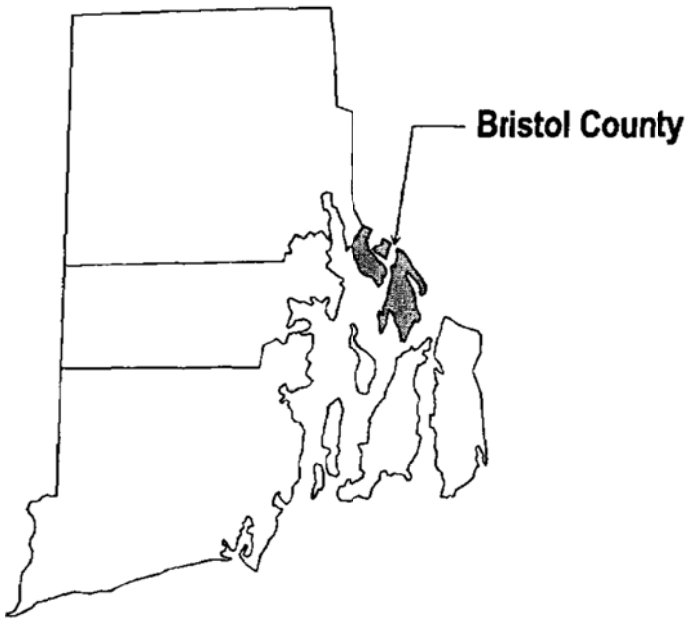
FLOOD INSURANCE STUDY



BRISTOL COUNTY, RHODE ISLAND
(ALL JURISDICTIONS)



COMMUNITY NAME	COMMUNITY NUMBER
BARRINGTON, TOWN OF	445392
BRISTOL, TOWN OF	445393
WARREN, TOWN OF	445408

Revision Date: July 7, 2014

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
44001CV000B

NOTICE TO
FLOOD INSURANCE STUDY USERS

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

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

Initial Countywide FIS Effective Date: March 5, 1996

Revised Countywide FIS Dates: November 16, 2006

Revised Coastal FIS Effective Date: July 7, 2014

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FLOOD INSURANCE STUDY
BRISTOL COUNTY, RHODE ISLAND (ALL JURISDICTIONS)

1.0 INTRODUCTION

1.1 Purpose of Study

This countywide-format Flood Insurance Study (FIS) investigates the existence and severity of flood hazards in, or revises previous FISs/Flood Insurance Rate Maps (FIRMs) for, the geographic area of Bristol County, Rhode Island, including: the Towns of Barrington, Bristol and Warren (hereinafter referred to collectively as Bristol County). This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates. This information will also be used by Bristol County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

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

1.2 Authority and Acknowledgments

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

The March 5, 1996, FIS was prepared to include the incorporated communities within Bristol County in a countywide format. Information on the authority and acknowledgments for each jurisdiction included in this countywide FIS, as compiled from their previously printed FIS report narratives, is shown below.

Barrington, Town of: the hydrologic and hydraulic analyses for the original FIS report were prepared by the U.S. Army Corps of Engineers (USACE), for the Federal Emergency Management Agency(FEMA), under Inter-Agency Agreement No. IAA-H-8-71, Project Order No. 5. The hydrologic and hydraulic analyses for the FIS report, dated August 16, 1982, were prepared by Harris-Toups Associates, for FEMA, under Contract No. H-4776. That work was completed in July 1980. The wave height analyses for the FIS

	report dated August 16, 1982, were prepared by Dewberry & Davis, for FEMA, under Contract No. EMW-C-0543. That work was completed in July 1981.
Bristol, Town of:	the hydrologic and hydraulic analyses for the original FIS report were prepared by the Soil Conservation Service (SCS), for FEMA. The hydrologic and hydraulic analyses for the FIS report dated December 1, 1982, were prepared by Harris-Toups Associates, for FEMA, under Contract No. H-4776. The wave height analyses for the FIS report dated December 1, 1982, were prepared by Dewberry & Davis, for FEMA, under Contract No. EMW-C-0543. That work was completed in July 1981.
Warren, Town of:	the hydrologic and hydraulic analyses for the original FIS report were prepared by the USACE, for FEMA. The hydrologic and hydraulic analyses for the FIS report, dated December 1, 1982, were prepared by Harris- Toups Associates, for FEMA, under Contract No. H-4776. That work was completed in September 1981.

For the countywide study dated March 5, 1996, the revised hydrologic and hydraulic analyses for Barrington, Narragansett Bay, Palmer, Providence, and Warren Rivers were prepared by ENSR Consulting and Engineering, for FEMA, under Contract No. EMW-91-R-3374. This work was completed in October 1992.

For the revised countywide study, the digital base mapping information was provided by the Rhode Island Geographic Information System (RIGIS). This information was derived from digital orthophotos produced at a scale of 1:5,000 with 2-foot Ground Sample Distance (GSD) from photography dated April 1997. The digital orthophotos were necessary to update the base map, therefore making the new FIRM maps FEMA compliant with the updated standards.

The projection used for the production of the revised countywide FIRM is Rhode Island State Plane, FIPSZONE 3800, North American Datum of 1983, GRS80 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 some jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

The Coastal wave height analysis for this coastal study was prepared by the Strategic Alliance for Risk Reduction (STARR) for FEMA under Order HSFEHQ-10-J-0004, Contract Number HSFEHQ-09-D-0370. This new analysis resulted in revisions to the Special Flood Harzard Areas (SFHAs) within the communities of the Towns of Barrington, Bristol, and Warren.

In 2011, STARR collected Light Detection and Ranging (LiDAR) topographic data covering approximately 25 square miles of Bristol County. The LiDAR data was captured to the 'highest' vertical accuracy requirement which is the equivalent of a 2-foot contour accuracy. A 1-meter Digital Elevation Model (DEM) was derived from the LiDAR data, referenced to North American Vertical Datum of 1988 (NAVD88). The DEM was projected in State Plane Rhode Island FIPS 3800 NAD 1983 US foot and used as the basis for coastal analysis and floodplain boundary delineation.

The LiDAR data does not cover elevations below the water surface; therefore, bathymetry data was downloaded from the National Oceanic and Atmospheric Administration's (NOAA) Coastal Relief Model (CRM) (NOAA 2011). The source data for the bathymetric products were soundings collected by the National Ocean Service (NOS) of NOAA. The resolution of the DEM is approximately 96 meters (converted from decimal degrees). The bathymetric data was referenced to the Mean Lower Low Water (MLLW) tidal datum, however, according to NOAA (NOAA 2011), the differences between MLLW and NAVD88 are less than the vertical accuracy of the CRM, therefore, no conversion to NAVD88 was made. The LiDAR and bathymetric data matched fairly well in the inter-tidal zone.

The following streams were redelineated for this coastal analysis; East Branch Silver Creek, Walker Creek and West Branch Silver Creek.

1.3 Coordination

An initial Consultation Coordination Officer's (CCO) meeting is held with representatives from FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the flooding sources to be studied by detailed methods.

A final CCO meeting is held with representatives from FEMA, the community, and the study contractor to review the results of the study.

The dates of the initial and final CCO meetings held for the incorporated communities within the boundaries of Bristol County are shown in the following tabulation:

Community Name	Initial CCO Date	Final CCO Date
Barrington, Town of	April 12, 1978	March 9, 1982
Bristol, Town of	May 1, 1978	June 9, 1982
Warren, Town of	April 1978	June 8, 1982

For the countywide FIS dated March 5, 1996, an initial CCO meeting was held for the Town of Barrington on June 11, 1990, and was attended by representatives of AECOM, the town, and FEMA. The USACE, New England Division, the U.S. Geological Survey (USGS), the National Oceanic Service, and the Barrington Times all contributed information pertinent to the study. In addition, the Towns of Barrington, Bristol, and Warren were notified by letter on November 12, 1993, that a countywide FIS would be prepared using ENSR Consulting and Engineering's analyses.

For this 2012 coastal revision, initial CCO meeting was held on April 6, 2011. The meetings were attended by representatives of STARR, Rhode Island State, the communities, and FEMA. A final CCO meeting was held on:

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Bristol County, Rhode Island, (All Jurisdictions).

All or portions of, the Barrington River, Brickyard Pond, East Branch Silver Creek, Echo Lake, Kickamuit River, Massachuck Creek, Mount Hope Bay, Narragansett Bay, Palmer River, Providence River, Walker Creek, Warren River, Warren Reservoir, and West Branch Silver Creek were studied by detailed methods. Limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Exhibit 2).

For the revised countywide analysis, this FIS incorporates the determination of a Letter of Map Revision (LOMR) issued by FEMA, case number 03-0l-045P, issued September 5, 2003. This LOMR was issued for the Town of Bristol and affects Bristol Harbor. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction.

A swampy area, located in the eastern portion of the Town of Warren, was studied by approximate methods. Approximate analyses were used to study this area having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the various affected communities.

