FLOOD INSURANCE STUDY

VOLUME 1 of 6

BUCKS COUNTY, PENNSYLVANIA (ALL JURISDICTIONS)

Bucks County

COMMUNITY NAME	COMMUNITY NUMBER	COMMUNITY NAME	COMMUNITY NUMBER	COMMUNITY NAME	COMMUNITY NUMBER
BEDMINSTER, TOWNSHIP OF	421049	MIDDLETOWN, TOWNSHIP OF	420193	*TELFORD, BOROUGH OF	422339
BENSALEM, TOWNSHIP OF	420181	MILFORD, TOWNSHIP OF	422337	TINICUM, TOWNSHIP OF	420205
BRIDGETON, TOWNSHIP OF	420182	MORRISVILLE, BOROUGH OF	420194	TRUMBAUERSVILLE, BOROUGH OF	422681
BRISTOL, BOROUGH OF	420183	NEW BRITAIN, BOROUGH OF	420986	TULLYTOWN, BOROUGH OF	420206
BRISTOL, TOWNSHIP OF	420984	NEW BRITAIN, TOWNSHIP OF	420987	UPPER MAKEFIELD, TOWNSHIP OF	420207
BUCKINGHAM, TOWNSHIP OF	420985	NEW HOPE, BOROUGH OF	420195	UPPER SOUTHAMPTON, TOWNSHIP OF	420989
CHALFONT, BOROUGH OF	420184	NEWTOWN, BOROUGH OF	420196	WARMINSTER, TOWNSHIP OF	420990
DOYLESTOWN, BOROUGH OF	421410	NEWTOWN, TOWNSHIP OF	421084	WARRINGTON, TOWNSHIP OF	420208
DOYLESTOWN, TOWNSHIP OF	420185	NOCKAMIXON, TOWNSHIP OF	420197	WARWICK, TOWNSHIP OF	420209
*DUBLIN, BOROUGH OF	422676	NORTHAMPTON, TOWNSHIP OF	420988	WEST ROCKHILL, TOWNSHIP OF	421123
DURHAM, TOWNSHIP OF	420186	PENNDEL, BOROUGH OF	422678	WRIGHTSTOWN, TOWNSHIP OF	421045
EAST ROCKHILL, TOWNSHIP OF	420187	PERKASIE, BOROUGH OF	420198	YARDLEY, BOROUGH OF	420210
FALLS, TOWNSHIP OF	420188	PLUMSTEAD, TOWNSHIP OF	420199		
HAYCOCK, TOWNSHIP OF	421127	QUAKERTOWN, BOROUGH OF	420200		
HILLTOWN, TOWNSHIP OF	420189	RICHLAND, TOWNSHIP OF	421095		
HULMEVILLE, BOROUGH OF	420190	*RICHLANDTOWN, BOROUGH OF	422679		
*IVYLAND, BOROUGH OF	422677	RIEGELSVILLE, BOROUGH OF	420201		
LANGHORNE MANOR, BOROUGH OF	422336	SELLERSVILLE, BOROUGH OF	420203		
LANGHORNE, BOROUGH OF	421074	SILVERDALE, BOROUGH OF	422338		
LOWER MAKEFIELD, TOWNSHIP OF	420191	SOLEBURY, TOWNSHIP OF	420202		
LOWER SOUTHAMPTON, TOWNSHIP OF	420192	SPRINGFIELD, TOWNSHIP OF	420204		

* No Special Flood Hazard Areas Identified

REVISED: MARCH 21, 2017

Reprinted with corrections on August 27, 2021

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
42017CV001D

NOTICE TO
FLOOD INSURANCE STUDY USERS

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

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

Initial Countywide FIS Effective Date: May 18, 1999

Revised Countywide FIS Date: June 20, 2001 – to change Base Flood Elevations, to change Special Flood Hazard Areas.

April 2, 2002 – to add Special Flood Hazard Areas and to change Base Flood Elevations

September 3, 2003 – to change Base Flood Elevations and Special Flood Hazard Areas and to change and add floodway.

April 2, 2004 – to change Base Flood Elevations and Special Flood Hazard Areas and to incorporate previously issued Letters of Map Revision.

March 16, 2015 – to add, change and delete Special Flood Hazard Areas; to reflect updated topographic information; to change, add Base Flood Elevations; and to incorporate previously issued Letters of Map Revision.

March 21, 2017 - to change Base Flood Elevations and Special Flood Hazard Areas and to change floodway.

This FIS report was reissued on August 27, 2021 to make a correction; this version replaces any previous versions. See the Notice-to-User Letter that accompanied this correction for details.

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Exhibit 1 - Flood Profiles – continued

FLOOD INSURANCE STUDY
BUCKS COUNTY, PENNSLYVANIA (ALL JURISDICTIONS)

1.0 INTRODUCTION

1.1 Purpose of Study

This countywide Flood Insurance Study (FIS) investigates the existence and severity of flood hazards in, or revises and updates the previous FIS / Flood Insurance Rate Map (FIRM) in the geographic area of Bucks County, Pennsylvania, including the following jurisdictions: the Townships of Bedminster, Bensalem, Bridgeton, Bristol, Buckingham, Doylestown, Durham, East Rockhill, Falls, Haycock, Hilltown, Lower Makefield, Lower Southampton, Middletown, Milford, New Britain, Newtown, Nockamixon, Northampton, Plumstead, Richland, Solebury, Springfield, Tinicum, Upper Makefield, Upper Southampton, Warminster, Warrington, Warwick, West Rockhill, and Wrightstown; and the Boroughs of Bristol, Chalfont, Doylestown, Hulmeville, Langhorne, Langhorne Manor, Morrisville, New Britain, New Hope, Newtown, Perkasie, Penndel, Quakertown, Riegelsville, Sellersville, Silverdale, Trumbauersville, Tullytown, and Yardley (hereinafter referred to collectively as Bucks County).

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

This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This FIS 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 Bucks County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and will also be used 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 more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence, and the State (or other jurisdictional agency) shall be able to explain them.

1.2 Authority and Acknowledgments

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

The original countywide FIS dated May 18, 1999, was prepared to include all jurisdictions within Bucks County into a countywide FIS. Information on the authority and acknowledgments for each jurisdiction included in this countywide FIS, as compiled from their previously printed FIS reports, is shown on the following pages.

Bedminster, Township of:	The hydrologic and hydraulic analyses for the FIS report dated June 1, 1983, were prepared by the Delaware River Basin Commission for the Federal Emergency Management Agency (FEMA), under Contract No. EMW-C-0249. That work was completed in January 1982.
Bensalem, Township of:	The hydrologic and hydraulic analyses for the FIS report dated January 1978 were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., for the Flood Insurance Administration (FIA), under Contract No. H-3813. That work was completed in April 1977. For the November 20, 1991, revision, the hydrologic and hydraulic analyses for Poquessing Creek were prepared by the U.S. Army Corps of Engineers (USACE), Philadelphia District, under Inter-Agency Agreement No. EMW-89-E-2994, Project Order No. 2, Task Letter No. 89-6. That work was completed in February 1990. For the December 3, 1993, revision, the hydrologic and hydraulic analyses were prepared by the USACE, Philadelphia District, for FEMA under Inter-Agency Agreement No. EMW-91-E-3529, Project Order No. 2, Task Letter No. 91-4. That work was completed in April 1992.
Bridgeton, Township of:	The hydrologic and hydraulic analyses for the FIS report dated September 1977 were prepared by Michael Baker, Jr., Inc., under the direction of the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in September 1976.
Bristol, Borough of:	The hydrologic and hydraulic analyses for all flooding sources except Adams Hollow Creek

for the FIS report dated June 1979 were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., for the FIA, under Contract No. H-3813. That work was completed in April 1977. The hydrologic and hydraulic analyses for Adams Hollow Creek were performed by Gannett, Fleming, Corddry and Carpenter, Inc., and were updated by Dewberry, Nealon & Davis.

Bristol, Township of: The hydrologic and hydraulic analyses for the FIS report dated September 29, 1978, were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., for FEMA, under Contract No. H-3813. That work was completed in June 1977. For the June 4, 1990, revision, the hydrologic and hydraulic analyses for the tidal flooding of the Delaware River were prepared by the USACE, Philadelphia District. That work was completed in April 1988. For the June 2, 1992, revision, the hydrologic and hydraulic analyses for Croydon Run were revised by the USACE, Philadelphia District, under Inter-Agency Agreement No. EMW-90-E-3286, Project Order No. 6, Task Letter No. 90-6. That work was completed in January 1991.

Buckingham, Township of: The hydrologic and hydraulic analyses for the FIS report dated September 1978 were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-16-75, Project Order No. 16. That work was completed in April 1977.

Chalfont, Borough of: The hydrologic and hydraulic analyses for the FIS report dated December 28, 1976, were prepared by Nebolsine, Toth, McPhee Associates, for the FIA. In the January 15, 1988, revision, the hydrologic and hydraulic analyses were prepared by the Delaware River Basin Commission for FEMA under Contract No. EMW-85-C-1876. That work was completed in June 1986.

Doylestown, Borough of: The hydrologic and hydraulic analyses for the FIS report dated December 1, 1983, were prepared by the Delaware River Basin

Commission for FEMA, under Contract No. EMW-C-0249. That work was completed in March 1982.

Doylestown, Township of: The hydrologic and hydraulic analyses for the FIS report dated March 1978 were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., for the FIA, under Contract No. H-3813. That work was completed in July 1977.

Durham, Township of: The hydrologic and hydraulic analyses for the FIS report dated February 1978 were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-2-73, Project Order No. 13; Inter-Agency Agreement No. IAA-H-2-73, Project Order No. 13, Amendment No. 1; Inter-Agency Agreement No. IAA-H-19-74, Project Order No. 15; and Inter-Agency Agreement No. IAA-H-16-77, Project Order No. 22. That work was completed in March 1977.

East Rockhill, Township of: The hydrologic and hydraulic analyses for the FIS report dated April 1982 were prepared by the Delaware River Basin Commission for FLA, under Contract No. H-3747. That work was completed in May 1976.

Falls, Township of: The hydrologic and hydraulic analyses for the FIS report dated September 30, 1980, were prepared by Michael Baker, Jr., Inc., under contract to the Delaware River Basin Commission, for the FIA, under Contract No. H-3747. That work was completed in October 1977. For the March 5, 1990, revision, the hydrologic and hydraulic analyses for the Delaware River tidal flooding were prepared by the USACE, Philadelphia District, for FEMA. That work was completed in April 1988.

Haycock, Township of: The hydrologic and hydraulic analyses for the FIS report dated March 1980 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4622. That work was completed in March 1979.

Hulmeville, Borough of: The hydrologic and hydraulic analyses for the

FIS report dated September 30, 1977, were prepared by E. H. Bourguard Associates, Inc., for the FIA, under Contract No. H-3747. That work was completed in May 1976. For the December 3, 1993, revision, the hydrologic and hydraulic analyses of Neshaminy Creek were prepared by the USACE, Philadelphia District, for FEMA, under Project Order No. 2, Task Letter No. 91-4. That work was completed in April 1992.

Langhorne, Borough of:	The hydrologic and hydraulic analyses for the FIS report dated January 1980 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4622. That work was completed in January 1979.
Langhorne Manor, Borough of:	The hydrologic and hydraulic analyses for the FIS report dated August 15, 1983, were prepared by the Delaware River Basin Commission for FEMA, under Contract No. EMW-C-0249. That work was completed in January 1982.
Lower Makefield, Township of:	The hydrologic and hydraulic analyses for the FIS report dated September 1977 were prepared by Michael Baker, Jr., Inc., under subcontract by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in May 1976.
Lower Southampton, Township of:	The hydrologic and hydraulic analyses for the FIS report dated March 15, 1977, were prepared by the USACE, Philadelphia District, for the FEMA, under Inter-Agency Agreement No. H-2-73, Project Order Nos. 13 and 14. For the May 18, 1992, revision, the hydrologic and hydraulic analyses of Poquessing Creek and Poquessing Creek Tributary No. 1 were revised by the USACE for FEMA, under Inter-Agency Agreement No. EMW-88-E-2768. That work was completed in November 1990.
Middletown, Township of:	The hydrologic and hydraulic analyses for the FIS report dated March 1978 were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., for the FIA, under Contract No. H-3813. That

work was completed in July 1977.

Milford, Township of: The hydrologic and hydraulic analyses for the FIS report dated December 1, 1981, were prepared by the USACE, Philadelphia District, for FEMA, under Inter-Agency Agreement No. IAA-H-18-78, Project Order No. 22. That work was completed in April 1980.

Morrisville, Borough of: The hydrologic and hydraulic analyses for the FIS report dated September 30, 1977, were prepared by Michael Baker, Jr., Inc., under Contract No. H-3747. That work was completed in May 1976. For the November 3, 1989, revision, the hydrologic and hydraulic analyses were prepared by the USACE, Philadelphia District. That work was completed in April 1988.

New Britain, Borough of: The hydrologic and hydraulic analyses for the FIS report dated October 1978 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in May 1976.

New Britain, Township of: The hydrologic and hydraulic analyses for the FIS report dated September 30, 1977, were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in November 1976. For the March 4, 1988, revision, the hydrologic and hydraulic analyses were prepared by the Delaware River Basin Commission for FEMA, under Contract No. EMW-85-C-l876. That work was completed in September 1986. For the January 2, 1992 revision, the hydrologic and hydraulic analyses for Pine Run were prepared by Urwiler & Walter, Inc. That work was completed in August 1990.

New Hope, Borough of: The hydrologic and hydraulic analyses for the original FIS report were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in May 1976. For the September 28, 1984, revision, the hydrologic and hydraulic analyses were prepared by Gannett Fleming Water Resources Engineering, Inc., under agreement with FEMA. That work was completed in August 1983.

Newtown, Borough of:	The hydrologic and hydraulic analyses for the FIS report dated June 1979 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4521. That work was completed in May 1978.
Newtown, Township of:	The hydrologic and hydraulic analyses for the FIS report dated June 1979 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4521. That work was completed in June 1978.
Nockamixon, Township of:	The hydrologic and hydraulic analyses for the FIS report dated November 1977 were prepared by Michael Baker Jr., Inc., for the FIA, under Contract No. H-3747. That work was completed in November 1976.
Northampton, Township of:	The hydrologic and hydraulic analyses for the FIS report dated August 1979 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in November 1976.
Perkasie, Borough of:	The hydrologic and hydraulic analyses for the FIS report dated June 1975 were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-2-73, Project Order Nos. 13 and 14.
Plumstead, Township of:	The hydrologic and hydraulic analyses for the FIS report dated March 1978 were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., for the FIA, under Contract No. H-38 13. That work was completed in July 1977.
Quakertown, Borough of:	The hydrologic and hydraulic analyses for the FIS report dated January 1977 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747.
Richland, Township of:	The hydrologic and hydraulic analyses for the

FIS report dated August 1978 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in May 1976. For the December 15, 1980, revision, the hydrologic and hydraulic analyses were prepared by the Delaware River Basin Commission for the FIA under contract No. H-4622. That work was completed in November 1979.

Riegelsville, Borough of: The hydrologic and hydraulic analyses for the FIS report dated October 1977 were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-19-74, Project Order No. 17 and Inter-Agency Agreement No. IAA-H-16-75, Project Order No. 6. That work was completed in March 1977.

Sellersville, Borough of: The hydrologic and hydraulic analyses for the original FIS report were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., under subcontract from the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in September 1976.

Silverdale, Borough of: The hydrologic and hydraulic analyses for the FIS report dated July 5, 1983, were prepared by the Delaware River Basin Commission for FEMA, under Contract No. EMW-C-0249. That work was completed in January 1982.

Solebury, Township of: The hydrologic and hydraulic analyses for the original FIS report were prepared by Nebolsine, Toth, McPhee Associates for FEMA, under Contract No. H-3598. That work was completed in March 1974. For the March 1, 1984, revision, the hydrologic and hydraulic analyses were prepared by Gannett Fleming Water Resources Engineering, Inc., under agreement with FEMA. That work was completed in August 1983.

Springfield, Township of: The hydrologic and hydraulic analyses for the FIS report dated September 1977 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in March 1976.

Tinicum, Township of:	The hydrologic and hydraulic analyses for the FIS report dated August 1978 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in May 1976.
Tullytown, Borough of:	The hydrologic and hydraulic analyses for the original FIS report were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4521. That work was completed in September 1978. For the January 3, 1990 revision, the hydrologic and hydraulic analyses for the tidal flooding of the Delaware River were prepared by the USACE, Philadelphia District. That work was completed in April 1988.
Upper Makefield, Township of:	The hydrologic and hydraulic analyses for the original FIS report were prepared by Michael Baker, Jr., Inc., for the Delaware River Basin Commission at the request of the FIA, under Contract No. H-3747. That work was completed in May 1976.
Upper Southampton, Township of:	The hydrologic and hydraulic analyses for the FIS report dated October 1977 were prepared by E. H. Borquard Associates, Inc., Consulting Engineers, under subcontract to the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in July 1976.
Warminster, Township of:	The hydrologic and hydraulic analyses for the FIS report dated September 1977 were prepared by E. H. Borquard Associates, Inc., Consulting Engineers, under subcontract to the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in November 1976. For the January 2, 1991, revision, the hydrologic and hydraulic analyses for Blair Mill Run and Blair Mill Run Tributary were prepared by the USACE, Philadelphia District, under agreement with FEMA. That work was completed in May 1988.
Warrington, Township of:	The hydrologic and hydraulic analyses for the

FIS report dated March 1978 were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., for the FIA, under Contract No. H-3813. That work was completed in June 1977.

Warwick, Township of:	The hydrologic and hydraulic analyses for the FIS report dated March 1978 were prepared by Gannett, Fleming, Corddry and Carpenter, Inc., for the FIA, under Contract No. H-3813. Portions of the analyses were developed by the Delaware River Basin Commission and the USACE. That work was completed in July 1977.
West Rockhill, Township of:	The hydrologic and hydraulic analyses for the FIS report dated January 5, 1984, were prepared by the Delaware River Basin Commission for FEMA, under Contract No. EMW-C-0249. That work was completed in July 1982.
Wrightstown, Township of:	The hydrologic and hydraulic analyses for the FIS report dated February 1978 were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-16-75. That work was completed in February 1977.
Yardley, Borough of:	The hydrologic and hydraulic analyses for the FIS report dated August 1977 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in May 1976.

There are no previous FISs for the Boroughs of Dublin, Ivyland, Penndel, Richlandtown, and Telford and Township of Hilltown; therefore the previous authority and acknowledgement information for these communities is not included in this FIS.

For the original May 18, 1999, countywide FIS, the updated hydrologic and hydraulic analyses for the Delaware River were prepared by the USACE, Philadelphia District, for FEMA, under Inter-Agency Agreement No. EMW-94-E-4371, Project Order No. 2. That work was completed in June 1996.

In addition, updated topographic information was used by the USACE, Philadelphia District, to redelineate the Special Flood Hazard Area (SFHA) for Beaver Run, Licking Creek, and Tohickon Creek within the Boroughs of Quakertown. This work was completed on February 5, 1998 under Inter-Agency Agreement No. EMW-97-IA-0154, Task Letter No. 97-1.

For the June 20, 2001, revision, the updated hydrologic and hydraulic analyses for East Branch Perkiomen Creek were prepared by the USACE, Philadelphia District, for FEMA, under Inter-Agency Agreement No. EMW-96-IA-0294, Project Order No. 19. That work was completed in September 1998.

