HCC RFP 1-4 - Hurricane Beryl outage causes recorded

CAUSE	TOTAL
HURRICANE	9829
STRONG WIND	1319
FLLNG TREE IN EASE	800
TREE CLEARANCE	649
FLLNG TREE OUT EAS	636
UNKNOWN	563
LIGHTNING	503
FALLING DEAD TREE	426
TRANSFORMER	368
CREW-INS/RPR/CHANG	274
OTHER	247
CREW-RESTR SVC OTH	225
SEC COND OR DROPS	201
OH SEC/DR CL HOT L	125
CREW-SYS EMERGENCY	124
OTHER EQUIPMENT	123
PRIMARY CONDUCTOR	123
BU DISC OR BARREL	114
VINES	96
LIGHTNING ARRESTER	70
METER EQUIPMENT	67
ROTTEN POLE	46
CUST EQP RELATED	44
OH SEC/DR CL NEUTR	41
URD XFMR SEC BUS	35
HUMAN ERROR	34
OVERLOAD	33
SQUIRREL	22
POLE TOP SWITCH	20
URD DROPS (CUST)	19
PRIMARY CABLE FAIL	17
CROSSARM	13
FOREIGN MATERIAL	12
O/H PRIMARY CLAMP	12
RECLOSER	11
CREW-CUST REQUEST	11
URD SEC PDSTL TRML	10
COLLISION	9
VANDALISM	8
TERMINATOR	7
URD ELBOW	5
TORNADO	5
RELAY	5
SLACK SPANS	5
URD BUSHING	5
O/H SPLICE	3
ICE	3
REGULATOR	3
SNAKE	3
INSULATOR	3
TRANSMISSION	3
SPLICE	3
URD DROPS (HL&P)	2
SECTIONALIZER	2
SUBSTATION	2
CONTRACTOR (HL&P)	1
OTHER CIRCUIT	1
OTHER WILDLIFE	1
BIRD	1
ANTS	1
FIRE	1
WORK TAG	1
3 PHASE UG CABLE	1

CENTERPOINT ENERGY HOUSTON ELECTRIC, LLC
PUC DOCKET NO. 57579
SOAH DOCKET NO. 473-25-11558

HOUSTON COALITION OF CITIES
REQUEST NO.: HCC-RFP01-05

QUESTION:

Provide the documents containing all reports, memos, and presentations containing, discussing, describing, and analyzing the need for flood control measures.

ANSWER:

Documents containing flood control measures:

1. Flood study for the following 10 substations in 2002 – Seawall, TH Wharton, Greens Rd, Intercontinental, Drouet, Grant, Downtown, Polk, Gable St and Franklin.
2. West Galveston's flood analysis in 2008
3. Addicks Reservoir dam breach analysis post Harvey in 2019 – Addicks and Brittmoore substations
4. Email with 8 substations identified for flood mitigation evaluation post Harvey
5. the DOE grant application for GRIP
6. Technical Volume

Guidehouse:

- All documents, websites, and other relevant sources used to discuss, describe, analyze, or otherwise support the need for flood control measures are cited in Exhibit ELS-2 of Shlatz direct testimony. Guidehouse evaluated both historical and future climate projections. The historical sources listed include NOAA data and the future projections are derived from Jupiter Intelligence which is a proprietary source. Sections 4.2.2, 5.4.3 and 5.4.4 of Exhibit ELS-2 include references and citations supporting the need for flood control measures.
- Additionally, please refer to supporting attachments in the response to HCC RFP 01-01.

SPONSOR:
David Mercado and Eugene Shlatz

RESPONSIVE DOCUMENTS:
HCC RFP01 05 Addicks Reservior Report Revised Set-FINAL 2019.pdf
HCC RFP01 05 flood mitigation substations.pdf
HCC RFP01 05 Flood Potential Study-Ten sub sites 2002.pdf
HCC RFP01 05 West Galveston flood memo.pdf
HCC RFP01 05 TechnicalVolume_Active_102204685_6..pdf
HCC RFP01 05 2022.12.14 CenterPoint Energy_DOE GRIP Topic 1 Concept Paper.pdf

FLOOD POTENTIAL STUDY

ADDICKS RESERVOIR DAM BREACH ANALYSIS

REVISED TO INCLUDE USACE FLOW RECOMMENDATION

PREPARED FOR
CENTERPOINT ENERGY
1111 Louisiana Street
Houston, TX 77002

October 11, 2019

BHA Job No. 5867

STATE OF TEXAS
JERRY I. GAINER
69787
REGISTERED
PROFESSIONAL ENGINEER

Jerry I. Gainer
10/11/19

Hutchison & Associates
Engineers • Land Planners • Surveyors
Engineering Firm #F-267
Surveying Firm #100293

1209 Decker Drive • Suite 100
Baytown, Texas 77520
(281) 422-8213 • Fax (281) 420-2717

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Definitions

Embankment – a wall or bank of earth or stone built to prevent a river flooding an area.

Hydraulics – the branch of science and technology concerned with conveyance of liquids through pipes, channels, especially as a source of mechanical force or control.

Hydrology – the branch of science concerned with properties of the earth's water, especially its movement in relation to land.

Inundation – flooding.

IDF Curve – a mathematical function that relates the rainfall intensity with its duration and frequency of occurrence.

Abbreviations

BHA – Busch, Hutchison & Associates, Inc
CFS – Cubic Feet Per Second
CNP - CenterPoint
FPS – Feet Per Second
IDF – Intensity Duration Frequency

Introduction

This study was requested by CenterPoint Energy to determine probable water surface elevations at the CenterPoint Facilities east of the Addicks Reservoir along Brittmoore Road if a dam failure occurred at the Addicks Reservoir during a flood. Simulation of embankment and dam breach events and their resulting floods are crucial to characterizing and identifying threats due to potential dam failures. Characterization of the threat to public safety that a dam poses establishes the Hazard Classification of the dam and the associated standard of care to which the dam is held. Development downstream of an old and in many cases deficient, dam is responsible for a growing concern within communities that have transitioned from rural to urban environments. There are instances of permitted development being constructed in the shadow of a dam embankment without regard to the potential consequences from a dam failure. The steps for finding potential hazards are to determine the area that will be inundated, the depth and velocity of the flood waters, and the length of time that the area will be inundated. This document outlines methods for assessing the impact of the downstream inundation with a main focus around the CenterPoint Energy's facilities that are between Brittmoore Road and the Addicks Dam.

Purpose and Scope

The purpose of this report is to give findings in the analysis of the Addicks Reservoir should there be a dam breach on the Northwestern part of the embankment at the uncontrolled overflow point of the dam. The procedures and analytical models described herein are intended to serve as a basis for estimation purposes. Breach parameters generally cannot be predicted with reasonable accuracy; as such more conservative assumptions are made. These assumptions include four critical elements 1) breach parameter estimation (breach size/shape and time of failure), 2) breach peak discharge and breach hydrograph estimation, 3) breach flood routing, and 4) estimation of the hydraulic conditions at critical locations. Our scope of work was to evaluate the potential for flooding or potential water surface elevation at the CenterPoint facilities following a dam breach.

Estimating Inundation Caused by a Dam Breach

For the estimation parameters HydroCad software was used for the analysis /modeling of Hydrology and Hydraulics. A location north of the CenterPoint buildings was chosen, based on location, contours, and survey. The location is situated in the Reservoir's emergency overflow spillway that is shown in the green hatch in Figure 1. Modeling assumptions are general in nature with the details of time of breach, soil deposit, initial wave surge, and the effect buildings have on direction and current make it impossible to predict with certainty. Assuming minimal soil transport and deposit around the CenterPoint facilities for this analysis, the assumed failure location is far enough away from the CenterPoint facilities indicating that the majority of the mudflow from the dam failure would be deposited north of the area of concern. The structures close to the Addicks dam would not allow a steady flow of deposits and the direction of discharge would be northern, causing the water to slow and change direction forcing settlement of any large deposits. This location is called the uncontrolled overflow section of the dam. This is where the study analyzes a dam breach of complete fail which would allow water to flow toward Tanner road then east and south along Brittmoore Road.

Figure 1. Location of Dam Breach

Selection of Reservoir Conditions for Breach Analysis

The selection of conditions for the rain storm analysis came from a list of storm events in the last 100 years, which was compiled by the Houston/Galveston National Weather Service Office. The main contributors were hurricanes that produced massive surge, tornadoes, and/or heavy rainfall.

1. Hurricane Carla – September 11, 1961
   a. Category 4 Hurricane which produced a 22 foot storm surge
   b. Spawned an F3 tornado over downtown Galveston
2. Tropical Storm Claudette – July 24-26, 1979
   a. 24 Hour deluge just south of Houston producing a 24 hour United States rainfall record of 43.0 inches 2 miles East Northeast of Alvin. The National Weather Service in Alvin reported 28.7 inches of rain in 20 hours.
   b. Clear Creek expanded to a width greater than 1 mile, rising 9 feet above normal
3. Tropical Storm Allison – June 5-10, 2001

   a. Stalled over Texas dropping 36.99 inches at Port Houston
   b. At most 6.3 inches/ hour and 28.5 inches/ 12 hours
4. Memorial Day Flood – May 26, 2015
   a. Nearly 1 foot of water in less than 10 hours
5. Tax Day Flood – April 17-18, 2016
   a. 17 inches in roughly 24 hours
   b. 4 inches per hour at most intense time
6. Hurricane Harvey – August 26-30, 2017
   a. Cedar Bayou received 51.88 inches of rainfall; some areas reported 40+ inches in 48 hours.

The rainfall that can cause a dam breach will most likely come from a tropical system that is stalled out in the Addicks Reservoir watershed. The tropical systems frequently stall out when trapped by high pressure systems which are what allowed Hurricane Harvey to inundate South East Texas with the greatest floods recorded. In less than 60 years there have been at least 2 storms to make a list of 100 worst in the Galveston/Houston area; these storms have produced rainfalls in excess of 40+ inches in a matter of days. The storms that caused major rainfall in the Houston area varied greatly in their type. Hurricane Harvey was downgraded from a Hurricane, but could not leave the area with high pressure on either side. Claudette was also stalled over Houston because of a high pressure system on one side. These storms occur without any frequency.

The next option to consider for the analysis is the location of the breach. The modeled breach location was selected northwest of the CenterPoint facilities where the dam breach flood would flow south and inundate the CNP facilities. The condition chosen for the reservoir is a 40+ inch rain within a 24 hour period, which would cause extremely high waters in the storm sewers, roads, and ditches. This would then add to the effect of the dam breach, because the water that discharges has no open flow path with all the water ways at capacity. This theoretical storm would allow the water to rise to a level that would be a worse case assumption for the CenterPoint facilities just prior to adding a dam breach at the same time.

Estimation of Dam Breach Peak Discharge

HydroCad was used to model and predict the potential elevation, velocity, and volume for the water. Regardless of how the reservoir fills up, the idea is that it fills up and breaches the dam or spills over the uncontrolled overflow spillway during an event when the downstream watershed is already flooded. The Harris County IDF curve was used for the basis of rainfall, and then input was increased for the duration and intensity of a storm to release 40 inches of rain in a 24 hour time frame. This 24 hour time frame will cause the Addicks reservoir to gather water from its watershed and reach a point of breaking at the uncontrolled overflow elevation of 112.5' at roughly 20 hours into the storm. At which point the dam breach will start and work into the embankment and break a twelve foot section at the top of the embankment, and work its way down to the bottom of the reservoir or until the water can flow freely from the breach that is now in the dam. The twelve foot break at the top will work down at a 45° angle until it reaches the bottom at roughly 30' wide. These are the parameters that were input into HydroCad to give discharge rates and velocities. The model predicts the peak discharge is 18,000cfs with a velocity of 16.88fps. For comparison the Addicks and Barker reservoirs were reported to be releasing 16,000 CFS combined during Hurricane Harvey.

United States Army Corps of Engineers - Flow Recommendation

The USACE – Hydraulics and Hydrology Branch reviewed the original report by BHA and recommended that the uncontrolled release of water that would flow around and over the north end of the dam would be in the magnitude of 40,000cfs. Based on this recommendation, BHA added 40,000cfs additional flow into the model to predict the flood levels from both the dam breach analysis and the uncontrolled release of water together. The results contained in this revised report are for a flood that is both a dam breach and an uncontrolled water release for a total flow of approximately 58,000cfs.

Downstream Routing of Dam Breach Flood

The downstream routing that was used is a channelized system where the water would break the dam in the north close to Tanner Road, and would flow east, and then south, south east, going downhill based on the contours of the ground. The contours in the area are higher in the northeastern part of the Addicks area toward Beltway 8 and going south from Tanner Road with a drop in elevations contours in a southern direction toward Interstate 10. The water flow would be channelized due to Beltway 8 on the East due to the barrier median system and retaining walls along its alignment. The water flow would be bounded on the western side by the Addicks Embankment and North by higher elevations. This forces the flow of water down Brittmoore, water channels flowing parallel and down Brittmoore, towards I-10 and ultimately Buffalo Bayou. Several factors involved can cause the water level to rise and fall with some of those being how the buildings, ditches, roads, and grass impede the flow of the water. The breach will fill the ditches and channels that it crosses until they are over capacity and the water spreads to the streets, storm systems, and eventually the buildings. The assumption is that a rain of this magnitude, enough to cause a breach, will most likely cause downstream water ways to have exceeded their capacity and thus produce tailwater and backwater conditions in addition to the water flowing from the failed dam.

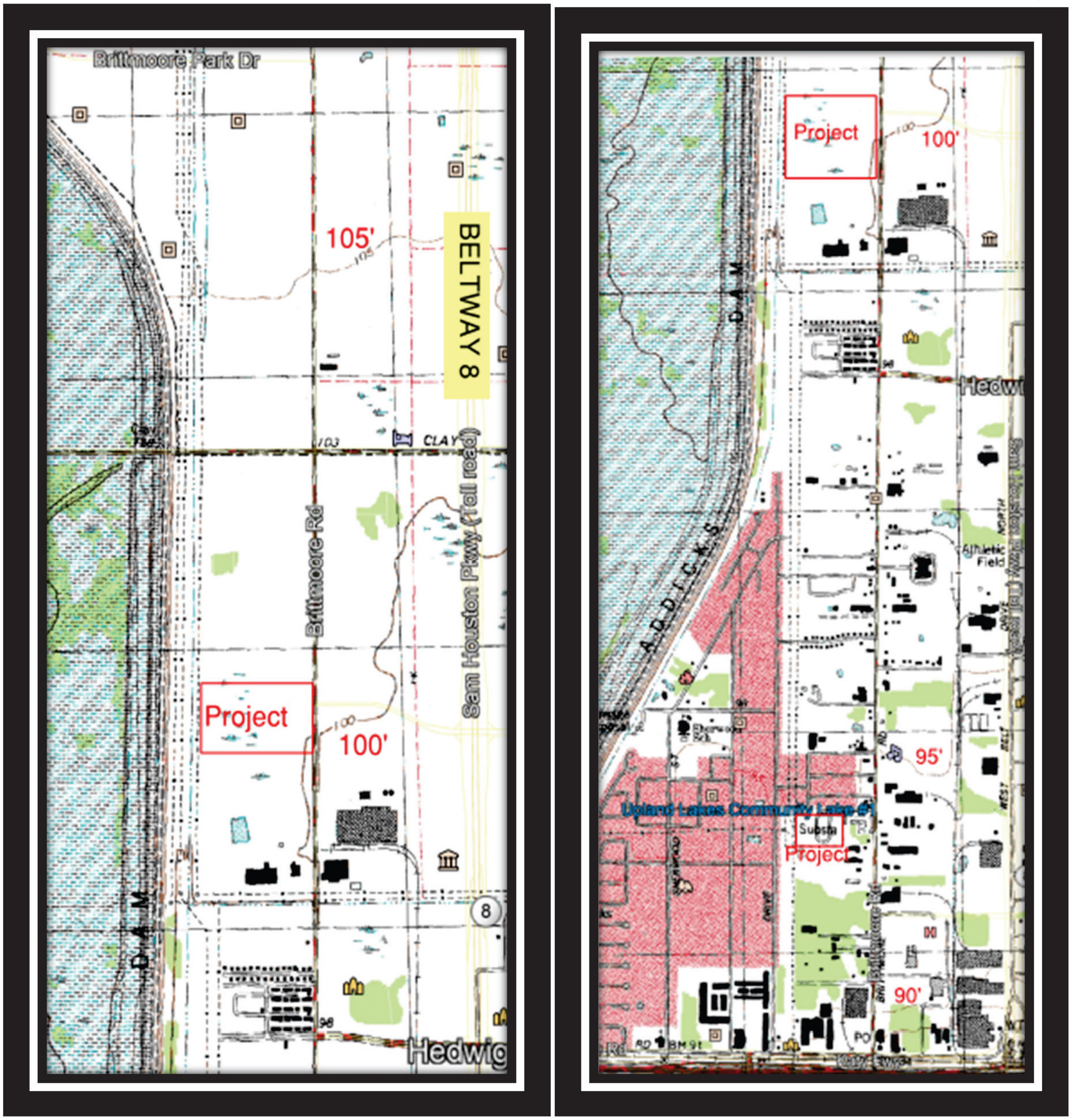

Figure 2. USGS Topographic Map with Contours.

Inundation Model Predictions

North of CenterPoint Facilities (Intersection of Tanner Road and Brittmoore Road)

The downstream inundation from this dam breach analysis has several factors and different inundation levels. The northern most part of the analysis is around the intersection of Brittmoore and Tanner Road which is the location closest to where the assumed dam breach would be located and is the section of the analysis with the highest elevation. The HydroCad model simulates the damn breach and the parameters of the area around this intersection. The model results predict an average depth of 5.45' with the highest depth being 5.52' and the lowest depth being 4.32'; the highest depth was located closer to the roadways.

Exhibit 3 (attached 11x17) is an overhead plan view of the CenterPoint Facilities with a FEMA Flood Map superimposed. This exhibit is to show where flooding should occur during a storm that is considered at least a 100-year storm; this area would be flooded prior to a dam breach which causes more reason for tailwater conditions around the CenterPoint Facilities.

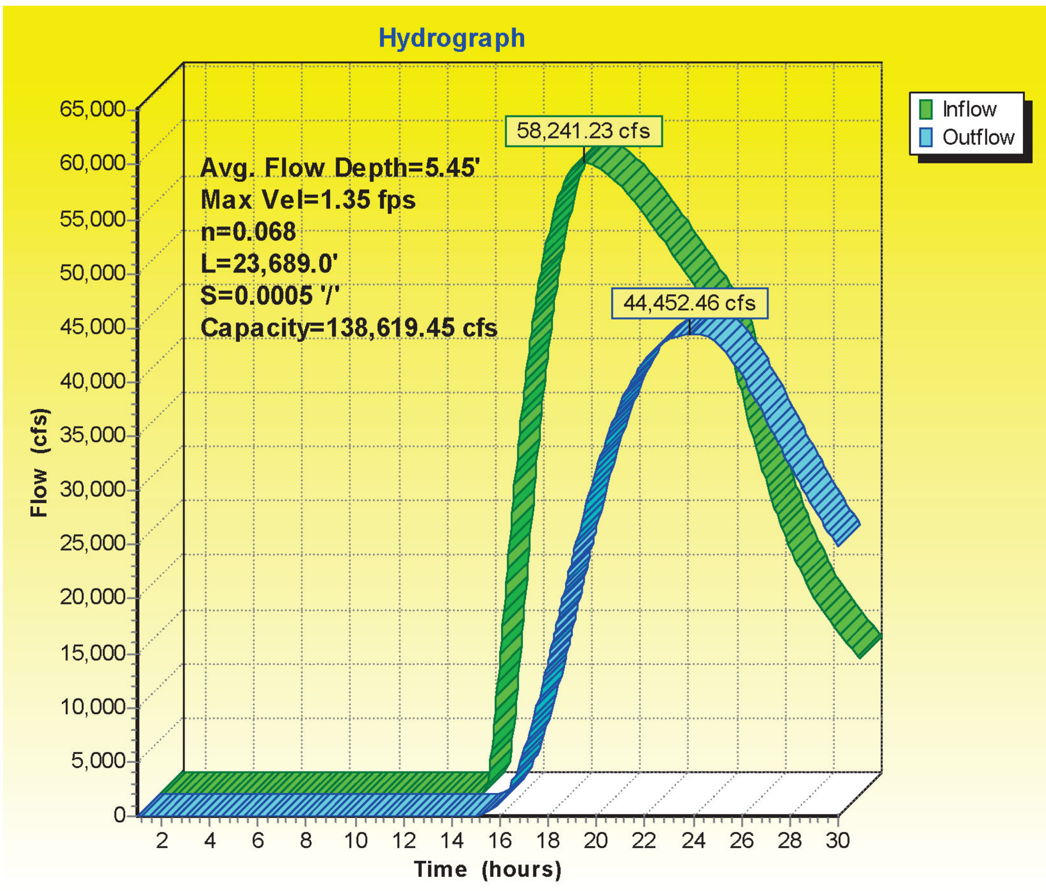

Figure 3. HydroCad output of Northern area (Tanner Road).

CenterPoint Facilities near Kempwood Drive (Addicks Substation, Spring Branch Service Center, A.O.C.)

The middle/center of the analysis is around the CenterPoint AOC, Spring Branch Center, and Addicks Substation at the intersection of Brittmoore and Kempwood. This cross section had the largest depth of water of 10.5', where the land bottle necks into a narrowed location with the bounds of the water confined closer to the CenterPoint Facilities.

The average water depth near the A.O.C. is 10.3' at elevation 104.3'. The Beltway has overpasses and intersections at grade that allows water to flow east out of the model confines. The majority of the water will still flow south toward Buffalo Bayou. Exhibit 1 (attached 11x17) is an overhead plan view of these facilities with survey shots and elevations.

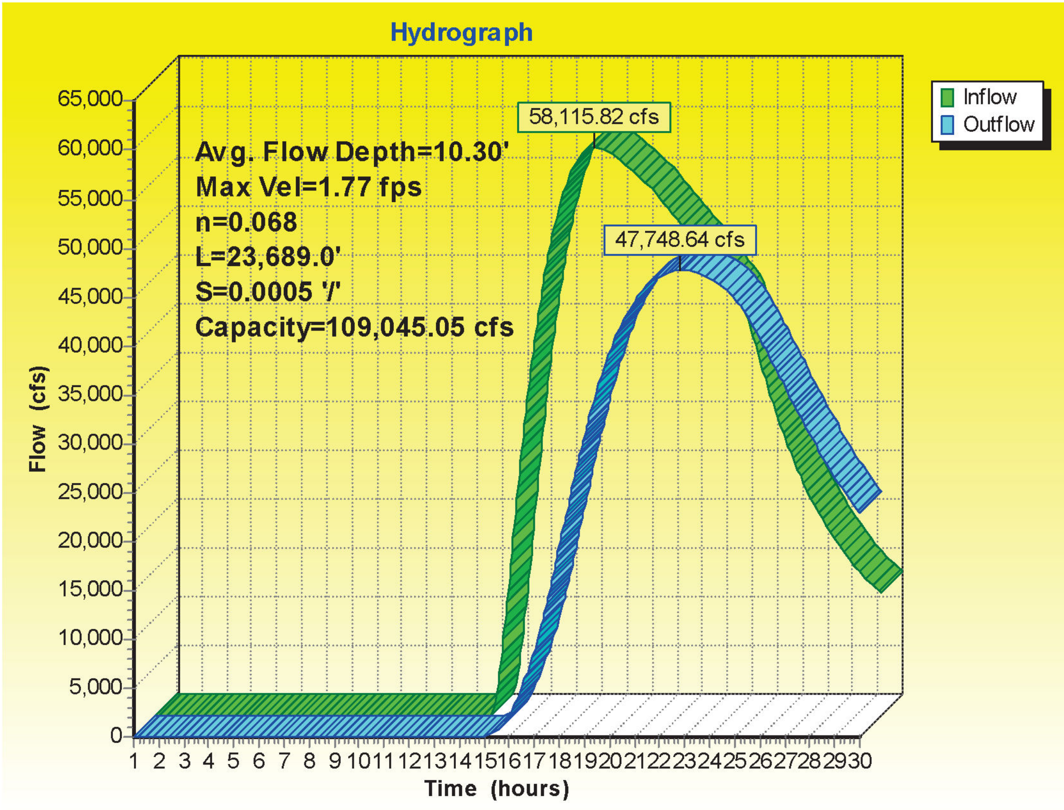

Figure 4. HydroCad output of the area by the A.O.C.

CenterPoint A.O.C.	**Model Elevations**
100-Year Floodplain Elevation from Addicks	94.00'
Brittmoore Road at Gate	95.59'
Finish Floor Elevation in A.O.C.	98.61'
Projected Water Surface Elevation from Dam Breach and Uncontrolled Flow	104.3'

Table 1. Elevation Data at CenterPoint Area of Operations Center (Area Operations Center).

CenterPoint SBSC.	**Model Elevations**
100-Year Floodplain Elevation from Addicks	94.00'
Brittmoore Road at Gate	95.59'
Finish Floor Elevation in SBSC	101.15’
Projected Water Surface Elevation from Dam Breach and Uncontrolled Flow	104.3'

Table 2. Elevation Data at CenterPoint Area of Operations Center (Spring Branch Service Center).

CenterPoint Addicks Substation.	Model Elevations
100-Year Floodplain Elevation from Addicks	94.00'
Brittmoore Road at Gate	95.59'
Finish Floor Elevation in Ctrl Rm	100.31'
Projected Water Surface Elevation from Dam Breach and Uncontrolled Flow	104.3'

Table 3. Elevation Data at CenterPoint Area of Operations Center (Addicks Substation).

Brittmoore Substation

The southern analysis point is located around the intersection of Brittmoore and Mayfield Road; at the Brittmoore Substation. This is the last section where an analysis took place. Due to the wide area, the low elevation and many outlets for water, this area should see a lower water elevation with an average of 4.52' predicted. The substation could actually see more than seven feet of water inside the yard and the road area and toward Beltway 8 and Interstate 10 have a low lying intersection that would see water closer to ten feet based on the model. Exhibit 2 (attached 11x17) is an overhead plan view of the Brittmoore Substation with survey shots and elevations.

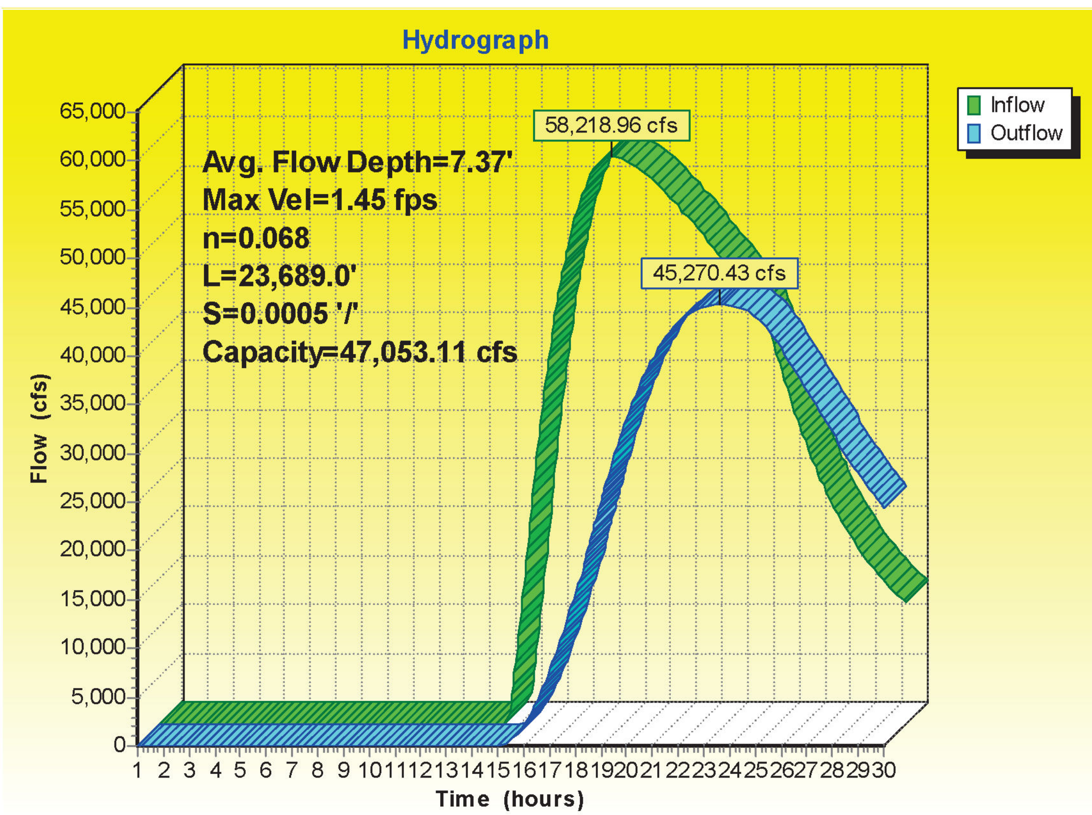

Figure 5. HydroCad output of the Brittmoore Substation.

