Texas Water Development Board

VOLUME 2

2023 REGIONAL FLOOD PLAN
REGION 6
SAN JACINTO

July 2023

PREPARED FOR THE **SAN JACINTO REGIONAL FLOOD PLANNING GROUP**

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Halls Bayou CDBG-MIT Application 1 Projects

HARRIS COUNTY FLOOD CONTROL DISTRICT
HCFCD.ORG
9900 Northwest Freeway
Houston, Texas 77092
346-286-4000

	YES	NO	ABSTAIN
Judge Lina Hidalgo	☑	☐	☐
Comm. Rodney Ellis	☑	☐	☐
Comm. Adrian Garcia	☑	☐	☐
Comm. Steve Radack	☑	☐	☐
Comm. R. Jack Cagle	☑	☐	☐

October 5, 2020

Commissioners Court
Administration Building
Houston, Texas 77002

Reference: Recommendation that the Harris County Flood Control District be authorized to apply for a grant application to address chronic flooding in the Halls Bayou watershed through the Texas General Land Office Community Development Block Grant – Mitigation (CDBG-MIT) Grant Program.
Bond ID's C-23, C-28, C-30, and C-41
HCFCD Unit's P118-08-00, P118-25-00, P118-25-01, P118-27-00, and P118-00-00
Harris County Precincts 1 and 2

Dear Court Members:

It is recommended that the Harris County Flood Control District (District) be authorized to apply for a grant application to address chronic flooding in the Halls Bayou watershed through the Texas General Land Office Community Development Block Grant – Mitigation (CDBG-MIT) Grant Program.

The application includes four Bond Projects in the Halls Bayou watershed including channel conveyance improvements to HCFCD Units P118-08-00 (Bond ID C-23), P118-25-00, P118-25-01, (Bond ID C-28), P118-27-00 (Bond ID C-30) and main stem improvements to P118-00-00 (Bond ID C-41). The total estimated construction cost is $110,671,999 and requests a federal share of $100,000,000. This will require a local match of $10,671,999. The Districts share of the funding for the local match will primarily come from the 2018 Bond Program, with additional funds as needed through the Districts Capital Improvement Program. This application is one of two that are being submitted for projects in the Halls Bayou watershed.

The District will present any grant awards, if made, to Commissioner Court for consideration at a future date.

Sincerely,

Russell A. Poppe, P.E.
Executive Director

RAP: ARB:ym

Attachments: Order
Project Summary
Grant Application

cc: County Auditor

101320 AGENDA GRANT Halls Bayou 1

Presented to Commissioners Court

October 13, 2020

Approve: E/G

HARRIS COUNTY, TEXAS

Office of Budget Management 1001 Preston; Suite 500 Houston, TX 77002 713-274-1135

Grants Coordination Section - Conveyance Form Application [X] Award [ ]

Department Name / Number	DUNs	Grant Title
HARRIS COUNTY FLOOD CONTROL - 090	174079756	Halls Bayou Watershed '22 (CDBG-MIT) #1

Funding Source: U.S. Department of Housing & Urban Development: CFDA# 14.228		**Grant Agency:** Texas General Land Office (GLO)	
Program Year:	1 st	**Program Ending:**	
Grant Begin Date:	03/01/2021	**Grant End Date:**	09/01/2026
Grant Org. Key:		**If applicable, Prior Year Org. Key:**	N/A

Grant Description:

In February of 2018, Congress appropriated $12 billion dollars in Community Development Block Grant (CDBG) funds specifically for mitigation activities for qualifying disasters in 2015, 2016, and 2017. HUD was able to allocate an additional $3.9 billion, bringing the amount available for mitigation to nearly $16 billion. The CDBG Mitigation (CDBG-MIT) Program is a unique and significant opportunity for eligible grantees to use this assistance in areas impacted by recent disasters to carry out strategic and high-impact activities to mitigate disaster risks and reduce future losses.

	Total Budget	Grant Funded	County Funded
Salary & Benefits	$0.00	$0.00	$0.00
Non-Labor	$110,671,999.00	$100,000,000.00	$10,671,999.00
Sub Tot. Incremental Cost	**$110,671,999.00**	**$100,000,000.00**	**$10,671,999.00**
Indirect Cost	$0.00	$0.00	$0.00*
TOTALS	**$110,671,999.00**	**$100,000,000.00**	**$10,671,999.00**

* under development

Full Time Equivalent Positions 0.00

% of Positions Paid by Grant 0.00 %

Date Guidelines are Available

Grant Submittal Deadline Date

Grant Discussion:

If awarded, this will be the first year for this project under this grant program. Grant funds would be used for various drainage improvement projects along Halls Bayou susceptible to repeated flooding in Commissioners 1 & 2. The Halls Bayou watershed historically has been an underserved area of north Harris County. The local match requirement amounts to $10,671,999 that will primarily come from the 2018 Bond Program with additional funds as needed through the District's Capital Improvement Program.

County Funded Cost Projection

Year	Required	Discretionary
2021	1,940,363.45	-
2022	1,940,363.45	-
2023	1,940,363.45	-
2024	1,940,363.45	-
2025	2,910,545.20	-

Completed by : Michael Mattingly Mattingly, Mike **Date :** 10/6/2020

Reviewed by: **Date :** 10/6/2020

ORDER

STATE OF TEXAS

COUNTY OF HARRIS

On this, the 13th day of October, 2020, the Commissioners' Court of Harris County, Texas, sitting as the governing body of Harris County, upon motion of Commissioner Ellis, seconded by Commissioner A. Garcia, duly put and carried,

IT IS ORDERED that County Judge Lina Hidalgo or her designee be hereby authorized to approve, and on behalf of Harris County, Texas, to apply for, a grant through the Texas General Land Office:

Halls Bayou Watershed

Grant Application Amount:	$100,000,000
Required Match:	$10,671,999
Period of Grant:	3/1/21 – 9/1/26

	YES	NO	ABSTAIN
Judge Lina Hidalgo	☑	☐	☐
Comm. Rodney Ellis	☑	☐	☐
Comm. Adrian Garcia	☑	☐	☐
Comm. Steve Radack	☑	☐	☐
Comm. R. Jack Cagle	☑	☐	☐

Presented to Commissioners Court

October 13, 2020

Approve: E/G

OMB Number: 4040-0004
Expiration Date: 12/31/2022

Application for Federal Assistance SF-424

*** 1. Type of Submission:**
- [ ] Preapplication
- [X] Application
- [ ] Changed/Corrected Application

*** 2. Type of Application:**
- [X] New
- [ ] Continuation
- [ ] Revision

* If Revision, select appropriate letter(s):

* Other (Specify):

* 3. Date Received: Completed by Grants.gov upon submission.

4. Applicant Identifier:

5a. Federal Entity Identifier:

5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:

7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name: Harris County Flood Control District

* b. Employer/Taxpayer Identification Number (EIN/TIN): 74-6019452

* c. Organizational DUNS:

d. Address:

* Street1: 9900 Northwest Freeway
Street2:
* City: Houston
County/Parish:
* State: Texas
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 77092

e. Organizational Unit:

Department Name:

Division Name:

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:
* First Name: Tak
Middle Name:
* Last Name: Makino
Suffix:

Title:

Organizational Affiliation:

* Telephone Number: 713-821-0359
Fax Number:

* Email: TMMakino@lan-inc.com

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

Grant

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

*** 10. Name of Federal Agency:**

Housing and Urban Development

11. Catalog of Federal Domestic Assistance Number:

CFDA Title:

*** 12. Funding Opportunity Number:**

Federal Register/Vol. 84, No.169

* Title:

CDBG-MIT

13. Competition Identification Number:

Title:

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant

* b. Program/Project TX-018, TX-029

Attach an additional list of Program/Project Congressional Districts if needed.

Please see attached list | Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date:

* b. End Date:

18. Estimated Funding ($):

* a. Federal	$100,000,000.00
* b. Applicant	$10,671,999.00
* c. State	
* d. Local	
* e. Other	
* f. Program Income	
* g. TOTAL	$110,671,999.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

☐ a. This application was made available to the State under the Executive Order 12372 Process for review on .

☐ b. Program is subject to E.O. 12372 but has not been selected by the State for review.

☒ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

☐ Yes ☒ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☒ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix:

* First Name: Lina

Middle Name:

* Last Name: Hidalgo

Suffix:

* Title: County Judge

* Telephone Number: 713-755-6444

Fax Number:

* Email: judge.hidalgo@cjo.hctx.net

* Signature of Authorized Representative: Completed by Grants.gov upon submission.

* Date Signed: Completed by Grants.gov upon submission.

SF 424 Attachment for Congressional Districts

APPLICANT

US Congressional District(s)

2
7
9
18
29

Texas State Representative District(s)

126	134	143
127	135	144
128	137	145
129	138	146
130	139	147
131	140	148
132	141	149
133	142	150

Texas Senate District(s)

4	13
6	15
7	17
11	18

PROJECT

US Congressional District(s)

18, 29

Texas State Representative District(s)

140, 141

Texas Senate District(s)

6, 13

HARRIS COUNTY FLOOD CONTROL DISTRICT
HCFCD.ORG
9900 Northwest Freeway
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346-286-4000

	YES	NO	ABSTAIN
Judge Lina Hidalgo	☑	☐	☐
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Completed by : Michael Mattingly Mattingly, Mike **Date :** 10/6/2020

Reviewed by: **Date :** 10/6/2020

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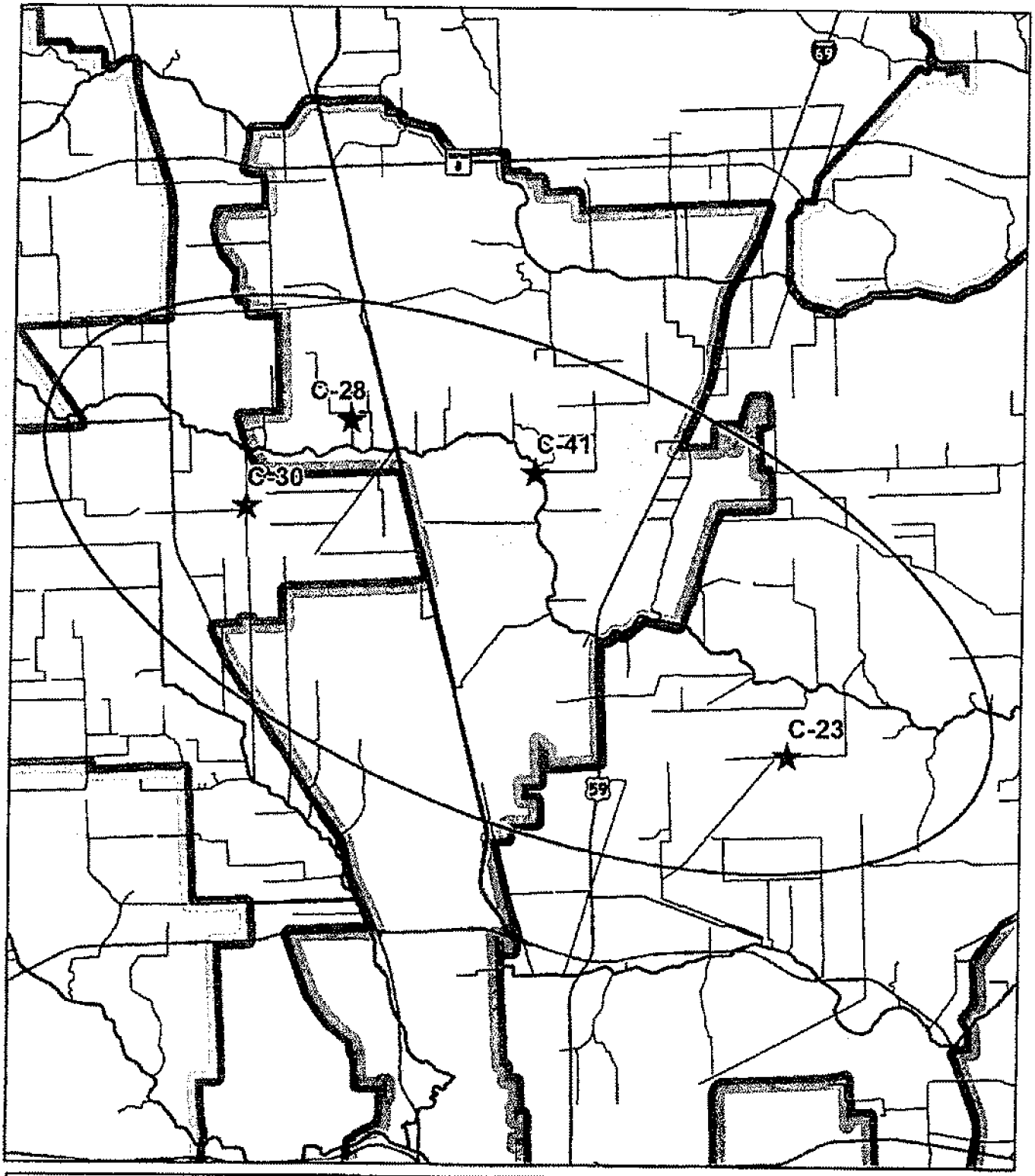
Comm. Rodney Ellis	☑	☐	☐
Comm. Adrian Garcia	☑	☐	☐
Comm. Steve Radack	☑	☐	☐
Comm. R. Jack Cagle	☑	☐	☐

Presented to Commissioners Court

October 13, 2020

Approve: E/G



CDBG-MIT Project Application
Halls Bayou Watershed

CDBG-MIT Grant Application

Halls Bayou Watershed Application 1

I. **SCOPE:**

The activities in this CDBG-MIT application are designed to provide watershed-wide flood threat reduction measures in Halls Bayou. The Halls Bayou watershed is a historically underserved area of north Harris County, TX. The residents of the watershed have been victim to repeated flooding events, including Tropical Storm Allison, the 2015 and 2016 floods, and Hurricane Harvey. Activities in this application include improvements in both conveyance and detention on both the mainstem of and tributaries of Halls Bayou. This strategy is designed to provide distributed risk reduction throughout the Halls Bayou watershed. This is anticipated to reduce water surface elevations during flood events. A reduction in water surface elevations will remove structures from the floodplain and reduce water surface elevations in structures that are not completely removed from the floodplain.

The application is a combination of five construction activities. While the activities are expected to show greatest benefits at a neighborhood level, engineering analysis has been performed at the watershed level. This combined application is provided for review as part of a holistic, watershed-wide flood risk reduction program.

The five activities included in this application are generally referred to by their Harris County Bond ID. Activities that share a bond ID have been provided with an additional name for clarification

Activity Name	HCFCD Unit ID	Description of Improvement
C-30	P118-27-00	Tributary conveyance improvements Tributary detention improvement – approx. 80 ac-ft storage
C-41 - Hardy West	P118-00-00	Mainstem detention improvements – approx. 700 ac-ft storage
C-23	P118-08-00	Tributary conveyance improvements Tributary detention improvements – approx. 50 ac-ft storage
C-28	P118-25-00 P118-25-01	Tributary channel conveyance improvements Tributary detention improvements – approx. 30 ac-ft Sub-tributary channel conveyance improvements
C-41 - Mainstem Combination	P118-00-00	Mainstem channel conveyance improvements

C-30

The C-30 activity will be located between Sweetwater Lane and Airline Drive. The activity is currently in the alternatives analysis stage and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in analysis. This activity has an approximate cost of $26 million. The objectives of this activity are twofold: to improve stormwater channel conveyance of P118-27-00 and to create stormwater detention to store stormwater during storm events and release it back into the tributary when the threat of flooding has passed.

C-41 - Hardy West

The C-41 – Hardy West activity will be located west of Hardy Toll Road up to Woodmoss Drive along the mainstem of Halls Bayou. The activity is currently in the alternatives analysis stage and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in analysis. This activity has an approximate cost of $47.3 million. The objective of this activity is to provide approximately 700 acre-feet of stormwater detention capacity to store excess stormwater during storm events and release the water back into the bayou once the threat of flooding has passed.

C-23

The C-23 activity will be located south of Tidwell road and west of Wayside drive. The activity is currently in the alternatives analysis stage and the exact activity limits are still being studied. The opinions of probable have been adjusted to reflect the degree of uncertainty associated with a activity still in analysis. The activity has an approximate cost of $18.7 million. The objectives of the activity are twofold: to improve stormwater channel conveyance of P118-08-00 and to create approximately 50 acre-feet of stormwater detention to store excess stormwater during storm events and release the water back into the bayou once the threat of flooding has passed.

C-28

Activity C-28 will be located north of the Halls Bayou mainstem, west of the Hardy Toll Road. The activity begin with a channel extension from Hollyvale Drive to Corvette Court and continuing to Hill Road. The activity provides conveyance and detention improvements on a local tributary/sub-tributary confluence of Halls Bayou. Channel P118-25-01 joins P118-25-00 about 1,200 feet south of Aldine Mail Route Road. The activity is currently in the preliminary engineering stage and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in analysis. The activity has a total cost of approximately $15 million. The objectives of the activity are twofold: to improve stormwater channel conveyance of P118-25-00 and P118-25-01 and to create approximately 30 acre-feet of stormwater detention on P118-25-00 to store excess stormwater during storm events and release the water back into the bayou once the threat of flooding has passed.

C-41 – Mainstem Combination

The C-41 – Mainstem Combination activity has two distinct locations. One will be located South of Hopper Road along Halls Bayou mainstem before intersecting with P118-35-00. The other location is further upstream, east of Aline Westfield road extending into Keith-Weiss Park. The activity is currently in the alternatives analysis phase and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in analysis. The activity has a total cost of approximately $3.7 million. The objective of the activity is to provide improved stormwater channel conveyance along the Halls Bayou mainstem during storm events.

II. COST ESTIMATE

The total estimated construction cost of this proposed project is $110,671,999.

$100,000,000 of this cost will be funded by a CDBG-MIT grant. CDBG-MIT funds will be used for the purposes of preliminary engineering, right-of-way acquisition, design, and construction of detention and conveyance improvements.

The remaining $10,671,999 will be funded by HCFCD.

Each Applicant for Community Development Block Grant Mitigation ("CDBG-MIT") funding must complete Federal Assistance Standard Form 424 (SF-424) and certify that local certifications included in this application guide were followed in the preparation of any CDBG-MIT program application. Additionally, Applicant must certify that it will continue to follow local certifications in the event that funding is awarded and Applicant is reclassified as a Subrecipient.

Each Applicant/Subrecipient must comply with the provisions of the National Environmental Policy Act ("NEPA"), the Council on Environmental Quality ("CEQ") regulations, the requirements set forth in Title 24 of the Code of Federal Regulations ("CFR") part 58, and applicable Texas General Land Office policy directives.

Each Applicant/Subrecipient must comply with all applicable federal and state laws, including environmental, labor (Davis-Bacon Act), the procurement procedures and contract requirements found at 2 C.F.R. §200.318 – §200.326, and all civil rights requirements.

Each Applicant/Subrecipient certifies, as outlined in 84 FR 45838 (August 30,2019), the following:

A. The Applicant/Subrecipient certifies that it has in effect and if following a residential anti-displacement and relocation assistance plan in connection with any activity assisted with CDBG-MIT funds.

B. The Applicant/Subrecipient certifies its compliance with restrictions on lobbying as required by 24 C.F.R. part 87, together with disclosure forms, if required by part 87.

C. Any entity or entities designated by the subrecipient, and any contractor, subrecipient, or designated public agency carrying out an activity with CDBG-MIT funds, possess(es) the legal authority to carry out the program for which it is seeking funding, in accordance with applicable HUD regulations and the federal register notice. The subrecipient certifies that activities to be undertaken with CDBG-MIT funds are consistent with the Action Plan.

D. The Applicant/Subrecipient certifies that it will comply with the acquisition and relocation requirements of the Uniform Relocation Act ("URA"), as amended, and implementing regulations at 49 CFR part 24, except where waivers or alternative requirements are provided for CDBG-MIT funds.

E. The Applicant/Subrecipient certifies that it will comply with Section 3 of the Housing and Urban Development Act of 1968 (12 U.S.C. §1701u) and implementing regulations at 24 C.F.R. part 135.

F. The Applicant/Subrecipient certifies that it is following a detailed citizen participation plan that satisfies the requirements of 24 CFR §91.115 or §91.105 (except as provided for in notices providing waivers and alternative requirements for this grant). Also, each local government receiving assistance from a state grantee must follow a detailed citizen participation plan that satisfies the requirements of 24 CFR §570.486 (except as provided for in notices providing waivers and alternative requirements for this grant).

G. The Applicant/Subrecipient certifies that it is complying with each of the following criteria:

1) Funds will be used solely for necessary expenses related to mitigation activities, as applicable, in the most impacted and distressed areas for which the President declared a major disaster in 2015, 2016, or 2017 pursuant to the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974 (42 U.S.C. §5121 et seq.).

2) With respect to activities expected to be assisted with CDBG-MIT funds, the relevant action plan has been developed to give priority to activities that will benefit low- and moderate-income families.

3) The aggregate use of CDBG-MIT funds shall principally benefit low- and moderate-income families in a manner that ensures that at least 50 percent (or another percentage permitted by HUD in a waiver published in an applicable Federal Register notice) of the CDBG-MIT grant amount is expended for activities that benefit such persons.

4) The Applicant/Subrecipient will not attempt to recover any capital costs of public improvements assisted with CDBG-MIT funds by assessing any amount against properties owned and occupied by persons of low- and moderate-income, including any fee charged or assessment made as a condition of obtaining access to such public improvements, unless:

i. CDBG-MIT funds are used to pay the proportion of such fee or assessment that relates to the capital costs of such public improvements that are financed from revenue sources other than under this title; or

ii. For purposes of assessing any amount against properties owned and occupied by persons of moderate income, the grantee certifies to the Secretary that it lacks sufficient CDBG funds (in any form) to comply with the requirements of clause (a).

H. The Applicant/Subrecipient certifies that the grant will be conducted and administered in conformity with title VI of the Civil Rights Act of 1964 (42 U.S.C. §2000d), the Fair Housing Act (42 U.S.C. §3601-§3619), and implementing regulations, and that it will affirmatively further fair housing.

I. The Applicant/Subrecipient certifies that it has adopted and is enforcing the following policies, and, in addition, must certify that they will require local governments that receive grant funds to certify that they have adopted and are enforcing:

1) A policy prohibiting the use of excessive force by law enforcement agencies within its jurisdiction against any individuals engaged in nonviolent civil rights demonstrations;

2) A policy of enforcing applicable state and local laws against physically barring entrance to or exit from a facility or location that is the subject of such nonviolent civil rights demonstrations within its jurisdiction.

J. The Applicant/Subrecipient certifies that it (and any administering entity) currently has or will develop and maintain the capacity to carry out mitigation activities, as applicable, in a timely manner and that the subrecipient has reviewed the respective requirements of this notice.

K. The Applicant/Subrecipient certifies that it will not use CDBG-MIT funds for any activity in an area identified as flood prone for land use or hazard mitigation planning purposes by the state, local, or tribal government or delineated as a Special Flood Hazard Area (or 100-year floodplain) in FEMA's most current flood advisory maps, unless it also ensures that the action is designed or modified to minimize harm to or within the floodplain, in accordance with Executive Order 11988 and 24 C.F.R. part 55. The relevant data source for this provision is the state, local, and tribal government land use regulations and hazard mitigation plans and the latest-issued FEMA data or guidance, which includes advisory data (such as Advisory Base Flood Elevations) or preliminary and final Flood Insurance Rate Maps.

L. The Applicant/Subrecipient certifies that its activities concerning lead-based paint will comply with the requirements of 24 CFR part 35, subparts A, B, I, K, and R.

M. The Applicant/Subrecipient certifies that it will comply with environmental requirements at 24 CFR part 58.

N. The Applicant/Subrecipient certifies that it will comply with applicable laws.

WARNING: ANY PERSON WHO KNOWLINGLY MAKES A FALSE CLAIM OR STATEMENT TO HUD MAY BE SUBJECT TO CIVIL OR CRIMINAL PENALTIES UNDER 18 U.S.C. §287; 18 U.S.C. §1001, AND 31 U.S.C. § 3729.

Except as otherwise provided under federal law, any person who knowingly and willfully falsifies, conceals, or covers up a material fact by any trick, scheme or device or who makes any materially false, fictitious, or fraudulent statement or representation or who makes or uses any false writing or document knowing the writing or document to contain materially false, fictitious, or fraudulent statement or entry shall be prosecuted under Title 18, United States Code, §1001.

COUNTY JUDGE LINA HIDALGO — October 13, 2020

Printed Name of Authorized Signatory — *Date*

[redacted] [redacted]

Signature of Authorized Signatory

View Burden Statement

OMB Number: 4040-0004
Expiration Date: 12/31/2022

Application for Federal Assistance SF-424

* 1. Type of Submission:
- ○ Preapplication
- ◉ Application
- ○ Changed/Corrected Application

* 2. Type of Application:
- ◉ New
- ○ Continuation
- ○ Revision

* If Revision, select appropriate letter(s):

* Other (Specify):

* 3. Date Received: 10/13/2020

4. Applicant Identifier:

5a. Federal Entity Identifier:

5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:

7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name: HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD)

* b. Employer/Taxpayer Identification Number (EIN/TIN): 74-6019452

* c. Organizational DUNS: 1740797560000

d. Address:

* Street1: 9900 NORTHWEST FREEWAY
Street2:
* City: HOUSTON
County/Parish: HARRIS COUNTY
* State: TX: Texas
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 77092-8601

e. Organizational Unit:

Department Name: HARRIS CTY FLOOD CONTROL DIST

Division Name:

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:
* First Name: ALAN
Middle Name:
* Last Name: BLACK
Suffix:

Title: DIRECTOR OF OPERATIONS

Organizational Affiliation: HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD)

* Telephone Number: 346-286-4260
Fax Number:

* Email: Alan.Black@hcfcd.hctx.net

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

D: Special District Government

Type of Applicant 2: Select Applicant Type:

B: County Government

Type of Applicant 3: Select Applicant Type:

*** Other (specify):**

*** 10. Name of Federal Agency:**

HOUSING AND URBAN DEVELOPMENT

11. Catalog of Federal Domestic Assistance Number:

14.228

CFDA Title:

*** 12. Funding Opportunity Number:**

FEDERAL REGISTER / VOL. 84, NO. 169

*** Title:**

CDBG-MIT

13. Competition Identification Number:

N/A

Title:

N/A

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Various flood protection improvements to benefit the Halls Bayou Watershed

Attach supporting documents as specified in agency instructions.

View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: ATTACH
* b. Program/Project: ATTACH

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 03/01/2021
* b. End Date: 09/01/2026

18. Estimated Funding ($):

* a. Federal	100,000,000.00
* b. Applicant	10,671,999.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	110,671,999.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

- ○ a. This application was made available to the State under the Executive Order 12372 Process for review on .
- ○ b. Program is subject to E.O. 12372 but has not been selected by the State for review.
- ◉ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

○ Yes ◉ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☑ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix:	
* First Name:	LINA
Middle Name:	
* Last Name:	HIDALGO
Suffix:	
* Title:	HARRIS COUNTY JUDGE
* Telephone Number:	(713)274-7000
Fax Number:	
* Email:	JUDGE.HIDALGO@CJO.HCTX.NET
* Signature of Authorized Representative:	[redacted]
* Date Signed:	10/13/2020

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CDI, SOVI, PCMV, PROJECT IMPACT, AND POVERTY RATE SCORING CRITERIA EVALUATION

HALLS BAYOU WATERSHED CDBG-MIT APPLICATION 1

Prepared for:

Harris County Flood Control District

October 2020

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

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EXECUTIVE SUMMARY

This memorandum describes the methodologies used to evaluate scoring criteria under the Hurricane Harvey State Mitigation Competition that are related to project service area characteristics for the Halls Bayou Watershed CDBG-MIT Application 1 submitted by the Harris County Flood Control District (HCFCD). Project service area-related scoring criteria evaluated in this document include the Composite Disaster Index (CDI), Social Vulnerability Index (SoVI), Per-Capita Market Value (PCMV), Project Impact, and Poverty Rate. The Low- and Moderate-Income (LMI) National Objective is another scoring criterion that is characterized by the project service area; however, this criterion was evaluated in a separate attachment (see **LMI Evaluation Attachment**).

Mitigation Competition guidelines describe some common terms related to the project service area that are used to evaluate scoring criteria. For clarity, these terms are specifically defined for the Halls Bayou Watershed CDBG-MIT Application 1:

- **Project Service Area:** The Halls Bayou Watershed contained within Harris County.
- **Project Beneficiaries:** The residential population within the Halls Bayou Watershed. **The total number of project beneficiaries is estimated to be 167,029.**
- **Jurisdiction:** The jurisdiction of the HCFCD (the applicant) is Harris County (both the incorporated and unincorporated areas). **The total population of the jurisdiction is equivalent to the total population of Harris County, which is estimated to be 4,602,523**, based on 2018 American Community Survey (ACS) 5-year estimate Table B01003[1].

In order to determine the total project beneficiaries of this Covered Project, populations and household sizes were estimated on a structure by structure basis throughout the defined project service area, then were aggregated to determine the total residential populations. More detailed information on the methodology used for this population analysis can be found in the **Population Estimate Attachment**.

Project service area-related scoring criteria were evaluated and determined for the Halls Bayou Watershed CDBG-MIT Application 1, as shown below. The methodologies used to evaluate these criteria are consistent with the Hurricane Harvey Mitigation Competition Guidelines, described in **Section 2.0**.

[1] U.S. Census Bureau. American Community Survey, 2014-2018. Detailed Tables, Subject Tables, and Data Profile Tables; generated by Freese & Nichols, Inc.; using the U.S. Census Bureau Application Programming Interface.

