

FLOOD INSURANCE STUDY

FEDERAL EMERGENCY MANAGEMENT AGENCY

VOLUME 1 OF 2



CITY OF BALTIMORE, MARYLAND (INDEPENDENT CITY)

COMMUNITY NAME	COMMUNITY NUMBER
CITY OF BALTIMORE, INDEPENDENT CITY	240087



FEMA

REVISED: June 16, 2021

FLOOD INSURANCE STUDY NUMBER
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Volume 1 Exhibits

Flood Profiles	<u>Panel</u>
Biddison Run	01-04 P
Gwynns Falls	05-11 P
Gwynns Falls split flow (CSX)	12 P
Gwynns Falls split flow (middle)	13 P
Gwynns Falls split flow (Westport)	14 P
Gwynns Run	15 P

Volume 2 Exhibits

Flood Profiles	<u>Panel</u>
Herring Run	16 P
Herring Run Tributary 1	17 P
Jones Falls	18-24 P
Maidens Choice Run	25-31 P
Maidens Choice Run (overland flow)	32 P
Moores Run	33-35 P
Stony Run	36-43 P
Western Run	44-50 P

Published Separately

Flood Insurance Rate Map (FIRM)

FLOOD INSURANCE STUDY REPORT CITY OF BALTIMORE, INDEPENDENT CITY, MARYLAND

SECTION 1.0 – INTRODUCTION

1.1 The National Flood Insurance Program

The National Flood Insurance Program (NFIP) is a voluntary Federal program that enables property owners in participating communities to purchase insurance protection against losses from flooding. This insurance is designed to provide an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.

For decades, the national response to flood disasters was generally limited to constructing flood-control works such as dams, levees, sea-walls, and the like, and providing disaster relief to flood victims. This approach did not reduce losses nor did it discourage unwise development. In some instances, it may have actually encouraged additional development. To compound the problem, the public generally could not buy flood coverage from insurance companies, and building techniques to reduce flood damage were often overlooked.

In the face of mounting flood losses and escalating costs of disaster relief to the general taxpayers, the U.S. Congress created the NFIP. The intent was to reduce future flood damage through community floodplain management ordinances, and provide protection for property owners against potential losses through an insurance mechanism that requires a premium to be paid for the protection.

The U.S. Congress established the NFIP on August 1, 1968, with the passage of the National Flood Insurance Act of 1968. The NFIP was broadened and modified with the passage of the Flood Disaster Protection Act of 1973 and other legislative measures. It was further modified by the National Flood Insurance Reform Act of 1994 and the Flood Insurance Reform Act of 2004. The NFIP is administered by the Federal Emergency Management Agency (FEMA), which is a component of the Department of Homeland Security (DHS).

Participation in the NFIP is based on an agreement between local communities and the Federal Government. If a community adopts and enforces floodplain management regulations to reduce future flood risks to new construction and substantially improved structures in Special Flood Hazard Areas (SFHAs), the Federal Government will make flood insurance available within the community as a financial protection against flood losses. The community's floodplain management regulations must meet or exceed criteria established in accordance with Title 44 Code of Federal Regulations (CFR) Part 60.3, *Criteria for land Management and Use*.

SFHAs are delineated on the community's Flood Insurance Rate Maps (FIRMs). Under the NFIP, buildings that were built before the flood hazard was identified on the community's FIRMs are generally referred to as "Pre-FIRM" buildings. When the NFIP was created, the U.S. Congress recognized that insurance for Pre-FIRM buildings would be prohibitively expensive if the premiums were not subsidized by the federal

government. Congress also recognized that most of these floodprone buildings were built by individuals who did not have sufficient knowledge of the flood hazard to make informed decisions. The NFIP requires that full actuarial rates reflecting the complete flood risk be charged on all buildings constructed or substantially improved on or after the effective date of the initial FIRM for the community or after December 31, 1974, whichever is later. These buildings are generally referred to as “Post-FIRM” buildings.

1.2 Purpose of this Flood Insurance Study Report

This Flood Insurance Study (FIS) Report revises and updates information on the existence and severity of flood hazards for the study area. The studies described in this report developed flood hazard data that will be used to establish actuarial flood insurance rates and to assist communities in efforts to implement sound floodplain management.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive than the minimum Federal requirements. Contact your State NFIP Coordinator to ensure that any higher State standards are included in the community’s regulations.

1.3 Jurisdictions Included in the Flood Insurance Study Project

This FIS Report covers the entire geographic area of City of Baltimore, Independent City, Maryland.

The jurisdictions that are included in this project area, along with the Community Identification Number (CID) for each community and the 8-digit Hydrologic Unit Codes (HUC-8) sub-basins affecting each, are shown in Table 1. The Flood Insurance Rate Map (FIRM) panel numbers that affect each community are listed. If the flood hazard data for the community is not included in this FIS Report, the location of that data is identified.

Table 1: Listing of NFIP Jurisdictions

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
City of Baltimore, Independent City	240087	02060003	2400870001F 2400870002F 2400870003F 2400870004F 2400870005F 2400870006E ¹ 2400870007E ¹ 2400870008F 2400870009F 2400870010F 2400870011F	

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
			2400870012F 2400870013F 2400870014F 2400870015F 2400870016F 2400870017E ¹ 2400870018G 2400870019F 2400870020F 2400870021F 2400870022F 2400870023F 2400870024G 2400870025G 2400870026F 2400870027F 2400870028F 2400870029E ¹ 2400870030G 2400870031F 2400870032F 2400870033F 2400870034E ¹ 2400870035F 2400870036G 2400870037F ¹	

¹ Panel Not Printed

1.4 Considerations for using this Flood Insurance Study Report

The NFIP encourages State and local governments to implement sound floodplain management programs. To assist in this endeavor, each FIS Report provides floodplain data, which may include a combination of the following: 10-, 4-, 2-, 1-, and 0.2-percent annual chance flood elevations (the 1% annual chance flood elevation is also referred to as the Base Flood Elevation (BFE)); delineations of the 1% annual chance and 0.2% annual chance floodplains; and 1% annual chance floodway. This information is presented on the FIRM and/or in many components of the FIS Report, including Flood Profiles, Floodway Data tables, Summary of Non-Coastal Stillwater Elevations tables, and Coastal Transect Parameters tables (not all components may be provided for a specific FIS).

This section presents important considerations for using the information contained in this FIS Report and the FIRM, including changes in format and content. Figures 1, 2, and 3

present information that applies to using the FIRM with the FIS Report.

- Part or all of this FIS Report may be revised and republished at any time. In addition, part of this FIS Report may be revised by a Letter of Map Revision (LOMR), which does not involve republication or redistribution of the FIS Report. Refer to Section 6.5 of this FIS Report for information about the process to revise the FIS Report and/or FIRM.

It is, therefore, the responsibility of the user to consult with community officials by contacting the community repository to obtain the most current FIS Report components. Communities participating in the NFIP have established repositories of flood hazard data for floodplain management and flood insurance purposes. Community map repository addresses are provided in Table 31, "Map Repositories," within this FIS Report.

- New FIS Reports are frequently developed for multiple communities, such as entire counties. A countywide FIS Report incorporates previous FIS Reports for individual communities and the unincorporated area of the county (if not jurisdictional) into a single document and supersedes those documents for the purposes of the NFIP.

The initial FIS Report for City of Baltimore became effective on March 15, 1978. Refer to Table 28 for information about subsequent revisions to the FIRMs.

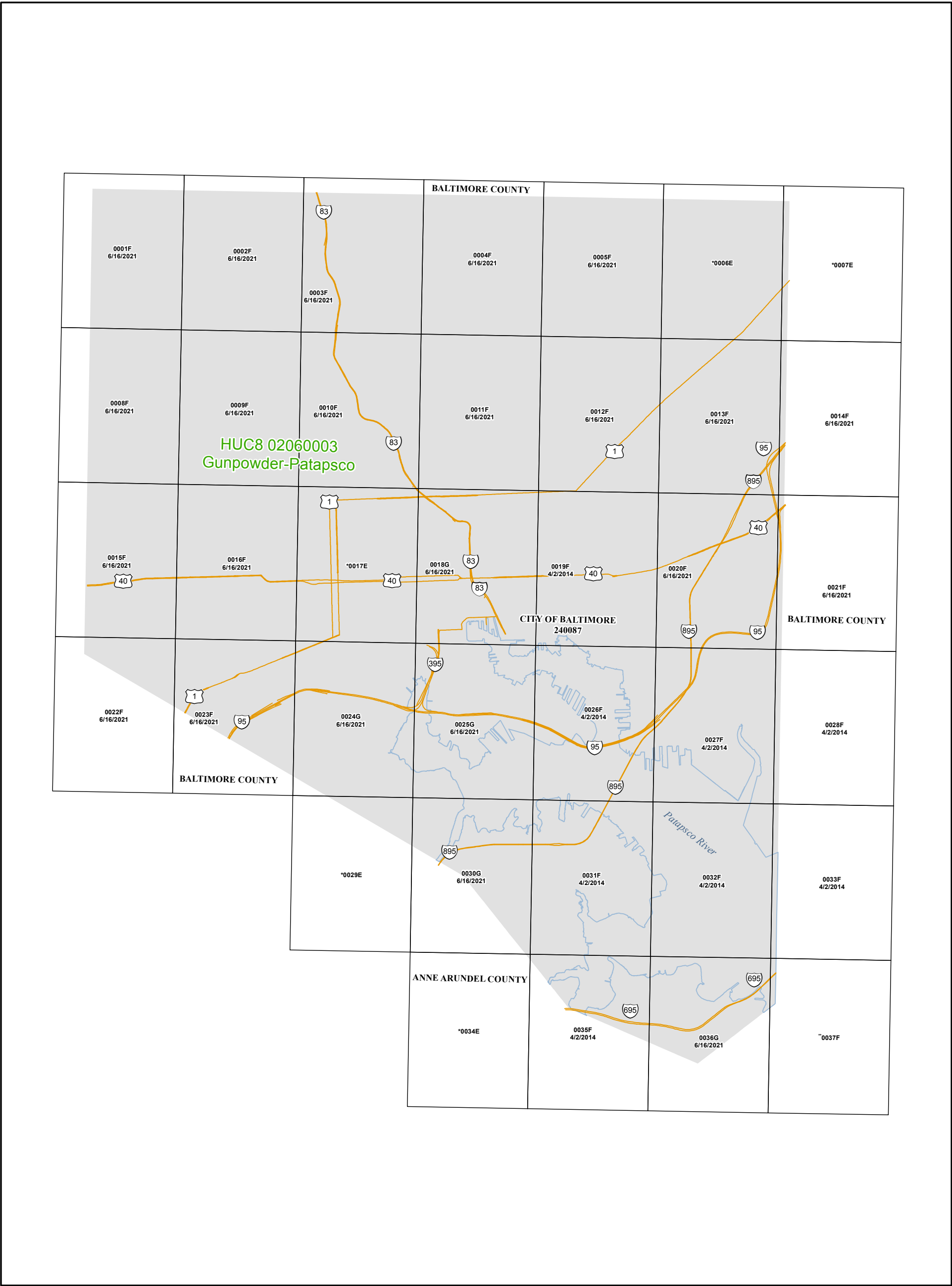
- FEMA does not impose floodplain management requirements or special insurance ratings based on Limit of Moderate Wave Action (LiMWA) delineations at this time. The LiMWA represents the approximate landward limit of the 1.5-foot breaking wave. If the LiMWA is shown on the FIRM, it is being provided by FEMA as information only. For communities that do adopt Zone VE building standards in the area defined by the LiMWA, additional Community Rating System (CRS) credits are available. Refer to Section 2.5.4 for additional information about the LiMWA.

The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Visit the FEMA Web site at <http://www.fema.gov> or contact your appropriate FEMA Regional Office for more information about this program.

- FEMA has developed a *Guide to Flood Maps* (FEMA 258) and online tutorials to assist users in accessing the information contained on the FIRM. These include how to read panels and step-by-step instructions to obtain specific information. To obtain this guide and other assistance in using the FIRM, visit the FEMA Web site at <http://www.fema.gov>.

The FIRM Index in Figure 1 shows the overall FIRM panel layout within City of Baltimore, and also displays the panel number and effective date for each FIRM panel in the community. Other information shown on the FIRM Index includes community boundaries, watershed boundaries, and United States Geological Survey (USGS) Hydrologic Unit Code 8 (HUC-8) codes.

Figure 1: FIRM Panel Index



1 inch = 7,000 feet

1:84,000

0

1,750

3,500

7,000

10,500

14,000

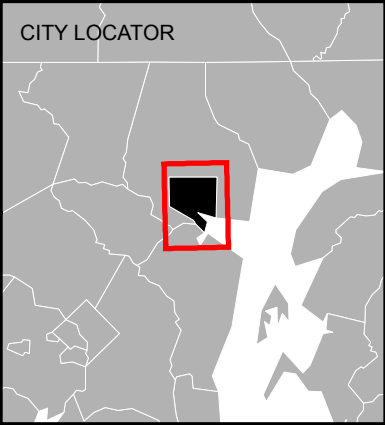
Feet

Map Projection:
Universal Transverse Mercator Zone 18 North;
North American Datum 1983

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING
DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT
HTTP://MSC.FEMA.GOV

SEE FLOOD INSURANCE STUDY FOR ADDITIONAL INFORMATION

* PANEL NOT PRINTED - NO SPECIAL FLOOD HAZARD AREAS
** PANEL NOT PRINTED - OPEN WATER AREA



NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP INDEX

CITY OF BALTIMORE, MARYLAND (Independent City)

PANELS PRINTED:
0001, 0002, 0003, 0004, 0005, 0008, 0009, 0010, 0011, 0012, 0013,
0014, 0015, 0016, 0018, 0019, 0020, 0021, 0022, 0023, 0024, 0025,
0026, 0027, 0028, 0030, 0031, 0032, 0033, 0035, 0036



FEMA

MAP NUMBER
240087IND0C

MAP REVISED
JUNE 16, 2021

Each FIRM panel may contain specific notes to the user that provide additional information regarding the flood hazard data shown on that map. However, the FIRM panel does not contain enough space to show all the notes that may be relevant in helping to better understand the information on the panel. Figure 2 contains the full list of these notes.

Figure 2: FIRM Notes to Users

NOTES TO USERS

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products, or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Map Service Center website at <http://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Map Service Center website or by calling the FEMA Map Information eXchange.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Map Service Center at the number listed above.

For community map dates, refer to Table 27 in this FIS Report.

To determine if flood insurance is available in the community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

The map is for use in administering the NFIP. It may not identify all areas subject to flooding, particularly from local drainage sources of small size. Consult the community map repository to find updated or additional flood hazard information.

BASE FLOOD ELEVATIONS: For more detailed information in areas where Base Flood Elevations (BFEs) and/or floodways have been determined, consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables within this FIS Report. Use the flood elevation data within the FIS Report in conjunction with the FIRM for construction and/or floodplain management.

Coastal Base Flood Elevations shown on the map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD88). Coastal flood elevations are also provided in the Coastal Transect Parameters table in the FIS Report for this jurisdiction. Elevations shown in the Coastal Transect Parameters table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on the FIRM.

FLOODWAY INFORMATION: Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the FIS Report for this jurisdiction.

Figure 2. FIRM Notes to Users

FLOOD CONTROL STRUCTURE INFORMATION: Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. Refer to Section 4.3 "Non-Levee Flood Protection Measures" of this FIS Report for information on flood control structures for this jurisdiction.

PROJECTION INFORMATION: The projection used in the preparation of the map was Universal Transverse Mercator (UTM) Zone 18N. The horizontal datum was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

ELEVATION DATUM: Flood elevations on the FIRM are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://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 20910-3282
(301) 713-3242*

Local vertical monuments may have been used to create the map. To obtain current monument information, please contact the appropriate local community listed in Table 31 of this FIS Report.

BASE MAP INFORMATION: Base map information shown on the FIRM was provided by various sources. For information about base maps, refer to Section 6.2 "Base Map" in this FIS Report.

Corporate limits shown on the map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after the map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Figure 2. FIRM Notes to Users

NOTES FOR FIRM INDEX

REVISIONS TO INDEX: As new studies are performed and FIRM panels are updated within City of Baltimore, Maryland, corresponding revisions to the FIRM Index will be incorporated within the FIS Report to reflect the effective dates of those panels. Please refer to Table 27 of this FIS Report to determine the most recent FIRM revision date for each community. The most recent FIRM panel effective date will correspond to the most recent index date.

SPECIAL NOTES FOR SPECIFIC FIRM PANELS

This Notes to Users section was created specifically for City of Baltimore, Maryland, effective June 16, 2021.

LIMIT OF MODERATE WAVE ACTION: Zone AE has been divided by a Limit of Moderate Wave Action (LiMWA). The LiMWA represents the approximate landward limit of the 1.5-foot breaking wave. The effects of wave hazards between Zone VE and the LiMWA (or between the shoreline and the LiMWA for areas where Zone VE is not identified) will be similar to, but less severe than, those in Zone VE.

FLOOD RISK REPORT: A Flood Risk Report (FRR) may be available for many of the flooding sources and communities referenced in this FIS Report. The FRR is provided to increase public awareness of flood risk by helping communities identify the areas within their jurisdictions that have the greatest risks. Although non-regulatory, the information provided within the FRR can assist communities in assessing and evaluating mitigation opportunities to reduce these risks. It can also be used by communities developing or updating flood risk mitigation plans. These plans allow communities to identify and evaluate opportunities to reduce potential loss of life and property. However, the FRR is not intended to be the final authoritative source of all flood risk data for a project area; rather, it should be used with other data sources to paint a comprehensive picture of flood risk

Each FIRM panel contains an abbreviated legend for the features shown on the maps. However, the FIRM panel does not contain enough space to show the legend for all map features. Figure 3 shows the full legend of all map features. Note that not all of these features may appear on the FIRM panels in City of Baltimore, Maryland.

Figure 3: Map Legend for FIRM

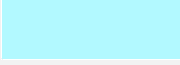
SPECIAL FLOOD HAZARD AREAS: <i>The 1% annual chance flood, also known as the base flood or 100-year flood, has a 1% chance of happening or being exceeded each year. Special Flood Hazard Areas are subject to flooding by the 1% annual chance flood. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights. See note for specific types. If the floodway is too narrow to be shown, a note is shown.</i>	
	Special Flood Hazard Areas subject to inundation by the 1% annual chance flood (Zones A, AE, AH, AO, AR, A99, V and VE)
Zone A	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. No base (1% annual chance) flood elevations (BFEs) or depths are shown within this zone.
Zone AE	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. Base flood elevations derived from the hydraulic analyses are shown within this zone.
Zone AH	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the hydraulic analyses are shown at selected intervals within this zone.
Zone AO	The flood insurance rate zone that corresponds to the areas of 1% 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 hydraulic analyses are shown within this zone.
Zone AR	The flood insurance rate zone that corresponds to areas that were formerly protected from the 1% annual chance flood 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% annual chance or greater flood.
Zone A99	The flood insurance rate zone that corresponds to areas of the 1% annual chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or flood depths are shown within this zone.
Zone V	The flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations are not shown within this zone.
Zone VE	Zone VE is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations derived from the coastal analyses are shown within this zone as static whole-foot elevations that apply throughout the zone.

Figure 3: Map Legend for FIRM

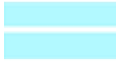
	Regulatory Floodway determined in Zone AE.
OTHER AREAS OF FLOOD HAZARD	
	Shaded Zone X: Areas of 0.2% annual chance flood hazards and areas of 1% annual chance flood hazards with average depths of less than 1 foot or with drainage areas less than 1 square mile.
	Future Conditions 1% Annual Chance Flood Hazard – Zone X: The flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined based on future-conditions hydrology. No base flood elevations or flood depths are shown within this zone.
	Area with Reduced Flood Risk due to Levee: Areas where an accredited levee, dike, or other flood control structure has reduced the flood risk from the 1% annual chance flood. See Notes to Users for important information.
OTHER AREAS	
	Zone D (Areas of Undetermined Flood Hazard): The flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.
	Unshaded Zone X: Areas of minimal flood hazard.
FLOOD HAZARD AND OTHER BOUNDARY LINES	
  (ortho) (vector)	Flood Zone Boundary (white line on ortho-photography-based mapping; gray line on vector-based mapping)
	Limit of Study
	Jurisdiction Boundary
	Limit of Moderate Wave Action (LiMWA): Indicates the inland limit of the area affected by waves greater than 1.5 feet
GENERAL STRUCTURES	
 <i>Aqueduct</i> <i>Channel</i> <i>Culvert</i> <i>Storm Sewer</i>	Channel, Culvert, Aqueduct, or Storm Sewer
 <i>Dam</i> <i>Jetty</i> <i>Weir</i>	Dam, Jetty, Weir

Figure 3: Map Legend for FIRM

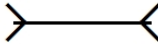
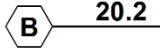
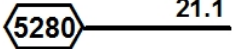
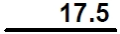
	Levee, Dike, or Floodwall
 <i>Bridge</i>	Bridge
REFERENCE MARKERS	
 22.0	River mile Markers
CROSS SECTION & TRANSECT INFORMATION	
	Lettered Cross Section with Regulatory Water Surface Elevation (BFE)
	Numbered Cross Section with Regulatory Water Surface Elevation (BFE)
	Unlettered Cross Section with Regulatory Water Surface Elevation (BFE)
	Coastal Transect
	Profile Baseline: Indicates the modeled flow path of a stream and is shown on FIRM panels for all valid studies with profiles or otherwise established base flood elevation.
	Coastal Transect Baseline: Used in the coastal flood hazard model to represent the 0.0-foot elevation contour and the starting point for the transect and the measuring point for the coastal mapping.
	Base Flood Elevation Line
ZONE AE (EL 16)	Static Base Flood Elevation value (shown under zone label)
ZONE AO (DEPTH 2)	Zone designation with Depth
ZONE AO (DEPTH 2) (VEL 15 FPS)	Zone designation with Depth and Velocity
BASE MAP FEATURES	
	River, Stream or Other Hydrographic Feature
	Interstate Highway
	U.S. Highway
	State Highway
	County Highway

Figure 3: Map Legend for FIRM

MAPLE LANE 	Street, Road, Avenue Name, or Private Drive if shown on Flood Profile
 RAILROAD	Railroad
	Horizontal Reference Grid Line
	Horizontal Reference Grid Ticks
	Secondary Grid Crosshairs
Land Grant	Name of Land Grant
7	Section Number
R. 43 W. T. 22 N.	Range, Township Number
⁴² 76 ^{000m} E	Horizontal Reference Grid Coordinates (UTM)
365000 FT	Horizontal Reference Grid Coordinates (State Plane)
80° 16' 52.5"	Corner Coordinates (Latitude, Longitude)

SECTION 2.0 – FLOODPLAIN MANAGEMENT APPLICATIONS

2.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1% annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2% annual chance (500-year) flood is employed to indicate additional areas of flood hazard in the community.