For this revision, the coastal analysis establishes the flood elevations for selected recurrence intervals primarily in the coastal communities of Towns of Barrington, Bristol, and Warren. East Branch Silver Creek, Walker Creek and West Branch Silver Creek were redelineated so they could be converted to NAVD88. There were no new LOMR determinations that resulted in FIRM revisions.

There was no approximate analysis performed on riverines in this coastal study.

2.2 Community Description

Bristol County is located in eastern Rhode Island. It is bordered by the City of East Providence to the northwest, the Town of Swansea, Massachusetts to the northeast, Narragansett Bay to the south and west, and Mount Hope Bay to the east. Bristol County has a total land area of approximately 24.9 square miles.

The 2010 population of Bristol County was reported by the U.S. Census to be 49,875 (US Census 2010).

Bristol County is located on a coastal peninsula having relatively flat topography. The Town of Barrington has a peak ground elevation of 49.2 feet NAVD88. The ridge has a peak elevation of 159.2 feet NAVD88 with gentle slopes. The peak elevation in the

Town of Warren is approximately 99.2 feet NAVD88. The Town of Barrington has considerable areas of salt marsh.

Bristol County's climate is moderate and moderated by the Atlantic Ocean's effects. Temperature ranges from 29.9 degrees Fahrenheit (^{o}F) in January to a mean of 72.8^{o}F in July (State of Rhode Island, 1976). Bristol County's mean annual precipitation is 39.41 inches.

Bristol County is highly developed along its coastline. For instance, development is present in the Town of Barrington along the shoreline of Bullock Cove, the northwest shoreline of Spring Bay, the Barrington Beach area, and the shoreline of the Barrington River. Developed floodplains in the Town of Bristol include the coastal region next to Bristol Highlands on Narragansett Bay, the eastern shore of Bristol Harbor, several areas along the eastern coastline, along most of Walker Creek, and the downstream portion of Silver Creek. The Town of Warren is densely developed along Belcher Cove, the Kickamuit River, and the Warren River.

In the Town of Bristol, Silver Creek and Walker Creek drain directly into tidal areas. Silver Creek originates just north of Gooding Avenue, crosses Chestnut Street, and drains into Bristol Harbor at Hope Street. Walker Creek originates near the intersection of State and Magnolia Streets, and flows southerly, crossing Mount Hope Avenue, Woodlawn Avenue, and Hope Street before draining into Bristol Harbor.

2.3 Principal Flood Problems

The major flooding source in the Towns of Barrington and Bristol is Narragansett Bay. Oriented north-south, the bay is susceptible to tidal surges caused by hurricanes. When a hurricane passes the area to the east, the counterclockwise wind circulation around the low pressure generates winds from the south, which cause the tidal surge to flow into the bay, funneling it toward Providence. This effect was evident during the hurricanes of 1938 and 1954.

The 1938 hurricane, with an estimated recurrence interval of 100-years, caused flood elevations ranging from 14.3 feet NAVD88 at Rumstick to 14.7 feet NAVD88 at Barrington Beach. Flood elevations at Bristol Point ranged from 13.2 feet NAVD88 to 14.6 feet NAVD88 at Bristol Harbor. The most damage in the Town of Bristol occurred around Bristol harbor in the Thames Street area, and at the head of the harbor. Residential and industrial buildings were inundated, docks were destroyed, boats were torn from moorings, roads were washed out, and power supplies were cut off. Elevations in the Town of Warren reached 13.2 feet NAVD88.

Elevations on the Warren River are generally comparable to coastal elevations. Above the Conrail bridges on the Barrington and Palmer Rivers, elevations were lower, ranging from 8 to 9 feet NAVD88, during the 1938 hurricane. This difference was caused by constrictions in the channels at the abandoned railroad grade bridges, which limit tidal flow upstream (Providence Journal, 1954; USACE, 1979; Fryar, 1977). The 1938 hurricane caused extensive damage throughout Barrington and destroyed many homes in the areas of Annawamscutt Beach and Bay Spring. On the Barrington and Warren Rivers, an abandoned railroad grade bridge and the Federal Road Bridge were washed out (Providence Journal, 1938; U.S. Department of the Interior, 1940).
The 1954 hurricane, Hurricane Carol, caused flood levels that were generally 1 to 2 feet lower than those of the 1938 hurricane. The 1954 hurricane caused severe damage to coastal areas (USACE, 1979). Historic flood elevations are shown in Table 1,

"High-Water Mark Elevations" (USACE, 1979).

From December 2010 through February 2011, the State of Rhode Island saw a series of six winter storms that led to record snowfalls across the state. These storms caused a number of problems statewide with transportation, power outages, and collapses. Snow accumulation from a winter storm on December 27, 2010 reached between 10 and 16 inches and left over 480,000 Rhode Island National Grid customers, without power.

TABLE 1 – HIGH-WATER MARK ELEVATIONS (NAVD88[1])

LOCATION	HURRICANE SEPTEMBER 21, 1938	HURRICANE AUGUST 31, 1954	HURRICANE SEPTEMBER 14, 1944
Narragansett Bay			
Newport			
Bailey Beach	12.7	**	**
Price Neck	14.2	10.2	**
Brenton Point	19.1, 17.8	**	**
Newport Harbor	10.6	**	**
U.S. Coast and Geodetic Survey tide gage	12.0	9.0	5.8
Middletown			
Coddington Cove	**	9.7	**
Portsmouth			
South End Providence Island	11.5	10.2	**
Melville	11.6	10.6	**
Homestead (Prudence Island)	13.4	11.2	**
Bristol			
Bristol Point	**	10.2	**
Bristol Harbor	12.4,13.2	11.7,12.2	**
Warren			
Warren River Mouth	13.8	12.4	**
Barrington			
Rumstick Neck	14.3	**	**
Barrington Beach	14.7	14.2	**
Nayatt Point	14.6	14.3	**
Bullock Cove	14.4	13.7	**
East Providence			
Bullock Point	15.0	14.0	**
Crescent Park	15.3	**	**
Squantum Point	15.1	15.4	**

**Data not available
[1]North American Vertical Datum of 1988

TABLE 1 – HIGH-WATER MARK ELEVATIONS (NAVD88[1]) - continued

LOCATION	HURRICANE SEPTEMBER 21, 1938	HURRICANE AUGUST 31, 1954	HURRICANE SEPTEMBER 14, 1944
Narragansett Bay (continued)			
Providence			
Seekonk River	15.3	14.1	**
Point Street Bridge	15.8	14.5	**
U.S. Coast and Geodetic Survey tide gage	15.0	14.0	9.2
Sakonnet River			
Little Compton			
Breakwater Point	13.0	9.9	**
Portsmouth			
Sandy Point	**	11.0	**
McCurry Point	**	10.5	**
Island Park	14.5	13.6	**
Railroad bridge	14.8	**	**
Common Fence Point	13.4	11.2	**
Warren			
Laurel Park	**	13.2	**
Kickamuit River	12.4	12.7	**
Fall River			
U.S. Coast and Geodetic Survey tide gage	13.0	12.6	8.5

**Data not available
[1]North American Vertical Datum of 1988

In the Town of Warren, damage from both the 1938 and 1954 hurricanes was extensive. Residential properties along the Warren and Kickamuit Rivers, Mount Hope Bay, and Belcher Cove were inundated. The Warren Reservoir was contaminated when water from the Kickamuit River poured over the Child Street dike.

Minor flooding in the Town of Bristol is caused by the overflow of Silver Creek and Walker Creek.

On Oct 28, 2012 hurricane Sandy ripped through New England Oct. 28 and 29, Rhode Island was left with close to $5.6 million of damages, the majority of which was concentrated in Newport, Bristol, Washington and Kent Counties. According to the National Grid, around 2,600 residents lost power that Monday morning, primarily in Bristol County, and many homes and businesses were destroyed. Sandy also damaged roads, sea walls and government buildings. Immediately

following the storm, the governor of Rhode Island requested $9.8 million for emergency highway repairs in the state. Rhode Island also experienced significant change in landscapes near the ocean, with beaches washed out and coastal highways damaged. “A lot of erosion has taken place. (Brown Daily Herald 2012)

A total of 590 households registered with FEMA for some form of disaster assistance, including financial grants, loans and other disaster-related services.• $368,374 has been approved in grants to cover repairs to homes and rental assistance• $22,086 has been approved to help Rhode Islanders with other disaster-related needs such as lost personal property and loss of transportation (RI Gov. press 2012).

The storm began in the southern Caribbean Sea and quickly developed first into a tropical storm, then into a hurricane. Hurricane Sandy made landfall in the United States the evening of October 29 near Atlantic City, New Jersey.

2.4 Flood Protection Measures

The Towns of Barrington, Bristol, and Warren have each amended its respective zoning laws and building codes to conform to FEMA regulations pertaining to the protecting new construction from flooding associated with the 1-percent-annual recurrence interval.