For the April 2, 2002, revision, the updated hydrologic and hydraulic analyses for Chubb Run were prepared by the USACE, Philadelphia District, for FEMA, under Inter-Agency Agreement No. EMW-1998-IA-0206, Project Letter 98-1. That work was completed in April 2000.

For the September 3, 2003, revision, the updated hydrologic and hydraulic analyses for the Delaware River and the Delaware River Overland Flow were prepared by GKY and Associates, Inc., for FEMA, under Contract No. EMP-99-CO-2255. That work was completed in May 2001.

The April 2, 2004, revision, was performed to incorporate the Best Available Data letter (BADL) effective on June 7, 2002, which contained updated hydrologic and hydraulic analyses from a report dated January 15, 2002, prepared by Schnabel Engineering Associates, Inc. The report contested the hydrology of the effective FIS. The reported drainage areas of the sub-areas of East Branch Perkiomen Creek were found to be incorrectly labeled and therefore, resulted in incorrect flows being entered into the hydraulic model. The hydraulic modeling prepared by the USACE, Philadelphia District, was modified by Dewberry & Davis LLC for this BADL.

For the March 16, 2015, revision, the revised hydrologic and hydraulic analyses for the Delaware River were prepared by T.Y. Lin International | Medina for FEMA under Contract No. HSFE02-08-J-0002 P00001. This work was completed in November 2009. The revised hydrologic and hydraulic analyses for the Pennypack Creek watershed which includes portions of Blair Mill Run, Blair Mill Run Tributary, and Southampton Creek were performed by Temple University under contracts with FEMA. This work was finalized in 2010. Redelineation of the rest of the detailed floodplains as well as revised hydrologic and hydraulic analyses for approximate streams were performed by AMEC Earth & Environmental Inc. for FEMA under Contract No. EMP-2001-CO-2411, Task Order 0017. Additionally, the floodplain for Tributary No. 2 of Martins Creek was updated using new topographic information and volumetric computations. This work was conducted by RAMPP (Risk Assessment, Mapping, and Planning Partners, a joint venture of Dewberry, URS, and ESP) under Contract No. HSFEHQ-09-D-0369, Task Order No. HSFE03-12-J-0013. This work was completed in June 2013.

Year 2010 digital orthophotos were provided by the Delaware Valley Regional Planning Commission (DVRPC). Streamlines were digitized from these 1:2400 scale photos. The floodways that were transferred from the previous FIRM have been adjusted to conform to these updated stream channel configurations. A 5 foot interval contour dataset was also provided by DVPRC, and was used in the delineation of the new floodplain boundaries. This revision reflects more detailed and up-to-date stream channel configurations and floodplain delineations than those shown on the previous FIRM for Bucks County. Municipality boundaries were downloaded from Pennsylvania Spatial Data Access (PASDA). The previous effective county boundary was adjusted to match existing effective and preliminary Digital Flood Insurance Rate Maps (DFIRM) of neighboring counties. The county boundary was also adjusted to the orthophotos where it overlaps geospatial features such as streams.

For the March 21, 2017 revision, revised hydrologic and hydraulic analyses for Black Ditch, Cooks Run, Croydon Run, Croydon Tributary, Ironworks Creek, Lahaska Creek, Martins Creek, Mill Creek No. 1, Newtown Creek, North Branch Neshaminy Creek, Tributary D to Delaware River, Tributary No. 1 of Martins Creek, Tributary No. 3 of Martins Creek, Tributary to West Branch Neshaminy Creek, and West Branch Neshaminy Creek, were prepared by RAMPP for FEMA under Contract No. HSFE03-12-J-0013. This work was completed in October, 2014. In addition, this revision also incorporates a storm surge study conducted for FEMA by the US Army Corps of Engineers (USACE) and its project partners under Project HSFE03-06-X-0023, "NFIP Coastal Storm Surge Model for Region III" and Project HSFE03-09-X-1108, "Phase III Coastal Storm Surge Model for FEMA Region III". The work was performed by the Coastal Processes Branch (HF-C) of the Flood and Storm Protection Division (HF), U.S. Army Engineer Research and Development Center – Coastal & Hydraulics Laboratory (ERDC-CHL). This work was initiated in 2008 and completed in 2013.
The coordinate system used for the production of this FIRM is Universal Transverse Mercator (UTM), Zone 18 North. The horizontal datum was North American Datum of 1983 (NAD 83), GRS 80 spheroid. Corner coordinates shown on the FIRM are in latitude and longitude referenced to the UTM projection, NAD 83. Differences in the datum and spheroid used in the production of FIRMs for adjacent counties may result in slight positional differences in map features at the county boundaries. These differences do not affect the accuracy of information shown on the FIRM.

1.3 Coordination

An initial CCO meeting is typically held with representatives of FEMA, the community, and the study contractor to explain the nature and purpose of a FIS and to identify the streams to be studied by detailed methods. A final CCO meeting is typically held with representatives of 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 Bucks County, previous to the initial countywide FIS, are shown in Table 1, "Initial and Final CCO Meetings."

TABLE 1 – INITIAL AND FINAL CCO MEETINGS

Community Name	Initial CCO Date	Final CCO Date
Bedminster, Township of	June 26, 1979	October 13, 1982
Bensalem, Township of	*	May 11, 1977
Bridgeton, Township of	October 30, 1975	September 17, 1976
Bristol, Borough of	March 1975	July 6, 1977
Bristol, Township of	March 1975	August 30, 1977
Buckingham, Township of	November 25, 1974	July 20, 1977
Chalfont, Borough of	November 24, 1984	March 11, 1987
Doylestown, Borough of	June 26, 1979	May 4, 1983
Doylestown, Township of	March 1975	September 21, 1977
Durham, Township of	January 12, 1977	April 26, 1977
East Rockhill, Township of	April 28, 1975	September 8, 1976
Langhorne, Borough of	February 23, 1978	August 8, 1979
Langhorne Manor, Borough of	July 26, 1980	October 13, 1982
Lower Makefield, Township of	April 30, 1975	September 30, 1976
Lower Southampton, Township of	*	*
Middletown, Township of	March 1975	July 19, 1978
Milford, Township of	January 5, 1978	July 6, 1981
Morrisville, Borough of	April 30, 1975	March 19, 1976
New Britain, Borough of	June 12, 1975	May 28, 1976
New Britain, Township of	November 24, 1984	April 20, 1987
New Hope, Borough of	May 15, 1975	April 5, 1976
Newtown, Borough of	March 25, 1977	January 9, 1979
Newtown, Township of	March 25, 1977	January 9, 1979
Nockamixon, Township of	May 12, 1975	September 20, 1976
Northampton, Township of	May 22, 1975	December 22, 1976
Perkasie, Borough of	*	*
Plumstead, Township of	March 1975	*
Quakertown, Borough of	April 30, 1975	March 24, 1976
Richland, Township of	February 23, 1978	July 11, 1980
Riegelsville, Borough of	January 12, 1977	April 18, 1977
Sellersville, Borough of	April 1975	November 5, 1976
Silverdale, Borough of	June 21, 1979	October 13, 1982
Solebury, Township of	*	*
Springfield, Township of	May 12, 1975	March 22, 1976
Tinicum, Township of	April 29, 1975	September 8, 1976
Tullytown, Borough of	March 25, 1977	February 21, 1979
Upper Makefield, Township of	May 15, 1975	March 16, 1976
Upper Southampton, Township of	May 22, 1975	*
Warminster, Township of	May 23, 1975	October 8, 1976
Warrington, Township of	March 1975	September 12, 1977
Warwick, Township of	March 1975	September 21, 1977

TABLE 1 – INITIAL AND FINAL CCO MEETINGS - continued

Community Name	Initial CCO Date	Final CCO Date
West Rockhill, Township of	June 21, 1979	May 24, 1983
Wrightstown, Township of	July 8, 1975	April 26, 1977
Yardley, Borough of	May 15, 1975	September 14, 1976

*Data not available

For the May 18, 1999, countywide FIS, an initial CCO meeting was held on August 12, 1993. Final CCO meetings were held on January 26, 1998, for the Borough of New Hope, the Township of Plumstead, the Township of Tinicum, and the Township of Solebury. Final CCO meetings were held on January 29, 1998, for the Borough of Yardley, the Township of Lower Makefield, and the Township of Upper Makefield. Final CCO meetings were held on February 5, 1998, for the Borough of Tullytown, the Township of Falls, and the Township of Durham. Final CCO meetings were held on February 10, 1998, for the Borough of Morrisville and the Township of Nockamixon. Final CCO meetings were held on February 12, 1998, for the Borough of Bristol, the Township of Bristol, and the Township of Bensalem. A final CCO meeting was held on February 24, 1998, for the Township of Bridgeton. A final CCO meeting was held on February 27, 1998, for the Borough of Riegelsville. These meetings were attended by representatives of the county and the incorporated communities therein, the USACE, and FEMA.

For the June 20, 2001, revision, the communities were notified that the FIS for Bucks County would be revised in a letter from FEMA dated March 13, 1997. An inventory of data pertinent to the study available from local communities, federal agencies, and the general public was conducted early in the study and continued throughout. A final CCO meeting was held on December 3, 1999, and was attended by representatives of the USACE and FEMA Region III.

For the April 2, 2002, revision, no coordination information is available.

For the April 2, 2004, revision, a final meeting was held on February 20, 2003, and was attended by representatives of Dewberry, the Borough of Perkasie, the Borough of Sellersville, and FEMA.

For the March 16, 2015, revision, two final CCO meetings were held on February 23, 2011 and were attended by representatives from the communities, AMEC, RAMPP and FEMA.

For the March 21, 2017 revision a final CCO meeting was held on June 30, 2015, in addition three Flood Risk Review meetings were held on November 16 and 20, 2014. All were attended by representatives from the communities, RAMPP and FEMA.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Bucks County, Pennsylvania.

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

TABLE 2 – FLOODING SOURCES STUDIED BY DETAILED METHODS

Aquetong Creek	Paunacussing Creek Tributary No. 1
Beaver Run	Paunacussing Creek Tributary No. 2
Black Ditch	Pidcock Creek
Blair Mill Run	Pine Run No. 1
Blair Mill Run Tributary (Tributary 02463 to Blair Mill Run)	Pine Run No. 2
Brock Creek	Pleasant Spring Creek
Buck Creek	Poquessing Creek
Cabin Run	Poquessing Creek Tributary No. 1
Cafferty Run	Poquessing Creek Tributary No. 2
Cafferty Run Tributary	Poquessing Creek Tributary No. 3
Chubb Run	Primrose Creek
Cooks Creek	Primrose Creek Tributary No. 1
Cooks Run	Queen Anne Creek
Coppernose Run	Queen Anne Creek (Newportville)
Core Creek	Rabbit Run
Croydon Run	Railroad Creek
Croydon Tributary	Ridge Valley Creek
Cuttalossa Creek	Robin Run
Deep Run	Rock Run
Delaware River	Rock Run Tributary
East Branch Perkiomen Creek	Silver Creek No. 1
Gallows Run	Silver Creek No. 2
Gallows Run Tributary No. 1	Southampton Creek
Gallows Run Tributary No. 2	Three Mile Run
Geddes Run	Tohickon Creek
Geddes Run Tributary	Tributary 1 to Mill Creek Tributary No. 1
Haycock Creek	Tributary A to Little Neshaminy Creek
Hough's Creek	Tributary A to Neshaminy Creek
Ironworks Creek	Tributary B to Little Neshaminy Creek
Jericho Creek	Tributary D to Neshaminy Creek
Kimples Creek	Tributary No. 1 of Martins Creek
Lahaska Creek	Tributary No. 1 of Queen Anne Creek
Licking Creek	Tributary No. 1 to Lahaska Creek

TABLE 2 – FLOODING SOURCES STUDIED BY DETAILED METHODS
(continued)

Licking Creek Tributary No. 1	Tributary No. 1 to Three Mile Run
Little Neshaminy Creek	Tributary No. 1 to Tributary B to Little Neshaminy Creek
Manor Lake	Tributary No. 2 of Queen Anne Creek
Martins Creek	Tributary No. 2 to Lahaska Creek
Mill Creek No. 1	Tributary No. 3 of Martins Creek
Mill Creek No. 2	Tributary to Ironworks Creek
Mill Creek No. 3	Tributary to Little Neshaminy Creek
Mill Creek No. 4	Tributary to Pidcock Creek
Mill Creek Tributary No. 1	Tributary to West Branch Neshaminy Creek
Morgan Creek	Unami Creek
Neshaminy Creek	Unnamed Tributary No. 2 to Beaver Run
Neshaminy Creek Tributary	Unnamed Tributary to Mill Creek Tributary No. 1
Newtown Creek	Van Sciver Lake
North Branch Neshaminy Creek	Watson Creek
Park Creek	West Branch Neshaminy Creek
Paunacussing Creek	

For the May 18, 1999, countywide FIS, the Delaware River was studied by detailed methods, including its backwater effects, for its entire length within Bucks County. Additionally, the SFHA for Beaver Run, Licking Creek, and Tohickon Creek were redelineated using more detailed topographic information.

For the June 20, 2001, revision, East Branch Perkiomen Creek was restudied by detailed methods from its confluence with the Main Stem Perkiomen Creek to the upstream corporate limits of the Borough of Perkasie. Pleasant Spring Creek was revised to reflect backwater effects from East Branch Perkiomen Creek. The revised analyses affected the Townships of East and West Rockhill and the Boroughs of Perkasie and Sellersville.

For the April 2, 2002, revision, Chubb Run was restudied by detailed methods from its confluence with Neshaminy Creek to a point approximately 100 feet upstream of Gillam Avenue. The revised analyses affect the Boroughs of Langhorne Manor and Penndel and the Township of Middletown.

For the September 3, 2003, revision, the Delaware River and the Delaware River Overland Flow were restudied from the Uhlerstown-Frenchtown Bridge to a point approximately 250 feet upstream of the corporate limits between the Township of Bridgeton and the Township of Tinicum. To accurately reflect the split flow conditions in this area, the Delaware River Overland Flow was modeled separately from the Delaware River, and the effects of the mining pits in the overland flow area were included in the hydrologic and hydraulic analyses. In addition, adjustments have been made to the floodway and floodplain for the Delaware River in the Township of Tinicum, from the confluence of Tohickon Creek to the Uhlerstown-Frenchtown Bridge. The floodway in the Township of Tinicum that was published on the May 18, 1999, Bucks County (All Jurisdictions) FIRM was based on the hydraulic model used to develop the floodway on the Township of Tinicum FIRM dated February 1, 1979 (and in the FIS report dated August 1978). For the 2003 revision, the floodway was changed to match the hydraulic model used to develop the elevations for the Delaware River on the May 18, 1999, FIRM for Bucks County (All Jurisdictions). The floodplains have been adjusted to reflect updated topographic information.

For the April 2, 2004, revision, a previously issued BADL effective June 7, 2002, was incorporated to reflect existing hydrologic and hydraulic conditions for East Branch Perkiomen Creek from County Line Road to approximately 340 feet upstream of East Callowhill Road and backwater adjustments on Pleasant Spring Creek. The updated analyses affected the Boroughs of Perkasie and Sellersville, and the Townships of East Rockhill and West Rockhill.

For the March 16, 2015, revision, revised hydrologic and hydraulic analyses were performed for the portion of Delaware River that is not under tidal influence (from approximately 600 feet downstream of U.S. Route 1 to upstream county boundary). The flood hazard data for what is referred to as the "Delaware River Overland Flow" in previous FISs is superseded by this update. In addition, revised hydrologic and hydraulic analyses were performed for Blair Mill Run (from County Line Road to approximately 1,200 feet upstream of County Line Road), Blair Mill Run Tributary (from County Line Road to approximately 9,000 feet upstream of County Line Road), and Southampton Creek (from County Line Road to approximately 600 feet upstream of Parmentier Road). Redelineation was performed for the rest of detailed floodplains based on previous effective hydrologic and hydraulic analyses and current topographic data.

For the March 21, 2017 revision, revised hydrologic and hydraulic analyses were performed for Black Ditch (from approximately 180 feet downstream of Holly Road to its confluence with Mill Creek No 1), Cooks Run (from East Swamp Road to its confluence with Neshaminy Creek), Croydon Run (from just downstream of Dixon Avenue to its confluence with Neshaminy Creek), Croydon Tributary (from a point approximately 520 feet upstream of Anne Street to its confluence with Neshaminy Creek), Ironworks Creek (from just upstream of Almshouse Rd to its confluence with Mill Creek No. 2), Lahaska Creek (from York Road to its confluence with Mill Creek No. 3), Martins Creek (from its upstream confluence with Tributary No. 3 of Martins Creek to its downstream confluence with Delaware River), Mill Creek No. 1 (from the New Falls Road crossing to its confluence with Delaware River), Newtown Creek (from just downstream of North Drive to its confluence with Neshaminy Creek), North Branch Neshaminy Creek (from the upstream corporate limits of the Borough of Chalfont to its confluence with Neshaminy Creek), Tributary D to Delaware River (from just downstream of Mill Creek Parkway to its confluence with Delaware River), Tributary No. 1 of Martins Creek (from just downstream of Turnabout Lane to its confluence with Martins Creek), Tributary No. 3 of Martins Creek (from a point approximately 1,090 feet upstream of Trenton Road to its confluence with Martins Creek), Tributary to West Branch Neshaminy Creek (from a point approximately 400 feet upstream of Highlands Drive to its confluence with West Branch Neshaminy Creek), and West Branch Neshaminy Creek (from the upstream corporate limits of New Britain township to its confluence with Neshaminy Creek). In addition, a storm surge study of the Delaware River, performed by the USACE, was also incorporated from the downstream county boundary to its confluence with Manor Lake.

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.

All or portions of numerous flooding sources in the county were studied by approximate methods. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and Bucks County.

2.2 Community Description

Bucks County is located in the southeastern corner of Pennsylvania, northeast of Philadelphia, along the Delaware River in the Piedmont Plateau. Bucks County is surrounded by Northampton, Lehigh, Montgomery, and Philadelphia Counties in Pennsylvania and Warren, Hunterdon, Mercer, and Burlington Counties in New Jersey. The Delaware River to the east is the major watercourse, which is fed by several tributaries flowing directly from the rolling uplands. Adjacent to the river are the lowlands with an average elevation of approximately 19 feet North America Vertical Datum 1988 (NAVD). These relatively flat lowlands are part of the historic floodplain of the Delaware River. The western portion of the county is characterized by ridge and valley topography. The soil varies from loam to silty loam. The temperatures in Bucks County typically range from a high of approximately 95 degrees Fahrenheit (˚F) to lows of approximately -20˚F. The average yearly rainfall of 45 inches is somewhat evenly distributed throughout the year, except for the hurricane months of August and September, which sometimes exhibit a marked increase in rainfall (Reference 1).

The county is primarily rural agricultural with some suburban residential areas, along with commercial, mining, and industrial development. Textile finishing is the major industry. The 2010 population of the county, as determined by the U.S. Census Bureau, was 625,249 (Reference 90).

The streams are located away from housing and urban development leaving the floodplains generally clear. However, the Delaware River, when it floods, creates a wide floodplain, which inundates the urban development located at the lower elevations.