Each flooding source included in the project scope has been studied and mapped using professional engineering and mapping methodologies that were agreed upon by FEMA and City of Baltimore as appropriate to the risk level. Flood risk is evaluated based on factors such as known flood hazards and projected impact on the built environment. Engineering analyses were performed for each studied flooding source to calculate its 1% annual chance flood elevations; elevations corresponding to other floods (e.g. 10-, 4-, 2-, 0.2-percent annual chance, etc.) may have also been computed for certain flooding sources. Engineering models and methods are described in detail in Section 5.0 of this FIS Report. The modeled elevations at cross sections were used to delineate the floodplain boundaries on the FIRM; between cross sections, the boundaries were interpolated using elevation data from various sources. More information on specific mapping methods is provided in Section 6.0 of this FIS Report.

Depending on the accuracy of available topographic data (Table 22), study methodologies employed (Section 5.0), and flood risk, certain flooding sources may be mapped to show both the 1- and 0.2-percent-annual-chance floodplain boundaries, regulatory water surface elevations (BFEs), and/or a regulatory floodway. Similarly, other flooding sources may be mapped to show only the 1-percent-annual-chance floodplain boundary on the FIRM, without published water surface elevations. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM. Figure 3, “Map Legend for FIRM”, describes the flood zones that are used on the FIRMs to account for the varying levels of flood risk that exist along flooding sources within the project area. Table 2 and Table 3 indicate the flood zone designations for each flooding source and each community within City of Baltimore, respectively.

Table 2, “Flooding Sources Included in this FIS Report,” lists each flooding source, including its study limits, affected communities, mapped zone on the FIRM, and the completion date of its engineering analysis from which the flood elevations on the FIRM and in the FIS Report were derived. Descriptions and dates for the latest hydrologic and hydraulic analyses of the flooding sources are shown in Table 13. Floodplain boundaries for these flooding sources are shown on the FIRM (published separately) using the symbology described in Figure 3. On the map, the 1-percent-annual-chance floodplain corresponds to the SFHAs. The 0.2-percent-annual-chance floodplain shows areas that, although out of the regulatory floodplain, are still subject to flood hazards.

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. The procedures to remove these areas from the SFHA are described in Section 6.5 of this FIS Report.

Table 2: Flooding Sources Included in this FIS Report

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Biddison Run	City of Baltimore	Confluence with Herring Run	Downstream of Sipple Avenue	2060003	1.7	Y	AE	2018
Chesapeake Bay / Patapsco River	City of Baltimore	Entire coastline	Entire coastline	N/A	*	N	AE, VE	2012
Chinquapin Run	City of Baltimore	Confluence with Herring Run	Downstream of Walker Avenue	2060003	2.4	N	A	2017
Dead Run	City of Baltimore	Confluence with Gwynns Falls	City limits	2060003	2.1	N	A	2017
Gwynns Falls	City of Baltimore	Confluence with Middle Branch Patapsco River	City limits	2060003	7.9	Y	AE	2018
Gwynns Falls split flow (CSX)	City of Baltimore	Confluence with Middle Branch Patapsco River	Split of Gwynns Falls	2060003	0.8	N	AE	2018
Gwynns Falls split flow (middle)	City of Baltimore	Confluence with Gwynns Falls	Split of Gwynns Falls split flow (CSX)	2060003	0.4	N	AE	2018
Gwynns Falls split flow (Westport)	City of Baltimore	Confluence with Middle Branch Patapsco River	Split of Gwynns Falls	2060003	0.3	N	AE	2018
Gwynns Falls Tributary 1**	City of Baltimore	City limits	City limits	2060003	0.5	N	A	2017
Gwynns Run	City of Baltimore	Upstream of Gwynns Falls Parkway	Approximately 1.7 square miles drainage area	2060003	0.4	Y	AE	2018

* Information for flooding sources that are not being revised in 2017-2018 has been captured from the FIS dated April 2, 2014. As such, some information is not available and users may wish to consult other sources, such as the corresponding FIRM panels.

** Flooding source is located primarily inside Baltimore County, therefore modeling is performed as part of Baltimore County update.

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Herring Run	City of Baltimore	City limits	Approximately 1,300 feet upstream of Interstate 895	2060003	1.1	Y	AE	2018
Herring Run	City of Baltimore	Approximately 1,300 feet upstream of Interstate 895	City limits	2060003	6.6	N	A	2017
Herring Run Tributary 1	City of Baltimore	Confluence with Herring Run	Approximately 0.5 square miles drainage area	2060003	0.6	Y	AE	2018
Jones Falls (2-Dimensional Analysis)	City of Baltimore	Mouth of Jones Falls	Approximately 600 feet downstream of US Highway 1 (West North Avenue)	2060003	2.1	N	AE	2018
Jones Falls	City of Baltimore	Approximately 600 feet downstream of US Highway 1 (West North Avenue)	City limits	2060003	5.5	Y	AE	2018
Maidens Choice Run	City of Baltimore	Confluence with Gwynns Falls	Approximately 270 feet downstream of South Beechfield Avenue	2060003	2.2	Y	AE	2018
Maidens Choice Run	City of Baltimore	Approximately 270 feet downstream of South Beechfield Avenue	Approximately 0.1 square miles drainage area	2060003	1.0	N	AE	2018

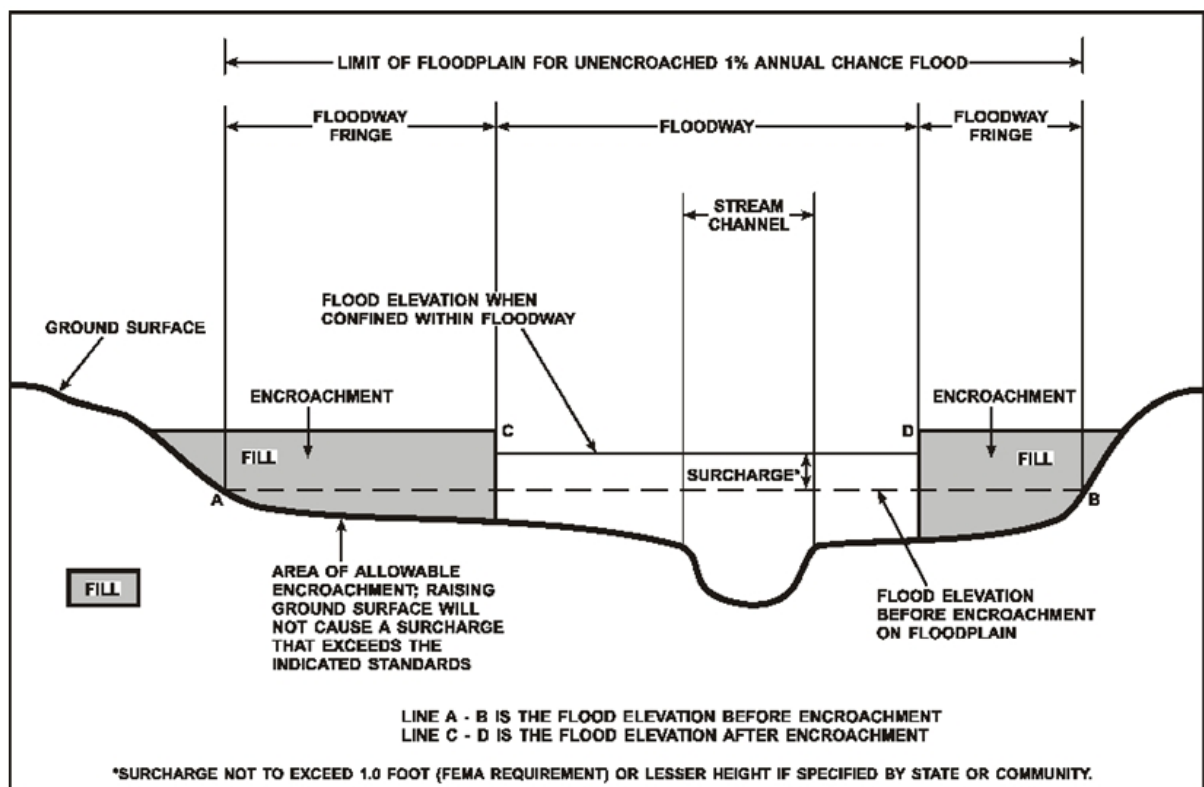
Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Maidens Choice Run (overland flow)	City of Baltimore	Approximately 250 feet downstream of South Beechfield Avenue	Approximately 200 feet upstream of Frederick Avenue	2060003	0.6	N	AE	2018
Maidens Choice Run Tributary 1	City of Baltimore	Confluence with Maidens Choice Run	City limits	2060003	0.3	N	A	2017
Moores Run	City of Baltimore	City limits	Approximately 2.9 square miles drainage area	2060003	2.5	Y	AE	2018
Patapsco River	City of Baltimore	Approximately 300 feet downstream of State Highway 2	City limits	2060003	0.9	N	A	2018
Stony Run	City of Baltimore	Confluence with Jones Falls	Upstream of West University Parkway	2060003	1.3	N	A	2017
Stony Run	City of Baltimore	Upstream of West University Parkway	Approximately 100 feet downstream of West Northern Parkway	2060003	1.9	Y	AE	2018
Stony Run	City of Baltimore	Approximately 100 feet downstream of West Northern Parkway	Downstream of West Melrose Avenue	2060003	0.3	N	A	2018
West Branch Herring Run	City of Baltimore	Confluence with Herring Run	City limits	2060003	1.1	N	A	2017
Western Run	City of Baltimore	Confluence with Jones Falls	Approximately 800 feet upstream of Clarks Lane	2060003	3.2	Y	AE	2018

2.2 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 balancing floodplain development against increasing flood hazard. With this approach, the area of the 1% annual chance floodplain on a river is divided into a floodway and a floodway fringe based on hydraulic modeling. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment in order to carry the 1% annual chance flood. The floodway fringe is the area between the floodway and the 1% annual chance floodplain boundaries where encroachment is permitted. The floodway must be wide enough so that the floodway fringe could be completely obstructed without increasing the water surface elevation of the 1% annual chance flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 4.

Figure 4: Floodway Schematic



To participate in the NFIP, Federal regulations require communities to limit increases caused by encroachment to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this project are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway projects.

Floodway widths presented in this FIS Report and on the FIRM were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. For certain stream segments, floodways were adjusted so that the amount of floodwaters conveyed on each side of the floodplain would be reduced equally. The results of the floodway computations have been tabulated for selected cross sections and are shown in Table 23, "Floodway Data."

All floodways that were developed for this Flood Risk Project are shown on the FIRM using the symbology described in Figure 3. In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary has been shown on the FIRM. For information about the delineation of floodways on the FIRM, refer to Section 6.3.

2.3 Base Flood Elevations

The hydraulic characteristics of flooding sources were analyzed to provide estimates of the elevations of floods of the selected recurrence intervals. The Base Flood Elevation (BFE) is the elevation of the 1% annual chance flood. These BFEs are most commonly rounded to the whole foot, as shown on the FIRM, but in certain circumstances or locations they may be rounded to 0.1 foot. Cross section lines shown on the FIRM may also be labeled with the BFE rounded to 0.1 foot. Whole-foot BFEs derived from engineering analyses that apply to coastal areas, areas of ponding, or other static areas with little elevation change may also be shown at selected intervals on the FIRM.

BFEs are primarily intended for flood insurance rating purposes. Cross sections with BFEs shown on the FIRM correspond to the cross sections shown in the Floodway Data table and Flood Profiles in this FIS Report. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS Report in conjunction with the data shown on the FIRM. For example, the user may use the FIRM to determine the stream station of a location of interest and then use the profile to determine the 1-percent-annual-chance elevation at that location. Because only selected cross sections may be shown on the FIRM for riverine areas, the profile should be used to obtain the flood elevation between mapped cross sections. Additionally, for riverine areas, whole-foot elevations shown on the FIRM may not exactly reflect the elevations derived from the hydraulic analyses; therefore, elevations obtained from the profile may more accurately reflect the results of the hydraulic analysis.

2.4 Non-Encroachment Zones

This section is not applicable to this Flood Risk Project.

2.5 Coastal Flood Hazard Areas

For most areas along rivers, streams, and small lakes, BFEs and floodplain boundaries are based on the amount of water expected to enter the area during a 1% annual chance flood and the geometry of the floodplain. Floods in these areas are typically caused by storm events. However, for areas on or near ocean coasts, large rivers, or large bodies of water, BFE and floodplain boundaries may need to be based on additional components, including storm surges and waves. Communities on or near ocean coasts face flood hazards caused by offshore seismic events as well as storm events.

Coastal flooding sources that are included in this Flood Risk Project are shown in Table 2.

2.5.1 Water Elevations and the Effects of Waves

Specific terminology is used in coastal analyses to indicate which components have been included in evaluating flood hazards.

The stillwater elevation (SWEL or still water level) is the surface of the water resulting from astronomical tides, storm surge, and freshwater inputs, but excluding wave setup contribution or the effects of waves.

- *Astronomical tides* are periodic rises and falls in large bodies of water caused by the rotation of the earth and by the gravitational forces exerted by the earth, moon and sun.
- *Storm surge* is the additional water depth that occurs during large storm events. These events can bring air pressure changes and strong winds that force water up against the shore.
- *Freshwater inputs* include rainfall that falls directly on the body of water, runoff from surfaces and overland flow, and inputs from rivers.

The 1% annual chance stillwater elevation is the stillwater elevation that has been calculated for a storm surge from a 1% annual chance storm. The 1% annual chance storm surge can be determined from analyses of tidal gage records, statistical study of regional historical storms, or other modeling approaches. Stillwater elevations for storms of other frequencies can be developed using similar approaches.

The total stillwater elevation (also referred to as the mean water level) is the stillwater elevation plus wave setup contribution but excluding the effects of waves.

- *Wave setup* is the increase in stillwater elevation at the shoreline caused by the reduction of waves in shallow water. It occurs as breaking wave momentum is transferred to the water column.

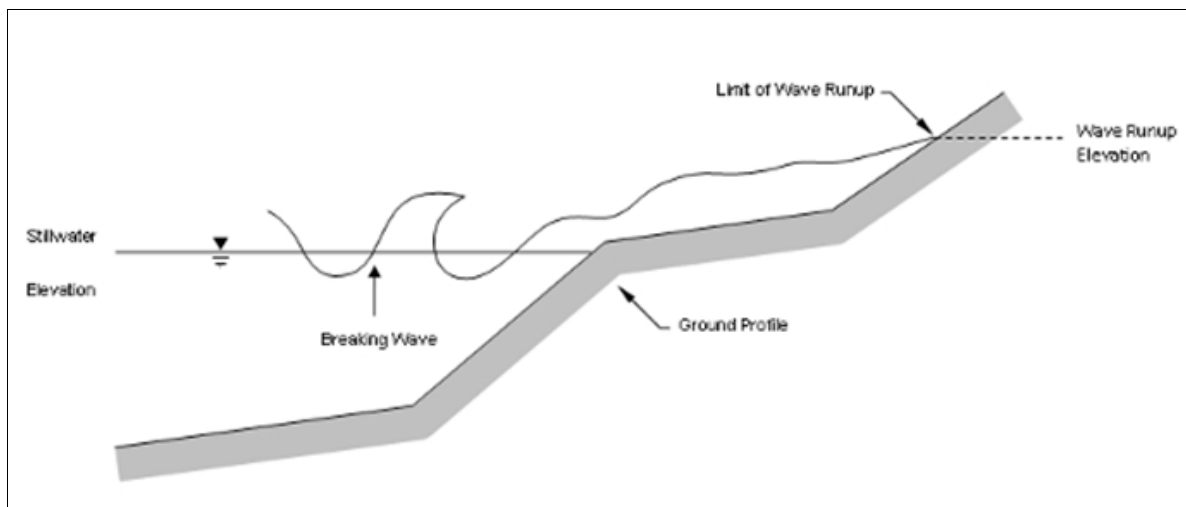
Like the stillwater elevation, the total stillwater elevation is based on a storm of a particular frequency, such as the 1% annual chance storm. Wave setup is typically estimated using standard engineering practices or calculated using models, since tidal gages are often sited in areas sheltered from wave action and do not capture this information.

Coastal analyses may examine the effects of overland waves by analyzing storm-

induced erosion, overland wave propagation, wave runup, and/or wave overtopping.

- *Storm-induced erosion* is the modification of existing topography by erosion caused by a specific storm event, as opposed to general erosion that occurs at a more constant rate.
- *Overland wave propagation* describes the combined effects of variation in ground elevation, vegetation, and physical features on wave characteristics as waves move onshore.
- *Wave runup* is the uprush of water from wave action on a shore barrier. It is a function of the roughness and geometry of the shoreline at the point where the stillwater elevation intersects the land.
- *Wave overtopping* refers to wave runup that occurs when waves pass over the crest of a barrier.

Figure 5: Wave Runup Transect Schematic



2.5.2 Floodplain Boundaries and BFEs for Coastal Areas

For coastal communities along the Atlantic and Pacific Oceans, the Gulf of Mexico, the Great Lakes, and the Caribbean Sea, flood hazards must take into account how storm surges, waves, and extreme tides interact with factors such as topography and vegetation. Storm surge and waves must also be considered in assessing flood risk for certain communities on rivers or large inland bodies of water.

Beyond areas that are affected by waves and tides, coastal communities can also have riverine floodplains with designated floodways, as described in previous sections.

Floodplain Boundaries

In many coastal areas, storm surge is the principle component of flooding. The extent of the 1% annual chance floodplain in these areas is derived from the total stillwater elevation (stillwater elevation including storm surge plus wave setup) for the 1% annual chance storm. The methods that were used for calculation of total stillwater elevations for coastal areas are described in Section 5.3 of this FIS Report. Location of total stillwater elevations for coastal areas are shown in Figure 8, "1% Annual Chance Total Stillwater Levels for Coastal Areas."

In some areas, the 1% annual chance floodplain is determined based on the limit of wave runup or wave overtopping for the 1% annual chance storm surge. The methods that were used for calculation of wave hazards are described in Section 5.3 of this FIS Report.

Table 25 presents the types of coastal analyses that were used in mapping the 1% annual chance floodplain in coastal areas.

Coastal BFEs

Coastal BFEs are calculated as the total stillwater elevation (stillwater elevation including storm surge plus wave setup) for the 1% annual chance storm plus the additional flood hazard from overland wave effects (storm-induced erosion, overland wave propagation, wave runup and wave overtopping).

Where they apply, coastal BFEs are calculated along transects extending from offshore to the limit of coastal flooding onshore. Results of these analyses are accurate until local topography, vegetation, or development type and density within the community undergoes major changes.

Parameters that were included in calculating coastal BFEs for each transect included in this FIS Report are presented in Table 16, "Coastal Transect Parameters." The locations of transects are shown in Figure 9, "Transect Location Map." More detailed information about the methods used in coastal analyses and the results of intermediate steps in the coastal analyses are presented in Section 5.3 of this FIS Report. Additional information on specific mapping methods is provided in Section 6.4 of this FIS Report.

2.5.3 Coastal High Hazard Areas

Certain areas along the open coast and other areas may have higher risk of experiencing structural damage caused by wave action and/or high-velocity water during the 1% annual chance flood. These areas will be identified on the FIRM as Coastal High Hazard Areas.

- *Coastal High Hazard Area (CHHA)* is a SFHA extending from offshore to the inland limit of the primary frontal dune (PFD) or any other area subject to damages caused by wave action and/or high-velocity water during the 1% annual chance flood.
- *Primary Frontal Dune (PFD)* is a continuous or nearly continuous mound or ridge of sand with relatively steep slopes immediately landward and adjacent to the beach. The PFD is subject to erosion and overtopping from high tides and waves during major coastal storms.

CHHAs are designated as "V" zones (for "velocity wave zones") and are subject to more stringent regulatory requirements and a different flood insurance rate structure. The areas of greatest risk are shown as VE on the FIRM. Zone VE is further subdivided into elevation zones and shown with BFEs on the FIRM.

