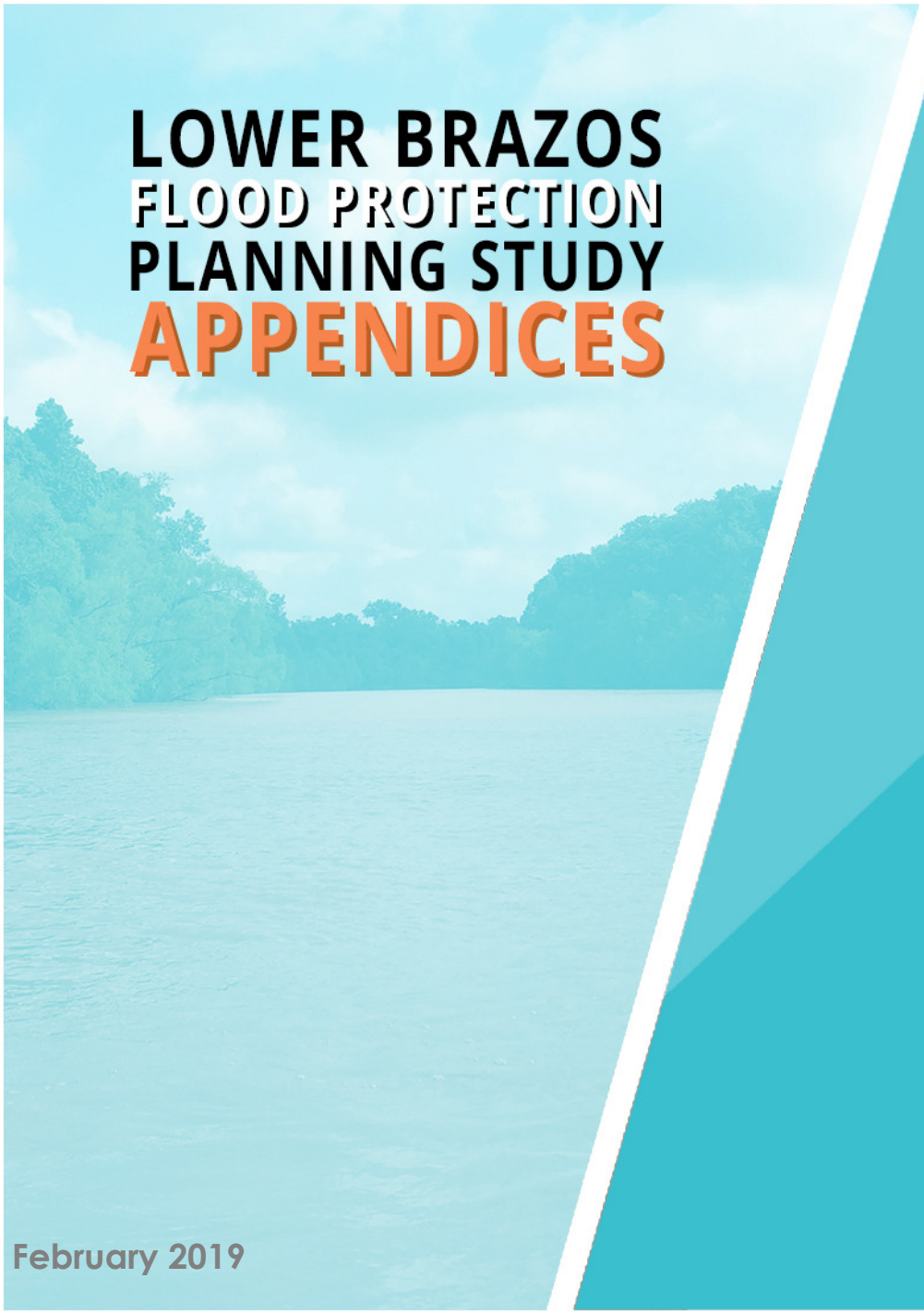
Appendix C:
Survey Data



February 2019

Appendix C – Survey Data

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Appendix C – Survey Data

C.1.0 Survey Scope

Current topographic information is critical to the production of accurate floodplain information. To supplement and confirm existing topographic data discussed in Appendix B, field surveys, measurements, and photographs were collected along the detailed study area of the Lower Brazos River. The project survey initially involved conducting limited field reconnaissance of the specific detailed study area to determine conditions along the Lower Brazos River including:

- types and numbers of hydraulic and/or flood control structures
- apparent maintenance or lack thereof of existing hydraulic structures
- locations of channel cross sections to be surveyed.

Photographs of the channel and structures were taken to aid in hydraulic modeling and to assign manning "n" roughness values. The field surveys were performed under the supervision of Billy Wolfram (Halff Associates, Inc. State of Texas RPLS #6244).

Surveyed points for bridges include the deck, low chord, parapet, and channel cross sections at the upstream and downstream faces. Intermediate channel cross sections were surveyed at accessible locations between structures where a significant change in conveyance occurred between cross sections.

The data acquisition also included sketches and photographs. Five (5) digital photos were taken for each structure. This includes downstream channel, downstream face of structure, overtopping cross section looking left to right, upstream face of structure, and upstream channel. Two (2) digital photos were taken at each channel cross section; downstream channel and upstream channel.

Survey sketches with measurements and notations were prepared for all structures and channel cross sections. All digital survey data can be found in the digital submittal included with this report.