2.3 Principal Flood Problems

Floods have been a problem along the Delaware River since the time of its settlement in the early part of the seventeenth century and were a yearly occurrence from 1901 to 1904 and 1933 to 1936. During the period from 1900 to 1955, 19 major floods occurred, with floods occurring twice during the years of 1924 and 1936. In general, floods occur in the Delaware River basin during late winter or early spring. However, each of the four greatest floods of record in the study area has occurred in different seasons of the year, thereby indicating that the local watershed is vulnerable to flooding at any time of the year. The greatest flood of record, in August 1955, caused extensive damage, with a flow of 329,000 cubic feet per second (cfs) at Trenton, New Jersey. In the Borough of Trenton, 233 residences and 26 commercial buildings were damaged to varying degrees from this flood. This flooding had a recurrence interval of approximately 200 years. The flood of October 1903, with a flow of 295,000 cfs at Trenton, New Jersey, was the second greatest flood. The double flood of March 11-12 and March 16-19, 1936, with a flow of 227,000 cfs at the gaging station located within the Borough of Trenton, New Jersey, was the third greatest flood, and the flood of May 1942, with a flow of 161,000 cfs at Trenton, New Jersey, was the fourth greatest flood (Reference 2). The heavy cover of vegetation along the floodplains causes increased flood stages and contributes to the debris load in the river during floods. The relatively low topography of the county causes the relatively wide floodplain for the Delaware River. The minor streams of Brock, Wilver, and Buck Creeks cause only minor flood problems.

The 1955 flood on Neshaminy Creek, recorded at the gaging station in Langhorne, reached a peak discharge of 49,300 cfs, the largest ever recorded at that location. The discharge associated with this flood is estimated to have a recurrence interval of 175 years.

2.4 Flood Protection Measures

Within this jurisdiction there is one levee that has not been demonstrated by the community or levee owner(s) to meet the requirements of 44 CFR Part 65.10 of the NFIP regulations as it relates to the levee's capacity to provide 1-percent annual chance flood protection. The levee was completed for the Rohm and Haas Plant at the confluence of Mill Creek No. 1 and the Delaware River, in July 1995. At the time of its construction, the levee was certified as providing protection from the 1-percent annual chance flood. In November 2013, FEMA Region III was informed that re-accreditation plans for this levee were terminated.

Therefore, the floodplain in this area has been delineated to reflect this deaccreditation.

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

The criteria used to evaluate protection against the 1- percent annual chance flood are 1) adequate design, including freeboard, 2) structural stability, and 3) proper operation and maintenance. Levees that do not protect against the 1- percent annual chance flood are not considered in the hydraulic analysis of the 1- percent annual chance floodplain.

There are five flood control dams on various tributaries of the Delaware River, upstream of Bucks County that help reduce flooding in Bucks County. These are the Jadwin Dam, built in 1959 on Dyberry Creek; the Prompton Dam, built in 1960 on the West Branch of the Lackawaxen River near Honesdale, Pennsylvania; the Francis Walter Reservoir Dam, built in 1961, on the Lehigh River; the Beltzville Reservoir Dam, built in 1969, on Pohopoco Creek; and the Nockamixon State Park Dam near Ottsville, Pennsylvania, which helps control flooding from Tohickon Creek. There are also wing dams on the Delaware River near New Hope. There are no dams on the Delaware River itself, making it the longest un-dammed river in the United States.

3.0 <u>ENGINEERING METHODS</u>

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 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 chance of annual exceedance) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

Within this jurisdiction, the Dow Chemical (formerly Rohm and Haas) Plant levee has not been demonstrated by the community or levee owner(s) to meet the requirements of 44 CFR Part 65.10 of the NFIP regulations as it relates to the levee's capacity to provide 1-percent annual chance flood protection.

3.1 Hydrologic Analyses

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

Each community within Bucks County, except for the Boroughs of Ivyland and Penndel and the Township of Hilltown, had a previously printed FIS report describing each community's hydrologic analyses. Those analyses not revised in the May 18, 1999, countywide FIS have been compiled from the FIS reports and are summarized below.

Precountywide Analyses

For Aquetong Creek, discharges were calculated using the PSU-III method and the Peterson formula, with coefficients developed by the USACE in Hydrologic Study - Tropical Storm Agnes - Report No. 3 (References 3 and 4).

For Beaver Run, Hough's Creek, and Jericho Creek, discharges were determined using a regional regression method, which used the log-Pearson Type III method (Reference 3). Missing flood peaks were estimated by correlation with long-term records at nearby gaging stations and the results plotted on log graph paper.

For Black Ditch, Mill Creek No. 1, Mill Creek No. 4, Park Creek, Queen Anne Creek and its tributaries, and Tributary A to Little Neshaminy Creek, the hydrologic analysis was a modification of the U.S. Soil Conservation Service (SCS) procedure discussed in "Design Hydrographs for Pennsylvania Watersheds" (Reference 5).

For Blair Mill Run and Blair Mill Run Tributary, flood flow-frequency data were based on the Pennypack Watershed Expanded Flood Plain Information Report (Reference 6).

For Brock Creek, Buck Creek, Cafferty Run, Cafferty Run Tributary, and Silver Creek No. 1, flood flow-frequency relationships were determined using the regional method, PSU-III, in which the Commonwealth of Pennsylvania is divided into regions with a graph of area versus flow for the 2.33-year flood developed for each region (Reference 3). This flow is then multiplied by a standard factor for the 10-, 2-, 1-, and 0.2- percent annual chance floods.

For Cabin Run and Deep Run, the hydrologic analysis was performed following the methodology discussed in Water Resources Bulletin No. 13, Floods in Pennsylvania (Reference 7). This method provides regionalized regression equations that use drainage area and relative location within the commonwealth to similar gaged streams to generate peak discharges for the selected recurrence interval flood flows.

For Chubb Run, the flood flow-frequency relationships were determined using the Rational Method. This method considers the development of the area and the rainfall intensity. The 0.2- percent annual chance flood values were computed by graphical extrapolation.

For Cooks Creek, peak flows for the 10-, 2-, and 1- percent annual chance floods were computed using the USACE regional frequency analysis (Reference 8). Discharges for the 0.2- percent annual chance flood were determined by extrapolation.

For Cooks Run, peak discharges were determined by criteria established in the USGS publication Magnitude and Frequency of Floods in the United States (Reference 2). Discharges were also calculated using the Rational Method and a method employed by the Department of Highways, which is a regional method similar to the USGS method. The 0.2- percent annual chance discharge was extrapolated on log-log graph paper.

For Coppernose Run, Cuttalossa Creek, Paunacussing Creek, Paunacussing Creek Tributaries Nos. 1 and 2, Primrose Creek, Primrose Creek Tributary No. 1, and Rabbit Run, discharges were computed using the Peterson Formula, with coefficients developed by the USACE in Hydrologic Study - Tropical Storm Agnes - Report No. 3 (Reference 4).

For Core Creek, peak discharge values were calculated using the methodology described in Bulletin No. 13 (Reference 7).

For Croydon Run, the hydrologic analysis was a modification of the SCS TR-55 procedure (Reference 9). Peak discharges downstream of the railroad embankment were modified to account for storage capacity produced by the embankment. The reach of Croydon Run from just downstream of Main Avenue to Dixon Avenue in the Township of Bristol was then restudied by preparing a hydrologic model to establish peak discharges at the railroad embankment. This was accomplished using the HEC-1 computer program to construct hypothetical frequency storm hydrographs and to perform modified Puls routing by passing the flow through the railroad embankment (Reference 10). The HEC-1 model was developed for the drainage basin upstream of the railroad embankment. Flows in the small section of the drainage basin downstream of the railroad embankment were limited to the discharges through the embankment.

For Croydon Tributary, Geddes Run and its tributaries, Tributary B of Little Neshaminy Creek, Tributary No. 1 to Tributary B of Little Neshaminy Creek, the hydrologic analysis was a modification of the Kirpich Tc, Condition III, SCS procedure discussed in the SCS National

Engineering Handbook (Reference 11).

For Deep Run, the hydrologic analysis was performed following the methodology discussed in Water Resources Bulletin No. 13, Floods in Pennsylvania (Reference 7). This method provides regionalized equations that use drainage area and relative location within the commonwealth to similar gaged streams to generate peak discharges for the selected recurrence interval flood flows.

For East Branch Perkiomen Creek, several methods of analysis were used to determine the discharges. The hydrologic analysis for one portion was performed using information obtained from a publication by the USACE, Hydrologic Engineering Center (Reference 12). This hydrologic analysis used a calibrated rainfall-runoff model to generate discharge hydrographs for hypothetical storm events, and a peak discharge-drainage area diagram was constructed to determine the selected recurrence interval flood flows. On another portion of the stream, the flood flow frequency relationships were determined using a regional method, which used a log-Pearson Type III analysis of 230 gaging stations in the Upper Delaware and Hudson River Basins to develop a formula from which flows for a particular drainage area were developed (References 8 and 13). Another portion of the stream was analyzed using a modification of the SCS procedure, which relates basin characteristics to stream flow characteristics (Reference 11). The results of the modified SCS procedure were compared with available discharge-frequency data published by the USGS, the USACE, and the Delaware River Basin Commission (DRBC) (References 8, 14, and 15). A final portion of the stream was analyzed using the synthetic method described in USGS Water-Supply Paper 1672 (Reference 2).

For Gallows Run and its tributaries, flood flow-frequency relationships were determined using a regional method (Reference 16).

For Geddes Run and its tributary, the hydrologic analysis was a modification of the Kirpich Tc, Condition III, SCS procedure discussed in the SCS National Engineering Handbook (Reference 11).

For Haycock Creek and Kimples Creek, the 10-, 2-, and 1- percent annual chance discharges were calculated using a regional flood-frequency method. This method consists of regression model methodologies that are based on the statistical analyses of streamflow records. The methodologies were developed through cooperative agreements between the USGS and the Pennsylvania Department of Environmental Resources (Reference 7). The 0.2- percent annual chance discharges were extrapolated from these discharges using straight-line two cycle log-probability graph paper.

For Ironworks Creek, peak discharges were based on data previously developed by the USACE in Flood Plain Information, Little Neshaminy Creek, Bucks County, Pennsylvania, published in 1974 (Reference 17). These were checked against the Anderson-Nichols method (Reference 18).

For Kimples Creek, the 10-, 2-, and 1- percent annual chance discharges were calculated using a regional flood-frequency method. This method consists of regression model methodologies that are based on the statistical analyses of streamflow records. The methodologies were developed through cooperative agreements between the USGS and the Pennsylvania Department of Environmental Resources (Reference 7). The 0.2- percent annual chance discharges were extrapolated from these discharges using straight-line two cycle log-probability graph paper.

For Lahaska Creek, Tributaries No. 1 and No. 2 to Lahaska Creek, and Watson Creek, discharge-frequency values were based on methods outlined in Water-Supply Paper 1672 and in a report titled Report on the Comprehensive Survey of Water Resources of the Delaware River Basin (References 2 and 19).

For Licking Creek and Licking Creek Tributary No. 1, discharges were determined using a regional method, which used the log-Pearson Type III method (Reference 3). Missing flood peaks were estimated by correlation with long-term records at nearby gaging stations and the results plotted on log graph paper.

For Little Neshaminy Creek, flood flow-frequency data were obtained from a USACE report (Reference 20).

For Tributary to Little Neshaminy Creek and Tributary to Ironworks Creek, discharges were calculated using the Rational Method (Reference 18).

For Martins Creek and its tributaries, the hydrologic analyses were performed by the DRBC. The flood flow frequency relationships were determined using the modified Rational Method. The Rational Method results were adjusted to simulate actual field conditions and were correlated with a regional method (Reference 3).

For Mill Creek No. 2, discharge-frequency values were determined from generalized curves developed in the Delaware River Basin Report (Reference 21). The 0.2- percent annual chance discharge was determined through linear extrapolation.

For Mill Creek No. 3, the hydrologic analysis was based on criteria established in the USGS publication Magnitude and Frequency of Floods in the United States and Valley Reports Group Publication (References 2 and 22).

For Morgan Creek, the same drainage area-discharge relationships that were used for Licking Creek were used, because they are adjacent basins with similar characteristics.

For Neshaminy Creek, the flood flow frequency data were based on a statistical analysis of discharge records covering a 44-year period at USGS gaging station No. 01465500 at Langhorne (References 23, 24, and 25). The analysis followed the standard log-Pearson Type III method for calculating the discharges (Reference 26). The resulting flows were then modified, using applicable empirical equations relating controlled and natural drainage areas to discharge values, to account for the effects of watershed regulation (Reference 15). The discharge for the 0.2- percent annual chance flood, which was not directly available from the analytical data, was determined by the extrapolation of a curve of analytically computed flood discharges plotted on log-log graph paper.

For Neshaminy Creek Tributary, flood flow-frequency relationships were determined using the Rational Method (Reference 18). This procedure considers both the development of the area and the rainfall intensity for determining the peak discharges. The 0.2- percent annual chance flood values were determined by graphical extrapolation.

For Newtown Creek, hydrologic analyses were performed using regression-model methodologies developed through cooperative agreements between the USGS and the Pennsylvania Department of Environmental Resources (Reference 27). Peak elevation-frequency data for SCS floodwater-retarding structure, PA-621, were obtained from the SCS. This analysis was based on the attenuation of flows by PA- 621.

For North Branch Neshaminy Creek, frequency-discharge curves used to determine the discharge were based on the knowledge that the flood detention structures constructed on this stream were operational.

For Paunacussing Creek and Paunacussing Creek Tributaries Nos. 1 and 2, discharges were computed using the Peterson Formula, with coefficients developed by the USACE in Hydrologic Study - Tropical Storm Agnes - Report No. 3 (Reference 4).

For Pidcock Creek, discharge-frequency data were determined using the regional frequency method developed by the USACE and outlined in the publication titled Regional Frequency Study. Upper Delaware and Hudson River Basins (Reference 8).

For Pine Run No. 1, the hydrologic analysis was a modification of the SCS procedure discussed in "Design Hydrographs for Pennsylvania Watersheds" (Reference 5). Discharges were modified to account for the effects of regulation using inflow/outflow relationships developed by the SCS for the PA-616 dam (Reference 28).

For Pine Run No. 2, discharges were determined by a method developed by the Pennsylvania Department of Highways (Reference 29). This is a regional method that takes into account topography, ground cover, length of watercourse, and drainage area to determine discharges.

For Pleasant Spring Creek and Tributary to West Branch Neshaminy Creek, the synthetic method described in USGS Water-Supply Paper 1672 was used to determine the discharges (Reference 2).

For Poquessing Creek and Poquessing Creek Tributary No. 1, the hydrologic analysis was performed by the USACE. Current available gage data from six USGS stream gages were analyzed to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals. This analysis was performed using methodology described in the USGS Bulletin 17B (Reference 30).

For Poquessing Creek Tributaries Nos. 2 and 3, discharge-frequency values were determined from generalized curves developed in the Delaware River Basin Report (Reference 21).

For Primrose Creek and Primrose Creek Tributary No. 1, discharges were computed using the Peterson Formula, with coefficients developed by the USACE in Hydrologic Study - Tropical Storm Agnes - Report No. 3 (Reference 4).

For Queen Anne Creek (Newportville), the hydrologic analysis was a modification of the SCS TR-55 procedure (Reference 9).

For Rabbit Run, discharges were computed using the Peterson Formula, with coefficients developed by the USACE in Hydrologic Study - Tropical Storm Agnes - Report No. 3 (Reference 4).

For Railroad Creek, the SCS office in Harrisburg supplied 12-hour duration hydrographs. Discharges are completely controlled by a flood detention structure.

For Ridge Valley Creek, the hydrologic analysis was performed using the PSU-IV procedures (Reference 31).

For Robin Run, a regression analysis correlating existing discharges with drainage area was developed.

For Rock Run and its tributary, flood flow frequency relationships were determined using a modified Rational Method. The Rational Method results were adjusted to actual field conditions and correlated with a regional method (Reference 3).

For Silver Creek No. 2, discharges were determined using a regional method developed at Pennsylvania State University, which used the log-Pearson Type III method (Reference 3).

For Southampton Creek, peak discharges for the 1- and 0.2- percent annual chance floods were based on data developed by the USACE

(Reference 32). Because only the peak discharges for the 1- and 0.2-percent annual chance floods were provided by the USACE, the rest of the discharge-frequency relationships were developed by the firm of Anderson-Nichols and Company, Inc. (Reference 15).

For Three Mile Run and Tributary No. 1 to Three Mile Run, the discharges were calculated using the PSU-IV method, which is a regional regression analysis (Reference 31).

For Tohickon Creek, flood flow frequency relationships were determined using the USACE regional method (Reference 8). This method used a log-Pearson Type III analysis of 230 gaging stations in the Upper Delaware and Hudson River basins to develop a formula from which the different flows for a particular drainage area were developed. This method also used the USGS gaging station on Tohickon Creek near Pipersville. The peak discharges were adjusted to account for the effects of the Nockamixon Reservoir.

For Tributary A to Neshaminy Creek, discharges were determined by a method developed by the Pennsylvania Department of Highways (Reference 29). This is a regional method that takes into account topography, ground cover, length of watercourse, and drainage area to determine discharges.

For Tributary B of Little Neshaminy Creek and Tributary No. 1 to Tributary B of Little Neshaminy Creek, the hydrologic analysis was a modification of the Kirpich Tc, Condition III, SCS procedure discussed in the SCS National Engineering Handbook (Reference 11).

For Tributary D to Neshaminy Creek, the hydrologic analysis was a combination of a modification of the SCS procedure discussed in "Design Hydrographs for Pennsylvania Watersheds" and a modification of the Kirpich Tc, Condition III, SCS procedure discussed in the SCS National Engineering Handbook (References 5 and 11).

For Tributary to Ironworks Creek, the Rational Method was used to compute the discharges (Reference 18).

For Tributary to West Branch Neshaminy Creek, the Rational Method was used to compute discharges (Reference 18). The 0.2- percent annual chance discharge was extrapolated.

For Unami Creek, the hydrologic analysis consisted of the development of a rainfall-runoff model for the Unami Creek basin using the HEC-1 computer program (HEC-1). Peak flows for the 0.2- percent annual chance flood were obtained by extrapolating the discharge-frequency curve.

For Watson Creek, discharge-frequency values were based on methods outlined in Water-Supply Paper 1672 and in a report titled Report on the

Comprehensive Survey of Water Resources of the Delaware River Basin (References 2 and 19).

For West Branch Neshaminy Creek, two SCS flood detention structures, PA-625 and PA-615, were analyzed for their effects on flooding. Discharges were obtained from the SCS and were determined using 12-hour duration hydrographs. The following formula, which was able to calculate peak flows upstream and downstream of points given by the SCS, was used:

$$Q_u/Q_d = (A_u/A_d)^{0.8}$$

where Q_u is the discharge upstream and Q_d is the discharge downstream of the given point, A_u is the area upstream and A_d is the area downstream of the given point, and 0.8 is a transfer coefficient.

For Tributary to West Branch Neshaminy Creek, which has a drainage area of less than 1 square mile, discharges were calculated using the Rational Method.

May 18, 1999, Countywide Analyses

The hydrologic analysis of the Delaware River was performed by the USACE, Philadelphia District. The hydrologic analysis used USGS gage data from gages at Trenton, Riegelsville, Belvidere, Port Jervis, and Barryville. A discharge-frequency analysis for these five gaging stations was performed to update the analysis presented in the report, Comprehensive Survey of the Water Resources of the Delaware River Basin, House Document 522, Appendix M, dated 1962 (Reference 22). As performed in the original analysis of House Document 522, the storm origins were classified as either hurricane or non-hurricane events analyzed separately and then combined to yield a single unregulated discharge-frequency relationship at each gage. Where recorded discharges used in the analysis were affected by upstream reservoir regulation, such discharges were "naturalized" to produce a consistent set of data. Thus, unregulated frequency curves were first determined for hurricane and non-hurricane events and then combined. The combined curves were ultimately adjusted to account for regulation effects of existing impoundments.