Composite Disaster Index (CDI)

The proposed project service area has beneficiaries wholly within Harris County (both the unincorporated and incorporated areas). **Harris County falls in the Top 10% of CDI (Rank 5, 10 Points).** Therefore, the applicable CDI rank for this project was calculated as seen below:

1) Top 10% = Rank 5
2) **Rank 5 = 10 Points**

Social Vulnerability Index (SoVI)

The proposed project service area has beneficiaries wholly within Harris County (both the unincorporated and incorporated areas). **Harris County has a "Medium" SoVI Score (Rank 3, 5 Points).** Therefore, the applicable SoVI rank for this Covered Project were calculated as seen below:

1) Medium = Rank 3
2) **Rank 3 = 5 Points**

Per Capita Market Value (PCMV)

The project service area and project beneficiaries are solely within Harris County (both incorporated and unincorporated areas). Estimated 2018 county population data were obtained from the American Community Surveys (ACS) 5-year estimates Table B01003, which is collected and provided by US Census Bureau[1]. **Based on 2018 data, Harris County has a Market Value of $529,092,108,213 and a total population of 4,602,523**. Thus, the applicable PCMV rank and score were calculated as seen below:

1) ($529,092,108,213 [Total Market Value] / 4,602,523 [Total Population]) = $114,956.97 [Per Capita Market Value]
2) $114,956.97 = Rank 2
3) **Rank 2 = 2 Points**

Project Impact – Cost per Person Ratio

The total project application amount for the Halls Bayou Watershed CDBG-MIT Application 1 is $100,000,000 and the total project beneficiaries was determined to be 167,029. Thus, the cost per person ratio component of the Project Impact scoring criteria is calculated as shown below:

1) **$**100,000,000 [Project Application Amount] / 167,029 [Total Project Beneficiaries] = $598.70 per project beneficiary (Rank 4, 9 Points)
2) **Rank 4 = 9 Points**

Project Impact - Percentage of Persons Benefitting within a Jurisdiction(s)

The project beneficiaries are located wholly within only the jurisdiction of Harris County (both the unincorporated and incorporated areas); thus, the total population of Harris County was used to calculate this criterion. **For this project, the total project beneficiaries were determined to be 167,029 and total population in the jurisdiction of Harris County is 4,602,523.** Therefore, the percentage of persons benefitting within the jurisdiction(s) score were calculated as seen below:

1) (167,029 [Total Project Beneficiaries] / 4,602,523 [Total Population]) = 0.036
2) **0.036 X 10 Points = 0.36 Points**

Poverty Rate (Tiebreaker)

The proposed project service area has beneficiaries wholly within Harris County (both the unincorporated and incorporated areas). **Harris County has a "percent below poverty level" of 16.2%, based on the most recent ACS 5-year estimates table S1701[1], which is the applicable poverty rate for this project.**

1) **0.1622 = 16.22% Below Poverty Level**

The table below summarizes the Hurricane Harvey State Mitigation Competition scoring criteria outcomes of the CDI, SoVI, PCMV, Project Impact, and Poverty Rate scoring criteria for the Halls Bayou Watershed CDBG-MIT Application 1.

Table 1
Project Service Area-Related Scoring Criteria Outcomes

Scoring Criteria	Rank	Score
County Composite Disaster Index	*5 out of 5*	10 out of 10
Social Vulnerability Index	*3 out of 5*	5 out of 10
Per Capita Market Value	*2 out of 5*	2 out of 10
Project Impact – Cost per Person Ratio	*4 out of 6*	9 out of 15
Project Impact – Percentage of Persons Benefitting within Jurisdiction(s)	*N/A*	0.36 out of 10
Poverty Rate	*N/A*	16.2%

.

1.0 OVERVIEW

On January 31, 2020, the Texas General Land Office (GLO) submitted to the U.S. Department of Housing and Urban Development (HUD) the State of Texas CDBG Mitigation (CDBG-MIT) Action Plan (hereafter "Action Plan"). The submitted plan included public comments and responses from the comment period 11/22/2019 – 1/10/2020. This plan incorporated updates made in consideration of these comments. HUD approved the Action Plan on March 31, 2020[2], which included the final guidelines for the Hurricane Harvey State Mitigation Competition scoring criteria.

This memorandum specifically discusses the methodologies used to evaluate scoring criteria that are primarily related to the project service area, which includes: Composite Disaster Index (CDI), Social Vulnerability Index (SoVI), Per Capita Market Value (PCMV), Project Impact, and Poverty Rate (Tiebreaker). The discussion and evaluation of other scoring criteria pertaining to this project are discussed in other attachments in the CDBG-MIT application, including the Low- to Moderate-Income (LMI) National Objective, Project Type Identified in Local Adopted Plan, Management Capacity, Leverage, and Mitigation/Resiliency Measures.

2.0 SCORING METHODOLOGIES AND OUTCOMES

Section 4.4.2.10 of the Action Plan outlines the Hurricane Harvey State Mitigation Competition Scoring Criteria used to score project applications. The following sections discuss the methodologies used to develop the evaluate the criteria related to the project service area. The methodologies applied are consistent with the scoring criteria guidelines described in the State of Texas CDBG-MIT Action Plan: Supplemental Material for the Hurricane Harvey State Mitigation Competition[3].

GLO previously determined the scoring metrics for CDI, SoVI, and PCMV on a county and city basis for all CDBG-MIT eligible areas. In correspondence after the approval of the Action Plan, GLO reiterated that the county and city data measurement levels have been determined to be the appropriate scope of analysis for CDI, SoVI, and PCMV, as well as for Poverty Rate for this particular Competition series.

[2] Texas General Land Office. 2020. State of Texas CDBG Mitigation (CDBG-MIT) Action Plan: Building Stronger for a Resilient Future.
[3] Texas General Land Office. 2020. Hurricane Harvey State Mitigation Competition: Applicant Eligibility and Scoring Criteria. *State of Texas CDBG-MIT Action Plan: Supplemental Material.*

2.1 COUNTY COMPOSITE DISASTER INDEX (MAXIMUM POINTS: 10 POINTS)

The County Composite Disaster Index (CDI), developed by the GLO and Center for Space Research (CSR) at UT Austin, represents a geospatial comparison of historical and potential natural hazard damages across Texas' 254 counties. CDI was developed using seven different historical datasets (2001 to 2018) of natural hazard damages across counties: (1) repetitive flood losses (National Flood Insurance Program); (2) high winds from hurricanes; (3) wildfires; (4) major river flood crests; (5) tornado; (6) persistent drought conditions; and (7) hail. The methodology used to determine CDI assigned a particularly high weighting factor to repetitive loss from flooding, as riverine flooding was one of the top two hazards identified in the state's Mitigation Needs Assessment. CDI is only compared at the county-level. CDI scores for each CDBG-MIT eligible county were calculated by GLO and was provided in MIT Application Supplemental Data[4]. *Table 2* outlines the rankings and associated points for the CDI scoring criteria in the Hurricane Harvey State Mitigation Competition.

Table 2
Composite Disaster Index Scoring Criteria

Rank Levels	Ranking	Points
Rank 5	High	10 Points
Rank 4	Medium High	8 Points
Rank 3	Medium	5 Points
Rank 2	Medium Low	2 Points
Rank 1	Low	0 Points
Multi-County Project	Prorated SoVI rank	Calculated Points

[4] "MIT Application Data Supplemental". Texas General Land Office. Mitigation Funding Competitions. Data available for download at: https://recovery.texas.gov/mitigation/competitions.html.

2.2 SOCIAL VULNERABILITY INDEX (MAXIMUM POINTS: 10 POINTS)

The Social Vulnerability Index (SoVI), developed by the University of South Carolina (USC), is a relative score that measures the social vulnerability of an area's population to environmental hazards in comparison to other assessed areas.[5] This index synthesizes 29 socioeconomic variables, including social and demographic characteristics, that contribute to a community's ability to prepare to, respond to, and recover from hazards. The USC SoVI methodology was prescribed by the Texas Division of Emergency Management (TDEM). In the Hurricane Harvey State Mitigation Competition, SoVI is compared at the county and city level to other CDBG-MIT eligible areas. SoVI score data for each CDBG-MIT eligible county and city was calculated by GLO and was provided in MIT Application Supplemental Data [4]. *Table 3* outlines the rankings and associated points for the SoVI scoring criteria in the Hurricane Harvey State Mitigation Competition.

Table 3
Social Vulnerability Index Scoring Criteria

Rank Levels	Ranking	Points
Rank 5	High	10 Points
Rank 4	Medium High	8 Points
Rank 3	Medium	5 Points
Rank 2	Medium Low	2 Points
Rank 1	Low	0 Points
Multi-County Project	Prorated SoVI rank	Calculated Points

[5] Cutter, S.L., B.J. Boruff, and W.L. Shirley. 2003. "Social Vulnerability to Environmental Hazards." Social Science Quarterly no. 84 (1):242-261.

2.3 PER CAPITA MARKET VALUE (MAXIMUM POINTS: 10 POINTS)

Per capita market value (PCMV) is the market value of all property in an area divided by the area's population. According to the Action Plan, the PCMV criteria represents "the ability of a unit of local government to generate revenue to fund its operations and capital expenditures." In this case, the relevant local entity is the HCFCD, so the PCMV for Harris County is applicable to this project. Total market value for each CDBG-MIT eligible county and city was calculated by GLO and was provided in MIT Application Supplemental Data[4]. To calculate market value, GLO used the most recently available (2018) County/City Tax Rates and Levies data set from the Texas Comptroller's Office, which included the total market value of properties for CDBG-MIT eligible counties and cities. *Table 4* outlines the rankings and associated points for the PCMV scoring criteria in the Hurricane Harvey State Mitigation Competition.

Table 4
Per Capita Market Value Scoring Criteria

Rank Levels	Ranking	Points
Rank 5	Less than $40,000.00	10 Points
Rank 4	$40,000.01 - $65,000.00	8 Points
Rank 3	$65,000.01 - $100,000.00	5 Points
Rank 2	$100,000.01 - $250,000.00	2 Points
Rank 1	$250,000.01 or greater	0 Points

2.4 PROJECT IMPACT (MAXIMUM POINTS: 25 POINTS)

The Project Impact scoring criteria is comprised of two components: (1) the total project application amount per total project beneficiaries (cost per person ratio); and (2) the percentage of total project beneficiaries out of the total population within a jurisdiction (percentage persons benefitted within a jurisdiction(s)). The values that comprise these two components have been defined previously but are also shown below in the calculations for reference. The calculations for the two Project Impact scoring criteria components are as follows.

2.4.1 Cost per Person Ratio (Maximum Points: 15 Points)

The cost per person ratio is calculated by dividing the CDBG-MIT project application amount by the number of project beneficiaries. *Table 5* outlines the rankings and associated points for the project cost per person ratio scoring criteria in the Hurricane Harvey State Mitigation Competition.

Table 5
CDBG-MIT Application Amount Per Total Project Beneficiaries Scoring Criteria

Rank Levels	Ranking	Points
Rank 6	< $100.01	15 Points
Rank 5	$100.01 - $500.00	12 Points
Rank 4	$500.01 - $1,500.00	9 Points
Rank 3	$1,500.01 - $5,000.00	6 Points
Rank 2	$5,000.01 - $10,000.00	3 Points
Rank 1	> $10,000.01	0 Points

2.4.2 Percentage of Persons Benefitting within a Jurisdiction(s) (Maximum Points: 10 Points)

The percentage of persons benefitted within a jurisdiction(s) is determined by dividing the total project beneficiaries by the total population of the jurisdiction(s).

2.5 POVERTY RATE (TIEBREAKER)

According to the Hurricane Harvey State Mitigation Competition scoring guidelines, in the case of a tie between CDBG-MIT application scores, the project that has the higher poverty rate will take precedence. The poverty rate within a jurisdiction is determined by reviewing the "Percent Below Poverty Level" column of ACS 5-year estimates Table S1701. In the case of a multi-jurisdictional area, the percent below poverty level is determined by reviewing the "Total" column and "Below Poverty Level" column of Table S1701. The 2018 American Community Surveys (ACS) 5-year estimates Table S1701 dataset[1] contains the most recent data for determining poverty rate at the jurisdictional (county and city) level. For reference, the average poverty rate across CDBG-eligible counties in 2017 was estimated to be 16.08%[6].

[6] Poverty rate documented in CDBG-MIT Action Plan is 16.08%, based on 2017 ACS data.

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POPULATION ESTIMATE

HALLS BAYOU WATERSHED CDBG-MIT APPLICATION 1

Prepared for:

Harris County

October 2020

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

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1.0 OVERVIEW

Populations and household sizes were estimated on a structure by structure basis . The estimated number of residents per structure was used in estimating the net present value social benefits as part of the benefit-cost analysis. Additionally, the structure-level resident counts were aggregated to determine the total residential population in the project service area.

A specific number of housing units were assigned to each structure, and residents per structure were estimated using data from the 2018 American Community Survey (ACS) 5-year data tables. Determination of household sizes were based on block group-level data, so the number of residents in each housing unit were assumed to be the same within each block group that intersected the service area. This document describes the assumptions and methodology used to estimate the number of persons living in each structure.

1.1 ASSUMPTIONS

The number of housing units ultimately assigned to each structure was based on the following assumptions:

- No permanent residents reside in hotels/motels, so these buildings were assigned zero units.
- Single-family structures have one unit.
- Multi-family structures have at least one unit. (These structures were typically assigned multiple units unless no data was available to support an estimate of number of units.)
- Non-residential structures have zero units.
- Each structure has an integer number of units.

The number of persons assigned to each housing unit was based on the following assumptions:

- Only one household lives in each unit.
- No units are empty. (No units are assigned zero residents because the specific units that are vacant will vary month to month. Instead, the population of a block group is distributed across all units equally, so the average household size may be slightly smaller than the true household size.)

- Each household includes at least one person.
- Household size is equal for all housing units within a block group.

Fractional values were used for number of persons per household, rather than integer values. This approach maintained more accurate aggregate estimates of persons in a block group or in the portion of a block group within the project service area.

1.2 CALCULATION PROCESS

Step 1 – Determine Number of Housing Units in each Structure

HCFCD maintains a detailed structure inventory of all structures in Harris County. This inventory includes data on the number of housing units in each structure, square footage, building style, and various other attributes. Where housing unit data was missing, data on structure type (e.g. "single-family residential"), building style descriptions (e.g. "residential 4-family") , and land use (e.g. "mobile home") were reviewed to determine the number of housing units in a structure. Additionally, zero housing units were allocated to any buildings with less than 500 square feet.

Step 2 – Calculate Average Household Size in each Block Group

The number of housing units determined in **Step 1** were summed to determine the total count of housing units in each block group. Then, an initial estimate of average household size in a block group was calculated based on 2018 ACS 5-year estimates for variable B01003_001E (total population estimate) at the block group level, as shown in *Equation 1*.

$$(Average\ Household\ Size)_{Step2} = \frac{(Total\ Block\ Group\ Population)_{2018ACS5year}}{Total\ Count\ of\ Housing\ Units\ in\ Block\ Group}$$ ***Equation 1***

Step 3 – Review and Adjust Average Household Size Estimates

Average Household Size was expected to meet the following conditions.

1. Household size must be at least 1 person/household.
2. Household size should not exceed the maximum average household size reported in 2018 ACS 5-year data for all block groups in the study area. ACS Data Profile 04 includes variables DP04_0048E (average household size of owner-occupied housing) and DP04_0049E (average household size of renter-occupied housing). These variables were not used directly to determine household sizes,

as they are available only at the tract level. The maximum of both rented and owned average household sizes across all census tracts in Harris County is 6.16 persons/household.

For each block group, if the Average Household Size calculated in **Step 2** did not meet the above-described conditions, an alternate Household Size value was applied:

1. If $(Average\ Household\ Size)_{Step2} < 1$, household size was set equal to 1 person/household.
2. If $(Average\ Household\ Size)_{Step2} > 6.16$, household size was set equal to the maximum threshold of 6.16 persons/household.

Step 4 – Calculate Number of Residents in Each Structure

The number of residents allocated to each structure in the Harris County structure inventory was calculated as shown in *Equation 2*.

$$(Number\ of\ Residents)_{structure} = (Number\ of\ Housing\ Units)_{structure\ (Step\ 1)}\ X\ (Average\ Household\ Size)_{block\ group\ (Step\ 3)}$$

Equation 2

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BENEFIT-COST ANALYSIS

HALLS BAYOU WATERSHED CDBG-MIT APPLICATION 1 COVERED PROJECT

Prepared for:

Harris County Flood Control District

October 2020

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

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APPENDICES

EXECUTIVE SUMMARY

The benefit-cost analysis performed for Halls Bayou Watershed CDBG-MIT Application 1 Covered Project included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

Net present value benefits were calculated using a 7% discount rate. *Table ES-1* summarizes benefits on an annual basis and at present value.

Table ES-1 – Summary of Project Benefits

Expected Benefits	Annual Benefit	Present Value Benefit
Structures + Contents	$1,810,964	$24,992,653
Displacement, Residential	$100,937	$1,393,009
Displacement, Non-residential	$6,562	$90,564
Social (Mental Health & Productivity)	$8,804,287	$121,505,725
Environmental (Ecosystem services of converted land)	$1,005,268	$13,873,449
Total Expected Benefits (all categories)	**$11,728,018**	**$161,855,399**

Social benefits represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

Social benefits of the Halls Bayou Watershed CDBG-MIT Application 1 Covered Project are shown in *Table ES-2*.

Table ES-2 – Summary of Social Benefits

Category	Number of Persons	Benefit per Person	Present Value Social Benefits
Number of Persons Directly Benefitted by Mitigation of Residential Structural Flooding	13,472	$ 2,443	$32,913,154
Number of Full-time Workers Directly Benefitted by Mitigation of Residential Structural Flooding	10,141	$ 8,736	$88,592,571
Total Social Benefit			**$121,505,725**

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. The Halls Bayou Watershed CDBG-MIT Application 1 Covered Project requires some acquisition and conversion of developed land to undeveloped floodplain or detention space. The benefit value for Green Open Space has been applied to these areas. Environmental benefits of the Halls Bayou Watershed CDBG-MIT Application 1 Covered Project are summarized in *Table ES-3*.

Table ES-3 – Summary of Environmental Benefits

Post-Mitigation Land Use	Acres Converted	Benefit per Acre per Year	Annual Benefits	Present Value Benefits
Green Open Space	121	$8,308	$1,005,268	$13,873,449
Riparian		$39,545	$ -	$ -
Wetlands		$6,010	$ -	$ -
Forests		$554	$ -	$ -
Marine / Estuary		$1,799	$ -	$ -
Total Environmental Benefit	**121**		**$1,005,268**	**$13,873,449**

In addition to environmental benefits, social benefits, and reduced structural damages and displacement costs, the Halls Bayou Watershed CDBG-MIT Application 1 Covered Project represents a holistic benefit to its service area, the Halls Bayou Watershed, by removing structures and land area from the floodplain. *Table ES-4* summarizes the impacts of the mitigation project.

Table ES-4 – Impacts of Mitigation Project

Number of structures benefitted in any event *(estimated losses to structural damage are reduced)*	4,318
Number of structures removed from 10% AEP (10-year) floodplain	221
Number of structures removed from 1% AEP (100-year) floodplain	404
Number of acres removed from 10% AEP (10-year) floodplain	313
Number of acres removed from 1% AEP (100-year) floodplain	335
Number of structures removed from risk* in 10% AEP (10-year) event	35
Number of structures removed from risk* in 1% AEP (100-year) event	275

**Structures "at risk" refer to those for which the modeled water surface elevation is at or above finished floor elevation.*

Project costs as estimated for the CDBG-MIT grant application include estimated costs of design and construction. The benefit-cost ratio was determined as the ratio of the present value of Total Expect Benefits to Total Project Cost; this ratio is presented in *Table ES-5*. It is important to note that the Halls Bayou Watershed CDBG-MIT Application 1 Covered Project will provide many community benefits for which an economic value could not be quantified as part of this analysis. Additional unquantified benefits are discussed further in the section on **Qualitative Benefits**.

Table ES-5 – Benefit-Cost Ratio

Present Value Total Benefits	$161,855,399
Present Value Total Cost	$110,671,999
Benefit-Cost Ratio	1.46

1.0 METHODOLOGY

1.1 BENEFIT-COST ANALYSIS REQUIREMENTS FOR CDBG-MIT PROJECTS

Although a benefit-cost ratio (BCR) is not a factor in the competition score as set forth by the Texas General Land Office (GLO), applicants are required to demonstrate that the benefits of any Covered Project outweigh its costs. As described in the Federal Register,[1] this requirement may be met in either of two ways:

1. Benefit-cost ratio developed during a benefit-cost analysis (BCA) is greater than 1.0.
    a. Calculations should be prepared in accordance with OMB Circular A-94[2].
    b. BCA methodology should follow FEMA standardized methodologies unless
        1) A BCA for the project has already been completed or is in progress under guidelines of other Federal agencies, or
        2) The BCA addresses a non-correctable flaw in the FEMA methodology, or
        3) A new approach is proposed that is unavailable using the FEMA Toolkit.
2. Alternately, projects may have a benefit-cost ratio of less than 1.0 under these conditions:
    a. A BCA is still completed following the methodologies described above.
    b. The project "serves low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster."
    c. A qualitative description is provided for "benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for low- and moderate- income persons or other persons that are less able to mitigate risks, or respond to and recover from disasters."

The analysis presented here meets these requirements as follows:

- In accordance with OMB Circular A-94, a 7% discount rate was used when determining equivalent present values of expected annual benefits and vice versa.

[1] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).
[2] *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

- The quantitative benefit-cost analysis (BCA) was based on benefit quantification methods and assumptions used in FEMA tools such as the FEMA BCA Toolkit version 6.0[3] (hereafter "FEMA Toolkit") and HAZUS (Hazards U.S. planning-level damage and loss estimating tool). These tools were not used directly, but the methods and assumptions in the FEMA Toolkit and HAZUS were applied using a combination of geospatial and tabular analysis tools to more efficiently:
    - Assess thousands of potentially impacted structures.
    - Utilize spatially variable modeled water surface elevation data.
    - Incorporate detailed information at an individual structure level.
- As indicated by the beneficiary population analysis detailed in the **LMI Evaluation Attachment**, over 51% of the project beneficiaries of are low- to moderate-income persons.
- The **Qualitative Benefits** section of this report discusses benefits of the Covered Project that could not be quantified.

1.2 QUANTITATIVE BENEFIT CATEGORIES

The benefit-cost analysis included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

1.3 INPUT DATA

A separate analysis was performed to estimate the number of residents and residential units per structure, as well as the number of residents who are full-time workers. The primary datasets used in the BCA are summarized in *Table 1-1.*

[3] *Benefit Cost Toolkit Version 6.0.* FEMA. October 2019. Available at https://www.fema.gov/media-library/assets/documents/179903.

Table 1-1 – Input Datasets to Benefit-Cost Analysis

Dataset	Source	Description
Harris County Structure Inventory	Harris County Flood Control District	attributes of individual structures in the study area, including use, size, and look-up codes for various reference tables
Right-of-Way Acquisition	Harris County Flood Control District	parcels and impacted structures to be bought out as part of project
Capital Costs	Harris County Flood Control District	project capital costs
Existing and Proposed Water Surface Elevations	Harris County Flood Control District	Estimated water surface elevations based on hydraulic modeling of conditions before and after project implementation
American Community Survey Data[4]	U.S. Census Bureau	2018 ACS 5-year data related to population, average household size, number of full-time workers, median household income, and other variables
Census Geographic Areas	U.S. Census Bureau	boundaries of 2010 Census tracts and block groups

HCFCD maintains a detailed structure inventory of all structures in Harris County. This inventory includes data on the number of housing units in each structure, square footage, building style, finished floor elevation, and numerous other attributes. The qualitative structure attributes in the inventory were used to determine the appropriate depth-damage functions and content-to-structure value ratios, and the finished floor elevation is the basis for determining damage and displacement costs based on depth of flooding above finished floor.

Data from the 2018 American Community Survey (ACS) 5-year[4] data tables was used in various parts of the BCA; the variables used are listed below. The following sections describe the use of this data in more detail.

- Subject Table S1903 –Median Income in the Past 12 Months
- Detail Table B01003 – Total Population
- Data Profile Table DP04 – Selected Housing Characteristics
- Detail Table B23027 – Full-Time, Year-Round Work Status in the Past 12 Months by Age for Population 16+ Years

[4] U.S. Census Bureau. American Community Survey, 2014-2018. Detailed Tables, Subject Tables, and Data Profile Tables; generated by Freese & Nichols, Inc. using the U.S. Census Bureau Application Programming Interface.

Table 1-2 lists the various standard values and lookup tables referenced in the calculations.

Table 1-2 – Sources of Standard Values and Reference Tables

Name	Purpose	Source
Discount Rate	calculate discount factors for converting between annual and present value equivalent costs/benefits	OMB Circular A-94
Demolition Threshold	threshold above which building is assumed to be fully lost and contents maximally lost	FEMA BCA Toolkit v6.0
Useful Life	project lifetime used in discounting	
Depth-Days Curve	table of days displaced for depth flooded	
Disruption Cost Factor	one-time cost per square foot for non-residential structures	
Monthly Cost Factor	recurring cost per square foot per month for non-residential structures	
Hotel per Diem Cost	daily cost per household, up to 5 people, for lodging	
Meal per Diem Cost	daily cost per person of eating out, less average cost of eating at home	
Mental Stress and Anxiety Unit Cost	cost of mental stress and anxiety per resident	
Productivity Loss Unit Cost	productivity loss per full-time worker	
Land Use Conversion Unit Benefit	value of ecosystem services ($/acre/year) provided by land use conversion	
Replacement Cost Models	building replacement values ($/sq. ft.)	Hazus Technical Manual[5]
Depth-Damage Functions	tables of percent damage for depth flooded given the building type	USACE New Orleans District[6]
SFR Content-to-Structure Value Ratios	ratio for single-family residences for 1 story, 2 stories, or mobile home	USACE New Orleans District[6]
Other Content-to-Structure Value Ratios	ratio for structures other than single-family residences	USACE New Orleans District[6]

1.4 CALCULATION OF EXPECTED ANNUAL BENEFITS

For benefit categories based on avoided losses, impacts are assessed for multiple storm recurrence intervals, and an Expected Annual Loss value is estimated from the estimated value of damages caused by each storm and the associated probability of such a storm in a single year. This annualized value is

[5] Hazus-MH MR3 Technical Manual. FEMA.

[6] *Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study*. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

estimated as the area under the Damage vs Probability curve using the trapezoidal area method. This method is described in a FEMA guidance document for flood risk assessments[7]. *Equation 1* demonstrates how this method is applied if impacts are modeled for 10-, 25-, 50-, 100-, and 500-year storms.

$$Expected\ Annual\ Loss = \left(\frac{1}{500} * Loss_{500yr}\right) + \left(\frac{1}{100} - \frac{1}{500}\right)\left(Loss_{100yr} + Loss_{500yr}\right) + \left(\frac{1}{50} - \frac{1}{100}\right)\left(Loss_{50yr} + Loss_{100yr}\right) + \left(\frac{1}{25} - \frac{1}{50}\right)\left(Loss_{25yr} + Loss_{50yr}\right) + \left(\frac{1}{10} - \frac{1}{25}\right)\left(Loss_{10yr} + Loss_{25yr}\right)$$

Equation 1

Loss values are not extrapolated to storm events with recurrence intervals smaller or larger than the events simulated in a hydraulic model. The Expected Annual Benefit (EAB) is the difference in Expected Annual Loss under existing and post-mitigation conditions *Equation 2*.

$$Expected\ Annual\ Benefit = (Expected\ Annual\ Loss)_{Existing} - (Expected\ Annual\ Loss)_{Post-mitigation}$$

Equation 2

1.5 PRESENT VALUE ANALYSIS

Benefits in most categories were determined on an annualized basis as described in the previous section. The present value of the Expected Annual Benefits (EAB) was then determined using the standard economic equivalence factor. Equivalence factors were determined using an annual discount rate of 7% as specified in OMB Circular A-94 and an assumed project useful life of 50 years. Equivalence factors for converting between annual and present values are shown in *Equation 3* and *Equation 4*. The 50-year life was based on a table of project lifetimes within the FEMA Toolkit (*Table 1-3*).

$$Annual\ Value = Present\ Value * \frac{i(1+i)^n}{(1+i)^n - 1}$$

Equation 3

$$Present\ Value = Annual\ Value * \frac{(1+i)^n - 1}{i(1+i)^n}$$

Equation 4

[7] "Guidance for Flood Risk Analysis and Mapping: Flood Risk Assessments." p. 18. FEMA. February 2018.

Table 1-3 – Standard Values for Project Useful Life in FEMA BCA Toolkit v6.0

Flood Hazard Mitigation Project Type	Useful Life (years)
Acquisition / Relocation	
Acquisition / Relocation	100
Building Elevation	
Residential Building	30
Non-Residential Building	25
Public Building	50
Historic Buildings	50
Mitigation Reconstruction	
Mitigation Reconstruction	50
Infrastructure Projects	
Major Infrastructure (dams, levees)	50
Concrete infrastructure, flood walls, roads, bridges, major drainage system	50
Culverts (concrete, PVC, CMP, HDPE, etc.) with end treatment	30
Culverts without end treatment	10
Major pump stations, substations, wastewater systems, or equipment such as generators	50
Minor pump stations, substations, wastewater systems, or equipment such as generators	5

Present Value Benefits were then compared to Total Project Cost to determine the Benefit-Cost Ratio (BCR) as shown in *Equation 5*.

$$BCR = ((Project\ Capital\ Cost) * (A/P\ Discount\ Factor) + Annual\ Maintenance\ Costs)/(Expected\ Annual\ Benefits) \quad \textit{Equation 5}$$

In the FEMA Toolkit, project useful life is specified for each structure individually, allowing a different factor to be applied to structures subject to buyouts, for which the useful life is assumed to be 100 years. However, for simplicity in the preliminary BCAs, a single discount factor based on a 50-year life was applied across the entire project. In other words, although the project does include acquisition and demolition of some structures, the shorter useful life of the primary project infrastructure has been used to apply a consistent present worth conversion factor to all components. This simplification causes a slight underestimation of benefits, but the difference is negligible.