The field surveys consisted of both channel and structure surveys along the Lower Brazos River. A total of eleven (11) bridges and thirty-six (36) cross sections were surveyed. Note that TxDOT as-built bridge plans were used for hydraulic modeling of most structures as described in Appendix A. Field survey for crossings and cross sections was not collected in Fort Bend County, as the effective model cross sections were surveyed by Fort Bend County for the 2009 hydraulic study of the Brazos River and the data was leveraged for this study.

Initial field reconnaissance was performed to confirm the locations with easy accessibility. Coordination was done in advance to notify property owners and to request access for field survey locations without public right-of-way. Survey data collected for this study was incorporated into the terrain data discussed in Appendix B to develop a current terrain data set.

C.2.0 Coordination with Property Owners

Project field surveyors required access to private property along the Lower Brazos river as well as public rights-of-way adjoining private property. Right-of-entry requests were sent to 58 property owners located along the survey cross section locations to obtain entry to the property to collect survey data on February 25, 2015. Right-of-entry was granted by 11 property owners. A copy of

the right of entry letter is included at the end of this Appendix. Access to the Brazos River was mainly done by utilizing public boat ramps within the project area.

C.3.0 Summary of Horizontal and Vertical Datum

The survey and topographic data used are referenced to the North American Horizontal Datum of 1983 (NAD83) with State Plane Texas South Central Projection (4204). The elevations are referenced to the 1988 North American Vertical Datum (NAVD88). The linear unit used for both horizontal and vertical measurements is U.S. Feet

C.4.0 Description of Survey Procedures

The field surveys were performed under the supervision of Billy Wolfram (Halff Associates, Inc. State of Texas RPLS #6244).

C.4.1 Project Survey Control

Halff Survey used the Trimble Real-Time Network and Leica SmartNet RTK (Real Time Kinematic) Network as the primary Global Navigation Satellite System (GNSS) control for these surveys. Both Horizontal and Vertical Datums were adjusted to published monuments from the National Geodetic Survey (NGS) GPS and Vertical Control monumentation network.

Halff Survey used GNSS surveying techniques to establish an Elevation Reference Mark (ERM) at the surveyed hydraulic structures and cross-sections. The ERMs were used to survey the horizontal location of the channels and hydraulic structures. Elevations at pertinent structure and channel points were observed and documented using differential levelling. Channel bathymetric cross-sections were observed using the Trimble R8 GPS system in tandem with the Seafloor Systems SonarMITE echo sounder mounted to a john boat. The horizontal and vertical datum for all surveys is Texas South Central State Plane Coordinate System – NAD83 (Zone 4204) and NAVD88, respectively. The survey data is documented in the Survey Data Capture Standards (DCS) data submittal and Geodatabase tables.

C.4.2 Survey Control Check - Horizontal

Halff Survey verified that the primary controls utilized in this project met the accuracy requirements by performing redundant occupations at several points throughout the project area. The GNSS-derived horizontal coordinates are all in the NAD83 Texas South Central State Plane Coordinate System with units in US Survey Feet.

C.4.3 Survey Control Check - Vertical

Primary control point elevations are in NAVD88 US Survey Feet and were calculated using the GNSS-derived ellipsoid heights from RTK Networks, adjusted to the NGS Control monuments, and applying the geoid heights that were interpolated from the GEOID 12A model. To check the accuracy of the controls and temporary bench marks, multiple observations were taken and averaged to establish the final coordinates and elevations. NGS monuments utilized included: PID(s) AW5472, AB3196, AW7089, AH3515, AM0052, AW4733, AW4731, AX0054, BM1106, AX0005, AW2192, and BM0154.

C.4.4 Survey Accuracy

The ERMs established and used for the structure surveys meet horizontal and vertical positional accuracy relative to the Primary Controls. Both the horizontal and vertical accuracy of the channel centerlines and alignment points at each structure are of survey-grade quality. The accuracy of the structure and channel dimensions varies depending on their size, shape, and orientations, and are not considered survey grade since the measurements were made with a cloth tape and/or measuring wheel as opposed to a high-precision surveying instrument like a total station.

C.4.5 Channel Cross-Section Survey and Bathymetry

Field survey for crossings was primarily collected March 2015 for phase 1 and August 2016 for phase 2 with Leica GPS GS-14 equipment connected to Leica SmartNet and processed with Leica Infinity Software Version 2.3.2.2825. Bathymetric data was also collected at various locations along the Brazos River. This data was collected by boat which traversed the channel multiple times to obtain depths using sonar. Field survey was collected along the river banks at these same locations where bathymetric data was collected. At each field survey location of crossing and cross section, photos and field sketches were obtained. A total of 11 bridges and 36 cross sections were surveyed.

The locations of the Brazos River detailed bridge crossings surveys are listed in Table C-1. Exhibit C-1 presents the locations of the bridge crossings surveys. The river station is measured in feet from the mouth of the Brazos River at the Gulf of Mexico.