Because hurricanes do not occur annually in the Delaware River basin, it was not possible to use the annual flood frequency analysis for the hurricane series. For purposes of statistical analysis, it was necessary to develop an array wherein the unit time period contained at least one hurricane event. On examination of hurricane events, it was determined that a minimum period of 3 years was required to satisfy this criterion. If more than one flood flow of hurricane origin occurred in a 3-year period, only the largest event was used in the array. Basic statistics, the mean and standard deviation, were computed analytically from the hurricane series and were adjusted for historical hurricane events in accordance with the Water Resources Council Guidelines. The frequency scale of the hurricane series curve represents probability of exceedance in a 3-year period.

According to probability methods, it is possible to determine the chance that a triannual peak flow of any frequency would have of being an annual peak flow. If P_{3Y} is the probability of any given event occurring in any given 3-year period, the probability that it will occur in 1 year, P_Y, is much less and can be expressed by:

$$P_Y = 1 - (1-P_{3Y})^{1/3}$$

Applying this equation, the annual peak hurricane series for each of the five gage sites was developed.

For the non-hurricane series analysis, the annual peak flow series was developed for each gage. If the annual peak flow was associated with a hurricane, the next highest peak flow not associated with a hurricane was obtained for the annual non-hurricane series. Where affected by upstream regulation, recorded flows were adjusted to natural (unregulated) conditions. The frequency statistics for the non-hurricane flood flows were computed analytically and adjusted for historical events in accordance with the Water Resources Council Guidelines.

Because the needs of the study require a determination of the frequency of any specified flow, regardless of source, it was necessary to combine the two component parts into a single composite annual frequency curve. Because hurricane and non-hurricane storms are not mutually exclusive, a combination of the component probabilities must be accomplished in a manner that permits assignment of the annual flood origin either to a hurricane or a non-hurricane event, but which precludes assignment to both flood causes in any one year. This condition is satisfied by application of the Additive Law of Probability, in which the sum of the hurricane and non-hurricane probability is corrected by a term that represents the probability of simultaneous occurrence of both as the flood peak source for any 1 year. The correction is made by deduction of the product of these probabilities. Thus, the composite probability may be expressed as:

$$P_C = P_H + P_N - (P_H \times P_N)/l00$$

where P_C is the composite annual frequency (%) for any flood without restriction to its cause, P_H is the hurricane frequency (%), and P_N is the non-hurricane frequency (S). This method of combining the hurricane and non-hurricane populations produces a composite frequency curve that closely follows the hurricane population curve at high flows and approaches the non-hurricane population curve at middle and low flows.

Upon completion of the hurricane and non-hurricane frequency analysis, meetings were held with the USGS to adopt a set of coordinated discharge-frequency curves for the main stem of the Delaware River. The slight difference in the discharge-frequency relationships as developed by the two agencies is attributable to the methods of analysis. While the USACE analysis was based on combining separate hurricane and non-hurricane frequency curves, the USGS analysis was based solely on a peak annual series without consideration of the source. Because the discharges computed by both methods were relatively close, and because there are no specific guidelines as to which procedure is preferred, it was mutually agreed that compromise curves would be used.

Numerous reservoirs exist within the Delaware River basin that have affected peak flows recorded throughout the basin. The frequency curves previously determined were adjusted to account for the effect of the reservoirs on peak flows. The effects of the currently operating reservoirs on four major historical floods and a hypothetical basin project flood were evaluated by routings of the flood hydrographs through the reservoirs and by plotting the resulting reduced peak flows below the natural (unregulated) frequency curve. A regulated frequency curve was drawn through the plotted points using the shape of the natural frequency curve as a general guide.

The study area includes part of the Delaware River that is subject to a combination of fluvial and tidal influences, referred to as the Delaware River estuary. The elevation versus frequency relationships adopted for locations within the Delaware River estuary are based on an analysis of gage records for several selected tide gages. The following tabulation lists the tide gage locations along the Delaware River and the Delaware Bay for which stage-frequency curves were developed and summarizes the period of record used in the analysis.

Location	Systematic Period of Record (years)	Historic Period of Record (years)	
Lewes, DE	35	55	(1919 to 1973)
New Castle, DE	27	41	(1916 to 1956)
Philadelphia, PA	74	76	(1901 to 1976)
Burlington, NJ	37	57	(1921 to 1977)
Trenton, NJ	47*	137*	(1841 to 1977)

* Includes stages recorded at the new Trenton tide gage located at the Marine Terminal, which has been adjusted to the Municipal Pier location.

To obtain a consistent set of annual peak stages, it was necessary to consider that the mean sea level has been rising at a long-term rate of approximately 0.014 feet per year off the coast of the Delaware Bay. Observed annual peak stages for Lewes, New Castle, Philadelphia, and Burlington were adjusted to 1979 by increasing the observed peak by 0.014 feet multiplied by the difference in years between 1979 and the year the peak was observed. Elevation versus frequency curves were developed for the five gage locations based on a graphical frequency analysis of the adjusted annual peak stages using Wiebull plotting positions with high outlier adjustments based on Water Resources Bulletin 17A (Reference 33). Elevation versus frequency relationships required for locations between the analyzed gages were developed using a graphical interpolation procedure based on trends shown by a profile plot of the observed peak stages of historic floods.

Information on the relationship between frequency and tide elevations for gages between Philadelphia and Trenton are shown in Table 3.

TABLE 3- TIDE FREQUENCY STAGES OF THE DELAWARE RIVER*

FLOODING SOURCE AND LOCATION	RETURN PERIOD (Percent - Annual - Chance) 10-	2-	1-	0.2-
Delaware River				
Philadelphia Tide Gage	6.7	8.3	9.1	11.2
"Old" Burlington Tide Gage	7.6	9.3	10.1	12.7
"Old" Trenton Municipal Pier Tide Gage	10.9	16.8	19.4	25.0

*In feet above North American Vertical Datum of 1988

June 20, 2001, Revision

The hydrologic analyses of East Branch Perkiomen Creek were performed by the USACE, Philadelphia District. Available hydrologic data was reviewed for consistency and applicability to present conditions along East Branch Perkiomen Creek, and along Perkiomen Creek in Montgomery County, Pennsylvania. The Hydrologic Engineering Center Special Project Memo No. 78-4 (SPM 78-4), the USGS annual peak flow data, and the current FIS were included in the review. For consistency, SPM 78-4 was selected for both streams. SPM 78-4 was updated to include 20 more years of record at the Graterford gage along Perkiomen Creek. A ratio of the old flows and new flows at the gage was computed.

April 2, 2002, Revision

The discharge-frequency relationships for Chubb Run were obtained using the TR-55 method.

September 3, 2003, Revision

Discharges for the Delaware River Overland Flow were determined using FESWMS-2D to calculate the diverted flow through this region along the Delaware River (Reference 93).

The discharges are shown in Figure 1, "Frequency-Discharge, Drainage Area Curves," for Aquetong Creek, Beaver Run, Coppernose Run, Cuttalossa Creek, East Branch Perkiomen Creek, Licking Creek, Licking Creek Tributary No. 1, North Branch Neshaminy Creek, Paunacussing Creek, Paunacussing Creek Tributaries Nos. 1 and 2, Poquessing Creek Tributaries Nos. 2 and 3, Pleasant Spring Creek, Primrose Creek, Primrose Creek Tributary No. 1, Rabbit Run, Silver Creek No. 2, and Tohickon Creek.

April 2, 2004, Revision

The drainage areas of the sub-areas of East Branch Perkiomen Creek were reported incorrectly in the June 20, 2001, FIS. Sub-area location labeling resulted in incorrect flows being entered into the hydraulic model. The correct drainage areas and corresponding flows at select locations along East Branch Perkiomen Creek are listed in Table 4, "Summary of Discharges".

March 16, 2015, Revision

The USGS developed flood magnitude and frequency values, including 10-, 2-, 1-, and 0.2- percent annual chance floods, for eight active USGS stream flow gaging stations on the main stem of Delaware River. The eight active gages include stations from Trenton, NJ to Callicoon, NY (Reference 94). This data was developed in collaboration with USACE Philadelphia District, New Jersey Department of Environmental Protection (NJDEP), FEMA Regions II & III and DRBC. The hydrologic analysis was performed in accordance to guidelines published by the Interagency Advisory Committee on Water Data in its Bulletin 17B. This involved the analysis of peak-flow gage data record utilizing the PeakFQ program. Five additional flow locations were established, between USGS gaging stations, to provide better flow distribution along the main stem. These flow locations are placed in the vicinity of tributaries with significant drainage area contribution. The discharges, including 10-, 2-, 1-, and 0.2- percent annual chance floods, were estimated per linear-interpolation of a discharge–frequency relationship as a function of drainage area for the eight active USGS gaging stations.

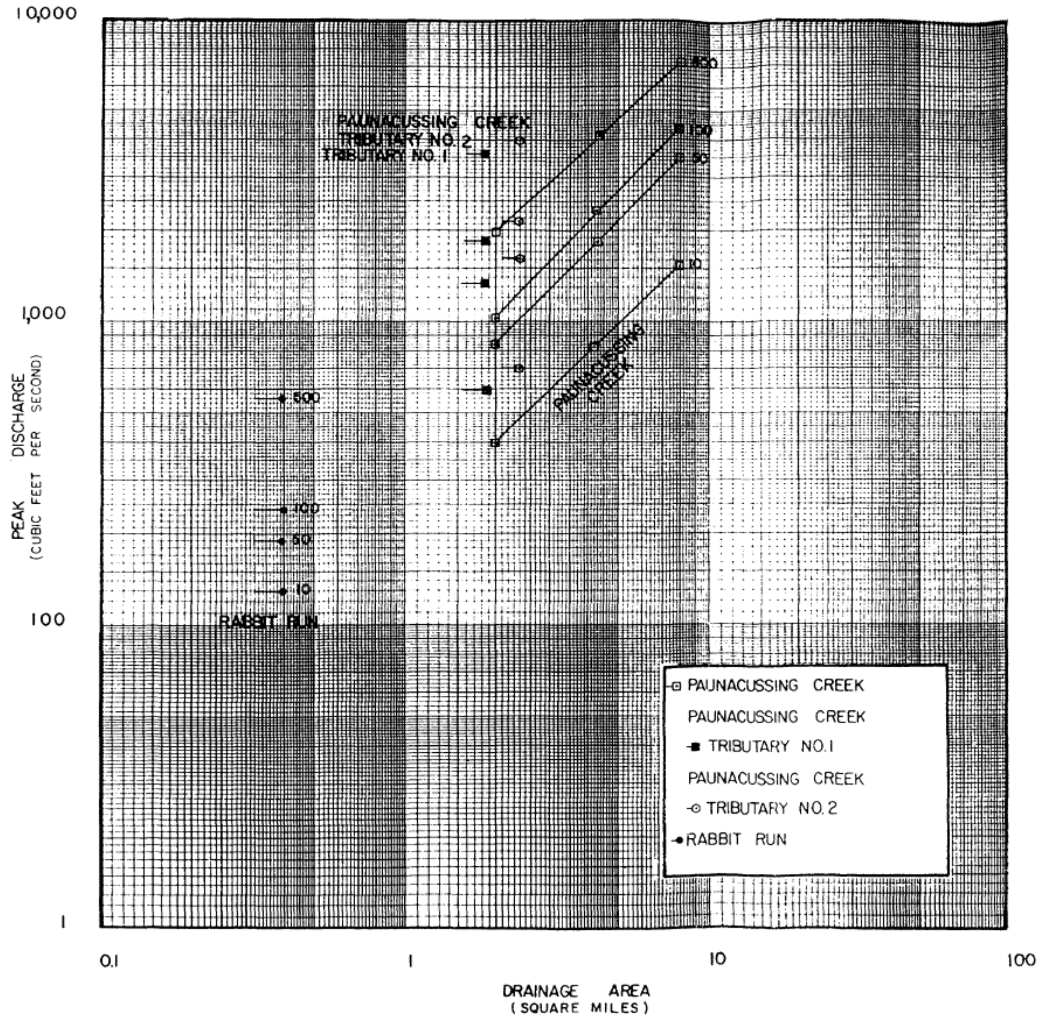


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENTY

BUCKS COUNTY, PA
(ALL JURISDICTIONS)

FREQUENCY –DISCHARGE, DRAINAGE AREA CURVES

RABBIT RUN, PAUNACUSSING CREEK, PAUNACUSSING CREEK TRIBUTARIES NO. 1 AND NO. 2

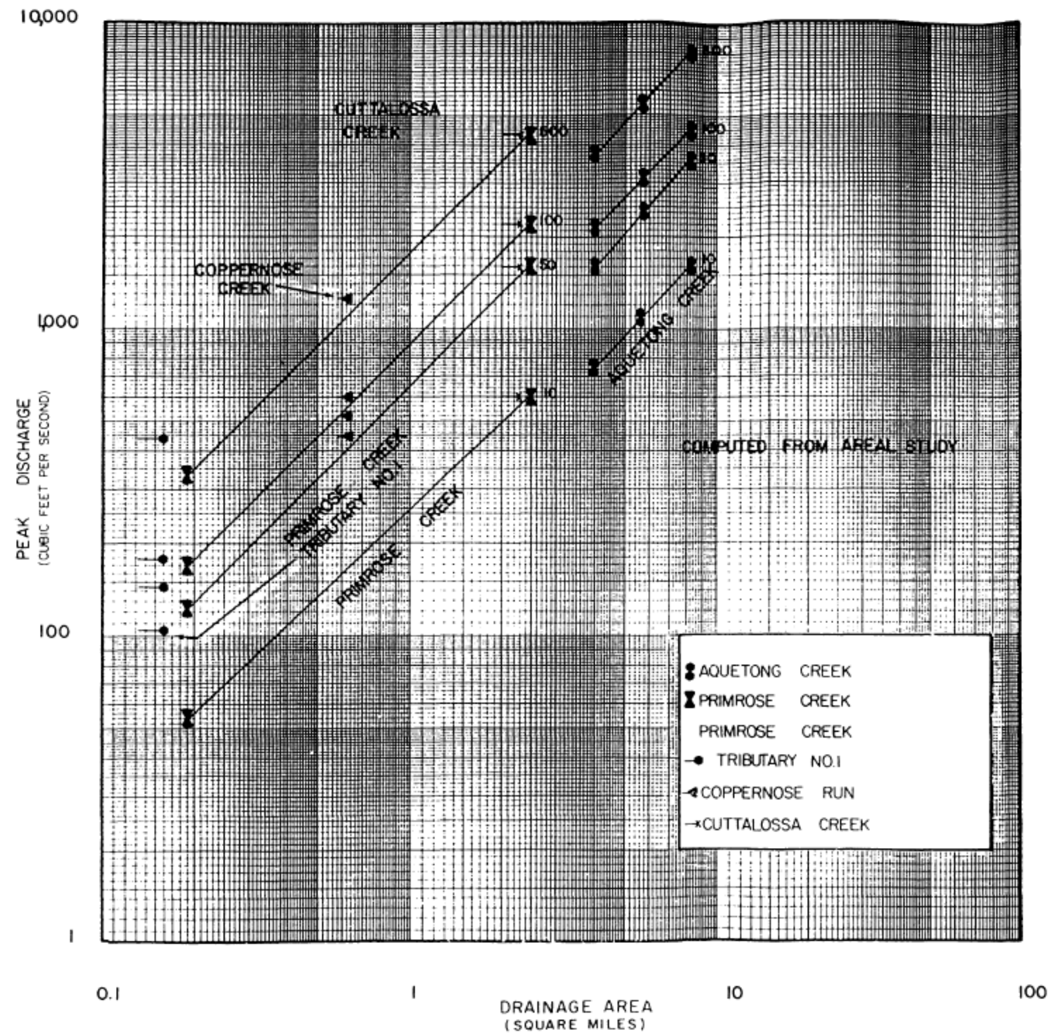


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENTY

BUCKS COUNTY, PA
(ALL JURISDICTIONS)

FREQUENCY –DISCHARGE, DRAINAGE AREA CURVES

COPPERNOSE RUN, AQUETONG, PRIMROSE, AND CUTTALOSSA CREEKS, AND PRIMOSE CREEK TRIBUTARY NO. 1

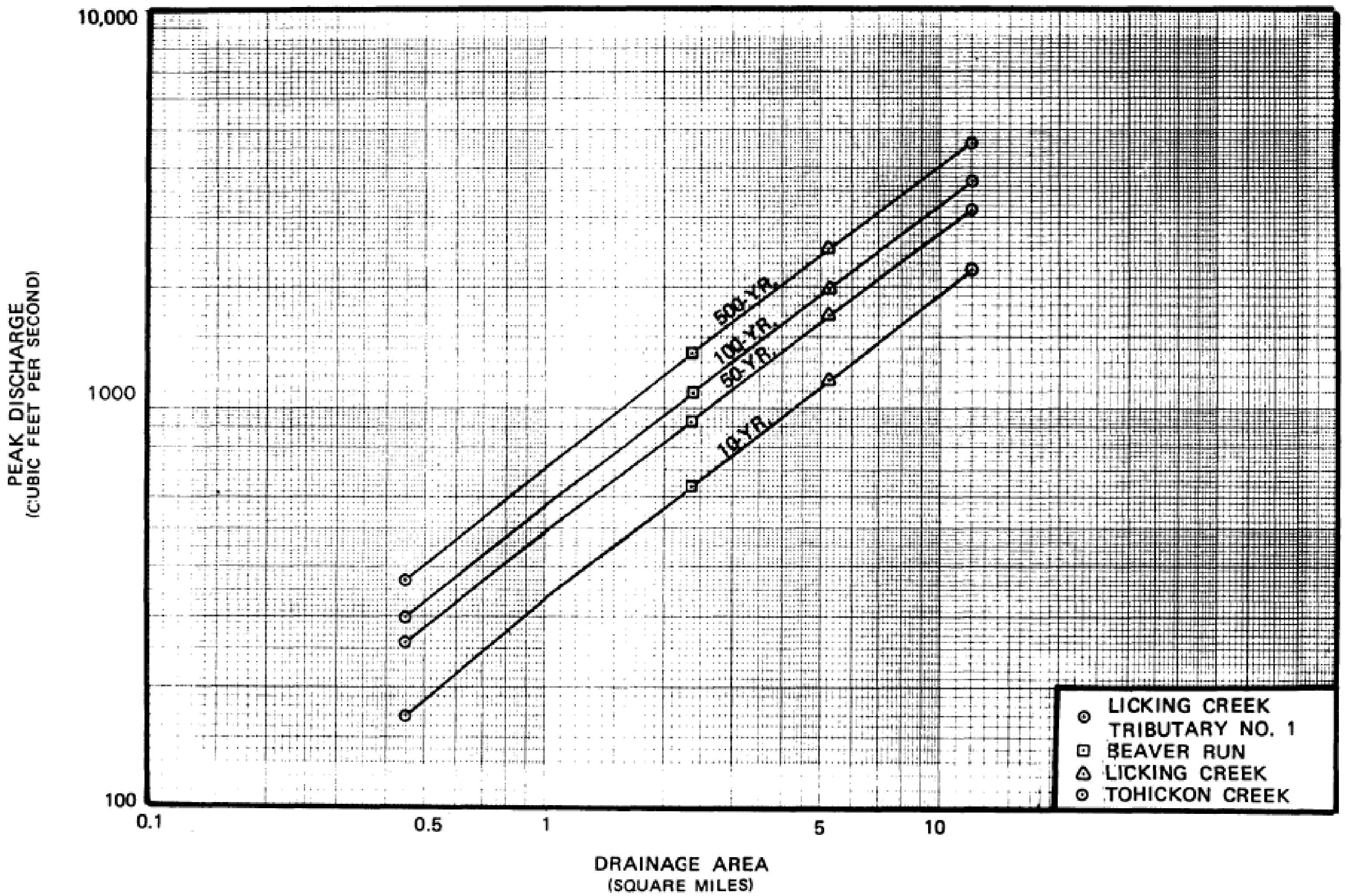


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENTY

BUCKS COUNTY, PA (ALL JURISDICTIONS)

