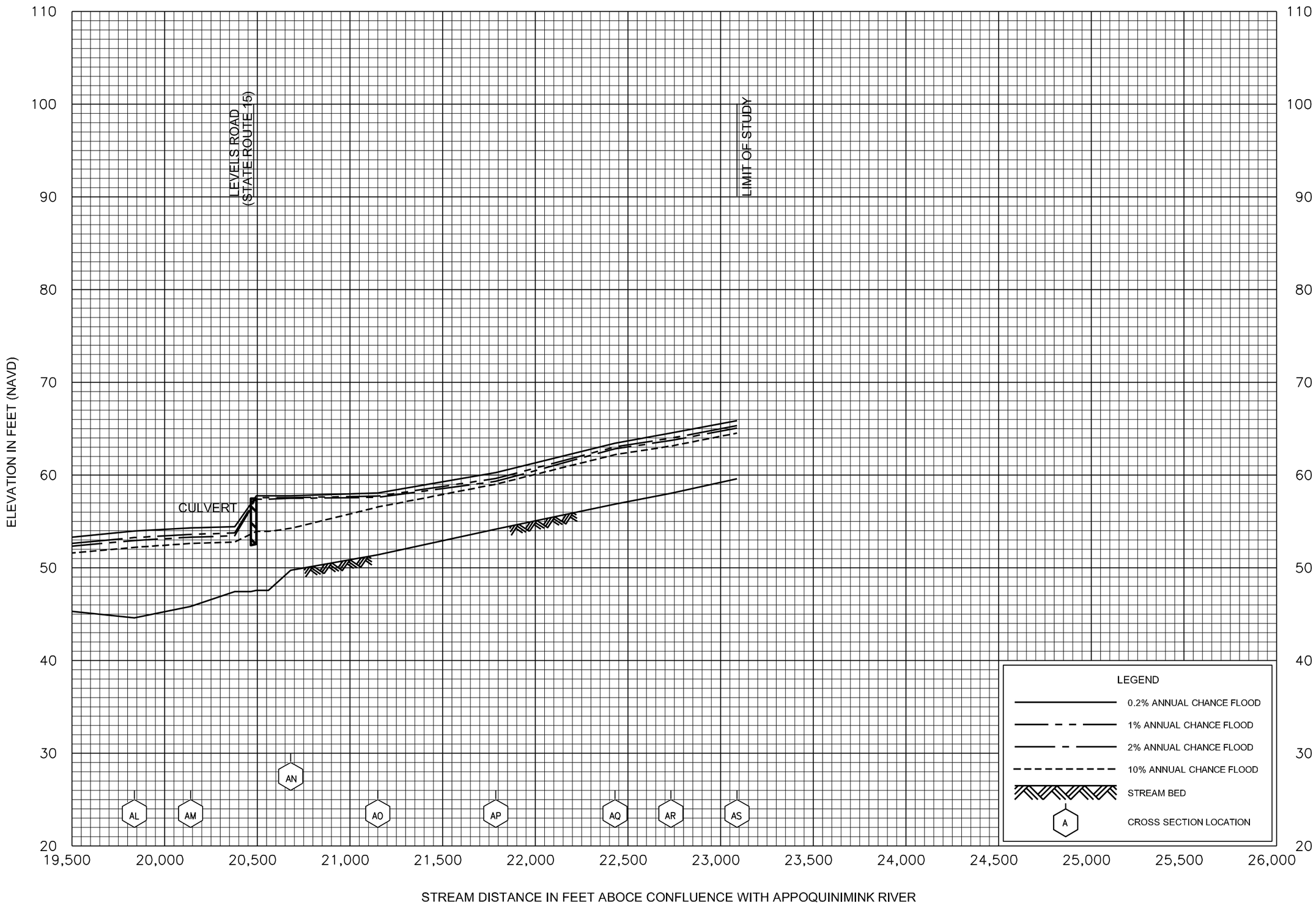


FLOOD PROFILES

DEEP CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

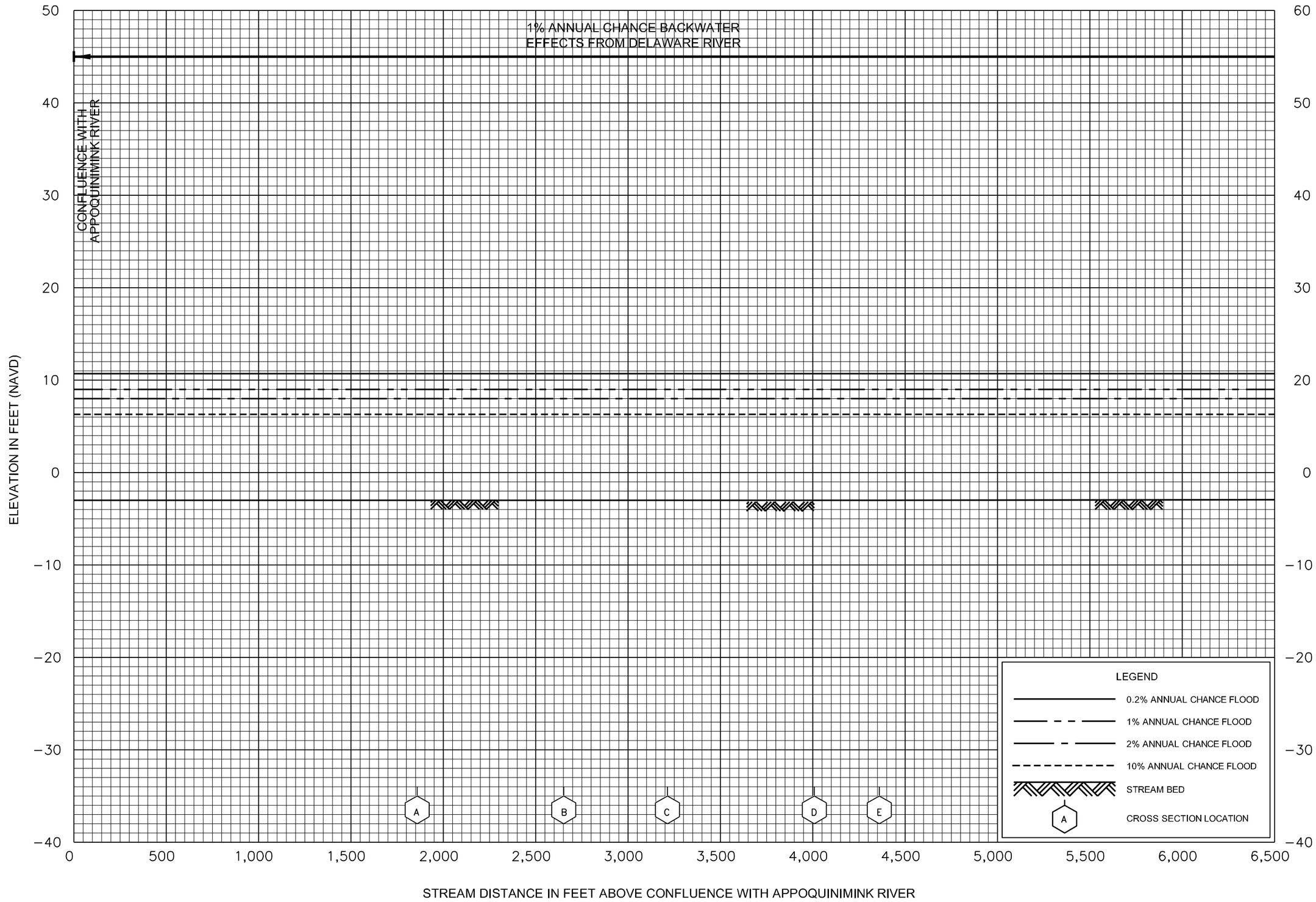


FLOOD PROFILES

