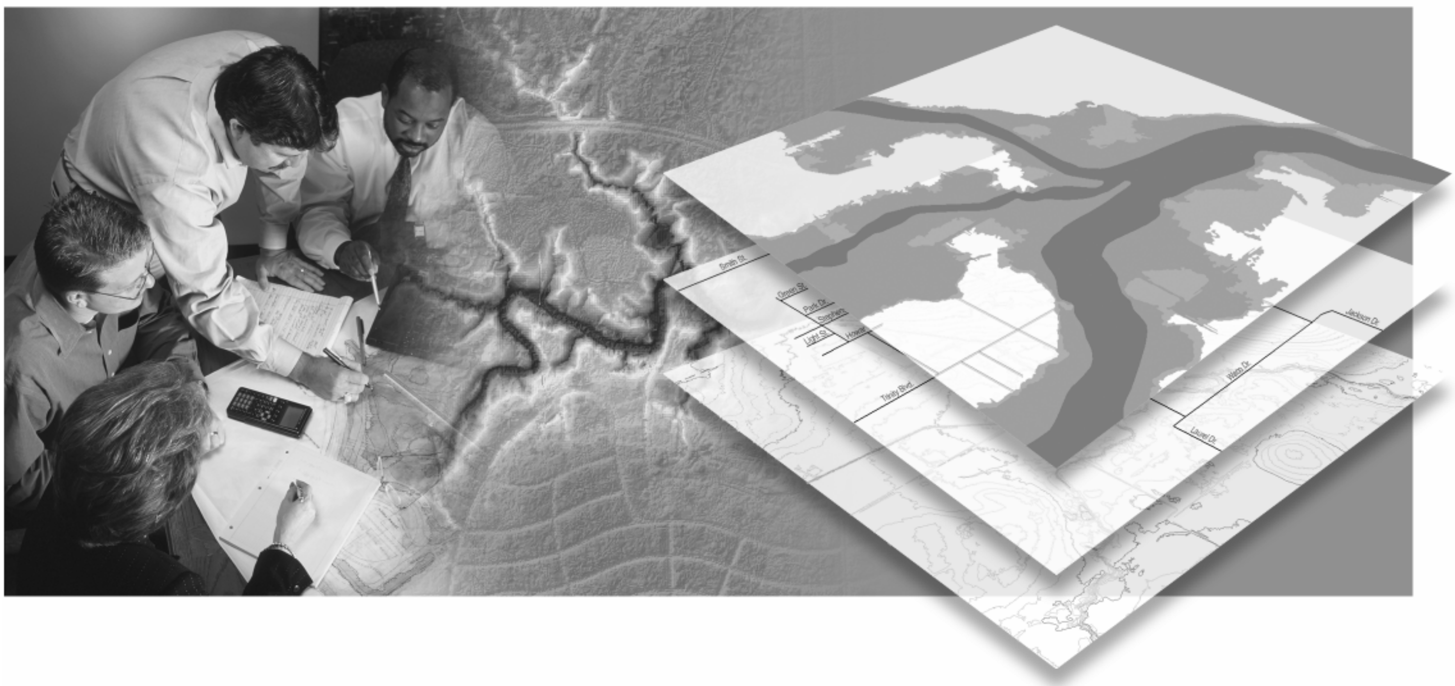
Flood Insurance Study

Harris County, Texas and Incorporated Areas

VOLUME 1 of 12



COMMUNITY NAME	COMMUNITY NO.	COMMUNITY NAME	COMMUNITY NO.
Baytown, City of	485456	Nassau Bay, City of	485491
Bellaire, City of	480289	Pasadena, City of	480307
Bunker Hill Village, City of [1]	480290	Pearland, City of	480077
Deer Park, City of	480291	Piney Point Village, City of	480308
El Lago, City of	485466	Seabrook, City of	485507
Galena Park, City of	480293	Shoreacres, City of	485510
Hedwig Village, City of[1]	480294	South Houston, City of	480311
Hilshire Village, City of	480295	Southside Place, City of	480312
Houston, City of	480296	Spring Valley Village, City of	480313
Humble, City of	480297	Stafford, City of	480233
Hunter's Creek Village, City of	480298	Taylor Lake Village, City of	485513
Jacinto City, City of	480299	Tomball, City of	480315
Jersey Village, City of	480300	Webster, City of	485516
La Porte, City of	485487	West University Place, City of	480318
Missouri City, City of	480304	Harris County Unincorporated Areas	480287
Morgans Point, City of	480305		

[1] No Special Flood Hazard Areas identified

Reprinted with corrections on August 8, 2023

REVISED: November 15, 2019
FLOOD INSURANCE STUDY NUMBER
48201CV001G

FEMA

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.

Part or all of this Flood Insurance Study 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 Flood Insurance Study. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current Flood Insurance Study components. A listing of the Community Map Repositories can be found on the Index Map.

This FIS report was reissued on August 8, 2023 to make a correction. See the Notice-to-User letter that accompanied this correction for details. This version replaces any previous versions.

This FIS was revised on November 15, 2019 Users should refer to Section 10.0, Revision Description, for further information. Section 10.0 is intended to present the most up-to-date information for specific portions of this FIS report. Therefore, users of this FIS report should be aware that the information presented in Section 10.0 supersedes information in Section 1.0 through 9.0 of this FIS report.

This publication incorporates revisions to the original FIS.

Initial Countywide FIS Effective Date: September 28, 1990

First Revised Countywide FIS Date: September 30, 1992 – to update corporate limits, to change Base Flood Elevations, to update map and format and roads and road names: and to incorporate previously issued letters of map amendment.

Second Revised Countywide FIS Date: November 6, 1996 – to update corporate limits, map format and roads and road names; to decrease Base Flood Elevations; and to incorporate previously issued letters of map amendment.

Third Revised Countywide FIS Date: April 20, 2000 – to update corporate limits, to add Base Flood Elevations, Special Flood Hazard Areas; to change Base Flood Elevations, Special Flood Hazard Areas, and zone designations; to add road and road names; to reflect updates topographic information; and to incorporate previously issues letters of map revision, and previously issues letters of map amendment.

Fourth Revised Countywide FIS Date: June 18, 2007 – to change Base Flood Elevations, Special Flood Hazard Areas, zone designations, and floodway; and to reflect updated topographic information.

Fifth Revised Countywide FIS Date: October 16, 2013 -- to change Base Flood Elevations, Special Flood Hazard Areas, and floodway; and to incorporate previously issued letters of map revision.

Sixth Revised Countywide FIS Date: June 9, 2014-- to change Base Flood Elevations, Special Flood Hazard Areas, and floodway; and to incorporate previously issued letters of map revision.

Seventh Revised Countywide FIS Date: May 4, 2015 – to update corporate limits.

Eighth Revised County FIS Date: January 6, 2017 – to change Base Flood Elevations, Special Flood Hazard Areas, zone designations, and floodway; to incorporate previously issued letters of map revision; to update the effects of wave action and road and road names, and to reflect revised shoreline and updated topographic information.

Ninth Revised County FIS Revision Date: May 2, 2019 – to update corporate limits, to change Base Flood Elevations, to change Special Flood Hazard Areas, to change zone designations, to update map format, to add roads and road names, to incorporate previously issued Letters of Map Revision, and to reflect updated topographic information.

Tenth Revised County FIS Revision Date: November 15, 2019 – to change Base Flood Elevations, Special Flood Hazard Areas, zone designations and floodway; to incorporate previously issued letters of map revision; to reflect updated topographic information; and to update roads and road names.

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**All Panels Not Printed as Areas Superseded by 1- percent annual chance coastal flooding

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FLOOD INSURANCE STUDY
HARRIS COUNTY, TEXAS AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This countywide Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Harris County, including the Cities of Baytown, Bellaire, Bunker Hill Village, Deer Park, El Lago, Friendswood (within Harris County), Galena Park, Hedwig Village, Hilshire Village, Houston, Humble, Hunters Creek Village, Jacinto City, Jersey Village, Katy (within Harris County), La Porte, League City (within Harris County), Missouri City (within Harris County), Morgans Point, Nassau Bay, Pasadena, Pearland (within Harris County), Piney Point Village, Seabrook, Shoreacres, South Houston, Southside Place, Spring Valley Village, Stafford (within Harris County), Taylor Lake Village, Tomball, Waller (within Harris County), Webster, and West University Place; and the unincorporated areas of Harris County (referred to collectively herein as Harris 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.

The Cities of Houston is geographically located in Harris, Fort Bend, and Montgomery Counties; and Seabrook is geographically located in Harris, Galveston, and Chambers Counties. Houston and Seabrook will be shown in their entirety in this countywide study as most of these communities' land areas are within Harris County. Similarly, the Cities of Baytown and Shoreacres are geographically located in Chambers and Harris Counties, and will be included in their entirety in this countywide study as most of these communities' land areas are within Harris County.

The Cities of Friendswood and League City are geographically located in Harris and Galveston Counties; the City of Katy is geographically located in Fort Bend, Harris, and Waller Counties; the City of Stafford is geographically located in Fort Bend and Harris Counties; and the City of Waller is geographically located in Harris and Waller Counties. Flood hazard information is provided for the portion of these communities within Harris County for informational purposes only. See separately published FIS reports and Flood Insurance Rate Maps (FIRM) for these communities for NFIP applications and purposes.

The City of Missouri City is geographically located in Harris and Fort Bend Counties, only the portions within Harris County will be included in this study.

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

In some 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. Any such criteria can be obtained from the appropriate community.

1.2 Authority and Acknowledgments

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

The FIS was prepared as part of the Tropical Storm Allison Recovery Project (TSARP), which was a joint effort by FEMA and its Cooperating Technical Partner (CTP), the Harris County Flood Control District (HCFCD), to provide timely flood hazard recovery data for Harris County. The CTP Agreement was established under FEMA Contract No. DR 1379, with the TSARP project facilitated by Mapping Activity Statements 1-7.

The FIS is based upon investigations and analyses that occurred between 2001 and 2004. Elevation and land use data is based upon conditions that existed in January 2002. The study was completed in 2004.

The lead contractors for the project were Michael Baker, Jr. Inc. and Brown & Gay Engineers, Inc., who both provided project management and technical review on behalf of the project. The following contractors provided hydrologic and hydraulic analysis for the study:

Flooding Source	**Hydrology Contractor**	**Hydraulic Contractor**
Clear Creek & Tributaries	Dannenbaum Engineering Corp.	Taylor Engineering, Inc.
Armand Bayou & Tributaries	Dannenbaum Engineering Corp.	Taylor Engineering, Inc.
Sims Bayou & Tributaries	S & B Infrastructure, Inc.	Watershed Concepts
Brays Bayou & Tributaries	Dodson & Associates	Dodson & Associates
White Oak Bayou & Tributaries	Klotz & Associates, Inc.	Halff Associates, Inc.
Galveston Bay Tributaries	Dannenbaum Engineering Corp.	FTN Associates, Ltd. & Taylor Engineering, Inc.
Houston Ship Channel & Tributaries	Dannenbaum Engineering Corp.	Taylor Engineering, Inc.
San Jacinto River & Tributaries	Dannenbaum Engineering Corp.	FTN Associates, Ltd.
Hunting Bayou & Tributaries	S & B Infrastructure, Inc.	Watershed Concepts
Vince Bayou & Tributaries	Dannenbaum Engineering Corp.	Taylor Engineering, Inc.

Flooding Source	Hydrology Contractor	Hydraulic Contractor
Spring Creek & Tributaries	Klotz & Associates, Inc.	Halff Associates, Inc.
Cypress Creek & Tributaries	Klotz & Associates, Inc.	Halff Associates, Inc.
Little Cypress Creek & Tributaries	Klotz & Associates. Inc.	Halff Associates, Inc.
Willow Creek & Tributaries	Klotz & Associates, Inc.	Halff Associates, Inc.
Carpenters Bayou & Tributaries	S & B Infrastructure, Inc.	Watershed Concepts
Goose Creek & Tributaries	S & B Infrastructure, Inc.	Watershed Concepts
Greens Bayou & Tributaries	Dannenbaum Engineering, Corp.	Watershed Concepts
Cedar Bayou & Tributaries	Dannenbaum Engineering, Corp.	FTN Associates, Ltd. & Taylor Engineering, Inc.
Jackson Bayou & Tributaries	Dannenbaum Engineering, Corp.	FTN Associates, Ltd.
Luce Bayou & Tributaries	Dannenbaum Engineering, Corp.	FTN Associates, Ltd.
Barker Reservoir & Tributaries	S & B Infrastructure, Inc.	Watershed Concepts
Addicks Reservoir & Tributaries	S & B Infrastructure, Inc.	Watershed Concepts
Buffalo Bayou & Tributaries	S & B Infrastructure, Inc.	Watershed Concepts

In this revised FIS, detailed studies were provided for some tributary channels that were not studied in detail in the previous FIS. The following contractors were involved in the hydraulic analysis of these channels: Turner Collie & Braden Inc.; Brown & Gay Engineers, Inc.; Costello, Inc.; Dannenbaum Engineering Corp.; and Jones & Carter, Inc.

Additional contractors were involved in the collection and analysis of the data used in the analysis. Terrapoint, LLP acquired and processed the Light Detection and Ranging (LiDAR) data utilized for the study. Dodson & Associates, Inc. provided technical support to the TSARP team. Historical flood data were compiled and analyzed in support of the project team by LJA Engineering & Surveying, Inc., and PBS&J, Inc.

1.3 Coordination

The TSARP project involved extensive coordination with the affected communities and the general public. Four committees were established to facilitate coordination with key elements in the community. The Executive Committee served to provide a mechanism to brief key leaders of the TSARP partnership and other key leaders in the community. The Users Group provided regular updates to the 36 floodplain administrators in Harris County (including those from five special districts which have withdrawn from the NFIP, and relinquished their duties to the county). The Stakeholder Group, with representatives from various affected organizations and interests, updated the community at large. The Technical Committee served as a discussion forum for the methods and approaches employed in the study. This committee included representatives from the engineering and surveying community. The communication effort also involved outreach to the general public. A project website was established to provide ongoing project status reports and other informational material. As the initial draft floodplain maps were delineated, they, along with models, profiles, and data tables, were made available on the project website as "Flood Hazard Recovery Data." The media were engaged and informed of project efforts. In addition, numerous community presentations were provided by the TSARP team.

Extensive communication took place between the Harris-Galveston Coastal Subsidence District and the National Geodetic Survey (NGS) in the establishment of a network of monuments to provide vertical elevation control.

The results of the study were reviewed at the final Consultation Coordination Officer (CCO) meetings held on October 25, 26, 27, 28, November 2, 3, 4, and 5, 2004, and attended by representatives of FEMA, HCFCD, and the 31 communities within Harris County regulated by this study. All problems raised at those meetings have been addressed in this study.

2.0 <u>AREA STUDIED</u>

2.1 Scope of Study

This FIS covers the geographic area of Harris County, Texas, including the incorporated communities listed in Section 1.1. The area of study is shown on the Vicinity Map (see Figure 1).

The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected or foreseeable development and proposed construction through January 2002. Most of the flood sources in Harris County have been studied by detailed methods. Approximate analyses are typically used to study those areas having a low development potential or minimal flood hazards. No approximate analyses were performed in Harris County. The scope and methods of study were proposed to, and agreed upon, by FEMA and the HCFCD.

Harris County has an extensive network of streams and bayous that serve to provide drainage for the region, but that also act as potential flooding sources. This FIS includes approximately 1,100 miles (mi.) of studied channels. Many of these channels have common names, but there are also a large number of unnamed tributaries. This FIS adopts the naming convention for these unnamed tributaries that was used in previous FIS studies for Harris County and unincorporated areas therein. Each unnamed tributary was assigned a name based upon the location of its confluence with the receiving body. For example, Tributary 26.20 to Brays Bayou is a tributary of Brays Bayou having its confluence 26.20 mi. upstream along Brays Bayou from the confluence of Brays Bayou and its receiving body.

The HCFCD also maintains a number designation for streams, also referred to as Units, in Harris County. This designation is included parenthetically along with the common name or tributary mile number. Under the HCFCD system, each of the 22 major watersheds is assigned a letter designation that is used as a prefix for all number designations in that watershed. The main channel typically starts the system with a number designation 100-00-00; the tributaries are assigned higher numbers (101-00-00, 102-00-00, etc.) progressively upstream along the main channel. Second-order tributaries use the middle sequence (101-01-00, 101-02-00, etc.). For example, the Brays Bayou watershed carries the letter designation "D". Therefore, Brays Bayou is known as Unit D100-00-00; Tributary 26.20 to Brays Bayou is known as Unit D129-00-00; a tributary to this channel might be known as D129-01-00.

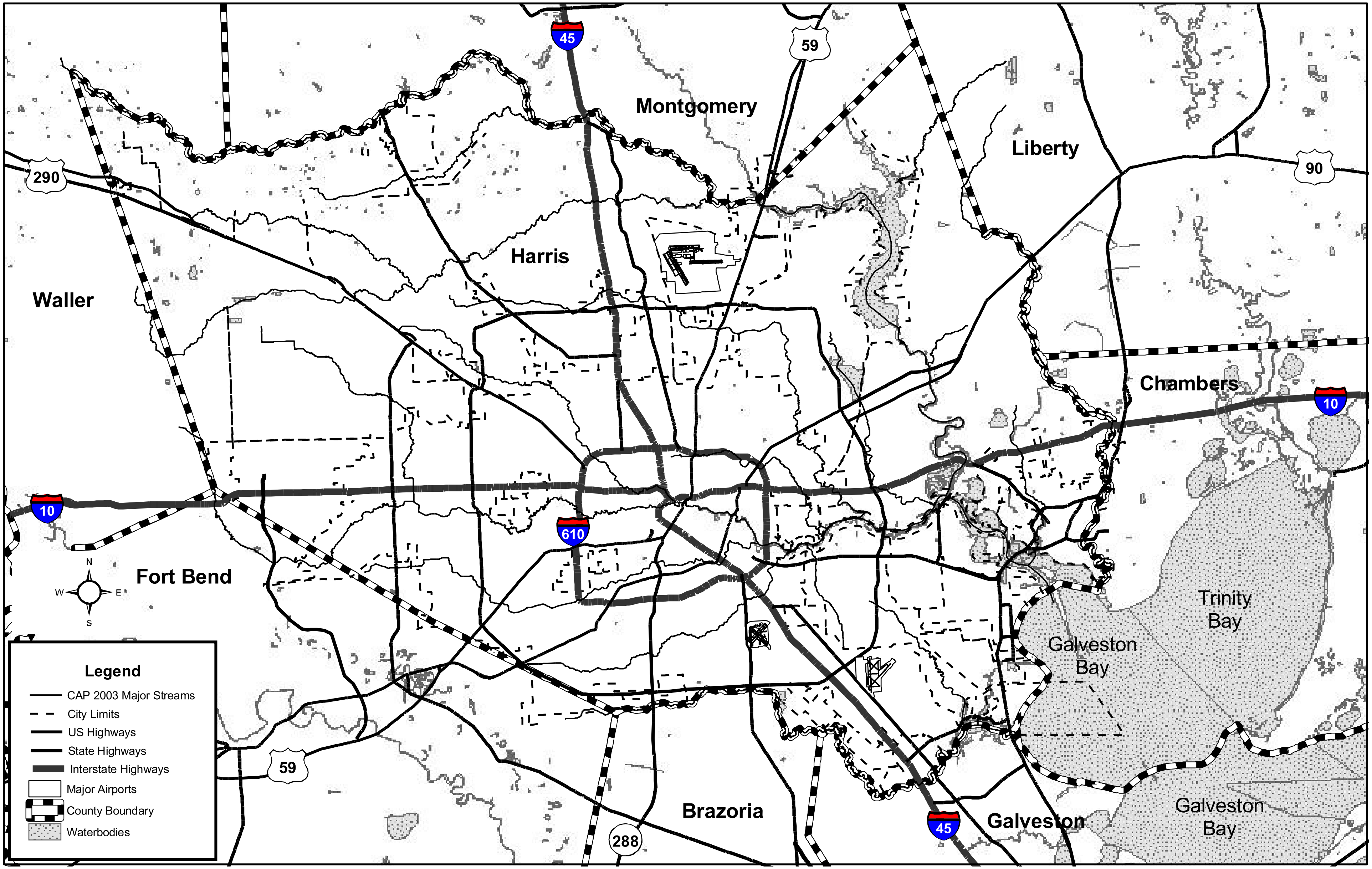


FIGURE 1

Federal Emergency Management Agency

HARRIS COUNTY, TX AND INCORPORATED AREAS

10 5 0 10 20 30 Miles

VICINITY MAP

Table 1, “Scope of Study,” lists the HCFCD designation and the common stream name for all riverine flooding sources studied by detailed methods in this study. Generally, detailed riverine analyses were terminated when the drainage area upstream was reduced to less than 1 square mile (sq. mi.) or when the 1-percent-annual-chance floodplain was found to be less than 200 feet wide for its entire length upstream. Limits of detail study from the prior study were retained. The flooding sources studied by detailed methods are grouped by watershed and listed in order by HCFCD designation. Limits of detailed study for each flooding source, from downstream to upstream, are listed in stream miles measured from the studied stream’s confluence with its receiving water body, or noted landmark. Table 2, “Stream Name Changes,” lists those streams whose name or HCFCD Unit Number has changed from that published in the previous FIS for Harris County. Figure 2 provides a map of the stream network in Harris County.

The analysis of tidal flooding in the coastal areas of Harris County was adopted from the previous FIS study for Harris County.

Tidal flooding, including its wave action, was studied by detailed methods along the northern shore of Clear Lake, from its confluence with Galveston Bay to just past the confluence of Clear Creek; along Taylor Lake, from its confluence with Clear Lake to the confluence of Taylor Bayou; along Forrest Lake, from its confluence with Clear Lake to just past the confluence of Armand Bayou; along Galveston Bay, from the confluence of Clear Lake to the confluence of Cedar Bayou; along the shoreline of Ash Lake; along the San Jacinto River, from its confluence with Galveston Bay to Bear Lake above Interstate Highway 10; and along Buffalo Bayou, from its confluence with the San Jacinto River to just past the confluence of Carpenters Bayou.

Tidal flooding without the effects of wave action was studied by detailed methods along Taylor Bayou including Taylor Lake, Forrest Lake, Clear Creek, the San Jacinto River, Buffalo Bayou, Greens Bayou, Halls Bayou, Ash Lake, and Cedar Bayou. Combined riverine and surge flooding was studied for all areas where riverine and surge flooding interface.

2.2 Community Description

Harris County is located in southeast Texas 24 mi. inland from the Gulf of Mexico. Harris County is bordered by the unincorporated areas of Chambers County to the east, Galveston County to the south, Brazoria County to the south, Fort Bend County to the southwest, Waller County to the north and west, Montgomery County to the north, and Liberty County to the east. Galveston Bay forms a portion of the eastern county boundary. Harris is one of eight counties forming the federally designated Houston Metropolitan Area, which consists of Harris, Brazoria, Chambers, Fort Bend, Galveston, Liberty, Montgomery and Waller Counties. The metropolitan area had a population of 4,669,571 in 2000 (Reference 2.2.1). The City of Houston, the largest city in Harris County and the fourth most populous city in the United States, had a 2000 population of 1,953,631. Harris County contains 34 incorporated communities, with a combined population of 3,400,578 in 2000.

Table 1. Scope of Study

Clear Creek Watershed (A)

HCFCD Designation	Stream Line	Receiving Body	Stream Mile From	Stream Mile To
A100-00-00	Clear Creek	F200-00-00	0.00	44.81
A104-00-00	Taylor Bayou	A100-00-00	0.00	5.83
A104-04-00	Tributary 3.10 to Taylor Bayou	A104-00-00	0.00	0.76
A104-07-00	Tributary 3.93 to Taylor Bayou	A104-00-00	0.00	1.75
A104-13-00	Tributary 3.36 to Taylor Bayou	A104-00-00	0.00	1.16
A104-14-00	Taylor Bayou Diversion Channel	F300-00-00	0.00	0.13
A107-00-00	Cow Bayou	A100-00-00	0.00	1.34
A107-03-00	Unnamed Tributary to Cow Bayou	A107-00-00	1.34	2.03
A111-00-00	Tributary 10.08 to Clear Creek	A100-00-00	0.00	3.21
A118-00-00	Cedar Gully	A100-00-00	0.00	0.27
A119-00-00	Turkey Creek	A100-00-00	0.00	4.47
A119-02-00	Tributary 0.16 to Turkey Creek	A119-00-00	0.00	0.74
A119-05-00	Unnamed Tributary to Turkey Creek	A119-00-00	0.00	1.61
A119-07-00	Unnamed Tributary to Turkey Creek	A119-00-00	0.00	0.11
A119-07-02	Unnamed Tributary to A119-07-00	A119-07-00	0.11	1.46
A120-00-00	Halls Road Ditch	A100-00-00	0.00	5.51

Armand Bayou Watershed (B)

HCFCD Designation	Stream Line	Receiving Body	Stream Mile From	Stream Mile To
B100-00-00	Armand Bayou	A100-00-00	0.00	13.17
B104-00-00	Horsepen Bayou	B100-00-00	0.00	6.37
B104-04-00	Tributary 4.51 to Horsepen Bayou	B104-00-00	0.00	1.72
B104-05-00	Tributary 5.44 to Horsepen Bayou	B104-00-00	0.00	0.87
B106-00-00	Big Island Slough	B100-00-00	0.00	6.89
B109-00-00	Spring Gully	B100-00-00	0.00	2.69
B109-03-00	B112-02-00 Interconnect	B109-00-00	0.00	0.29
B111-00-00	Tributary 9.39 to Armand Bayou	B100-00-00	0.00	1.86
B112-00-00	Willow Springs Bayou	B100-00-00	0.00	3.37
B112-02-00	Tributary 1.78 to Willow Springs Bayou	B112-00-00	0.00	2.28
B112-04-00	Tributary B to Willow Springs Bayou	B112-00-00	0.00	1.15
B113-00-00	Tributary 10.46 to Armand Bayou	B100-00-00	0.00	3.44
B114-00-00	County "C," D.D. #5	B100-00-00	0.00	1.42
B114-01-00	Private "G," D.D. #5	B114-00-00	0.00	0.63
B114-02-00	Unnamed Tributary to B114-00-00	B114-00-00	0.00	0.12
B115-00-00	Tributary 12.18 to Armand Bayou	B100-00-00	0.00	1.06
B115-01-00	Tributary 12.18 to Armand Bayou (continued)	B115-00-00	1.06	1.47
B204-04-00	Horsepen Bayou Diversion Channel	B104-00-00	0.00	0.29

Table 1. Scope of Study (cont'd)

Sims Bayou Watershed (C)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
C100-00-00	Sims Bayou	G100-00-00	0.00	22.09
C102-00-00	Plum Creek	C100-00-00	0.00	1.83
C103-00-00	Pine Gully	C100-00-00	0.00	2.57
C106-00-00	Berry Bayou	C100-00-00	0.00	5.54
C106-01-00	Berry Creek	C106-00-00	0.00	4.43
C106-01-07	Unnamed Tributary to Berry Creek	C106-01-00	4.43	4.71
C106-03-00	Tributary 2.00 to Berry Bayou	C106-00-00	0.00	1.84
C106-08-00	Tributary 3.31 to Berry Bayou	C106-00-00	0.00	1.14
C118-00-00	Salt Water Ditch	C100-00-00	0.00	1.16
C123-00-00	Tributary 10.77 to Sims Bayou	C100-00-00	0.00	0.66
C223-00-00	Tributary 10.77 to Sims Bayou (continued)	C123-00-00	0.66	1.43
C127-00-00	Swengel Ditch	C100-00-00	0.00	1.22
C132-00-00	Tributary 13.83 to Sims Bayou	C100-00-00	0.00	0.88
C147-00-00	Tributary 20.25 to Sims Bayou	C100-00-00	0.00	1.59
C161-00-00	Tributary 17.82 to Sims Bayou	C100-00-00	0.00	1.48

Brays Bayou Watershed (D)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
D100-00-00	Brays Bayou	G100-00-00	0.00	30.07
D109-00-00	Harris Gully	D100-00-00	0.00	1.35
D111-00-00	Poor Farm Ditch	D100-00-00	0.00	2.35
D112-00-00	Willow Waterhole Bayou	D100-00-00	0.00	4.23
D118-00-00	Keegans Bayou	D100-00-00	0.00	6.71
D120-00-00	Tributary 20.90 to Brays Bayou	D100-00-00	0.00	2.98
D122-00-00	Tributary 21.95 to Brays Bayou	D100-00-00	0.00	3.28
D124-00-00	Tributary 22.69 to Brays Bayou	D100-00-00	0.00	1.69
D126-00-00	Tributary 23.53 to Brays Bayou	D100-00-00	0.00	2.85
D129-00-00	Tributary 26.20 to Brays Bayou	D100-00-00	0.00	3.20
D132-00-00	Tributary 29.16 to Brays Bayou	D100-00-00	0.00	1.62
D133-00-00	Bintliff Ditch	D100-00-00	0.00	2.00
D139-00-00	Chimney Rock Diversion Channel	D100-00-00	0.00	1.79
D140-00-00	Fondren Diversion Channel	D100-00-00	0.00	3.17
D140-04-00	Fondren Diversion Channel (continued)	D140-00-00	3.17	3.77
D142-00-00	Tributary 20.86 to Brays Bayou	D100-00-00	0.00	2.38
D144-00-00	City Ditch	D100-00-00	0.00	1.57

Table 1. Scope of Study (cont'd)

White Oak Bayou Watershed (E)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
E100-00-00	White Oak Bayou	W100-00-00	0.00	25.57
E101-00-00	Little White Oak Bayou	E100-00-00	0.00	8.56
E115-00-00	Brickhouse Gully	E100-00-00	0.00	6.12
E115-04-00	Tributary 1.61 to Brickhouse Gully	E115-00-00	0.00	1.76
E116-00-00	Tributary 10.1 to White Oak Bayou	E100-00-00	0.00	0.57
E116-05-00	Tributary 10.1 to White Oak Bayou (continued)	E116-00-00	0.57	1.71
E117-00-00	Cole Creek	E100-00-00	0.00	6.82
E121-00-00	Vogel Creek	E100-00-00	0.00	6.47
E122-00-00	Unnamed Tributary to White Oak Bayou	E100-00-00	0.00	3.42
E124-00-00	Tributary 15.8 to White Oak Bayou	E100-00-00	0.00	1.33
E125-00-00	Rolling Fork	E100-00-00	0.00	1.95
E127-00-00	Tributary 19.05 to White Oak Bayou	E100-00-00	0.00	1.60
E135-00-00	Tributary 19.82 to White Oak Bayou	E100-00-00	0.00	1.73
E141-00-00	Beltway 8 Outfall Ditch	E100-00-00	0.00	2.87

Galveston Bay Watersheds (F)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
F216-00-00	Little Cedar Bayou	F200-00-00	0.00	3.16
F220-00-00	Pine Gully	F200-00-00	0.00	1.93
F220-03-00	Pine Gully (continued)	F220-00-00	1.93	2.22

San Jacinto River Watershed (G)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
G100-00-00	San Jacinto River, Houston Ship Channel	F200-00-00	0.00	9.50
G100-00-00	Buffalo Bayou, Houston Ship Channel	G100-00-00	0.00	15.25
G103-00-00	San Jacinto River	G100-00-00	11.93	28.85
G103-01-00	Unnamed Tributary to San Jacinto River	Old River	0.00	1.77
G103-07-00	Unnamed Tributary to San Jacinto River	G103-00-00	0.00	2.57
G103-00-00	Lake Houston	G103-00-00	0.02	6.77
G103-00-00	West Fork San Jacinto River	G103-00-00	8.34	17.27
G103-33-00	Bens Branch	G103-00-00	0.00	5.55
G103-43-00	Jordan Gully	G103-00-00	0.00	2.31
G103-44-00	TxDOT Ditch #4	G103-43-00	0.00	1.72
G103-48-00	Blacks Branch	G103-00-00	0.00	1.58
G103-80-00	Lake Houston (continued)	G103-00-00	6.77	9.68
G103-80-00	East Fork San Jacinto River	G103-00-00	9.68	22.39
G103-80-03	Caney Creek	G103-80-00	0.00	2.25

Table 1. Scope of Study (cont'd)

White Oak Bayou Watershed (E)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
G103-80-03.1	White Oak Creek	G103-80-03	0.00	2.72
G103-80-03.1A	Mills Branch	G103-80-	0.00	1.67
G103-80-03.1B	Taylor Gully	G103-80-	0.00	2.53
G104-00-00	Patrick Bayou	G100-00-00	0.00	3.68
G104-08-00	E. 13th St. Outfall Channel	G104-00-00	0.00	1.97
G105-00-00	Boggy Bayou	G100-00-00	1.86	3.19
G108-00-00	Glenmore Ditch	G100-00-00	0.00	2.56
G109-00-00	Tributary 6.77 to Buffalo Bayou	G100-00-00	0.00	0.47
G110-00-00	Cotton Patch Bayou	G100-00-00	0.00	1.05
G112-00-00	Panther Creek	G100-00-00	0.00	0.93

Hunting Bayou Watershed (H)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
H100-00-00	Hunting Bayou	G100-00-00	0.00	14.42
H103-00-00	Wallisville Outfall	H100-00-00	0.00	2.76
H110-00-00	Tributary 12.70 to Hunting Bayou	H100-00-00	0.00	0.85
H112-00-00	Schramm Gully	H100-00-00	0.00	0.44
H118-00-00	Tributary 12.05 to Hunting Bayou	H100-00-00	0.00	1.31

Vince Bayou Watershed (I)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
I100-00-00	Vince Bayou	G100-00-00	0.00	6.05
I101-00-00	Little Vince Bayou	I100-00-00	0.00	4.16

Spring Creek Watershed (J)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
J100-00-00	Spring Creek	G103-00-00	0.00	69.65
J109-00-00	Bender Lake	J100-00-00	0.00	0.38
J109-01-00	Continuation of Bender Lake	J109-00-00	0.38	1.25
J121-00-00	Tributary 21.08 to Spring Creek	J100-00-00	0.00	1.14
J131-00-00	Boggs Gully	J100-00-00	0.00	4.10
J131-01-00	Tributary 1.25 to Boggs Gully	J131-00-00	0.00	1.17
J158-00-00	Kickapoo Creek	J100-00-00	0.00	6.13

Table 1. Scope of Study (cont'd)

Cypress Creek Watershed (K)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
K100-00-00	Cypress Creek	J100-00-00	0.00	51.90
K111-00-00	Turkey Creek	K100-00-00	0.00	6.15
K111-03-00	Tributary to Turkey Creek	K111-00-00	0.00	1.44
K112-00-00	Wild Cow Gulch	K100-00-00	0.00	2.15
K116-00-00	Schultz Gully	K100-00-00	0.00	1.07
K120-00-00	Lemm Gully	K100-00-00	0.00	3.09
K120-01-00	Senger Gully	K120-00-00	0.00	3.17
K120-03-00	Wunsche Gully	K120-00-00	0.00	1.94
K124-00-00	Seals Gully	K100-00-00	0.00	4.43
K124-02-00	Kothman Gully	K124-00-00	0.00	2.73
K131-00-00	Spring Gully	K100-00-00	0.00	3.97
K131-02-00	Theiss Gully	K131-00-00	0.00	3.19
K131-02-04	Tributary to Theiss Gully	K131-02-00	3.19	4.30
K131-03-00	Tributary 2.1 to Spring Gully	K131-00-00	0.00	1.67
K131-04-00	Tributary to Spring Gully	K131-00-00	0.00	2.02
K133-00-00	Dry Gully	K100-00-00	0.00	2.83
K140-00-00	Pillot Gully	K100-00-00	0.00	3.69
K142-00-00	Faulkey Gully	K100-00-00	0.00	5.84
K145-00-00	Dry Creek	K100-00-00	0.00	4.53
K150-00-00	Tributary 36.6 to Cypress Creek	K100-00-00	0.00	2.58
K152-00-00	Tributary 37.1 to Cypress Creek	K100-00-00	0.00	0.84
K155-00-00	Tributary 40.7 to Cypress Creek	K100-00-00	0.00	3.48
K157-00-00	Tributary 42.7 to Cypress Creek	K100-00-00	0.00	3.73
K159-00-00	Channel A to Cypress Creek	K100-00-00	0.00	2.50
K159-01-00	Channel D to Channel A to Cypress Creek	K159-00-00	0.00	0.94
K160-00-00	Rock Hollow	K100-00-00	0.00	6.22
K160-01-00	Tributary 1.63 to Rock Hollow	K160-00-00	0.00	2.80
K166-00-00	Mound Creek	K100-00-00	0.00	8.54
K166-01-00	East Fork Mound Creek	K166-00-00	0.00	2.60
K166-02-00	Little Mound Creek	K166-00-00	0.00	2.75
K166-03-00	Tributary 7.62 to Mound Creek	K166-00-00	0.00	0.80
K172-00-00	Tributary 44.5 to Cypress Creek (continued)	K185-00-00	1.43	5.33
K185-00-00	Tributary 44.5 to Cypress Creek	K100-00-00	0.00	1.43

Table 1. Scope of Study (cont'd)

Little Cypress Creek Watershed (L)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
L100-00-00	Little Cypress Creek	K100-00-00	0.00	21.82
L109-00-00	Tributary 9.36 to Little Cypress Creek	L100-00-00	0.00	1.13
L112-00-00	Tributary 10.99 to Little Cypress Creek	L100-00-00	0.00	2.24
L114-00-00	Tributary13.92 to Little Cypress Creek	L100-00-00	0.00	1.23
L114-01-00	Tributary 0.12 to Tributary 13.92 to Little Cypress Creek	L114-00-00	0.00	2.60

Willow Creek Watershed (M)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
M100-00-00	Willow Creek	J100-00-00	0.00	19.87
M101-00-00	Tributary 0.26 to Willow Creek	M100-00-00	0.00	0.73
M102-00-00	Unnamed Tributary to Willow Creek	M100-00-00	0.00	0.57
M104-00-00	Tributary 2.44 to Willow Creek	M100-00-00	0.00	1.70
M108-00-00	Hughes Gully	M100-00-00	0.00	0.60
M109-00-00	Cannon Gully	M100-00-00	0.00	1.10
M109-01-00	Metzler Creek	M109-00-00	0.00	0.68
M112-00-00	Roan Gully	M100-00-00	0.00	2.12
M116-00-00	Tributary 8.16 to Willow Creek	M100-00-00	0.00	1.33
M124-00-00	Tributary 13.50 to Willow Creek	M100-00-00	0.00	2.55
M129-00-00	Continuation of Willow Creek	M100-00-00	19.87	20.38

Carpenters Bayou Watershed (N)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
N100-00-00	Carpenters Bayou	G100-00-00	0.00	11.95
N100-00-00	Sheldon Reservoir	N100-00-00	n/a	n/a
N104-00-00	Tributary 3.33 to Carpenters Bayou	N100-00-00	0.00	2.13
N117-00-00	Tributary 11.715 to Carpenters Bayou	N100-00-00	0.00	1.62

Goose Creek Watershed (O)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
O100-00-00	Goose Creek	G103-00-00	0.00	11.40
O105-00-00	East Fork Goose Creek	O100-00-00	0.00	2.47
O200-00-00	Spring Gully	Burnett Bay	0.00	6.68
O208-00-00	Spring Gully Diversion Channel	G103-00-00	0.00	0.35

Table 1. Scope of Study (cont'd)

Greens Bayou Watersheds (P)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
P100-00-00	Greens Bayou	G100-00-00	0.00	43.31
P107-00-00	Big Gulch	P100-00-00	0.00	5.13
P109-00-00	Sulphur Gully	P100-00-00	0.00	1.74
P110-00-00	Spring Gully	P100-00-00	0.00	1.62
P114-00-00	Unnamed Tributary to Greens Bayou	P100-00-00	0.00	2.65
P118-00-00	Halls Bayou	P100-00-00	0.00	19.74
P118-14-00	Tributary 6.71 to Halls Bayou	P118-00-00	0.00	2.01
P118-23-00	Tributary 11.96 to Halls Bayou	P118-00-00	0.00	1.45
P125-00-00	Tributary 14.27 to Greens Bayou	P100-00-00	0.00	4.28
P125-04-00	Tributary 14.27 to Greens Bayou (continued)	P125-00-00	4.28	4.38
P126-00-00	Tributary 14.82 to Greens Bayou	P100-00-00	0.00	4.03
P130-00-00	Garners Bayou	P100-00-00	0.00	9.83
P130-02-00	Williams Gully	P130-00-00	0.00	4.37
P130-02-02	Tributary 2.01 to Williams Gully	P130-02-00	0.00	2.00
P130-03-00	Tributary 3.19 to Garners Bayou	P130-00-00	0.00	1.26
P130-03-01	Tributary 0.55 to Tributary 3.19 Garners Bayou	P130-03-00	0.00	1.31
P130-05-00	Reinhardt Bayou	P130-00-00	0.00	3.70
P133-00-00	Tributary 20.88 to Greens Bayou	P100-00-00	0.00	2.23
P138-00-00	Tributary 24.97 to Greens Bayou	P100-00-00	0.00	4.56
P140-00-00	Tributary 26.64 to Greens Bayou -- Hoods Bayou	P100-00-00	0.00	2.12
P140-04-00	Continuation of Tributary 26.64 to Greens Bayou	P140-00-00	2.12	3.83
P140-04-03	Continuation of Tributary 26.64 to Greens Bayou	P140-04-00	3.83	5.43
P145-00-00	North Fork Greens Bayou	P100-00-00	0.00	4.57
P145-03-00	Tributary 1.95 to North Fork Greens Bayou	P145-00-00	0.00	2.49
P146-00-00	Tributary 32.23 to Greens Bayou	P100-00-00	0.00	1.77
P147-00-00	Unnamed Tributary to Greens Bayou	P100-00-00	0.00	2.92
P148-00-00	Tributary 34.60 to Greens Bayou	P100-00-00	0.00	1.63
P155-00-00	Unnamed Tributary to Greens Bayou	P100-00-00	0.00	1.36
P156-00-00	Unnamed Tributary to Greens Bayou	P100-00-00	0.00	0.91

Table 1. Scope of Study (cont'd)

Cedar Bayou Watershed (Q)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
Q100-00-00	Cedar Bayou	F200-00-00	0.00	39.87
Q101-00-00	Pine Gully	Q100-00-00	0.00	0.56
Q112-00-00	Cary Bayou	Q100-00-00	0.00	3.14
None	Horsepen Bayou (City of Baytown)	Q100-00-00	0.00	0.96
Q114-00-00	McGee Gully	Q100-00-00	0.00	3.21
Q122-00-00	Clawson Ditch	Q100-00-00	0.00	3.72
Q128-00-00	Adlong Ditch	Q100-00-00	0.00	6.23
Q130-00-00	Unnamed Tributary to Cedar Bayou	Q100-00-00	0.00	2.74
Q200-00-00	Cedar Bayou Diversion Channel	F200-00-00	0.00	0.98

Jackson Bayou Watershed (R)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
R100-00-00	Jackson Bayou	G103-00-00	0.00	4.87
R102-00-00	Gum Gully	R100-00-00	0.00	7.68
R102-03-00	Tributary 2.70 to Gum Gully	R102-00-00	0.00	0.55
R102-03-01	Tributary 2.70 to Gum Gully (continued)	R102-03-00	0.55	1.27
R102-13-00	Tributary 3.08 to Gum Gully	R102-00-00	0.00	1.76

Luce Bayou Watershed (S)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
S100-00-00	Luce Bayou	G103-80-00	0.00	7.47
S110-00-00	Shook Gully	S100-00-00	0.00	2.09
S114-00-00	Mexican Gully	S100-00-00	0.00	0.39

Barker Reservoir Watershed (T)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
T100-00-00	Upper Buffalo Bayou / Cane	W100-00-00	n/a	n/a
T100-00-00	Cane Island Branch	T100-00-00	0.00	5.51
T101-00-00	Mason Creek	T100-00-00	1.05	7.08
T101-03-00	Tributary 4.96 to Mason Creek	T101-00-00	0.00	3.08
T101-10-00	Unnamed Tributary to Mason Creek	T101-00-00	7.08	7.37
T103-00-00	Tributary 52.9 to Upper Buffalo Bayou / Cane	T100-00-00	1.20	2.50
T103-01-00	Tributary 2.17 to Tributary 52.9 to Upper Buffalo Cane	T103-00-00	0.00	0.83

Table 1. Scope of Study (cont'd)

Addicks Reservoir Watershed (U)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
U100-00-00	Langham Creek	W100-00-00	2.87	16.88
U101-00-00	South Mayde Creek	U100-00-00	3.98	19.29
U101-07-00	Tributary 9.4 to South Mayde Creek	U101-00-00	0.00	3.94
U101-22-00	Unnamed Tributary to South Mayde Creek	U100-00-00	19.29	21.78
U102-00-00	Bear Creek	U100-00-00	3.12	14.72
U102-01-00	Unnamed Tributary to Bear Creek	U102-00-00	0.00	1.75
U106-00-00	Horsepen Creek	U200-00-00	0.00	6.09
U120-00-00	Dinner Creek	U100-00-00	0.00	3.59
U200-00-00	Addicks Reservoir Diversion Channel	U100-00-00	4.23	5.68
U202-01-00	Bear Creek Diversion Channel	U102-00-00	3.32	4.08
W167-01-00	Tributary 3.9 to Turkey Creek	W167-00-00	1.53	3.26

Buffalo Bayou Watershed (W)

HCFCD Designation	Stream Name	Receiving Body	Stream Mile From	Stream Mile To
W100-00-00	Buffalo Bayou	G100-00-00	15.25	47.09
W140-00-00	Spring Branch	W100-00-00	0.00	3.64
W140-01-00	Briar Branch	W140-00-00	0.00	2.52
W141-00-00	Soldiers Creek	W100-00-00	0.00	1.92
W142-00-00	Bering Ditch	W100-00-00	0.00	1.26
W156-00-00	Rummel Creek	W100-00-00	0.00	4.11
W157-00-00	Unnamed Tributary to Buffalo Bayou	W100-00-00	0.00	1.75
W167-00-00	Turkey Creek	W100-00-00	0.00	1.98
W167-04-00	Continuation of Turkey Creek	W167-00-00	1.98	8.60
W167-01-00	Tributary 3.9 to Turkey Creek (See Addicks)	W167-00-00	--	--
W170-00-00	Unnamed Tributary to Buffalo Bayou	W100-00-00	0.00	3.22
W190-00-00	Clodine Ditch	W100-00-00	0.00	6.58

n/a = not applicable

Table 2. Stream Name Changes

HCFCD Designation	Old Name	New Name
A107-03-00	Cow Bayou (A107-00-00)	Unnamed Tributary to Cow Bayou
B100-00-00	Forest Lake / Armand Lake / Mud Lake	Armand Bayou
B115-01-00	Tributary 12.18 to Armand Bayou (B115-00-00)	B115-01-00 (Tributary 12.18 to Armand Bayou (continued))
B204-04-00	Diversion Channel (B104-00-00) & Diversion Channel (B204-04-00)	B204-04-00 (Horsepen Bayou Diversion Channel)
C118-00-00	Tributary 10.12 to Sims Bayou	C118-00-00 (Salt Water Ditch)
C223-00-00	Tributary 10.77 to Sims Bayou (C123-00-00)	C223-00-00 (Tributary 10.77 to Sims Bayou (continued))
D133-00-00	Tributary 17.42 to Brays Bayou	Bintliff Ditch
D140-00-00	Fondren Diversion Channel	D140-00-00 (Fondren Diversion Channel)
D140-04-00	Fondren Diversion Channel (D140-00-00)	D140-04-00 (Fondren Diversion Channel (continued))
D144-00-00	Tributary 19.77 to Brays Bayou	City Ditch
E116-00-00	Tributary 10.1 to White Oak Bayou (E116-05-00)	E116-00-00 (Tributary 10.1 to White Oak Bayou)
E116-05-00	Tributary 10.1 to White Oak Bayou (E116-05-00)	E116-05-00 (Tributary 10.1 to White Oak Bayou (continued))
E141-00-00	Ditch (E141-00-00)	E141-00-00 (Beltway 8 Outfall Ditch)
F220-03-00	Pine Gully (F220-00-00)	F220-03-00 (Pine Gully (continued)
G100-00-00	San Jacinto River (G103-00-00) Houston Ship Channel	G100-00-00 (San Jacinto River, Houston Ship Channel)
G100-00-00	Buffalo Bayou (W100-00-00) Houston Ship Channel	G100-00-00 (Buffalo Bayou, Houston Ship Channel)
G103-44-00	Tributary 16.8 to W Fork San Jacinto River	G103-44-00 (TxDOT Ditch #4)

Table 2. Stream Name Changes (cont'd)