FREQUENCY –DISCHARGE, DRAINAGE AREA CURVES

BEAVER RUN, LICKING CREEK, TOHICKON CREEK AND LICKING CREEK TRIBUTARY NO. 1

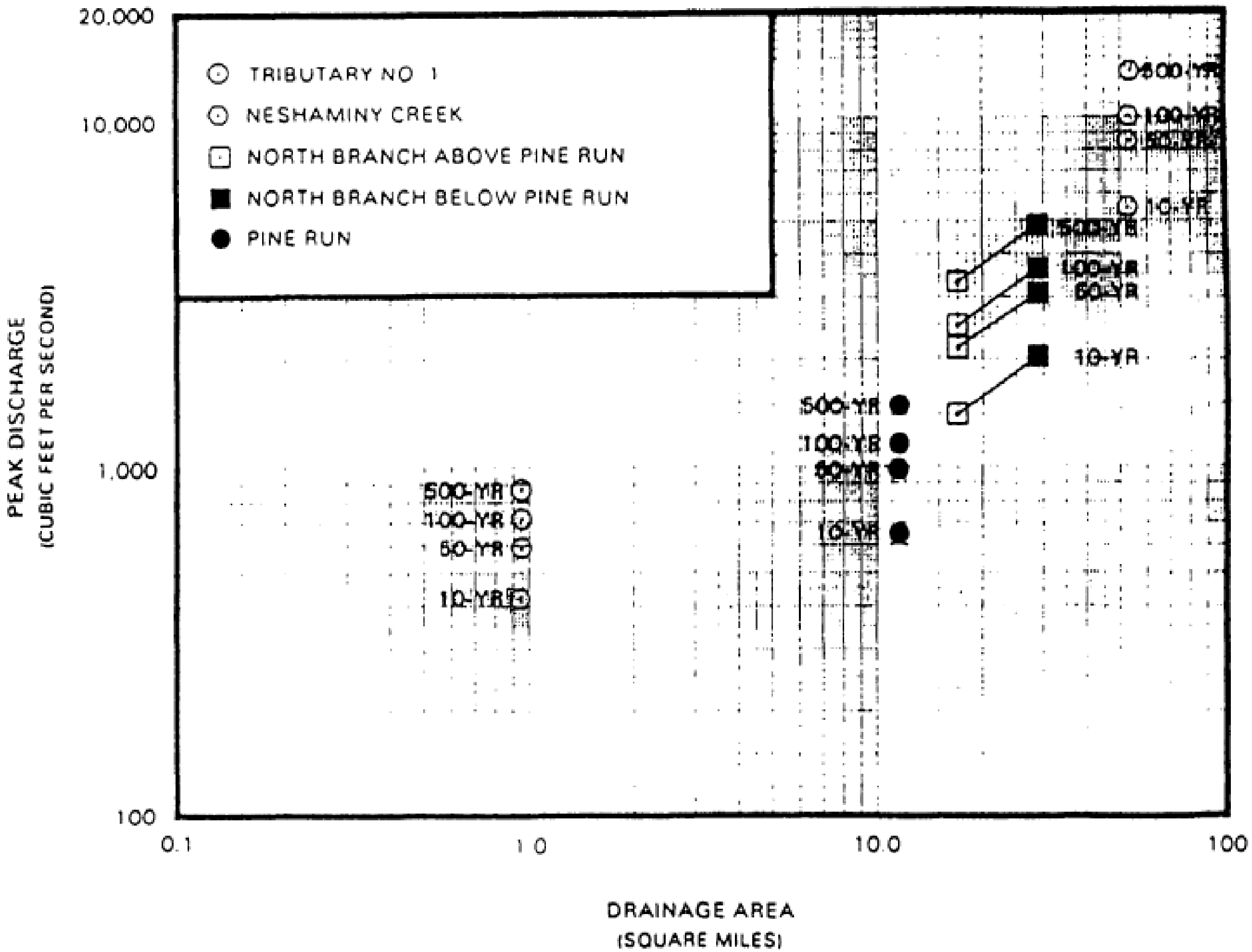
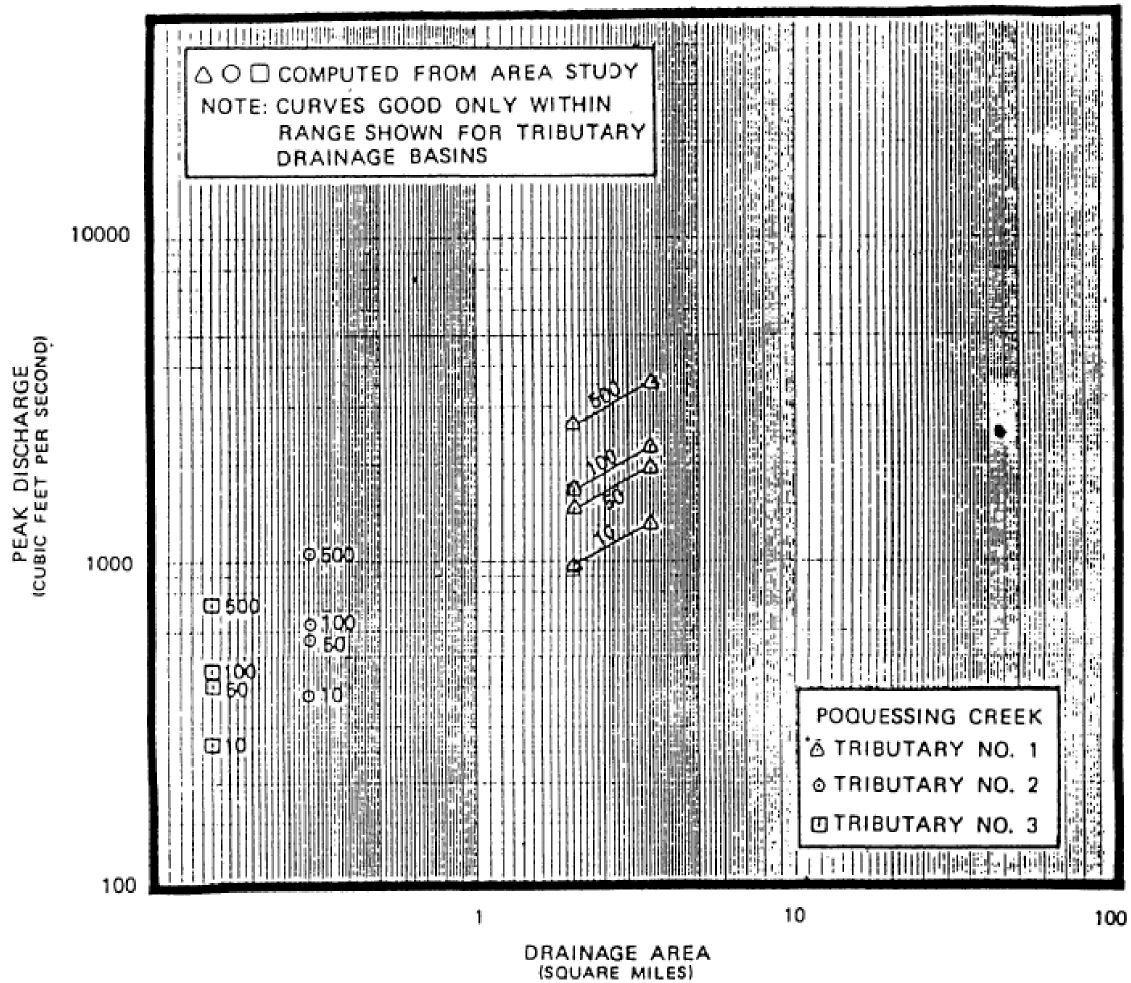


FIGURE 1	FEDERAL EMERGENCY MANAGEMENT AGENTY **BUCKS COUNTY, PA (ALL JURISDICTIONS)**	**FREQUENCY –DISCHARGE, DRAINAGE AREA CURVES** **NORTH BRANCH NESHAMINY CREEK**



Note – Hydrologic data for Tributary 1 has been superseded.

FIGURE 1	FEDERAL EMERGENCY MANAGEMENT AGENTY BUCKS COUNTY, PA (ALL JURISDICTIONS)	FREQUENCY –DISCHARGE, DRAINAGE AREA CURVES POQUESSING CREEK TRIBUTARIES NO. 2 AND NO. 3

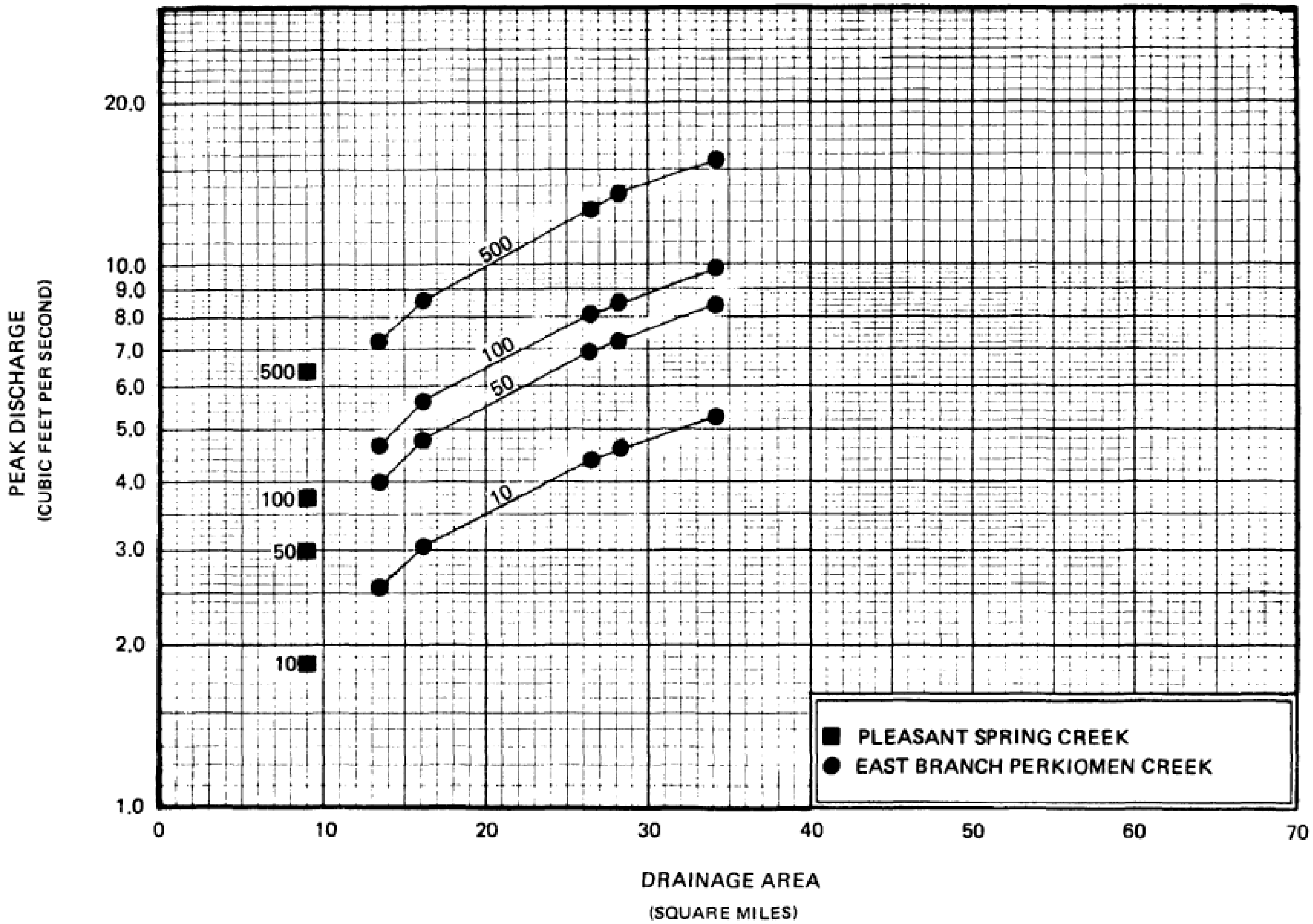


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENTY

BUCKS COUNTY, PA
(ALL JURISDICTIONS)

FREQUENCY –DISCHARGE, DRAINAGE AREA CURVES

PLEASANT SPRING CREEK AND EAST BRANCH PERKIOMEN CREEK

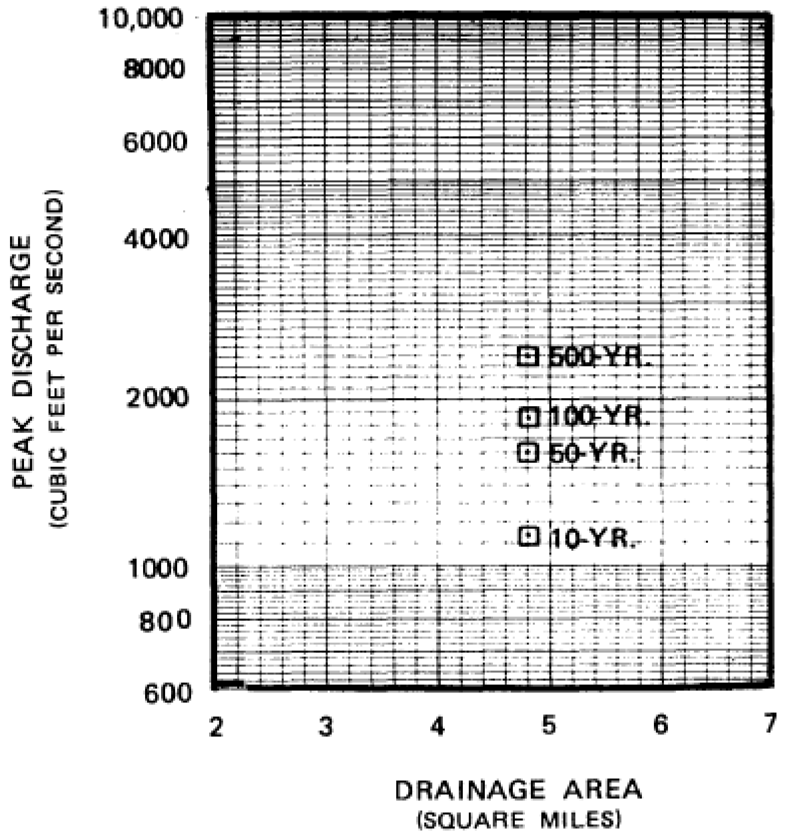


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENTY

BUCKS COUNTY, PA
(ALL JURISDICTIONS)

FREQUENCY –DISCHARGE, DRAINAGE AREA CURVES

SILVER CREEK NO. 2

For Pennypack Creek Watershed, which includes Blair Mill Run, Blair Mill Run Tributary, and Southampton Creek in Bucks County, Temple University used USACE's HEC-HMS. The watershed was treated as consisting of 10 subbasins. A curve number was computed for each subbasin based on land use / land cover and soil type data, which is obtained from DVRPC. The routing of water flow through the reaches was conducted using the Modified Puls method. Eight storms of various total rainfall and duration were used for the hydrologic model calibration. Discharges for the 10-, 2-, 1-, and 0.2- percent annual chance floods were estimated. The peak flow Q_i in each stream "i" was obtained according to the formula:

$$Q_i = \frac{A_i}{A_b} Q_b + Q_{upstream}$$

Where Q_b is the peak flow from the subbasin in which stream "i" is located, A_i is the area draining into stream i, and A_b is the drainage area of the subbasin. The term $Q_{upstream}$ indicates peak flow rate from an upstream subbasin that is routed through reach "i".

At 0.4 square mile, Tributary No. 2 of Martins Creek is a smaller watershed than is typically studied in detail for a FIS, and the floodplain is very wide on this stream. Therefore, to evaluate the flooding risks for the surrounding neighborhood, a volumetric analysis was performed on the watershed. A SCS hydrograph was produced using HEC-HMS. The 100 year rainfall was obtained from the National Oceanic and Atmospheric Administration (NOAA), a curve number of 95 was assumed due to the highly urbanized nature of the watershed. A variety of lag times were also evaluated, due to the unknown nature of the specific drainage patterns in the neighborhood.

For all streams studied by approximate methods, regression equations from the USGS report titled "Regression Equations for Estimating Flood Flows at Selected Recurrence intervals for Ungaged Streams in Pennsylvania" (Reference 92) were used to estimate the 1- percent annual chance flood discharge. Equations were developed utilizing peak flow data from 322 gaging stations within Pennsylvania and surrounding states. Pennsylvania was divided into four regions, and Bucks County lies in region 1 and 2. Discharge in region 1 was computed based on two parameters: drainage area (as determined from 30 meter digital elevation model) and percent storage (lakes, ponds and wetlands) within the drainage area. The equation for region 2 uses three parameters to estimate discharge: drainage area, percent carbonate bedrock, and percent urban area. However, the impact of percent urban area on the 1- percent annual chance flood is so small that this parameter was not included in the analysis.

March 21, 2017 Revision

Three sources of information were evaluated for each flooding source included in this study: the previous FIS, Pennsylvania Department of Environmental Protection Stormwater Management Act 167 data (Act 167) (HEC-HMS model which was based on an SCS rainfall runoff model), and discharges developed through StreamStats using Pennsylvania Regression Equations. The HEC-HMS models used in the Act 167 studies did not include the 0.2-percent annual chance flood in the analysis. To comply with the scope of this hydrologic task, the 0.2-percent annual chance flood was added to the HEC-HMS models using rainfall depths obtained for Bucks County from NOAA's Hydrometeorological Design Studies Center. The hydrologic engineering methods used in each one of these sources, in combination with the unique basin characteristics, were used to evaluate the resulting discharges and select the most appropriate information to use as the hydrologic source for this revision. Generally, preference was given to the Act 167 studies due to the communities' involvement and support of the studies. The 2004 FIS table was selected only in situations where it could be documented that it provided superior data to the Act 167 studies.

For Black Ditch, examination of the watershed revealed the Act 167 drainage area (DA) to be correct and the difference in DA between the Act 167 data and the previous FIS could be attributed to updated topographic information. The flow differences can be partially attributed to the reduction in DA. In addition, the Act 167 HEC-HMS model uses a long lag time of 265 minutes, which would produce a flat hydrograph with a lower peak discharge. The flat terrain, in combination with the urbanized nature of the watershed creates a significant chance of localized attenuation in low-lying areas or designed stormwater management facilities, justifying the long lag time and lower flow rate. The Act 167 data, supplemented with DA reductions, was used for this revision.

Three sources of information were evaluated for Cooks Run, the previous FIS which was based on the USGS/Rational Method, the Act 167 HEC-HMS model which was based on an SCS rainfall runoff model, and a StreamStats report which was based on USGS regression equations. All three analysis methods produced similar results. The discharges from the Act 167 HEC-HMS model, along with DA reduction are used in the Neshaminy Watershed Risk MAP study because they are the most up-to-date and detailed information. In addition the comparison with the 2004 FIS and StreamStats reports supports the validity of the hydrologic data.

For Croydon Run, HEC-HMS Version 3.5 was used for computation of discharges. The SCS method within HEC-HMS was used to determine discharges for the model. Due to lack of observed data, calibration was not performed on this model.

