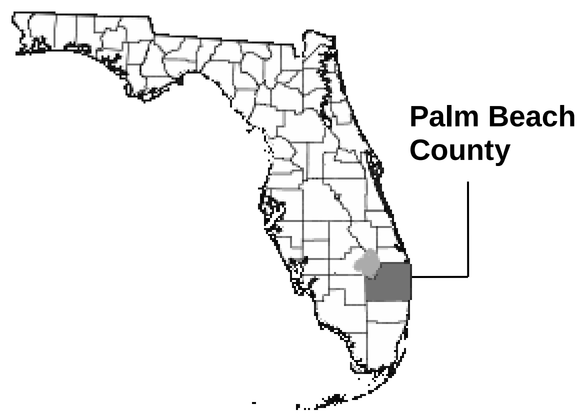
FLOOD INSURANCE STUDY

PALM BEACH COUNTY, FLORIDA
AND INCORPORATED AREAS



Community Name	Community Number
PALM BEACH COUNTY (UNINCORPORATED AREAS)	120192
ATLANTIS, CITY OF	120193
BELLE GLADE, CITY OF	120194
BOCA RATON, CITY OF	120195
BOYNTON BEACH, CITY OF	120196
BRINY BREEZES, TOWN OF	120197
CLOUD LAKE, TOWN OF	120198
DELRAY BEACH, CITY OF	125102
GLEN RIDGE, TOWN OF	120200
GOLF, VILLAGE OF	120201
GREENACRES, CITY OF	120203
GULF STREAM, TOWN OF	125109
HAVERHILL, TOWN OF	120205
HIGHLAND BEACH, TOWN OF	125111
HYPOLUXO, TOWN OF	120207
JUNO BEACH, TOWN OF	120208
JUPITER, TOWN OF	125119
JUPITER INLET COLONY, TOWN OF	125120
LAKE CLARKE SHORES, TOWN OF	120211
LAKE PARK, TOWN OF	120212
LAKE WORTH, CITY OF	120213
LANTANA, TOWN OF	120214
LOXAHATCHEE GROVES, TOWN OF	120309
MANALAPAN, TOWN OF	120215
MANGONIA PARK, TOWN OF	120216
NORTH PALM BEACH, VILLAGE OF	120217
OCEAN RIDGE, TOWN OF	125134
PAHOKEE, CITY OF	120219
PALM BEACH, TOWN OF	120220
PALM BEACH GARDENS, CITY OF	120221
PALM BEACH SHORES, TOWN OF	125137
PALM SPRINGS, VILLAGE OF	120223
RIVIERA BEACH, CITY OF	125142
ROYAL PALM BEACH, VILLAGE OF	120225
SOUTH BAY, CITY OF	120226
SOUTH PALM BEACH, TOWN OF	120227
TEQUESTA, VILLAGE OF	120228
WELLINGTON, VILLAGE OF	125157
WEST PALM BEACH, CITY OF	120229

EFFECTIVE:
October 5, 2017

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
12099CV000A

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 may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Selected Flood Insurance Rate Map panels for the community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways, cross sections). In addition, former flood hazard zone designations have been changed as follows:

Old Zone	New Zone
A1 through A30	AE
V1 through V30	VE
B	X
C	X

Part or all of this FIS may be revised and republished at any time. In addition, part of this Flood Insurance Study 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: October 5, 2017

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FLOOD INSURANCE STUDY

PALM BEACH COUNTY, FLORIDA AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Palm Beach County, Florida including the Cities of Atlantis, Belle Glade, Boca Raton, Boynton Beach, Delray Beach, Greenacres, Lake Worth, Pahokee, Palm Beach Gardens, Riviera Beach, South Bay, and West Palm Beach; the Towns of Briny Breezes, Cloud Lake, Glen Ridge, Gulf Stream, Haverhill, Highland Beach, Hypoluxo, Juno Beach, Jupiter, Jupiter Inlet Colony, Lake Clarke Shores, Lake Park, Lantana, Loxahatchee Groves, Manalapan, Mangonia Park, Ocean Ridge, Palm Beach, Palm Beach Shores, and South Palm Beach; the Villages of Golf, North Palm Beach, Palm Springs, Royal Palm Beach, Tequesta, and Wellington; and the unincorporated areas of Palm Beach County (referred to collectively herein as Palm Beach County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

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

The Digital Flood Insurance Rate Map (DFIRM) and FIS Report for this countywide study have been produced in digital format. Flood hazard information was converted to meet the Federal Emergency Management Agency (FEMA) DFIRM database specifications and geographic information standards and is provided in a digital format so that it can be incorporated into a local Geographic Information System (GIS) and be accessed more easily by the community.

1.2 Authority and Acknowledgments

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

This update combines all communities (References 1-10), as well as the unincorporated areas of Palm Beach County (Reference 11), into a countywide FIS, as compiled from previously published FIS narratives (References 1-11). In addition to previously published FIS reports, this study incorporates wave action studies associated with flooding from the Intracoastal Waterway (including Jupiter Sound), Loxahatchee River (including the North, Northwest, and Southwest Forks), North Palm Beach Waterway, Lake Okeechobee, Little Lake Worth, Lake Worth, and the Atlantic Ocean at the open coast (References 12-32). This study also incorporates flooding sources studied by detailed methods by Engineering Methods and Applications for the 2000 countywide FIS that was not published (Reference 33).

Engineering Methods & Applications, Inc. (EMA), was contracted by FEMA to perform a coastal flood study and wave height analyses as well as a riverine hydrologic and hydraulic analysis for Palm Beach County, under Contract No. EMW-94-C-4392. EMA also subcontracted DeGrove Surveyors, Inc. EMA's work was completed by May of 1996. Revised hydrologic analyses for the C-51 Canal were performed by BPC Group Inc. on behalf of K-F Group, Inc. for Palm Beach County. This work was completed by June 2004. Revised hydrologic analyses for Keller Canal, Lake Osborne, L-14 Canal and L-16 Canal were performed by Dewberry and Davis LLC under contract to FEMA. All work was completed by May of 2005.

For this countywide FIS, new and revised hydrologic and hydraulic analyses were prepared by South Florida Water Management District (SFWMD) and the City of Boca Raton. These analyses were completed in May 2015.

Collective Water Resources performed an engineering analysis of the C-51 Basin study, created by South Florida Water Management District (SFWMD), and provided the floodplains and Base Flood Elevations used in this FIS study.

Tomasello Consulting Engineers, Inc. performed an engineering analysis of the E-2E/E-3/E-4 Basin study for the City of Boca Raton and provided the cross sections, profiles, floodplains, and Base Flood Elevations used in this FIS study.

The following flooding sources were included in the new analyses.

- C-51Canal and Tributaries
- E-3 and E-4 Canal

Table 1, "Summary of Flooding Sources Presented in Current Study," provides a chronological summary of the most recent analyses of flooding sources studied within Palm Beach County, the contract number under which they were performed (if known), and the communities affected by each.

**Table 1: Summary of Flooding Sources
Presented in Current Study**

Flooding Source	Completion Date	Study Contractor(s)	Contract or Inter-Agency Agreement No.	Communities Affected
Atlantic Ocean/ Intracoastal Waterway (Wave Height Analysis)	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas, Belle Glade, Boynton Beach, Briny Breezes, Delray Beach, Gulf Stream, Highland Beach, Juno Beach, Jupiter, Jupiter Inlet Colony, Lake Worth, Lantana, Manalapan, N. Palm Beach, Ocean Ridge, Pahokee, Palm Beach (Town), Palm Beach Shores, Riviera, S. Palm Beach, Tequesta
Atlantic Ocean/ Intracoastal Waterway (Coastal Stillwater)	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Backwater Tributaries 1, 2, 3, and 4	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Backwater 1	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
C-15 Canal Subbasin	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
C-16 Canal Subbasin	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
C-17 Canal Subbasin	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
C-18 Canal Subbasin	January 1988	Mock, Roos and Associates, Inc.	H-3839	Palm Beach Gardens

Table 1: Summary of Flooding Sources
Presented in Current Study (continued)

Flooding Source	Completion Date	Study Contractor(s)	Contract or Inter-Agency Agreement No.	Communities Affected
C-51	May 2015	SFWMD		Palm Beach Co., Uninc. Areas, Cloud Lake, Glen Ridge, Greenacres, Haverhill, Lake Clarke Shores, Lake Worth, Loxahatchee Groves, Palm Springs, Royal Palm Springs, Wellington, West Palm Beach
C-51	June 2004	BPC Group Inc.		Palm Beach Co., Uninc. Areas, Cloud Lake, Glen Ridge, Greenacres, Haverhill, Lake Clarke Shores, Lake Worth, Loxahatchee Groves, Palm Springs, Royal Palm Springs, Wellington, West Palm Beach
C-51	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
E-3 Canal	February 2014	Mock Roos and Associates, Inc.		Palm Beach Co., Uninc. Areas, Boca Raton
E-3 Canal	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas
E-3 Canal	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
E-4 Canal	February 2014	Mock Roos and Associates, Inc.		Palm Beach Co., Uninc. Areas, Boca Raton
E-4 Canal	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas

Table 1: Summary of Flooding Sources Presented in Current Study (continued)

Flooding Source	Completion Date	Study Contractor(s)	Contract or Inter-Agency Agreement No.	Communities Affected
E-4 Canal	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
E-4 Canal	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Hillsboro Canal	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
Hillsboro Canal	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Intracoastal Waterway	April 1982	Tetra Tech, Inc.[1]	H-3839	Palm Beach Co., Uninc. Areas, Belle Glade, Boynton Beach, Briny Breezes, Delray Beach, Gulf Stream, Highland Beach, Juno Beach, Jupiter, Jupiter Inlet Colony, Lake Worth, Lantana, Manalapan, N. Palm Beach, Ocean Ridge, Pahokee, Palm Beach (Town), Palm Beach Shores, Riviera, S. Palm Beach, Tequesta
Intracoastal Waterway	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Jupiter Creek	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas
Jupiter Creek	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
Keller Canal	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas
Keller Canal	May 2005	Dewberry & Davis, Inc.		Palm Beach Co., Uninc. Areas

[1]Analyses performed by Tetra Tech, Inc., reported in August 1978 FIS Report for Palm Beach County Unincorporated Areas

Table 1: Summary of Flooding Sources Presented in Current Study (continued)

Flooding Source	Completion Date	Study Contractor(s)	Contract or Inter-Agency Agreement No.	Communities Affected
Keller Canal	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
L-14 Canal	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas
L-14 Canal	May 2005	Dewberry & Davis, Inc.		Palm Beach Co., Uninc. Areas
L-14 Canal	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
L-16 Canal	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas
L-16 Canal	May 2005	Dewberry & Davis, Inc.		Palm Beach Co., Uninc. Areas
L-16 Canal	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
Lake Ida Canal and Tributaries	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
Lake Okeechobee (Dam Breach Analysis)	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas
Lake Okeechobee	April 1982	Tetra Tech, Inc.[1]	H-3839	Palm Beach Co., Uninc. Areas, Belle Glade, Pahokee,
Lake Okeechobee	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas, Belle Glade, Pahokee
Lake Osborne and Tributaries	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas
Lake Osborne and Tributaries	May 2005	Dewberry & Davis, Inc.		Palm Beach Co., Uninc. Areas

[1]Analyses performed by Tetra Tech, Inc., reported in August 1978 FIS Report for Palm Beach County Unincorporated Areas

Table 1: Summary of Flooding Sources Presented in Current Study (continued)

Flooding Source	Completion Date	Study Contractor(s)	Contract or Inter-Agency Agreement No.	Communities Affected
Lake Osborne and Tributaries	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
Lake Worth	April 1982	Tetra Tech, Inc.[1]	H-3839	Palm Beach Co., Uninc. Areas, Boynton Beach, Palm Beach Gardens
Lake Worth	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Little Lake Worth	April 1982	Tetra Tech, Inc.[1]	H-3839	Palm Beach Co., Uninc. Areas
Little Lake Worth	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Loxahatchee River	April 1982	Tetra Tech, Inc.[1]	H-3839	Palm Beach Co., Uninc. Areas, Jupiter, Jupiter Inlet Colony,
Loxahatchee River	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
North Fork Loxahatchee River	April 1982	Tetra Tech, Inc.[1]	H-3839	Palm Beach Co., Uninc. Areas
North Fork Loxahatchee River	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
North Palm Beach Waterway	April 1982	Tetra Tech, Inc.[1]	H-3839	Palm Beach Co., Uninc. Areas
North Palm Beach Waterway	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Northwest Fork Loxahatchee River	April 1982	Tetra Tech, Inc.[1]	H-3839	Palm Beach Co., Uninc. Areas

[1]Analyses performed by Tetra Tech, Inc., reported in August 1978 FIS Report for Palm Beach County Unincorporated Areas

Table 1: Summary of Flooding Sources Presented in Current Study (continued)

Flooding Source	Completion Date	Study Contractor(s)	Contract or Inter-Agency Agreement No.	Communities Affected
Northwest Fork Loxahatchee River	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Rainfall ponding and shallow sheet flow	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
Rainfall ponding and shallow sheet flow	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Southwest Fork Loxahatchee River and Tributaries	April 1982	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Southwest Fork Loxahatchee River and Tributaries	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
C-5 Canal and Tributaries	September 2012	Watershed IV Alliance	EMA-2002-CO-0011A	Palm Beach Co., Uninc. Areas
C-51 Canal and Tributaries	May 1996	Engineering Methods & Applications	EMW-94-C-4392	Palm Beach Co., Uninc. Areas
C-51 Canal	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas
Various unnamed streams	May 1996	Engineering Methods & Applications	EMW-94-C-4392	All
Various unnamed streams	May 1977	Tetra Tech, Inc.	H-3839	Palm Beach Co., Uninc. Areas

Base map information for Palm Beach County and all incorporated communities within Palm Beach County was provided in digital format by Palm Beach County. The original orthophotographic base imagery was provided in color with a one-foot pixel resolution at a scale of 1” = 200’ from photography flown November 2010 - January 2011 (Reference 82).

The coordinate system used for the preparation of this FIRM is Transverse Mercator State Plane Florida East FIPS Zone 0901 Feet. The horizontal datum was North American Datum of 1983 (NAD 83), HARN, Geodetic Reference System of 1980 spheroid. 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.

LiDAR information used for both C-51 modeling and mapping redelineation efforts was flown between 11/24/2007 - 1/29/2008 as part of a National Oceanic and Atmospheric Administration (NOAA) coastal elevation project for the Atlantic and Okeechobee coastlines.

1.3 Coordination

An initial Consultation Coordination Officer (CCO) meeting (also occasionally referred to as the Scoping meeting) is held with representatives of the communities, FEMA, and the study contractors to explain the nature and purpose of the FIS and to identify the streams to be studied by detailed methods. A final CCO (often also referred to as the Preliminary DFIRM Community Coordination, or PDCC, meeting) is held with representatives of the communities, FEMA, and the study contractors to review the results of the study.

For this countywide FIS, the initial CCO meeting was held on September 30, 2008, and attended by representatives of FEMA, Palm Beach County, 19 of the 39 local communities, South Florida Water Management District (SFWMD), Florida Department of Emergency Management, other local government agencies and local engineers, and Watershed IV Alliance.

The final CCO meeting was held on September 8, 2014 to review and accept the results of this FIS. Those who attended this meeting included representatives of SFWMD and Palm Beach County, the Study Contractor, FEMA, and the communities. All problems raised at that meeting have been addressed in this study.

The dates of the historical initial and final CCO meetings held for the communities within the boundaries of Palm Beach County are shown in Table 2, “Historical CCO Meeting Dates.”

Table 2: Historical CCO Meeting Dates

Community Name	Initial CCO Date	Final CCO Date
Atlantis, City of	*	February 14, 1977
Belle Glade, City of	*	June 3, 1977

*Date not available

Table 2: Historical CCO Meeting Dates - continued

Community Name	Initial CCO Date	Final CCO Date
Boca Raton, City of	May 23, 1975	April 4, 1977
Boca Raton, City of (wave height analysis)	*	December 2, 1981
Boynton Beach, City of	*	June 27, 1977
Briny Breezes, Town of	*	June 27, 1977
Cloud Lake, Town of	*	June 29, 1977
Delray Beach, City of	*	*
Glen Ridge, Town of	*	June 30, 1977
Golf, Village of	*	*
Greenacres, City of	*	*
Gulf Stream, Town of	*	*
Haverhill, Town of	*	*
Highland Beach, Town of	*	*
Hypoluxo, Town of	*	June 28, 1977
Juno Beach, Town of	*	June 27, 1977
Jupiter, Town of	*	*
Jupiter Inlet Colony, Town of	*	*
Lake Clarke Shores, Town of	*	February 14, 1977
Lake Park, Town of	*	June 29, 1977
Lake Worth, City of	*	June 28, 1977
Lantana, Town of	*	*
Loxahatchee Groves, Town of	*	*
Manalapan, Town of	*	*
Mangonia Park, Town of	*	February 15, 1977
North Palm Beach, Village of	*	July 26, 1977
Ocean Ridge, Town of	*	*
Pahokee, City of	*	July 1, 1977
Palm Beach, Town of	*	June 29, 1977
Palm Beach County (Unincorporated Areas)	*	July 25, 1977
Palm Beach Gardens, City of	*	June 29, 1977

*Date not available

Table 2: Historical CCO Meeting Dates - continued

Community Name	Initial CCO Date	Final CCO Date
Palm Beach Shores, Town of	*	*
Palm Springs, Village of	*	February 14, 1977
Riviera Beach, City of	*	*
Royal Palm Beach, Village of	*	*
South Bay, City of	*	*
South Palm Beach, Town of	*	June 28, 1977
Tequesta, Village of	*	June 29, 1977
Wellington, Village of	*	*
West Palm Beach, City of	*	July 26, 1977

*Date not available

The authority and acknowledgments for the Town of Haverhill, Cities of Greenacres and South Bay, and Villages of Golf, and Royal Palm Beach are not available because no FIS reports were ever published for these communities.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS report covers the geographic area of Palm Beach County, Florida, including the incorporated communities listed in Section 1.1. The scope and methods of this study were proposed to, and agreed upon, by FEMA, Palm Beach County, and Watershed IV Alliance.

The entire coastline of Palm Beach County was restudied where the major flooding sources are the Atlantic Ocean and Intracoastal Waterway, including Lake Worth, Lake Worth Creek, Lake Boca Raton, and Loxahatchee River.

The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction. The scope and methods of study were proposed to and agreed upon by FEMA and Palm Beach County. The flooding sources studied by detailed methods are presented in Table 3, "Flooding Sources Studied by Detailed Methods."