2.0 QUANTITATIVE BENEFITS

2.1 BENEFITS BASED ON DEPTH OF FLOODING

A traditional BCA for flood mitigation projects assesses the difference in probable damages to a structure and its contents under existing (baseline) conditions and post-mitigation (proposed) conditions. Baseline

and proposed impacts to a structure and its contents are assessed for multiple storm recurrence intervals based on the depth to which the structure is inundated in each scenario. Flooding depth for each structure is calculated as the difference in modeled water surface elevation (WSE) and finished floor elevation (FFE) as provided in the structure inventory. For structures with missing FFE data, FFE was estimated at 6 inches above ground elevation, using the same ground elevation data as was used in development of the structure inventory[8].

Depth-related benefit categories include traditional structural benefits as well as others that can be related to the depth of flooding in a given storm frequency:

- Building Damages – Depth related to % of value lost.
- Content Damages – Depth related to % of value lost.
- Displacement Costs – Depth related to number of days displaced.
- Loss of Income / Loss of Function – Depth related to number of days rent payment income or commercial function is lost.

The following sections explain how these categories were assessed in the BCA.

2.1.1 Building and Content Damages

The FEMA Toolkit requires structural damages to be calculated based on a Building Replacement Value (BRV), not the appraised value or market value. The Unit BRV (cost per square foot) has a default value of $100/sf in the FEMA Toolkit. This default value was replaced with a value specific to each structure's attributes as described in the Hazus Technical Manual[9]. Hazus unit BRVs depend on building type and number of stories. Residential unit BRVs are further broken down by construction class (economy, average, custom, or luxury). Using Hazus methodology[10], a weighted composite building replacement value was assigned to single-family residential structures in the project service area based on the ratio of median household income in each census tract to median income across Texas (median household income determined from 2018 ACS 5-year data from Subject Table S1903). Finally, the Total Building Replacement Value of a structure is calculated by multiplying the Unit BRV by the building size *Equation 6*. This

[8] Bare Earth LiDAR, HGAC 2008 Datum Adjusted. Houston-Galveston Area Council. 2008.
[9] Hazus-MH MR3 Technical Manual. FEMA.
[10] Hazus-MH MR3 Technical Manual. FEMA. "Section 14.2.1 – Full Building Replacement Costs."

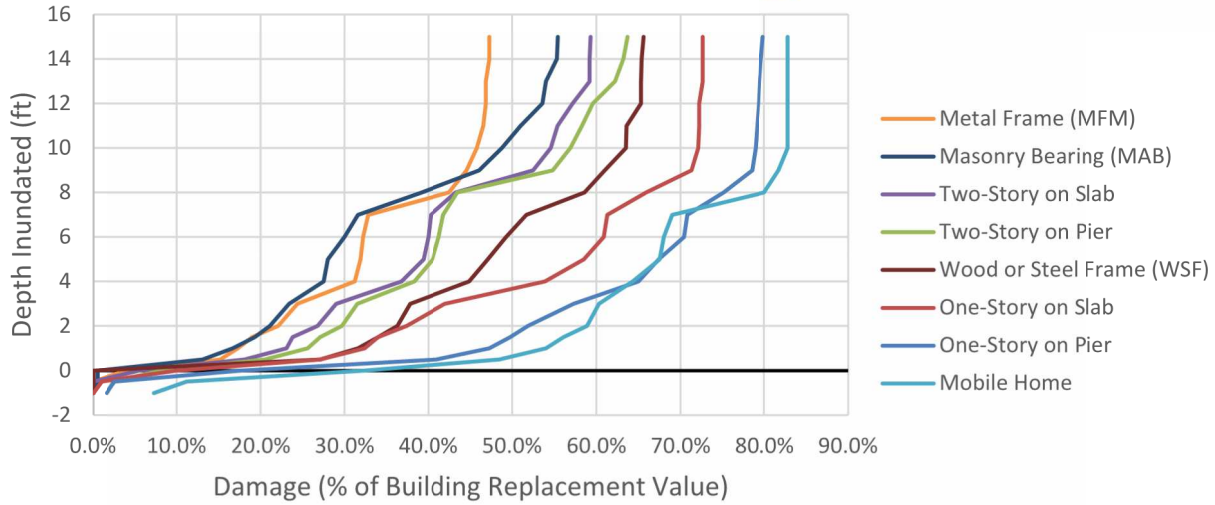
approach allowed for the use of local data to appropriately reflect structure values in the project service area.

$$Total\ BRV = Unit\ BRV\ (\$/sf) * Area\ (sf) \qquad \textit{Equation 6}$$

Values documented in the Hazus Technical Manual are based on standard cost-estimation models published in *Means Square Foot Costs*[11] and were reported in 2006 dollars. For this analysis, these values were scaled up using the RSMeans Historical Cost Indices from 2006 to 2020 to be consistent with project cost estimates. Building replacement values can be found in **Appendix A**.

Once depth of flooding is determined for a structure under a given scenario, the percent of the Total BRV that is lost to damage is determined from a depth-damage function (DDF). The DDFs used in this BCA were developed by the USACE New Orleans District[12] and are illustrated in *Figure 1*. It should be noted that some structures are expected to experience damage even when WSE is below FFE by up to 2 feet, depending on structure type.

Figure 1 – Depth-Damage Functions



The percent damage estimated from the DDFs is also applied to the value of the contents in the structures. The total value of contents in each structure was estimated from content-to-structure value ratios

[11] R.S. Means, 2005.
[12] Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

developed by the USACE New Orleans District[12], which specify a percentage of the building value depending on the building type.

A demolition threshold was set to 50%, which is the default value in the FEMA Toolkit. If percent damage based on depth and the depth-damage curve exceeded this threshold, the structure is expected to be substantially damaged and is assumed to need replacement rather than repair. In this case, the value of Expected Structure Damage is the Total BRV. Additionally, the value of Expected Content Losses is assumed to be maximized at this point (not a total loss, but the maximum value on the depth-damage curve).

Total benefits of avoided structure and content losses are summarized in the **Executive Summary**.

2.1.2 Displacement Costs (Residential)

Residential displacement losses represent the cost to residents of being out of their home after a flood event. The cost of residential displacement under baseline and proposed conditions for each modeled event was calculated using the method and standard values (shown in *Table 2-1*) in the FEMA Toolkit:

- Temporary lodging for each displaced household (assumes up to 5 household members per hotel room)
- Increase in meal cost (above average cost of eating at home) for each displaced resident

Expected annual benefits depend on a relationship between number of days displaced for depth of inundation. Using the relationship in the FEMA Toolkit, 45 days of displacement were assumed for each foot of flooding above FFE. No displacement was assumed if WSE did not exceed FFE. Total benefits of avoided residential displacement costs are summarized in the **Executive Summary**.

Table 2-1 – Residential Displacement Unit Costs

Meals per diem per capita	Cost of eating at home	Hotel per diem per family, up to 5 people	Meal cost / person / day
$55	$7	$94	$48

2.1.3 Displacement Costs (Non-Residential)

The costs of non-residential displacement, as defined by FEMA, include:

- One-time cost of relocating business equipment

- Monthly rental costs of new space

The same relationship between depth flooded and days displaced was used for non-residential displacement as for residential displacement. Cost factors provided in the FEMA Toolkit as $/sq. ft. values were used to estimate both the monthly and one-time cost components of non-residential displacement (*Table 2-2*). Total benefits of avoided non-residential displacement costs are summarized in the **Executive Summary**.

Table 2-2 – Non-residential Displacement Cost Factors

Occupancy Class	Disruption Cost Factor ($/sf)	Rental Cost Factor ($/sf)
Retail Trade	1.09	1.16
Wholesale Trade	0.95	0.48
Personal and Repair Services	0.95	1.36
Technical Business	0.95	1.36
Banks	0.95	1.7
Hospital	1.36	1.36
Medical Office/Clinic	1.36	1.36
Entertainment and Recreation	0	1.7
Theaters	0	1.7
Heavy	0	0.2
Light	0.95	0.27
Food/Drugs/Chemicals	0.95	0.27
Metals/Mineral Processing	0.95	0.2
High Technology	0.95	0.34
Construction	0.95	0.14
Agriculture	0.73	0.73
Religious/Nonprofit/Membership Organization	0.68	0.68
Government, General Services	0.95	1.36
Government, Emergency Response	0.95	1.36
Schools/Libraries	0.95	1.02
College/Universities	0.95	1.36

2.1.4 Loss of Income / Loss of Function

Loss of Income represents the loss of monthly rental income to owners of rental properties. Because additional monthly rental costs were considered as a displacement cost to non-residential tenants, property owner income losses were excluded from this BCA to avoid double-counting benefits.

Loss of Function represents the lost revenue due to inability to operate a business for some amount of time after a flood event. This avoided cost benefit category requires knowledge of the operating budget of the business for each individual non-residential structure in a project service area. As the majority of flood mitigation benefits in the project service area are to residential structures, this category was not assessed.

2.2 ANCILLARY BENEFITS

In addition to the benefit categories that represent avoided costs based on reduction in flooding depth, social and environmental benefits of the project were also quantified.

2.2.1 Avoided Social Costs

Social benefits based on the FEMA Toolkit represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

The calculation of social benefits replicated the method used in the FEMA Toolkit, which applies a present value benefit amount per impacted person to estimate the avoided costs of mental health treatment and of lost productivity *(Table 2-3*). These values are based on studied prevalence, severity, and course of mental effects following a disaster[13]. It should be noted that because these values are present value benefits, they are not dependent on the annual expected probability of a storm event or the level of flooding anticipated from a given event. Instead, these benefits represent the positive impact of a mitigation project reducing flooding in a resident's home, which may include an existing condition of minor flooding compared to a post-mitigation condition of no flooding. Even when traditional benefit

[13] *Final Sustainability Benefits Methodology Report.* FEMA. Task order HSFEHQ-11-J-1408. August 2012.

estimates might indicate a very small value of saved structural and content damages, the positive impact on residents of not having to do any repairs instead of a few repairs is significant.

Table 2-3 – Unit Values for Social Benefits as Avoided Costs of Mental Health Impacts

Category	Benefit per Person (Present Value)	Unit
Treatment for mental stress and anxiety	$2,443	Resident of home benefitted by project
Lost productivity	$8,736	Resident of home benefitted by project who works full-time

The present value benefits per person for treatment of mental stress and anxiety were applied to all residents of structures which experienced a reduced modeled WSE after project implementation, regardless of event frequency. The **Population Estimate Attachment** describes how ACS Table B01003 (Total Population Estimates) and ACS Data Profile DP04 (Selected Housing Characteristics) were used to allocate numbers of residents to each structure in the watershed. The number of full-time workers in each Census tract (B23027_001E) was compared to the total tract population (B01003_001E) to estimate the number of full-time workers living in each structure. Costs of lost productivity were based on the estimated number of full-time workers residing in each structure. Estimated social benefits are summarized in the **Executive Summary**.

2.2.2 Environmental Benefits

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. Unlike other benefit categories based on avoided costs, environmental benefits represent an added service. *Table 2-4* indicates the value of each land use type (assuming existing condition of is developed land).

Table 2-4 – Unit Benefit Values for Conversion of Developed Land to Land Use of Higher Ecosystem Value

Documented Benefit/acre/year[14]				
Green Open Space	Riparian	Wetlands	Forests	Marine /Estuary
$8,308	$39,545	$6,010	$554	$1,799

[14] Help Section of B/C Analysis Toolkit v6.0, as of 01/28/2020.

Expected environmental benefits are summarized in the **Executive Summary**.

3.0 QUALITATIVE BENEFITS

As described in the Federal Register,[15] as long as a quantitative BCA has been completed, projects may have a benefit-cost ratio of less than 1.0 when the project provides concrete benefits to "low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster," including benefits that cannot be quantified. Qualitative benefits of this project are discussed below.

3.1 BENEFICIARIES VULNERABLE TO FLOOD RISK

This application has demonstrated that 70.6% of the beneficiaries of Halls Bayou Watershed CDBG-MIT Application 1 Covered Project are low- to moderate-income persons. Additionally, many of the residents of the project service area may be considered particularly vulnerable to disasters. 36.5% of the households in the project service area are considered to be housing cost-burdened, and 19.0% are severely housing cost-burdened. These households spend 30+% and 50+% of their monthly income on housing-related costs, respectively. This cost burden may make it particularly hard for these households to recover from disaster, as they are less likely to have additional funds available for repairs, hotel stays, and lost wages during and after a flood. Additionally, 41.5% of the households in the project service area have no computer and/or no internet subscription. Lack of reliable internet access may reduce residents' ability to benefit from early warning systems in case of flooding events, making them more vulnerable.

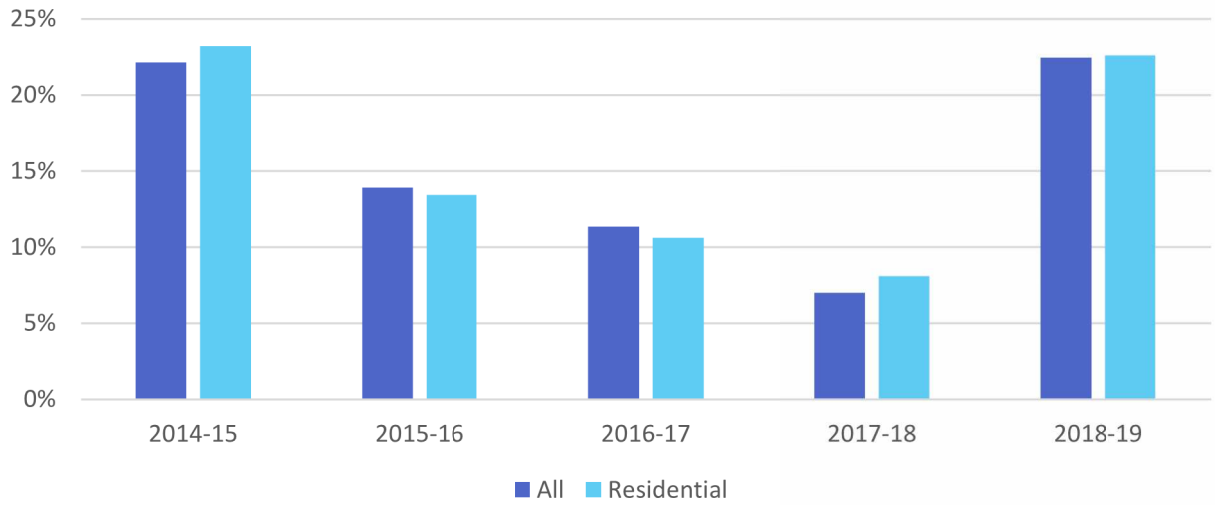
3.2 BENEFIT OF REDUCING FLOOD IMPACTS TO PROPERTY VALUES

A review of parcel appraisal values from the Harris County Appraisal District suggests that the annual rate of growth in property values generally slowed from 2014 to 2018 in the Halls Bayou Watershed (*Figure 2*). These trends could be caused or influenced by floods in 2015, 2016, and 2017, but the degree to which local flooding impacted the value growth rates cannot be ascertained. General economic conditions in Harris County following Hurricane Harvey, as well as other external economic factors, could also contribute to changes in property values. Although the exact impact of local flooding on property values cannot be quantified, flood risk mitigation projects are likely to have a positive impact on the residents of

[15] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

flood-prone areas, as falling property values can have a negative effect on the financial flexibility of housing cost-burdened homeowners and even renters. Finally, the Halls Bayou Watershed CDBG-MIT Application 1 Covered Project will remove 335 acres from the 100-year floodplain, providing a potential positive impact to property values.

Figure 2 – Median Year-to-Year Percent Change in Assessed Values of Individual Parcels in Halls Bayou
**Parcels included in assessment were limited to those which had values available for all years 2014 – 2019. Percent change values of 0% were excluded to avoid errors from repeated entries across years.*



3.3 TRANSPORTATION BENEFITS

Street closures due to flooding in the Halls Bayou Watershed during Hurricane Harvey likely impacted a large number of commuters, including those who do not live in the watershed. Frequently, residential streets are inundated and may become impassable without the water level reaching a point of causing any damage to homes. In these scenarios, no quantitative benefits are counted in the BCA as there is no structural damage or displacement of residents. However, the street flooding poses an inconvenience and in some cases a safety risk, as it can inhibit evacuations, potentially trapping residents in homes that may lose power or keeping them from accessing groceries or medical supplies. The Halls Bayou Watershed CDBG-MIT Application 1 Covered Project will provide some reduction in street inundation as a benefit to residents in the service area.

In Harris County, over 50,000 workers 16 years and older use a bus or trolley bus as means of transportation to work. Of workers living within the watershed, 2.2% (1,473 workers) use a bus to commute to work. Data from the Metropolitan Transit Authority of Harris County (Metro) indicates that 17 bus routes through the watershed were closed for up to 9 days during and after Hurricane Harvey. No

methods were found that could be used to quantify the productivity losses of workers impacted by road closures. Additionally, all Metro bus routes passing through the project service area also extend across multiple floodplains in Harris County. It was determined that even if a substantial section of a route is removed from the floodplain as a result of the Halls Bayou Watershed CDBG-MIT Application 1 Covered Project, inundation elsewhere could still cause route closure. Because of this, assigning quantitative economic benefits to reduced flooding along bus routes that could be attributed only to this project was not considered to be a valid approach. However, the Halls Bayou Watershed CDBG-MIT Application 1 Covered Project is important to reducing the overall flooding along major commuter routes, providing significant benefit to residents of the project service area as well as workers traveling to and through the area.

4.0 SUMMARY

The approach to benefit-cost analysis documented here was based on FEMA BCA methodologies and considered various categories of benefits afforded by the Halls Bayou Watershed CDBG-MIT Application 1 Covered Project. However, as discussed in Section 2.1.1, the use of structural damages in a benefit-cost ratio, while valid, means that a project in a lower income service area that provides flood mitigation benefits to the same number of homes as a project in a higher-income area may have a lower calculated benefit-cost ratio due to the lower replacement values of homes in the service area. As a result, the low- and moderate-income populations that the CDBG-MIT funding seeks to serve may be underserved by funding sources which rely primarily on traditional benefit-cost analysis methods. Considering this, it is important to recognize that quantitative BCRs should not be used alone when evaluating the effectiveness of a mitigation project, and in fact, comparing BCRs between projects may actually work against the goal of serving of CDBG-MIT funding to serve LMI and other vulnerable populations.

APPENDIX A
BUILDING REPLACEMENT VALUES

Table A-1
Single-Family Residential Building Replacement Values (2020 dollars, assuming no basements)

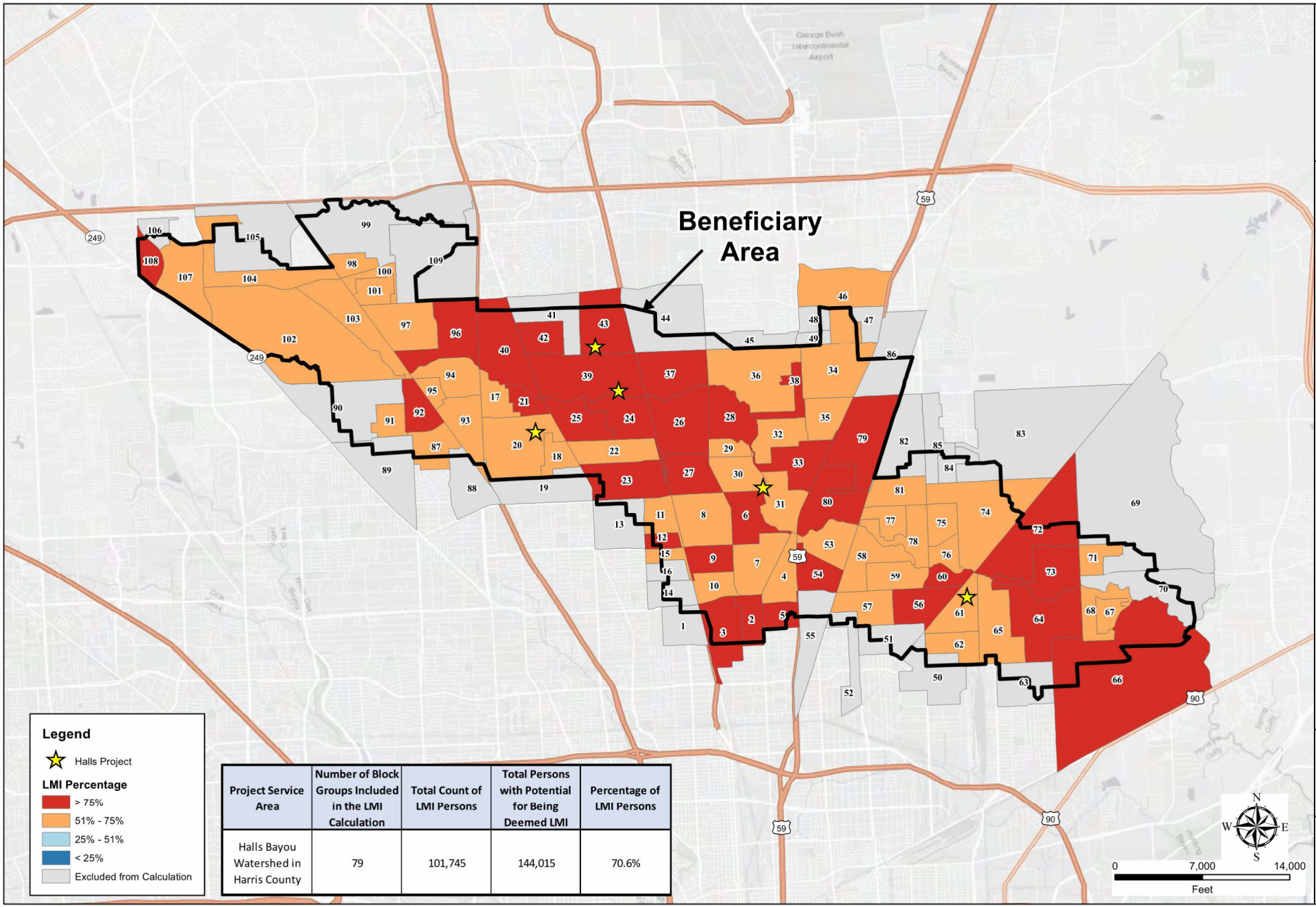
Income Ratio (r) Number of Stories	r < 0.5	0.5 <= r < 0.85	0.85 <= r < 1.25	1.25 <= r < 2.0	r >= 2.0
1	$97.28	$107.21	$145.17	$169.60	$206.28
2	$103.51	$110.89	$141.45	$166.65	$196.43
3	$103.51	$112.50	$147.76	$172.67	$202.32
split	$95.14	$102.70	$132.88	$155.34	$184.21

Table A-2
Multi-Family Residential Building Replacement Values (2020 dollars)

Number of Units	Unit Building Replacement Value ($/sf)
2	$117.00
3-4	$128.00
5-9	$228.00
10-19	$203.00
20-49	$200.00
50+	$195.00

Table A-3
Non-Residential Building Replacement Values (2020 dollars)

Occupancy Class	Occupancy Sub-Class	Unit Building Replacement Value ($/sf)
Manufactured Housing	Manufactured Housing	$52.76
Retail Trade	Dept Store, 1 st	$121.96
Wholesale Trade	Warehouse, medium	$112.10
Personal and Repair Services	Garage, Repair	$151.05
Prof./ Tech./Business Services	Office, medium	$196.93
Banks	Bank	$282.68
Hospital	Hospital, medium	$331.04
Medical Office/Clinic	Med. Office, medium	$242.32
Entertainment & Recreation	Restaurant	$251.66
Theaters	Movie Theatre	$180.14
Parking	Parking garage	$64.53
Heavy	Factory, small	$130.29
Light	Warehouse, medium	$112.10
Food/Drugs/Chemicals	College Laboratory	$214.11
Metals/Minerals Processing	College Laboratory	$214.11
High Technology	College Laboratory	$214.11
Construction	Warehouse, medium	$112.10
Agriculture	Warehouse, medium	$112.10
Church	Church	$204.52
General Services	Town Hall, small	$158.34
Emergency Response	Police Station	$245.87
Schools/Libraries	High School	$170.19
Colleges/Universities	College Classroom	$213.61



Project Service Area	Number of Block Groups Included in the LMI Calculation	Total Count of LMI Persons	Total Persons with Potential for Being Deemed LMI	Percentage of LMI Persons
Halls Bayou Watershed in Harris County	79	101,745	144,015	70.6%

FN PROJECT NO: SCG17287
DATE CREATED: 9/28/2020
DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
FILE NAME: Halls_Project_Area_Map_LMI_1_App1
PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed Beneficiary CDBG-MIT Application1

EXHIBIT
2
(1 of 2)

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Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
1	482012206001	57	2,814	2%	No	75.7%
2	482012207001	889	909	98%	Yes	84.0%
3	482012207005	1,623	2,396	68%	Yes	75.3%
4	482012209001	1,047	1,047	100%	Yes	73.6%
5	482012209002	675	749	90%	Yes	76.4%
6	482012210001	1,706	1,706	100%	Yes	77.4%
7	482012210002	2,499	2,499	100%	Yes	70.7%
8	482012211001	1,471	1,471	100%	Yes	73.2%
9	482012211002	1,290	1,294	100%	Yes	83.3%
10	482012211003	1,065	1,065	100%	Yes	67.3%
11	482012212001	1,852	2,039	91%	Yes	70.7%
12	482012212002	896	1,239	72%	Yes	84.3%
13	482012212003	671	3,454	19%	No	73.2%
14	482012213001	773	2,018	38%	No	72.4%
15	482012213002	774	1,263	61%	Yes	61.1%
16	482012213003	991	1,732	57%	No	65.7%
17	482012216001	1,997	2,001	100%	Yes	54.2%
18	482012216002	993	993	100%	Yes	69.1%
19	482012216003	343	1,702	20%	No	68.6%
20	482012216004	3,327	3,327	100%	Yes	57.8%
21	482012216005	1,838	1,838	100%	Yes	86.5%
22	482012217001	1,795	1,795	100%	Yes	54.9%
23	482012217002	1,272	1,644	77%	Yes	87.9%
24	482012217003	2,305	2,305	100%	Yes	79.8%
25	482012217004	2,496	2,496	100%	Yes	85.5%
26	482012218001	2,739	2,742	100%	Yes	78.0%
27	482012218002	1,258	1,258	100%	Yes	93.8%
28	482012219001	1,678	1,678	100%	Yes	81.5%
29	482012219002	1,010	1,010	100%	Yes	57.7%
30	482012219003	2,102	2,102	100%	Yes	72.0%
31	482012220001	2,373	2,376	100%	Yes	65.5%
32	482012221001	3,177	3,177	100%	Yes	58.9%
33	482012221002	2,440	2,440	100%	Yes	82.8%
34	482012222001	2,014	2,030	99%	Yes	53.6%
35	482012222002	1,687	1,687	100%	Yes	59.2%
36	482012223001	1,922	1,928	100%	Yes	70.0%
37	482012223002	1,564	1,564	100%	Yes	80.0%
38	482012223003	1,428	1,428	100%	Yes	89.9%
39	482012224011	1,368	1,368	100%	Yes	85.7%
40	482012224012	1,890	1,895	100%	Yes	76.9%
41	482012224021	1,407	2,971	47%	No	53.9%
42	482012224022	740	740	100%	Yes	97.9%
43	482012224023	2,258	2,706	83%	Yes	82.9%
44	482012228002	1,078	1,828	59%	No	70.6%
45	482012229004	225	2,238	10%	No	60.1%
46	482012230011	2,722	3,228	84%	Yes	73.7%
47	482012230012	19	1,237	2%	No	70.9%
48	482012230021	540	1,721	31%	No	63.0%
49	482012230022	375	2,149	17%	No	92.4%
50	482012302004	325	1,675	19%	No	56.5%
51	482012303001	830	1,451	57%	No	73.5%
52	482012304001	236	829	28%	No	84.8%
53	482012305001	672	672	100%	Yes	59.9%
54	482012305002	1,927	1,927	100%	Yes	76.5%
55	482012305003	303	1,138	27%	No	58.4%
56	482012306001	932	932	100%	Yes	81.8%
57	482012306002	1,895	1,895	100%	Yes	70.9%
58	482012307001	842	842	100%	Yes	64.7%
59	482012307002	1,633	1,633	100%	Yes	62.3%
60	482012307003	398	398	100%	Yes	82.7%