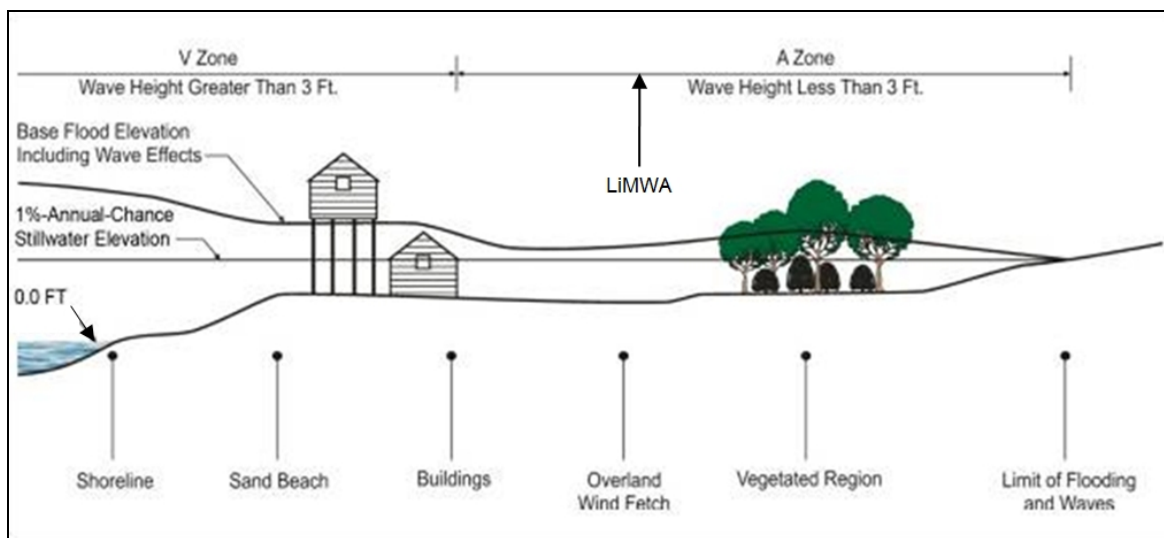
The landward limit of the PFD occurs at a point where there is a distinct change from a relatively steep slope to a relatively mild slope; this point represents the landward

extension of Zone VE. Areas of lower risk in the CHHA are designated with Zone V on the FIRM. More detailed information about the identification and designation of Zone VE is presented in Section 6.4 of this FIS Report.

Areas that are not within the CHHA but are SFHAs may still be impacted by coastal flooding and damaging waves; these areas are shown as “A” zones on the FIRM.

Figure 6, “Coastal Transect Schematic,” illustrates the relationship between the base flood elevation, the 1% annual chance stillwater elevation, and the ground profile as well as the location of the Zone VE and Zone AE areas in an area without a PFD subject to overland wave propagation. This figure also illustrates energy dissipation and regeneration of a wave as it moves inland.

Figure 6: Coastal Transect Schematic



Methods used in coastal analyses in this Flood Risk Project are presented in Section 5.3 and mapping methods are provided in Section 6.4 of this FIS Report.

Coastal floodplains are shown on the FIRM using the symbology described in Figure 3, “Map Legend for FIRM.” In many cases, the BFE on the FIRM is higher than the stillwater elevations shown in Table 17 due to the presence of wave effects. The higher elevation should be used for construction and/or floodplain management purposes.

2.5.4 Limit of Moderate Wave Action

Laboratory tests and field investigations have shown that wave heights as little as 1.5 feet can cause damage to and failure of typical Zone AE building construction. Wood-frame, light gage steel, or masonry walls on shallow footings or slabs are subject to damage when exposed to waves less than 3 feet in height. Other flood hazards associated with coastal waves (floating debris, high velocity flow, erosion, and scour) can also damage Zone AE construction.

Therefore, a LiMWA boundary may be shown on the FIRM as an informational layer to assist coastal communities in safe rebuilding practices. The LiMWA represents the

approximate landward limit of the 1.5-foot breaking wave. The location of the LiMWA relative to Zone VE and Zone AE is shown in Figure 6.

The effects of wave hazards in Zone AE between Zone VE (or the shoreline where Zone VE is not identified) and the limit of the LiMWA boundary are similar to, but less severe than, those in Zone VE where 3-foot or greater breaking waves are projected to occur during the 1% annual chance flooding event. Communities are therefore encouraged to adopt and enforce more stringent floodplain management requirements than the minimum NFIP requirements in the LiMWA. The NFIP Community Rating System provides credits for these actions.

SECTION 3.0 – INSURANCE APPLICATIONS

3.1 National Flood Insurance Program Insurance Zones

For flood insurance applications, the FIRM designates flood insurance rate zones as described in Figure 3, “Map Legend for FIRM.” Flood insurance zone designations are assigned to flooding sources based on the results of the hydraulic or coastal analyses. Insurance agents use the zones shown on the FIRM and depths and base flood elevations in this FIS Report in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

The 1% annual chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (e.g. Zones A, AE, V, VE, etc.), and the 0.2% annual chance floodplain boundary corresponds to the boundary of areas of additional flood hazards.

Table 3 lists the flood insurance zones in City of Baltimore.

Table 3: Flood Zone Designations by Community

Community	Flood Zone(s)
City of Baltimore, Independent City	A, AE, AO, VE, X

SECTION 4.0 – AREA STUDIED

4.1 Basin Description

Table 4 contains a description of the characteristics of the HUC-8 sub-basins within which each community falls. The table includes the main flooding sources within each basin, a brief description of the basin, and its drainage area.

Table 4: Basin Characteristics

HUC-8 Sub-Basin Name	HUC-8 Sub-Basin Number	Primary Flooding Source	Description of Affected Area	Drainage Area (square miles)
Gunpowder-Patapsco	02060003	Gunpowder Falls, Little Gunpowder Falls, Patapsco River	The entire City of Baltimore lies within the Gunpowder-Patapsco sub-basin.	1,417

4.2 Principal Flood Problems

Table 5 contains a description of the principal flood problems that have been noted for City of Baltimore by flooding source.

Table 5: Principal Flood Problems

Flooding Source	Description of Flood Problems
All flooding sources	(FEMA, 2014) The City of Baltimore is subject to tidal flooding caused by northeasters and hurricanes. Northeasters can occur at any time of the year but are more prevalent in late fall through early spring, whereas hurricanes usually occur in late summer and early fall. Riverine flooding in the city can be attributed to the following problems: urbanization, which creates more runoff from impervious zones and higher, sharper flood peaks; stream channel encroachments, which include structures within the floodplain and undersized railroad and roadway bridges; and inadequate storm sewer drainage. These flooding problems are enhanced by high tides along the city waterfront. Flooding in the city has caused loss of life; the flood of 1966 had 39 fatalities. There has also been loss of dwellings, factories, bridges, and farm animals. The most severe storm of record in the Baltimore area was a hurricane that occurred in 1933. This hurricane hit the coast at a higher latitude than most tropical storms that affect the region and entered the Chesapeake Bay directly from the ocean. There was no loss of energy by passing overland. Damage from tidal flooding in the Baltimore area was estimated to be approximately \$5 million. Wind velocities reached 60 miles per hour, and tides rose to a record height of 7.87 feet at Fort McHenry. One of the most significant flooding events in recent years was Tropical Storm Isabel in September 2003. Isabel was a federally declared disaster, which

	caused over \$8 million in damage in Maryland. Newspaper accounts have shown evidence of flooding, particularly for Jones Falls. One of the earliest of such accounts was the flood of 1817, which occurred on August 8. One resident recalls that “. . . houses and bridges, horses and cattle were swept down the Jones Falls. Flood level was 15 or 20 feet above usual level. Water reached the windows of second story.” Another resident recalled that the floodwaters of Jones Falls had risen approximately 12 feet. In December 1872, Ross Winans proposed a plan for flood control on Jones Falls to the City Council. His plan entailed “. . . amending the present channel as to curves and width, and increasing the depth 24 feet below mid-tide.” From south of North Avenue to the Northwest Harbor, Jones Falls flows through an underground triple-celled concrete box storm sewer. This sewer lacks adequate conveyance capacity to carry the major Jones Falls floodwaters; therefore, sheet flooding is common on streets in the vicinity of the storm sewer during heavy rain periods. Gwynns Run, from Hanlon Park to Gwynns Falls, also flows through an underground storm sewer. The restricted natural drainage for this storm sewer area causes sheet flow along the streets in this vicinity. It is also noted that three bridges across Jones Falls are undersized and cause major backwater flooding. These are the Union Avenue bridge, the Smith Avenue bridge, and the Amtrak box culvert in the vicinity of North Avenue. In addition, Maidens Choice Run has three major culverts that cause backwater flooding, which include the culverts under Boswell Road, North Bond Road, and Stonecroft Road.
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Table 6 contains information about historic flood elevations in City of Baltimore.

Table 6: Historic Flooding Elevations

Flooding Source	Location	Historic Peak (relative to gage datum)	Event Date	Approximate Recurrence Interval (years)	Source of Data
Gwynns Falls	USGS Gage 01589352 at Washington Boulevard, Baltimore, Maryland	20.03	1999	unknown	USGS gage
Gwynns Falls	USGS Gage 01589352 at Washington Boulevard, Baltimore, Maryland	17.97	2004	Unknown	USGS gage
Gwynns Falls	USGS Gage 01589352 at Washington Boulevard, Baltimore, Maryland	17.72	2016	Unknown	USGS gage

Flooding Source	Location	Historic Peak (relative to gage datum)	Event Date	Approximate Recurrence Interval (years)	Source of Data
Moores Run	USGS Gage 01585230 at Radecke Avenue, Baltimore, Maryland	10.48	2003	Unknown	USGS gage
Moores Run	USGS Gage 01585230 at Radecke Avenue, Baltimore, Maryland	10.27	2006	Unknown	USGS gage

4.3 Non-Levee Flood Protection Measures

Table 7 contains information about non-levee flood protection measures within City of Baltimore such as dams, jetties, and or dikes. Levees are addressed in Section 4.4 of this FIS Report.

Table 7: Non-Levee Flood Protection Measures

Flooding Source	Structure Name	Type of Measure	Location	Description of Measure
Multiple flooding sources	N/A	Various	Various	(FEMA, 2014) The City of Baltimore had a channel straightening project on a stretch of Moores Run between the eastern corporate limits and Interstate Route 95. On Western Run, several bridges with inadequate waterway openings are to be replaced by the city. Portions of Jones Falls, Herring Run, and Western Run have paved channel beds to facilitate passage of flood flows. The trash catcher on Jones Falls at 29th Street keeps large upstream debris from clogging the underground sections of that stream.

4.4 Levees

This section is not applicable to this Flood Risk Project.

Table 8: Levees
[Not Applicable to this Flood Risk Project]

SECTION 5.0 – ENGINEERING METHODS

For the flooding sources in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded at least once on the average during any 10-, 25-, 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-, 25-, 50-, 100-, and 500-year floods, have a 10-, 4-, 2-, 1-, and 0.2% annual 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 that equals or exceeds the 100-year flood (1-percent chance of annual exceedance) during the term of a 30-year mortgage is approximately 26 percent (about 3 in 10); 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 community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

The engineering analyses described here incorporate the results of previously issued Letters of Map Change (LOMCs) listed in Table 26, “Incorporated Letters of Map Change”, which include Letters of Map Revision (LOMRs). For more information about LOMRs, refer to Section 6.5, “FIRM Revisions.”

5.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied. Hydrologic analyses are typically performed at the watershed level. Depending on factors such as watershed size and shape, land use and urbanization, and natural or man-made storage, various models or methodologies may be applied. A summary of the hydrologic methods applied to develop the discharges used in the hydraulic analyses for each stream is provided in Table 13. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

A summary of the discharges is provided in Table 9. Coastal stillwater elevations are discussed in Section 5.3 and shown in Table 16. Stream gage information is provided in Table 11.

Table 9: Summary of Discharges

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Biddison Run	Approximately 400 feet downstream of Moravia Road	1.2	526	823	1,120	1,510	2,850
Gwynns Falls	Upstream of I-95	63.7	13,937	18,797	23,627	29,527	48,127
Gwynns Falls	Approximately 260 feet upstream of Hilton Parkway	50.3	11,864	16,483	20,968	26,443	43,719
Gwynns Falls	Approximately 1,600 feet upstream of confluence of Dead Run	41.9	10,270	14,106	17,904	22,537	37,361
Gwynns Falls split flow (CSX)	Downstream of the split on Gwynns Falls	N/A	1	57	1,284	4,273	15,096
Gwynns Falls split flow (middle)	Downstream of the split on Gwynns Falls split flow (CSX)	N/A	1	1	177	759	2,707
Gwynns Falls split flow (Westport)	Downstream of the split on Gwynns Falls	N/A	1	153	520	921	4,621
Gwynns Run	Upstream of Gwynns Falls Parkway	2.3	1,610	2,300	2,920	3,650	5,790
Herring Run	At downstream city limits	20.9	5,159	7,448	9,548	12,099	19,966
Herring Run Tributary 1	Approximately 150 feet downstream of North Point Road	0.7	650	1,060	1,490	2,060	4,150

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Jones Falls (two-dimensional analysis of overland flow)	Upstream of the entrance to the Jones Falls Conduit	54.6	*	*	15,400	19,300	28,970
Jones Falls	Upstream of North Howard Street	54.6	9,150	13,600	17,800	23,100	40,100
Jones Falls	Approximately 560 feet upstream of confluence of Stony Run	48.9	8,300	12,400	16,300	21,200	37,200
Jones Falls	Approximately 450 feet upstream of confluence of Western Run	38.2	6,740	10,200	13,500	17,700	31,600
Maidens Choice Run	Approximately 700 feet upstream of Wilkens Avenue	4.1	2,151	3,117	3,983	5,019	8,178
Maidens Choice Run	Approximately 500 feet upstream of Yale Avenue	2.8	1,730	2,490	3,190	4,010	6,490
Maidens Choice Run	Upstream of North Bend Road	0.4	498	715	910	1,140	1,800
Maidens Choice Run	Upstream limit	0.1	243	353	454	570	915
Maidens Choice Run (overland flow)	Near the intersection of Frederick Avenue and Wyndholme Way	N/A	**	**	394	918	2212
Moores Run	Downstream city limits	4.8	1,489	2,240	2,974	3,882	6,888
Moores Run	Upstream limit	2.9	1,244	1,889	2,519	3,308	5,941

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Stony Run	Approximately 2,200 feet downstream of West University Parkway	3.0	1,730	2,510	3,240	4,090	6,720
Stony Run	Approximately 350 feet downstream of West Cold Spring Lane	2.1	1,380	2,020	2,600	3,300	5,440
Stony Run	Approximately 360 feet downstream of Wyndhurst Avenue	0.8	817	1,200	1,560	1,980	3,280
Stony Run	Approximately 360 feet downstream of West Northern Parkway	0.4	478	707	922	1,180	1,960
Western Run	Approximately 280 feet upstream of the confluence with Jones Falls	5.6	2,500	3,640	4,690	5,960	9,870
Western Run	Approximately 450 feet upstream of Clarks Avenue	2.0	1,290	1,890	2,450	3,110	5,170

* 10% and 4% annual chance discharges contained by the conduit system

** Discharge completely contained in culvert

Figure 7: Frequency Discharge-Drainage Area Curves

[Not Applicable to this flood Risk Project]

Table 10: Summary of Non-Coastal Stillwater Elevations
[Not Applicable to this flood Risk Project]

Table 11: Stream Gage Information used to Determine Discharges

Flooding Source	Gage Identifier	Agency that Maintains Gage	Site Name	Drainage Area (Square Miles)	Period of Record	
					From	To
Dead Run	01589330	USGS	Dead Run At Franklinton, MD	5.5	9/12/1960	7/30/2016
Gwynns Falls	01589300	USGS	Gwynns Falls At Villa Nova, MD	33.0	7/21/1956	7/30/2016
Jones Falls	01589440	USGS	Jones Falls At Sorrento, MD	25.2	1/25/1958	7/30/2016
West Branch Herring Run	01585200	USGS	West Branch Herring Run At Idlewyde, MD	2.1	7/6/1958	2/24/2016

5.2 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. Base flood elevations on the FIRM represent the elevations shown on the Flood Profiles and in the Floodway Data tables in the FIS Report. Rounded whole-foot elevations may be shown on the FIRM in coastal areas, areas of ponding, and other areas with static base flood elevations. These whole-foot elevations may not exactly reflect the elevations derived from the hydraulic analyses. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS Report in conjunction with the data shown on the FIRM. The hydraulic analyses for this FIS were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

For streams for which hydraulic analyses were based on cross sections, locations of selected cross sections are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 6.3), selected cross sections are also listed on Table 23, "Floodway Data."

A summary of the methods used in hydraulic analyses performed for this project is provided in Table 12. Roughness coefficients are provided in Table 13. Roughness coefficients are values representing the frictional resistance water experiences when passing overland or through a channel. They are used in the calculations to determine water surface elevations. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

Table 12: Summary of Hydrologic and Hydraulic Analyses

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Biddison Run	Confluence with Herring Run	Downstream of Sipple Avenue	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	
Chesapeake Bay / Patapsco River	Entire coastline	Entire coastline	*	SWAN + ADCIRC	2012	AE, VE	
Chinquapin Run	Confluence with Herring Run	Downstream of Walker Avenue	2010 State Regression Equations	HEC-RAS 4.1	2017	A	
Dead Run	Confluence with Gwynns Falls	City limits	2010 State Regression Equations	HEC-RAS 4.1	2017	A	
Gwynns Falls	Confluence with Middle Branch Patapsco River	City limits	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	Updated Discharges with Gage Weighting where applicable
Gwynns Falls split flow (CSX)	Confluence with Middle Branch Patapsco River	Split of Gwynns Falls	2010 State Regression Equations	HEC-RAS 4.1	2018	AE	Overland flow analysis
Gwynns Falls split flow (middle)	Confluence with Gwynns Falls	Split of Gwynns Falls split flow (CSX)	2011 State Regression Equations	HEC-RAS 4.1	2018	AE	Overland flow analysis
Gwynns Falls split flow (Westport)	Confluence with Middle Branch Patapsco River	Split of Gwynns Falls	2012 State Regression Equations	HEC-RAS 4.1	2018	AE	Overland flow analysis
Gwynns Falls Tributary 1	City limits	City limits	2010 State Regression Equations	HEC-RAS 4.1	2017	A	
Gwynns Run	Upstream of Gwynns Falls Parkway	Approximately 1.7 square miles drainage area	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	

* Information for flooding sources that are not being revised in 2017 has been captured from the FIS dated April 2, 2014. As such, some information is not available and users may wish to consult other sources, such as the corresponding FIRM panels.

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Herring Run	City limits	Approximately 1,300 feet upstream of Interstate 895	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	
Herring Run	Approximately 1,300 feet upstream of Interstate 895	City limits	2010 State Regression Equations	HEC-RAS 4.1	2017	A	
Herring Run Tributary 1	Confluence with Herring Run	Approximately 0.5 square miles drainage area	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	
Jones Falls (downstream Two-dimensional analysis)	Mouth of Jones Falls	Approximately 600 feet downstream of US Highway 1 (West North Avenue)	2016 State Regression Equations	HEC-RAS 5.0.3 and PCSWMM 7.0	2018	AE	Used PCSWMM for Jones Falls Tunnel systems capacity analysis and 2D for overland analysis of the overtopping flows
Jones Falls	Approximately 600 feet downstream of US Highway 1 (West North Avenue)	City limits	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	Updated Discharges with Gage Weighting where applicable
Maidens Choice Run	Confluence with Gwynns Falls	Approximately 270 feet downstream of South Beechfield Avenue	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	
Maidens Choice Run	Approximately 270 feet downstream of South Beechfield Avenue	Approximately 0.1 square miles drainage area	2010 State Regression Equations	HEC-RAS 4.1	2018	AE	
Maidens Choice Run (overland flow)	Approximately 250 feet downstream of South Beechfield Avenue	Approximately 200 feet upstream of Frederick Avenue	2010 State Regression Equations	HEC-RAS 4.1	2018	AE	Used overtopping flows from upstream of Frederick Ave.