Table C-1: Field Survey of Brazos River Bridge Crossings

Survey Cross Section ID	River Station (feet)	Location	County
BRZ_7000	1062127	US 290	Waller, Washington
BRZ_12000	987127	TX 159	Waller, Washington
BRZ_18000	884436	FM 529	Waller, Washington
BRZ_23000	811251	FM 1458	Waller, Washington
BRZ_25000	782329	Union Pacific RR	Waller, Washington
BRZ_25000	782128	IH-10	Waller, Washington
BZR_22000	305693	FM 1462	Brazoria, Fort Bend
BZR_15000	178983	SH 35	Brazoria
BZR_10000	128733	TX 521	Brazoria
BZR_7000	82748	FM 2004	Brazoria
BZR_2000	25875	SH 36	Brazoria

Surveys of the bridge crossings in Fort Bend County were obtained from Fort Bend County that were used in the development of the 2009 Fort Bend Lower Brazos River effective hydraulic model (See Appendix A). Therefore, no field survey of Brazos River crossings was obtained in Fort Bend County for the current study.

In addition to survey of the bridge crossings, cross sections along the Brazos River were surveyed to interpolate the bathymetry of the river. The Brazos River was accessed using boat ramps to measure the bathymetry by reading elevations perpendicular to the river centerline. The locations of the detailed cross section surveys are listed in Table C-2 and shown on Exhibit C-1. The river station is measured in feet from the mouth of the Brazos River at the Gulf of Mexico.

Table C-2: Field Survey of the Brazos River Cross Sections

Survey Name	River Station (feet)	County
BRZ_1000	1155776	Waller, Washington
BRZ_2000	1143752	Waller, Washington
BRZ_3000	1127605	Waller, Washington
BRZ_4000	1114038	Waller, Washington
BRZ_5000	1098272	Waller, Washington
BRZ_6000	1074880	Waller, Washington
BRZ_8000	1043028	Waller, Washington
BRZ_9000	1027560	Waller, Washington
BRZ_10000	1012206	Waller, Washington
BRZ_11000	1000049	Waller, Austin
BRZ_13000	971724	Waller, Austin
BRZ_14000	951013	Waller, Austin
BRZ_15000	937463	Waller, Austin
BRZ_16000	915977	Waller, Austin
BRZ_17000	898958	Waller, Austin
BRZ_19000	873052	Waller, Austin
BRZ_20000	858483	Waller, Austin
BRZ_21000	838768	Waller, Austin
BRZ_22000	818888	Waller, Austin
BRZ_24000	793449	Waller, Austin
BRZ_26000	766102	Waller, Austin
BZR_21000	285654	Brazoria
BZR_20000	273833	Brazoria
BZR_19000	245582	Brazoria
BZR_18000	232299	Brazoria
BZR_17000	218197	Brazoria
BZR_16000	196788	Brazoria
BZR_14000	174104	Brazoria
BZR_13000	143092	Brazoria
BZR_9000	113665	Brazoria
BZR_8000	96764.3	Brazoria
BZR_6000	72649.6	Brazoria

Survey Name	River Station (feet)	County
BZR_5000	51424	Brazoria
BZR_4000	41087	Brazoria
BZR_3000	32269	Brazoria
BZR_1000	18177	Brazoria

C.4.6 Incorporation of Survey Data into Terrain

The LiDAR based terrain, described in Appendix B, was generated using ground point cloud data. The ground points do not include elevation data below water areas, building footprints, or bridges. In these areas of no data the terrain triangulates a surface across. Additional survey point data and bathymetry data were incorporated into the terrain to add definition in some areas with no data. The survey data was added to the terrain as either 3d points or interpolated 3d break lines.

For the detailed study reach of the Lower Brazos River, the river bathymetry was interpolated between each of the 36 field cross sections. A GIS process was developed to generate interpolated channel geometry between the surveyed locations. Unlike the cross section interpolator built into HEC-RAS, which can only interpolate in a straight line, this utility was able to account for expansions, contractions, and bends in the river.

The GIS process used a set of break lines running the length of the river and through the survey data points collected. This interpolated channel geometry was then incorporated into the terrain along with all the other terrain datasets. Incorporating the channel geometry into the terrain provided the benefit of being able to extract cross section geometry at any point along the river and not just at survey locations.

C.5.0 Site Visits

Several site visits were conducted during the 2016 event to establish high-water marks and observe the impacts of the storm event. Site visits were conducted on May 31, June 3, and June 6, 2016 for Waller, Fort Bend and Brazoria Counties, respectively. Major flooding impacts were observed along bridges crossing the Brazos River with some bridges blocked off due to safety concerns. Many photos were taken on or near these bridges to visually document the high-water during the 2016 event. Several high-water marks were staked out during the site visits for survey crews to obtain water surface elevations. A photo of the Brazos River during the 2016 event along FM 529 is shown in Figure C-1: *Brazos River along FM 529*. Exhibit C-2 shows the locations of photos taken during the site visits.

Figure C-1: Brazos River along FM 529

C.6.0 High-water Mark Surveys

Several high-water marks were placed during field reconnaissance for the 2016 storm event. These high-water marks were staked near bridge structures with elevations determined later from survey crews. These high-water marks were utilized to verify the results of the hydraulic modeling for the 2016 storm event. The high-water mark survey elevations from the 2016 storm event are listed below in Table C-3. Exhibit C-2 shows the location of high-water marks from the 2016 storm event.