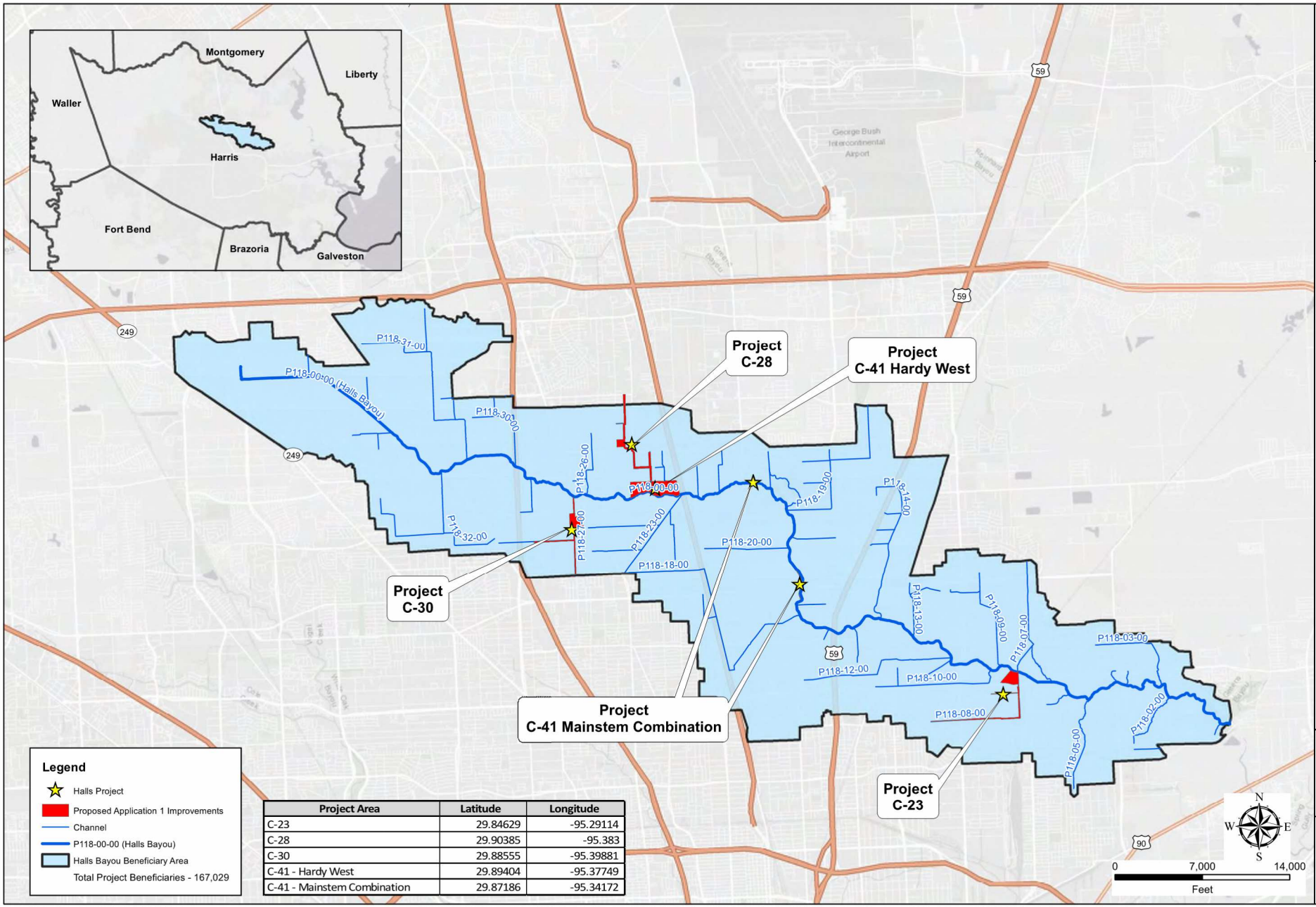
Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
61	482012308001	1,300	1,300	100%	Yes	67.7%
62	482012308002	1,223	1,223	100%	Yes	57.2%
63	482012309001	229	1,147	20%	No	68.9%
64	482012310001	2,606	2,609	100%	Yes	80.6%
65	482012310002	1,806	1,831	99%	Yes	70.2%
66	482012311001	1,548	1,645	94%	Yes	94.0%
67	482012311002	2,123	2,123	100%	Yes	58.1%
68	482012311003	1,099	1,099	100%	Yes	64.9%
69	482012312001	1,832	3,126	59%	No	85.8%
70	482012312002	369	1,793	21%	No	76.2%
71	482012312003	2,079	2,079	100%	Yes	61.8%
72	482012313001	1,640	1,750	94%	Yes	83.1%
73	482012313002	2,865	2,865	100%	Yes	78.6%
74	482012314001	2,645	2,645	100%	Yes	60.9%
75	482012315001	2,015	2,015	100%	Yes	61.0%
76	482012315002	985	985	100%	Yes	73.8%
77	482012316001	1,248	1,251	100%	Yes	59.1%
78	482012316002	1,885	1,885	100%	Yes	63.7%
79	482012317001	2,604	2,604	100%	Yes	81.9%
80	482012317002	839	839	100%	Yes	82.4%
81	482012318001	1,067	1,067	100%	Yes	69.3%
82	482012318002	309	1,858	17%	No	65.7%
83	482012319002	151	2,509	6%	No	32.6%
84	482012319003	872	1,470	59%	No	78.0%
85	482012319004	116	1,367	8%	No	100.0%
86	482012321002	981	2,788	35%	No	81.9%
87	482015333001	2,002	2,247	89%	Yes	70.6%
88	482015333002	283	2,631	11%	No	97.8%
89	482015334001	336	2,315	15%	No	62.8%
90	482015334002	3,540	5,941	60%	No	66.5%
91	482015334003	2,318	2,318	100%	Yes	72.7%
92	482015334004	1,601	1,601	100%	Yes	76.2%
93	482015335001	2,467	2,467	100%	Yes	63.0%
94	482015335002	1,110	1,110	100%	Yes	70.4%
95	482015335003	780	780	100%	Yes	50.0%
96	482015336001	748	748	100%	Yes	81.9%
97	482015336002	4,720	4,720	100%	Yes	62.6%
98	482015337012	2,416	2,416	100%	Yes	69.6%
99	482015337013	226	1,804	13%	No	72.9%
100	482015337021	1,311	1,311	100%	Yes	60.0%
101	482015337022	2,446	2,446	100%	Yes	72.5%
102	482015338011	7,905	8,982	88%	Yes	61.0%
103	482015338012	2,069	2,069	100%	Yes	53.0%
104	482015338021	1,448	1,981	73%	Yes	73.7%
105	482015338022	1,563	3,874	40%	No	68.9%
106	482015339012	354	1,112	32%	No	34.1%
107	482015339013	5,099	5,099	100%	Yes	59.2%
108	482015339022	3,198	3,198	100%	Yes	84.3%
109	482015337011	0	1,531	0%	No	100.0%

FN PROJECT NO: SCG17397
DATE CREATED: 9/28/2020
DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
FILE NAME: Halls_Project_Area_Map_LMI_2
PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed Beneficary Area Table

EXHIBIT
2
(2 of 2)



Project Area	Latitude	Longitude
C-23	29.84629	-95.29114
C-28	29.90385	-95.383
C-30	29.88555	-95.39881
C-41 - Hardy West	29.89404	-95.37749
C-41 - Mainstem Combination	29.87186	-95.34172

FN PROJECT NO: SCG17297
DATE CREATED: 9/28/2020
DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
FILE NAME: Halls_Project_Area_Map_App1
PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed - CDBG MIT Application 1

EXHIBIT
1

Date Saved: 9/28/2020 4:53:35 PM

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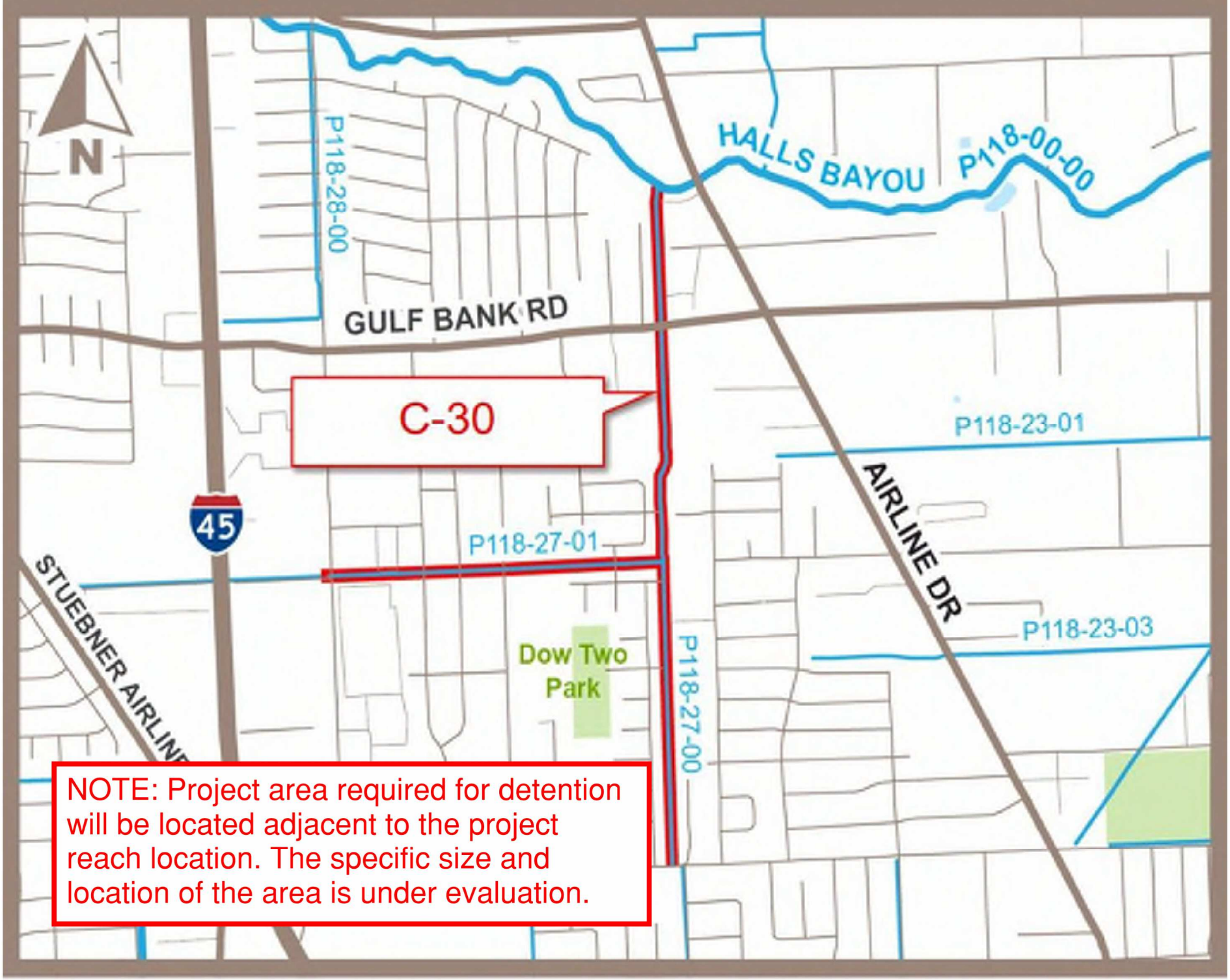
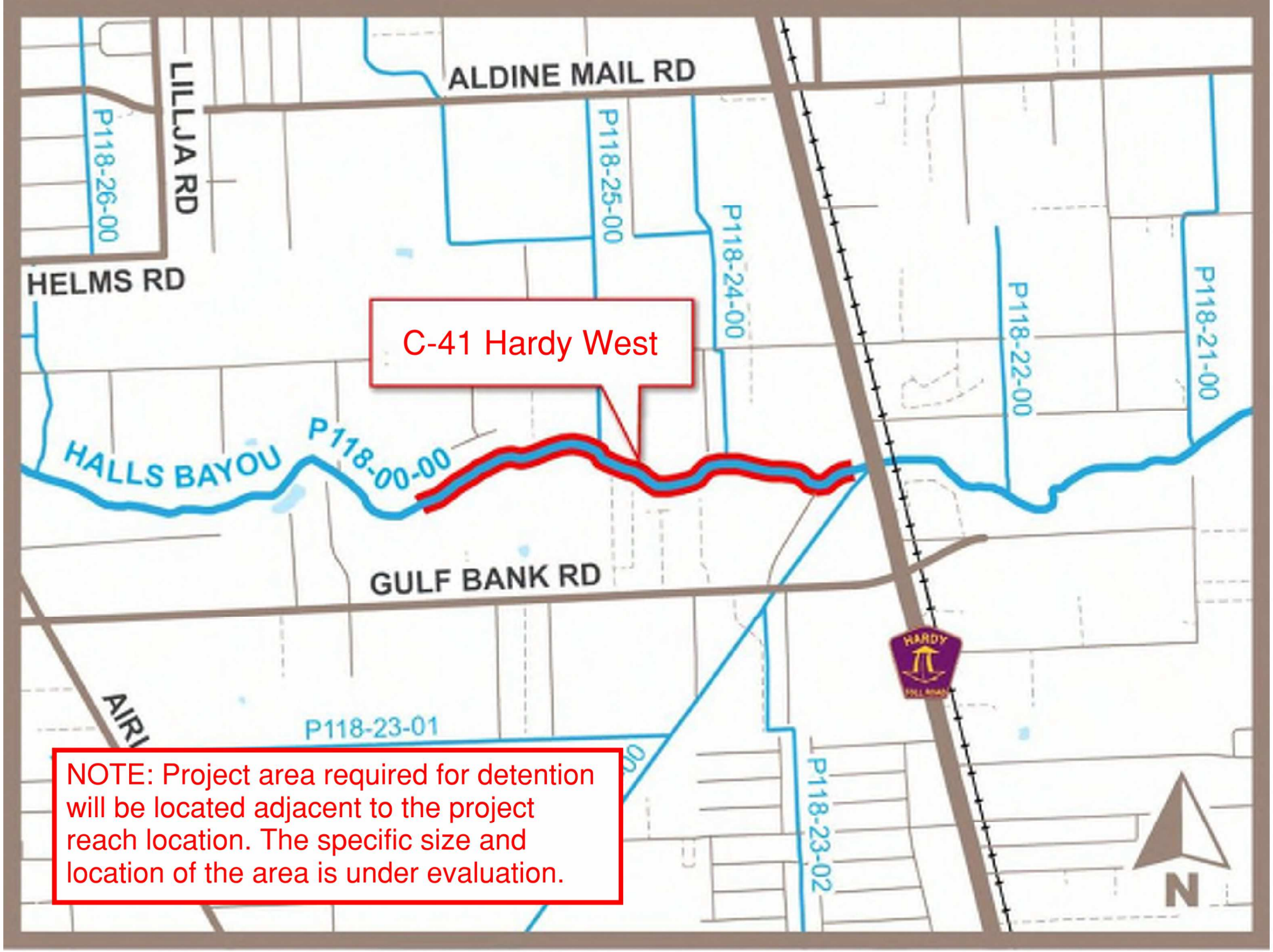
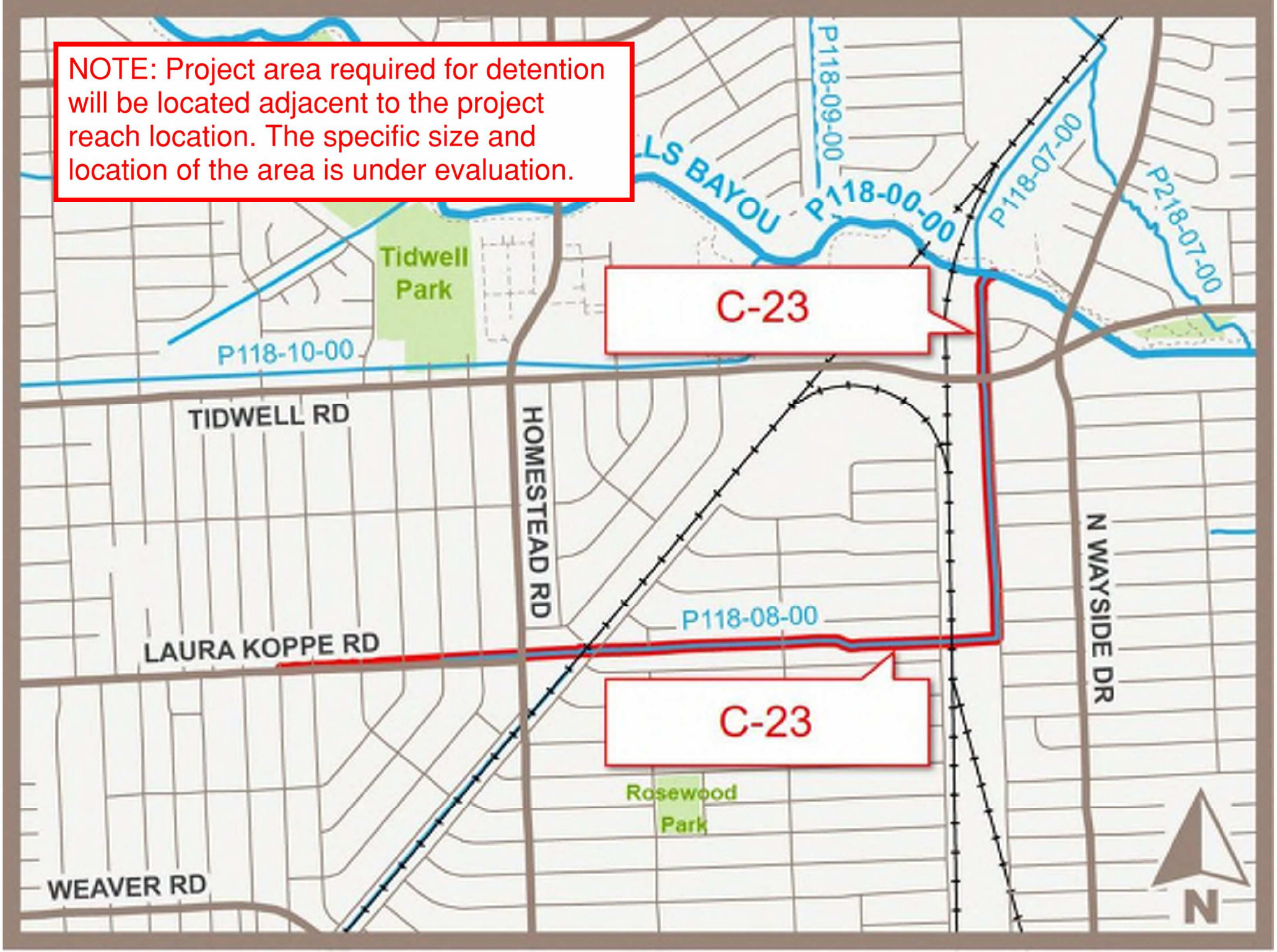
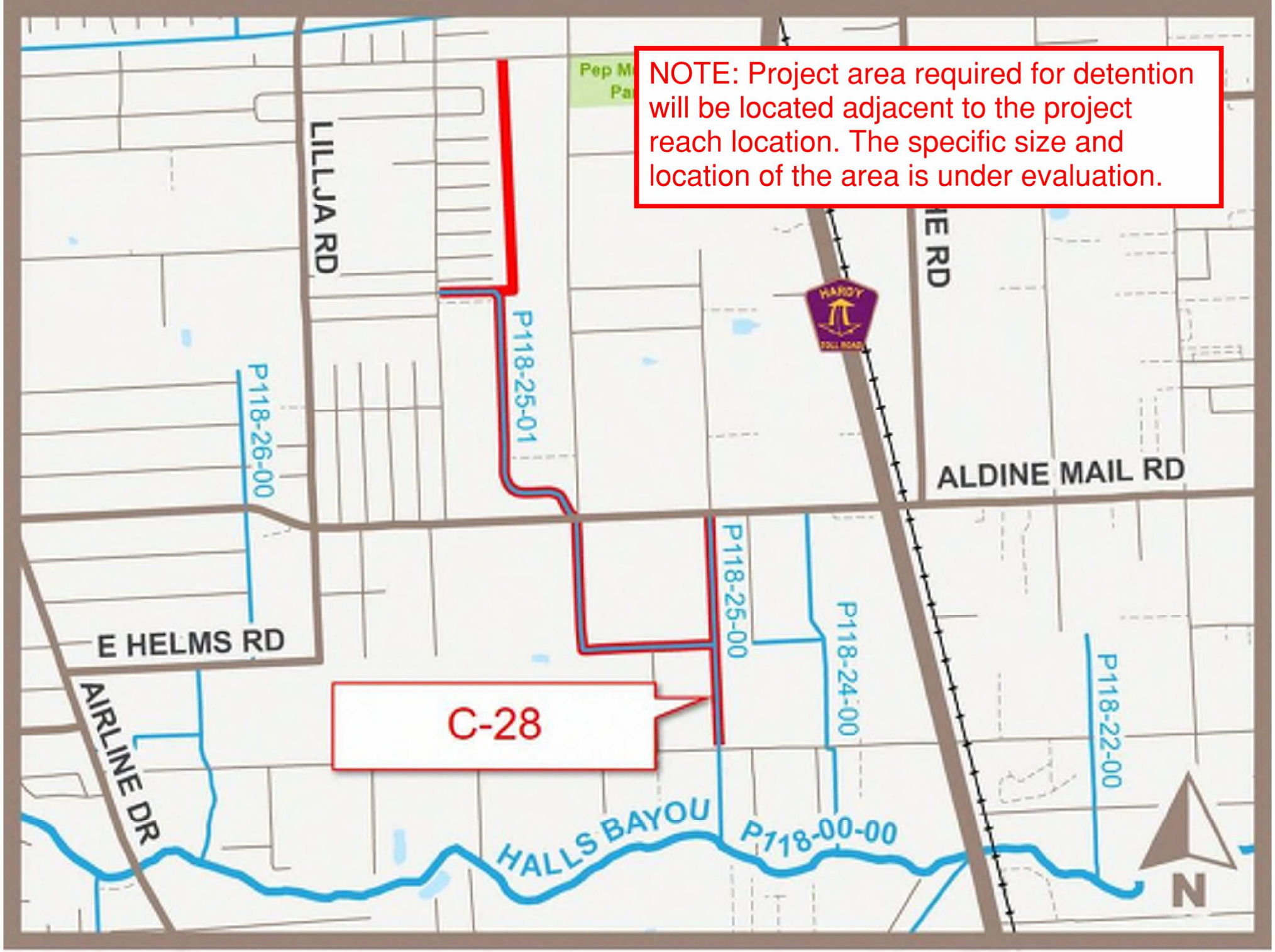
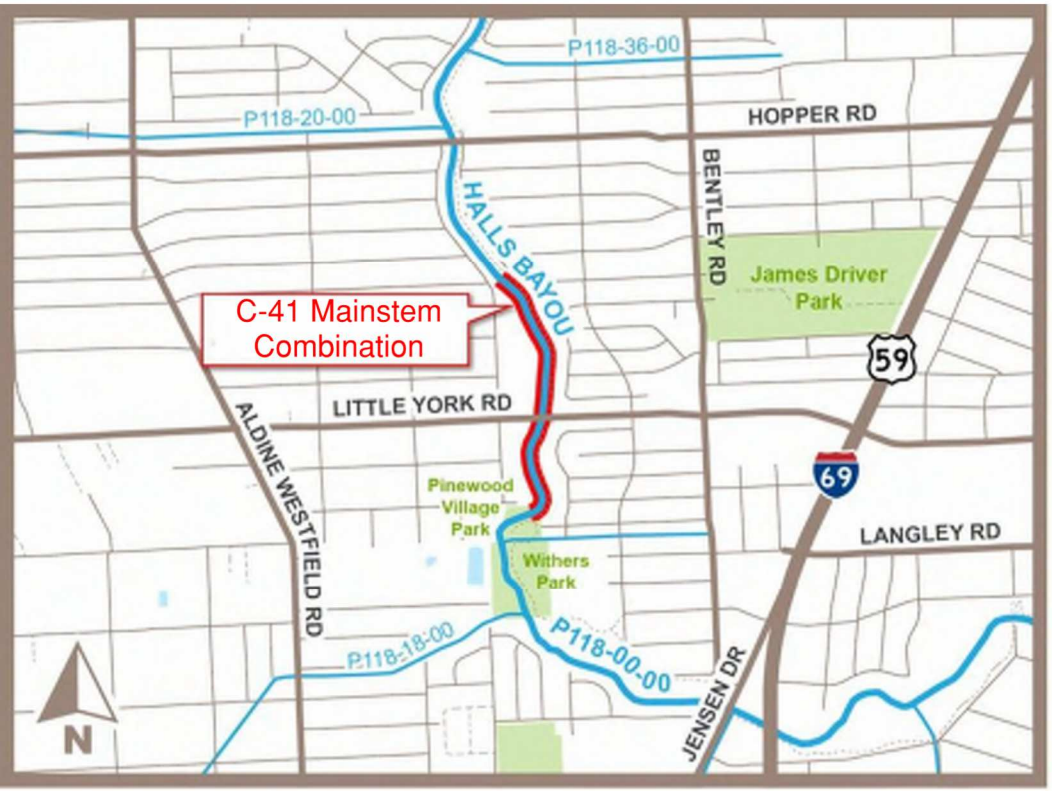

N
P118-28-00
HALLS BAYOU
P118-00-00
GULF BANK RD
C-30
P118-23-01
AIRLINE DR
45
P118-27-01
STUEBNER AIRLIN
Dow Two
Park
P118-27-00
P118-23-03
NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
PROJECT REACH

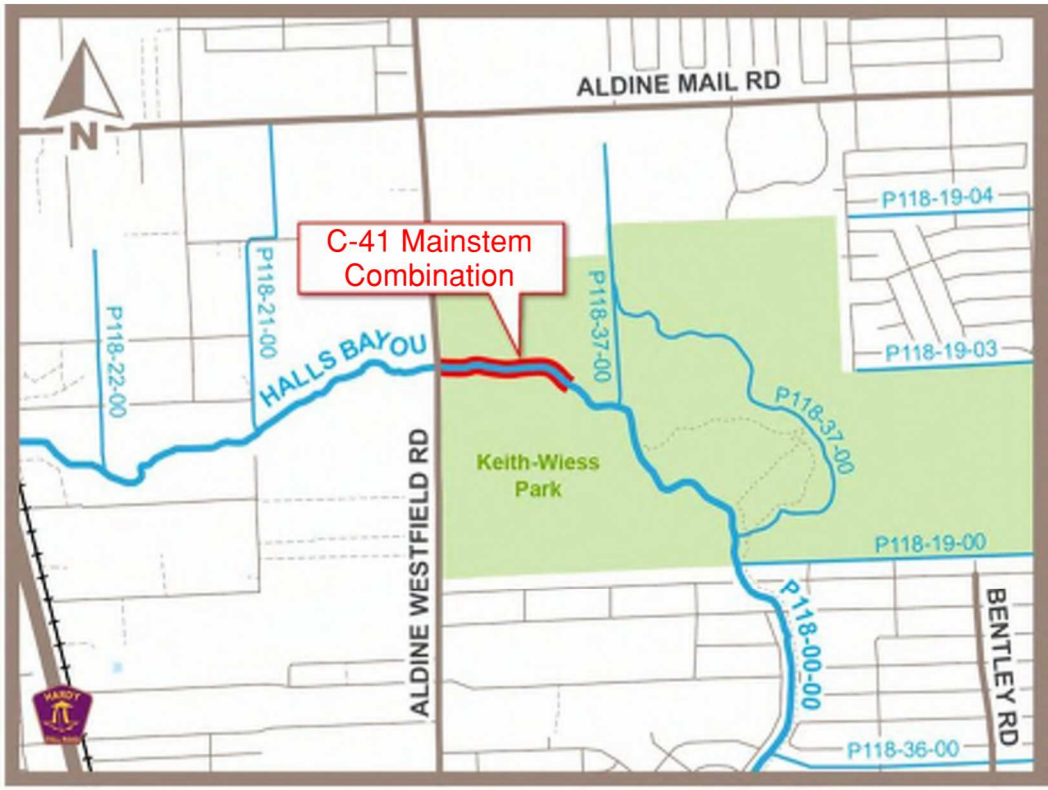

ALDINE MAIL RD
LILLJA RD
HELMS RD
P118-26-00
P118-25-00
P118-24-00
P118-22-00
P118-21-00
C-41 Hardy West
HALLS BAYOU
P118-00-00
GULF BANK RD
HARDY
P118-23-01
P118-23-02
NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
N
PROJECT REACH


NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
P118-09-00
LS BAYOU
P118-00-00
P118-07-00
P218-07-00
Tidwell Park
C-23
P118-10-00
TIDWELL RD
HOMESTEAD RD
N WAYSIDE DR
P118-08-00
LAURA KOPPE RD
C-23
Rosewood Park
WEAVER RD
N
PROJECT REACH


NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
LILLJA RD
P118-25-01
P118-26-00
ALDINE MAIL RD
P118-25-00
P118-24-00
P118-22-00
E HELMS RD
AIRLINE DR
C-28
HALLS BAYOU
P118-00-00
N
PROJECT REACH



PROJECT REACH



PROJECT REACH

OMB Number: 4040-0004
Expiration Date: 12/31/2022

Application for Federal Assistance SF-424

*** 1. Type of Submission:**
- [ ] Preapplication
- [X] Application
- [ ] Changed/Corrected Application

*** 2. Type of Application:**
- [X] New
- [ ] Continuation
- [ ] Revision

* If Revision, select appropriate letter(s):

* Other (Specify):

* 3. Date Received: Completed by Grants.gov upon submission.

4. Applicant Identifier:

5a. Federal Entity Identifier:

5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:

7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name: Harris County Flood Control District

* b. Employer/Taxpayer Identification Number (EIN/TIN): 74-6019452

* c. Organizational DUNS:

d. Address:

* Street1: 9900 Northwest Freeway
Street2:
* City: Houston
County/Parish:
* State: Texas
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 77092

e. Organizational Unit:

Department Name:

Division Name:

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:
* First Name: Tak
Middle Name:
* Last Name: Makino
Suffix:

Title:

Organizational Affiliation:

* Telephone Number: 713-821-0359
Fax Number:

* Email: TMMakino@lan-inc.com

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

Grant

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

*** 10. Name of Federal Agency:**

Housing and Urban Development

11. Catalog of Federal Domestic Assistance Number:

CFDA Title:

*** 12. Funding Opportunity Number:**

Federal Register/Vol. 84, No.169

* Title:

CDBG-MIT

13. Competition Identification Number:

Title:

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant

* b. Program/Project TX-018, TX-029

Attach an additional list of Program/Project Congressional Districts if needed.