HCFCD Designation	Old Name	New Name
G103-48-00	Tributary 17.7 to W Fork San Jacinto River	G103-48-00 (Blacks Branch)
G103-48-00	Lake Houston (G103-00-00)	G103-80-00 (Lake Houston)
G103-80-03.1	White Oak Creek (G103-80-03.2)	G103-08-03.1 (White Oak Creek)
G103-80-03.1A	Mills Branch (G103-80-03.2A)	G103-08-03.1A (Mills Branch)
G103-80-03.1B	Taylor Gully (G103-80-03.1)	G103-08-03.1B (Taylor Gully)
G109-00-00	Tributary 6.77 to Buffalo Bayou	G109-00-00 (Tributary 6.77 to Buffalo Bayou)
G110-00-00	Tributary 8.17 to Buffalo Bayou	Cotton Patch Bayou
H103-00-00	Tributary 5.22 to Hunting Bayou	Wallisville Outfall
H112-00-00	Tributary 13.85 to Hunting Bayou	Schramm Gully
J109-00-00	Bender Lake	J109-00-00 (Bender Lake)
J109-01-00	Bender Lake	J109-01-00 (continuation of Bender Lake)
J131-00-00	Boggs Gully (reach between stations 12000 and 16000)	J131 OLD [stream re-aligned, this reach no longer a studied stream]
K166-01-00	Tributary 8.18 to Mound Creek	East Fork Mound Creek
K172-00-00	Tributary 44.5 to Cypress Creek	K172-00-00 (Tributary 44.5 to Cypress Creek)
K185-00-00	Tributary 44.5 to Cypress Creek	K185-00-00 (Tributary 44.5 to Cypress Creek)
L114-00-00	Tributary 0.12 to Tributary 13.92 to Little Cypress Creek (L114-01-00)	L114-00-00 (Tributary 13.92 to Little Cypress Creek)
L114-01-00	Tributary 13.92 to Little Cypress Creek (L114-00-00)	L114-01-00 (Tributary 0.12 to Tributary 13.92 to Little Cypress Creek)
M112-00-00	Tributary 6.52 to Willow Creek	Roan Gully
M129-00-00	Willow Creek (M100-00-00)	M129-00-00 (continuation of Willow Creek)

Table 2. Stream Name Changes (cont'd)

HCFCD Designation	Old Name	New Name
P125-04-00	Tributary 14.27 to Greens Bayou (P125-00-00)	P125-04-00 (Tributary 14.27 to Greens Bayou (continued))
P140-00-00	Tributary 26.64 to Greens Bayou	P140-00-00 (Tributary 26.64 to Greens Bayou; Hoods Bayou)
P140-04-00	Tributary 26.64 to Greens Bayou	P140-04-00 (continuation of Tributary 26.64 to Greens Bayou)
P140-04-03	Tributary 26.64 to Greens Bayou	P140-04-03 (continuation of Tributary 26.64 to Greens Bayou)
None	Horsepen Bayou (Q113-00-00)	Horsepen Bayou (City of Baytown)
R102-03-01	Tributary 2.70 to Gum Gully (R102-03-00)	R102-03-01 (Tributary 2.70 to Gum Gully continued)
T100-00-00	Buffalo Bayou (T100-00-00)	T100-00-00 (Upper Buffalo Bayou / Cane)
T101-10-00	Mason Creek (T101-00-00)	Unnamed Tributary to Mason Creek
T103-00-00	Tributary 52.9 to Buffalo Bayou (T103-00-00)	T103-00-00 (Tributary 52.9 to Upper Buffalo Bayou / Cane)
T103-01-00	Tributary 2.17 to Tributary 52.9 to Buffalo Bayou (T103-01-00)	T103-01-00 (Tributary 2.17 to Tributary 52.9 to Upper Buffalo Bayou / Cane)
U101-22-00	South Mayde Creek (U101-00-00)	U101-22-00 (Unnamed Tributary to South Mayde Creek)
U101-07-00	Tributary 9.4 to South Mayde Creek (U101-07-01)	U101-07-00 (Tributary 9.4 to South Mayde Creek)
U200-00-00	Diversion Channel	Addicks Reservoir Diversion Channel
W141-00-00	Tributary No. 1 to Buffalo Bayou	W141-00-00 (Soldiers Creek)
W167-00-00	Turkey Creek	W167-00-00 (Turkey Creek)
W167-04-00	Turkey Creek (W167-00-00)	W167-04-00 (Continuation of Turkey Creek)

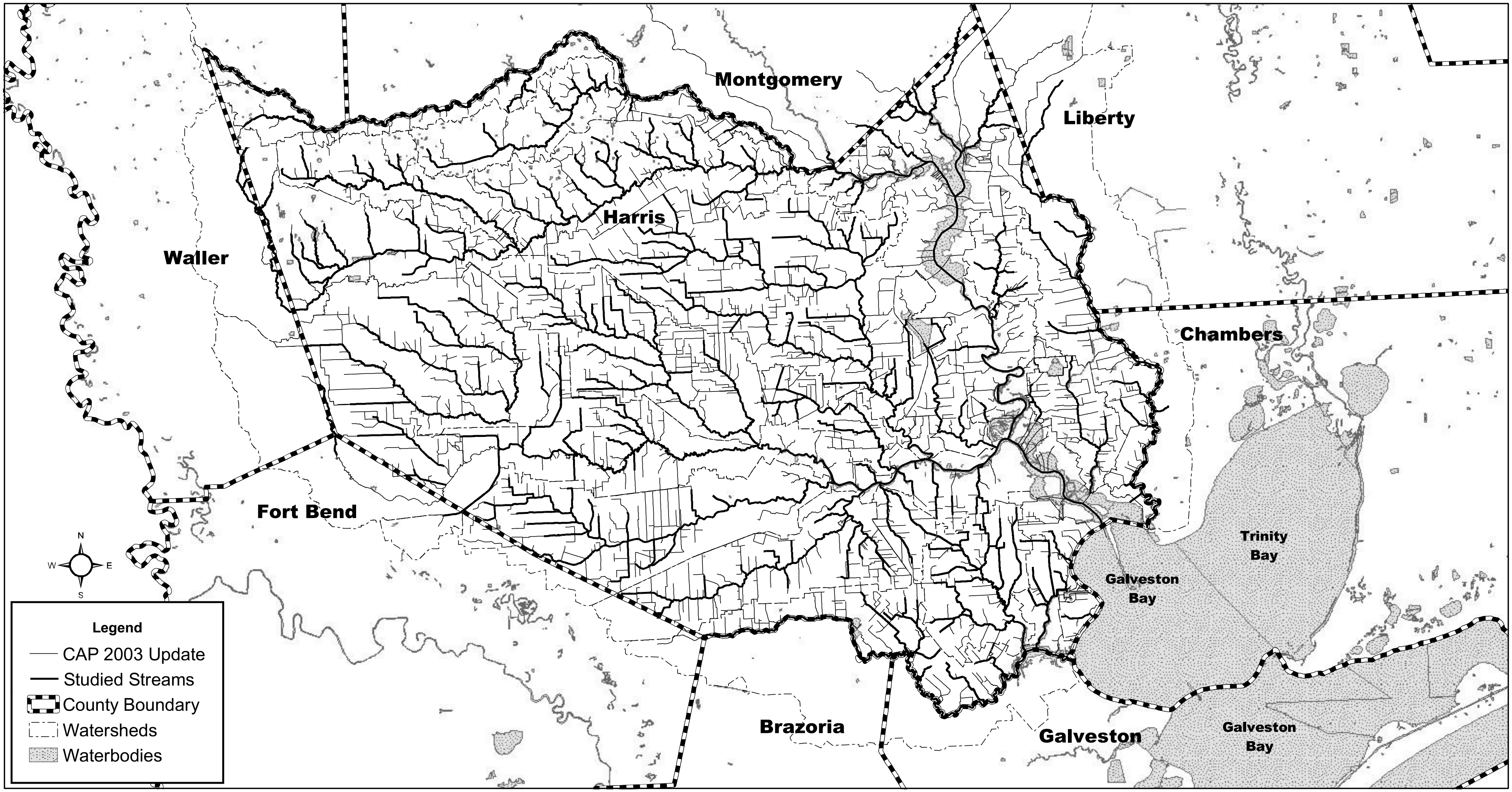


FIGURE 2

Federal Emergency Management Agency

HARRIS COUNTY, TX AND INCORPORATED AREAS

STREAM NETWORK MAP

There are 31 NFIP communities, including unincorporated Harris County, within Harris County, Texas, and each community has its own floodplain administrator. The HCFCD is a special purpose district created by the Texas Legislature in 1937 in response to devastating floods that struck the region in 1929 and 1935. The HCFCD's jurisdictional boundaries are set to coincide with Harris County. The HCFCD does not issue development permits, does not act as floodplain administrator in the NFIP, and has limited regulatory jurisdiction over drainage and flood-related matters in Harris County. The HCFCD does provide technical assistance to the County Engineer, who administers floodplain management and permit programs in the unincorporated portions of Harris County. Both agencies are under the jurisdiction of the Harris County Commissioners Court (Reference 2.2.2).

The medical, energy, and aeronautical industries and the Houston Ship Channel drive Harris County’s economy. The Port of Houston is the largest port in the United States and the second busiest port for foreign tonnage in the world (Reference 2.2.3). In 2002, approximately 175 million tons of cargo moved through the port. The county has the largest concentration of petrochemical plants in the country, with over 400 companies. Harris County is highly industrialized, with more than 2,100 metal manufacturing plants employing over 70,000 people. Nineteen Fortune 500 companies are headquartered in Harris County (Reference 2.2.3). The Texas Medical Center had an annual operating budget of over $5.4 billion in 2001 for the combined member institutions serving more than 5.1 million patient visits (Reference 2.2.4).

The topography of most of the area is extremely flat, with coastal salt marshes and sand flats along the southeastern bay shoreline, piney woods in the northeast, and gently rolling coastal prairies in the northern and western portions of the county. Lawn grasses, trees, and shrubs have replaced large areas of natural vegetation and agricultural land uses in the county as a result of heavy urbanization. The remaining natural vegetation is comprised of mixed hardwood and pine forest, coastal prairie grasses, marsh, and tall grasses.

Hot summers and mild winters characterize the climate of the area. The average annual temperature for Harris County for years 1947 through 2003 was 70.9 degrees Fahrenheit (°F). Over the same period, the average annual rainfall was 51.5 inches (Reference 2.2.5).

The most recent phase of geologic history to affect the study area was the Late Wisconsin Glacial Stage when the sea level dropped during this last period of glaciation. Rivers that could no longer shift from their courses built deltas along the new shorelines on the continental shelf. Deep, broad valleys were cut across the earlier fluvial and delta plains. As the last glacial period diminished approximately 18,000 years ago, sea level began its most recent rise. Large point-bar sand bodies and extensive overbank mud sheets were deposited as rivers meandered within the filling valleys.

The soils in southern Harris County consist mostly of poorly draining clays and loams that are classified as Natural Resources Conservation Service (NRCS) Hydrologic Soil Group “D.” In the northern portion of the county, the soils consist mostly of moderate to poorly draining sandy loams that are classified as NRCS Hydrologic Soil Group “C.”

In the last 4,500 years, sea level has been relatively constant, probably changing in elevation only 10 feet to 15 feet. In modern times, the study area has evolved to its present condition as a result of erosion, deposition, compaction, and subsidence. These processes are still important and are operating today (References 2.2.6, 2.2.7, and 2.2.8). Subsidence and its implications to this study are discussed in Section 3.4.

Harris County Watersheds

Harris County consists of portions of two larger watershed systems, the San Jacinto River and Buffalo Bayou, along with a number of smaller watershed systems. Each of these ultimately drains into Galveston Bay on the southeast side of the county. These watersheds are drained by 22 major waterways, and are likewise subdivided into 22 watersheds for descriptive purposes. The channels and corresponding watersheds that make up portions of the San Jacinto River system are the San Jacinto River, Spring Creek, Cypress Creek, Little Cypress Creek, Willow Creek, Luce Bayou, Jackson Bayou, and Goose Creek. The channels and corresponding watersheds that make up the Buffalo Bayou watershed are Buffalo Bayou, Sims Bayou, Brays Bayou, White Oak Bayou, Hunting Bayou, Vince Bayou, Carpenters Bayou, Greens Bayou, Barker Reservoir, and Addicks Reservoir. Channels and corresponding watersheds that drain directly to Galveston Bayou include Clear Creek, Armand Bayou, and Cedar Bayou. In addition, a number of smaller channels that drain directly into Galveston Bay are grouped together as Galveston Bay Tributaries. These watersheds are shown on the Harris County Watershed Map (Figure 3).

Most of the floodwaters in Harris County result from rainfall within the county. With the exception of the San Jacinto River system, minimal flows are conveyed into Harris County from upstream watersheds.

Clear Creek (A) – Clear Creek forms the southern boundary of Harris County, bordering Galveston and Brazoria Counties and then extending upstream to its headwaters in Fort Bend County. The watershed drains approximately 198 sq. mi. in an easterly direction into Clear Lake, a natural estuary lake, and then into Galveston Bay. A light to moderate level of development has occurred in the watershed, with most of it concentrated in the downstream and middle reaches. Although the development is mostly residential and commercial, National Aeronautics and Space Administration's Johnson Space Center and associated industries make up a considerable portion of the development in the areas near Clear Lake in the downstream portion of the watershed. Significant tributaries to Clear Creek include Mary's Creek, Cowart Creek, and Hickory Slough, all of which drain from adjacent counties to the south; and Armand Bayou, which is described separately. Communities in the watershed include the Cities of Houston, El Lago, Friendswood, La Porte, League City, Missouri City, Nassau Bay, Pasadena, Pearland, Seabrook, Shoreacres, Taylor Lake Village, Webster, and unincorporated Harris County.

Armand Bayou (B) – Armand Bayou is a tributary of Clear Creek but is treated as a separate watershed. It drains an area of 59 sq. mi. southward into Clear Lake near Galveston Bayou. The watershed is moderately developed, with a mix of residential and dense industrial. This development is evenly distributed across the watershed. Communities in the watershed include the Cities of Houston, Deer Park, La Porte, Nassau Bay, Pasadena, Taylor Lake Village, Webster, and unincorporated Harris County.

Sims Bayou (C) – Sims Bayou is a tributary to Buffalo Bayou. It drains eastward over a length of about 25 mi. from its headwaters in Fort Bend County to its confluence with the Houston Ship Channel. The Sims Bayou watershed is approximately 93 sq. mi. in size. It is moderately developed, consisting mostly of a relatively high-density (for Harris County) residential, with most of the development concentrated in the downstream and upstream portions of the watershed. The largest tributary to Sims Bayou is Berry Bayou. Communities within the watershed include the Cities of Houston, Missouri City, South Houston, Stafford, and Pasadena, and unincorporated Harris County.

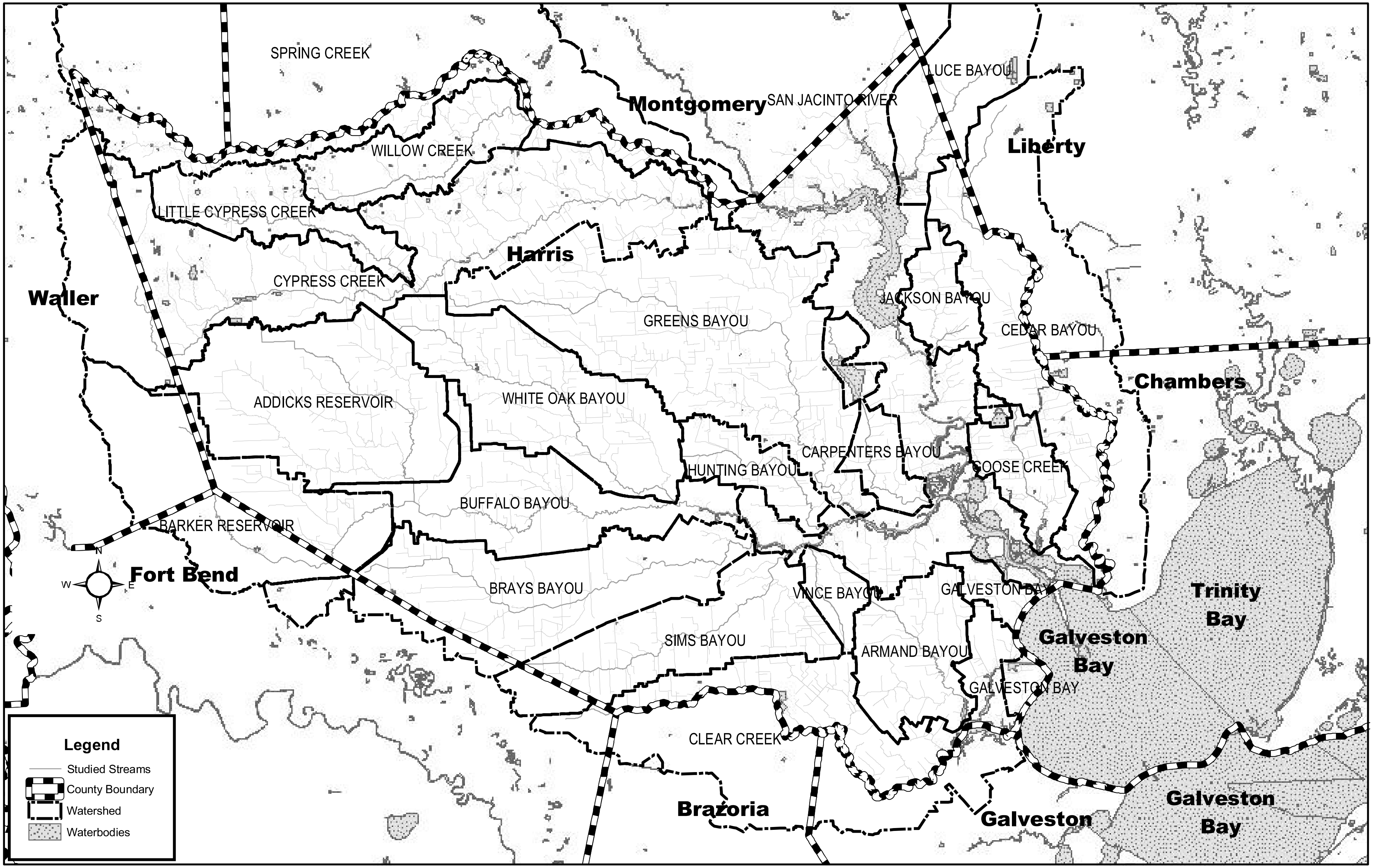


FIGURE 3

Federal Emergency Management Agency

HARRIS COUNTY, TX
AND INCORPORATED AREAS

10 5 0 10 20 30 Miles

WATERSHED MAP

Brays Bayou (D) – Brays Bayou is a tributary of Buffalo Bayou. It drains eastward over a length of about 32 mi. from its headwaters in Fort Bend County and southwest Harris County to its confluence with the Houston Ship Channel. The Brays Bayou Watershed is approximately 128 sq. mi. in size. It is highly developed, with land use ranging from residential to dense commercial. The watershed includes the Texas Medical Center, Herman Park, and the Reliant Park Complex. Notable tributaries include Keegans Bayou and Willow Waterhole Bayou. Communities include the Cities of Houston, Bellaire, Southside Place, Stafford, and West University Place, and unincorporated Harris County.

White Oak Bayou (E) – White Oak Bayou is a tributary of Buffalo Bayou. It drains southeastward over a length of about 30 mi. from its headwaters in northwest Harris County to its confluence with Buffalo Bayou near downtown Houston. The White Oak Bayou Watershed is approximately 111 sq. mi. in size. It is highly developed, with primarily residential land use. Notable tributaries include Little White Oak Bayou, Brickhouse Gully, Cole Creek, and Vogel Creek. Communities in the watershed include the Cities of Houston and Jersey Village, along with unincorporated Harris County.

Galveston Bay Tributaries (F) – A number of small tributaries drain directly into Galveston Bay and are not included in other watersheds. The Galveston Bay Tributaries refers to these, and include areas along the Galveston Bayou between Clear Lake and the Houston Ship Channel. This area is moderately developed, and includes both residential areas and dense commercial and industrial. Notable tributaries include Little Cedar Bayou and Pine Gully. Communities included in this watershed include the Cities of La Porte, Morgans Point, Pasadena, Seabrook, Shoreacres, and unincorporated Harris County.

San Jacinto River (G) – The San Jacinto River drains a 3,600 sq. mi. watershed (including 487 sq. mi. in Harris County) that originates well outside and upstream of Harris County. In addition, it drains all or part of Harris, Montgomery, Waller, Walker, Grimes, Liberty, and San Jacinto Counties. The river is formed by the junction of the West and East Forks, which each enter northern Harris County. Lake Houston is a water supply reservoir located in northeast Harris County along the San Jacinto River, which includes the confluence of the East and West Forks. The San Jacinto River extends southward through the eastern portion of Harris County from the Lake Houston Dam to its confluence with the Houston Ship Channel continuing on to its mouth at Galveston Bay. The Port of Houston Authority operates the Houston Ship Channel, which originates at the Turning Basin, follows the original alignment of Buffalo Bayou to the San Jacinto River, and continues through the San Jacinto River and San Jacinto Bay to Galveston Bay. Although it is part of the original alignment of Buffalo Bayou, for organizational purposes the ship channel below the Turning Basin is considered a part of the San Jacinto Watershed. Notable tributaries include the East and West Forks. Spring Creek, Cypress Creek, Little Cypress Creek, Willow Creek, Luce Bayou, Goose Creek, and Jackson Bayou also part of the San Jacinto River system but are described separately. Most of the watershed is rural and undeveloped, although some more moderate levels of development have occurred within Harris County. Communities in the watershed include the Cities of Houston, Baytown, Deer Park, Galena Park, Humble, La Porte, Morgans Point, Pasadena, and unincorporated Harris County.

Hunting Bayou (H) – Hunting Bayou is a tributary of Buffalo Bayou. It drains eastward and then southward over a length of about 15 mi. from its headwaters in northeast Houston to its confluence with the Houston Ship Channel near the Washburn Tunnel. The Hunting Bayou Watershed is approximately 30 sq. mi. in size. It is moderately to highly developed, with mostly dense residential development in the upper portion of the watershed and industrial and commercial development in the middle and lower portions of the watershed. Communities within the Hunting Bayou Watershed include the Cities of Houston, Galena Park, and Jacinto City, along with unincorporated Harris County.

Vince Bayou (I) – Vince Bayou is a tributary of Buffalo Bayou. It drains northward for a length of about 6 mi. from its headwaters in Pasadena to its confluence with the Houston Ship Channel. The watershed is densely developed, with a mixture of residential, commercial, and industrial uses. Communities within the watershed include the Cities of Houston, South Houston, and Pasadena.

Spring Creek (J) – Spring Creek forms the northern boundary of Harris County, bordering Montgomery and Waller Counties. The watershed also includes a portion of Grimes County. The watershed drains approximately 761 sq. mi. in an easterly direction to its confluence with the West Fork of the San Jacinto River upstream of Lake Houston. Notable tributaries and sub-tributaries to Spring Creek from Harris County include Cypress Creek, Little Cypress Creek, and Willow Creek, all of which are described separately in this report. Consequently, this description of the Spring Creek watershed only considers the 59.5 sq. mi. of the watershed that are not in these other watersheds. Notable tributaries from Montgomery County include Lake Creek and Panther Branch. Spring Creek is approximately 68 mi. in length. The watershed is lightly developed, with some residential development. Communities in the watershed include the Cities of Houston, Humble, Tomball, and unincorporated Harris County.

Cypress Creek (K) – Cypress Creek is a tributary of Spring Creek and is a part of the San Jacinto River Watershed system. It drains eastward over a length of about 50 mi. from its origin at the junction of Mound Creek and Snake Creek in Waller County to its confluence with Spring Creek near the West Fork of the San Jacinto River. The Cypress Creek Watershed is approximately 320 sq. mi., but excluding the Little Cypress Creek Watershed (which is described separately), the watershed is 268 sq. mi. in size. The middle and lower portions of the watershed have a moderate level of residential development, while the upstream portion of the watershed is predominately rural and agricultural. Notable tributaries include Mound Creek, Snake Creek, Rock Hollow, Dry Creek, Little Cypress Creek, Faulkey Gully, Theiss Gully, Seals Gully, and Turkey Creek. Communities within the watershed include the Cities of Houston and Waller and unincorporated Harris County.

Little Cypress Creek (L) – Little Cypress Creek is a tributary of Cypress Creek. It drains southeastward for a length of about 22 mi. from its headwaters in far northwest Harris County to its confluence with Cypress Creek. The Little Cypress Creek Watershed consists of about 52 sq. mi. and has a light amount of predominately residential development. The remainder of the watershed is either open land or agricultural. Communities within the watershed include unincorporated Harris County.

Willow Creek (M) – Willow Creek is a tributary of Spring Creek. It drains northeastward for a length of about 20 mi. from its headwaters near Tomball to its confluence with Spring Creek. The watershed drains an area of about 56 sq. mi. The watershed has a light amount of residential development. The remainder of the watershed is either open or agricultural. Communities within the watershed include the City of Tomball and unincorporated Harris County.

Carpenters Bayou (N) – Carpenters Bayou is a tributary of Buffalo Bayou. It drains southward over a length of about 13 mi. from its headwaters in northeast Harris County to its confluence with the Houston Ship Channel. The Carpenters Bayou Watershed is approximately 31 sq. mi. in size. It has a low to moderate amount of development, consisting mostly of small lot residential and commercial. Sheldon Reservoir is located in the upper basin. This shallow lake and adjoining lands are owned by the State of Texas and were formally used by the Texas Parks and Wildlife Department for fish research and hatchery. Communities within the watershed include the City of Houston and unincorporated Harris County.

Goose Creek (O) – Goose Creek is a tributary of the San Jacinto River. It drains southward over a length of about 15 mi. from its headwaters in east Harris County to its confluence with the San Jacinto River just downstream of its confluence with the Houston Ship Channel. The Goose Creek Watershed is approximately 33 sq. mi. in size. It is moderately developed, but the lower half of the watershed has mostly dense residential along with some concentrations of commercial and industrial development. For descriptive purposes, the Goose Creek watershed includes Spring Gully, which drains directly into the San Jacinto River and does not have a common confluence with Goose Creek. Communities within the watershed include the City of Baytown and unincorporated Harris County.

Greens Bayou (P) – Greens Bayou is a tributary of Buffalo Bayou. It drains eastward and then southward for a distance of about 42 mi. from its headwaters in northwest Harris County to its confluence with the Houston Ship Channel. The Greens Bayou Watershed is approximately 211 sq. mi. in size. It is moderately developed; most of the land use is residential and light commercial. The watershed includes George Bush Intercontinental Airport. Notable tributaries include Halls Bayou and Garners Bayou. Communities within the watershed include the Cities of Houston and Humble and unincorporated Harris County.

Cedar Bayou (Q) – Cedar Bayou forms the eastern boundary of Harris County, bordering Chambers County. It drains southward for a distance of about 51 mi. from its headwaters in Liberty County to its confluence with Galveston Bay. The Cedar Bayou Watershed is approximately 199 sq. mi. in size and is lightly developed. Notable tributaries include Pine Gully. Communities within the watershed include the City of Baytown and unincorporated Harris County.

Jackson Bayou (R) – Jackson Bayou is a tributary of the San Jacinto River. It drains southward over a length of about seven mi. from its headwaters in east Harris County to its confluence with the San Jacinto River. The Jackson Bayou watershed is approximately 50 sq. mi. in size. It is lightly developed, with some rural subdivisions in the lower portion of the watershed. Notable tributaries include Gum Gully. Communities within the watershed include the City of Houston and unincorporated Harris County.

Luce Bayou (S) – Luce Bayou is a tributary of the East Fork of the San Jacinto River. It drains southward for about 35 mi. from its headwaters in the Sam Houston National Forest in San Jacinto County to its confluence with the East Fork of the San Jacinto River in the upper portion of Lake Houston. The watershed covers about 227 sq. mi. and includes portions of San Jacinto, Liberty, and Harris Counties. The Harris County portion includes only the lower 17 sq. mi. of the watershed. There is minimal development in the watershed; most of the land is forest. Communities within the watershed include the City of Houston and unincorporated Harris County.

Barker Reservoir (T) – Barker Reservoir was constructed with Addicks Reservoir to protect downtown Houston and the Houston Ship Channel by impounding flood flows in the upper portion of Buffalo Bayou. The Barker Reservoir Watershed includes all those areas that contribute drainage into the reservoir. This watershed encompasses 129 sq. mi. much of which is within Fort Bend County. A moderate amount of development has occurred in the watershed, consisting predominately of residential development. The primary streams that feed the reservoir are Upper Buffalo Bayou, Cane Island Branch, and Mason Creek. Communities within the watershed include the Cities of Houston and Katy, and unincorporated Harris County.

Addicks Reservoir (U) – Addicks Reservoir was constructed with Barker Reservoir to protect downtown Houston and the Houston Ship Channel by impounding flood flows in the upper tributaries of Buffalo Bayou. The Addicks Reservoir Watershed includes all those areas that contribute drainage into the reservoir. This watershed encompasses 136 sq. mi. of area, all of which is in northwest Harris County. A moderate amount of predominately residential development has occurred in the watershed. The primary streams that feed the reservoir are Langham Creek, South Mayde Creek, Bear Creek, Horsepen Creek, and Dinner Creek. Communities within the watershed include the Cities of Houston and Katy and unincorporated Harris County.

Buffalo Bayou (W) – The Buffalo Bayou Watershed is described as the area downstream of Addicks and Barker Reservoirs that drains to Buffalo Bayou and is not part of another designated watershed tributary to Buffalo Bayou. This area totals approximately 102 sq. mi., and drains into Buffalo Bayou as it extends eastward for about 50 mi. from Barker Reservoir to the Houston Ship Channel Turning Basin just east of downtown Houston. The Buffalo Bayou Watershed is highly urbanized, with a mix of residential and commercial land uses. Features within the watershed include Memorial Park and downtown Houston. Communities within the watershed include the Cities of Houston, Bunker Hill Village, Hedwig Village, Hilshire Village, Hunter's Creek Village, Piney Point Village, Spring Valley, and unincorporated Harris County.

2.3 Principal Flood Problems

Harris County is located near the Gulf of Mexico along the coastal plain of southeast Texas in an area subject to the natural overflow of land from intense rainfalls. The area is subject to intense local thunderstorms of short duration, general storms extending over periods of several days, and torrential rainfall associated with tropical events. The resulting potential for extreme rainfall events, coupled with the flat topography and poorly draining soils, contribute to the frequent occurrence of flooding. Furthermore, flooding also results from tidal surge along Galveston Bay caused by hurricanes and tropical storms. This was the environment the Allen brothers faced when they founded the City of Houston, at the confluence of Buffalo Bayou and White Oak Bayou in 1836. Shortly thereafter, every structure in the new settlement flooded.

Since 1900, Harris County has had 33 major flood events. In September 1900, the Great Galveston Hurricane hit the region, leaving more than 8,000 fatalities and Harris County with over $30 million dollars in damages (Reference 2.3.1). Then in 1907, Harris County experienced another major flood. A major Brazos River flood in December 1913 spread to Harris County and impacted Buffalo, White Oak, Brays, and Greens Bayous. Citizens had to be evacuated as these streams overtopped their banks. Another Galveston hurricane in

August 1915 caused major flooding and $56 million in damages in Buffalo Bayou and throughout the City of Houston. A tropical system producing 10 inches of rain in 14 hours in April 1929 caused almost all bayous to leave their banks and an estimated $1.4 million in damages. The next month, May 1929, the San Jacinto River crested 30 feet above normal, damaging structures, flooding streets, and damaging crops. A stationary storm cell in May 1930 produced as much as 12.5 inches (average 8 inches) of rain within the entire county. A hurricane claimed 40 lives and produced widespread flooding in August 1932. Buffalo Bayou crested 52 feet above normal in December 1935, causing almost $3 million in damages, killing seven people, and crippling the Port of Houston for months with its docks submerged, its channel clogged with tons of mud and wreckage, and its railroad tracks uprooted. Twenty-five blocks of the downtown business district were inundated, as were 100 residential blocks. Five days of rain in November 1940 caused the death of 10,000 head of cattle. The hurricane in July 1943, which landed near Galveston caused $16.5 million in damages. Another hurricane in October of that year flooded more than 11,000 residences. In August 1945, a hurricane produced the heaviest rainfall recorded to date; 15 inches in 24 hours flooded all bayous. Greens Bayou residents were evacuated in February 1950 when thunderstorms preceding a cold front flooded the area. A thunderstorm in May 1955 flooded houses in northern Harris County. Hurricane Audrey in June 1957 flooded the county. More than 100 residences were flooded from a thunderstorm in October 1959. A thunderstorm in June 1960 led to the evacuation of 200 families from Spring and Cypress Creeks and the San Jacinto River basin. Hurricane Carla in September 1961 claimed 34 lives and caused over $300 million in damages when it flooded southern Harris County. Another thunderstorm preceding a cold front flooded 250 residences and caused more than $3.3 million in damages in February 1969. More than 700 families were evacuated in northern Harris County from a thunderstorm-induced flood in March 1972. Sims and Greens Bayous left their banks after receiving 10 to 15 inches of rain in June 1973, causing over $50 million in damages. In July 1979, Tropical Storm Claudette produced the record 24-hour rainfall of 43 inches in the area in Alvin, Texas with damages exceeding over $700 million. A thunderstorm in May 1983 caused over $14 million in damages. Hurricane Alicia in August 1983 devastated Harris County with over $1 billion in damages from wind and flooding. Brays Bayou received over 9 inches of rainfall, flooding 1,000 residences and causing $38 million in damages in September 1983. Much of Harris County, including 1,400 residences, flooded from 7 to 14 inches of rain in May 1989. Tropical Storm Allison flooded over 1,100 residences from 6 to 12 inches of rain in June 1989. A major storm in June 1992 flooded over 1,500 residences and shut down Interstate Highway 10. Over a 3-day period in October 1994, as much as 29 inches of rainfall flooded 3,400 residences. In September 1998, Tropical Storm Frances flooded White Oak Bayou and more than 1,300 residences. Another storm shortly thereafter flooded hundreds more homes in October and November 1998.

When Tropical Storm Allison suddenly formed 80 mi. off the coast of Galveston, Texas, on Tuesday, June 5, 2001, no one expected that, 5 days later, it would go on record as one of the most devastating rain events in the history of the United States. Neither historical data nor weather forecasts could adequately predict this extraordinary storm that, before leaving the area, would dump as much as 80 percent of the area's average annual rainfall over much of Harris County, simultaneously affecting more than 2 million people. When the rains finally eased, Allison left Harris County, Texas, with 22 fatalities; 95,000 damaged automobiles and trucks; 73,000 damaged residences; 30,000 stranded residents in shelters; and over $5 billion in property damage in its wake. Leaving 31 counties with Presidential Declared disasters in Texas, Allison went on to spread disaster declarations to Louisiana (25 parishes), Mississippi (5 counties), Florida (9 counties), and Pennsylvania (2 counties). Allison was the costliest tropical storm in United States history. Flood Protection Measures

2.4 Flood Protection Measures

After the devastating floods of 1929 and 1935, the State of Texas created the Harris County Flood Control District in 1937 for the purpose of "the control, storing, preservation, and distribution of the storm and flood waters, and the waters of the rivers and streams in Harris County and their tributaries, for domestic, municipal, flood control, irrigation, and other useful purposes, the reclamation and drainage of the overflow land of Harris County, the conservation of forests, and to aid in the protection of navigation on the navigable waters by regulating the flood and storm waters that flow into said navigable streams" (Reference 2.4.1). Since that time, there have been many significant projects to reduce flood damage in Harris County. Many of these projects are the results of partnerships between the HCFCD and the U.S. Army Corps of Engineers (USACE), FEMA, and others. Currently, the HCFCD is engaged in many such partnerships to address flooding in Harris County.

Sheldon Reservoir (N100-00-00) is located 16 miles east of downtown Houston, and six miles upstream from Channelview in northwestern Harris County in the Carpenters Bayou (N100-00-00) Watershed. The reservoir is managed by the Texas Parks and Wildlife Department as the Sheldon Wildlife Management Area and includes a fish hatchery, waterfowl refuge, and public fishing. The drainage area upstream of Sheldon Dam is approximately 12,000 acres. The dam is a 10-foot high earthen embankment with a spillway elevation of 46.0 and a storage capacity of 157,584 acre-feet (Reference 2.4.2).

Addicks Reservoir is on Langham Creek (U100-00-00), a mile east of Addicks in western Harris County. Barker Reservoir is southwest of the intersection of Interstate Highway 10 and State Highway 6, about one mile south of Addicks in western Harris County. The filled roller compacted concrete-earth dams are over 61,200 feet long in Addicks and 71,900 feet in Barker. The USACE completed Barker Dam in 1945 and Addicks Dam in 1948 in an effort to provide flood control along Buffalo Bayou in the San Jacinto River basin. The USACE owns, operates, and maintains the facilities. The dams help protect the City of Houston from floodwaters. Water is stored only for flood control and is released when flooding is no longer a danger. The total storage capacity of the reservoirs is 212,500 acre-feet in Addicks and 192,500 acre-feet in Barker (Reference 2.4.3).

The drainage area above the Addicks Dam is 136 square miles and includes four primary streams: Bear Creek (U102-00-00), Horsepen Creek (U106-00-00), Langham Creek (U100-00-00), and South Mayde Creek (U101-00-00).

Barker Dam is located in west Harris County extending into Fort Bend County. The Barker Reservoir Watershed, in Harris, Fort Bend, and Waller Counties, covers approximately 126 square miles and includes two primary streams: Mason Creek (T101-00-00) and Upper Buffalo Bayou/Cane Island Branch (T101-00-00).

The reservoirs are operated to reduce flooding along Buffalo Bayou (W100-00-00). The five (5) 8' x 6' Reinforced Concrete Boxes (RCBs) at Addicks Dam and five (5) 9' x 7' RCBs at Barker Dam are operated with vertical slide gates. The total discharge from the reservoirs and the intervening area is controlled to limit the flow to 2,000 cubic feet per second (cfs) (considered a non-damaging discharge) at the Piney Point Gage (08073700), approximately 11 miles downstream of the Barker Dam control structure.

Under normal operating conditions when the reservoirs have negligible ponding areas and are experiencing no precipitation, the low flows are allowed to pass. When significant run- off producing storms occur, the gates are closed and remain closed until the peak at Piney Point passes and the discharge drops below 2,000 cfs. Reservoir releases will not be made any time the 2,000 cfs limit is exceeded in Buffalo Bayou (W100-00-00) at Piney Point (Reference 2.4.4).

Other projects constructed by USACE as part of their partnership with the HCFCD to reduce flood risk in Harris County include the enlarging, straightening, and lining of portions of Brays Bayou, White Oak Bayou, Vince Bayou, Buffalo Bayou, Cedar Bayou, as well as the buyout of floodprone homes along Cypress Creek. Other Federal flood control projects under construction include the Sims Bayou Federal Flood Control Project, which involves the enlargement of Sims Bayou for much of its extent; and the Brays Bayou Federal Flood Control Project, which involves the enlargement of Brays Bayou, in addition to the construction of four detention basins, and the replacement and/or adjustment of numerous bridges. The USACE and HCFCD are currently involved in planning studies to seek Federal flood control projects along Clear Creek, Greens Bayou, Halls Bayou, Buffalo Bayou, and Harris Gully (in cooperation with the Texas Medical Center).

The HCFCD is also involved in active partnerships with FEMA to purchase floodprone homes. Prior to Tropical Storm Allison in June 2001, 440 homes were purchased at a total cost of about $44 million. An additional 2,000 homes, with a total cost of approximately $170 million, have been bought out or approved for buyout since that time (Reference 2.4.5). In addition, HCFCD and FEMA partnered to construct a levee to protect a flood prone subdivision along Cypress Creek in the early 1990s.

There have been a considerable number of projects to reduce flooding that have been constructed entirely with local funds. Many regional detention basins have been constructed throughout Harris County, and numerous channel improvement projects have been constructed and are maintained by the HCFCD.

The HCFCD currently is implementing a five-year Capital Improvement Program. This program calls for expenditures from all sources, including both local and Federal, in the order of $1 billion over this five-year period.

Harris County and the Houston region are subject to an intense amount of development pressure. New developments in the area are required to construct detention basins to offset potential increases to flood flows. In some areas, the HCFCD implements adopted Regional Plans by collecting impact fees from developers and then using the funds to construct regional facilities.

The floodplains are managed by the 31 floodplain administrators in Harris County. The overwhelming majority of the land area is within either the City of Houston or the unincorporated areas of Harris County. These two communities work together regarding floodplain management policy, and the remaining communities tend to follow their lead. These communities have taken an aggressive approach to floodplain management. Proposed fill in the floodplain must be offset by appropriate compensating volume. In addition, the floodplain administrators require analysis to ensure that there will be no rise in the Base Flood Elevation (BFE) for both areas within the floodway and the floodway fringe.

To ensure successful performance of the drainage and flood control infrastructure, the HCFCD manages over 2,500 mi. of channel and an array of detention basins. This management includes mowing, debris removal, de-snag operations, vegetation promotion, specialized herbicide operations, selective tree clearing, tree trimming and removal, and watering.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in Harris County, standard hydrologic and hydraulic study methods were used to determine the flood-hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded 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 100-year flood (1-percent chance of annual exceedance) 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

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

The original countywide study was completed and published in 1990. This countywide study was based upon hydrologic methods and analysis developed by the USACE and the HCFCD. Originally, the USACE-Galveston District developed watershed-specific hydrologic methodologies between 1977 and 1979 for all the watersheds in Harris County. However, these methods did not have a mechanism to account for a change in land use. There was a significant amount of development in Harris County between that time and 1983, and the HCFCD subsequently developed revised methodologies to account for this (Reference 3.1.1). These revised methods were only applied to those areas that were subject to watershed changes in this time-period. This revised methodology is described in detail in *Hydrology for Harris County* (Reference 3.1.2), and is commonly known as the HCFCD Hydrology. This methodology was applied to all revised studies that were included in the subsequent revisions to the FIS in 1992, 1996, and in 2000.

This revised FIS introduced some refinements to the HCFCD Hydrology. The vast majority of the watersheds studied utilized this methodology as described in the following section. Additional hydrologic methods were applied in certain areas. These methods include Flood Frequency Analysis, Regression Equations, and the USACE Methods mentioned above. All of these are described in the following pages.

HCFCD Hydrology

The HCFCD Hydrology refers to the hydrologic methods developed by the HCFCD as described in *Hydrology for Harris County* (Reference 3.1.2), as well as refinements made as part of the TSARP study. These refinements are contained within a series of White Papers completed as part of the TSARP study, and are available from the HCFCD (Reference 3.1.3). The original hydrologic methods were developed in 1985 for use in the HEC-1 program (Reference 3.1.4). The HCFCD Hydrology described herein was developed for use in the HEC-HMS program (Reference 3.1.5). Unless noted otherwise, this methodology was utilized to determine the discharges for the flooding sources studied.

The purpose of the HEC-HMS program is to determine discharge hydrographs and subsequent peak discharges at various locations within a watershed. Watersheds are modeled in HEC-HMS by subdividing them into a series of smaller subbasins. The HEC-HMS program computes discharge hydrographs, which is the relationship of runoff discharge over time, and then tracks these hydrographs as they proceed through the watershed. Progressing upstream to downstream, hydrographs are compiled and routed down the channel until a final discharge hydrograph is computed at the mouth of the watershed.

HEC-HMS represents the next generation of HEC hydrologic software. There are only subtle computational differences between the HEC-1 program and the HEC-HMS program. The more notable differences have to do with user interface and computational abilities. The underlying theory is essentially the same though some changes did require certain refinements to the HCFCD Hydrology.

To model a basin, topologic features must be described, and the precipitation runoff parameters must be defined and entered into the computer program. The topologic features include drainage basin boundaries, stream channels, and relationships between drainage areas and stream channels. Average rainfall values are used for each subbasin. Runoff is computed from average basin parameters; therefore, a unit hydrograph and a loss-rate criterion are required. The program considers routing to be governed by storage and can be computed by one of several hydrologic methods, each with its own set of parameters.

The process of the HEC-HMS program includes inputting and distributing the precipitation, determining the subbasin outflow hydrograph from unit hydrograph methods, computing rainfall and excess values, and routing hydrographs by hydrologic methods. Equations to compute Clark's unit hydrograph parameters of time of concentration (Tc) and attenuation constant (R) were optimized from a regression analysis evaluating historic storm events obtained at various gages. Urbanization rates were taken into account by separating the above data into three categories: (1) undeveloped, (2) partially developed, and (3) developed conditions.

Ponding, caused by extensive rice farming in the western and southern portions of the county, was taken into account by the development of a relationship between the percentage of ponding and R. This relationship was obtained from the NRCS Technical Release 55 (Reference 3.1.6). A method was developed to account for areas that have been urbanized but that are also served by on-site detention. The Green & Ampt method was utilized to approximate runoff losses.

In the following subsections are detailed descriptions of the parameters that were used to develop the HEC-HMS models and the resultant discharges.

<u>Rainfall</u>

Flood hazard flows were developed assuming a uniform area rainfall distribution over the entire modeled watershed. The distribution of the rainfall is represented by a succession of 15-minute incremental rainfall intensities over a 24-hour storm duration. The incremental rainfall pattern is a frequency-based rainfall pattern assigned by HEC-HMS (Reference 3.1.7) with the peak rainfall occurring at 67 percent of the storm duration. No depth-area reduction adjustments were made and the storm area was set to be 0.01 sq. mi.

Partial-duration point precipitation depths that correspond to the selected exceedance frequency were based upon U.S. Geological Survey (USGS) values for three (3) hydrologic regions (Reference 3.1.8) in Harris County.

Region 1 – Spring Creek, Cypress Creek, Little Cypress Creek, Willow Creek, Barker Reservoir, and Addicks Reservoir.

Region 2 – Brays Bayou, White Oak Bayou, Upper San Jacinto River, Hunting Bayou, Greens Bayou, Luce Bayou, and Buffalo Bayou.

Region 3 – Clear Creek, Armand Bayou, Sims Bayou, Galveston Bay, Lower San Jacinto River, Vince Bayou, Carpenters Bayou, Goose Creek, Cedar Bayou, and Jackson Bayou.

The rainfall depths for the 10-percent-annual-chance event (10-year) to 0.2-percent-annual-chance event (500-year) for durations from 5 minutes to 4 days can be found below for each region.

HARRIS COUNTY HYDROLOGIC REGION 1 RAINFALL (INCHES)

	Annual-Chance Event			
Duration	10-percent	2-percent	1.0-percent	0.2-percent
5-Minute	1.0	1.2	1.3	1.5
15-Minute	1.5	2.0	2.2	2.7
30-Minute	2.1	2.7	3.0	3.9
60-Minute	2.8	3.8	4.2	5.5
2-Hour	3.5	4.9	5.5	7.5
3-Hour	3.9	5.6	6.5	9.0
6-Hour	4.9	7.2	8.5	12.2
12-Hour	5.9	8.7	10.2	14.7
24-Hour	7.1	10.6	12.4	17.7
2-Day	8.1	11.8	13.6	18.7
4-Day	9.2	13.1	14.9	19.8

HARRIS COUNTY HYDROLOGIC REGION 2 RAINFALL (INCHES)

Duration	Annual-Chance Event			
	10-percent	2-percent	1.0-percent	0.2-percent
5-Minute	0.9	1.1	1.2	1.4
15-Minute	1.5	1.9	2.1	2.6
30-Minute	2.1	2.7	3.0	3.8
60-Minute	2.9	3.8	4.3	5.5
2-Hour	3.6	5.0	5.7	7.6
3-Hour	4.1	5.8	6.7	9.2
6-Hour	5.1	7.6	8.9	12.8
12-Hour	6.2	9.2	10.8	15.5
24-Hour	7.6	11.3	13.2	18.9
2-Day	8.6	12.5	14.5	20.0
4-Day	9.8	14.0	15.9	21.1

HARRIS COUNTY HYDROLOGIC REGION 3 RAINFALL (INCHES)

Duration	Annual-Chance Event			
	10-percent	2-percent	1.0-percent	0.2-percent
5-Minute	0.9	1.1	1.2	1.4
15-Minute	1.5	1.9	2.1	2.5
30-Minute	2.1	2.7	3.0	3.7
60-Minute	2.9	3.8	4.3	5.5
2-Hour	3.7	5.0	5.7	7.7
3-Hour	4.2	5.9	6.8	9.4
6-Hour	5.3	7.7	9.1	13.1
12-Hour	6.4	9.5	11.1	15.9
24-Hour	7.8	11.6	13.5	19.3
2-Day	9.0	13.1	15.1	20.7
4-Day	10.5	14.8	16.9	22.3

Loss Rates

Harris County uses the Green & Ampt method to approximate runoff losses in HEC-HMS. The Green & Ampt method is physically-based and estimates losses based on a function of soil texture and the capacity of the given soil type to convey water. Generalized Green & Ampt watershed parameters were developed for Harris County (Reference 3.1.9). The final values used in modeling were derived from these generalized values through the calibration process to known storm rainfall intensities and streamflows.

Drainage Areas

Each watershed was divided into subbasins of at least 1 sq. mi. in size and of uniform hydrometeorological parameters and behavior. Where it was necessary to have a subbasin with a drainage area less than 1 sq. mi., the subbasin's resultant peak flows were checked for reasonableness.

The shape of a subbasin has a direct effect on the subbasin's watershed length (L) and watershed length to centroid (L_{ca}). The 1984 Flood Hazard Study (Reference 3.1.1) derived a relationship among drainage area (A), (L), and (L_{ca}). If the relationship among (L), (L_{ca}), and (A) for any subbasin varied substantially, the subbasin boundary was modified.

In undeveloped areas, the LiDAR derived Digital Elevation Model (DEM) and computer-modeling tools in Arc Hydro (Reference 3.1.10) were used to delineate drainage boundaries. In developed areas, roads, railroads, or lot gradings typically forms drainage boundaries. Storm sewer systems do not usually define drainage boundaries, as they only carry a fraction of the 1-percent-annual-chance storm event.

Sub-Watershed Parameters

The physical characteristics that define the hydrologic properties of a watershed were measured and computed from topographic maps, aerial photographs, survey notes, construction drawings, and DEMs. Harris County's Hydrologic Methodology (Reference 3.1.2) uses watershed parameters to compute Clark's unit graph time of concentration (T_C) and storage coefficient (R) values. The Clark unit graph parameters, drainage area, and Green & Ampt rainfall loss rates of a subbasin are used by HEC-HMS to develop the runoff hydrograph for a particular subbasin.