Table 3: Flooding Sources Studied by Detailed Methods

Flooding Source	Reach Length (miles)	Study Limits
Atlantic Ocean	n/a	Entire coastline

Table 3: Flooding Sources Studied by Detailed Methods - continued

Flooding Source	Reach Length (miles)	Study Limits
C-51 Canal[1]	20.8	From the confluence with Lake Worth/Intracoastal Waterway to a point approximately 3.2 miles upstream of Flying Ranch Road
E-3 Canal[1]	4.5	From the confluence with Hillsboro Canal to Yamato Road Control Structure
E-4 Canal[1]	6.5	From the confluence with Hillsboro Canal to Congress Avenue Control Structure
Hillsboro Canal[1]	4.0	From the confluence with Intracoastal Waterway to a point approximately 1.2 miles upstream of Interstate 95
Intracoastal Waterway	n/a	Entire coastline
Jupiter Creek[1]	1.6	From a point approximately 100 feet downstream of Center Street to Toney Penna Drive
Jupiter Sound (Intracoastal Waterway)	n/a	Entire coastline
Keller Canal[1]	2.8	From the confluence with C-51 Canal to the confluence with Lake Osborne
L-14 Canal[1]	2.2	From the confluence with Lake Osborne to Military Trail
L-16 Canal[1]	2.2	From the confluence with Lake Osborne to Lantana Road
Lake Boca Raton (Intracoastal Waterway)	n/a	Entire coastline
Lake Okeechobee	n/a	Entire coastline
Lake Osborne[1]	3.1	From the confluence with Keller Canal to Hypoluxo Road
Lake Worth (Intracoastal Waterway)	n/a	Entire coastline
Lake Worth Creek	n/a	Entire coastline
Lake Wyman (Intracoastal Waterway)	n/a	Entire coastline
Loxahatchee River	n/a	Entire coastline

[1] Flooding source with new or revised analyses incorporated as part of the current study update

Numerous streams were studied by approximate methods, as indicated in Table 4, "Flooding Sources Studied by Approximate Methods." Approximate analyses were used to study those areas having a low development potential or minimal flood hazards.

Table 4: Flooding Sources Studied by Approximate Methods

Flooding Source	Reach Length (miles)	Study Limits
Various Zone A *	6.0	Palm Beach County

* Flooding source with new or revised analyses incorporated as part of the current study update

Table 5, "Letter of Map Revision (LOMRs) Incorporated into Current Study," lists the appropriate Letters of Map Revision within Palm Beach County and Incorporated Areas which have been incorporated into the revised FIRMs.

Table 5: Letters of Map Revision (LOMRs) Incorporated into Current Study

Case Number	Flooding Source(s)	Communities Affected	Effective Date
97-04-1554P	Canal 25, Canal 26, and Canal E-3	Palm Beach County	9/17/1998

Floodplain boundaries for all flooding sources within the study area have been mapped based upon the most up-to-date topographic data available.

2.2 Community Description

Palm Beach County is located on the southeastern Atlantic coast of Florida. Palm Beach County is bordered on the north by Martin County; on the east by the Atlantic Ocean; on the south by Broward County; on the west by Hendry County; and on the northwest by Okeechobee and Glades Counties. The county encompasses an area of 2,386 square miles, with 1,974 square miles of land.

Palm Beach County lies in the subtropical climatic zone with a generally mild and dry season alternating with a warm and rainy season. The rainy season extends from June through October and coincides with the hurricane season. During these months, the county receives nearly two-thirds of its annual precipitation, which varies across Palm Beach County. At the beaches, rainfall is the lowest and averages approximately 45 inches annually (Reference 11). West of the coastal ridge, the average annual rainfall of 62 inches is the highest in the county. From there, the average annual rainfall gradually decreases to approximately 50 inches near the county's western limit. The county's annual temperature averages approximately 75°F.

The topography of Palm Beach County can be divided into three major regions: coastal (including coastal ridge), sandy flatlands, and Everglades. Paralleling the Atlantic Ocean, the coastal ridge extends approximately 3 miles inland in various locations of the county. Elevations in this region range between 25 and 40 feet (Reference 11). The sandy flatlands adjoin the coastal ridge and extend far inland. As its name implies, this region is uniformly flat, varying only from 10 to 15 feet in elevation. The Loxahatchee National Wildlife Refuge, located in the west and southwest region of the county, is part of the Florida Everglades. The refuge covers approximately 221 square miles. The Everglades is characterized by flat, swampy lands, with elevations ranging from only 6 to 14 feet.

Groundwater in Palm Beach County is associated with a shallow unconfined aquifer composed of sands and limestones. The thickness of this aquifer ranges from a maximum of 250 feet near the coast to a minimum of approximately 100 feet near the western boundary of the county. This aquifer is a major source of freshwater for many communities in the county.

The vegetation of the study area is typically subtropical. Along the coast, a variety of palms and trees such as the West Indies mahogany, sapodilla, and lignum vitae flourish in urban areas. The Water Catchment Area, comprising slightly more than one-half of the area of West Palm Beach, is covered primarily by native grasses and brush. The higher regions of the county provide a suitable habitat for pine, saw palmetto, broomgrass, and gallberry, with occasional hammocks of cabbage palm. In the sloughs and ponds, the principal growth consists of sedges, primarily sawgrass and water plants. The predominant plant in the Everglades is sawgrass, which grows with a variety of other plants. Flag, pickerel weed, maidencane, royal ferns, myrtle, willow, and buttonbush coexist in the sawgrass stands. This sawgrass plain is occasionally interspersed with small, green tree islands (hammocks). The predominant trees include willow, red bay, holly, strangler fig, maple, elderberry, cocoplum, custard apple, and groundsel bush.

The major industries in Palm Beach County are tourism, construction and agriculture (Reference 34). About 32 percent of the county land is dedicated to the production of sugar cane. As of 2007, U.S. Census base population for the county was estimated at 1,266,451 (Reference 35). The population of Palm Beach County grew an average of 1.6 percent from July 2000 to July 2007.

The City of West Palm Beach, located in the central and eastern portion of the county, is the county seat and largest city in Palm Beach County. The estimated 2008 population of West Palm Beach and the immediately adjacent Census Designated Places is 134,795. Most of the communities in Palm Beach County lie along the coast and experience a significant gain in population during the winter months. This seasonal influx is not considered in U.S. Bureau of the Census figures.

Palm Beach County includes 45 miles of Atlantic shoreline, but for much of that distance, the mainland is separated from the ocean by barrier beaches and lagoons and other bodies of water. The mainland for the extreme northeastern portion of Palm Beach County is bordered on the east by the Indian River, a part of the Indian River lagoon system. This 156-mile long estuary lies between the mainland and barrier islands from Volusia and Brevard Counties to the north, through Indian River County, and extending south to Palm

Beach County, where it connects to the Atlantic Ocean by Jupiter Inlet. The Atlantic Intracoastal Waterway runs through the Indian River Lagoon for its length.

South of the Indian River lagoon between the Port of Palm Beach (Lake Worth Inlet) and Boynton Beach, the Intracoastal Waterway runs through the Lake Worth lagoon. The Lake Worth lagoon extends approximately 21 miles parallel to the coast, connected to the Atlantic Ocean by the two permanent, man-made inlets.

The Intracoastal Waterway widens at three points within the City of Boca Raton, creating Lake Boca Raton, Lake Wyman, and Lake Rogers. The Atlantic Ocean is connected to the Intracoastal Waterway by the Boca Raton Inlet.

Natural, well-defined drainage channels are apparent only close to the coast where the coastal ridge rises inland from the Atlantic Ocean. This is the only area in Palm Beach County with defined riverine floodplains. The Loxahatchee River serves as the border between Palm Beach County and Martin County to the north. This river flows 7.6 miles to the Atlantic Ocean via Jupiter inlet and includes several large tributaries. The other natural coastal flooding sources included in this study are the Earman River and several backwater tributaries.

The general topography of the interior portions of Palm Beach County is essentially flat and there are no major natural streams. Instead, runoff occurs primarily as overland flow over wide, flat areas; in sloughs; and through man-made canal systems in populated areas. The major canals are managed by the South Florida Water Management District. These canals include the C-51 Canal, Hillsboro Canal, North New River Canal, Miami Canal, and the C-15, C-16, C-17, C-18 and L-8 Canals. The Earman River is the discharge point at various locations for several canals; which include the Bellwood, Gardenia, Lake Catherine, and C-17 Canals, all of which are part of the C-17 Canal Subbasin.

In the populated coastal regions of the county, a system of smaller, or secondary, canals helps transport runoff water into the major canals. These smaller canals are administered by several localized authorities, including the Lake Worth Drainage District, the North Palm Beach Drainage District, and the Acme Drainage District.

The interior area also includes three large lakes: Lake Mangonia (540 acres), Clear Lake (401 acres), and Lake Osborne (356 acres). Lake Mangonia and Clear Lake are located one mile inland and are connected by a channel. These lakes are the source of municipal water for the City of West Palm Beach. Although they are naturally a part of the surface hydrologic system, the topography around these two lakes has been modified to eliminate the inflow of significant quantities of storm runoff. Lake Osborne is a 378-acre freshwater lake located just west of the Intracoastal Waterway in the City of Lake Worth.

Palm Beach County is one of five counties containing portions of Lake Okeechobee, on the northwestern boundary of the county. Lake Okeechobee is the largest freshwater lake in Florida at 488,000 acres, but has an average depth of only 9 feet. This lake is connected to the Indian River lagoon by the Okeechobee Waterway and the St. Lucie River.

2.3 Principal Flood Problems

Flooding results from two major sources in Palm Beach County. Coastal areas are subject to inundation from ocean surges as the result of hurricanes and tropical storms. Inland areas become flooded during the rainy season when intense rainfall accumulates in low, flat areas and the capacity of streams is exceeded. A transition region near the coast is vulnerable to both rainfall and ocean surge flooding.

Several communities in Palm Beach County are located on the open coast and are subject to flooding from tidal surges associated with hurricanes, including Briny Breezes, Boynton Beach, Delray Beach, Gulf Stream, Highland Beach, Juno Beach, Jupiter, Jupiter Inlet Colony, Lake Worth, Lantana, Manalapan, North Palm Beach, Palm Beach, Palm Beach Gardens, Palm Beach Shores, Riviera Beach, South Palm Beach, Tequesta, and West Palm Beach. Flooding from ocean storm surges may be augmented with storm surges on Lake Worth and subsequent rising water levels in areas adjacent to Lake Worth and the Intracoastal Waterway. The rise of the water level in Lake Worth causes a rise in the water level in the Intracoastal Waterway, which is compounded by any increases caused by rainfall runoff. These effects are complicated by wave action in Jupiter Inlet and Jupiter Sound for Jupiter Inlet Colony and by Pelican Pond for Juno Beach. The Cities of Pahokee and Belle Glade are vulnerable to flooding from similar storm surges on Lake Okeechobee.

Most of the communities in Palm Beach County and the unincorporated areas are susceptible to surface flooding because of flat terrain. During the rainy season, the water table rises and the amount of water that can be absorbed decreases. As a result, water accumulates in low lying areas and either slowly infiltrates or eventually flows into a canal or storm drain (Reference 1). Much of the unincorporated land in the county is covered by ponded water during the rainy season and development has only taken place where measures such as drainage ditches, culverts, and elevated foundations are employed to minimize water damage. The flooding that results from extreme rainfalls is generally shallow and is characterized by its low velocities of flow.

A few communities on the coastal ridge, including portions of Boca Raton, Hypoluxo, and Lake Park, have good natural drainage due to their topography.

Some communities also experience flooding from specific sources. Drainage is provided by a canal system that readily accommodates the day-to-day rainfall. However, in periods of heavy rainfall, the aquifers discharge into the canals and the capacity of canals and streams to accommodate additional storm runoff is exceeded. The communities of Jupiter and Tequesta are affected by flooding of the Loxahatchee River and its tributaries. North Palm Beach is vulnerable to flooding from Canal C-17 and the North Palm Beach Canal.

Reports from both the U.S. Army Corps of Engineers (USACE) and the NOAA document several damaging floods that have occurred in Palm Beach County (References 36; 37; 38). Most of these floods have been attributable to hurricanes which have passed over Florida in the vicinity of Palm Beach County.

Since 1871, 12 hurricanes have passed through Palm Beach County. Among the more severe were the storms of September 1928, September 1947, October 1947, and August-September 1964.

The hurricane of September 1928 is considered one of the most violent ever to strike Florida. The center of the storm smashed into the West Palm Beach area with winds in excess of 100 miles per hour. Nearly 95 percent of the commercial and residential property in the West Palm Beach area was damaged. High tides ranged from 8 feet in Lake Worth to 10 feet at Palm Beach. As a result of the storm, the West Palm Beach area was left with 26 dead, 1,437 injured, and damages in excess of $11 million. Severe wave action was responsible for the washout of several bridges crossing Lake Worth. This storm also caused flooding from wind-driven tides in Lake Okeechobee, when winds of up to 75 miles per hour were reported on the lake. A wind-driven tidal wave, ranging from 5 to 10 feet, brought about widespread loss of life and destruction of property along the southwest shore of the lake.

The hurricane of October 1947 climaxed an extremely wet rainy season in which precipitation in the county ranged from 70 to 85 inches (Reference 12).

The hurricane of August 1949 was the worst to hit the Lake Okeechobee area since September 1928. However, the Herbert Hoover Dike, constructed in the early 1930s, prevented the occurrence of any flooding.

Historically, the most intense rainfalls have resulted from thunderstorm activity. Large quantities of rain over somewhat longer periods also occur with the passage of hurricanes. The highest recorded rainfall for a Palm Beach County coastal area occurred in October 1965, when 18.9 inches fell within 1 day near Boca Raton (Reference 39).

2.4 Flood Protection Measures

Flood protection measures within Palm Beach County include the Herbert Hoover Dike system and its associated flood gates which were designed and constructed in the 1950s to provide hurricane surge and high lake level flooding protection from Lake Okeechobee. The Herbert Hoover Dike and flood gate system is operated and maintained by the USACE. The adjacent northwestern and western Palm Beach County areas are generally protected from flooding by the Herbert Hoover Dike. Presently, the Herbert Hoover Dike cannot be certified by the USACE as being capable of providing flood protection during prolonged periods of high lake levels in Lake Okeechobee. Adjacent low-lying floodplains and communities along the eastern reaches of the dike may be subject to flood inundation from Lake Okeechobee due to structural failure and breaching of the dike due to seepage. The affected areas subject to this potential flood hazard have been identified through a Dam Breach Analysis completed in September 2012 and the flood risk has been shown on the FIRM for Palm Beach County.

In addition to the Herbert Hoover Dike, there are other flood control canals, locks and pump stations near Lake Okeechobee and in numerous other locations within Palm Beach County which are operated and maintained by the SFWMD. Other canals have been constructed to remove excess runoff from inland regions. Water may be ponded for several months in areas that do not drain readily. The canals serve as a path for flow and have increased the fraction of rainfall that runs off land. They also tend to shorten the time required for water to travel from interior regions to the ocean. When runoff exceeds the capacity of the canal system, the excess is stored in the canal basin, with the stage increasing until the canal discharge surpasses inflow. The major canal systems include the Hillsboro Canal; the C-51 Canal; the North New River Canal; the Miami Canal; and the C-15, C-16, C-17, and C-18 canals. The SFWMD regulates all these canals. Some levees have been constructed to control the spread of water in swampy areas.

Along the shorelines of the Atlantic coast and inland rivers and sounds, there are numerous individual seawalls and bulkheads protecting private property, but these do not provide a flood protection capacity. There are several Federally-sponsored (USACE) and maintained beach nourishment projects located along the Atlantic Ocean coastal shoreline, including projects in Jupiter, Palm Beach, Ocean Ridge, and Boca Raton. These beach nourishment projects are not designed to provide protection during the 1-percent-annual-chance flood. There are also major seawall structures located in separate communities along the Atlantic coast, including Palm Beach, South Palm Beach, Lake Worth, Manalapan, Ocean Ridge, and Boca Raton. It is not known if these seawall structures have been designed to provide flood protection during the 1-percent-annual-chance flood.

Other non-structural floodplain management measures within the county are exercised. These include county zoning ordinances, building codes designed to reduce flood damage and hurricane advisories and emergency plans.

Rapidly rising sand dunes and seawalls provide considerable protection along the open coast of Palm Beach County (Reference 11). These dunes and seawalls are expected to remain intact during the 1-percent-annual-chance storm surge and are considered effective wave energy dissipaters. Much of the shoreline along Lake Worth and the Intra-coastal Waterway is protected by bulkheads. These bulkheads are capable of dissipating wave energy.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood-hazard data required for this study. Flood events of a magnitude that is 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 that equals or exceeds the 1-percent-annual-chance flood in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

For this countywide study, hydrologic analyses were carried out to establish peak discharge frequency relationships for each flooding source studied by detailed and approximate methods affecting the community. A summary of peak discharge-drainage area relationships for streams studied by detailed methods is shown in Table 6, “Summary of Discharges.” Stillwater elevations are shown in Table 7, “Summary of C-51 Stillwater Elevations” and Table 10, “Summary of Coastal Stillwater Elevations.”

3.1.1 Methods for Flooding Sources with New or Revised Analyses in Current Study

The hydrologic analyses for C-51 Canal were performed using HEC-HMS version 3.5 following SFWMD Technical Memorandum “ Frequency Analysis of One and Three-Day Rainfall Maxima for Central and Southern Florida.” The storm events used in the analysis are the 10% annual chance, 72- hours with 10.1 inches of rainfall depth and 1-percent-annual-chance, 72-hours with 16.3 inches of rainfall depth.

The unit hydrograph method was altered for this analysis to recompute peak rate values; the Delmarva unit hydrograph method was applied in place of the SCS unit hydrograph. Total runoff volumes computed with both methods were the same, the Delmarva method was used because it resulted in lower peak rate values. Curve numbers were developed based on hydrologic soil groups, soil conditions and existing land use. The hydrological parameters were adjusted during model calibration process. The runoff hydrographs for the C-51 Canal were generated for each sub-basin. The SCS method assumes the initial abstraction (I, inches) is equal to 0.2 times the basin storage (S, inches). Initial abstraction value entries were left blank to allow HEC-HMS to compute using the default values (Reference 84).

The C-51 model was developed using an unsteady flow model. The discharges for C-51 are not listed in Table 6 because the discharge values vary with time and change from cross section to cross section. A breakdown of flow values by subbasin is presented in the C-51 Basin Rule report prepared by SFWMD (Reference 84).

For the 2000 FIS, all detailed hydrologic studies were performed using HEC-1 except for the C-51 Canal, which was studied using HEC-HMS (Reference 33).

The hydrologic analyses for E-2E/E3/E4 basin were performed by Tomasello Consulting Engineers, Inc. using S2DMM. S2DMM is a FEMA approved model that was specifically designed for South Florida watersheds. The calibrated S2DMM was applied to design rainfall conditions for the 10-year, 50-year, 100-year, and 500-year return frequencies. The SFWMD modified Type II rainfall distribution was used in each design event (Reference 85).