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Maidens Choice Run Tributary 1	Confluence with Maidens Choice Run	City limits	2010 State Regression Equations	HEC-RAS 4.1	2018	A	Overland flow analysis was performed to support mapping
Moores Run	City limits	Approximately 2.9 square miles drainage area	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	
Patapsco River	Approximately 300 feet downstream of State Highway 2	City limits	Flow taken from the February 18, 2015 Anne Arundel County FIS report	HEC-RAS 4.1	2018	A	Used NOAA tidal maps for channel data where applicable; flows from Anne Arundel County FIS
Stony Run	Confluence with Jones Falls	Upstream of West University Parkway	2010 State Regression Equations	HEC-RAS 4.1	2017	A	
Stony Run	Upstream of West University Parkway	Approximately 100 feet downstream of West Northern Parkway	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	
Stony Run	Approximately 100 feet downstream of West Northern Parkway	Downstream of West Melrose Avenue	2010 State Regression Equations	HEC-RAS 4.1	2018	A	
West Branch Herring Run	Confluence with Herring Run	City limits	2010 State Regression Equations	HEC-RAS 4.1	2017	A	Updated Discharges with Gage Weighting where applicable;
Western Run	Confluence with Jones Falls	Approximately 800 feet from Clarks Lane	2010 State Regression Equations	HEC-RAS 4.1	2018	AE w/ Floodway	

Table 13: Roughness Coefficients

Flooding Source	Channel “n”	Overbank “n”
Biddison Run	0.045	0.016 - 0.100
Chinquapin Run	0.016 - 0.045	0.060 - 0.100
Dead Run	0.045	0.060 - 0.100
Gwynns Falls	0.030 - 0.045	0.016 - 0.160
Gwynns Falls split flow (CSX)	*	0.016 - 0.070
Gwynns Falls split flow (middle)	*	0.060
Gwynns Falls split flow (Westport)	*	0.016 - 0.060
Gwynns Falls Tributary 1	0.045	0.080 - 0.120
Gwynns Run	0.045	0.080 - 0.100
Herring Run (downstream Zone AE model)	0.035 - 0.045	0.010 - 0.100
Herring Run (upstream Zone A model)	0.045	0.060 - 0.120
Herring Run Tributary 1	0.045	0.016 - 0.100
Jones Falls (downstream 2-dimensional model)	buildings: 10.000 open space: 0.060 paved areas: 0.013 - 0.016 water: 0.030	
Jones Falls (upstream 1-dimensional model)	0.020 - 0.045	0.016 - 0.100
Maidens Choice Run	0.045	0.012 - 0.100
Maidens Choice Run (overland flow)	*	0.012 - 0.120
Maidens Choice Run Tributary 1	*	0.013 - 0.150
Moores Run	0.033 - 0.045	0.016 - 0.100
Patapsco River	0.030 - 0.035	0.080 - 0.100
Stony Run (downstream Zone A model)	0.045	0.045 - 0.100
Stony Run (upstream Zone AE and A hybrid model)	0.011 - 0.045	0.010 - 0.120
West Branch Herring Run	0.035 - 0.045	0.060 - 0.100
Western Run	0.030 - 0.045	0.012 - 0.100

* Overland flow, no open channel

5.3 Coastal Analyses

For the areas of City of Baltimore that are impacted by coastal flooding processes,

coastal flood hazard analyses were performed to provide estimates of coastal BFEs (FEMA, 2014). Coastal BFEs reflect the increase in water levels during a flood event due to extreme tides and storm surge as well as overland wave effects.

The following subsections provide summaries of how each coastal process was considered for this FIS Report. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation. Table 14 summarizes the methods and/or models used for the coastal analyses. Refer to Section 2.5.1 for descriptions of the terms used in this section.

Table 14: Summary of Coastal Analyses

Flooding Source	Study Limits From	Study Limits To	Hazard Evaluated	Model or Method Used	Date Analysis was Completed
Chesapeake Bay / Patapsco River	Entire coastline of City of Baltimore	Entire coastline of City of Baltimore	Storm Surge	SWAN + ADCIRC	2012
Chesapeake Bay / Patapsco River	Entire coastline of City of Baltimore	Entire coastline of City of Baltimore	Wave Setup	SWAN + ADCIRC	2012
Chesapeake Bay / Patapsco River	Entire coastline of City of Baltimore	Entire coastline of City of Baltimore	Wave Runup	(FEMA, 2007(a))	2012
Chesapeake Bay / Patapsco River	Entire coastline of City of Baltimore	Entire coastline of City of Baltimore	Wave Generation	unSWAN	2012
Chesapeake Bay / Patapsco River	Entire coastline of City of Baltimore	Entire coastline of City of Baltimore	Dune Erosion	(FEMA, 2007(b))	2012
Chesapeake Bay / Patapsco River	Entire coastline of City of Baltimore	Entire coastline of City of Baltimore	Overland Wave Propagation	WHAFIS 4.0 (FEMA, 2007(b))	2012

5.3.1 Total Stillwater Elevations

The total stillwater elevations (stillwater including storm surge plus wave setup) for the 1% annual chance flood were determined for areas subject to coastal flooding. The models and methods that were used to determine storm surge and wave setup are listed in Table 14. The stillwater elevation that was used for each transect in coastal analyses is shown in Table 16, "Coastal Transect Parameters." Figure 8 shows the total stillwater elevations for the 1% annual chance flood that was determined for this coastal analysis.

Figure 8: 1% Annual Chance Total Stillwater Elevations for Coastal Areas
[Not Available to this Flood Risk Project]

Storm Surge Statistics

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 (Luettich et. al, 2008). ADCIRC was dynamically coupled to the unstructured numerical wave model Simulating WAVes Nearshore (unSWAN) to calculate the contribution of waves to total storm surge (USACE, 2012). The resulting model system is typically referred to as SWAN+ADCIRC (USACE, 2012). 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 (2003), Hurricane Ernesto (2006), and extratropical storm Ida (2009). Model skill was assessed by quantitative comparison of model output to wind, wave, water level and high water mark observations (FEMA, 2014).

The tidal surge for those estuarine areas of the Chesapeake Bay affects the entire shoreline of City of Baltimore. The entire open coastline is more prone to damaging wave action during high wind events due to the significant fetch over which winds can operate. Inland from the mouth of the Patapsco River, river widths narrow considerably as it converges with non-tidal tributaries. In this area, the fetch over which winds can operate for wave generation is significantly less (FEMA, 2014).

Table 15: Tide Gage Analysis Specifics
[Not Applicable to this Flood Risk Project]

Wave Setup Analysis

For the City of Baltimore coastal analysis, wave setup was determined directly from the coupled wave and storm surge model (SWAN+ADCIRC) (FEMA, 2014).

5.3.2 Waves

As previously described, unSWAN is used to model nearshore wave fields.

5.3.3 Coastal Erosion

Due to the developed nature, dune erosion was not taken into account along the Chesapeake Bay coastline. A review of the geology and shoreline type in City of Baltimore 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 (FEMA, 2007(a)). 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 (FEMA, 2014).

5.3.4 Wave Hazard Analyses

Overland wave hazards were evaluated to determine the combined effects of ground elevation, vegetation, and physical features on overland wave propagation and wave runup. These analyses were performed at representative transects along all shorelines for which waves were expected to be present during the floods of the selected recurrence intervals. The results of these analyses were used to determine elevations for the 1% annual chance flood.

Transect locations were chosen with consideration given to the physical land characteristics as well as development type and density so that they would closely represent conditions in their locality. Additional consideration was given to changes in the total stillwater elevation. Transects were spaced close together in areas of complex topography and dense development or where total stillwater elevations varied. In areas having more uniform characteristics, transects were spaced at larger intervals. Transects shown in Figure 9, "Transect Location Map," are also depicted on the FIRM. Table 16 provides the location, stillwater elevations, and starting wave conditions for each transect evaluated for overland wave hazards. In this table, "starting" indicates the parameter value at the beginning of the transect.

Wave Height Analysis

Wave height analyses were performed to determine wave heights and corresponding wave crest elevations for the areas inundated by coastal flooding and subject to overland wave propagation hazards. Refer to Figure 6 for a schematic of a coastal transect evaluated for overland wave propagation hazards.

Wave heights and wave crest elevations were modeled using the methods and models listed in Table 14, "Summary of Coastal Analyses".

Wave Runup Analysis

Wave runup analyses were performed to determine the height and extent of runup beyond the limit of stillwater inundation for the 1% annual chance flood. Wave runup elevations were modeled using the methods and models listed in Table 14.

Table 16: Coastal Transect Parameters

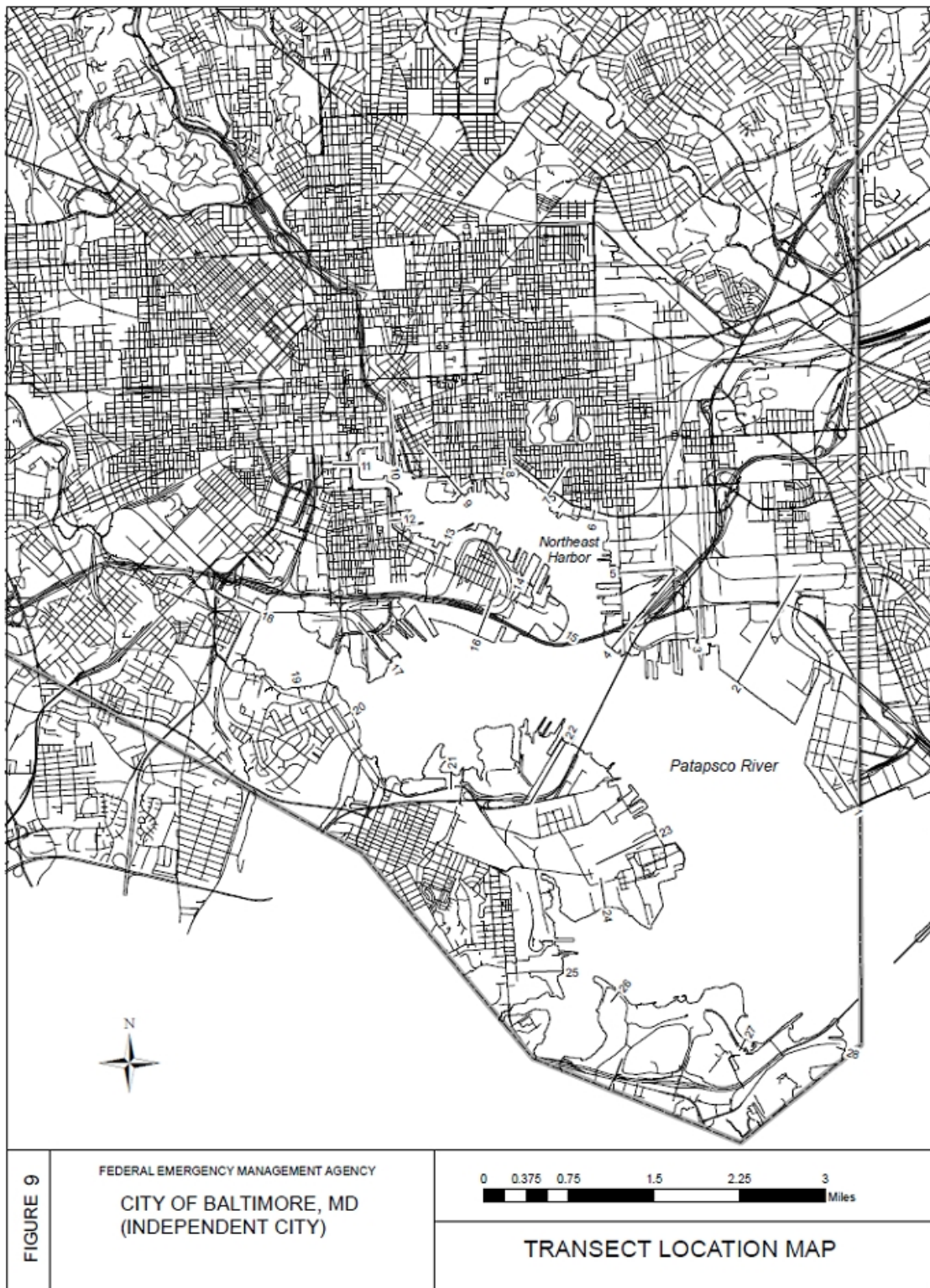
Flood Source	Coastal Transect	Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations and Range of Stillwater Elevations** (ft NAVD88)				
		Significant Wave Height H _s (ft)	Peak Wave Period T _p (sec)	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Patapsco River	1	2.7	3.2	4.2	*	4.8	5.1	7.1
Patapsco River	2	3.2	3.8	4.2	*	4.8	5.2	7.2
Patapsco River	3	3.7	3.9	4.2	*	4.8	5.2	7.3
Patapsco River	4	3.5	4.0	4.2	*	4.8	5.2	7.3
Northwest Harbor	5	2.0	2.9	4.2	*	4.7	5.2	7.3
Northwest Harbor	6	1.8	2.9	4.2	*	4.8	5.2	7.3
Northwest Harbor	7	1.8	2.7	4.2	*	4.8	5.2	7.4
Northwest Harbor	8	1.7	2.7	4.2	*	4.8	5.2	7.4
Northwest Harbor	9	1.4	2.6	4.2	*	4.8	5.2	7.4
Northwest Harbor	10	1.3	2.2	4.2	*	4.8	5.2	7.5
Northwest Harbor	11	1.1	2.2	4.2	*	4.8	5.3	7.5
Northwest Harbor	12	1.2	2.3	4.2	*	4.8	5.2	7.4
Northwest Harbor	13	1.2	2.5	4.2	*	4.8	5.2	7.4
Northwest Harbor	14	1.6	2.6	4.2	*	4.8	5.2	7.4
Middle Branch	15	3.3	3.9	4.2	*	4.8	5.2	7.3

Flood Source	Coastal Transect	Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations and Range of Stillwater Elevations** (ft NAVD88)				
		Significant Wave Height H _s (ft)	Peak Wave Period T _p (sec)	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Middle Branch	16	2.7	3.7	4.2	*	4.8	5.2	7.3
Middle Branch	17	2.2	3.2	4.2	*	4.8	5.2	7.4
Middle Branch	18	1.4	2.3	4.2	*	4.9	5.3	7.6
Middle Branch	19	1.1	2.2	4.2	*	4.8	5.2	7.5
Middle Branch	20	1.5	3.0	4.2	*	4.8	5.2	7.4
Patapsco River	21	1.1	3.8	4.1	*	4.8	5.2	7.3
Patapsco River	22	3.1	4.0	4.2	*	4.8	5.2	7.2
Patapsco River	23	3.4	4.0	4.2	*	4.8	5.2	7.2
Curtis Bay	24	2.2	3.1	4.1	*	4.7	5.1	7.2
Curtis Bay	25	1.7	3.0	4.1	*	4.8	5.1	7.1
Curtis Bay	26	2.3	3.1	4.1	*	4.7	5.1	7.1
Patapsco River	27	2.3	3.4	4.1	*	4.7	5.1	7.0
Patapsco River	28	3.6	4.3	4.1	*	4.7	5.0	6.9

*Not calculated for this Flood Risk Project

**Range of Stillwater Elevations Not Available

Figure 9: Transect Location Map



5.4 Alluvial Fan Analyses

This section is not applicable to this Flood Risk Project.

Table 17: Summary of Alluvial Fan Analyses

[Not Applicable to this Flood Risk Project]

Table 18: Results of Alluvial Fan Analyses

[Not Applicable to this Flood Risk Project]

SECTION 6.0 – MAPPING METHODS

6.1 Vertical and Horizontal Control

All FIS Reports 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 used for newly created or revised FIS Reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the completion of the North American Vertical Datum of 1988 (NAVD88), many FIS Reports and FIRMs are now prepared using NAVD88 as the referenced vertical datum.

Flood elevations shown in this FIS Report and on the FIRMs are referenced to NAVD88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between NGVD29 and NAVD88 or other datum conversion, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

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 archived project documentation associated with the FIS Report and the FIRMs for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks in the area, please visit the NGS website at www.ngs.noaa.gov.

The datum conversion from NGVD29 to NAVD88 for City of Baltimore was -0.784 (FEMA, 2014).

Table 19: Countywide Vertical Datum Conversion

[Not Applicable to this Flood Risk Project]

Table 20: Stream-Based Vertical Datum Conversion

[Not Applicable to this Flood Risk Project]

6.2 Base Map

The FIRMs and FIS Report for this project have been produced in a digital format. The flood hazard information was converted to a Geographic Information System (GIS) format that meets FEMA's FIRM database specifications and geographic information standards. This information is provided in a digital format so that it can be incorporated into a local GIS and be accessed more easily by the community. The FIRM Database includes most of the tabular information contained in the FIS Report in such a way that the data can be associated with pertinent spatial features. For example, the information

contained in the Floodway Data table and Flood Profiles can be linked to the cross sections that are shown on the FIRMs. Additional information about the FIRM Database and its contents can be found in FEMA's *Guidelines and Standards for Flood Risk Analysis and Mapping*, <http://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping>.

Base map information shown on the FIRM was derived from the sources described in Table 21.

Table 21: Base Map Sources

Data Type	Data Provider	Data Date	Data Scale	Data Description
Color orthoimagery	State of Maryland	GIS service	GIS service	6 inch resolution image covering the state of Maryland
Political boundaries	FEMA	2017	shapefile	In March 2017, the city boundary from the 2014 effective DFIRM is edge matched to effective DFIRM boundaries of all surrounding counties.
Transportation Features	Downloaded from City of Baltimore GIS website	May 2016 (download date)	shapefile	Road centerlines (railroad features are carried over from the S_Trnsport_Ln layer of the 2014 effective DFIRM)
Surface Water Features	N/A	2016	shapefile	Centerline of studied reaches was derived from the Maryland imagery; The S_WTR_LN layer of the 2014 effective DFIRM was carried over and shown between studied reaches where necessary to demonstrate drainage relations

6.3 Floodplain and Floodway Delineation

The FIRM shows tints, screens, and symbols to indicate floodplains and floodways as well as the locations of selected cross sections used in the hydraulic analyses and floodway computations.

For riverine flooding sources, the mapped floodplain boundaries shown on the FIRM have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using the topographic elevation data described in Table 22. For each coastal flooding source studied as part of the FIS Report (FEMA, 2014), the mapped floodplain boundaries on the FIRM have been delineated using the flood and wave elevations determined at each transect; between transects, boundaries were delineated using land use and land cover data, topographic elevation data, and knowledge of coastal flood processes. In ponding areas, flood elevations were determined at each junction of the model; between junctions, boundaries were interpolated using topographic elevation data.

In cases where the 1% and 0.2% annual chance floodplain boundaries are close together, only the 1% 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.

The floodway widths presented in this FIS Report and on the FIRM 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. Table 2 indicates the flooding sources for which floodways have been determined. The results of the floodway computations for those flooding sources have been tabulated for selected cross sections and are shown in Table 23, "Floodway Data."

Table 22: Summary of Topographic Elevation Data used in Mapping

Community	Flooding Source	Source for Topographic Elevation Data			
		Description	Scale	Contour Interval	Citation
City of Baltimore, Independent City	All riverine flooding sources	Light Detection and Ranging data (LiDAR)	1 meter resolution Digital Elevation Model	N/A	Sanborn, 2008

BFEs shown at cross sections on the FIRM represent the 1% annual chance water surface elevations shown on the Flood Profiles and in the Floodway Data tables in the FIS Report. Rounded whole-foot elevations may be shown on the FIRM in coastal areas, areas of ponding, and other areas with static base flood elevations.

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	62	36	168	9.0	32.1	21.9 ²	22.2	0.3
B	510	32	153	9.9	32.1	27.0 ²	27.3	0.3
C	869	33	191	7.9	32.1	31.1 ²	31.6	0.5
D	1,118	50	321	4.7	36.2	36.2	36.2	0.0
E	1,482	36	243	6.2	36.8	36.8	36.8	0.0
F	1,947	74	344	4.4	41.1	41.1	41.1	0.0
G	2,122	94	310	4.9	41.5	41.5	41.5	0.0
H	2,750	51	481	3.1	47.7	47.7	47.7	0.0
I	3,476	113	576	2.5	52.3	52.3	52.4	0.1
J	4,138	67	208	6.9	54.7	54.7	55.0	0.3
K	4,769	40	241	5.9	59.5	59.5	60.4	0.9
L	5,346	35	232	6.2	62.1	62.1	62.8	0.7
M	6,123	52	511	2.5	73.7	73.7	73.7	0.0
N	7,078	59	374	3.4	75.8	75.8	76.2	0.4
O	7,815	25	169	7.7	81.6	81.6	81.7	0.1
P	9,079	26	150	8.4	93.0	93.0	93.9	0.9

¹ Feet above confluence with Herring Run

² Elevation computed without consideration of backwater from Herring Run

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: BIDDISON RUN

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	7,123	162	2,666	11.1	22.4	22.4	23.4	1.0
B	8,367	250	3,296	9.0	26.1	26.1	27.0	0.9
C	8,658	157	2,659	11.1	27.1	27.1	27.8	0.7
D	8,927	331	6,129	4.8	29.6	29.6	30.1	0.5
E	10,353	359	3,815	7.7	32.0	32.0	32.0	0.0
F	10,987	268	3,373	8.7	34.3	34.3	34.3	0.0
G	11,541	168	3,567	8.0	38.5	38.5	38.5	0.0
H	12,152	114	1,925	14.8	39.0	39.0	39.0	0.0
I	13,796	168	2,717	10.5	50.7	50.7	50.7	0.0
J	14,379	156	3,746	7.3	54.8	54.8	55.7	0.9
K	15,408	145	3,354	8.1	56.2	56.2	57.1	0.9
L	15,724	185	4,158	6.5	57.4	57.4	58.4	1.0
M	16,347	153	2,089	13.0	57.4	57.4	57.5	0.1
N	17,234	117	2,614	10.4	66.4	66.4	66.4	0.0
O	17,687	145	3,219	8.5	69.8	69.8	70.7	0.9
P	18,923	149	1,759	15.4	71.2	71.2	72.2	1.0
Q	19,397	159	2,487	10.9	76.0	76.0	76.5	0.5
R	20,911	111	1,418	19.1	92.1	92.1	92.1	0.0
S	22,279	226	3,038	8.9	115.6	115.6	115.7	0.1
T	23,160	420	6,151	4.4	119.0	119.0	119.0	0.0

¹ Feet above confluence with Middle Branch Patapsco River

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: GWYNNS FALLS

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
U	24,250	454	5,940	4.6	122.4	122.4	122.4	0.0
V	25,852	275	3,084	8.8	125.3	125.3	125.3	0.0
W	26,616	210	2,241	12.1	127.4	127.4	128.4	1.0
X	27,330	147	2,312	11.4	133.0	133.0	133.0	0.0
Y	29,400	164	1,967	13.4	141.9	141.9	142.4	0.5
Z	30,050	212	2,495	10.6	149.4	149.4	150.0	0.6
AA	32,253	150	1,518	14.8	160.7	160.7	161.5	0.8
AB	34,954	125	1,567	14.3	194.5	194.5	194.6	0.1
AC	36,695	58	1,000	22.4	218.8	218.8	218.9	0.1
AD	37,829	203	1,822	12.3	231.1	231.1	231.1	0.0
AE	38,851	206	1,892	11.9	240.1	240.1	240.1	0.0
AF	39,595	232	2,997	7.4	254.9	254.9	255.5	0.6
AG	40,355	148	3,054	7.1	266.3	266.3	266.8	0.5
AH	41,430	105	1,250	17.3	272.5	272.5	272.9	0.4
AI	42,670	175	1,717	12.6	285.5	285.5	285.5	0.0