The Town of Warren has seawall protection, but the seawalls exist mainly to prevent erosion rather than to prevent flooding during severe storms.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent-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 which equals or exceeds the 100-year flood (1-percent-annual-chance exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

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

Each community within Bristol County has a previously printed FIS report. The hydrologic analyses described in those reports have been compiled and is summarized on the following pages.

For Brickyard Pond, Echo Lake, Massachuck Creek, and flow hydrographs were developed to establish discharges for the Massachuck Creek basin and to establish peak discharge-frequency relationships for Brickyard Pond and Echo Lake. Hydrographs were computed by a synthetic unit hydrograph analysis as outlined by the SCS (U.S. Department of Agriculture, 1972). Storm hydrographs were developed using methods outlined by Chien and Sarikelle in conjunction with information from U.S. Weather Bureau Technical Paper 40 (Chien and Sarikelle, 1976; U.S. Department of Commerce, 1963).

Discharge frequency relationships for East Branch Silver Creek, Walker Creek, and West Branch Silver Creek were calculated by the SCS for the original FIS for the Town of Bristol (U.S. Department of Urban and Housing Development, 1971). Rainfall data for the 10-, 2-, 1- and 0.2-percent-annual-chance storms were determined using the 24-hour type II storm distribution method. The time of concentration was calculated using upland and stream hydraulics as outlined in the National Engineering Handbook (U.S. Department of Agriculture, 1972).

At the Brickyard Pond and Echo Lake outlets, stage-discharge relationships were developed and compared to the discharge-frequency relationships at each point to determine stage-frequency relationships.

A summary of the drainage area-peak discharge relationships for a portion of Brickyard Pond and Echo Lake is shown in Table 2, "Summary of Discharges."

TABLE 2- SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
BRICKYARD POND					
At outlet	1.08	153	275	346	568
ECHO LAKE					
At outlet	0.83	105	185	232	376

Tidal elevation-frequency relationships for the flooding sources located within the Town of Bristol were determined by analyzing the tide gage records and historical high-water data for Narragansett Bay, the Sakonnet River, and Rhode Island Sound (USACE, 1979; Fryar, 1977; U.S. Department of the Interior, 1940; U.S. Department of Agriculture, 1972; USACE, 1979).

Tidal elevation-frequency relationships for the flooding sources located within the Town of Warren were determined by analyzing the tide gage records and historical high-water data for Mount Hope Bay, Narragansett Bay, and Sakonnet River (USACE, 1979).

Tide gages were placed by the National Oceanic and Atmospheric Administration (NOAA) at Newport and Providence. At points where reliable high-water mark

records were available, stage correlation analyses were performed to develop frequency curves at these points. The analyses for both the tide gage data and high-water mark records were used to develop profiles for floods of the selected recurrence intervals for the flooding sources studied by detailed methods within the Town of Bristol.

The analyses for both the tide gage data and high-water mark records, supplemented with other available high-water marks, were used to develop profiles for floods of the selected recurrence intervals for the flooding sources studied by detailed methods within the Town of Warren.

For the flooding sources located within the Town of Bristol, the Providence and Newport gage elevation-frequency relationships developed from the gage records by the USACE were used. At Fall River-Somerset, the elevation-frequency relationships developed from high-water mark records by the USACE were used.

For the flooding sources located within the Town of Warren, the Providence and Newport gages were also used (USACE, 1979). The Newport tide gage elevation-frequency curve was revised from the USACE 1964 analysis because the 1964 curve used an elevation of 10 feet NAVD88 for the 1938 hurricane rather than the recorded 11.7 feet NAVD88.

For the Warren Reservoir, storm surge hydrographs were developed for overflow from the Palmer River and for flow from the Kickamuit River at the Child Street dike. The storm surge was routed over the Child Street dike and combined with flow from the Palmer River and Belcher Cove to determine total volumes of overflow. These volumes were compared with curves of elevation versus storage for the reservoir to determine the flood elevation-frequency relationship for the Warren Reservoir.

For the countywide FIS dated March 5, 1996, in 1988, the USACE published tidal flood profiles for the New England coastline developed from an analysis of tidal gage records and historical water mark data (USACE, 1988). Near Barrington, NOAA tide gages are located in the Narragansett Bay at Newport and Providence. These gages, Numbers 16420 and 16421, have been operating since 1939. The 10-, 2- and 1-percent-annual-chance stillwater surge elevations for the Barrington River, Palmer River, Providence River, Narragansett Bay, and the Warren River were adopted for this revision from the USACE publication (USACE, 1988). Since the 0.2-percent-annual-chance stillwater surge elevation for this area was not included in the USACE report, it was adopted from the USACE tidal elevation-frequency relationships developed in 1964 at Providence, Fall River, and Newport (USACE, 1979). The elevation-frequency analysis at the Newport gage was revised because the 1964 curve used 10 feet NAVD88 for the 1938 hurricane high-water mark rather than the recorded 12 feet NAVD88. The change to the Newport curve does not affect the tidal elevation frequency relationship for Barrington. Above the abandoned railroad bridges on the Barrington and Palmer Rivers, the stillwater surge elevations were reduced using high-water mark data from the 1938 and 1954 hurricanes. This reduction in elevations is caused by the constriction in the two rivers due to the abandoned railroad bridges (Fryar, 1977; Hunter, 1978).

The stillwater surge elevation is the elevations of the water due solely to the effects of the astronomical tides, storm surge, and wave setup on the water surface. The inclusion of wave heights, which is the distance from the trough to the crest of the wave, increases the water-surface elevations. The height of a wave is dependent on

wind speed and its duration, water depth, and fetch length. The wave crest elevation is the sum of the stillwater elevation and the portion of the wave height above the stillwater elevation.

Wave heights and corresponding wave crest elevations were determined using the National Academy of Sciences methodology (National Academy of Sciences, 1977).

3.2 Hydraulic Analyses

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

Hydraulic analyses for East Branch Silver Creek, Walker Creek, and West Branch Silver Creek were obtained from the original FIS for the Town of Bristol (U.S. Department of Urban and Housing Development, 1971).

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

For Massachuck Creek, the outer coast surge hydrographs for the 10-, 2-, 1-, 0.2-percent-annual-chance floods were routed over the Washington Road bridge to determine surge volume in the Massachuck Creek basin. The volumes were compared to stage-storage curves developed for the basin, to establish the elevation-frequency relationship due to tidal influence within the basin.

Using the flood hydrography analysis, the runoff volumes were plotted on elevation-storage curves for the basin to establish the elevation-frequency relationship to fresh water storm events. The most severe flooding for the 1- and 0.2-percent-annual- chance flood is caused by overtopping of Washington Road. The 10- and 2- percent-annual-chance peak flood elevations are caused by ponding behind the tide gate at Washington Road.

For those flooding sources studied by approximate methods, 1-percent-annual-chance water-surface elevations were calculated considering a number of factors including surface area (lakes and ponds) determinations, contributing drainage area determinations, and normal depth calculations.

The hydraulic analyses for this study 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.

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

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

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

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

To obtain current elevation, description, and/or location information for bench marks shown on the FIRM for this jurisdiction, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their Web site at www.ngs.noaa.gov.

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

2012 Coastal Update

Based on the results of the new coastal analysis, riverine backwater elevations have changed but are not incorporated into the new coastal study. The backwater elevations for East Branch Silver Creek, Walker Creek, West Branch Creek will need to be updated in future revisions

3.3 Coastal Hydrologic Analyses

The stillwater elevations (SWELs) for different recurrence intervals were derived by statistical analysis of tide gauge records in New England. The results of the analysis at the tide gauge stations were used to develop flood profiles along the New England coastline. The statistical analysis is presented in the STARR report: Updated Tidal Profiles for the New England Coastline (STARR 2012). The 1-percent SWELs in the study area are similar to the storm surge elevations produced by the 1938 hurricane that impacted the study area; therefore, the characteristics of this event were used as a model for generating corresponding wave conditions using the Steady-State Spectral Wave model (STWAVE) (USACE 2001).

For areas subject to coastal flood effects, the 10-, 2-, 1-, and 0.2-percent-annual-chance

stillwater elevations were taken directly from a detailed storm surge study documented in Updating Tidal Profiles for the New England Coastline, prepared by FEMA (FEMA 2008). This storm surge study was completed in November 2011. SWELs were linearly interpolated to all coastal transects throughout Bristol County.

Table 3 - "Summary of Stillwater Elevations" contains the stillwater elevations determined from the stillwater curves in Figure C8 of the Updating Tidal Profiles for the New England Coastline report (STARR 2012). These values were linearly interpolated to all coastal transects throughout the county for use in coastal hydraulic analyses.

The stillwater elevations for the 10-, 2-, 1-, 0.2-percent-annual-chance floods have been determined for the Barrington River, Brickyard Pond, Echo Lake, Kickamuit River, Massachuck Creek, Mount Hope Bay, Narragansett Bay, Palmer River, Providence River, the Warren River, and Warren Reservoir are summarized in Table 3, "Summary of Stillwater Elevations."