Table 6: Summary of Discharges

Flooding Source and Location	Drainage Area (Square miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
E-3 CANAL					
Control Structure at the downstream outlet	10.74	732	1,491	1,693	2,021
Palmetto Park Road	5.66	488	679	725	824
Potomac Road	1.02	255	373	383	405
E-4 CANAL					
Southwest 18th Street	12.95	3,197	5,317	6,192	8,373
NW 20th Street	6.54	1,084	1,796	2,033	2,382
Clint Moore Road	0.42	106	196	252	279
JUPITER CREEK					
At mouth	2.45	1,063	1,401	1,556	1,775
At Indian Town Road	2.16	845	1,095	1,208	1,367
At Pennock Lane	0.8	399	481	496	501
At Toney Penna Drive	0.56	156	210	271	334
KELLER CANAL					
At confluence with C-51/ West Palm Beach Canal	*	1,162	*	1,232	*
LAKE OSBORNE					
At Hypoluxo Road	*	1,781	*	3,419	*
L-14 CANAL					
At mouth	5.8	735	*	1,363	*
At Military Trail	3.4	450	*	892	*

* Data not available

Table 6: Summary of Discharges - continued

Flooding Source and Location	Drainage Area (Square miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
L-16 CANAL					
At mouth\	1.6	385	*	583	*
At Military Trail	0.9	191	*	411	*
HILLSBORO CANAL					
At Intracoastal Waterway	64	1,600	4,000	6,000	9,800

* Data not available

Stillwater elevations for the 10- and 1-percent-annual-chance floods for the C-51 canal in Palm Beach County are summarized in Table 7. Figure 1 shows the subbasin locations within the C-51 basin.

Table 7: Summary of C-51 Stillwater Elevations

	Water Surface Elevations (Feet NAVD88[1])			
Subbasin	10-percent annual-chance	2-percent-annual-chance	1-percent-annual-chance	0.2-percent-annual-chance
1	17.34	*	19.24	*
2A	*	*	13.44	*
2B	13.04	*	13.84	*
3	13.64	*	14.54	*
4	14.94	*	15.54	*
5	15.84	*	17.24	*
6	17.04	*	17.24	*
7	17.54	*	17.64	*
8	18.14	*	18.54	*
9	15.84	*	17.24	*
10	17.54	*	17.64	*
11	17.54	*	17.64	*
12	17.54	*	17.64	*
13	14.04	*	15.44	*
14	14.04	*	15.44	*
15A	14.44	*	16.84	*
15B	17.94	*	18.64	*
16A	14.44	*	16.84	*
16B-1	17.64	*	18.64	*
16B-2	17.84	*	18.84	*
16B-3	17.54	*	18.34	*
17	12.94	*	14.54	*
18	12.94	*	14.54	*
20A	13.94	*	16.04	*
20B	14.44	*	15.54	*

[1]North American Vertical Datum of 1988; The datum conversion factor from NGVD to NAVD 88 in Palm Beach County is -1.56 feet

*Data not available

Table 7: Summary of C-51 Stillwater Elevations (continued)

Subbasin	Water Surface Elevations (Feet NAVD88[1]) 10-percent annual-chance	2-percent-annual-chance	1-percent-annual-chance	0.2-percent-annual-chance
21A	15.94	*	16.44	*
21B	16.24	*	16.64	*
22	15.24	*	16.54	*
23	14.64	*	15.84	*
24	15.34	*	16.44	*
25A	13.14	*	12.54	*
25B	13.14	*	12.64	*
26	11.74	*	12.44	*
27	9.34	*	12.74	*
28	9.84	*	11.54	*
29A	12.04	*	12.74	*
29B	12.44	*	13.44	*
30	10.94	*	11.94	*
31	9.04	*	11.14	*
32	9.24	*	11.34	*
33	9.44	*	11.14	*
34	10.74	*	11.04	*
35	9.64	*	11.64	*
36	11.24	*	12.54	*
37	14.04	*	14.94	*
38	15.34	*	17.44	*
39	11.84	*	11.94	*
Sect24	14.44	*	15.14	*

[1]North American Vertical Datum of 1988; The datum conversion factor from NGVD to NAVD 88 in Palm Beach County is -1.56 feet.
*Data not available

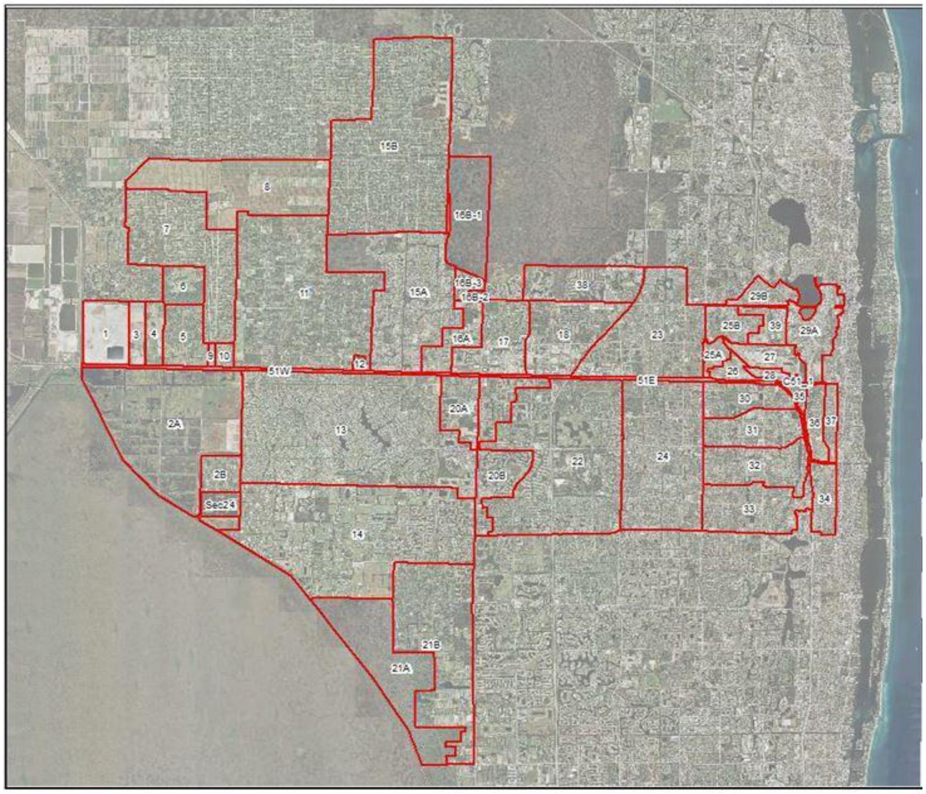

Figure 1: C-51 Subbasins

Collective Water Resources first mapped AE zones from the C-51 model based on the subbasin shapefile provided by SFWMD. Peak elevations from the model were used to map level-pool floodplains for each subbasin. BFEs were first assigned based on the subbasin shapefile for the SFWMD C-51 model. The subbasin shapefile was not created in GIS and preceded floodplain mapping needs, so the BFEs had to be adjusted based on floodplain connectivity. If this adjustment was not made, multiple BFEs would be assigned for one continuous flooded area. Engineering judgment was used to assign BFEs for each flooded area when an adjustment was needed. This engineering adjustment is the reason that some BFEs do not match the SFWMD reported values in all areas.

3.1.2 Methods for Flooding Sources Incorporated from Previous Studies

This section describes the methodology used in previous studies of flooding sources incorporated into this FIS that were not revised for this countywide study.

Hydrologic analyses for previous FIS reports were based on rainfall depth, duration and frequency studies. The area that was affected by both coastal surge and rainfall was analyzed using a combined probability method.

The hydrologic analysis for Palm Beach County included a hydrologic budget based on the following factors: rainfall, infiltration, groundwater levels, evapotranspiration, canal flow, and surface ponding. Three sources of rainfall data were utilized in the study. The USACE developed maps of maximum rainfall quantities for several periods over southern Florida (References 47; 48). Curves were also presented which related 1-day rainfall to longer periods. The U.S. Weather Bureau has analyzed rainfall for numerous stations throughout the United States and presented depth-duration- frequency data for the 10-, 2-, and 1-percent-annual-chance rainfall events (Reference 49). These data were also plotted on log-normal probability paper and extrapolated to obtain the depth of the 0.2-percent-annual-chance storm.

Unpublished records of daily rainfall in Palm Beach County were provided by the South Florida Water Management District for various locations. The maximum period of record for these locations was 20 years. In that period, the maximum observed daily rainfall event was 18.9 inches, occurring in October 1965 near Boca Raton (Reference 41). These records were analyzed to determine the 10-, 2-, 1-, and 0.2-percent-annual-chance storms of different durations as prescribed by the U.S. Water Resources Council (Reference 50).

The computed values of the storms of different duration and frequency were then compared to the maps of maximum daily rainfall of the USACE and the depth-duration-frequency curves of the U.S. Weather Bureau. Rainfall depths of different frequencies were then selected for several geographical sections of Palm Beach County based on all three studies. Table 8, “Twenty-Four Hour Rainfalls Palm Beach County (Inches),” shows these values.

Table 8: Twenty-Four Hour Rainfalls Palm Beach County (Inches)

Region	Frequency			
	10-percent annual-chance	2-percent-annual-chance	1-percent-annual-chance	0.2-percent-annual-chance
North Coast	9.5	14.0	16.0	24.0
South Coast	10.0	16.5	19.5	27.0
Central	8.0	14.0	15.0	19.0
Western	8.0	11.0	12.5	16.0

Stillwater elevations for hurricane surges with 10-, 2-, 1-, and 0.2-percent-annual-chance frequency were determined by Tetra Tech, Inc. for all areas of Palm Beach County and its incorporated communities inundated by tidal flooding. These elevations were determined by the joint probability method. The storm populations were described by probability distributions of five parameters which influence surge heights. These parameters were central pressure depression (which measures the intensity of the storm), radius to maximum winds, forward speed of the storm, shoreline crossing point, and crossing angle. These characteristics were described statistically based on an analysis of observed storms in the vicinity of Palm Beach County. Primary sources of data for the parameters were publications by the National Weather Service, Weather Bureau, and NOAA, including those for the National Hurricane Research Project (Reference 51; 52; 53; 54). These parameters can be found in Table 9, “Parameter Values for Surge Elevations.”

Table 9: Parameter Values for Surge Elevations

Parameter	Assigned Values								
Central pressure depression (millibars)	27.39	27.68	27.97	28.26	28.55	28.84	29.12	29.4	29.7
Probability (exiting)	0.06	0.04	0.08	0.12	0.127	0.129	0.115	0.146	0.189
Probability (landfalling)	0.067	0.046	0.086	0.129	0.141	0.144	0.110	0.121	0.156
Storm radius to maximum winds (nautical miles)	24.0								
Probability	1.0								
Forward speed (knots)	7			13			19		
Probability (exiting)	0.228			0.417			0.355		
Probability (landfalling)	0.644			0.308			0.0481		
Direction of storm path (degrees from true north)	-90		-45		0		45		90
Probability	0.109		0.327		0.096		0.247		0.222
Frequency of storm occurrence (storm/nautical mile/year) crossing the coastline	0.00323								
Frequency of storm occurrence (storm/nautical mile/year) parallel to the coastline	0.00134								

The coastal stillwater elevations developed for the previous FISs for Palm Beach County and incorporated areas have been evaluated and accepted for use in the coastal hydraulic analyses. In addition, the investigations performed for this FIS have determined that wave setup significantly contributes to the total stillwater flood levels along the Atlantic Ocean coastline. Because the previous studies did not include analyses for wave setup, wave setup was calculated and applied to this restudy. The amount of wave setup was calculated using the methodology outlined in the USACE publication, Shore Protection Manual, published in 1984, and described in FEMA’s 1995 Guidelines and Specifications for Wave Elevation Determination and V-Zone Mapping.

The previous studies have determined the stillwater elevations for the 10-, 2-, 1-, and 0.2-percent annual chance storms for the flooding sources studied by detailed methods and summarized in Table 10, "Summary of Coastal Stillwater

Elevations." The analyses reported herein reflect the stillwater elevations due to tidal and wind setup, and include further contributions from wave action. Wave setup effects are reflected only in the Atlantic Ocean open coast 1-percent-annual-chance elevations tabulated here.

The FEMA Region IV Office in Atlanta has undertaken a multiyear coastal engineering analysis and mapping effort to better identify, quantify, and communicate flood hazards and associated risks in South Florida (SFL) and other coastal areas of the Southeastern United States. The update hazard and risk information and produce new FIRMs for the SFL Study Area (Palm Beach County), FEMA has initiated studies through its Production and Technical Services mapping partner and is coordinating closely with the Florida Division of Emergency Management (FDEM), Florida’s National Flood Insurance Program (NFIP) Coordinator; community officials; and other stakeholders in the affected communities.

Table 10: Summary of Coastal Stillwater Elevations

	ELEVATION (feet NAVD 88)			
FLOODING SOURCE AND LOCATION	10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
ATLANTIC OCEAN				
Along the coastline from the Martin County/Palm Beach County boundary extending south to Jupiter Inlet	2.8	4.6	7.4[1]	6.7
Along the shoreline from Jupiter Inlet extending south to the Town of Palm Beach near the intersection of Ocean Boulevard and Parc Monceau Court	2.7	4.4	7.2[1]	6.5
Along the coastline from the intersection of Ocean Boulevard and Parc Monceau Court to the southern limits of the Town of Palm Beach	2.8	4.5	7.3[1]	6.6
Along the coastline from the Town of Palm Beach/Town of Lantana corporate limits to east of Lewis Cove Road in the City of Delray Beach	2.8	4.6	7.4[1]	6.7
Along the coastline from east of Lewis Cove Road in the city of Delray Beach to the Palm Beach County/Broward County boundary	3.0	4.9	7.7[1]	7.1
JUPITER SOUND (INTRACOASTAL WATERWAY)				
From the Martin County/Palm Beach County boundary extending south to the confluence with the Loxahatchee River	1.5	3.8	4.4	5.9
LAKE BOCA RATON (INTRACOASTAL WATERWAY)				
The entire length of Lake Boca Raton within the City of Boca Raton	2.8	4.7	5.4	7.1

[1]Includes wave setup of 2.0 feet

Table 10: Summary of Coastal Stillwater Elevations - continued

	ELEVATION (feet NAVD 88)			
FLOODING SOURCE AND LOCATION	10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
LAKE WORTH (INTRACOASTAL WATERWAY)				
Along Lake Worth from the Palm Beach County/Village of North Palm Beach Boundary extending south to Munyon Island	2.9	4.7	5.5	7.2
Along Lake Worth from Munyon Island Extending south to the Palm Beach County/ Town of Palm Beach boundary	2.9	4.7	5.4	7.1
Along Lake Worth from Palm Beach County/Town of Palm Beach boundary extending south to the City of West Palm Beach and the Town of Palm Beach at Southern Boulevard Bridge	3.0	4.8	5.6	7.3
Along Lake Worth from Southern Boulevard Bridge extending south to the confluence of the C-51Canal	3.0	4.8	5.7	7.4
Along Lake Worth from the confluence of the C-51 Canal south to the Town of Hypoluxo/ City of Boynton Beach boundary	3.1	4.9	5.8	7.5
Along Lake Worth from the Town of Hypoluxo/Boynton Beach south to the confluence with Intracoastal Waterway and Spanish River in the Town of Ocean Ridge	3.0	4.8	5.7	7.4
Lake Worth Creek	1.5	3.8	4.4	5.9
LAKE WYMAN (INTRACOASTAL WATERWAY)				
The entire length of Lake Wyman within the City of Boca Raton	2.8	4.7	5.4	7.1

Table 10: Summary of Coastal Stillwater Elevations - continued

FLOODING SOURCE AND LOCATION	ELEVATION (feet NAVD 88) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
LOXAHATCHEE RIVER				
Inland from the Martin County/ Palm Beach County boundary extending south to Jupiter Inlet in Jupiter Inlet Colony including North and Northwest Forks of the Loxahatchee River	1.5	3.8	4.4	5.9
LAKE OKEECHOBEE				
Along lake shoreline from Martin County/ Palm Beach county boundary to Pahokee State Park	18.9	20.8	21.4	22.9
Along lake shoreline from Pahokee State Park Kreamer Island	19.7	22.2	23.2	24.7
Along lake shoreline from south of Kreamer Island to South Bay and Torry Island	19.9	22.6	23.7	25.2
Along lake shoreline from South Bay to Lake Harbor just east of Ritta Island	19.6	22.0	23.0	24.5
Along lake shoreline around Ritta Island and Lake Harbor	19.4	21.8	22.7	24.2
Along lake shoreline from west of Ritta Island past Little Bare Beach to the Palm Beach County/ Hendry County boundary	19.0	21.0	21.6	23.1

3.2 Hydraulic Analyses

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

Several types of hydraulic analyses were conducted in this study: riverine flooding sources, rainfall ponding and shallow sheet flow, storm surge in coastal areas, and analysis of wave movement upstream as well as downstream in lagoons, sounds, rivers, and canals.

Flood profiles were drawn showing the 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). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM (Exhibit 2).

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

3.2.1 Methods for Flooding Sources with New or Revised Analyses in Current Study

Riverine Analyses

For the C-51 Canal, peak stage elevations of the 10- and 1-percent annual chance recurrence intervals were computed for each sub-basin using HEC-RAS v4.1 unsteady model. The boundary condition at the eastern canal limit is a fixed stage of elevation 4.6ft NGVD. The western limit coincides with the location of flood control structure S5A-E. The upstream (western) boundary condition is specified by flow discharged through the S-5AE structure at the rate of 300 cfs whenever structure S-155A is discharging to the east and equals zero when the S-155A structure is closed. The inflow value was taken from the seepage estimation performed by USACE for design of the STA-1E storage area. The initial conditions for peripheral reaches were specified by assuming flows. An initial flow in the range of 10 to 30 cfs was specified for the equalizer and lateral canals, and initial flow for C-51 reaches ranges from 100 to 300 cfs. The stage-storage relationship of each storage area was computed from the digital terrain model that was developed using recent LiDAR data.

The necessary channel cross sections and hydraulics structures were obtained from a variety of sources including DeGrove Surveyors, Inc., Greenhorne and O'Mara, the South Florida Water Management District, Lake Worth Drainage District, and USACE.

Channel roughness factors (Manning’s “n”) used in the hydraulic computations were selected on the basis of field observations, aerial photos, and photographs of the canal and floodplain areas. The Manning’s values were adjusted during calibration. Roughness values used for the main channels ranged from 0.03 to 0.05, with overbank roughness values of 0.08.

The unsteady HEC-RAS model for C-51 Canal was calibrated using gage data collected during Tropical Storm Issac (August 26-29, 2012). The available gages on C-51 Canal with stage and flow measurements from the South Florida Water Management District are S-5AE-TW, S-319-HW, S-155AHW, S-155A-TW and S-155-HW (Reference 84).