For Croydon Tributary the flows from the previous FIS were used since the DA is too small for the other methods to be applied.

For Ironworks Creek, the Act 167 HEC-HMS model along with DA reduction was used because it accounts for the attenuation at the dam for the Springfield Lake. The backwater caused by the attenuation was accounted for using an internal boundary condition.

For Lahaska Creek, the previous FIS report has three reported discharge locations, directly upstream or downstream of the two tributaries. The Act 167 HEC-HMS model used a single DA and SCS curve number method to evaluate the discharges. StreamStats was used to give an independent verification. The Act 167 model had the most detailed methodology and was used to calculate discharge values, along with DA reductions.

For Martins Creek, Tributary No. 1 of Martins Creek, and Tributary No. 3 of Martins Creek, the HEC-HMS model for the Act 167 report contained errors in this specific watershed. The New Jersey Regression Equations for the Inner Coastal Plain were investigated and ultimately used due to Martins Creek's location seaward of the fall line in Falls Township and the area's geological similarity to NJ. As an unsteady hydraulic model was developed for the Martins Creek subwatershed,, a Delmarva Hydrograph was developed for each point. A Delmarva Hydrograph is supported in this area due to its geographic location and flat terrain. The Delmarva Synthetic Unit hydrograph is very similar to the SCS dimensionless unit hydrograph, only specific to this particular topography. The lag times were developed using Worksheet 3 from the TR-55 manual. The flow paths/slopes for the lag time calculations were developed from the RAMPP GeoTerrain processing tools.

For Mill Creek No. 1, the Act 167 HEC-HMS model was used as the primary source of information, and validated using the previous FIS. DA reductions were used as needed.

For Newtown Creek, the Act 167 HEC-HMS model was used as the primary source of information, and validated using the previous FIS. Although there is a significant difference between the 1-percent annual chance flood elevation downstream of the dam, the overall scale of the attenuation and flow reduction is consistent between the two studies, validating the Act 167 model. DA reductions were used as needed.

The primary source of information used for the North Branch Neshaminy Creek was the Act 167 HEC-HMS model which was verified using StreamStats. In addition, the Act 167 data compared very well with the USGS gages 01464645 and 01464720.

For Tributary D to Delaware River, the Act 167 HEC-HMS model was used.

For West Branch Neshaminy Creek, the Act 167 HEC-HMS model was used after verification with StreamStats. For Tributary to West Branch Neshaminy Creek, the effective flows based on the Rational Method were used due to the small size of the DA.

A summary of the drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 4, "Summary of Discharges."

TABLE 4- SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
AQUETONG CREEK					
At confluence with the Delaware River	6.75	1,270	1,900	2,230	2,790
BEAVER RUN					
At Old Bethlehem Pike	2.0	580	850	990	1,230
At State Route 309	1.6	450	660	780	960
At Trumbauersville Road	1.2	365	535	630	770
Downstream of confluence of unnamed tributary	0.8	260	390	450	560
Downstream of confluence of Unnamed Tributary No. 2 to Beaver Run	0.73	*	*	526	*
Approximately 700 feet downstream of Milford Square Road	0.32	*	*	363	*
BLACK DITCH					
At confluence with Mill Creek No. 3	2.9	575	929	1,150	1,697
At Mill Creek Road	0.9	176	285	353	520
BLAIR MILL RUN					
Downstream of confluence of unnamed tributary	0.89	446	702	834	1,199
At upstream limit of detailed study	0.11	46	73	87	125
BLAIR MILL RUN TRIBUTARY					
Downstream of confluence with Tributary B	0.49	697	1,097	1,304	1,873
Upstream of confluence with Tributary A	0.20	223	351	417	599
At upstream limit of detailed study	0.17	56	88	104	150

* Data not available

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
BROCK CREEK					
At confluence with the Delaware River	6.5	1,119	1,669	1,964	2,454
At downstream Township of Lower Makefield corporate limits	4.3	828	1,234	1,452	1,851
Approximately 0.37 miles downstream of Edgewood Road	3.9	770	1,149	1,350	1,689
At CONRAIL	2.8	606	903	1,062	1,328
BUCK CREEK					
At confluence with Brock Creek	2.1	485	725	850	1,065
CABIN RUN					
At Durham Road	4.45	1,560	2,975	3,805	6,000
At State Route 4l3	0.62	319	591	748	1,170
CAFFERTY RUN					
At confluence with Pennsylvania Canal	4.2	1,020	1,540	1,820	2,250
Approximately 500 feet downstream of confluence of Cafferty Run Tributary	4.0	990	1,490	1,750	2,140
Approximately 140 feet upstream of Geigel Hill Road bridge	3.0	790	1,200	1,400	1,710
CAFFERTY RUN TRIBUTARY					
At confluence with Cafferty Run	1.0	350	540	630	770
CHUBB RUN					
At the confluence with Neshaminy Creek	1.23	1,313	1,869	2,195	3,200

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
CHUBB RUN (continued)					
Just upstream of Hulmville Road	0.96	1,116	1,588	1,865	2,700
At Highland Avenue	0.48	555	836	994	1,550
COOKS CREEK					
At mouth	29.5	3,240	5,950	7,580	12,300
Downstream of Stouts Mill Road	23.0	2,860	5,250	6,700	10,860
COOKS RUN					
At confluence with Neshaminy Creek	3.6	1,365	2,142	2,541	3,671
Apprx. 1,200 feet upstream of State Route 302	2.9	1,123	1,768	2,083	3,021
Apprx. 850 feet downstream of State Route 611	1.8	706	1,111	1,309	1,898
CORE CREEK					
At Newtown-Yardley Road	4.8	1,235	2,310	2,930	4,650
At upstream Township of Newton corporate limits	4.0	1,015	1,890	2,385	3,750
CROYDON RUN					
At confluence with Neshaminy Creek[#]	1.82	280	436	496	642
Downstream of Main Ave.	1.79	356	570	662	898
Below railroad and Rt. 13	1.26	99	124	134	148
Upstream of Franklin Ave.	0.90	346	537	618	815
CROYDON TRIBUTARY					
At confluence with Neshaminy Creek	0.54	402	567	638	796
At Excelsior Avenue	0.30	117	164	204	265
DEEP RUN					
At Stone Bridge Road	3.62	1,325	2,515	3,210	5,150
At Smith School Road	0.95	450	840	1,065	1,620

[#]Discharges are reduced because of significant amount of storage at the Conrail embankment

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
DELAWARE RIVER					
At USGS Gage 01463500 at Trenton, NJ	6,780	169,000	245,000	280,000	372,000
Downstream of confluence of Tohickon Creek	6,588	168,150	243,301	277,451	366,053
At USGS Gage 01457500 at Riegelsville, PA	6,328	167,000	241,000	274,000	358,000
At Belvidere, NJ	4,535	118,000	190,000	230,000	350,000
At Port Jervis, NY	3,076	88,000	140,000	170,000	270,000
EAST BRANCH PERKIOMEN CREEK					
At Bucks County/ Montgomery County Line	38.2	7,220	10,490	11,890	13,980
Downstream of Pleasant Spring	26.9	5,780	8,390	9,120	11,080
Upstream of Pleasant Spring	17.8	4,360	6,390	7,060	8,280
GALLOWS RUN					
At confluence with the Delaware River	8.6	1,759	2,664	3,116	3,820
Approximately 345 feet upstream of Fire Lane Road	8.2	1,709	2,589	3,028	3,712
Approximately 725 feet downstream of Ealer Road	7.0	1,512	2,290	2,679	3,283
At confluence of Gallows Run Tributary No. 1	3.0	796	1,205	1,409	1,728
GALLOWS RUN TRIBUTARY NO. 1					
Approximately 0.25 miles downstream of confluence of Gallows Run Tributary No.2	1.9	570	870	1,020	1,250
At confluence of Gallows Run Tributary No.2	1.6	500	760	890	1,090

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
GALLOWS RUN TRIBUTARY NO. 1 (continued)					
Approximately 0.26 miles upstream of Church Hill Road	1.0	355	533	630	770
Approximately 0.52 miles upstream of Church Hill Road	0.7	260	355	460	560
GALLOWS RUN TRIBUTARY NO. 2					
At confluence with Gallows Run Tributary No. 1	0.3	150	200	270	320
Approximately 0.25 miles upstream of confluence with Gallows Run Tributary No. 1	0.2	120	165	210	260
Approximately 0.43 miles upstream of confluence with Gallows Run Tributary No. 1	0.1	75	105	135	165
GEDDES RUN					
At Meetinghouse Road	1.75	703	1,193	1,415	1,920
GEDDES RUN TRIBUTARY					
At Carversville-Wismer Road	0.87	285	585	735	1,110
HAYCOCK CREEK					
At Church Road	6.4	2,100	4,025	5,150	8,500
At Haycock Run Road	3.6	1,305	2,480	3,165	5,100
HOUGH'S CREEK					
At confluence with the Delaware River	5.2	953	1,421	1,671	2,089

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
IRONWORKS CREEK					
At confluence with Mill Creek No. 2	5.9	717	1,388	1,890	3,406
Upstream of Churchville Dam	5.5	1,959	3,200	3,850	5,724
Apprx. 2,400 feet upstream of Elm Avenue	3.8	1,353	2,211	2,660	3,955
Apprx. 140 feet upstream of State Route 232	1.3	318	522	628	934
JERICHO CREEK					
At confluence with the Delaware River	9.2	1,451	2,164	2,546	3,182
Approximately 0.27 miles upstream of River Road	8.5	1,366	2,037	2,397	2,732
Approximately 0.25 miles upstream of Stony Brook Road	7.5	1,246	1,858	2,185	2,732
KIMPLES CREEK					
At confluence with Tohickon Creek	7.3	2,340	4,480	5,740	9,600
At Lake Towhee Dam	4.1	1,455	2,765	3,535	6,000
LAHASKA CREEK					
At confluence with Mill Creek No. 3	7.0	1,572	3,328	4,102	6,341
LICKING CREEK					
At Tohickon Creek	5.3	1,140	1,670	1,960	2,420
Upstream of confluence of Beaver Run	2.3	720	1,060	1,240	1,540
LITTLE NESHAMINY CREEK					
At mouth	43.3	3,800	7,266	9,000	17,650
At Township of Warwick downstream corporate limits	42.2	3,800	7,266	9,000	17,650
At Walton Road	40.1	3,525	6,212	8,379	16,100

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
LITTLE NESHAMINY CREEK (continued)					
At Township of Warwick upstream corporate limits	28.7	2,492	4,334	5,851	11,350
At Township of Warminster western corporate limits	28.0	2,400	4,300	5,800	11,380
At Township of Warminster northern corporate limits	25.5	2,400	4,250	5,500	10,800
At PA-611, outflow	10.9	474	514	528	562
At PA-611, inflow	10.9	2,382	3,816	4,379	5,839
At Township of Warrington upstream corporate limits	6.5	956	1,585	1,722	2,587
TRIBUTARY TO LITTLE NESHAMINY CREEK					
At Township of Warminster western corporate limits	0.6	285	370	405	470
MARTINS CREEK					
At downstream limit	12.2	1,189	1,843	2,156	2,862
At Penn Valley Road	7.9	946	1,485	1,745	2,338
MILL CREEK NO. 1					
At confluence with the Delaware River	20.7	3,616	5,798	7,173	9,980
At Bath Road	19.4	3,501	5,623	6,961	9,731
At confluence with Black Ditch	15.2	3,162	5,072	6,240	9,061
At footbridge west of Mill Drive	7.4	1,327	2,107	2,587	3,737
At downstream Township of Middletown corporate limits	6.5	1,500	1,920	2,450	3,400

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
MILL CREEK NO. 1 (continued)					
At State Route 213 bridge	2.8	956	1,499	1,758	2,367
At Roosevelt Boulevard	1.6	870	1,297	1,484	1,910
MILL CREEK NO. 2					
At mouth	17.4	3,213	5,100	5,950	9,500
At southeast Township of Upper Southampton corporate limits	6.75	1,550	2,325	2,825	4,450
At northeast Township of Upper Southampton corporate limits	2.60	690	1,125	1,290	1,950
MILL CREEK NO. 3					
At confluence with Neshaminy Creek	21.9	3,700	6,000	7,000	14,500
Downstream of private road	20.92	3,595	5,800	6,700	14,400
Downstream of Robin Run	18.73	3,160	5,150	6,000	12,600
Downstream of unnamed tributary	17.90	2,845	4,600	5,400	11,740
At downstream Township of Buckingham corporate limits	16.29	2,845	4,600	5,400	11,740
Downstream of Smith Road	14.61	2,600	4,200	4,900	10,700
Downstream of Watson Creek	11.23	2,195	3,530	4,100	8,800
MILL CREEK NO. 4					
At confluence with Neshaminy Creek	4.9	2,100	3,097	3,487	4,510
MILL CREEK TRIBUTARY NO. 1					
Approximately 1,300 feet upstream of Cherry Lane	1.4	*	*	3,165	*

* Data not available

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
MORGAN CREEK					
At confluence with Tohickon Creek	4.5	1,000	1,480	1,740	2,150
At Conrail bridge	3.7	855	1,260	1,480	1,820
At State Route 309	2.1	570	840	990	1,220
At Township of Richland corporate limits	1.0	325	480	560	690
NESHAMINY CREEK					
At confluence with the Delaware River	233	20,658	34,098	41,103	60,973
At Borough of Hulmeville corporate limits	221.3	21,370	33,390	38,740	56,550
At upstream Township of Bristol corporate limits	215	19,800	33,000	38,600	56,500
At upstream Township of Bensalem corporate limits	212	19,800	33,000	38,600	56,600
Near Borough of Langhorne	210.6	22,170	36,300	43,600	56,800
At Langhorne gage	210.0	20,339	31,780	36,864	53,814
Downstream of confluence of Core Creek	187.8	18,135	28,336	32,869	47,982
Upstream of confluence of Core Creek	178.2	17,488	28,106	32,603	47,592
Downstream of confluence of Newtown Creek	173.0	17,420	27,219	31,574	47,189
Upstream of confluence of Newtown Creek	166.9	16,781	26,219	30,413	44,397
At upstream Township of Newtown corporate limits	160.4	16,218	25,339	29,393	42,826
Downstream of confluence of Mill Creek No. 2	154.6	15,654	24,459	28,373	41,254
Downstream of confluence of Little Neshaminy Creek	135.9	13,772	21,519	24,962	36,439
At downstream Township of Warwick corporate limits	91.4	9,164	15,125	18,233	27,047
Upstream of confluence of Little Neshaminy Creek	91.0	9,150	14,990	18,000	24,800

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
NESHAMINY CREEK (continued)					
At Wrightstown and Buckingham Township boundary	90.5	9,060	14,840	17,830	24,500
At upstream Township of Buckingham corporate limits	86.0	8,620	14,110	16,950	23,300
At downstream Township of Doylestown corporate limits	82.0	8,550	13,600	16,100	22,100
At upstream Township of Doylestown corporate limits	61.9	6,954	10,170	11,550	16,896
At Bristol Road	59.1	6,544	9,660	10,976	15,805
NESHAMINY CREEK TRIBUTARY					
At confluence with Neshaminy Creek	3.3	1,201	1,867	2,143	2,869
At upstream Township of Doylestown corporate limits	1.10	825	1,179	1,330	1,720
At upstream Borough of Doylestown corporate limits	0.21	280	375	415	510
NEWTOWN CREEK					
At confluence with Neshaminy Creek	6.3	647	2,641	3,194	4,605
Just downstream of State Route 621	3.4	107	134	249	1,250
Just upstream of State Route 621	3.2	1,419	2,268	2,709	3,965
NORTH BRANCH NESHAMINY CREEK					
At confluence with Neshaminy Creek	31.7	2,524	5,482	6,523	9,482
Upstream of confluence of Pine Run No. 1	19.9	1,532	4,387	5,266	7,784

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
PARK CREEK					
At confluence with Little Neshaminy Creek	11.8	1,780	2,747	3,104	3,824
PIDCOCK CREEK					
Upstream of Street Road	4.30	940	1,990	2,730	5,880
At limit of study	3.18	740	1,570	2,140	4,620
PINE RUN NO. 1					
At downstream Township of New Britain corporate limits	11.0	##	##	1,200	##
At downstream Township of Doylestown corporate limits	9.7	440	460	466	483
At upstream Township of Doylestown corporate limits	7.2	1,394	2,022	2,212	2,854
PINE RUN NO. 2					
At mouth	2.8	500	750	880	1,100
At Buck Road	1.8	350	525	620	770
POQUESSING CREEK					
At USGS Gage 01465798	21.4	5,630	8,940	10,600	15,500
At USGS Gage 01465770	5.08	1,400	2,100	2,400	3,400
Upstream of confluence of Poquessing Creek Tributary No. 1	1.63	790	1,200	1,400	1,900
Approximately 250 feet upstream of Street Road	0.64	500	750	850	1,200
POQUESSING CREEK TRIBUTARY NO. 1					
At mouth	3.45	1,100	1,700	2,000	2,800

Discharge reduced by dam PA-616

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
QUEEN ANNE CREEK					
At confluence with Mill Creek No. 3	7.0	877	1,244	1,401	1,778
At upstream Township of Bristol corporate limits	5.4	849	1,199	1,345	1,699
At confluence of Tributary No. 1 of Queen Anne Creek	2.2	720	930	1,050	1,250
QUEEN ANNE CREEK (NEWPORTVILLE)					
At confluence with Neshaminy Creek	0.65	440	611	708	863
At Groveland Avenue	0.38	322	447	517	631
RAILROAD CREEK					
At confluence with West Branch Neshaminy Creek	3.7	115	115	115	120
RIDGE VALLEY CREEK					
At downstream Township of West Rockhill corporate limits	5.46	1,310	2,350	2,790	4,310
At Allentown Road	4.06	1,060	1,910	2,260	3,500
ROBIN RUN					
At confluence with Mill Creek No.3	2.27	189	289	328	458
Downstream of SCS Dam	1.87	69	84	89	101
Upstream of SCS Dam	1.87	422	801	947	1,432
Upstream of Lower Mountain Road	0.42	223	380	448	679
ROCK RUN					
At confluence with Tributary No. 3 of Martins Creek	4.5	1,110	1,430	1,600	1,920

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
ROCK RUN (continued)					
At downstream Township of Lower Makefield corporate limits	1.7	630	810	910	1,090
At Valley Road	1.1	480	620	690	830
ROCK RUN TRIBUTARY					
At confluence with Rock Run	0.6	340	440	490	590
SILVER CREEK NO. 1					
At confluence with Pennsylvania Canal	1.6	408	608	715	894
Approximately 0.29 miles upstream of confluence with Pennsylvania Canal	1.0	293	437	515	643
SOUTHAMPTON CREEK					
At confluence with Tributary C southwest corporate limits	2.80	1,459	2,339	2,797	4,064
At confluence with an unnamed tributary (near Holly Road)	2.28	1,224	1,961	2,346	3,408
Downstream of confluence with an unnamed tributary (near Rose Valley Road)	2.25	1,059	1,697	2,030	2,949
At confluence with an unnamed tributary (near Laurel Road)	2.19	1,035	1,660	1,985	2,884
Downstream of confluence with Tributary G	1.40	706	1,132	1,354	1,966
Downstream of confluence with Tributary B	1.17	565	905	1,083	1,573
Downstream of confluence with Tributary A	0.83	518	830	993	1,442
At upstream limit of detailed study	0.32	339	543	650	944