Watershed Length

The watershed length (L) is the length of the longest watercourse for the sub-area. It is defined from the outflow point to the upstream sub-area watershed boundary and is measured in miles. The watershed length is a factor in determining the value of T_C+R, but only affects Clark's storage coefficient (R) of a subbasin (Reference 3.1.2).

For an undeveloped watershed, the watershed length typically follows the longest definable channel and overland flow path. This path can be measured from the DEM, topographic maps, and aerial photos. However, in developed subbasins the watershed length often follows roadside ditches and major streets.

Watershed Length to Centroid

Watershed length to centroid (L_{ca}) is defined in *Hydrology for Harris County (*Reference 3.1.2) as the length along the longest watercourse (L) from the outflow point to a point perpendicular to the computed centroid of the drainage area and is measured in miles. The length to centroid represents the average distance a particle of runoff water will travel before reaching the outflow point, and is used in determining the Clark's time of concentration (T_C) of the subbasin.

Since watershed length to centroid is dependent upon shape, it is important that subbasins are properly shaped so as to not provide unrealistic L_{ca} values. If unreasonable values of L_{ca} are produced, the subbasin boundaries can be altered, or L_{ca} can be artificially adjusted by separately considering different areas of the subbasin. In addition, if two or more points along L are the same distance from a subbasin's centroid, the point that best represents the average watercourse length was used.

Channel Slope

Channel slope (S) is the weighted average slope of the longest watercourse of a watershed (Reference 3.1.2). It is representative of how fast the runoff moves through a subbasin watercourse. The average channel slope is the divisor in the hydrologic equation that calculates the time of concentration (T_C) and storage coefficient (R) of a subbasin. It was measured from stream profile plots, construction drawings, and topographic maps, and is computed in feet per mile.

The average channel slope must neglect all abrupt changes in flowlines, such as drop structures. In addition, the first 10 percent and last 15 percent of the channel reach should be ignored, since channel slopes typically vary at the upstream and downstream limits of the reach (Reference 3.1.2).

Watershed Slope

The watershed slope (S_o) is the average overland slope of a subbasin. It was measured from the DEM and topographic maps at several representative overland flow paths, averaged, and computed in feet per mile. Sudden changes in overland slope should be excluded.

Similar to the channel slope (S), the watershed slope helps represent the speed that runoff drains overland from the drainage boundary to a subbasin watercourse. It is used in the calculation of a subbasin's time of concentration (T_C) for three classes defined as slopes less than 20-feet-per-mile, greater than 40-feet-per-mile, and between 20- and 40-feet-per-mile.

Percent Land Urbanization

Percent land urbanization (DLU) or development percentage is the portion of a drainage area that is used for residential, industrial, commercial, and institutional purposes. Urban development reduces the infiltration area of a watershed, thereby creating more excess runoff and increasing the speed that overland runoff will travel to a watercourse. It is used in the interpolation between undeveloped and fully developed values for the time of concentration (T_C) and storage coefficient (R) of a subbasin, and is expressed as a percent of the total drainage area. Land urbanization also is a factor in the rainfall loss rates (Reference 3.1.2).

DLU was determined by measuring the amount of each land use type within a subbasin. Land use was derived by sampling the classification of each parcel within the subbasin and weighting the area of the parcel by the value in the following table (Reference 3.1.11). Parcel data was provided by the Harris County Appraisal District (Reference 3.1.12).

Percent impervious was calculated in the same manner as DLU. Using the land-use area measurements, a weighted impervious percentage can be computed for each sub-watershed using the land use impervious percentage relationship shown below.

IMPERVIOUS AND DEVELOPMENT VALUES

Land Use	Code	Percent Land Urbanization (DLU)	Typical Percent Impervious
High Density	HD	100%	85%
Undeveloped	U	0%	0%
Developed Green Areas	GA	50%	15%
Residential – Small Lot	RS	100%	40%
Residential - Large Lot	RL	50%	20%
Residential - Rural Lot	RR	0%	5%
Isolated Transportation	T	100%	90%
Water	W	0%	100%
Light Industrial	IC	100%	60%
Airport	Air	100%	50%

Percent Land Urbanization Affected by On-Site Detention

Starting in 1984, HCFCD began to require that all new development mitigate peak flow impacts through detention. Typically, mitigation is provided through on-site detention, or, in some cases, regional detention capacity may be purchased to mitigate a development's flow impacts. The effects of large regional detention ponds owned by HCFCD were incorporated directly within the HEC-HMS models. The need to individually model the more than 2,000 on-site ponds would not have enhanced the outcome of this study, and would have required the use of unnecessary resources to accurately survey the geometry, outfall structures, and behavior of these ponds that serve areas as small as one-half acre. A modeling technique was applied to determine the benefits of on-site detention at the scale of the study.

To reflect the effects of Harris County's on-site detention requirements, the percentage of each subbasin that is affected by on-site detention was measured. The percentage of the subbasin affected by detention is identified in the Tc + R equations and is used to adjust DLU to reflect the benefits of on-site detention (Reference 3.1.13).

Minimum Percent Land Urbanization

The Tc + R equation varies depending on whether a subbasin is developed or undeveloped. In the previous HCFCD methodology (Reference 3.1.2), a subbasin was considered undeveloped if its DLU was less than 18 percent. However, inconsistencies in flows would sometimes occur around the 18 percent threshold. Peak flows would often decrease as development increased.

To remedy the flow inconsistency around 18 percent DLU, the DLU threshold between the undeveloped and developed conditions is no longer fixed at 18 percent. Based upon definitions and equations from *Hydrology for Harris County*, (Reference 3.1.2), a threshold (DLU_{MIN}) between undeveloped and developed subbasin conditions was defined by the TSARP Hydrology Committee (Reference 3.1.11).

Each subbasin will have this threshold, or DLU_{MIN}, defined based upon its Percent Channel Conveyance (DCC) value. The equation for DLU_{MIN} is as follows:

$$DLU_{MIN} = 11344(DCC)^{-1.4048}$$

Percent Land Urbanization (Detention)

As previously discussed, Percent Land Urbanization (DLU) is adjusted to reflect the presence of on-site detention. The Percent Land Urbanization (Detention), or DLU_{DET} value is used in the Tc+R equations to reflect on-site detention and is dependent upon DET and DLU_{MIN}. The equations for Percent DLU_{DET} are shown below:

$$DLU_{DET} = DLU - DET \qquad (\text{if } DLU_{DET} >= DLU_{MIN})$$

$$DLU_{DET} = DLU_{MIN} \qquad (\text{if } DLU_{DET} < DLU_{MIN})$$

$$DLU_{DET} = DLU \qquad (\text{if } DLU < DLU_{MIN})$$

Please note that the impervious percentage should remain unadjusted and should account for all impervious cover, regardless of the existence of on-site detention. This allows the runoff peak to behave as if it had been through a detention pond and discharged at predevelopment conditions, while maintaining the higher runoff volume from the developed area.

Percent Channel Improvement

Percent Channel Improvement (DCI) is the portion of the longest watercourse which has an improved channel. It is expressed as a percent of the longest definable channel (Reference 3.1.2). An improved channel section is defined as a section that has been significantly altered from its natural state by a construction project, for the purpose of providing storm flow capacity for existing or proposed urban development. It is used in the interpolation between undeveloped and fully developed values of the Time of Concentration (T_C) for a subbasin. Aerial photographs, construction plans, and field investigations are used to determine the extent of channel improvements.

Percent Channel Conveyance

Percent Channel Conveyance (DCC) is the ratio of discharge carried between channel banks to the 1 percent exceedance event discharge that would be anticipated if the channel had full conveyance (References 3.1.2 and 3.1.14). The conveyance of a channel is interpreted to be its ability to carry runoff in an area of uniform high velocity.

The 1-percent-annual-chance exceedance event full conveyance discharge can be determined by estimating the total drainage area upstream of the computation point, its weighted urban development, and average channel slope, then reading the discharge from figures presented in *Hydrology for Harris County* (Reference 3.1.2).

DCC is measured from a HEC-RAS model in which the 1-percent-annual-chance exceedance event full conveyance discharge for a subbasin is held constant through the basin's channel reach. DCC, or the percentage of flow conveyed within channel banks, is measured at all cross sections along the channel reach. A weighted average DCC value, based upon channel reach length, is determined for the main channel of the subbasin. DCC is then rounded to the nearest 10 percent for the subbasin under consideration.

By definition, an undeveloped watershed has a percent channel conveyance of 100 percent. In other words, the natural floodplain carries the water it is expected to in order to accommodate the undeveloped watershed. Assuming no channel improvements, a basin's DCC will decrease as DLU increases.

Unit Hydrograph Parameters

Utilizing the calculated unit hydrograph parameters in the Clark's Unit Hydrograph method allows for development of an estimated runoff hydrograph for a subbasin. Harris County utilizes the Clark's Unit Hydrograph technique, due to its wide acceptance and the large number of storm hydrographs that have already been correlated to Clark's Unit Hydrograph parameters.

The HEC-HMS model requires three (3) parameters to predict runoff hydrographs using Clark's methodology:

> Time of Concentration (Tc) - The time required for rainfall excess to travel the entire length of the longest watercourse (L).
>
> Storage Coefficient (R) - Attenuates the hydrograph at the outflow point to account for storage in the subbasin.
>
> Time–Area Curve - Defines the cumulative area of the subbasin as a function of time. The default curve in HEC-HMS is used.

Experience has shown that the optimized individual values of T_C and R are a function of the calibration procedure used, but that the sum of the two parameters, Tc+R, is relatively independent of the procedure. As a result, the Flood Hazard Study (Reference 3.1.1) developed one equation that computes Tc directly, and another that computes the sum of Tc+R. The storage coefficient (R) is simply the difference between the two computed values.

The HCFCD unit hydrograph equations are as follows:

$$Tc = D\ [1 - (0.0062)(0.7\ DCI + 0.3\ DLU_{DET})](L_{ca}/\ S^{1/2})^{1.06}$$

$$C=7.25 \qquad \text{(if DLU} < DLU_{MIN})$$

or

$$C=4295\ (DLU_{DET})^{-0.678}\ (DCC)^{-0.967} \qquad \text{(if DLU} >= DLU_{MIN})\ Tc+R = C\ (L/\ S1/2)0.706$$

Where:

L	=	watershed length, in miles
L_{ca}	=	length to centroid, in miles
S	=	channel slope, in feet per mile
DLU	=	percent urban development*
DLU_{MIN}	=	percent land urbanization (minimum)*

DLU_{DET}	=	percent land urbanization (detention)*
DCI	=	percent channel improvement*
DCC	=	percent channel conveyance *
D	=	2.46 (if $S_o \leq 20$ feet/mile)
D	=	3.79 (if 20 feet/mile<$S_o \leq$40 feet/mile)
D	=	5.12 (if S_o>40 feet/mile)
S_o	=	watershed slope, in feet per mile

*Note: The values for DLU, DLU_{MIN}, DLU_{DET}, DCI, and DCC should be whole numbers (i.e., 50 percent would be represented by the number 50).

Stream Reach Routing

The routing of flood flows through channels was done with the Modified Puls Routing Method. This flood routing method is based on the continuity equation and a relationship between flow and storage or stage. The routing is modeled on an independent-reach basis from upstream to downstream.

The Modified Puls Routing Method is applicable to both channel and reservoir routing. This method is usually referred to as a reservoir routing technique because it assumes an invariable storage-outflow relationship. The method neglects the variable slope of the water surface that occurs during the passage of a flood wave down a channel. However, the method's limitations can be partially overcome by making successive routings through a number of relatively short stream reaches. In effect, this procedure reduces the relative importance of the wedge storage and simulates the stream flow through small contiguous reservoirs. Also, wedge storage is generally not as significant a factor in the sluggish Gulf Coast systems because of the relatively flat and wide floodplains.

Many of the other methods of flood routing utilize coefficients that are calibrated on the original configuration of the channel from historic gage information. The effects of channel improvements negate gage data, and can make adjustments to routing parameters difficult. An advantage of the Modified Puls Method is that it is more amenable to simulations of varying degrees of channel improvements. The effects of channel improvements can be measured directly by the storage-outflow relationship used in the Modified Puls Method. A good correlation between computed and historic hydrographs was obtained using the Modified Puls Method for the calibration effort of the Flood Hazard Study (Reference 3.1.1).

The Modified Puls method of routing requires three parameters (Reference 3.1.5) to function:

- Storage-outflow relationship
- Number of subreaches
- Initial conditions

The storage-outflow relationship for a reach is determined from HEC-RAS by executing a multiple profile run with predetermined flow rates. The flow rates should encompass the expected 0.2-percent-annual-chance exceedance event discharge. Flows in the storage-outflow HEC-RAS model should be kept constant between HEC-HMS routing reaches.

The number of subreaches for a routing reach is calculated from the multiple profile run used to develop the reach's storage-outflow relationship. The average of all the profiles' travel time through a routing reach should be determined. Dividing the average travel time by the HEC-HMS model's time increment yields the number of subreaches for a given routing reach. The number of subreaches should be rounded to the nearest whole number.

If during the travel time calculations, the average velocity in the reach is found to be less than 1 foot per second and the reach's energy grade is relatively flat, it may be reasonable to assume that the reach is functioning as a linear reservoir. Therefore, instead of a high number of routing steps produced by the low velocity, the number of routing steps should be set to 1 since it is behaving as a reservoir (Reference 3.1.15).

Calibration

A verification and calibration process was utilized to ensure the appropriateness of the computed hydrographs. The initial hydrology verification process involved the replacement of the theoretical rainfall with actual observed rainfall events (Reference 3.1.16), and then compared the computed hydrographs with observed hydrographs at gaging stations in the watershed. This comparison involved evaluations of the peak discharge, the hydrograph shape, and the volume of the streamflow.

In addition, the computed peak discharges from the observed rainfall events were input into the HEC-RAS models utilized to compute water profiles. This allowed for a comparison of computed high water elevations from observed events to those observed in the field.

These comparisons provided insight into the effectiveness of the modeling activity in duplicating the behavior of the watershed. If the models did not demonstrate an adequate level of comfort in this evaluation, the results were evaluated and appropriate refinements to the model input were made. This process was utilized to the maximum extent practical to develop models that accurately replicated real events.

The calibration techniques described above were utilized to improve the overall performance of the models. A second verification technique employed was a flood frequency analysis. Observed annual peak discharges at USGS gages were utilized to develop a discharge frequency relationship and a one standard deviation confidence interval. The resultant 10-, 2-, 1-, and 0.2-percent-annual-chance discharges computed from the HEC-HMS analysis were compared to ensure that the computed discharges were within one standard deviation of the discharge-frequency curve. If not, appropriate adjustments to the model were applied, and the verification and calibration process was repeated.

In some watersheds, gage data was not available. In those areas, comparisons to high water marks were utilized as well as area-discharge relationships from similar watersheds.

Flood Frequency Analysis

Flood Frequency Analysis involves developing a discharge-frequency relationship from observed annual peak discharges over an acceptable period of time. Assuming a watershed with minimal physical change over time, and a suitable period of record, this is the preferred method of developing a discharge-frequency relationship. Unfortunately, there are few instances of either of these in Harris County. The method employed is the same as that utilized in the calibration and verification process described above.

The only channel in Harris County that utilized this method to develop a discharge-frequency relationship and subsequent peak discharges is Luce Bayou. Luce Bayou is predominately upstream of Harris County, with only the most downstream reach within Harris County. The watershed has experienced virtually no urbanization over time, and there is a USGS gaging station (Gage 8071280 – Luce Bayou above Lake Houston near Huffman, Texas) on Luce Bayou near the Harris County line.

Regression Equation

In areas where there is not a suitable gage, and it is undesirable to develop a HEC-HMS model, it might be useful to develop a regional regression equation to develop a discharge-frequency relationship. In this FIS, this methodology was used for the Houston Ship Channel.

This method involves developing a trend line from a number of other gaging stations in the vicinity, even if they are located on other flooding sources. It is desirable to utilize gage stations that are along streams and watersheds that are as similar as possible to the one being analyzed.

The drainage areas and 10-, 2-, 1-, and 0.2-percent-annual chance discharges for these urban gaging stations are shown below (Reference 3.1.17):

Drainage Area	$Q_{10\%}$	$Q_{2\%}$	$Q_{1\%}$	$Q_{0.2\%}$	USGS Station	Station Name
(mi^2)	(cfs)	(cfs)	(cfs)	(cfs)	Number	
34.5	9,938	16,960	20,610	30,930	08074020	White Oak Bayour-Alabonson Rd
7.5	2,102	3,437	4,140	6,159	08074150	Cole Creek- Deihl Rd
11.4	6,054	8,772	9,957	12,780	08074250	Brickhouse Gully- Costa Rico St
12.7	4,392	5,489	5,886	6,688	08074800	Keegans Bayou – Roark Rd
52.5	14,660	1,600	21,470	25,360	08074810	Brays Bayou – Gessner Dr
36.6	9,525	14,360	16,460	21,460	08075900	Greens Bayou – US Hwy 75
8.3	4,372	6,265	7,142	9,369	08075730	Vince Bayou – Pasadena
20.2	6,308	8,933	9,970	12,210	08075400	Sims Bayou – Hiram Clarke
10.7	4,534	7,336	8,642	11,930	08075650	Berry Bayou – Forest Oaks
182.0	25,470	48,820	62,810	108,500	08076700	Greens Bayou – Ley Rd
68.7	12,520	23,170	29,250	48,100	08076000	Greens Bayou - Houston
31.0	8,479	14,890	18,230	27,590	08076180	Garners Bayou- Humble
63.0	12,270	19,080	22,140	29,560	08075500	Sims Bayou – Houston
94.9	27,770	36,070	39,240	45,950	08075000	Brays Bayou- Houston
86.3	17,730	25,710	29,330	38,370	08074500	White Oak Bayou – Houston

Peak flood discharges were then computed based on trend line equations derived from the discharges from 15 urban gaging stations in Harris County. The trend line in Figure 4 is based on the base flood discharges from these 15 gaging stations. Trend lines for the 10-, 2-, and 0.2-percent-annual chance discharges were derived by the same method.

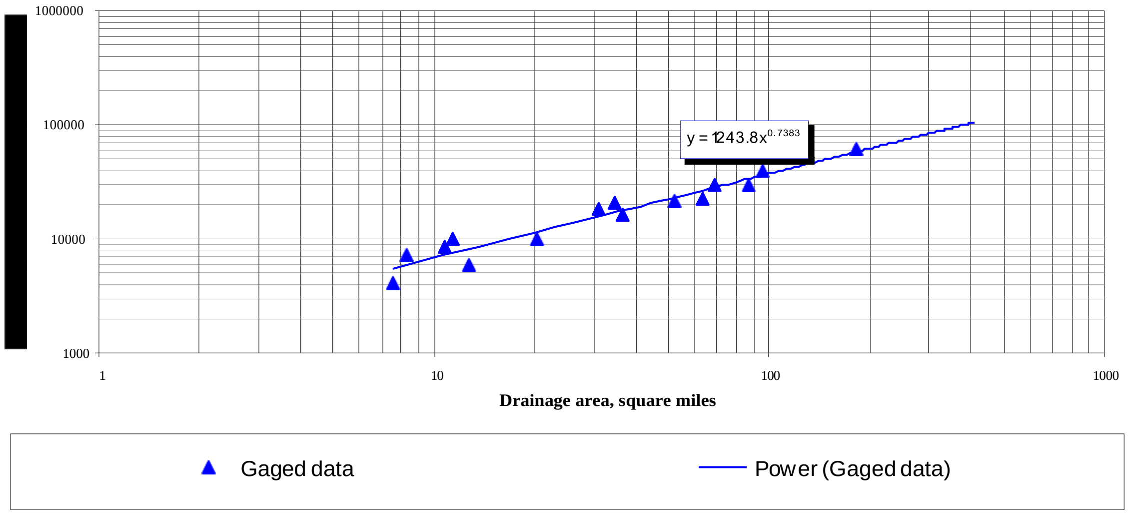


Figure 4. Graph of Base Flood Discharges for 15 Urban Gaging Stations in Harris County

The adopted equations are as follows:

$Q_{10\%} = 822.4*(DA^{0.6904})$
$Q_{2\%} = 1123.5*(DA^{0.7240})$
$Q_{1\%} = 1243.8*(DA^{0.7383})$
$Q_{0.2\%} = 1508.1*(DA^{0.7711})$

where DA is the drainage area in sq. mi.

USACE Methods

This section describes hydrologic methods developed by the USACE-Galveston District. Discharges using these or similar methods were originally developed for all of Harris County, but the HCFCD updated the computations for most watersheds. However, certain watersheds were not updated because there have not been substantial physical changes in the watersheds.

The HEC-1 computer program (Reference 3.1.18) was used for the flooding sources originally studied by the USACE. The purpose of the HEC-1 program is to determine peak discharges at various locations within a watershed. The most useful feature of the program is its capacity to model flood runoff from a single storm event for a complex river basin. To model a basin, topologic features must be described, and the precipitation runoff parameters must be defined and entered into the computer program. The topologic features include drainage basin boundaries, stream channels, and relationships between drainage areas and stream channels. Average rainfall values are used for each subbasin. Runoff is computed from average basin parameters; therefore, a unit hydrograph and a loss rate criterion is required. The program considers routing to be governed by storage and can be computed by one of several hydrologic methods, each with its own set of parameters.

The process of the HEC-1 program includes inputting and distributing the precipitation, determining the subbasin outflow hydrographs from unit hydrograph methods, computing rainfall and excess values, and routing hydrographs by hydrologic methods. This hydrologic methodology was used to develop the discharges for most of the county. The Clark's unit hydrograph parameters of time of concentration (Tc) and attenuation constant (R) were optimized from regression analyses evaluating data obtained at various gages.

The USACE used different assumptions in applying HEC-1 for different groups of streams. These differences are described below.

HEC-1 Method A

Discharges for G103-00-00 (San Jacinto River, Lake Houston, and West Fork San Jacinto River), G103-80-00 (East Fork San Jacinto River), and G103-80-03 (Caney Creek) were developed utilizing Method A.

To establish the 10-, 2-, 1-, and 0.2-percent-annual-chance floods, a log-Pearson Type III analysis was performed on the following gages.

USGS Gaging Station	Location
No. 08068000	West Fork San Jacinto River near Conroe, Texas
No. 08068500	Spring Creek near Spring, Texas
No. 08069000	Cypress Creek near Westfield, Texas
No. 08069500	West Fork San Jacinto River near Humble, Texas
No. 08070000	East Fork San Jacinto River near Cleveland, Texas
No. 08070500	Caney Creek near Splendora, Texas
No. 08071000	Peach Creek near Splendora, Texas
No. 08071500	San Jacinto River near Huffman, Texas

The skew coefficient for the Spring Creek gage was determined in accordance with *Bulletin 17A* (Reference 3.1.19). The skew coefficients for the other gages were determined to reflect that the PMF (QMAX) would have a recurrence interval of 1 in 10,000 years. QMAX was developed using HEC-1 with the revision for overflow developed by the Southwestern Division of the USACE for several flooding sources in the Lake Houston area.

For ungaged areas, rainfall exceedance frequencies were developed from a regression analysis using the results from multiple HEC-1 runs and the QMAX weighted frequency curve of the following gages.

USGS Gaging Station	Location
No. 08068000	West Fork San Jacinto River near Conroe, Texas
No. 08068500	Spring Creek near Spring, Texas
No. 08069500	West Fork San Jacinto River near Humble, Texas
No. 08070000	East Fork San Jacinto River near Cleveland, Texas
No. 08070500	Caney Creek near Splendora, Texas
No. 08071000	Peach Creek near Splendora, Texas
No. 08071500	San Jacinto River near Huffman, Texas
No. 08072500	Barker Reservoir near Addicks, Texas
No. 08073000	Addicks Reservoir near Addicks, Texas

No. 08115000	Big Creek near Needville, Texas
No. 08116400	Dry Creek near Rosenberg, Texas

The regression analyses used drainage area, length, length to centroid, main channel slope, and mean basin elevation as possible parameters. The regression analyses disclosed that the drainage area and mean basin elevation were the characteristics that best explained the variation in the rainfall exceedance frequencies. The adopted equations are as follows:

10-percent-annual-chance rainfall = (PMS) (0.00485) $(DA^{0.2933})$ $(EL^{1.1832})$ (1/100)

2-percent-annual-chance rainfall = (PMS) (0.0093) $(DA^{0.2644})$ $(EL^{1.2013})$ (1/100)

1-percent-annual-chance rainfall = (PMS) (0.0357) $(DA^{0.2247})$ $(EL^{1.03075})$ (1/100)

0.2-percent-annual-chance rainfall = (PMS) (0.8284) $(DA^{0.1426})$ $(EL^{0.6075})$ (1/100)

where PMS is probable maximum storm, in inches; DA is the drainage area in sq. mi.; and EL is the mean basin elevation, in feet.

These equations compared favorably to USGS Gage No. 08069000, on Cypress Creek near Westfield, Texas.

For both the gaged and ungaged areas, the HEC-1 model was used to develop the 10-, 2-, 1- and 0.2-percent-annual-chance flood discharges. To determine the basin runoff parameters, a regional analysis was performed on the following USGS gages.

USGS Gaging Station	Location
No. 08073000	Addicks Reservoir near Addicks, Texas
No. 08072500	Barker Reservoir near Addicks, Texas
No. 08115000	Big Creek near Needville, Texas
No. 08072400	Buffalo Bayou near Clodine, Texas
No. 08070500	Caney Creek near Splendora, Texas
No. 08077000	Clear Creek near Pearland, Texas
No. 08077550	Cowart Creek near Friendswood, Texas
No. 08116400	Dry Creek near Rosenberg, Texas
No. 08115500	Fairchild Creek near Needville, Texas
No. 08075780	Greens Bayou at Cutten Road, Houston, Texas
No. 08075900	Greens Bayou at U.S. Route 75, Houston, Texas
No. 08074780	Keegans Bayou near Keegans Road, Houston, Texas
No. 08067750	Langham Creek Tributary near Montgomery, Texas
No. 08072800	Langham Creek near Addicks, Texas
No. 08068300	Mill Creek Tributary near Dobbin, Texas
No. 08068450	Panther Creek at Splendora
No. 08071000	Peach Creek at Splendora
No. 08114900	Seabourne Creek near Rosenberg, Texas
No. 08072700	South Mayde Creek near Addicks, Texas
No. 08068500	Spring Creek near Spring, Texas

The drainage areas of these basins varied from 0.13 to 409.3 sq. mi. Values for Clark's coefficients, Tc (time of concentration), and R (attenuation constant) were calculated for a total of 136 storms that occurred over the gaged area between 1945 and 1975. These storms produced from 0.59 to 14.36 inches of total basin average rainfall. Computations were performed using the HEC-1 "Loss Rate and Unit Graph Optimization."

The results of these regression analyses are shown below:

$Tc + R = C_1 (31.3648\ Lca^{0.478} / S^{0.592})$

$R / (Tc + R) = C_2 (2.0576 / [DA^{0.239} S^{0.326}])$

QRSCN = 10 percent of peak discharge

log RTIOR = (log DA –2.63) / -6.92

Where Tc is the time of concentration,
R is the attenuation constant,
Lca is the length to centroid in miles,
S is the slope in feet per mile,
DA is the drainage area in square miles,
C_1 is the map coefficient for Tc + R shown in Figure 5,
C_2 is the map coefficient for R / (Tc + R) shown in Figure 6,
QRCSN is the flow in cubic feet per second (cfs) below which recession can control (Reference 3.1.18),
and RTIOR is the ratio of recession flow to that 10 intervals later (Reference 3.1.18).

The storage-discharge relationships were obtained from backwater computations using the HEC-2 computer program (Reference 3.1.20). The rainfall loss rates were set at 1.0 inch initial and 0.05 inch per hour uniform.

HEC-1 Method B

Method B was used for G103-80-03.1 (White Oak Creek) in the San Jacinto River watershed. Rainfall amounts for the 10-, 2-, 1- and 0.2-percent-annual-chance flooding events were determined by relating the drainage areas to percentages of the 1 percent chance rainfall event taken from the U.S. Weather Bureau Technical Paper No. 40 (Reference 3.1.21). The relationship was determined by analyzing seven gages. Figure 7 shows a plot of the drainage area versus percent of the 1 percent rainfall event for related recurrence intervals along with the actual values determined for the seven gages.

For G103-80-03.1, the 10-, 2-, and 1-percent-annual-chance flood events used an initial loss rate of 1.0 inch and a uniform loss rate of 0.1-inch per hour. The 0.2-percent-annual-chance flooding event used an initial loss rate of 1 inch and a uniform loss rate of 0.05 inch per hour. The unit hydrograph coefficients were determined as stated in Method A. Storage-discharge relationships were determined using the HEC-2 computer program (Reference 3.1.20).

Peak discharge-drainage area relationships for all flooding sources studied in detail are shown in Table 3, "Summary of Discharges".

The static elevations determined for the selected recurrence intervals for the Harris County reservoirs are shown in Table 4, "Summary of Reservoir Elevations."

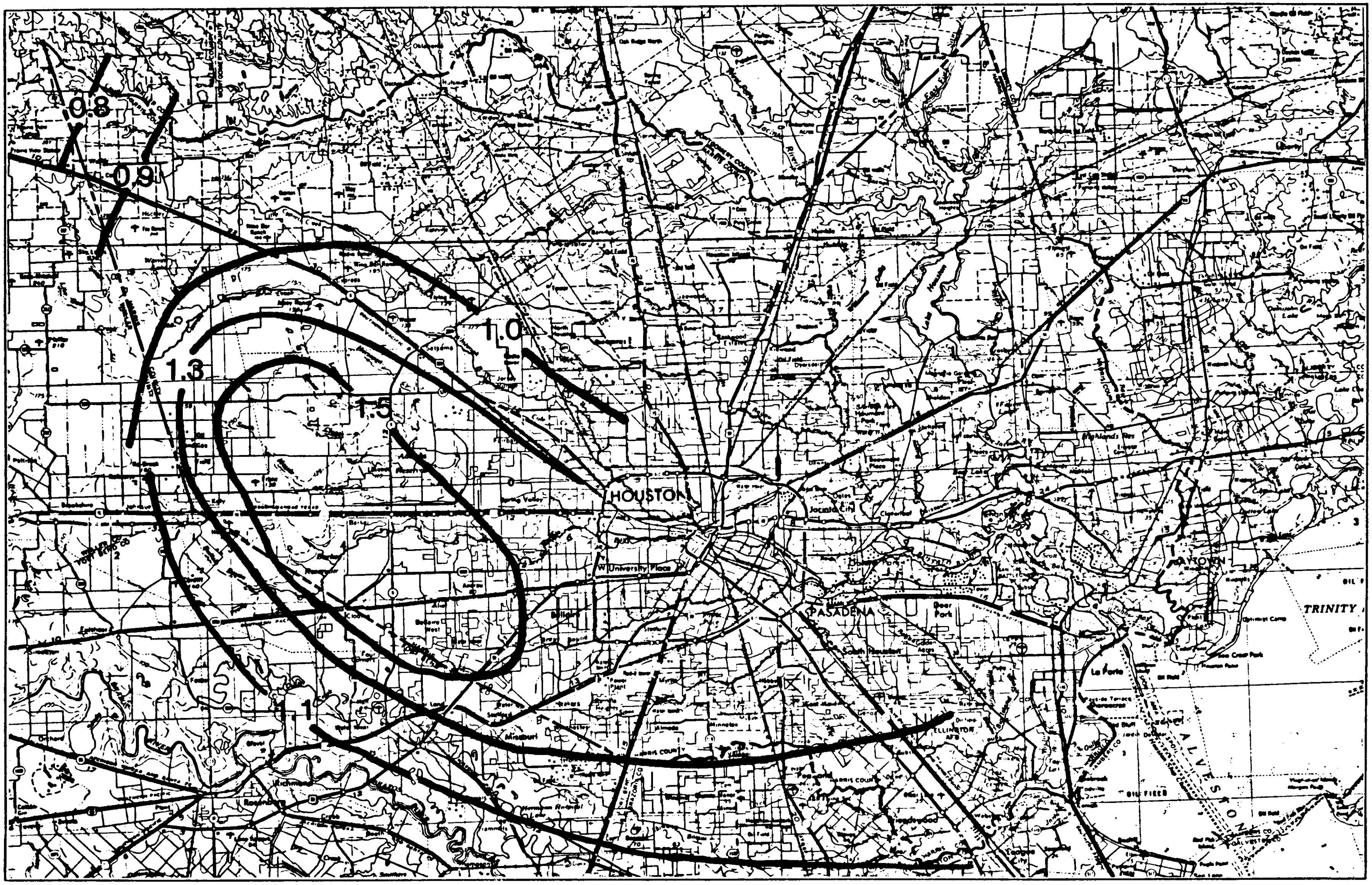


FIGURE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX
AND INCORPORATED AREAS

APPROXIMATE SCALE

4 0 4 8 12 MILES

MAP COEFFICIENT-C1

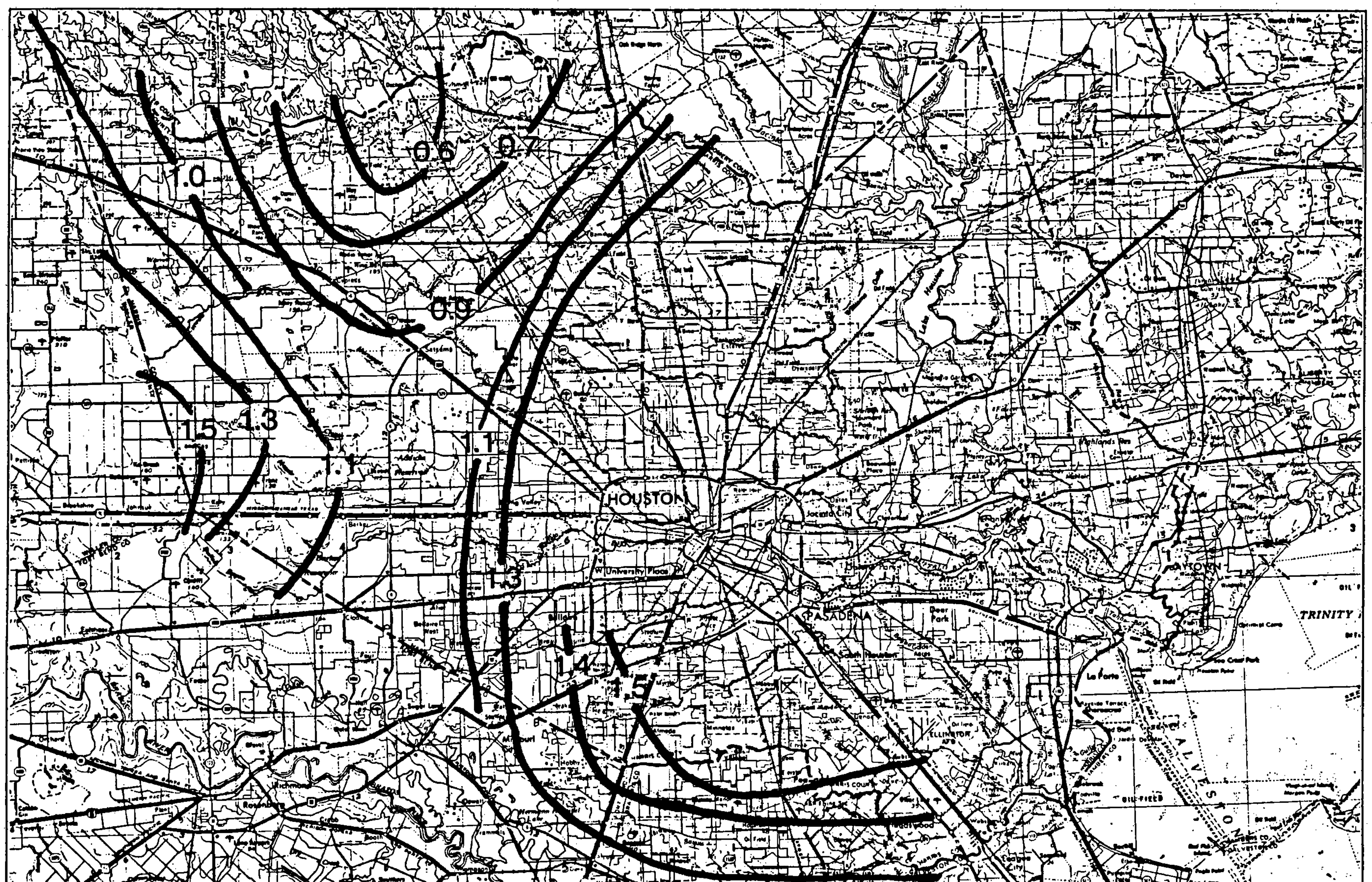


FIGURE 6

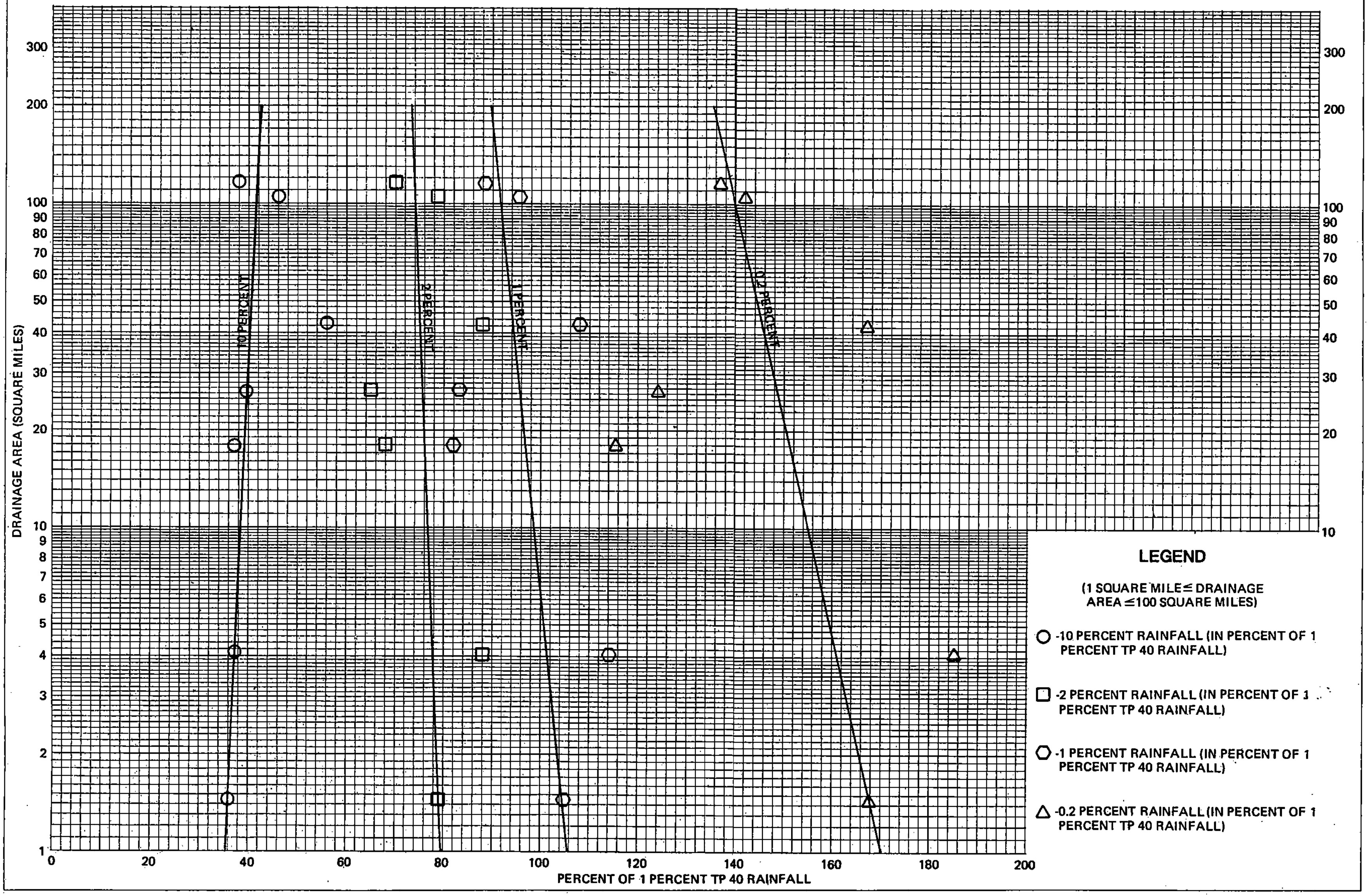
FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

APPROXIMATE SCALE

4 0 4 8 12 MILES

MAP COEFFICIENT-C2



DRAINAGE AREA VS PERCENT OF THE 1 PERCENT TP 40 RAINFALL

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

FIGURE 7

Table 3. Summary of Discharges

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
A100-00-00 (CLEAR CREEK)					
At mouth	259.99	21,618	38,098	46,341	71,847
At confluence of Taylor Bayou (A104-00-00)	250.77	22,481	38,995	47,042	72,745
At confluence of Armand Bayou (B100-00-00)	231.94	20,938	35,377	42,013	64,427
At confluence of Robinson Bayou (RB100-00-00)	172.84	14,229	21,633	24,879	33,496
At confluence of Cow Bayou (A107-00-00)	166.19	14,051	21,317	24,557	32,750
At confluence of tributary A111-00-00	154.03	13,729	20,766	23,940	31,637
At confluence of Landing Ditch (LD100-00-00)	150.01	13,563	20,518	23,660	31,516
At confluence of Magnolia Creek (MG100-00-00)	144.86	13,407	20,253	23,340	31,269
At confluence of Chigger Creek (CH100-00-00)	139.14	13,201	19,868	22,891	30,896
At confluence of Cowart Creek (CW100-00-00)	118.46	11,700	17,710	20,329	28,726
At confluence of Mary's Creek (MA100-00-00)	95.64	9,343	14,080	16,162	22,566
At confluence of Turkey Creek (A119-00-00)	77.30	6,876	10,632	12,282	17,205
At confluence of Halls Road Ditch (A120-00-00)	67.18	4,361	6,766	7,901	10,572
At confluence of Hickory Slough (HI100-00-00)	46.37	2,871	4,553	5,376	7,966
At stream mile 37.5	32.03	2,203	3,438	4,244	7,002
Downstream of SH 288	16.36	1,122	1,902	2,342	3,918
At stream mile 43.85	13.00	1,031	1,883	2,382	3,951
At Almeda Road (FM 521)	5.43	388	670	814	1,751
At McHard Road (FM 2234)	3.21	414	821	1,077	1,925

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
A104-00-00 (TAYLOR BAYOU)					
At mouth	16.29	2,078	5,115	6,532	10,394
At Red Bluff Road	13.47	2,768	4,671	5,619	8,384
At Port Road	9.64	1,751	2,952	3,604	5,439
At confluence of tributary 3.93 (A104-07-00)	5.96	820	1,290	1,539	2,291
A104-04-00 (TRIBUTARY 3.10 TO TAYLOR BAYOU)					
At mouth	2.78	986	1,488	1,749	2,523
A104-07-00 (TRIBUTARY 3.93 TO TAYLOR BAYOU)					
At mouth	2.84	728	1,124	1,333	1,955
A104-13-00 (TRIBUTARY 3.36 TO TAYLOR BAYOU)					
At mouth	3.18	1,539	2,248	2,617	3,683
A104-14-00 (TAYLOR BAYOU DIVERSION CHANNEL)					
At mouth	--	837	1,257	1,475	2,110
A107-00-00 (COW BAYOU)					
At mouth	4.08	2,091	3,036	3,542	4,988
A107-03-00 (UNNAMED TRIBUTARY TO COW BAYOU)					
At stream mile 2.03	2.05	1,289	1,843	2,133	2,949
A111-00-00 (TRIBUTARY 10.18 TO CLEAR CREEK)					
At mouth	4.02	1,074	1,655	1,960	2,870
A118-00-00 (CEDAR GULLY)					
At mouth	1.22	893	1,269	1,467	2,007

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	**Drainage Area (sq. mi.)**	**Peak Discharges (cfs)** 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
A119-00-00 (TURKEY CREEK)					
At mouth	10.13	3,526	5,118	5,714	7,969
At confluence of tributary A119-05-00	6.48	3,099	4,464	5,035	6,321
At Scarsdale Blvd	3.57	1,709	2,643	3,074	4,401
A119-02-00 (TRIBUTARY 0.16 TO TURKEY CREEK)					
At mouth	1.40	193	358	457	775
A119-05-00 (UNNAMED TRIBUTARY TO TURKEY CREEK)					
At mouth	2.18	974	1,385	1,540	1,998
At S.H. 3	0.94	488	712	829	1,162
A119-07-00 (UNNAMED TRIBUTARY TO TURKEY CREEK)					
At mouth	2.13	943	1,411	1,632	2,238
A119-07-02 (UNNAMED TRIBUTARY TO A119-07-00)					
At I.H. 45	1.36	440	660	775	1,029
At B.W. 8	0.98	436	638	743	1,051
A120-00-00 (HALL'S ROAD DITCH)					
At mouth	9.39	3,368	4,825	5,398	6,769
Downstream diversion to Turkey Creek (A119-00-00)	6.60	2,368	3,219	3,692	4,332
Upstream diversion to Turkey Creek (A119-00-00)	6.60	2,368	3,359	3,908	5,126
At Hall Road	5.27	1,731	2,617	3,098	4,472
At Kingspoint Road	3.04	736	1,137	1,350	1,981
At mouth	0.40	311	532	641	910
Downstream diversion to Horsepen (B204-04-0040)	0.00	53	162	209	300

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
B100-00-00 (ARMAND BAYOU)					
At mouth	59.10	15,433	24,076	29,102	40,693
At confluence of Horsepen Bayou (B104-00-00)	55.30	14,895	23,173	28,030	39,139
At confluence of Big Island Slough (B106-00-00)	34.80	10,116	15,049	17,444	24,139
At confluence of Spring Gully (B109-00-00)	24.22	7,847	11,309	13,278	19,414
At confluence of tributary 9.39 (B111-00-00)	19.67	6,360	9,160	10,886	15,687
At confluence of Willow Springs Bayou (B112-00-00)	17.99	5,897	8,643	10,176	14,369
At confluence of tributary 10.46 (B113-00-00)	6.70	2,574	4,156	4,770	6,472
At confluence of tributary 12.18 (B115-00-00)	5.33	2,234	3,489	4,057	5,486
At confluence of tributary 12.09 (B114-00-00)	2.66	1,138	1,670	1,946	2,759
Upstream of confluence of tributary 12.09 (B114-00-00)	1.43	520	775	907	1,301
At Dupont Street	0.65	289	431	505	724
B104-00-00 (HORSEPEN BAYOU)					
At mouth	19.45	8,412	12,119	13,656	17,098
At confluence of tributary (B104-01-00)	18.77	8,259	11,832	13,279	16,570
At confluence of tributary (B104-02-00)	17.46	7,627	10,829	12,179	14,946
At confluence of tributary (B104-08-00)	16.53	7,118	10,038	11,359	13,712
At confluence of tributary (B104-03-00)	15.22	6,314	8,956	10,145	12,164
At confluence of tributary 4.51 (B104-04-00)	11.47	4,183	6,086	6,697	8,322
At Clear Lake City Blvd	7.58	3,554	5,226	5,710	6,916
At Space Center Blvd	7.48	3,487	5,126	5,639	6,896

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	**Drainage Area (sq. mi.)**	**Peak Discharges (cfs) 10% Annual Chance**	**2% Annual Chance**	**1% Annual Chance**	**0.2% Annual Chance**
B104-00-00 (HORSEPEN BAYOU) (cont'd)					
At confluence of tributary 5.44 (B104-05-00)	6.82	2,999	4,390	5,057	6,583
At stream mile 5.64	3.59	1,654	2,431	2,831	3,517
At stream mile 6.37	2.92	1,328	1,970	2,304	3,273
B104-04-00 (TRIBUTARY 4.51 TO HORSEPEN BAYOU)					
At mouth	0.40	311	532	641	910
Downstream of diversion B204-04-00 to Horsepen	0.00	53	162	209	300
Upstream of diversion B204-04-00 to Horsepen	3.90	690	1,023	1,196	1,707
Downstream of regional detention (B504-01-00)	2.30	402	556	767	1,574
B104-05-00 (TRIBUTARY 5.44 TO HORSEPEN BAYOU)					
At mouth	2.70	1,299	1,906	2,220	3,115
At Galveston Highway (SH 3)	1.88	667	1,011	1,190	1,721
B106-00-00 (BIG ISLAND SLOUGH)					
At mouth	7.98	3,932	5,720	6,590	8,702
At Fairmont Parkway	4.39	2,923	4,226	4,783	6,329
At Main Street	2.97	1,858	2,673	3,112	4,309
At L Street	1.68	807	1,187	1,385	1,956
B109-00-00 (SPRING GULLY)					
At mouth	2.87	1,240	1,855	2,174	3,118
B109-03-00 (B112-02-00 INTERCONNECT)					
At mouth	--	576	815	935	1,289