Please see attached list | Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date:

* b. End Date:

18. Estimated Funding ($):

* a. Federal	$100,000,000.00
* b. Applicant	$7,278,820.00
* c. State	
* d. Local	
* e. Other	
* f. Program Income	
* g. TOTAL	$107,278,820.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

- [ ] a. This application was made available to the State under the Executive Order 12372 Process for review on .
- [ ] b. Program is subject to E.O. 12372 but has not been selected by the State for review.
- [X] c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

- [ ] Yes
- [X] No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

- [X] ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix:

* First Name: Lina

Middle Name:

* Last Name: Hidalgo

Suffix:

* Title: County Judge

* Telephone Number: 713-755-6444

Fax Number:

* Email: judge.hidalgo@cjo.hctx.net

* Signature of Authorized Representative: Completed by Grants.gov upon submission.

* Date Signed: Completed by Grants.gov upon submission.

SF 424 Attachment for Congressional Districts

APPLICANT

US Congressional District(s)

2
7
9
18
29

Texas State Representative District(s)

126	134	143
127	135	144
128	137	145
129	138	146
130	139	147
131	140	148
132	141	149
133	142	150

Texas Senate District(s)

4	13
6	15
7	17
11	18

PROJECT

US Congressional District(s)

18, 29

Texas State Representative District(s)

140, 141

Texas Senate District(s)

6, 13

HARRIS COUNTY FLOOD CONTROL DISTRICT
HCFCD.ORG
9900 Northwest Freeway
Houston, Texas 77092
346-286-4500

	YES	NO	ABSTAIN
Judge Lina Hidalgo	☑	☐	☐
Comm. Rodney Ellis	☑	☐	☐
Comm. Adrian Garcia	☑	☐	☐
Comm. Steve Radack	☑	☐	☐
Comm. R. Jack Cagle	☑	☐	☐

October 5, 2020

Commissioners Court
Administration Building
Houston, Texas 77002

Reference: Recommendation that the Harris County Flood Control District be authorized to apply for a grant application to address chronic flooding in the Halls Bayou watershed through the Texas General Land Office Community Development Block Grant – Mitigation (CDBG-MIT) Grant Program.
Bond ID's C-01, C-24, C-26, and C-41
HCFCD Unit's P518-26-00, P518-26-01, P118-09-00, P118-23-00, P118-23-02, and P118-00-00.
Harris County Precincts 1 and 2

Dear Court Members:

It is recommended that the Harris County Flood Control District (District) be authorized to apply for a grant application to address chronic flooding in the Halls Bayou watershed through the Texas General Land Office Community Development Block Grant – Mitigation (CDBG-MIT) Grant Program.

The application includes four Bond Projects in the Halls watershed including channel conveyance improvements to HCFCD Units P518-26-00, P518-26-01 (Bond ID C-01), P118-09-00 (Bond ID C-24), P118-23-00, P118-23-02, (Bond ID C-26) and main stem improvements to P118-00-00 (Bond ID C-41). The total estimated construction cost is $107,278,820 and requests a federal share of $100,000,000. This will require a local match of $7,278,820. The Districts share of the funding for the local match will primarily come from the 2018 Bond Program, with additional funds as needed through the Districts Capital Improvement Program. This application is one of two that are being submitted for projects in the Halls Bayou watershed.

The District will present any grant awards, if made, to Commissioner Court for consideration at a future date.

Sincerely,

Russell A. Poppe, P.E.
Executive Director

RAP:ARB:ym

Attachments: Order
Project Summary
Grant Application

cc: County Auditor

101320 AGENDA GRANT Halls Bayou 2

Presented to Commissioners Court

October 13, 2020

Approve: E/G

HARRIS COUNTY, TEXAS

Office of Budget Management 1001 Preston; Suite 500 Houston, TX 77002 713-274-1135

Grants Coordination Section - Conveyance Form Application [X] Award [ ]

Department Name / Number	DUNs	Grant Title
HARRIS COUNTY FLOOD CONTROL - 090	174079756	Halls Bayou Watershed '22 (CDBG-MIT) #2

Funding Source: U.S. Department of Housing & Urban Development: CFDA# 14.228		**Grant Agency:** Texas General Land Office (GLO)	
Program Year:	1 st	**Program Ending:**	
Grant Begin Date:	03/01/2021	**Grant End Date:**	09/01/2026
Grant Org. Key:		**If applicable, Prior Year Org. Key:**	N/A

Grant Description:

In February of 2018, Congress appropriated $12 billion dollars in Community Development Block Grant (CDBG) funds specifically for mitigation activities for qualifying disasters in 2015, 2016, and 2017. HUD was able to allocate an additional $3.9 billion, bringing the amount available for mitigation to nearly $16 billion. The CDBG Mitigation (CDBG-MIT) Program is a unique and significant opportunity for eligible grantees to use this assistance in areas impacted by recent disasters to carry out strategic and high-impact activities to mitigate disaster risks and reduce future losses.

	Total Budget	Grant Funded	County Funded
Salary & Benefits	$0.00	$0.00	$0.00
Non-Labor	$107,278,820.00	$100,000,000.00	$7,278,820.00
Sub Tot. Incremental Cost	**$107,278,820.00**	**$100,000,000.00**	**$7,278,820.00**
Indirect Cost	$0.00	$0.00	$0.00*
TOTALS	**$107,278,820.00**	**$100,000,000.00**	**$7,278,820.00**

* under development

Full Time Equivalent Positions	0.00	**Date Guidelines are Available**	
% of Positions Paid by Grant	0.00 %	**Grant Submittal Deadline Date**	

Grant Discussion:

If awarded, this will be the first year for this project under this grant program. Grant funds would be used for various drainage improvement projects along Halls Bayou susceptible to repeated flooding in Commissioners 1 & 2. The Halls Bayou watershed historically has been an underserved area of north Harris County. The local match requirement amounts to $7,278,820 that will primarily come from the 2018 Bond Program with additional funds as needed through the District's Capital Improvement Program.

County Funded Cost Projection

Year	Required	Discretionary
2022	1,310,187.60	-
2023	1,310,187.60	-
2024	1,310,187.60	-
2025	1,310,187.60	-
2026	2,038,069.60	-

Completed by : Mattingly, Mike **Date :** 10/6/2020

Reviewed by: **Date :** 10/6/2020

ORDER

STATE OF TEXAS

COUNTY OF HARRIS

On this, the 13th day of October, 2020, the Commissioners' Court of Harris County, Texas, sitting as the governing body of Harris County, upon motion of Commissioner Ellis, seconded by Commissioner A. Garcia, duly put and carried,

IT IS ORDERED that County Judge Lina Hidalgo or her designee be hereby authorized to approve, and on behalf of Harris County, Texas, to apply for, a grant through the Texas General Land Office:

Halls Bayou Watershed '22 (CDBG-MIT) #2

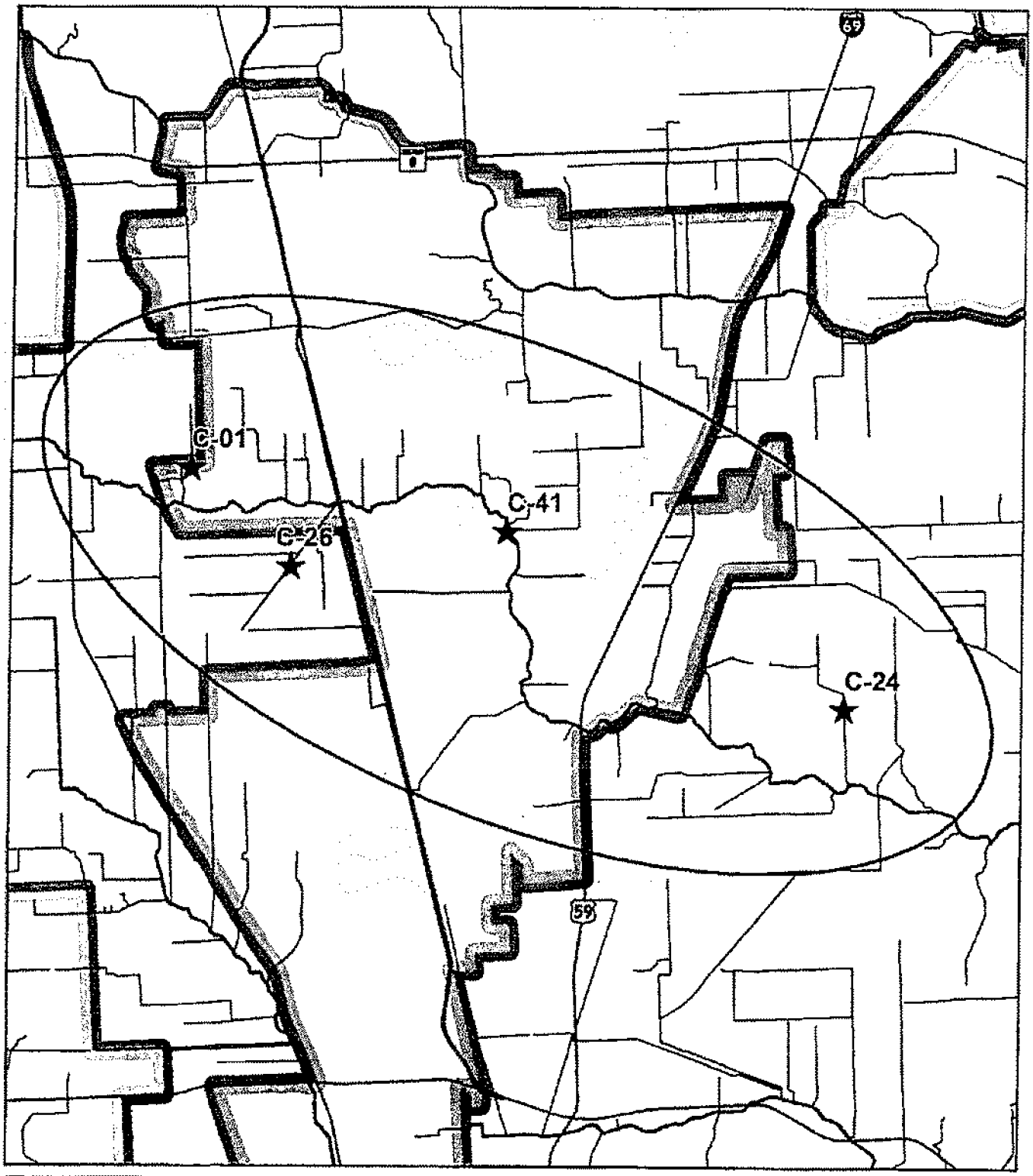
Grant Application Amount:	$100,000,000
Required Match:	$7,278,820.00
Period of Grant:	3/1/21 – 9/1/26

	YES	NO	ABSTAIN
Judge Lina Hidalgo	☑	☐	☐
Comm. Rodney Ellis	☑	☐	☐
Comm. Adrian Garcia	☑	☐	☐
Comm. Steve Radack	☑	☐	☐
Comm. R. Jack Cagle	☑	☐	☐

Presented to Commissioners Court

October 13, 2020

Approve: E/G



CDBG-MIT Project Application
Halls Bayou Watershed

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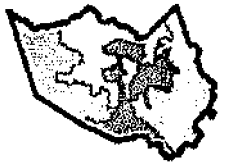


CDBG-MIT Grant Application

Halls Bayou Watershed Application 2

I. SCOPE

The activities in this CDBG-MIT application are designed to provide watershed-wide flood threat reduction measures in Halls Bayou. The Halls Bayou watershed is a historically underserved area of north Harris County, TX. The residents of the watershed have been victim to repeated flooding events, including Tropical Storm Allison, the 2015 and 2016 floods, and Hurricane Harvey. Activities in this application include improvements in both conveyance and detention on both the mainstem of and tributaries of Halls Bayou. This is anticipated to reduce water surface elevations during flood events. A reduction in water surface elevations will remove structures from the floodplain and reduce water surface elevations in structures that are not completely removed from the floodplain.

The application is a combination of four construction activities. While the activities are expected to show greatest benefits at a neighborhood level, engineering analysis has been performed at the watershed level. This combined application is provided for review as part of a holistic, watershed-wide flood risk reduction program.

The four activities included in this application are generally referred to by their Harris County Bond ID. Activities that share a bond ID with other HCFCD activities have been provided with an additional name for clarification.

Activity Name	HCFCD Unit ID	Description of Improvement
C-26	P118-23-00 P118-23-02	Tributary conveyance improvements Tributary detention improvements – approx. 300 ac-ft storage Sub-tributary conveyance improvements
C-24	P118-09-00	Tributary conveyance improvements Tributary detention improvements -approx. 50 ac-ft storage
C-01	P518-26-00 P518-26-01	Tributary conveyance improvements Tributary detention improvements – approx. 120 ac-ft Sub-tributary conveyance improvements
C-41 P118-23-00 Phase II	P118-00-00	Mainstem detention improvements

C-26

The C-26 activity will be located west of Hardy Toll Road with the channel terminating at Canino Road. Sub-tributary P118-23-02 intersects with P118-23-00 near Gulf Bank Road. The activity is currently in the preliminary engineering stage and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in preliminary engineering. This activity has an approximate cost of $31.3 million. The objectives of this activity are twofold: to improve stormwater channel conveyance of P118-23-00 and P118-23-02 and to create approximately 300 ac-ft stormwater detention capacity along P118-23-00 to store stormwater during storm events and release it back into the channels when the threat of flooding has passed.

C-24

The C-24 activity will be located between Cheeves Drive and Rebel Road in the Scenic Woods neighborhood, along P118-09-00, north of the Halls Bayou mainstem. The activity is currently in the alternatives analysis stage and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in analysis. This activity has an approximate cost of $38.5 million. The objective of this activity is twofold: to provide channel stormwater conveyance improvements along P118-09-00 and to provide approximately 50 acre-feet of stormwater detention capacity to store excess stormwater during storm events and release the water back into the tributary once the threat of flooding has passed.

C-01

The C-01 activity will be located along Halls Bayou tributary P118-26-00 north of Halls Bayou and east of Airline Drive, from near Holtman Street to the confluence with Halls Bayou. The activity is currently in the final design stage. The activity has an approximate cost of $20.4 million. The objectives of the activity are twofold: to improve stormwater channel conveyance of Halls Bayou tributary P118-26-00 and sub-tributary P118-26-01 and to create approximately 120 acre-feet of stormwater detention along P118-26-00 to store excess stormwater during storm events and release the water back into the bayou once the threat of flooding has passed. CDBG-MIT funds will be used for the purposes of preliminary engineering, right-of-way acquisition, design, and construction of detention improvements.

C-41 - P118-21-00 Phase II

The P118-21-00 Phase II activity will be located north of the Halls Bayou mainstem and west of Aline Westfield road, ending south of Isom Street. The activity is currently in the preliminary analysis phase and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in analysis. The activity has a total cost of approximately $17.1 million. The objective of the activity is to provide improved stormwater detention capacity along the Halls Bayou mainstem during storm events. This will allow for excess stormwater to be stored during heavy rain events and released back into the bayou when the threat of

flooding has passed. CDBG-MIT funds will be used for the purposes of preliminary engineering, right-of-way acquisition, design, and construction of detention improvements.

I. COST ESTIMATE

The total estimated construction cost of this proposed project is $107,278,820.

$100,000,000 of this cost will be funded by a CDBG-MIT grant. CDBG-MIT funds will be used for the purposes of preliminary engineering, right-of-way acquisition, design, and construction of detention and conveyance improvements.

The remaining $7,278,820 will be funded by HCFCD.

Each Applicant for Community Development Block Grant Mitigation ("CDBG-MIT") funding must complete Federal Assistance Standard Form 424 (SF-424) and certify that local certifications included in this application guide were followed in the preparation of any CDBG-MIT program application. Additionally, Applicant must certify that it will continue to follow local certifications in the event that funding is awarded and Applicant is reclassified as a Subrecipient.

Each Applicant/Subrecipient must comply with the provisions of the National Environmental Policy Act ("NEPA"), the Council on Environmental Quality ("CEQ") regulations, the requirements set forth in Title 24 of the Code of Federal Regulations ("CFR") part 58, and applicable Texas General Land Office policy directives.

Each Applicant/Subrecipient must comply with all applicable federal and state laws, including environmental, labor (Davis-Bacon Act), the procurement procedures and contract requirements found at 2 C.F.R. §200.318 – §200.326, and all civil rights requirements.

Each Applicant/Subrecipient certifies, as outlined in 84 FR 45838 (August 30,2019), the following:

A. The Applicant/Subrecipient certifies that it has in effect and if following a residential anti-displacement and relocation assistance plan in connection with any activity assisted with CDBG-MIT funds.

B. The Applicant/Subrecipient certifies its compliance with restrictions on lobbying as required by 24 C.F.R. part 87, together with disclosure forms, if required by part 87.

C. Any entity or entities designated by the subrecipient, and any contractor, subrecipient, or designated public agency carrying out an activity with CDBG-MIT funds, possess(es) the legal authority to carry out the program for which it is seeking funding, in accordance with applicable HUD regulations and the federal register notice. The subrecipient certifies that activities to be undertaken with CDBG-MIT funds are consistent with the Action Plan.

D. The Applicant/Subrecipient certifies that it will comply with the acquisition and relocation requirements of the Uniform Relocation Act ("URA"), as amended, and implementing regulations at 49 CFR part 24, except where waivers or alternative requirements are provided for CDBG-MIT funds.

E. The Applicant/Subrecipient certifies that it will comply with Section 3 of the Housing and Urban Development Act of 1968 (12 U.S.C. §1701u) and implementing regulations at 24 C.F.R. part 135.

F. The Applicant/Subrecipient certifies that it is following a detailed citizen participation plan that satisfies the requirements of 24 CFR §91.115 or §91.105 (except as provided for in notices providing waivers and alternative requirements for this grant). Also, each local government receiving assistance from a state grantee must follow a detailed citizen participation plan that satisfies the requirements of 24 CFR §570.486 (except as provided for in notices providing waivers and alternative requirements for this grant).

G. The Applicant/Subrecipient certifies that it is complying with each of the following criteria:

1) Funds will be used solely for necessary expenses related to mitigation activities, as applicable, in the most impacted and distressed areas for which the President declared a major disaster in 2015, 2016, or 2017 pursuant to the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974 (42 U.S.C. §5121 et seq.).

2) With respect to activities expected to be assisted with CDBG-MIT funds, the relevant action plan has been developed to give priority to activities that will benefit low- and moderate-income families.

3) The aggregate use of CDBG-MIT funds shall principally benefit low- and moderate-income families in a manner that ensures that at least 50 percent (or another percentage permitted by HUD in a waiver published in an applicable Federal Register notice) of the CDBG-MIT grant amount is expended for activities that benefit such persons.

4) The Applicant/Subrecipient will not attempt to recover any capital costs of public improvements assisted with CDBG-MIT funds by assessing any amount against properties owned and occupied by persons of low- and moderate-income, including any fee charged or assessment made as a condition of obtaining access to such public improvements, unless:

i. CDBG-MIT funds are used to pay the proportion of such fee or assessment that relates to the capital costs of such public improvements that are financed from revenue sources other than under this title; or

ii. For purposes of assessing any amount against properties owned and occupied by persons of moderate income, the grantee certifies to the Secretary that it lacks sufficient CDBG funds (in any form) to comply with the requirements of clause (a).

H. The Applicant/Subrecipient certifies that the grant will be conducted and administered in conformity with title VI of the Civil Rights Act of 1964 (42 U.S.C. §2000d), the Fair Housing Act (42 U.S.C. §3601-§3619), and implementing regulations, and that it will affirmatively further fair housing.

I. The Applicant/Subrecipient certifies that it has adopted and is enforcing the following policies, and, in addition, must certify that they will require local governments that receive grant funds to certify that they have adopted and are enforcing:

1) A policy prohibiting the use of excessive force by law enforcement agencies within its jurisdiction against any individuals engaged in nonviolent civil rights demonstrations;

2) A policy of enforcing applicable state and local laws against physically barring entrance to or exit from a facility or location that is the subject of such nonviolent civil rights demonstrations within its jurisdiction.

J. The Applicant/Subrecipient certifies that it (and any administering entity) currently has or will develop and maintain the capacity to carry out mitigation activities, as applicable, in a timely manner and that the subrecipient has reviewed the respective requirements of this notice.

K. The Applicant/Subrecipient certifies that it will not use CDBG-MIT funds for any activity in an area identified as flood prone for land use or hazard mitigation planning purposes by the state, local, or tribal government or delineated as a Special Flood Hazard Area (or 100-year floodplain) in FEMA's most current flood advisory maps, unless it also ensures that the action is designed or modified to minimize harm to or within the floodplain, in accordance with Executive Order 11988 and 24 C.F.R. part 55. The relevant data source for this provision is the state, local, and tribal government land use regulations and hazard mitigation plans and the latest-issued FEMA data or guidance, which includes advisory data (such as Advisory Base Flood Elevations) or preliminary and final Flood Insurance Rate Maps.

L. The Applicant/Subrecipient certifies that its activities concerning lead-based paint will comply with the requirements of 24 CFR part 35, subparts A, B, I, K, and R.

M. The Applicant/Subrecipient certifies that it will comply with environmental requirements at 24 CFR part 58.

N. The Applicant/Subrecipient certifies that it will comply with applicable laws.

WARNING: ANY PERSON WHO KNOWLINGLY MAKES A FALSE CLAIM OR STATEMENT TO HUD MAY BE SUBJECT TO CIVIL OR CRIMINAL PENALTIES UNDER 18 U.S.C. §287; 18 U.S.C. §1001, AND 31 U.S.C. § 3729.

Except as otherwise provided under federal law, any person who knowingly and willfully falsifies, conceals, or covers up a material fact by any trick, scheme or device or who makes any materially false, fictitious, or fraudulent statement or representation or who makes or uses any false writing or document knowing the writing or document to contain materially false, fictitious, or fraudulent statement or entry shall be prosecuted under Title 18, United States Code, §1001.

COUNTY JUDGE LINA HIDALGO — October 13, 2020

Printed Name of Authorized Signatory — *Date*

Signature of Authorized Signatory

View Burden Statement

OMB Number: 4040-0004
Expiration Date: 12/31/2022

Application for Federal Assistance SF-424

* 1. Type of Submission:	* 2. Type of Application:	* If Revision, select appropriate letter(s):
○ Preapplication	◉ New	
◉ Application	○ Continuation	* Other (Specify):
○ Changed/Corrected Application	○ Revision	

* 3. Date Received:	4. Applicant Identifier:
10/13/2020	

5a. Federal Entity Identifier:	5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:	7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name:	HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD)
* b. Employer/Taxpayer Identification Number (EIN/TIN):	74-6019452
* c. Organizational DUNS:	1740797560000

d. Address:

* Street1:	9900 NORTHWEST FREEWAY
Street2:	
* City:	HOUSTON
County/Parish:	HARRIS COUNTY
* State:	TX: Texas
Province:	
* Country:	USA: UNITED STATES
* Zip / Postal Code:	77092-8601

e. Organizational Unit:

Department Name:	Division Name:
HARRIS CTY FLOOD CONTROL DIST	

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:		* First Name:	ALAN
Middle Name:			
* Last Name:	BLACK		
Suffix:			

Title:	DIRECTOR OF OPERATIONS
Organizational Affiliation:	HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD)
* Telephone Number:	346-286-4260
Fax Number:	
* Email:	Alan.Black@hcfcd.hctx.net

Application for Federal Assistance SF-424

*** 8. Type of Applicant 1: Select Applicant Type:**

D: Special District Government

Type of Applicant 2: Select Applicant Type:

B: County Government

Type of Applicant 3: Select Applicant Type:

*** Other (specify):**

*** 10. Name of Federal Agency:**

HOUSING AND URBAN DEVELOPMENT

11. Catalog of Federal Domestic Assistance Number:

14.228

CFDA Title:

*** 12. Funding Opportunity Number:**

FEDERAL REGISTER / VOL. 84, NO. 169

*** Title:**

CDBG-MIT

13. Competition Identification Number:

N/A

Title:

N/A

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Various flood protection improvements to benefit the Halls Bayou Watershed

Attach supporting documents as specified in agency instructions.

View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: ATTACH
* b. Program/Project: ATTACH

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 03/01/2021
* b. End Date: 09/01/2026

18. Estimated Funding ($):

* a. Federal	100,000,000.00
* b. Applicant	7,278,820.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	107,278,820.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

- ○ a. This application was made available to the State under the Executive Order 12372 Process for review on .
- ○ b. Program is subject to E.O. 12372 but has not been selected by the State for review.
- ◉ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

○ Yes ◉ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☑ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix:	
* First Name:	LINA
Middle Name:	
* Last Name:	HIDALGO
Suffix:	
* Title:	HARRIS COUNTY JUDGE
* Telephone Number:	(713)274-7000
Fax Number:	
* Email:	JUDGE.HIDALGO@CJO.HCTX.NET
* Signature of Authorized Representative:	[redacted]
* Date Signed:	10/13/2020

CDBG-MIT Grant Application

Halls Bayou Watershed Application 2

I. SCOPE

The activities in this CDBG-MIT application are designed to provide watershed-wide flood threat reduction measures in Halls Bayou. The Halls Bayou watershed is a historically underserved area of north Harris County, TX. The residents of the watershed have been victim to repeated flooding events, including Tropical Storm Allison, the 2015 and 2016 floods, and Hurricane Harvey. Activities in this application include improvements in both conveyance and detention on both the mainstem of and tributaries of Halls Bayou. This is anticipated to reduce water surface elevations during flood events. A reduction in water surface elevations will remove structures from the floodplain and reduce water surface elevations in structures that are not completely removed from the floodplain.

The application is a combination of four construction activities. While the activities are expected to show greatest benefits at a neighborhood level, engineering analysis has been performed at the watershed level. This combined application is provided for review as part of a holistic, watershed-wide flood risk reduction program.

The four activities included in this application are generally referred to by their Harris County Bond ID. Activities that share a bond ID with other HCFCD activities have been provided with an additional name for clarification.

Activity Name	**HCFCD Unit ID**	**Description of improvement**
C-26	P118-23-00 P118-23-02	Tributary conveyance improvements Tributary detention improvements – approx. 300 ac-ft storage Sub-tributary conveyance improvements
C-24	P118-09-00	Tributary conveyance improvements Tributary detention improvements -approx. 50 ac-ft storage
C-01	P518-26-00 P518-26-01	Tributary conveyance improvements Tributary detention improvements – approx. 120 ac-ft Sub-tributary conveyance improvements
C-41 P118-23-00 Phase II	P118-00-00	Mainstem detention improvements

C-26

The C-26 activity will be located west of Hardy Toll Road with the channel terminating at Canino Road. Sub-tributary P118-23-02 intersects with P118-23-00 near Gulf Bank Road. The activity is currently in the preliminary engineering stage and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in preliminary engineering. This activity has an approximate cost of $31.3 million. The objectives of this activity are twofold: to improve stormwater channel conveyance of P118-23-00 and P118-23-02 and to create approximately 300 ac-ft stormwater detention capacity along P118-23-00 to store stormwater during storm events and release it back into the channels when the threat of flooding has passed.

C-24

The C-24 activity will be located between Cheeves Drive and Rebel Road in the Scenic Woods neighborhood, along P118-09-00, north of the Halls Bayou mainstem. The activity is currently in the alternatives analysis stage and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in analysis. This activity has an approximate cost of $38.5 million. The objective of this activity is twofold: to provide channel stormwater conveyance improvements along P118-09-00 and to provide approximately 50 acre-feet of stormwater detention capacity to store excess stormwater during storm events and release the water back into the tributary once the threat of flooding has passed.

C-01

The C-01 activity will be located along Halls Bayou tributary P118-26-00 north of Halls Bayou and east of Airline Drive, from near Holtman Street to the confluence with Halls Bayou. The activity is currently in the final design stage. The activity has an approximate cost of $20.4 million. The objectives of the activity are twofold: to improve stormwater channel conveyance of Halls Bayou tributary P118-26-00 and sub-tributary P118-26-01 and to create approximately 120 acre-feet of stormwater detention along P118-26-00 to store excess stormwater during storm events and release the water back into the bayou once the threat of flooding has passed. CDBG-MIT funds will be used for the purposes of preliminary engineering, right-of-way acquisition, design, and construction of detention improvements.

C-41 - P118-21-00 Phase II

The P118-21-00 Phase II activity will be located north of the Halls Bayou mainstem and west of Aline Westfield road, ending south of Isom Street. The activity is currently in the preliminary analysis phase and the exact activity limits are still being studied. The opinions of probable cost have been adjusted to reflect the degree of uncertainty associated with an activity still in analysis. The activity has a total cost of approximately $17.1 million. The objective of the activity is to provide improved stormwater detention capacity along the Halls Bayou mainstem during storm events. This will allow for excess stormwater to be stored during heavy rain events and released back into the bayou when the threat of

flooding has passed. CDBG-MIT funds will be used for the purposes of preliminary engineering, right-of-way acquisition, design, and construction of detention improvements.

I. COST ESTIMATE

The total estimated construction cost of this proposed project is $107,278,820.

$100,000,000 of this cost will be funded by a CDBG-MIT grant. CDBG-MIT funds will be used for the purposes of preliminary engineering, right-of-way acquisition, design, and construction of detention and conveyance improvements.

The remaining $7,278,820 will be funded by HCFCD.

See the attached “CDBT-MIT: Budget Justification of Retail Costs (Former Table 2)” for a detailed breakdown of the estimated construction costs.