Table C-3: High-water Marks for 2016 Storm Event

River Reach	County	Location	Elevation (NAVD 88 feet)
Brazos River	Waller	Upstream of TX 159	149.63
Brazos River	Waller	Downstream of FM 529	137.38
Brazos River	Waller	Upstream of IH 10	121.26
Brazos River	Fort Bend	FM 1489	91.81
Brazos River	Fort Bend	Downstream of US 90A	81.43
Brazos River	Fort Bend	Upstream of TX 99	76.02
Brazos River	Fort Bend	Upstream of SH 59	74.98
Oyster Creek	Brazoria	Downstream of FM 1462	46.45

Appendix C: Survey

Exhibits

Brazos River Authority

Lower Brazos River Floodplain Protection Planning Study

Exhibit C-1
Survey Location Map

Index

- Survey Point
- Basin Limits
- County Line

N

0 4 8
Miles

1 inch = 4 miles

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2 of 4

3 of 4

4 of 4

Brazos River

Brazos River Tidal

Navasota River

Yegua Creek

Lake Conroe

San Jacinto River

Lake Houston

Cow Creek

Oyster Creek

Colorado River

Matagorda Bay

Gulf of Mexico

Burleson
Brazos
Grimes
Walker
San Jacinto
Washington
Montgomery
Liberty
Austin
Waller
Harris
Colorado
Fort Bend
Chambers
Wharton
Galveston
Jackson
Brazoria
Matagorda

SNOOK
COLLEGE STATION
MILLICAN
ANDERSON
SOMERVILLE
NAVASOTA
HUNTSVILLE
NEW WAVERLY
MONTGOMERY
WILLIS
PANORAMA VILLAGE
CONROE
CUT AND SHOOT
TODD MISSION
MAGNOLIA
STAGECOACH
WOODLOCH
SHENANDOAH
OAK RIDGE NORTH
SPLENDORA
PATTON VILLAGE
WOODBRANCH
ROMAN FOREST
TOMBALL
BRENHAM
HEMPSTEAD
PINE ISLAND
PRAIRIE VIEW
WALLER
BELLVILLE
SEALY
SAN FELIPE
PATTISON
BROOKSHIRE
BRAZOS COUNTRY
COLUMBUS
JERSEY VILLAGE
HUMBLE
HILSHIRE VILLAGE
SPRING VALLEY
BUNKER HILL VILLAGE
HUNTERS CREEK VILLAGE
PINEY POINT VILLAGE
HOUSTON
WEST UNIVERSITY PLACE
SOUTHSIDE PLACE
BELLAIRE
JACINTO CITY
GALENA PARK
BAYTOWN
EAGLE LAKE
SIMONTON
FULSHEAR
WALLIS
ORCHARD
MEADOWS PLACE
STAFFORD
EAST BERNARD
RICHMOND
ROSENBERG
SUGAR LAND
SOUTH HOUSTON
DEER PARK
PASADENA
LA PORTE
MORGAN'S POINT
BEASLEY
KENDLETON
PLEAK
FAIRCHILDS
THOMPSONS
MISSOURI CITY
ARCOLA
PEARLAND
BROOKSIDE VILLAGE
SHOREACRES
TAYLOR LAKE VILLAGE
SEABROOK
EL LAGO
NASSAU BAY
CLEAR LAKE SHORES
KEMAH
NEEDVILLE
MANVEL
FRIENDSWOOD
WEBSTER
WHARTON
EL CAMPO
IOWA COLONY
ALVIN
LEAGUE CITY
DICKINSON
HILLCREST
BONNEY
SANTA FE
TEXAS CITY
LIVERPOOL
LA MARQUE
BAYOU VISTA
HITCHCOCK
TIKI ISLAND
WEST COLUMBIA
DANBURY
BAILEY'S PRAIRIE
ANGLETON
JAMAICA BEACH
GALVESTON
SWEENY
BAY CITY
RICHWOOD
LAKE JACKSON
CLUTE
JONES CREEK
OYSTER CREEK
FREEPORT
SURFSIDE BEACH
QUINTANA
PALACIOS