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
B111-00-00 (TRIBUTARY 9.39 TO ARMAND BAYOU)					
At mouth	1.39	771	1,123	1,301	1,821
At stream mile 0.78	0.95	502	738	861	1,209
B112-00-00 (WILLOW SPRINGS BAYOU)					
At mouth	7.61	2,741	4,092	4,788	6,628
Downstream of confluence with tributary 1.78 (B112-02-00)	5.68	1,788	2,673	3,138	4,494
Upstream of confluence with tributary 1.78 (B112-02-00)	3.16	1,675	2,432	2,827	3,959
B112-02-00 (TRIBUTARY 1.78 TO WILLOW SPRINGS BAYOU)					
At mouth	2.52	126	264	341	576
Upstream of diversion B109-03-00 to Spring Gully	2.52	702	1,078	1,275	1,864
B112-04-00 (TRIBUTARY B TO WILLOW SPRINGS BAYOU)					
At mouth	0.75	579	840	977	1,368
B113-00-00 (TRIBUTARY 10.46 TO ARMAND BAYOU)					
At mouth	3.68	1,019	1,470	1,636	2,167
At B.W. 8	1.53	536	800	937	1,344
B114-00-00 (COUNTY "C," D.D. #5)					
At mouth	1.23	626	908	1,056	1,480
Upstream of Spencer Highway	1.06	539	781	909	1,274
At Glenwood Road	0.67	340	494	574	805
B114-01-00 (PRIVATE "G," D.D. #5)					
At mouth	0.15	74	107	125	175
Upstream of Wakeshire Road	0.08	41	60	69	97

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
B114-02-00 (UNNAMED TRIBUTARY TO B114-00-00)					
At mouth	0.06	29	42	49	69
B115-00-00 & B115-01-00 (TRIBUTARY 12.18 TO ARMAND BAYOU)					
At mouth	2.67	1,254	1,860	2,159	2,902
At confluence of tributary B115-01-00	1.13	858	1,210	1,396	1,902
B204-00-00 (HORSEPEN BAYOU DIVERSION CHANNEL)					
At mouth	3.90	637	861	988	1407
C100-00-00 (SIMS BAYOU)					
At mouth	93.51	22,903	38,495	44,553	58,495
Downstream of Plum Creek	91.75	22,531	37,816	43,765	57,455
Upstream of Pine Gully	86.15	21,760	36,370	42,049	54,410
Upstream of Berry Bayou	68.69	17,568	28,921	33,294	39,974
Upstream of Tributary 10.77 to Sims Bayou	48.74	13,785	22,280	26,317	32,542
Upstream of Tributary 13.83 to Sims Bayou	34.73	10,712	17,084	20,619	28,736
At Hiram-Clarke Road	20.73	5,928	9,366	11,400	16,880
Upstream of Tributary 20.25 to Sims Bayou	7.91	2,316	3,712	4,470	6,449
Upstream of Sam Houston Parkway	2.26	706	1,090	1,292	1,897
C102-00-00 (PLUM CREEK)					
At mouth	3.99	1,486	2,223	2,572	3,585
At Broadway Road	2.90	680	1,037	1,229	1,803
C103-00-00 (PINE GULLY)					
At mouth	1.61	1,468	2,068	2,384	3,231
At Reveille Road	0.30	597	841	969	1,313

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	**Drainage Area (sq. mi.)**	**Peak Discharges (cfs) 10% Annual Chance**	**2% Annual Chance**	**1% Annual Chance**	**0.2% Annual Chance**
C106-00-00 (BERRY BAYOU)					
At mouth	17.46	7,852	11,634	13,575	18,806
Upstream of Tributary 2.00 to Berry Bayou	6.62	4,511	6,632	7,739	10,921
Upstream of Spencer Highway	6.59	3,094	4,562	5,329	7,544
Upstream of Tributary 3.31 to Berry Bayou	3.02	2,271	3,360	3,929	5,583
Downstream of Witt Road	1.70	758	1,128	1,323	1,895
C106-01-00 (BERRY CREEK)					
At mouth	4.80	1,812	2,649	3,129	4,549
Upstream of C106-01-02	2.78	1,045	1,572	1,851	2,677
C106-01-07 (UNNAMED TRIBUTARY TO BERRY CREEK)					
Upstream of Hobby Airport Runway	1.33	500	753	887	1,282
C106-03-00 (TRIBUTARY 2.00 TO BERRY BAYOU)					
At mouth	2.86	1,302	1,925	2,250	3,205
Upstream of College Avenue	1.40	767	1,134	1,326	1,889
C106-08-00 (TRIBUTARY 3.31 TO BERRY BAYOU)					
At mouth	1.82	999	1,460	1,702	2,388
Downstream of Coronation Drive	1.50	917	1,341	1,563	2,194
C118-00-00 (SALT WATER DITCH)					
At mouth	3.87	1,762	2,604	3,048	4,344
Upstream of Bellfort Ave	2.50	1,149	1,699	1,988	2,834
C123-00-00 (TRIBUTARY 10.77 TO SIMS BAYOU)					
At mouth	2.44	801	1,228	1,452	2,102

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
C223-00-00 (TRIBUTARY 10.77 TO SIMS BAYOU)					
Upstream of confluence with C123-00-00	2.05	568	870	1,029	1,489
Downstream of Almeda-Genoa Road	1.00	387	593	701	1,014
C127-00-00 (SWENGEL DITCH)					
At mouth	2.14	1,030	1,545	1,816	2,595
C132-00-00 (TRIBUTARY 13.83 TO SIMS BAYOU)					
At mouth	4.07	759	1,222	1,476	2,242
At Airport Boulevard	3.30	630	1,015	1,226	1,861
Downstream of Reed Road	2.80	532	856	1,034	1,569
C147-00-00 (TRIBUTARY 20.25 TO SIMS BAYOU)					
At mouth	7.16	2,034	3,461	4,391	7,018
At South Post Oak Road	6.73	1,943	3,306	4,194	6,704
C161-00-00 (TRIBUTARY 17.82 TO SIMS BAYOU)					
At mouth	2.35	636	1,007	1,205	1,800
Downstream of Airport Boulevard	2.30	623	985	1,179	1,762
Downstream of Tidewater Drive	1.96	531	840	1,005	1,501
At Orem Drive	1.70	460	728	872	1,302
D100-00-00 (BRAYS BAYOU)					
At mouth	128.74	37,545	44,124	47,258	55,389
Upstream of Scott Street	111.67	32,102	36,320	38,484	44,397
Downstream of Main Street	98.73	28,200	30,333	31,831	36,226
Downstream of Chimney Rock Street	76.73	25,294	31,219	32,975	37,060
Upstream of Gessner Street	54.09	18,869	22,483	23,624	27,142
Downstream of D142-00-00 Confluence	32.99	12,970	17,208	18,226	21,615

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
D100-00-00 (BRAYS BAYOU) (cont'd)					
Upstream of D126-00-00 Confluence	16.04	5,293	6,485	7,025	8,095
Upstream of Dairy Ashford Road	13.21	4,743	6,098	6,624	8,043
Downstream of SH 6	6.80	2,439	3,636	4,250	5,865
D109-00-00 (HARRIS GULLY)					
At mouth	5.13	2,450	3,611	4,064	5,989
At Main Street	3.59	1,299	2,010	2,407	3,583
At Rice Boulevard	2.96	890	1,440	1,760	2,720
D111-00-00 (POOR FARM DITCH)					
At mouth	2.07	906	1,335	1,552	2,176
At University Boulevard	1.11	485	714	830	1,164
D112-00-00 (WILLOW WATERHOLE BAYOU)					
At mouth	4.50	3,218	4,769	5,438	6,941
At Post Oak Road	2.88	2,201	3,208	3,628	4,519
At Chimney Rock Diversion Channel	1.26	1,099	1,370	1,546	1,914
D118-00-00 (KEEGAN'S BAYOU)					
At mouth	18.11	5,461	7,212	7,925	9,652
Downstream of Roark Road	13.16	3,587	4,992	5,687	7,650
At Keegan Street	8.21	1,718	2,615	2,970	3,996
D120-00-00 (TRIBUTARY 20.90 TO D100-00-00)					
At mouth	3.43	2,322	3,343	3,779	4,921
D122-00-00 (TRIBUTARY 21.95 TO BRAYS BAYOU)					
At mouth	5.20	3,224	5,721	6,507	8,582

Table 3. Summary of Discharges (cont'd)

		Peak Discharges (cfs)			
Flooding Source and Location	**Drainage Area (sq. mi.)**	**10% Annual Chance**	**2% Annual Chance**	**1% Annual Chance**	**0.2% Annual Chance**
D124-00-00 (TRIBUTARY 22.69 TO D100-00-00)					
At mouth	2.94	1,554	2,265	2,627	3,645
D126-00-00 (TRIBUTARY 23.53 TO D100-00-00)					
At mouth	1.84	991	1,447	1,679	2,328
D129-00-00 (TRIBUTARY 26.20 TO D100-00-00)					
At mouth	4.52	2,335	3,383	3,707	4,527
D132-00-00 (TRIBUTARY 29.16 TO D100-00-00)					
At mouth	4.55	1,819	2,710	3,162	4,465
D133-00-00 (BINTLIFF DITCH)					
At mouth	4.55	1,133	1,719	2,021	2,925
D139-00-00 (CHIMNEY ROCK DIVERSION CHANNEL)					
At mouth	1.41	1,379	1,655	1,872	2,544
D140-00-00 & D140-04-00 (FONDREN DIVERSION CHANNEL)					
At mouth	8.60	3,592	4,695	5,163	6,329
Upstream of Bellfort Street	6.66	2,619	3,942	4,343	5,169
D142-00-00 (TRIBUTARY 20.86 TO D100-00-00)					
At mouth	2.16	1,568	2,230	2,569	3,500
D144-00-00 (CITY DITCH)					
At mouth	1.13	502	737	856	1,198

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
E100-00-00 (WHITE OAK BAYOU)					
At mouth	110.99	29,067	41,250	44,661	56,866
At Heights Blvd	85.95	22,617	31,324	34,455	42,293
At Lazybrook Drive	83.00	22,833	31,444	34,950	42,584
Downstream of E115-00-00 Confluence	73.91	22,105	30,781	34,124	43,028
Downstream of E117-00-00 Confluence	58.33	16,431	21,691	24,185	33,857
Downstream of E121-00-00 Confluence	45.70	12,447	16,891	19,820	28,253
Downstream of E122-00-00 Confluence	35.68	10,836	14,697	16,648	23,368
Downstream of E141-00-00 Confluence, At Beltway 8	27.15	9,065	11,769	13,154	17,887
Downstream of E127-00-00 Confluence	19.35	7,872	10,214	11,395	15,310
At West Road	12.62	5,810	7,500	8,350	10,300
At Jones Road	9.99	4,100	5,550	6,250	8,140
Downstream of E133-00-00 Confluence	3.01	1,130	1,710	1,990	2,820
E101-00-00 (LITTLE WHITE OAK BAYOU)					
At mouth	22.02	8,616	11,630	12,967	17,865
At North Loop IH-610	16.56	7,290	9,330	10,290	14,040
At E101-12-00 Confluence	10.09	4,470	5,720	6,580	9,280
At E101-15-00 Confluence	5.77	2,860	4,020	4,450	5,950
Downstream of Yale Street	3.45	1,320	1,980	2,310	3,260
E115-00-00 (BRICKHOUSE GULLY)					
At mouth	11.63	6,230	7,743	8,598	12,166
Downstream of E115-04-00 Confluence	9.31	5,270	6,510	7,060	10,120
At Hollister Road	5.84	3,380	4,860	5,600	7,770
Downstream of E115-07-00 Confluence	2.91	1,950	2,600	2,900	3,800
At Gessner Road	1.03	900	1,080	1,200	1,280

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
E115-04-00 (TRIBUTARY 1.61 TO BRICKHOUSE GULLY)					
At mouth	1.97	1,500	2,100	2,500	3,500
Upstream of Pinemont Drive	0.68	690	1,020	1,230	1,750
E116-00-00 & E116-05-00 (TRIBUTARY 10.1 TO WHITE OAK BAYOU)					
At mouth	2.38	1,500	2,100	2,400	3,400
Downstream of E116-05-00 Confluence, at stream mile 1.71	0.23	260	370	440	600
E117-00-00 (COLE CREEK)					
At mouth	9.65	3,676	5,527	6,496	8,698
At Bingle Road	7.89	2,960	4,450	5,220	6,980
At Guhn Road	5.23	1,710	2,600	3,140	5,150
Downstream of Windfern Road, at stream mile 5.16	2.55	1,050	1,750	2,070	3,610
Downstream of Fisher Road, at stream mile 6.69	1.21	630	990	1,150	1,680
E121-00-00 (VOGEL CREEK)					
At mouth	8.04	3,059	4,003	4,536	6,049
At Mount Houston Road	4.29	1,840	2,700	3,140	4,420
At Antoine Road	2.86	1,350	1,980	2,350	3,240
Downstream of E121-07-00 Confluence, at stream mile 5.35	1.21	720	1,120	1,320	1,840
Downstream of Crooked Wood, at stream mile 6.47	0.48	350	520	600	860
E122-00-00 (UNNAMED TRIBUTARY TO WHITE OAK BAYOU)					
At mouth	4.36	2,064	3,081	3,599	5,102
Upstream of Round Banks Road	2.45	1,250	1,840	2,140	2,990
At stream mile 3.42	2.04	1,130	1,680	1,900	2,670

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
E124-00-00 (TRIBUTARY 15.8 TO WHITE OAK BAYOU)					
At mouth	1.56	1,339	1,894	2,178	2,946
Upstream of E124-01-00 Confluence	0.96	1,020	1,440	1,700	2,260
At stream mile 1.33	0.50	620	870	1,000	1,410
E125-00-00 (ROLLING FORK)					
At mouth	2.40	784	1,187	1,392	1,997
At Rodney Ray Boulevard	1.64	620	940	1,150	1,650
At stream mile 1.90	1.22	490	750	890	1,360
E127-00-00 (TRIBUTARY 19.05 TO WHITE OAK BAYOU)					
At mouth	2.24	862	1,284	1,499	2,121
At Rio Grande Street	1.47	660	980	1,230	1,660
Upstream of US 290, at stream mile 1.60	0.69	440	660	750	1,110
E135-00-00 (TRIBUTARY 19.82 TO WHITE OAK BAYOU)					
At mouth	2.41	963	1,430	1,669	2,358
At Hempstead Road	1.47	680	1,010	1,220	1,720
E141-00-00 (BELTWAY 8 OUTFALL DITCH)					
At mouth	3.35	1,244	1,955	2,315	3,306
At stream mile 2.57	1.98	860	1,290	1,510	2,140
F216-00-00 (LITTLE CEDAR BAYOU)					
At mouth	3.49	1,649	2,440	2,799	3,842
At confluence w/tributary F216-01-00	3.42	1,609	2,378	2,724	3,744
F220-00-00 & F220-03-00 (PINE GULLY)					
At mouth	3.28	1,574	2,333	2,720	3,856
At confluence w/tributary F220-01-00	3.28	1,577	2,335	2,722	3,858
At confluence w/tributary F220-02-00	2.19	1,106	1,630	1,900	2,674

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
G100-00-00 (BUFFALO BAYOU, HOUSTON SHIP CHANNEL)					
At confluence of San Jacinto River	763.58	147,736	209,729	238,342	303,412
At confluence of Carpenter's Bayou (N100-00-00)	762.97	147,610	209,537	238,111	303,076
At confluence of Patrick Bayou (G104-00-00)	727.81	141,300	199,680	225,257	284,413
At confluence of Glenmore Ditch (G108-00-00)	713.1	138,826	195,201	219,674	277,983
At confluence of tributary 6.77 (G109-00-00)	497.6	110,002	154,639	175,970	221,923
At confluence of Hunting Bayou (H100-00-00)	494.19	109,244	153,458	174,575	220,203
At confluence of Vince Bayou (I100-00-00)	460.08	102,085	143,284	163,066	206,247
At confluence of Sim's Bayou (C100-00-00)	441.38	98,243	137,342	154,471	195,719
At confluence of Bray's Bayou (D100-00-00)	342.49	73,943	98,317	108,650	139,654
At confluence of Buffalo Bayou (W100-00-00), Turning Basin	211.78	38,530	56,154	63,778	86,154
G103-00-00 (SAN JACINTO RIVER)					
At confluence w/ G100-00-00	2896.8	83,000	181,000	252,000	419,000
At IH-10	2890.5	83,000	181,000	252,000	420,000
At U.S. Highway 90	2864.8	85,000	183,000	254,000	422,000
At Lake Houston Dam	2828.0	82,400	180,200	246,100	409,900
G103-01-00 (UNNAMED TRIBUTARY TO SAN JACINTO RIVER)					
At mouth	2.91	2,200	3,125	3,611	4,969

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
G103-07-00 (UNNAMED TRIBUTARY TO SAN JACINTO RIVER)					
At mouth	6.55	3,830	5,519	6,407	8,991
Downstream of U.S. Highway 90	5.41	3,298	4,735	5,489	7,690
Upstream of Sheldon Road	3.76	2,598	3,744	4,343	6,022
Upstream of confluence with tributary G103-07-04	1.24	513	753	877	1,246
G103-00-00 (WEST FORK SAN JACINTO RIVER)					
Downstream of Bens Branch	1776.0	66,800	143,000	174,300	333,600
At U.S. Highway 59	1741.0	62,300	127,200	167,500	306,000
G103-33-00 (BEN'S BRANCH)					
At mouth	14.06	3,404	4,794	5,454	7,175
At confluence with tributary G103-33-04	13.18	3,308	4,636	5,261	6,894
At confluence with tributary G103-33-01	12.02	1,921	2,707	3,334	5,228
Downstream of Kingwood Diversion Channel	8.96	1,040	1,769	2,133	3,314
Upstream of Kingwood Diversion Channel	8.96	1,814	2,687	3,132	4,609
Downstream of Bentwood Diversion Channel	4.80	0	0	0	378
G103-43-00 (JORDAN GULLY)					
At mouth	2.61	1,782	2,546	2,940	4,118
At stream mile 1.61	1.98	1,687	2,288	2,625	3,557
Downstream of confluence with tributary G103-04-00	1.53	1,418	1,908	2,184	2,944
Upstream of confluence with tributary G103-04-00	1.18	1,259	1,740	1,989	2,648

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
G103-44-00 (TXDOT DITCH #4)					
At mouth	2.10	1,211	1,756	2,032	2,790
At confluence of tributary G103-44-01	0.67	747	1,031	1,178	1,566
G103-48-00 (BLACK'S BRANCH)					
At mouth	2.99	1,891	2,659	3,061	4,301
Downstream of U.S. Highway 59	2.74	1,818	2,530	2,917	4,088
At Townsend Blvd	2.16	1,484	2,070	2,410	3,373
At confluence of tributary G103-48-02	1.74	1,226	1,743	2,008	2,729
G103-80-00 (EAST FORK SAN JACINTO RIVER)					
At north end of Lake Houston	1002.0	41,400	85,200	109,500	185,000
Downstream of confluence with G103-80-03	766.0	41,300	84,400	108,500	182,800
Upstream of confluence with G103-80-03	396.0	11,000	25,500	35,200	66,600
At FM 1485	384.0	10,500	24,500	34,200	66,100
G103-80-03 (CANEY CREEK)					
At mouth	370.0	22,200	52,000	72,400	133,000
G103-80-03.1 (WHITE OAK CREEK)					
At mouth	29.5	1,900	3,480	4,230	6,080
At county boundary	24.7	2,370	5,450	7,260	12,600
G103-80-03.1A (MILL'S BRANCH)					
At mouth	0.93	421	622	725	1,067
G103-80-03.1B (TAYLOR GULLY)					
At mouth	4.15	1,897	2,739	3,078	4,010

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
G104-00-00 (PATRICK BAYOU)					
At mouth	4.88	3,985	5,595	6,455	8,669
At confluence of tributary G104-04-00	4.39	3,560	5,009	5,774	7,741
Downstream of SH 225	2.28	1,918	2,687	3,093	4,181
Upstream of SH 225	2.01	1,723	2,414	2,780	3,754
Upstream of confluence with E. 13th Street (G104-08-00)	1.11	1,030	1,433	1,647	2,216
G104-08-00 (EAST 13TH STREET OUTFALL CHANNEL)					
At mouth	0.76	542	773	894	1,225
G105-00-00 (BOGGY BAYOU)					
Upstream of SH 225	3.64	1,615	2,121	2,396	3,375
At approximately 1,060' Downstream of 13th Street	2.85	1,654	2,129	2,373	3,320
Upstream of 13th Street	2.50	1,708	2,140	2,342	3,247
G108-00-00 (GLENMORE DITCH)					
At mouth	3.03	2,215	3,020	3,408	4,289
Downstream of Southern Pacific Railroad	2.70	2,060	2,774	3,116	3,883
At S.H. 225	1.90	1,505	2,056	2,299	2,906
G109-00-00 (TRIBUTARY 6.77 TO BUFFALO BAYOU)					
At mouth	0.88	713	1,005	1,159	1,588
G110-00-00 (COTTON PATCH BAYOU)					
At mouth	1.69	893	1,413	1,716	2,565
At stream mile 1.05	1.61	1,113	1,586	1,847	2,583
At SH 225	1.00	687	975	1,127	1,548

Table 3. Summary of Discharges (cont'd)

		Peak Discharges (cfs)			
	Drainage	**10%**	**2%**	**1%**	**0.2%**
Flooding Source and Location	**Area (sq. mi.)**	**Annual Chance**	**Annual Chance**	**Annual Chance**	**Annual Chance**
G112-00-00 (PANTHER CREEK)					
At mouth	1.96	1,860	2,575	2,963	4,010
At Clinton Drive	1.59	1,508	2,100	2,428	3,263
H100-00-00 (HUNTING BAYOU)					
At mouth	30.98	6,270	9,002	10,568	15,234
At confluence of H103-00-00	24.08	5,493	7,351	8,299	11,498
Downstream of H125-00-00	19.13	4,761	6,416	7,148	9,057
At IH 610	14.99	4,181	5,829	6,534	8,193
Downstream of H118-00-00	9.42	2,482	3,916	4,589	6,631
Downstream of H110-00-00	4.48	1,238	1,953	2,267	3,283
At confluence of H112-00-00	2.35	910	1,102	1,311	1,936
H103-00-00 (WALLISVILLE OUTFALL)					
At mouth	2.78	1,515	2,318	2,735	3,901
Upstream of Mercury Drive	1.84	998	1,514	1,783	2,547
Upstream of Interstate 610	1.42	541	812	953	1,365
At Gellhorn Drive	0.87	409	614	721	1,033
H110-00-00 (TRIBUTARY 12.70 TO HUNTING BAYOU)					
At mouth	1.00	349	535	635	930
At Cavalcade Street	0.47	169	259	307	450
At Crane Street	0.32	147	226	268	393
H112-00-00 (SCHRAMM GULLY)					
At mouth	1.23	288	447	534	804
H118-00-00 (TRIBUTARY 12.05 TO HUNTING BAYOU)					
At mouth	2.57	964	1,493	1,765	2,554
At Wipprecht Road	1.59	379	591	707	1067

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
I100-00-00 (VINCE BAYOU)					
At mouth	15.28	8,778	12,199	13,987	18,778
Downstream of confluence with tributary I101-00-00	14.91	8,630	11,968	13,728	18,335
Upstream of confluence with tributary I101-00-00	9.84	5,862	7,954	8,908	11,365
At Jackson Street	8.93	5,461	7,332	8,175	10,315
At Ellaine Avenue	7.60	4,748	6,283	6,819	8,176
Downstream of Allendale Rd	6.46	4,031	5,177	5,512	6,603
At Queens Street	5.17	3,136	4,000	4,573	5,745
At confluence of tributary I112-00-00	4.66	2,846	4,024	4,651	5,413
At Spencer Highway	3.06	1,882	2,708	3,138	4,203
At Llano Street	1.72	1,034	1,489	1,728	2,396
I101-00-00 (LITTLE VINCE BAYOU)					
At mouth	5.06	3,335	4,759	5,505	7,512
At SH 225	4.62	2,986	4,258	4,923	6,769
At Harris Avenue	3.43	2,162	3,080	3,561	4,890
At Martha Lane	2.76	1,672	2,386	2,760	3,800
At Wichita Street	1.16	439	650	760	1,087
J100-00-00 (SPRING CREEK)					
At mouth	760.91	30,772	60,592	76,749	132,093
Upstream of K100-00-00 Confluence	437.62	22,579	44,774	56,871	100,372
At Riley Fuzzel Road	421.05	23,336	45,957	57,889	102,286
Upstream of M100-00-00 Confluence	362.33	22,460	42,884	49,790	67,233
Downstream of Mill Creek Confluence	266.34	23,472	44,114	54,369	87,549
Downstream of Walnut Creek Confluence	180.77	16,919	34,150	44,311	74,666
Downstream of Threemile Creek Confluence	96.93	11,510	20,900	26,167	43,073
Downstream of J158-00-00 Confluence	34.27	3,800	7,000	9,000	15,500

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
J100-00-00 (SPRING CREEK) (cont'd)					
Downstream of Mayer Rd/Field Store at stream Mile 64.48	11.19	2,200	3,800	4,700	7,300
At FM 1736	1.55	550	950	1,200	1,800
J109-00-00 & J109-01-00 (BENDER LAKE)					
At mouth	2.42	1,691	2,536	2,921	4,087
At stream mile 0.46	2.26	1,700	2,420	2,780	3,930
At stream mile 0.83	1.15	920	1,430	1,610	2,180
At stream mile 1.25	0.56	490	740	850	1,280
J121-00-00 (TRIBUTARY 21.08 TO SPRING CREEK)					
At mouth	1.78	1,050	1,613	1,875	2,672
At stream mile 1.14	1.14	740	1,160	1,500	1,890
J131-00-00 (BOGGS GULLY)					
At mouth	4.72	1,860	2,915	3,441	5,024
Downstream of J131-01-00 Confluence	3.82	1,650	2,580	3,000	4,440
Upstream of Rudolph Road, at stream mile 3.06	1.16	670	1,100	1,310	1,890
Upstream of Baker Road, at stream mile 3.71	0.40	320	510	600	890
J131-01-00 (TRIBUTARY 1.25 TO BOGGS GULLY)					
At mouth	0.64	400	620	790	1,250
At stream mile 1.17	0.06	80	130	150	230
J158-00-00 (KICKAPOO CREEK)					
At mouth	10.85	2,565	4,358	5,314	8,132
At stream mile 1.27	9.83	2,450	4,110	5,100	7,700
Downstream of Kickapoo Road	8.20	2,170	3,610	4,530	6,720
At Binford Road	5.23	1,600	2,660	3,310	5,080

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
J158-00-00 (KICKAPOO CREEK) (cont'd)					
Downstream of Unnamed Tributary Confluence, at stream mile 5.31	2.71	970	1,690	2,020	3,080
K100-00-00 (CYPRESS CREEK)					
At mouth	319.47	15,050	23,186	27,258	38,505
Upstream of K111-00-00 Confluence	302.56	13,765	21,038	24,412	33,658
Downstream of K116-00-00 Confluence	296.66	13,739	20,797	24,023	32,914
At IH 45	291.12	11,188	17,347	20,198	31,493
Downstream of K124-00-00 Confluence	280.28	11,188	17,347	21,198	31,493
Downstream of K131-00-00 Confluence	263.73	10,026	16,687	20,374	31,162
Downstream of K133-00-00 Confluence	245.07	8,775	14,402	17,831	28,807
Upstream of K140-00-00 Confluence	229.56	7,337	13,682	17,839	28,652
Upstream of K142-00-00 Confluence	214.54	7,345	13,592	17,864	28,802
Upstream of Little Cypress Confluence	157.27	4,913	8,219	10,275	15,287
Downstream of K145-00-00 Confluence	151.20	4,656	7,998	10,161	16,962
At K150-00-00 Confluence	139.48	4,449	7,337	9,128	15,128
Downstream of K155-00-00 Confluence	119.59	3,875	5,742	6,886	10,740
At Katy-Hockley Road	109.98	3,807	4,982	5,619	7,667
At stream mile 43.29	89.41	2,900	2,900	2,900	2,900
At stream mile 45.91	79.34	5,300	7,700	8,700	12,500
At stream mile 49.8*	67.34	11,075	20,391	25,485	40,336
At stream mile 51.9	47.34	8,885	15,548	19,105	29,789

*Overflow occurs downstream from here into Addicks Reservoir

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
K111-00-00 (TURKEY CREEK)					
At mouth	12.40	4,179	6,749	8,065	11,807
Downstream of K111-03-00 Confluence	10.46	3,980	6,330	7,500	10,890
At Hardy Toll Road	2.18	1,749	2,680	3,138	4,523
At stream mile 6.15	0.89	580	860	1,060	1,530
K111-03-00 (TRIBUTARY TO TURKEY CREEK)					
At mouth	3.04	894	1,424	1,693	2,496
At Farrel Road	2.36	750	1,250	1,500	2,050
K112-000-00 (WILD COW GULCH)					
At mouth	3.58	2,119	3,184	3,676	5,160
At Reynaldo Drive	2.20	1,580	2,390	2,790	3,710
At stream mile 2.15	0.92	890	1,430	1,660	2,110
K116-00-00 (SCHULTZ GULLY)					
At mouth	1.77	1,580	2,319	2,652	3,657
At Aldine Westfield Road	1.48	1,420	2,030	2,290	3,070
At stream mile 1.07	1.18	1,280	1,830	2,050	2,770
K120-00-00 (LEMM GULLY)					
At mouth	4.43	1,205	1,895	2,254	3,311
At stream mile 1.11	3.75	1,090	1,750	2,060	3,000
Downstream of K120-03-00 Confluence	2.92	930	1,560	1,790	2,550
At Riley Fuzzel Road	0.54	270	410	510	740
K120-01-00 (SENGER GULLY)					
At mouth	3.85	1,402	2,175	2,567	3,710
At IH 45	3.27	1,330	1,980	2,380	3,390
At Cypresswood Drive	2.81	1,150	1,790	2,080	2,990
At Louetta Road	1.66	800	1,280	1,580	2,040

Table 3. Summary of Discharges (cont'd)

		Peak Discharges (cfs)			
	Drainage	10%	2%	1%	0.2%
Flooding Source and Location	**Area (sq. mi.)**	**Annual Chance**	**Annual Chance**	**Annual Chance**	**Annual Chance**
K120-03-00 (WUNSCHE GULLY)					
At mouth	1.87	630	1,000	1,250	1,750
At stream mile 1.46	1.48	530	830	1,010	1,520
At Spring-Stuebner Road	1.20	490	770	920	1,410
K124-00-00 (SEALS GULLY)					
At mouth	8.11	3,450	5,168	6,085	8,723
At stream mile 2.00	6.86	2,870	4,453	5,319	7,773
Downstream of K124-04-00 Confluence	3.92	1,765	2,609	3,212	4,551
At stream mile 3.70	2.33	1,141	1,921	2,177	3,270
At Kuykendahl Road	1.73	1,012	1,696	2,011	2,779
K124-02-00 (KOTHMAN GULLY)					
At mouth	2.54	857	1,338	1,577	2,298
At Spring Cypress Road	1.89	740	1,140	1,390	1,960
At FM 2920	1.30	560	880	1,070	1,570
At Spring-Stuebner Road	0.36	230	370	440	650
K131-00-00 (SPRING GULLY)					
At mouth	14.62	4,525	7,021	8,352	12,183
Downstream of K131-03-00 Confluence	6.46	2,031	3,232	3,839	5,549
Upstream of K131-03-00 Confluence	4.90	1,390	2,195	2,606	3,858
At stream mile 3.33	1.07	520	830	980	1,470
At stream mile 3.97	0.33	340	520	640	900
K131-02-00 (THEISS GULLY)					
At mouth	6.92	2,297	3,597	4,254	6,195
At Louetta Road	6.47	2,130	3,430	3,960	5,950
At Stuebner Airline Road	5.38	1,930	3,060	3,470	5,130
K131-02-04 (TRIBUTARY TO THEISS GULLY)					
At mouth	3.84	1,580	2,350	2,830	4,190
At stream mile 0.79	2.88	1,270	1,950	2,170	3,400

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
K131-03-00 (TRIBUTARY 2.1 TO SPRING GULLY)					
At mouth	1.23	700	1,050	1,300	1,800
At Kuykendahl Road	0.50	390	570	690	980
K131-04-00 (TRIBUTARY TO SPRING GULLY)					
At mouth	3.48	883	1,302	1,609	2,372
At Pinelakes Boulevard	2.63	714	1,141	1,341	2,028
At Kuykendahl Road	1.36	591	996	1,149	1,607
K133-00-00 (DRY GULLY)					
At mouth	5.42	1,410	2,222	2,647	3,900
At Louetta Road	4.75	1,380	2,120	2,580	3,770
At stream mile 2.02	3.51	1,160	1,810	2,150	3,090
At stream mile 2.83	2.78	930	1,560	1,770	2,520
K140-00-00 (PILLOT GULLY)					
At mouth	5.21	1,388	2,247	2,698	4,012
At stream mile 1.83	4.07	1,260	1,980	2,360	3,460
At Hufsmith-Kohrville Road	2.27	642	979	1,139	1,629
At W. Montgomery Road	0.87	579	878	1,019	1,452
K142-00-00 (FAULKEY GULLY)					
At mouth	11.79	3,916	6,386	7,613	10,986
Downstream of K142-07-00 Confluence	7.29	2,320	3,660	4,350	6,390
At Shaw Road	2.22	1,080	1,770	2,050	2,980
Downstream of K142-09-00 and K142-10-00 Confluence	1.39	790	1,300	1,530	2,190
K145-00-00 (DRY CREEK)					
At mouth	7.74	1,406	2,281	2,753	4,143
At Dry Creek Lane	5.83	1,230	2,030	2,460	3,790
Downstream of K145-05-00 Confluence	3.51	840	1,500	1,700	2,500
At Mueschke Road	1.28	155	478	672	1,123

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
K150-00-00 (TRIBUTARY 36.6 TO CYPRESS CREEK)					
At mouth	6.25	485	1,025	1,381	2,590
At stream mile 0.65	5.54	470	990	1,350	2,510
At stream mile 1.49	4.35	400	840	1,150	2,100
At stream mile 2.04	3.53	340	710	960	1,860
At stream mile 2.58	2.68	300	630	830	1,670
K152-00-00 (TRIBUTARY 37.1 TO CYPRESS CREEK)					
At mouth	0.87	160	300	390	690
At U.S. Highway 290	0.42	110	220	280	480
K155-00-00 (TRIBUTARY 40.7 TO CYPRESS CREEK)					
At mouth	4.17	1,076	1,740	2,087	3,105
At stream mile 1.43	3.03	910	1,520	1,780	2,570
At stream mile 2.36	2.35	730	1,160	1,460	2,030
At stream mile 3.48	1.43	510	790	970	1,480
K157-00-00 (TRIBUTARY 42.7 TO CYPRESS CREEK)					
At mouth	8.44	1,035	2,082	2,719	4,767
At stream mile 2.48	6.13	740	1,470	1,920	3,400
At stream mile 3.27	4.93	600	1,300	1,670	2,890
At Jack Road	4.17	530	1,100	1,450	2,660
K159-00-00 (CHANNEL A TO CYPRESS CREEK)					
At mouth	4.52	1,772	2,917	3,535	5,265
At Southern Pacific Railroad	3.56	1,580	2,500	2,970	4,330
At Mason Road	2.34	1,300	1,900	2,300	3,400
K159-01-00 (CHANNEL D TO CHANNEL A TO CYPRESS CREEK)					
At mouth	0.63	420	650	800	1,250
At Oak Orchard/Edworthy	0.49	370	580	700	1,030

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
K160-00-00 (ROCK HOLLOW)					
At mouth	11.13	884	1,780	2,319	3,962
At stream mile 1.75	9.24	850	1,530	1,910	3,790
At Warren Lake*	4.76	80	280	660	2,150
At Warren Ranch Road	3.52	380	880	1,290	2,580
At Mound Road	3.14	630	1,270	1,570	2,690
* Flow reductions from Warren Lake					
K160-01-00 (TRIBUTARY 1.63 TO ROCK HOLLOW)					
At mouth	3.32	401	779	1,012	1,762
At stream mile 1.76	2.05	290	570	730	1,450
At stream mile 2.80	1.41	230	430	570	1,020
K166-00-00 (MOUND CREEK)					
At mouth	35.58	6,932	12,853	16,179	25,158
At stream mile 4.81	31.55	6,510	11,710	14,670	22,780
At stream mile 7.71	22.71	5,560	9,310	11,270	17,020
K166-01-00 (EAST FORK MOUND CREEK)					
At mouth	4.45	1,657	2,593	3,052	4,438
At stream mile 0.81	2.47	1,320	2,040	2,400	3,490
At Business 290	2.13	990	1,620	1,850	2,750
At U.S. Highway 290	1.46	810	1,380	1,610	2,250
K166-02-00 (LITTLE MOUND CREEK)					
At mouth	5.48	3,192	4,960	5,839	8,373
At Betka Road	4.24	2,580	4,160	4,930	7,120
At stream mile 2.75	3.07	2,060	3,310	3,910	5,670
K166-03-00 (TRIBUTARY 7.62 TO MOUND CREEK)					
At mouth	2.06	1,406	2,116	2,443	3,429
At stream mile 0.80	1.36	1,170	1,800	2,080	2,940

Table 3. Summary of Discharges (cont'd)

		Peak Discharges (cfs)			
	Drainage	10%	2%	1%	0.2%
Flooding Source and Location	**Area (sq. mi.)**	**Annual Chance**	**Annual Chance**	**Annual Chance**	**Annual Chance**
K185-00-00 & K172-00-00 (TRIBUTARY 44.5 TO CYPRESS CREEK)					
At mouth	7.01	1,296	2,136	2,585	3,917
At stream mile 1.31	6.37	1,260	1,950	2,440	3,670
At stream mile 2.36	5.28	1,150	1,770	2,200	3,270
At stream mile 3.09	4.49	950	1,630	1,870	2,870
At stream mile 3.93	2.16	600	1,040	1,240	1,920
At stream mile 4.90	1.26	410	680	830	1,270
At stream mile 5.31	0.58	360	600	720	1,100
L100-00-00 (LITTLE CYPRESS CREEK)					
At mouth	52.29	2,676	5,771	7,686	14,060
At Cypress Rosehill Road	40.35	2,582	5,136	6,932	12,825
Downstream of L112-00-00 Confluence	34.75	2,654	4,669	6,242	11,315
Downstream of L114-00-00 Confluence	23.85	1,548	3,275	4,435	8,167
At Roberts Road	10.89	771	1,655	2,227	4,191
Upstream of L120-00-00 Confluence	1.26	210	410	480	790
L109-00-00 (TRIBUTARY 9.36 TO LITTLE CYPRESS CREEK)					
At mouth	1.24	430	690	820	1,350
Upstream of Mueschke Road, at stream mile 1.13	0.50	220	360	410	650
L112-00-00 (TRIBUTARY 10.99 TO LITTLE CYPRESS CREEK)					
At mouth	6.66	1,834	3,005	3,614	5,431
Downstream of L112-01-00 Confluence	6.05	1,790	2,890	3,370	5,180
At stream mile 1.72	1.17	570	890	1,060	1,690
At stream mile 2.24	0.80	460	710	860	1,400

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	**Drainage Area (sq. mi.)**	**Peak Discharges (cfs) 10% Annual Chance**	**2% Annual Chance**	**1% Annual Chance**	**0.2% Annual Chance**
L114-00-00 (TRIBUTARY 13.92 TO LITTLE CYPRESS CREEK)					
At mouth	8.93	1,701	2,966	3,678	5,912
At stream mile 0.74	3.96	1,165	1,900	2,280	3,414
At stream mile 1.23	3.30	1,060	1,680	1,990	3,060
L114-01-00 (TRIBUTARY 0.12 TO TRIBUTARY 13.92 TO LITTLE CYPRESS CREEK)					
At mouth	4.82	536	1,066	1,401	2,498
Downstream of L114-01-01 Confluence	4.26	500	990	1,340	2,370
At stream mile 1.65	1.07	180	360	470	840
At stream mile 2.60	0.54	100	200	280	480
M100-00-00 (WILLOW CREEK)					
At mouth	55.57	4,979	8,769	10,929	17,974
Downstream of M104-00-00 Confluence	49.60	4,300	7,700	9,600	15,700
Downstream of M108-00-00 Confluence	46.72	4,015	7,106	8,811	14,353
Downstream of M112-00-00 Confluence	39.99	3,227	5,731	7,327	13,371
Downstream of M116-00-00 Confluence	33.34	2,990	5,633	7,174	13,050
At West Montgomery Road	27.65	2,910	5,390	6,850	12,500
At SH 249	22.42	2,960	5,430	6,910	11,690
Upstream of Telge Road, at stream mile 16.17	13.53	1,566	2,773	3,555	5,679
At Cypress Rosehill Road	6.96	1,610	2,710	3,300	5,030
Downstream of M129-00-00 Confluence	2.32	750	1,190	1,420	2,230
M101-00-00 (TRIBUTARY 0.26 TO WILLOW CREEK)					
At mouth	1.79	608	973	1,155	1,698

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
M102-00-00 (UNNAMED TRIBUTARY TO WILLOW CREEK)					
At mouth	1.93	550	950	1,200	1,700
At stream mile 0.57	1.52	490	850	1,030	1,570
M104-00-00 (TRIBUTARY 2.44 TO WILLOW CREEK)					
At mouth	1.94	630	1,045	1,255	1,872
Downstream of Alderly Road, at stream mile 1.51	1.22	490	780	970	1,480
At stream mile 1.70	0.87	390	630	770	1,170
M108-00-00 (HUGHES GULLY)					
At mouth	1.77	597	965	1,147	1,693
Upstream of Lenze Road	1.23	470	740	920	1,450
M109-00-00 (CANNON GULLY)					
At mouth	3.40	1,343	2,143	2,524	3,690
Upstream of Kuykendahl Road	1.58	650	1,000	1,200	1,800
M109-01-00 (METZLER CREEK)					
At mouth	1.55	671	1,058	1,240	1,807
At stream mile 0.68	1.12	560	910	1,080	1,610
M112-00-00 (ROAN GULLY)					
At mouth	4.31	1,393	2,191	2,608	3,826
Upstream of Stuebner Airline Road	1.65	760	1,220	1,450	2,140
M116-00-00 (TRIBUTARY 8.16 TO WILLOW CREEK)					
At mouth	3.07	994	1,607	1,910	2,832
At stream mile 0.75	2.57	930	1,560	1,860	2,730
Upstream of Tomball Country Club Road	1.25	550	880	1,100	1,640

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
M124-00-00 (TRIBUTARY 13.5 TO WILLOW CREEK)					
At mouth	4.22	964	1,848	2,336	3,808
At stream mile 2.55	1.97	950	1,520	1,800	2,640
N100-00-00 (CARPENTERS BAYOU)					
At mouth	31.14	6,472	9,815	11,458	16,094
Upstream of Tributary 3.33 (N104-00-00)	24.52	5,706	5,806	9,948	14,045
Downstream of Tributary 11.715 (N117-00-00)	11.45	1,116	1,631	1,915	2,767
N104-00-00 (TRIBUTARY 3.33 TO CARPENTERS BAYOU)					
At mouth	3.03	1,080	1,629	1,915	2,763
At Interstate Route 10	2.21	869	1,312	1,542	2,224
At Woodforest Road	1.46	577	870	1,023	1,476
N117-00-00 (TRIBUTARY 11.715 TO CARPENTERS BAYOU)					
At mouth	1.99	551	861	1,025	1,511
At stream mile 1.21	1.00	89	139	165	244
O100-00-00 (GOOSE CREEK)					
At mouth	27.03	9,597	13,636	15,951	21,578
Downstream of confluence with East Fork (O105-00-00)	21.74	7,295	10,339	11,951	15,502
Upstream of confluence with East Fork Goose Creek (O105-00-00)	17.26	5,541	7,720	8,678	10,452
Downstream of confluence with tributary O107-00-00	15.79	4,966	6,879	7,532	9,073
Upstream of confluence with tributary O107-00-00	14.35	4,268	5,787	6,150	7,502
At Baker Road	13.80	4,079	5,478	5,764	7,431
Downstream of confluence with tributary O111-00-00	12.28	3,499	4,652	5,201	6,946
Upstream of confluence with tributary O111-00-00	10.97	2,967	4,164	4,652	6,328

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
O100-00-00 (GOOSE CREEK) (cont'd)					
At confluence of tributary O114-00-00	9.40	2,573	3,678	4,134	5,601
At IH 10	6.65	1,888	2,870	3,327	4,652
Downstream of confluence with tributary O119-00-00	2.87	1,019	1,547	1,947	2,936
Upstream of confluence with tributary O119-00-00	1.41	513	776	913	1,318
O105-00-00 (EAST FORK GOOSE CREEK)					
At mouth	4.48	2,125	3,139	3,660	5,169
At Baker Road	1.75	717	1,066	1,247	1,782
O200-00-00 (SPRING GULLY)					
At mouth	5.68	1,517	2,042	2,324	3,064
Upstream of IH 10	4.04	863	1,102	1,229	1,446
Downstream of diversion channel O208-00-00	3.66	666	873	961	1,170
Upstream of diversion channel O208-00-00	3.66	1,106	1,631	1,912	2,729
Downstream of confluence with tributary O207-00-00	3.03	760	1,226	1,471	2,054
At confluence of tributary O206-00-00	2.20	443	759	927	1,415
Upstream of diversion channel G103-03-00	1.22	378	582	689	1,005
At Fig Orchard Road	1.22	119	261	335	555
Downstream of diversion channel G103-03-00	1.22	119	261	335	555
Upstream of diversion channel G103-03-00	1.22	378	582	689	1005
O208-00-00 (SPRING GULLY DIVERSION CHANNEL)					
At mouth	3.66	440	758	951	1,559

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
P100-00-00 (GREEN'S BAYOU)					
At mouth	210.88	34,189	43,160	48,545	62,823
At IH 10	205.31	34,091	42,938	47,955	62,475
At confluence of tributary P107-00-00	201.50	33,890	42,457	47,110	61,500
At confluence of tributary P109-00-00	196.02	33,355	41,416	45,610	58,796
At confluence of tributary P110-00-00	194.61	33,258	41,217	45,333	58,409
At confluence of tributary P114-00-00	190.67	32,866	40,492	44,391	57,600
At Beaumont Highway	187.73	32,671	40,151	43,961	57,715
At confluence of Hall's Bayou (P118-00-00)	185.86	32,500	39,717	43,871	57,754
At confluence of tributary P121-00-00	138.29	22,834	29,866	33,362	47,462
At confluence of tributary P125-00-00	134.47	22,486	29,403	32,806	47,082
At confluence of tributary P126-00-00	130.25	22,238	29,131	32,480	47,554
At confluence of tributary P127-00-00	123.92	21,716	28,522	31,742	48,101
At confluence of Garner's Bayou (P130-00-00)	113.48	20,951	27,297	30,262	46,866
At confluence of tributary P133-00-00	76.53	15,710	21,605	24,988	36,448
At U.S. Highway 59	69.27	15,422	21,268	24,620	35,432
At confluence of tributary P138-00-00	64.93	15,095	21,043	24,401	34,716
At B.W. 8 (Second Pass)	55.90	14,385	19,920	23,052	32,433
At confluence of tributary P155-00-00	46.84	13,655	18,583	21,617	29,516
At Hardy Toll Road	45.37	13,054	17,591	20,478	27,607
At I.H. 45	37.26	11,278	15,335	17,408	23,104
At confluence of tributary P146-00-00	25.22	7,221	9,388	10,314	12,795

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
P100-00-00 (GREEN'S BAYOU) (cont'd)					
At confluence of tributary P147-00-00	24.66	7,015	9,147	9,964	12,456
At B.W. 8 (First Pass)	20.01	5,506	7,038	7,559	8,915
At confluence of tributary P152-00-00	16.49	4,361	5,662	6,264	8,145
At Cutten Road	9.68	3,345	4,544	5,027	6,480
At confluence of tributary P150-00-00	7.90	2,789	3,773	4,279	5,377
At Tomball Parkway	6.05	2,152	3,095	3,412	4,446
At confluence of tributary P151-00-00	4.72	1,704	2,604	3,126	4,502
At confluence of tributary P161-00-00	2.27	1,240	1,791	2,072	2,859
P107-00-00 (BIG GULCH)					
At mouth	4.98	2,012	2,960	3,271	4,142
At U.S. Highway 90	2.57	947	1,408	1,642	2,326
P109-00-00 (SULPHUR GULLY)					
At mouth	1.42	744	1,083	1,256	1,743
P110-00-00 (SPRING GULLY)					
At mouth	1.99	1,256	1,811	2,093	2,877
P114-00-00 (UNNAMED TRIBUTARY TO GREENS BAYOU)					
At mouth	2.94	1,890	2,930	3,435	4,809
At Beaumont Highway	2.47	1,550	2,487	2,905	4,021
At Mesa Road	0.68	521	744	859	1,171
P118-00-00 (HALL'S BAYOU)					
At mouth	44.60	9,944	13,800	15,642	20,346
Downstream of confluence with tributary P118-09-00	37.28	8,003	10,702	11,331	13,798
At confluence of tributary P118-14-00	31.59	7,107	9,376	10,462	13,855

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
P118-00-00 (HALL'S BAYOU) (cont'd)					
At confluence of tributary P118-18-00	27.70	6,693	8,750	9,605	12,351
At Hardy Toll Road	17.86	4,926	6,464	7,311	9,803
At confluence of tributary P118-31-00	10.25	3,652	5,296	5,914	7,727
At Mosielee Street	1.67	649	964	1,122	1,909
P118-14-00 (TRIBUTARY 6.71 TO HALLS BAYOU)					
At mouth	2.87	1,037	1,541	1,798	2,549
P118-23-00 (TRIBUTARY 11.96 TO HALLS BAYOU)					
At mouth	1.58	653	964	1,121	1,576
P125-00-00 & P125-04-00 (TRIBUTARY 14.27 TO GREENS BAYOU)					
At mouth	4.22	1,292	1,995	2,359	3,502
At Union Pacific Railroad	2.35	735	1,105	1,295	1,854
P126-00-00 (TRIBUTARY 14.82 TO GREENS BAYOU)					
At mouth	3.71	1,028	1,565	1,840	2,658
P130-00-00 (GARNER'S BAYOU)					
At mouth	33.87	8,984	12,962	14,877	20,487
At confluence of William's Gully (P130-02-00)	31.50	8,671	12,320	14,129	19,347
At confluence of tributary P130-03-00	22.40	6,623	9,172	10,391	14,243
At confluence of Reinhardt Bayou (P130-05-00)	18.94	5,420	7,729	8,810	12,233
At confluence of tributary P130-07-00	11.41	3,084	4,521	5,136	7,494
At confluence of tributary P130-08-00	9.89	2,491	3,710	4,272	6,518