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
THREE MILE RUN					
At Rockhill Road	4.3	800	1,200	1,400	1,760
At Old Bethlehem Pike in West Rockhill	2.45	740	1,330	1,580	2,440
At Catch Basin Road	0.33	180	320	380	585
TOHICKON CREEK					
At confluence with the Delaware River	112	7,780	13,000	16,200	27,200
At Iron Bridge Road	97.4	6,280	10,000	12,700	22,200
At Gruver Road	92.5	4,980	8,500	10,700	19,200
Approximately 0.42 miles upstream of Bedminster Road	77.0	3,780	6,700	8,700	16,200
At Thatcher Road	27.2	3,430	5,590	6,700	9,500
Upstream of confluence of Tributary to Tohickon Creek	12.4	2,190	3,220	3,800	4,900
At dam near State Route 212	12.1	2,150	3,160	3,690	4,570
TRIBUTARY 1 TO MILL CREEK TRIBUTARY NO. 1					
At the confluence with Mill Creek Trib No. 1	0.2	*	*	550	*
TRIBUTARY A TO LITTLE NESHAMINY CREEK					
At confluence with Little Neshaminy Creek	4.4	1,776	2,676	3,042	3,852
TRIBUTARY A TO NESHAMINY CREEK					
At mouth	2.0	360	520	600	780
At Buck Road	1.0	187	270	312	407

* Data not available

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
TRIBUTARY B TO LITTLE NESHAMINY CREEK					
At confluence with Little Neshaminy Creek	1.2	630	1,130	1,358	1,826
Upstream of confluence of Tributary 1 to Tributary B to Little Neshaminy Creek	0.5	212	408	568	683
TRIBUTARY D TO DELAWARE RIVER					
At confluence with Delaware River	1.6	184	267	334	470
At Kingwood Lane	1.0	84	143	180	258
TRIBUTARY D TO NESHAMINY CREEK					
At confluence with Neshaminy Creek	2.7	1,198	1,724	1,945	2,495
Approximately 2,400 feet downstream of Almshouse Road	1.5	813	1,413	1,689	2,301
TRIBUTARY NO. 1 TO LAHASKA CREEK					
At confluence with Lahaska Creek	1.84	370	600	700	1,520
TRIBUTARY NO. 1 OF MARTINS CREEK					
At confluence with Martins Creek	1.9	*	*	345	*
Just upstream of Thorndale Road	1.2	*	*	261	*

*Data not available

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
TRIBUTARY NO. 1 OF QUEEN ANNE CREEK					
At confluence with Queen Anne Creek	9.9	1,170	1,520	1,700	2,030
Upstream of confluence of Tributary No. 2 of Queen Anne Creek	1.8	640	820	920	1,100
At Lincoln Highway	0.7	370	470	530	630
TRIBUTARY NO. 1 TO THREE MILE RUN					
At confluence with Three Mile Run	1.26	590	1,060	1,260	1,950
At Forest Road	0.61	360	650	770	1,190
TRIBUTARY 1 TO TRIBUTARY B TO LITTLE NESHAMINY CREEK					
At confluence with Tributary B to Little Neshaminy Creek	0.4	170	313	428	511
TRIBUTARY NO. 2 TO LAHASKA CREEK					
At confluence with Lahaska Creek	1.29	260	420	500	1,120
TRIBUTARY NO. 2 OF QUEEN ANNE CREEK					
At confluence with Lake Caroline	0.9	425	540	610	730
At Lincoln Highway	0.4	265	340	380	450

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
TRIBUTARY NO. 3 OF MARTINS CREEK					
At confluence with Martins Creek	2.3	*	*	671	*
Just upstream of Thorndale Road	0.4	*	*	333	*
TRIBUTARY TO IRONWORKS CREEK					
At confluence with Ironworks Creek	0.33	212	275	300	370
TRIBUTARY TO PIDCOCK CREEK					
Upstream of Buckmanville Road	0.46	*	*	852	*
TRIBUTARY TO WEST BRANCH NESHAMINY CREEK					
At U.S. Route 202	0.65	518	683	745	965
At Cornwall Drive	0.3	398	530	578	745
UNAMI CREEK					
Downstream of confluence of Schmoutz Creek	24.3	4,900	9,800	12,700	21,500
Downstream of confluence of Molasses Creek	19.7	4,500	9,200	11,900	19,200
Downstream of confluence of Licking Creek	9.7	2,400	5,200	6,900	12,000
UNNAMED TRIBUTARY NO. 2 TO BEAVER RUN					
At confluence with Beaver Run	0.28	*	*	185	*

*Data not available

TABLE 4- SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
UNNAMED TRIBUTARY TO MILL CREEK TRIBUTARY NO. 1					
At confluence with Tributary to Mill Creek No. 1	0.12	*	*	480	*
WATSON CREEK					
At confluence with Mill Creek No. 3	4.26	870	1,410	1,645	3,480
WEST BRANCH NESHAMINY CREEK					
At confluence with Neshaminy Creek	25.0	2,671	10,810	12,761	19,382

*Data not available

The stillwater elevations have been determined for the 10-, 2-, 1-, and 0.2- percent annual chance floods for the flooding sources studied by detailed methods and are summarized in Table 5, "Summary of Stillwater Elevations."

TABLE 5- SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet NAVD88) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
MANOR LAKE				
At the Borough of Tullytown upstream corporate limits	8.3	10.8	11.8	15.2
VAN SCIVER LAKE				
At Bordentown Road	8.3	10.8	11.8	15.2

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 table in the FIS report. 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 us the flood elevation data presented in this FIS report in conjunction with the data shown on the FIRM.

Cross sections for the flooding sources studied by detailed methods were obtained from field and aerial surveys. Below-water cross sections were obtained from field measurements. Cross sections were located at close intervals above and below bridges in order to compute the backwater effects of these structures. Digitized natural ground sections were obtained at points between bridges. All bridges, dams, and culverts were field surveyed to obtain elevation data and structural geometry.

Flood Profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1), and selected cross section locations are also shown on the FIRM (Exhibit 2).

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.

Precountywide Analyses

Each community within Bucks County, except for the Township of Hilltown and the Boroughs of Ivyland and Penndel, had a previously printed FIS report. The hydraulic analyses described in these FIS reports have been compiled and are summarized below.

For Aquetong Creek, Brock Creek, Cafferty Run, Cafferty Run Tributary, Cooks Run, Coppernose Run, Cuttalossa Creek, Gallows Run, Haycock Creek, Hough's Creek, Ironworks Creek, Jericho Creek, Kimples Creek, Licking Creek, Martins Creek, Mill Creek No. 2, Morgan Creek, Paunacussing Creek, Pidcock Creek, Pine Run No. 2, Pleasant Spring Creek, Primrose Creek, Primrose Creek Tributary No. 1, Queen Anne Creek, Rabbit Run, Railroad Creek, Rock Run Tributary, Silver Creek No. 1, Silver Creek No. 2, Tributary No. 1 of Martins Creek, Tributary No. 2 of Martins Creek, Tributary No. 3 of Martins Creek, Tributary to Ironworks Creek, and Unami Creek, cross sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined using the slope/area method.

For Beaver Run, Buck Creek, Cooks Creek, Gallows Run Tributary No. 1, Gallows Run Tributary No. 2, Lahaska Creek, Licking Creek Tributary No. 1, Poquessing Creek Tributary No. 1, Poquessing Creek Tributary No. 2, Poquessing Creek Tributary No. 3, Robin Run, Rock Run, Tributary No. 1 to Lahaska Creek, Tributary No. 1 of Queen Anne Creek, Tributary No. 2 to Lahaska Creek, Tributary No. 2 of Queen Anne Creek, Watson Creek, and West Branch Neshaminy Creek, cross sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were obtained from backwater computations at its mouth.

For Black Ditch, Croydon Tributary, Mill Creek No. 3, Mill Creek No. 4, Park Creek, Queen Anne Creek (Newportville), Tributary A to Little Neshaminy Creek, Tributary B to Little Neshaminy Creek, Tributary D to Little Neshaminy Creek, and Tributary No. 1 to Tributary B to Little Neshaminy Creek, cross sections were obtained from aerial photographs at a scale of 1:12,000, flown in February 1973 (Reference 35). Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were obtained from backwater computations at its mouth.

For Blair Mill Run, the hydraulic analyses were obtained from a USACE report entitled Limited Map Maintenance Program: Blair Mill Run, published in 1988 (Reference 36).

For Blair Mill Run Tributary, the hydraulic analyses were obtained from a USACE report entitled Limited Map Maintenance Program: Blair Mill Run Tributary, published in 1988 (Reference 37).

For Cabin Run, Deep Run, and East Branch Perkiomen Creek, cross sections were obtained from aerial photographs at a scale of 1:16,000, flown on March 16, 1980 (Reference 38). Below-water sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were computed using the slope/area method.

For Chubb Run, Ridge Valley Creek, Three Mile Run, Tributary No. 1 to Three Mile Run, cross sections were obtained from aerial photographs, at a scale of 1:9,600, flown in March 1980, and from field surveys (Reference 38). Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were computed using the slope/area method.

For Core Creek, cross sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were computed using critical depth calculations.

For Croydon Run, cross sections were obtained from aerial photographs at a scale of 1:12,000, flown in February 1973, and from field surveys (Reference 35). Water-surface elevations were computed by using data obtained in a HEC-l reservoir routing in the USACE HEC-2 step-backwater program (References 10 and 34). Starting water-surface elevations were obtained from normal depth calculations.

For Geddes Run, Geddes Run Tributary, and Mill Creek No. 1, cross sections were obtained from aerial photographs at a scale of 1:12,000, flown in February 1973 (Reference 35). Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined using the slope/area method.

For Little Neshaminy Creek, cross sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were obtained from a 1973 USACE report (Reference 20).

For Tributary to Little Neshaminy Creek, cross sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined from normal depth computations.

For Neshaminy Creek, cross sections were obtained from aerial photographs (Reference 35). Below-water sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were obtained from backwater computations at its mouth.

For Neshaminy Creek Tributary, cross sections were obtained from topographic maps prepared from aerial photographs and from field surveys (Reference 38). Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined using the slope/area method.

For Newtown Creek, cross sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined using critical depth calculations.

For North Branch Neshaminy Creek, cross sections were obtained from aerial photographs at a scale of 1:10,000, flown in April 1985 (Reference 39). Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were obtained from backwater computations at its mouth.

For Paunacussing Creek Tributary No. 1 and Paunacussing Creek Tributary No. 2, cross sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined using the slope/area method.

For Pine Run No. 1, cross sections were obtained from aerial photographs at a scale of 1:10,000, flown in April 1985 (Reference 39). Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined by the slope/area method.

For Poquessing Creek, cross sections were obtained from aerial photographs (Reference 35). Below-water sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined by calibrating the HEC-2 model to data from USGS gage number 01465770.

For Southampton Creek, cross sections were obtained from field surveys. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were obtained from a 1973 USACE report (Reference 32).

For Tohickon Creek, cross sections were field surveyed. Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). The starting water-surface elevation was obtained from a stage-discharge curve of the USGS stream gage near Pipersville, Pennsylvania (Reference 40).

For Tributary A to Neshaminy Creek, cross sections were obtained from field surveys and aerial surveys conducted by Quinn and Associates. Water-surface elevations were computed using the USACE HEC-2 step backwater program (Reference 34).

For Tributary to West Branch Neshaminy Creek, cross sections were obtained from aerial photographs at a scale of 1:10,000, flown in April 1985 (Reference 39). Water-surface elevations were computed using the USACE HEC-2 step-backwater program (Reference 34). Starting water-surface elevations were determined by the slope/area method.

May 18, 1999, Countywide Analyses

Information on the methods used to determine water-surface elevation data for the Delaware River restudied as part of the May 18, 1999, countywide FIS is shown below.

Cross sections for the Delaware River were obtained from a Digital Terrain Model (DTM), which was developed from aerial photography flown in April 1994 (References 41, 42, and 43). The below-water portion of this DTM was developed from recent channel surveys and existing HEC-2 models using CHANNEL, an ARC/INFO software application (References 44, 45, and 46). When appropriate, bridge geometries were taken from existing HEC-2 models. New, recently renovated, or altered structures were modeled using as-built drawings provided by the Delaware River Joint Toll Bridge Commission (DRJTBC). All bridges, dams, and culverts were field surveyed to obtain elevation data and structural geometry.

For the other flooding sources studied in detail, water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-2 step-backwater computer program (Reference 34). The HEC-2 hydraulic models for the Delaware River were calibrated against gage information. The final profiles all match gage rating curves within acceptable tolerances. Comparisons were made with high water marks collected during the Flood of 1955, the flood of record for the Delaware River. These marks were also modeled within acceptable limits.

The Delaware River remains under tidal influence downstream of Trenton, NJ. Water-surface profiles for locations between gages were developed using a graphical interpolation procedure based on trends shown by a profile plot of the observed peak stages of historical floods.

Starting water-surface elevations of the Delaware River were set at the one year tide as obtained from the Philadelphia Tide Gage.

Roughness factors were chosen by engineering judgment and were based on field inspection and aerial photography. The channel "n" values used are less than for smaller streams of similar conditions because the banks offer less effective resistance. The roughness factors for the Delaware River are listed in Table 6, “Manning’s ’n’ Values.”

June 20, 2001, Revision

Cross sections for East Branch Perkiomen Creek were obtained from a DTM, which was developed from aerial photography flown in March 1997 (References 47 and 48).

For East Branch Perkiomen Creek, water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-RAS step-backwater program (Reference 49).

April 2, 2002, Revision

Water-surface elevations of floods of the selected recurrence intervals for

Chubb Run were computed using the USACE HEC-RAS program (Reference 87).

Cross sections for Chubb Run were obtained from topographic mapping developed by 3D Imaging, LLC in 1997 (Reference 88).

Roughness factors were chosen by engineering judgment and based on field observations. Starting water-surface elevations were taken from the Flood Profile for Neshaminy Creek at its confluence with Chubb Run.

September 3, 2003, Revision

The HEC-2 model for the Delaware River was revised to accurately reflect the split flow conditions along the Delaware River Overland Flow as well as the Delaware River through this area.

April 2, 2004, Revision

The East Branch Perkiomen Creek HEC-RAS hydraulic model was revised to reflect existing conditions hydrology (Reference 91).

March 16, 2015, Revision

For the Delaware River, cross sections were obtained from two-foot contour data developed from Light Detection and Ranging (LiDAR) data collected in spring 2008. Below-water sections were obtained by field surveys. All bridges, wing dams, and miscellaneous structures were field surveyed to obtain elevation data and structural geometry. As-built drawings provided by the DRJTBC were utilized to supplement survey data where needed. Water-surface elevations for floods of the selected recurrence intervals were computed through use of the USACE HEC-RAS 4.0 step-backwater computer program (Reference 95). The HEC-RAS model was calibrated to the recorded high water mark elevations from the flood event of April 2005 (Reference 96). The Manning’s "n" values were adjusted within reasonable parameters so that the computed water surface elevations generally matched the recorded high water marks. Comparisons were made with high water mark elevations collected for floods of August 1955 and June 2006. The results were within acceptable limits. The Delaware River remains under tidal influence downstream from its mouth to approximately 600 feet downstream of U.S. Route 1 in the Borough of Morrisville (The corresponding community on the New Jersey side of the river is the City of Trenton). Starting water-surface elevations were set per tidal conditions established in the Bucks County FIS (Reference 97) and per NJDEP Delineation of Floodway & Flood Hazard Area Maps for the City of Trenton (References 98 and 99).

For the Pennypack Creek watershed, which includes Blair Mill Run, Blair Mill Run Tributary, and Southampton Creek in Bucks County, Temple University used HEC-RAS to perform the hydraulic analyses at the subbasin level. The Manning's "n" values were assigned from 24 categories based on the land use data obtained from DVPRC.

Tributary No. 2 of Martins Creek is a perched stream with a limited drainage area of approximately 0.4 square mile. The 1– percent annual chance discharge is expected to be in the range of 200-350 cfs. The channel capacity in the upstream section of North Park Drive is approximately 200 cfs, resulting in discharge overtopping the channel banks. Once the flow overtops the channel banks it extends into a wide flat floodplain. The flooding source and floodplain were initially analyzed by HEC-RAS which is limited to one dimensional analysis and doesn't account for the lateral distribution of flow across the floodplain. To more closely evaluate the flooding risks for the surrounding neighborhood, a volumetric analysis was performed on the watershed. The resultant flood depths average 0.1 foot across the floodplain. Due to the small drainage area and minimal depths, this stream is mapped as Shaded Zone X: "areas of 1– percent annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile".

For streams studied by approximate methods, HEC-RAS hydraulic models were generated in an automated environment. The water-surface elevations determined by the HEC-RAS models were then utilized to plot the 1– percent annual chance floodplain boundaries. The aforementioned HEC-RAS models do not include hydraulic structure data. Water surface profiles were computed using HEC-RAS steady state simulation. HEC-RAS applies a peak discharge at each cross section to determine a maximum water surface elevation. The elevations are calculated using the standard step method and the energy, continuity, and Manning equations. A subcritical flow regime was assumed for all reaches. Conservative Manning's n-values were applied in the HEC-RAS model.

March 21, 2017 Revision

Hydraulic analyses were completed for Black Ditch, Cooks Run, Croydon Run, Croydon Tributary, Ironworks Creek, Lahaska Creek, Martins Creek, Mill Creek No.1, Newtown Creek, North Branch Neshaminy Creek, Tributary D to Delaware River, Tributary No.1 of Martins Creek, Tributary No. 3 of Martins Creek, Tributary to West Branch Neshaminy Creek, and West Branch Neshaminy Creek. The analyses consisted of using the updated topography of the overbank data from PAMAP LiDAR, and using field reconnaissance data for the channel and structures. The analyses also consisted of determining WSELs for the 10-, 2-, 1- and 0.2-percent-annual-chance flood events and floodway computation for the streams studied by updated detail analysis.

For the hydraulic simulations of updated detailed studies, all structures were assumed to remain fully functional and have unobstructed flows. A split flow analysis was performed on Lahaska Creek and an unsteady analysis was performed on Martins Creek. Additional details for these analysis can be found in the exceptions and special problems section of the Hydraulics Report.

HEC-RAS Version 4.1 was used for the hydraulic analysis. GeoRAS Version 10 for ArcGIS 10 was used to generate the required geometry file from the terrain. GeoTerrain, a RAMPP in-house toolset, was used to generate the 3-D elevations from the terrain. Check-RAS Version 2.0.1beta was used to verify the models.

An Environmental Systems Research Institute (ESRI) Terrain dataset was created from the PAMAP LiDAR. Terrain is a technology developed by ESRI that provides an efficient methodology for working with huge volumes of data. It organizes the measurements into a logical order of varying resolutions and vertical tolerances, and the result is a single dataset that can rapidly deploy and visualize Triangular Irregular Network (TIN)-based surfaces at multiple scales. Based on the pyramid level of details and z-tolerance, Terrain can be viewed as TIN in ArcGIS. The multi-point LAS files containing the LiDAR data were used to build the Terrain dataset. All the elevations were referenced to NAVD 88.

Field reconnaissance was done on all streams to determine conditions along the floodplain, types and numbers of hydraulic and flood control structures. Limited detailed field measurements were collected at 165 in-line structures. Measurements included rod height to channel invert, deck/rail height, hydraulic length, and structure opening width or culvert size and shape. Invert elevations were taken at the upstream and downstream face of the structure. Channel dimensions were also taken just upstream of the abutments at each structure that included channel invert and bank elevations, bottom width, and top bank width.

The delineation of the main channel was accomplished using PAMAP contour data and the 2008 aerial photographs for Bucks County. The streamline was digitized in a Geographic Information System (GIS) platform by digitizing along the contours and verifying from the aerial photography.