DEEP CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

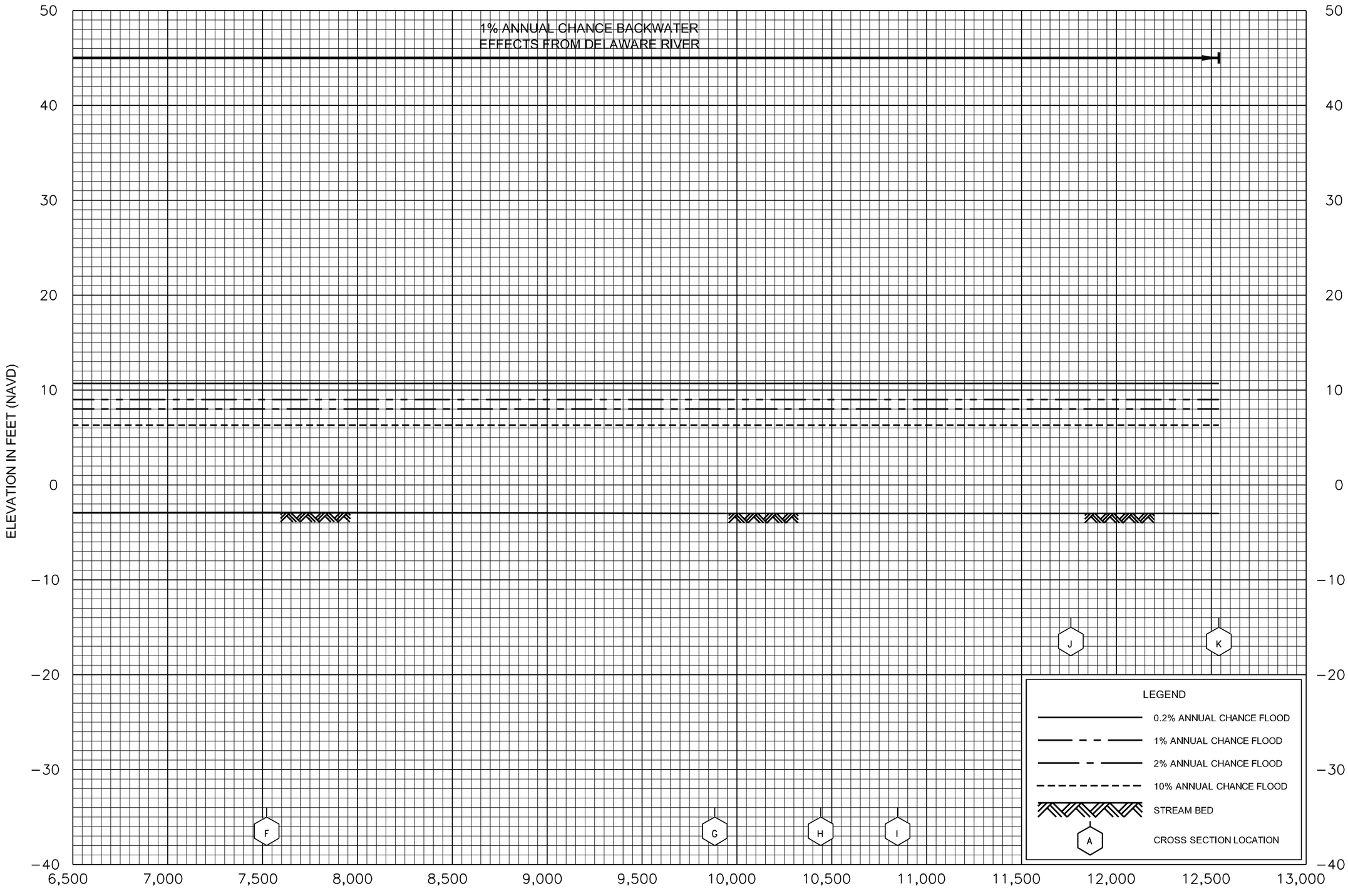


FLOOD PROFILES

DRAWYER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

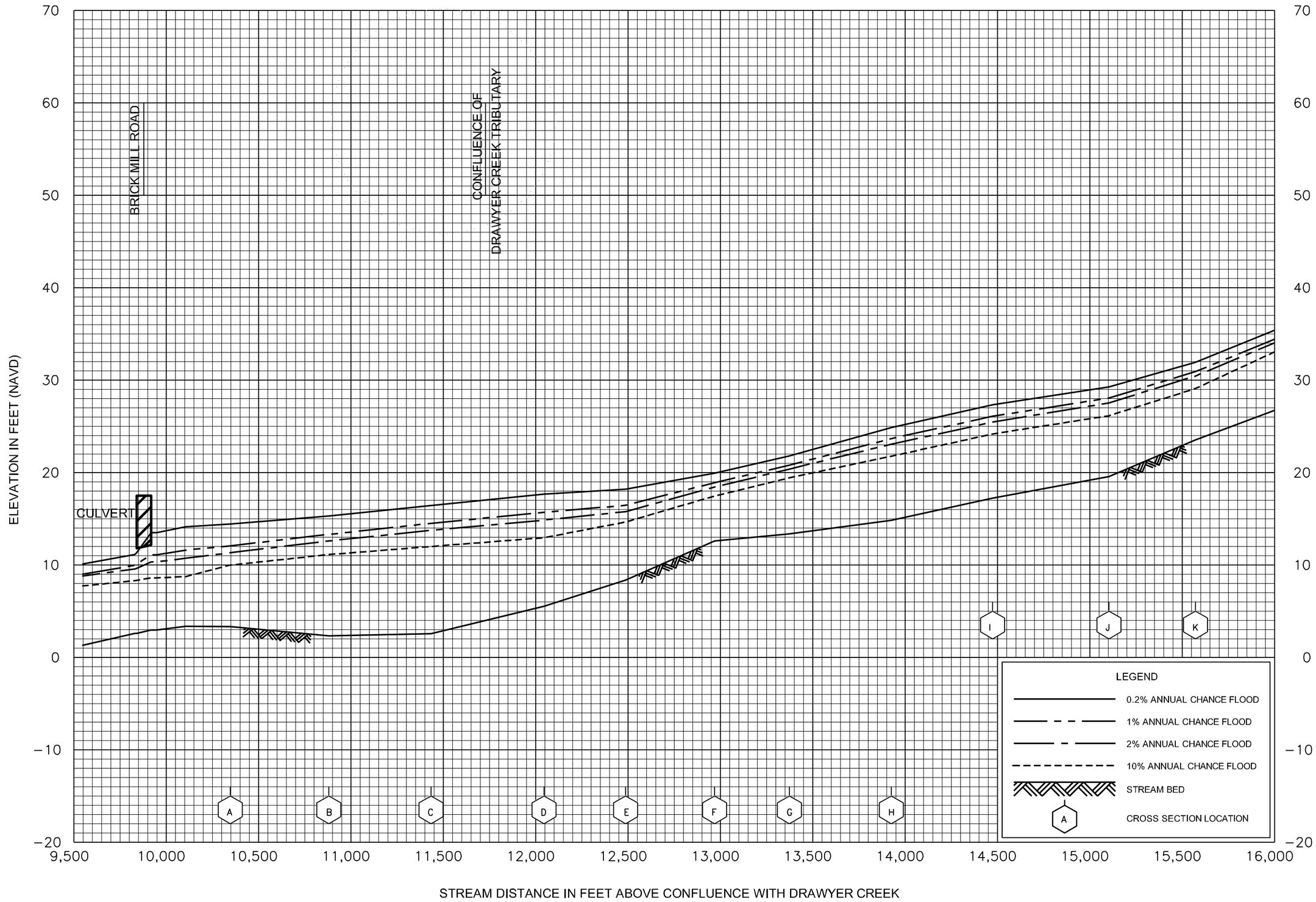


FLOOD PROFILES