Brazos River Authority

Lower Brazos River Floodplain Protection Planning Study

Exhibit C-1
Survey Location Map

1 of 4

Survey Point
Basin Limits
County Line

N

0 1 2
Miles

1 inch = 1 miles

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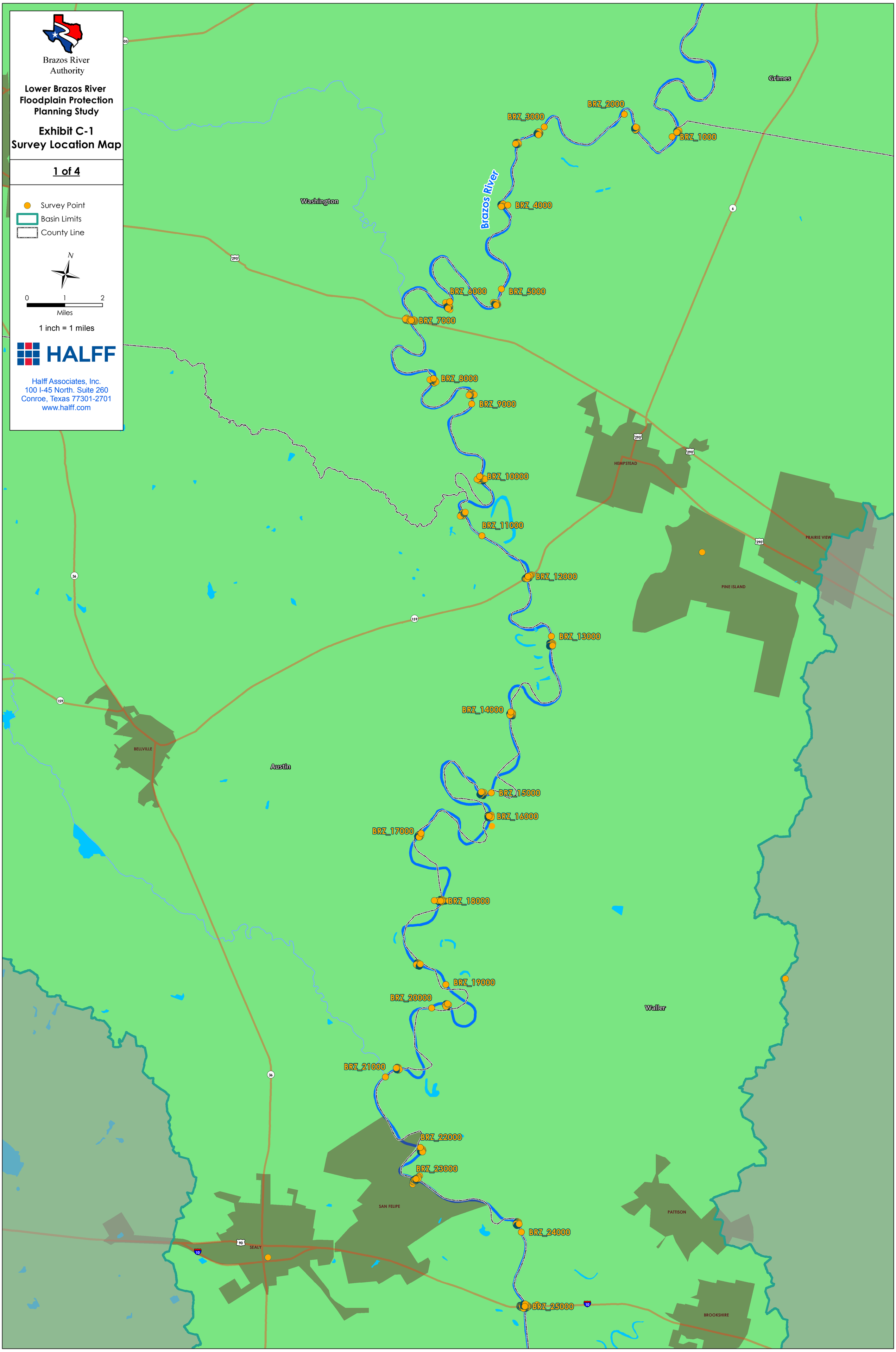

Brazos River Authority

Lower Brazos River Floodplain Protection Planning Study

Exhibit C-1
Survey Location Map

2 of 4

Survey Point
Basin Limits
County Line

N

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Miles

1 inch = 1 miles

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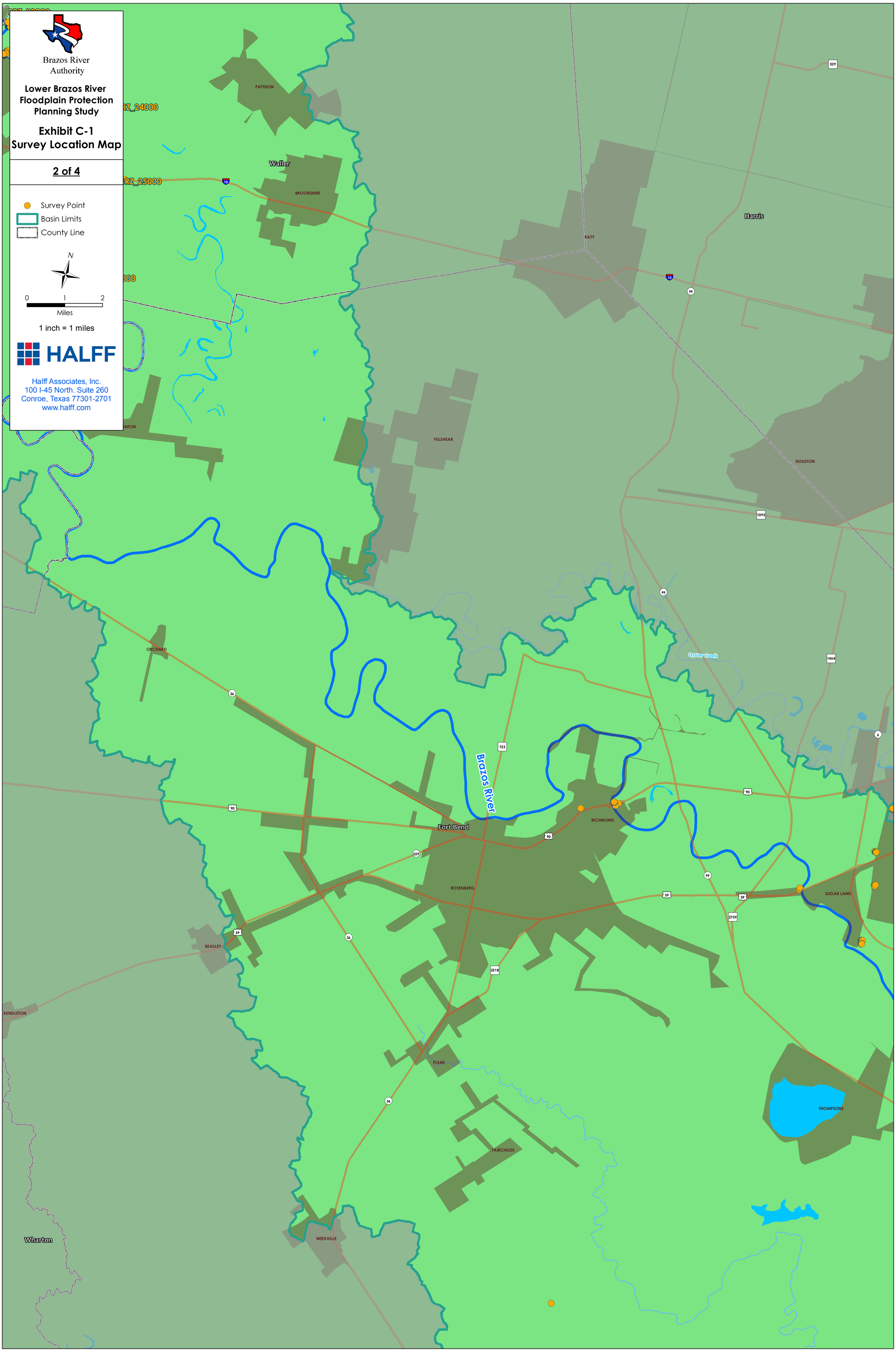