¹ Feet above confluence with Middle Branch Patapsco River

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: GWYNNS FALLS

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	28	24	222	16.5	204.2	204.2	204.5	0.3
B	265	32	253	14.4	211.6	211.6	211.9	0.3
C	943	37	304	12.0	229.3	229.3	230.1	0.8
D	1,540	35	238	13.0	247.1	247.1	247.2	0.1
E	1,944	51	341	9.1	257.0	257.0	257.6	0.6

¹ Feet above Gwynns Falls Parkway

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: GWYNNS RUN

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	3,770	120	1,555	7.8	16.2	16.2	16.9	0.7
B	4,199	210	2,367	5.1	18.6	18.6	18.6	0.0
C	4,912	154	1,784	6.8	19.5	19.5	19.6	0.1
D	6,217	156	1,755	6.9	25.4	25.4	26.1	0.7
E	6,592	260	3,646	3.3	30.4	30.4	30.4	0.0
F	8,427	140	2,221	5.2	31.5	31.5	31.7	0.2
G	9,332	132	1,799	6.4	31.7	31.7	32.1	0.4

¹ Feet above confluence with Back River

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: HERRING RUN

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	1,843	46	251	8.2	26.3	26.3	26.3	0.0
B	2,466	40	224	9.2	31.5	31.5	32.3	0.8
C	3,429	31	317	5.3	41.4	41.4	42.2	0.8

¹ Feet above confluence with Herring Run

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: HERRING RUN TRIBUTARY 1

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	13,285	340	4,152	5.6	69.0	69.0	69.6	0.6
B	15,508	157	1,460	15.3	73.6	73.6	73.6	0.0
C	15,853	202	1,621	13.8	77.1	77.1	77.1	0.0
D	17,218	95	1,591	13.3	88.8	88.8	89.0	0.2
E	18,099	95	1,947	10.9	106.6	106.6	107.2	0.6
F	19,140	129	1,370	15.5	115.3	115.3	115.3	0.0
G	20,351	120	1,713	12.4	134.6	134.6	134.6	0.0
H	21,932	247	2,365	8.9	140.1	140.1	140.3	0.2
I	24,073	195	2,594	8.0	150.6	150.6	150.9	0.3
J	25,941	167	1,789	11.6	157.0	157.0	157.2	0.2
K	27,759	90	1,242	16.7	168.8	168.8	169.0	0.2
L	29,421	290	4,802	4.2	181.4	181.4	181.7	0.3
M	29,925	219	2,635	7.7	181.4	181.4	181.7	0.3
N	31,071	205	3,260	6.3	186.5	186.5	187.3	0.8
O	32,002	502	4,977	4.1	188.1	188.1	189.1	1.0
P	33,393	201	2,843	7.1	188.5	188.5	189.3	0.8
Q	34,805	102	2,076	9.8	188.8	188.8	189.7	0.9
R	36,362	150	2,414	8.3	194.1	194.1	194.6	0.5
S	37,709	357	5,630	3.5	197.5	197.5	197.9	0.4
T	38,215	500	7,577	2.6	197.6	197.6	198.1	0.5

¹ Feet above mouth of Jones Falls

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: JONES FALLS

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
U	39,496	482 ²	5,110	3.5	198.1	198.1	198.9	0.8
V	41,146	164	1,775	10.0	199.8	199.8	199.9	0.1

¹ Feet above mouth of Jones Falls

² While a bare earth Digital Elevation Model is used for this study, certain buildings are modeled as obstructions in the HEC-RAS model. Floodway width reported by HEC-RAS excludes obstructions. One such building is located on this cross section. As a result, this width does not match the floodway width measured on the map.

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: JONES FALLS

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	133	56	656	7.7	51.2	45.1 ²	46.1	1.0
B	267	58	1,063	4.7	55.0	55.0	55.9	0.9
C	887	77	473	10.6	67.9	67.9	67.9	0.0
D	2,405	48	368	13.4	83.6	83.6	84.4	0.8
E	3,110	62	492	10.0	94.8	94.8	95.6	0.8
F	3,345	46	325	15.1	99.5	99.5	99.5	0.0
G	3,778	46	724	6.8	112.3	112.3	113.1	0.8
H	4,132	118	1,291	3.8	113.3	113.3	114.0	0.7
I	6,334	50	440	11.2	129.3	129.3	129.4	0.1
J	7,231	120	854	5.8	139.8	139.8	139.8	0.0
K	7,762	95	593	7.3	142.5	142.5	142.6	0.1
L	8,409	53	471	9.2	147.9	147.9	148.1	0.2
M	9,029	69	965	4.5	159.4	159.4	159.4	0.0
N	9,655	222	1,632	2.5	160.1	160.1	160.2	0.1
O	10,343	141	429	9.3	161.8	161.8	161.9	0.1
P	11,179	162	834	4.8	172.0	172.0	172.0	0.0

¹ Feet above confluence with Gwynns Falls

² Elevation computed without consideration of backwater from Gwynns Falls

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: MAIDENS CHOICE RUN

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	4,006	65	648	6.0	16.1	16.1	16.9	0.8
B	4,307	64	789	4.9	17.7	17.7	18.3	0.6
C	5,749	65	696	5.6	21.3	21.3	21.9	0.6
D	6,182	57	651	5.8	22.1	22.1	22.9	0.8
E	6,828	47	446	8.5	23.0	23.0	23.8	0.8
F	7,523	76	628	6.0	26.8	26.8	27.5	0.7
G	9,189	183	1,040	3.5	31.1	31.1	31.6	0.5
H	10,379	109	678	5.3	34.6	34.6	35.1	0.5
I	11,450	102	662	5.4	38.6	38.6	39.6	1.0
J	12,088	91	614	5.7	44.2	44.2	44.5	0.3
K	12,909	90	463	7.6	48.0	48.0	48.1	0.1
L	13,090	53	438	8.1	48.5	48.5	49.4	0.9
M	14,394	40	318	10.6	60.2	60.2	60.8	0.6
N	15,896	44	273	12.1	82.9	82.9	83.9	1.0
O	16,170	56	453	7.3	86.5	86.5	87.4	0.9

¹ Feet above confluence with Back River and Herring Run

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: MOORES RUN

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	7,778	80	419	8.5	215.4	215.4	215.4	0.0
B	8,112	95	353	10.1	219.9	219.9	219.9	0.0
C	8,625	72	451	7.9	225.5	225.5	225.5	0.0
D	9,511	67	769	4.6	244.5	244.5	245.0	0.5
E	10,505	46	270	12.2	247.9	247.9	247.9	0.0
F	10,999	67	428	7.7	258.3	258.3	258.7	0.4
G	11,995	43	173	11.4	278.2	278.2	278.2	0.0
H	12,651	43	177	11.2	290.4	290.4	290.4	0.0
I	13,778	42	159	11.0	306.2	306.2	306.2	0.0
J	14,145	60	280	6.2	316.4	316.4	316.6	0.2
K	14,606	76	320	5.5	318.8	318.8	319.3	0.5
L	15,773	37	201	8.0	333.0	333.0	333.8	0.8
M	16,031	68	731	2.2	343.5	343.5	344.3	0.8
N	16,525	39	211	5.6	344.0	344.0	344.9	0.9
O	16,980	42	122	9.7	353.5	353.5	353.5	0.0

¹ Feet above Confluence with Jones Falls

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: STONY RUN

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	1,241	123	534	10.8	204.4	204.4	204.4	0.0
B	1,803	100	633	9.1	212.5	212.5	212.5	0.0
C	2,474	44	368	15.7	220.2	220.2	220.2	0.0
D	2,771	57	442	13.1	223.9	223.9	224.4	0.5
E	3,182	64	605	9.6	232.2	232.2	232.2	0.0
F	3,571	52	395	14.6	235.8	235.8	235.8	0.0
G	4,328	87	582	9.6	247.9	247.9	247.9	0.0
H	4,962	70	391	13.6	259.1	259.1	259.1	0.0
I	5,613	41	330	16.1	275.6	275.6	275.6	0.0
J	6,062	60	459	11.6	285.7	285.7	286.0	0.3
K	7,077	123	692	7.7	299.3	299.3	300.2	0.9
L	7,783	61	381	12.4	310.4	310.4	310.7	0.3
M	9,070	105	433	10.3	323.6	323.6	323.6	0.0
N	9,903	141	453	9.9	335.5	335.5	335.5	0.0
O	10,379	172	485	8.9	342.0	342.0	342.0	0.0
P	11,094	114	442	9.8	349.0	349.0	349.2	0.2
Q	11,760	113	427	10.2	357.8	357.8	357.8	0.0
R	12,092	106	410	9.2	361.2	361.2	361.2	0.0
S	13,487	48	275	13.7	381.2	381.2	381.2	0.0
T	14,644	113	438	8.0	398.3	398.3	398.3	0.0

¹ Feet above confluence with Jones Falls

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: WESTERN RUN

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
U	14,863	134	688	5.1	401.0	401.0	401.7	0.6
V	15,486	77	446	7.2	405.1	405.1	405.8	0.7
W	15,965	70	397	8.1	408.5	408.5	409.1	0.6
X	16,941	55	271	11.5	420.9	420.9	421.4	0.5

¹ Feet above confluence with Jones Falls

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD

(INDEPENDENT CITY)

FLOODWAY DATA

FLOODING SOURCE: WESTERN RUN

Table 24: Flood Hazard and Non-Encroachment Data for Selected Streams

[Not Applicable to this Flood Risk Project]

6.4 Coastal Flood Hazard Mapping

Flood insurance zones and BFEs including the wave effects were identified on each transect based on the results from the onshore wave hazard analyses. Between transects, elevations were interpolated using topographic maps, land-use and land-cover data, and knowledge of coastal flood processes to determine the aerial extent of flooding.

Zone VE is subdivided into elevation zones and BFEs are provided on the FIRM.

The limit of Zone VE shown on the FIRM is defined as the farthest inland extent of any of these criteria (determined for the 1% annual chance flood condition):

- The *primary frontal dune zone* is defined in 44 CFR Section 59.1 of the NFIP regulations. The primary frontal dune represents a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes that occur immediately landward and adjacent to the beach. The primary frontal dune zone is subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune zone occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope.
- The *wave runup zone* occurs where the (eroded) ground profile is 3.0 feet or more below the 2-percent wave runup elevation.
- The *wave overtopping splash zone* is the area landward of the crest of an overtopped barrier, in cases where the potential 2-percent wave runup exceeds the barrier crest elevation by 3.0 feet or more.
- The *breaking wave height zone* occurs where 3-foot or greater wave heights could occur (this is the area where the wave crest profile is 2.1 feet or more above the total stillwater elevation).
- The *high-velocity flow zone* is landward of the overtopping splash zone (or area on a sloping beach or other shore type), where the product of depth of flow times the flow velocity squared (hV^2) is greater than or equal to 200 ft³/sec². This zone may only be used on the Pacific Coast.

The SFHA boundary indicates the limit of SFHAs shown on the FIRM as either “V” zones or “A” zones.

Table 25 indicates the coastal analyses used for floodplain mapping and the criteria used to determine the inland limit of the open-coast Zone VE and the SFHA boundary at each transect.

Table 25: Summary of Coastal Transect Mapping Considerations

[Data not Available]

A LiMWA boundary has also been added in coastal areas subject to wave action for use by local communities in safe rebuilding practices. The LiMWA represents the approximate landward limit of the 1.5-foot breaking wave.

6.5 FIRM Revisions

This FIS Report and the FIRM are based on the most up-to-date information available to FEMA at the time of its publication; however, flood hazard conditions change over time. Communities or private parties may request flood map revisions at any time. Certain types of requests require submission of supporting data. FEMA may also initiate a revision. Revisions may take several forms, including Letters of Map Amendment (LOMAs), Letters of Map Revision Based on Fill (LOMR-Fs), Letters of Map Revision (LOMRs) (referred to collectively as Letters of Map Change (LOMCs)), Physical Map Revisions (PMRs), and FEMA-contracted restudies. These types of revisions are further described below. Some of these types of revisions do not result in the republishing of the FIS Report. To assure that any user is aware of all revisions, it is advisable to contact the community repository of flood-hazard data (shown in Table 31, “Map Repositories”).

6.5.1 Letters of Map Amendment

A LOMA is an official revision by letter to an effective NFIP map. A LOMA results from an administrative process that involves the review of scientific or technical data submitted by the owner or lessee of property who believes the property has incorrectly been included in a designated SFHA. A LOMA amends the currently effective FEMA map and establishes that a specific property is not located in a SFHA. A LOMA cannot be issued for properties located on the PFD (primary frontal dune).

To obtain an application for a LOMA, visit www.fema.gov/floodplain-management/letter-map-amendment-loma and download the form “MT-1 Application Forms and Instructions for Conditional and Final Letters of Map Amendment and Letters of Map Revision Based on Fill”. Visit the “Flood Map-Related Fees” section to determine the cost, if any, of applying for a LOMA.

FEMA offers a tutorial on how to apply for a LOMA. The LOMA Tutorial Series can be accessed at www.fema.gov/online-tutorials.

For more information about how to apply for a LOMA, call the FEMA Map Information eXchange; toll free, at 1-877-FEMA MAP (1-877-336-2627).

6.5.2 Letters of Map Revision Based on Fill

A LOMR-F is an official revision by letter to an effective NFIP map. A LOMR-F states FEMA’s determination concerning whether a structure or parcel has been elevated on fill above the base flood elevation and is, therefore, excluded from the SFHA.

Information about obtaining an application for a LOMR-F can be obtained in the same manner as that for a LOMA, by visiting www.fema.gov/floodplain-management/letter-map-amendment-loma for the “MT-1 Application Forms and Instructions for Conditional

and Final Letters of Map Amendment and Letters of Map Revision Based on Fill” or by calling the FEMA Map Information eXchange, toll free, at 1-877-FEMA MAP (1-877-336-2627). Fees for applying for a LOMR-F, if any, are listed in the “Flood Map-Related Fees” section.

A tutorial for LOMR-F is available at www.fema.gov/online-tutorials.

6.5.3 Letters of Map Revision

A LOMR is an official revision to the currently effective FEMA map. It is used to change flood zones, floodplain and floodway delineations, flood elevations and planimetric features. All requests for LOMRs should be made to FEMA through the chief executive officer of the community, since it is the community that must adopt any changes and revisions to the map. If the request for a LOMR is not submitted through the chief executive officer of the community, evidence must be submitted that the community has been notified of the request.

To obtain an application for a LOMR, visit www.fema.gov/media-library/assets/documents/1343 and download the form “MT-2 Application Forms and Instructions for Conditional Letters of Map Revision and Letters of Map Revision”. Visit the “Flood Map-Related Fees” section to determine the cost of applying for a LOMR. For more information about how to apply for a LOMR, call the FEMA Map Information eXchange; toll free, at 1-877-FEMA MAP (1-877-336-2627) to speak to a Map Specialist.

Previously issued mappable LOMCs (including LOMRs) that have been incorporated into the City of Baltimore FIRM are listed in Table 26. Please note that this table only includes LOMCs that have been issued on the FIRM panels updated by this map revision. For all other areas within the city, users should be aware that revisions to the FIS Report made by prior LOMRs may not be reflected herein and users will need to continue to use the previously issued LOMRs to obtain the most current data.

Table 26: Incorporated Letters of Map Change

Case Number	Effective Date	Flooding Source	FIRM Panel(s)
17-03-1132P	12/18/2017	Gwynns Falls	2400870016F
20-03-0958P ¹	6/17/2020	Chesapeake Bay via Patapsco River	2400870025G, 2400870026F ² , 2400870027F ² , 2400870030G, 2400870031F ² , 2400870032F ² , 2400870035F ² , 2400870036G

¹ LOMR has been incorporated into the DFIRM Database but falls within some FIRM panels that have not been revised in this study.

² Unrevised FIRM panel with an effective date of 4/2/2014..

6.5.4 Physical Map Revisions

A Physical Map Revisions (PMR) is an official republication of a community’s NFIP map to effect changes to base flood elevations, floodplain boundary delineations, regulatory floodways and planimetric features. These changes typically occur as a result of structural works or improvements, annexations resulting in additional flood hazard areas or correction to base flood elevations or SFHAs.

The community's chief executive officer must submit scientific and technical data to FEMA to support the request for a PMR. The data will be analyzed and the map will be revised if warranted. The community is provided with copies of the revised information and is afforded a review period. When the base flood elevations are changed, a 90-day appeal period is provided. A 6-month adoption period for formal approval of the revised map(s) is also provided.

For more information about the PMR process, please visit www.fema.gov and visit the "Flood Map Revision Processes" section.

6.5.5 Contracted Restudies

The NFIP provides for a periodic review and restudy of flood hazards within a given community. FEMA accomplishes this through a national watershed-based mapping needs assessment strategy, known as the Coordinated Needs Management Strategy (CNMS). The CNMS is used by FEMA to assign priorities and allocate funding for new flood hazard analyses used to update the FIS Report and FIRM. The goal of CNMS is to define the validity of the engineering study data within a mapped inventory. The CNMS is used to track the assessment process, document engineering gaps and their resolution, and aid in prioritization for using flood risk as a key factor for areas identified for flood map updates. Visit www.fema.gov to learn more about the CNMS or contact the FEMA Regional Office listed in Section 8 of this FIS Report.

6.5.6 Community Map History

The current FIRM presents flooding information for the entire geographic area of City of Baltimore. Previously, separate FIRMs, Flood Hazard Boundary Maps (FHBM) and/or Flood Boundary and Floodway Maps (FBFMs) may have been prepared for the incorporated communities and the unincorporated areas in the county that had identified SFHAs. Current and historical data relating to the maps prepared for the project area are presented in Table 27, "Community Map History." A description of each of the column headings and the source of the date is also listed below.

- *Community Name* includes communities falling within the geographic area shown on the FIRM, including those that fall on the boundary line, nonparticipating communities, and communities with maps that have been rescinded. Communities with No Special Flood Hazards are indicated by a footnote. If all maps (FHBM, FBFM, and FIRM) were rescinded for a community, it is not listed in this table unless SFHAs have been identified in this community.
- *Initial Identification Date (First NFIP Map Published)* is the date of the first NFIP map that identified flood hazards in the community. If the FHBM has been converted to a FIRM, the initial FHBM date is shown. If the community has never been mapped, the upcoming effective date or "pending" (for Preliminary FIS Reports) is shown. If the community is listed in Table 28 but not identified on the map, the community is treated as if it were unmapped.
- *Initial FHBM Effective Date* is the effective date of the first Flood Hazard Boundary Map (FHBM). This date may be the same date as the Initial NFIP Map Date.

- *FHBM Revision Date(s)* is the date(s) that the FHBM was revised, if applicable.
- *Initial FIRM Effective Date* is the date of the first effective FIRM for the community. This is the first effective date that is shown on the FIRM panel.
- *FIRM Revision Date(s)* is the date(s) the FIRM was revised, if applicable. This is the revised date that is shown on the FIRM panel, if applicable. As countywide studies are completed or revised, each community listed should have its FIRM dates updated accordingly to reflect the date of the countywide study. Once the FIRMs exist in countywide format, as PMRs of FIRM panels within the county are completed, the FIRM Revision Dates in the table for each community affected by the PMR are updated with the date of the PMR, even if the PMR did not revise all the panels within that community.

The initial effective date for the City of Baltimore FIRMs was 03/15/1978.

Table 27: Community Map History

Community Name	Initial Identification Date (First NFIP Map Published)	Initial FHBM Effective Date	FHBM Revision Date(s)	Initial FIRM Effective Date	FIRM Revision Date(s)
City of Baltimore, Independent City	06/28/1974	06/28/1974	N/A	03/15/1978	06/16/2021 04/02/2014 02/02/2012 09/30/1988 04/03/1985 03/16/1983

SECTION 7.0 – CONTRACTED STUDIES AND COMMUNITY COORDINATION

7.1 Contracted Studies

Table 28 provides a summary of the contracted studies, by flooding source, that are included in this FIS Report.