II. ATTACHMENTS

Project Budget Sheets

Project Area Map

Project Beneficiary Map

CDBG-MIT: Budget Justification of Retail Costs
(Former Table 2)

Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

Applicant/Subrecipient:	Harris County Flood Control District
Site/Activity Title:	Halls Bayou Watershed CDBG-MIT Application 2 - Activity C-26
Eligible Activity:	Construction Activities

Materials/Facilities/Services	**$/Unit**	**Unit**	**Quantity**	**Construction**	**Acquisition**	**Total**
Basin Excavation P118-23-00						
Clearing and Grubbing	$ 7,500.00	Acre	50	$ 377,203.34	$ -	$ 377,203.34
Demolition	$ 465,000.00	LS	1	$ 465,000.00	$ -	$ 465,000.00
Excavation & Offsite Disposal	$ 14.00	CY	495000	$ 6,930,000.00	$ -	$ 6,930,000.00
10% Miscellaneous	$ -		0	$ 777,220.33	$ -	$ 777,220.33
Subtotal	$ -		0	$ -	$ -	$ 8,549,423.67
Rectangular Concrete-Lined Channel P118-23-02						
Concrete Lining	$ 110.00	SY	20000	$ 2,200,000.00	$ -	$ 2,200,000.00
Concrete Wall Lining	$ 250.00	SY	4000	$ 1,000,000.00	$ -	$ 1,000,000.00
Excavation & Offsite Disposal	$ 14.00	CY	10000	$ 140,000.00	$ -	$ 140,000.00
Pipeline Relocation	$ 3,750,000.00	LS	1	$ 3,750,000.00	$ -	$ 3,750,000.00
Utility Adjustment	$ 1,500,000.00	LS	1	$ 1,500,000.00	$ -	$ 1,500,000.00
10% Miscellaneous	$ -		0	$ 859,000.00	$ -	$ 859,000.00
Subtotal	$ -		0	$ -	$ -	$ 9,449,000.00
Subtotal DCC	$ -		0	$ -	$ -	$ 17,998,423.67
5% Mob/Demob	$ 899,921.18	LS	1	$ 899,921.18	$ -	$ 899,921.18
ROW Acquisition	$ 7,307,874.00	LS	1	$ 7,307,874.00	$ -	$ 7,307,874.00
ROW Relocations	$ 606,355.00	LS	1	$ 606,355.00	$ -	$ 606,355.00
12% Planning and Engineering	$ -		0	$ 2,159,810.84	$ -	$ 2,159,810.84
10% Construction Management	$ -		0	$ 1,799,842.37	$ -	$ 1,799,842.37
3% Management / Design Management	$ -		0	$ 539,952.71	$ -	$ 539,952.71
TOTAL				$ 31,312,179.78	$ -	$ 31,312,179.78

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

This project along with all HCFCD CDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFCD. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFCD are included in this budget

2. Identify and explain any special engineering activities.

Date:	
Phone Number:	

Seal

Signature of Registered Engineer/Architect Responsible For Budget Justification:

CDBG-MIT: Budget Justification of Retail Costs
(Former Table 2)

Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

Applicant/Subrecipient:	Harris County Flood Control District
Site/Activity Title:	Halls Bayou Watershed CDBG-MIT Application 2 - Activity C24
Eligible Activity:	Construction Activities

Materials/Facilities/Services	**$/Unit**	**Unit**	**Quantity**	**Construction**	**Acquisition**	**Total**
CLEARING (& GRUBBING) - BASIN	$ 7,000.00	AC	8.33	$ 58,333.33	$ -	$ 58,333.33
CLEARING (& GRUBBING) - CHANNEL	$ 7,000.00	AC	13.00	$ 91,000.00	$ -	$ 91,000.00
EXCAVATION & OFF-SITE DISPOSAL (Basin)	$ 14.00	CY	85,506.00	$ 1,197,084.00	$ -	$ 1,197,084.00
EXCAVATION & OFF-SITE DISPOSAL (Channel)	$ 14.00	CY	81,770.00	$ 1,144,780.00	$ -	$ 1,144,780.00
20% Miscellaneous	$ -		0	$ 498,239.47	$ -	$ 498,239.47
Subtotal DCC	$ -		0	$ -	$ -	$ 2,989,436.80
5% Mob/Demob	$ 149,471.84	LS	1.00	$ 149,471.84	$ -	$ 149,471.84
Pipeline Relocations	$ 8,450,000.00	LS	1.00	$ 8,450,000.00	$ -	$ 8,450,000.00
ROW Acquisition	$ 13,547,679.00		1.00	$ -	$ 13,547,679.00	$ 13,547,679.00
ROW Relocations	$ 12,614,113.00	LS	1.00	$ 12,614,113.00	$ -	$ 12,614,113.00
12% Planning and Engineering	$ -		0	$ 358,732.42	$ -	$ 358,732.42
10% Construction Management	$ -		0	$ 298,943.68	$ -	$ 298,943.68
3% Management / Design Management	$ -		0	$ 89,683.10	$ -	$ 89,683.10
TOTAL				$ 24,950,380.84	$ 13,547,679.00	$ 38,498,059.84

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

This project along with all HCFCD CDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFCD. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFCD are included in this budget

2. Identify and explain any special engineering activities.

Date:	
Phone Number:	

Seal

Signature of Registered Engineer/Architect Responsible For Budget Justification:

CDBG-MIT: Budget Justification of Retail Costs
(Former Table 2)

Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

Applicant/Subrecipient:	Harris County Flood Control District
Site/Activity Title:	Halls Bayou Watershed CDBG-MIT Application 2 - Activity C-01
Eligible Activity:	Construction Activities

Materials/Facilities/Services	$/Unit	Unit	Quantity	Construction	Acquisition	Total
North Basin						
Excavation & Off-Site Disposal	$ 15	CY	117,859	$ 1,767,879	$ -	$ 1,767,879
Backslope Drainage System Swales	$ 3	LF	1980	$ 5,940	$ -	$ 5,940
Concrete Interceptor Structure	$ 120	SY	100	$ 12,000	$ -	$ 12,000
6'x9' RCB	$ 850	LF	170	$ 144,500	$ -	$ 144,500
Subtotal	$ -		0	$ -	$ -	$ 1,930,319
South Basin						
Excavation & Off-Site Disposal	$ 15	CY	51,294	$ 769,404	$ -	$ 769,404
Backslope Drainage System Swales	$ 3	LF	1450	$ 4,350	$ -	$ 4,350
Concrete Interceptor Structure	$ 120	SY	100	$ 12,000	$ -	$ 12,000
72" RCP	$ 450	LF	100	$ 45,000	$ -	$ 45,000
Subtotal	$ -		0	$ -	$ -	$ 830,754
Storm Sewer						
Backslope Drainage System Swales	$ 3	LF	4,700	$ 14,100	$ -	$ 14,100
Concrete Interceptor Structure	$ 120	SY	70	$ 8,400	$ -	$ 8,400
Clearing and Grubbing	$ 7,000	AC	6	$ 42,000	$ -	$ 42,000
Excavation and Disposal	$ 15	CY	56,000	$ 840,000	$ -	$ 840,000
Excavation and Fill (On-site Material)	$ 5	CY	5,700	$ 28,500	$ -	$ 28,500
Cement Stabilization Sand Backfill	$ 115	CY	426	$ 48,990	$ -	$ 48,990
9'x9' RCB	$ 945	LF	10,890	$ 10,291,050	$ -	$ 10,291,050
10'x10' RCB (Enclosure along Helms RD)	$ 1,000	LF	600	$ 600,000	$ -	$ 600,000
Headwalls and Wingwalls	$ 1,200	CY	130	$ 156,000	$ -	$ 156,000
Concrete Pavement 6"	$ 49	SY	666	$ 32,634	$ -	$ 32,634
Backslope Drainage Interceptor Structure for 24" CMP	$ 4,200	EA	36	$ 152,460	$ -	$ 152,460
Turf Establishment	$ 1,400	AC	31	$ 43,400	$ -	$ 43,400
Silt Fencing with Wire Reinforcement	$ 2.36	LF	9,801	$ 23,130	$ -	$ 23,130
Subtotal	$ -		0	$ -	$ -	$ 12,280,664
Pipeline Crossings	$ 500,000	EA	1	$ 500,000	$ -	$ 500,000
Subtotal DCC	$ -		0	$ -	$ -	$ 15,041,737
5% Mob/Demob	$ 752,087	LS	1	$ 752,087	$ -	$ 752,087
ROW Acquisition	$ 222,300	LS	1	$ 222,300	$ -	$ 222,300.00
ROW Acquisition - TCEs	$ 75,000	LS	1	$ 75,000	$ -	$ 75,000.00
12% Planning and Engineering	$ -		0	$ 1,805,008.42	$ -	$ 1,805,008
10% Construction Management	$ -		0	$ 1,504,173.68	$ -	$ 1,504,174
3% Management / Design Management	$ -		0	$ 451,252.11	$ -	$ 451,252
TOTAL				$ 20,351,557.89	$ -	$ 20,351,557.89

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

This project along with all HCFCD CDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFCD. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFCD are included in this budget

2. Identify and explain any special engineering activities.

Date:	
Phone Number:	

Seal

Signature of Registered Engineer/Architect Responsible For Budget Justification:

CDBG-MIT: Budget Justification of Retail Costs
(Former Table 2)

Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

Applicant/Subrecipient:	Harris County Flood Control District
Site/Activity Title:	Halls Bayou Watershed CDBG-MIT Application 2 - Activity P118-21-00 Phase II
Eligible Activity:	Construction Activities

Materials/Facilities/Services	**$/Unit**	**Unit**	**Quantity**	**Construction**	**Acquisition**	**Total**
Rem. & Dis. of Channel Lining	$ 10	SY	13,000	$ 130,000.00	$ -	$ 130,000.00
Clearing and Grubbing	$ 5,000	AC	35	$ 175,000.00	$ -	$ 175,000.00
Excavation & Off-site Disposal	$ 14	CY	716,400	$ 10,029,600.00	$ -	$ 10,029,600.00
Concrete Interceptor Structure	$ 150	SY	33	$ 4,950.00	$ -	$ 4,950.00
24" CMP	$ 70	LF	240	$ 16,800.00	$ -	$ 16,800.00
15% Miscellaneous	$ -		0	$ 1,553,452.50	$ -	$ 1,553,452.50
Subtotal DCC	$ -		0	$ -	$ -	$ 11,909,802.50
5% Mob/Demob	$ 595,490.13	LS	1	$ 595,490.13	$ -	$ 595,490.13
ROW Acquisition	$ 1,634,278.80	LS	1	$ -	$ 1,634,278.80	$ 1,634,278.80
12% Planning and Engineering	$ -		0	$ 1,429,176.30	$ -	$ 1,429,176.30
10% Construction Management	$ -		0	$ 1,190,980.25	$ -	$ 1,190,980.25
3% Management/Design Management	$ -		0	$ 357,294.08	$ -	$ 357,294.08
TOTAL				$ 15,482,743.25	$ 1,634,278.80	$ 17,117,022.05

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

This project along with all HCFCD CDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFCD. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFCD are included in this budget

2. Identify and explain any special engineering activities.

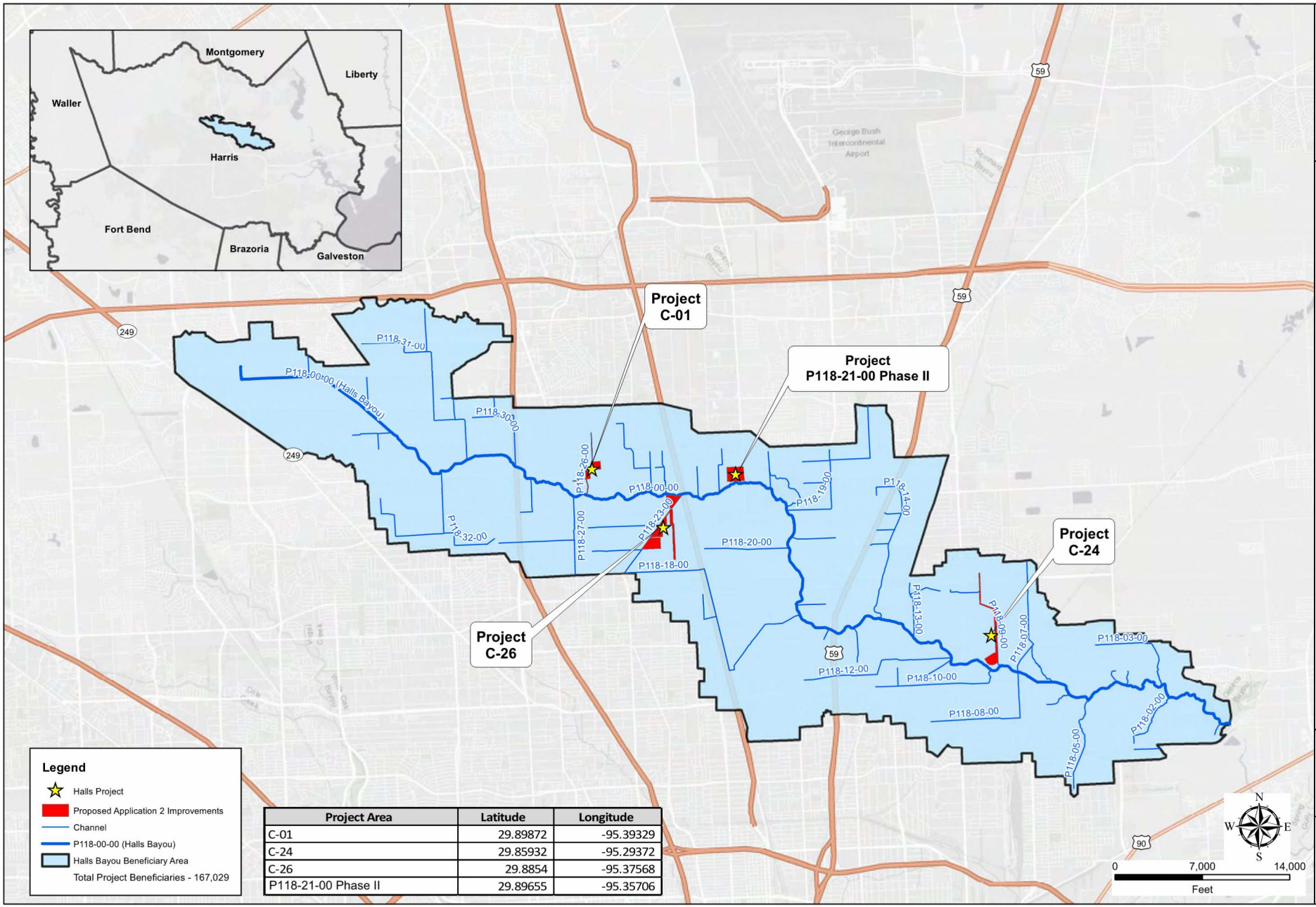
Date:	
Phone Number:	

Seal

Signature of Registered Engineer/Architect Responsible For Budget Justification:

PROJECT AREA

MAP



Legend

- Halls Project
- Proposed Application 2 Improvements
- Channel
- P118-00-00 (Halls Bayou)
- Halls Bayou Beneficiary Area

Total Project Beneficiaries - 167,029

Project Area	Latitude	Longitude
C-01	29.89872	-95.39329
C-24	29.85932	-95.29372
C-26	29.8854	-95.37568
P118-21-00 Phase II	29.89655	-95.35706

FN PROJECT NO: SCG17297
DATE CREATED: 9/28/2020
DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
FILE NAME: Halls_Project_Area_Map_App2
PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed - CDBG-MIT Application 2

FREESE NICHOLS

EXHIBIT
1

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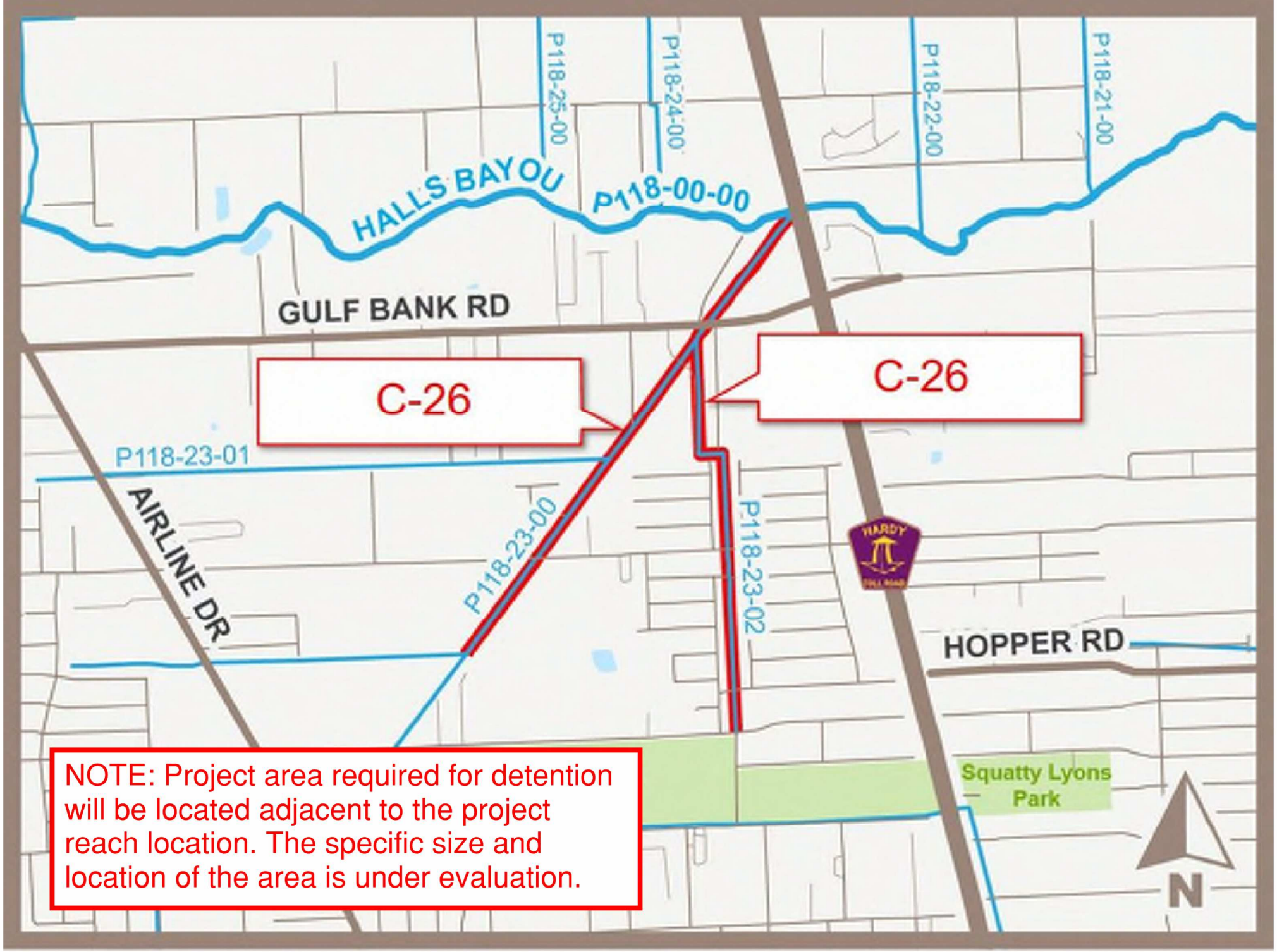
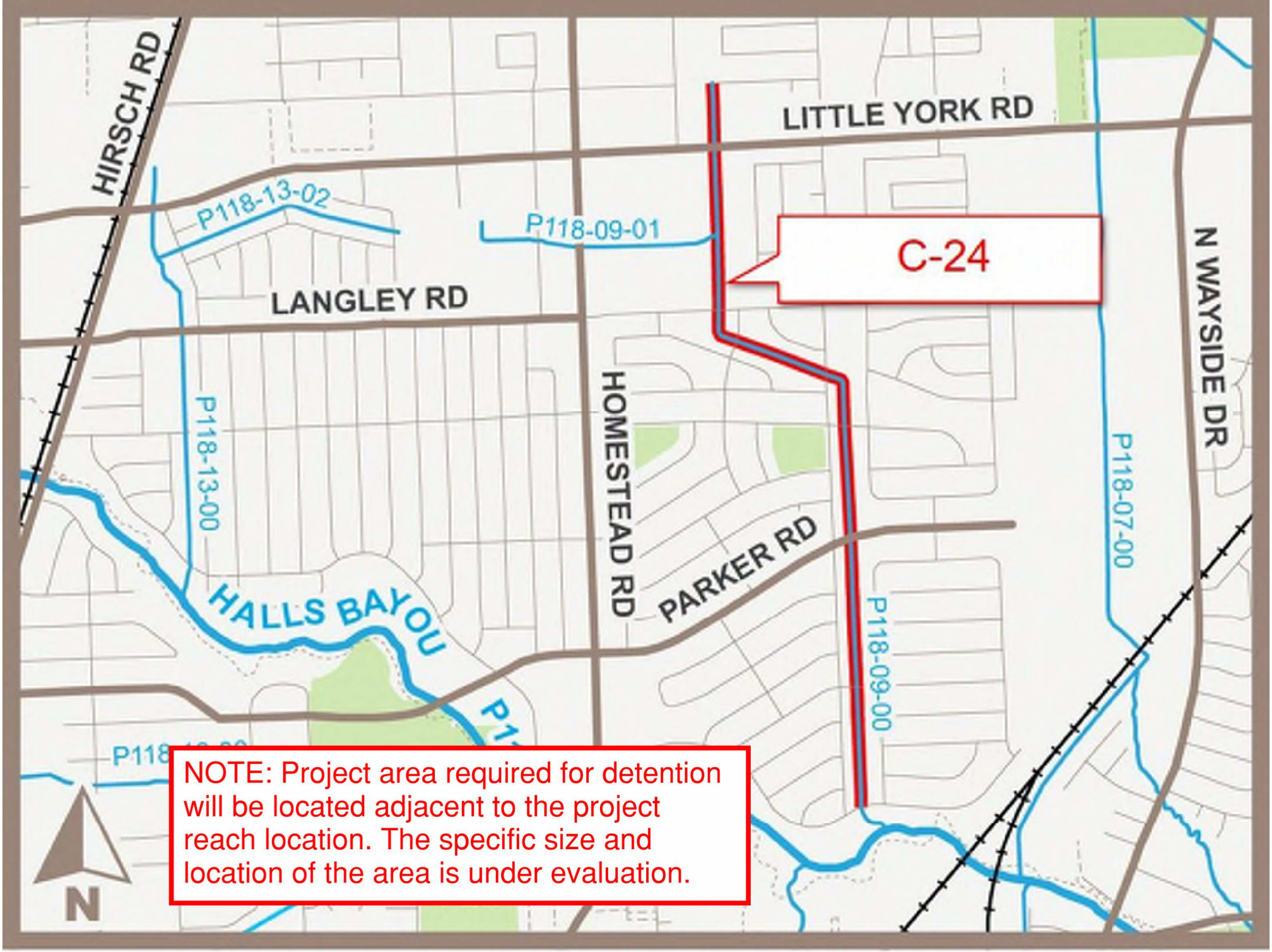

P118-25-00
P118-24-00
P118-22-00
P118-21-00
HALLS BAYOU
P118-00-00
GULF BANK RD
C-26
C-26
P118-23-01
AIRLINE DR
P118-23-00
P118-23-02
HARDY TOLL ROAD
HOPPER RD
Squatty Lyons Park
N
NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
PROJECT REACH


HIRSCH RD
LITTLE YORK RD
P118-13-02
P118-09-01
C-24
LANGLEY RD
N WAYSIDE DR
P118-13-00
HOMESTEAD RD
P118-07-00
PARKER RD
HALLS BAYOU
P118-09-00
NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
N
PROJECT REACH

PROJECT AREA MAP
BOND ID C-01

HALLS BAYOU WATERSHED
CDBG-MIT APPLICATION 2

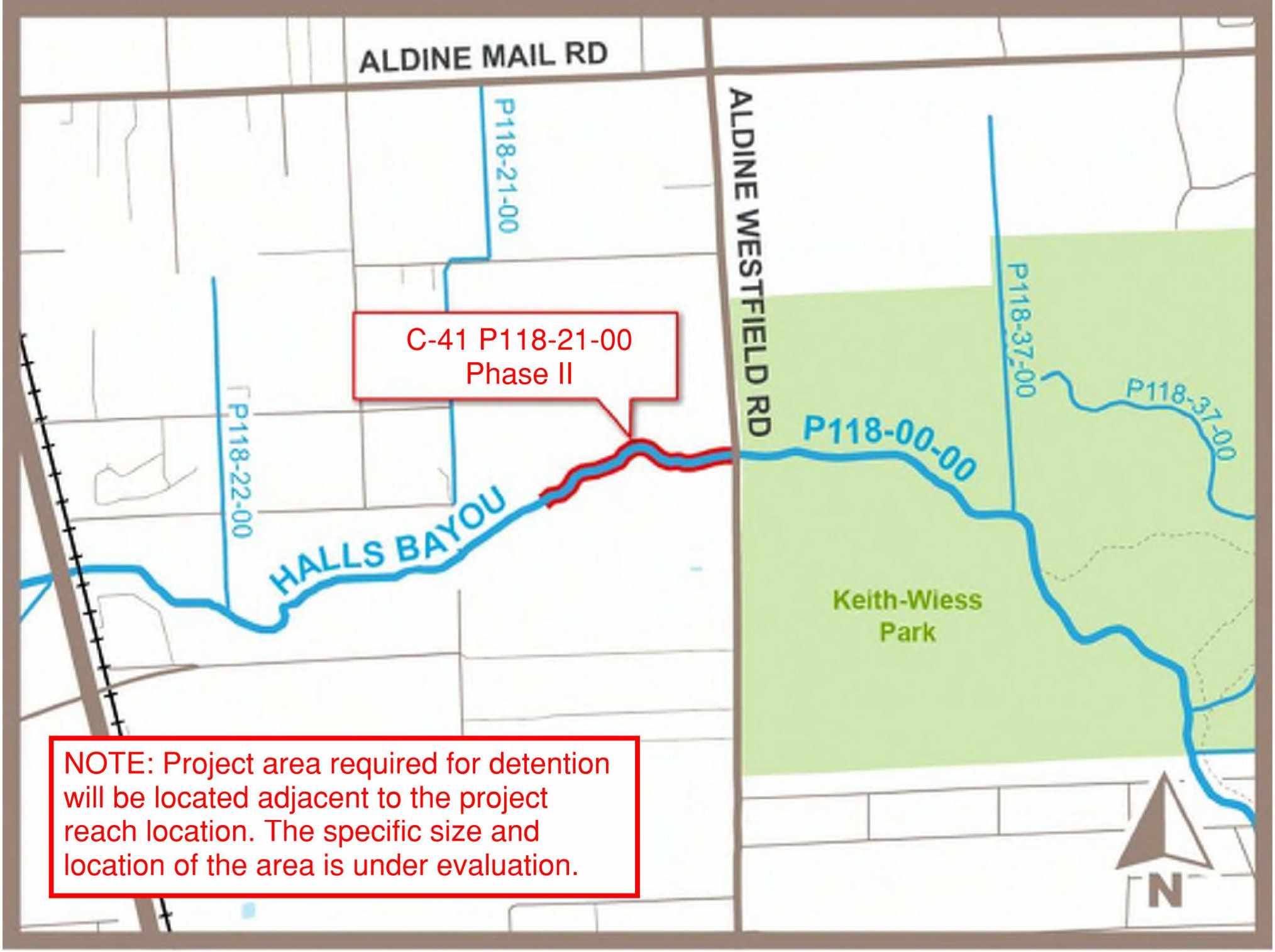
PREPARED: TMM
CHECKED:
APPROVED:

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FREESE NICHOLS

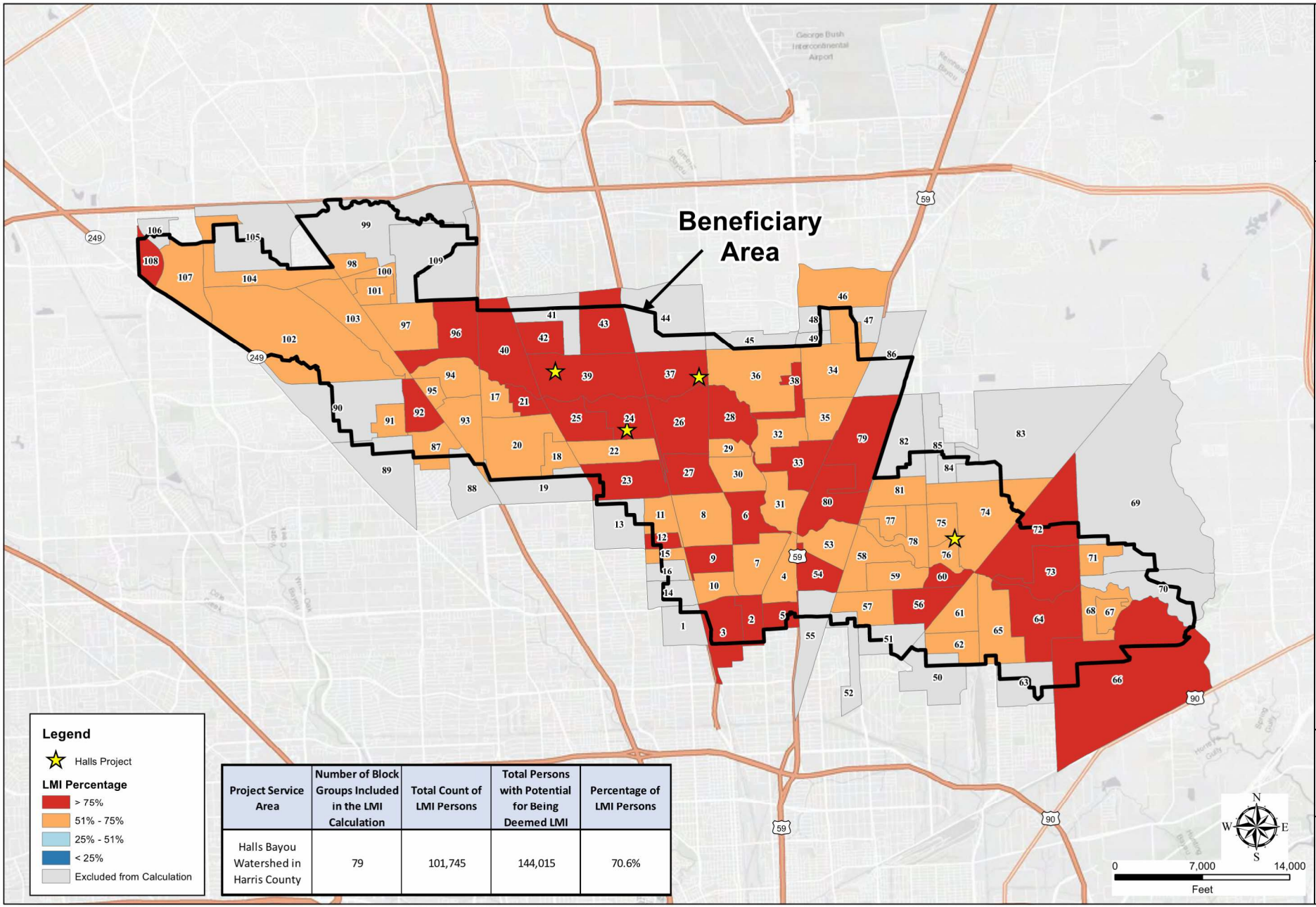
HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

DATE: SEPT., 2020
SCALE: AS NOTED

EXHIBIT 1
PAGE 1


ALDINE MAIL RD
ALDINE WESTFIELD RD
P118-21-00
P118-22-00
P118-37-00
P118-37-00
P118-00-00
C-41 P118-21-00
Phase II
HALLS BAYOU
Keith-Wiess
Park
N
NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
PROJECT REACH

PROJECT BENEFICIARY MAP



Project Service Area	Number of Block Groups Included in the LMI Calculation	Total Count of LMI Persons	Total Persons with Potential for Being Deemed LMI	Percentage of LMI Persons
Halls Bayou Watershed in Harris County	79	101,745	144,015	70.6%

FN PROJECT NO: SCG17287
DATE CREATED: 9/28/2020
DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
FILE NAME: Halls_Project_Area_Map_LMI_1_App2
PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed Beneficiary CDBG-MIT Application 2

EXHIBIT
2
(1 of 2)

Date Saved: 9/28/2020 3:42:50 PM

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Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
1	482012206001	57	2,814	2%	No	75.7%
2	482012207001	889	909	98%	Yes	84.0%
3	482012207005	1,623	2,396	68%	Yes	75.3%
4	482012209001	1,047	1,047	100%	Yes	73.6%
5	482012209002	675	749	90%	Yes	76.4%
6	482012210001	1,706	1,706	100%	Yes	77.4%
7	482012210002	2,499	2,499	100%	Yes	70.7%
8	482012211001	1,471	1,471	100%	Yes	73.2%
9	482012211002	1,290	1,294	100%	Yes	83.3%
10	482012211003	1,065	1,065	100%	Yes	67.3%
11	482012212001	1,852	2,039	91%	Yes	70.7%
12	482012212002	896	1,239	72%	Yes	84.3%
13	482012212003	671	3,454	19%	No	73.2%
14	482012213001	773	2,018	38%	No	72.4%
15	482012213002	774	1,263	61%	Yes	61.1%
16	482012213003	991	1,732	57%	No	65.7%
17	482012216001	1,997	2,001	100%	Yes	54.2%
18	482012216002	993	993	100%	Yes	69.1%
19	482012216003	343	1,702	20%	No	68.6%
20	482012216004	3,327	3,327	100%	Yes	57.8%
21	482012216005	1,838	1,838	100%	Yes	86.5%
22	482012217001	1,795	1,795	100%	Yes	54.9%
23	482012217002	1,272	1,644	77%	Yes	87.9%
24	482012217003	2,305	2,305	100%	Yes	79.8%
25	482012217004	2,496	2,496	100%	Yes	85.5%
26	482012218001	2,739	2,742	100%	Yes	78.0%
27	482012218002	1,258	1,258	100%	Yes	93.8%
28	482012219001	1,678	1,678	100%	Yes	81.5%
29	482012219002	1,010	1,010	100%	Yes	57.7%
30	482012219003	2,102	2,102	100%	Yes	72.0%
31	482012220001	2,373	2,376	100%	Yes	65.5%
32	482012221001	3,177	3,177	100%	Yes	58.9%
33	482012221002	2,440	2,440	100%	Yes	82.8%
34	482012222001	2,014	2,030	99%	Yes	53.6%
35	482012222002	1,687	1,687	100%	Yes	59.2%
36	482012223001	1,922	1,928	100%	Yes	70.0%
37	482012223002	1,564	1,564	100%	Yes	80.0%
38	482012223003	1,428	1,428	100%	Yes	89.9%
39	482012224011	1,368	1,368	100%	Yes	85.7%
40	482012224012	1,890	1,895	100%	Yes	76.9%
41	482012224021	1,407	2,971	47%	No	53.9%
42	482012224022	740	740	100%	Yes	97.9%
43	482012224023	2,258	2,706	83%	Yes	82.9%
44	482012228002	1,078	1,828	59%	No	70.6%
45	482012229004	225	2,238	10%	No	60.1%
46	482012230011	2,722	3,228	84%	Yes	73.7%
47	482012230012	19	1,237	2%	No	70.9%
48	482012230021	540	1,721	31%	No	63.0%
49	482012230022	375	2,149	17%	No	92.4%
50	482012302004	325	1,675	19%	No	56.5%
51	482012303001	830	1,451	57%	No	73.5%
52	482012304001	236	829	28%	No	84.8%
53	482012305001	672	672	100%	Yes	59.9%
54	482012305002	1,927	1,927	100%	Yes	76.5%
55	482012305003	303	1,138	27%	No	58.4%
56	482012306001	932	932	100%	Yes	81.8%
57	482012306002	1,895	1,895	100%	Yes	70.9%
58	482012307001	842	842	100%	Yes	64.7%
59	482012307002	1,633	1,633	100%	Yes	62.3%
60	482012307003	398	398	100%	Yes	82.7%

Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
61	482012308001	1,300	1,300	100%	Yes	67.7%
62	482012308002	1,223	1,223	100%	Yes	57.2%
63	482012309001	229	1,147	20%	No	68.9%
64	482012310001	2,606	2,609	100%	Yes	80.6%
65	482012310002	1,806	1,831	99%	Yes	70.2%
66	482012311001	1,548	1,645	94%	Yes	94.0%
67	482012311002	2,123	2,123	100%	Yes	58.1%
68	482012311003	1,099	1,099	100%	Yes	64.9%
69	482012312001	1,832	3,126	59%	No	85.8%
70	482012312002	369	1,793	21%	No	76.2%
71	482012312003	2,079	2,079	100%	Yes	61.8%
72	482012313001	1,640	1,750	94%	Yes	83.1%
73	482012313002	2,865	2,865	100%	Yes	78.6%
74	482012314001	2,645	2,645	100%	Yes	60.9%
75	482012315001	2,015	2,015	100%	Yes	61.0%
76	482012315002	985	985	100%	Yes	73.8%
77	482012316001	1,248	1,251	100%	Yes	59.1%
78	482012316002	1,885	1,885	100%	Yes	63.7%
79	482012317001	2,604	2,604	100%	Yes	81.9%
80	482012317002	839	839	100%	Yes	82.4%
81	482012318001	1,067	1,067	100%	Yes	69.3%
82	482012318002	309	1,858	17%	No	65.7%
83	482012319002	151	2,509	6%	No	32.6%
84	482012319003	872	1,470	59%	No	78.0%
85	482012319004	116	1,367	8%	No	100.0%
86	482012321002	981	2,788	35%	No	81.9%
87	482015333001	2,002	2,247	89%	Yes	70.6%
88	482015333002	283	2,631	11%	No	97.8%
89	482015334001	336	2,315	15%	No	62.8%
90	482015334002	3,540	5,941	60%	No	66.5%
91	482015334003	2,318	2,318	100%	Yes	72.7%
92	482015334004	1,601	1,601	100%	Yes	76.2%
93	482015335001	2,467	2,467	100%	Yes	63.0%
94	482015335002	1,110	1,110	100%	Yes	70.4%
95	482015335003	780	780	100%	Yes	50.0%
96	482015336001	748	748	100%	Yes	81.9%
97	482015336002	4,720	4,720	100%	Yes	62.6%
98	482015337012	2,416	2,416	100%	Yes	69.6%
99	482015337013	226	1,804	13%	No	72.9%
100	482015337021	1,311	1,311	100%	Yes	60.0%
101	482015337022	2,446	2,446	100%	Yes	72.5%
102	482015338011	7,905	8,982	88%	Yes	61.0%
103	482015338012	2,069	2,069	100%	Yes	53.0%
104	482015338021	1,448	1,981	73%	Yes	73.7%
105	482015338022	1,563	3,874	40%	No	68.9%
106	482015339012	354	1,112	32%	No	34.1%
107	482015339013	5,099	5,099	100%	Yes	59.2%
108	482015339022	3,198	3,198	100%	Yes	84.3%
109	482015337011	0	1,531	0%	No	100.0%

FN PROJECT NO: SCG17397
DATE CREATED: 9/28/2020
DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
FILE NAME: Halls_Project_Area_Map_LMI_2
PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed Beneficary Area Table

EXHIBIT
2
(2 of 2)

Innovative approaches
Practical results
Outstanding service

BENEFIT-COST ANALYSIS

HALLS BAYOU WATERSHED CDBG-MIT APPLICATION 2 COVERED PROJECT

Prepared for:

Harris County Flood Control District

October 2020

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

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APPENDICES

EXECUTIVE SUMMARY

The benefit-cost analysis performed for Halls Bayou Watershed CDBG-MIT Application 2 Covered Project included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

Net present value benefits were calculated using a 7% discount rate. *Table ES-1* summarizes benefits on an annual basis and at present value.

Table ES-1 – Summary of Project Benefits

Expected Benefits	Annual Benefit	Present Value Benefit
Structures + Contents	$ 325,868	$ 4,494,711
Displacement, Residential	$ 12,642	$ 174,464
Displacement, Non-residential	$ 1,691	$ 23,343
Social (Mental Health & Productivity)	$ 5,927,702	$ 81,806,705
Environmental (Ecosystem services of converted land)	$ 454,448	$ 6,271,716
Total Expected Benefits (all categories)	**$ 6,722,168**	**$ 92,770,939**

Social benefits represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

Social benefits of the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project are shown in *Table ES-2*.

Table ES-2 – Summary of Social Benefits

Category	Number of Persons	Benefit per Person	Present Value Social Benefits
Number of Persons Directly Benefitted by Mitigation of Residential Structural Flooding	9216	$ 2,443	$ 22,513,702
Number of Full-time Workers Directly Benefitted by Mitigation of Residential Structural Flooding	6787	$ 8,736	$ 59,293,004
Total Social Benefit			**$ 81,806,705**

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. The Halls Bayou Watershed CDBG-MIT Application 2 Covered Project requires some acquisition and conversion of developed land to undeveloped floodplain or detention space. The benefit value for Green Open Space has been applied to these areas. Environmental benefits of the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project are summarized in *Table ES-3*.

Table ES-3 – Summary of Environmental Benefits

Post-Mitigation Land Use	Acres Converted	Benefit per Acre per Year	Annual Benefits	Present Value Benefits
Green Open Space	54.7	$8,308	$ 454,448	$ 6,271,716
Riparian		$39,545	$ -	$ -
Wetlands		$6,010	$ -	$ -
Forests		$554	$ -	$ -
Marine / Estuary		$1,799	$ -	$ -
Total Environmental Benefit			**$ 454,448**	**$ 6,271,716**

In addition to environmental benefits, social benefits, and reduced structural damages and displacement costs, the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project represents a holistic benefit to its service area, the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project, by removing structures and land area from the floodplain. *Table ES-4* summarizes the impacts of the mitigation project.

Table ES-4 – Impacts of Mitigation Project

Number of structures benefitted in any event *(estimated losses to structural damage are reduced)*	3136
Number of structures removed from 10% AEP (10-year) floodplain	128
Number of structures removed from 1% AEP (100-year) floodplain	294
Number of acres removed from 10% AEP (10-year) floodplain	254
Number of acres removed from 1% AEP (100-year) floodplain	375
Number of structures removed from risk* in 10% AEP (10-year) event	0
Number of structures removed from risk* in 1% AEP (100-year) event	21

**Structures "at risk" refer to those for which the modeled water surface elevation is at or above finished floor elevation.*

Project costs as estimated for the CDBG-MIT grant application include estimated costs of design and construction. The benefit-cost ratio was determined as the ratio of the present value of Total Expect Benefits to Total Project Cost; this ratio is presented in *Table ES-5*. It is important to note that the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project will provide many community benefits for which an economic value could not be quantified as part of this analysis. Additional unquantified benefits are discussed further in the section on **Qualitative Benefits**.

Table ES-5 – Benefit-Cost Ratio

Present Value Total Benefits	**$92,770,939**
Present Value Total Cost	**$107,278,820**
Benefit-Cost Ratio	**0.87**

1.0 METHODOLOGY

1.1 BENEFIT-COST ANALYSIS REQUIREMENTS FOR CDBG-MIT PROJECTS

Although a benefit-cost ratio (BCR) is not a factor in the competition score as set forth by the Texas General Land Office (GLO), applicants are required to demonstrate that the benefits of any Covered Project outweigh its costs. As described in the Federal Register,[1] this requirement may be met in either of two ways:

1. Benefit-cost ratio developed during a benefit-cost analysis (BCA) is greater than 1.0.
    a. Calculations should be prepared in accordance with OMB Circular A-94[2].
    b. BCA methodology should follow FEMA standardized methodologies unless
        1) A BCA for the project has already been completed or is in progress under guidelines of other Federal agencies, or
        2) The BCA addresses a non-correctable flaw in the FEMA methodology, or
        3) A new approach is proposed that is unavailable using the FEMA Toolkit.
2. Alternately, projects may have a benefit-cost ratio of less than 1.0 under these conditions:
    a. A BCA is still completed following the methodologies described above.
    b. The project "serves low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster."
    c. A qualitative description is provided for "benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for low- and moderate- income persons or other persons that are less able to mitigate risks, or respond to and recover from disasters."

The analysis presented here meets these requirements as follows:

- In accordance with OMB Circular A-94, a 7% discount rate was used when determining equivalent present values of expected annual benefits and vice versa.

[1] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).
[2] *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

- The quantitative benefit-cost analysis (BCA) was based on benefit quantification methods and assumptions used in FEMA tools such as the FEMA BCA Toolkit version 6.0[3] (hereafter "FEMA Toolkit") and HAZUS (Hazards U.S. planning-level damage and loss estimating tool). These tools were not used directly, but the methods and assumptions in the FEMA Toolkit and HAZUS were applied using a combination of geospatial and tabular analysis tools to more efficiently:
    - Assess thousands of potentially impacted structures.
    - Utilize spatially variable modeled water surface elevation data.
    - Incorporate detailed information at an individual structure level.
- As indicated by the beneficiary population analysis detailed in the **LMI Evaluation Attachment**, over 51% of the project beneficiaries of are low- to moderate-income persons.
- The **Qualitative Benefits** section of this report discusses benefits of the Covered Project that could not be quantified.

1.2 QUANTITATIVE BENEFIT CATEGORIES

The benefit-cost analysis included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

1.3 INPUT DATA

A separate analysis was performed to estimate the number of residents and residential units per structure, as well as the number of residents who are full-time workers. The primary datasets used in the BCA are summarized in *Table 1-1.*

Table 1-1 – Input Datasets to Benefit-Cost Analysis

Dataset	Source	Description

[3] *Benefit Cost Toolkit Version 6.0.* FEMA. October 2019. Available at https://www.fema.gov/media-library/assets/documents/179903.

Harris County Structure Inventory	Harris County Flood Control District	attributes of individual structures in the study area, including use, size, and look-up codes for various reference tables
Right-of-Way Acquisition	Harris County Flood Control District	parcels and impacted structures to be bought out as part of project
Capital Costs	Harris County Flood Control District	project capital costs
Existing and Proposed Water Surface Elevations	Harris County Flood Control District	Estimated water surface elevations based on hydraulic modeling of conditions before and after project implementation
American Community Survey Data[4]	U.S. Census Bureau	2018 ACS 5-year data related to population, average household size, number of full-time workers, median household income, and other variables
Census Geographic Areas	U.S. Census Bureau	boundaries of 2010 Census tracts and block groups

HCFCD maintains a detailed structure inventory of all structures in Harris County. This inventory includes data on the number of housing units in each structure, square footage, building style, finished floor elevation, and numerous other attributes. The qualitative structure attributes in the inventory were used to determine the appropriate depth-damage functions and content-to-structure value ratios, and the finished floor elevation is the basis for determining damage and displacement costs based on depth of flooding above finished floor.

Data from the 2018 American Community Survey (ACS) 5-year[4] data tables was used in various parts of the BCA; the variables used are listed below. The following sections describe the use of this data in more detail.

- Subject Table S1903 –Median Income in the Past 12 Months
- Detail Table B01003 – Total Population
- Data Profile Table DP04 – Selected Housing Characteristics
- Detail Table B23027 – Full-Time, Year-Round Work Status in the Past 12 Months by Age for Population 16+ Years

Table 1-2 lists the various standard values and lookup tables referenced in the calculations.

[4] U.S. Census Bureau. American Community Survey, 2014-2018. Detailed Tables, Subject Tables, and Data Profile Tables; generated by Freese & Nichols, Inc. using the U.S. Census Bureau Application Programming Interface.

Table 1-2 – Sources of Standard Values and Reference Tables

Name	Purpose	Source
Discount Rate	calculate discount factors for converting between annual and present value equivalent costs/benefits	OMB Circular A-94
Demolition Threshold	threshold above which building is assumed to be fully lost and contents maximally lost	FEMA BCA Toolkit v6.0
Useful Life	project lifetime used in discounting	
Depth-Days Curve	table of days displaced for depth flooded	
Disruption Cost Factor	one-time cost per square foot for non-residential structures	
Monthly Cost Factor	recurring cost per square foot per month for non-residential structures	
Hotel per Diem Cost	daily cost per household, up to 5 people, for lodging	
Meal per Diem Cost	daily cost per person of eating out, less average cost of eating at home	
Mental Stress and Anxiety Unit Cost	cost of mental stress and anxiety per resident	
Productivity Loss Unit Cost	productivity loss per full-time worker	
Land Use Conversion Unit Benefit	value of ecosystem services ($/acre/year) provided by land use conversion	
Replacement Cost Models	building replacement values ($/sq. ft.)	Hazus Technical Manual[5]
Depth-Damage Functions	tables of percent damage for depth flooded given the building type	USACE New Orleans District[6]
SFR Content-to-Structure Value Ratios	ratio for single-family residences for 1 story, 2 stories, or mobile home	USACE New Orleans District[6]
Other Content-to-Structure Value Ratios	ratio for structures other than single-family residences	USACE New Orleans District[6]

1.4 CALCULATION OF EXPECTED ANNUAL BENEFITS

For benefit categories based on avoided losses, impacts are assessed for multiple storm recurrence intervals, and an Expected Annual Loss value is estimated from the estimated value of damages caused by each storm and the associated probability of such a storm in a single year. This annualized value is estimated as the area under the Damage vs Probability curve using the trapezoidal area method. This

[5] Hazus-MH MR3 Technical Manual. FEMA.

[6] *Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study*. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

method is described in a FEMA guidance document for flood risk assessments[7]. *Equation 1* demonstrates how this method is applied if impacts are modeled for 10-, 25-, 50-, 100-, and 500-year storms.

$$Expected\ Annual\ Loss = \left(\frac{1}{500} * Loss_{500yr}\right) + \left(\frac{1}{100} - \frac{1}{500}\right)\left(Loss_{100yr} + Loss_{500yr}\right) + \left(\frac{1}{50} - \frac{1}{100}\right)\left(Loss_{50yr} + Loss_{100yr}\right) + \left(\frac{1}{25} - \frac{1}{50}\right)\left(Loss_{25yr} + Loss_{50yr}\right) + \left(\frac{1}{10} - \frac{1}{25}\right)\left(Loss_{10yr} + Loss_{25yr}\right)$$

Equation 1

Loss values are not extrapolated to storm events with recurrence intervals smaller or larger than the events simulated in a hydraulic model. The Expected Annual Benefit (EAB) is the difference in Expected Annual Loss under existing and post-mitigation conditions *Equation 2*.

$$Expected\ Annual\ Benefit = (Expected\ Annual\ Loss)_{Existing} - (Expected\ Annual\ Loss)_{Post-mitigation}$$

Equation 2

1.5 PRESENT VALUE ANALYSIS

Benefits in most categories were determined on an annualized basis as described in the previous section. The present value of the Expected Annual Benefits (EAB) was then determined using the standard economic equivalence factor. Equivalence factors were determined using an annual discount rate of 7% as specified in OMB Circular A-94 and an assumed project useful life of 50 years. Equivalence factors for converting between annual and present values are shown in *Equation 3* and *Equation 4*. The 50-year life was based on a table of project lifetimes within the FEMA Toolkit (*Table 1-3*).

$$Annual\ Value\ =\ Present\ Value * \frac{i(1+i)^n}{(1+i)^n - 1}$$

Equation 3

$$Present\ Value\ =\ Annual\ Value * \frac{(1+i)^n - 1}{i(1+i)^n}$$

Equation 4

[7] "Guidance for Flood Risk Analysis and Mapping: Flood Risk Assessments." p. 18. FEMA. February 2018.

Table 1-3 – Standard Values for Project Useful Life in FEMA BCA Toolkit v6.0

Flood Hazard Mitigation Project Type	Useful Life (years)
Acquisition / Relocation	
Acquisition / Relocation	100
Building Elevation	
Residential Building	30
Non-Residential Building	25
Public Building	50
Historic Buildings	50
Mitigation Reconstruction	
Mitigation Reconstruction	50
Infrastructure Projects	
Major Infrastructure (dams, levees)	50
Concrete infrastructure, flood walls, roads, bridges, major drainage system	50
Culverts (concrete, PVC, CMP, HDPE, etc.) with end treatment	30
Culverts without end treatment	10
Major pump stations, substations, wastewater systems, or equipment such as generators	50
Minor pump stations, substations, wastewater systems, or equipment such as generators	5

Present Value Benefits were then compared to Total Project Cost to determine the Benefit-Cost Ratio (BCR) as shown in *Equation 5*.

$$BCR = ((Project\ Capital\ Cost) * (A/P\ Discount\ Factor) + Annual\ Maintenance\ Costs)/(Expected\ Annual\ Benefits) \quad \textit{Equation 5}$$

In the FEMA Toolkit, project useful life is specified for each structure individually, allowing a different factor to be applied to structures subject to buyouts, for which the useful life is assumed to be 100 years. However, for simplicity in the preliminary BCAs, a single discount factor based on a 50-year life was applied across the entire project. In other words, although the project does include acquisition and demolition of some structures, the shorter useful life of the primary project infrastructure has been used to apply a consistent present worth conversion factor to all components. This simplification causes a slight underestimation of benefits, but the difference is negligible.

2.0 QUANTITATIVE BENEFITS

2.1 BENEFITS BASED ON DEPTH OF FLOODING

A traditional BCA for flood mitigation projects assesses the difference in probable damages to a structure and its contents under existing (baseline) conditions and post-mitigation (proposed) conditions. Baseline

and proposed impacts to a structure and its contents are assessed for multiple storm recurrence intervals based on the depth to which the structure is inundated in each scenario. Flooding depth for each structure is calculated as the difference in modeled water surface elevation (WSE) and finished floor elevation (FFE) as provided in the structure inventory. For structures with missing FFE data, FFE was estimated at 6 inches above ground elevation, using the same ground elevation data as was used in development of the structure inventory[8].

Depth-related benefit categories include traditional structural benefits as well as others that can be related to the depth of flooding in a given storm frequency:

- Building Damages – Depth related to % of value lost.
- Content Damages – Depth related to % of value lost.
- Displacement Costs – Depth related to number of days displaced.
- Loss of Income / Loss of Function – Depth related to number of days rent payment income or commercial function is lost.

The following sections explain how these categories were assessed in the BCA.

2.1.1 Building and Content Damages

The FEMA Toolkit requires structural damages to be calculated based on a Building Replacement Value (BRV), not the appraised value or market value. The Unit BRV (cost per square foot) has a default value of $100/sf in the FEMA Toolkit. This default value was replaced with a value specific to each structure's attributes as described in the Hazus Technical Manual[9]. Hazus unit BRVs depend on building type and number of stories. Residential unit BRVs are further broken down by construction class (economy, average, custom, or luxury). Using Hazus methodology[10], a weighted composite building replacement value was assigned to single-family residential structures in the project service area based on the ratio of median household income in each census tract to median income across Texas (median household income determined from 2018 ACS 5-year data from Subject Table S1903). Finally, the Total Building Replacement Value of a structure is calculated by multiplying the Unit BRV by the building size *Equation 6*. This

[8] Bare Earth LiDAR, HGAC 2008 Datum Adjusted. Houston-Galveston Area Council. 2008.
[9] Hazus-MH MR3 Technical Manual. FEMA.
[10] Hazus-MH MR3 Technical Manual. FEMA. "Section 14.2.1 – Full Building Replacement Costs."

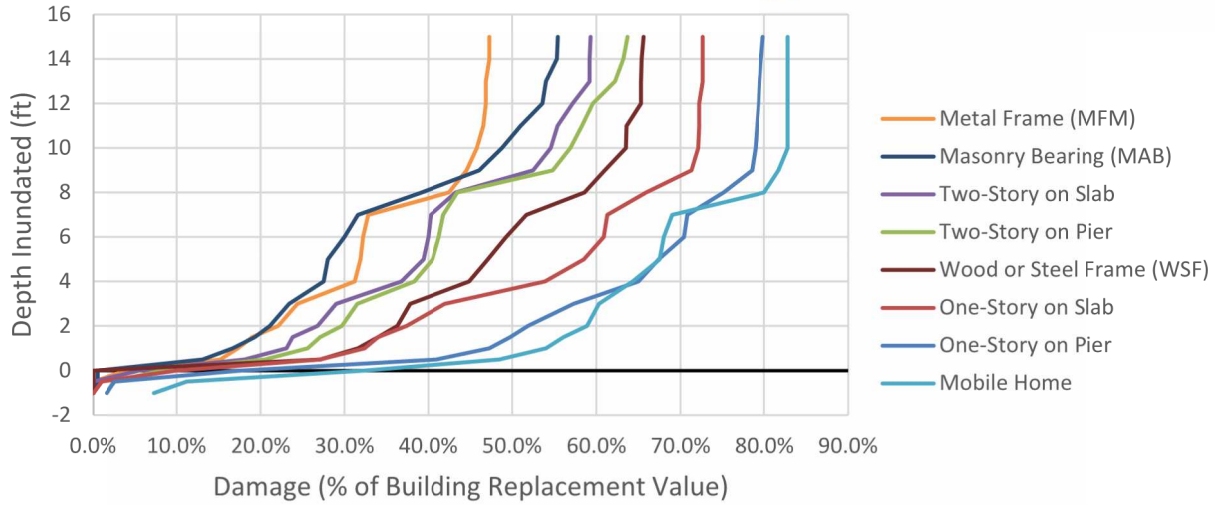
approach allowed for the use of local data to appropriately reflect structure values in the project service area.

$$Total\ BRV = Unit\ BRV\ (\$/sf) * Area\ (sf) \qquad \textit{Equation 6}$$

Values documented in the Hazus Technical Manual are based on standard cost-estimation models published in *Means Square Foot Costs*[11] and were reported in 2006 dollars. For this analysis, these values were scaled up using the RSMeans Historical Cost Indices from 2006 to 2020 to be consistent with project cost estimates. Building replacement values can be found in **Appendix A**.

Once depth of flooding is determined for a structure under a given scenario, the percent of the Total BRV that is lost to damage is determined from a depth-damage function (DDF). The DDFs used in this BCA were developed by the USACE New Orleans District[12] and are illustrated in *Figure 1*. It should be noted that some structures are expected to experience damage even when WSE is below FFE by up to 2 feet, depending on structure type.

Figure 1 – Depth-Damage Functions



The percent damage estimated from the DDFs is also applied to the value of the contents in the structures. The total value of contents in each structure was estimated from content-to-structure value ratios

[11] R.S. Means, 2005.
[12] Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

developed by the USACE New Orleans District[12], which specify a percentage of the building value depending on the building type.

A demolition threshold was set to 50%, which is the default value in the FEMA Toolkit. If percent damage based on depth and the depth-damage curve exceeded this threshold, the structure is expected to be substantially damaged and is assumed to need replacement rather than repair. In this case, the value of Expected Structure Damage is the Total BRV. Additionally, the value of Expected Content Losses is assumed to be maximized at this point (not a total loss, but the maximum value on the depth-damage curve).

Total benefits of avoided structure and content losses are summarized in the **Executive Summary**.