Flows by S2DMM during simulations of the 100 year rainfall event were applied to a HEC-RAS model setup of the primary channels for the hydraulic analyses of the E3/E4 canals (Reference 85).

Detailed hydraulic studies for 16.3 miles of riverine flooding sources taken from the 2000 FIS were performed using HEC-2 or UNET, except for C-51 Canal, which was studied using HEC-RAS (Reference 55). The flood profile for Keller Canal is completely inundated by backwater from C-51 Canal and Lake Osborne, and has been omitted from this FIS report.

Roughness coefficients (Manning's “n”) were chosen by engineering judgment and based on field observation of the channel and floodplain areas. Table 11, “Summary of Roughness Coefficients,” contains the channel and overbank “n” values for the streams studied by detailed methods.

Table 11: Summary of Roughness Coefficients

Flooding Source	Channel	Overbanks
Old studies	0.015 – 0.06	0.06 – 0.19
Hillsboro Canal - Boca Raton	0.035*	0.1 – 0.2
E-4 Canal - Boca Raton	0.035*	0.1 – 0.2
C-17 Canal	0.035*	0.1 – 0.2
C-51 Canal	0.03-0.05	0.08

* Average

Please note, Hillsboro Canal is entirely influenced by the Intracoastal Waterway; therefore, no flood profile is available.

Herbert Hoover Dike Analysis

Watershed IV Alliance — a Joint Venture (JV) including AECOM and Taylor Engineering, Inc. — conducted a study to estimate the 1% annual-chance-flood elevations downstream of the unaccredited Herbert Hoover Dike (HHD or Dike) surrounding Lake Okeechobee. The state-of-the-art study approach, consistent with FEMA's Guidelines and Specifications, Analysis and Mapping Procedures for Non-Accredited Levees (revised), and coastal surge study methodologies, incorporated a Technical Steering Committee including Messrs. Donald Resio, PhD and Arthur Miller, PhD, P.E.

The study of HHD failure and associated flood risks comprised three major tasks: (1) an analysis of stage-frequencies for lake water levels, (2) establishment of dike fragility curves for each dike reach, and (3) joint probability analyses of downstream flood inundations created by various dike breach scenarios (11 breach locations and 8 lake water levels). For a given water level behind the dike, task 1 established the frequency of occurrence of the water level, and task 2 established the associated dike failure probability. Considering these probabilities, along with the results of the model simulations for various lake level breaches, task 3 established the joint probability of HHD failure (failure rate at each breach location) and corresponding probability of downstream flood elevations associated with dike breaching. The 1999 USACE *Herbert Hoover Dike Major Rehabilitation Evaluation Report*, called the MRR (Reference 83), provided the critical lake stage-frequency curve and dike fragility curves representing each reach (breach location) around HHD. Based on FEMA-funded LiDAR topography, a 2011 USACE study performed by Taylor Engineering provided the advanced, 2-dimensional hydrodynamic dam breach model (MIKE modeling system) to simulate breaches and the associated downstream flooding caused by seepage/piping and slope stability. (This study did not address alternative mechanisms of failure such as overtopping.) Because the USACE's main study goal was part of emergency planning, rather than mitigation and flood insurance rate map production, this study included additional activities aimed at estimating 1-percent-annual-chance flood elevations, including additional hydrodynamic simulations and statistical analyses.

A component of the statistical analyses (task 3), Figure 1 illustrates the calculated HHD failure rate (events per year) for lake levels from 14 ft to 21 ft, NAVD 88.

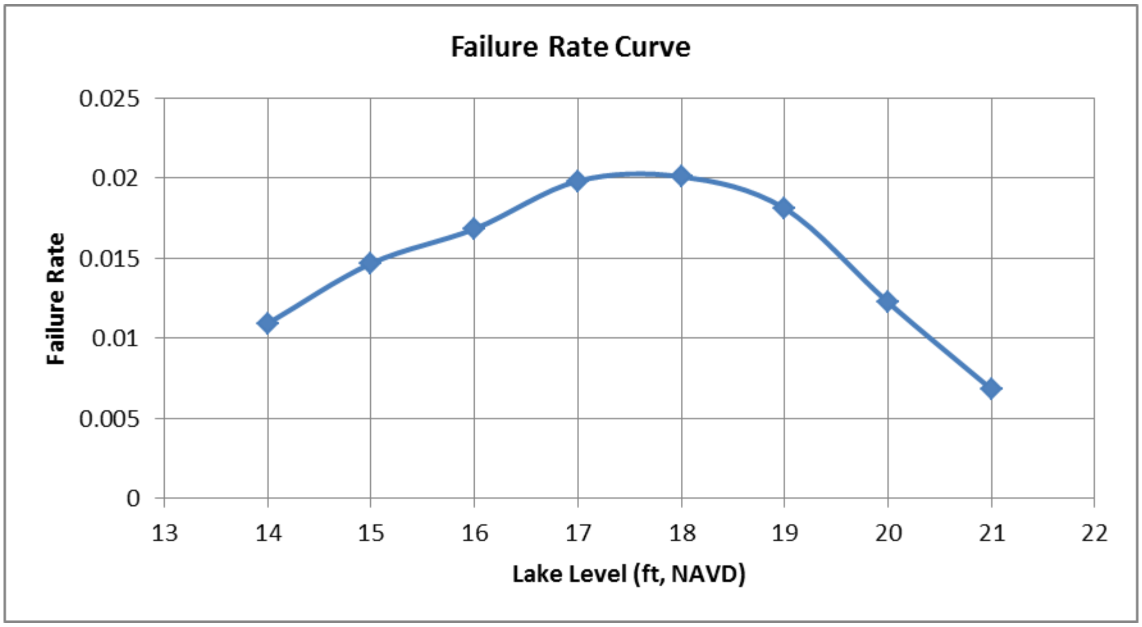

Figure 2: HHD Failure Rate (Events per Year) for Various Lake Okeechobee Lake Levels

Note the calculated failure rates in the figure apply to the total dike system (i.e., the total dike failure rate at a given lake level represents the combined failure rate of all reaches). Each dike reach around the circumference of the lake must receive a portion of the total failure rate. Because the dike comprises 11 reaches with an established fragility curve for each reach based on characteristic geotechnical conditions for that reach, the failure probability of each reach provides the basis to allocate (through Equation 1) the total failure rate.

$$Rate_{i,j} = \frac{P_{i,j}}{\sum_{i=1A\_}^{8} P_{i,j}} \times TotalRate_j \qquad \text{(Equation 1)}$$

Here, i denotes the reach number from 1A to 8; j denotes the lake level from 14 ft to 21 ft; $Rate_{i,j}$ is the occurrence rate of each breach; $TotalRate_j$ is the total dike failure rate.

Table 12, “Allocated Failure Rate (Events per Year) for each Breach Simulation,” shows the rate for each breach simulation. Note the MRR fragility curves indicate a 100 % chance of failure at a lake level of 20 ft NAVD 88 somewhere along HHD; therefore, the allocated rates for all reaches at 21 ft (from Equation 1) are combined into the allocated rates at 20 ft in Table 1, and the allocated rates for 21 ft are set to zero.

Table 12: Allocated Failure Rate (Events per Year) for each Breach Simulation

	Lake Level (NAVD 88)							
Reach	**14 ft**	**15 ft**	**16 ft**	**17 ft**	**18 ft**	**19 ft**	**20 ft**	**21 ft**
1A	0.000117	0.000157	0.000181	0.000266	0.001551	0.001585	0.001925	0
1B	0.000117	0.000157	0.000181	0.000266	0.001351	0.001375	0.001724	0
1C	0.003464	0.004644	0.005321	0.007578	0.004713	0.003815	0.003712	0
2	0.003892	0.00523	0.006028	0.004256	0.00377	0.003318	0.003389	0
3	0.002997	0.004027	0.004642	0.004965	0.004271	0.003737	0.003761	0
4	3.89E-05	5.23E-05	6.03E-05	8.87E-05	0.000184	0.000179	0.000209	0
5	3.89E-05	5.23E-05	6.03E-05	8.87E-05	0.000184	0.000179	0.000209	0
6A	1.56E-05	2.09E-05	3.01E-06	4.61E-05	7.54E-05	7.21E-05	8.36E-05	0
6B	2.34E-05	3.14E-05	4.52E-06	7.09E-05	0.000117	0.000112	0.000131	0
7	0.000195	0.000261	0.000301	0.002114	0.003701	0.003562	0.003728	0
8	3.89E-05	5.23E-05	6.03E-05	8.87E-05	0.000184	0.000179	0.000209	0

Applied to the breach flooding simulation results, the statistical analysis yielded a statistical flood surface, which represents flood levels at every computational node for a given flood frequency, in this case the 1-percent-annual-chance. The statistical surface then became the basis for work maps that show the extent of 1-percent-annual-chance flooding, proposed Base Flood Elevations, and proposed Special Flood Hazard Area zones. A detailed report documents the study approach and results. Engineering and mapping products are consistent with FEMA's Guidelines and Specifications and the study's scope of work.

Revised Zone AEs, from the above results, were mapped where appropriate. In areas that do not reach the 1-percent-annual-chance flood level, Zone X-Shaded was mapped using the simulated flood inundation from a breach with an initial lake level of 20 ft NAVD 88 88. Also, some Special Flood Hazard Areas remained unchanged depending on the location and flooding source, and Zone A's were mapped where the 1-percent-annual-chance flood level was not determined due to lack of modeling data (breach location limitations).

The study also included coordination with stakeholders, specifically the USACE, South Florida Water Management District, and local communities. Leveraging existing studies and reports, including the USACE's HHD breach model and MRR, also proved critical to the cost-effective and timely completion of this scope of work. The USACE authorized the use of its HHD hydrodynamic breach model in May 2011 as the foundation for this study and provided other supporting insight, information, and clarification about the MRR data, Lake Okeechobee water levels and regulation, and ongoing HHD improvements.

Coastal Analyses

For this revision, the FIS includes a technical wave height analysis using the previously determined 1-percent annual chance flood elevations as described in Section 3.2.2 below. The analysis was performed as specified in FEMA's Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping (FEMA, FIA, 1995). This revision updates the existing FIS on the basis of the new wave height analyses, FEMA's updated definition of "coastal hazard areas," and "primary frontal dunes," field investigations, and more detailed topography and aerial photography.

As of 1989, FEMA defines a "coastal high hazard area" as an area of special flood hazard extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action (i.e., wave heights greater than or equal to 3 feet) from storms or seismic sources. The "primary frontal dune" is defined as a continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms, such as hurricanes. The inland limit of the primary frontal dune occurs at the point which there is a distinct change from a relatively steep slope to a relatively mild slope.

Some dunes in Palm Beach County were found to be sufficient enough in size to sustain wave attack, while others were subjected to failure due to wave attack, erosion and overtopping. Therefore, using standard erosion analysis procedures as outlined in the Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping, dune erosion and retreat were used in developing the eroded profiles. Data used to develop the transects were compiled from various sources, including Florida Department of Environmental Protection (FDEP) aerial photography and topographic surveys.

The wave height transects for this revision were located along the barrier island coastline and inland bay shores of Palm Beach County. For the barrier islands, the FEMA erosion treatment (540 square foot method) was performed to adjust the wave transect profiles to an eroded condition before conducting the wave height or wave runup analyses using the FEMA wave height analysis models (WHAFIS 3.0 and RUNUP 2.0). For each coastal transect without overtopping by the 1-percent annual chance stillwater elevation, wave runup analyses were conducted using the FEMA wave runup model (RUNUP 2.0). Wave setup was only included in the 1-percent annual chance elevation for the WHAFIS 3.0 wave height analyses. The transects used in this study are in the same locations as those used in the pre-countywide analyses (Figures 4A and 4B, "Transect Location Maps"), and were chosen based on some criteria of topography, vegetation, and cultural development.

Each transect was taken perpendicular to the shoreline and extend inland to a point where wave action ceased. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevations, vegetation, and physical features. The stillwater elevations for the 1-percent annual chance flood were used as the starting elevations for these computations. Wave heights and runup depths were calculated to the nearest 0.1 foot, wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V zone (area with velocity wave action) was also computed at each transect."

Ponding and Shallow Flow Analyses

FEMA granted permission for Palm Beach County to re-map sections of AO Zones in the southwestern portion of the county, affecting Palm Beach County Unincorporated areas and the City of Boca Raton, using current Environmental Resource Permits (ERPs) from the SFWMD. Collective Water Resources used peak elevations as provided in the ERPs (rounded to the first decimal place) became the static base flood elevations (BFEs) for these flood hazard areas. If a neighborhood was partially in the AO Zone and partially in the adjacent X Zone, Collective Water Resources placed the neighborhood in the X Zone. Floodplains were mapped based on the peak elevations wherever possible. If issues related to the re-mapping could not be overcome, the neighborhood remained in the AO Zone. Floodplains and static BFEs were reviewed by Collective Water Resources for each neighborhood; modifications were made as needed and final results were back-checked by a professional engineer (Reference 86).

3.2.2 Methods for Flooding Sources Incorporated from Previous Studies

Riverine Analyses

Hydraulic analyses of rivers and canals for this study were taken from previous FIS reports for the communities of Palm Beach County. The major canals accepting drainage from Palm Beach County are Hillsboro Canal; North New River Canal; Miami Canal; and, the C-14, C-15, C-16, C-17, and C-18 Canals.

Allowed inflow rates vary with each canal and are regulated by the South Florida Water Management District. The capacity of a canal at a particular point depends upon the design characteristics of that canal. The existing canal system, as controlled by the Central and Southern Florida Flood Control District, is designed to remove up to 3 inches of water in any 24-hour period. The canals were analyzed based on a typical cross section and an estimated Manning's roughness coefficient of 0.035. It was concluded that the canal system is not a source of flooding, but is unable to accommodate the entire peak runoff during a 1-percent-annual-chance rainfall.

The kinematic wave approach was applied to simulate the overland flow aspects of the watershed (Reference 56). Synthetic overland hydrographs were created based upon land slope, roughness factors, flow path length, and different storm durations and intensities. By modeling the runoff from several duration-intensity combinations with the same probability of occurrence, a maximum value was determined. Lateral flow was then applied to a model of the canal hydraulic system.

The hydraulic calculations utilized a volumetric analysis to determine the amount of excess water temporarily stored in the low areas. Inflow rates were based on design conditions for the regulated canals and on a kinematic wave analysis for overland flows (Reference 56). Discharge rates were based on unpublished stage-discharge curves for the discharge structures.

Combined Riverine and Surge

The canal system serves as a means of removing excess water, but also makes it possible for ocean surge effects to travel inland up the canal. In the case of a combined ocean surge and rainfall event, location determines which event dominates. The surge effect varies with distance from the coast, and both effects vary with channel geometry and runoff characteristics.

In normal tidal areas, including the Intracoastal Waterway, the surge was found to be the controlling factor. Several computer models were used to simulate flow in the canal system including HEC-2 (References 57; 58; 59).

Analysis of each canal began from the mouth of the canal, with the starting water-surface elevations determined in the coastal surge analysis. At confluences, the starting water-surface elevations were determined by the backwater computation of the other canal at the point of confluence.

Where the surge was not the controlling factor, the hydraulic calculations utilized a volumetric analysis to determine the amount of excess water temporarily stored in the low areas. Inflow rates were based on design conditions for the regulated canals and on a kinematic wave analysis for overland flows (Reference 56). Discharge rates were based on stage discharge curves for the discharge structures.

Ponding and Shallow Flow Analyses

Lands in southeastern Florida are extremely flat, with slopes often less than 1.0 foot per mile. Canals do not typically overflow their banks; instead, flooding is typically sheet flooding, with unpredictable flow paths. Overland flow was studied by considering flow barriers such as roads, levees, railways, and natural topography. The assumption was made that water would flow to low areas when flow barriers did not obstruct its movement.

Overland flow depths were partly based on the kinematic wave approach, which relates the depth of water to rainfall intensity, the path length, slope, and surface roughness (Reference 56). In the kinematic wave analysis of surface flow, the flow depth at the end of a catchment of length, “L,” is given by the equation

$$y = \left[\frac{L_i}{a}\right]^{1/m}$$

for rainfall durations equal to or greater than the time of concentration. In this expression, i is the rainfall intensity and a is a constant, 1.49 $s^{1/2}/n$. Here, “n” is the Manning's roughness coefficient and “s” is ground slope. Values assumed for Manning's “n” for shallow overland flow ranged from 0.1 to 0.2, depending upon the ground cover and estimated depth of flow. The constant, “m”, was taken as 5/3. The time of concentration was calculated from the equation

$$t_c = \left[\frac{L_i}{a}^{1-m}\right]^{1/m}$$

When the rainfall duration is less than the time of concentration, the flow depth becomes simply y = it, where “t” is the rainfall duration. The time “t^*_c” required to reach maximum flow depth is given by the equation

$$t^*_c = \frac{L_y}{a}^{(1-m)}$$

Because rainfall duration affects intensity, a unique intensity results for catchments of different lengths and slopes. The discharge per unit width may be calculated from the equation $q = ay^m$.

The previously described calculations, as well as duration-intensity and infiltration relationships, were coded into a computer program. A set of tables was generated that showed the flow depth and discharge for a wide range of land slopes and flow distances. These values were utilized in evaluating the depths of overland flow.

The hydraulic analysis also utilized a volumetric ponding analysis to determine the amount and distribution of excess water in the low areas. The final ponding depth was based on the volume of water that migrated to the low areas and the amount of excess water that remained ponded in the low areas after allowances were made for discharge to the coast via the canal system.

In Atlantis, the analysis showed that flood water from rainfall could fill land depressions up to an elevation of 14 feet for the 1-percent-annual-chance event. The area of the greatest ponding depth lies in the eastern portion of the city around Congress Lake. Shallow ponding depths occur in areas throughout the city.

In Lake Clarke Shores, the analyses showed that floodwaters from rainfall could fill land depressions up to an elevation of 12 feet for the 1-percent-annual-chance event. Shallow ponding depths occur in areas throughout the town, with the greatest depths along the banks of the various water bodies.

In Mangonia Park, the analyses showed that excess rainfall forms temporary ponds in the low areas. The area of the greatest ponding depth lies east of Australian Avenue, where water-surface elevations can reach approximately 17 feet. Shallow ponding depths occur in areas throughout the town. The only area not subject to shallow ponding is the ridge lying west of Australian Avenue.

For overland flow, surface roughness coefficients (Manning's “n”) were estimated from field observations. The values ranged from 0.1 to 0.2, depending on vegetation, ground cover, and estimated depth of surface water.