DRAWYER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

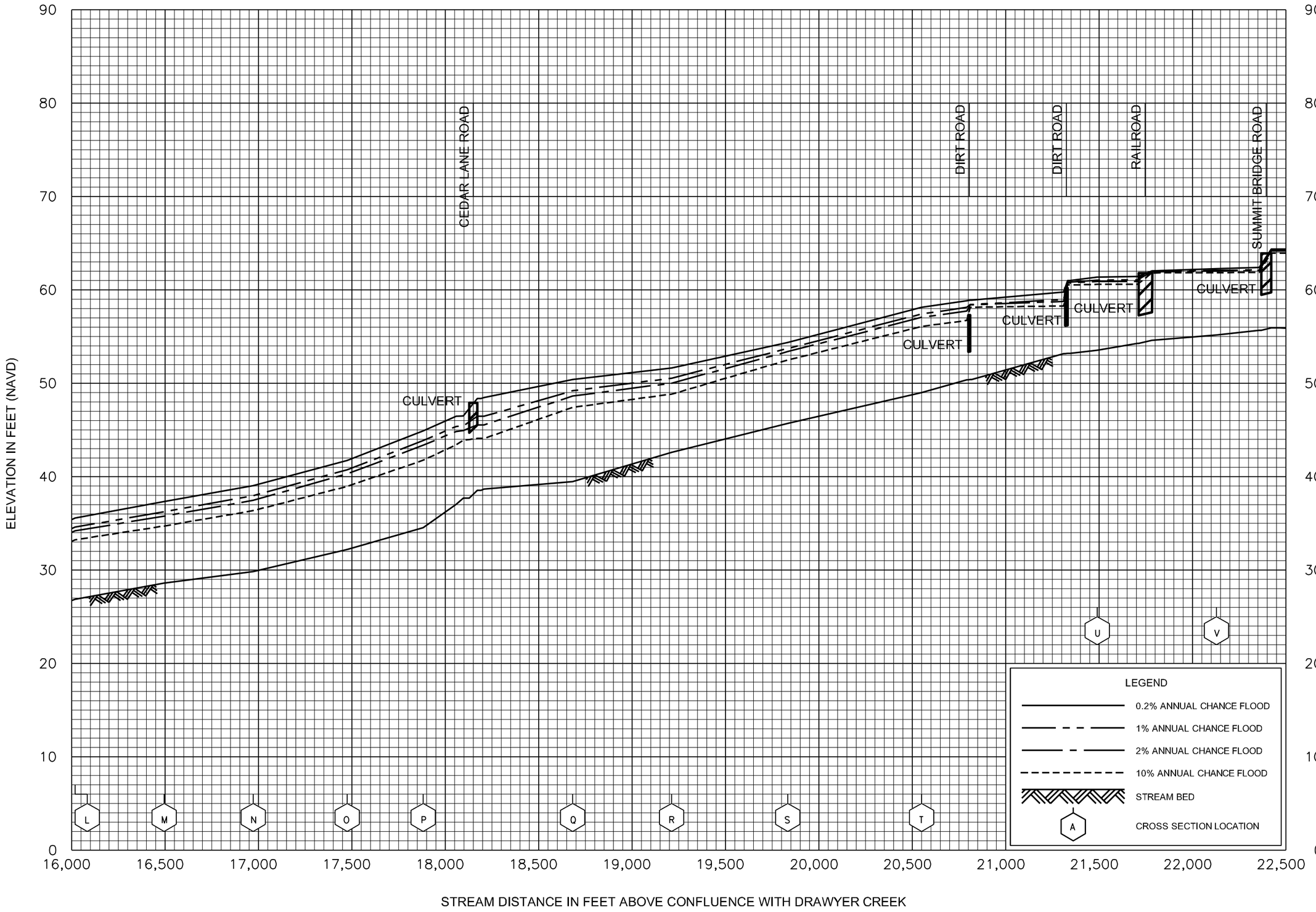


FLOOD PROFILES

DRAWYER CREEK TRIBUTARY NO. 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