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Lower Brazos River Floodplain Protection Planning Study

Exhibit C-1
Survey Location Map

3 of 4

Survey Point
Basin Limits
County Line

N

0 1 2
Miles

1 inch = 1 miles

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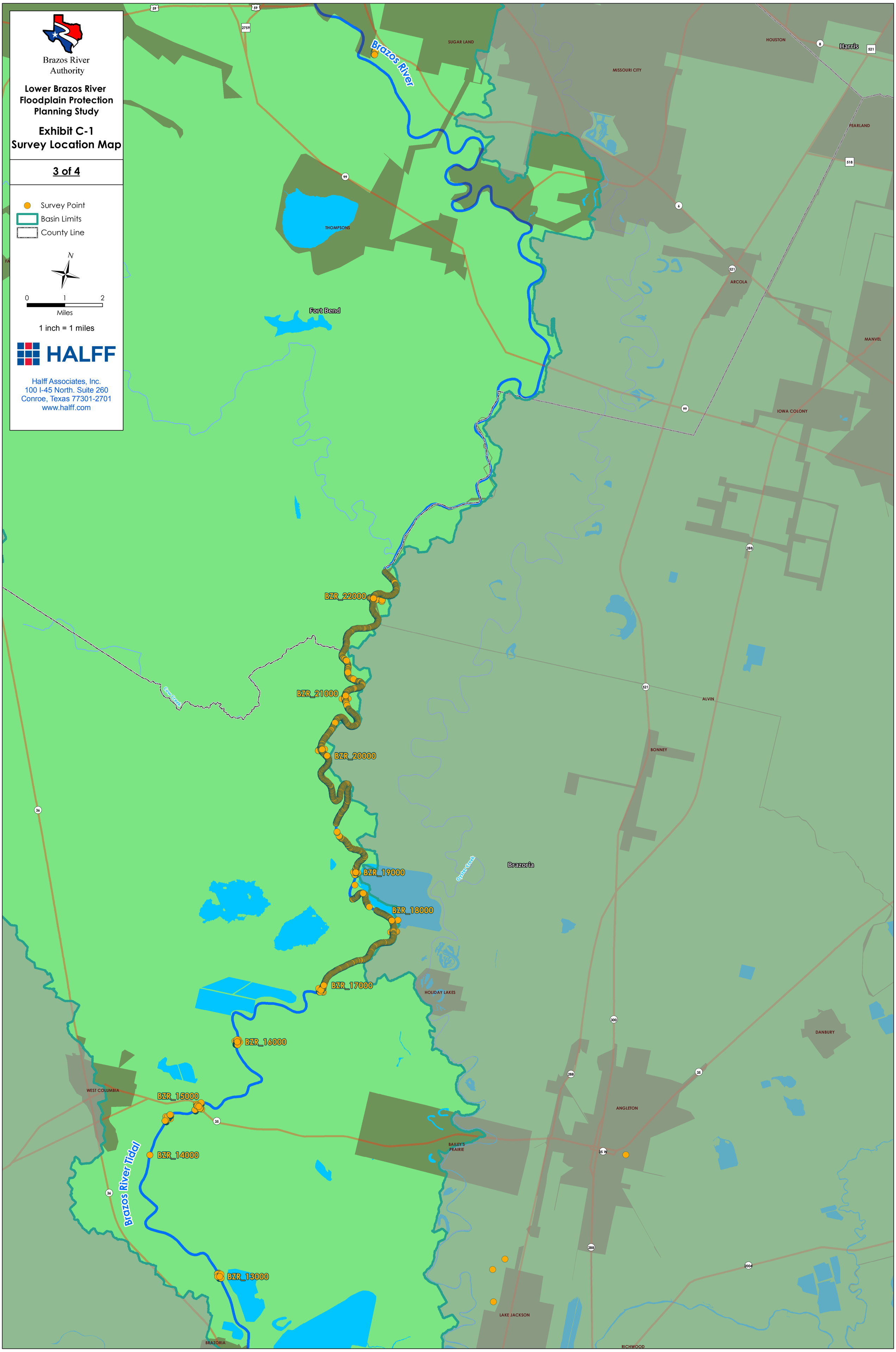