TABLE 3- SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet NAVD88)[1] 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
PROVIDENCE RIVER	6.8	9.6	11.5	18.1
NARRAGANSETT BAY	6.5	9.4	11.2	17.8
WARREN RIVER				
At mouth	6.6	9.5	11.3	17.9
BARRINGTON RIVER				
Below Conrail	6.8	9.7	11.6	18.3
Above Conrail	6.8	9.6	11.5	18.1
PALMER RIVER				
Below Conrail	6.9	9.8	11.7	18.5
Above Conrail	5.2	7.6	11.5	18.1
MASSACHUCK CREEK				
Above Washington Road	6.8	9.6	11.5	18.1
ECHO LAKE	6.8	9.6	11.5	18.1
BRICKYARD POND	6.8	9.6	11.5	18.1
MOUNT HOPE BAY	6.4	9.3	11.1	17.6
KICKAMUIT RIVER	6.6	9.5	11.3	17.9
WARREN RESERVOIR	6.8	9.6	11.5	18.1

[1]North American Vertical Datum of 1988

Transects (profiles) were located for coastal hydrologic and hydraulic analyses perpendicular to the average shoreline along areas subject to coastal flooding and extending inland to a point where wave action ceased in accordance with the Users Manual for Wave Height Analysis. Transects were placed with consideration of

topographic and structural changes of the land surface, as well as the cultural characteristics of the land so that they would closely represent local conditions. A total 20 transects sites were chosen to capture the variability in coast orientation, large-scale vegetation, and development.

3.4 Coastal Hydraulic Analyses

Wave height is the distance from the wave trough to the wave crest. The height of a wave is dependent upon wind speed, wind duration, water depth, and length of fetch. Offshore (deep water) and near shore (shallow water) wave heights and wave periods were calculated for restricted and unrestricted fetch settings following the methodology described in the February 2007 FEMA Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (FEMA 2007), for each coastal transect.

An analysis of historic hurricane events was performed to determine a wind scenario for the study. A wind scenario that is consistent with the stillwater elevation was sought. The stillwater elevation for the 1938 hurricane is very close to the estimated 1%- annual-chance SWEL. Therefore, wind speed was based on wind speed records for the 1938 hurricane, and adjusted upward to 40 m/s for the STWAVE model. Wind speed data were obtained from the HURDAT database maintained by the National Hurricane Center (NHC) (NHC 2011). The data set consists of storm parameters recorded at 6 hour intervals for hurricanes and tropical storms; the record extends back to 1851.

In performing the coastal analyses, nearshore waves were required as inputs to wave runup and overland wave propagation calculations. Wave momentum (radiation stress) was considered as a contribution to elevated water levels (wave setup). The STWAVE model was used to generate and transform waves to the shore for the study. STWAVE is a finite difference model that calculates wave spectra on a rectangular grid. The model outputs zero-moment wave height (Hmo), peak wave period (Tp), and mean wave direction at all grid points and two-dimensional spectra at selected grid points. STWAVE includes an option to input spatially variable wind and storm surge field. Storm surge significantly alters wave transformation and generation for the hurricane simulations in shallow-flooded areas. The starting wave condition data was derived from the STWAVE model of Narragansett Bay. The data contained the significant wave height (Hs) and significant wave period (Ts) for the 1-percent-annual-chance storm.

Wave setup was assumed to be an important factor in determining total water level, since the coastline has historically experienced flooding damage above the predicted storm surge elevations. Wave setup is based upon wave breaking characteristics and profile slope. As stated in the Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (FEMA 2007), "Wave setup can be a significant contributor to the total water level landward of the +/- MSL shoreline and should be included in the determination of coastal Base Flood Elevations (BFEs)." Wave setup values were calculated to the entire open coast shoreline in each community. Wave setup for each coastal transect was calculated by the Direct Integration Method (DIM) developed by Goda (2000) as described in the FEMA Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (FEMA 2007). For those coastal transects where a structure was located, the wave setup against the coastal structure was also calculated. For profiles with vertical structures or revetments, a failed structure analysis was performed and a new profile of the failed structure was generated and analyzed, in accordance with Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (FEMA 2007).

Erosion analysis using FEMA's Coastal Hazard Analysis Modeling Program (CHAMP) Version 2.0 was performed for profiles with erodible dunes and without coastal structures, such as vertical walls or revetments (FEMA 2007). The dune subject to erosion is a sandy feature with potentially light vegetation. Any thickly vegetated, rocky, silty, or clayey dune features or bluffs are assumed not subject to erosion. Predicted post-storm erosion profiles were used for analysis of wave heights associated with coastal storm surge flooding, where appropriate.

Wave height was computed using CHAMP version 2.0 which includes the wave height analysis (WHAFIS) model. WHAFIS is capable of calculating the effects of open fetches and obstructions on the growth and attenuation of wave heights (FEMA 2007). A primary input to the WHAFIS model was the ground profile consisting of station (distance in feet) and elevation (in feet above NAVD88 datum) pairs that represent the bare-earth ground elevation along the transect, accompanied by the SWEL. For each of the 34 transects, detailed ground profiles were extracted from the high-resolution terrain. Along each transect, overland wave propagation was computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Wave heights were calculated to the nearest 0.1 foot, and wave crest elevations were determined at whole-foot increments. The calculations were carried inland along the transect until the wave crest elevation was permanently less than 0.5 foot above the total water elevation or the coastal flooding met another flood source (i.e. riverine) with an equal water-surface elevation.

Areas of the coastline subject to significant wave attack are referred to as coastal high hazard zones. The USACE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (USACE 1975). The 3-foot wave has been determined as the minimum size wave capable of causing major damage to conventional wood frame or brick veneer structures. This criterion has been adopted by FEMA for the determination of V-zones.

It has been shown in laboratory tests and observed in post storm damage assessments that wave heights as little as 1.5 feet can cause damage to and failure of typical Zone AE construction. Therefore, for advisory purposes only, a Limit of Moderate Wave Action (LiMWA) boundary has been added in coastal areas subject to moderate wave action. The LiMWA represents the approximate landward limit of the 1.5-foot breaking wave, and was delineated for all areas subject to significant wave attack in accordance with Procedure Memorandum No. 50 – Policy and Procedures for Identifying and Mapping Areas Subject to Wave Heights Greater than 1.5 feet as an Informational Layer on FIRMS (FEMA 2008).

The effects of wave hazards in the Zone AE (or shoreline in areas where VE Zones are not identified) and the limit of the LiMWA boundary are similar to, but less severe than, those in Zone VE where 3-foot breaking waves are projected during a 1-percent-annual-chance flooding event.

In areas where wave runup elevations dominate over wave heights, such as areas with steeply sloped beaches, bluffs, and/or shore-parallel flood protection structures, there is no evidence to date of significant damage to residential structures by runup depths less than 3 feet. However, to simplify representation, the LiMWA was continued immediately landward of the VE/AE boundary in areas where wave runup elevations dominate. Similarly, in areas where the Zone VE designation is based on the presence of a primary frontal dune (PFD) or wave overtopping, the LiMWA was also delineated

immediately landward of the Zone VE/AE boundary.

Wave runup is the uprush of water caused by the interaction of waves with the area of shoreline where the stillwater hits the land or other barrier intercepting the stillwater level. The wave runup elevation is the vertical height above the stillwater level ultimately attained by the extremity of the uprushing water. Wave runup at a shore barrier can provide flood hazards above and beyond those from stillwater inundation. Guidance in the February 2007 FEMA Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (FEMA 2007) suggests using the 2-percent wave runup value, the value exceeded by 2-percent of the runup events. The 2-percent wave runup value is particularly important for steep slopes and vertical structures. Wave runup was calculated for each coastal transect using methods from the Shore Protection Manual (SPM) (USACE 1984) for vertical structures, Technical Advisory Committee for Water Retaining Structures (TAW) method for structures with a slope steeper than 1:8, and FEMA Wave Runup Model RUNUP 2.0 for slopes less than 1:8. Both the SPM vertical structure runup and RUNUP 2.0 methods provide mean runup values. The mean runup values from these two methods were multiplied by 2.2 to obtain the 2-percent runup height, as described in the February 2007 Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update to Appendix D, Guidance for Coastal Flooding Analysis and Mapping (FEMA 2007).

When the runup is greater than or equal to 3 feet above the maximum ground elevation, the BFE was determined to be 3 feet above the ground crest elevation, in accordance with guidance in Appendix D. Computed runup was not adjusted if less than three feet above the ground crest.

When runup overtops a barrier such as a partially eroded bluff or a structure, the floodwater percolates into the bed and/or runs along the back slope until it reaches another flooding source or a ponding area. Standardized procedures for the treatment of shallow flooding and ponding were applied as described in Appendix D of the Guidance for Coastal Flooding Analysis and Mapping (FEMA 2003).

Where uncertified coastal structures such as vertical walls and revetments were present, additional analysis for wave setup and wave runup was performed on profiles assuming the structure will partially fail during the base flood. The post-failure slopes applied for this analysis were 1:3 for sloped revetments, and 1:1.5 for vertical walls, which are within the range suggested by the February 2007 Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update to Appendix D (FEMA 2007).