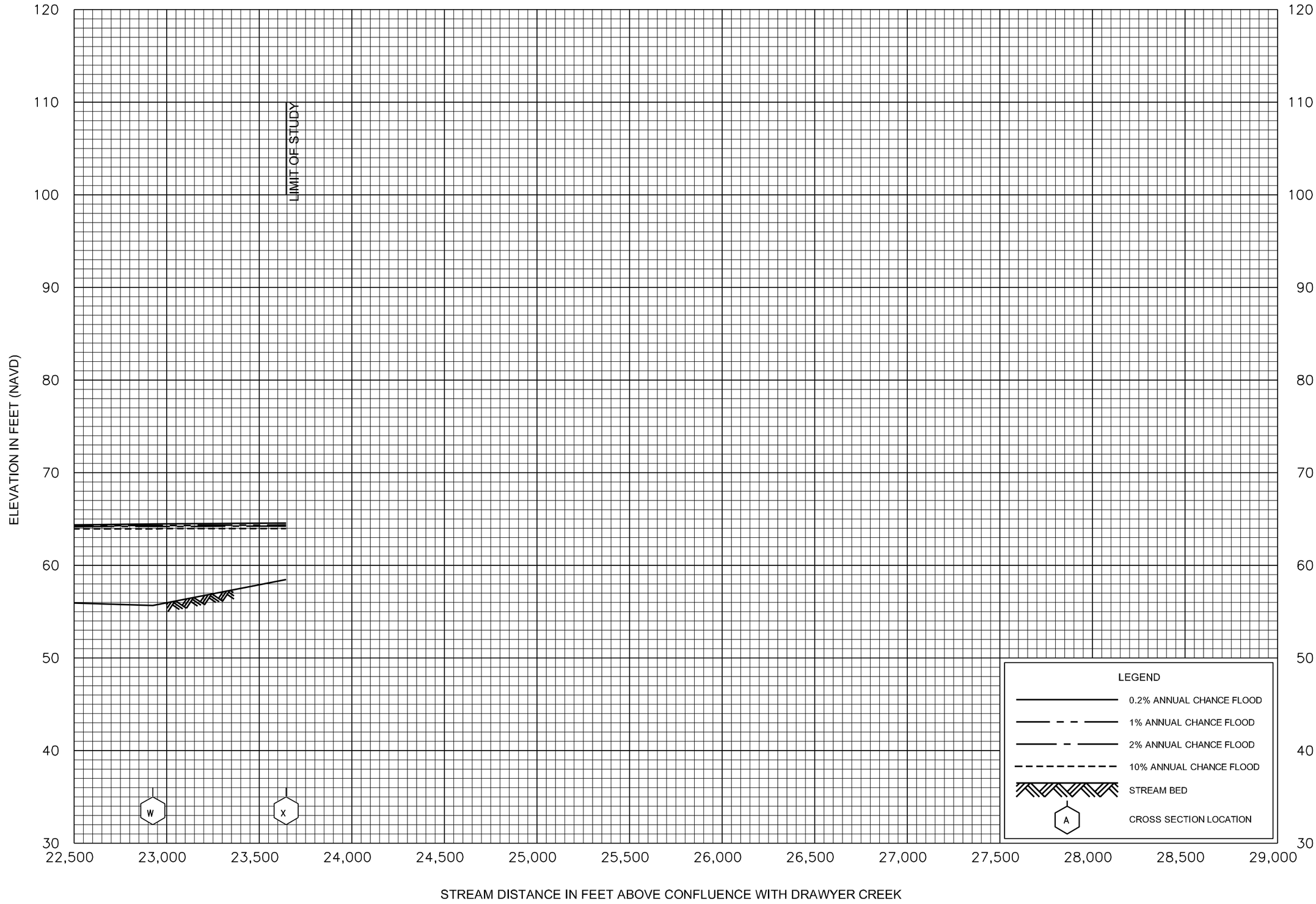


FLOOD PROFILES

DRAWYER CREEK TRIBUTARY NO. 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