CenterPoint Brittmoore Substation	Model Elevations
Brittmoore Road at Substation	88.06'
Finish Floor Elevation Control Bldg	91.05'
Projected Water Surface Elevation from Dam Breach and Uncontrolled Flow	96.37’

Table 4. Elevation Data at CenterPoint Brittmoore Substation.

Conclusion

The Addicks Reservoir has survived all of the major storms to hit the Galveston/Houston area since 1938, when it was built. Hurricane Harvey was the latest test to the dam embankment that contains the water that is captured. In our opinion it would take almost a combination of several storms to breach the dam embankment, but that isn’t to say that the embankment will never break. This analysis took the flooding and rainfall of Hurricane Harvey and added some additional rain. Based on the model storm, dam break model and the USACE recommended uncontrolled release amount of 40,000cfs anywhere from 7’ to 10’ of water in the Brittmoore road area is possible. This model also predicts the average of water will be one to four (4) feet of water in the Addicks Substation control room, 3.2 feet of water in the Spring Branch Service Center, and one to 6.6 feet inside the A.O.C. As the analysis went further south from the breach, the water is an average of eight to nine feet of water in the Brittmoore road area. This will cause five to six feet of water in the Brittmoore Substation.

Recommendation

Based on this study, BHA recommends that the modeled water surface elevation plus three (3) feet of freeboard be used as the basis for the CenterPoint facility protection in the Addicks Reservoir study area. This results in the A.O.C. needing 8.7’ flood doors added to the building, the Spring Branch Service Center needing 11.3’ of protection, the Addicks Substation needing 10.3’ of protection, and Brittmoore Substation needing 10.4’of protection.

Location	Ground Elevation (ft)	Finish Floor Elevation (ft)	Water Surface Elevation (ft)	Prop. Protection (ft)
CenterPoint A.O.C. (Storm Doors)	94 - 96.77	98.61	104.3	8.7
CenterPoint SBSC.	96.39 - 97.46	101.15	104.3	11.3
CenterPoint ADSS.	97.06 - 98.36	100.31	104.3	10.3
CenterPoint Brittmoore Substation	89.32 - 91.05	91.05	96.4	10.4

Table 5. Elevation Data of each location with Water Surface Elevation.

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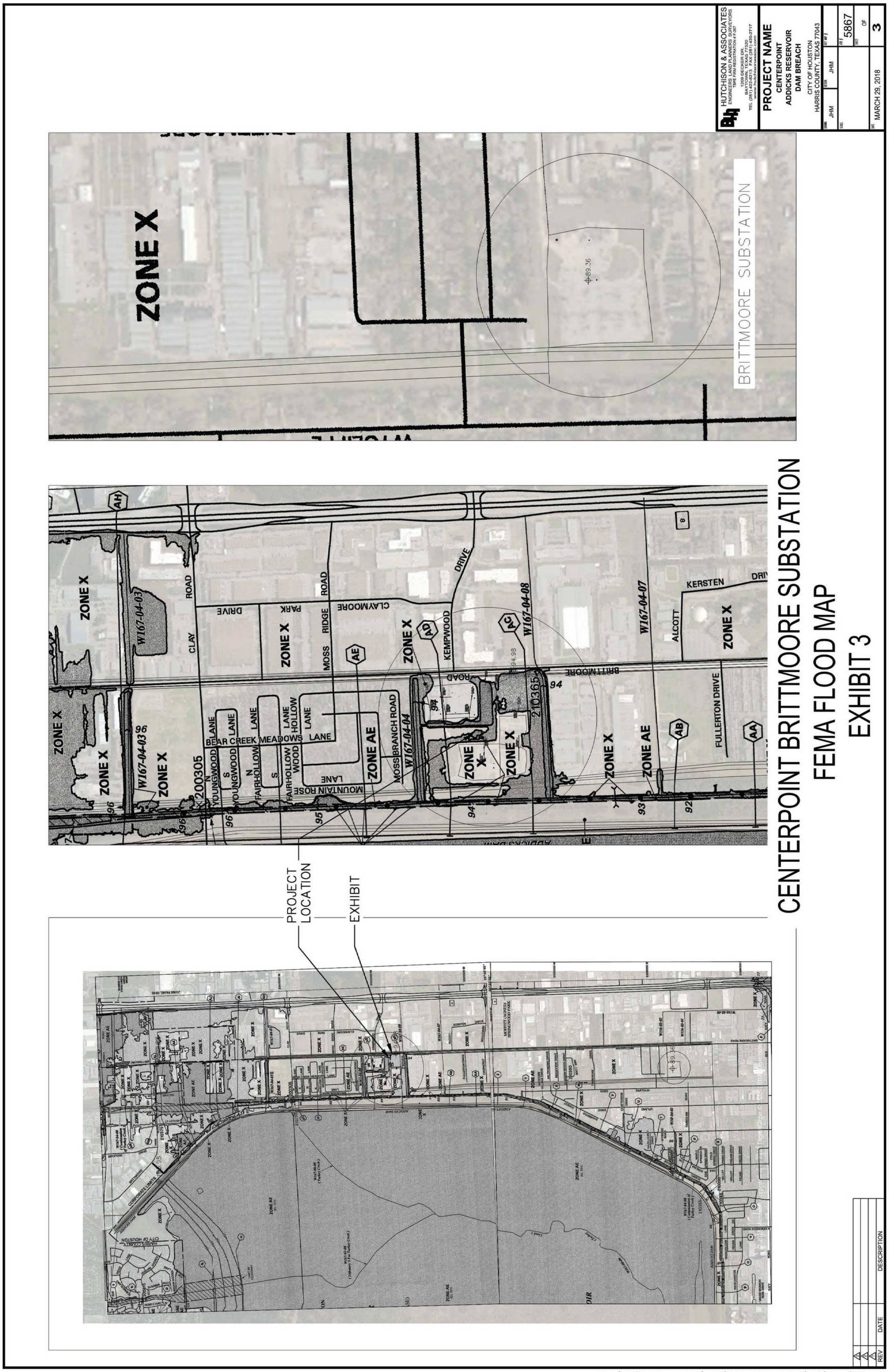
CENTERPOINT BRITTMOORE CENTER
EXHIBIT 1
A.O.C.
FFE: 98.61'
WSE: 104.3'
SPRING BRANCH
FFE: 101.15'
WSE: 104.3'
ADDICKS SUBSTATION
FFE: 100.31'
WSE: 104.3'
DETENTION POND
HUTCHISON & ASSOCIATES
ENGINEERS, LAND PLANNERS, SURVEYORS
PROJECT NAME
CENTERPOINT
ADDICKS RESERVOIR
DAM BREACH
CITY OF HOUSTON
HARRIS COUNTY, TEXAS 77043
JHM
JHM
1" = 80'
5867
MARCH 29, 2018
1
DATE
DESCRIPTION


CENTERPOINT BRITTMOORE SUBSTATION
EXHIBIT 2
FFE: 91.17'
WSE: 96.37'
FFE: 91.05'
HUTCHISON & ASSOCIATES
PROJECT NAME
CENTERPOINT
ADDICKS RESERVOIR
DAM BREACH
CITY OF HOUSTON
HARRIS COUNTY, TEXAS 77043
1" = 60'
MARCH 29, 2018
5867
2
REV
DATE
DESCRIPTION


HUTCHISON & ASSOCIATES
ENGINEERS LAND PLANNERS SURVEYORS
PROJECT NAME
CENTERPOINT
ADDICKS RESERVOIR
DAM BREACH
CITY OF HOUSTON
HARRIS COUNTY, TEXAS 77043
JHM
JHM
5867
3
MARCH 29, 2018
ZONE X
BRITTMOORE SUBSTATION
CENTERPOINT BRITTMOORE SUBSTATION
FEMA FLOOD MAP
EXHIBIT 3
PROJECT LOCATION
EXHIBIT
ZONE AE
CLAY ROAD
MOSS RIDGE ROAD
CLAYMOORE PARK DRIVE
KEMPWOOD DRIVE
BRITTMOORE ROAD
BEAR CREEK MEADOWS LANE
MOUNTAIN ROSE LANE
MOSS BRANCH ROAD
FULLERTON DRIVE
KERSTEN DRIVE
ALCOTT
W167-04-03
W167-04-04
W167-04-07
W167-04-08
REV
DATE
DESCRIPTION

From: Billings, John J
To: Tamez, David
Cc: Bryant, Kevin J
Subject: Flood Mitigation Substations
Date: Tuesday, July 10, 2018 4:43:17 PM
Attachments: ~~image001.png~~

David,

The substations that are currently on the list to be evaluated for long term flood mitigation.

1. Wallisville(2018 Project)
2. West Columbia(Possible 2019)
3. Greens Bayou
4. Brays
5. Parkway
6. Northbelt
7. Wharton
8. Brazos Valley

Let me know if you have any questions or need more information.

Thank you,

John (Jacob) Billings
Electrical Engineer, R&S
Substation Project Engineering
CNP-T 1563C, Office 713-207-7296
john.billings@centerpointenergy.com

FLOOD POTENTIAL STUDY
Draft Version

TEN SUBSTATION SITES
HOUSTON/GALVESTON AREA

REPORTED TO:
RELIANT ENERGY HL&P

BHA PROJECT NO: 01-5089

JANUARY 2002

STATE OF TEXAS
JERRY I. GAINER
69787
REGISTERED
PROFESSIONAL ENGINEER

1-31-02

PREPARED BY:

BUSCH, HUTCHISON & ASSOCIATES, INC.
1209 Decker Drive, Suite 100
Baytown, Texas 77520

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TABLE OF CONTENTS

January 31, 2001

Project Title: Flood Potential Study for 10 Reliant Energy HL&P Substation Sites

I. EXECUTIVE SUMMARY

In the wake of Tropical Storm Allison from June 5 – June 9, 2001 many areas of Houston experienced extensive flooding. Because of these unusual events, Busch, Hutchison & Associates, Inc. was retained by Reliant Energy HL&P to perform a flood potential study for 10 substation sites. Nine of the sites are located throughout the Houston area while one is in Galveston near the Seawall. They are:

1. The Seawall Substation	6. The Grant Substation
2. The TH Wharton Substation(s)	7. The Downtown Substation
3. The Greens Road Substation	8. The Polk Substation
4. The Intercontinental Substation	9. The Gable Substation
5. The Drouet Substation	10. The Proposed Franklin Substation

NOTES:
a) Substation Numbers 6 and 9 are recommended for major flood protection devices or measures.
b) Substation 2 is recommended for minor measures.
c) No protection measures are recommended for the rest of the substations.

Our scope of work was to evaluate the potential for flooding using historical storm data and current rainfall data from Tropical Storm Allison. We also established site elevations by field surveying for each of the ten substations. These elevations were then related to the 1973 datum, which is where the Federal Emergency Management Agency (FEMA) 100-year flood plain on the Flood Insurance Rate Maps (FIRM) comes from. We obtained the hydrological and hydraulic models from the Harris County Flood Control District (HCFCD) for the streams that impact the substations. The worst part of Allison was then superimposed over the watersheds that affected the various sites in order to predict the potential flood elevation for each site. Based on the results, we have included a detailed discussion on how each site could be impacted as well as recommendations and conclusions.

II. INTRODUCTION

In the worst part of Allison, a total of 36 inches of rain over a five-day period fell in Northeast Houston inside the Beltway resulting in massive flooding. Approximately 24 of the total 36 inches fell from 6:00 P.M. on Friday, June 8 through 6:00 A.M. the following morning (refer to Figure 1). Consequently, Greens Bayou crested at 15.9 feet above the 100-year flood stage level at Ley Street. Other areas of Houston also felt the brunt of Allison including but not limited to the Medical Center in the Downtown area and various freeway underpasses. There were also thousands of homes and other structures damaged from the floodwaters causing an estimated five billion dollars in total damage.

In 1978, the United States National Weather Service (US NWS) developed an all-season 24-hour probable maximum precipitation (PMP) for the United States (refer to Figure 5). The PMP for the Houston area is listed as greater than 39.50 inches of rainfall in a 24-hour period. In July of 1979, Tropical Storm Claudette dumped 43 inches of rain in 24 hours in Alvin, Texas and set a United States record. In comparison, Tropical Storm Allison produced about 24.4 inches over a 24-hour period (refer to Figure 1). Allison was a major event but it certainly could have been worse. Section IV below provides for a historical perspective.

FEMA uses the 100-year storm as the standard recurrence interval to establish flood elevations. The 100-year rainfall event is defined as having a one percent or one in one hundred probability that it could occur in any given year. This does not imply that these storms will or should be spaced 100 years apart due to the fact that extreme rainfall events are mutually exclusive events. For example, a stream or portions of a watershed could experience 100-year flood levels multiple times in a decade and then not have one for another fifty years. The amount of rainfall associated with the FEMA established 100-year event is based on Technical Paper 40, which was published in the 1960's by the U.S. Army Corps of Engineers (USACE). For Harris County and the surrounding area, the 100-year rainfall amount is defined as 12.8 inches over a 24-hour period. In comparing with the worst part of Tropical Storm Allison, about twice as much rain fell in half that time, 24 inches in 12 hours (see Figure 1).

III. ANALYSIS PROCEDURE

In 1968, Congress created the National Flood Insurance Program (NFIP) in response to the rising cost of taxpayer funded disaster relief for flood victims and the increasing amount of damage caused by floods. This program is managed by FEMA and it is the means for how flood insurance and rates are established. The accepted and approved method that FEMA uses in delineating the 100-year floodplain boundaries is through hydrological and hydraulic computer models. These models were developed by the USACE Hydrologic Engineering Center (HEC) in the 1960's. The hydrological model, HEC-1, consists of precipitation data from Technical Paper 40 along with the watershed parameters for a particular watercourse. The 100-year precipitation totals are input into the HEC-1 model, which then calculates the 100-year stream peak discharges. These peak 100-year discharges are then placed into the hydraulic model, HEC-2, in order to establish the computed water surface elevations during a 100-year flooding event. The HEC-2 model consists of cross-section data and it defines the channel characteristics along the stream. The 100-year flood wave is then modeled through the stream by incorporating the peak discharges from the HEC-1 model.

The Harris County Flood Control District (HCFCD) provided us with the accepted HEC-1 and HEC-2 computer models. We then obtained the Allison storm precipitation data from the Harris County Office of Emergency Management (HCOEM) for use with the models. Tropical Storm Allison produced its greatest rainfall totals in northeast Houston (~35 inches) and consequently, we used the Ley Street stream gauge data (see Figure 1). The 35 inches of rainfall was then coded into the HEC-1 models for all of the watersheds where the substations are located. The associated peak flows from Tropical Storm Allison were then placed into the HEC-2 models to obtain the theoretical water surface elevations.

IV. HISTORICAL PERSPECTIVE

The Houston area is no stranger to flooding. Coupled with the area's flat terrain, relatively limited capacity watercourses, and its proximity to the Gulf of Mexico, Houston is especially prone to severe flooding from tropical storms and hurricanes. There are six major bayous that run through the City of Houston and Harris County from west to east. They are: Greens Bayou, Halls Bayou, White Oak Bayou, Buffalo Bayou, Brays Bayou, and Sims Bayou. These bayous all drain into the Houston Ship Channel and carry the runoff east into Burnett Bay with eventual outfall into Galveston Bay.

Areas in and around Harris County have experienced several severe flooding events over the past 102 years. Figure 2 depicts six of the largest rainfall events to hit the surrounding Houston area on the Texas Gulf Coast area between 1899 and 2001. As shown by this graphical representation of the rainfall intensity and storm area size, Tropical Storm Allison was not that large of a storm. It covered a relatively small area compared with the other storms and it was only 44% as big in terms of size than the next largest storm (Claudette, 1979). In other words, Claudette was 2.3 times the size of Allison. A very small portion of Houston actually experienced the maximum 30 plus inches of rainfall over the life of Tropical Storm Allison (five days).

Other notable historical flood events include ones that occurred in May of 1929 and December of 1935. Both storms caused extensive flooding in the Houston downtown area, but the 1935 storm caused floodwaters to rise to the second and third floors in many downtown office buildings. More than 100 city blocks were inundated causing an estimated $164 million in damage (today's dollars). The 1935 flood event was what led to the formation of the Harris County Flood Control District (HCFCD).

V. FUTURE REGULATORY CHANGES

The local civil engineering community along with FEMA and flood control officials realize that the existing FEMA Flood Insurance Rate Maps (FIRM) are out of date and in some cases woefully inaccurate. For example, the United States Geological Survey (USGS) stream gauge at Greens Bayou and Ley Street in northeast Houston has exceeded the 100-year flood stage level a total of 12 times since 1972. This indicates that the existing hydraulic and/or hydrological computer models are in need of revisions with respect to the surrounding topography, bayou geometry, and/or its ability to convey floodwaters.

As a result of Tropical Storm Allison, the FEMA Flood Insurance Rate Maps (FIRM) for Harris County will be updated using new technology. With the help of global positioning satellites, the entire county will be remapped using a highly accurate laser measurement system mounted on small aircrafts. The new map contours will then be used to restudy local streams and bayous and determine the new flood plain boundaries. Preliminary numbers from FEMA and HCFCD indicate that the floodplain elevations could rise as much as four-and-a-half feet in some areas as a result of the new study. This could mean that thousands of homes and businesses currently not in the floodplain could wind up in the new floodplain boundaries.

VI. RESULTS AND RECOMMENDATIONS

SEAWALL SUBSTATION

Galveston Island faces the Gulf of Mexico and is therefore especially prone to both tropical storm systems and hurricanes. The coastal plain is quite low and it gently slopes seaward thus making the storm surge envelope from a hurricane very broad. In other words, a coastline with a shallow slope along the Continental Shelf will have a far greater storm surge than that of a coastline with a steep slope. The Galveston Bay area can basically be characterized as having a low-lying topography coupled with a gentle offshore/near shore sloping bottom.

In the Great Storm of September 8, 1900, a hurricane with sustained winds in excess of 130 miles per hour caused extensive damage to Galveston and an estimated 6,000 to 8,000 deaths. Although the meteorological records are sketchy, the storm surge apparently reached a height of about 20 feet above sea level. This storm intensity was either category 3 or 4 on the Saffir-Simpson Hurricane Scale (see Table below). As a result, a coastal engineering structure known as the Galveston Seawall was constructed to protect the most vulnerable part of the island. The seawall was built to an elevation of around 14 feet, which in theory should protect the seaward face of the island from a category 3 or 4 hurricane.

Hurricane Intensity Scale

Category	Wind Speed	Barometric Pressure	Storm Surge	Damage Potential
1 (Weak)	75-95 mph 65-82 kts	28.94" or more 980.02 mb or more	4.0' – 5.0' 1.2 m – 1.5 m	Minimal damage to vegetation
2 (Moderate)	96-110 mph 83-95 kts	28.50" – 28.93" 965.12 mb – 979.68 mb	6.0' – 8.0' 1.8 m – 2.4 m	Moderate Damage to Houses
3 (Strong)	111-130 mph 96-113 kts	27.91" – 28.49" 945.14 mb – 964.78 mb	9.0' – 12.0' 2.7 m – 3.7 m	Extensive Damage to Small Buildings
4 (Very Strong)	131-155 mph 114-135 kts	27.17" – 27.90" 920.08 mb – 944.80 mb	13.0' – 18.0' 3.9 m – 5.5 m	Extreme Structural Damage
5 (Devastating)	> 155 mph > 135 kts	Less than 27.17" Less than 920.08 mb	> 18.0' > 5.5 m	Catastrophic Building Failures Possible

Source: Federal Emergency Management Agency

The strongest storm to hit the United States in recent times was Hurricane Andrew in August of 1992. Upon landfall in Homestead, Florida, Andrew packed winds of 144 miles per hour and was classified as a strong category 4 hurricane. In the last century, there have been two category 5 hurricanes to strike the U.S. mainland. The 1935 Labor Day Hurricane that hit the Florida Keys, reached wind speeds up to 200 miles per hour and had the lowest pressure ever recorded at 892 millibars. In 1969, Hurricane Camille came on shore along the Mississippi Gulf Coast with 180 mile per hour winds and produced the biggest United States storm surge on record at 25 feet.

Researchers from the National Oceanic and Atmospheric Administration (NOAA) say that we have been in a period of relatively low activity, especially in the past 20-30 years. During this period, the coastal areas experienced rapid growth and development with a large population of people now residing near the coast. NOAA predicts that there will now be a 20-30 year period of "above-normal hurricane activity." The experts have linked this to a natural ocean cycle called the Atlantic Multidecadal Mode, which is a sea surface temperature shift between warm and cool phases that lasts 25 to 40 years each.

The Seawall substation in Galveston is located at the corner of 4th Street and Avenue E four blocks from the shoreline and the Seawall itself. The site is currently not in the floodplain as defined by the FEMA FIRM map (see Exhibit A) and it is in the unshaded Zone C, which is considered to be "areas of minimal flooding." The floodplain close to the substation site is 11 feet. The 100-year storm along the coast is determined from the National Weather Service's SLOSH simulation computer model. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model predicts storm surge elevations associated with hurricanes. The SLOSH model, which is used by the National Hurricane Center, simulates wind speeds and storm surges based on meteorological conditions and surface characteristics such as sea bottom configurations, land elevations, and engineering structures such as dikes, rubble revetments, levees, and concrete seawalls. A category 3 storm with wind speeds of 111-130 miles per hour is roughly equivalent to the 100-year event. According to FEMA, the storm surge associated with a category 3 storm is 9.0 - 12.0 feet (see the Hurricane Intensity Scale above). However, the Galveston area could experience an even higher storm surge based on the moderate and gradual slope of the near shore sea bottom.

Both the finished floor of the Seawall Substation and the top of the Seawall lies at an elevation of around 14.40 feet. The two pull boxes that were surveyed have elevations of 13.19 and 14.29 feet. Since the 100-year floodplain elevation is 11 feet, the site is approximately 3.40 feet higher (see table below).

Seawall Substation

100-Year Floodplain Elevation	11.00'
Projected Storm Surge from a Category 4 Hurricane with Winds up to 155 mph	18.00'
Top of Seawall	14.36'
Finished Floor Elevations of the Control Building	14.37' and 14.48'
Pull Boxes	13.19' and 14.29'

It is our understanding that the existing structure is rated for 120 mile per hour winds, which would be that of a category 3 hurricane. In considering raising the buildings at the site, one must also take into account the wind speed and the associated pressure imposed on the structures from a hurricane. If a category 4 storm should hit the Galveston area, it could bring winds in excess of 150 miles per hour and a storm surge of around 18 feet. Since the building is rated for 120 miles per hour, the structural integrity of the buildings at the substation site would be in jeopardy. The pull boxes could be raised to a higher elevation and if Reliant Energy HL&P considers raising the control building, it should also be reinforced to withstand sustained winds of up to 150 miles per hour.

According to FEMA, a major hurricane is defined as a category 3 or higher. In the event of a category 3 or 4 hurricane, one would expect a storm surge up to 18 feet. Even if the building were raised two feet to an elevation 16.50 feet, it would still be inundated with seawater not to mention damage to the buildings from the powerful winds. In spite of this, it is our recommendation to do nothing for this site since the island would be evacuated and the damage to most island facilities would be extensive. There is, however, a risk factor. Experts say that Galveston is among one of the most "vulnerable cities" for a major hurricane to strike. The last major hurricane that struck the area was that of Hurricane Alicia on August 18, 1983. It made landfall with 115 mph winds and produced a storm surge of 10 feet.

TH WHARTON SUBSTATIONS

The TH Wharton substation site is located within the Greens Bayou watershed next to Highway 249 and Beltway 8 in northwest Houston. It lies just east of the ECDC facility. And the site drains both north to Greens Bayou and south to White Oak Bayou. There are several ditches that flows to the north of the site while one flows to the south. The floodplain associated with the TH Wharton site is from Greens Bayou. According to

FEMA FIRM panel number 435, the substation site is outside of the 500-year floodplain (refer to Exhibit A). Based on the survey that we conducted, the building foundations as well as the pull boxes are all below the 100-year floodplain elevation of 123 feet from Greens Bayou (see table below). By superimposing the worst part of Tropical Storm Allison (35" of rain) over the Greens Bayou watershed and running the hydraulic and hydrological models for Greens Bayou, the TH Wharton site could experience a theoretical floodplain elevation of 123.60 feet. The potential water surface elevation only rose 0.60 feet above flood stage because the site is located on the upper end of the Greens Bayou watershed. The water simply does not have enough time to build up before it starts to runoff and flow downstream. As previously stated, the site is situated on the watershed divide between what drains north to Greens Bayou and south to White Oak Bayou. In a major flood event, the majority of the water would change direction and flow south across the substation site to White Oak Bayou. The water surface elevation would not be able to rise to the theoretical floodplain elevation because of the natural ground slope to White Oak Bayou. The water will be displaced across a wide area and it would not build up but rather it would sheet flow to the south. The TH Wharton power plant has been in operation since 1948 and historically, it has not experienced any significant flooding according to plant personnel. This further indicates that the site is relatively safe from flooding at this time.

TH Wharton Substations

100-Year Floodplain Elevation	123.00'
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	123.60'
Finished Floor Elevations of the Three Control Buildings	121.89', 122.35', and 122.76'
Pull Boxes	121.34', 121.97', 122.25', 122.29'

Our assessment for the TH Wharton substation site is that the site is not especially prone to flooding and that no major flood control devices or measures are needed. We do, however, recommend that a flap gate assembly be installed on the downstream end of the culvert under the access road along the north side of the property (see FEMA FIRM panel number 435 in Exhibit A). This would ensure that the outfall ditch that drains directly into Greens Bayou would not back up water during a significant rain event as was evidenced during Tropical Storm Allison. The estimated cost to install a flap gate assembly would be around $5,000.00.

GREENS ROAD SUBSTATION

The Greens Road substation is located just south of Busch Intercontinental Airport and in between John F. Kennedy Boulevard and Milner Road. The site runoff drains to the west approximately one mile along Greens Road and outfalls into a tributary of Greens Bayou. This tributary then drains due south a distance of about three quarters of a mile to the confluence with Greens Bayou. The substation site is located outside of the 500-year floodplain as outlined on FEMA FIRM panel number 480. After running the computer models with the 35-inch rain distribution from Tropical Storm Allison, the computed water surface elevation rose five feet above the 100-year floodplain elevation. However, the substation site is two to four feet above this highest level (see table below).

Greens Road Substation

100-Year Floodplain Elevation at Tributary to Greens Bayou	75.00'
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	80.00'
Concrete Roadway Entrance to the Site	81.76'
Finished Floor Elevation of the Control Building	84.20'
Pull Boxes	82.74' and 82.90'

Based on the results of the analysis, we feel that this site is safe and therefore, recommend a do nothing scenario.

INTERCONTINENTAL SUBSTATION

The Intercontinental substation is located nearby the Greens Road substation just west of the Busch Intercontinental Airport on Aldine Westfield Road (see Exhibit A). The storm water runoff drains due south approximately 1.40 miles and empties into the same tributary of Greens Bayou that the Greens Road substation does. Per FEMA FIRM panel number 480, the substation site is located outside of the 500-year floodplain. As was the case for the Greens Road site, this area of Greens Bayou would also experience about a five-foot increase in the computed water surface elevation from the 100-year floodplain elevation. As depicted in the table below, this site is situated well above what the worst of Allison would produce.