Wave Height Analyses

The wave height for coastal flooding in this FIS report was taken from the 1982 Wave Height Analysis. This wave height analysis was performed to determine wave heights and corresponding wave crest elevations for the areas inundated by tidal flooding. The flooding sources included in this analysis were the Intracoastal Waterway (including Jupiter Sound), Loxahatchee River (including the North, Northwest, and Southwest Forks), North Palm Beach Waterway, Lake Okeechobee, Little Lake Worth, Lake Worth, and the Atlantic Ocean at the open coast.

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding was National Academy of Sciences storm surge analysis (Reference 60). Wave height calculations were based on such parameters as the size and density of vegetation, natural barriers (such as sand dunes), buildings, and other manmade structures. This method is based on the following major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions, such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures prescribed in the National Academy of Sciences storm surge analysis. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

The stillwater elevations were used as starting water-surface elevations for wave height analysis. All available source data required for wave height calculations were collected and analyzed to determine the physical and cultural features of the study area. The principal topographic data materials were USGS topographic maps, National Ocean Survey storm evacuation maps, phototopographic maps, a spot elevation map of Herbert Hoover Dike at Belle Glade, beach profiles from the South Florida Water District, beach profiles from the Florida Department of Natural Resources, a nautical chart of Lake Okeechobee, and highway bridge plans (References 49; 41; 61; 51; 52; 53; 54). Stereoscopic aerial photography and National Wetlands Inventory Maps were used to determine vegetation and building parameters and to supplement the topographic data materials (References 62; 63; 64).

Wave heights were computed along transects (cross section lines) in accordance with the *User’s Manual for Wave Height Analysis* (Reference 65). The transects were located along the coastline as shown in Figure 4A and along Lake Okeechobee as shown in Figure 4B. Transects were placed with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

Each transect was taken perpendicular to the shoreline and extended to the inland limit of tidal flooding. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. The stillwater elevations developed for the 1978 FIS were used as starting water-surface elevations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V Zone (area with velocity wave action) was also computed at each transect.

Figure 3 represents a sample transect that illustrates the relationship between the stillwater elevation, the wave crest elevation, the ground elevation profile, and the location of the V/A zone boundary. This figure shows the wave elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations, and being increased by open, unobstructed wind fetches. Actual wave conditions in Palm Beach County may not necessarily include all the situations illustrated in Figure 3, "Transect Schematic."

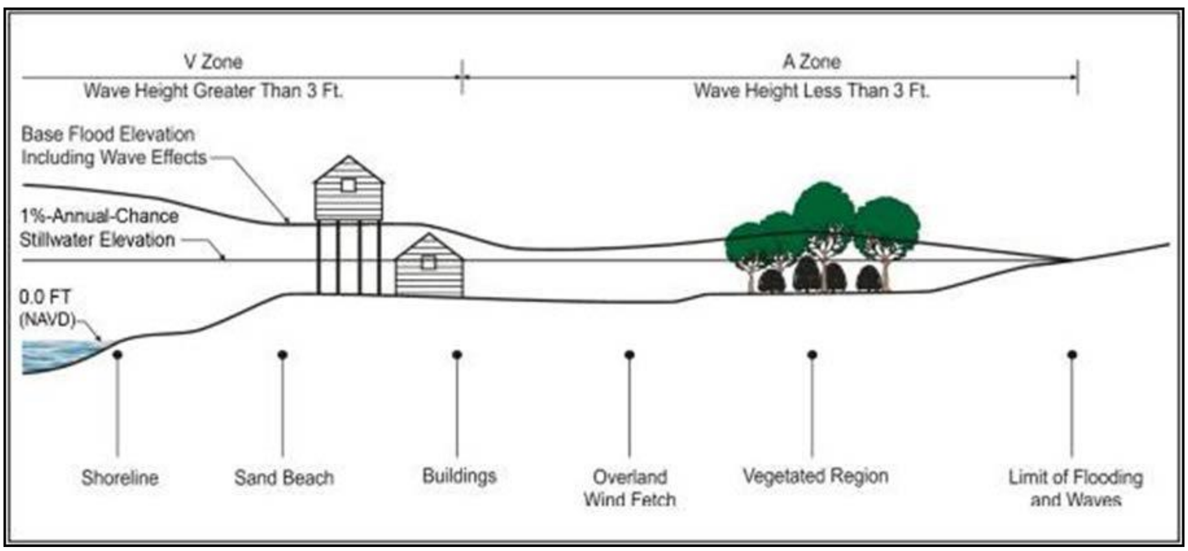

Figure 3: Transect Schematic

Table 13 provides a listing of the transect locations, stillwater starting elevations, and initial wave crest elevations.

After analyzing wave heights along each transect, wave elevations were interpolated between transects. Various source data were used in the interpolation, including topographic maps (References 66; 67; 68), beach profiles (Reference 69), and aerial photographs, along with engineering judgment (Reference 70). Controlling features affecting the elevations were identified and considered in relation to their positions at a particular transect and their variation between transects.

The *primary frontal dune zone* is defined in 44 CFR Section 59.1 of the NFIP regulations. The primary frontal dune represents a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes that occur immediately landward and adjacent to the beach. The primary frontal dune zone is subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune zone occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope.

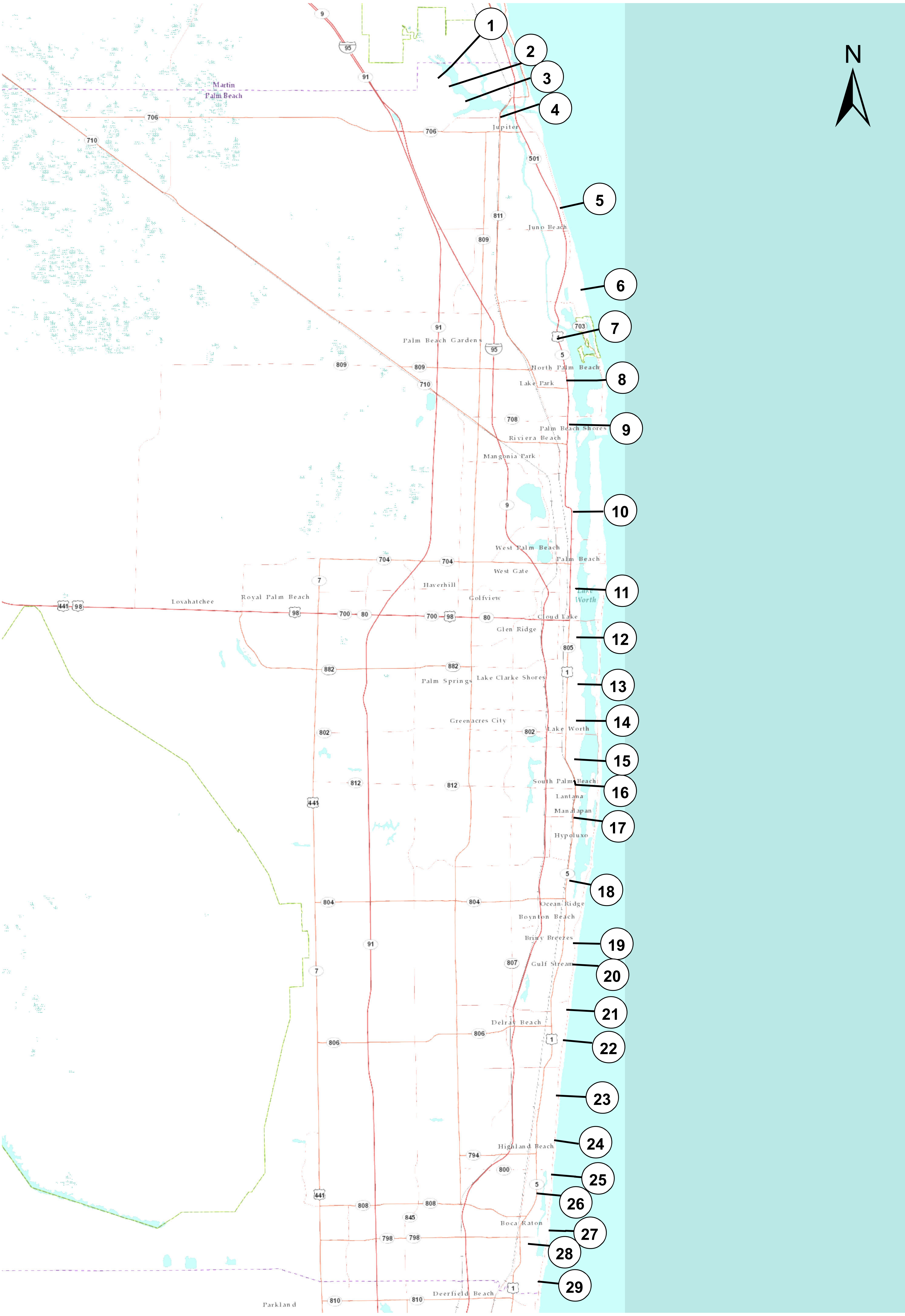

FIGURE 4A

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL AND INCORPORATED AREAS

APPROXIMATE SCALE

4 2 0 4 8 12 Miles

TRANSECT LOCATION MAP

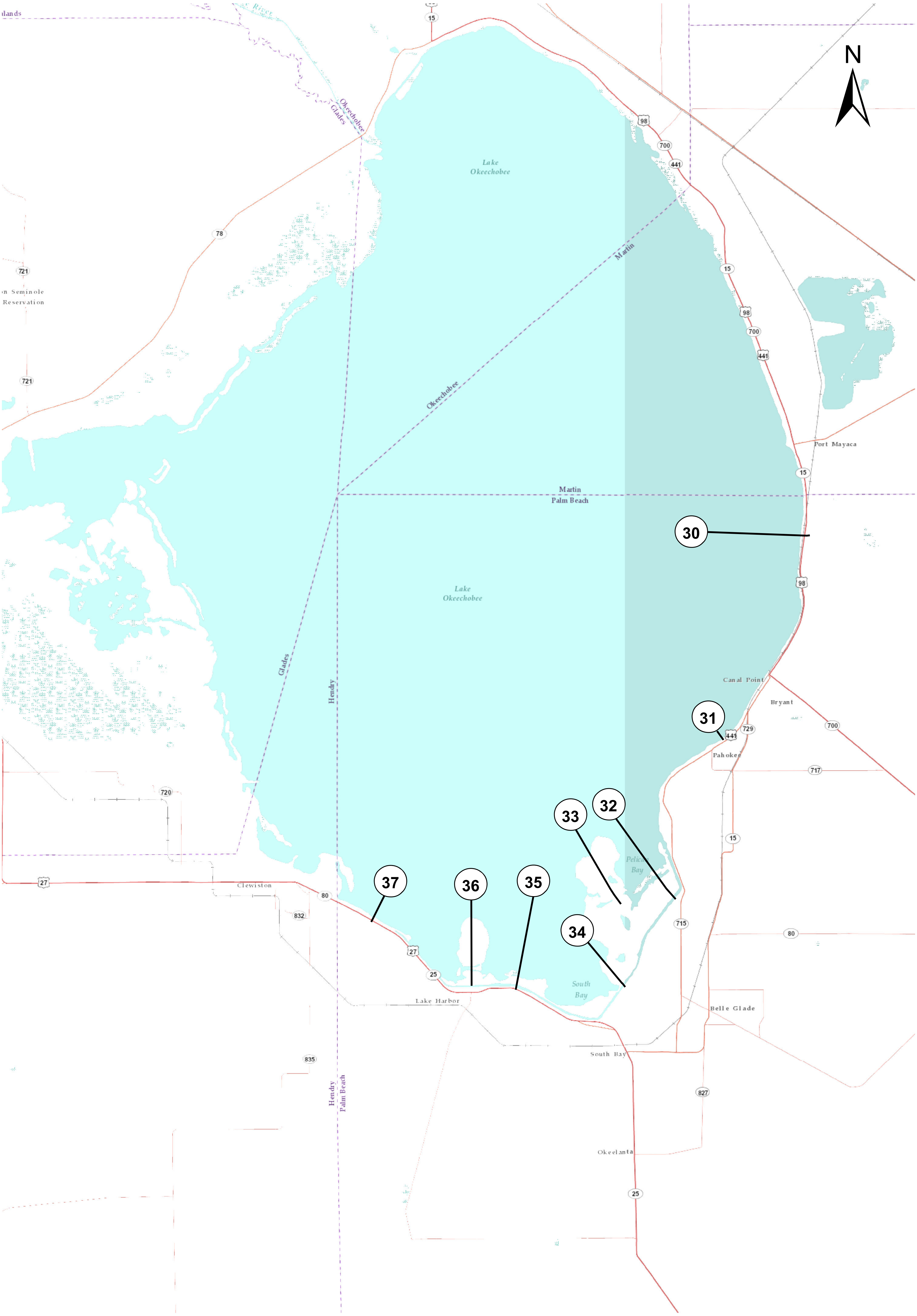

FIGURE 4B

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL AND INCORPORATED AREAS

APPROXIMATE SCALE

4 2 0 4 8 12 Miles

TRANSECT LOCATION MAP

Table 13: Transect Locations, Stillwater Starting Elevations, and Maximum Wave Crest Elevations

Transect	Location	1-Percent-Annual-Chance Elevation (Feet NAVD 88)	
		Stillwater[1]	Wave Crest[2]
1	At the shoreline of the Northwest Fork of the Loxahatchee River, in the Unincorporated Areas of Palm Beach County, southeast of the intersection of Fox Run Circle and Loxahatchee Road	4.4	6.2
2	At the shoreline of the Atlantic Ocean, in the Unincorporated Areas of Palm Beach County, northeast of the intersection of Harbor Road North and Federal Highway (US 1)	7.4[3]	12.2
	At the shoreline of Jupiter Sound, in the Unincorporated Areas of Palm Beach County, northeast of intersection of Old Dixie Highway and Village Boulevard	4.4	5.4
	At the shoreline of the Loxahatchee River, in the Unincorporated Areas of Palm Beach County, east of the intersection of Gulf Stream Drive and Bimini Road	4.4	5.9
	At the shoreline of the North Branch Loxahatchee River, in the Unincorporated Areas of Palm Beach County, southeast of the intersection of Bamboo Lane and Loxahatchee River Road	4.4	5.3
3	At the shoreline of the Atlantic Ocean, in the Unincorporated Areas of Palm Beach County, east of the intersection of Waterway Road and Tequesta Drive	7.4[3]	12.2
	At the shoreline of Jupiter Sound, in the Village of Tequesta, east of the intersection of Waterway Road and Tequesta Drive	6.0/4.4	6.9/5.3

[1]Because of map scale limitations, the 1-percent annual chance stillwater may not be shown on the FIRM.

[2]Because of map scale limitations, the maximum wave elevation may not be shown on the FIRM.

[3]Includes wave setup of 2.0 feet.

Table 13: Transect Locations, Stillwater Starting Elevations, and Maximum Wave Crest Elevations - continued

Transect	Location	1-Percent-Annual-Chance Elevation (Feet NAVD 88)	
		Stillwater[1]	Wave Crest[2]
3	At the shoreline of the Loxahatchee River, in the Unincorporated Areas of Palm Beach County, at the intersection of Point Drive and Rio Vista Drive	6.0/4.4	7.7/6.1
	At the shoreline of North Branch Loxahatchee River, in the Unincorporated Areas of Palm Beach County, east of the intersection of Pennock Road and Point Lane East	6.0/4.4	7.0/5.4
4	At the shoreline of the Atlantic Ocean, in the Town of Jupiter Inlet Colony, east of the intersection of Colony Road and Beacon Lane	9.0/7.4	13.8/12.2
	At the shoreline of Jupiter Sound, in the Unincorporated Areas of Palm Beach County, east of the intersection of East Center Street and Old Dixie Highway	6.0/4.4	7.1/5.5
5	At the shoreline of the Atlantic Ocean, in the Town of Juno Beach, southeast of the intersection of Federal Highway (US 1) and Marcinski Road	7.2[3]	11.9
6	On the Atlantic coast in the unincorporated Areas of Palm Beach County, north of Lakehouse Drive	7.2[3]	11.9
7	On the Atlantic coastline in the Village of North Palm Beach, crossing South Ocean Boulevard north of Munyon Island	7.2[3]	11.9
	On the shoreline of Lake Worth in the Village of North Palm Beach, between Gulfstream Road and Fathom Road South	5.5	7.8
8	On the Atlantic coastline in the City of Riviera Beach, crossing Ocean Boulevard north of Harbor Point Drive	7.2[3]	11.9

[1]Because of map scale limitations, the 1-percent annual chance stillwater may not be shown on the FIRM.

[2]Because of map scale limitations, the maximum wave elevation may not be shown on the FIRM.

[3]Includes wave setup of 2.0 feet.

Table 13: Transect Locations, Stillwater Starting Elevations, and Maximum Wave Crest Elevations - continued

Transect	Location	1-Percent-Annual-Chance Elevation (Feet NAVD 88)	
		Stillwater[1]	Wave Crest[2]
8 (cont.)	On the shoreline of Lake Worth in the Town of Lake Park, crossing Lakeshore Drive north of Jasmine Drive	5.4	8.0
9	On the Atlantic coastline in the of Palm Beach Shores, crossing South Ocean Avenue just north of Cascade Lane	7.2[3]	11.9
	On the shoreline of Lake Worth in the City of Riviera Beach, crossing Avenue B at West 20th Street	5.4	8.0
10	On the Atlantic coastline in the Town of Palm Beach, crossing North County Road between La Costa Way and Tangier Avenue	7.2[3]	11.9
	On the shoreline of Lake Worth in the City of West Palm Beach, between 23rd Street and Piccadilly Street	5.6	7.5
11	On the Atlantic coastline in the Town of Palm Beach, between El Vedado Road and Jungle Road	7.2[3]	11.9
	On the shoreline of Lake Worth in the City of West Palm Beach, crossing South Flagler Drive at Valencia Road	5.6	7.3
12	On the Atlantic coastline in the Town of Palm Beach, crossing Ocean Boulevard north of Ocean View Road	7.2[3]	11.9
	On the shoreline of Lake Worth in the City of West Palm Beach, crossing South Flagler Drive just north of Plymouth Road	5.7	7.8
13	On the Atlantic coastline in the Town of Palm Beach, crossing Ocean Boulevard north of Ibis Way	7.3[3]	12.1
	On the shoreline of Lake Worth in the City of Lake Worth, crossing North Lakeside Drive between Vassar Drive and Bryn Mawr Drive	5.8	7.3

[1]Because of map scale limitations, the 1-percent annual chance stillwater may not be shown on the FIRM.

[2]Because of map scale limitations, the maximum wave elevation may not be shown on the FIRM.

[3]Includes wave setup of 2.0 feet.