In accordance with 44 CFR Section 59.1 of the NFIP the effect of the PFD on coastal high hazard area (V Zone) mapping was evaluated for the Towns of Barrington, Bristol, and Warren. Identification of the PFD was based upon a FEMA approved numerical approach for analyzing the dune's dimensional characteristics. This approach utilized LiDAR data for the study areas and assessed change in back slope to determine the landward toe of the PFD. In areas where the PFD defines the landward limit of the V Zone, the V Zone extends to the landward toe of the dune. No PFDs were identified in the study area.

Because wave height calculations are based on such parameters as the size and density of vegetation, natural barriers such as sand dunes, buildings, and other man-made structures, detailed information on the physical and cultural features of the study area were obtained from aerial photography. LiDAR data of the shorelines of the Cities of

Cranston, East Providence, Pawtucket, and Providence was used for the topographic data.

Figure 1 "Transect Schematic" represents a sample transect which illustrates the relationship between the stillwater elevation, the wave crest elevation, the ground elevation profile, and the location of the A/V zone boundary. Actual wave conditions may not include all the situations illustrated in Figure 1.

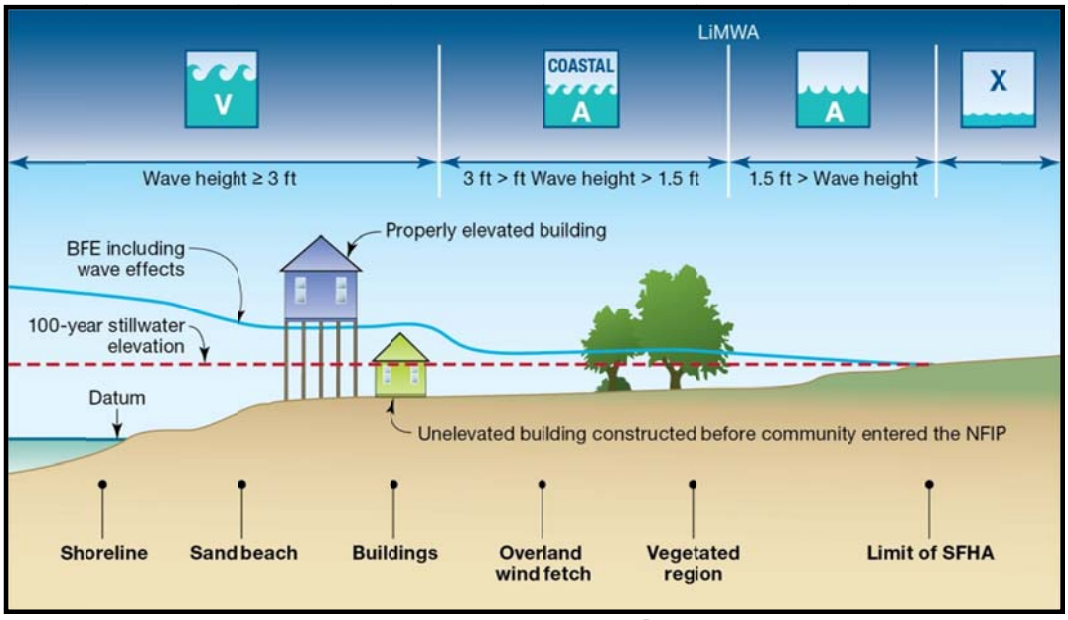


Figure 1 - Transect Schematic

After analyzing computed wave heights along each transect, wave elevations were interpolated between transects. Various source data were used in the interpolation, including the topographic work maps, aerial photographs, and engineering judgment. Controlling features affecting the elevations are identified and considered in relation to their positions at a particular transect and their variation between transects.

Along each transect, wave envelope elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Between transects, elevations were interpolated using the previously cited topographic maps, land-use data, land-cover data, and engineering judgment to determine the areal extent of flooding. The results of the calculations are accurate until local topography, vegetation, or cultural development within the community undergoes any major changes.

Table 4 "Transect Descriptions" provides a description of the transect locations, the 1-percent-annual-chance stillwater elevations, and the maximum 1-percent-annual-chance wave crest elevations. Figure 2, "Transect Location Map," illustrates the location of the transects for the county.

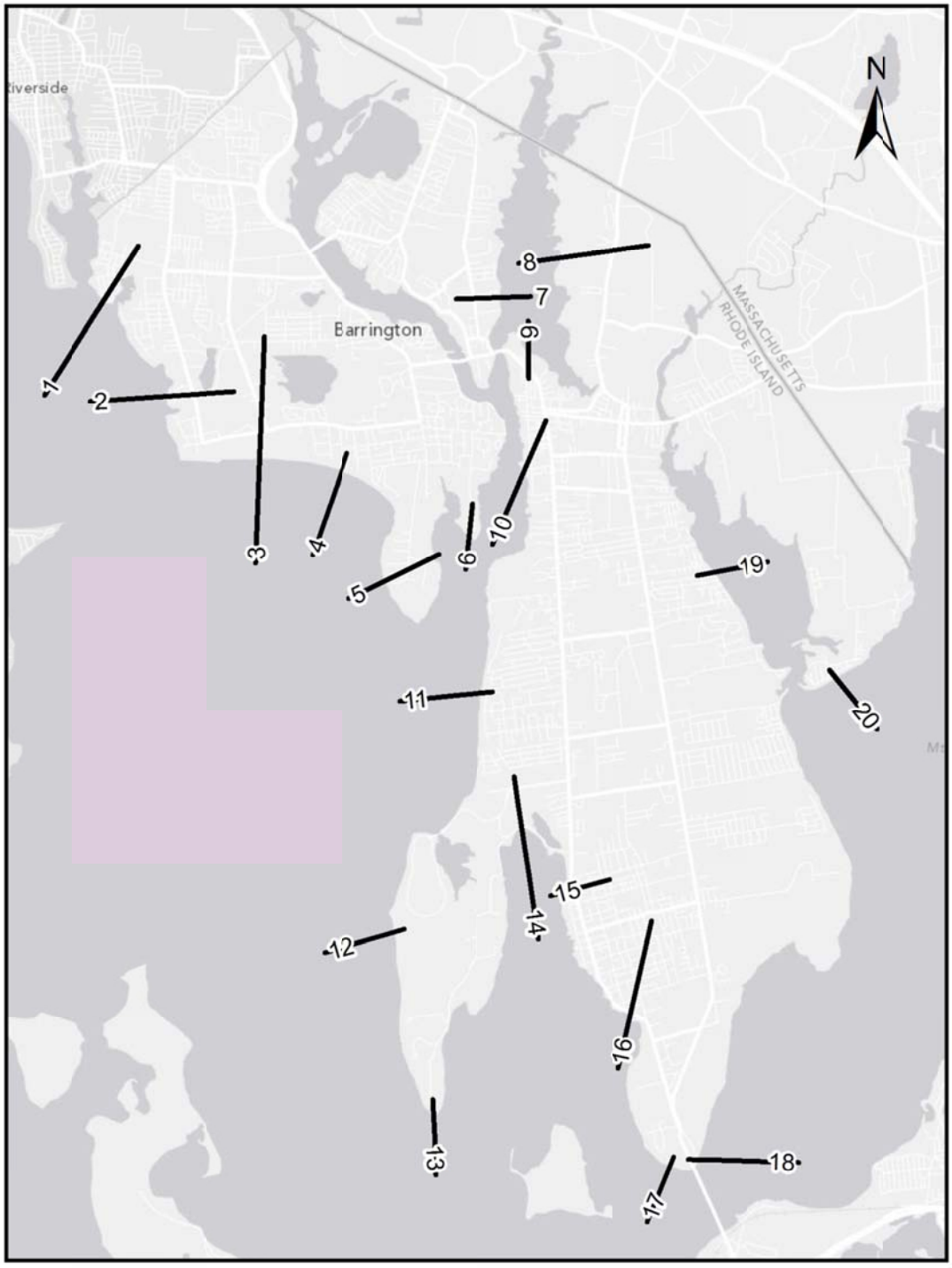


Figure 2 - Transect Location Map

Table 4, "Transect Descriptions," provides a listing of the transect locations, stillwater elevations, and maximum wave crest (or wave runup) elevations along the shoreline. Transects have been re-numbered to conform to countywide standard.

Along each transect, wave heights and wave crest elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Wave heights were calculated to the nearest 0.1 foot, and wave crest elevations were determined at whole-foot increments. The calculations were carried inland along the transect until the wave crest elevation was permanently less than 0.5 foot above the stillwater elevation or the coastal flooding met another flood source (i.e. riverine) with an equal water-surface elevation or was extended inland to a point where wave action ceased. Between transects, elevations were interpolated using topographic maps, land-use and land-cover data, and engineering judgment to determine the area extent of flooding. The results of the calculations are accurate until local topography, vegetation, or cultural development within the community undergoes any major changes. The results of this analysis are summarized in Table 5, "Transect Data."