Intercontinental Substation

100-Year Floodplain Elevation from Tributary to Greens Bayou	89.00'
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	94.00'
Rock Roadway Entrance to the Site	95.78'
Finished Floor Elevation of the Control Building	98.43'
Pull Boxes	96.53', 97.00', and 97.05'

Based on the results of the study, the recommendation would be to do nothing.

DROUET SUBSTATION

The Drouet substation is located at 6719 Tipperary Lane just east of Telephone Road and south of Loop 610. The site drains west to Telephone Road and then north with outfall into Sims Bayou. The 100-year floodplain elevation from Sims Bayou is 32.00 feet as outlined on FEMA FIRM panel number 895. The existing substation site is shown to be outside of the 500-year floodplain. After modeling the 35-inch rainfall from Tropical Storm Allison on the Sims Bayou watershed, the projected water surface rise above the 100-year level is about 3.50 feet. The lowest part of the site is over one foot above the theoretical water surface of 35.50 feet (refer to the table below).

Drouet Substation

100-Year Floodplain Elevation from Sims Bayou	32.00'
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	35.50'
Concrete Roadway Entrance to the Site	36.62'
Finished Floor Elevation of the Control Building	38.01'
Pull Boxes	37.36' and 37.42'

This site should be safe in a large event such as Tropical Storm Allison. We, therefore, recommend for Reliant Energy HL&P to not take any preventative flood control measures.

GRANT SUBSTATION

The Grant substation is situated along the north bank of Brays Bayou by the Texas Medical Center at Fannin Street. The site drains directly into the bayou. The 100-year floodplain elevation from Brays Bayou is 45.00 feet as outlined on FEMA FIRM panel number 860. The substation site is shown to be entirely within the 100-year floodplain. After modeling the Allison storm that fell in northeast Houston on the Brays Bayou watershed (~35 inches), the water surface could rise as much as five feet above the 100-year level (refer to the table below). This could produce as much as six to seven feet of water within the substation site.

During Allison, Brays Bayou received about 14.8 inches of rainfall in a 12-hour period at the Texas Medical Center (TMC). According to Dr. Philip Bedient, Professor and Herman Brown Chair of Engineering at Rice University, the 14.8 inches of rainfall at the TMC represented greater than 100-year totals for the lower reaches of Brays Bayou and Mid-Brays Bayou (see Figure 4). However, the upper reach of Brays Bayou only experienced about a 10 or 25-year event. The TMC is located adjacent to the lower reach area of the bayou, which is defined as being East of Main Street.

Grant Substation

100-Year Floodplain Elevation from Brays Bayou	45.00'
500-Year Floodplain Elevation from Brays Bayou (from HEC-2 Model)	46.80'
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	50.00'
Top of Roadway Entrance at the Northwest Corner of the Site	43.24'
Natural Ground Elevations	42.30', 42.68', 43.59', and 44.21'
Finished Floor Elevation of the Two Control Buildings	45.85' and 46.39'
Pull Boxes	43.86', 43.93', and 44.53'

It is our understanding that the Grant substation has not had any significant problems with flooding in the past. In June of 1976, about 10 inches of rain fell in a six-hour period over the Brays and Sims Bayou watersheds of which the TMC experienced the most extensive flooding. Although many of the medical facilities designed and installed protective devices as a result of the 1976 event, Tropical Storm Allison caused the water to exceed these design measures. At the substation, reports indicate that as much as one foot of water was present within the site during the Allison flood.

The United States Army Corps of Engineers (USACE) and the Harris County Flood Control District (HCFCD) have initiated a $440 million flood protection plan for Brays Bayou. It is divided into an upstream and a downstream part. The upstream project started in 1994 and is expected to be complete by 2008. It involves the construction of three major detention basins upstream of the Sam Houston Tollway and 3.7 miles of channel enlargements. The downstream part is scheduled to begin in 2006 and finish around 2016. The downstream section will include widening Brays Bayou from the Ship Channel back to Fondren Road a total of 17 miles to increase its current capacity. The reason that it will take 10 years to complete is because it includes modifications of roadways, railroads, pipelines, and utility crossings as well as 14 bridge replacements and 17 bridge extensions.

Although the results of this study indicate that the water level from Brays Bayou could reach elevations up to 50 feet at the Grant substation, the site has fared well during major storm events. The planned work by the USACE and the HCFCD should also improve the stream capacity of Brays Bayou and its ability to convey floodwaters. As a result, the level of protection for this substation would be a function of the risk that Reliant Energy HL&P is willing to take. A reinforced concrete wall could be erected to provide protection from a future flood event. A floodgate would also be necessary at the main access point to the facility. To completely protect the site from a major flood, the height of the wall should be seven feet tall. This wall would cover the entire perimeter of the site and encompass a distance of 1490 feet. The estimated cost associated with this wall is outlined below.

Height of Wall (ft)	Cost per Linear Foot	Volume of Concrete (CY/LF)	*Projected Cost of Wall
3'	$90.00	0.17	$134,100.00
4'	$105.00	0.22	$156,450.00
5'	$120.00	0.28	$178,800.00
6'	$135.00	0.34	$201,150.00
7'	$150.00	0.42	$223,500.00

* A 20-foot wide floodgate is projected to cost around $30,000.00 and would be in addition to the estimate for the wall.

A pump station would also be necessary to pump out the rainwater from the site once the wall is built. The projected cost for this pump station is $50,000.00.

THE DOWNTOWN SUBSTATIONS

There are four downtown substation sites in close proximity to each other that we were asked to study. They are: 1) Gable substation, 2) Downtown substation, 3) Polk substation, and 4) the proposed Franklin substation. These four substations are affected by Buffalo Bayou and White Oak Bayou because the downtown area is located adjacent to the confluence of the two bayous (see FEMA FIRM panel number 690 in Exhibit A). White Oak Bayou empties directly into Buffalo Bayou at the Main Street overpass. As previously mentioned in the Historical Perspective section, the December 1935 storm caused severe flooding in the downtown area when the floodwaters rose to the second and third floors in many downtown office buildings. According to the United States Geological Survey (USGS), the stream gage at the Capitol Street Bridge measured 51.50 feet above mean sea level during the 1935 flood. Although Tropical Storm Allison caused both White Oak and Buffalo Bayou to exceed their 100-year flood levels, the downtown area received about half as much rain (18 inches) as that of Northeast Houston (35 inches) over the five-day period. The flooding downtown would have been far worse if the 35 inches would have fallen on the Buffalo and White Oak watersheds rather than that of Greens Bayou.

After modeling Tropical Storm Allison and placing 35 inches of rainfall on both Buffalo Bayou and White Oak Bayou, the results indicate that there could be as much as 10 feet of water or a water surface elevation of 60 feet in the downtown area. However, we think that a more reasonable estimate would be that the downtown area could experience a water surface up to an elevation of 53 feet on the west side and 47.50 feet on the east side of downtown. The natural ground elevation in the downtown area varies but on the average it is about 50 feet. It basically ranges from around 42 feet down by Buffalo Bayou to about 51 feet by the downtown substation. This would mean that the downtown area could have as much as three to 11 feet of water depending on the location. The following tables show each substation and its critical elevations.

Downtown Substation

100-Year Floodplain Elevation from Buffalo and White Oak Bayous	39.50’
500-Year Floodplain Elevation from Buffalo and White Oak Bayous (from HEC-2 Model)	41.60’
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	53.00’
Top of Roadway Entrance to the Site	49.30’
Finished Floor Elevation of the Control Building	52.31’
Pull Boxes	51.82’ and 51.92’

Of the four substations in the downtown area, the “Downtown substation” is at the highest elevation and is in the least danger of flooding. The substation site is located next to the east side of Interstate 45 by Pease Street. Though the site lies below the projected ultimate elevation that a large storm could cause, the control building is situated 12.80 and 10.70 feet above the 100 and 500-year floodplains, respectively. Consequently, we do not feel that this site needs to be protected with any flood control measures and/or devices.

Polk Substation

100-Year Floodplain Elevation from Buffalo and White Oak Bayous	35.00’
500-Year Floodplain Elevation from Buffalo and White Oak Bayous (from HEC-2 Model)	38.30’
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	48.00’
Top of Concrete Inside Facility	46.40’
Finished Floor Elevation of the Control Building	47.71’
Pull Box	46.84’
Polk Street Elevation	45.38’

The Polk substation is located toward the east side of downtown at the corner of Crawford and Polk. U.S. Highway 59 is just to the east of the facility. The control building is situated 12.70 feet above the 100-year floodplain and 9.40 feet above the 500-year floodplain. In a large flooding event, the water surface could rise to an elevation of 48 feet, which would produce about 1.60 feet of water inside the substation site and around 2.50 feet in the adjacent streets. The finished floor of the control building lies 0.30 feet below the projected water surface elevation of 48 feet. Based on these numbers, the site would be relatively safe in a large storm event and we do not recommend taking extensive flood control measures to protect the site.

Gable Substation

100-Year Floodplain Elevation from Buffalo and White Oak Bayous	34.00'
500-Year Floodplain Elevation from Buffalo and White Oak Bayous (from HEC-2 Model)	36.80'
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	47.50'
Entrance Road to Facility	45.58'
Finished Floor Elevations of the Two Control Buildings	43.28' and 46.94'
Pull Boxes	41.45', 42.66', 43.43', 44.86', 44.90', and 45.33'
Finished Floor of Entry to the Old Brick Power Plant Building	41.42'
Natural Ground Elevation Range	38.93' - 44.98'

The Gable substation is located on McKee Street on the east side of Buffalo Bayou in the downtown area. The site lies south of Interstate 10 and west of Highway 59. There are three major sections to the Gable substation site as described below. The lower section (Gable 1) lies about six feet lower in elevation than that of Gable 2 and 3.

Gable Number 1: The 138 KV on the lower portion of the site.
Gable Number 2: The 69 KV on the upper portion of the site.
Gable Number 3: The old brick power plant building.

After performing the analysis, the expected water surface from a severe flood could rise to an elevation of around 47.50 feet. This equates to a rise in the 100 and 500-year floodplains of 13.50 and 10.70 feet, respectively. It is our understanding that the old brick power plant building contains switchgear and generators on its second floor. This equipment should be safe even during a massive flood. The finished floor of the entry to this old building would be safe in both a 100 and 500-year storm but not in a major event. The old building could have up to six feet of water in the first floor during a 35-inch rainfall event. The control building of the lower portion (Gable 1) would have as much as 4.50 feet of water in it during a severe event while the upper control buildings at Gable 2 could have about 0.50 feet. All of the pull boxes would also be inundated.

After speaking Mr. Glenn DeShazo of Reliant Energy HL&P, the Gable substation has not flooded in the 31 years that he has been there. Historically, Buffalo Bayou experienced its worst flood in 1935 when the downtown area was inundated with water to an elevation of 51.50 feet. There is about a five-foot drop in both the floodplain elevation and natural ground from the Capitol Street Bridge down to the Gable substation site. In light of the historical track record for this site, we do not recommend that Reliant Energy HL&P do anything to protect the upper portion of the site (Gable Number 2 & 3). However, Gable Number 1 would be at risk in a severe flood. The control building at

Gable Number could have as much as four feet of water during a large event. Our recommendation is to relocate the lower control building to the upper side by Gable Street Number 2 and raise the pull boxes.

Proposed Franklin Substation

100-Year Floodplain Elevation from White Oak Bayou	40.00'
500-Year Floodplain Elevation from White Oak Bayou (HEC-2 Model)	46.00'
Projected Water Surface Elevation from Tropical Storm Allison (35 inches)	53.00'
Natural Ground at Proposed Site	42.16', 42.56', 42.57', 42.69', and 42.81'

The site of the proposed Franklin substation is located from 3.20 to 3.80 feet below the 500-year floodplain. Reliant Energy HL&P should consider a finished floor elevation above 53.00 feet to attain a substantial level of protection. Additional design considerations should be considered with respect to controls, switchgear, and pull boxes.

VII. SUMMARY OF RESULTS/CONCLUSION

This flood potential study to assess ten Reliant Energy HL&P substation sites followed the standard criteria that HCFCD and FEMA uses to establish floodplain elevations for the National Flood Insurance Program (NFIP). We obtained the hydraulic and hydrological models from the HCFCD and performed a storage discharge analysis on each of the streams that affects the substation sites. Coupled with the models, we surveyed each substation site in order to obtain elevations that correspond to the elevations in the models. The analysis was completed by superimposing 35 inches of rainfall in the affected watershed models. The 35 inches of rainfall represents the worst part of Tropical Storm Allison in Northeast Houston. The 35 inches of rainfall caused Greens Bayou at Ley Street inside Beltway 8 to crest at almost 16 feet above the 100-year floodplain elevation.

The following outlines the summary of results for each substation:

The Seawall Substation:
Based on the detailed discussion in Section VI of the report, we do not recommend installing any flood protective devices for this site.

The TH Wharton Substations:
Based on the detailed discussion in Section VI of the report, we do not recommend installing any flood protective devices for this site other than a flap gate assembly on the downstream end of the culvert under the access road to the ECDC. This culvert is located at the north end of the site and it empties into an open channel, which drains north with outfall into Greens Bayou. The proposed flap gate assembly would prevent water from backing up during large rainfall events. Please refer to FEMA FIRM panel number

435 in Exhibit A for the site location and the proposed flap gate assembly. The projected cost for this protective device is about $5,000.00.

The Greens Road Substation:
Based on the detailed discussion in Section VI of the report, we do not recommend installing any flood protective devices for this site.

The Intercontinental Substation:
Based on the detailed discussion in Section VI of the report, we do not recommend installing any flood protective devices for this site.

The Drouet Substation:
Based on the detailed discussion in Section VI of the report, we do not recommend installing any flood protective devices for this site.

The Grant Substation:
This site would be considered at risk to flood during a major rainfall event. Consequently, the level of protection should be based on the level of risk that Reliant Energy HL&P is willing to take. In section VI, we recommended that a reinforced concrete wall ranging from three to seven feet tall be constructed to provide the necessary protection during a future flood event. A floodgate would then also need to be installed at the main entrance to the site. The wall is estimated to cost anywhere from $134,000.00 to $223,500.00 depending on the chosen height and the floodgate is estimated to cost an additional $20,000.00. A pump station would also be needed and it would cost an estimated $50,000.00.

The Downtown Substation:
Based on the detailed discussion in Section VI of the report, we do not recommend installing any flood protective devices for this site.

The Polk Substation:
Based on the detailed discussion in Section VI of the report, we do not recommend installing any flood protective devices for this site.

The Gable Substation:
This substation consists of three sections. Gable Street Number 1 is located on the lower portion of the site and could be subject to flooding in a severe flooding event. As a result, we make the recommendation to consider moving the control building up to Gable Street Number 2 and raise the existing pull boxes.

The Proposed Franklin Substation:
This proposed substation should be built to have a finished floor elevation of 53.00 feet to provide for substantial protection against a major flood. Reliant Energy HL&P should also consider additional design considerations concerning the controls, switchgear, and pull boxes.

In conclusion, it is important to point out that the projected water surface elevations obtained from the computer analysis are a function of stream flooding and the streams ability to convey storm water runoff only. During heavy rainfall events, the existing storm sewer systems are not large enough to convey runoff from a major event. Generally, storm sewer systems are designed to handle a two or three-year rainfall event while the receiving streams such as the bayous can normally carry up to the 100-year event. Inadequacy of storm sewer systems and sewer obstructions can produce localized street flooding and cause the water surface in some areas to rise above the projected level from adjacent streams, bayous, and rivers. During very intense downpours, runoff cannot get into the storm sewer systems quick enough due to lack of inlet capacity and limited storm sewer capacity. In addition, during large flood events, the storm water can back up through the storm sewer system and spill back into the streets through inlets and manholes.

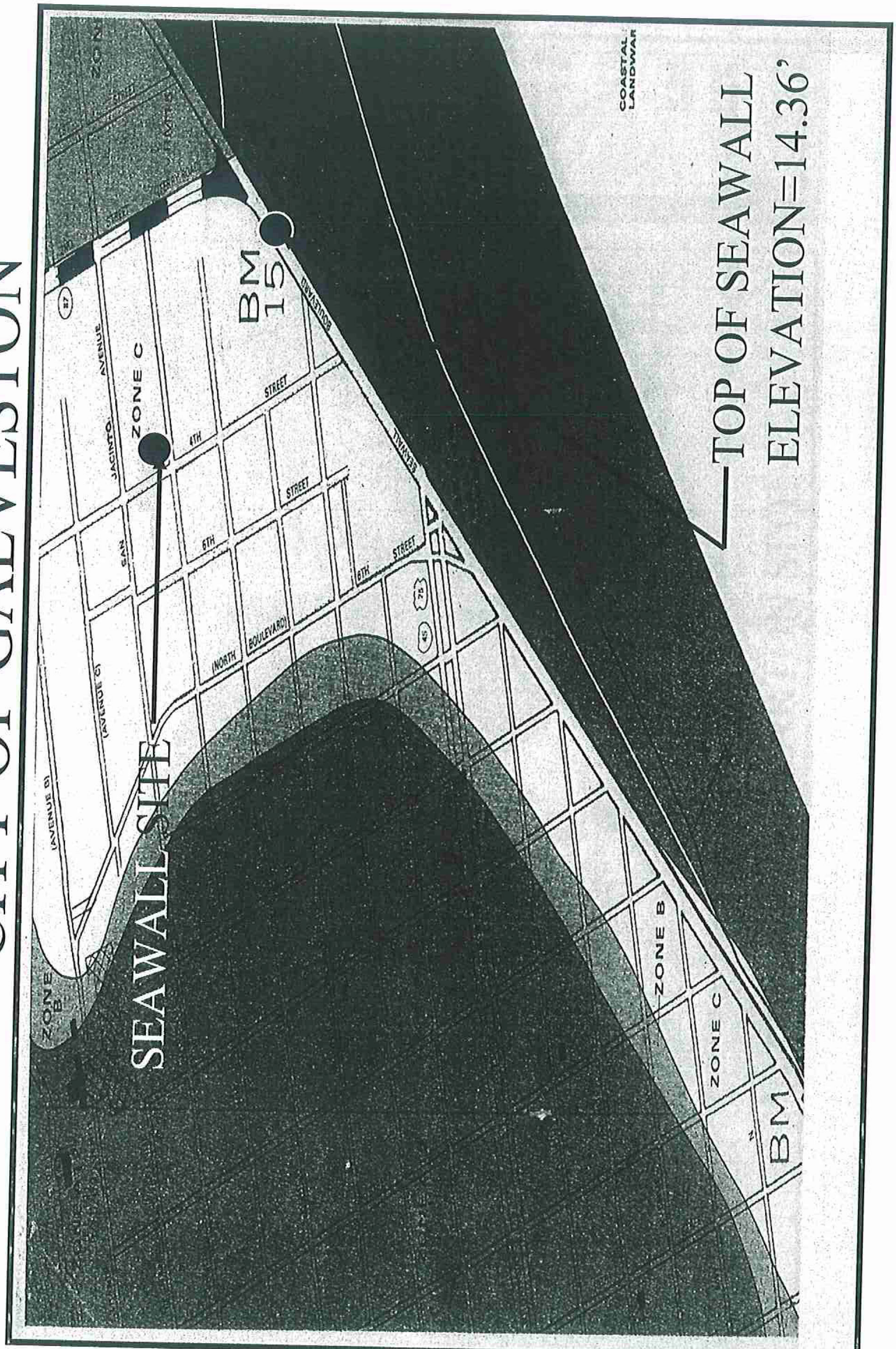
REFERENCES/SOURCES:

1. *The Houston Chronicle*
2. *The United States Geological Survey (USGS)*
3. *KHOU News*
4. *The National Weather Service (NWS) Houston/Galveston*
5. *The United States National Weather Service(US NWS)*
6. *The Federal Emergency Management Agency (FEMA)*
7. *Rice University/Texas Medical Center*
   Brays Bayou Flood Alert System
   Dr. Philip B. Bedient, Professor & Herman Chair of Engineering
8. *Texas Medical Center News*
9. *United States Army Corps of Engineers (USACE) Hydraulic Engineering Center*
10. *The National Oceanic and Atmospheric Administration (NOAA*
11. *Coastal Geomorphic Responses to Sea Level Rise: Galveston Bay, Texas*
    Stephen P. Leatherman, Chapter 5, 1982
12. *The Weather Channel and weather.com*
13. *The Harris County Flood Control District (HCFCD)*
14. *The Harris County Office of Emergency Management*