Brazos River Authority

Lower Brazos River Floodplain Protection Planning Study

Exhibit C-1
Survey Location Map

4 of 4

Survey Point
Basin Limits
County Line

N

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Miles

1 inch = 1 miles

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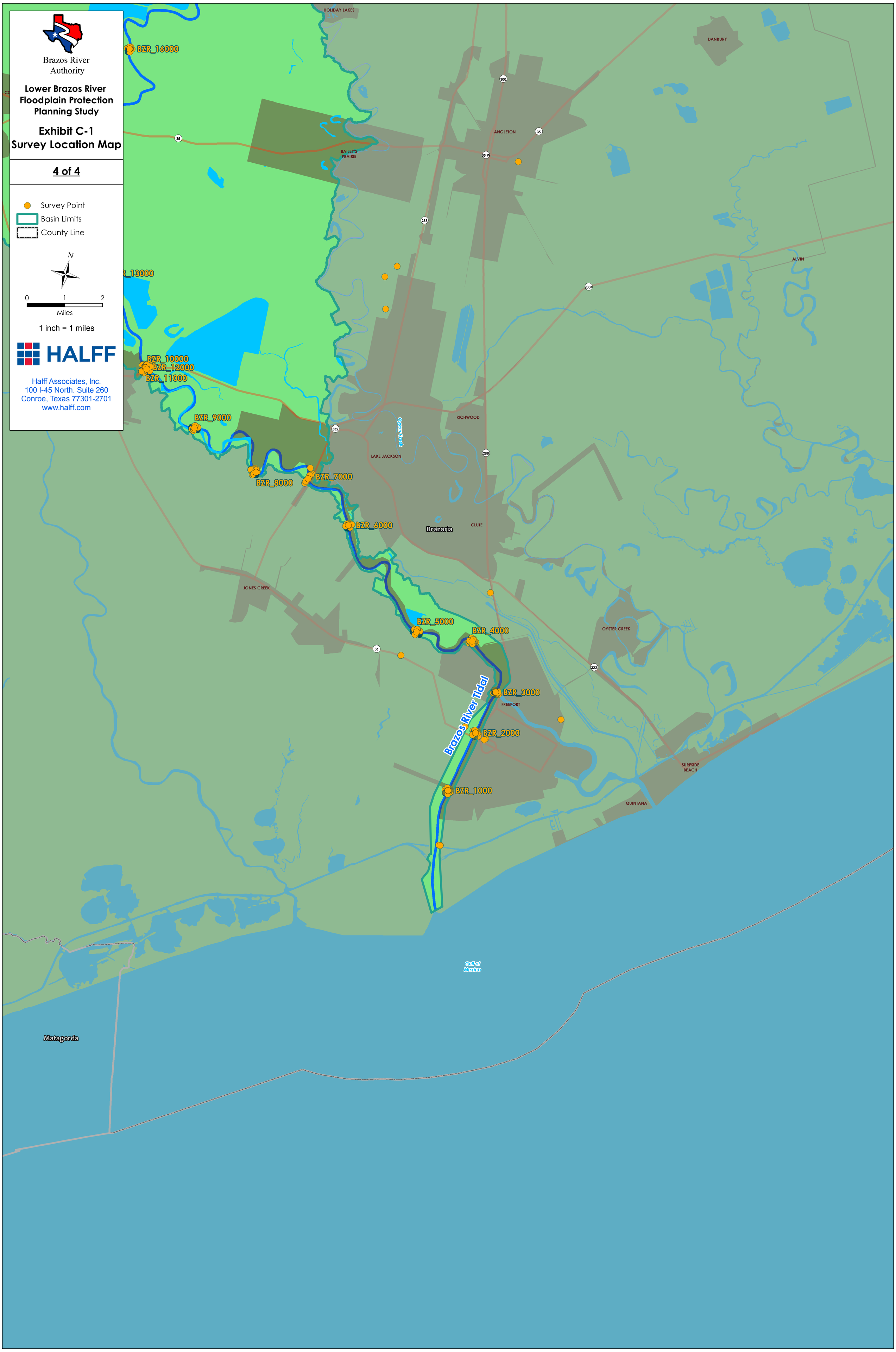