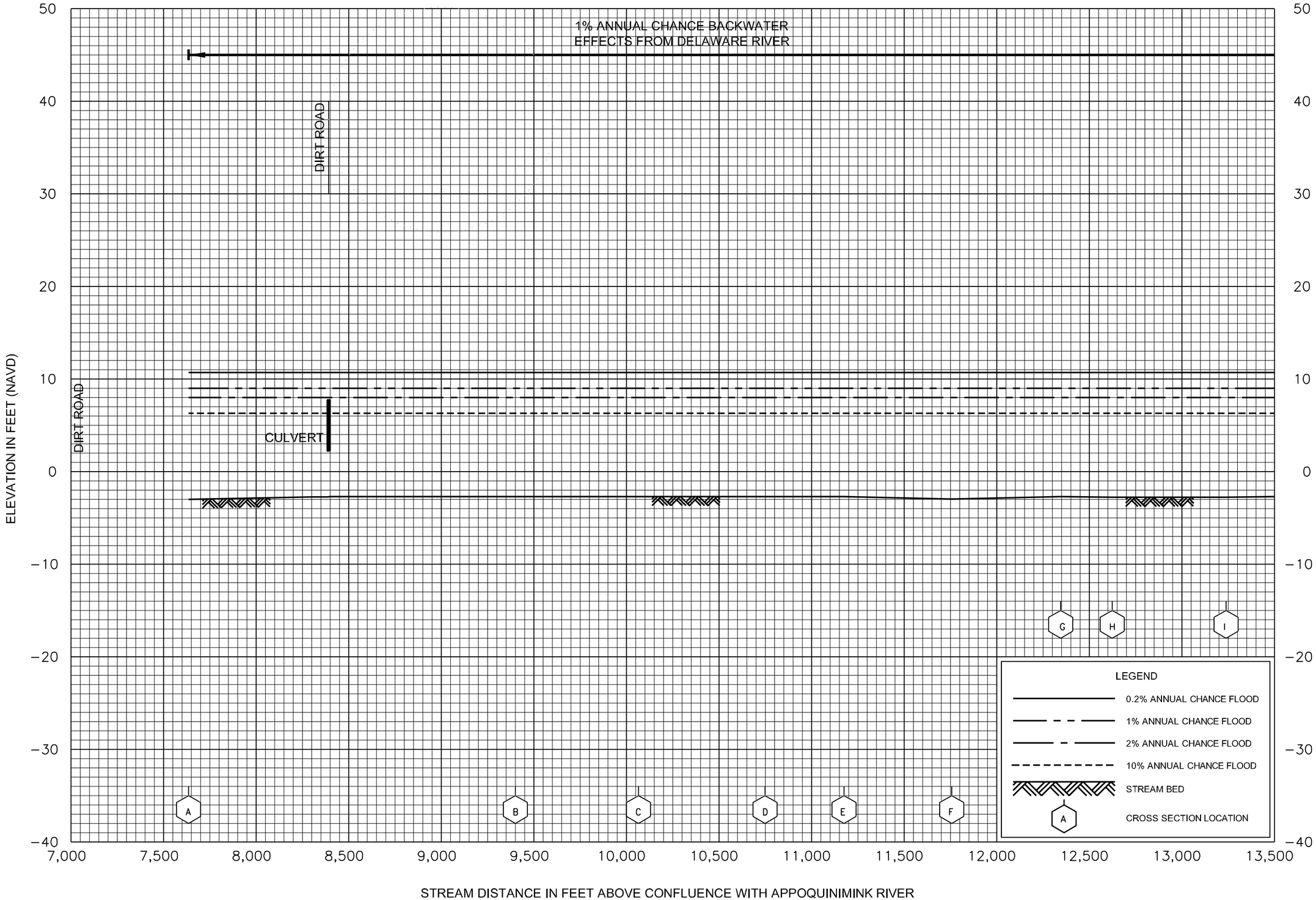


FLOOD PROFILES

DRAWYER CREEK TRIBUTARY NO. 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS



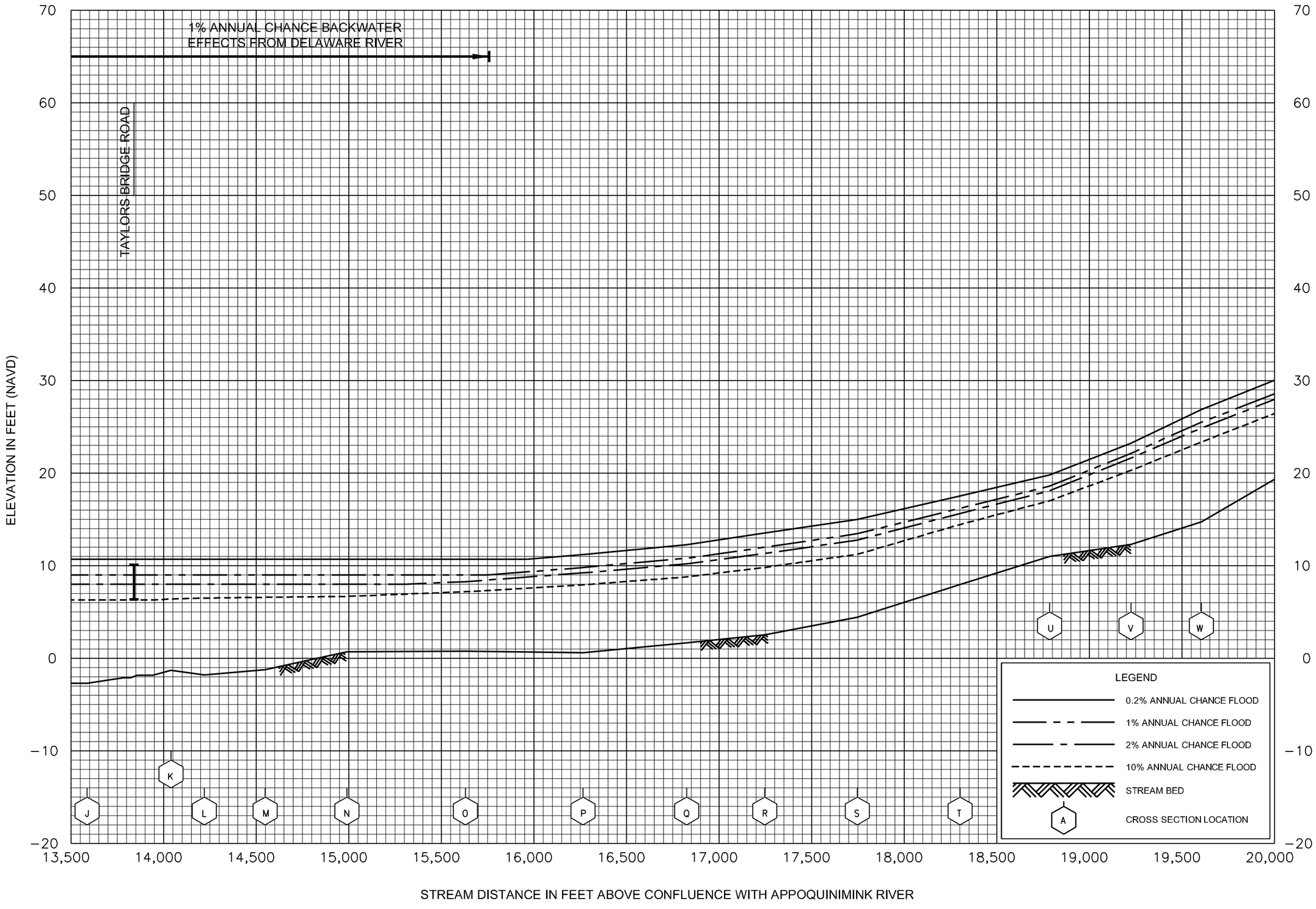
FLOOD PROFILES

HANGMANS RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

126P



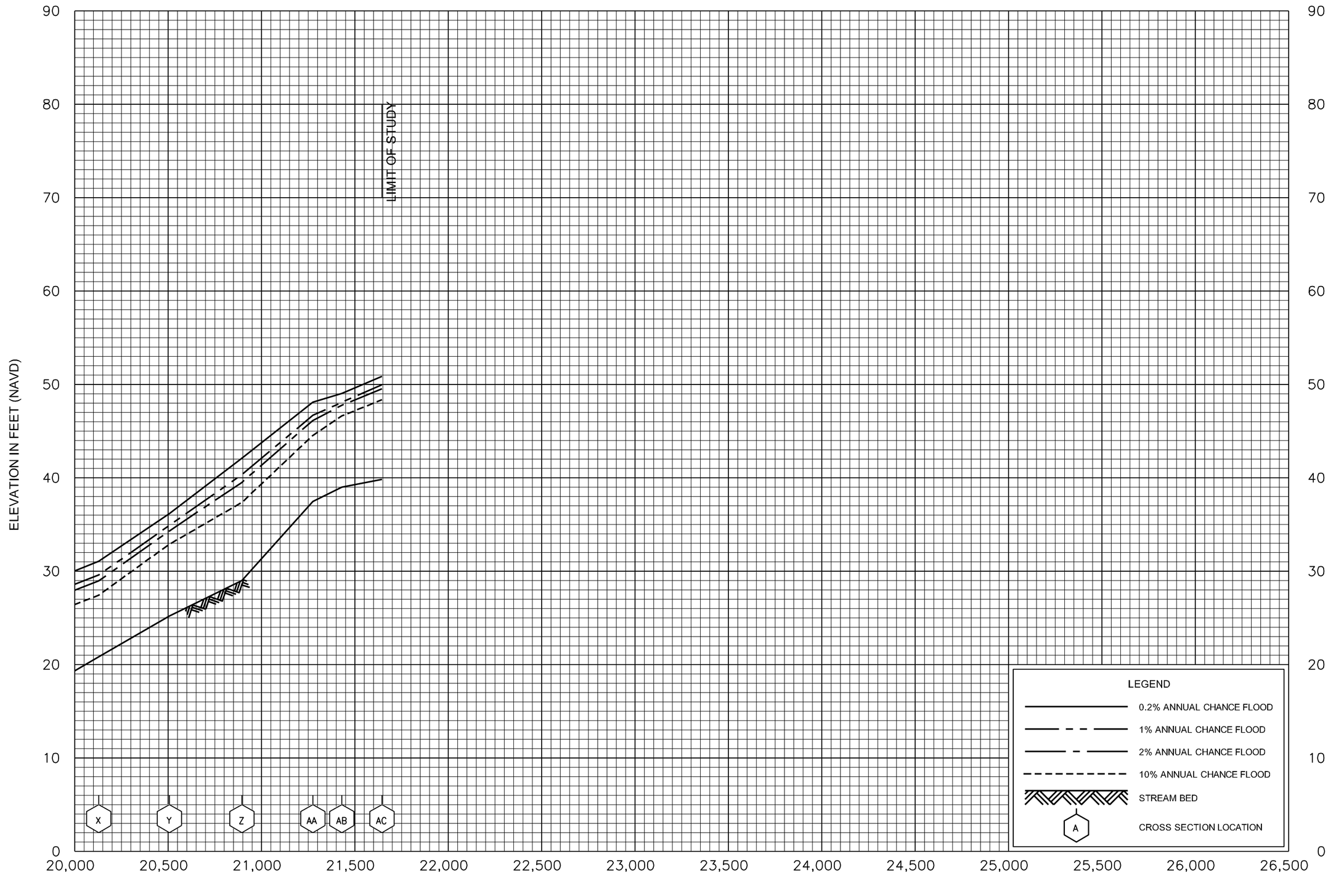
FLOOD PROFILES

HANGMANS RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

127P

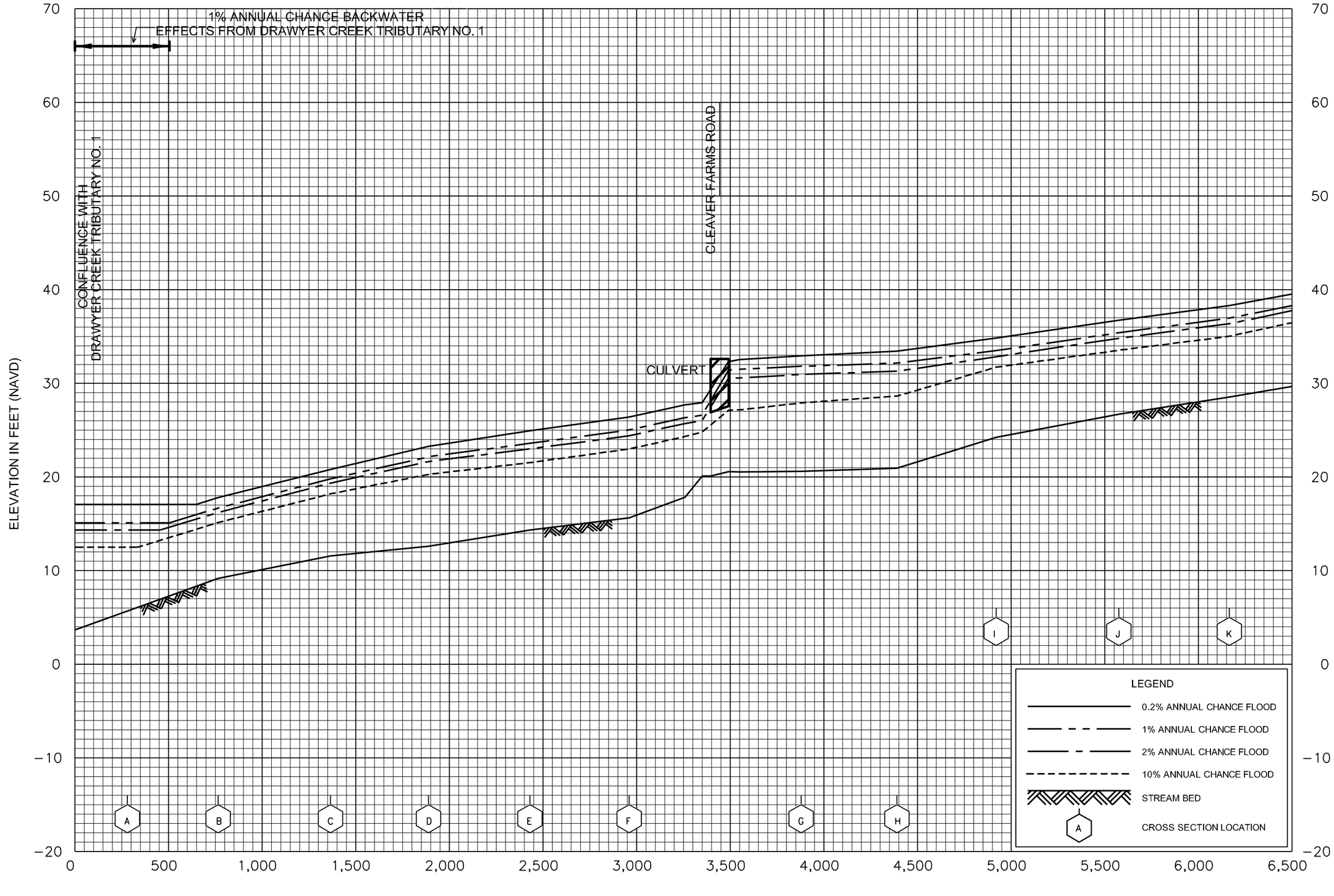


FLOOD PROFILES