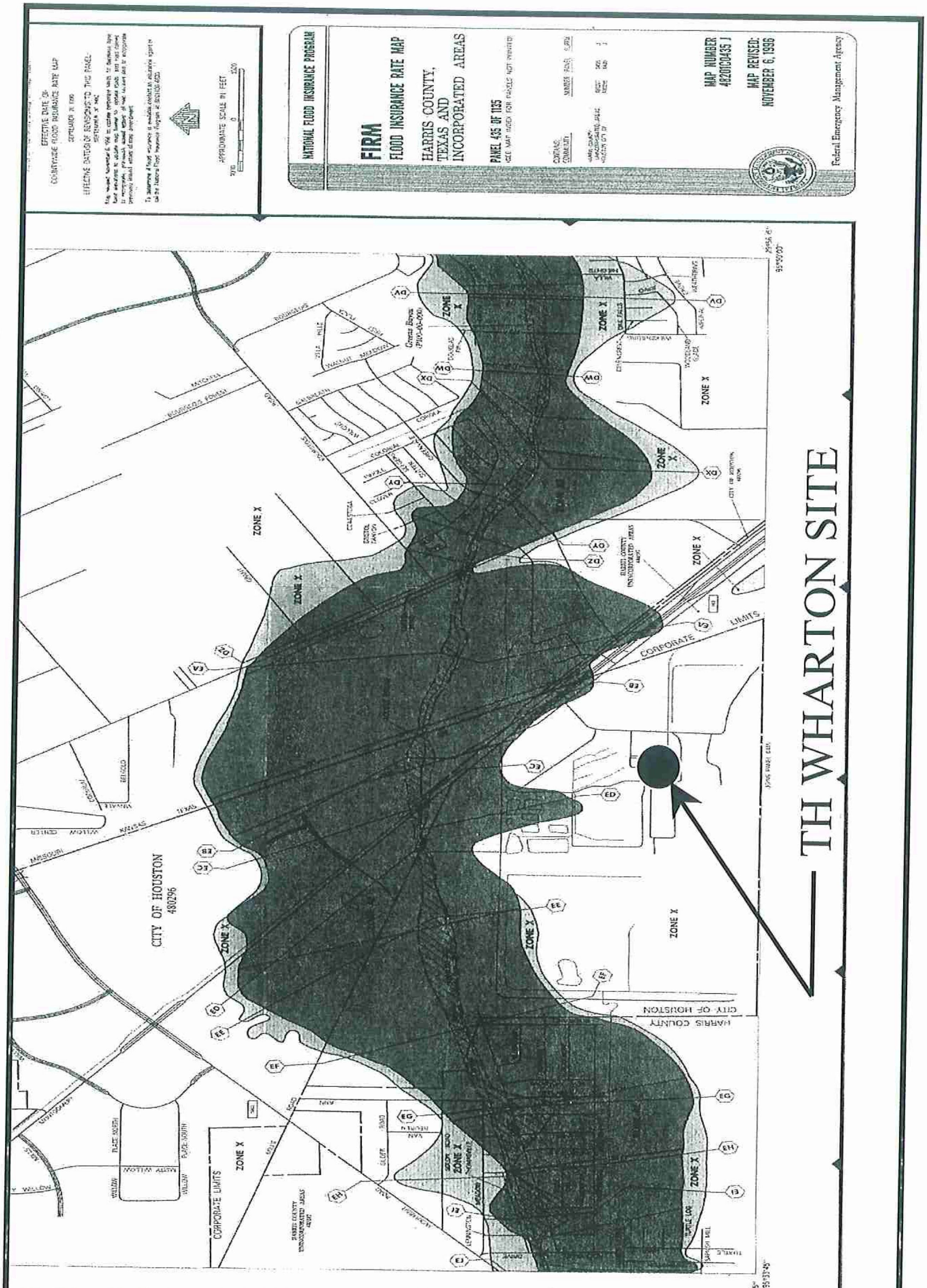
Exhibit A

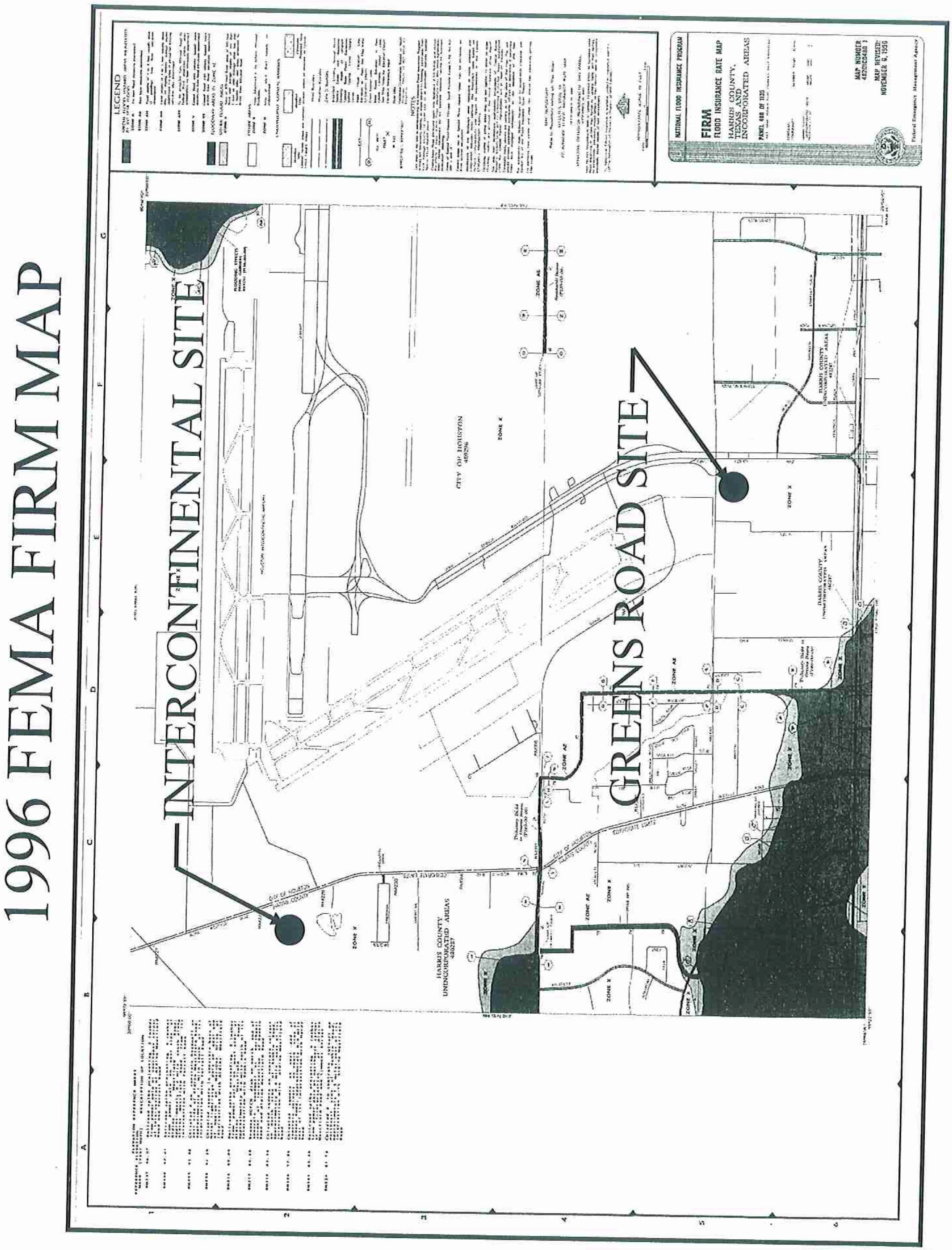
Figures

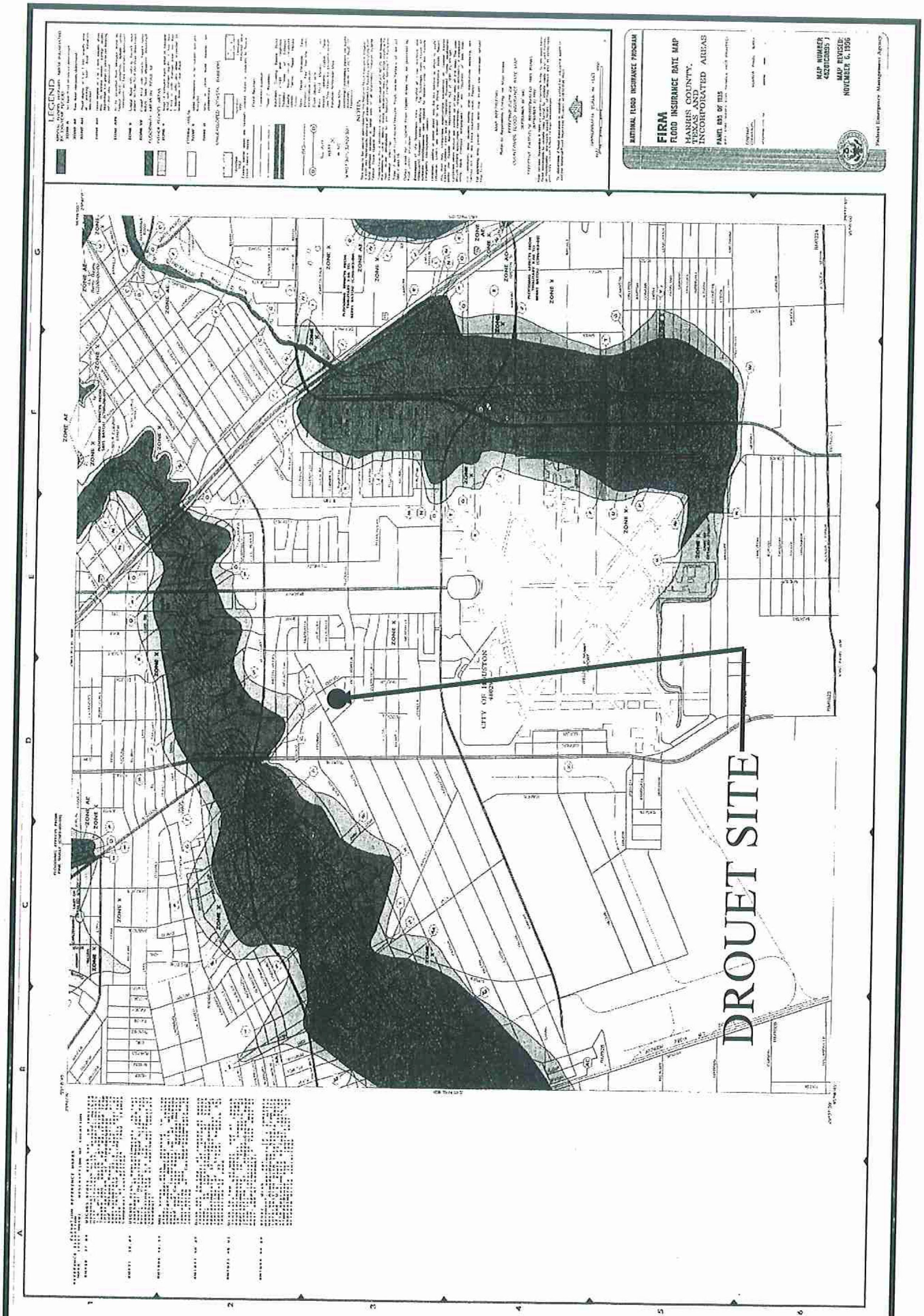
1983 FEMA FIRM MAP
CITY OF GALVESTON

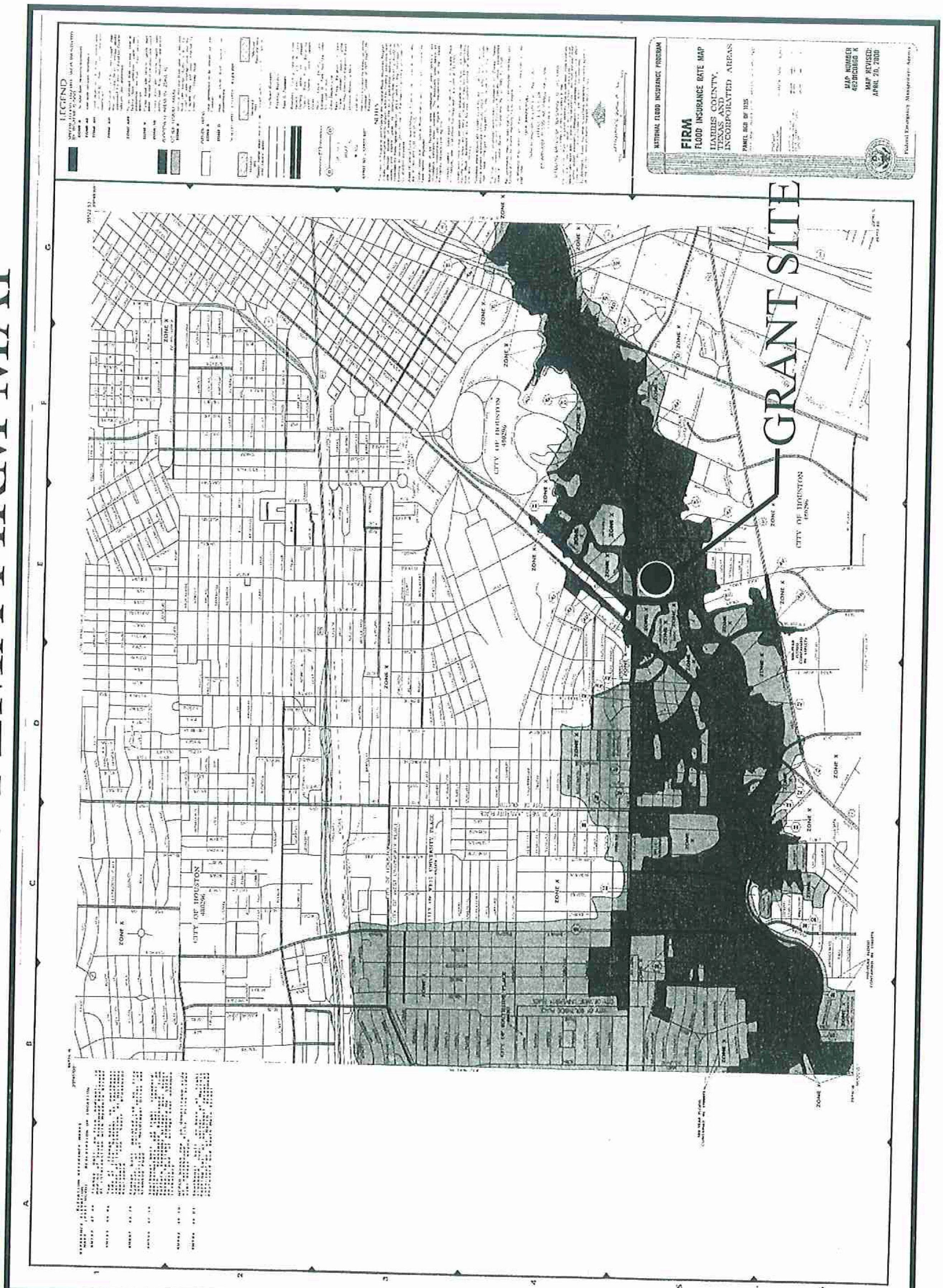


1996 FEMA FIRM MAP

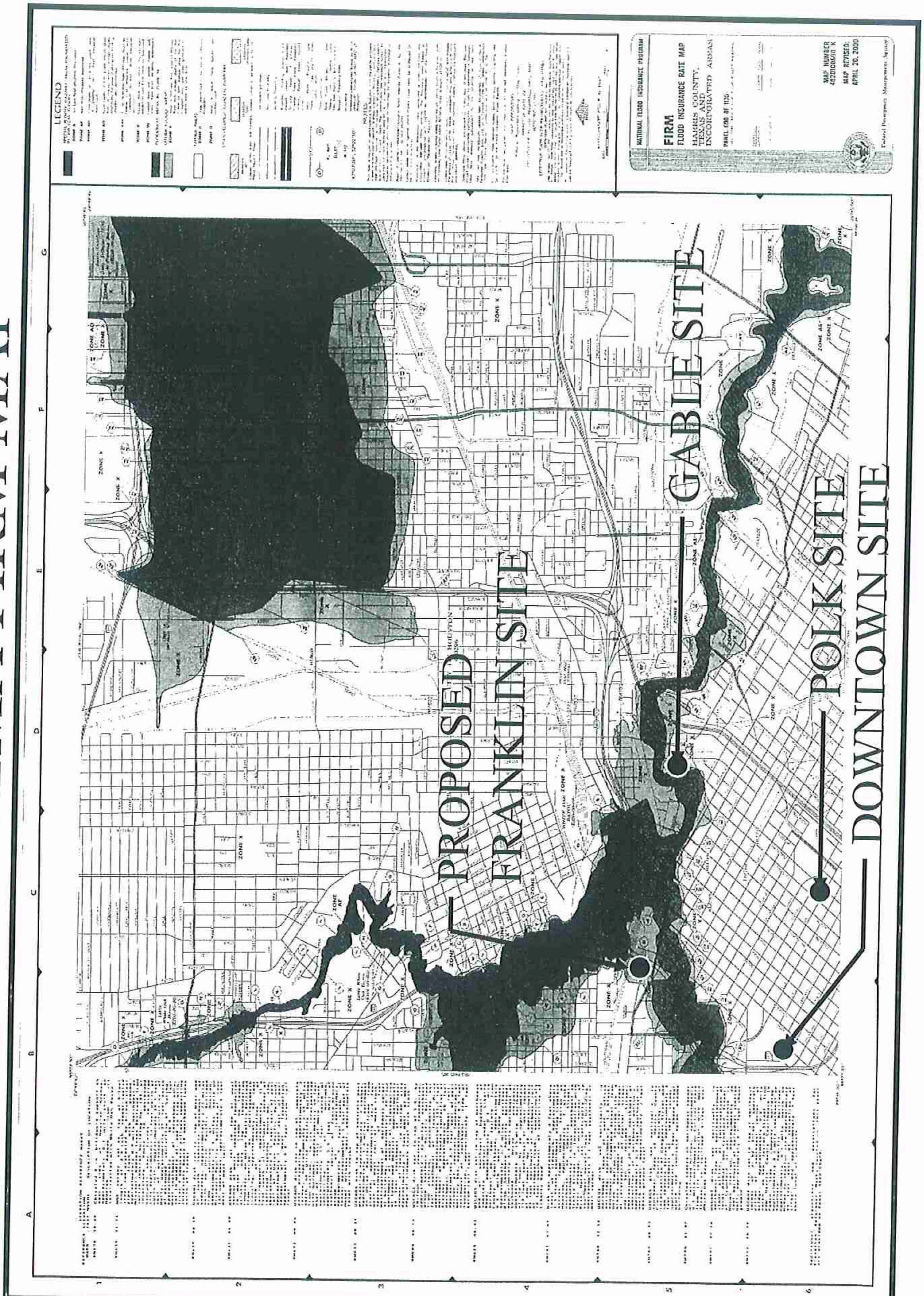



1996 FEMA FIRM MAP
INTERCONTINENTAL SITE
GREENS ROAD SITE
CITY OF HOUSTON
HARRIS COUNTY UNINCORPORATED AREAS
ZONE X
ZONE AE
FIRM
FLOOD INSURANCE RATE MAP
HARRIS COUNTY, TEXAS AND INCORPORATED AREAS


1996 FEMA FIRM MAP
DROUET SITE
LEGEND
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
HARRIS COUNTY, TEXAS AND INCORPORATED AREAS
MAP REVISED: NOVEMBER 6, 1996
Federal Emergency Management Agency
CITY OF HOUSTON
ZONE X
ZONE AE


2000 FEMA FIRM MAP
GRANT SITE
FIRM
FLOOD INSURANCE RATE MAP
HARRIS COUNTY, TEXAS AND INCORPORATED AREAS
CITY OF HOUSTON
ZONE X

2000 FEMA FIRM MAP



Figures

CUMULATIVE RAINFALL OVER FIVE DAYS DURING ALLISON, GAUGE # 1685

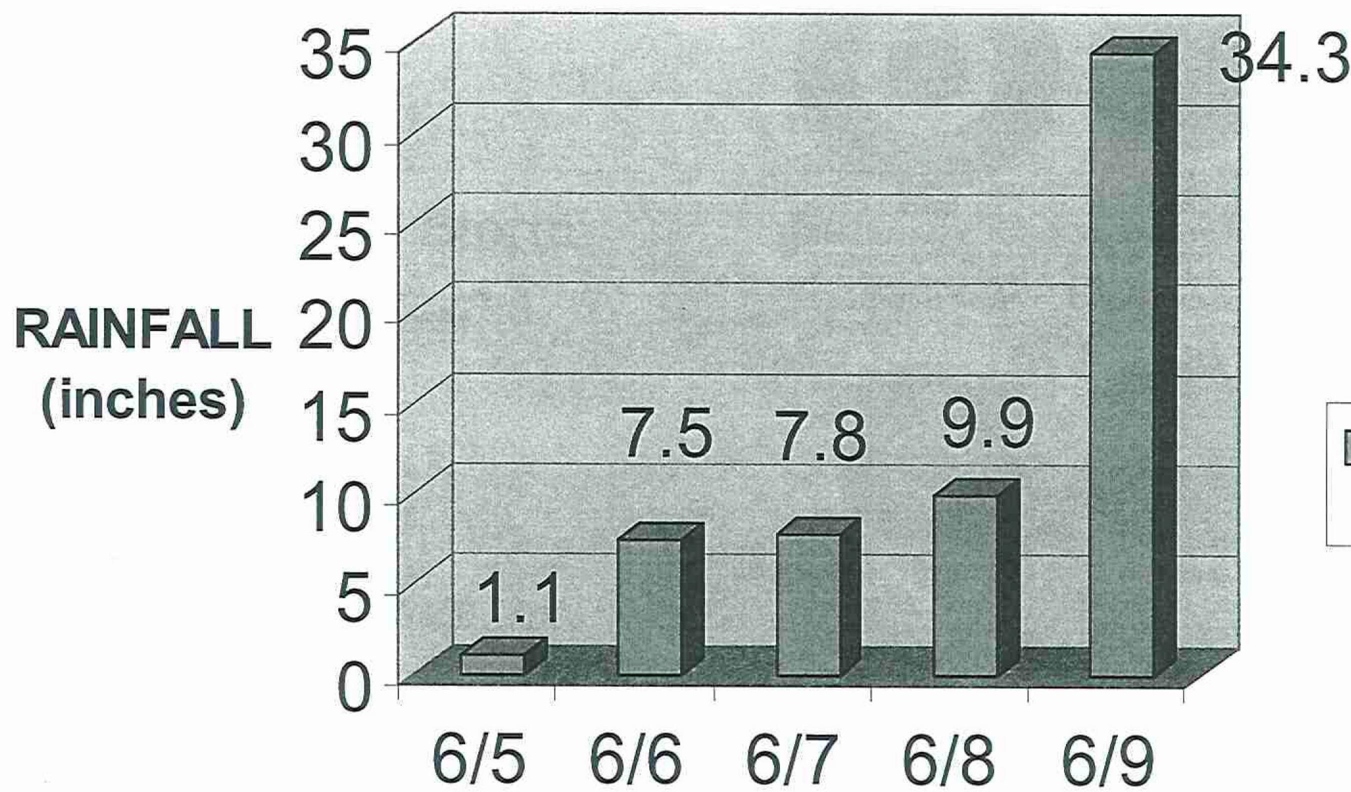


FIGURE 1
ALLISON, JUNE 2001
TUESDAY-SATURDAY

- **Rain Gauge along Greens Bayou at Ley Street in N.E. Houston Inside Beltway 8.**

- From 6:00 P.M. on Friday to 6:00 A.M. on Saturday: 24" in 12 hours.
- From 6:00 P.M. on Friday to 6:00 P.M. on Saturday: 24.4" in 24 hours.

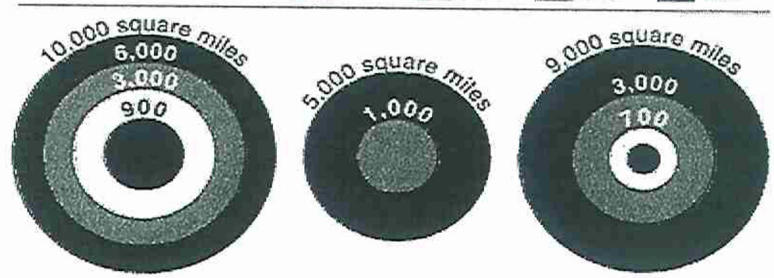
FIGURE 2

As shown in this Figure, Tropical Storm Allison was, in terms of total area, the smallest of the six worst storms to have hit this region over the last 102 years

Allison: A historical perspective

A study of 300 storms in the 13-county Texas upper Gulf Coast found six that had the broadest, deepest rainfall. These rainfall schematics represent the area, in square miles, that was affected by each storm:

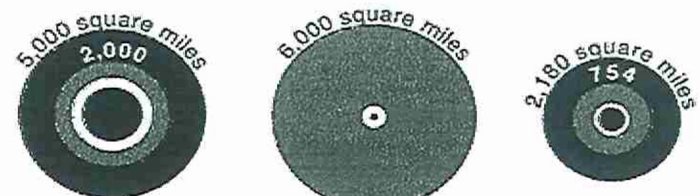
Inches of rainfall: 15+ | 20+ | 25+ | 30+



1899
June 27-July 1: Heaviest rainfall in Brenham, but heavy through Fort Bend County.

1943
July 27-29: Hurricane up Galveston Bay pounds Liberty County hardest.

1960
June 24-26: Tropical storm leaves largest rainfall accumulation at Port Lavaca.

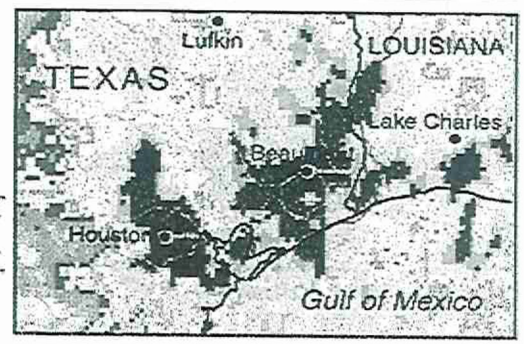


1979
July 24-28: Rainfall from Tropical Storm Claudette in Alvin is greatest 24-hour total ever in the United States.

1994
Oct. 15-19: Liberty, Polk and southwest Montgomery counties get the heaviest rainfall.

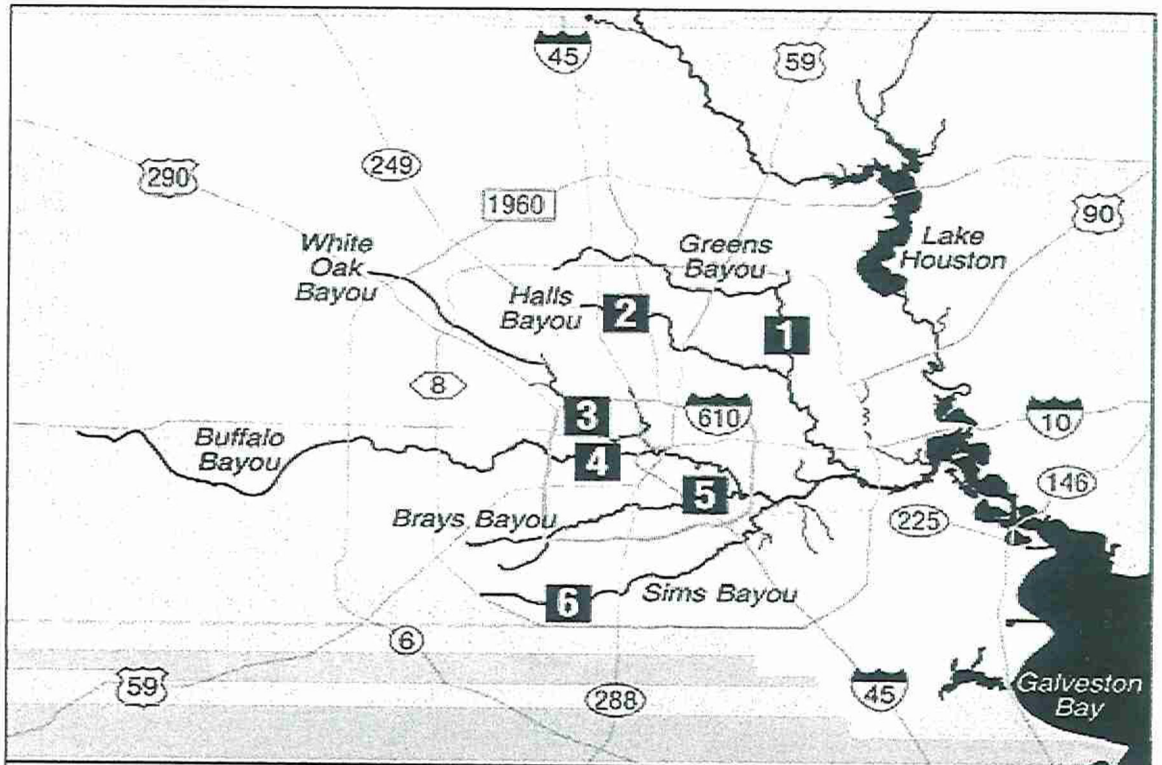
2001
June 5-10: Tropical Storm Allison hits hardest in east Harris County and the Jefferson-Liberty county line.

Enhanced radar showing total rainfall accumulation from Tropical Storm Allison. Heaviest rainfall is in the red and purple areas.



Sources: Chronicle calculations of Tropical Storm Allison using radar data, U.S. Geological Survey, National Oceanic and Atmospheric Administration

B.C. Oren/Chronicle



Bayou flooding

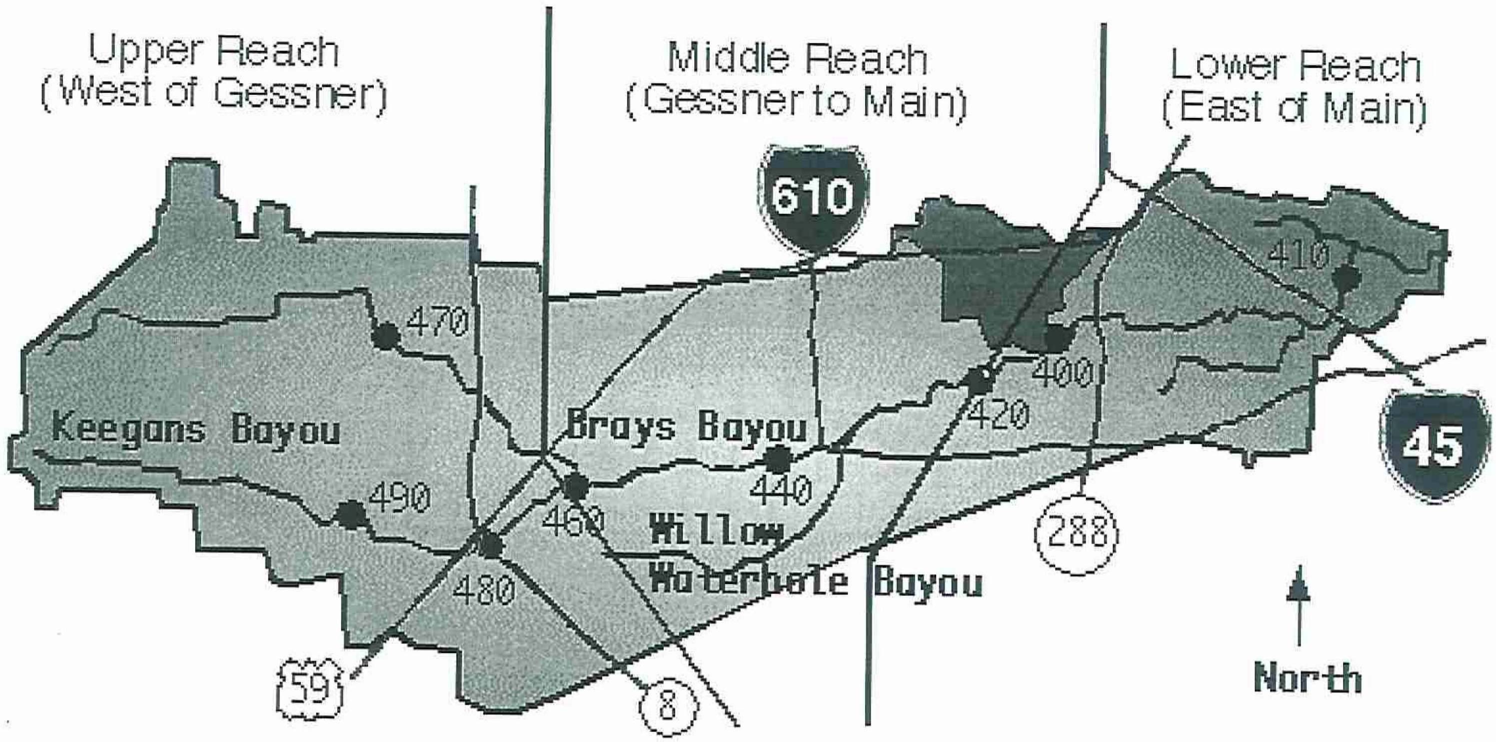
By 3:30 p.m. Saturday afternoon all six of the area's major bayous had begun receeding. During the heaviest flooding five of them exceeded their banks, and four of them were higher than their 100-year flood levels.

	Top of bank	100-year flood level	Crest	Time	Current level
1. **Greens Bayou** (at Ley)	28.0 feet	31.6	47.5	8:00 a.m.	44.0
2. **Halls Bayou** (at Airline)	77.0 feet	78.4	91.4	5:20 a.m.	78.2
3. **White Oak Bayou** (at Ella)	52.9 feet	51.0	67.8	4:15 a.m.	62.3
4. **Buffalo Bayou** (at Shepherd)	41.7 feet	40.2	41.4	5:30 a.m.	34.4
5. **Brays Bayou** (at Lawndale)	11.0 feet	20.7	19.0	6:20 a.m.	6.8
6. **Sims Bayou** (at Hiram Clarke)	53.0 feet	55.3	54.5	3:10 a.m.	49.0

Robert Dibrell / Chronicle

FIGURE 3

FIGURE 4
BRAYS BAYOU STREAM MAP



PROBABLE MAXIMUM PRECIPITATION

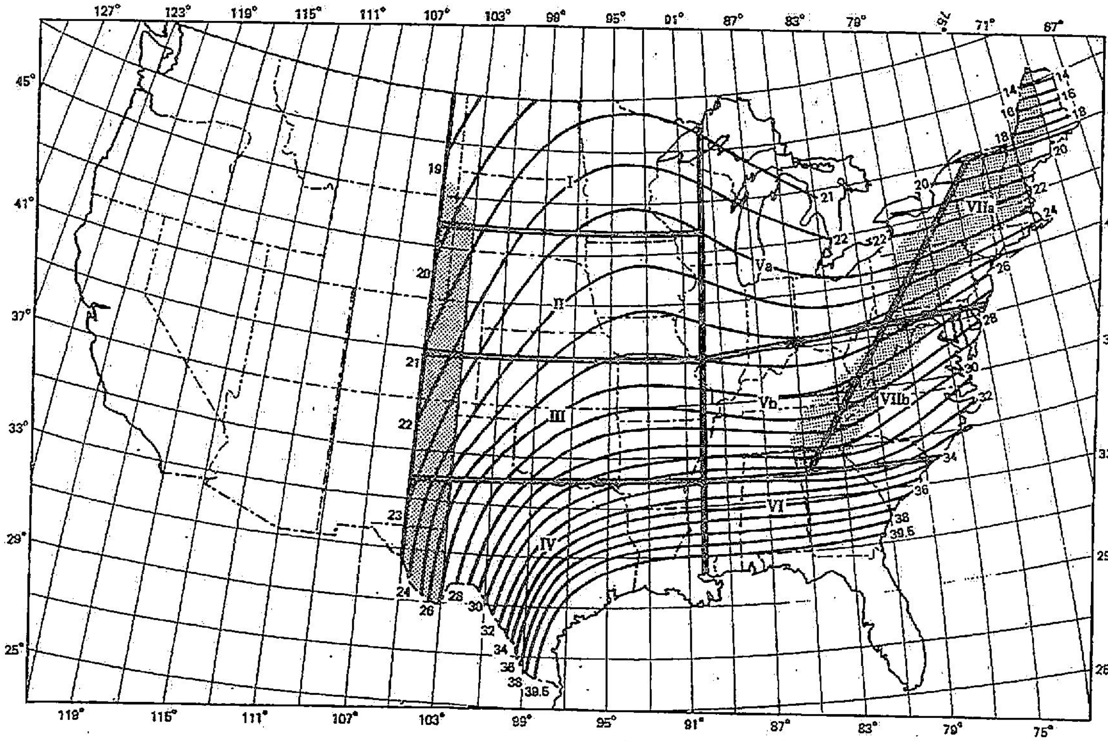


Figure 8.8 All-season PMP (in.) for 200 mi², 24 hr (based on US NWS, 1978).