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	**Drainage Area (sq. mi.)**	**Peak Discharges (cfs)** 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
P130-00-00 (GARNER'S BAYOU) (cont'd)					
At Old Lee Road	3.93	872	1,447	1,666	2,355
Downstream of North Pond	2.91	681	1,147	1,308	1,830
Upstream of North Pond	2.91	1,073	1,606	1,876	2,662
P130-02-00 (WILLIAM'S GULLY)					
At mouth	7.41	2,067	3,165	3,727	5,389
Downstream of confluence with tributary P130-02-02	4.76	1,395	2,119	2,490	3,587
Upstream of confluence with tributary P130-02-02	2.49	649	996	1,174	1,706
P130-02-02 (TRIBUTARY 2.01 TO WILLIAMS GULLY)					
At mouth	2.27	747	1,126	1,320	1,888
P130-03-00 (TRIBUTARY 3.19 TO GARNERS BAYOU)					
At mouth	2.25	1,093	1,602	1,861	2,595
P130-03-01 (TRIBUTARY 0.55 TO TRIBUTARY 3.19 TO GARNERS BAYOU)					
At mouth	0.68	328	481	559	780
P130-05-00 (REINHARDT BAYOU)					
At mouth	6.50	1,941	2,722	3,163	4,363
At confluence of tributary P130-05-02	3.82	1,165	1,646	1,878	2,875
Downstream of detention pond	2.13	940	1,070	1,121	2,510
Upstream of detention pond	2.13	1,166	1,693	1,961	2,711
At stream mile 3.70	1.20	781	1,121	1,295	1,777
P133-00-00 (TRIBUTARY 20.88 TO GREENS BAYOU)					
At mouth	4.24	1,172	1,741	2,046	2,821
At Southern Pacific Railroad	2.99	736	1,123	1,322	1,919

Table 3. Summary of Discharges (cont'd)

		Peak Discharges (cfs)			
Flooding Source and Location	**Drainage Area (sq. mi.)**	**10% Annual Chance**	**2% Annual Chance**	**1% Annual Chance**	**0.2% Annual Chance**
P138-00-00 (TRIBUTARY 24.97 TO GREENS BAYOU)					
At mouth	6.31	1,760	2,676	3,055	4,047
At Hardy Toll Road	2.73	770	1,161	1,362	1,960
P140-00-00 (TRIBUTARY 26.64 TO GREENS BAYOU -- HOOD'S BAYOU)					
At mouth*	7.42	1,642	2,454	2,858	4,041
At Rankin Road*	3.55	604	861	983	1,328
P140-04-00 (TRIBUTARY 26.64 TO GREENS BAYOU)					
Downstream of diversion and overflow to tributary P155-00-00*	2.28	154	178	183	191
Upstream of diversion and overflow to tributary P155-00-00	2.28	843	1,163	1,308	1,785
P140-04-03 (TRIBUTARY 26.64 TO GREENS BAYOU)					
At Farrell Road	0.97	471	687	797	1,109
P145-00-00 (NORTH FORK GREEN'S BAYOU)					
At mouth	12.04	4,810	7,090	8,094	10,554
At confluence of tributary P145-03-00	10.17	3,944	5,853	6,727	9,261
At confluence of tributary P245-00-00	5.15	2,174	3,218	3,739	5,152
At stream mile 3.54	2.62	1,254	1,833	2,119	2,933
At confluence of tributary P145-07-00	2.01	1,043	1,512	1,752	2,411
At Walters Road	1.03	629	902	1,042	1,431

*discharges adjusted to reflect basin overflows

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
P145-03-00 (TRIBUTARY 1.95 TO NORTH FORK GREENS BAYOU)					
At mouth	5.02	1,791	2,674	3,059	4,240
At Kuykendahl Road	4.10	1,498	2,239	2,619	3,711
At confluence of tributary P145-03-03	1.70	551	830	972	1,391
P146-00-00 (TRIBUTARY 32.23 TO GREENS BAYOU)					
At mouth	0.55	271	398	462	644
P147-00-00 (UNNAMED TRIBUTARY TO GREENS BAYOU)					
At mouth	2.52	1,030	1,522	1,767	2,469
At T.C. Jester Blvd	1.47	640	940	1,092	1,529
P148-00-00 (TRIBUTARY 34.60 TO GREENS BAYOU)					
At mouth*	2.14	1,014	1,736	2,141	3,331
P155-00-00 (UNNAMED TRIBUTARY TO GREENS BAYOU)					
At mouth*	1.47	1,627	2,410	2,781	3,802
P156-00-00 (UNNAMED TRIBUTARY TO GREENS BAYOU)					
At mouth	2.22	1,246	1,809	2,098	2,900
At Rankin Road	1.31	566	837	975	1,369
Q100-00-00 (CEDAR BAYOU)					
At mouth	199.00	6,286	10,301	12,646	20,442
Downstream of diversion channel Q200-00-00	187.96	5,688	8,948	10,891	17,604
Upstream of diversion channel Q200-00-00	187.96	14,328	20,658	24,193	36,237
At confluence of Pine Gully (Q101-00-00)	186.23	14,250	20,381	23,722	35,341

*Discharges adjusted to reflect basin overflows

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Q100-00-00 (CEDAR BAYOU) (cont'd)					
At confluence of Sutton Gully	180.27	14,078	20,146	22,770	32,170
At confluence of Saw Pit Gully	170.49	13,244	18,837	21,361	30,016
At confluence of Horsepen Bayou (City of Baytown)	160.57	12,865	18,306	20,876	29,610
At confluence of McGee Gully (Q114-00-00)	156.20	12,612	17,933	20,503	29,226
At IH 10	148.32	12,189	17,302	19,844	28,427
At Dayton-Goose Creek Railroad	145.98	11,995	17,019	19,562	28,302
At stream mile 19.77	142.04	11,717	16,716	19,306	28,249
At stream mile 22.45	129.83	11,142	15,677	18,112	26,144
At confluence of Clawson Ditch (Q122-00-00)	127.46	11,175	15,519	17,918	25,316
At confluence of Adlong Ditch	82.87	6,016	8,861	10,694	16,417
At confluence of tributary Q130-00-00	66.26	3,903	6,224	7,537	11,732
At U.S. Highway 90	60.76	3,439	5,535	6,700	10,909
At confluence of Twin Ditches	51.76	2,954	4,656	5,628	9,118
At Crosby Eastgate Road	37.45	2,176	3,332	4,032	6,443
At confluence of tributary Q134-00-00	33.50	2,086	3,198	3,837	6,235
At FM 1960	23.09	1,622	3,125	4,012	6,948
Q101-00-00 (PINE GULLY)					
At mouth	2.13	933	1,383	1,616	2,297
Q112-00-00 (CARY BAYOU)					
At mouth	5.88	2,397	3,537	4,126	5,886
At Lynchburg-Cedar Bayou	3.07	1,010	1,509	1,780	2,593
At confluence of tributary Q112-05-00	1.47	504	765	901	1,305

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
HORSEPEN BAYOU (City of Baytown)					
At mouth	3.22	485	915	1,176	2,015
Q114-00-00 (McGEE BAYOU)					
At mouth	4.58	1,519	2,236	2,581	3,720
At IH 10	3.39	1,047	1,517	1,783	2,554
At stream mile 2.97	1.36	424	650	768	1,119
Q122-00-00 (CLAWSON DITCH)					
At mouth	8.09	2,230	3,367	4,008	5,895
At confluence of tributary Q122-01-00	7.69	2,137	3,245	3,898	5,965
At confluence of tributary Q122-04-00	2.68	1,012	1,526	1,794	2,584
Q128-00-00 (ADLONG DITCH)					
At mouth	11.49	2,444	3,504	4,007	5,968
At confluence of tributary Q128-07-00	8.88	1,802	2,523	3,089	4,578
At U.S. Highway 90	6.57	1,355	2,041	2,558	3,584
At Adlong Johnson Road	4.11	1,439	2,192	2,582	3,736
Q130-00-00 (UNNAMED TRIBUTARY TO CEDAR BAYOU)					
At mouth	3.53	956	1,437	1,705	2,333
At U.S. Highway 90	2.89	722	1,117	1,343	2,006
Downstream of Crosby Eastgate Road	1.14	338	522	618	904
Q200-00-00 (CEDAR BAYOU DIVERSION CHANNEL)					
At mouth	0.00	8,640	11,710	13,302	18,633

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
R100-00-00 (JACKSON BAYOU)					
At mouth	25.92	8,177	12,543	14,755	21,303
At confluence of tributary R101-00-00	25.37	8,138	12,413	14,569	20,984
At confluence of tributary R102-00-00	23.27	7,544	11,417	13,368	19,290
At confluence of tributary R110-00-00	2.86	1,488	2,189	2,552	3,597
R102-00-00 (GUM GULLY)					
At mouth	18.51	5,833	8,702	10,187	14,770
At confluence of tributary 2.70 (R102-03-00)	16.74	5,366	7,933	9,282	13,454
At confluence of tributary 3.08 (R102-13-00)	14.26	4,420	6,622	7,790	10,970
At confluence of tributary R102-06-00	9.35	2,910	4,372	5,079	7,114
At confluence of tributary R102-09-00	7.44	2,322	3,491	4,091	5,772
At stream mile 7.38	3.93	1,254	1,924	2,272	3,308
R102-03-00 & R102-03-01 (TRIBUTARY 2.70 TO GUM GULLY)					
At mouth	2.48	996	1,392	1,571	2,504
At confluence of tributary R102-03-01	2.31	1,003	1,394	1,574	2,529
At stream mile 1.27	1.12	442	664	779	1,119
R102-13-00 (TRIBUTARY 3.08 TO GUM GULLY)					
At mouth	2.86	1,435	2,121	2,475	3,496
At stream mile 1.10	1.20	676	989	1,152	1,611
S100-00-00 (Luce Bayou)					
At mouth	227.0	14,650	33,850	45,700	84,540
At County Line	210.0	14,650	33,850	45,700	84,540

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
S110-00-00 (SHOOK GULLY)					
At mouth*	3.25	1,050	1,588	1,860	2,454
Downstream of overflow*	1.92	653	987	1,145	1,363
Upstream of overflow	1.92	653	987	1,158	1,657
S114-00-00 (MEXICAN GULLY)					
At mouth	0.77	362	535	623	872
T100-00-00 (CANE ISLAND BRANCH)					
At mouth	24.72	1,230	2,458	3,383	6,420
Upstream of Stockdick Road	23.90	1,115	2,456	3,381	6,415
Upstream of U.S. Highway 90	23.71	1,088	2,455	3,380	6,414
Upstream of Tenth Street	21.39	1,015	2,380	3,285	6,279
Upstream of Franz Road	20.88	999	2,364	3,265	6,250
Upstream of Morton Road	19.71	947	2,271	3,154	6,017
Upstream of Pitts Road	18.43	890	2,171	3,034	5,764
T101-00-00 (MASON CREEK)					
At mouth	16.37	4,774	7,666	9,234	13,655
At Fry Road	13.95	3,974	6,402	7,712	11,363
Downstream of Kingsland Boulevard	10.64	2,880	4,644	5,570	8,238
At IH 10	8.76	2,260	3,641	4,366	6,457
At Mason Road	7.71	1,979	3,191	3,824	5,659
Downstream of Colonial Parkway	6.16	1,565	2,528	3,027	4,485
Downstream of Peek Road	3.38	824	1,340	1,597	2,381
Downstream of Franz Road	2.40	34	55	66	98
T101-03-00 (TRIBUTARY 4.96 TO MASON CREEK)					
At mouth	2.89	601	951	1,136	1,681

*Discharges adjusted to reflect basin overflows

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
T101-10-00 (UNNAMED TRIBUTARY TO MASON CREEK)					
At mouth	n/a	34	55	66	98
T103-00-00 (TRIBUTARY 52.9 TO UPPER BUFFALO BAYOU/CANE)					
At Mouth	8.60	1,997	3,159	3,776	5,581
Upstream of Fry Road	7.18	1,635	2,577	3,077	4,546
T103-01-00 (TRIBUTARY 2.17 TO TRIBUTARY 52.9 TO UPPER BUFFALO BAYOU/CANE)					
At mouth	2.48	605	953	1,138	1,682
U100-00-00 (LANGHAM CREEK)					
At Clay Road	49.28	6,973	12,166	15,203	24,506
At Addicks Satsuma Road	29.02	4,413	7,274	8,701	13,062
At confluence of Dinner Creek	18.86	2,465	4,112	5,012	7,639
At stream mile 13.07	12.66	1,601	2,627	3,187	4,906
At stream mile 17.25	4.55	622	1,060	1,294	1,992
U101-00-00 (SOUTH MAYDE CREEK)					
At mouth	43.29	6,901	11,322	13,294	18,312
Upstream of Barker Cypress Road	36.08	6,504	10,503	12,322	17,157
Upstream of Groeschke Road	35.77	6,172	9,817	11,508	16,189
Upstream of Fry Road	29.37	5,443	8,434	9,871	14,126
Downstream of Morton Ranch Road	26.70	4,000	6,316	7,622	11,430
Upstream of Clay Road	20.47	3,342	5,276	6,361	9,536
Upstream of Peek Road	12.54	2,191	3,470	4,173	6,264
At Katy-Hockley Cut-Off	8.60	1,442	2,353	2,842	4,317

n/a = not available

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	**Drainage Area (sq. mi.)**	**Peak Discharges (cfs)** 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
U101-07-00 (TRIBUTARY 9.4 TO SOUTH MAYDE CREEK)					
At mouth	3.19	403	667	815	1,254
At Porter Road	1.89	251	443	548	845
At Katy-Hockley Cut-Off	1.14	181	299	363	552
U101-22-00 (UNNAMED TRIBUTARY TO SOUTH MAYDE CREEK)					
At stream mile 18.46	3.19	115	292	386	742
U102-00-00 (BEAR CREEK)					
At mouth	27.67	4,548	7,327	8,829	13,106
Downstream of Longhorn Road	26.17	4,090	6,606	7,961	12,064
At Clay Road	24.64	3,621	5,845	7,035	11,990
At Stockdick Road	13.59	2,521	4,034	4,822	11,903
At Longenbaugh Road	3.94	1,561	2,494	2,980	7,544
U102-01-00 (UNNAMED TRIBUTARY TO BEAR CREEK)					
At mouth	2.98	860	1,334	1,580	2,308
Upstream of Clay Road	2.62	740	1,149	1,361	1,988
Downstream of Kieth Harrow Blvd.	1.64	462	718	850	1,241
Downstream of Confluence with U102-01-02	1.29	406	630	746	1,089
U106-00-00 (HORSPEN CREEK)					
At mouth	18.20	6,244	9,937	11,749	16,989
At Spencer Road (FM 529)	15.08	5,821	9,228	10,904	15,804
At FM 1960	12.19	4,616	7,218	8,499	12,428
Downstream of West Road	8.54	2,804	4,383	5,178	7,625
Downstream of Barker Cypress Road	3.15	689	1,124	1,361	2,076
U120-00-00 (DINNER CREEK)					
At confluence of Langham Creek	6.20	1,207	1,993	2,409	3,642
At Freeman Road	4.30	629	1,038	1,255	1,897
At stream mile 4.00	1.42	276	456	552	834

Table 3. Summary of Discharges (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
U200-00-00 (ADDICKS RESERVOIR DIVERSION CHANNEL)					
Downstream of Confluence of Horsepen Creek	49.28	6,973	12,166	15,203	24,506
Upstream of Confluence of Horsepen Creek	29.02	4,413	7,274	8,701	13,062
W167-01-00 (TRIBUTARY 3.9 TO TURKEY CREEK)					
At Addicks Reservoir	5.30	1,652	2,505	2,944	4,218
Upstream of Tanner Road	2.02	749	1,116	1,300	1,845
W100-00-00 (BUFFALO BAYOU)					
At 69th Street	211.78	39,606	53,872	61,636	83,981
Upstream of Confluence of White Oak Bayou	85.29	8,535	14,033	17,393	25,223
Upstream of Confluence of Spring Branch	54.60	6,995	11,067	13,225	18,583
Downstream of Confluence of Rummel Creek	30.23	4,130	6,486	7,857	11,738
At Dairy Ashford Road	28.84	4,122	6,473	7,844	11,727
Upstream of Confluence of Turkey Creek	14.30	1,654	2,972	3,753	5,718
W140-00-00 (SPRING BRANCH)					
At mouth	10.86	3,853	5,996	7,104	10,379
Upstream of confluence of Briar Branch	6.15	2,712	4,260	5,025	7,291
At Campbell Road	1.79	994	1,498	1,760	2,508
W140-01-00 (BRIAR BRANCH)					
At mouth	4.71	1,158	1,795	2,142	3,200
At Voss Road	3.44	789	1,223	1,459	2,191
W141-00-00 (SOLDIERS CREEK)					
At mouth	1.87	496	778	931	1,406
Upstream of Voss Road	1.44	374	587	702	1,060

Table 3. Summary of Discharges (cont'd)

		Peak Discharges (cfs)			
Flooding Source and Location	**Drainage Area (sq. mi.)**	**10% Annual Chance**	**2% Annual Chance**	**1% Annual Chance**	**0.2% Annual Chance**
W142-00-00 (BERING DITCH)					
At mouth	1.25	437	661	779	1,133
At San Felipe Road	1.00	311	471	555	807
W156-00-00 (RUMMEL CREEK)					
At mouth	4.62	2,144	3,392	4,048	5,697
Downstream of Beltway 8	2.78	1,509	2,263	2,661	3,760
W157-00-00 (UNNAMED TRIBUTARY TO BUFFALO BAYOU)					
At mouth	0.84	188	292	347	519
At Holly Springs Drive	0.76	143	222	264	395
Downstream of Briar Forest Drive	0.42	79	123	146	218
W167-00-00 (TURKEY CREEK)					
At mouth	6.77	1,227	1,915	2,269	3,232
W167-04-00 (CONTINUATION OF TURKEY CREEK)					
At Extension of Timberline Road	5.49	489	775	938	1,459
Downstream of Clay Road	2.70	300	476	676	896
W170-00-00 (UNNAMED TRIBUTARY TO BUFFALO BAYOU)					
At mouth	2.50	699	1,096	1,313	1,970
Downstream of Addicks-Clodine Road	1.73	475	745	893	1,339
Downstream of Barker-Clodine Road	0.78	218	342	410	615
W190-00-00 (CLODINE DITCH)					
At mouth	10.49	1,215	2,138	2,696	4,419
At county line	9.99	1,068	1,864	2,341	3,856
Downstream of FM 1093	8.67	1,034	1,800	2,259	3,726

Table 4. Summary of Reservoir Elevations

Flooding Source	Peak Elevations (feet; NAVD88, 2001 Adjustment)			
	10%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
Addicks Reservoir (U500-00-00)	97.6	99.9	100.8	102.4
Barker Reservoir (T500-00-00)	93.8	96.4	97.2	99.0
Sheldon Reservoir (N500-00-00)	47.3	47.6	47.7	48.1

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail were carried out to provide estimates of the elevations of floods of the selected recurrence intervals (10-, 2-, 1-, and 0.2-percent-annual-chance) along each of the 249 studied streams within the 22 watersheds in the Harris County. In the coastal areas, both riverine and surge analyses were performed to determine the most significant source of flooding.

Water-surface elevations (WSELs) of the floods of the selected recurrence intervals for the streams studied in detail were computed using the HEC-RAS step-backwater computer program, Version 3.0.1 (Reference 3.2.1). The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Where riverine analyses were performed, the channel and near overbank (50 feet to 100 feet from the channel) ground elevation data were generally obtained from field surveys while the remaining overbank data were obtained from the LiDAR-based DEM. Cross sections were typically located approximately 1,000 feet apart. Structural geometry for the bridges and road sections for culverts were obtained from field surveys and record construction drawings. The selection of roughness coefficients was based on review of aerial photographs, field reconnaissance, channel size and alignment, and channel and overbank ground cover. In areas where other streams are included in the overbank of a study stream, the channel portion of the adjacent stream is blocked horizontally and a Manning's "n" value of 0.01 is used for that area. The ranges of channel and overbank Manning's "n" values for streams studied by detailed methods are shown in Table 5. The ranges indicated for the overbank "n" values in the table do not include the value of "n" = 0.99. The "n" = 0.99 value was applied in the model in the overbanks for ineffective flow areas.

Starting WSELs were taken at the mouth of each stream using the normal depth option of the HEC-RAS program, with the exception of areas where the normal depth option indicated an elevation of less than 1 foot. In these areas, 1 foot Mean Sea Level (MSL) was used to show tidal effects during normal conditions. The starting WSELs of the following streams were set at the mean tidal elevation: Clear Creek, Cow Bayou, Tributary 9.97 to Clear Creek, Taylor Bayou, Taylor Bayou Diversion Channel, the San Jacinto River, Goose Creek, Spring Gully, Cedar Bayou, the Houston Ship Channel, Patrick Bayou, Carpenters Bayou, and Greens Bayou. The starting WSELs for Buffalo Bayou and White Oak Bayou are based on the backwater from the Houston Ship Channel and Buffalo Bayou, respectively. The starting WSELs for Lake Houston were determined from a rating curve at the dam.

Flood profiles were drawn showing the computed WSELs for floods of the selected recurrence intervals. Areas of backwater flooding and/or combined probability effects are referenced on the profiles. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1), and are shown on the Digital Flood Insurance Rate Map (DFIRM). All elevations are referenced to the North American Vertical Datum of 1988 (NAVD) with a 2001 vertical height adjustment. The locations of the Bench Marks (BMs) are shown on the maps.

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Table 5. Summary of Roughness Coefficients

Clear Creek Watershed (A)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Overbanks
A100-00-00	Clear Creek	0.025-0.081	0.070-0.150
A104-00-00	Taylor Bayou	0.035	0.070-0.150
A104-04-00	Tributary 3.10 to Taylor Bayou	0.035	0.070-0.150
A104-07-00	Tributary 3.93 to Taylor Bayou	0.035	0.070-0.150
A104-13-00	Tributary 3.36 to Taylor Bayou	0.035	0.070-0.150
A104-14-00	Taylor Bayou Diversion Channel	0.035	0.070
A107-00-00	Cow Bayou	0.035	0.070-0.150
A107-03-00	Unnamed Tributary to Cow Bayou	0.015-0.035	0.070-0.150
A111-00-00	Tributary 10.08 to Clear Creek	0.015-0.035	0.070-0.150
A118-00-00	Cedar Gully	0.035	0.070-0.150
A119-00-00	Turkey Creek	0.015-0.045	0.070-0.150
A119-02-00	Tributary 0.16 to Turkey Creek	0.045	0.070-0.150
A119-05-00	Unnamed Tributary to Turkey Creek	0.015-0.060	0.070-0.090
A119-07-00	Unnamed Tributary to Turkey Creek	0.040	0.070
A119-07-02	Unnamed Tributary to A119-07-00	0.015-0.040	0.060-0.100
A120-00-00	Halls Road Ditch	0.015-0.040	0.070-0.150

Armand Bayou Watershed (B)

HCFCD Designation	Stream Name	Channel	Overbanks
B100-00-00	Armand Bayou	0.032	0.070-0.150
B104-00-00	Horsepen Bayou	0.032-0.042	0.070-0.150
B104-04-00	Tributary 4.51 to Horsepen Bayou	0.032	0.070-0.150
B104-05-00	Tributary 5.44 to Horsepen Bayou	0.032	0.070-0.150
B106-00-00	Big Island Slough	0.032	0.070-0.150
B109-00-00	Spring Gully	0.032-0.042	0.070-0.150
B109-03-00	B112-02-00 Interconnect	0.035	0.070-0.150
B111-00-00	Tributary 9.39 to Armand Bayou	0.032	0.070-0.150
B112-00-00	Willow Springs Bayou	0.015-0.032	0.070-0.150
B112-02-00	Tributary 1.78 to Willow Springs Bayou	0.015-0.032	0.070-0.150
B112-04-00	Tributary B to Willow Springs Bayou	0.015	0.070-0.150
B113-00-00	Tributary 10.46 to Armand Bayou	0.032	0.070-0.150
B114-00-00	County "C," D.D. #5	0.015-0.060	0.015-0.060
B114-01-00	Private "G," D.D. #5	0.040	0.040-0.060
B114-02-00	Unnamed Tributary to B114-00-00	0.040	0.040-0.060
B115-00-00	Tributary 12.18 to Armand Bayou	0.015-0.032	0.070-0.150
B115-01-00	Tributary 12.18 to Armand Bayou (continued)	0.015-0.032	0.070-0.150
B204-04-00	Horsepen Bayou Diversion Channel	0.032	0.150

Table 5. Summary of Roughness Coefficients (cont'd)

Sims Bayou Watershed (C)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Overbanks
C100-00-00	Sims Bayou	0.030-0.045	0.060-0.200
C102-00-00	Plum Creek	0.040-0.045	0.080-0.200
C103-00-00	Pine Gully	0.040-0.055	0.100-0.200
C106-00-00	Berry Bayou	0.015-0.045	0.060-0.200
C106-01-00	Berry Creek	0.015-0.055	0.060-0.200
C106-01-07	Unnamed Tributary to Berry Creek	0.015	0.060-0.200
C106-03-00	Tributary 2.00 to Berry Bayou	0.015-0.040	0.100-0.200
C106-08-00	Tributary 3.31 to Berry Bayou	0.015-0.055	0.010-0.200
C118-00-00	Salt Water Ditch	0.040	0.100-0.200
C123-00-00	Tributary 10.77 to Sims Bayou	0.040-0.050	0.100-0.200
C223-00-00	Tributary 10.77 to Sims Bayou (continued)	0.035-0.045	0.012-0.200
C127-00-00	Swengel Ditch	0.015-0.04	0.016-0.070
C132-00-00	Tributary 13.83 to Sims Bayou	0.025-0.040	0.080-0.200
C147-00-00	Tributary 20.25 to Sims Bayou	0.015-0.040	0.080-0.200
C161-00-00	Tributary 17.82 to Sims Bayou	0.040	0.060-0.200

Brays Bayou Watershed (D)

HCFCD Designation	Stream Name	Channel	Overbanks
D100-00-00	Brays Bayou	0.015-0.035	0.030-0.130
D109-00-00	Harris Gully	0.011-0.025	0.013-0.032
D111-00-00	Poor Farm Ditch	0.015	0.015-0.100
D112-00-00	Willow Waterhole Bayou	0.017-0.040	0.080-0.150
D118-00-00	Keegans Bayou	0.040	0.080-0.150
D120-00-00	Tributary 20.90 to Brays Bayou	0.040	0.080-0.150
D122-00-00	Tributary 21.95 to Brays Bayou	0.015-0.040	0.080-0.150
D124-00-00	Tributary 22.69 to Brays Bayou	0.040	0.080-0.150
D126-00-00	Tributary 23.53 to Brays Bayou	0.040	0.080-0.150
D129-00-00	Tributary 26.20 to Brays Bayou	0.040	0.080-0.150
D132-00-00	Tributary 29.16 to Brays Bayou	0.040	0.080-0.150
D133-00-00	Bintliff Ditch	0.015	0.120-0.150
D139-00-00	Chimney Rock Diversion Channel	0.040	0.100-0.150
D140-00-00	Fondren Diversion Channel	0.017-0.040	0.080-0.150
D140-04-00	Fondren Diversion Channel (continued)	0.017-0.040	0.100-0.150
D142-00-00	Tributary 20.86 to Brays Bayou	0.015-0.040	0.080-0.150
D144-00-00	City Ditch	0.015	0.080-0.150

Table 5. Summary of Roughness Coefficients (cont'd)

White Oak Bayou Watershed (E)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Manning's "n" Values Overbanks
E100-00-00	White Oak Bayou	0.015-0.120	0.026-0.120
E101-00-00	Little White Oak Bayou	0.015-0.080	0.015-0.120
E115-00-00	Brickhouse Gully	0.015-0.080	0.015-0.120
E115-04-00	Tributary 1.61 to Brickhouse Gully	0.015-0.080	0.015-0.120
E116-00-00	Tributary 10.1 to White Oak Bayou	0.015-0.080	0.040-0.120
E116-05-00	Tributary 10.1 to White Oak Bayou (continued)	0.015-0.080	0.040-0.100
E117-00-00	Cole Creek	0.015-0.050	0.026-0.200
E121-00-00	Vogel Creek	0.040-0.060	0.040-0.120
E122-00-00	Unnamed Tributary to White Oak Bayou	0.015-0.080	0.015-0.080
E124-00-00	Tributary 15.8 to White Oak Bayou	0.030-0.045	0.040-0.200
E125-00-00	Rolling Fork	0.040-0.100	0.040-0.200
E127-00-00	Tributary 19.05 to White Oak Bayou	0.015-0.080	0.040-0.120
E135-00-00	Tributary 19.82 to White Oak Bayou	0.030-0.040	0.015-0.120
E141-00-00	Beltway 8 Outfall Ditch	0.015-0.040	0.040-0.120

Galveston Bay Watersheds (F)

F216-00-00	Little Cedar Bavou	0.045-0.070	0.060-0.120(1)
F220-00-00	Pine Gully	0.032-0.040	0.070-0.150
F220-03-00	Pine Gully (continued)	0.040-0.042	0.070-0.150

(1) An "n" value of 0.010 was used for water-filled bodies located in the overbanks.

San Jacinto River Watershed (G)

G100-00-00	San Jacinto River, Houston Ship Channel	n/a	n/a
G100-00-00	Buffalo Bayou, Houston Ship Channel	0.025	0.050-0.150
G103-00-00	San Jacinto River	0.030-0.035	0.110-0.120
G103-01-00	Unnamed Tributary to San Jacinto River	0.040-0.060	0.060-0.120
G103-07-00	Unnamed Tributary to San Jacinto River	0.035-0.060	0.030-0.100
G103-00-00	Lake Houston	0.030-0.040	0.085-0.130
G103-00-00	West Fork San Jacinto River	0.030-0.040	0.110-0.120
G103-33-00	Bens Branch	0.040-0.070	0.060-0.125
G103-43-00	Jordan Gully	0.040-0.065	0.090-0.120
G103-44-00	TxDOT Ditch #4	0.030-0.040	0.060-0.100
G103-48-00	Blacks Branch	0.030-0.055	0.050-0.100
G103-80-00	Lake Houston (continued)	0.030-0.040	0.085-0.130
G103-80-00	East Fork San Jacinto River	0.035-0.050	0.110-0.120
G103-80-03	Caney Creek	0.040-0.060	0.080-0.120

Table 5. Summary of Roughness Coefficients (cont'd)

San Jacinto River Watershed (G) (Cont'd)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Manning's "n" Values Overbanks
G103-80-03.1	White Oak Creek	0.040-0.060	0.080-0.120
G103-80-03.1A	Mills Branch	0.015-0.040	0.110
G103-80-03.1B	Taylor Gully	0.060	0.110-0.120
G104-00-00	Patrick Bayou	0.015-0.060	0.070-0.150
G104-08-00	E. 13th St. Outfall Channel	0.015	0.070-0.150
G105-00-00	Boggy Bayou	0.040-0.100	0.100
G108-00-00	Glenmore Ditch	0.015-0.040	0.070-0.150
G109-00-00	Tributary 6.77 to Buffalo Bayou	0.035	0.070-0.150
G110-00-00	Cotton Patch Bayou	0.027-0.050	0.070-0.120
G112-00-00	Panther Creek	0.015-0.030	0.070-0.150

Hunting Bayou Watershed (H)

HCFCD Designation	Stream Name	Channel	Overbanks
H100-00-00	Hunting Bayou	0.015-0.055	0.050-0.200
H103-00-00	Wallisville Outfall	0.040-0.045	0.030-0.200
H110-00-00	Tributary 12.70 to Hunting Bayou	0.020	0.100-0.200
H112-00-00	Schramm Gully	0.030	0.070-0.200
H118-00-00	Tributary 12.05 to Hunting Bayou	0.040	0.100-0.200

Vince Bayou Watershed (I)

HCFCD Designation	Stream Name	Channel	Overbanks
I100-00-00	Vince Bayou	0.015-0.030	0.07-0.150
I101-00-00	Little Vince Bayou	0.015-0.035	0.07-0.150

Spring Creek Watershed (J)

HCFCD Designation	Stream Name	Channel	Overbanks
J100-00-00	Spring Creek	0.060-0.080	0.030-0.200(1)
J109-00-00	Bender Lake	0.030-0.050	0.080-0.200
J109-01-00	Continuation of Bender Lake	0.030-0.050	0.080-0.200
J121-00-00	Tributary 21.08 to Spring Creek	0.060	0.080-0.200
J131-00-00	Boggs Gully	0.015-0.070	0.070-0.200
J131-01-00	Tributary 1.25 to Boggs Gully	0.070	0.070-0.200
J158-00-00	Kickapoo Creek	0.050-0.070	0.065-0.200

(1) An n value of 0.030 was used for pond areas located on the overbanks.

Table 5. Summary of Roughness Coefficients (cont'd)

Cypress Creek Watershed (K)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Manning's "n" Values Overbanks
K100-00-00	Cypress Creek	0.025-0.140	0.025-0.200
K111-00-00	Turkey Creek	0.020-0.045	0.030-0.200
K111-03-00	Tributary to Turkey Creek	0.020-0.040	0.020-0.100
K112-00-00	Wild Cow Gulch	0.040-0.070	0.026-0.200
K116-00-00	Schultz Gully	0.030-0.070	0.040-0.120
K120-00-00	Lemm Gully	0.020-0.083	0.020-0.140
K120-01-00	Senger Gully	0.020-0.080	0.020-0.200
K120-03-00	Wunsche Gully	0.020-0.140	0.045-0.140
K124-00-00	Seals Gully	0.020-0.100	0.026-0.140
K124-02-00	Kothman Gully	0.040-0.060	0.026-0.120
K131-00-00	Spring Gully	0.020-0.120	0.014-0.140
K131-02-00	Theiss Gully	0.020-0.100	0.026-0.200
K131-02-04	Tributary to Theiss Gully	0.020-0.100	0.026-0.200
K131-03-00	Tributary 2.1 to Spring Gully	0.020-0.045	0.045-0.140
K131-04-00	Tributary to Spring Gully	0.020-0.060	0.026-0.100
K133-00-00	Dry Gully	0.015-0.045	0.040-0.120
K140-00-00	Pillot Gully	0.040-0.100	0.026-0.140
K142-00-00	Faulkey Gully	0.020-0.080	0.026-0.140
K145-00-00	Dry Creek	0.020-0.080	0.026-0.100
K150-00-00	Tributary 36.6 to Cypress Creek	0.040-0.060	0.050-0.100
K152-00-00	Tributary 37.1 to Cypress Creek	0.070-0.070	0.060-0.200
K155-00-00	Tributary 40.7 to Cypress Creek	0.050-0.070	0.060-0.070
K157-00-00	Tributary 42.7 to Cypress Creek	0.060-0.080	0.060-0.080
K159-00-00	Channel A to Cypress Creek	0.020-0.050	0.060-0.100
K159-01-00	Channel D to Channel A to Cypress Creek	0.040-0.050	0.040-0.120
K160-00-00	Rock Hollow	0.026-0.080	0.026-0.080
K160-01-00	Tributary 1.63 to Rock Hollow	0.040-0.070	0.040-0.100
K166-00-00	Mound Creek	0.070-0.120	0.026-0.120
K166-01-00	East Fork Mound Creek	0.020-0.080	0.035-0.120
K166-02-00	Little Mound Creek	0.050-0.080	0.045-0.100
K166-03-00	Tributary 7.62 to Mound Creek	0.050-0.080	0.050-0.100
K172-00-00	Tributary 44.5 to Cypress Creek (continued)	0.050-0.080	0.050-0.120
K185-00-00	Tributary 44.5 to Cypress Creek	0.050-0.080	0.050-0.120

Table 5. Summary of Roughness Coefficients (cont'd)

Little Cypress Creek Watershed (L)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Manning's "n" Values Overbanks
L100-00-00	Little Cypress Creek	0.040-0.080	0.030-0.150
L109-00-00	Tributary 9.36 to Little Cypress Creek	0.040-0.075	0.045-0.120
L112-00-00	Tributary 10.99 to Little Cypress Creek	0.045-0.075	0.040-0.120
L114-00-00	Tributary13.92 to Little Cypress Creek	0.060-0.065	0.040-0.100
L114-01-00	Tributary 0.12 to Tributary 13.92 to Little Cypress Creek	0.045-0.055	0.040-0.100

Willow Creek Watershed (M)

HCFCD Designation	Stream Name	Channel	Overbanks
M100-00-00	Willow Creek	0.050-0.080	0.050-0.200
M101-00-00	Tributary 0.26 to Willow Creek	0.070-0.080	0.100-0.200
M102-00-00	Unnamed Tributary to Willow Creek	0.040-0.080	0.050-0.200
M104-00-00	Tributary 2.44 to Willow Creek	0.045-0.080	0.030-0.200
M108-00-00	Hughes Gully	0.040	0.060-0.200
M109-00-00	Cannon Gully	0.040	0.050-0.200
M109-01-00	Metzler Creek	0.040	0.050-0.200
M112-00-00	Roan Gully	0.040	0.050-0.200
M116-00-00	Tributary 8.16 to Willow Creek	0.035-0.070	0.050-0.200
M124-00-00	Tributary 13.50 to Willow Creek	0.045-0.070	0.050-0.200
M129-00-00	Continuation of Willow Creek	0.070	0.050

Carpenter Bayou Watershed (N)

HCFCD Designation	Stream Name	Channel	Overbanks
N100-00-00	Carpenter Bayou	0.040-0.055	0.060-0.200
N100-00-00	Sheldon Reservoir	n/a	n/a
N104-00-00	Tributary 3.33 to Carpenters Bayou	0.040-0.070	0.060-0.200
N117-00-00	Tributary 11.715 to Carpenters Bayou	0.040	0.060-0.200

Goose Creek Watershed (O)

HCFCD Designation	Stream Name	Channel	Overbanks
O100-00-00	Goose Creek	0.025-0.060	0.035-0.120
O105-00-00	East Fork Goose Creek	0.015-0.045	0.035-0.080
O200-00-00	Spring Gully	0.035-0.060	0.040-0.130
O208-00-00	Spring Gully Diversion Channel	0.015-0.040	0.100

Table 5. Summary of Roughness Coefficients (cont'd)

Greens Bayou Watersheds (P)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Manning's "n" Values Overbanks
P100-00-00	Greens Bayou	0.015-0.040	0.030-0.200
P107-00-00	Big Gulch	0.040-0.070	0.080-0.200
P109-00-00	Sulphur Gully	0.040-0.070	0.070-0.200
P110-00-00	Spring Gully	0.040-0.045	0.080-0.200
P114-00-00	Unnamed Tributary to Greens Bayou	0.015-0.110	0.060-0.150
P118-00-00	Halls Bayou	0.035-0.045	0.050-0.200
P118-14-00	Tributary 6.71 to Halls Bayou	0.040-0.070	0.040-0.200
P118-23-00	Tributary 11.96 to Halls Bayou	0.040	0.070-0.200
P125-00-00	Tributary 14.27 to Greens Bayou	0.040	0.060-0.200
P125-04-00	Tributary 14.27 to Greens Bayou (continued)	0.040	0.100
P126-00-00	Tributary 14.82 to Greens Bayou	0.040-0.070	0.070-0.200
P130-00-00	Garners Bayou	0.035-0.045	0.040-0.200
P130-02-00	Williams Gully	0.040	0.035-0.200
P130-02-02	Tributary 2.01 to Williams Gully	0.035-0.045	0.035-0.200
P130-03-00	Tributary 3.19 to Garners Bayou	0.035-0.040	0.100-0.200
P130-03-01	Tributary 0.55 to Tributary 3.19 Garners Bayou	0.060	0.100-0.200
P130-05-00	Reinhardt Bayou	0.035-0.045	0.035-0.200
P133-00-00	Tributary 20.88 to Greens Bayou	0.040-0.045	0.050-0.200
P138-00-00	Tributary 24.97 to Greens Bayou	0.040-0.042	0.060-0.200
P140-00-00	Tributary 26.64 to Greens Bayou -- Hoods Bayou	0.040-0.045	0.040-0.200
P140-04-00	Continuation of Tributary 26.64 to Greens Bayou	0.040-0.050	0.040-0.200
P140-04-03	Continuation of Tributary 26.64 to Greens Bayou	0.040-0.050	0.070-0.200
P145-00-00	North Fork Greens Bayou	0.040	0.060-0.200
P145-03-00	Tributary 1.95 to North Fork Greens Bayou	0.040-0.050	0.050-0.200
P146-00-00	Tributary 32.23 to Greens Bayou	0.040-0.070	0.050-0.200
P147-00-00	Unnamed Tributary to Greens Bayou	0.015-0.060	0.100-0.200
P148-00-00	Tributary 34.60 to Greens Bayou	0.040	0.100-0.200
P155-00-00	Unnamed Tributary to Greens Bayou	0.015-0.035	0.050-0.200
P156-00-00	Unnamed Tributary to Greens Bayou	0.030	0.040-0.100

Cedar Bayou Watershed (Q)

HCFCD Designation	Stream Name	Channel	Overbanks
Q100-00-00	Cedar Bayou	0.030-0.040	0.068-0.148
Q101-00-00	Pine Gully	0.025-0.045	0.120
Q112-00-00	Cary Bayou	0.040-0.060	0.090-0.120
None	Horsepen Bayou (City of Baytown)	0.080	0.120
Q114-00-00	McGee Gully	0.040-0.045	0.080-0.130
Q122-00-00	Clawson Ditch	0.040	0.040-0.110

Table 5. Summary of Roughness Coefficients (cont'd)

Cedar Bayou Watershed (Q)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Manning's "n" Values Overbanks
Q128-00-00	Adlong Ditch	0.040-0.045	0.040-0.110
Q130-00-00	Unnamed Tributary to Cedar Bayou	0.040-0.080	0.050-0.110
Q200-00-00	Cedar Bayou Diversion Channel	0.035-0.050	0.100-0.130

Jackson Bayou Watershed (R)

HCFCD Designation	Stream Name	Channel	Overbanks
R100-00-00	Jackson Bayou	0.150-0.060	0.060-0.110
R102-00-00	Gum Gully	0.045-0.050	0.085-0.120
R102-03-00	Tributary 2.70 to Gum Gully	0.020-0.050	0.080-0.120
R102-03-01	Tributary 2.70 to Gum Gully (continued)	0.020-0.050	0.080 -0.120
R102-13-00	Tributary 3.08 to Gum Gully	0.035-0.050	0.110-0.120

Luce Bayou Watershed (S)

HCFCD Designation	Stream Name	Channel	Overbanks
S100-00-00	Luce Bayou	0.050-0.080	0.060-0.120
S110-00-00	Shook Gully	0.040-0.060	0.060-0.120
S114-00-00	Mexican Gully	0.060	0.110-0.120

Barker Reservoir Watershed (T)

HCFCD Designation	Stream Name	Channel	Overbanks
T100-00-00	Upper Buffalo Bayou/Cane	n/a	n/a
T100-00-00	Cane Island Branch	0.040-0.050	0.060-0.200
T101-00-00	Mason Creek	0.035-0.045	0.040-0.200
T101-03-00	Tributary 4.96 to Mason Creek	0.040-0.045	0.040-0.200
T101-10-00	Unnamed Tributary to Mason Creek	0.040	0.100-0.200
T103-00-00	Tributary 52.9 to Upper Buffalo Bayou/Cane	0.040-0.045	0.060-0.200
T103-01-00	Tributary 2.17 to Tributary 52.9 to Upper Buffalo Bayou / Cane	0.040	0.040-0.200

Table 5. Summary of Roughness Coefficients (cont'd)

Addicks Reservoir Watershed (U)

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Manning's "n" Values Overbanks
U100-00-00	Langham Creek	0.035-0.055	0.040-0.200
U101-00-00	South Mayde Creek	0.040-0.060	0.060-0.200
U101-07-00	Tributary 9.4 to South Mayde Creek	0.040-0.065	0.040-0.200
U101-22-00	Unnamed Tributary to South Mayde Creek	0.040-0.045	0.080
U102-00-00	Bear Creek	0.015-0.055	0.040-0.200
U102-01-00	Unnamed Tributary to Bear Creek	0.015-0.130	0.015-0.150
U106-00-00	Horsepen Creek	0.035-0.060	0.035-0.200
U120-00-00	Dinner Creek	0.040-0.050	0.040-0.200
U200-00-00	Addicks Reservoir Diversion Channel	0.035-0.055	0.040-0.200
W167-01-00	Tributary 3.9 to Turkey Creek	0.035-0.050	0.060-0.200

Buffalo Bayou Watershed (W)

HCFCD Designation	Stream Name	Channel	Overbanks
W100-00-00	Buffalo Bayou	0.020-0.060	0.040-0.200
W140-00-00	Spring Branch	0.015-0.055	0.100-0.200
W140-01-00	Briar Branch	0.025-0.060	0.100-0.200
W141-00-00	Soldiers Creek	0.015-0.080	0.015-0.080
W142-00-00	Bering Ditch	0.015-0.050	0.080-0.200
W156-00-00	Rummel Creek	0.015-0.035	0.015-0.200
W157-00-00	Unnamed Tributary to Buffalo Bayou	0.040	0.040-0.100
W167-00-00	Turkey Creek	0.025-0.040	0.040-0.200
W167-04-00	Continuation of Turkey Creek	0.020-0.040	0.040-0.200
W167-01-00	Tributary 3.9 to Turkey Creek (See Addicks)	--	--
W170-00-00	Unnamed Tributary to Buffalo Bayou	0.040	0.015-0.100
W190-00-00	Clodine Ditch	0.035	0.050-0.200

Note: Listed values do not include the use of "n" = 0.99 for ineffective flow areas in the overbanks.

Basin overflow is a characteristic of many of the drainage basins within Harris County. Basin overflow occurs when the WSELs of a flooding source exceed the elevations of the drainage basin divide. This results in part of the discharge leaving the original flooding source. This situation occurs when a relatively high discharge flows in a flat area where the difference in elevation between the channel and basin divide is small. Three hydraulic methods were used to calculate basin overflow: Manning's Equation, Weir Equation, or a known stage-discharge curve. The equations for these methods are as follows:

Manning's Equation: $Q = (1.49AR^{(2/3)}S^{(1/2)})/n$

Weir Equation: $Q = CLH^{1.5}$

where:
Q = overflow discharge
n = Manning's "n" value
A = area
R = hydraulic radius
S = slope in direction of overflow
C = Weir coefficient
L = Weir length
H = energy head assuming negligible velocities

The third method used to predict the amount of basin overflow was from a known stage-discharge curve. This method was used to evaluate some of the diversion channels. The stage-discharge relationship was developed from multiple backwater computations

Particular aspects of the hydraulic modeling within each of the 22 watersheds are described below.

<u>Clear Creek (A)</u> – Prior to this study, a hydraulic model for Clear Creek was created by the USACE-Galveston District as part of their ongoing planning study for Clear Creek. The starting water surface elevation for Tributary 3.10 to Taylor Bayou was set to the known water surface elevation from Taylor Bayou. Within the Clear Creek Watershed, an overflow occurs from Halls Road Ditch to Turkey Creek through Sage Orchard Boulevard and Hughes Road.

<u>Armand Bayou (B)</u> – This watershed has two diversion channels: the B112-02-00 Interconnect and the Horsepen Bayou Diversion Channel. Regulatory elevations for the B1112-02 Interconnect diversion are an interpolation of the upstream elevation for Spring Gully and the elevation at the confluence with the B112-02-00 Interconnect. For the Horsepen Bayou Diversion Channel, the profiles at the downstream confluence with Horsepen Bayou and the upstream divergence with Tributary 4.51 to Horsepen Bayou correspond.

<u>Sims Bayou (C)</u> - Two HEC-RAS models were used for the hydraulic analysis of Sims Bayou. Due to the ongoing Federal flood control project (Reference 3.2.2), a model was developed to analyze the stream at the time of the field survey. A separate model was developed that accounted for the completion of the improvement project based on the design plans. As phases of the project are completed over the next several years, the downstream WSELs will gradually increase and reach their maximum when the final phase is finished. At the time of the survey, the Federal project had been completed through Martin Luther King Boulevard. Due to higher discharges in the downstream portion of the future conditions model, water surfaces in that model were higher than those in the current Sims Bayou model through Cullen Boulevard. For this reason, the Sims Bayou model that reflects the completion of the improvements was used to determine the WSELs to be mapped downstream of Cullen Boulevard. The model that reflects current conditions was used to determine WSELs upstream of Cullen Boulevard. This will help minimize changes on the DFIRM downstream of Cullen Boulevard that result from further construction. The floodway for Sims Bayou was determined using this combination of HEC-RAS models as

well. Basin overflow occurs in the Sims Bayou Watershed between Tributary 2.00 to Berry Bayou and Berry Bayou.