Table 28: Summary of Contracted Studies Included in this FIS Report

Flooding Source	FIS Report Dated	Contractor	Number	Work Completed Date	Affected Communities
Biddison Run	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Chesapeake Bay / Patapsco River	4/2/2014	RAMPP	HSFEHQ-09-D-0369	2012	City of Baltimore
Chinquapin Run	6/16/2021	AMEC Foster Wheeler	14-07-07	2017	City of Baltimore
Dead Run	6/16/2021	AMEC Foster Wheeler	14-07-07	2017	City of Baltimore
Gwynns Falls	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Gwynns Falls split flow (CSX)	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Gwynns Falls split flow (middle)	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Gwynns Falls split flow (Westport)	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Gwynns Falls Tributary 1	6/16/2021	AMEC Foster Wheeler	14-07-07	2017	City of Baltimore
Gwynns Run	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Herring Run (downstream zone AE model)	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Herring Run (upstream zone A model)	6/16/2021	AMEC Foster Wheeler	14-07-07	2017	City of Baltimore

Flooding Source	FIS Report Dated	Contractor	Number	Work Completed Date	Affected Communities
Herring Run Tributary 1	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Jones Falls (two – dimensional analysis)	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Jones Falls	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Maidens Choice Run	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Maidens Choice Run (overland flow)	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Maidens Choice Run Tributary 1	6/16/2021	AMEC Foster Wheeler	14-07-07	2017	City of Baltimore
Moores Run	6/16/2021	AMEC Foster Wheeler	14-07-07	2017	City of Baltimore
Patapsco River	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
Stony Run (downstream zone A model)	6/16/2021	AMEC Foster Wheeler	14-07-07	2017	City of Baltimore
Stony Run (upstream zone AE/A model)	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore
West Branch Herring Run	6/16/2021	AMEC Foster Wheeler	14-07-07	2017	City of Baltimore
Western Run	6/16/2021	AMEC Foster Wheeler	14-07-07	2018	City of Baltimore

7.2 Community Meetings

The dates of the community meetings held for this Flood Risk Project and any previous Flood Risk Projects are shown in Table 29. These meetings may have previously been referred to by a variety of names (Community Coordination Officer (CCO), Scoping, Discovery, etc.), but all meetings represent opportunities for FEMA, community officials, study contractors, and other invited guests to discuss the planning for and results of the project.

Table 29: Community Meetings

Community	FIS Report Dated	Date of Meeting	Meeting Type	Attended By
City of Baltimore, Independent City	09/30/1988	04/1983	Initial CCO	FEMA, City of Baltimore, MD DNR and the study contractor
		08/22/1986	Final CCO	FEMA, City of Baltimore, and the study contractor
	02/02/2012	05/13/2009	Final CCO	FEMA, City of Baltimore, and the study contractors
	04/02/2014	02/20/2013	Final CCO	FEMA, City of Baltimore, and the study contractor
	06/16/2021	12/1/2014	Kick-Off Meeting	City of Baltimore, MDE, and the study contractor
		12/18/2017	Project Meeting	FEMA, City of Baltimore, MDE, and the study contractor
		08/16/2018	Flood Risk Review	FEMA, City of Baltimore, MDE, and the study contractor
		01/18/2019	CCO	FEMA, City of Baltimore, MDE, and the study contractor
		04/02/2019	Public Open House	City of Baltimore (with support from FEMA, MDE, and the study contractor) and affected property owners

* Meeting information is not available for the City of Baltimore FIS Reports dated 03/15/1978, 03/16/1983, and 04/03/1985.

SECTION 8.0 – ADDITIONAL INFORMATION

Information concerning the pertinent data used in the preparation of this FIS Report can be obtained by submitting an order with any required payment to the FEMA Engineering Library. For more information on this process, see www.fema.gov.

The additional data that was used for this project includes the FIS Report and FIRM that were previously prepared for City of Baltimore (FEMA, 2014).

Table 30 is a list of the locations where FIRMs for City of Baltimore can be viewed. Please note that the maps at these locations are for reference only and are not for distribution. Also, please note that only the maps for the community listed in the table are available at that particular repository. A user may need to visit another repository to view maps from an adjacent community.

Table 30: Map Repositories

Community	Address	City	State	Zip Code
City of Baltimore, Independent City	Department of Planning 417 East Fayette Street	Baltimore	Maryland	21202

The National Flood Hazard Layer (NFHL) dataset is a compilation of effective FIRM databases and LOMCs. Together they create a GIS data layer for a State or Territory. The NFHL is updated as studies become effective and extracts are made available to the public monthly. NFHL data can be viewed or ordered from the website shown in Table 31.

Table 31 contains useful contact information regarding the FIS Report, the FIRM, and other relevant flood hazard and GIS data. In addition, information about the State NFIP Coordinator and GIS Coordinator is shown in this table. At the request of FEMA, each Governor has designated an agency of State or territorial government to coordinate that State's or territory's NFIP activities. These agencies often assist communities in developing and adopting necessary floodplain management measures. State GIS Coordinators are knowledgeable about the availability and location of State and local GIS data in their state.

Table 31: Additional Information

FEMA and the NFIP	
FEMA and FEMA Engineering Library website	www.fema.gov/national-flood-insurance-program-flood-hazard-mapping/engineering-library
NFIP website	www.fema.gov/national-flood-insurance-program
NFHL Dataset	msc.fema.gov

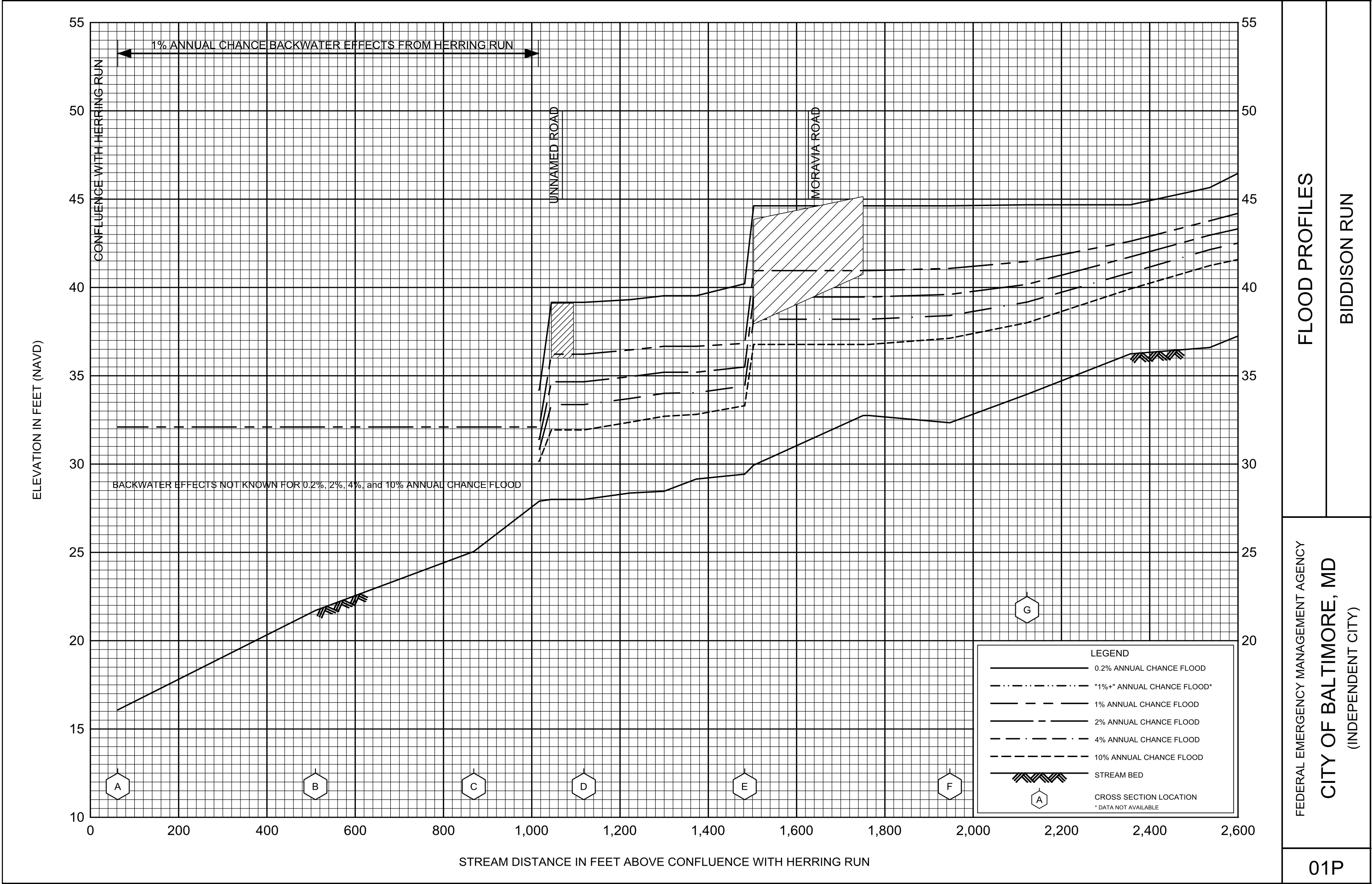
FEMA Region III	615 Chestnut Street One Independence Mall, Sixth Floor Philadelphia, PA 19106-4404 (215) 931-5500
Other Federal Agencies	
USGS website	www.usgs.gov
Hydraulic Engineering Center website	www.hec.usace.army.mil
State Agencies and Organizations	
State NFIP Coordinator	David Guignet, P.E. Maryland Department of the Environment Water Management Administration 1800 Washington Blvd., Suite 430 Baltimore, MD 21230 410-537-3775 dave.guignet@maryland.gov

SECTION 9.0 – BIBLIOGRAPHY AND REFERENCES

Table 32 includes sources used in the preparation of and cited in this FIS Report as well as additional studies that have been conducted in the study area.

Table 32: Bibliography and References

Citation in this FIS	Publisher/ Issuer	Publication Title, "Article," Volume, Number, etc.	Author/Editor	Place of Publication	Publication Date/ Date of Issuance	Link
FEMA, 2007(a)	Federal Emergency Agency	<i>Atlantic Ocean and Gulf of Mexico Coastal Guideline Update - Final Draft</i>			February, 2007	http://www.fema.gov/medialibrary-data/1388780453134-c5e577ea3d1da878b40e20b776804736/Atlantic+Ocean+and+Gulf+of+Mexico+Coastal+Guidelines+Update+%28Feb+2007%29.pdf
FEMA, 2007(b)	Federal Emergency Agency	<i>Wave Height Analyses for Flood Insurance Studies (WHAFIS), Version 4.0</i>		Washington, D.C.	August, 2007	
FEMA, 2014	Federal Emergency Agency	<i>Flood Insurance Study, City of Baltimore, Maryland (Independent City)</i>			April 2, 2014	http://msc.fema.gov/portal
Luetlich et. al, 2008	University of North Carolina at Chapel Hill, Institute of Marine Sciences	<i>A (Parallel) Advanced Circulation Model for Oceanic, Coastal and Estuarine Waters (ADCIRC). Version 45.12</i>	Luetlich, R.A. and Westerink, J.J.	Morehead City, North Caroline	February 6, 2008	
Sanborn, 2008	Sanborn	<i>2008 City of Baltimore Lidar</i>	KCI/Sanborn Joint Venture Partnership, L.L.C.		2008	
USACE, 2012	U.S. Army Corps of Engineers	<i>FEMA Region III Storm Surge Study, Coastal Storm Surge Analysis: Modeling System Validation Submission No. 2</i>			2012	

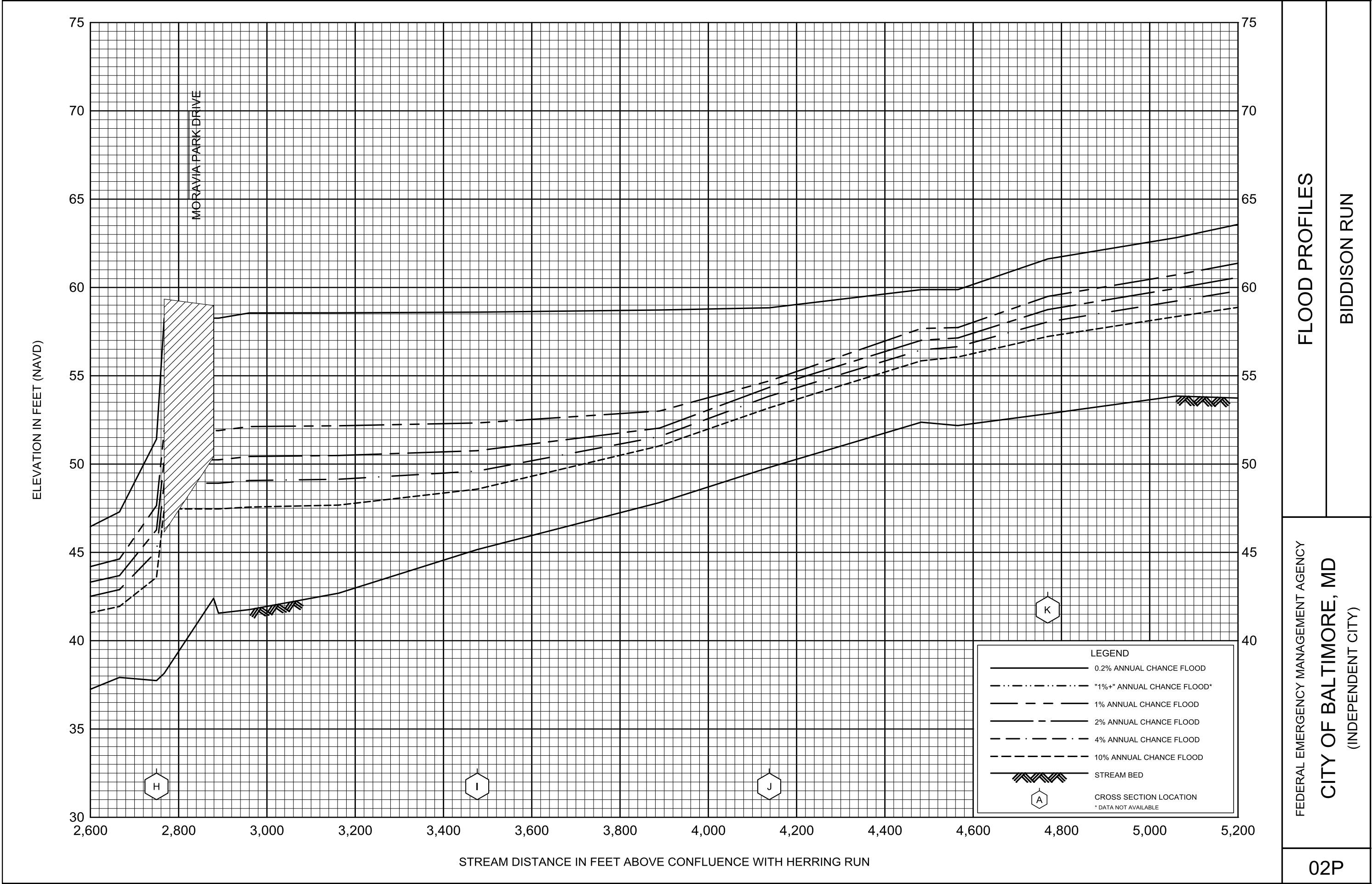


FLOOD PROFILES

BIDDISON RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

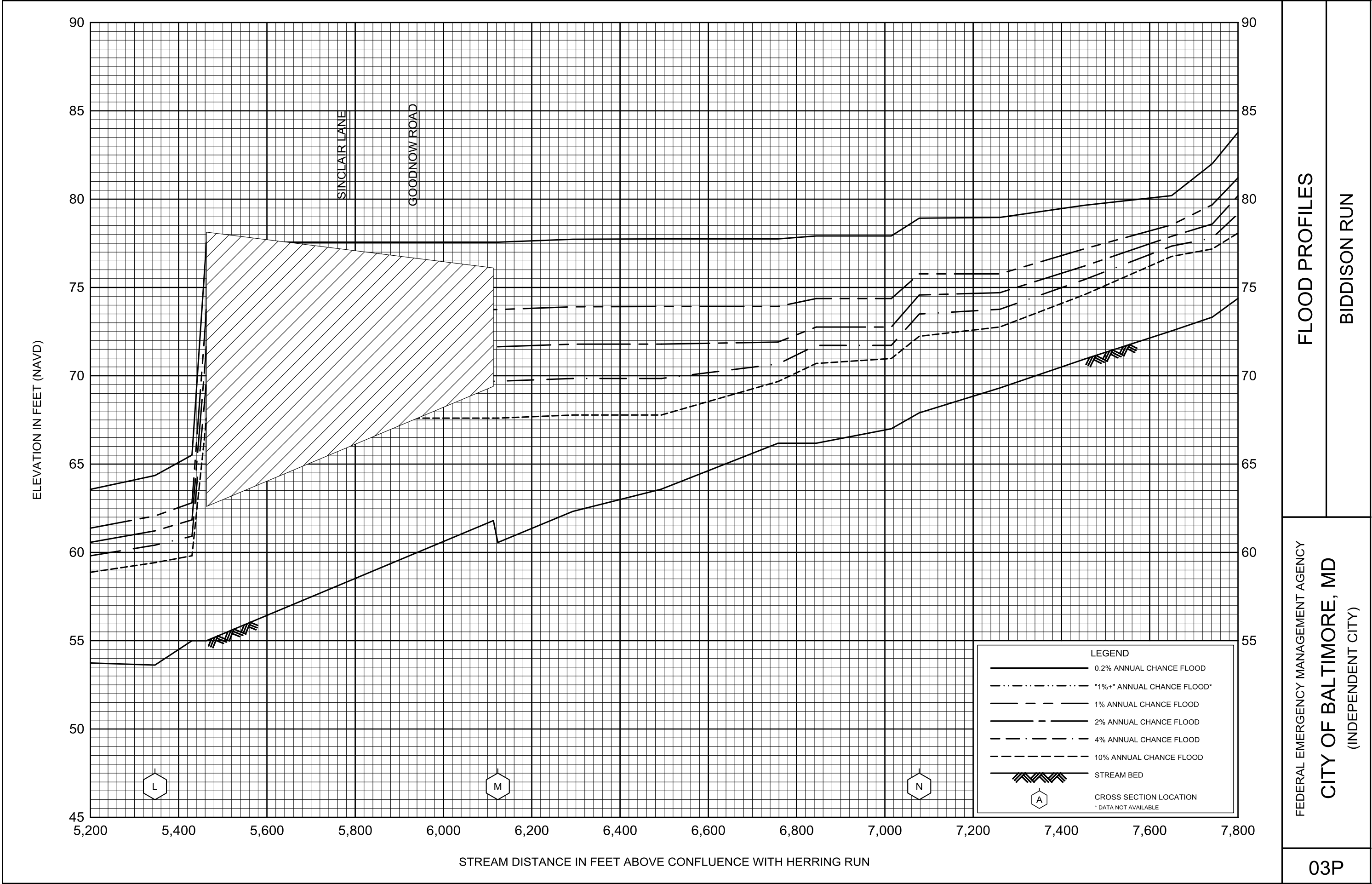
CITY OF BALTIMORE, MD
(INDEPENDENT CITY)



FLOOD PROFILES

BIDDISON RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF BALTIMORE, MD
(INDEPENDENT CITY)

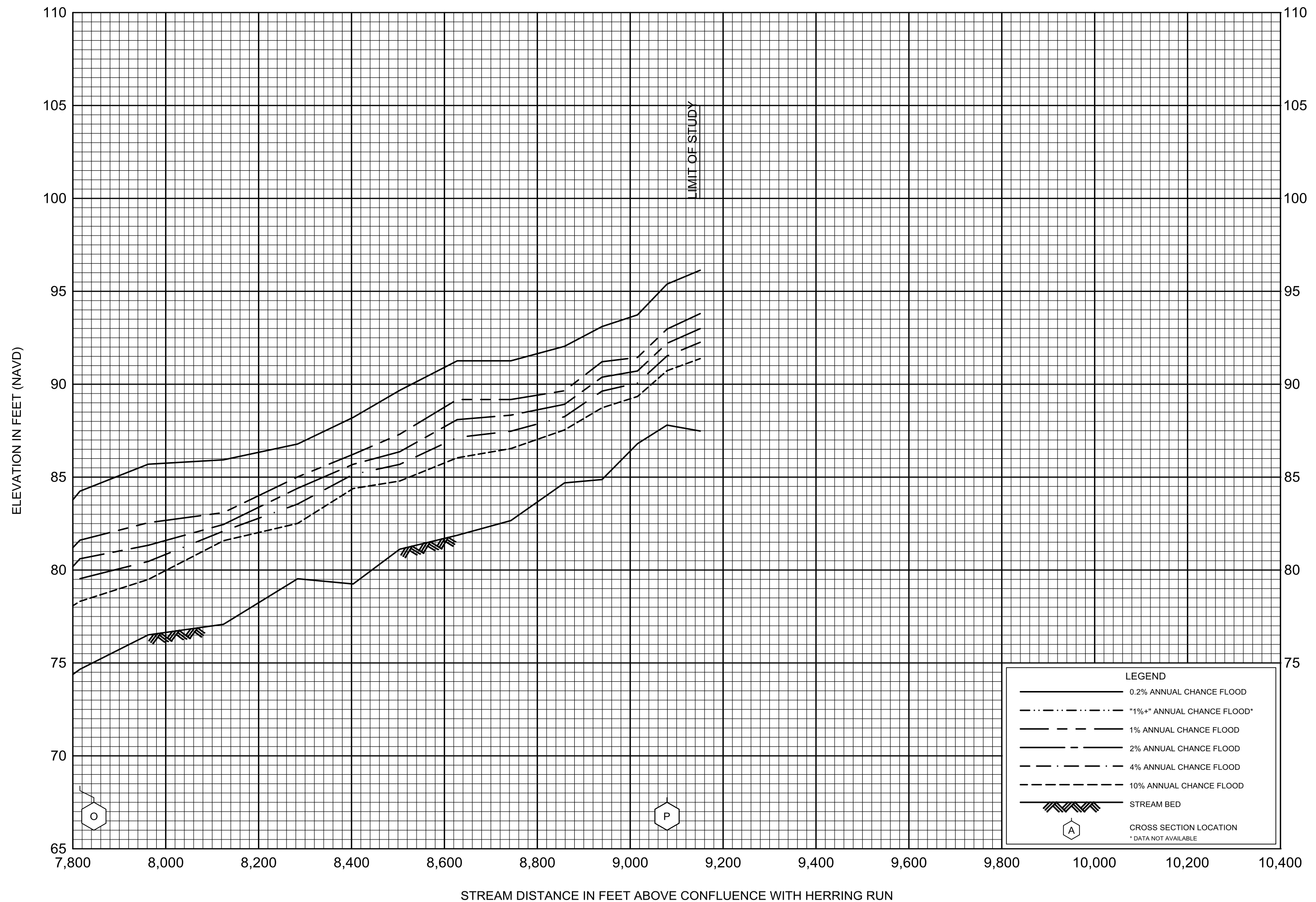


FLOOD PROFILES

BIDDISON RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)