FIGURE 5

TTL

TTL Corp
P.O. Box 1537
Cypress, TX 77410-1537
Phone (713) 501-6993
Fax (281) 213-9535

Technical Memo No 2 – W. Galveston Substation

Date: October 1, 2008 (Updated October 3, 2008)

To: Ken Hicks, CenterPoint Energy Substation (*CNP*)

From: Brian Tao, P.E.

Subject: Elevation Considerations for Proposed Redevelopment at West Galveston Substation

Due to the impact of Hurricane Ike, the control house of West Galveston Substation was flooded with recorded flood elevation of 13.78 (*NGVD 29*). This memo documents the considerations of proposed elevations for the re-development of the substation, including the control house reconstruction. Three sets of data are utilized:

- Forecasting/modeling data from National Hurricane Center (NHC)
- Historical hurricane data that impacted Galveston Island
- FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) for City of Galveston dated December 6, 2002

Table 1 below summarizes storm surge elevations based on the *NHC* data. *Attachment 1* lists the Tropical Cyclone Scales. *Attachment 2* includes the *NHC SLOSH* model results for Galveston Island. *Attachment 3* lists historical hurricanes that impacted Galveston Island.

Table 1. Summary of Storm Surge Elevations - NHC SLOSH Models (NGVD 29)

Hurricane Category	Surge/Coast (ft)	Surge/Bay (ft)	MOMs* (ft)	Central Wind (MPH)
1	4 - 5	4 - 7	7	74 - 95
2	6 - 8	8 -12	11	96 - 110
3	9 - 12	13 - 18	16	111 - 130
4	13 - 18	19 - 24	22	131 - 155
5	18+	24+	26	155+

** Maximum of Maximum Envelop of Waters, estimated from SLOSH runs*

West Galveston Substation is located between Transects 10 and 11 of *FEMA FIS*. *Table 2* below lists the *FIS* flood data. Stillwater elevations are the elevations of the water surface resulting solely from storm surge due to the action of wind and the drop in atmospheric pressure associated with a storm. Wave heights are the heights above the wave trough of the crests of wind-driven waves. Wave runup is the rush of wave water up a slope. The maximum wave crest elevation is determined by the maximum wave height, which depends largely on the 100 year stillwater depth. In comparison, surge elevation (stillwater) is the output of the SLOSH model, which does not include waves or wave runup. *Attachment 6* includes wave diagrams for determining 100-year flood elevation or Base Flood Elevation (BFE). All elevations mentioned in this memo refer to stillwater elevations except the maximum 100-year wave crest elevation.

The substation site is approximately ¼-mile from Galveston Bay to the north, approximately one-mile from Offatt Bayou to the southwest and approximately two miles from Gulf of Mexico to the south. *Attachment 4* includes the *FEMA FIRM* Map Panel *4854690022E*, which shows that the West Galveston Substation is inside Zone AE with Base Flood Elevation of 11-ft. However, the high water mark (HWM) of 13.78-ft was recorded at the West Galveston Substation control house for Hurricane Ike.

■ TTL

Table 2. Summary of FEMA FIS Flood Elevations (NAVD 88)

	Flood Source	
Frequency	Gulf of Mexico	Galveston Bay
10-yr (10% chance) Stillwater	7.3	5.3
50-yr (2% chance) Stillwater	11.7	9.7
100-yr (1% chance) Stillwater	13.1	11.1
500-yr (0.2% chance) Stillwater	16	14
Floodplain Zone	VE along shoreline	AE
BFE	15 to 20	11 to 12
Maximum 100-yr Wave Crest	20.3	

To minimize future hurricane damages to the critical elements (control house, breakers, transformers etc.) of the substation, it is recommended for the control house finish floor to be minimum 18-in above the maximum 100-yr wave crest elevation of 20.3-ft, i.e. 21.8-ft. The site needs be considered as VE Zone due to its closeness to the bay waters.

Please note that this recommendation needs be coordinated with level of protections as required by the substation structural and electrical component designs, and consider economic implications for various levels of protection.

Attachments

1. Tropical Cyclone Scales
2. National Hurricane Center *SLOSH* Model
3. Historical Storm Surge Data – Galveston Island
4. *FEMA FIRM* Maps (2)
5. Aerial photo – West Galveston Substation
6. Wave diagrams
7. Hurricane Ike Wind Map

Attachment 1 Tropical Cyclone Scales

Tropical Cyclone Scales

All hurricanes are dangerous, but some are more so than others. The way storm surge, wind, and other factors combine determine the hurricane's destructive power. To make comparisons easier, and to make the predicted hazards of approaching hurricanes clearer to emergency forces, hurricane forecasters use a disaster-potential scale, which assigns storms to five categories. Category 1 is a minimum hurricane; category 5 is the worst case scenario. The criteria for each category are shown below. The winds are used in the determination of category.

CATEGORY	PRESSURE (MB)	CENTRAL WINDS (MPH)	SURGE DAMAGE COAST (FEET)	SURGE DAMAGE BAYS (FEET)	STORM EXAMPLE AND YEAR
1 MINIMAL	980+	74 - 95	4 - 5	4 - 7	HUMBERTO 2007
2 MODERATE	965 - 979	96 - 110	6 - 8	8 - 12	IKE 2008
3 EXTENSIVE	945 - 964	111 - 130	9 - 12	13 - 18	ALICIA 1983
4 EXTREME	920 - 944	131 - 155	13 - 18	19 - 24	CARLA 1961
5 CATASTROPHIC	920	155+	18+	24+	ANDREW 1992

Effects

- **Category 1** - Minimal damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal road flooding and minor pier damage.
- **Category 2** - Some roofing material, door, and window damage to buildings, Considerable damage to vegetation, mobile homes, and piers. Small craft in unprotected anchorages break moorings.
- **Category 3** - Structural damage to small residences and utility buildings with a minor amount of curtainwall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures with larger structures damaged by floating debris.
- **Category 4** - More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Major damage to lower floors of structures near the shore.
- **Category 5** - Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Major damage to lower floors of all structures located less than 15 feet above sea level.

Source: http://www.srh.noaa.gov/hgx/tropical/scale.htm

Attachment 2 National Hurricane Center *SLOSH* Model

National Hurricane Center SLOSH Models

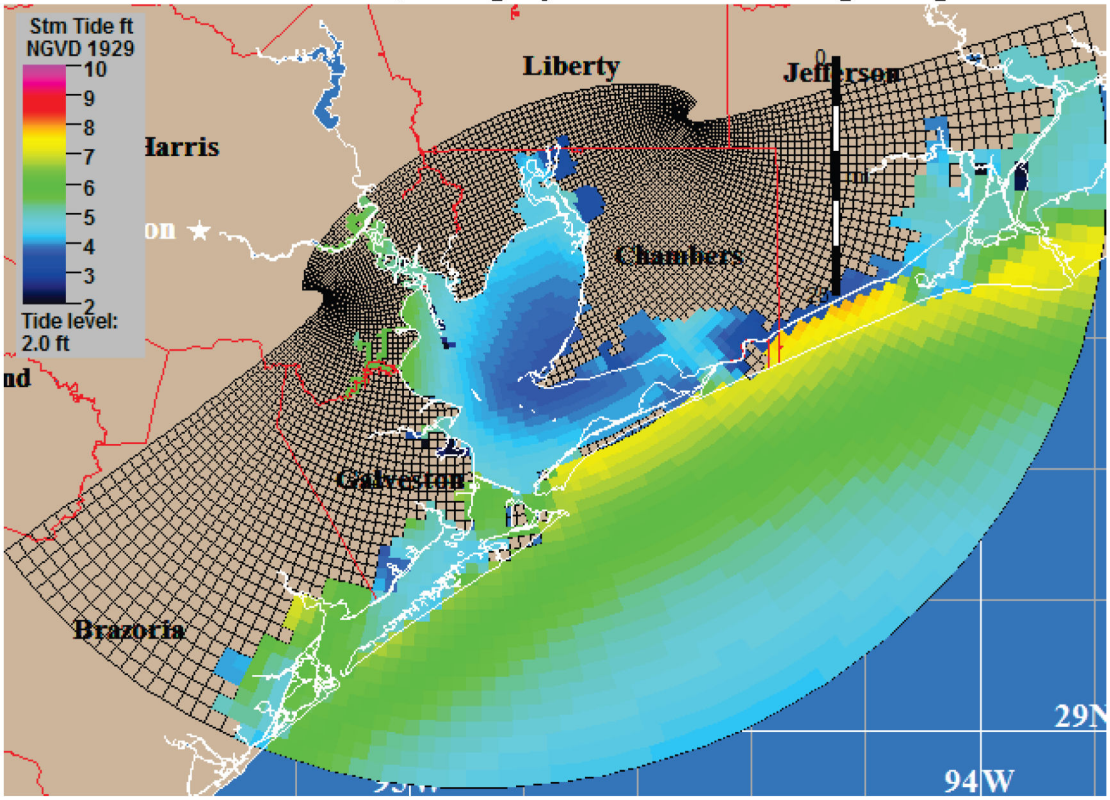
SLOSH (Sea, Lake and Overland Surges from Hurricanes) is a computerized model run by the National Hurricane Center (NHC) to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account:

- Pressure
- Size
- Forward speed
- Track
- Winds

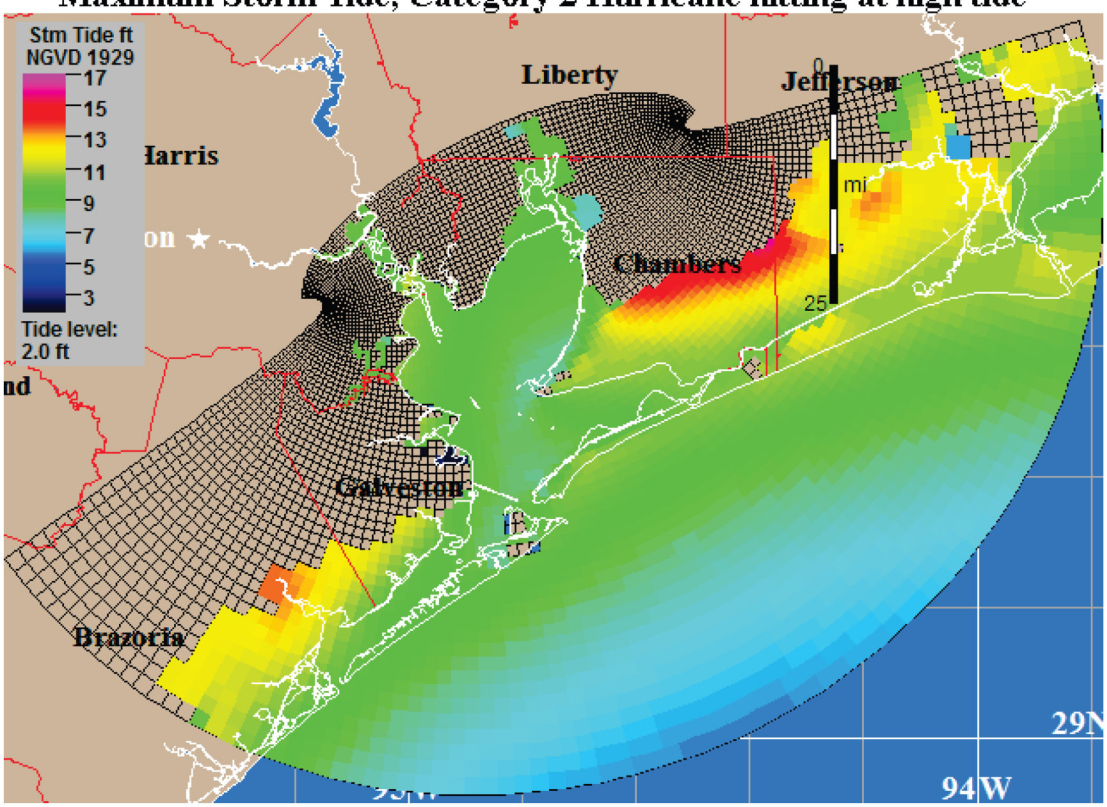
Graphical output from the model displays color coded storm surge heights for a particular area in feet above the model's reference level, the National Geodetic Vertical Datum (NGVD), which is the elevation reference for most maps. The calculations are applied to a specific locale's shoreline, incorporating the unique bay and river configurations, water depths, bridges, roads and other physical features.

Images below show the expected high water from the combination of a hurricane's storm surge plus an extra adjustment in case the storm hits at high tide. These so-called "MOMs" (Maximum of the Maximum Envelope of Waters) are computed using the SLOSH storm surge models. These plots are the MAXIMUM high water for a mid-strength hurricane of each Saffir-Simpson Category moving at the worst possible angle at the worst possible forward speed. As such, one plot is the combination of SLOSH runs from over 50 different simulated hurricanes approaching the coast at different angles and different forward speeds. The maximums plotted here will only occur along about a 20-mile stretch of the coast on the right front side of where the hurricane makes landfall. SLOSH model runs are advertised as being in error by plus or minus 20%.

Maximum Storm Tide, Category 1 Hurricane hitting at high tide

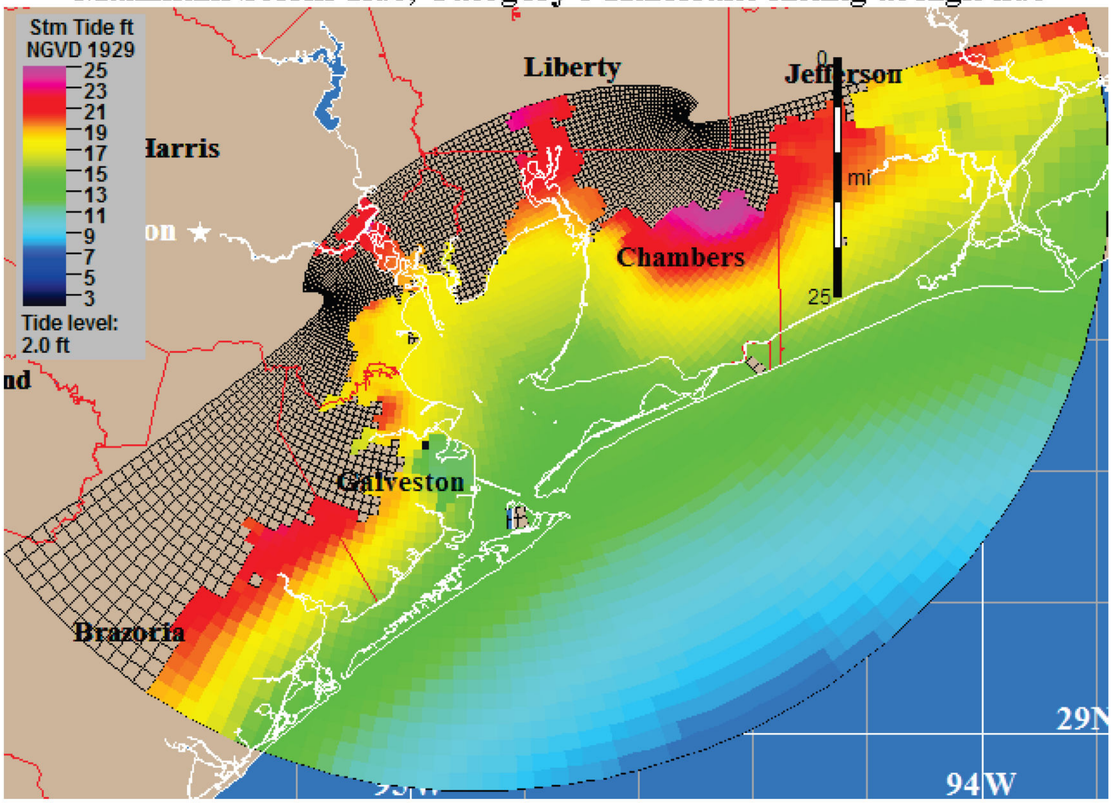


Maximum Storm Tide, Category 2 Hurricane hitting at high tide

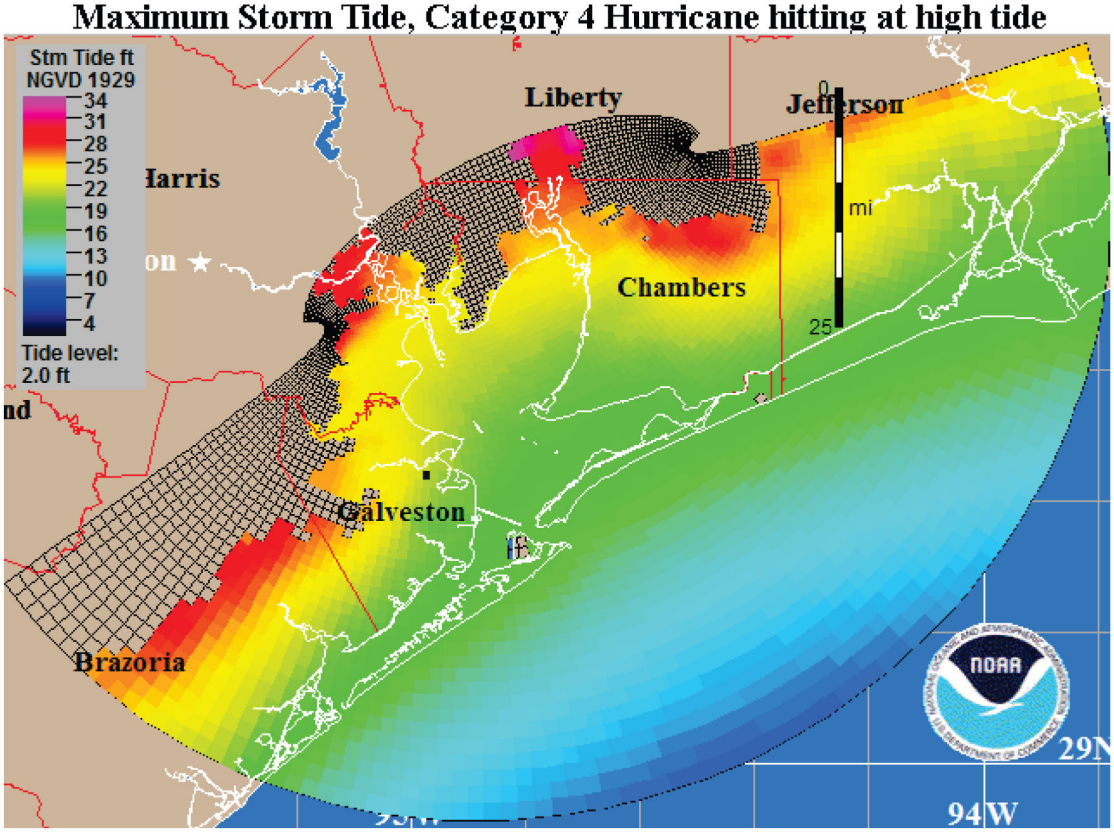


Source http://www.wunderground.com/hurricane/texsurge.asp

Maximum Storm Tide, Category 3 Hurricane hitting at high tide

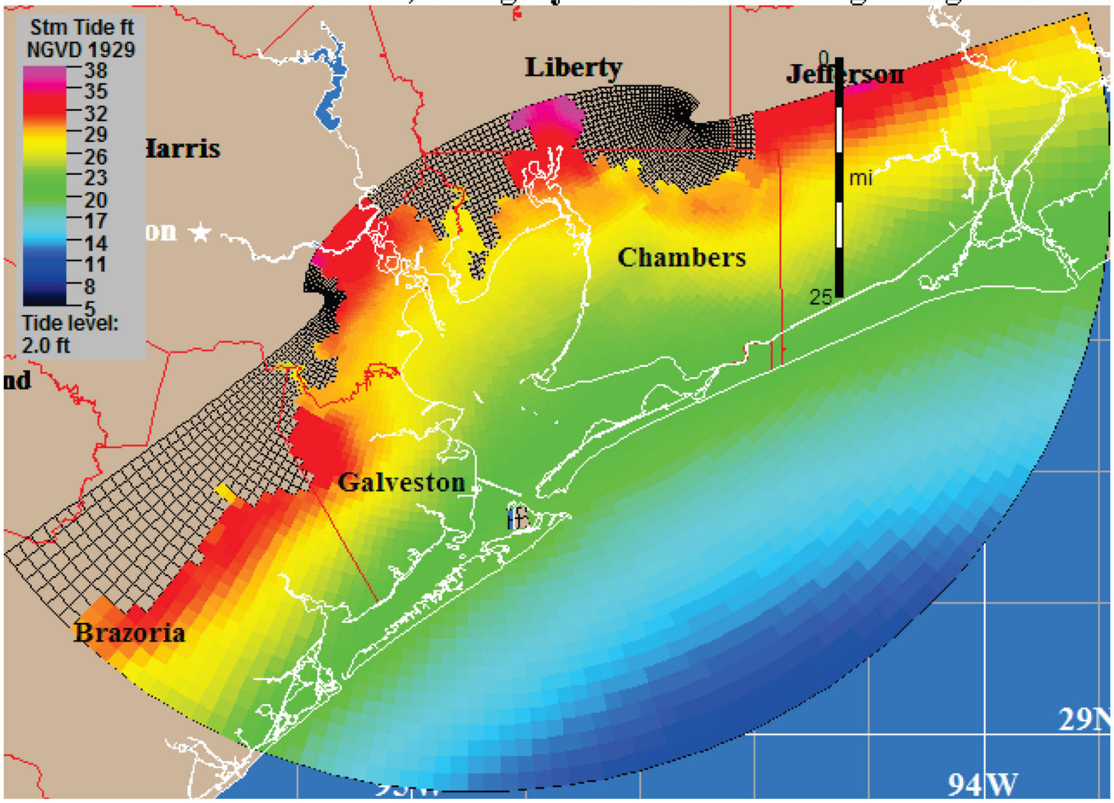


Maximum Storm Tide, Category 4 Hurricane hitting at high tide



Source http://www.wunderground.com/hurricane/texsurge.asp

Maximum Storm Tide, Category 5 Hurricane hitting at high tide



Source http://www.wunderground.com/hurricane/texsurge.asp

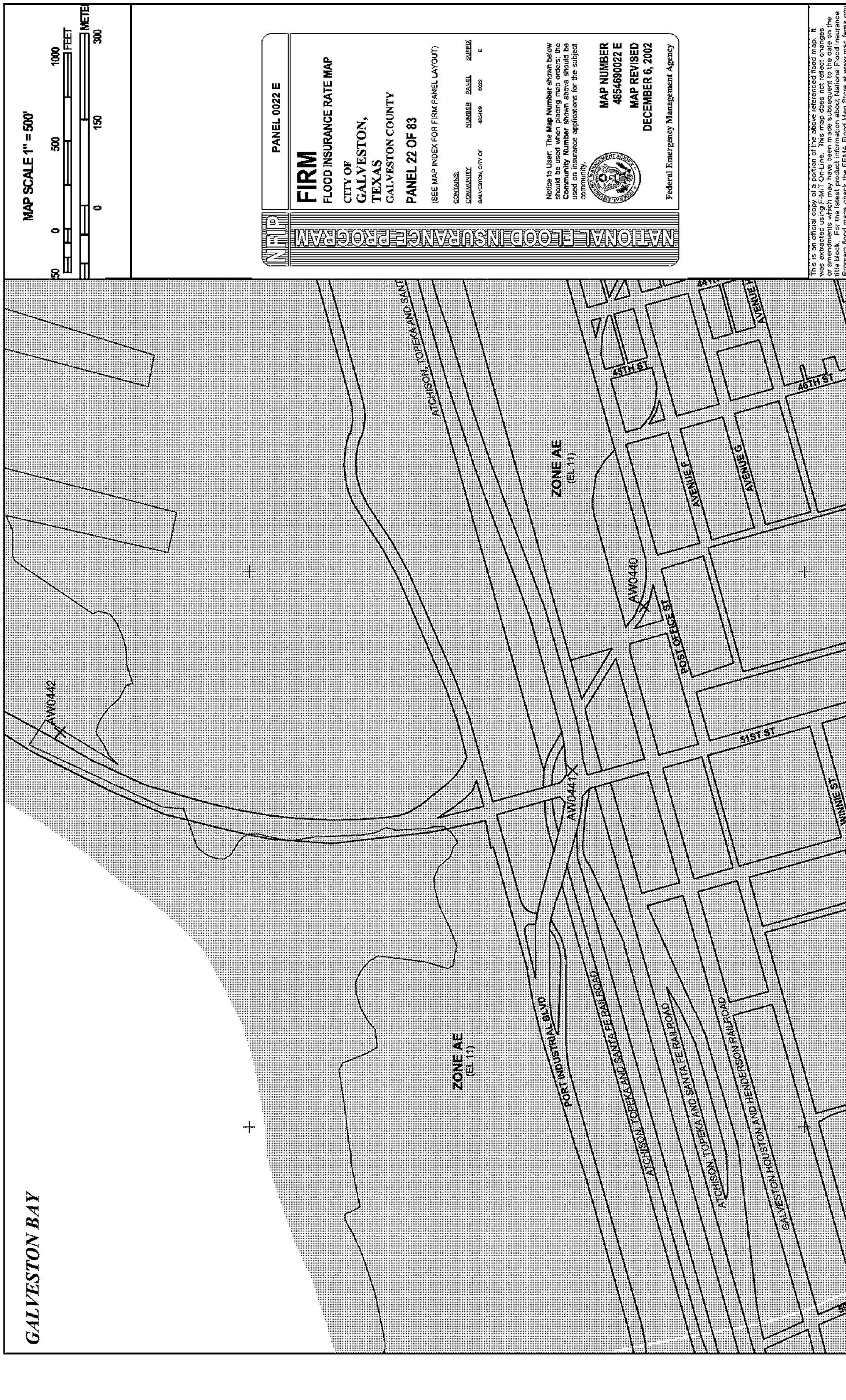
Attachment 3 Historical Storm Surge Data – Galveston Island