Hydraulic cross sections were cut from the Terrain dataset for the HEC-RAS hydraulic model for all the streams studied. Generally, Terrain was the source of overbank topography and field reconnaissance data was used for underwater sections at cross sections and at the upstream and downstream face of the structure. For the sections between the structures, the channel portion was obtained by interpolating channel depth of upstream and downstream bounding structures, and the overbank topography was obtained from the Terrain dataset.

There is a non-accredited levee along Mill Creek No. 1. The levee at the Dow Chemical property (formerly Rohm & Haas) was deaccredited on January 31, 2014. The levee was modeled using the Natural Valley Approach, where the structure is reflected in the hydraulic cross sections, but is not reflected as holding water in.

An Unsteady Analysis was conducted for Tributary No. 1 of Martins Creek. This greatly reduced the size of the SFHA by allowing the hydraulic model to take into account the storage contained in the channel itself. A 500-year analysis was run for this flooding source. However, the 0.2-percent annual chance floodplain is almost coincident with the 1-percent annual chance floodplain and is not shown on the FIRM panel. On the profile, only a single profile is shown for the 1-percent annual chance flood elevation.

Normal depth at the confluence based on uniform flow conditions was used for all the models. Often, the downstream boundary condition for a revised flooding source is another river or stream. At a confluence of two flooding sources, the higher BFE will control regulatory BFEs.

The reduced conveyance due to structure crossings is reflected in the HEC-RAS model by defining ineffective flow areas for the cross sections immediately upstream and downstream of the structures. The stationing and elevation of the ineffective flow areas were based on the HEC-RAS Applications Guide (USACE, 2010).

The channel and overbank "n" values for the streams studied by detailed methods are shown in Table 6, "Manning's 'n' Values."

TABLE 6- MANNING'S "n" VALUES

Stream	Channel "n"	Overbank "n"
Aquetong Creek	0.040	0.100
Beaver Run	0.040-0.050	0.040-0.100
Black Ditch	0.040-0.050	0.030-0.120
Blair Mill Run	0.020-0.100	0.020-0.100
Blair Mill Run Tributary	0.020-0.100	0.020-0.100
Brock Creek	0.040	0.100
Buck Creek	0.040-0.060	0.100
Cabin Run	0.030-0.045	0.025-0.070
Cafferty Run	0.030-0.050	0.070-0.080
Cafferty Run Tributary	0.030-0.050	0.070-0.080
Chubb Run	0.035-0.04	0.05-0.10
Cooks Creek	*	*
Cooks Run	0.035-0.045	0.030-0.120
Coppernose Run	*	*
Core Creek	0.040	0.030-0.065
Croydon Run	0.030-0.050	0.030-0.120
Croydon Tributary	0.040	0.030-0.120

* Data not available

TABLE 6- MANNING'S “n” VALUES (continued)

Stream	Channel "n"	Overbank "n"
Cuttalossa Creek	*	*
Deep Run	0.035-0.045	0.030-0.700
Delaware River	0.020-0.100	0.035-0.100
East Branch Perkiomen Creek	0.04-0.05	0.045-0.13
Gallows Run	0.035-0.045	0.080-0.100
Gallows Run Tributary No. 1	0.035-0.045	0.080-0.100
Gallows Run Tributary No. 2	0.035-0.045	0.080-0.100
Geddes Run	0.030-0.060	0.070-0.080
Geddes Run Tributary	0.045-0.050	0.075
Haycock Creek	0.035-0.060	0.030-0.090
Hough's Creek	0.035-0.040	0.100
Ironworks Creek	0.035-0.050	0.030-0.120
Jericho Creek	0.030-0.040	0.100
Kimples Creek	0.020-0.050	0.035-0.090
Lahaska Creek	0.040-0.050	0.050-0.120
Licking Creek	0.040-0.060	0.080-0.090
Licking Creek Tributary No. 1	0.024-0.060	0.080-0.090
Little Neshaminy Creek	0.040-0.050	0.050-0.130
Tributary to Little Neshaminy Creek	0.040-0.050	0.010-0.150
Martins Creek	0.036-0.045	0.040-0.120
Mill Creek No. 1	0.040-0.042	0.030-0.120
Mill Creek No. 2	0.040-0.080	0.030-0.080
Mill Creek No. 3	0.040-0.080	0.030-0.080
Mill Creek No. 4	0.040-0.080	0.030-0.080
Morgan Creek	0.040-0.050	0.040-0.110
Neshaminy Creek	0.035-0.100	0.025-0.100
Neshaminy Creek Tributary	0.035-0.050	0.030-0.150
Newtown Creek	0.040	0.030-0.120
North Branch Neshaminy Creek	0.040	0.030-0.120
Park Creek	0.045	0.090
Paunacussing Creek	*	*
Paunacussing Creek Tributary No. 1	*	*
Paunacussing Creek Tributary No. 2	*	*
Pidcock Creek	0.035-0.040	0.070-0.100
Pine Run No. 1	0.040-0.070	0.080-0.150
Pine Run No. 2	0.040-0.070	0.080-0.150
Pleasant Spring Creek	0.022-0.075	0.030-0.080
Poquessing Creek	0.035-0.045	0.050-0.120
Poquessing Creek Tributary No. 1	0.035-0.045	0.050-0.120
Poquessing Creek Tributary No. 2	*	*
Poquessing Creek Tributary No. 3	*	*
Primrose Creek	*	*
Primrose Creek Tributary No. 1	*	*

* Data not available

TABLE 6- MANNING'S “n” VALUES (continued)

Stream	Channel "n"	Overbank "n"
Queen Anne Creek	0.070-0.080	0.035-0.070
Queen Anne Creek (Newportville)	0.060	0.035-0.060
Rabbit Run	*	*
Railroad Creek	0.040	0.150
Ridge Valley Creek	0.030-0.065	0.060-0.150
Robin Run	0.035-0.040	0.070-0.100
Rock Run	0.015-0.042	0.090-0.100
Rock Run Tributary	0.040	0.100-0.120
Silver Creek No. 1	0.040-0.045	0.100
Silver Creek No. 2	0.040-0.045	0.100
Southampton Creek	0.020-0.100	0.020-0.100
Three Mile Run	0.040	0.100
Tohickon Creek	0.035	0.070-0.100
Tributary A to Little Neshaminy Creek	0.035-0.050	0.065-0.150
Tributary A to Neshaminy Creek	0.040-0.050	0.050-0.130
Tributary B to Little Neshaminy Creek	0.015-0.050	0.060-0.090
Tributary D to Delaware River	0.045-0.047	0.040-0.120
Tributary D to Neshaminy Creek	0.035-0.050	0.065-0.150
Tributary No. 1 to Lahaska Creek	0.035-0.040	0.070-0.100
Tributary No. 1 of Martins Creek	0.040-0.045	0.030-0.120
Tributary No. 1 of Queen Anne Creek	0.035	0.090-0.100
Tributary No. 1 to Three Mile Run	0.040	0.040-0.100
Tributary No. 1 to Tributary B to Little Neshaminy Creek	0.035	0.065
Tributary No. 2 to Lahaska Creek	0.035-0.040	0.070-0.100
Tributary No. 2 of Queen Anne Creek	0.035	0.100
Tributary No. 3 of Martins Creek	0.040	0.030-0.120
Tributary to Ironworks Creek	0.040-0.050	0.050-0.130
Tributary to West Branch Neshaminy Creek	0.030-0.045	0.030-0.120
Unami Creek	0.035-0.050	0.050-0.100
Watson Creek	0.035-0.040	0.070-0.100
West Branch Neshaminy Creek	0.038-0.040	0.030-0.120

*Data not available

This entire study was updated to the North American Vertical Datum of 1988 (NAVD 88).

All qualifying benchmarks within a given jurisdiction that are catalogued 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.

Benchmarks 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 (e.g., mounted in bedrock)
- Stability B: Monuments which generally hold their position/elevation (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 benchmarks, 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 benchmarks 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 the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

3.3 Coastal Analyses

Coastal analysis, considering storm characteristics and the shoreline and bathymetric characteristics of the flooding sources studied, were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along the shoreline. Users of the FIRM should be aware that coastal flood elevations are provided in Table 7, “Summary of Coastal Stillwater Elevations”, in this report. If the elevation on the FIRM is higher than the elevation shown in this table, a wave height, wave runup, and/or wave setup component likely exists, in which case, the higher elevation should be used for construction and/or floodplain management purposes.

Development is extensive along the entire Delaware River shoreline within Bucks County. Shoreline development includes residential and industrial areas, as well as parkland and historic sites. Elevations vary from sea level to approximately twenty feet NAVD, with higher elevations progressing inland. Behind the shoreline, development continues with extensive high density residential areas and manufacturing sites.

For this revision, an analysis was performed to establish the frequency peak elevation relationships for coastal flooding in Bucks County. The Federal Emergency Management Agency (FEMA), Region III office, initiated a study in 2008 to update the coastal storm surge elevations within the states of Virginia, Maryland, Pennsylvania, and Delaware, and the District of Columbia, including the Atlantic Ocean, Chesapeake Bay and its tributaries, Delaware Bay, and tidal portions of the Delaware River. The study replaces outdated coastal storm surge stillwater elevations for all FISs in the study area, including Bucks County, PA, and serves as the basis for updated FIRMs. Study efforts were initiated in 2008 and concluded in 2013.

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. 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, Hurricane Ernesto, and Extratropical Storm Ida. Model skill was accessed by quantitative comparison of model output to wind, wave, water-level and high water mark observations.

The static tidal surge for the Delaware Bay is mapped up to cross section “T”. From “T” to the railroad bridge above cross section “AC” the tidal profiles developed for the previous FIS are maintained.

The storm-surge elevations for the 10-, 50-, 100-, and 500-year floods were determined for the Delaware River and are shown in Table 7, “Summary of Coastal Stillwater Elevations.” The analyses reported herein reflect the stillwater elevations due to tidal and wind setup effects.

TABLE 7 - SUMMARY OF COASTAL STILLWATER ELEVATIONS

FLOODINGSOURCE AND LOCATION	ELEVATION (feet NAVD*) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
DELAWARE RIVER				
At confluence of Poquessing Creek	8.6	10.0	10.7	13.2
At confluence of Neshaminy Creek	8.9	10.4	11.2	13.8
At confluence of Mill Creek No. 1	9.1	10.7	11.6	14.2

*North American Vertical Datum of 1988

Wave heights were not computed for riverfront areas of Bucks County.

The coastal analysis involved transect layout, field reconnaissance, erosion analysis, and overland wave modeling including wave setup, wave height analysis and wave runup. Because of the upstream location of Bucks County, the coastal analysis was limited to revised stillwater elevations, for those areas of the Delaware River shoreline of the county, southeast of the Conrail crossing. Revised flood profiles were not developed for the tidal reach, therefore flood profiles start at cross section "T" from the previous analyses.

3.4 Vertical Datum

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 (NGVD 29). With the completion of the North American Vertical Datum of 1988 (NAVD 88), many FIS reports and FIRMs are now prepared using NAVD 88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD 88. Structure and ground elevations in the community must, therefore, be referenced to NAVD 88. In order to perform this conversion from NGVD29 to NAVD88, effective NGVD 29 elevation values should be adjusted downward by 0.91 foot. It is important to note that adjacent communities may be referenced to NGVD 29. This may result in differences in base flood elevations across the corporate limits between the communities.

For more information on NAVD 88, see Converting the National Flood Insurance Program to the North American Vertical Datum of 1988, FEMA

Publication FIA-20/June 1992, or contact the National Geodetic Survey at the following address:

Spatial Reference System Division
National Geodetic Survey, NOAA
Silver Spring Metro Center 3
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3242
http://www.ngs.noaa.gov/

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

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

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2- percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the county. For the streams studied in detail, the 1- and 0.2- percent annual chance floodplain boundaries have been determined at each cross section. The delineations are based on the best available topographic information.

For the May 18, 1999, countywide FIS, the floodplain boundaries for the Delaware River were interpolated between cross sections using the DTM and DFMAP, an ARC/INFO software information application (References 41 and 53). For Beaver Run, Licking Creek, and Tohickon Creek, SFHAs were delineated using topographic mapping at a scale of 1"=50, and a 2-foot contour interval (Reference 51).

For the June 20, 2001, revision, floodplain boundaries were interpolated between sections using the aforementioned DTM and DFMAP, an ARC/INFO software application (Reference 53).

For the April 2, 2002, revision, floodplain boundaries between cross sections were mapped according to the water-surface elevation (Reference 53).

For the September 3, 2003, revision, floodplain boundaries between cross sections were mapped according to the water-surface elevation using DTM and DFMAP, an ArcInfo software application (Reference 41 and 53).

For the April 2, 2004, revision, floodplain boundaries were interpolated between cross sections using the DTM for East Branch and Main Stem Perkiomen Creek (Reference 47). For the streams studied by approximate methods, the 1-percent annual chance floodplain boundaries were delineated using the effective FIRMs for the communities within Bucks County.

For the March 16, 2015, revision, the 1- percent and 0.2- percent annual chance floodplain boundaries were delineated based on the 5-ft contour data provided by DVRPC and shown on the FIRM, with the exception of Delaware River floodplains. Floodplains for the Delaware River were delineated on 2-ft contour data provided by PAMAP. On this map, the 1-percent annual chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE), and the 0.2- percent annual chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- percent 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.

Approximate studies were performed for streams that were not previously studied by detailed methods. For the streams studied by approximate methods, only the 1 percent annual chance floodplain boundary is shown on the FIRM. The floodplain boundaries were delineated to water-surface elevations on the 5-ft contour dataset obtained from DVRPC. However, if the drainage area of a stream is less than one square mile, it is considered a local drainage issue and not within the typical NFIP scope. The decision by FEMA is that if the floodplain of such a stream is consistently narrower than 200 feet, it should not be mapped.

For the March 21, 2017 revision, the floodplain boundaries for the restudied flooding sources were mapped using LiDAR data obtained from PAMAP. An ESRI Terrain dataset was created from the PAMAP LiDAR data.

Within this jurisdiction there is one levee that has not been demonstrated by the community or levee owner(s) to meet the requirements of 44 CFR Part 65.10 of the NFIP regulations as it relates to the levee's capacity to provide 1-percent annual chance flood protection. This levee near the mouth of Mill Creek No. 1 has been de-accredited and the SFHA has been mapped to reflect this deaccreditation.

4.2 Floodways

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

The floodways presented in this FIS were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 8 in Volume 2 of this report). The computed floodways are shown on the FIRM. In cases where the floodway and 1 percent annual chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown. Portions of the floodway widths for the Delaware River, Poquessing Creek, and Ridge Valley Creek extend beyond the county boundary.

Floodways were not computed for Chubb Run, Croydon Run, the portion of Delaware River under tidal influence, Pine Run No. 1, Primrose Creek No. 1, a portion of Tributary D to Delaware River, and Tributary No. 1 of Martins Creek.

The floodway for East Branch Perkiomen Creek was computed using the HEC-RAS standard step-backwater computer program, utilizing the equal conveyance reduction method. The results of these computations are tabulated in detail at selected cross sections in Table 8, “Floodway Data” presented in Volume 2 of this report.

For the March 16, 2015, revision, a Delaware River study performed for counties in New Jersey was incorporated. As a requirement of NJDEP, a floodway based on 0.2 foot encroachment was computed for the Delaware River. In addition to the standard floodway data, information on the 0.2 ft encroachment floodway is presented in Table 8, “Floodway Data”, in the form of “Width within Bucks County (0.2 ft encroachment)”. Should any community decide to adopt a more stringent regulation standard, the boundary of the 0.2 ft encroachment floodway can be determined at each cross section by measuring from the county boundary along the cross section on the FIRM. Please note there are “holes” in the floodway at some locations. While the 1.0 ft encroachment floodway width listed in Table 8 does not include the “holes”, the 0.2 ft encroachment floodway width is computed with the “holes” filled, so that the outmost boundary of the 0.2 ft encroachment floodway can be determined for regulation purposes. Cross sections that go through “holes” in the 0.2 ft encroachment floodway are marked out by a footnote in Table 8. Digital files showing the 0.2 ft encroachment floodway can be obtained through FEMA.

The Delaware River is affected by tidal influence from the most downstream community within Bucks County to a point within the Borough of Morrisville (approximately 600 feet downstream of U.S. Route 1) where regulatory Base Flood Elevations were taken from tide frequency stages at tidal gages. Therefore, the downstream limit of floodway begins in the Borough of Morrisville and extends to the upstream county boundary.

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 8 for certain downstream cross sections of Aquetong Creek, Black Ditch, Brock Creek, Cafferty Run, Croydon Tributary, Cuttalossa Creek, Gallows Run, Haycock Creek, Hough's Creek, Ironworks Creek, Jericho Creek, Kimples Creek, Mill Creek No. 4, Morgan Creek, Martins Creek, Mill Creek No. 1, Neshaminy Creek, North Branch Neshaminy Creek, Paunacussing Creek, Pine Run No. 2, Poquessing Creek, Queen Anne Creek, Railroad Creek, Tohickon Creek, Tributary A to Little Neshaminy Creek, Tributary A to Neshaminy Creek, Tributary B to Little Neshaminy Creek, and Tributary No. 1 to Three Mile Run are lower than the regulatory flood elevations in that area, which must take into account the 1 percent annual chance flooding due to backwater from other sources.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage, and heightens potential flood hazards by further increasing velocities. A listing of stream velocities at selected cross sections is provided in Table 8. In order to reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

The area between the floodway and 1- percent annual chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1 percent annual chance flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2.

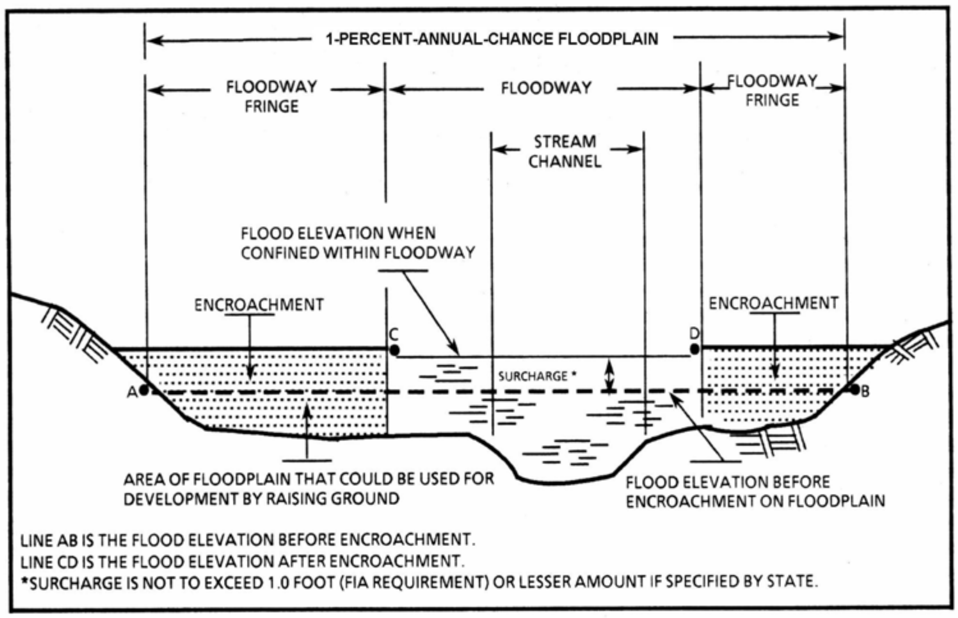


FIGURE 2 - FLOODWAY SCHEMATIC