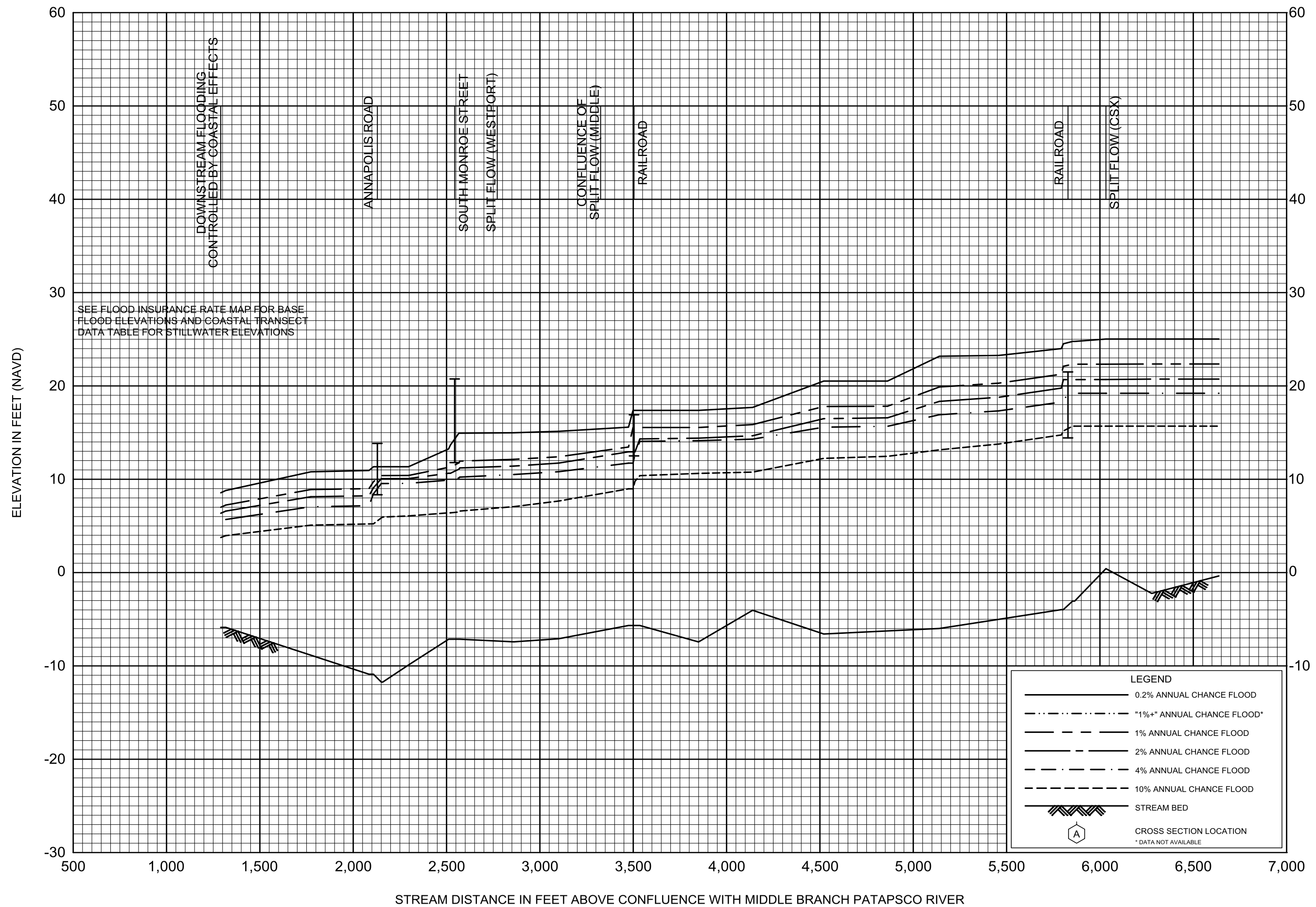
FLOOD PROFILES

BIDDISON RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)

04P



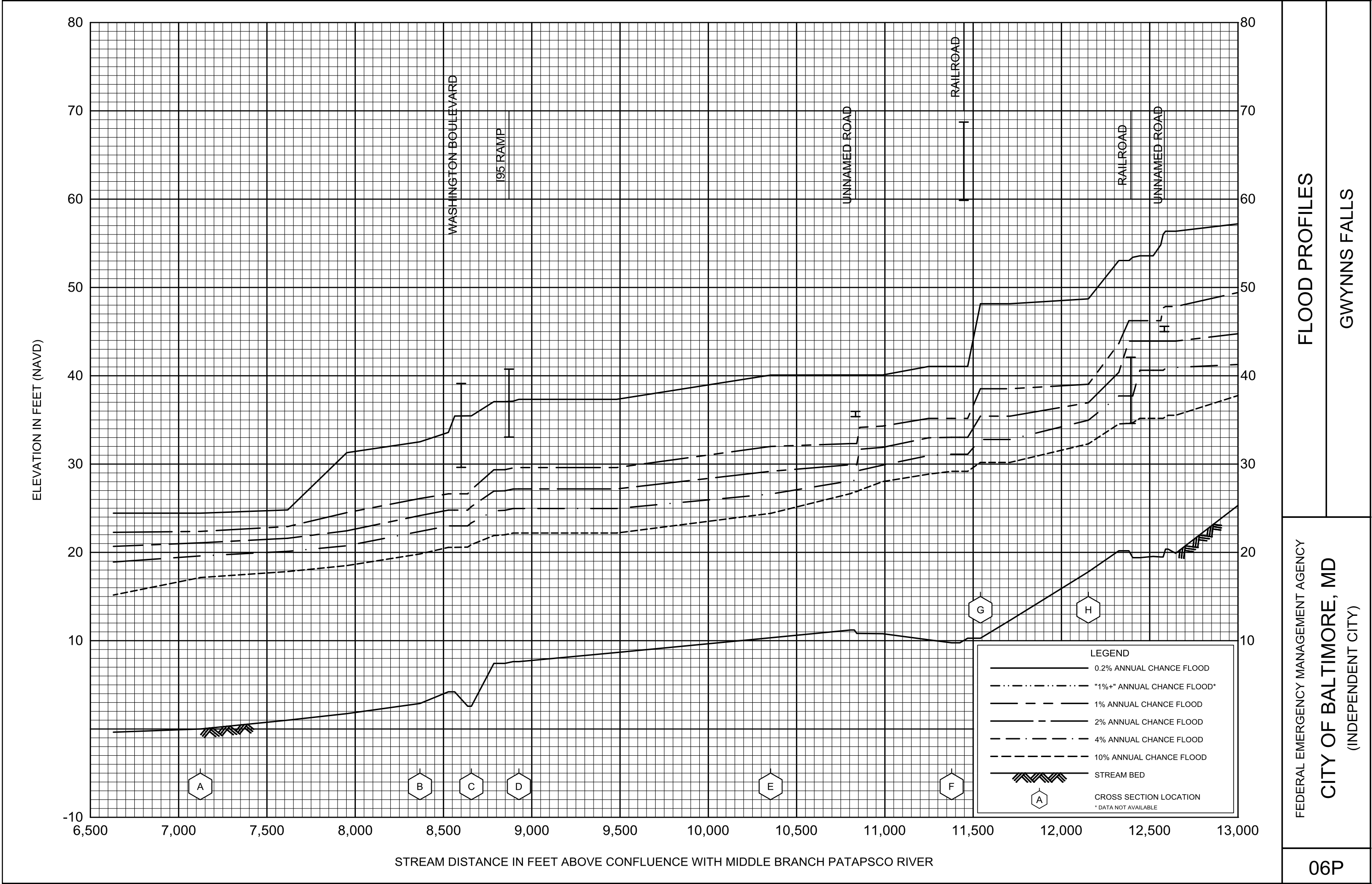
FLOOD PROFILES

GWYNNS FALLS

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)

05P

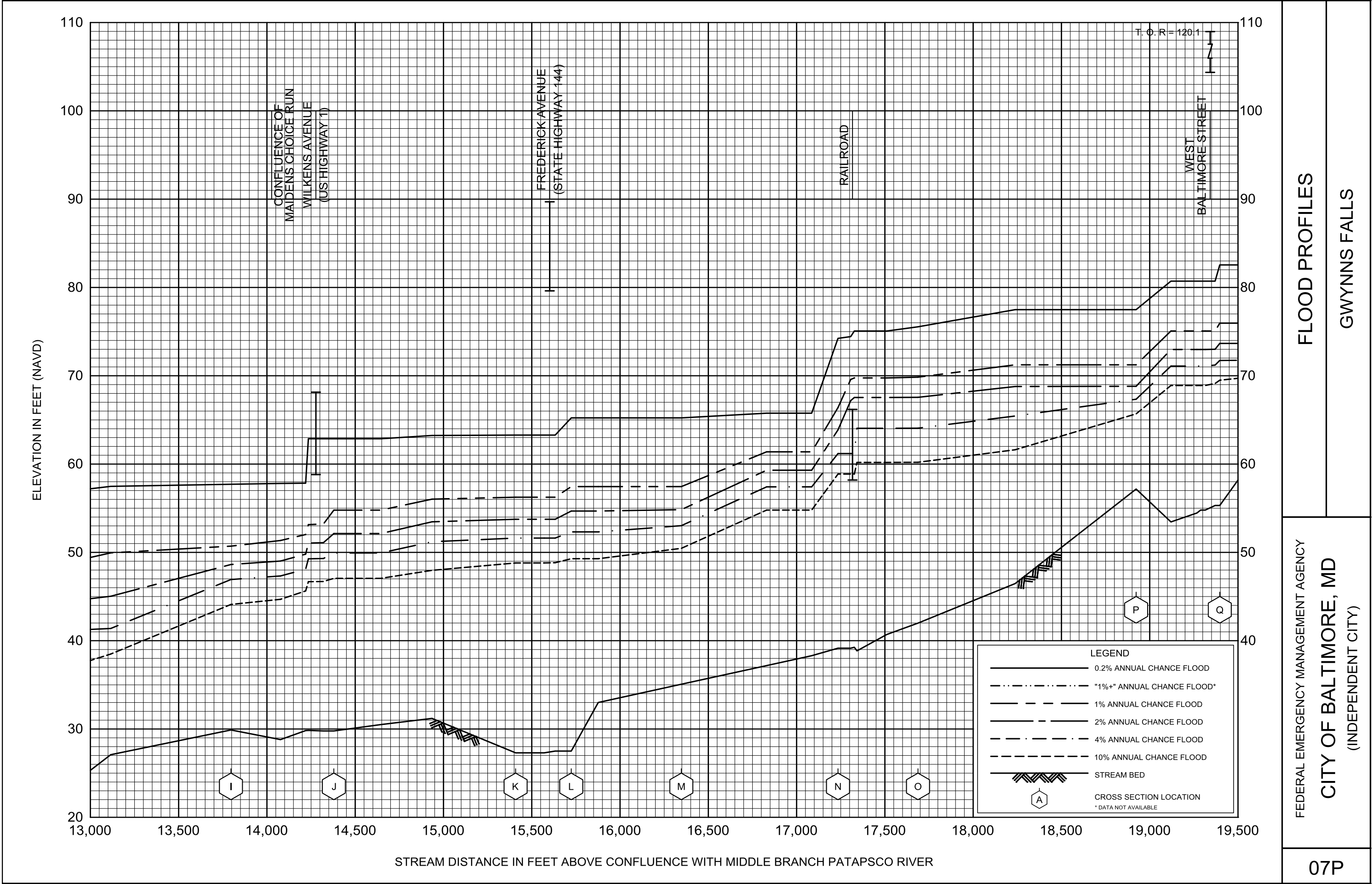


FLOOD PROFILES

GWYNNS FALLS

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)