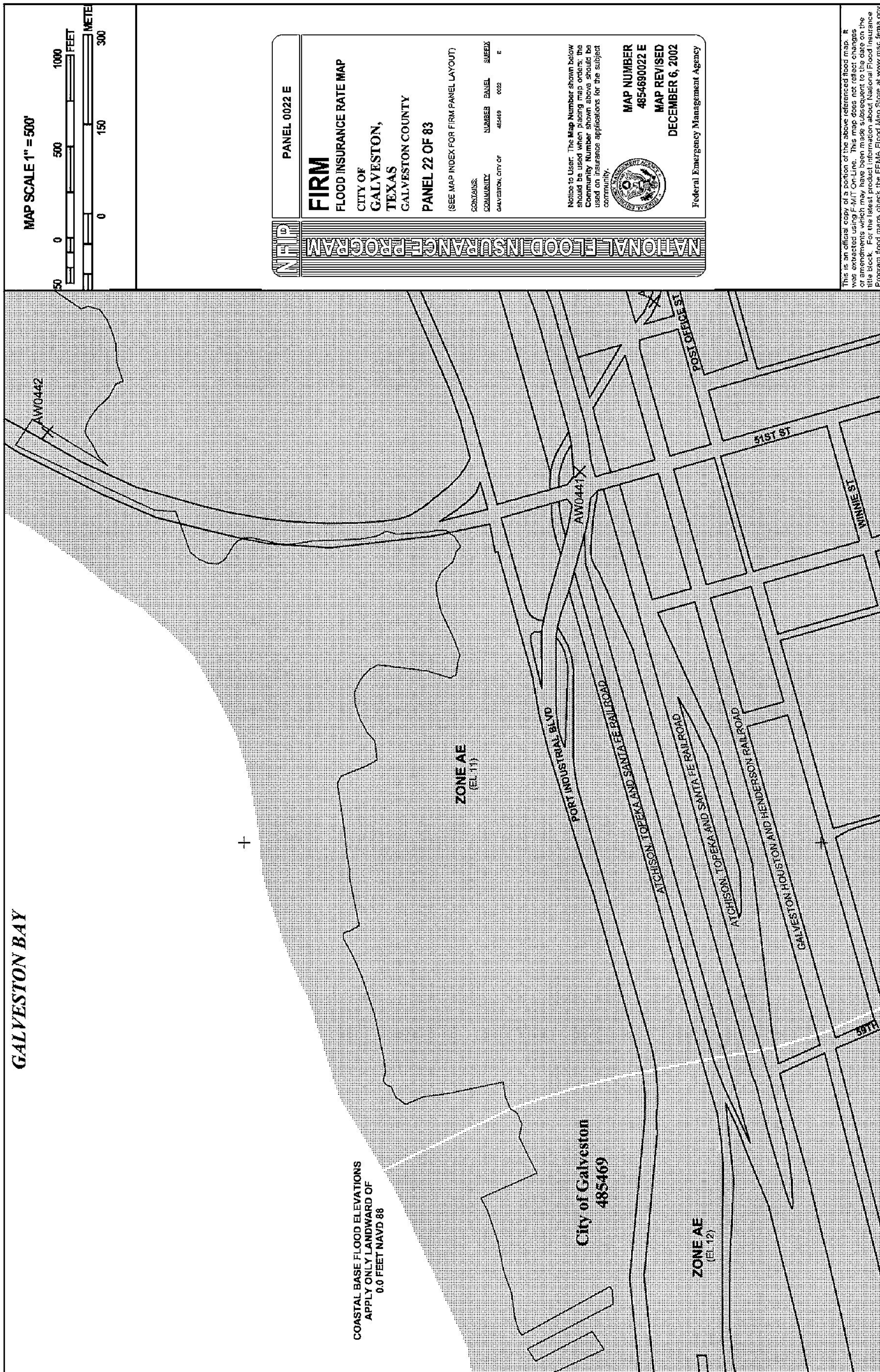
Historical Hurricane Storm Surge Elevations - Galveston Island

Date	Description	Wind Speed	Surge (ft)(NGVD 29)
September 7-10, 1900	This severe hurricane crossed the Texas coastline near San Luis Pass, about 20 miles south of Galveston. The peak of the storm surge that was generated by this hurricane, which inundated the city for approximately 7 hours, was about 14.5 feet (NGVD29).	-	14.5
July 21, 1909	This hurricane originated near the Cape Verde Islands and made landfall near Freeport at Velasco on July 21.	-	10
August 16-17, 1915	This hurricane, which had a radius of 32 nautical miles, made landfall near Matagorda near the mouth of the Brazos River, approximately 40 miles southwest of Galveston. Storm tides inundated the city for more than 40 hours. It was estimated that crests of breaking waves reached 21 feet at the seawall. Great quantities of water, thrown over the wall, caused extensive damage and scouring of pavement and building foundations. The seawall held and protected the City of Galveston.	-	12.7/(16.1 at causeway)
September 14, 1919	Although this hurricane, which passed 140 miles south of Galveston and landed in the vicinity of Corpus Christi, was considered relatively minor.	53	8.8
August 30, 1942	This storm originated in the eastern Atlantic, moved across the Caribbean Sea, and went inland on August 30 near Port O'Connor, about 120 miles southwest of the city.	50	6.3
July 27, 1957 (Hurricane Audrey)	The first hurricane of the 1957 season brought tides of 6.0 feet (NGVD29) to Galveston Island 2 to 3 hours before the center of the hurricane passed inland to the east of Port Arthur. Almost all of Galveston's downtown streets were flooded; some in the strand area near the waterfront were under 2 feet of water.	-	6
July 24-25, 1959 (Hurricane Debra)	This hurricane's peak winds were measured at 105 mph when it struck Galveston.	105	5 to 6
September 11, 1961 (Hurricane Carla)	The 30- to 40-mile diameter eye of this slow-moving hurricane crossed the shoreline more than 100 miles south of Galveston, near Port O'Connor. The 4-day rainfall at Galveston was 15.32 inches.	-	9.3
August 2-5, 1970 (Hurricane Celia)	This hurricane originated in the Caribbean Sea near Cuba, struck the Texas coast, and moved inland at Corpus Christi. However, nearly all of the damage was from severe wind, not flooding or storm surge.	-	3.0 to 4.0
August 3-10, 1980 (Hurricane Allen)	Before making landfall near Brownsville, this storm had churned its way from the Caribbean Sea to Texas as a category 5 hurricane. Fortunately, the storm suddenly weakened just hours before it moved inland. The highest wind gusts reported were 138 mph at Port Mansfield.	-	8.8
August 15-18, 1983 (Hurricane Alicia)	A Category 3 hurricane, struck the southwestern tip of Galveston Island with wind speeds estimated to be 115 mph. The weather service office in downtown Galveston recorded wind gusts of 102 mph.	115	4.8 to 11.0
Sept 12-13, 2008 (Hurricane Ike)	A Category 2 hurricane, The diameter of tropical storm force winds covering a total of 425 miles from the northwest to southeast as Ike approached the upper Texas coast on Friday, September 12th. Ike made landfall at 2:10 am CDT Saturday, September 13th near Galveston, Texas.	110	12.64' at Pleasure Pier in Galveston

Sources: Flood Insurance Study, City of Galveston; December 6, 2002
National Weather Services http://www.srh.noaa.gov/hgx/projects/ike08.htm

Attachment 4 *FEMA FIRM* Maps (2)


MAP SCALE 1" = 500'
FEET
METERS
PANEL 0022 E
FIRM
FLOOD INSURANCE RATE MAP
CITY OF
GALVESTON,
TEXAS
GALVESTON COUNTY
PANEL 22 OF 83
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
NATIONAL FLOOD INSURANCE PROGRAM
MAP NUMBER
4854690022 E
MAP REVISED
DECEMBER 6, 2002
Federal Emergency Management Agency
GALVESTON BAY
ZONE AE
(EL 11)
ZONE AE
(EL 11)
AW0442
AW0441
AW0440
ATCHISON, TOPEKA AND SANTA FE RAILROAD
PORT INDUSTRIAL BLVD
ATCHISON, TOPEKA AND SANTA FE RAILROAD
GALVESTON HOUSTON AND HENDERSON RAILROAD
POST OFFICE ST
AVENUE F
AVENUE G
51ST ST
46TH ST
WINNIE ST


GALVESTON BAY
MAP SCALE 1" = 500'
FEET
METERS
PANEL 0022 E
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
CITY OF GALVESTON, TEXAS
GALVESTON COUNTY
PANEL 22 OF 83
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
MAP NUMBER 4854690022 E
MAP REVISED DECEMBER 6, 2002
Federal Emergency Management Agency
ZONE AE (EL 11)
ZONE AE (EL 12)
City of Galveston 485469
COASTAL BASE FLOOD ELEVATIONS APPLY ONLY LANDWARD OF 0.0 FEET NAVD 88
PORT INDUSTRIAL BLVD
ATCHISON, TOPEKA AND SANTA FE RAILROAD
ATCHISON, TOPEKA AND SANTA FE RAILROAD
GALVESTON HOUSTON AND HENDERSON RAILROAD
POST OFFICE ST
51ST ST
WINNIE ST
59TH ST
AW0442
AW0441

Attachment 5 Aerial photo

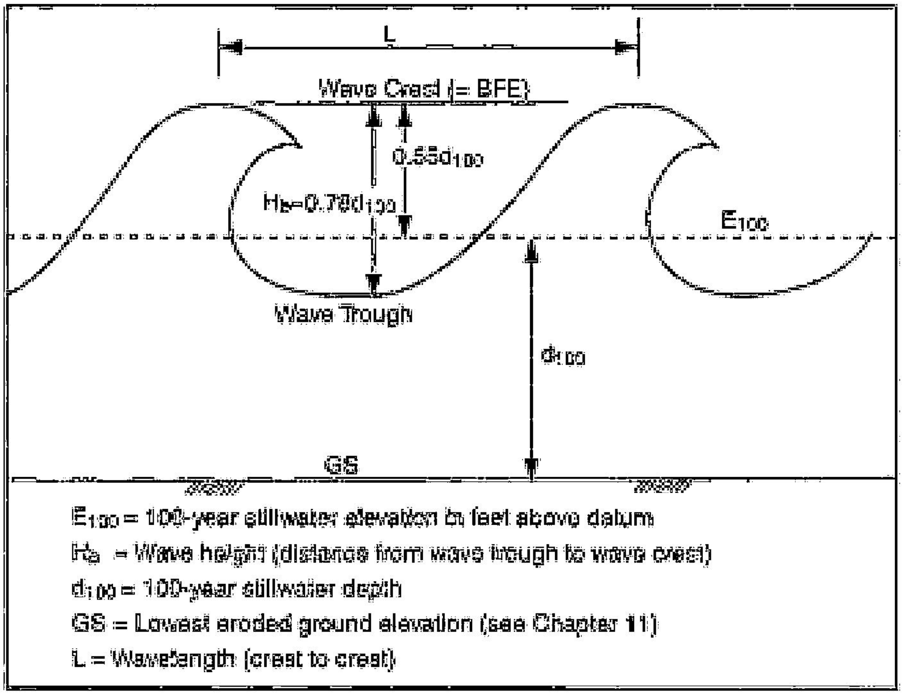
0 0.25 0.5 1 Miles

AERIAL PHOTO - W. GALVESTON SUBSTATION

Attachment 6 Wave Diagrams

Figure 3-8

Determination of BFE in coastal flood hazard areas where wave crest elevations exceed wave runup elevations (Zones A and V). Note that the BFE = $E_{100} + 0.55d_{100}$



CROSS-REFERENCE

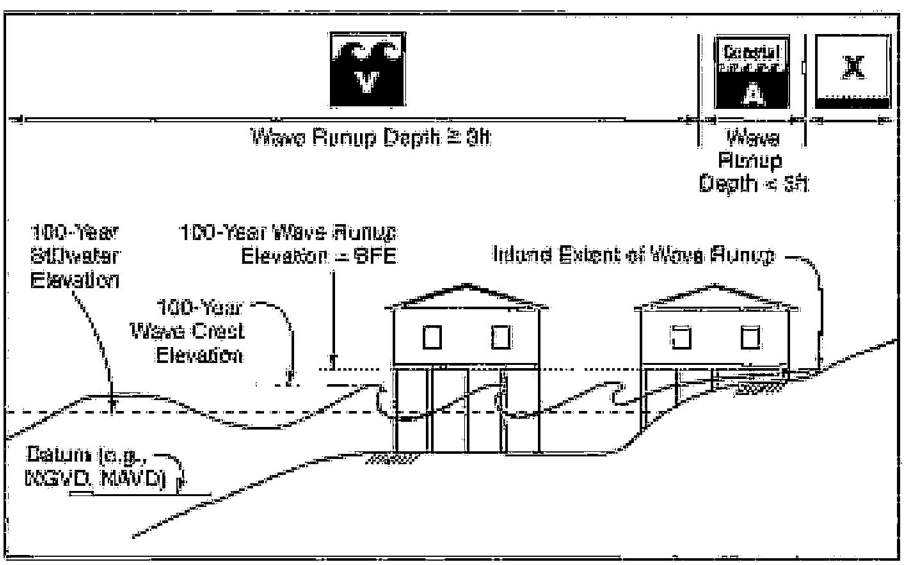
See Section 11.6.4, in Chapter 11, for a discussion of wave setup and its contribution to flood depth.

DEFINITION

Wave setup is an increase in the stillwater surface near the shoreline, due to the presence of breaking waves. Wave setup typically adds 1.5 – 2.5 feet to the 100-year stillwater flood elevation.

Figure 3-9

Where wave runup elevations exceed wave crest elevations, the BFE is equal to the runup elevation.



DEFINITION

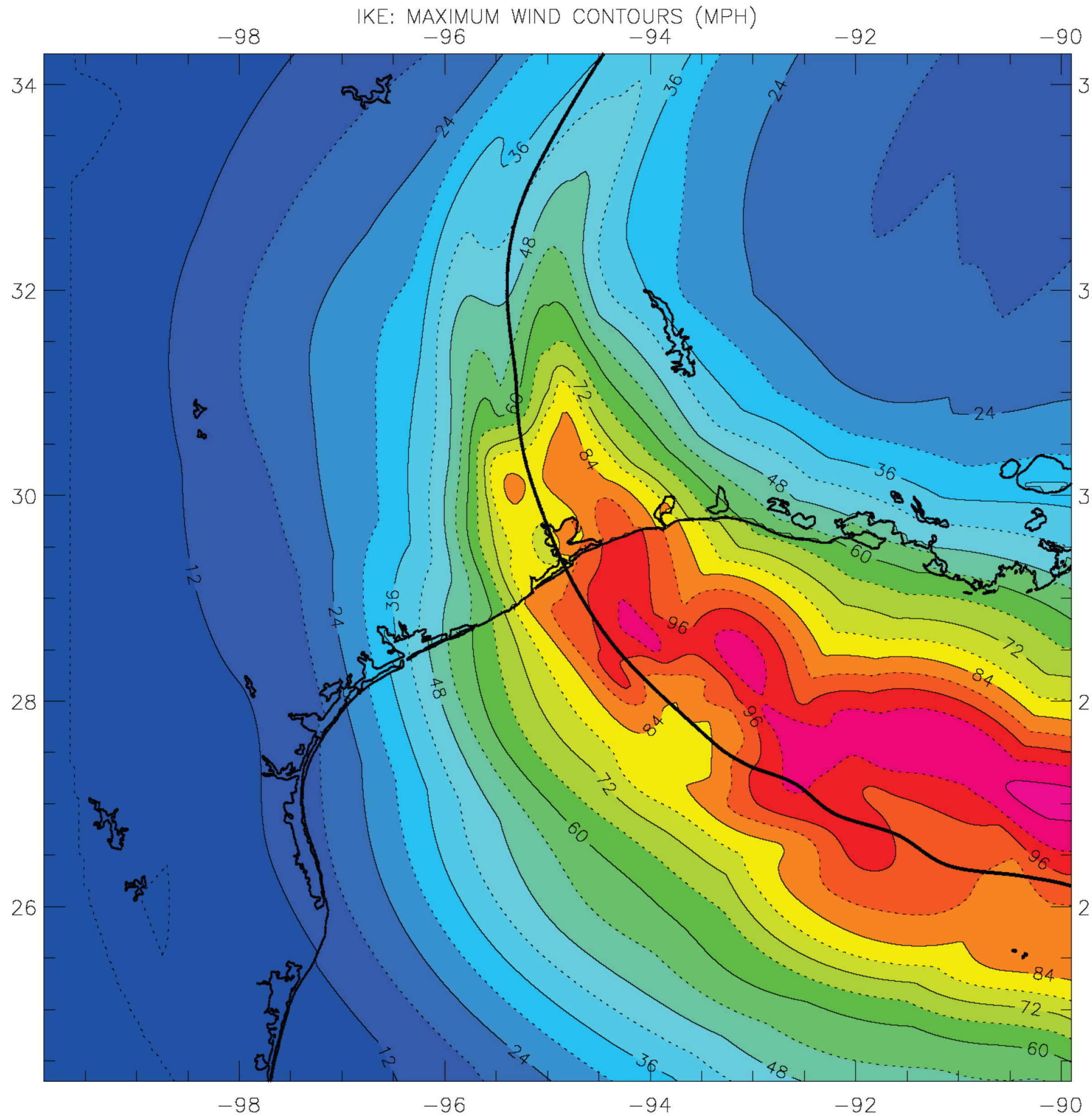
Wave runup elevation is the elevation reached by wave runup, referenced to the National Geodetic Vertical Datum of 1929 (NGVD) or other datum.

Wave runup depth at any point is equal to the maximum wave runup elevation minus the lowest eroded ground elevation at that point.

Attachment 7 Hurricane Ike Wind Map

Hurricane Ike Wind Analysis

Since 1996 the NOAA Hurricane Research Division has participated in the H*Wind Project. The purpose is to develop an integrated tropical cyclone observing system in which wind measurements from a variety of observation platforms could be used to develop an objective analysis of the distribution of wind speeds in a hurricane. This product is designed to improve understanding of the extent and strength of the wind field, and to improve the assessment of hurricane intensity. The experimental H*Wind "snapshot" products are provided in image and gridded form for research purposes and have been especially useful for storm surge and wave forecasting applications. The map below shows maximum sustained wind swaths as preliminary results.



Source http://www.aoml.noaa.gov/hrd/Storm_pages/ike2008/wind.html

Technical Volume

Grid Resilience and Innovation Partnerships Funding Opportunity Announcement Number: DE-FOA-0002740

Project Title: Distribution Circuit and Substation Resilience Improvements

Topic Area 1: Grid Resilience Grants (40101(c))

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Project Location: Houston Metropolitan Area (Harris County, Texas)

Confidentiality Statement: Not Applicable

I. Project Overview

A. Background

As the only investor-owned electric and gas utility based in Texas, CenterPoint Energy, Inc. (NYSE: CNP) is an energy delivery company with electric transmission and distribution, power generation, and natural gas distribution operations that serve more than seven million homes and businesses in Indiana, Louisiana, Minnesota, Mississippi, Ohio and Texas. As of December 31, 2022, the company owned approximately $38 billion in assets. With approximately 9,000 employees, CenterPoint Energy and its predecessor companies have been in business for more than 150 years.[1]

CenterPoint Energy Houston Electric, LLC ("CenterPoint" or "Company" or "We"), the applying entity, provides electric transmission and distribution service to approximately 2.5 million homes and businesses in the greater Houston area. A principal area of focus for CenterPoint's strategic capital investments is the modernization and hardening of our existing transmission, substation, and distribution infrastructure to support a more reliable and resilient energy delivery system.

In recent years, the Houston area has experienced numerous severe weather events – the 2015 Memorial Day Floods, Hurricane Harvey in 2017, Winter Storm Uri in February 2021, and Hurricane Nicholas in September 2021 to name a few – that have led to both widespread and localized power outages. The impacts of outages, as with all disruptive events, tend to fall more harshly on the disadvantaged communities we serve. In the wake of Winter Storm Uri, for example, a recent study in *Nature* found a significant disparity in the extent and duration of power outages experienced by low-income and minority groups as well as a disparity in disrupted food access.[2]

These outages not only affect communities at the local level but can also have cumulative impacts on the rest of the country. Outages here can impact the Port of Houston, the country's largest port by total foreign and domestic waterborne tonnage. The Port of Houston's economic activity totals $339 billion in Texas – 20.6 percent of Texas' total gross domestic product (GDP) – and $801.9 billion in economic impact across the nation.[3] Houston is central to the lifeblood of the U.S. economy. Thus, benefits from grid resilience improvements in Houston flow from local communities out to the entire country.

While Houston's recent severe weather events were disastrous for the city and its people, they have underscored the need for improved grid resilience and helped reveal the areas in most urgent need of remediation. CenterPoint is modernizing and transforming the area's grid

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[1] For more information, see CenterPointEnergy.com.

[2] Cheng-Chun Lee, Mikel Maron & Ali Mostafavi, *Community-scale big data reveals disparate impacts of the Texas winter storm of 2021 and its managed power outage*, 9 NATURE: HUMANITIES AND SOCIAL SCIENCES COMMUNICATIONS 335 (2022), https://doi.org/10.1057/s41599-022-01353-8.

[3] Port Houston, *Port Houston Posts Record Volume in 2022* (Jan. 17, 2023), available at: https://www.porthouston.com/wp-content/uploads/2023/01/Dec-2022-By-the-Numbers-FINAL-1.pdf.

resilience by weatherizing its distribution systems and substations to prepare for potential and increasingly severe weather events. This Project is a critical part of that resilience modernization.

B. Project Goal

CenterPoint seeks funding from DOE's Grid Resilience and Innovation Partnerships ("GRIP") program for two specific interrelated aspects of its ongoing resilience-strengthening efforts: **Distribution Resiliency Circuit Rebuilds** and **Substation Flood Control** ("Project"). CenterPoint is already engaging in a 25–30-year effort to modernize the Houston electric grid. A $100 million Topic 1 GRIP grant from DOE would allow CenterPoint to significantly accelerate these efforts by hardening a total of approximately 900 miles of distribution circuit infrastructure, most within vulnerable communities, and upgrading ten substation locations over the next five years. Without such DOE funding, CenterPoint would be able to address only 600 miles and five substation sites in the same period. That is, the net benefit of DOE funding will be 300 miles of distribution circuit infrastructure improvements and five substation sites with state-of-the-art resilience over two years earlier than without funding, dramatically reducing the vulnerability of disadvantaged communities in Houston over that period. Eighty-five percent of the communities benefitting from these accelerated resilience improvements would be disadvantaged communities. Moreover, CenterPoint expects to create and retain high-quality union jobs, or jobs that exceed the prevailing local wage, for the Project in both construction and operations roles.

CenterPoint estimates the distribution circuits will constitute approximately 90% of the Project spend, with the substation flood control work making up the remaining 10%. Details specific to each component of the Project are below:

Distribution Resiliency Circuit Rebuilds: The distribution portion of this Project will accelerate the hardening of distribution circuits to current standards that exceed the National Electric Safety Code ("NESC") minimum design wind loading requirements. Currently, CenterPoint's existing distribution circuit structures are predominantly comprised of wood. CenterPoint will use GRIP funding to install new pole distribution structures comprised of steel truss-reinforced wood and modern engineered material poles composed of innovative materials, such as state-of-the-art modular fiberglass and ductile iron. These new poles will be substantially more resilient to extreme weather events, decreasing the odds of power outages and increasing reliability.

Substation Flood Control: The Substation Flood Control Program will minimize the risk of flood waters meeting sensitive electrical equipment within the substation yard's perimeter. CenterPoint will (1) physically raise sensitive substation equipment by at least 10 feet and secure them firmly to new foundations and (2) elevate protective relay panels and Supervisory Control and Data Acquisition ("SCADA") hardware. CenterPoint will also assess telecom and high voltage equipment's control cabinets and related items for flood control mitigation concerns. Through studying past weather events and flood maps that analyze the 500-year floodplain, CenterPoint is elevating each substation by at least 10 feet to reduce physical risk to critical substation equipment.

C. DOE Impact

CenterPoint has ongoing long-term programs for the distribution resiliency circuit rebuilds and substation flood control in its capital plan, but DOE funding will significantly accelerate these programs, predominantly to the benefit of disadvantaged communities ("DACs").

A cost summary for the Project is shown below in Table 1. This table depicts the eligible Project costs that CenterPoint will incur in years 2024 through 2028, and the portion of those costs the Company is committed to providing in the form of matching contributions.[4] This is only a subset of CenterPoint's total grid resiliency investment, which also includes costs outside the Project time frame.

Table 1. CenterPoint's Project Costs

	CenterPoint's Commitment	DOE Grant	Total Cost
	(Millions of US Dollars)		
2024-2028 Distribution Resiliency Circuit Rebuilds	$230	$90	$320
2024-2028 Substation Flood Control	$20	$10	$30
Total Project	**$250**	**$100**	**$350**
Percentage of Total Project Costs	**71%**	**29%**	**100%**

Full DOE funding of approximately $100M, complemented by matching investment of approximately $250M from CenterPoint, would result in the following:

1. **Hardened Substations** - Hardening of ten substation sites within a five-year period, effectively shortening the projected completion of vulnerable substations two years early, from 2030 to 2028.
2. **Stronger Circuits** - The distribution improvements would reach approximately 900 miles of distribution circuits and the communities they serve two years earlier than without such funding.
3. **Jobs** - As described more fully in the Community Benefits Plan, GRIP funding will have positive labor force impacts. CenterPoint would expect to hire 125 additional contractors, line workers, and appropriate supervision over the 5-year life of this Project.

D. Community Benefits Plan

CenterPoint's proposed Project would directly contribute to the Biden Administration's Justice40 Initiative goal that 40% of the overall benefits of climate and clean energy investments

[4] A more detailed explanation of Project costs to be incurred in years 2024 through 2028 is contained in the Budget Justification Workbook.

flow to disadvantaged communities. We expect 85% of the Project work to be accomplished and a corresponding amount of the Project benefits to go toward Justice40 communities.

The map below shows: (1) the distribution circuits that will be rebuilt for this Project (green); (2) circuits served by the substations that will be elevated for flood control (red); and (3) disadvantaged communities identified on the White House Climate and Economic Justice Screening Tool map[5] (gray). There is substantial overlap between the circuits that will be transformed and the historically disadvantaged communities they serve.

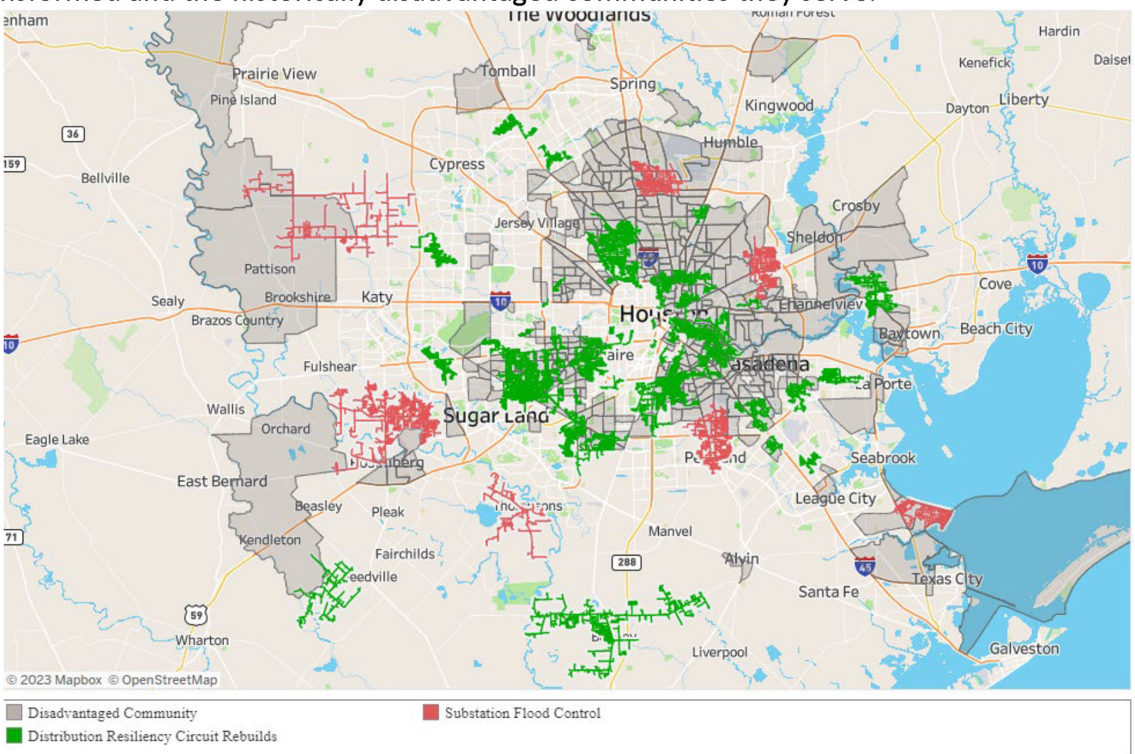

Figure 1: Project Impacts Map

As the map above demonstrates, the Project would substantially improve the resilience of the grid in disadvantaged communities. Using another metric, if awarded, the federal funding would allow the acceleration of grid resiliency efforts to deliver full completion by 2028 versus 2030 for the City of Houston's identified Complete Communities, which are Acres Home, Alief-Westwood, Fort Bend Houston, Gulfton, Kashmere Gardens, Magnolia Park-Manchester, Near Northside, Second Ward, Sunnyside, and Third Ward.[6] As detailed above and below, the improvements provided by the Project will include measurable direct and indirect investments, positive project outcomes, and community-wide benefits for disadvantaged communities.