Table 13: Transect Locations, Stillwater Starting Elevations, and Maximum Wave Crest Elevations - continued

Transect	Location	1-Percent-Annual-Chance Elevation (Feet NAVD 88)	
		Stillwater[1]	Wave Crest[2]
14	On the Atlantic coast in the Town of Palm Beach, north of Lucerne Avenue and crossing South Ocean Boulevard	7.3[3]	12.1
	Crossing Lake Worth in the City of Lake Worth between 7th Avenue North and 6th Avenue North	5.8	7.4
15	On the Atlantic Coast in the Town of Palm Beach, crossing South Ocean Boulevard	7.3[3]	12.1
	On the shoreline of Lake Worth in the City of Lake Worth, just east of the intersection of South Lakeside Drive and 10th Avenue South	5.8	8.1
16	On the Atlantic coastline in the Town of South Palm Beach, north of East Ocean Avenue and crossing South Ocean Boulevard	7.4[3]	12.2
	On the shoreline of Lake Worth in the City of Lake Worth, just east of the intersection of Federal Highway and Lakeview Avenue	5.8	8.1
17	On the Atlantic coastline in the Town of Manalapan, crossing South Ocean Boulevard and northwest of the intersection of Atlantic Drive and Land's End Road	7.4[3]	12.2
	On the shoreline of Lake Worth in the Town of Hypoluxo, southeast of the intersection of Federal Highway and Half Moon Circle	5.8	7.7
18	On the Atlantic coastline in the Town of Ocean Ridge, crossing South Ocean Boulevard and Sabal Pine Drive	7.4[3]	12.2

[1]Because of map scale limitations, the 1-percent annual chance stillwater may not be shown on the FIRM.

[2]Because of map scale limitations, the maximum wave elevation may not be shown on the FIRM.

[3]Includes wave setup of 2.0 feet.

Table 13: Transect Locations, Stillwater Starting Elevations, and Maximum Wave Crest Elevations - continued

Transect	Location	1-Percent-Annual-Chance Elevation (Feet NAVD 88)	
		Stillwater[1]	Wave Crest[2]
18 (cont.)	On the shoreline of Lake Worth in the City of Boynton Beach, crossing through the intersection of South Road and Central Road	5.7	6.9
19	On the Atlantic coastline in the Unincorporated Areas of Palm Beach County, south of Surf Road	7.4[3]	12.2
20	On the Atlantic coastline in the Town of Gulf Stream, east of the intersection of Polo Drive and Palm Way	7.4[3]	12.2
21	On the Atlantic Coast in the City of Delray Beach, east of the intersection of Andrews Avenue and Island Drive	7.4[3]	12.2
22	On the Atlantic coastline in the City of Delray Beach, south of the intersection of South Ocean Boulevard and Casuarina Road	7.7[3]	12.7
23	On the Atlantic coastline in the Town of Highland Beach, crossing South Ocean Boulevard	7.7[3]	12.7
24	On the Atlantic coastline in the Town of Highland Beach, east of the intersection of South Ocean Boulevard and Highland Beach Drive	7.7[3]	12.7
25	On the Atlantic coastline in the City of Boca Raton, south of NE Spanish River Boulevard and crossing South Ocean Boulevard	7.7[3]	12.7
26	On the Atlantic coastline in the City of Boca Raton, south of the intersection of Lake Wyman Road and South Ocean Boulevard	7.7[3]	12.7
	On the shoreline of Lake Wyman in the City of Boca Raton, south of the intersection of NE Harbor Tr. and NE 26th Street	5.4	6.4

[1]Because of map scale limitations, the 1-percent annual chance stillwater may not be shown on the FIRM.

[2]Because of map scale limitations, the maximum wave elevation may not be shown on the FIRM.

[3]Includes wave setup of 2.0 feet.

Table 13: Transect Locations, Stillwater Starting Elevations, and Maximum Wave Crest Elevations - continued

Transect	Location	1-Percent-Annual-Chance Elevation (Feet NAVD 88)	
		Stillwater[1]	Wave Crest[2]
27	On the Atlantic coastline in the City of Boca Raton, between NE 4th Street and NE 2nd Street	7.7[3]	12.7
28	On the Atlantic coastline in the City of Boca Raton, south of Lake Drive	7.7[3]	12.7
	On the shoreline of Lake Boca Raton, south of East Palmetto Park Road	5.4	6.8
29	On the Atlantic coastline in the City of Boca Raton, south of Seminole Drive	7.7[3]	12.7
30	Palm Beach County - Crosses Lake Okeechobee to the limit of inundation by the 1-percent annual chance storm surge at Herbert Hoover Dike approximately 1.4 miles south of the Palm Beach-Martin County limits	23.0[4]	28.4
31	Palm Beach County/Pahokee crosses Lake Okeechobee to the limit of inundation by the 1-percent annual chance storm surge at Herbert Hoover Dike approximately 750 feet north of the intersection of Pahokee Road and Larrimore Road in Pahokee	21.4[4]	28.4
32	Palm Beach County - Crosses Lake Okeechobee and Pelican Bay, through the northeastern portion of Torry Island to the limit of inundation by the 1-percent annual chance storm surge at Herbert Hoover Dike	23.2[4]	29.4
33	Palm Beach County - Across Lake Okeechobee to a dike in the north-central portion of Kreamer Island	23.2[4]	29.4

[1]Because of map scale limitations, the 1-percent annual chance stillwater may not be shown on the FIRM.

[2]Because of map scale limitations, the maximum wave elevation may not be shown on the FIRM.

[3]Includes wave setup of 2.0 feet.

[4]Lake Okeechobee

Table 13: Transect Locations, Stillwater Starting Elevations, and Maximum Wave Crest Elevations - continued

Transect	Location	1-Percent-Annual-Chance Elevation (Feet NAVD 88)	
		Stillwater[1]	Wave Crest[2]
34	Palm Beach County/Belle Glade-crosses Lake Okeechobee and the southern tip of Torry Island to the limit of inundation by the 1-percent annual chance storm surge at Herbert Hoover Dike in Belle Glade	23.7[4]	29.4
35	Palm Beach County - Across the Lake Okeechobee to the limit of inundation by the 1-percent annual chance storm surge at Herbert Hoover Dike approximately 1.5 miles east of Lake Harbor	23.0[4]	28.4
36	Palm Beach County - Across Lake Okeechobee, through Ritta Island to the limit of inundation by the 1-percent annual chance storm surge at Herbert Hoover Dike just east of Miami Canal at Lake Harbor	22.7[4]	28.4
37	Palm Beach County - Across Lake Okeechobee to the limit of inundation by the 1-percent annual chance storm surge at Herbert Hoover Dike at Little Bare Beach	21.6[4]	27.4

[1]Because of map scale limitations, the 1-percent annual chance stillwater may not be shown on the FIRM.

[2]Because of map scale limitations, the maximum wave elevation may not be shown on the FIRM.

[3]Includes wave setup of 2.0 feet.

[4]Lake Okeechobee

3.3 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). With the completion of the NAVD 88 88 of 1988 (NAVD 88), many FIS reports and FIRMs are now prepared using NAVD 88 as the referenced vertical datum.

Flood elevations shown in this FIS report and on the FIRM are referenced to NAVD 88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. It is important to note that adjacent counties may be referenced to NGVD, which may result in differences in base flood elevations across county lines.

Some of the data used in this revision were taken from the prior effective FIS reports and FIRMs and adjusted to NAVD 88. The datum conversion factor from NGVD to NAVD 88 in Palm Beach County is -1.56 feet.

For more information regarding conversion between the NGVD and NAVD 88, see the FEMA publication entitled *Converting the National Flood Insurance Program to the NAVD 88 88 of 1988* (Reference 71), visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

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

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at 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- 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 flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 1- and

0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section.

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

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

Due to the topographic flatness and lack of adequate drainage, large areas of Palm Beach County are subject to shallow ponding. The 0.2-percent-annual-chance flood will also pond in indeterminate areas in large areas.

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 base flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1 foot, provided that hazardous velocities are not produced. The floodways in this study 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 study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections and provided in Table 14, “Floodway Data Table.” The computed floodway is shown on the FIRM (Exhibit 2). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown on the FIRM.

Many communities in Palm Beach County have no natural riverine systems or watercourses to produce floods. The canal system has been constructed for flood control and navigational purposes. A floodway generally is not appropriate in areas that are inundated by floodwaters from ocean surge or by canal overflow; therefore, no floodway was computed in these communities.

Near the confluence of streams studied in detail, floodway computations were made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 14 for certain downstream cross sections of Jupiter Creek and E4 Canal 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. 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 (WSEL) of the base flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 5, "Floodway Schematic."

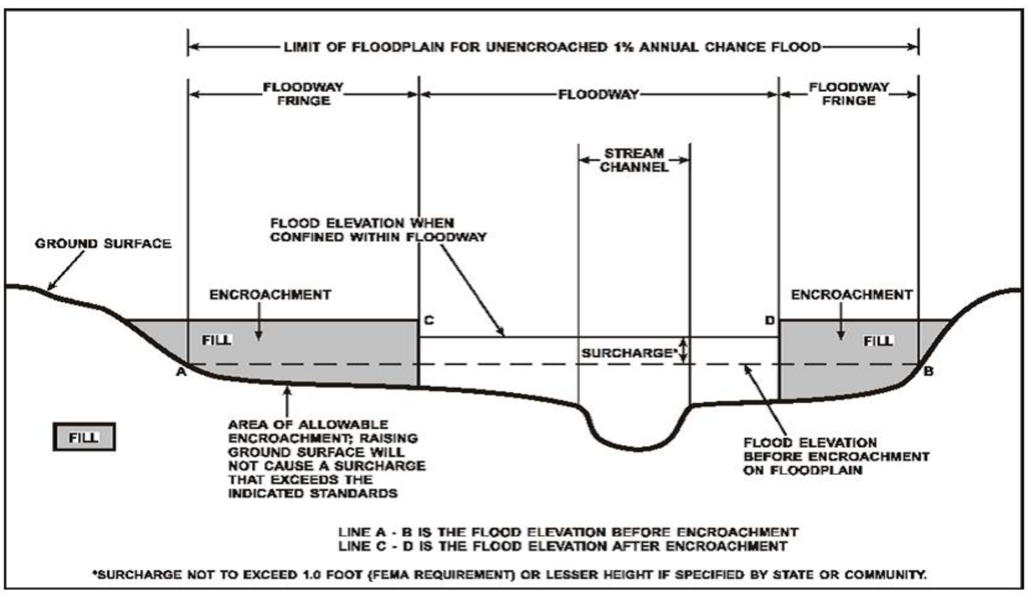

Figure 5: Floodway Schematic

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD 88)	WITHOUT FLOODWAY (FEET NAVD 88)	WITH FLOODWAY (FEET NAVD 88)	INCREASE (FEET)
E-3 Canal								
A	910	75.5	464	3.6	10.2	10.2	10.2	0.0
B	2,230	79	515	3.0	10.5	10.5	10.5	0.0
C	5,530	68	550	2.0	11.3	11.3	11.3	0.0
D	7,510	81	526	1.7	11.5	11.5	11.5	0.0
E	8,830	87.4	511	1.4	11.6	11.6	11.6	0.0
F	11,470	61.5	483	1.4	11.8	11.8	11.8	0.0
G	13,450	64	352	2.1	12.5	12.5	12.5	0.0
H	15,430	87.6	410	1.6	12.5	12.5	12.5	0.0
I	17,410	52	306	1.6	13.0	13.0	13.0	0.0
J	20,710	73	306	1.3	13.1	13.1	13.1	0.0
K	22,690	73	306	1.2	13.1	13.1	13.2	0.1

[1] Feet above mouth

TABLE 14

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL

AND INCORPORATED AREAS

FLOODWAY DATA

E-3 CANAL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD 88)	WITHOUT FLOODWAY (FEET NAVD 88)	WITH FLOODWAY (FEET NAVD 88)	INCREASE (FEET)
E-4 Canal								
A	1,320[1]	162	1,217	5.3	5.7	0.7	0.7	0.0
B	3,960[1]	124	1,281	4.8	5.7	1.5	1.5	0.0
C	8,580[1]	148	1,191	4.1	5.7	4.2	4.2	0.0
D	10,560[1]	99.9	509	7.8	5.7	4.2	4.2	0.0
E	13,860[1]	131	801	3.7	6.6	6.6	6.8	0.2
F	15,840[1]	86	812	2.9	7.2	7.2	7.4	0.2
G	18,480[1]	80	597	3.3	8.6	8.6	8.6	0.0
H	20,460[1]	71.1	881	2.0	8.8	8.8	8.9	0.1
I	22,440[1]	73	722	2.4	8.8	8.8	8.8	0.0
J	23,760[1]	85	767	2.3	8.8	8.8	8.9	0.1
K	27,060[1]	84.4	669	1.0	9.3	9.3	9.3	0.0
L	29,700[1]	84	896	0.6	9.4	9.4	9.4	0.0
M	32,340[1]	82	744	0.3	9.4	9.4	9.4	0.0
Jupiter Creek								
A	867[2]	96	590	2.6	4.4	1.2[3]	1.7	0.5
B	2,547[2]	172	1,091	1.4	4.4	1.6[3]	2.0	0.4
C	4,828[2]	78	427	2.8	4.4	2.0[3]	2.3	0.3
D	6,788[2]	100	630	0.8	4.4	2.5[3]	2.8	0.3
E	7,980[2]	24	117	4.2	4.6	4.6	4.9	0.3

[1] Feet above mouth
[2] Feet above mouth of Southwest Fork Loxahatchee River
[3] Elevation computed without consideration of backwater effects from Southwest Fork Loxahatchee River

TABLE 14

FEDERAL EMERGENCY MANAGEMENT AGENCY
PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

FLOODWAY DATA

E-4 CANAL – JUPITER CREEK

5.0 INSURANCE APPLICATIONS

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

Zone A

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

Zone AE

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

Zone AH

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

Zone AO

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

Zone V

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

Zone VE

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

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of

1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile (sq. mi.), and areas protected from the base flood by levees. No BFEs or depths are shown within this zone.

Zone D

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

6.0 FLOOD INSURANCE RATE MAP

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

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

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

The current FIRM presents flooding information for the entire geographic area of Palm Beach County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the County identified as flood-prone. This countywide FIRM also includes flood-hazard information that was presented separately on Flood Boundary and Floodway Maps (FBFMs), where applicable. Historical data relating to the maps prepared for each community are presented in Table 15, “Community Map History.”

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Palm Beach County, Unincorporated Areas	June 19, 1970	---	February 1, 1979	October 15, 1982; June 2, 1992
Atlantis, City of	December 6, 1974	---	November 1, 1978[1]	---
Belle Glade, City of	July 19, 1974	February 27, 1976	May 15, 1978	September 30, 1982
Boca Raton, City of	January 24, 1975	October 10, 1975	June 1, 1978	September 19, 1984
Boynton Beach, City of	March 8, 1974	October 31, 1975	January 3, 1979	September 30, 1982
Briny Breezes, Town of	January 23, 1974	January 30, 1976	May 15, 1978	September 30, 1982
Cloud Lake, Town of	December 6, 1974	---	May 15, 1978[1]	---
Delray Beach, City of	April 9, 1971	---	April 9, 1971	July 1, 1974; July 16, 1976; March 9, 1979; September 30, 1982; January 5, 1989
Glen Ridge, Town of	December 6, 1974	---	May 15, 1978[1]	---
Golf, Village of [2,3]	October 5, 2017	---	October 5, 2017	---

[1] Conversion to regular program
[2] Non-Floodprone community
[3] This community did not have a FIRM prior to the firtst countywide FIRM for Palm Beach County

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Greenacres, City of [2]	---	---	---	---
Gulf Stream, Town of	November 24, 1972	---	November 24, 1972	July 1, 1974; September 26, 1975; December 15, 1978; September 30, 1982
Haverhill, Town of [2]	---	---	---	---
Highland Beach, Town of	October 17, 1970	---	October 17, 1970	July 1, 1974; January 9, 1976; January 26, 1979; September 30, 1982
Hypoluxo, Town of	August 23, 1974	---	May 15, 1978[1]	---
Juno Beach, Town of	January 4, 1974	May 28, 1976	December 1, 1978	September 30, 1982
Jupiter, Town of	September 27, 1972	---	September 27, 1972	July 1, 1974; May 14, 1976; February 9, 1979; September 30, 1982; June 2, 1992
Jupiter Inlet Colony, Town of	September 22, 1972	---	September 22, 1972	July 1, 1974; April 16, 1976; January 26, 1979; September 30, 1982

[1] Conversion to regular program

[2] This community did not have a FIRM prior to the first countywide FIRM for Palm Beach County.

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Lake Clarke Shores, Town of	January 9, 1974	October 24, 1975	November 1, 1978[1]	---
Lake Park, Town of	November 23, 1973	January 30, 1976	September 15, 1978[1]	---
Lake Worth, City of	August 2, 1974	March 26, 1976	December 1, 1978	September 30, 1982
Lantana, Town of	March 12, 1971	---	March 12, 1971	July 1, 1974; October 1, 1976; January 5, 1979; October 15, 1982
Loxahatchee Groves, Town of[2]	---	---	---	---
Manalapan, Town of	August 18, 1970	---	August 18, 1970	July 1, 1974; October 1, 1976; June 29, 1979; September 30, 1982
Mangonia Park, Town of	January 16, 1974	February 13, 1976	March 1, 1978[1]	---
North Palm Beach, Village of	December 6, 1974	December 19, 1975	August 15, 1978	April 4, 1983; June 2, 1992
Ocean Ridge, Town of	September 18, 1970	---	April 9, 1971	July 1, 1974; December 5, 1975; June 29, 1979; September 30, 1982

[1] Conversion to regular program

[2] This community did not have a FIRM prior to the first countywide FIRM for Palm Beach County.

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Pahokee, City of	September 5, 1975	---	May 15, 1978	October 15, 1982
Palm Beach, Town of	September 13, 1974	September 5, 1975	May 15, 1978	September 30, 1982
Palm Beach Gardens, City of	January 18, 1974	August 6, 1976	January 3, 1979	January 6, 1988
Palm Beach Shores, Town of	April 27, 1970	---	June 25, 1971	July 1, 1974; May 23, 1975; December 30, 1977; September 30, 1982
Palm Springs, Village of	March 15, 1974	June 11, 1976	March 1, 1978	October 23, 1981; December 22, 1998
Riviera Beach, City of	September 27, 1972	---	September 27, 1972	July 1, 1974; October 24, 1975; June 29, 1979; September 30, 1982
Royal Palm Beach, Village of [1]	---	---	---	---
South Bay, City of [1]	---	---	---	---
South Palm Beach, Town of	January 16, 1974	September 26, 1975	May 15, 1978	September 30, 1982

[1] This community did not have a FIRM prior to the first countywide FIRM for Palm Beach County.

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Tequesta, Village of	June 11, 1971	---	June 11, 1971	July 1, 1974; October 8, 1976; January 5, 1979; September 30, 1982
Wellington, Village of[1]	June 19, 1970	---	June 19, 1970	October 15, 1982; June 2, 1992
West Palm Beach, City of	October 31, 1975	March 18, 1977	March 1, 1979	---

[1]Dates taken from Palm Beach Unincorporated Areas

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

In April 1955, the USACE conducted a study of the C-17 Canal (Reference 73). In October 1973, the South Florida Water Management District prepared a *Preliminary Evaluation Report on Land and Water Management Planning in the C-51 Watershed* (Reference 40)). The present FIS is compatible with the results of that study.