TABLE 4 - TRANSECT DESCRIPTIONS

TRANSECT	LOCATION	ELEVATION (feet NAVD88[3]) 1-PERCENT-ANNUAL-CHANCE STILLWATER[1]	ELEVATION (feet NAVD88[3]) MAXIMUM 1-PERCENT-ANNUAL-CHANCE WAVE CREST[2]
1	The transect is located approximately 300 feet east of the intersection of County Road and Washington Road, extending southwest towards the Providence River.	11.5	18.0
2	The transect is located at the intersection of Jenny's Lane and Rumstick Road, extending east towards the Providence River.	11.5	16.9
3	The transect is located at the intersection of Church Street and Barrington Avenue, extending south towards the Narragansett Bay.	11.4	18.1
4	The transect is located approximately 300 feet northeast of the intersection of Bluff Road and Arnold Street, extending southwest towards the Narragansett Bay.	11.4	18.3
5	The transect is located at the end of Apple Tree Lane, extending southwest towards the Narragansett Bay.	11.3	17.4
6	The transect is located approximately 1,500 feet south of the intersection of Bourne Lane and Adams Point Road, extending south towards the Warren River.	11.3	16.4
7	The transect is located at the intersection of Linden Road and New Meadow Road, extending east towards the Palmer River.	11.6	12.8
8	The transect is located approximately 2,000 feet southeast of the intersection of Market Street and Birch Swamp Road, extending west towards the Palmer River.	11.6	13.4

[1]Including stillwater elevation and effects of wave setup.
[2]Because of map scale limitations, maximum wave elevations may not be shown on the FIRM
[3]North American Vertical Datum of 1988

TABLE 4 - TRANSECT DESCRIPTIONS

TRANSECT	LOCATION	ELEVATION (feet NAVD88[3]) 1-PERCENT-ANNUAL-CHANCE STILLWATER[1]	ELEVATION (feet NAVD88[3]) MAXIMUM 1-PERCENT-ANNUAL-CHANCE WAVE CREST[2]
9	The transect is located at the intersection of Union Street and Bowen Street, extending north towards the Palmer River.	11.6	13.6
10	The transect is located at the intersection of State Street and Joyce Street extending southwest towards the Warren River.	11.4	13.4
11	The transect is located approximately 250 east of the end of Shore Road, extending west towards the Narragansett Bay.	11.2	13.7
12	The transect is located in Colt State Park approximately 3,000 feet west of the intersection of Freeborn Road and Poppasquash Road, extending east towards the Narragansett Bay.	11.0	15.5
13	The transect is located at the southern end of Poppasquash Road, extending south towards the Narragansett Bay.	10.9	17.2
14	The transect is located approximately 550 feet north of the intersection of Asylum Road and Harbor View Avenue, extending south towards Narragansett Bay.	11.1	15.0
15	The transect is located 100 feet north of the intersection of wood Street and Roma Street, extending east towards the Narragansett Bay.	11.0	14.8
16	The transect is located approximately 550 feet northeast of the intersection of Mt. Hope Avenue and Third School Street, extending southwest towards the Narragansett Bay.	11.0	15.2

[1]Including stillwater elevation and effects of wave setup.
[2]Because of map scale limitations, maximum wave elevations may not be shown on the FIRM
[3]North American Vertical Datum of 1988

TABLE 4 - TRANSECT DESCRIPTIONS

		ELEVATION (feet NAVD88[3])	
TRANSECT	**LOCATION**	**1-PERCENT-ANNUAL-CHANCE STILLWATER[1]**	**MAXIMUM 1-PERCENT-ANNUAL-CHANCE WAVE CREST[2]**
17	The transect is located approximately 1,300 feet southwest of the intersection of Ferry Road and Low Lane, extending southwest towards the Narragansett Bay.	10.9	14.9
18	The transect is located approximately 400 feet north of the south end of Old Ferry Road, extending southeast towards Mt. Hope Bay.	10.9	*
19	The transect is located approximately 200 feet west of the intersection of Franca Drive and Hawthorne Avenue, extending east towards the Kikemuit River.	11.3	14.3
20	The transect is located approximately 270 feet northwest of the intersection of Leonard Street and Brownell Street, extending southeast towards Mt. Hope Bay.	11.2	*

[1]Including stillwater elevation and effects of wave setup.
[2]Because of map scale limitations, maximum wave elevations may not be shown on the FIRM
[3]North American Vertical Datum of 1988
*1% annual chance water level governed by wave runup

TABLE 5 - TRANSECT DATA

TRANSECT	FLOODING SOURCE	STILLWATER ELEVATION[1] 10-PERCENT-ANNUAL-CHANCE	2-PERCENT-ANNUAL-CHANCE	1-PERCENT-ANNUAL-CHANCE	0.2-PERCENT-ANNUAL-CHANCE	ZONE	BASE FLOOD ELEVATION (feet NAVD88[*])[2]
1	Providence River	6.8	9.7	11.5	18.2	VE	18
						AE	13
2	Providence River	6.8	9.6	11.5	18.1	VE	17
						AE	12
3	Narragansett Bay	6.7	9.5	11.4	18.0	VE	18
						VE	17
						VE	16
						AE	14
4	Narragansett Bay	6.7	9.5	11.4	18.0	VE	18
						VE	17
5	Narragansett Bay	6.6	9.5	11.3	17.9	VE	17
6	Warren River	6.6	9.5	11.3	17.9	VE	16
						VE	15
						VE	14
						AE	14
7	Palmer River	6.8	9.7	11.6	18.2	AE	13
						AE	12
8	Palmer River	6.8	9.7	11.6	18.3	AE	13
9	Palmer River	6.8	9.6	11.6	18.1	AE	14
						AE	13
10	Warren River	6.7	9.5	11.4	18	VE	16
						VE	15
						AE	12
11	Narragansett Bay	6.5	9.4	11.2	17.8	VE	16
12	Narragansett Bay	6.3	9.2	11.0	17.3	VE	16
						AE	14
13	Narragansett Bay	6.2	9.0	10.9	17.1	VE	17
14	Narragansett Bay	6.4	9.3	11.1	17.5	VE	15
						AE	13
						AE	12
15	Narragansett Bay	6.3	9.2	11.0	17.4	VE	15
						VE	14
						AE	13
16	Narragansett Bay	6.2	9.1	11.0	17.2	VE	15
						VE	14
17	Narragansett Bay	6.2	9.0	10.9	17.1	VE	15
18	Mt. Hope Bay	6.2	9.0	10.9	17.1	VE	21
						AO	3
19	Kikemuit River	6.6	9.5	11.3	17.9	VE	14
						AE	14
						AE	13
20	Mt. Hope Bay	6.5	9.4	11.2	17.8	VE	22

[1]Including stillwater elevation and effects of wave setup.
[2]Because of map scale limitations, base flood elevations shown on the FIRM represent average elevations for the zones depicted.
[*]North American Vertical Datum of 1988

3.5 Vertical Datum

All FISs and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FISs and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the finalization of the NAVD88, many FIS reports and FIRMs are being prepared using NAVD88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD88. Structure and ground elevations in the community must, therefore, be referenced to NAVD88. It is important to note that adjacent communities may be referenced to NGVD29. This may result in differences in base flood elevations across the corporate limits between the communities.

As noted above, the elevations shown in the FIS report and on the FIRM for Bristol County are referenced to NAVD88. Ground, structure, and flood elevations may be compared and/or referenced to NGVD29 by applying a standard conversion factor. The conversion factor from NGVD29 to NAVD88 is -0.8, and from NAVD88 to NGVD29 is +0.8.

The BFEs shown on the FIRM represent whole-foot rounded values. For example, a BFE of 102.4 will appear as 102 on the FIRM and 102.6 will appear as 103. Therefore, users that wish to convert the elevations in this FIS to NGVD29 should apply the stated conversion factor(s) to elevations shown on the Flood Profiles and supporting data tables in the FIS report, which are shown at a minimum to the nearest 0.1 foot.

For additional information regarding conversion between the NGVD29 and NAVD88, 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

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

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at http://www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS provides 1-percent-annual-chance flood elevations and delineations of the 1- and 0.2-percent-annual-chance floodplain boundaries and 1-percent-annual-chance floodway to assist in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent -annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community. For the streams studied in detail, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at scales of 1:1,200 and 1:4,800 with contour intervals of 2 and 5 feet, respectively (Camp, Dresser, McKee, Inc., 1973; Geod Aerial Mapping, Inc., 1979).

For the countywide FIS dated March 5, 1996, the boundaries were interpolated between cross sections using topographic maps at a scale of 1:1,200 with a contour interval of 2 feet. (Camp, Dresser, McKee, Inc., 1973).