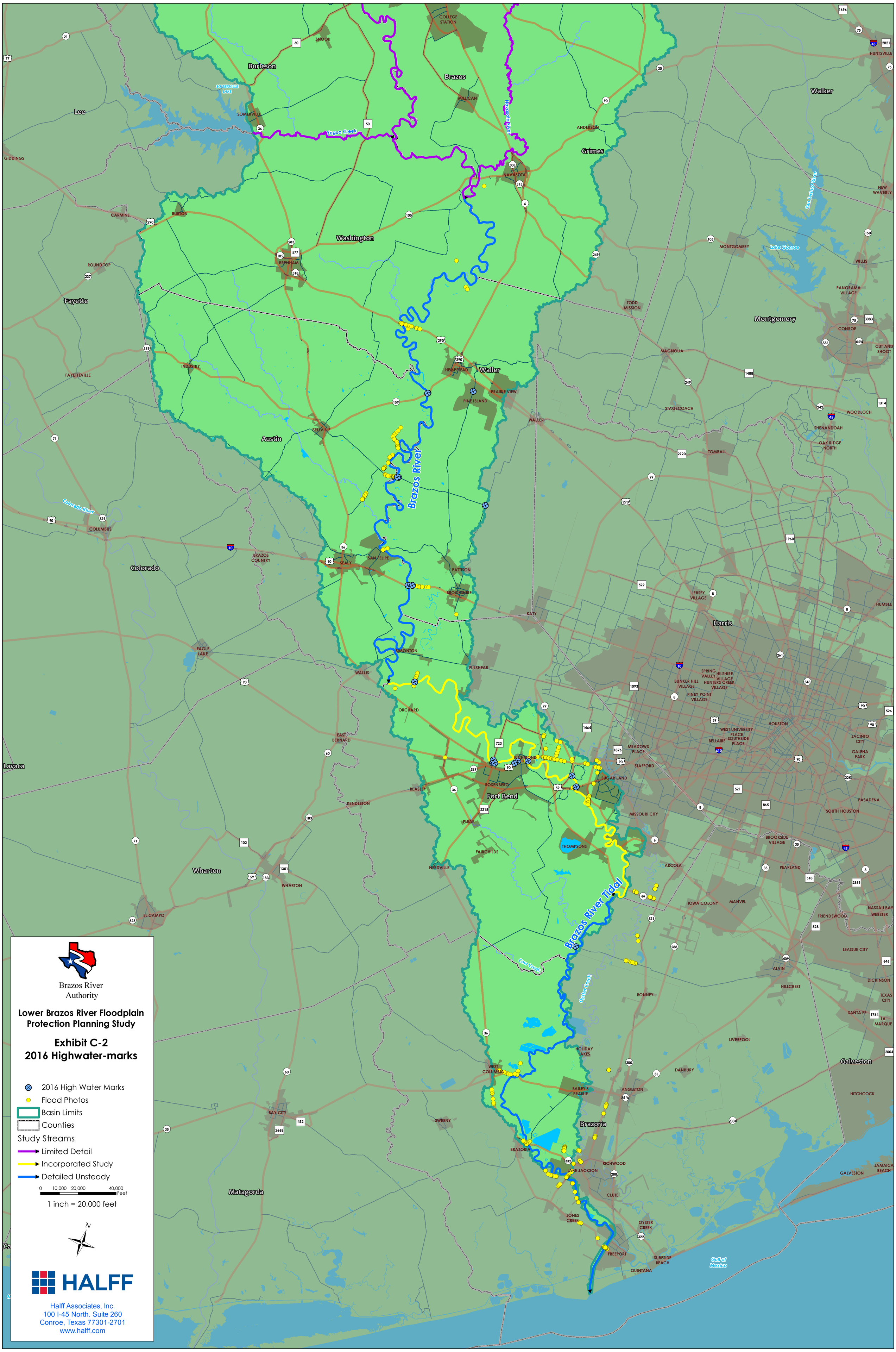
Brazos River Authority
Lower Brazos River Floodplain Protection Planning Study
Exhibit C-2
2016 Highwater-marks
2016 High Water Marks
Flood Photos
Basin Limits
Counties
Study Streams
Limited Detail
Incorporated Study
Detailed Unsteady
0 10,000 20,000 40,000 Feet
1 inch = 20,000 feet
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Brazos River
Brazos River Tidal
Yegua Creek
Navasota River
San Jacinto River
Colorado River
Cow Creek
Oyster Creek
Lake Conroe
Gulf of Mexico
Lee
Burleson
Brazos
Grimes
Walker
Washington
Fayette
Montgomery
Waller
Austin
Colorado
Harris
Lavaca
Fort Bend
Wharton
Brazoria
Galveston
Matagorda
SOMERVILLE LAKE
SOMERVILLE
SNOOK
COLLEGE STATION
MILLICAN
ANDERSON
NAVASOTA
GIDDINGS
CARMINE
BURTON
ROUND TOP
BRENHAM
INDUSTRY
FAYETTEVILLE
HEMPSTEAD
PRAIRIE VIEW
PINE ISLAND
WALLER
BELLVILLE
COLUMBUS
BRAZOS COUNTRY
SEALY
SAN FELIPE
PATTISON
BROOKSHIRE
KATY
EAGLE LAKE
SIMONTON
FULSHEAR
WALLIS
ORCHARD
EAST BERNARD
RICHMOND
ROSENBERG
SUGAR LAND
BEASLEY
KENDLETON
PLEAK
FAIRCHILDS
THOMPSONS
NEEDVILLE
WHARTON
EL CAMPO
BAY CITY
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BRAZORIA
LAKE JACKSON
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BONNEY
ARCOLA
IOWA COLONY
MANVEL
MISSOURI CITY
STAFFORD
MEADOWS PLACE
BELLAIRE
WEST UNIVERSITY PLACE
SOUTHSIDE PLACE
HOUSTON
BUNKER HILL VILLAGE
SPRING VALLEY VILLAGE
HILSHIRE VILLAGE
HUNTERS CREEK VILLAGE
PINEY POINT VILLAGE
JERSEY VILLAGE
HUMBLE
ALVIN
HILLCREST
PEARLAND
BROOKSIDE VILLAGE
SOUTH HOUSTON
PASADENA
JACINTO CITY
GALENA PARK
FRIENDSWOOD
NASSAU BAY
WEBSTER
LEAGUE CITY
DICKINSON
TEXAS CITY
SANTA FE
LA MARQUE
HITCHCOCK
GALVESTON
JAMAICA BEACH
TOMBALL
MAGNOLIA
STAGECOACH
SHENANDOAH
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