Four previous flood studies have been done in Palm Beach County. Three studies were done by the USACE (References 36; 74; 75) and one by the NOAA (Reference 38). The USACE study covering tidal flooding in Palm Beach County does not specify a recurrence interval; however, the Standard Project Flood level specified therein is close to the 1-percent-annual-chance flood level predicted by the 1978 study for the unincorporated areas of Palm Beach County.

Palm Beach County completed its first countywide FIS in 2000 (Reference 33). It was comprised of detailed and approximate studies of coastal, riverine, and lacustrine sources. That study was designated "Preliminary" but the maps that were produced were not adopted. That study updated the flooding sources from previous effective FIS and also included new flooding sources.

Prior to the preliminary countywide FIS, FIS reports were previously prepared for Palm Beach County unincorporated areas and for the incorporated communities of Atlantis, Boca Raton, Cloud Lake, Glen Ridge, Hypoluxo, Lake Clarke, Lake Park, Mangonia, Palm Beach Gardens, and West Palm Beach (References 1-11). In addition, reports for Wave Height Analysis were developed for Palm Beach County unincorporated areas and for the incorporated communities of Belle Glade, Boynton Beach, Briny Breezes, Delray Beach, Gulf Stream, Highland Beach, Juno Beach, Jupiter, Jupiter Inlet Colony, Lake Worth, Lantana, Manalapan, North Palm Beach, Ocean Ridge, Pahokee, Palm Beach (Town of), Palm Beach Shores, Riviera Beach, South Palm Beach, and Tequesta (References 12-32).

FIS reports were previously prepared for the unincorporated areas of Okeechobee County and for the unincorporated and incorporated areas of Indian River County and Martin County (References 76; 77; 78).

This FIS report supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting Federal Insurance and Mitigation Division, FEMA Region IV, Koger-Center — Rutgers Building, 3003 Chamblee Tucker Road, Atlanta, GA 30341.

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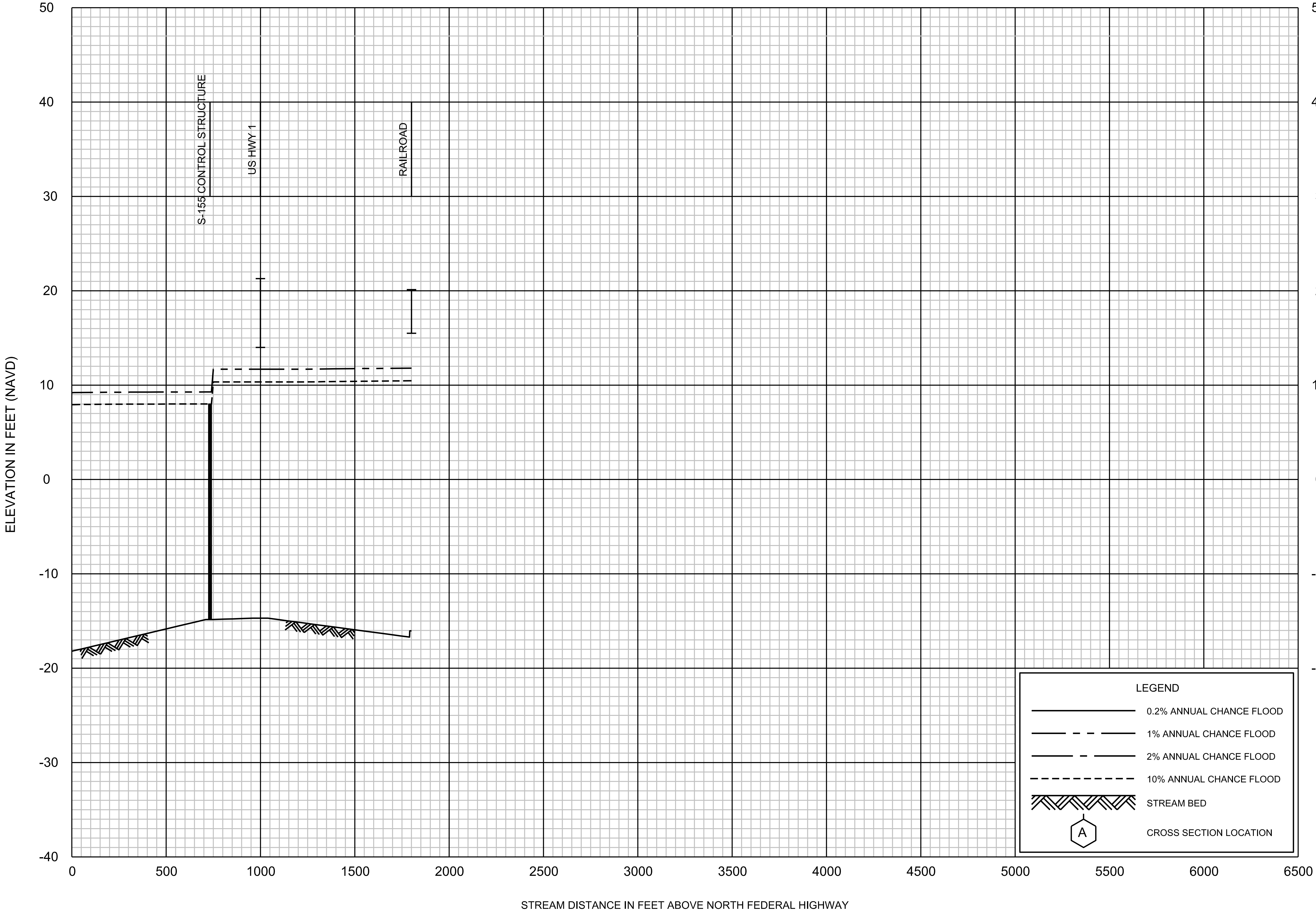


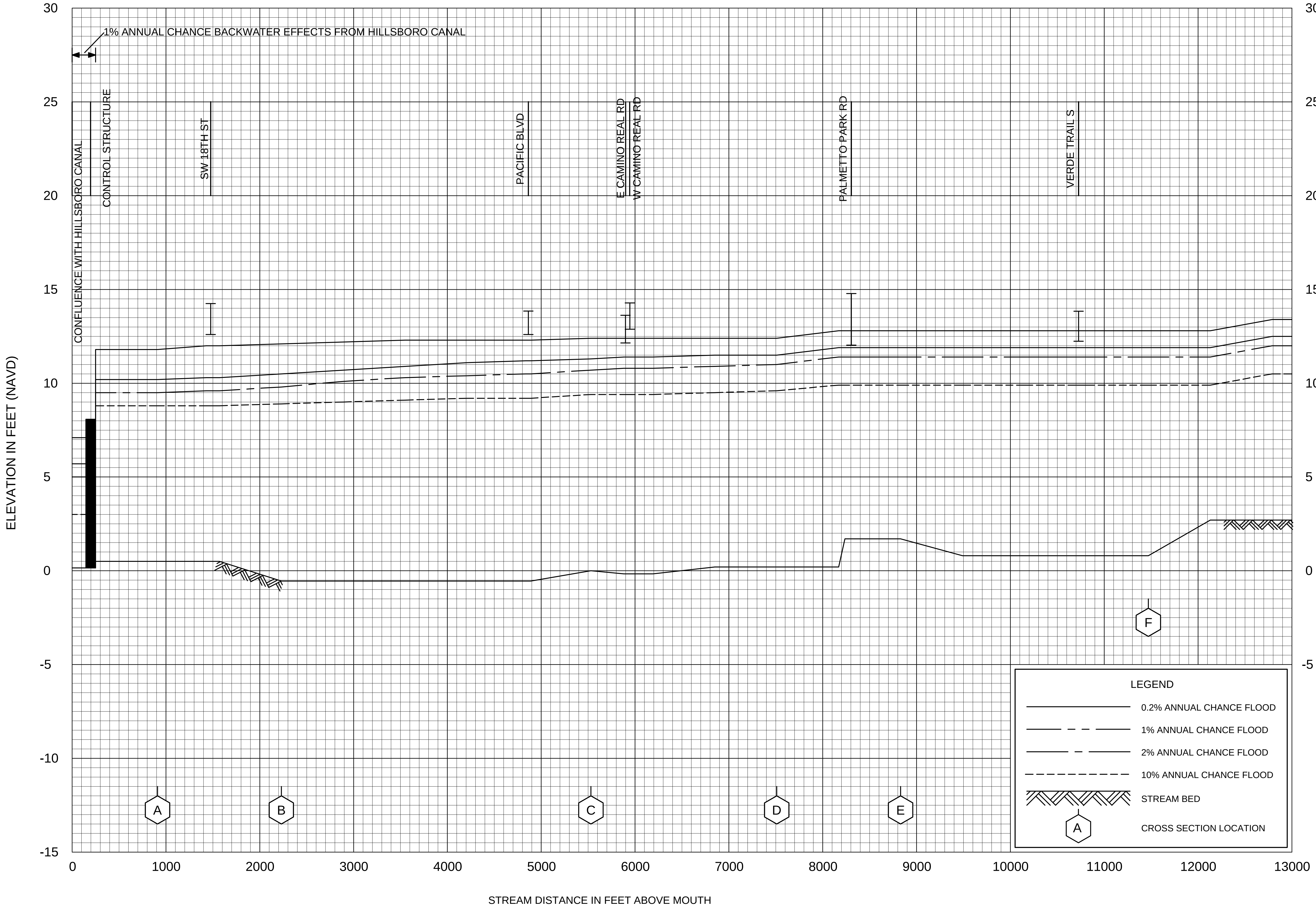
FLOOD PROFILES

C-51 CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

01P

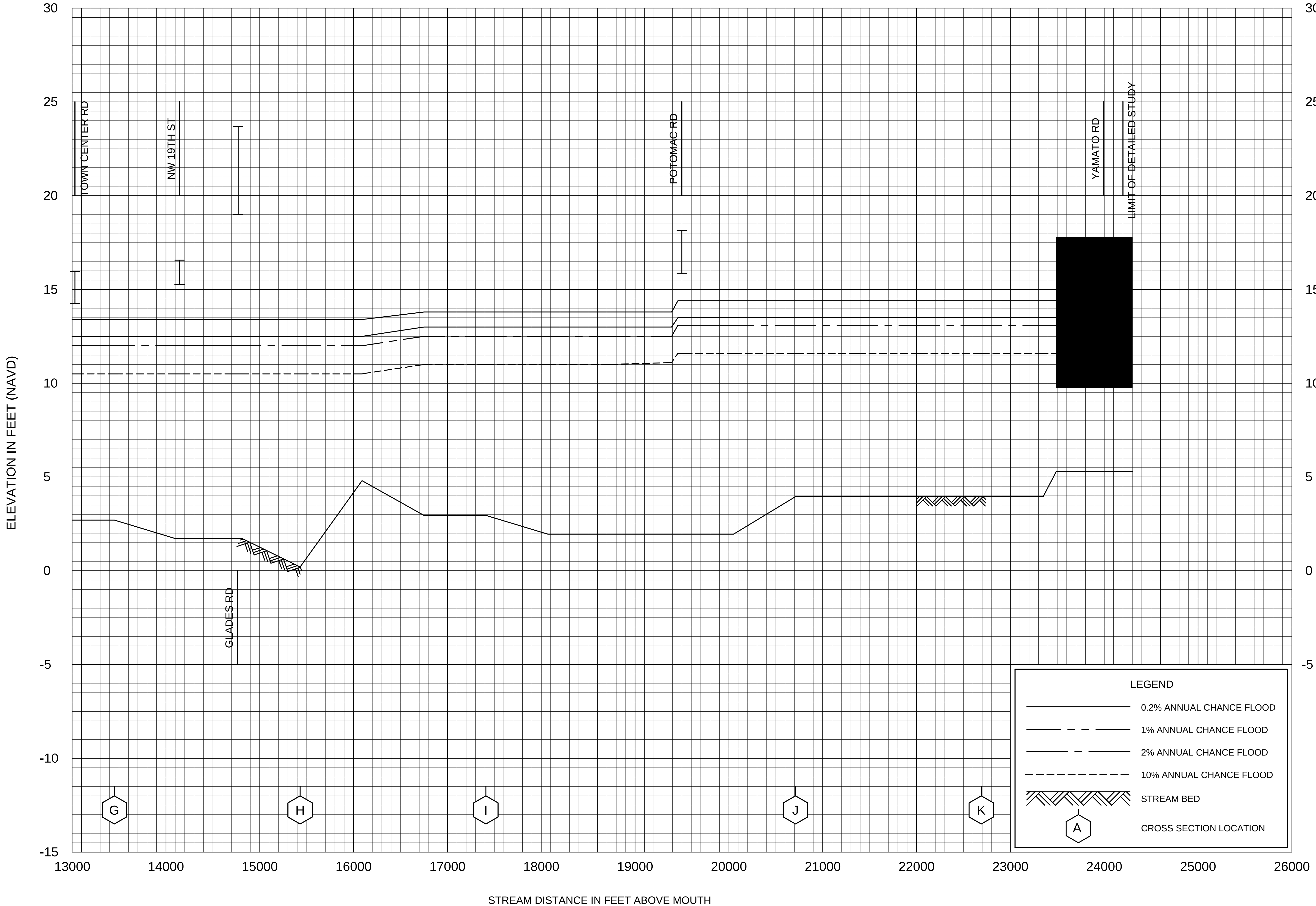


FLOOD PROFILES

E-3 CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS



FLOOD PROFILES

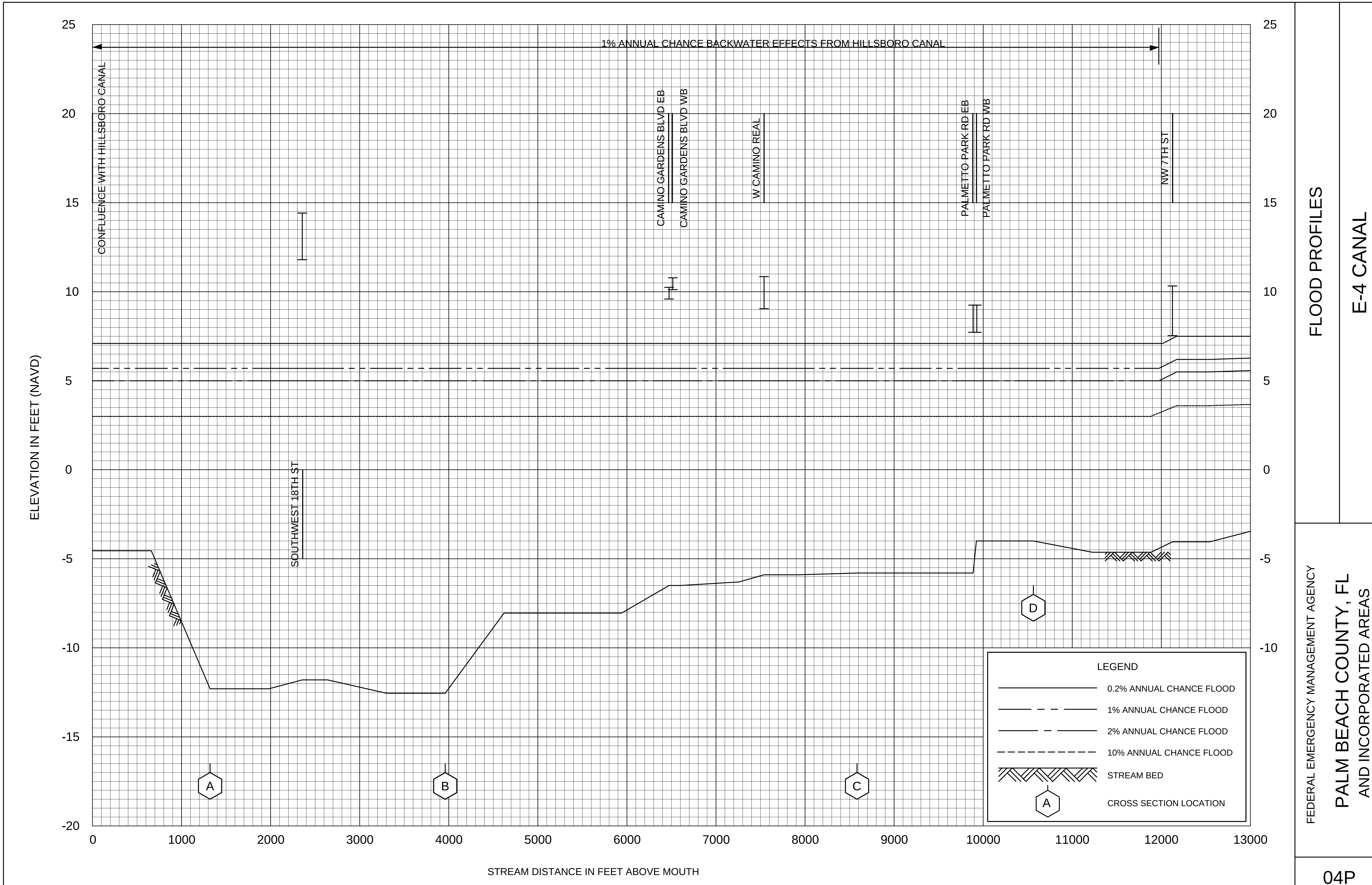
E-3 CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL

AND INCORPORATED AREAS

03P



1% ANNUAL CHANCE BACKWATER EFFECTS FROM HILLSBORO CANAL
CONFLUENCE WITH HILLSBORO CANAL
SOUTHWEST 18TH ST
CAMINO GARDENS BLVD EB
CAMINO GARDENS BLVD WB
W CAMINO REAL
PALMETTO PARK RD EB
PALMETTO PARK RD WB
NW 7TH ST
ELEVATION IN FEET (NAVD)
25
20
15
10
5
0
-5
-10
-15
-20
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
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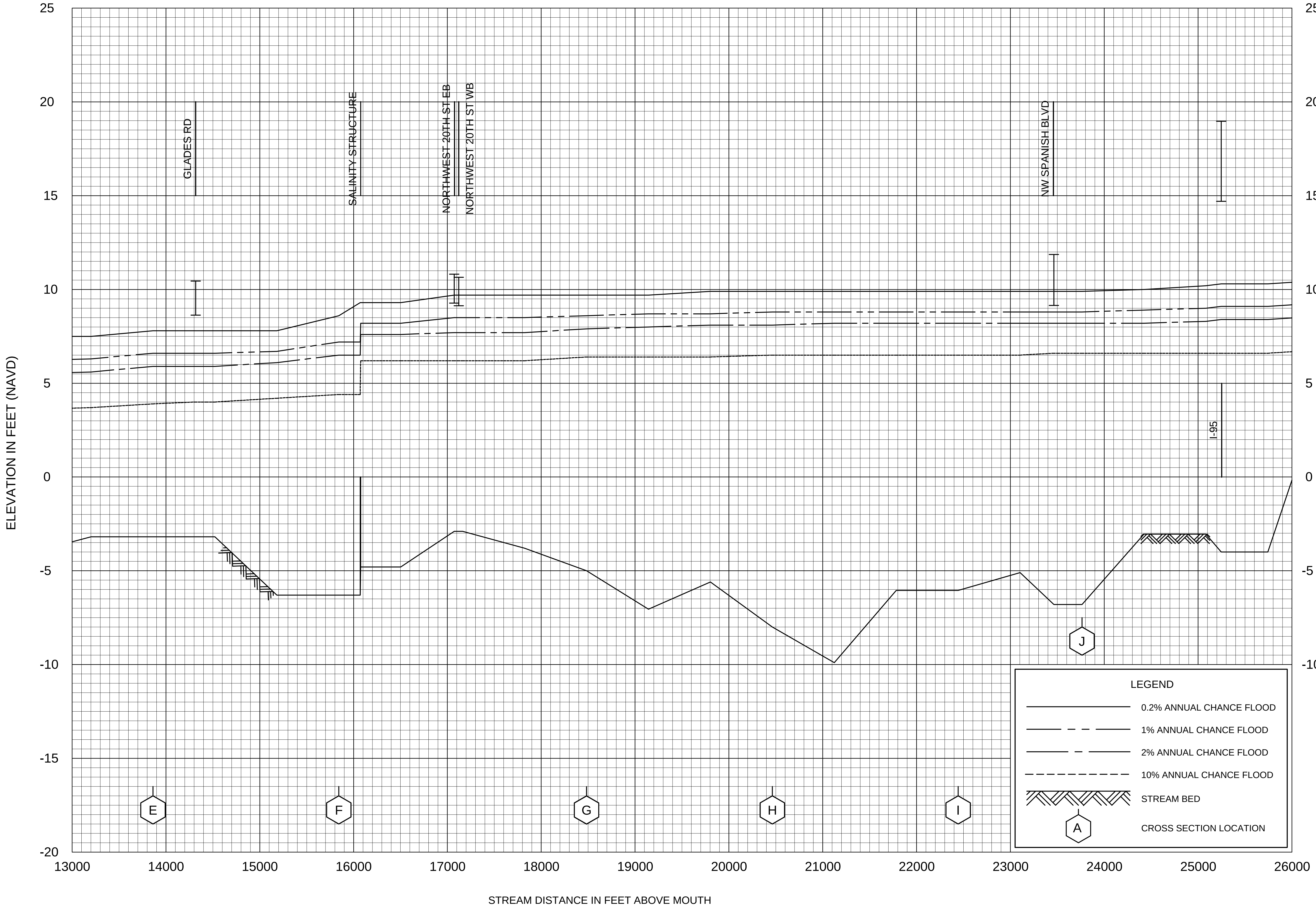
12000
13000
STREAM DISTANCE IN FEET ABOVE MOUTH
A
B
C
D
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
E-4 CANAL
FEDERAL EMERGENCY MANAGEMENT AGENCY
PALM BEACH COUNTY, FL
AND INCORPORATED AREAS
04P



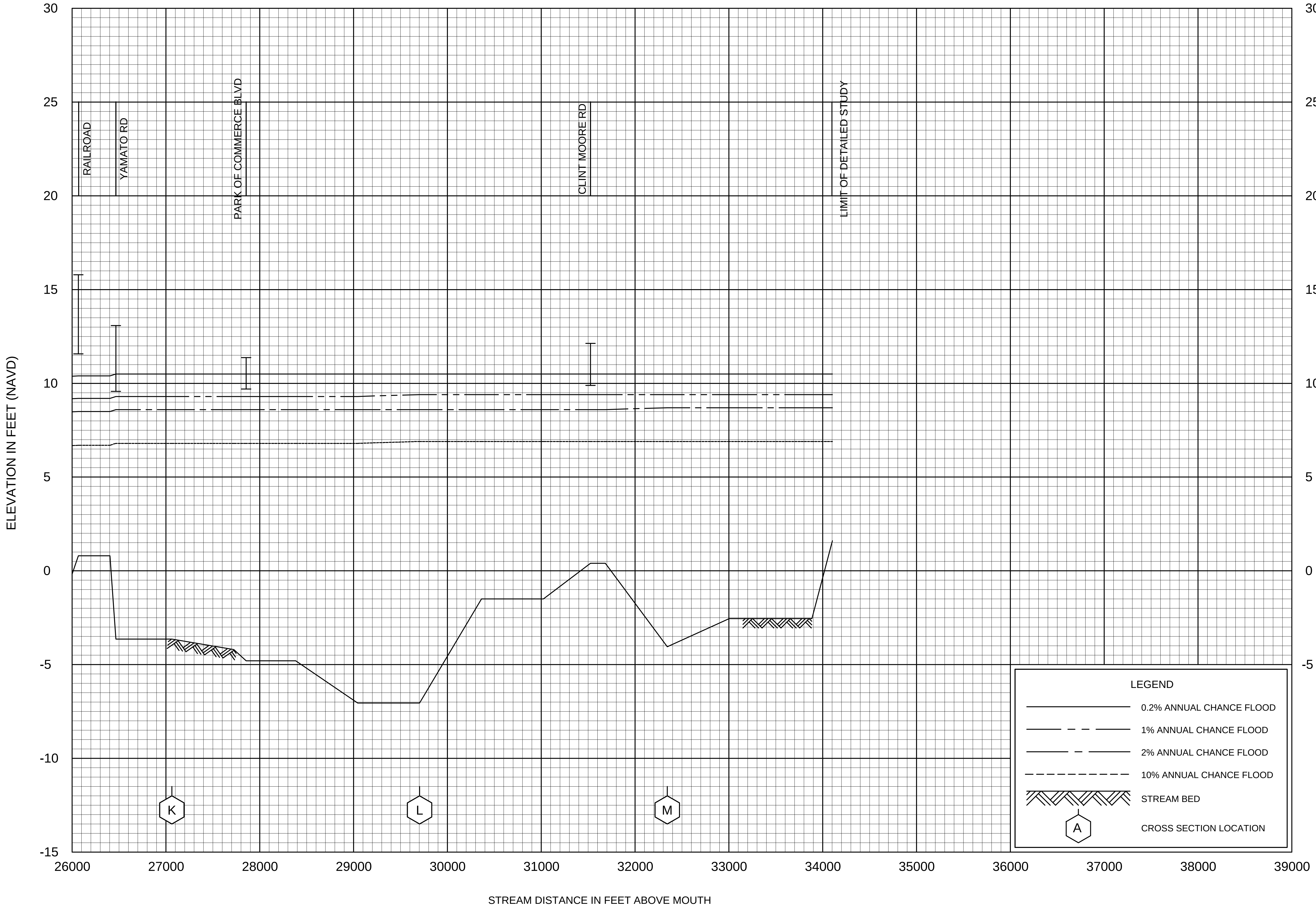
FLOOD PROFILES

E-4 CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

05P

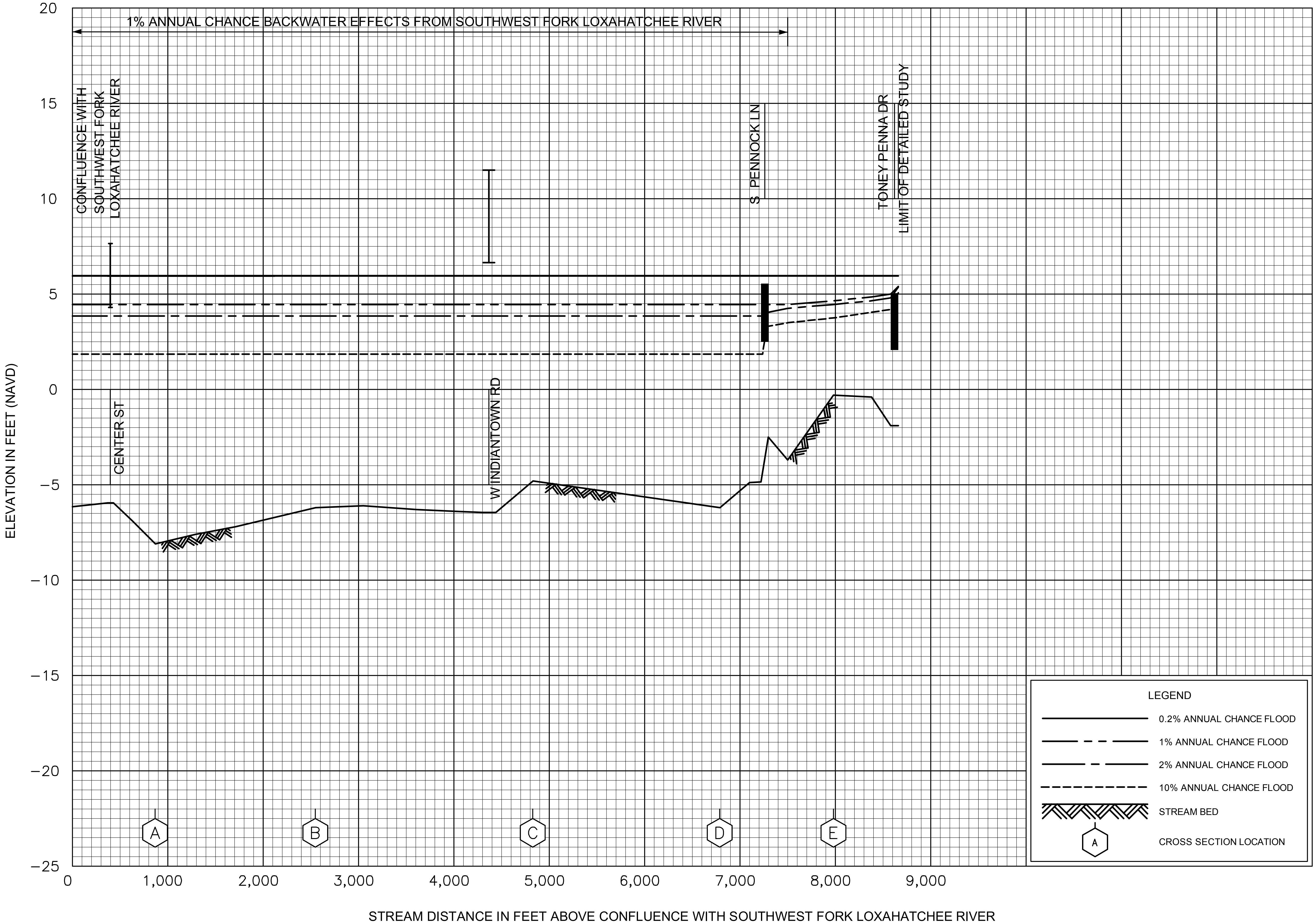


FLOOD PROFILES

E-4 CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS



FLOOD PROFILES

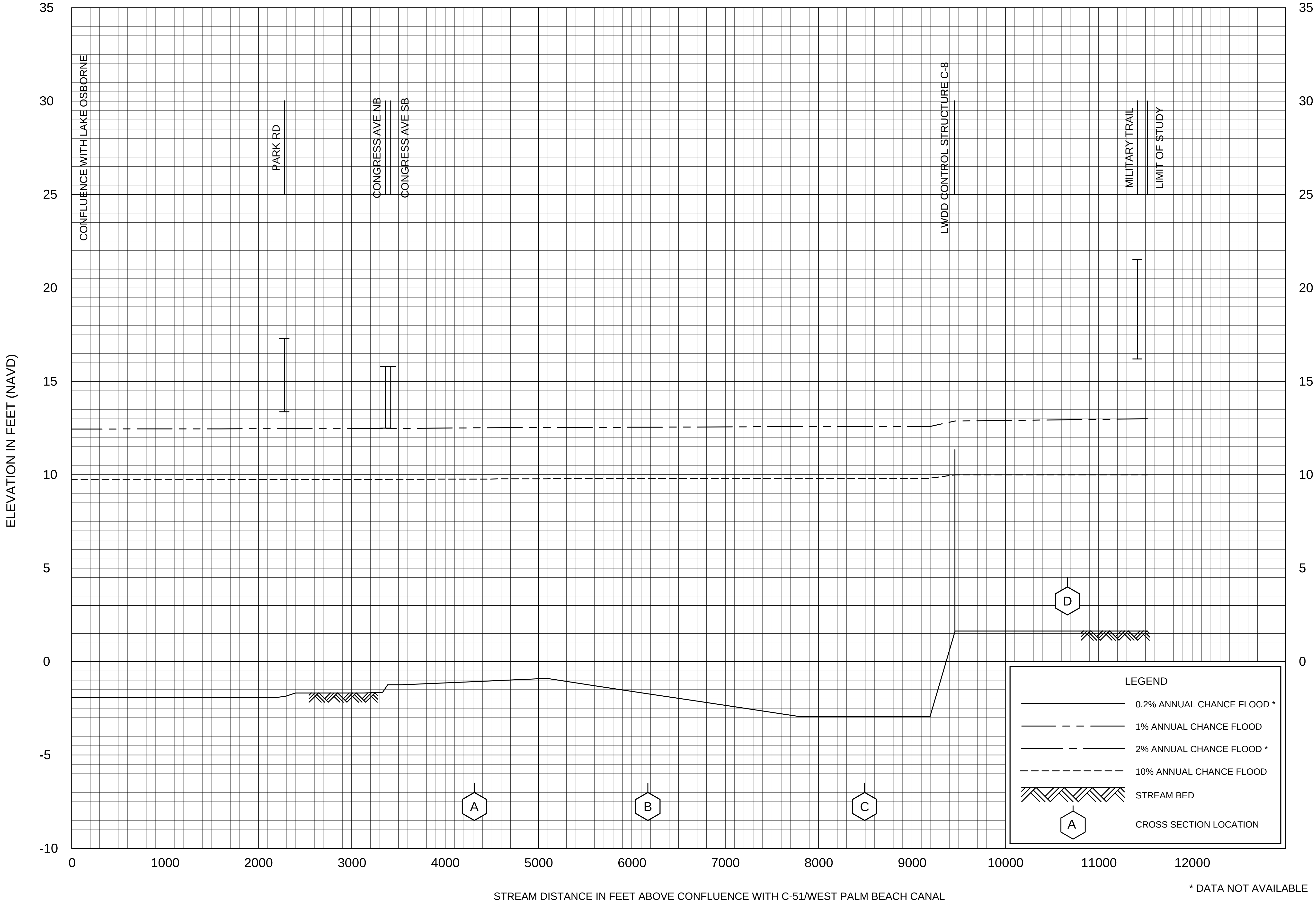
JUPITER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL

AND INCORPORATED AREAS

07P



* DATA NOT AVAILABLE

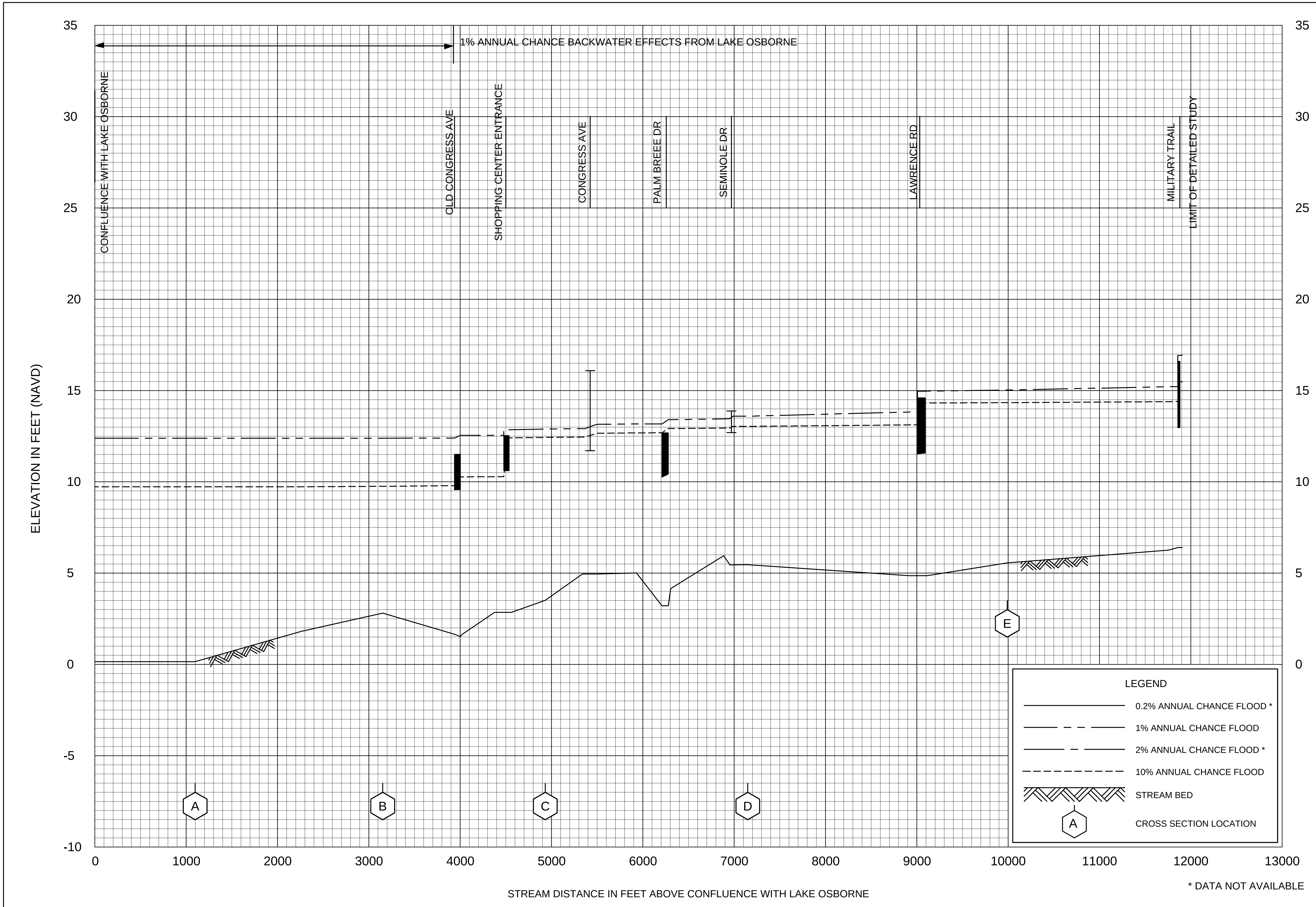
FLOOD PROFILES

L-14 CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

08P



FLOOD PROFILES

L-16 CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

PALM BEACH COUNTY, FL
AND INCORPORATED AREAS

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