The Community Benefits Plan provides greater detail as to the labor and community impacts of DOE funding on this Project.

[5] U.S. Department of Energy, *Energy Justice Dashboard (BETA)*, https://www.energy.gov/diversity/energy-justice-dashboard-beta (last accessed Dec. 13, 2022)
[6] *Houston Complete Communities*, https://www.houstoncc.org/ (last accessed Dec. 13, 2022).

A. Long-Term Constraints

CenterPoint will conduct grid-hardening activities on existing infrastructure. Distribution pole hardening will be conducted within existing circuit configurations and pole locations, and all substation flood control work will be contained within existing substation yard perimeters. If needed, detention ponds will be utilized for any run-off, and containment walls will be redesigned for auto-transformer depletion.

Because the Project involves work in already developed areas within existing footprints, CenterPoint expects little to no negative impacts on natural resources. By hardening the distribution system with more durable poles and equipment, CenterPoint will reduce the likelihood of catastrophic system failure during storm events, reduce the potential for impacts from emergency pole and equipment replacement, and increase the interval at which CenterPoint would need to conduct routine system maintenance and replacement. Accordingly, CenterPoint anticipates that the Project will result in no net increase of environmental impacts; in fact, the Project will reduce environmental impacts in the long-term.

E. Climate Resilience Strategy

There are few, if any, locations in the United Sates at greater risk of substantial impacts from climate change and severe weather events than Harris County, Texas, the only region nationally to score 100 (the highest score) on NOAA's National Center for Environmental Information Weather and Climate Hazard risk scale.[7] CenterPoint is acutely aware of the climate risks the Houston-area faces and is actively working to combat those risks and help Houston be able to withstand and quickly recover from extreme weather events. Several projects comprise CenterPoint's Climate Resilience Strategy, including the Project itself. The chart below describes several of CenterPoint's climate resilience programs. The two green highlighted rows are part of the Project.

[7] *NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022), https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73*

Table 2: Climate Resilience Strategy		
Program	**Purpose**	**Target**
Distribution Grid Resilience (Pole)	Transform, harden, and modernize distribution infrastructure for increased reliability and resiliency	150 – 300 miles of circuits per year 25 – 30 year program
Transmission Grid Resilience (Towers)	Transform, harden, and modernize transmission -infrastructure	Transmission line inspection and rehabilitation program based on a 5-year cycle 20% of transmission system is ground inspected and maintained each year
Substation Flood Control	Advance structural and foundation design technology to protect sensitive substation equipment from water damage	For Retrofit applications, target 1-2 substations a year to raise the control cubicle (original completion of program is projected for 2030) For New substation installation near a flood plain, control cubicle and high voltage assets will be raised to mitigate risk of future flooding
Mobile Generators	Catalyze communities by deploying 500 MW of mobile generator capacity at strategic substation locations to supplement- significant generation loss in the ERCOT market due to extreme weather events	Target 20% of 12kV substations to have capability for mobile generator connection
Mobile Substations	Deploy mobile substations when existing power transformers and/or breakers are impacted due to extreme weather events or catastrophic failures	Six units exist in fleet that can support a combination of temporary transformer and breaker needs.
Winterization of Equipment	Define standard practices to mitigate risk due to extreme winter events	CEHE Winter Weather Preparedness Document – Submitted to ERCOT annually

II. Technical Description, Innovation, and Impact

A. Relevance and Outcomes

The frequency of extreme weather events has increased dramatically in recent years. These events have severely impacted power systems, with consequences ranging from long outage times to the destruction of major equipment, including substations, transmission lines, and power plants. Because of these growing climate-related risks, the Project is not only relevant but critical to the energy security of the greater Houston area.

The Project will employ innovative technologies to address these vulnerabilities and create a more resilient grid. Specifically, the Project will: (1) harden distribution circuits with modern material technologies, such as modular fiberglass and ductile iron, and (2) physically elevate substations to weatherize them from flooding events that have become all-too-common in the Houston area. By performing targeted improvements to distribution infrastructure (on an accelerated basis with DOE funding), the Project will transform local and regional resilience by weatherizing the grid in the U.S.'s most vulnerable major city and focusing those efforts in disadvantaged communities.

As part of the existing Distribution Circuit Resilience Improvement Program, CenterPoint has already strengthened 125 miles on 33 distribution circuits by replacing all major equipment poles with engineered poles, as well as replacing and/or trussing overloaded poles using the extreme wind and ice loading criteria. With the assistance of the DOE grant, we plan to rebuild an additional 900 miles on 191 distribution circuits (with the grant funding 300 of these miles and 67 of these circuits) over the next 5 years, providing disadvantaged communities with significant infrastructure improvements and improved grid hardening on an accelerated basis.

As part of the existing Substation Flood Control Program, CenterPoint Energy has transformed seven substations by elevating control houses in the past three years and plans to transform 10 more substation sites over the next 5 years (with the grant funding 5 of these substation sites). This will further accelerate our grid hardening efforts and provide significant infrastructure improvements for disadvantaged communities.

B. Feasibility[8]

CenterPoint has already begun a smaller-scale version of the distribution circuit resiliency rebuilds and, as such, we have incorporated the necessary systems, processes, and personnel to coordinate and finalize the Project. Upon receiving the DOE grant, we would leverage the systems and processes already in place to ramp up this Project and add necessary personnel to coordinate and finalize the additional circuits on an accelerated basis. CenterPoint engaged with more than 50 crews from four contract firms to rebuild 125 miles in 2022, and CenterPoint is in the process of completing an additional 150 miles in 2023. To complete these efforts, CenterPoint employs a variety of highly trained, certified, skilled workers (both internal and contract), including head linemen, journeyman linemen, apprentice linemen, radio communications technicians, engineers, and IT technicians.

CenterPoint's Substation Flood Control projects are also technologically readily achievable. The Project will initially consist of selecting a footprint for placing a new raised control cubicle. Once the area has been selected, CenterPoint will follow standard design and construction practices to safely secure the control cubicle. CenterPoint has already assessed substations that would benefit from a flood control redesign. CenterPoint initially concentrated its efforts in the Galveston area, which suffered catastrophic damage after Hurricane Ike in 2008. Since then, CenterPoint has installed raised control cubicles at more than 20 substations. Each of these installations has generated lessons learned that are now part of CenterPoint flood control design specifications. As such, CenterPoint has the skills, experience, and resources to complete the Project in an efficient, safe, and effective manner.

C. Innovation and Impacts

CenterPoint has reviewed and evaluated data from significant extreme weather events that have impacted both the Houston area and Gulf Coast region within the last several years to

[8] Neither of these projects requires pre-approval by the Public Utilities Commission of Texas.

develop resilience metrics and evaluation methods that (1) compare planning and operation alternatives and (2) provide techno-economic justifications for resilience enhancement. These extreme events include Hurricane Ike (Category 2; Galveston, TX - 2008), Hurricane Laura (Category 4; Cameron, LA - 2020), and Hurricane Ida (Category 4; Port Fourchon, LA - 2021). These events disrupted power for multiple weeks and created material supply chain issues. Below, we address the data relevant for both components of the Project, the standards that apply, and the innovative technologies we plan to implement.

a. Distribution Circuit Resilience Improvements

CenterPoint analyzed wind data from Hurricanes Ike, Laura, and Ida to project anticipated wind speeds across its service territory. The first wind map below depicts Hurricane Ike's maximum sustained winds of 110mph (Category 2) at landfall, the second map shows Hurricane Laura winds layered on the CenterPoint service territory, and the third map shows Hurricane Ida winds layered on the CenterPoint service territory.

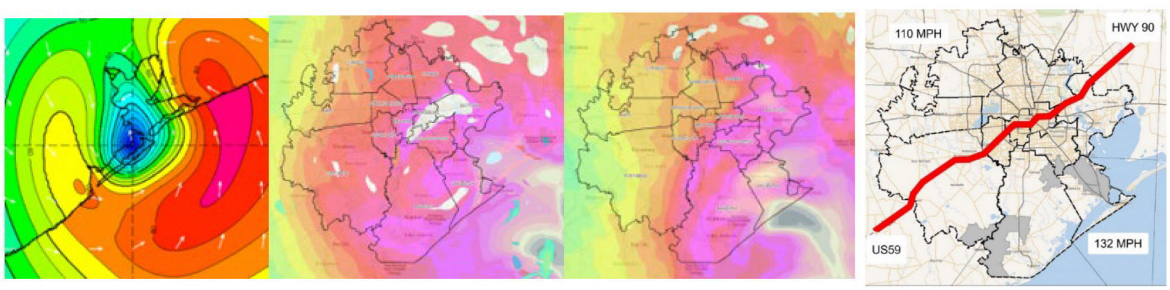

Figure 2: Hurricane Wind Maps

Taken together, the maps demonstrate that extreme wind speeds are likely to occur across CenterPoint's service territory, as high as 130 miles per hour along the coast and 100 miles per hour nearly 90 miles inland. Based on the data and wind overlays across the CenterPoint's service area, we have chosen US59 and Highway 90 as reference boundaries to develop two distinct wind modeling regions, shown in the fourth image above. We have incorporated this study's data into our hardening design criteria, which is foundational to the Project's distribution circuit resilience improvements.

Current distribution design practices outlined in the National Electric Safety Code ("NESC") allow poles to be exempt from national extreme wind design requirements if they are less than 60 feet above ground, and only need to be designed in accordance with regional wind speeds. In accordance with these standards, CenterPoint previously designed poles using a nine pound per square foot wind pressure design, approximately equivalent to a 60 mile per hour wind, with associated safety factors. The Project, however, applies a modernized and innovative design methodology based on the recent regional wind data for hurricane-force winds data, resulting in stronger poles, which in turn will create more resilient communities.

CenterPoint will modernize and harden existing distribution circuits by either retrofitting existing wood pole structures with a steel truss or replacing existing wood poles with modern engineered materials. Distribution circuits will consist of a variety of poles that include several different types of critical equipment[9] that have been identified as essential both during and after extreme weather events. These installations will be constructed on either a fiberglass pole or a ductile iron pole that will withstand and recover faster from an extreme weather event. The images below show examples of a steel truss reinforced wood pole (left), a pole top switch on a fiberglass pole (middle), and an intelligent grid switching device installed on a ductile iron pole (right).

Figure 3: Innovative Poles

CenterPoint is replacing wood poles because they are susceptible to rot and decay and require continued remediation treatments. By contrast, fiberglass and ductile iron poles eliminate these issues and provide a consistent, long-term resilient structure. The use of fiberglass and ductile iron in pole manufacturing is innovative and leverages each material's specific advantages. These poles are significantly more resilient to extreme weather conditions and provide reliable power distribution, even during significant storm events.

Fiberglass Poles: Fiberglass poles are comprised of long-strand E-Glass fibers that are fully saturated with a blend of polyurethane resin and ultraviolet inhibitors and are wound into their final tapered tubular form. Fiberglass poles provide superior strength, advanced electrical characteristics, and lower weight as compared to wood poles. Unlike wood poles, fiberglass poles are resistant to decay, rot, or leeching of preservatives. Fiberglass poles use the same CenterPoint framing standards as wood poles during construction. The manufacturer's currently quoted service life is 80 years for fiberglass. Fiberglass poles are manufactured in the United States and comply with Buy America initiatives.

Ductile Iron Poles: Ductile iron poles are an exceptionally durable and sustainable modern product composed of recycled ductile iron and are centrifugally cast into a tapered tubular form. They are also 100% recyclable when they reach the end of their expected operating life. They also utilize an acrylic topcoat for increased durability.

[9] Critical equipment includes pole top switches, regulator banks, large transformer banks, double circuit poles, capacitor banks, junction poles, and intelligent grid switching devices.

Ductile iron poles provide similar advantages of increased strength without the corresponding increase in weight when using concrete poles. Ductile iron poles are impervious to rot, insects, and woodpeckers, are highly fire resistant, and do not leech preservatives into the ground. The manufacturer's currently quoted service life is 75+ years for ductile iron. Ductile iron poles are manufactured in the United States and comply with Buy America initiatives.

The Distribution Circuit Rebuild Project will catalyze economic growth and transform the electric grid into a resilient system with the application of these modern engineered products. CenterPoint has rebuilt and hardened over 125 distribution overhead circuit-miles in 2022 with 600 more circuit miles planned over the next 5 years. DOE funding would accelerate this modernization and transformation effort to rebuild an additional 300 circuit miles, during the same period, further aiding vulnerable communities within the CenterPoint's service territory. As such, these efforts will support state, local, regional, and national resilience. Further, CenterPoint expects that using innovative fiberglass and ductile iron polls will spur private sector investment, as their efficacy is proven in real-world conditions.

b. Substation Flood Control

Hurricane Ike's storm surge took its toll on coastal substations, severely damaging multiple locations. Learning from Ike, CenterPoint changed coastal substation design criteria to account for Category 5 hurricane storm surges and built flood walls to mitigate flooding in other areas. The flooding resulting from Hurricane Harvey required eight substations to be taken out of service and rendered an additional nine inaccessible.

Following Hurricane Harvey, the City of Houston revised regulations requiring new structures or improvements to existing structures located in special flood hazard areas be elevated above 500-year flood level instead of the 100-year flood level.

CenterPoint has developed a flood resiliency program that evaluates short and long-range plans to provide appropriate flood protection to substations. The flood resiliency program considers the 500-year flood level and National Oceanic and Atmospheric Administration (NOAA) storm surge map to assign risk of a flood occurrence and severity of damage that a flood would cause at any substation. These substations are often located in disadvantaged communities, and these flood control projects can transform energy resilience and reliability in these areas.

DOE defines "flood hardening" as "a physical alteration to the substation to reduce the susceptibility of contact between flood waters and sensitive substation equipment and energized conductors."[10] Our short-term plan includes installing flood barriers around the critical components of a substation. Our long-term plan involves physically raising substations or control houses, which include sensitive electronic equipment. All new or major re-builds to substation facilities will be designed to exceed the highest of the following four flood protection criteria: (1)

[10] R. E. Costa and G. R. McAllister, "Substation flood program and flood hardening case study," 2017 IEEE Power & Energy Society General Meeting, Chicago, IL, USA, 2017, at 1-5, doi: 10.1109/PESGM.2017.8273905.

City of Houston: 500-year flood plain + 3 feet; (2) other Jurisdictions: highest available flood plain elevation + 1 foot; (3) NOAA Storm Surge Levels, and (4) historic data of flood levels

Digital Substation Resiliency. CenterPoint plans to incorporate an innovative component to the proposed flood control program by adding digital substation resiliency into the design. The digital substation resiliency strategy aims to: (1) improve the economic cost of engineering and installation of a control cubicle and its contents (which include the relaying and SCADA technology); (2) incorporate innovative designs to safeguard this critical protective relaying hardware from an electromagnetic pulse ("EMP") event; and (3) establish a resilient solution for extreme weather events that may have otherwise compromised traditionally built control cubicles, hindering restoration efforts.

Since 2015, CenterPoint has been improving this resilient digital substation solution, with each improvement incorporating lessons learned and influencing the design of future iterations. In total, CenterPoint has conducted four pilot installations since 2015 with two more substations scheduled to begin design in 2023. CenterPoint has executed license agreements with Siemens and ETS Lindgren to provide these digital substation solutions.

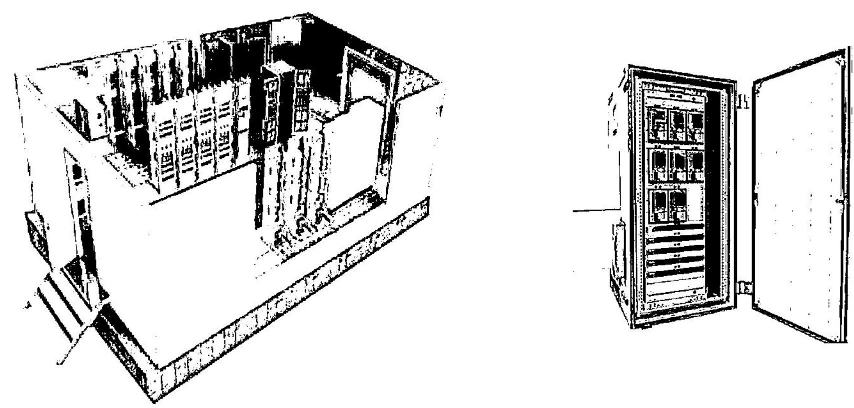

Figure 4 - compact control cubicle with resilient digital substation module

D. Topic Area 1 Specifics

This Project will satisfy multiple eligible uses and technical approaches designated for Topic 1 grants, including: weatherization technologies and equipment; the undergrounding of electrical equipment; utility pole management; hardening of power lines, facilities, substations, and other systems; and replacement of old overhead conductors and underground cables.

After Hurricane Ike left a trail of destruction in its wake, CenterPoint needed to replace 8,500 poles. CenterPoint moved quickly to minimize disruptions, but the scope of work meant that the repairs took 18 days. Many of the downed poles, which included critical infrastructure and equipment poles, were severely damaged by high winds. The Distribution Circuit Rebuilds Project intentionally and immediately addresses the root cause of many of these extreme weather impacts by hardening these distribution circuits to withstand extreme wind speeds. CenterPoint's additional efforts to address resilience, such as by undergrounding freeway crossing circuits, decreasing the possibility that these locations would require restoration after significant weather events. Moreover, by using advanced material technologies such as fiberglass and ductile iron poles on identified critical infrastructure equipment, and limiting the exposure of overhead distribution lines, the Distribution Circuit Rebuild Project reinforces the ability of those essential locations to provide immediate power to communities during and after extreme weather events.

Additional funding from DOE will ensure that the Project is completed on a substantially accelerated timeframe. CenterPoint will design the supporting columns for the control cubicle in-house, and delegate construction of the control cubicle and its contents to a third party. By retaining control of the columns, CenterPoint can design and start construction of all ten proposed sites and phase in the delivery of the pre-built control cubicles per schedule. By having all protective relay panels pre-installed in the control cubicle, CenterPoint can reduce the time commitment for construction and testing activities on site.[11]

III. Workplan

A. Project Objectives

CenterPoint seeks funding from DOE's GRIP program for two specific aspects of its resilience-strengthening efforts: **distribution resiliency circuit rebuilds** and **substation flood control**. A $100 million Topic 1 GRIP grant from DOE would allow CenterPoint to harden approximately 900 miles of distribution circuit infrastructure in vulnerable communities and 10 substation sites over the next five years, accelerating resilience efforts substantially, as described above.

B. Scope of Work

The distribution circuit resiliency improvements will primarily involve the replacement of wood poles with engineered poles more capable of withstanding extreme weather events. This improved restoration effort will result in decreased likelihood of power outages and improved restoration times for those in Houston's most vulnerable communities. The substation flood control component of the Project involves elevating control cubicles by at least 10 feet to significantly reduce the likelihood of flood damage. The new elevated control cubicles will be installed with the necessary internal hardware and support structure to mitigate damage from flooding and higher wind loads due to elevated height. The Project will be managed across two different sets of budget periods to account for the difference in complexity between the Project components.

C. Technical Scope Summary

a. Distribution Circuit Resilience Improvements

[11] More information about the impacts of CenterPoint's resilience efforts is available in the Report on Resilience Investments.

CenterPoint implemented a data-driven approach to determine technical feasibility and prioritization of the distribution circuit rebuild. CenterPoint analyzed multiple data inputs to prioritize certain circuits. CenterPoint assessed all circuits to determine the following criteria: (1) circuits that serve critical infrastructure facilities, (2) circuits supporting mobile generation, and (3) circuits serving disadvantaged communities. CenterPoint prioritizes circuits based on the number of criteria met. CenterPoint splits up which circuits it plans to modernize each year based on location: 60% mileage in the 132mph wind zone and 40% mileage in the 110mph wind zone.

Rebuild Year	Number of Circuits	Approximate Mileage
2024	41	178
2025	38	178
2026	40	183
2027	37	176
2028	35	182
Total	191	898

The table above summarizes the scope of the Project for the distribution resiliency circuit rebuilds for the next five years based on CenterPoint's existing prioritization methodology. The approximately 900 miles of distribution lines CenterPoint is targeting for hardening are comprised of 191 circuits, which originate at 62 distinct substations. For project organizational purposes, circuits will be treated as a suite of circuits, grouped by common substation of origin. Environmental Questionnaires and Project/Performance Site Location forms are submitted for each suite of distribution circuits by substation.

Each individual distribution circuit operates independently of all other circuits. For project implementation, each circuit will comprise an individual subproject. Requisitions and work orders will be issued for the rebuild of each distribution circuit separately. CenterPoint will complete environmental reviews for each individual distribution circuit, and the reconstruction of each individual circuit will occur as an independent effort, potentially by separate contractors within each suite of common substations of origin.

b. Substation Flood Control

CenterPoint surveyed all substations assessing flood damage from previous storms and new building, mitigation, and control requirements around flooding. Through this process, CenterPoint determined there were at least 17 substation sites that would benefit from remediation efforts. These improvements include both flood remediation and leveraging the new digital technology where feasible. This includes elevating critical infrastructure above maximum proposed flood levels and economic efficiencies through removal of copper and addition of fiber.

CenterPoint prioritizes these substations based on a number of criteria (location, historical impacts, etc.) including benefits to disadvantaged communities. The scope of the Project for the substation flood control comprises 10 substation sites that are located at seven substations.

Environmental Questionnaires and Project/Performance Site Location forms are submitted by substation, but each site is considered a separate subproject.

To take advantage of the improved economics of the digital substation resiliency technology and strategy, CenterPoint is proposing a few different approaches for mitigating flood control for the proposed substation sites listed below.

Substation	Category	Flood Control Strategy
1	Distribution	Raise new control cubicle with current relay panel standards
2	Distribution	Raise new control cubicle with current relay panel standards
3	Distribution	Raise new compact **digital substation** control cubicle – Technology 'A'
4	Distribution	Raise new compact **digital substation** control cubicle – Technology 'B'
5	Distribution	Raise new compact **digital substation** control cubicle – Technology 'A' or 'B'[11]
6	Distribution	Raise new compact **digital substation** control cubicle – Technology 'A' or 'B'
7	Distribution	Raise new compact **digital substation** control cubicle – Technology 'A' or 'B'
8	Transmission	Raise new compact **digital substation** control cubicle – Technology 'A' or 'B'
9	Transmission	Raise new compact **digital substation** control cubicle – Technology 'A' or 'B'
10	Transmission	Raise new compact **digital substation** control cubicle – Technology 'A' or 'B'

Two of the ten substation sites will be designed per current standards, which is to raise a new control cubicle and demolish the former control cubicle. The remaining eight substation sites will maintain the existing control cubicle as the primary system and raise a second compact control cubicle to house the digital substation hardware (acting as a back-up compact solution when needed).

D. Work Breakdown Structure ("WBS") and Task Description Summary

a. Distribution Circuit Resilience Improvements Tasks

The distribution resiliency circuit rebuild work activities occur along road right of ways, utility easements, and company property. Some coordination with local permitting agencies is required to ensure equipment is installed to minimize or exclude it from interfering with any public infrastructure. Major components to the project will include the purchase of poles, conductors, equipment, and other associated materials, which will all be manufactured in the United States to support the Buy America Requirements for Infrastructure Projects. The Distribution Circuit Rebuilds Tasks and Subtasks will recur annually over the duration of the Project.

- **Task P1 - Pre-Assessment Phase**
  - **Sub-Task P1.1 – Circuit Prioritization Selection.** CenterPoint will use a data-driven approach to determine the technical feasibility and prioritization of the distribution circuits to be rebuilt each year.

- **Sub-Task P1.2 - Assess Sites.** CenterPoint believes many, if not all, Project sites would be subject to NEPA Categorical Exclusions, such as B4.6. To the extent an Environmental Assessment is required, we believe that it should be expedited. To comply with federal guidance on grant awards, CenterPoint will confirm whether Categorical Exclusions apply, or whether an Environmental Assessment is required, before beginning work. As needed, CenterPoint will contract with third-party consultants to assist with this activity.

- **Task P2 - Pre-Design/Pre-Construction**
  - **Sub-Task P2.1 - Issue RFP.** Prior to each year's planned circuit rebuilds, CenterPoint will evaluate circuit data and begin acquiring, or securing procurement slots for, poles, equipment, and other associated materials that will be used during the Construction phase.
- **Task 1 – Project Management and Planning**
  - **Sub-task 1.1 – Project Management (PMP).** Within 30 days of award, the Recipient shall submit a Project Management Plan (PMP) to the designated Federal Project Officer (FPO). The Recipient shall not proceed beyond Task 1.0 until the PMP has been accepted by the FPO. The PMP shall be revised and resubmitted as often as necessary, during the course of the project, to capture any major/significant changes to the planned approach, budget, key personnel, major resources, etc. The Recipient shall manage and direct the project in accordance with the accepted PMP to meet all technical, schedule and budget objectives and requirements. The Recipient will coordinate activities to effectively accomplish the work. The Recipient will ensure that project plans, results, and decisions are appropriately documented, and that project reporting and briefing requirements are satisfied.
  - **Sub-Task 1.2: National Environmental Policy Act (NEPA) Compliance.** As required, CenterPoint shall provide the documentation necessary for NEPA compliance.
  - **Sub-Task 1.3: Cybersecurity Plan.** Per the FOA, this is not required for Topic Area 1 grants.
  - **Sub-Task 1.4 Continuation Briefing.** CenterPoint will brief DOE on roughly an annual basis to explain the plans, progress and results of the technical effort. The briefing shall also describe performance relative to project success criteria, milestones, and the Go/No-Go Decision point that are documented in the Project Management Plan (PMP).
  - **Sub-Task 1.5 – Distribution Circuit Rebuild Design.** CenterPoint will collaborate with our third-party design partners to review, inspect, and design each pole structure on determined circuits. Each pole will receive a structural load analysis to determine resiliency adequacy, retrofitted to meet resilient criteria, or replaced with a more resilient structure. CenterPoint will identify all critical infrastructure to be installed on either a fiberglass or ductile iron pole.
  - **Sub-Task 1.6 – Work Order Creation.** CenterPoint will create work orders that compile the pole load analysis and upgrade results that will be issued for Construction.
  - **Sub-Task 1.7 – Procurement.** CenterPoint procurement specialists will procure all additional materials required for the issuance of work orders based on the material requirements within the Work Orders.
- **Task 2 - Construction**
  - **Sub-Task 2.1 - Construction**
    CenterPoint will release the Work Orders for each distribution circuit to Contract

Operations partners who will hire qualified personnel to work on our distribution system to replace and install newer, hardened structures and equipment across the circuit.

- **Task 3 – Quality Assurance and Completion**
  - **Sub-Task 3.1 – Quality Assurance**
    CenterPoint will review the performed Construction to ensure the Construction meets the Design that were issued in the Work Orders.
  - **Sub-Task 3.2 – Completion**
    Once quality assurance is performed and Construction is determined to be accurate, the work orders for each of the distribution circuits identified as part of the Project are closed and status changed to Complete.

b. Substation Flood Control Tasks

All substation flood control work activities will occur within the substation perimeter (CenterPoint property) which will exclude it from interfering with any public infrastructure. Major components of the project, including control cubicles and protective relay hardware, will all be manufactured in the United States to support the Buy America Requirements for Infrastructure Projects.