HANGMANS RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

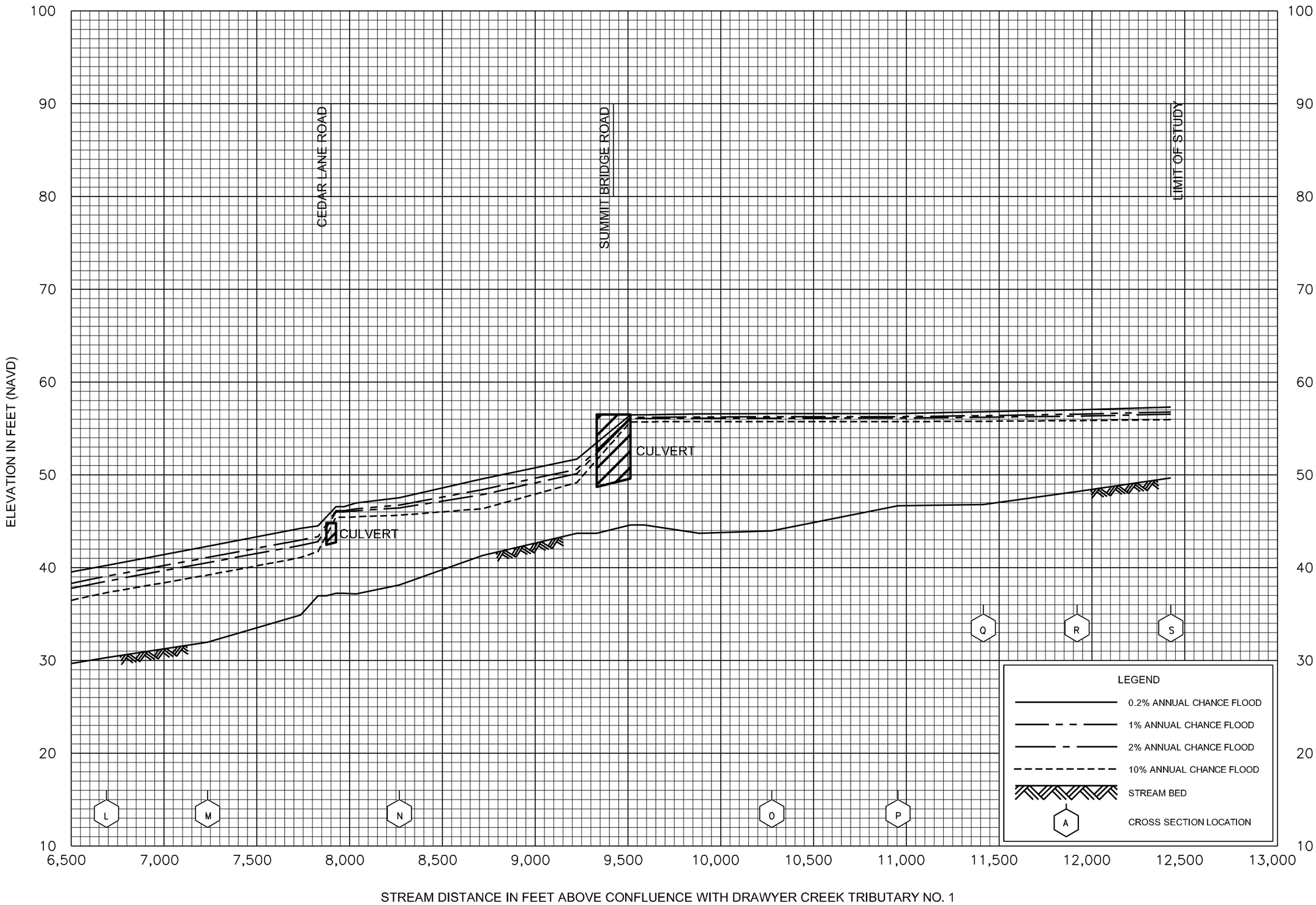


FLOOD PROFILES

TRIBUTARY OF DRAWYER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS



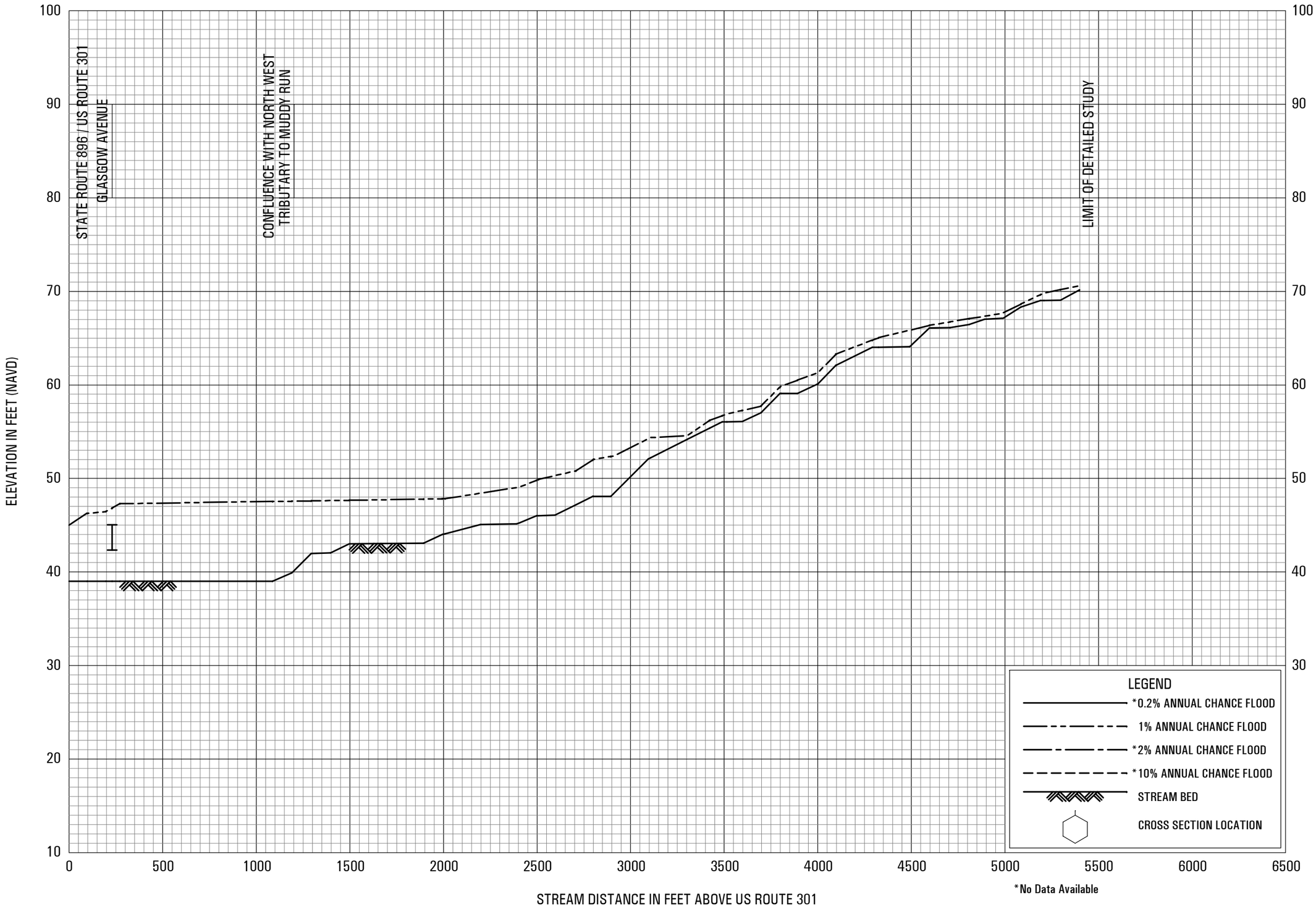
FLOOD PROFILES

TRIBUTARY OF DRAWYER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE COUNTY, DE