Brays Bayou (D) - Brays Bayou and all its tributaries have been channelized to at least some extent. The channel of Brays Bayou itself is partially concrete-lined for much of its length, and segments of a number of tributaries have been either lined with concrete or completely enclosed. A total of six overflow areas were identified within the Brays Bayou Watershed: two between Keegans Bayou and Tributary 20.90 to Brays Bayou, one between Keegans Bayou and Brays Bayou, two between Tributary 20.90 to Brays Bayou and Tributary 21.95 to Brays Bayou, and one between Brays Bayou and Tributary 21.95 to Brays Bayou. No floodway data has been calculated for Harris Gully, as the system is entirely an enclosed double-box culvert running beneath Rice University and the Texas Medical Center (TMC) campuses and a number of buildings and other structures have already been constructed directly over the Harris Gully box culverts. Harris Gully was modified from its original natural channel to its current enclosed state during the late 1940s or early 1950s. Plans of the enclosed Harris Gully produced by the City of Houston Public Works Department were originally dated 1947 and revised 1959. Floods in the sub-watershed are the result of storm water runoff exceeding the capacity of the storm sewer system, at which time the surface runoff tends to concentrate in an overland flow path following streets and low elevations that generally coincide with the position of the former open channel. The TMC's location at the downstream end of the Harris Gully Watershed makes it especially vulnerable to flooding, since nearly all overland flow from the 5.13 square mile watershed must flow through the TMC on its way to Brays Bayou.

White Oak Bayou (E) - Approximately 1 mile of cross-sections from the Buffalo Bayou HEC-RAS model have been inserted at the downstream end of the White Oak Bayou HEC-RAS model to correctly represent the backwater effect from the receiving stream. An overflow occurs from White Oak Bayou into Cole Creek between Guhn and Gessner Roads. Vogel Creek is approximately 3,000 feet shorter than the mapping shown on the previous effective FIRM dated April 20, 2000. Field inspection confirmed that a subdivision was under construction and a detention basin was being enlarged in the upper basin, thus reducing the stream length. Tributary 15.8 to White Oak Bayou was truncated upstream of the Fairbanks-N. Houston culvert, where the stream is enclosed in a storm sewer system. Runoff from Rolling Fork headwaters was re-directed towards the Beltway 8 Outfall Channel during the construction of the Sam Houston Racepark, located south of the Sam Houston Tollway.

Galveston Bay (F) – The results of tidal surge dominate the Galveston Bay Watershed and override most of the riverine-only floodplain results. Combined probability analysis was performed for Little Cedar Bayou to calculate the effect of riverine and coastal flooding. As subsidence occurs in these areas, the depth of riverine flooding tends to remain constant while the depth of coastal flooding increases. Mean high water level was used to show tidal effects in these areas. The starting water-surface elevation of Pine Gully (F220-00-00) was set at MHW at the confluence with Galveston Bay taken from NOAA's website (1.42 ft, NAVD) for the 10-percent-annual-chance event, and adjusted appropriately for the other recurrence intervals to eliminate achieving critical depth.

San Jacinto River (G) – The cross section data in the lake and channel areas for the San Jacinto River were taken from the prior effective FIS HEC-2 models and adjusted for subsidence. The starting WSEL computed by the normal depth slope method was used for the San Jacinto River model as it exceeded the reported Mean High Tide of 1.5 ft. However, combined probability elevations were used for mapping in the downstream areas. The spillway elevation at the Lake Houston Dam was obtained from the previous effective FIS HEC-2 data, adjusted for subsidence, and used as the downstream boundary condition for the Lake Houston model. Stream stationing for Lake Houston, the East Fork and the West Fork are all measured along a profile baseline from the downstream face of the Lake Houston Dam. Structure data for FM 1960, the McKay Bridge on Lake Houston, and the new US Highway 90 Bridge across the San Jacinto River were obtained from plan information received from the Texas Department of Transportation (TxDOT). Since the vertical datum for FM 1960 and U.S. Highway 90 plan information was not available from TxDOT, no subsidence adjustment was applied to the bridge elevations taken from the plans. Cross Section 51110 of Lake Houston is the first section for East Fork San Jacinto River and it is the common cross-section for both the models. Cross Section 48519 of Lake Houston is the common cross section for West Fork San Jacinto River, while it is Cross Section 44044 for the West Fork San Jacinto River model. The common section between Lake Houston and West Fork San Jacinto River is stationed differently because of the different profile baselines used for the two models.

Subbasin overflows occur along Caney Creek and White Oak Creek. Due to the significant overflow between these two streams, a combined HEC-RAS model with updated channel and overbank elevation data was prepared, with Caney Creek considered as the main channel. Model geometry from the prior effective study was reprocessed with some realignment of cross sections to better analyze the combined floodplain. All of the structures are located on White Oak Creek, and not on Caney Creek, so they are not included as "structures" in the model, but are represented in the channel area of White Oak Creek by adjustments to Manning's "n" values. The profiles are based upon WSELs computed from the combined Caney Creek/White Oak Creek HEC-RAS model.

Hunting Bayou (H) - An overflow occurs between Tributary 12.05 and Hunting Bayou to Hunting Bayou. This overflow is primarily contained in a channel that connects the floodplain of H118-00-00 to the channel of Hunting Bayou. The overflow was mapped from bank to bank in the overflow channel.

Vince Bayou (I) - Major rectification, including concrete lining, has been completed along most of the length of Vince Bayou and its major tributary, Little Vince Bayou. There are no notable aspects to the hydraulic modeling of Vince Bayou.

Spring Creek (J) - A certified levee is located along Spring Creek at Northgate Crossing just downstream of IH-45.

Cypress Creek (K) - Cypress Creek includes two FEMA certified levees and five detention areas. The Inverness Forest Levee, with record drawings dated October 19, 1993, lies on the right overbank of Cypress Creek between the Hardy Toll Road and IH-45. The Wastewater Treatment Plant Levee lies on the right overbank of Cypress Creek between IH-45 and Kuykendahl Road. There are two overflow areas between Cypress Creek and Tributary 44.5 to Cypress Creek. These overflows continue to the south out of the Cypress Creek Watershed, and contribute significant flow into the Addicks Reservoir Watershed and the Barker Reservoir Watershed.

Little Cypress Creek (L) – There are no notable aspects of the hydraulic modeling of Little Cypress Creek.

Willow Creek (M) – There are no notable aspects of the hydraulic modeling of Willow Creek.

Carpenters Bayou (N) – The level pool elevations for Sheldon Reservoir were calculated by reservoir routing with HEC-HMS.

Goose Creek (O) - Combined probability analysis was applied to Goose Creek, East Fork Goose Creek, and Spring Gully. The Lynchburg Reservoir Canal crosses above Goose Creek and Spring Gully near the upstream end of the study reach and represents a significant obstruction to flood flows. In the Spring Gully Diversion Channel, the culvert at the downstream end has an extremely steep slope causing supercritical flow. Critical depth was determined and utilized in the profiles and mapping in this area.

Greens Bayou (P) - There are five areas of intra-basin overflow in the Greens Bayou Watershed. Greens Bayou spills into Tributary 24.97 to Greens Bayou upstream of the Missouri Pacific Railroad, which in turn overflows into Halls Bayou. Tributary 14.82 to Greens Bayou overflows into Tributary 14.27 to Greens Bayou. The overflow from Tributary 26.64 and Greens Bayou to P155-00-00 is contained almost entirely within a culvert under Rankin Road. The overflow from Tributary 34.60 to Greens Bayou results from backwater from Greens Bayou and flows into Halls Bayou.

Cedar Bayou (Q) - The starting water surface elevation of Cedar Bayou was set to MHW level at 1.5 ft (NAVD 1988, 2001 adjustment) to show tidal effects. Combined probability analysis was applied to Cedar Bayou, Pine Gully, and Cedar Bayou Diversion Channel.

Jackson Bayou (R) - The San Jacinto River Authority Canal, that passes beneath Jackson Bayou and Gum Gully near the upstream end of the study reach significantly obstructs flood flows. The Jackson Bayou channel is concrete lined at this overpass. There are four energy dissipaters along Tributary 2.70 to Gum Gully, which are all modeled as inline weirs.

Luce Bayou (S) – There are no notable aspects to the hydraulic modeling of Luce Bayou.

Barker Reservoir (T) - The following streams discharge into Barker Reservoir and were started at known WSELs that matched the WSEL of the reservoir for the same annual chance event: Upper Buffalo Bayou, Mason Creek, and Tributary 52.9 to Upper Buffalo Bayou. The level pool elevations for Barker Reservoir were calculated using HEC-5 (Reference 3.2.3).

Addicks Reservoir (U) - The following streams discharge into Addicks Reservoir and were started at known WSELs that matched the water surface elevation of the reservoir for the same annual chance event: Langham Creek, South Mayde Creek, Bear Creek, and Tributary 3.9 to Turkey Creek. There is an inter-basin overflow from Cypress Creek into the Addicks Reservoir Watershed. This overflow impacts discharges in Bear Creek and South Mayde Creek. There are inter-basin overflows between Tributary 9.4 to South Mayde Creek and Mason Creek, and between South Mayde Creek and Cane Island Branch in the Barker Reservoir Watershed. Additionally, intra-basin overflow occurs from Bear Creek to South Mayde Creek. The level pool elevations for Addicks Reservoir were calculated using HEC-5 (Reference 3.2.3).

Buffalo Bayou (W) - There are no notable aspects to the hydraulic modeling of Buffalo Bayou.

3.3 Vertical Datum

All FIS reports and DFIRMs 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 DFIRMs was the National Geodetic Vertical Datum of 1929 (NGVD). With the completion of the NAVD of 1988, many FIS reports and DFIRMs are now prepared using NAVD as the referenced vertical datum.

Flood elevations shown in this FIS report and on the DFIRM are referenced to the NAVD (2001 adjustment). These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the NGVD and NAVD, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

Vertical Network Branch, N/CG13
National Geodetic Survey, NOAA
Silver Spring Metro Center 3
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3191

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 DFIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and DFIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for the NGS 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.

To obtain current elevation, descriptions, and/or location information for benchmarks shown on this map provided by Harris County, please contact the Permits Office of the Public Infrastructure Department at (713) 956-3000. Benchmark information is also published on the Harris County Permit Division website at http://www.eng.hctx.net/permits/.

3.4 Effects of Land Subsidence

Harris County and Incorporated Areas are affected by land subsidence. Land subsidence is the lowering of the ground as a result of water, oil, and gas extraction, as well as other phenomena such as soil compaction, decomposition of organic material, and tectonic movement. The prevalence of land subsidence in the study area complicates the determination of the height a given property lies above or below the BFE. Changes in flood hazards, caused by changed hydrologic and hydraulic conditions, could include increases or decreases in (1) depths of flooding, (2) the amount of land inundated, and (3) the intensity of wave action in coastal areas. The nature and extent of possible flood-hazard changes are different depending on the type of flooding (riverine, coastal, or combined riverine and coastal) present.

Historically, subsidence was initially concentrated near the early development and industrial areas along the Houston Ship Channel. The Ship Channel serves as the primary conduit for floodwaters for much of the Harris County area. Subsidence in some coastal areas has lowered ground elevations relative to sea level where the effects on flooding are obvious—more permanently inundated land from normal daily tides and more land subject to flooding from tidal surges associated with tropical storms. The historic subsidence patterns generally increased the gradient of tributaries to the Ship Channel, which was believed to actually benefit inland drainage and flooding.

The Harris-Galveston Coastal Subsidence District (H-GCSD) was created by the Texas Legislature in 1975 as an underground water conservation district for the purpose of controlling subsidence. Since that time, the H-GCSD has successfully implemented policies and programs that have significantly reduced the rate of subsidence throughout much of Harris County, especially in coastal areas. New groundwater wells to support the water supply needs of increased northern and western growth has resulted in continued inland subsidence. This inland subsidence toward the north and west has the potential to adversely affect stream gradients. However, the continued implementation of the Groundwater Management Plan (Reference 3.4.1) is expected to reduce the rate of future subsidence in these inland areas.

The original FIS reports for Harris County and Incorporated Areas, published in the mid-1980s, were referenced primarily to the 1973 benchmark re-leveling of the NGVD (1929). Periodically, the NGS releveled some benchmarks to determine new elevations above the NGVD. However, not all benchmarks were re-leveled each time. The 1973 re-leveling was relatively extensive, while the re-levelings performed in 1978, 1987, and 1995 were significantly less extensive. Subsequent revisions to the FIRM and FIS report were performed using either the original re-leveling (1973) or more recent NGS re-levelings.

In 2000, the H-GCSD and NGS, with the assistance of numerous local surveying firms, conducted a major re-leveling effort in the Harris County area. Updated elevations were established on 181 benchmarks in a 9-county area (114 benchmarks within Harris County). The datum of this network is NAVD 1988 with a vertical height adjustment to 2001. Within this network, an additional 1,635 class A, B, or C benchmarks were established with elevations at this datum. The locations are shown on the revised DFIRM panels for Harris County and the location descriptions and elevation data have been published. For more information regarding the location descriptions and elevation data, contact HCFCD or your local community.

As this updated datum was being released by NGS, FEMA was initiating its restudy of Harris County. In keeping with FEMA's policy of converting all studies to NAVD 1988, this datum was used for the acquisition of all topographic data, field survey, and LiDAR. All computer models were then prepared based on this datum. For those flooding sources that were not field surveyed for this restudy, the existing data was adjusted to the current datum. One of the major benefits of this new data was that all of the FIRMs for the entire county were mapped on the same datum adjustment. This was the first time since the original maps were published that the datum is consistent throughout the county.

The BFEs shown on the effective FIRM and in the effective FIS report were developed using benchmarks referenced to the NAVD 1988 (2001 Adjustment).

The need for more definitive information on the effects of subsidence became evident as local governmental entities moved forward in planning for water supply, drainage and flood control, and ground-water regulation. In response to the need for better information, a study was undertaken by the local entities primarily responsible for water supply, subsidence, and flood control in the Houston metropolitan area: HCFCD, Fort Bend County Drainage District, Harris-Galveston Coastal Subsidence District (H-GCSD), and the City of Houston. The report, dated December 1986, is entitled "A Study of the Relationship Between Subsidence and Flooding" (Reference 3.4.2). The results of this study were confirmed in an August 2000 follow up study "Impact of Subsidence on Base Flood Elevations". The effects of subsidence on flooding, and the different methods used to account for land subsidence for each type of flooding (riverine, coastal, and combined riverine and coastal), are discussed below.

Riverine Flooding (inland flooding not associated with coastal flooding)

Subsidence within inland watersheds has little or no effect on flood depths when the entire watershed, including all hydraulic structures, subsides uniformly. However, differential subsidence (the presence of differing amounts of subsidence within a watershed) can cause changes in stream-channel slope and stream-valley geometry, which can result in changes in flood depths. Where stream-channel slopes are steepened (where there is more subsidence downstream than upstream), flood discharges usually increase and hydraulic efficiency, as measured by the amount of discharge for a given flood depth, increase. In this situation, the depth of flow usually decreases. The opposite is generally true where stream channel slopes are flattened.

Other effects of land subsidence can include changes in cross-section floodplain geometry and changes in drainage-basin boundaries. Changes in cross-section geometry can affect conveyance, overbank storage, and flow diversions and result in localized changes in flood hazards. Changes in drainage basin boundaries affect the size of the drainage area and can result in changes in discharges and flood depths in the altered basins.

Harris County and Incorporated Areas are affected by relatively wide-scale, uniform subsidence with minor differential subsidence within individual watersheds. (For example, deferential subsidence within the Brays Bayou and White Oak watersheds between 1973 and 1987 resulted in changes in the main channel slope of approximately 1 inch per mile.) Historically, flood depths have remained relatively constant and BFEs generally subside as the ground subsides (see Figure 8). The local effects of subsidence may be adequately addressed, in the short term, by assuming that BFEs subside by the same amount the ground subsides. For floodplain management (setting lowest-floor elevations and regulating construction in the floodplain) and flood insurance (determining the amount the lowest floor of a structure lies above or below the BFE) purposes, the effects of subsidence can be accounted for by determining ground and structure elevations using benchmark elevations with the same relevel date at the benchmark used to develop the BFEs on the FIRM. No adjustment is necessary to the BFEs on the FIRM.

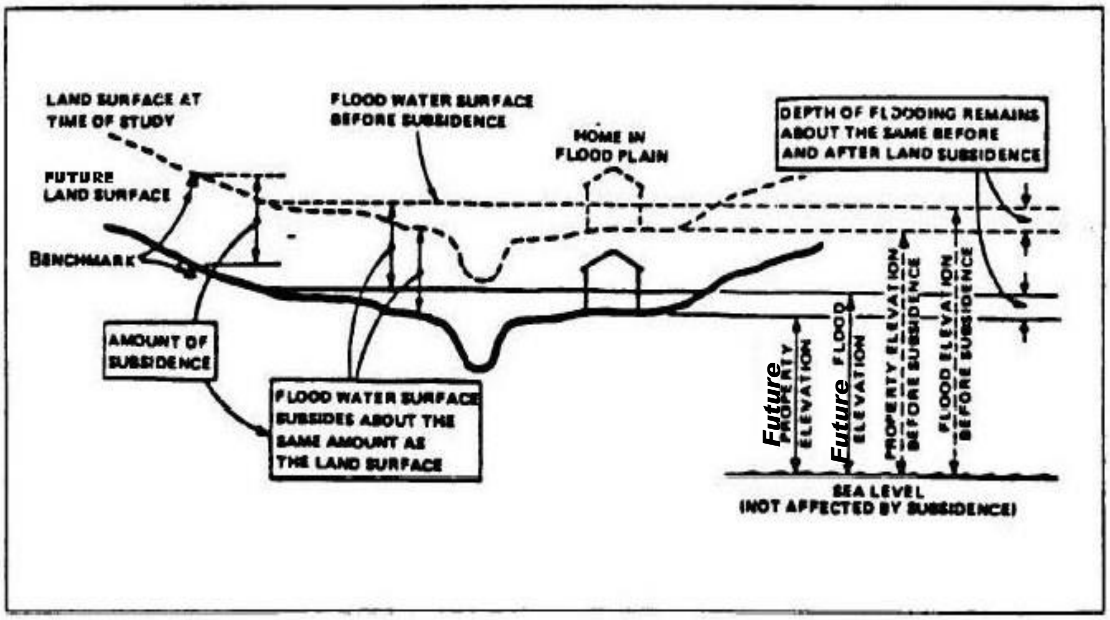

Figure 8. Land Subsidence Schematic - Riverine Flooding

The locations of Elevation Reference Marks (ERMs) are provided on the DFIRM to assist in determining ground and structure elevations. These ERMs are permanent benchmarks established by NGS, FEMA, H-GCSD, and HCFCD during the time the FIS was conducted. Because the elevations on these ERMs were established at the time the BFEs were determined, the ERMs and BFEs are based on the same re-leveling and are therefore compatible to use together.

Generally, the ERMs closest to a flood-prone area are compatible for use with the BFEs on the FIRM. However, this may not be the case in the future where two floodplains are within close proximity of each other and the BFEs for each flooding source are based on different re-levelings. Other benchmarks of third-order accuracy or higher not shown on the FIRM may be used provided the relevel date of the benchmark is the same as the relevel date associated with the BFEs. The local city or county engineering or permitting department should be contacted to verify the compatibility of ERMs and benchmark elevations for use with the BFEs on the FIRM. (Note: More recent re-levelings of ERMs or other benchmarks may be used with the BFEs on the FIRM; however, this may result in: (1) an underestimation of the amount a structure or property is above the BFE, (2) an overestimation of the amount a structure is below the BFE, or (3) problems tying in a revised hydraulic analysis to the FIS profile upstream and downstream of the revised reach.)

When reviewing development permit applications for new construction in areas subject to ongoing subsidence, and using the ERM elevations on the FIRM or other benchmarks with the same relevel date as the BFEs, consideration should be given to setting the lowest-floor elevation above the BFE by an amount associated with potential increases in flood depths as a result of past and future subsidence. In the absence of site-specific engineering data, elevating a structure by an additional 1.5 feet above the BFE is recommended at this time. This recommendation is based on information on potential increases in flood depths due to worst-case scenarios of predicted future differential subsidence as discussed in the report titled “A Study of the Relationship Between Subsidence and Flooding” (Reference 3.4.2).

In watersheds where minor differential subsidence can be considered negligible in the short term, greater differentials in subsidence may occur over time and uniform subsidence assumptions may no longer be appropriate. Additionally, local conditions may produce changes in ground elevations that cannot always be predicted. As a result, more uncertainty is introduced with respect to potential changes in flood depth. The useful life of an FIS is limited and the FIS must eventually be updated. When an entire watershed, or large portions of a watershed, is restudied, and the effects of differential subsidence may be significant, it may be appropriate to re-level benchmark elevations at that time or use the most recently re-leveled benchmark elevations. The new or more recent benchmark elevations should be used for developing new topography and new cross-section data for hydrologic and hydraulic models.

When two streams with BFEs based on different re-leveling dates confluence, the backwater projected onto the tributary is at a different re-leveling date than the tributary riverine profile. When reviewing development permit applications for new construction in areas subject to ongoing subsidence, consideration should be given to setting the lowest-floor elevation above the BFE by an amount associated with the potential increases in flood depths as a result of past and future subsidence. It is recommended that the elevations of the more recent re-leveling of benchmarks be used for ground surveying in setting lowest-floor elevations with the BFEs shown on the FIRM.

Coastal Flooding

In areas subject to coastal flooding, storm-surge elevations generally are not affected as the ground subsides. The changes in topography due to subsidence are minor compared to the overall size of the Gulf of Mexico and Galveston Bay, where storm surges are generated. However, as a result of subsidence, increases in flood depths and flooding of additional inland areas may occur. BFEs may increase due to increased wave heights resulting from increased flood depths, and the A/V- zone boundary may be located farther inland than shown on the effective FIRM. For floodplain management and flood insurance purposes, increases in BFEs usually can be disregarded in the short term, and increases in flood depth must be taken into account by comparing the BFE on the FIRM with current (at that time) and accurate (true elevation above NAVD within the limits of surveying accuracy) ground and structure elevations (see Figure 9).

Because coastal BFEs generally are not affected by subsidence, the relevel date of benchmarks used to develop onshore topography is not an important factor in determining BFEs. However, using the elevation of ERMs on the FIRM is not sufficient for floodplain management and flood insurance purposes if an area has experienced significant subsidence (0.5 foot or more) since the relevel date of the ERM. Current and accurate ground and structure elevations above the NAVD must be obtained by field surveys or other appropriate methods. Using outdated ERMs would result in (1) setting the lowest-floor elevations below the BFE, and (2) an improper determination of the amount an existing structure lies above or below the BFE. The error introduced is the same as the amount the land has subsided since the relevel date of the ERM used.

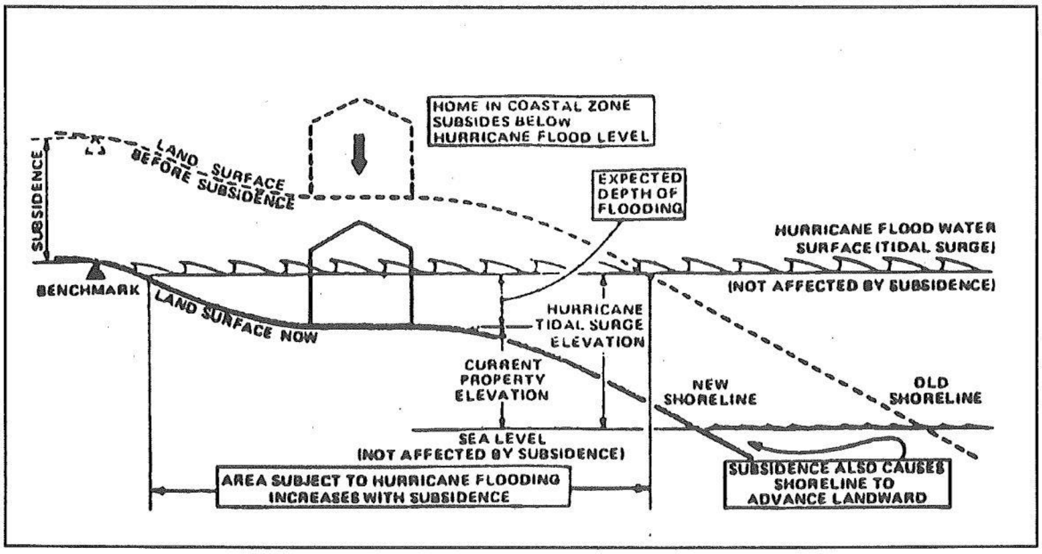

Figure 9. Land Subsidence Schematic – Hurricane/Tidal Surge Flooding

When reviewing development permit applications for construction in areas subject to ongoing subsidence, a community should consider setting the lowest-floor elevation above the BFE by an amount equal to expected future subsidence plus any expected increase in wave heights. In addition, a community should consider the potential flood risks when regulating construction in non-Special Flood Hazard Areas (SFHAs), the areas subject to inundation by the base flood that are adjacent to coastal flood zones and may be susceptible to coastal flood inundation due to subsidence. Requirements in these non-SFHAs should include setting the lowest-floor elevation at or above the BFE shown in the adjacent coastal flood zone.

<u>Combined Riverine and Coastal</u>

Certain areas are affected by both riverine and coastal flooding. These areas are identified on the Flood Profiles and in the Floodway Data Table in this report as Combined Probability or Combined Flooding areas. As subsidence occurs in these areas, the depth of riverine flooding tends to remain constant, while the depth of coastal flooding increases. For floodplain management and flood insurance purposes, criteria used in coastal areas should be applied in areas of combined riverine and coastal flooding.

Information regarding the location and amount of subsidence is available from the H-GCSD in Friendswood, Texas, and the Fort Bend Subsidence District in Richmond, Texas. Subsidence information is available for periods of record including 1906-1943, 1943-1964, 1964-1973, 1973-1978, 1978-1987, 1987-1995, and 1995-2000. In areas affected by subsidence, benchmarks that have been installed with the foundation of the benchmark deep in the ground on a non-subsiding subterranean layer may provide stable benchmark elevations even though the surrounding ground is subsiding. Several of these types of benchmarks, referred to as "extensometers," are located within Harris County and

Incorporated Areas. Information concerning the location and stability of these benchmarks may be obtained from the H-GCSD. As of June 2003, there were 13 located within the two county area.
FEMA Form 81-31 (January 2003), "Elevation Certificate and Instructions," and its successors, is to be used to provide elevation information necessary to ensure compliance with applicable community floodplain management ordinances, to determine the proper insurance premium rate, and to support any request for a FEMA Letter of Map Change. The Instructions for completing Section C, Item C3, of the Elevation Certificate states, in part: "For property experiencing ground subsidence, the most recently adjusted reference mark elevations must be used for determining building elevations." The information in this report for Harris County and Incorporated Areas supersedes the instructions for Section C, Item C3, of the Elevation Certificate and Instructions.

3.5 Coastal Analyses

The hydraulic characteristics of coastal flood sources were analyzed to provide estimates of flood elevations for 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 in the coastal data tables and flood profiles provided in the FIS Report.

3.5.1. Storm Surge Analysis and Modeling

For areas subject to coastal flood effects, the 10-, 2-, 1-, and 0.2-percent-annual-chance stillwater elevations were taken directly from a detailed storm surge study documented in *Flood Insurance Study: Coastal Counties, Texas Intermediate Submission 2 – Scoping and Data Review* prepared by the U.S. Army Corps of Engineers (Reference 3.5.15). This storm surge study was completed in November 2011.

The Advanced Circulation (ADCIRC) model for coastal ocean hydrodynamics developed by the USACE was applied to calculate stillwater elevations for coastal Texas. The ADCIRC model uses an unstructured grid and is a finite element long wave model. It has the capability to simulate tidal circulation and storm surge propagation over large areas and is able to provide highly detailed resolution in areas of interest along shorelines, open coasts and inland bays. It solves three dimensional equations of motion, including tidal potential, Coriolis, and non-linear terms of the governing equations. The model is formulated from the depth-averaged shallow water equations for conservation of mass and momentum which result in the generalized wave continuity equation.

In performing the coastal analyses, nearshore waves were required as inputs to wave runup and overland wave propagation calculations, and wave momentum (radiation stress) was considered as contribution to elevated water levels (wave setup). The Steady State Spectral Wave (STWAVE) model was used to generate and transform waves to the shore for the Texas Joint Storm Surge (JSS) Study. STWAVE is a finite difference model that calculates wave spectra on a rectangular grid. The model outputs zero-moment wave height, peak wave period (Tp), and mean wave direction at all grid points and two-dimensional spectra at selected grid points. STWAVE includes an option to input spatially variable wind and storm surge field. Storm surge significantly alters wave transformation and generation for the hurricane simulations in shallow-flooded areas.

STWAVE was applied on five grids for the Texas JSS: NE, CE, SW, NEn, and CEn. Three large grids (NE, CE, SW) with offshore boundaries at depths near 100 feet (30 meters) encompassed the entire coast of Texas and applied the efficient half-plane version of STWAVE (which must approximately align with the shoreline). Two nested grids (NEn and

CEn) covered Galveston Bay and Corpus Christi Bay and applied the fullplane version of STWAVE to allow generation of wind waves in all directions. Notably, memory requirements for the full-plane model precluded its use for the large grids with offshore boundaries. The input for each grid includes the bathymetry (interpolated from the ADCIRC domain), surge fields (interpolated from ADCIRC surge fields), and wind fields (interpolated from the ADCIRC wind fields, which apply land effects to the base wind fields). The wind and surge applied in STWAVE are spatially and temporally variable for all domains. STWAVE was run at 30-minute intervals for 93 quasi-time steps (46.5 hours).

The ADCIRC model computational domain and the geometric/topographic representation developed for the Joint Coastal Surge effort was designated as the TX2008 mesh. This provided a common domain and mesh from the Texas-Mexico border to western Louisiana, extends inland across the floodplains of Coastal Texas (to the 30- to 75-foot contour NAVD88), and extends over the entire Gulf of Mexico to the deep Atlantic Ocean. The TX2008 domain boundaries were selected to ensure the correct development, propagation, and attenuation of storm surge without necessitating nesting solutions or specifying ad hoc boundary conditions for tides or storm surge. The TX2008 computational mesh contains more than 2.8 million nodes and nodal spacing varies significantly throughout the mesh. Grid resolution varies from approximately 12 to15 miles in the deep Atlantic Ocean to about 100 ft. in Texas. Further details about the terrain data as well as the ADCIRC mesh creation and grid development process can be found in Flood Insurance Study: Coastal Counties, Texas Intermediate Submission 2 – Scoping and Data Review.

3.5.2. Statistical Analysis

The Joint Probability Method (JPM) is a simulation methodology that relies on the development of statistical distributions of key hurricane input variables such as central pressure, radius to maximum wind speed, maximum wind speed, translation speed, track heading, etc., and sampling from these distributions to develop model hurricanes. The resulting simulation results in a family of modeled storms that preserve the relationships between the various input model components, but provides a means to model the effects and probabilities of storms that historically have not occurred.

Due to the excessive number of simulations required for the traditional JPM method, the JPM-Optimum Sampling (JPM-OS) was utilized to determine the stillwater elevations associated with tropical events. JPM-OS is a modification of the JPM method and is intended to minimize the number of synthetic storms that are needed as input to the ADCIRC model. The methodology entails sampling from a distribution of model storm parameters (e.g., central pressure, radius to maximum wind speed, maximum wind speed, translation speed, and track heading) whose statistical properties are consistent with historical storms impacting the region, but whose detailed tracks differ. The methodology inherently assumes that the hurricane climatology over the past 60 to 65 years (back to 1940) is representative of the past and future hurricanes likely to occur along the Texas coast.

A set of 446 storms (two sets of 152 low frequency storms + two sets of 71 higher frequency storms) was developed by combining the “probable” combinations of central pressure, radius to maximum winds, forward speed, angle of track relative to coastline, and track. Tracks were defined by five primary tracks and four secondary tracks. Storm parameters for synthetic storms are provided in Table 11 of Flood Insurance Study: Coastal Counties, Texas Intermediate Submission 2 – Scoping and Data Review ((Reference 3.5.15). The estimated range of storm frequencies using the selected parameters was between the 10%- and 0.2%-annual-chance storm events. The ADCIRC-STWAVE modeling system was validated using five historic storms: Hurricanes Carla (1961), Allen (1980), Bret (1999), Rita (2005), and Ike (2008).

3.5.3 Stillwater Elevations

The results of the ADCIRC model and JPM-OS provided 10-, 2-, 1-, and 0.2-percent-annual- chance stillwater elevations which include wave setup effects. Stillwater elevations are assigned at individual ADCIRC mesh nodes throughout the Texas coast. Triangular Irregular Networks (TINs) and raster datasets were built from these nodes for use in wave analysis and floodplain mapping.

An Independent Technical Review (ITR) was performed on the overall storm surge study process. This review process was performed in accordance with USACE regulations. The ITR team was composed of experts in the fields of coastal engineering and science, and was engaged throughout the study. Appendix K of Flood Insurance Study: Coastal Counties, Texas Intermediate Submission 2 – Scoping and Data Review includes all comments received from the ITR panel, as well as responses to those comments. Table 6 summarizes the elevations from this study.

Table 6 – Summary of Coastal Elevations

	Elevation in Feet (NAVD 88 – 2001 Adjustment)			
FLOODING SOURCE AND LOCATION	**10% Annual Chance**	**2% Annual Chance[1]**	**1% Annual Chance[1,2]**	**0.2% Annual Chance[1]**
A100-00-00 (CLEAR LAKE AND CREEK)				
At Challenger 7 Memorial Park	9.00	11.90	14.60	20.00
At confluence of Tributary 10.08 to Clear Creek (A111-00-00)	9.00	11.90	14.50	19.40
At confluence of Ditch No. 5109-00-00)	9.00	11.90	14.60	18.30
At confluence of Cow Creek (A107-00-00)	9.00	12.00	14.70	18.20
Entire shoreline affecting City of Nassua Bay	9.00	11.70	14.80	19.00
At confluence of Armand Bayou (B100-00-00)	9.20	12.00	14.80	19.70
A104-00-00 (TAYLOR LAKE AND TAYLOR BAYOU)				
Entire shoreline affecting City of El Lago	9.20	12.40	15.20	20.10
At Red Bluff Road	9.10	12.30	15.00	20.10
At Port Road	8.90	11.90	14.60	19.90
At State Route 146	9.16	12.40	15.30	20.20
A107-00-00 (COW BAYOU)				
At the confluence with Clear Creek (A100-00-00)	9.10	12.10	14.90	19.80
At NASA Road 1	**	9.60	14.90	20.40
B100-00-00 (ARMAND BAYOU)				
At the confluence with Clear Lake (A100-00-00)	9.20	12.00	14.80	19.70
At Bay Area Boulevard	9.40	12.40	15.10	20.80
At confluence of B107-00-00	8.00	11.90	14.90	19.30

Table 6 – Summary of Coastal Elevations (cont'd)

FLOODING SOURCE AND LOCATION	Elevation in Feet (NAVD 88 – 2001 Adjustment)			
	10% Annual Chance	**2% Annual Chance**[1]	**1% Annual Chance**[1,2]	**0.2% Annual Chance**[1]
F200-00-00 (GALVESTON BAY)				
At mouth of Clear Lake (A100-00-00)	8.90	11.80	14.50	19.80
At Todville Road	9.20	12.40	15.20	20.10
At Meyer Road	9.40	12.00	14.70	20.00
At Pine Gully (F220-00-00)	9.30	11.70	14.60	20.00
At Port of Houston Terminal	9.00	11.70	14.40	20.10
At City of Shoreacres	9.16	12.40	15.30	20.20
At Little Cedar Bayou Park	8.90	11.30	14.20	18.30
At Sylvan Beach	8.90	11.30	14.20	18.10
At San Jacinto River, Houston Ship Channel (G100-00-00)	8.80	11.30	14.60	18.90
At Cedar Bayou (Q100-00-00)	8.40	10.50	13.30	17.30
F216-00-00 (LITTLE CEDAR BAYOU)				
Approximately 0.2 miles upstream of Old State Route 146	5.60	10.60	12.50	16.30
G100-00-00 (SAN JACINTO RIVER, HOUSTON SHIP CHANNEL)				
At confluence of Goose Creek (O100-00-00)	9.20	11.90	15.60	21.60
At State Highway 146	9.20	11.80	14.90	20.70
At northern portion of Black Duck Bay	9.20	11.80	15.60	21.20
At southern portion of Mitchell Bay	9.20	11.90	15.40	20.80
At Mitchell Bay	9.20	11.80	14.90	20.80
At Scott Bay	9.30	12.00	15.20	19.70
At Baytown Nature Center (Maple Avenue)	9.40	12.20	16.00	22.60
At Crystal Bay	9.50	12.00	16.00	22.40
At confluence of Spring Gully (O200-00-00)	9.50	12.40	15.70	20.30
Downstream side of State Route 134/Crosby Lynchburg Road	9.61	12.60	15.90	20.60
At San Jacinto State Park	9.50	12.40	16.30	22.60
G100-00-00 (BUFFALO BAYOU, HOUSTON SHIP CHANNEL)				
At confluence with San Jacinto River (G100-00-00)	9.60	12.60	16.30	22.20
At confluence of Boggy Bayou (G105-00-00)	9.80	13.00	16.40	20.90
At confluence of Greens Bayou (P100-00-00)	10.00	13.20	16.80	21.40
At confluence of Hunting Bayou (H100-00-00)	10.10	13.50	17.10	21.70
At confluence of Vince Bayou (I100-00-00)	10.10	13.60	17.20	21.80
At confluence of Sims Bayou (G110-00-00)	10.20	13.70	17.40	21.90

Table 6 – Summary of Coastal Elevations (cont'd)

FLOODING SOURCE AND LOCATION	Elevation in Feet (NAVD 88 – 2001 Adjustment)			
	10% Annual Chance	**2% Annual Chance[1]**	**1% Annual Chance[1,2]**	**0.2% Annual Chance[1]**
G100-00-00 (BUFFALO BAYOU, HOUSTON SHIP CHANNEL) (cont'd)				
At confluence of Brays Bayou (D110-00-00)	10.30	14.00	17.70	22.30
At confluence of Buffalo Bayou (W110 00-00)	10.40	14.30	18.10	22.80
At Lockwood Street	10.50	14.50	18.50	23.20
At Jensen Street	10.60	14.70	18.70	23.40
Upstream of Interstate Highway 10	10.60	14.80	18.70	23.50
G103-00-00 (SAN JACINTO RIVER)				
Across from Lynchburg Reservoir	9.70	12.60	16.0	20.60
Upstream of Interstate Highway 10	9.70	12.60	15.90	20.50
At Railroad Bridge	9.90	12.90	16.30	20.90
At confluence of Bear Bayou (G103-02-00)	9.90	13.00	16.40	21.10
At confluence of Bluff Gully (G103-03-00)	9.70	12.50	16.00	19.80
At Muleshoe Lake	9.50	12.20	16.00	19.10
At State Highway 90	9.50	12.20	15.00	19.20
At Beaumont Highway	9.50	12.20	15.10	19.10
At Dwight D Eisenhower Park	9.60	12.40	15.40	19.50
O100-00-00 (GOOSE CREEK)				
At Market Street	9.10	11.70	14.80	19.20
At State Highway 380	9.10	11.70	14.80	19.30
At State Highway 146	9.20	11.80	15.00	19.50
Q100-00-00 (CEDAR BAYOU)				
At confluence with Galveston Bay (F200-00-00)	8.40	10.50	13.30	17.30
At Missouri Pacific Railroad	8.70	11.00	13.90	18.20
At Ferry Road	8.80	11.10	14.10	18.50
At State Highway 146	8.80	11.10	14.10	18.60

[1] Stillwater elevation
** Data Not Available

3.5.4. Wave Height Analysis

Using storm surge study results, wave height analysis was performed to identify areas of the coastline subject to overland wave propagation or wave runup hazards (Reference 3.5.16). Figures 10a, 10b and 10c, "Transect Location Map", illustrates the location of transects in Harris County. Figure 11 shows a cross-section for a typical coastal analysis transect, illustrating the effects of energy dissipation and regeneration of wave action over inland areas. This figure shows the wave crest elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations, and being increased by open, unobstructed wind fetches. Figure 11 also illustrates the relationship between the local stillwater elevations, the ground profile, and the location of the VE/AE Zone boundary at the limit of 3 ft. breaking waves. This inland limit of the coastal high hazard area is delineated to ensure that adequate insurance rates apply and appropriate construction standards are imposed, should local agencies permit building in this coastal high hazard area. Table 7 summarizes the analysis results.

It has been shown in laboratory tests and observed in field investigations that wave heights as little as 1.5 feet can cause damage to and failure of typical Zone AE construction. Therefore, for advisory purposes only, a Limit of Moderate Wave Action (LiMWA) boundary has been added in coastal areas subject to wave action. The LiMWA represents the approximate landward limit of the 1.5-foot breaking wave.

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

In areas where wave runup elevations dominate over wave heights, such as areas with steeply sloped beaches, bluffs, and/or shore-parallel flood protection structures, there is no evidence to date of significant damage to residential structures by runup depths less than 3 feet. However, to simplify representation, the LiMWA was continued immediately landward of the VE/AE boundary in areas where wave runup elevations dominate.

Table 7 – Transect Data

FLOODING SOURCE AND LOCATION	Stillwater Elevation in Feet (NAVD 88) 10% Annual Chance	1% Annual Chance	Zone	Base Flood Elevation (Feet, NAVD 88)*
Clear Creek and Tributaries				
Transect 1	9	14.6	AE	14-16
			VE	
Transect 2-10	9	14.5	AE	13-16
			VE	17-18
Transect 11-13	9	14.3	AE	11-17
			VE	16-18
Clear Creek and Tributaries				
Transect 14-18	8.9	14.3	AE	11-15
			VE	16-17
Transect 19-20	8.9	14.2	AE	12-17
			VE	16-18
Transect 21-25	8.8	14.1	AE	12-16
			VE	16-18
Transect 26-28	8.7	13.9	AE	11-16
			VE	16-18
Transect 29-31	8.6	13.7	AE	11-16
			VE	16-18
Transect 32-35	8.5	13.4	AE	11-16
			VE	15-20
Galveston Bay				
Transect 36-39	8.6	13.6	AE	11-17
			VE	16-21
Transect 40	8.2	13.5	AE	11-16
			VE	16-20
Transect 41	8.4	13.6	AE	11-16
			VE	16-20
Transect 42	7.8	13.6	AE	11-17
			VE	16-19
Transect 43	8	13.4	AE	12-17
			VE	16-20
Transect 44	7.8	12.9	AE	12-16
			VE	15-19
Transect 45	8.6	13.5	AE	11-16
			VE	15-19
Transect 46-48	8.4	13.2	AE	11-15
			VE	15-20

Table 7 – Transect Data(cont'd)

FLOODING SOURCE AND LOCATION	Stillwater Elevation in Feet (NAVD 88) 10% Annual Chance	1% Annual Chance	Zone	Base Flood Elevation (Feet, NAVD 88)*
Transect 49	8.4	13	AE	12-15
			VE	15-18
Transect 50	8.5	13.3	AE	12-16
			VE	15-18
Transect 51	8.6	12.8	AE	10-16
			VE	15-17
Galveston Bay				
Transect 52	8.6	13.5	AE	11-16
			VE	16-20
Transect 53	8.6	13.6	AE	12-17
			VE	15-19
Transect 54-56	8.7	13.8	AE	12-17
			VE	16-19
Transect 57-60	8.8	13.9	AE	11-16
			VE	16-21
Transect 61-63	8.8	14	AE	11-16
			VE	16-20
Transect 64-76	8.9	14.1	AE	11-16
			VE	16-21
Transect 77-80	8.8	14	AE	14-16
			VE	16-21
Transect 81	8.4	13.2	AE	13-16
			VE	14-20
Transect 82	8.4	13.6	AE	1-16
			VE	16
Transect 83	8.5	13.4	AE	12-15
			VE	15-19
Transect 84-85	8.5	13.5	AE	13-16
			VE	15-19
Transect 86	8.6	13.6	AE	14-16
			VE	16-19
Transect 87-88	8.7	13.8	AE	14-16
			VE	16-20
Transect 89	8.8	12.3	AE	12-16
			VE	16-18
Transect 90	8.7	13.8	AE	
			VE	18-19
Transect 91	8.7	13.9	AE	15-16
			VE	16-20
Transect 92	8.8	14	AE	16
			VE	16-19
Transect 93	8.8	14.1	AE	15-16
			VE	16-20

Table 7 – Transect Data(cont'd)

FLOODING SOURCE AND LOCATION	Stillwater Elevation in Feet (NAVD 88) 10% Annual Chance	1% Annual Chance	Zone	Base Flood Elevation (Feet, NAVD 88)*
Galveston Bay (cont'd)				
Transect 94	8.9	14.1	AE	11-16
			VE	16-19
Transect 95-96	8.9	14.3	AE	11-16
			VE	16-19
Transect 97-100	9	14.5	AE	11-17
			VE	16-19
Transect 101-105	9.2	14.8	AE	12-17
			VE	17-19
Ship Channel				
Transect 106	9.2	15	AE	14-17
			VE	17-18
Transect 107-110	9.3	15.1	AE	13-17
			VE	17-20
Transect 111-114	9.4	15.5	AE	16-17
			VE	17-21
Transect 115	9.5	15.3	AE	16-18
			VE	18-20
Transect 116	9.5	15.7	AE	
			VE	17-20
Transect 117-120	9.5	15.6	AE	15-18
			VE	17-21
Transect 121-123	9.6	15.7	AE	14-18
			VE	16-22
Transect 124-125	9.6	16	AE	17-18
			VE	18-21
Transect 126	9	16.7	AE	18
			VE	18-22
Transect 127	9.3	16	AE	16-17
			VE	17-21
Transect 128	9.5	16.2	AE	15-17
			VE	17-22
Transect 129	9.6	15	AE	16-17
			VE	17-19
Transect 130-131	9.7	15.9	AE	17
			VE	
Transect 132-134	9.7	16	AE	15-18
			VE	18-20
Transect 135	9.7	15.9	AE	17
			VE	
Transect 136	9.7	16	AE	15-18
			VE	18-20
Transect 137-139	9.7	15.9	AE	16-18
			VE	17-19

Table 7 – Transect Data(cont'd)

FLOODING SOURCE AND LOCATION	Stillwater Elevation in Feet (NAVD 88) 10% Annual Chance	1% Annual Chance	Zone	Base Flood Elevation (Feet, NAVD 88)*
Ship Channel (cont'd)				
Transect 140	9.7	16	AE	
			VE	18-19
Transect 141	9.7	16	AE	18
			VE	18
Transect 140-143	9.8	16.1	AE	16-18
			VE	18-20
Transect 144-146	9.8	16.2	AE	12-19
			VE	16-21
Transect 147	9.5	16.2	AE	13-18
			VE	16-21
Transect 148-149	9.9	16.5	AE	11-19
			VE	17-22
Transect 150	9.9	16.4	AE	
			VE	19-20
Transect 151	9.9	16.3	AE	17-18
			VE	18-20
Transect 152	9.93	16.4	AE	16-18
			VE	18-20
Transect 153-154	9.7	16.2	AE	15-19
			VE	17-21
Transect 155	9.5	16.25	AE	17-19
			VE	19-20
Transect 156	9.7	16	AE	16-18
			VE	18-20
Transect 157	9.5	15.2	AE	17-18
			VE	17-18
Transect 158	9.8	16.25	AE	16-18
			VE	
Transect 159	9.9	16.3	AE	16-18
			VE	18
Transect 160	9.9	16.4	AE	17-18
			VE	
Transect 161	9.74	16.3	AE	17
			VE	
Transect 162	9.8	16.1	AE	1-19
			VE	18-19
Transect 163	9.7	15.6	AE	12-17
			VE	17-19
Transect 164	9.7	16.1	AE	15-18
			VE	
Transect 165	9.7	16	AE	15-18
			VE	18-19
Transect 166-168	9.6	15.9	AE	15-18
			VE	16-21

Table 7 – Transect Data(cont'd)

FLOODING SOURCE AND LOCATION	Stillwater Elevation in Feet (NAVD 88) 10% Annual Chance	1% Annual Chance	Zone	Base Flood Elevation (Feet, NAVD 88)*
Ship Channel (cont'd)				
Transect 169	9.5	15.7	AE	16-18
			VE	17-21
Transect 170-171	9.5	15.6	AE	11-18
			VE	18-21
Transect 172-174	9.4	15.5	AE	11-18
			VE	16-20
Transect 175	9.3	15.3	AE	15-18
			VE	18-20
Transect 176-177	9.3	15.1	AE	15-17
			VE	17-18
Transect 178	9.2	15	AE	
			VE	17-19
Transect 179	9.2	14.8	AE	15-17
			VE	17-19
Transect 180	9.1	14.6	AE	15-17
			VE	17-18

*Because of map-scale limitations, base flood elevations shown on the DFIRM may represent average elevations for the zones depicted.

A set of 0.2-percent annual chance wave envelope profiles along transects which have a 0.2-percent annual chance wave envelope has been added to this FIS. Please note, not all transects have a 0.2-percent annual chance wave envelope profile. For those transects that do not appear in the FIS with a 0.2-percent annual chance wave envelope profile there was no starting 0.2-percent annual chance stillwater elevation.

3.5.5. Combined Probability Analysis

Certain areas are affected by both riverine and coastal flooding. These areas are identified on the Flood Profiles and in the Floodway Data Table in this report as Combined Probability or Combined Flooding areas In these areas, for specific elevations, the recurrence intervals of separate events were added together to find the recurrence interval for the combined event.