The 1- and 0.2 -percent -annual -chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, AO, and VE), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2- percent-annual-chance floodplain boundaries are close together, only the 1-percent -annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For this revision, STARR performed coastal flood hazard analysis for the study area that included the collection of storm surge (coastal hydrology) data and conducting overland wave height analysis (coastal hydraulics). For storm surge or stillwater elevations, the STARR team used the "Tidal Flood Profiles New England Coastline," prepared by New England Division, U.S. Army Corps of Engineers, dated September 1988. STARR has reviewed the FEMA HQ report titled, "Updating Tidal Profiles for New England Coastline," dated December 3, 2008, for the 10-, 2-, 1-, and 0.2-percent-annual-chance flood events. The 1988 profiles also reflect highwater information for multiple areas resulting from the Hurricanes of 1938 and February 1978 extra-tropical events.

The overland wave height analysis was performed using CHAMP. Results of the overland wave height analysis were transferred to topographic work maps. There were no PFD's located in Bristol County, RI.

After the wave models were reviewed, the model outputs were imported into ArcMap and zone point shapefiles were generated. The zone point shapefiles delineate the change in BFEs along the transect and can be used to map the BFE changes. The BFEs were separated by drawing gutter lines which connect the zone point breaks between

transects.

STARR delineated the 1- and 0.2-percent-annual-chance floodplain boundaries for Bristol County using standard GIS utilities. The STARR team manually drew the floodplain boundaries on the on 2-foot topographic contours derived from the terrain model using LiDAR collected in 2011. Aerial imagery and land use data assisted in the development of these features.

Zone VE (high wave velocity action area) was assigned to areas where the wave height is at least 3 feet. Since the wave crest is 70 percent of the controlling wave height above the stillwater plus setup surface, the wave crest in Zone VE is at least 2.1 feet higher than the stillwater plus wave setup elevation. Zone AE was assigned to areas where the total wave height is less than 3 feet and the wave crest is less than 2 feet above the stillwater plus wave setup elevation. Any zone width that is less than 0.2 times the FIRM scale was merged into the adjacent higher elevation zone. In the case of Bristol County, the FIRM scales are 1 inch equals 500 feet, so zone widths of less than 100 feet were usually merged to the adjacent higher zone.

In March 2007, FEMA developed the guidance on the identification and mapping of the LiMWA. For Bristol County, RI this mapping was done by identifying the LiMWA location(s) along each transect using the WHAFIS output and connecting those points between transects using gutter lines. In areas where runup elevations dominate over WHAFIS wave height, such as areas with steeply sloping beaches or high bluffs, there is no need to delineate the LiMWA. To retain continuous LiMWA lines in runup areas, the LiMWA was placed immediately landward of the mapped VE/AE Zone boundary and coincident with the 1-percent-annual-chance floodplain boundary in areas without an AE zone.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, V, and VE), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

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

4.2 Base Flood Elevations

Areas within the community studied by detailed engineering methods have BFEs established in A and V Zones. These are the elevations of the base (l-percent-annual - chance) flood relative to NAVD88. In coastal areas affected by wave action, BFEs are generally maximal at the normal open shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in BFEs have been shown in 1-foot increments on the FIRMs. However, where the scale did not permit, 2- or 3-foot increments were sometimes used. BFEs shown in the wave action areas represent the

average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is above the BFE in A and V Zones.

4.3 Velocity Zones

The USACE has established the 3-foot wave as the criterion for identifying coastal high hazard zones. This was based on a study of wave action effects on structures. This criterion has been adopted by FEMA for the determination of V Zones. Because 60 of the additional hazards associated with high-energy waves, the NFIP regulations require much more stringent floodplain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in V Zones are higher than those in A Zones with similar numerical designations. The location of the V Zone is determined by the 3-foot wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the V Zone to be established. The V Zone generally extends inland to the point where the 1-percent-annual-chance flood depth is insufficient to support a 3-foot wave.

5.0 INSURANCE APPLICATIONS

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

Zone A

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

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

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

Zone V

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

Zone VE

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

Zone X

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

6.0 FLOOD INSURANCE RATE MAP

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

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

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

The current FIRM presents flooding information for the entire geographic area of Bristol County. Previously, separate Flood Hazard Boundary Maps and/or FIRMs were prepared for each identified flood-prone incorporated community and the unincorporated areas of the county. This countywide FIRM also includes flood hazard information that was presented separately on Flood Boundary and Floodway Maps, where applicable. Historical data relating to the maps prepared for each community are presented in Table 6, “Community Map History.”

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Barrington, Town of	May 15, 1970	None	April 16, 1971	July 1, 1974 October 17, 1975 October 3, 1979 February 16, 1983 June 16, 1992
Bristol, Town of	December 2, 1972	None	December 2, 1972	July 1, 1974 October 17, 1975 June 1, 1983
Warren, Town of	July 28, 1972	None	July 28, 1972	July 1, 1974 October 31, 1975 June 1, 1983

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

BRISTOL COUNTY, RI
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

Narragansett Bay, the Warren River, the Barrington River, and the Palmer River were studied by the USACE in 1964 and 1980 as part of their analysis of tidal flooding in Narragansett Bay and the Sakonnet River due to hurricanes (USACE, 1979; Hunter,1978). The results of the 1964 USACE study at Providence and Fall Rivers were used to develop the 0.2- and 2-percent-annual-chance floods for tidal areas in Barrington. The 1- and 10-percent annual chance floods for these areas were developed from the 1980 USACE study. In October 1977, elevations of the Barrington and Palmer Rivers above the abandoned railroad bridge were reduced due to a re-examination of the high-water marks by the USACE and the Town of Barrington. This change was adopted by FEMA in January 1978 (Hunter, 1978).

FISs have been prepared for the City of East Providence, Rhode Island, and the Town of Swansea, Massachusetts (FEMA, 1983, 1986).

Revised Countywide FIS report for Bristol County went effective November 6, 2006

Because it is based on more up-to-date analyses, this FIS supersedes the previously printed FISs for the Towns of Barrington, Bristol, and Warren (FEMA, 1983), and for Bristol County (All Jurisdictions) (FEMA, 1996) and Bristol County revised countywide (FEMA,2006).

8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, Mitigation Division, 99 High Street, 6th Floor, Boston, Massachusetts 02110.

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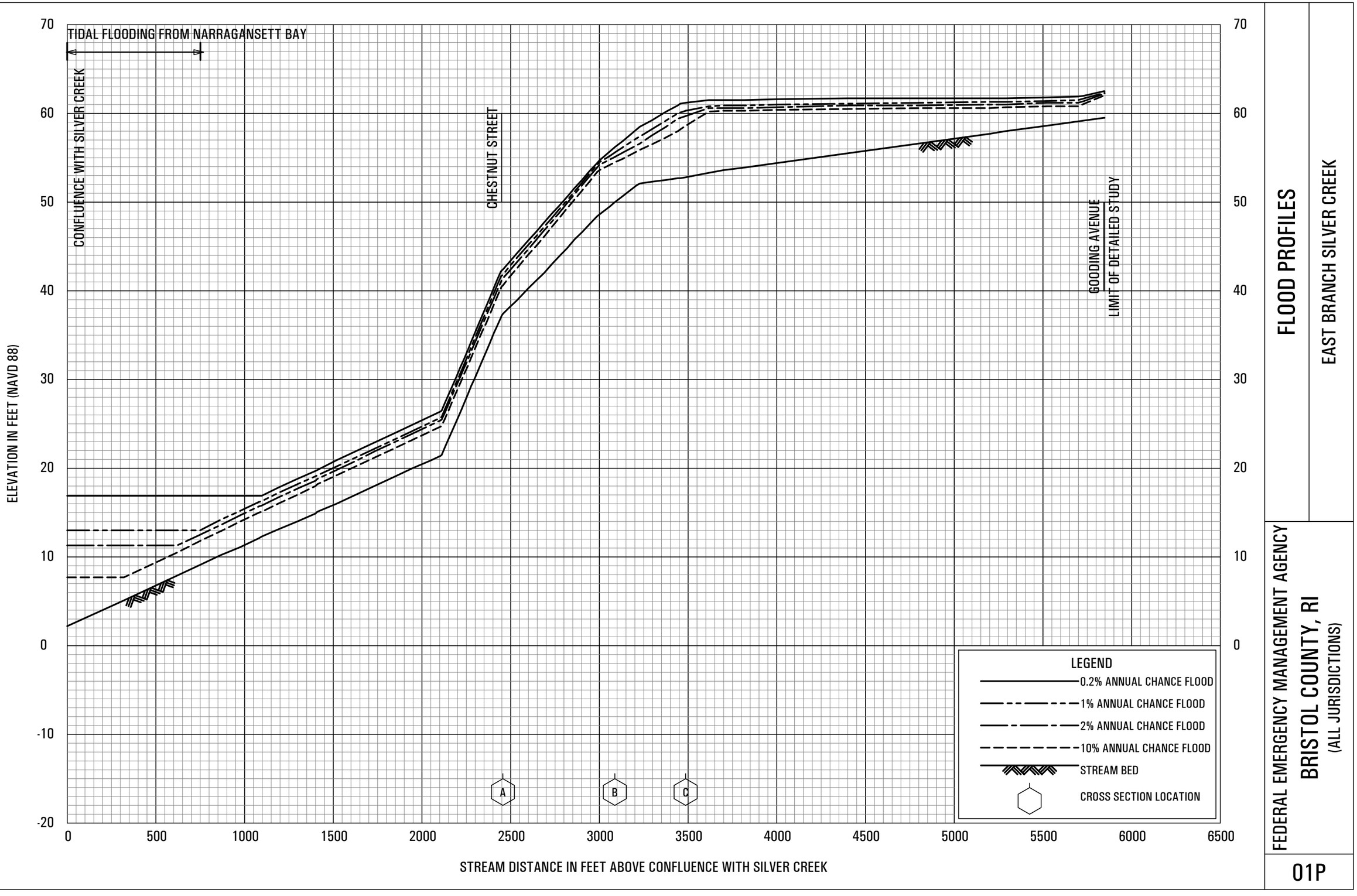
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FLOOD PROFILES