- **Task P1 - Pre-Assessment Phase (Budget Period 1)**
  - **Sub-Task P1.1 - Assess Sites**. CenterPoint believes many, if not all, Project sites would be subject to NEPA Categorical Exclusions, such as B4.6. To the extent an Environmental Assessment is required, we believe that it should be expedited. To comply with federal guidance on grant awards, CenterPoint will confirm whether Categorical Exclusions apply, or whether an Environmental Assessment is required, before beginning work. As needed, CenterPoint will contract with third-party consultants to assist with this activity.
- **Task P2 - Pre-Design/Pre-Construction (Budget Period 2)**
  - **Sub-Task P2.1 - Issue RFP**. CenterPoint will issue a competitive bid to award turn-key services for the delivery of a control cubicle with pre-installed relay panels and SCADA systems for each of the proposed sites.
  - **Sub-Task P2.2 - Award Contract**. As a result of the competitive bid, CenterPoint will award the turn-key services to the most qualified respondent that can provide a high-quality engineering solution and deliver on time per the Project's schedule. CenterPoint will also consider supplier diversity in the bidding process.
- **Task 1 – Project Management and Planning (Budget Period 2)**
  - **Sub-task 1.1: Project Management (PMP).** Within 30 days of award, the Recipient shall submit a Project Management Plan (PMP) to the designated Federal Project Officer (FPO). The Recipient shall not proceed beyond Task 1.0 until the PMP has been accepted by the FPO. The PMP shall be revised and resubmitted as often as necessary, during the course of the project, to capture any major/significant changes to the planned approach, budget, key personnel, major resources, etc. The Recipient shall manage and direct the project in accordance with the accepted PMP to meet all technical, schedule and budget objectives and requirements. The Recipient will coordinate activities to effectively accomplish the

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- **Sub-Task 1.5: Control Cubicles.** CenterPoint will provide standards and specifications to turn-key provider on control cubicles and relay/SCADA panels. Design will account for dimensions of the control cubicle for each respective substation's needs and all necessary contents of the control cubicle, such as protective relay panels and wiring between them. Expected deliverables will be front/back panel design, AC/DC schematics, communication diagrams, and control house layout with elevations.
- **Sub-Task 1.6 - Support Columns.** CenterPoint's internal engineering team will design the civil needs for site preparation and the support columns that the control cubicle will permanently rest on. CenterPoint will coordinate with the turn-key service provider to confirm that the support columns have the correct measurements for each respective control cubicle. This will be critical to ensure that both the support columns and control cubicles are able to fit together.

- **Task 2 – Procurement (Budget Period 2)**
  - **Sub-Task 2.1 - Control Cubicles**
    The turn-key service provider will be responsible for procuring all necessary equipment and material in relation to the final approved design. Expected deliverable is a schedule of material delivery times.
  - **Sub-Task 2.2 - Bid Labor**
    CenterPoint plans to bid the necessary labor to construct the control cubicle's support columns and site preparation.
- **Task 3 – Construction (Budget Period 3)**
  - **Sub-Task 3.1 - Site work**
    Due to a compressed schedule, CenterPoint will conduct the necessary site work at all ten proposed substation sites during the same period. This will maximize efficiency and allow CenterPoint to manage all ten sites and prioritize delivery and installation of control cubicles. CenterPoint will conduct most of the work through contract labor hired for this purpose.
  - **Sub-Task 3.2 - Factory Acceptance Test (Protective Relay & SCADA)**
    Before control cubicle vendor ships any units, CenterPoint will test all protective relay and SCADA communications to confirm that wiring and local networks are assembled correctly to reduce any delays once on-site. CenterPoint will modify testing procedures for the substation control cubicles containing the digital substation application due to its prominence in communication network schemes.
  - **Sub-Task 3.3 - Elevate new control cubicles**
    Once site work is complete, CenterPoint can accept delivery of the control cubicles and

prioritize installation by site readiness. The control cubicle vendor will coordinate with CenterPoint to schedule crane activity.

- **Task 4 – Commission (Budget Period 3 - 4)**
  - **Sub-Task 4.1 - Validate performance of relay panels**. CenterPoint will perform standard testing on all relay panels and SCADA technology to confirm that any external power/network connections are not impacting performance.
- **Task 5 – Close-out (Budget Period 4)**
  - **Sub-Task 5.1** - **Punch list items.** Review any punch list items that need to be addressed and corrected and close out any open work-orders and purchase orders. Close out project financially.

E. Milestone Summary

CenterPoint will assess operational performance, track progress, improve its distribution and substation operations, and report to DOE on results of its projects, tools, and techniques. Milestones are key achievements in the Project and reviewed semi-monthly by the PMO and monthly by the Executive Steering Committee. The main milestones for the Project are shown in the table below:

Milestone	Task	Description	2024				2025				2026				2027				2028			
Substation Flood Control			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
A	P1	NEPA Assessment	X																			
B	P2	Bid/Award Project	X																			
C	1	Preliminary Design Review		X																		
D	1	Final Design Approved			X																	
E	2	Confirm Material Delivery Lead Times			X																	
F	2	Confirm Construction Schedule			X																	
G	3	Site work starts				X																
H	3	Columns ready					X															
I	3	Install control cubicles									X	X	X	X	X	X	X	X				
J	4	Relay Panel Testing – Pass Results									X	X	X	X	X	X	X	X				
Distribution Circuit Rebuild																						
K	All	Circuit miles rebuilt	178				178				183				176				182			

F. Go/No-Go Decision Points

The distribution circuit resilience improvements leverage SMART goals, is based on the number of circuits being completed each year and will be reviewed annually. This review is designed to capture locations that may be delayed and provide opportunities for schedule adjustments, potentially moving circuits into different years.

Distribution Circuit Resilience Improvements					
Go/No-Go Period	**Specific**	**Measurable**	**Attainable**	**Relevance**	**Time**
Annual Review	Project Funded – capital plan has been established for initial year of activities and forecasted into subsequent years	Fiscal year final budget approval	CNP has an increasing capital plan for next 10 years, establishing funds for this project will be attainable (DOE grant will facilitate accelerated budget and project completion)	Without approved capital dollars, project cannot continue	Q4-Prior Year

The substation flood control program leverages SMART goals and is scheduled to be a multi-year project leveraging different tasks each year. Each year, CenterPoint will perform a review to ensure tasks are funded and accomplishable.

Substation Flood Control Program					
Go/No-Go Period	**Specific**	**Measurable**	**Attainable**	**Relevance**	**Time**
2024	Project Funded – capital plan has been established for initial year of activities and forecasted into subsequent years	Fiscal year final budget approval	CenterPoint has an increasing capital plan for next 10 years, establishing funds for this project will be attainable. (DOE grant will facilitate accelerated budget and project completion)	Without approved capital dollars, project cannot continue	Q3-2023
2025	Deliver control cubicles on time	Review construction schedule with respective lead times from vendor	Distributed risk by going with variations of standards for control cubicle (1) standard control cubicle (2) compact digital substation	Control cubicles need to be delivered on time to complete project by deadline	Q4 - 2025
2026	Install Labor is readily available	Determine worker-hours needed to complete each recommended work location	Worker-hours can increase if needed by re-deploying resources from other projects	Due to large capital workload across service territory, having available labor capacity is important to not delay work	Q1 - 2026

G. End of Project Goal

a. Distribution Circuit Resilience Improvements

The end of Project goal is to accelerate our efforts to modernize the Houston electric grid and improve our ability to quickly recover from natural disasters by hardening a total of approximately 900 miles of distribution circuit infrastructure, most within disadvantaged communities, and upgrading 10 substation sites over the next five years. Below is a summary of the SMART goal:

- **Specific**: To reduce the impact of a natural disaster on our community by hardening 900 miles of distribution circuits and improving flood control at 10 substation sites.
- **Measurable**: We will be able to measure the number of distribution circuit miles rebuilt and track the progress of the substation flood control project monthly.
- **Achievable**: This goal is achievable with proper planning and resources. We will implement a system for tracking progress and measuring success.
- **Relevant**: This goal is relevant because it addresses a critical need for our community to prepare for and respond to natural disasters. It will improve the safety and well-being of our residents, as well as the overall resilience of our community.
- **Time-bound**: We have set a five-year timeline to achieve this goal, which will provide a sense of urgency and help us stay on track with our progress. At the end of each year, we will assess our success and adjust as needed to continue improving our resiliency efforts.

H. Project Schedule

The chart shown below details both portions of the project schedule and details the specific milestones to be achieved each year.

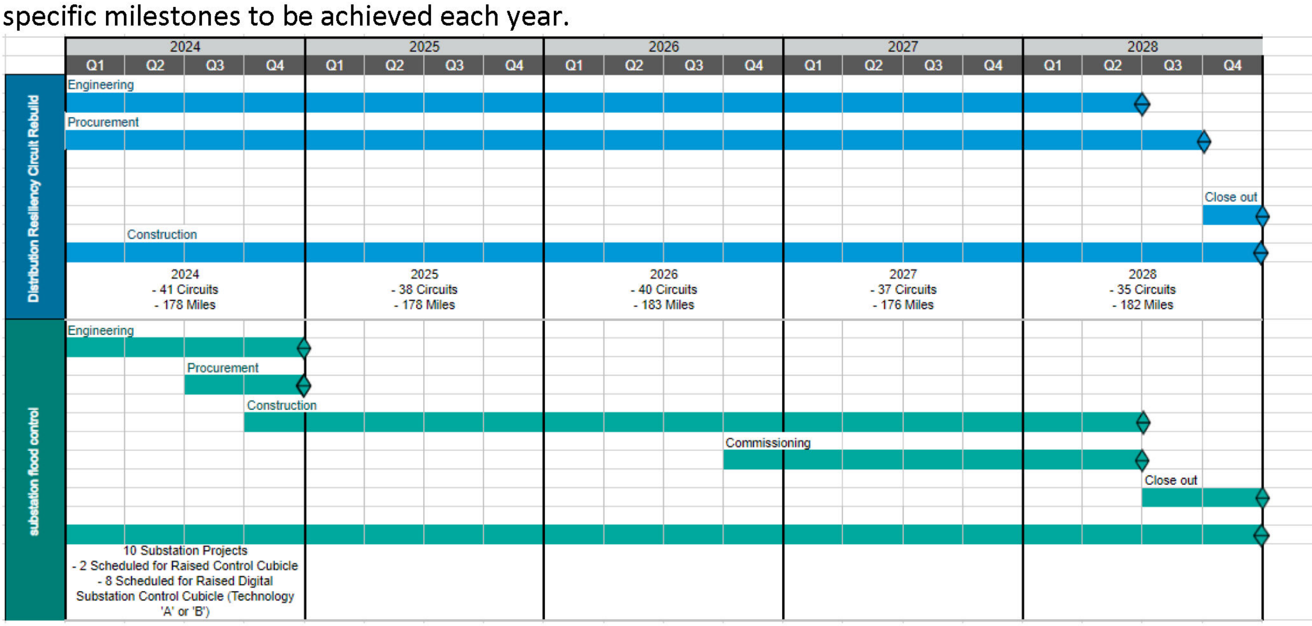


Figure 5: Project Schedule

I. Project Management

The Project Management Organization ("PMO") for the identified distribution resiliency circuit rebuild and substation flood control projects will reside in the Capital Program Management organization within CenterPoint. This team will be comprised of a highly skilled and capable workforce consisting of Functional Area Managers, Project Managers, Cost Controllers, and Schedulers as shown in the diagram below. The teams lead by the Manager of Distribution Capital Programs and Manager of Substation Capital Programs will support the execution of this Project.

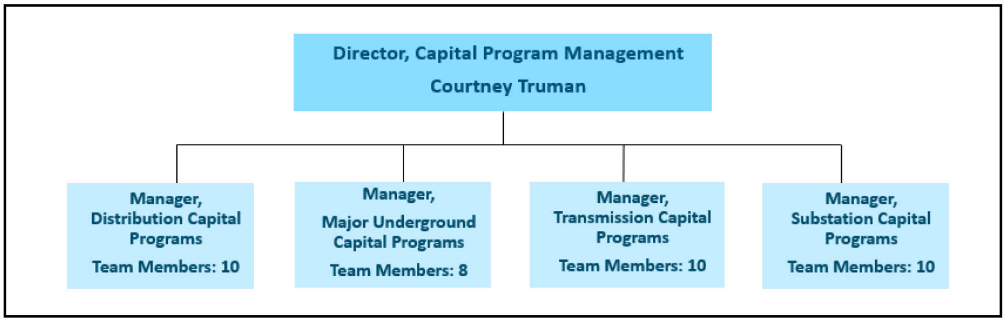


Figure 6: Capital Program Management Organization Chart

The PMO will provide project life cycle structure and ensure all participants and internal stakeholders understand and accept the scope of the projects, and its accompanying risk factors. Specifically, the PMO will be responsible for:

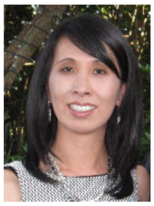
- Managing the entire project list across all CenterPoint internal stakeholders
- Ensuring timely communication for project status updates and risk mitigation to guarantee timely completion
- Working with stakeholders as risks and/or complex issues arise to mitigate as needed to achieve the accelerated completion window
- Adhering to CenterPoint's safety and authorization policies, and governance culture
- Making sure that the projects meet the key capital portfolio and program goals and abides by all regulatory, legal, and financial requirements
- Reporting program and project progress to all relevant internal and external stakeholders as needed

The PMO is managed by CenterPoint and the responsible functional work teams will track the projects and programs on a continuous basis throughout their life cycle and provide completed work packages, inclusive of schedule and cost updates, on a semi-monthly basis to internal stakeholders, including the Project Team.

IV. Technical Qualifications and Resources

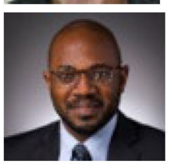
A. Project Team Qualifications and Expertise

The Project Team will be led by **Randy Pryor**, CenterPoint's Vice President for Major Underground and Distribution Modernization, **Eric Easton**, Vice President of Grid Transformation and Investment Strategy, **Mandie Shook**, Vice President of Electric Engineering, **Hong Ablack**, Director of Asset Planning and Optimization, and **Lynnae Wilson**, Senior Vice President of Electric Business. Below are brief descriptions of key personnel, in alphabetical order.



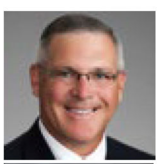
Hong Ablack is responsible for development of asset analytics, rehab program prioritization strategies, reliability monitoring and reporting, capital portfolio optimization, and long-term grid resiliency strategies that will be a key component of the company's capital plan. She is a registered Professional Engineer in the State of Texas and a Certified Information Systems Security Professional.

Jeff DallaRosa leads a team on environmental permitting and compliance for new electric utility construction projects, including substations, transmission lines, and distribution lines He also represents the company on national environmental policy advocacy and technical research committees for Edison Electric Institute and Electric Power Research Institute



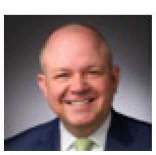
Eric Easton manages the company's plans and response to transformative challenges, such as distributed generation, electric vehicles and mass electrification, and ensures that executed plans provide modern and resilient service. He is a registered Professional Engineer in the state of Texas.

Richard Orum is responsible for the oversight of the design, permitting, and construction of all overhead electrical distribution equipment within the CenterPoint service area.



Randy Pryor provides executive leadership and oversight for large distribution construction projects serving the Houston Electric service area including grid modernization, distribution resiliency programs and vegetation management serving 2.6M+ electric customers.

Mike Roeder is responsible for CenterPoint's legislative policy team and engaging in government relations with local, state, and federal governments.



Jason Ryan is responsible for CenterPoint's regulatory services and government affairs team. He was appointed by the Texas Public Utilities Commission to lead the aggregated virtual power plant task force. He is a licensed attorney in the State of Texas.

Mandie Shook is responsible for transmission and substation project engineering, system protection, reliability, material and standards, and CenterPoint Energy's North American Electric Reliability Corporation reliability compliance program. She is a registered Professional Engineer.

Tim Sullivan is responsible for all aspects of substation engineering design including structural design, relay and SCADA design, protection, SCADA, and communication settings, standards development, and material specification. He is a registered Professional Engineer.

Courtney Truman is responsible for the project management organization and ensuring the team has the tools necessary to execute the CenterPoint Energy Houston Electric capital portfolio in a timely manner.

Brad Tutunjian is the responsible lead on innovative projects and strategy requiring regulatory approval, lead pursuits of grant funding for resiliency and breakthrough technology projects and testify on key policy initiatives before legislators.

Lynnae Wilson leads all aspects of the electric distribution, transmission, and generation utilities in Indiana and Texas.

Together, they have collective decades of experience in successfully delivering projects that have increased energy reliability in transmission and distribution as well as substation operations. They each have the skill, expertise, and drive to successfully execute all aspects of the Project.

B. Existing Equipment or Facilities

While DOE funding will allow CenterPoint to meet Project goals in an accelerated manner, CenterPoint has the equipment and facilities necessary to accomplish this effort. CenterPoint has been planning its distribution and substation upgrades for years. As part of the Project schedule, CenterPoint has identified the distribution circuits targeted to be rebuilt for each upcoming year. As such, the number of poles, critical equipment locations, and locations for underground conversion have also been identified. Using those quantities, we have secured in advance from the vendors/manufacturers ample supply of, or procurement slots for, fiberglass and ductile iron poles, and their associated construction materials, to support the planned circuit rebuilds for the upcoming year(s).

CenterPoint does not expect any unusual challenges in procuring equipment for our distribution hardening efforts. There are currently plans for a new fiberglass pole manufacturing facility within a disadvantaged community near Humble, Texas (a suburb of Houston). Similarly, in our substation flood control effort, we also have access to the substation facilities and have good relationships with vendors to obtain the equipment necessary to weatherize these substations and increase their resilience. We have the access to all equipment, resources, and materials to complete and accelerate this Project.

C. Time Commitment of Key Team Members

CenterPoint and its holding company, CenterPoint Energy, Inc., are fully committed to the Project. The key project team members will meet on a semi-monthly basis and update the Executive Steering Committee monthly to communicate Project results and discuss future plans. The PMO will facilitate the meetings and engage additional stakeholders as needed to help ensure successful completion of the Project.

CenterPoint has well-trained personnel to implement the Project, and it will retain additional employees and contractors as needed to accelerate the work. Commitment letters from key vendors and partners are also included in in the Letters of Commitment Attachment. Contracts have already been executed with these vendors and can be provided upon request.

FOA Number: DE-FOA-0002740

Concept Paper from CenterPoint Energy, Inc.

Grid Resilience and Innovation Partnerships Funding Opportunity Announcement Number: DE-FOA-0002740

Topic Area 1: Grid Resilience Grants (40101(c))

Proposed Budget: $200M (approx. $100M grant, plus $100M cost share)
Proposed Non-Federal Cost Share: 50%
Proposed Award Duration: 24 months

Technical Point of Contact:	**Randy Pryor** Vice President, Major Underground and Distribution Modernization CenterPoint Energy, Inc. 1111 Louisiana St. Houston, TX 77002 randy.pryor@centerpointenergy.com

Business Point of Contact:	**Christine Keck** Managing Director, Federal Government Affairs CenterPoint Energy, Inc. 211 NW Riverside Drive Evansville, IN 47708 christine.keck@centerpointenergy.com

Team Members:	**Jason Ryan**, Executive Vice President, Regulatory and Government Affairs **Lynnae Wilson**, Senior Vice President, Houston Electric **Shane Kimzey**, Senior Vice President, Deputy General Counsel **Eric Easton**, Vice President, Grid Transformation and Investment Strategy **Mandie Shook**, Vice President, Electric Engineering **Hong Ablack**, Director, Asset Planning and Optimization **Brandy Spainhoward**, Director, Utility Marketing **Mike Roeder**, Vice President, State and Federal Governmental Affairs

Confidentiality Statement: Not Applicable

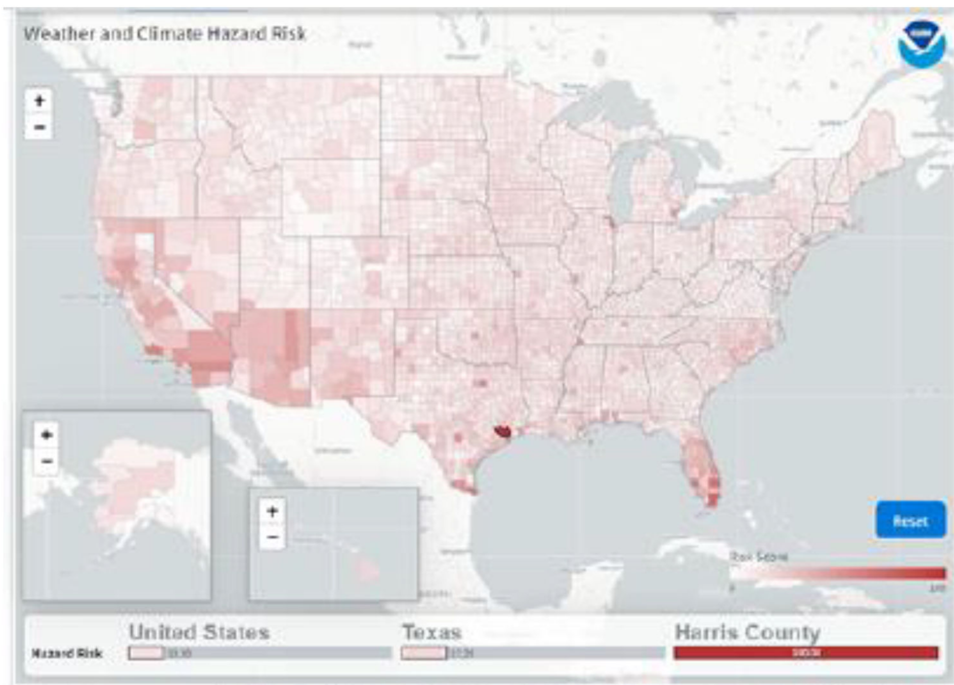
FOA Number: DE-FOA-0002740

Project Description

Distribution Circuit Resilience Improvements and Substation Flood Control

I. Overview

There are few, if any, locations in the United States at greater risk of substantial impacts from climate change and severe weather events than Harris County, Texas, which lies at the heart of CenterPoint Energy, Inc.'s ("CenterPoint") Houston-area service territory. Indeed, NOAA's National Center for Environmental Information identified Harris County as the only region scoring 100 on its Weather and Climate Hazard risk scale, meaning that it is projected to have the most negative future impacts across several socioeconomic metrics.[1] Harris County's particular vulnerabilities and high-risk profile for flooding and severe storms highlight the critical need for weatherization, resilience, and flood control in the Houston area.



Data for the above maps are accessible via FEMA National Risk Index (NRI), Social Vulnerability Index (SoVI), Climate Impact Lab, and CDC Social Vulnerability Index. [2]

Accordingly, CenterPoint has invested substantial resources and efforts implementing grid resiliency plans to strengthen the electric system to enhance and build a stronger, smarter, and more adaptable grid to make it more resilient to severe weather events and improve service to CenterPoint's customers. CenterPoint's resilience planning is an integrated effort, involving numerous state and local governments and agencies, as well as community organizations dedicated to serving disadvantaged communities within the service territory. CenterPoint seeks funding from DOE's GRIP program for two specific aspects of its resilience-

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[1] *NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73*

[2] Id.

strengthening efforts: **distribution resiliency circuit rebuilds** and **substation flood control** ("Project"). An approximately $100 million Topic 1 GRIP grant from DOE would allow CenterPoint to harden approximately 300 miles of distribution circuit infrastructure in vulnerable communities and five substations, accelerating resilience efforts substantially. The distribution circuit work should constitute approximately 90% of the Project spend, with the substations making up the remaining 10%. Moreover, this Project would result in additional hiring and would encourage significant private investment, as described below.

II. Background

The Houston area has experienced numerous recent severe weather events that have led to both widespread and localized power outages, including in its most vulnerable communities. Houston's recent severe weather events – the 2015 Memorial Day Floods, Hurricane Harvey in 2017, and the February 2021 Winter Storm Uri, just to name a few – have put a sharp focus on the need for energy resilience, including upgrades such as distribution circuit rebuilds and substation flood control. While those events were undisputedly disastrous for the city and its people, they also provided opportunities to examine what areas are in the most urgent need of remediation and improved transmission and distribution infrastructure. DOE funding will help modernize and weatherize those areas' distribution systems and substations to be prepared for the future of increasing severe weather.

CenterPoint's broader resilience investments in recent years have prioritized important transmission-related initiatives, including improving the most critical "backbone" pieces of the transmission system. Indeed, CenterPoint has been pro-active in resilience since the 1950s by incorporating anti-cascade designs, which limit the damage from downed structures. In particular, CenterPoint's recent transmission hardening activities have focused on meeting the National Electric Safety Code (NESC) C2 extreme wind loading requirements and resilience to 140 MPH winds along the coast, with diminishing requirements as facilities move away from the coast. Since Hurricane Ike in 2008, CenterPoint has replaced over 3,600 transmission structures, with approximately 300 transmission circuit miles hardened so far. Approximately 260 additional circuit miles of transmission hardening are planned over the next 10 years. CenterPoint plans for all energized transmission circuits to be on steel or concrete structures by the end of 2030. In addition, CenterPoint is modernizing its transmission system with important voltage upgrades, moving from 69kV circuits to 138kV.

III. CenterPoint's Proposed Project for GRIP Funding

A. Distribution Resiliency Circuit Rebuilds

These transmission upgrades, while critical for improving grid resilience, are not sufficient in isolation without a fully integrated plan that also includes distribution upgrades. CenterPoint proposes to use a GRIP award to complement this transmission work with distribution and substation efforts that go to the heart of key infrastructure and to communities likely to be hardest hit by future severe weather events and most susceptible to power outages. At a rate of 300-350 distribution circuit miles per year, and a cost of approximately $300,000 per mile, fully hardening the entire distribution system would take about 25-30 years. With full GRIP funding of approximately $100M, CenterPoint believes we can accelerate that timeline by approximately one year for distribution circuits, and multiple years for substations, to reach key resilience goals sooner than without such funding.

1. Technical Design Standards and Equipment.

CenterPoint Energy plans and seeks federal GRIP funding to rebuild the current distribution facilities to new design standards to mitigate risk of outages to critical infrastructure across its service territory, including in vulnerable communities.

First, CenterPoint plans for all new distribution structures and replacements, regardless of pole height, to be designed for hurricane level extreme wind speeds ranging from 110-mph to 132-mph, consistent with CenterPoint's adoption of the NESC Rule 250C (Extreme Wind) and 250D (Extreme Ice with Concurrent Wind Loading) standards. This Extreme Wind Loading (EWL) standard will be critical to mitigate large-scale outages from increasingly severe storms. For example, Hurricane Ike damaged nearly 8,800 poles to the point of needing repairs, the majority of which were not designed to extreme wind conditions as specified in the NESC. CenterPoint plans to uniformly design to the latest NESC rules for Extreme Wind and Extreme Ice. As these poles will be designed to withstand severe winds, fewer will be lost and there will be less resulting debris. Another positive consequence will be greatly reduced restoration times, allowing us to provide electricity to customers and return to normal operating conditions faster and more efficiently.

Second, CenterPoint will increase its use of undergrounding for critical distribution features such as substation getaways and freeway crossings. The first distribution section terminating from a substation feeder will use underground construction, and if overhead construction must be used, it will be non-wood, engineered structures (described below). Similarly, for all freeway crossings, underground construction will be the primary design option. If that is not feasible, then overhead construction with concrete poles will be considered. Placing the feeder getaway underground and/or using non-wood structures will reduce wire exposure to potential failure risks, such as car collisions or extreme weather events. By having the first feeder section energized, operations teams can reduce restoration time by picking up load downstream more efficiently and performing their restoration tasks outside of the substation without dependency on other crews. Similarly, placing the freeway crossings underground will reduce the overhead feeder exposure of the section which will reduce the risk of wire failure from external forces.

Third, CenterPoint plans to use innovative materials and equipment at scale to achieve substantial resilience gains. All major distribution system equipment including Intelligent Grid Switching Devices (IGSDs), large three-phase transformer banks (>250kVA), pole top switches, terminal poles, capacitor banks, regulator racks, and double stacked circuits will be installed on poles composed of a non-wood, engineered material such as fiberglass and ductile iron. In some instances, where necessary, concrete will be used. Ductile iron (DI) poles feature high strength but are approximately the weight of wooden poles. They are field drillable and fully coated for corrosion protection. DI poles typically are comprised of over 96% recycled material and are 100% recyclable at end-of-life. The ceramic-epoxy embedment coating used on DI poles