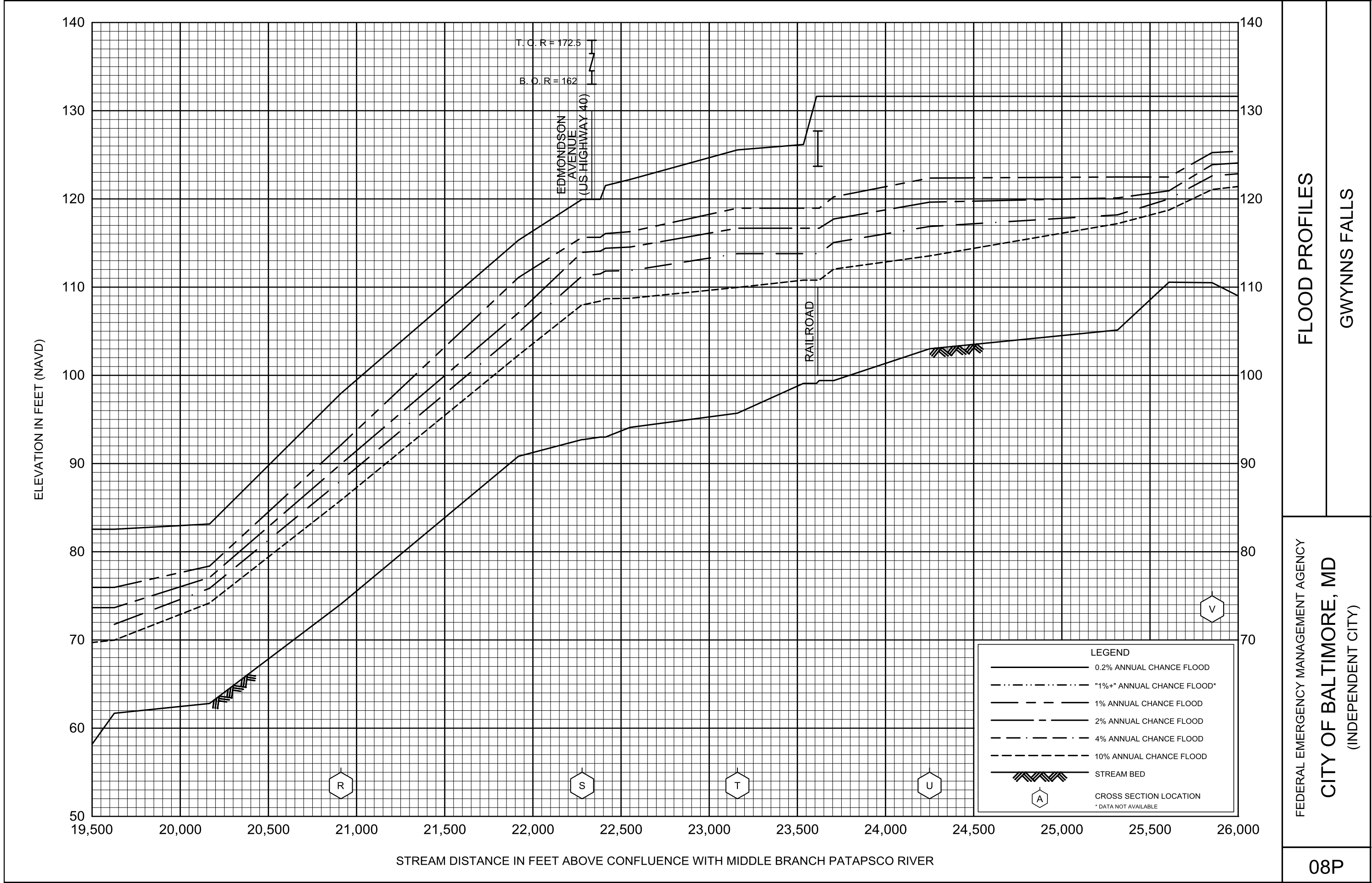


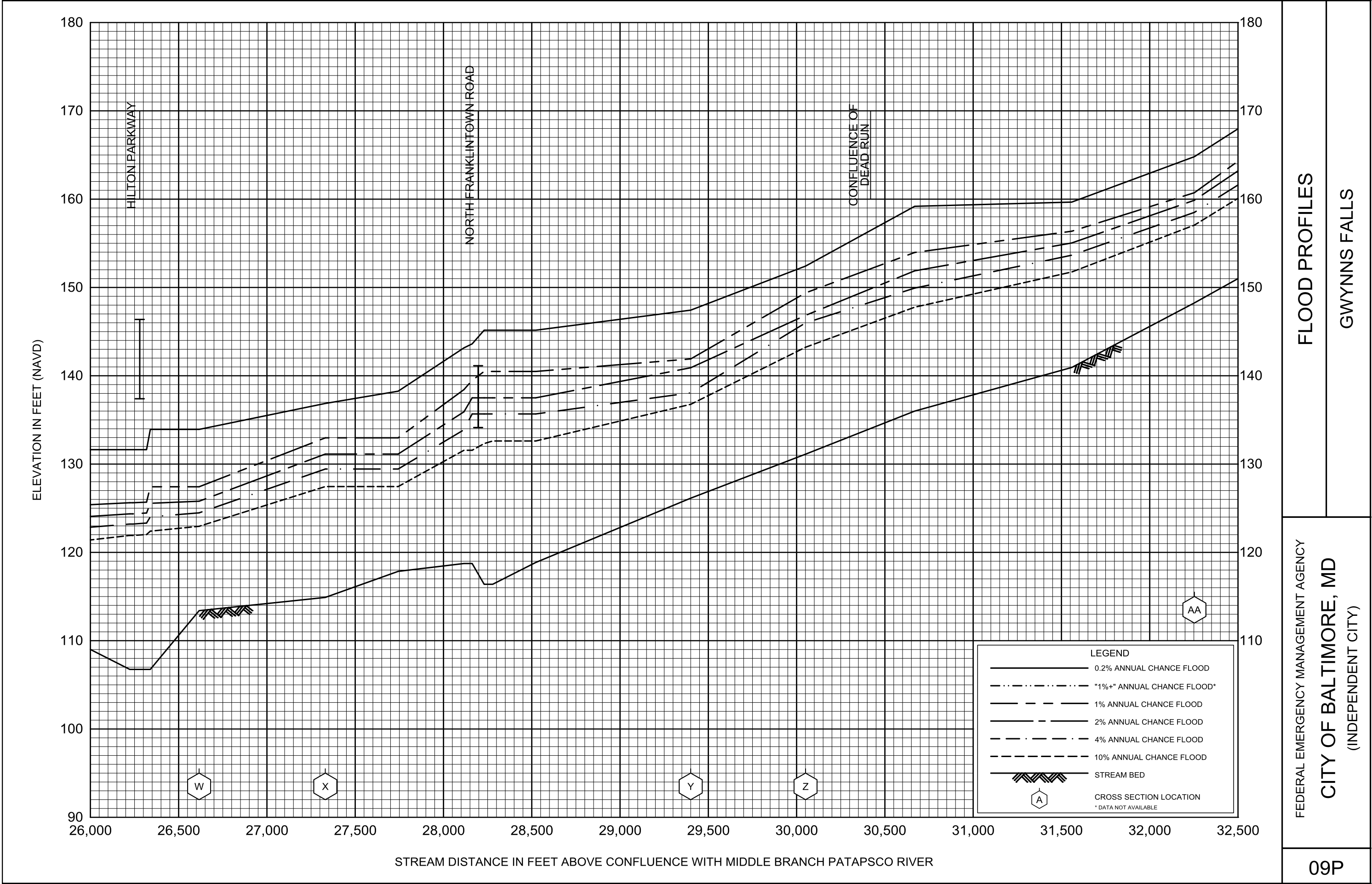
FLOOD PROFILES

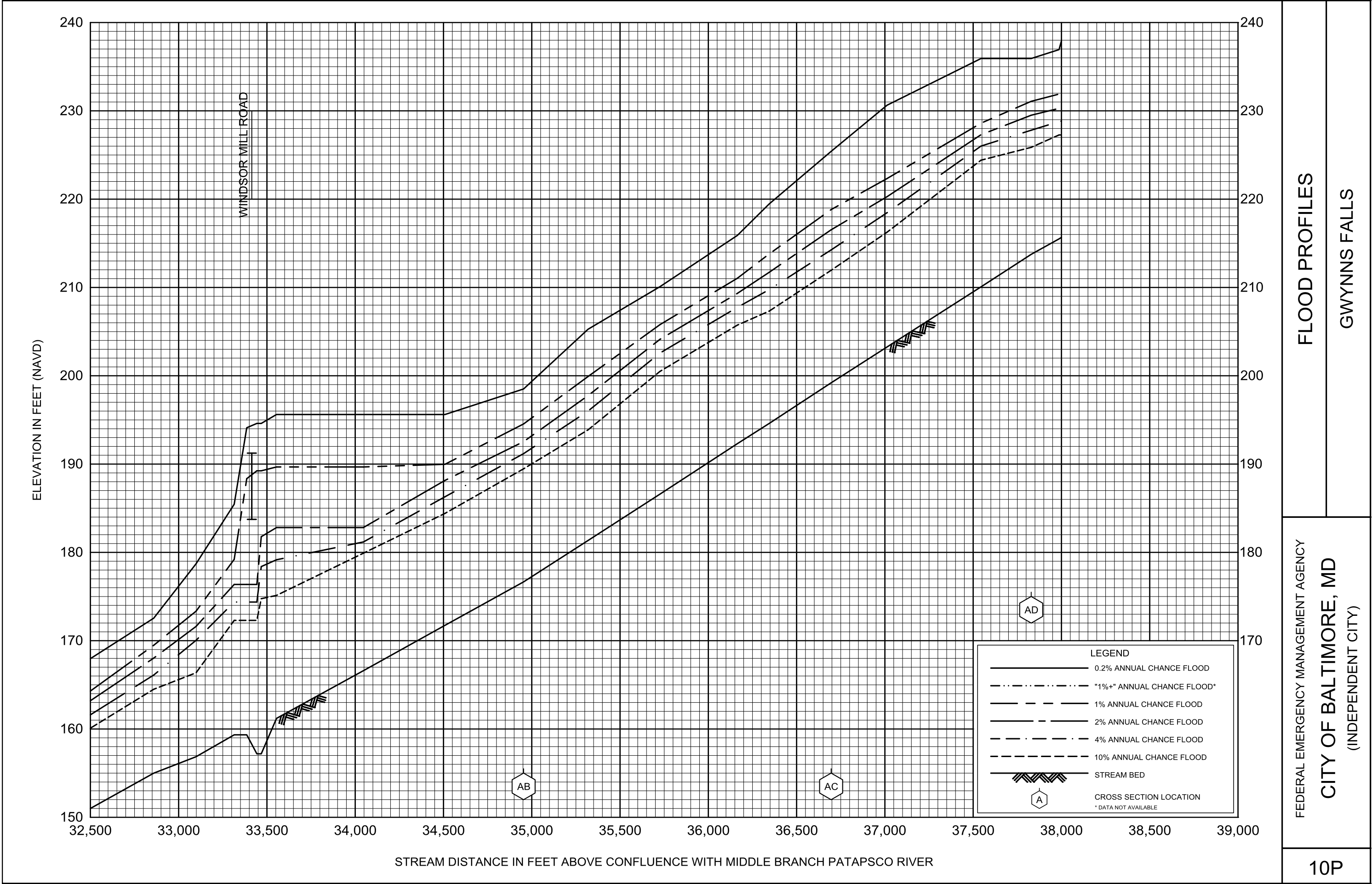
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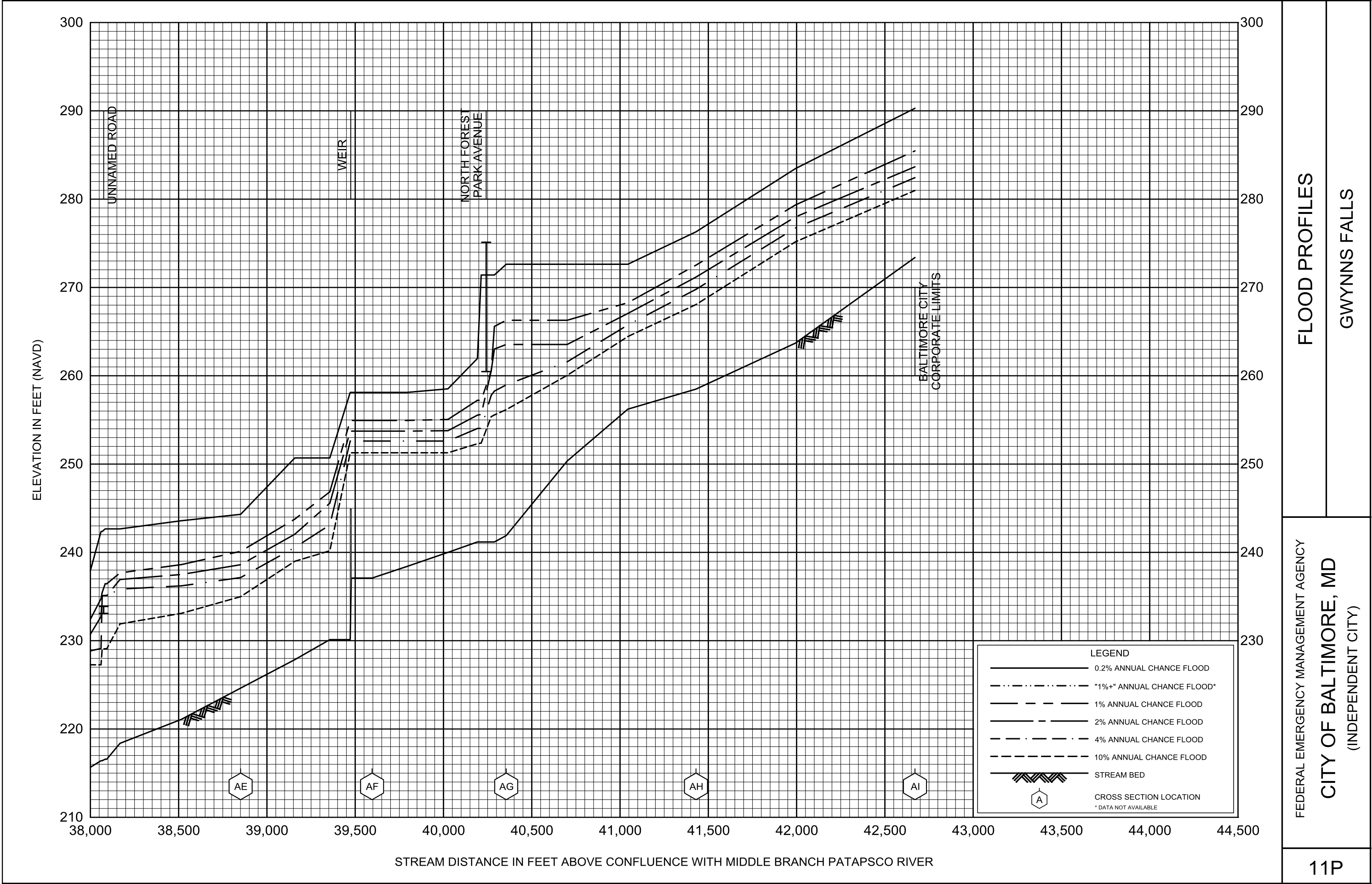
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)







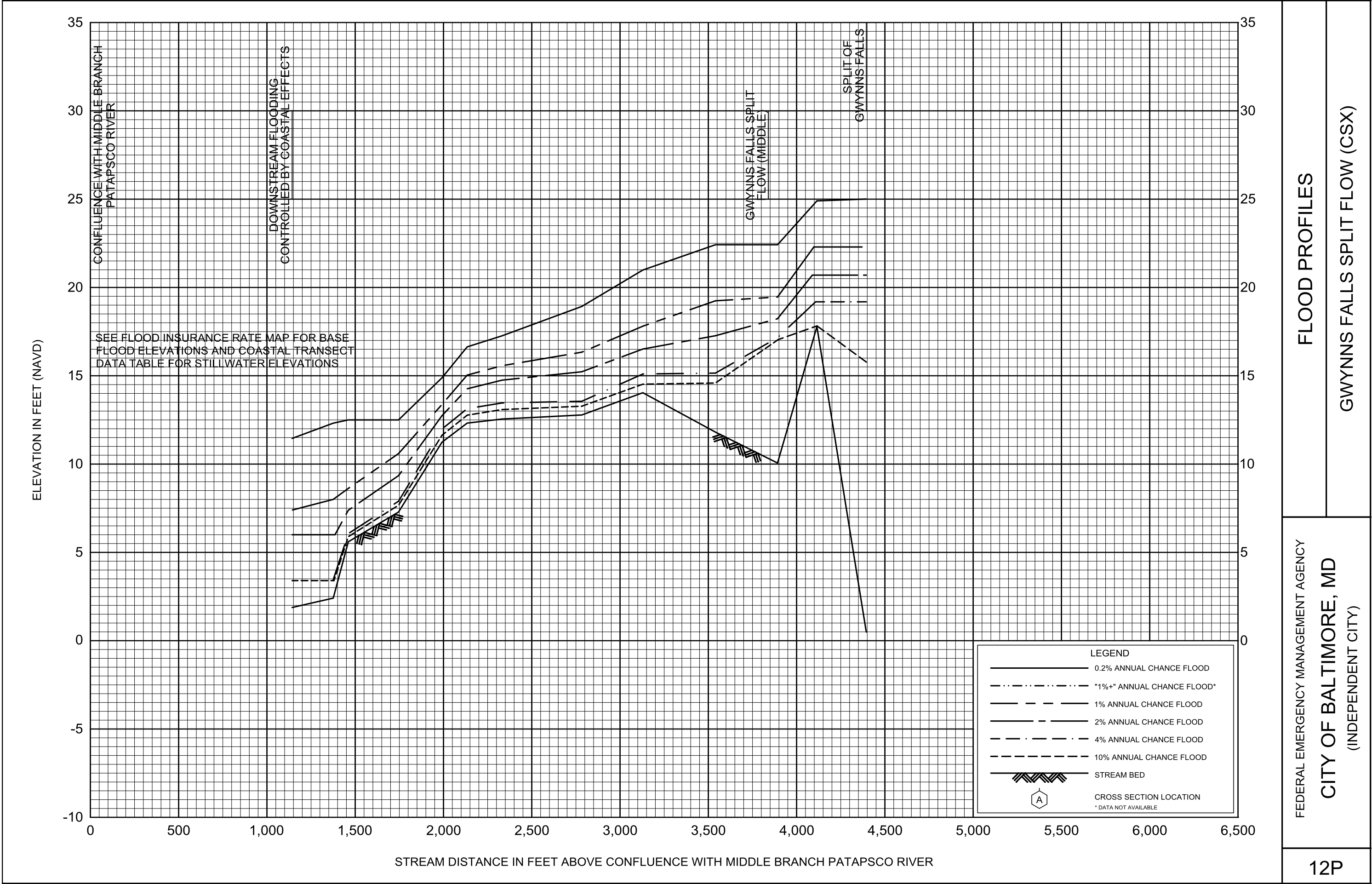


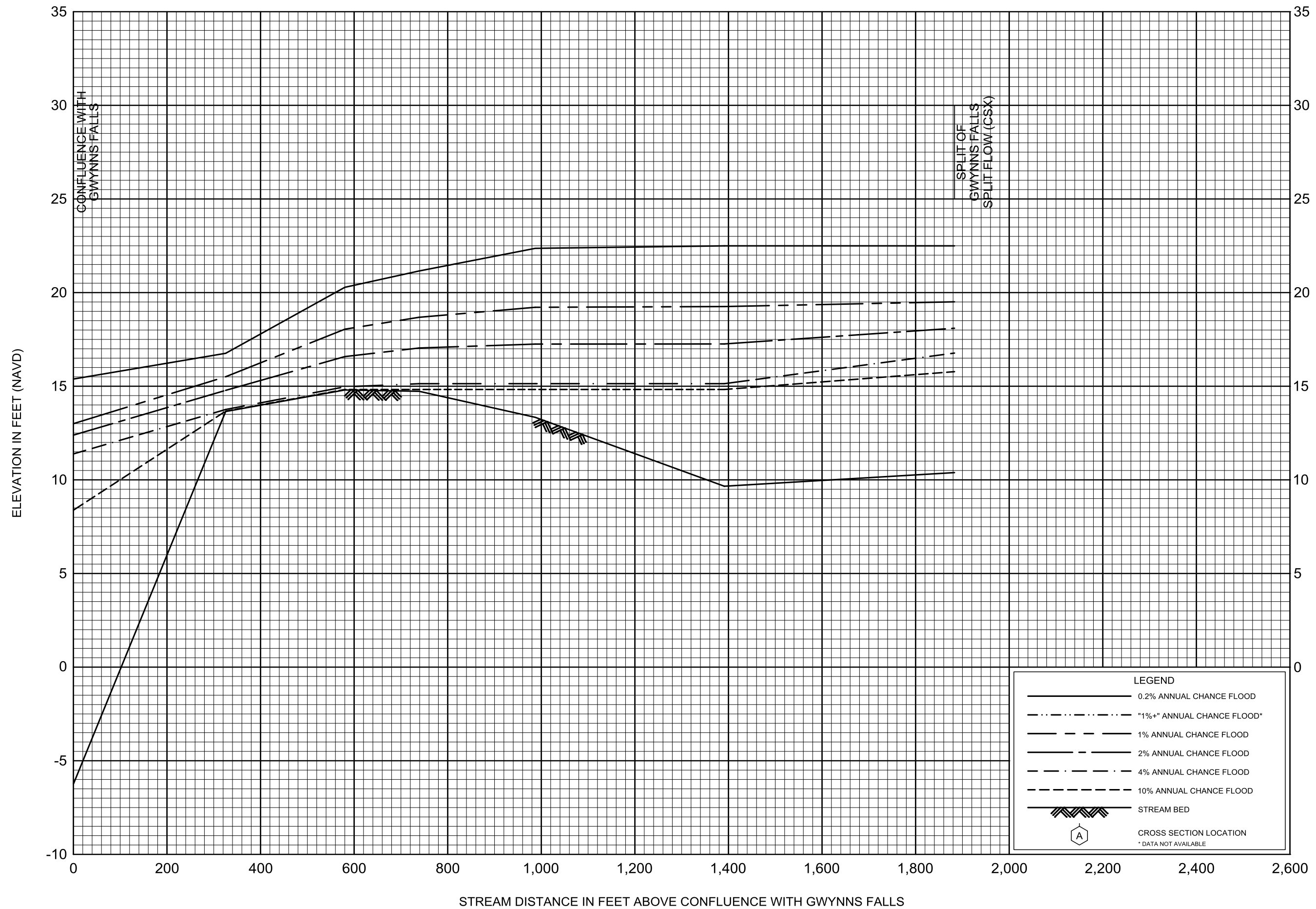
FLOOD PROFILES

GWYNNS FALLS

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)



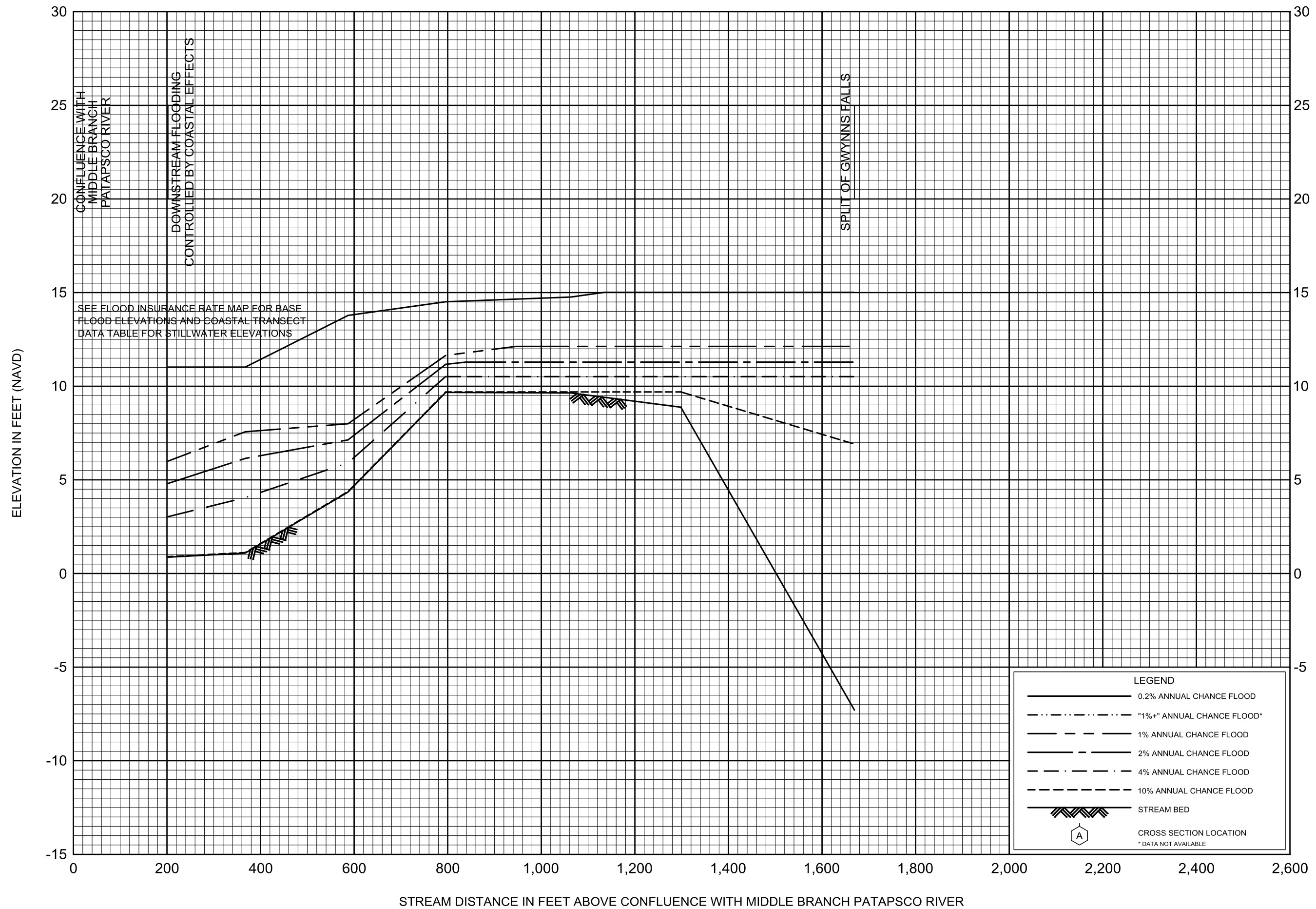


FLOOD PROFILES

GWYNNS FALLS SPLIT FLOW (MIDDLE)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)

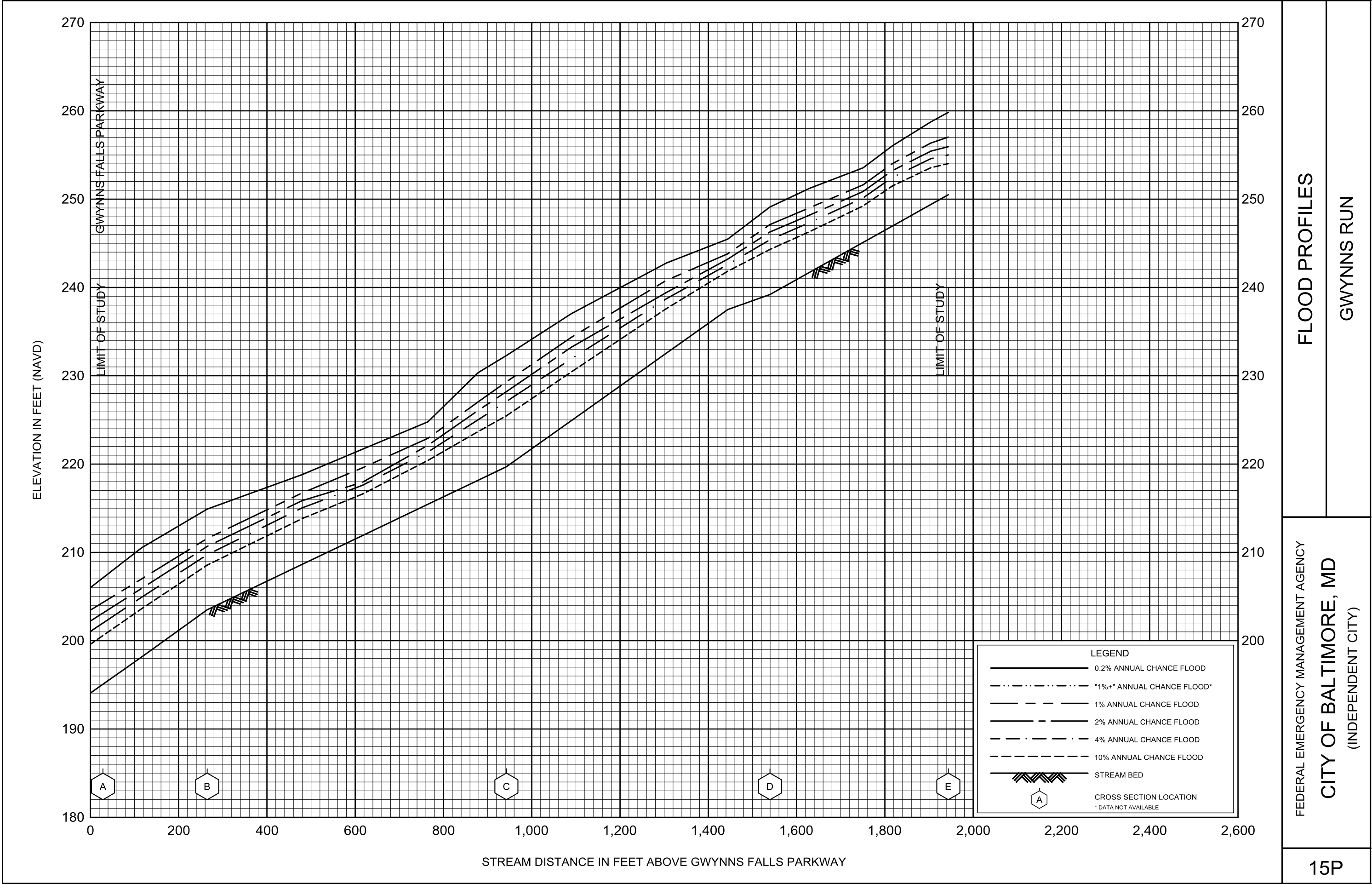


FLOOD PROFILES

GWYNNS FALLS SPLIT FLOW (WESTPORT)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)



FLOOD PROFILES

GWYNNS RUN

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BALTIMORE, MD
(INDEPENDENT CITY)