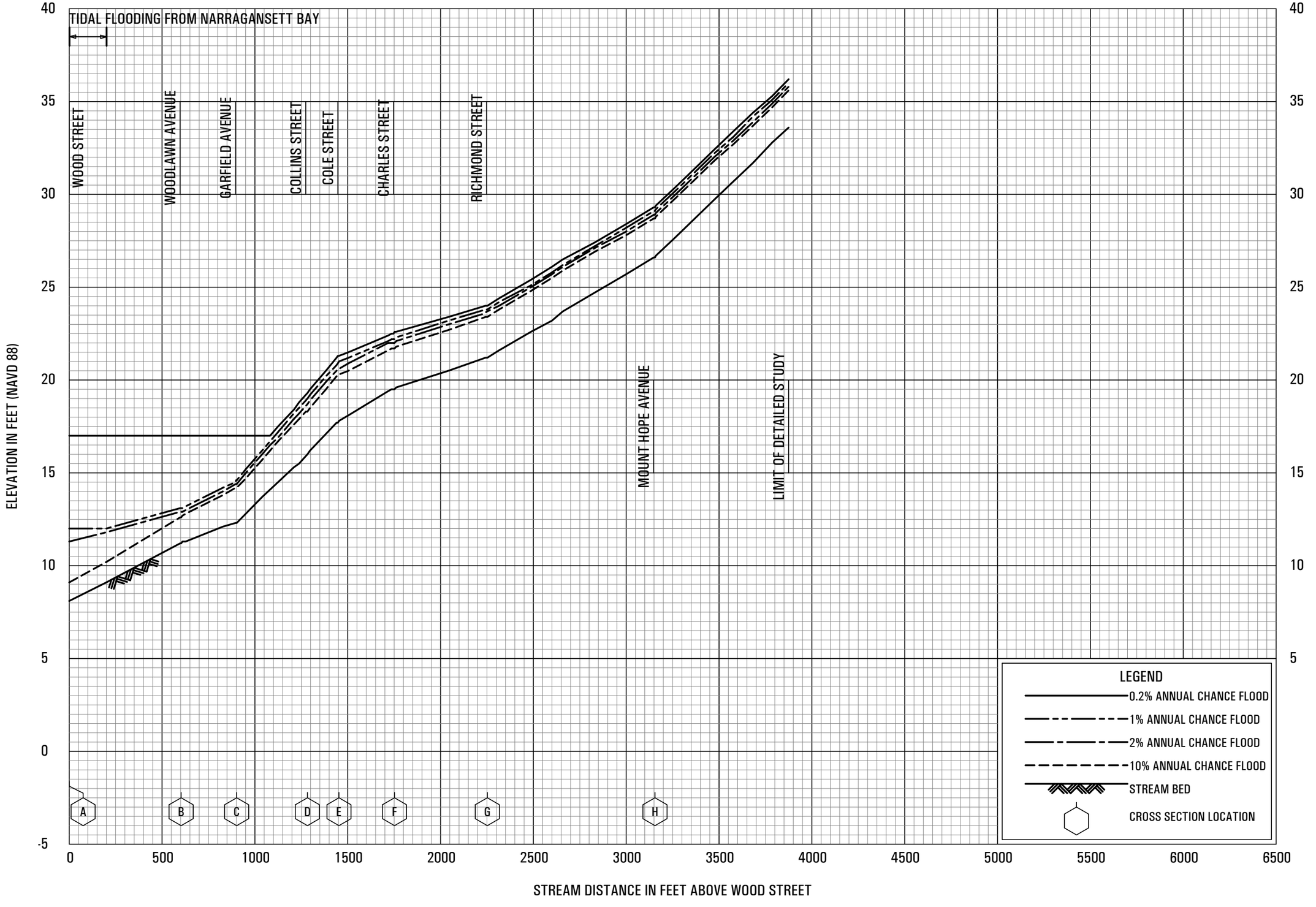
EAST BRANCH SILVER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BRISTOL COUNTY, RI

(ALL JURISDICTIONS)

01P



FLOOD PROFILES

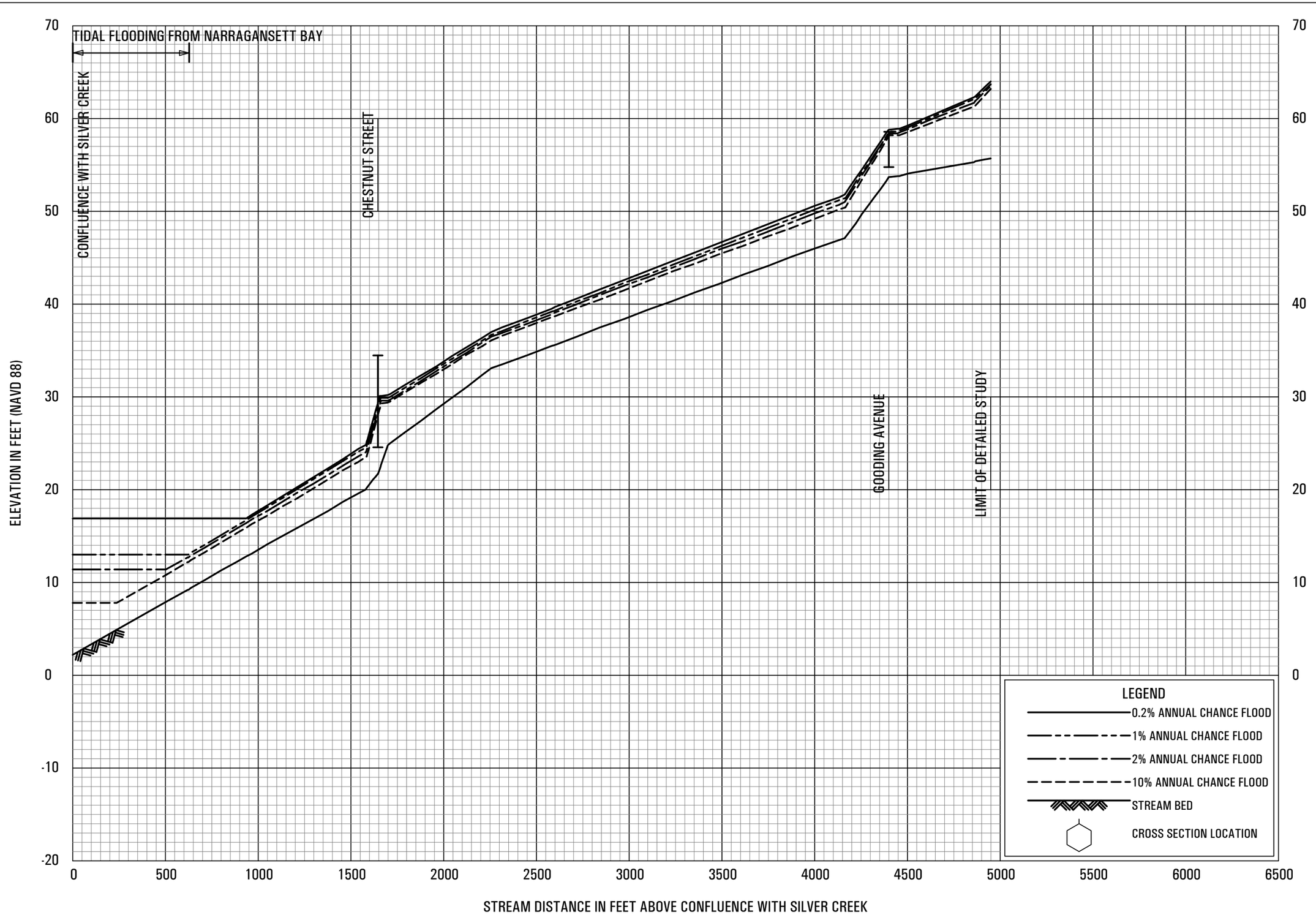
WALKER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BRISTOL COUNTY, RI

(ALL JURISDICTIONS)

02P



FLOOD PROFILES

WEST BRANCH SILVER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BRISTOL COUNTY, RI

(ALL JURISDICTIONS)

03P