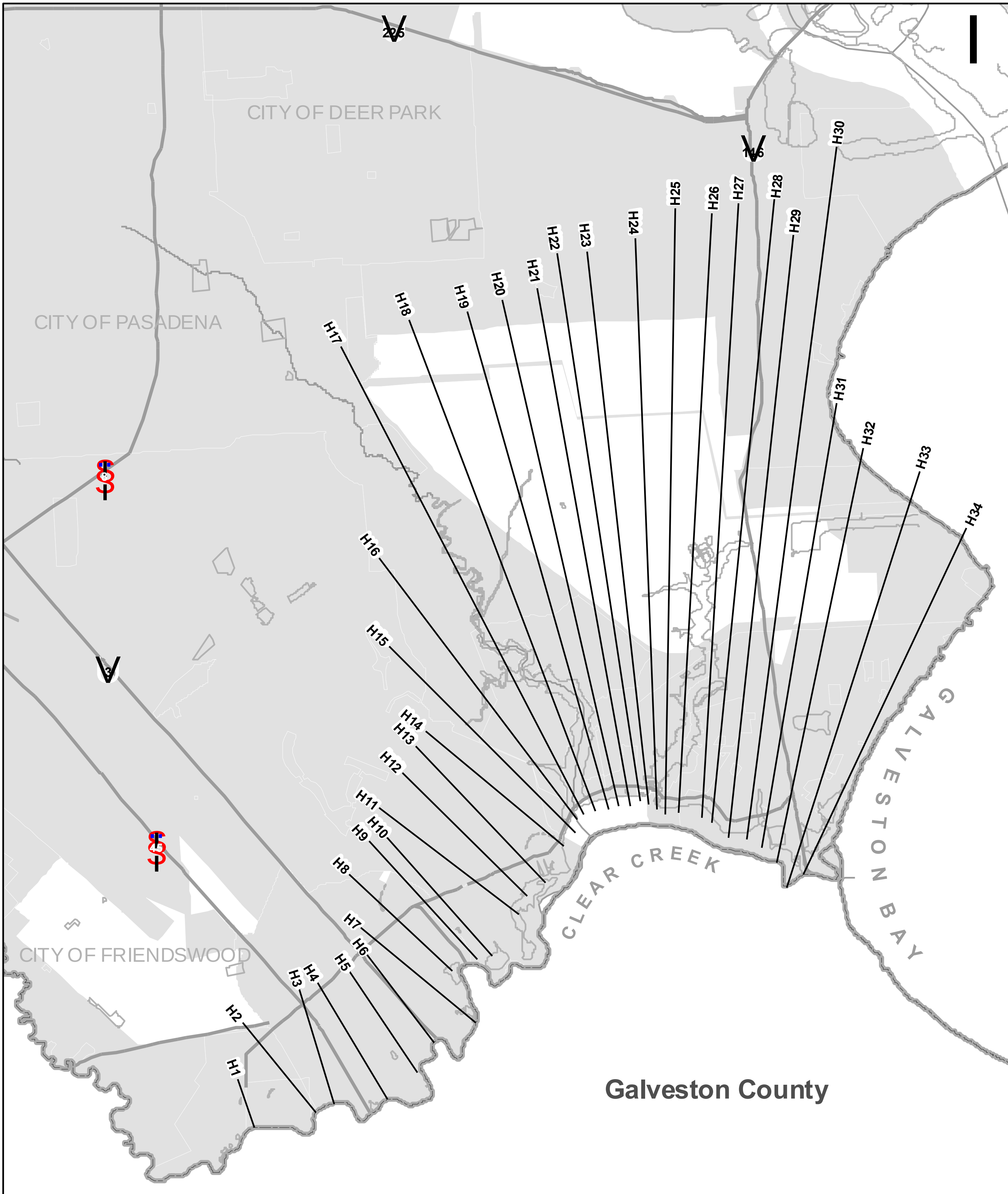

Figure 10a

Federal Emergency Management Agency

HARRIS COUNTY, TX

AND INCORPORATED AREAS

APPROXIMATE SCALE

2 1 0 2 Miles

TRANSECT LOCATION MAP - CLEAR CREEK

Figure 10b

Federal Emergency Management Agency

HARRIS COUNTY, TX
AND INCORPORATED AREAS

TRANSECT LOCATION MAP - GALVESTON BAY

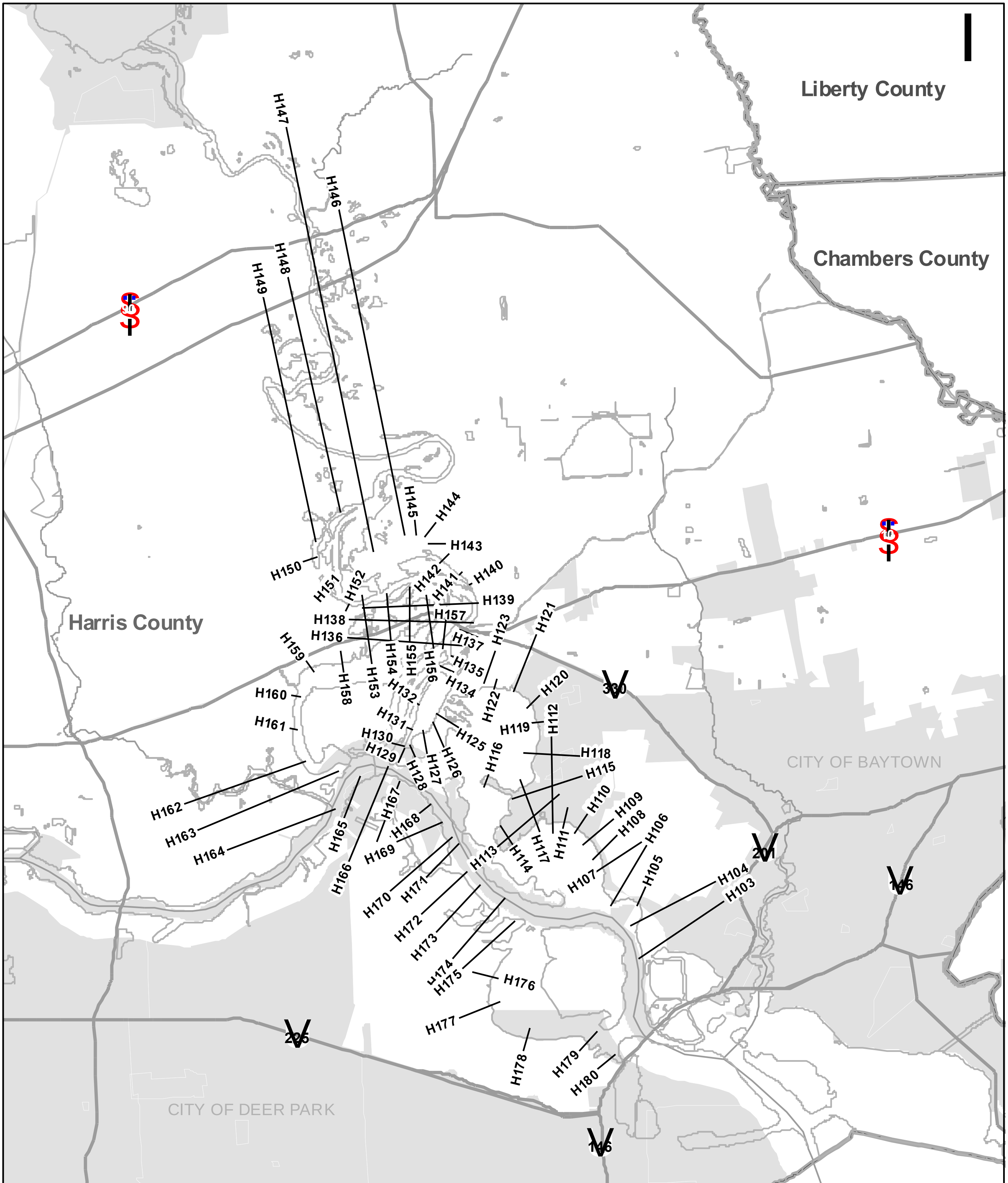

Figure 10c

Federal Emergency Management Agency

HARRIS COUNTY, TX

AND INCORPORATED AREAS

APPROXIMATE SCALE

2 1 0 2 Miles

TRANSECT LOCATION MAP - SHIP CHANNEL

The following equation was used:

$$TR_{combined} = \frac{1}{\frac{1}{TR_{riverine}} + \frac{1}{TR_{surge}}}$$

where $TR_{riverine}$ is the recurrence interval of the riverine event at a specific elevation, TR_{surge} is the recurrence interval of the tidal event at the same elevation, and $TR_{combined}$ is the recurrence interval of the combined riverine and tidal event at the same elevation.

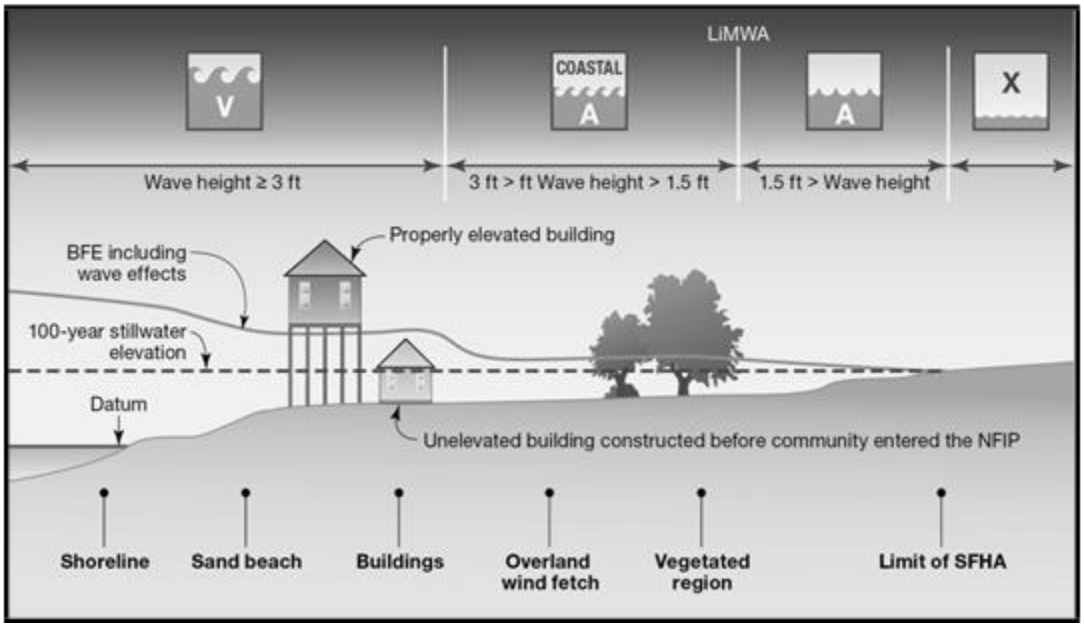

Figure 11. Transect Schematic

3.6 Light Detection and Ranging (LiDAR)

Light Detection and Ranging (LiDAR) system technology was used to collect and produce the topographic base data for Harris County. TerraPoint, LLC provided these LiDAR data collection and processing services. TerraPoint used their custom-built, Airborne Laser Topographic Mapping System (ALTMS) LiDAR to collect approximately 2,200 square miles of the project area which encompassed all of Harris County, Texas and a one-mile buffer around the county boundary. The LiDAR data were collected over a 20-day period in October and November of 2001. Fall in southeastern Texas is still considered “leaf-on” conditions, since foliage and underbrush remain quite dense until mid-winter. The LiDAR data collection followed specifications listed in “FEMA Guidelines and Specifications for Study Contractors, Appendix 4B” (November 1997) (Reference 3.6.1). Following these requirements, the LiDAR data were specified to have multi-returns with data collection at three-meter postings (1.5 meter or better) and 15 centimeter Root Mean Squared Error (RMSE) in open, level areas. TerraPoint requested and was granted an exception to the complete specification for an allowance of a lesser RMSE for areas other than open, level areas.

TerraPoint requested and was granted an exception to the complete specification for an allowance of a lesser RMSE for areas other than open, level areas, since the data were acquired in "leaf-on" conditions and penetration of the LiDAR laser might have been impaired.

The ALTMS system includes a coherent infra-red, laser light source which is pulsed out to the earth's surface at a rate of 20,000 pulses per second and received as reflected energy from the earth back to the processing unit. A pulsed laser is directed out of the aircraft by a 10-sided, rotating mirror. This mirror presents an even distribution of laser pulses to the earth's surface in a regular distribution grid both along the swath track and across the track. The LiDAR unit also consists of a Global Positioning System (GPS) to record latitude and longitude location, and Inertial Measurement Unit (IMU) to measure the roll, pitch, and yaw of the aircraft.

When the landscape intercepts the laser pulse, it is reflected back to the aircraft and recorded. Laser pulses may reflect from trees and vegetation, structures or buildings, or be reflected back from the open ground. Laser pulses can also penetrate through holes or gaps in the vegetation canopy and be reflected back to the aircraft. Water and some dark surfaces can absorb the laser pulse rather than reflect it back to the aircraft. The time interval between the laser pulse leaving the aircraft and the return of the terrain-reflected-pulse back to the sensor is measured precisely. In post-flight data processing, the LiDAR time interval measurements are converted to distance and subsequently referenced to the aircraft's GPS and IMU, and ground-based reference GPS stations. The GPS data is used to accurately determine the aircraft position in longitude, latitude, and altitude using the NAVSTAR constellation of orbiting satellites. These data are used to calculate the laser beam exit geometry. By combining the LiDAR, GPS, and IMU data, digital terrain maps of the earth can be accurately derived.

The Primary Control Network for the project consisted of four semi-permanent GPS base station installations: WEST, HKS1 (David Wayne Hooks Airport), TPNT (TerraPoint Woodlands Office), and EST1; three CORS sites: PID AW5607 (Houston), AA9861 (Lake Houston), AA9859 (Northeast 2250); five Harris-Galveston Coastal Subsidence District (H-GCSD) benchmarks: (PID AW1723, AW5431, AW5634, BL1989 and BL2031); and one NGS survey marker (PID AW1555). The HGCSD benchmarks and NGS survey markers were selected based on location, accessibility, suitability for GPS observation, and in part because of the work completed in 2000 for Texas Department of Transportation. The benchmarks and survey markers were re-observed by GPS, and combined with observations from the semi-permanent base stations and the CORS sites in one integrated network adjustment. In the adjustment, the Houston CORS site was fixed horizontally to NGS published latitude and longitude. The Lake Houston CORS was fixed vertically to an ellipsoidal height of –7.06m. The geoidal undulation model, GEOID99, was used in the adjustment to derive orthometric heights.

The kinematic GPS acquired with the LiDAR data on each flight was processed with GPS from the base station installations at WEST, HKS1, or EST1. All three base stations operated continuously. The base station nearest in proximity to the flight lines completed during a mission was used as the Master Station for the GPS processing to determine aircraft position.

In addition to the GPS base station set-up and maintenance, 143 RMSE checkpoints were collected using traditional RTK survey techniques across the project area before the LiDAR flights were completed. Twenty-two RMSE survey points were collected in each of the following vegetation categories: bare earth/urban, deciduous/coniferous trees, mixed brush, and tall grass.

The LiDAR system and aircraft flew at 3,200 feet above ground level, at approximately 150 knots following a north/south flightline pattern of 258 flightlines across the project area. In addition to the collection flightlines, several cross lines were also flown. The data from the cross lines were integrated into the complete, raw data set. Flightlines were laid out with a 30 percent overlap between lines to eliminate slivers or issues with navigation. LiDAR data were collected starting on the west side of the county primarily at night between 11 pm and 4 am when air traffic was at a minimum.

Five topographic products were produced for the project which included: raw LiDAR data as X, Y, and Z points; a full-featured Digital Terrain Model (DTM) model as grids; a bare earth Digital Elevation Model (DEM) as 15 foot grids; stream centerlines and top of bank breaklines; and a 2-foot contour line product.

The collected raw LiDAR data were loaded into the TerraScan software and an initial automated process was run to preliminarily separate data into bare earth and other categories. The LiDAR points were then extracted from the TerraScan files and DTM grid files were created with ESRI ArcInfo software. A subset of the DTM consisting of the bare-earth points was resampled on a 15-foot by 15-foot grid to create a DEM model. Where three or more points were contained within a grid cell, the lowest three were averaged to determine the elevation for that grid and produce the final DEM deliverable product. Iterative reviews by Study Contractors then resulted in several rounds of "mowing" the bare earth DEM product to ensure that it met the needs of the project.

A comparison between the LiDAR data and the field survey of over 10,000 cross sections was made. Areas along the channel with vertical discrepancies of greater than two feet near the channel high banks were flagged for consideration of additional review and possible enhancement to the DEM. These discrepancies resulted primarily from dense trees that overhung the channel. Penetration to the earth's surface of the LiDAR laser was limited by the foliage and, in some instances, there were no returns at the ground. LiDAR systems do not penetrate and receive returns from water or wet, damp surfaces; therefore, the field survey was integrated into the DEM to enhance the data.

Once all DEM reviews were complete, the RMSE for the LiDAR DEM was calculated, resulting in a 14.22 cm for tree canopy, 16.02 cm for mixed brush and 15.18 for tall grass. The overall Bare Earth RMSE was 13.55 cm.

Top of bank and stream centerline breaklines along with 2-foot contours were created from a bare-earth subset of the DTM and verified with checks against available aerial photography. Contour lines were created with limited cartographic smoothing and vertex weeding. In areas of poor LiDAR penetration along streams, the 2-foot contours were manually adjusted using points from the survey cross sections and from the stream centerline breaklines, which forced a water flow path resulting in hydro-conscious contours.

After the raw contour lines were produced, closed contours with a perimeter of less than 250 feet were eliminated. These extraneous contours often represented vegetation artifacts that remained in the DTM. Aerial photography was also used to identify highly vegetated areas where extra cleanup of the contour lines was performed.

3.7 Base Map

All 31 communities located within Harris County, Texas were included in the base map, which consists of over 1,700 sq. mi. of area, 14,270 mi. of roadways, 2,600 mi. of streams, 560 parks covering 52,000 acres, 1,500 mi. of railroads, and the political boundaries. Data from each of the 31 communities, the Houston-Galveston Area Council, Texas Department of Transportation, USGS, TIGER, and the Harris County Appraisal District was received in

ArcView 3.2, ArcGIS 8.2, AutoCAD, Microstation, and hardcopy formats. The data behind the Base map encompasses all of Harris County as well as a two-mile buffer outside of the county limits.

All 31 communities received written notification about the project as well as a request for information related to street centerlines, parks, and corporate limits within their prospective communities. The data sets subsequently submitted by the cities depended entirely on the technical capabilities of each city. Therefore, a variety of formats were submitted for review and incorporation into the base map. These formats included hard copy faxes, hand annotated blue-lines, AutoCAD drawings, and spatially referenced shapefiles. Many of the faxed submissions lacked clarity and were difficult to inspect. Most cities that submitted electronic formats lacked the correct projection system defined by the project scope. Therefore, all electronic submission had to be converted into the project defined projection system and then overlaid on the existing base map and aerials. Submitted data provided by each city or Harris County were integrated into the base map.

Differences in the submissions posed major problems when it came to delineating corporate limits. Adjacent communities would often both claim the same area as theirs and orphan other areas. Different individuals within a city often disagreed as to the location or name of a feature. Draft versions with all updates were submitted back to each individual city for review and comment on their prospective map. All significant issues were resolved.

The base map originated from a street center line coverage provided by the Houston-Galveston Area Council (H-GAC); this coverage is known as the STAR*Map (Reference 3.7.1). Unfortunately, the STAR*Map did not meet the minimum FEMA specifications, as stated in "Guidelines and Specifications for Flood Hazard Mapping Partners," Appendix L (Reference 3.7.2). Therefore, this map was rectified to the January 1999 aerials (Reference 3.7.3). These digital raster images were processed on a 0.5-meter resolution, and claimed an accuracy of +/-10 feet. These aerial photographs determined the overall projection system for the project, which was State Plane, NAD83, Texas South Central. This aerial photography was used to rectify roadways, railroads, parks, and airports. Other major submissions included the data provided by the City Houston, and HCFCD (Reference 3.7.4).

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS provides 1-percent-annual-chance (100-year) flood elevations and delineations of the 1- and 0.2-percent-annual-chance (100- and 500-year) floodplain boundaries and 1-percent-annual-chance (100-year) floodway to assist communities in developing floodplain management measures. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles and Floodway Data Table. Users should reference the data presented in the FIS report as well as additional information that may be available at the local repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance (500-year) flood is employed to indicate additional areas of flood risk in the 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. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1 inch = 1,000 feet, with a contour interval of 2 feet (Reference 4.1.1).

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

There are no streams studied by approximate methods shown on the FIRM.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent 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 (see Table 8, "Floodway Data"). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent 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 12.

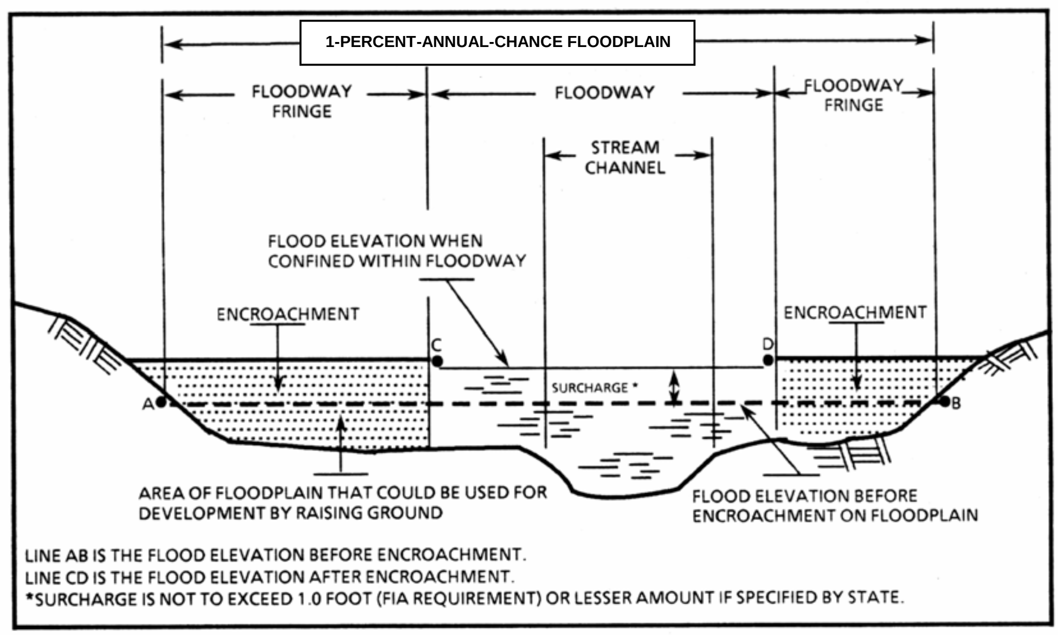

Figure 12. Floodway Schematic

No floodway was computed for D109-00-00 (Harris Gully) because the stream is fully enclosed.

5.0 INSURANCE APPLICATION

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 by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no 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 by detailed methods. 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 areas of 1-percent shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 foot and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 1-percent 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 sq. mi., and areas protected from the 1.0-percent flood by levees. No BFEs or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

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

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use the 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-percent and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The countywide FIRM presents flooding information for the entire geographic area of Harris County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the County identified as flood-prone. Historical data relating to the maps prepared for each community prior to their inclusion in the initial countywide FIS are presented in Table 9, “Community Map History.”

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	INITIAL FIRM DATE	FIRM REVISION DATE(S)
Baytown, City of	February 26, 1970	None	February 26, 1970	July 1, 1974 November 14, 1975 February 9, 1979 November 15, 1985 March 4, 1987
Bellaire, City of	June 28, 1974	June 14, 1977	September 30, 1981	May 4, 1987
Bunker Hill Village, City of[1]	May 3, 1974	March 26, 1976	April 17, 1979	March 16, 1981
Deer Park, City of	August 9, 1974	None	August 15, 1980	February 1, 1984

[1]No Special Flood Hazard Areas identified

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	INITIAL FIRM DATE	FIRM REVISION DATE(S)
El Lago, City of	July 2, 1971	None	July 2, 1971	July 1, 1974 July 11, 1975 December 15, 1974
Galena Park, City of	February 21, 1975	November 19, 1976	November 2, 1982	None
Harris County (Unincorporated Areas)	May 26, 1970	None	May 26, 1970	March 10, 1972 July 1, 1974 July 30, 1976 February 24, 1981 March 30, 1982 September 27, 1985 February 4, 1988

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	INITIAL FIRM DATE	FIRM REVISION DATE(S)
Hedwig Village, City of[1,2]	N/A	None	N/A	None
Hilshire Village, City of [2]	N/A	None	N/A	None
Houston, City of	December 27, 1974	March 10, 1972 July 1, 1974 July 30, 1976 April 8, 1977	December 11, 1979	September 21, 1982 September 27, 1985 September 4, 1987
Humble, City of	November 29, 1977	None	September 16, 1982	None
Hunter's Creek Village, City of	May 10, 1974	December 17, 1976	November 5, 1980	None
Jacinto City, City of	June 28, 1974	None	September 2, 1981	None

[1]No Special Flood Hazard Areas identified

[2]This community does not have map history prior to the September 28, 1990 countywide mapping

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	INITIAL FIRM DATE	FIRM REVISION DATE(S)
Jersey Village, City of	April 5, 1974	June 27, 1975	March 15, 1982	April 3, 1985
La Porte, City of	February 17, 1971	None	February 17, 1971	July 1, 1974 July 11, 1975 August 22, 1975 November 1, 1985
Missouri City, City of	January 17, 1975	October 25, 1977	January 6, 1982	December 17, 1987

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	INITIAL FIRM DATE	FIRM REVISION DATE(S)
Morgans Point, City of	June 28, 1974	September 19, 1975	December 1, 1983	None
Nassau Bay, City of	November 17, 1970	None	November 17, 1970	July 1, 1974 July 11, 1975 September 5, 1975 July 23, 1976 March 15, 1984
Pasadena, City of	May 24, 1974	None	May 24, 1974	July 1, 1974 November 7, 1975 April 23, 1976 June 3, 1986
Pearland, City of	January 31, 1975	August 13, 1976	July 5, 1984	None

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	INITIAL FIRM DATE	FIRM REVISION DATE(S)
Piney Point Village, City of	June 28, 1974	None	December 2, 1980	None
Seabrook, City of	May 26, 1970	None	May 26, 1970	July 1, 1974 August 22, 1975 March 1, 1984
Shoreacres, City of	November 20, 1970	None	November 20, 1970	July 1, 1974 September 19, 1975 February 16, 1982 May 15, 1984
South Houston, City of	June 28, 1974	October 17, 1975	March 18, 1987	None
Southside Place, City of[1]	N/A	None	N/A	None

[1]This community does not have map history prior to April 20, 2000 countywide mapping

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	INITIAL FIRM DATE	FIRM REVISION DATE(S)
Spring Valley Village, City of	June 28, 1974	December 3, 1976	June 4, 1980	None
Stafford, City of	March 1, 1982	None	March 1, 1982	None
Taylor Lake Village, City of	August 27, 1970	None	November 13, 1970	July 1, 1974 September 5, 1975 June 6, 1980
Tomball, City of	January 24, 1975	None	December 18, 1984	None

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	INITIAL FIRM DATE	FIRM REVISION DATE(S)
Webster, City of	May 19, 1972	None	May 19, 1972	July 1, 1974 June 10, 1977 February 27, 1981 June 15, 1984
West University Place, City of[1]	N/A	None	N/A	June 18, 2007

[1]This community does not have map history prior to April 20, 2000 countywide mapping

TABLE 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

There is one other known study underway in Harris County. There are ongoing Flood Insurance Studies in the adjacent counties: Brazoria, Chambers, Fort Bend, Galveston, Liberty, Montgomery, and Waller.

This report either 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 FEMA, Mitigation Division, Federal Regional Center, Room 206, 800 North Loop 288, Denton, Texas 76201-3698.

9.0 BIBLIOGRAPHY AND REFERENCES

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2.2.4 http://www.tmc.edu/tmc-facts.html (Texas Medical Center)

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2.3.1 http://www.wordiq.com/definition/Great Galveston Hurricane

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3.5.13 Aerial Photos, Scale 1": 18,000', Wallace Aerial Survey, Inc., Houston, Texas, February 1980.

3.5.14 LiDAR/2-Foot Contour Data (DVD), Harris County Flood Control District, Houston, Texas, June 19, 2003.

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10.1.3 LiDAR/2-Foot Contour Data (DVD), Harris County Flood Control District, Houston, Texas, June 19, 2003.

10.0 <u>REVISION DESCRIPTIONS</u>

This section has been added to provide information regarding significant revisions made since the original FIS was printed. Future revisions may be made that do not result in the republishing of the FIS report. To assure that user is aware of all revisions, it is advisable to contact the community repository of flood-hazard data listed on the FIRM Index.

10.1 Fifth Revision - October 16, 2013

This Physical Map Revision (PMR) revised the map panels associated with the Cypress Creek watershed. The PMR is a continuation of the publication of Letter of Map Revision (LOMR) Case Number 08-06-2369P submitted by the Harris County Flood Control District. This LOMR incorporated updated hydrologic and hydraulic information reflecting additional model calibration along the entire reach of Cypress Creek and its tributaries. Under contract No. HSFEHQ-09-D-0369 to FEMA, RAMPP incorporated the LOMR into the FIRMs and FIS. This work was completed in September 2010.

Base map used for this PMR was provided in digital format by the Harris Galveston Area Council and was revised and enhanced by Harris County.

For this PMR, an initial CCO meeting was held on April 15, 2010, and was attended by representatives of the community, the study contractor, and FEMA. A final CCO meeting was held on November 10, 2010, and attended by representatives of the community, the study contractor, and FEMA. All problems raised at that meeting have been addressed in this study.

The hydrologic analysis was completed using the U.S. Army Corps of Engineers (USACE) HEC-HMS Version 3.4 computer program (Reference 10.1.1). The revised HEC-HMS 3.4 analysis was included in a submittal by Dodson & Associates, Inc., for the Harris County Flood Control District in 2008.

Along Cypress Creek, the discharges are higher downstream of tributary K140-00-00 and are lower upstream of K140-00-00 as compared to the previously determined discharges. A summary of the revised drainage area-peak discharge relationships for the Cypress Creek watershed is shown in Table 10, "Revised Summary of Discharges".

The revised hydraulic analysis used the USACE HEC-RAS 3.1.3 computer program (Reference 10.1.2). Cross sections for the backwater analysis were obtained from previous effective hydraulics models. Roughness coefficients (Manning's "n" values) used in the hydraulic computations shown in Table 11, “Revised Summary of Roughness Coefficients”, were revised based on engineering judgment and based on field observations of the stream and floodplain areas. The resulting water-surface elevations are higher upstream of House Hahl Road and lower downstream.

Floodplain boundaries were delineated using Harris County’s LiDAR data collected in 2001 (Reference 10.1.3).

Table 8, "Floodway Data," and Exhibit 1, "Flood Profiles," were revised to reflect changes as a result of the restudy.

Table 10. Revised Summary of Discharges - Fifth Revision

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharge (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
K100-00-00 (CYPRESS CREEK)					
At mouth	319.47	16,085	25,383	30,412	42,956
Downstream of K116-00-00 Confluence	296.66	14,731	23,150	27,499	38,181
Downstream of K1200-00-00 Confluence	291.12	13,902	21,696	25,704	35,569
Downstream of K124-00-00 Confluence	280.28	11,901	19,231	22,819	32,902
Downstream of K131-00-00 Confluence	262.62	10,684	17,353	20,832	31,725
Downstream of K133-00-00 Confluence	245.07	9,193	15,178	18,260	27,400
Downstream of K140-00-00 Confluence	234.76	7,729	12,841	15,552	24,336
Upstream of K142-00-00 Confluence	214.54	6,223	10,932	14,112	24,026
Upstream of L100-00-00 Confluence	157.27	3,451	5,437	6,740	10,283
Downstream of K145-00-00 Confluence	151.20	3,197	5,437	6,797	10,619
At Fry Road	139.48	2,329	3,587	4,469	7,184
Downstream of K155-00-00 Confluence	119.59	2,480	3,707	4,156	5,404
At Katy Hockley Road	109.98	3,012	4,288	5,361	8,893
At stream mile 43.44	89.41	2,959	4,674	5,718	9,068
At stream mile 46.33	79.34	6,556	12,896	16,840	28,948
At steam mile 49.8*	67.34	10,774	19,260	23,901	38,202
At stream mile 51.9	47.34	9,421	16,341	19,943	31,059
K111-00-00 (TURKEY CREEK)					
At mouth	12.40	4,166	6,892	8,051	11,916
Downstream of K111-03-00 Confluence	10.46	3,811	6,129	7,186	10,497
At Hardy Toll Road	4.58	1,842	2,835	3,317	4,788
At stream mile 6.15	0.89	580	860	1,060	1,530
K131-00-00 (Spring Gully)					
At mouth	13.51	4,482	6,944	8,222	11,934
Downstream of K131-03-00 Confluence	6.46	1,474	2,314	2,724	3,997
Upstream of K131-03-00 Confluence	4.90	941	1,483	1,770	2,587

*Overflow occurs downstream from here into Addicks reservoir

Table 10. Revised Summary of Discharges - Fifth Revision (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharge (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
K131-00-00 (Spring Gully)(cont'd)					
At stream mile 3.39	1.07	614	956	1,156	1,662
At stream mile 3.97	0.33	353	541	665	937
K150-00-00 (TRIBUTARY 36.6 TO CYPRESS CREEK)					
At mouth*	5.15	358	665	992	1,478
Approximately 1,500 feet upstream of Kirby's Knack Drive*	4.62	273	451	641	852
Approximately 3,200 feet upstream of Kirby's Knack Drive	3.62	242	516	714	1,320
Approximately 8,750 feet upstream of Kirby's Knack Drive	2.50	192	407	548	1,029
K150-01-00 (TRIBUTARY 36.6-A TO CYPRESS CREEK)					
At mouth*	1.17	385	470	494	530
Approximately 6,500 feet upstream of North Bridgelands Lake Parkway	0.37	52	158	216	363
K152-00-00 (TRIBUTARY 37.1 TO CYPRESS CREEK)					
At mouth	1.93	79	155	202	356
K155-00-00 (TRIBUTARY 40.7 TO CYPRESS CREEK)					
At mouth	4.17	342	717	963	1,796
At stream mile 1.43	3.03	177	371	499	930
At stream mile 2.36	2.35	167	349	463	874
At stream mile 3.48	1.43	138	289	389	725
K157-00-00 (TRIBUTARY 42.7 TO CYPRESS CREEK)					
At mouth	8.44	528	1,139	1,533	2,901
At stream mile 2.48	6.13	379	797	1,071	2,014
At stream mile 3.27	4.93	299	617	829	1,551
At stream mile 3.78	4.17	292	603	810	1,516
K160-00-00 (ROCK HOLLOW)					
At mouth	11.13	928	1,624	2,062	3,465
At stream mile 1.75	9.27	685	1,271	1,624	2,754
At Warren Lake**	4.76	53	99	209	835

* Discharges are attenuated due to storage in Amenity Lakes

** Flow reductions from Warren Lake

Table 10. Revised Summary of Discharges - Fifth Revision (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharge (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
K160-00-00 (ROCK HOLLOW) (cont'd)					
At Warren Ranch Road	3.52	236	497	670	1,265
At Mound Road	3.14	206	434	584	1,103
K160-01-00 (TRIBUTARY 1.63 TO ROCK HOLLOW)					
At mouth	3.32	341	686	904	1,622
At stream mile 1.76	2.05	222	447	589	1,057
At stream mile 2.80	1.41	188	379	499	896
K166-00-00 (MOUND CREEK)					
At mouth	35.58	7,040	12,628	15,740	24,708
At stream mile 5.3	31.55	6,583	11,679	14,440	22,348
At stream mile 8.09	22.71	5,468	9,106	11,010	16,544
K185-00-00 & K172-00-00 (TRIBUTARY 44.5 TO CYPRESS CREEK)					
At mouth	7.01	413	885	1,198	2,278
At stream mile 1.31	6.37	367	787	1,065	2,025
At stream mile 2.36	5.28	271	582	788	1,497
At stream mile 3.09	4.49	252	540	731	1,390
At stream mile 3.93	2.16	123	264	357	679
At stream mile 4.90	1.26	83	178	242	459
At stream mile 5.31	0.58	78	167	226	429

Table 11. Revised Summary of Roughness Coefficients – Fifth Revision

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Overbanks
K100-00-00	Cypress Creek	0.0188-0.140	0.014-0.560
K131-00-00	Spring Gully	0.020-0.120	0.026-0.140
K150-00-00	Tributary 36.6 to Cypress Creek	0.013-0.050	0.060-0.100
K150-01-00	Tributary 36.3-A to Cypress Creek	-	-
K160-00-00	Rock Hollow	0.026-0.080	0.026-0.120

This revision also incorporates the determinations of Letters of Map Revision (LOMRs) issued by FEMA for the projects listed by community in Table 12, "Letters of Map Revision." These changes are also reflected in Table 8, "Floodway Data", and Exhibit 1, "Flood Profiles". Please note that this table only includes LOMRs that have been issued on the FIRM panels updated by this map revision. For all other areas within this county, users should be aware that revisions to the FIS report made by prior LOMRs may not be reflected herein and users will need to continue to use the previously issued LOMRs to obtain the most current data.

Table 12. Letters of Map Revision – Fifth Revision

Case No.	Date Issued	Project Identifier	Revised Map Panels	Revised FWDTs	Revised Profiles
07-06-1885P	11/28/2008	9,000 Acre Bridgelands Development, Phase 1 Project	48201C0415M & 48201C0405M	K150-00-00 & K150-01-00	K42P, K43P, & K44P
08-06-0268P	12/23/2008	Canyon Lakes West Langham Creek Phase One Improvements	48201C0415M & 48201C0420M	U100-00-00	U04P & U05P
08-06-1092P	8/29/2008	Faulkey Gully LOMR Request	48201C0220L* 48201C0240M	K142-00-00	N/A
09-06-1932P	6/26/2009	370-Acre Cheng Tract	48201C0235M 48201C0255L**	J100-00-00	N/A
10-06-0650P	5/27/2010	Jarvis Road Bridge	48201C0410M	K145-00-00	K40P
10-06-0320P	01/12/2011	Ella Boulevard	48201C0265M	K124-00-00	K24P
10-06-2260P	01/07/2011	Cypress Rose Hill Road Over Dry Creek	N/A	K145-00-00	K41P
12-06-1133P	03/28/2013	Fair Grange Lane Bridge	48201C0415M	U100-00-00	U04P
12-06-2603P	01/28/2013	Dowdell WWTP Bridge	48201C0235M	M100-00-00	M03P & M04P
12-06-2710P	01/22/2013	Ella Boulevard	48201C0265M	K124-00-00	K24P

*LOMR only incorporated on panel 48201C0240M. The portion of the LOMR located on panel 48201C0220L will be reflected in a reissued version of the LOMR following publication of the revised FIRM.

**LOMR only incorporated on panel 48201C0235M. The portion of the LOMR located on panel 48201C0255L will be reflected in a reissued version of the LOMR following publication of the revised FIRM.

Case number 07-06-1885P also includes revision to the "Summary of Discharges" table, "Summary of Roughness Coefficients" table, "Scope of Study" table and "Summary of Stillwater Elevations" table (titled "Summary of Reservoir Elevations" in the FIS document) as shown in Tables 10, 11, 13 and 14.

Table 13. Revised Scope of Study – Fifth Revision

HCFCD Designation	Stream Name	Receiving Body	Stream Mile	
			From	To
K150-01-00	Tributary 36.6-A to Cypress Creek	K100-00-00	0	1.23

Table 14. Revised Summary of Stillwater Elevations – Fifth Revision

	Peak Elevations (feet; NAVD88, 2001 Adjustment)			
Flooding Source	**10%-Annual-Chance**	**2%-Annual-Chance**	**1%-Annual- Chance**	**0.2%-Annual-Chance**
Amenity Lake B Upstream of House Hahl Road	146.36/148.55[1]	147.71/149.42[1]	148.39/149.86[1]	151.66/151.14[1]
Amenity Lake C Downstream of House Hahl Road	146.36/149.59[2]	147.71/149.91[2]	148.39/150.06[2]	151.67/150.40[2]
Amenity Lake 5 At North Bridgelands Lake Parkway	147.10[3]	147.70[3]	148.20[3]	148.70[3]
Amenity Lake 6 At North Bridgelands Lake Parkway	147.10[3]	147.70[3]	148.20[3]	148.70[3]

[1]Elevation computed with consideration of flooding effects from K100-00-00 (Cypress Creek)
[2]Elevation computed with consideration of flooding effects from K150-00-00 (Tributary 36.6 to Cypress Creek)
[3]Elevation computed with consideration of flooding effects from K150-01-00 (Tributary 36.6-A to Cypress Creek)

10.2 Sixth Revision – June 9, 2014

This PMR revised the map panels associated with the White Oak Bayou Watershed and the watershed of Garners Bayou within the Greens Bayou Watershed. The PMR is a continuation of the publication of Letter of Map Revision (LOMR) Case Numbers 10-06-0969P, for White Oak Bayou, submitted by the Harris County Flood Control District and 10-06-2789P, for Garners Bayou, submitted by the Houston Airport System - George Bush Intercontinental Airport (HAS). These LOMRs incorporated updated hydrologic and hydraulic information along the entire reaches of White Oak Bayou and Garners Bayou.

Base map used for this PMR was provided in digital format by the Houston-Galveston Area Council and was revised and enhanced by Harris County.

A CCO meeting was held on September 12, 2012, and attended by representatives of the community, the study contractor, and FEMA. All problems raised at that meeting have been addressed in this study.

The hydrologic analysis for 10-06-0969P was completed using the USACE HEC-HMS Version 3.3 computer program. The hydraulic analysis for 10-06-0969P was completed with the USACE HEC-RAS 4.0 computer program. The revised HEC-HMS 3.3 and HEC-RAS 4.0 analyses were included in a submittal by PBS&J, for the Harris County Flood Control District in 2010.

The 10-06-0969P LOMR objective was to correct issues with the effective models identified by PBS&J and the Harris County Flood Control District. Another objective was to update the effective hydrologic and hydraulic models to the latest versions.

On average, the 10-06-0969P LOMR reduced the 1%-annual-chance flood event peak flows. The largest reduction is 10.4 percent and occurs downstream of the confluence of E122-00-00. The largest increase is 4.5 percent and occurs downstream of the confluence of E141-00-00. At the mouth of White Oak Bayou, the flow is reduced by 0.6 percent.

The average change in the 1%-annual-chance flood event base flood elevation for White Oak Bayou is a reduction of 0.27 feet. Between W. 18th and the mouth of White Oak Bayou, the average change is a reduction of 0.64 feet. From W. Little York to W. 18th there is no change on average. From Beltway 8 to W. Little York the average change is a reduction of 0.17 feet and upstream of Beltway 8 the average change is a reduction of 0.20 feet. The maximum increase is 0.73 feet just upstream of Pinemont and the maximum decrease is 2.13 feet just upstream of the Union Pacific Railroad Bridge near Yale Street.

The hydrologic analysis for 10-06-2789P was completed using the USACE HEC-HMS Version 3.1.0 computer program. The hydraulic analysis for 10-06-2789P was completed with the USACE HEC-RAS 3.0.1 computer program. The revised HEC-HMS 3.1.0 and HEC-RAS 3.0.1 analyses were included in a submittal by Grounds Anderson, LLC, for the Harris County Flood Control District in 2010.

The 10-06-2789P LOMR objective was to update the effective model for changes to Garners Bayou within the HAS property, including the Kenswick Diversion. Additionally, the hydrologic and hydraulic characteristics in Garners Bayou Watershed were also updated to the most current available data to update the delineation of the resulting floodplain and floodway for Garners Bayou.

The 10-06-2789P LOMR results in significant peak flow decreases at the upstream end of Garners Bayou where a diversion (Kenswick Ditch) and control structure were added. A second significant flow reduction is where Ditch P acts as a diversion. The remainder of peak flows increase by 20 percent or less. At the mouth of Garners Bayou, the flow is increased by less than 5 percent.

The upstream end of Garners Bayou saw reductions in the 1%-annual-chance flood event base flood elevation from cross section 43262.1 to 51681.5, with the maximum reduction of 1.51 feet occurring at cross section 44681.4. The changes in flood elevation from cross section 1400 to 42585.9 vary from increases up to 0.42 feet to decreases down to 0.30 feet.

Table 15, "Revised Summary of Discharges", Table 8, "Floodway Data," and Exhibit 1, "Flood Profiles," were revised to reflect changes as a result of the two restudies (10-06-0969P and 10-06-2789P).

Table 15. Revised Summary of Discharges - Sixth Revision

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
E100-00-00 (WHITE OAK BAYOU)					
At mouth	110.99	31,625	40,965	44,376	54,399
At Heights Blvd	85.95	23,359	29,876	32,654	42,102
At Lazybrook Drive	83.00	22,599	29,511	32,482	42,191
Downstream of E115-00-00 Confluence	73.91	20,620	28,688	31,939	41,558
Downstream of E117-00-00 Confluence	58.33	14,792	20,015	22,899	31,584
Downstream of E121-00-00 Confluence	45.70	11,496	15,965	18,126	25,001
Downstream of E122-00-00 Confluence	35.07	9,941	13,440	14,838	19,407
Downstream of E141-00-00 Confluence, At Beltway 8	24.75	8,957	12,237	13,685	17,612
Downstream of E127-00-00 Confluence	19.35	7,170	10,127	11,420	14,968
At West Road	12.88	4,993	6,995	7,939	10,073
At Jones Road	9.99	3,859	5,444	6,239	8,355
Downstream of E133-00-00 Confluence	3.01	1,034	1,558	1,827	2,610
UNNAMED TRIBUTARY TO HALLS BAYOU					
Overflow from Tributary 34.60 to Greens Bayou	N/A	*	*	329	*

*Data Not Available

Table 15. Revised Summary of Discharges - Sixth Revision (cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
P130-00-00 (GARNER'S BAYOU)					
At mouth	33.67	9,426	13,467	15,554	20,664
At confluence of William's Gully (P130-02-00)	31.30	9,141	12,881	14,905	19,698
Upstream of William's Gully	23.89	7,344	10,338	11,925	15,608
At Wilson Road	22.20	6,996	9,860	11,378	14,794
Between Mesa Road and Wilson	19.95	6,101	8,606	10,155	13,160
At confluence of P130-05-00	18.74	5,727	8,370	9,622	12,417
Between Rankin Road and Old Humble Road	12.24	3,558	4,952	5,691	7,854
At confluence of P1300700	11.21	3,268	4,538	5,213	7,418
Downstream of Southern Pacific	10.36	3,203	4,446	5,106	7,321
At confluence of P1300900	9.69	2,886	4,006	4,584	7,451
At East Will Clayton Parkway	6.29	1,811	2,607	3,030	4,856
At confluence of Kenswick Ditch (P1301300)	4.50	1,397	2,043	2,346	4,921
At Lee Road	2.98	1,298	1,900	2,171	4,714
At Runway Access Road	2.06	518	654	762	2,928

In addition to LOMRs 10-06-0969P and 10-06-2789P, this revision incorporates the determinations of Letters of Map Revision issued by FEMA for the projects listed by case number in Table 16, "Letters of Map Revision - Sixth Revision." These changes are also reflected in Table 8, "Floodway Data", and Exhibit 1, "Flood Profiles".

Table 16. Letters of Map Revision - Sixth Revision

Case Number	Date Issued	Project Identifier	Revised Map Panels	Revised Floodway Data Tables	Revised Profiles
07-06-1889P	9/28/2007	Maple Ridge Place Subdivision, Section 3	48201C0465M	N/A	P37P
08-06-1925P	2/26/2009	Sprint Sand & Clay L.P. - Fairbanks LOMR	48201C0445M	N/A	E28P
09-06-2519P	12/31/2009	Northwest Park Colony	48201C0445M & 48201C0465M	E121-00-00	E24P

Table 16. Letters of Map Revision - Sixth Revision (Cont'd)

Case Number	Date Issued	Project Identifier	Revised Map Panels	Revised Floodway Data Tables	Revised Profiles
10-06-1715X	4/30/2010	Northwest Park Colony	48201C0465M	N/A	E24P
11-06-2873P	7/26/2011	Little White Oak Bayou Floodway Revision	48201C0660M	E101-00-00	N/A
12-06-1071P	5/30/2012	Buffalo Bayou	48201C0670M	N/A	W05P
12-06-3003P	3/7/2013	Tributary 34.6 to Greens Bayou	48201C0465M	N/A	N/A

Case number 07-06-1889P also includes revision to the "Summary of Discharges" table, as shown in Table 15.

10.3 Seventh Revision – May 4, 2015

This PMR revises map panels associated with the City of Baytown. The City of Baytown is geographically located in Chambers and Harris Counties. See the separately published FIS reports and Flood Insurance Rate Maps (FIRM) for NFIP applications and purposes.

10.4 Eighth Revision – January 6, 2017

This revised FIS, produced as part of a PMR, incorporates the new U.S. Army Corps of Engineers (USACE) Storm Surge Study (Reference 3.5.15). The subsequent Wave Height Analysis, Combined Probability Analysis and mapping were developed by Comprehensive Flood Risk Resources and Response Joint Venture (CF3R), for FEMA under contract number EMT-2002-CO-0049. This work was completed in November 2011. Risk Assessment Mapping and Planning Partners (RAMPP) performed Joint Probability Analysis for Carpenters Bayou and resultant mapping update related to LOMR application case number 13-06-4399P, for FEMA under RiskMAP Change Request R6-12-01-002, "Harris County, TX PMR," dated December 8, 2013. This work was completed in July 2015.

Base map used for this PMR was provided in digital format by the Houston-Galveston Area Council and was revised and enhanced by Harris County.