AND INCORPORATED AREAS

130P



FLOOD PROFILES

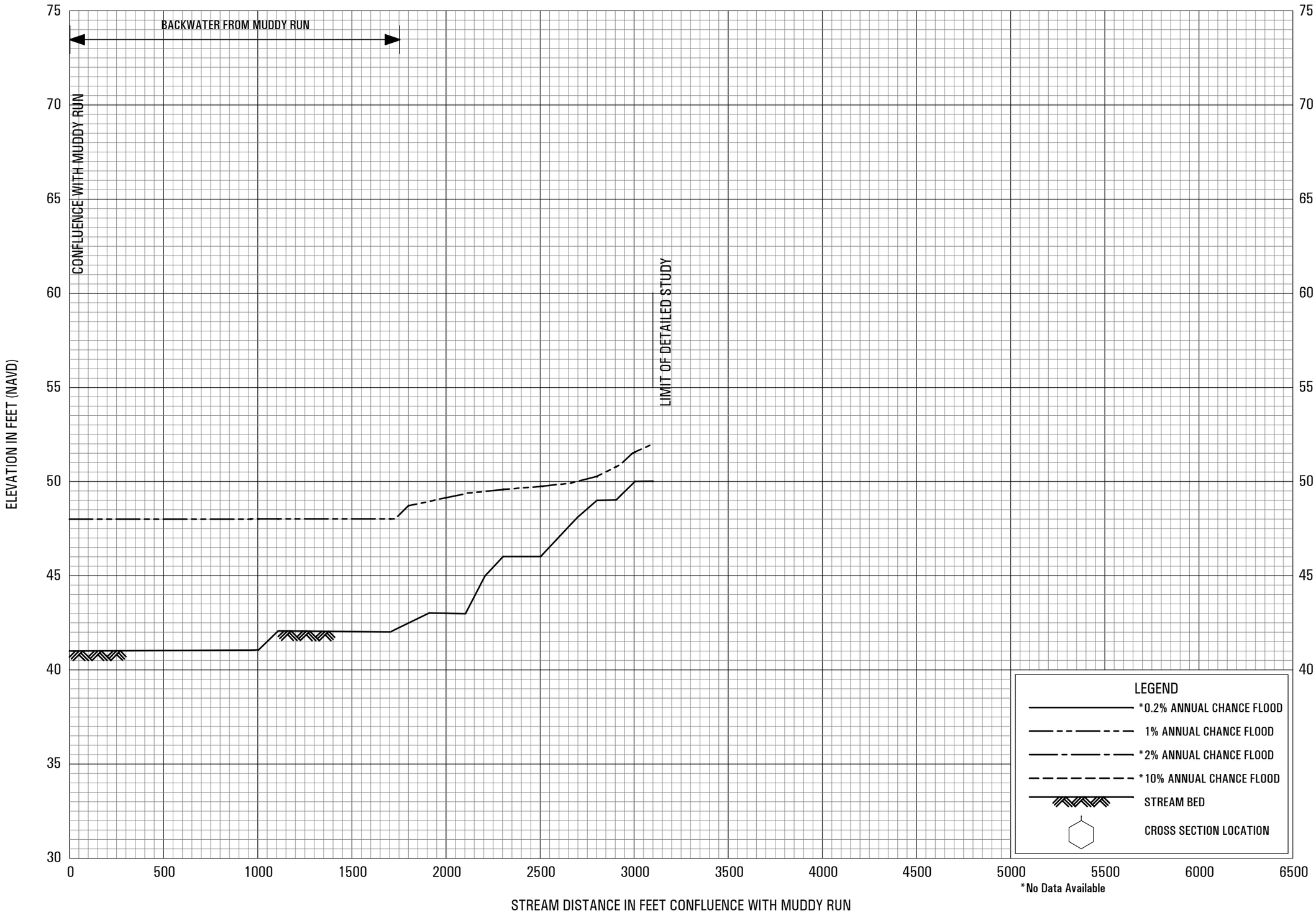
MUDDY RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE, DE

(AND INCORPORATED AREAS)

131P



FLOOD PROFILES

NW TRIBUTARY TO MUDDY RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

NEW CASTLE, DE

(AND INCORPORATED AREAS)