A CCO meeting was held on May 15, 2013, and attended by representatives from the Cities of Baytown, Deer Park, El Lago, Galena Park, Friendswood, Houston, Jacinto City, La Porte, League City, Morgan's Point, Nassau Bay, Pasadena, Pearland, Seabrook, Shoreaces, South Houston, Taylor Lake Village, and Webster; Harris County; FEMA; the Texas State National Flood Insurance Program Coordinator; Texas Water Development Board; and the study contractor, RAMPP. All concerns and/or issues raised at that meeting have been addressed in this study.

Using storm surge study results, wave height analysis was performed to identify areas of the coastline subject to overland wave propagation or wave runup hazards. Detailed explanation of the analysis can be found in section 3.5 of this FIS report.

Combined probability analysis was performed along approximately 170 miles of streams. In addition to the coastal revisions, six (6) LOMRs were incorporated into the mapping, as present in Table 17, "Letters of Map Revision – Eighth Revision." In total 36 FIRM panels were updated to incorporate the revised coastal mapping information and LOMRs. Detailed explanation of the coastal analysis can be found in section 3.5 of this report.

This revised FIS does not show Regulatory Elevations in the Floodway Data tables at stream stations superseded by coastal flooding. Profiles have been revised to show elevations from the combined probability analysis. The profiles do not show elevations in areas superseded by coastal flooding. A set of 0.2-percent annual chance wave envelope profiles along transects which have a 0.2-percent annual chance wave envelope have been added to the FIS report. Please note, not all transects have a 0.2-percent annual chance wave envelope profile. For those transects that do not appear in the FIS with a 0.2-percent annual chance wave envelope profile there was no starting 0.2-percent annual chance stillwater elevation.

Table 17. Letters of Map Revision - Eighth Revision

Case Number	Effective Date	Project Identifier	Revised Map Panels	Revised Floodway Data Tables	Revised Profiles
08-06-0819P	10/29/2009	Scarsdale Boulevard	48201C1065M	A100-00-00	A06P, A07P
10-06-2360X	06/15/2010	Space Center Boulevard (correction of LOMR 09-06-3048P)	48201C0920M	N/A	B12P
10-06-3282P	07/07/2011	Magellan Tank Farm Floodway LOMR	48201C0695M	H100-00-00	H04P, H05P
12-06-1235P	09/05/2012	Beltway 8 Main Lanes	48201C0705M 48201C0710M	P107-00-00	P20P, P21P
14-06-4559P	10/16/2015	B113-00-00 Drainage Study	48201C0920M 48201C0940M	B100-00-00, B113-00-00,	B03P, B18P, B23P
15-06-1550P	12/01/2015	Liberty Lakes Remapping	48201C0710M	N100-00-00	N/A

LOMR Revised discharges are shown in Table 18, "Revised Summary of Discharges – Eighth Revision."

An examination of LOMR 11-06-4571P was conducted and the updated combined probability analysis supersedes the analysis in LOMR 11-06-4571P. Therefore, LOMR 11-06-4571P has not been included in this revision.

At the request of FEMA, RAMPP evaluated the combined probability of flooding due to runoff and storm surge for Carpenters Bayou from LOMR case number 13-06-4399P. As a result, LOMR 13-06-4399P appears on the Summary of Map Action (SOMA) document as "superseded," however, the LOMR has been evaluated and partially included as per the following analysis and mapping.

In streams potentially impacted by coastal and riverine flooding, it is necessary to evaluate the combined probability of flooding due to runoff and storm surge. In order to perform the analysis as described in Section D.2.4.5.4 of FEMA's Atlantic and Gulf of Mexico Coastal Guidelines Update (Final Draft February 2007), the two flooding mechanisms must be assumed independent, or at least separated in time. A cursory review of significant rainfall events recorded by the Houston/Galveston, TX National Weather Service Office reveals this assumption is valid for Harris County, TX. Daily rainfall records were set on November 26, 1987, and reset on the same day in 2013 with the National Hurricane Center reporting no tropical storm events in the Gulf of Mexico at that time. Further, on July 2, 2010, 5.43 inches of rain fell in Houston. This precipitation was part of Hurricane Alex, which made landfall in northern Mexico and contributed no reported storm surge in the Houston/Galveston area.

An automated methodology was developed for computing the effects of combined riverine + coastal surge on Carpenters Bayou following the methods described in Section D.2.4.5.4.

On Carpenters Bayou the combined flooding extends from cross section H to cross section AF. The downstream boundary was determined by identifying the first cross section contributing a higher combined BFE than the mapped coastal flood hazard. The upstream limit is the cross section where the combined analysis resulted in less than 0.1ft change from the riverine-only flooding at the 1-percent annual chance and 0.2-percent annual chance flood levels. The riverine analysis from LOMR upstream of cross section AF has been incorporated into this revision. Revised discharges from LOMR 13-06-4399P that are still valid are shown in Table 18, "Revised Summary of Discharges – Eighth Revision."

Table 18. Revised Summary of Discharges - Eighth Revision

		Peak Discharges (cfs)			
Flooding Source and Location	**Drainage Area (sq. mi.)**	**10% Annual Chance**	**2% Annual Chance**	**1% Annual Chance**	**0.2% Annual Chance**
B-100-00-00 (ARMAND BAYOU)					
At confluence of Willow Springs Bayou (B112-00-00)	17.99	5,952	8,893	10,295	14,731
At confluence of tributary 10.46 (B113-00-00)	6.70	2,727	4,410	5,029	6,920
At confluence of tributary 12.18 (B115-00-00)	5.33	2,397	3,720	4,333	5,864

Table 18. Revised Summary of Discharges - Eighth Revision (Cont'd)

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
B-100-00-00 (ARMAND BAYOU) (continued)					
At confluence of tributary 12.09 (B114-00-00)	2.66	1,138	1,670	1,946	2,759
Upstream of confluence of tributary 12.09 (B114-00-00)	1.43	520	775	907	1,301
At Dupont Street	0.65	289	431	505	724
B113-00-00 (TRIBUTARY 10.46 TO ARMAND BAYOU)					
At mouth	3.68	936	1,369	1,609	2,117
At B.W. 8	1.53	397	592	693	995
B115-00-00 & B115-01-00 (TRIBUTARY 12.18 TO ARMAND BAYOU)					
At mouth	2.67	1,414	2,089	2,428	3,225
At confluence of tributary B115-01-00	1.13	828	1,170	1,351	1,845
G103-07-00 (UNNAMED TRIBUTARY 2 TO SAN JACINTO RIVER)					
At mouth	5.87	3,695	5,310	6,146	8,550
Downstream of U.S. Highway 90	4.94	3,160	4,253	5,227	7,228
Upstream of Sheldon Road	1.74	1,141	1,623	1,877	2,585
Upstream of confluence with Tributary G103-07-04	0.54	347	492	569	783
N100-00-00 (CARPENTERS BAYOU)					
At mouth	31.80	6,343	9,758	11,448	16,067
Upstream of Tributary 3.33 (N104-00-00)	24.52	5,475	8,272	9,633	13,763
Downstream of Tributary 11.715 (N117-00-00)	11.45	1,110	1,622	1,906	2,753

10.5 Ninth Revision – May 2, 2019

This PMR revises the map panels associated with the Sims Bayou watershed. It incorporates Risk Mapping, Assessment, and Planning (RiskMAP) products based on the hydrology and hydraulic models that were updated to reflect key changes in the Sims Bayou Watershed (HCFCD Unit # C100-00-00). These changes include recently completed US Army Corps of Engineering (USACE) channel modifications associated with the Federal Flood Damage Reduction Project on the Sims Bayou main stem, approved LOMRs from the date of the Effective FIS, effects of constructed regional detention facilities, and updating of the hydrologic and hydraulic modeling software. This 2014 Study was a joint effort between FEMA and its Cooperating Technical Partner (CTP), Harris County Flood Control District (HCFCD). The CTP Agreement was established under FEMA Contract No. EMW-2014-CA-00203, with Mapping Activity Statement (MAS) 21. Table 19 lists the revised scope of study streams for this 2014 Risk MAP Project. The work was completed in 2015.

The final CCO meeting was held on April 21, 2017 to review and accept the results of this FIS. Those who attended this meeting included representatives of FEMA, the Study Contractor, and the communities. All problems raised in that meeting have been addressed by this study.

Base map information shown on this FIRM was provided in digital format by the Houston-Galveston Area Council (H-GAC) and was revised and enhanced by Harris County (2015). The Texas Natural Resources Information System (TNRIS) provided the Texas Department of Transportation (TXDOT) community boundaries and transportation layers dated 2015.

The hydrologic analysis was completed using the USACE HEC-HMS Version 4.0 computer program. The storage volume that represents the flow attenuation provided by the main stem of Sims Bayou, Berry Bayou (C106-00-00) and Tributary 3.31 to Berry Bayou (C106-08-00) was updated to reflect channel modifications completed by the USACE on Sims, and concrete lining of the channel for Berry Bayou and its tributary. The updated hydrologic model for the Sims Bayou watershed also incorporates three completed regional detention facilities. Two of which are located on the main stem of Sims Bayou, C500-01-00 and C500-03-00, and one on a tributary, C547-01-00. Table 20 below summarizes the updated peak runoff rates at key locations along Sims Bayou and its tributaries.

The revised hydraulic analysis used the USACE HEC-RAS 4.1.0 computer program. Cross sections were obtained from the effective hydraulic models, “as-built” survey plans for modified or new bridges required to accommodate the improved channel, and 2008 topographic LiDAR. Roughness coefficients (Manning’s “n” values) used in the hydraulic computations are shown below in Table 21, “Revised Summary of Roughness Coefficients”, and were revised based on engineering judgment and based on field observations of the stream and floodplain areas.

Floodplain boundaries were delineated using Harris County’s contour data developed from 2001 LiDAR.

Floodway Data (Table 8) and Flood Profiles (C01P – C24P) were revised to reflect changes as a result of the study.

Table 19. Revised Scope of Study- Ninth Revision

Sims Bayou Watershed (C)

HCFCD Designation	Steam Name	Receiving Body	Stream Mile From	Stream Mile To
C100-00-00	Sims Bayou	G100-00-00	0.00	21.74
C102-00-00	Plum Creek	C100-00-00	0.00	1.83
C103-00-00	Pine Gully	C100-00-00	0.00	2.57
C106-00-00	Berry Bayou	C100-00-00	0.00	5.54
C106-01-00	Berry Creek	C106-00-00	0.00	4.43
C106-01-07	Unnamed Tributary to Berry Creek	C106-01-00	4.43	4.71
C106-03-00	Tributary 2.00 to Berry Bayou	C106-00-00	0.00	1.84
C106-08-00	Tributary 3.31 to Berry Bayou	C106-00-00	0.00	1.14
C118-00-00	Salt Water Ditch	C100-00-00	0.00	1.16
C123-00-00	Tributary 10.77 to Sims Bayou	C100-00-00	0.00	0.66
C223-00-00	Tributary 10.77 to Sims Bayou (continued)	C123-00-00	0.66	1.43
C127-00-00	Swengel Ditch	C100-00-00	0.00	1.22
C132-00-00	Tributary 13.83 to Sims Bayou	C100-00-00	0.00	0.88
C147-00-00	Tributary 20.25 to Sims Bayou	C100-00-00	0.00	1.78
C161-00-00	Tributary 17.82 to Sims Bayou	C100-00-00	0.00	1.48

Table 20. Revised Summary of Discharges- Ninth Revision

Flooding Source and Location	Drainage Area (sq.mi^2)	Peak Discharge (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
C100-00-00 (SIMS BAYOU)					
At mouth	93.51	21,580	36,938	42,935	57,613
Downstream of Plum Creek	91.75	21,191	36,352	42,136	56,731
Upstream of Pine Gully	86.15	20,359	35,011	40,288	53,521
Upstream of Berry Bayou	68.69	16,242	27,066	31,412	38,930
Upstream of Tributary 10.77 to Bayou	48.74	12,378	20,021	23,592	30,614
Upstream of Tributary 13.83 to Sims Bayou	34.73	9,387	15,855	19,474	27,493
At Hiram-Clark Road	20.73	5,778	9,990	12,227	17,429
Upstream of Tributary 20.25 to Sims Bayou	7.91	2,416	3,889	4,674	6,679
Upstream of Sam Houston Parkway	2.26	704	1,088	1,291	1,895

Table 20. Revised Summary of Discharges- Ninth Revision (cont'd)

		Peak Discharge (cfs)			
Flooding Source And Location	**Drainage Area (sq.mi^2)**	**10% Annual Chance**	**2% Annual Chance**	**1% Annual Chance**	**0.2% Annual Chance**
C102-00-00 (PLUM CREEK)					
At mouth	3.99	1,471	2,215	2,565	3,577
At Broadway Road	2.90	672	1,029	1,221	1,796
C103-00-00 (PINE GULLY)					
At mouth	1.61	1,468	2,068	2,384	3,231
At Reveille Road	0.30	597	841	969	1,313
C106-00-00 (BERRY BAYOU)					
At mouth	17.46	7,834	11,648	13,518	18,771
Upstream of Tributary 2.00 to Berry Bayou	6.62	4,374	6,435	7,491	10,590
Upstream of Spencer Highway	6.59	2,880	4,254	4,968	7,047
Upstream of Tributary 3.31 to Berry Bayou	3.02	2,260	3,346	3,914	5,563
Downstream of Witt Road	1.70	756	1,126	1,321	1,893
C106-01-00 (BERRY CREEK)					
At mouth	4.80	1,807	2,645	3,125	4,545
Upstream of C106-01-02	2.78	1,042	1,570	1,848	2,675
C106-01-07 (UNNAMED TRIBUTARY TO BERRY CREEK)					
Upstream of Hobby Airport Runway	1.33	498	752	886	1,281
C106-03-00 (TRIBUTARY 2.00 TO TO BERRY BAYOU)					
At mouth	2.86	1,299	1,922	2,248	3,203
Upstream of College Avenue	1.40	765	1,132	1,325	1,888
C106-08-00 (TRIBUTARY 3.31 TO BERRY BAYOU)					
At mouth	1.82	996	1,456	1,698	2,383
Downstream of Coronation Drive	1.50	914	1,337	1,559	2,189
C118-00-00 (SALT WATER DITCH)					
At mouth	3.87	1,759	2,601	3,045	4,342

Table 20. Revised Summary of Discharges- Ninth Revision (cont'd)

Flooding Source And Location	Drainage Area (sq. mi^2)	Peak Discharge (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
C118-00-00 (SALT WATER DITCH)					
Upstream of Bellfort Avenue	2.50	1,147	1,697	1,986	2,832
C123-00-00 (TRIBUTARY 10.77 TO SIMS BAYOU)					
At mouth	2.44	800	1,227	1,451	2,101
C223-00-00 (TRIBUTARY 10.77 TO SIMS BAYOU)					
Upstream of confluence with C123-00-00	2.05	567	870	1,028	1,489
Downstream of Almeda-Genoa Road	1.00	386	593	700	1,014
C127-00-00 (SWENGEL DITCH)					
At mouth	2.14	1,030	1,544	1,815	2,594
C132-00-00 (TRIBUTARY 13.83 TO SIMS BAYOU)					
At mouth	4.07	755	1,218	1,473	2,238
At Airport Boulevard	3.30	627	1,012	1,223	1,858
Downstream of Reed Road	2.80	529	853	1,032	1,566
C147-00-00 (TRIBUTARY 20.25 TO SIMS BAYOU)					
At mouth	7.16	1,993	3,677	4,510	6,456
Upstream of South Post Oak Road	6.73	2,894	4,161	4,854	6,699
C161-00-00 (TRIBUTARY 17.82 TO SIMS BAYOU)					
At mouth	2.39	635	1005	1203	1799
Downstream of West Orem	2.30	621	984	1178	1761
Downstream of Tidewater Drive	1.99	530	839	1004	1501
At Airport Boulevard	1.73	459	727	871	1302

Table 21. Revised Summary of Roughness Coefficients Ninth Revision

HCFCD Designation	Stream Name	Manning's "n" Values Channel	Manning's "n" Values Overbanks
C100-00-00	Sims Bayou	0.015-0.045	0.050-0.200
C102-00-00	Plum Creek	0.040-0.045	0.080-0.200
C103-00-00	Pine Gully	0.040-0.055	0.100-0.200
C106-00-00	Berry Bayou	0.015-0.045	0.060-0.200
C106-01-00	Berry Creek	0.015-0.055	0.060-0.200
C106-01-07	Unnamed Tributary to Berry Creek	0.015	0.060-0.200
C106-03-00	Tributary 2.00 to Berry Bayou	0.015-0.040	0.100-0.200
C106-08-00	Tributary 3.31 to Berry Bayou	0.015-0.055	0.080-0.200
C118-00-00	Salt Water Ditch	0.040-0.050	0.070-0.200
C123-00-00	Tributary 10.77 to Sims Bayou	0.040-0.050	0.100-0.200
C223-00-00	Tributary 10.77 to Sims Bayou (continued)	0.035-0.045	0.120-0.200
C127-00-00	Swengel Ditch	0.015-0.040	0.016-0.070
C132-00-00	Tributary 13.83 to Sims Bayou	0.025-0.040	0.080-0.200
C147-00-00	Tributary 20.25 to Sims Bayou	0.020-0.040	0.080-0.200
C161-00-00	Tributary 17.82 to Sims Bayou	0.040	0.060-0.200

Table 22. Letters of Map Revision Ninth Revision

Case Number	Effective Date	Project Identifier	Revised Map Panels	Revised Floodway Data Tables	Revised Profiles
13-06-1076P	3/6/2014	Galperti Tract	48201C1010M	A100-00-00 (Clear Creek)	N/A
13-06-1908P	2/06/2014	AAA Storage McHard	48201C1005M	A100-00-00 (Clear Creek)	N/A
14-06-3038P	12/26/2014	Brunswick Meadows, Section 18	48201C1010M, 48201C1030M	A100-00-00 (Clear Creek)	N/A
16-06-2490P	06/02/2017	D140-00-00 Pedestrian Bridge Removal	48201C0845M	D140-00-00 (Fondren Diversion Channel)	D26P

10.6 Tenth Revision – November 15, 2019

This PMR is a joint effort between FEMA and its Cooperating Technical Partner (CTP), the Harris County Flood Control District (HCFCD). The CTP Agreement was established under FEMA contract No. EMT-2010-CA-0014, with Mapping Activity Statement (MAS) 16. This PMR incorporates updated hydrology and hydraulic models for approximately 59.4 stream miles that have been updated to reflect key changes in the Addicks Reservoir Watershed (HCFCD Unit # U100-00-00). These changes include approved Letters of Map Revision (LOMRs), extensive development with its associated on-site detention resulting in land use and other watershed parameter changes, and updated hydrology and hydraulics from the adjacent Cypress Creek Watershed (HCFCD Unit # K100-00-00) overflows to the Addicks Reservoir Watershed and updated floodplain boundaries for Addicks Reservoir as a result of more up-to-date topographic information. The study also incorporates changes to T101-00-00 (Mason Creek), T101-13-00 (Diversion Channel to Mason Creek), and T101-10-00 (Unnamed Tributary to Mason Creek) from previously approved LOMR 08-06-1677P, for which the Addicks Reservoir Watershed portions have been superseded. Under contract No. HSFEHQ-09-D-0369, FY13, TO1 to FEMA, the Risk Assessment, Mapping, and Planning Partners (RAMPP) incorporated the Addicks Reservoir Watershed study into the FIRMs and FIS. This work was completed in May 2015.

As a result of the regulatory appeals process, they hydrology and hydraulics for U100-00-00 (Langham Creek) were revised based on updated topography in conjunction with channel improvements between cross section Z to approximately 550 feet downstream of cross section AE. Please note, only the floodplain mapping between cross section Z to approximately 550 feet down stream of cross section AE was modified as a result. This work was completed in June 2017.

Base map used for this PMR was provided in digital format by the Harris Galveston Area Council and was revised and enhanced by Harris County.

For this PMR, an initial kickoff meeting for the Addicks Reservoir Watershed study was held on October 1, 2010, and attended by representatives from HCFCD, Lockwood, Andrews and Newnam, Inc., Grounds Anderson, Sirrus, Brooks and Sparks, and West Belt Surveying. A final CCO meeting was held on September 24, 2015, and attended by representatives from HCFCD, Jersey Village, FEMA, and study contractor, RAMPP. All concerns and issues raised at that meeting have been addressed in this study.

The Addicks Reservoir watershed covers an area approximately 137 square miles in west Harris County and includes six primary streams: Langham Creek (U100-00-00), South Mayde Creek (U101-00-00), Bear Creek (U102-00-00), Horsepen Creek (U106-00-00), Dinner Creek (U120-00-00) and Turkey Creek (W167-00-00), with additional smaller streams. The Addicks Reservoir watershed is located north of Interstate (IH-10), south of U.S. Highway (US) 290, west of Beltway (BW) 8, and east of the Harris County line with Waller County. Approximately 1 square mile of the Addicks Reservoir watershed is within Waller County. The majority of the watershed is located in unincorporated areas of Harris County with only the Addicks Reservoir in the City of Houston.

The Addicks Reservoir and Dam were constructed in the late 1940’s under the authorization of the United States Army Corps of Engineers (USACE) to provide flood damage protection to the City of Houston and other downstream communities by reducing downstream flooding of Buffalo Bayou (HCFCD Unit # W100-00-00). The

Addicks Dam is located on the north side of IH-10 and comprised of five 8-foot by 6-foot gated outlet box conduits.

Table 23. Scope of Revision – November 15, 2019 Revision

Stream	Limits of Revised or New Detailed Study
T101-00-00 (Mason Creek)	From approximately 4,000 feet downstream of Peek Road South to approximately 4,600 feet upstream of Franz Road
T101-10-00 (Unnamed Tributary to Mason Creek)	From the confluence with T101-00-00 (Mason Creek) to approximately 1,700 feet upstream of the confluence with T101-00-00
T101-08-00*	From the confluence with T101-00-00 (Mason Creek) to approximately 5,700 feet upstream
T101-13-00 (South Diversion Channel to Mason Creek)	From the confluence with T101-00-00 (Mason Creek) to just upstream of Morton Road
U100-00-00 (Langham Creek)	From approximately 38,300 feet upstream of the confluence with W100-00-00 (Buffalo Bayou) to approximately 450 feet upstream of South of House Hail Road
U101-00-00 (South Mayde Creek) and U101-22-00 (Unnamed Tributary to South Mayde Creek)	From approximately 19,300 feet upstream of the confluence with U100-00-00 (Langham Creek) within Addicks Reservoir to approximately 10,500 feet upstream of Katy Hockley Road
U101-07-00 (Tributary 9.4 to South Mayde Creek)	From the confluence with U101-00-00 (South Mayde Creek) to approximately 3,300 feet upstream of the confluence with U101-00-00 (South Mayde Creek)
U101-08-00 (Tributary 9.6 to South Mayde Creek)	From the confluence with U101-00-00 (South Mayde Creek) to approximately 11,200 feet upstream of the confluence with U101-00-00 (South Mayde Creek)
U102-00-00 (Bear Creek) and U202-01-00 (Bear Creek Diversion Channel)	From approximately 10,800 feet downstream of Barker Cypress Road to approximately 3,900 feet upstream of Longenbaugh Road

*Area went from Zone AO to Zone X (unshaded)

Stream	Limits of Revised or New Detailed Study
U102-01-00 (Unnamed Tributary to Bear Creek)	From the confluence with U102-00-00 (Bear Creek) to approximately 9,275 feet upstream of the confluence with U102-00-00 (Bear Creek)
U106-00-00 (Horsepen Creek)	From the confluence with U200-00-00 (Addicks Reservior Diversion Channel) to approximately 6,000 feet upstream of Queenston Boulevard
U120-00-00 (Dinner Creek)	From the confluence with U100-00-00 (Langham Creek) to approximately 3,100 feet upstream of Fry Road
W167-01-00 (Tributary 3.9 to Turkey Creek)	From the confluence with W167-01-00 (Turkey Creek) to approximately 2,050 feet upstream of Acacia Arbor

In addition to the Addicks Reservoir Watershed study, this revision also incorporated the following LOMRs. These changes are also reflected in Table 8, "Floodway Data," and Exhibit 1, "Flood Profiles". Case number 14-06-1080P also includes revisions to the "Summary of Discharges" table, as shown in Table 18.

Table 24. Letters of Map Revision Tenth Revision

Case Number	Date Issued	Project Identifier	Revised Map Panels	Revised Floodway Data Tables	Revised Profiles
16-06-3975P	April 14, 2017	Cypress 600-Acre Tract	48201C0195N	L100-00-00	L07P & L08P
14-06-1080P	October 10, 2014	524-Acre Stone Creek Ranch Development	48201C0195N & 48201C0385N	K155-00-00	K46P & K47P
13-06-4636P	August 21, 2014	Mason Creek Corporate – Merchants Way Bridge	48201C0595M	N/A	T05P & T06P
14-06-1079P	September 15, 2013	T101-00-00 (Mason Creek)	N/A[1]	T101-00-00	N/A
13-06-0262P	May 20, 2013	T101-00-00 (Mason Creek)	N/A[1]	T101-00-00	N/A
11-06-3712P	September 6, 2011	Centerpoint Energy Bridge Replacement Over HCFCD Unit No. W167-04-00	N/A[2]	N/A	W28P
08-06-1677P	April 10, 2009	Morton Creek Ranch, Phase 1	48201C0585M, 48201C0595M, 48201C0605M	T101-00-00 T101-13-00 T101-10-00 U101-07-00 U101-08-00	T06P, T06P(a), T06P(b), U14P, U15P, U28P

[1] N/A = Not Applicable. No revision to the Flood Insurance Rate Map (FIRM) panel 48201C0615M, Flood Insurance Study (FIS) report revision only.
[2] N/A = Not Applicable. No revision to FIRM panel 48201C0630M, FIS report revision only.

Topographic information used for basin delineation was derived from LiDAR data flown between February and March 2008 under authority from the Houston-Galveston Area Council (H-GAC) and HCFCD. One-foot contours were developed from the 2008 LiDAR for HCFCD by Merrick & Company. Differential subsidence has occurred across Harris County from 2001 to 2008 varying from less than 0.1 foot in the southeast portion of the county to approximately 0.6 foot in the west. In order to remove the effects of subsidence on the 2008 LiDAR, HCFCD used information provided by the Harris Galveston Subsidence District and the United States Geological Survey. This information provided an accurate approximation of the overall subsidence across the county between 2001 and 2008 at various locations. A more detailed summary of the process and data used can be found in Appendix C, Addicks Reservoir (U100-00-00) Hydraulic Update, 2013 (Reference 10.6.1).

The hydrologic model was updated to reflect current conditions in the Addicks Reservoir Watershed. These updates included changing the modeling version used, from the USACE, Hydrologic Engineering Center (HEC) HEC-HMS, version 3.1.0, to HEC-HMS, version 3.4. The watershed parameters were also updated based on the changes in the land use with associated on-site detention, subbasin delineation, and known improvement projects. The land use parameters (percent urban development and percent impervious) were also updated to reflect 2008 ground conditions. This is consistent with the time period for the capture of the primary topographic resource, the 2008 LiDAR (one-foot contours). Other watershed parameters, such as watershed lengths (L) or percent channel improvement (PCI), were updated where necessary to address know improvement projects or other updates to the watershed. Watershed parameters in the effective model were also updated to ensure consistency with current HCFCD methodology (Reference 10.6.2).

The storage volume that represents the flow attenuation through the overflow area between Cypress Creek and Addicks Reservoir in the effective hydrologic model was approximated during the Tropical Storm Allison Recovery Project. The latest Cypress Creek model was updated in the Harris County, Texas and Incorporated Areas Fifth Revision dated October 16, 2013, which resulted in an update of the overflow characteristics. The updated hydrologic model for the Addicks Reservoir includes this updated overflow from Cypress Creek.

For T-101-00-00 (Mason Creek) and associated tributaries, HEC-HMS was used for developing the hydrologic model as a part of LOMR 08-06-1677P. The LOMR has been partially superseded due to the Addicks Reservoir update, however the hydrology associated with T-101-00-00 (Mason Creek) and associated tributaries remains valid and has been incorporated in this study. The parameters were updated based on the changes in the land use with associated on-site detention, subbasin delineation, and known improvement projects. The land use parameters (percent urban development and percent impervious) were also updated to reflect 2008 ground conditions. This is consistent with the time period for the capture of the primary topographic resource, the 2008 LiDAR (one-foot contours). Other parameters, such as watershed lengths (L) or percent channel improvement (PCI), were updated where necessary to address know improvement projects or other updates.

Table 25. Revised Summary of Discharges – November 15, 2019 Revision

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) Percent Annual Chance 10-percent	2-percent	1-percent	0.2-percent
K155-00-00					
(Tributary 40.7 to Cypress Creek)					
At mouth	4.17	342	717	963	1,796
At stream mile 1.43	3.03	177	371	499	930
At stream mile 2.32	2.35	167	349	469	874
At stream mile 3.44	1.43	138	289	389	725
T101-00-00					
(Mason Creek)					
At mouth	16.37	4,774	7,666	9,234	13,655
At Fry Road	13.95	3,974	6,402	7,712	11,363
Downstream of Kingsland Boulevard	10.64	2,880	4,644	5,570	8,238
At IH 10	8.76	2,260	3,641	4,366	6,457
At Mason Road	7.71	1,979	3,191	3,824	5,659
Downstream of Colonial Parkway	6.16	1,565	2,528	3,027	4,485
Downstream of Confluence with T101-08-00	4.86	1,563	2,519	3,015	3,481
Downstream of Peek Road	3.38	1,109	1,797	2,163	3,275
Downstream of Franz Road	2.40	724	1,168	1,404	2,133
T101-03-00					
(South Diversion Channel To Mason Creek)					
At Mouth	1.99	417	676	809	1,264
U100-00-00					
(Langham Creek)					
At Addicks Dam Road	136.76	21,628	35,767	43,220	64,101
At confluence of U101-00-00 (South Mayde Creek)	125.98	19,066	31,755	38,478	57,237
At confluence of U102-00-00 (Bear Creek)	85.94	14,814	24,511	29,581	43,452
At Clay Road	46.26	10,194	16,688	20,052	28,915
At confluence of U118-00-00	21.44	4,575	7,362	8,760	12,590
At confluence of U120-00-00 Dinner Creek	18.56	3,338	5,332	6,378	9,378
At Longenbaugh Road	11.67	1,365	2,330	2,882	4,629
At Househahl Road	0.00	--	57	153	646

Table 25. Revised Summary of Discharges – November 15, 2019 Revision (Cont'd)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) Percent Annual Chance 10-percent	2-percent	1-percent	0.2-percent
U101-00-00					
(South Mayde Creek)					
At confluence with U100-00-00 (Langham Creek)	40.04	5,072	8,775	10,551	15,941
At confluence of U101-03-00	31.09	5,017	7,814	9,153	13,120
At confluence with U101-08-00 (Tributary 9.6 to South Mayde Creek)	23.10	3,237	5,211	6,267	9,693
At Stockdick School Road	14.36	1,930	3,197	3,912	6,464
At Katy Hockley Cut Off Road	8.25	1,555	2,543	3,077	4,662
U101-07-00					
(Tributary 9.4 to South Mayde Creek)					
At mouth	0.33	33	95	132	255
Just upstream of Elrod Road	0.19	86	150	187	244
Just downstream of Grand Parkway	0.18	68	106	124	181
Just downstream of Porter Road	0.00	--	4	20	40
-- Data Not Available					
U101-08-00					
(Tributary 9.6 to South Mayde Creek)					
At mouth	2.47	476	724	870	1,353
At Grand Parkway	1.70	255	393	465	700
U101-22-00					
(Unnamed Tributary to South Mayde Creek)					
Downstream of Pitts Road	0.00	452	1,106	1,572	3,036
U102-00-00					
(Bear Creek)					
Upstream of State Highway 6	30.80	3,647	6,243	7,601	11,741
Downstream of Fry Road	20.60	2,202	3,882	4,694	6,697
At Grand Parkway	13.61	1,453	2,904	4,568	12,136
Downstream of Katy Hockley Cut Off Road	6.17	1,749	4,728	6,845	14,237
U102-01-00					
(Unnamed Tributary to Bear Creek)					
Downstream of Clay Road	2.93	1,463	2,196	2,542	3,597
U106-00-00					
(Horsepen Creek)					
At mouth	18.99	4,610	7,480	8,919	12,737
At State Highway 6 (FM 1960)	13.95	3,261	5,194	6,251	9,224
At confluence of U106-13-00	10.32	1,663	2,695	3,250	4,817
At confluence of U106-10-00	4.85	530	818	980	1,437
Downstream of Baker Cypress Road	2.99	420	714	883	1,380

Table 25. Revised Summary of Discharges – November 15, 2019 Revision (Cont'd)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) Percent Annual Chance 10-percent	2-percent	1-percent	0.2-percent
U120-00-00 (Dinner Creek)					
Downstream of Barker Cypress Road	5.01	1,213	1,905	2,270	3,350
U200-00-00 (Addicks Reservoir Diversion Channel)					
At confluence of U106-00-00 (Horsepen Creek)	43.70	9,892	16,013	19,258	27,615
W167-01-00 (Tributary 3.9 to Turkey Creek)					
At mouth	4.06	1,219	1,872	2,198	3,129
At West Little York Road	1.74	901	1,313	1,507	2,103

The hydraulic models were updated to reflect the current conditions in the Addicks Reservoir Watershed. These updates included changing the modeling version used, from HEC-RAS, version 3.0.1, to HEC-RAS, version 4.1. Modeled flows were based on the updated hydrology of the watershed that reflects current conditions. One-foot contours, derived from LiDAR, were used as the topographic surface to update the overbank topography in the hydraulic models. New field survey data was used, for 27 structures constructed after the development of the effective models or significantly modified since the effective models were developed), to reflect current ground conditions within the channel banks. The hydraulic models also evaluated the geometric components of the effective hydraulic models, such as cross sections, n-values, and streams centerlines for potential inconsistencies with HCFCD methodology. Some of these inconsistencies included the routing step used and the impacts on peak flows due to updated storage models for the watershed.

The effective cross sections were the basis for the updated cross sections. Cross sections were compared with the one-foot contours and survey and modified where needed. These modifications included reorienting cross sections to better represent the overall stream flood wave, lengthening or shortening, relocating to avoid bridge abutments or to better follow surveyed elevation points.

Starting water surface elevations for Langham Creek, Bear Creek, South Mayde Creek, and Tributary 3.9 to Turkey Creek were set at known water surface elevations from the static pool elevations of Addicks Reservoir. These static pool elevations were based on the report "Static Pool Water Surface Elevation in Addicks (U100-00-00) and Barker (T100-00-00) Reservoirs" prepared December 2013 by Brown and Gay Engineers, Inc. The starting water surface elevations for Tributary 9.4 to South Mayde Creek, Tributary 9.6 to South Mayde Creek, Tributary 4.5 to Bear Creek, Horsepen Creek, and Dinner Creek were based on the normal depth method.

Overflows out of the Cypress Creek Watershed contribute significant flow into the Addicks Reservoir Watershed. A coupled 1D/2D model was developed as part of the Cypress Creek Overflow Management Study to better understand the overflow phenomenon and evaluate potential flood mitigation measures. In the model, Cypress Creek and Addicks Reservoir Watersheds were modeled together. Flow Hydrographs from the Cypress Creek PMR HEC-HMS output were used as 2D model flow input. The channel area of Cypress Creek in Cypress Creek Watershed and

South Mayde, Bear and Langham Creeks in the Addicks Reservoir Watershed were modeled in 1D and the overbank areas in 2D. H-GAC 2008 LiDAR based topographic data with 5 ft resolution was used to develop the 1D cross-sections. The cross-sections were placed and named the same as in the effective HEC-RAS model. A 70 ft grid cell size was used for the overbank area 2D computations. The various berms and elevated roadways in the project area were digitized into the model to better define the high points in the area that would have been subdued by the 70 ft grid cell. All culverts were coded into the model using data from effective PMR HEC-RAS model. Bridges were modeled using rating curves developed from the PMR HEC-RAS model. The manning's "n" roughness coefficients for the 1D channel area were also from the PMR HEC-RAS model. The roughness co-efficient in the 2D overbank area were developed based on the Land Use and Land Cover (LULC) data provided by HCFCD and H-GAC. The LULC data had similar classification as the HCFCD data, but for Agricultural area which was further divided to highlight lands no longer being cultivated. The roughness values varied from 0.22 in dense undeveloped areas to 0.08 for open lands.

Figure 12, "AE Overflow Base Flood Elevation Map," may be used to estimate BFEs in an area defined by the results from a 2D modeling analysis. More precise results are available as output from the effective model. Shown on the map are points spaced 630 feet apart connected by gridlines and labeled with the BFEs (in feet) for each point location. The gridlines and points form grid squares. For points within grid squares, take a distance-weighted average of the four points at the corners of the square. For points along a gridline, take a distance-weighted average of the elevations of the two points at either end of the gridline.

Gaps in the points within the 2D modeling Limit indicate locations where the ground elevation is higher than the BFE. For BFEs in the mapped floodplain near these areas, use a conservative estimate of the highest BFE of the 2 or 3 nearest points.

For T-101-00-00 (Mason Creek) and associated tributaries, a HEC-RAS model was developed as a part of LOMR 08-06-1677P. The LOMR has been partially superseded due to the Addicks Reservoir update, however the hydraulic modeling associated with T-101-00-00 (Mason Creek) and associated tributaries remains valid and has been incorporated in this study.

Overbank Manning's "n" Values were developed with the aid of aerial photography following the HCFCD Policy, Criteria, and Procedures Manual criteria. The channel and overbank "n" values for the streams listed below are shown in Table 19. "Revised Manning's "n" Values – November 15, 2019 Revision." For the streams not listed below the Manning's "n" Values have not been revised, please refer to Section 3.2, "Hydraulic Analyses."

Table 26. Revised Manning's "n" Values – November 15, 2019 Revision

Stream	Channel "n"	Overbank "n"
U100-00-00 (Langham Creek)	0.04-0.055	0.07-0.15
U101-00-00 (South Mayde Creek)	0.015-0.06	0.05-0.15
U101-07-00 (Tributary 9.4 to South Mayde Creek)	0.04	0.07-0.15
U101-08-00 (Tributary 9.6 to South Mayde Creek)	0.015-0.04	0.07-0.15
U102-00-00 (Bear Creek)	0.015-0.06	0.07-0.15
U102-01-00	0.04-0.06	0.07-0.15

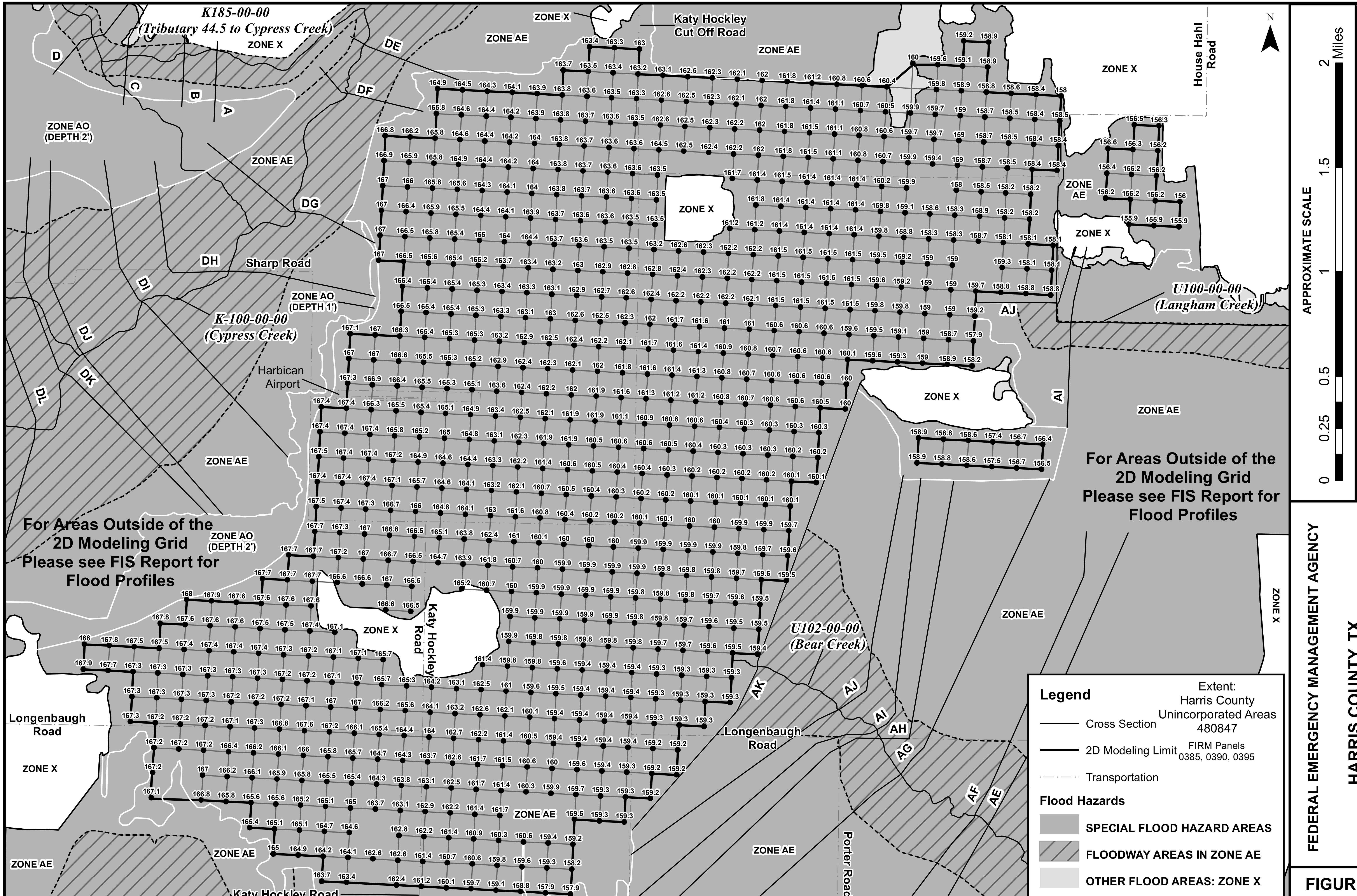
Stream	Channel "n"	Overbank "n"
(Unnamed Tributary to Bear Creek)		
U106-00-00	0.015-0.04	0.07-0.15
(Horsepen Creek)		
U120-00-00	0.015-0.04	0.07-0.15
(Dinner Creek)		
W167-01-00	0.015-0.04	0.07-0.15
(Tributary 3.9 to Turkey Creek)		

Floodplain boundaries were delineated topographic information derived from LiDAR data flown between February and March 2008 under authority from the H-GAC and HCFCD as described previously for this revision.

Table 8, "Floodway Data," and Exhibit 1, "Flood Profiles," were revised to reflect changes as a result of this restudy.

10.6.1 Addicks Reservoir (U100-00-00) Hydraulic Update, Harris County Flood Control District, Houston, Texas, June 19, 2013.

10.6.2 Addicks Reservoir (U100-00-00 Hydrology Update, Harris County Flood Control District, Houston, Texas, June 19, 2013.



AE OVERFLOW BASE FLOOD ELEVATION MAP

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX
AND INCORPORATED AREAS

FIGURE 13

Each FIRM panel may contain specific notes to the user that provide additional information regarding the flood hazard data shown on that map. However, the FIRM panel does not contain enough space to show all the notes that may be relevant in helping to better understand the information on the panel. Figure 14 contains the full list of these notes.

Figure 14: FIRM Notes to Users

NOTES TO USERS

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

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

For community and countywide map dates, refer to Community Map History in this FIS Report.

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

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

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

Figure 14: FIRM Notes to Users (Cont'd)

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

FLOOD CONTROL STRUCTURE INFORMATION: Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. Refer to Section 2.4 "Flood Protection Measures" of this FIS Report for information on flood control structures for this jurisdiction.

PROJECTION INFORMATION: The projection used in the preparation of the map was Universal Transverse Mercator Zone 15N Meters. The horizontal datum was North American Datum 1983, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

ELEVATION DATUM: Flood elevations on the FIRM are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at www.ngs.noaa.gov/.

Local vertical monuments may have been used to create the map. To obtain current monument information, please contact the appropriate local community listed in Section 3.3 of this FIS Report.

BASE MAP INFORMATION: Base map information shown on this FIRM was provided in digital format by the Houston-Galveston Area Council (H-GAC) and was revised and enhanced by Harris County (2015). The Texas Natural Resources Information System (TNRIS) provided the Texas Department of Transportation (TXDOT) community boundaries and transportation layers dated 2015.

The map reflects more detailed and up-to-date stream channel configurations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables may reflect stream channel distances that differ from what is shown on the map.

Figure 14: FIRM Notes to Users (Cont'd)

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

NOTES FOR FIRM INDEX

REVISIONS TO INDEX: As new studies are performed and FIRM panels are updated within Harris County, Texas, corresponding revisions to the FIRM Index will be incorporated within the FIS Report to reflect the effective dates of those panels. Please refer to Table 9 of this FIS Report to determine the most recent FIRM revision date for each community. The most recent FIRM panel effective date will correspond to the most recent index date.

ATTENTION: The corporate limits shown on this FIRM Index are based on the best information available at the time of publication. As such, they may be more current than those shown on FIRM panels issued before November 15, 2019.

SPECIAL NOTICES FOR SPECIFIC FIRM PANELS

This Notes to Users section was created specifically for Harris County, Texas, effective November 15, 2019.

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

Each FIRM panel contains an abbreviated legend for the features shown on the maps. However, the FIRM panel does not contain enough space to show the legend for all map features. Figure 15 shows the full legend of all map features. Note that not all of these features may appear on the FIRM panels in Harris County.

Figure 15: Map Legend for FIRM

SPECIAL FLOOD HAZARD AREAS: *The 1% annual chance flood, also known as the base flood or 100-year flood, has a 1% chance of happening or being exceeded each year. Special Flood Hazard Areas are subject to flooding by the 1% annual chance flood. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights. See note for specific types. If the floodway is too narrow to be shown, a note is shown.*

	Special Flood Hazard Areas subject to inundation by the 1% annual chance flood (Zones A, AE, AH, AO, AR, A99, V and VE)
Zone A	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. No base (1% annual chance) flood elevations (BFEs) or depths are shown within this zone.
Zone AE	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. Base flood elevations derived from the hydraulic analyses are shown within this zone.
Zone AH	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the hydraulic analyses are shown at selected intervals within this zone.
Zone AO	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the hydraulic analyses are shown within this zone.
Zone AR	The flood insurance rate zone that corresponds to areas that were formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
Zone A99	The flood insurance rate zone that corresponds to areas of the 1% annual chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or flood depths are shown within this zone.
Zone V	The flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations are not shown within this zone.

Figure 15: Map Legend for FIRM (Cont'd)

Zone VE	Zone VE is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations derived from the coastal analyses are shown within this zone as static whole-foot elevations that apply throughout the zone.
	Regulatory Floodway determined in Zone AE.
OTHER AREAS OF FLOOD HAZARD	
	Shaded Zone X: Areas of 0.2% annual chance flood hazards and areas of 1% annual chance flood hazards with average depths of less than 1 foot or with drainage areas less than 1 square mile.
	Future Conditions 1% Annual Chance Flood Hazard – Zone X: The flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined based on future-conditions hydrology. No base flood elevations or flood depths are shown within this zone.
	Area with Reduced Flood Risk due to Levee: Areas where an accredited levee, dike, or other flood control structure has reduced the flood risk from the 1% annual chance flood.
	Area with Flood Risk due to Levee: Areas where a non-accredited levee, dike, or other flood control structure is shown as providing protection to less than the 1% annual chance flood.
OTHER AREAS	
	Zone D (Areas of Undetermined Flood Hazard): The flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.
NO SCREEN	Unshaded Zone X: Areas of minimal flood hazard.
FLOOD HAZARD AND OTHER BOUNDARY LINES	
(ortho) (vector)	Flood Zone Boundary (white line on ortho-photography-based mapping; gray line on vector-based mapping)
	Limit of Study
	Jurisdiction Boundary
	Limit of Moderate Wave Action (LiMWA): Indicates the inland limit of the area affected by waves greater than 1.5 feet

Figure 15: Map Legend for FIRM (Cont'd)

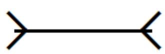
GENERAL STRUCTURES	
Aqueduct *Channel* *Culvert* *Storm Sewer*	Channel, Culvert, Aqueduct, or Storm Sewer
Dam *Jetty* *Weir*	Dam, Jetty, Weir
	Levee, Dike, or Floodwall
 *Bridge*	Bridge
REFERENCE MARKERS	
22.0 ●	River mile Markers

Figure 15: Map Legend for FIRM (Cont'd)

CROSS SECTION & TRANSECT INFORMATION	
B 20.2	Lettered Cross Section with Regulatory Water Surface Elevation (BFE)
5280 21.1	Numbered Cross Section with Regulatory Water Surface Elevation (BFE)
17.5	Unlettered Cross Section with Regulatory Water Surface Elevation (BFE)
8	Coastal Transect
	Profile Baseline: Indicates the modeled flow path of a stream and is shown on FIRM panels for all valid studies with profiles or otherwise established base flood elevation.
	Coastal Transect Baseline: Used in the coastal flood hazard model to represent the 0.0-foot elevation contour and the starting point for the transect and the measuring point for the coastal mapping.
513	Base Flood Elevation Line
ZONE AE (EL 16)	Static Base Flood Elevation value (shown under zone label)
ZONE AO (DEPTH 2)	Zone designation with Depth
ZONE AO (DEPTH 2) (VEL 15 FPS)	Zone designation with Depth and Velocity
BASE MAP FEATURES	
Missouri Creek	River, Stream or Other Hydrographic Feature
234	Interstate Highway
234	U.S. Highway
234	State Highway
234	County Highway

Figure 15: Map Legend for FIRM (Cont'd)

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