2.1.2 Displacement Costs (Residential)

Residential displacement losses represent the cost to residents of being out of their home after a flood event. The cost of residential displacement under baseline and proposed conditions for each modeled event was calculated using the method and standard values (shown in *Table 2-1*) in the FEMA Toolkit:

- Temporary lodging for each displaced household (assumes up to 5 household members per hotel room)
- Increase in meal cost (above average cost of eating at home) for each displaced resident

Expected annual benefits depend on a relationship between number of days displaced for depth of inundation. Using the relationship in the FEMA Toolkit, 45 days of displacement were assumed for each foot of flooding above FFE. No displacement was assumed if WSE did not exceed FFE. Total benefits of avoided residential displacement costs are summarized in the **Executive Summary**.

Table 2-1 – Residential Displacement Unit Costs

Meals per diem per capita	Cost of eating at home	Hotel per diem per family, up to 5 people	Meal cost / person / day
$55	$7	$94	$48

2.1.3 Displacement Costs (Non-Residential)

The costs of non-residential displacement, as defined by FEMA, include:

- One-time cost of relocating business equipment

- Monthly rental costs of new space

The same relationship between depth flooded and days displaced was used for non-residential displacement as for residential displacement. Cost factors provided in the FEMA Toolkit as $/sq. ft. values were used to estimate both the monthly and one-time cost components of non-residential displacement (*Table 2-2*). Total benefits of avoided non-residential displacement costs are summarized in the **Executive Summary**.

Table 2-2 – Non-residential Displacement Cost Factors

Occupancy Class	Disruption Cost Factor ($/sf)	Rental Cost Factor ($/sf)
Retail Trade	1.09	1.16
Wholesale Trade	0.95	0.48
Personal and Repair Services	0.95	1.36
Technical Business	0.95	1.36
Banks	0.95	1.7
Hospital	1.36	1.36
Medical Office/Clinic	1.36	1.36
Entertainment and Recreation	0	1.7
Theaters	0	1.7
Heavy	0	0.2
Light	0.95	0.27
Food/Drugs/Chemicals	0.95	0.27
Metals/Mineral Processing	0.95	0.2
High Technology	0.95	0.34
Construction	0.95	0.14
Agriculture	0.73	0.73
Religious/Nonprofit/Membership Organization	0.68	0.68
Government, General Services	0.95	1.36
Government, Emergency Response	0.95	1.36
Schools/Libraries	0.95	1.02
College/Universities	0.95	1.36

2.1.4 Loss of Income / Loss of Function

Loss of Income represents the loss of monthly rental income to owners of rental properties. Because additional monthly rental costs were considered as a displacement cost to non-residential tenants, property owner income losses were excluded from this BCA to avoid double-counting benefits.

Loss of Function represents the lost revenue due to inability to operate a business for some amount of time after a flood event. This avoided cost benefit category requires knowledge of the operating budget of the business for each individual non-residential structure in a project service area. As the majority of flood mitigation benefits in the project service area are to residential structures, this category was not assessed.

2.2 ANCILLARY BENEFITS

In addition to the benefit categories that represent avoided costs based on reduction in flooding depth, social and environmental benefits of the project were also quantified.

2.2.1 Avoided Social Costs

Social benefits based on the FEMA Toolkit represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

The calculation of social benefits replicated the method used in the FEMA Toolkit, which applies a present value benefit amount per impacted person to estimate the avoided costs of mental health treatment and of lost productivity *(Table 2-3*). These values are based on studied prevalence, severity, and course of mental effects following a disaster[13]. It should be noted that because these values are present value benefits, they are not dependent on the annual expected probability of a storm event or the level of flooding anticipated from a given event. Instead, these benefits represent the positive impact of a mitigation project reducing flooding in a resident's home, which may include an existing condition of minor flooding compared to a post-mitigation condition of no flooding. Even when traditional benefit

[13] *Final Sustainability Benefits Methodology Report.* FEMA. Task order HSFEHQ-11-J-1408. August 2012.

estimates might indicate a very small value of saved structural and content damages, the positive impact on residents of not having to do any repairs instead of a few repairs is significant.

Table 2-3 – Unit Values for Social Benefits as Avoided Costs of Mental Health Impacts

Category	Benefit per Person (Present Value)	Unit
Treatment for mental stress and anxiety	$2,443	Resident of home benefitted by project
Lost productivity	$8,736	Resident of home benefitted by project who works full-time

The present value benefits per person for treatment of mental stress and anxiety were applied to all residents of structures which experienced a reduced modeled WSE after project implementation, regardless of event frequency. The **Population Estimate Attachment** describes how ACS Table B01003 (Total Population Estimates) and ACS Data Profile DP04 (Selected Housing Characteristics) were used to allocate numbers of residents to each structure in the watershed. The number of full-time workers in each Census tract (B23027_001E) was compared to the total tract population (B01003_001E) to estimate the number of full-time workers living in each structure. Costs of lost productivity were based on the estimated number of full-time workers residing in each structure. Estimated social benefits are summarized in the **Executive Summary**.

2.2.2 Environmental Benefits

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. Unlike other benefit categories based on avoided costs, environmental benefits represent an added service. *Table 2-4* indicates the value of each land use type (assuming existing condition of is developed land).

Table 2-4 – Unit Benefit Values for Conversion of Developed Land to Land Use of Higher Ecosystem Value

Documented Benefit/acre/year[14]				
Green Open Space	Riparian	Wetlands	Forests	Marine /Estuary
$8,308	$39,545	$6,010	$554	$1,799

[14] Help Section of B/C Analysis Toolkit v6.0, as of 01/28/2020.

Expected environmental benefits are summarized in the **Executive Summary**.

3.0 QUALITATIVE BENEFITS

As described in the Federal Register,[15] as long as a quantitative BCA has been completed, projects may have a benefit-cost ratio of less than 1.0 when the project provides concrete benefits to "low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster," including benefits that cannot be quantified. Qualitative benefits of this project are discussed below.

3.1 BENEFICIARIES VULNERABLE TO FLOOD RISK

This application has demonstrated that 70.6% of the beneficiaries of Halls Bayou Watershed CDBG-MIT Application 2 Covered Project are low- to moderate-income persons. Additionally, many of the residents of the project service area may be considered particularly vulnerable to disasters. 36.53% of the households in the project service area are considered to be housing cost-burdened, and 19.01% are severely housing cost-burdened. These households spend 30+% and 50+% of their monthly income on housing-related costs, respectively. This cost burden may make it particularly hard for these households to recover from disaster, as they are less likely to have additional funds available for repairs, hotel stays, and lost wages during and after a flood. Additionally, 2.21% of the households in the project service area have no computer and/or no internet subscription. Lack of reliable internet access may reduce residents' ability to benefit from early warning systems in case of flooding events, making them more vulnerable.

3.2 BENEFIT OF REDUCING FLOOD IMPACTS TO PROPERTY VALUES

A review of parcel appraisal values from the Harris County Appraisal District suggests that the annual rate of growth in property values, at least for residential properties, generally slowed from 2014 to 2018 in the Halls Bayou Watershed *(Figure 2)*. These trends could be caused or influenced by floods in 2015, 2016, and 2017, but the degree to which local flooding impacted the value growth rates cannot be ascertained. General economic conditions in Harris County following Hurricane Harvey, as well as other external economic factors, could also contribute to changes in property values. Although the exact impact of local flooding on property values cannot be quantified, flood risk mitigation projects are likely to have a positive

[15] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

impact on the residents of flood-prone areas, as falling property values can have a negative effect on the financial flexibility of housing cost-burdened homeowners and even renters. Finally, the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project will remove 375 acres from the 100-year floodplain, providing a potential positive impact to property values.

Figure 2 – Median Year-to-Year Percent Change in Assessed Values of Individual Parcels in Halls Bayou
****Parcels included in assessment were limited to those which had values available for all years 2014 – 2019. Percent change values of 0% were excluded to avoid errors from repeated entries across years.***

3.3 TRANSPORTATION BENEFITS

Street closures due to flooding in the Halls Bayou Watershed during Hurricane Harvey likely impacted a large number of commuters, including those who do not live in the watershed. Frequently, residential streets are inundated and may become impassable without the water level reaching a point of causing any damage to homes. In these scenarios, no quantitative benefits are counted in the BCA as there is no structural damage or displacement of residents. However, the street flooding poses an inconvenience and in some cases a safety risk, as it can inhibit evacuations, potentially trapping residents in homes that may lose power or keeping them from accessing groceries or medical supplies. The XXX Watershed Covered Project will provide some reduction in street inundation as a benefit to residents in the service area.

In Harris County, over 50,000 workers 16 years and older use a bus or trolley bus as means of transportation to work. Of workers living within the watershed, 2.21% (1,473 workers) use a bus to

commute to work. Data from the Metropolitan Transit Authority of Harris County (Metro) indicates that 17 bus routes through the watershed were closed for up to 9 days during and after Hurricane Harvey. No methods were found that could be used to quantify the productivity losses of workers impacted by road closures. Additionally, all Metro bus routes passing through the project service area also extend across multiple floodplains in Harris County. It was determined that even if a substantial section of a route is removed from the floodplain as a result of the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project, inundation elsewhere could still cause route closure. Because of this, assigning quantitative economic benefits to reduced flooding along bus routes that could be attributed only to this project was not considered to be a valid approach. However, the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project is important to reducing the overall flooding along major commuter routes, providing significant benefit to residents of the project service area as well as workers traveling to and through the area.

4.0 SUMMARY

The approach to benefit-cost analysis documented here was based on FEMA BCA methodologies and considered various categories of benefits afforded by the Halls Bayou Watershed CDBG-MIT Application 2 Covered Project. However, as discussed in Section 2.1.1, the use of structural damages in a benefit-cost ratio, while valid, means that a project in a lower income service area that provides flood mitigation benefits to the same number of homes as a project in a higher-income area may have a lower calculated benefit-cost ratio due to the lower replacement values of homes in the service area. As a result, the low- and moderate-income populations that the CDBG-MIT funding seeks to serve may be underserved by funding sources which rely primarily on traditional benefit-cost analysis methods. Considering this, it is important to recognize that quantitative BCRs should not be used alone when evaluating the effectiveness of a mitigation project, and in fact, comparing BCRs between projects may actually work against the goal of serving of CDBG-MIT funding to serve LMI and other vulnerable populations.

APPENDIX A
BUILDING REPLACEMENT VALUES

Table A-1
Single-Family Residential Building Replacement Values (2020 dollars, assuming no basements)

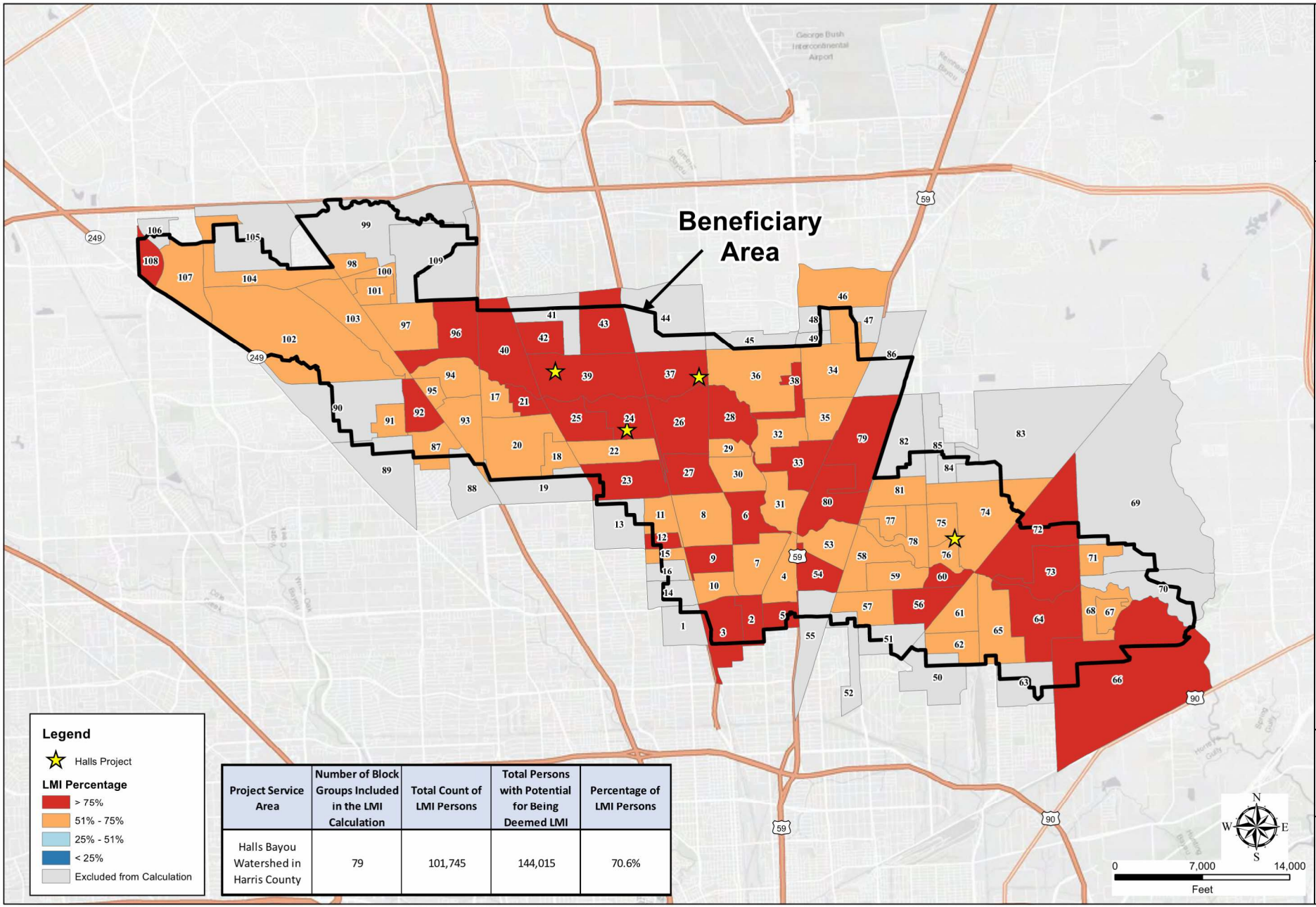
Income Ratio (r) Number of Stories	r < 0.5	0.5 <= r < 0.85	0.85 <= r < 1.25	1.25 <= r < 2.0	r >= 2.0
1	$97.28	$107.21	$145.17	$169.60	$206.28
2	$103.51	$110.89	$141.45	$166.65	$196.43
3	$103.51	$112.50	$147.76	$172.67	$202.32
split	$95.14	$102.70	$132.88	$155.34	$184.21

Table A-2
Multi-Family Residential Building Replacement Values (2020 dollars)

Number of Units	Unit Building Replacement Value ($/sf)
2	$117.00
3-4	$128.00
5-9	$228.00
10-19	$203.00
20-49	$200.00
50+	$195.00

Table A-3
Non-Residential Building Replacement Values (2020 dollars)

Occupancy Class	Occupancy Sub-Class	Unit Building Replacement Value ($/sf)
Manufactured Housing	Manufactured Housing	$52.76
Retail Trade	Dept Store, 1 st	$121.96
Wholesale Trade	Warehouse, medium	$112.10
Personal and Repair Services	Garage, Repair	$151.05
Prof./ Tech./Business Services	Office, medium	$196.93
Banks	Bank	$282.68
Hospital	Hospital, medium	$331.04
Medical Office/Clinic	Med. Office, medium	$242.32
Entertainment & Recreation	Restaurant	$251.66
Theaters	Movie Theatre	$180.14
Parking	Parking garage	$64.53
Heavy	Factory, small	$130.29
Light	Warehouse, medium	$112.10
Food/Drugs/Chemicals	College Laboratory	$214.11
Metals/Minerals Processing	College Laboratory	$214.11
High Technology	College Laboratory	$214.11
Construction	Warehouse, medium	$112.10
Agriculture	Warehouse, medium	$112.10
Church	Church	$204.52
General Services	Town Hall, small	$158.34
Emergency Response	Police Station	$245.87
Schools/Libraries	High School	$170.19
Colleges/Universities	College Classroom	$213.61



Project Service Area	Number of Block Groups Included in the LMI Calculation	Total Count of LMI Persons	Total Persons with Potential for Being Deemed LMI	Percentage of LMI Persons
Halls Bayou Watershed in Harris County	79	101,745	144,015	70.6%

FN PROJECT NO: SCG17287
DATE CREATED: 9/28/2020
DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
FILE NAME: Halls_Project_Area_Map_LMI_1_App2
PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed Beneficiary CDBG-MIT Application 2

EXHIBIT
2
(1 of 2)

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Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
1	482012206001	57	2,814	2%	No	75.7%
2	482012207001	889	909	98%	Yes	84.0%
3	482012207005	1,623	2,396	68%	Yes	75.3%
4	482012209001	1,047	1,047	100%	Yes	73.6%
5	482012209002	675	749	90%	Yes	76.4%
6	482012210001	1,706	1,706	100%	Yes	77.4%
7	482012210002	2,499	2,499	100%	Yes	70.7%
8	482012211001	1,471	1,471	100%	Yes	73.2%
9	482012211002	1,290	1,294	100%	Yes	83.3%
10	482012211003	1,065	1,065	100%	Yes	67.3%
11	482012212001	1,852	2,039	91%	Yes	70.7%
12	482012212002	896	1,239	72%	Yes	84.3%
13	482012212003	671	3,454	19%	No	73.2%
14	482012213001	773	2,018	38%	No	72.4%
15	482012213002	774	1,263	61%	Yes	61.1%
16	482012213003	991	1,732	57%	No	65.7%
17	482012216001	1,997	2,001	100%	Yes	54.2%
18	482012216002	993	993	100%	Yes	69.1%
19	482012216003	343	1,702	20%	No	68.6%
20	482012216004	3,327	3,327	100%	Yes	57.8%
21	482012216005	1,838	1,838	100%	Yes	86.5%
22	482012217001	1,795	1,795	100%	Yes	54.9%
23	482012217002	1,272	1,644	77%	Yes	87.9%
24	482012217003	2,305	2,305	100%	Yes	79.8%
25	482012217004	2,496	2,496	100%	Yes	85.5%
26	482012218001	2,739	2,742	100%	Yes	78.0%
27	482012218002	1,258	1,258	100%	Yes	93.8%
28	482012219001	1,678	1,678	100%	Yes	81.5%
29	482012219002	1,010	1,010	100%	Yes	57.7%
30	482012219003	2,102	2,102	100%	Yes	72.0%
31	482012220001	2,373	2,376	100%	Yes	65.5%
32	482012221001	3,177	3,177	100%	Yes	58.9%
33	482012221002	2,440	2,440	100%	Yes	82.8%
34	482012222001	2,014	2,030	99%	Yes	53.6%
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43	482012224023	2,258	2,706	83%	Yes	82.9%
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56	482012306001	932	932	100%	Yes	81.8%
57	482012306002	1,895	1,895	100%	Yes	70.9%
58	482012307001	842	842	100%	Yes	64.7%
59	482012307002	1,633	1,633	100%	Yes	62.3%
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Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
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64	482012310001	2,606	2,609	100%	Yes	80.6%
65	482012310002	1,806	1,831	99%	Yes	70.2%
66	482012311001	1,548	1,645	94%	Yes	94.0%
67	482012311002	2,123	2,123	100%	Yes	58.1%
68	482012311003	1,099	1,099	100%	Yes	64.9%
69	482012312001	1,832	3,126	59%	No	85.8%
70	482012312002	369	1,793	21%	No	76.2%
71	482012312003	2,079	2,079	100%	Yes	61.8%
72	482012313001	1,640	1,750	94%	Yes	83.1%
73	482012313002	2,865	2,865	100%	Yes	78.6%
74	482012314001	2,645	2,645	100%	Yes	60.9%
75	482012315001	2,015	2,015	100%	Yes	61.0%
76	482012315002	985	985	100%	Yes	73.8%
77	482012316001	1,248	1,251	100%	Yes	59.1%
78	482012316002	1,885	1,885	100%	Yes	63.7%
79	482012317001	2,604	2,604	100%	Yes	81.9%
80	482012317002	839	839	100%	Yes	82.4%
81	482012318001	1,067	1,067	100%	Yes	69.3%
82	482012318002	309	1,858	17%	No	65.7%
83	482012319002	151	2,509	6%	No	32.6%
84	482012319003	872	1,470	59%	No	78.0%
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86	482012321002	981	2,788	35%	No	81.9%
87	482015333001	2,002	2,247	89%	Yes	70.6%
88	482015333002	283	2,631	11%	No	97.8%
89	482015334001	336	2,315	15%	No	62.8%
90	482015334002	3,540	5,941	60%	No	66.5%
91	482015334003	2,318	2,318	100%	Yes	72.7%
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97	482015336002	4,720	4,720	100%	Yes	62.6%
98	482015337012	2,416	2,416	100%	Yes	69.6%
99	482015337013	226	1,804	13%	No	72.9%
100	482015337021	1,311	1,311	100%	Yes	60.0%
101	482015337022	2,446	2,446	100%	Yes	72.5%
102	482015338011	7,905	8,982	88%	Yes	61.0%
103	482015338012	2,069	2,069	100%	Yes	53.0%
104	482015338021	1,448	1,981	73%	Yes	73.7%
105	482015338022	1,563	3,874	40%	No	68.9%
106	482015339012	354	1,112	32%	No	34.1%
107	482015339013	5,099	5,099	100%	Yes	59.2%
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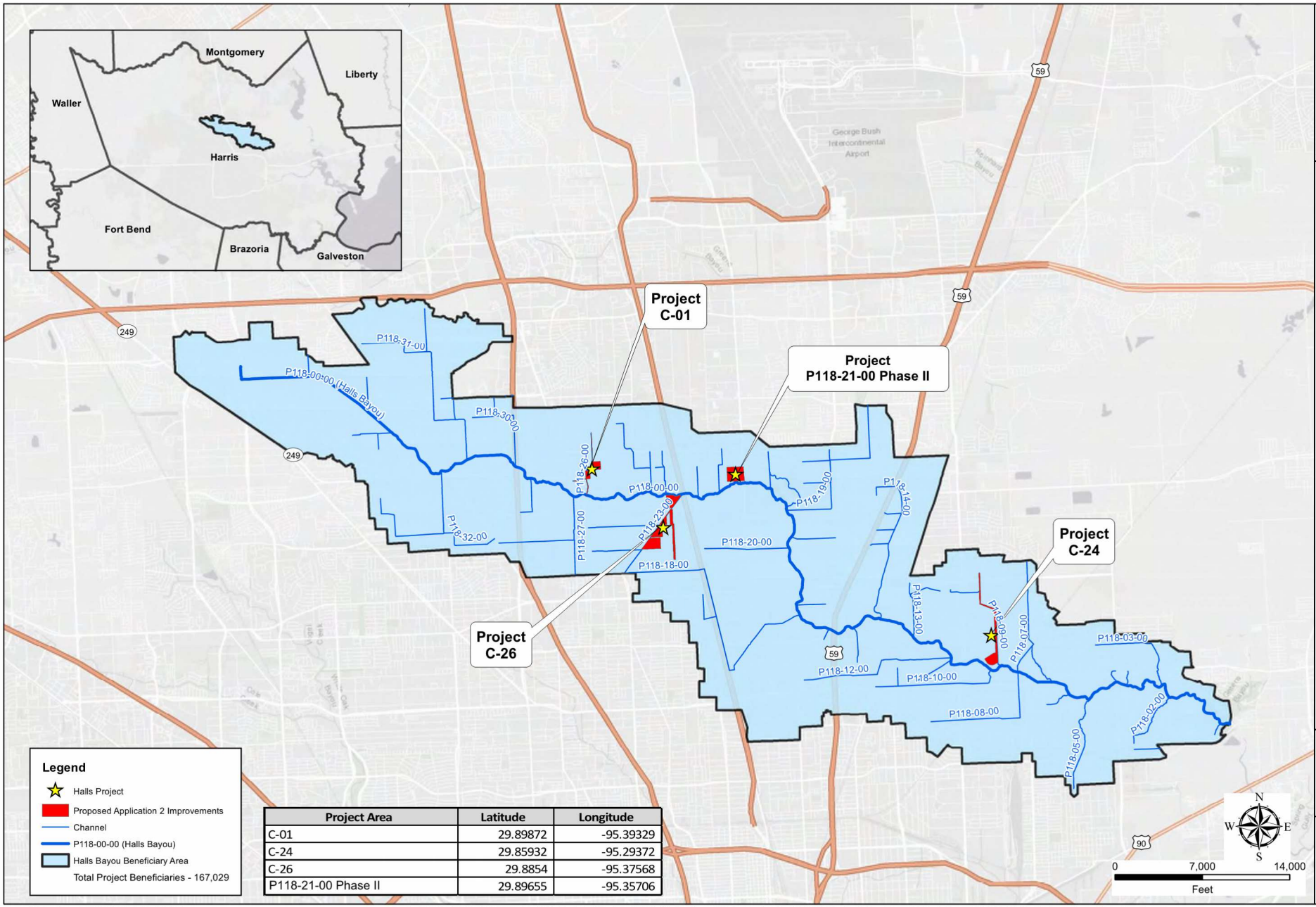
DATE CREATED: 9/28/2020
DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
FILE NAME: Halls_Project_Area_Map_LMI_2
PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed Beneficary Area Table

EXHIBIT
2
(2 of 2)



Legend

- Halls Project
- Proposed Application 2 Improvements
- Channel
- P118-00-00 (Halls Bayou)
- Halls Bayou Beneficiary Area

Total Project Beneficiaries - 167,029

Project Area	Latitude	Longitude
C-01	29.89872	-95.39329
C-24	29.85932	-95.29372
C-26	29.8854	-95.37568
P118-21-00 Phase II	29.89655	-95.35706

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PREPARED BY: AMJ

LOCKWOOD, ANDREWS & NEWNAM, INC.
CDBG-MIT

Halls Bayou Watershed - CDBG-MIT Application 2

FREESE NICHOLS

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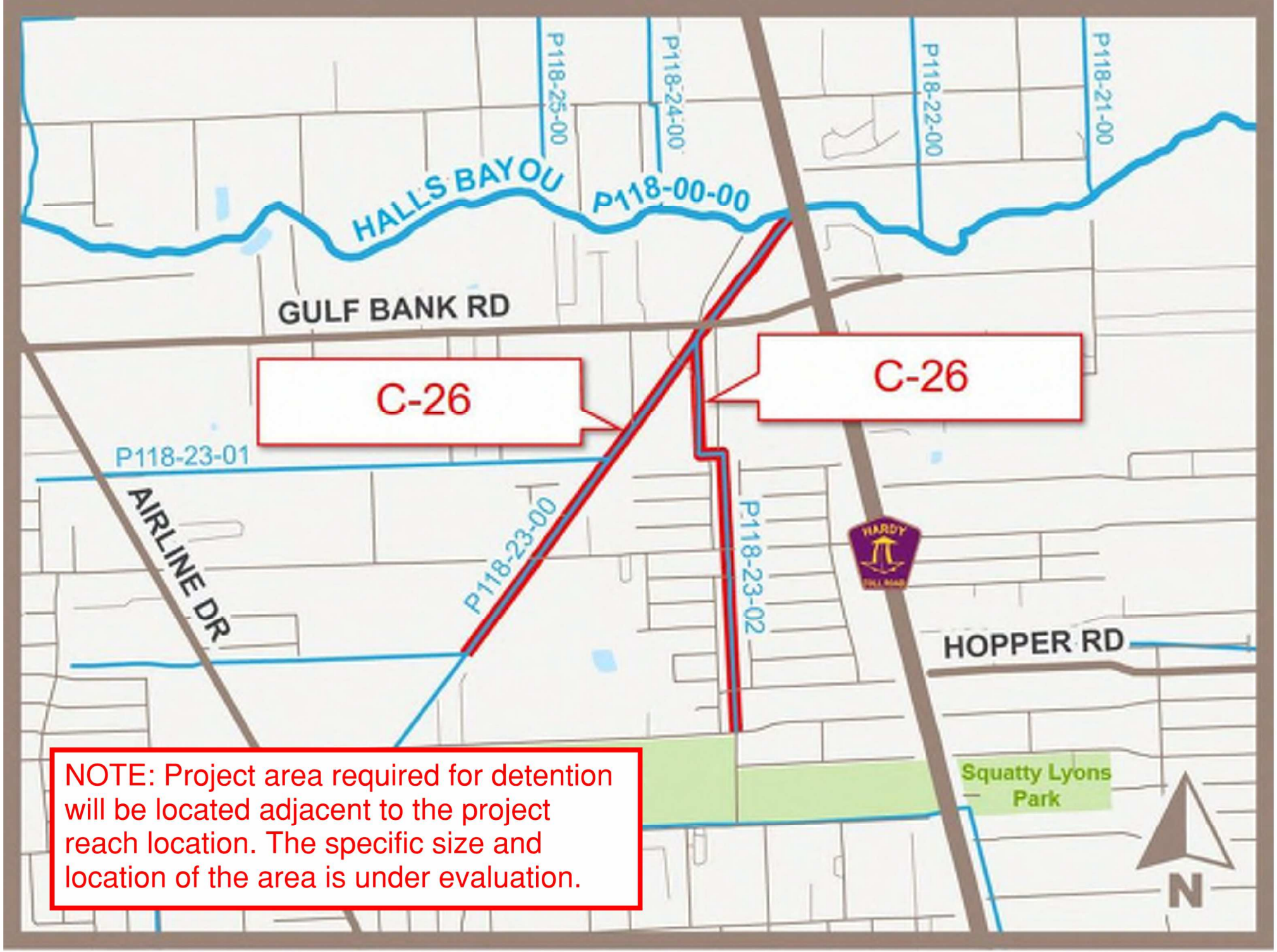
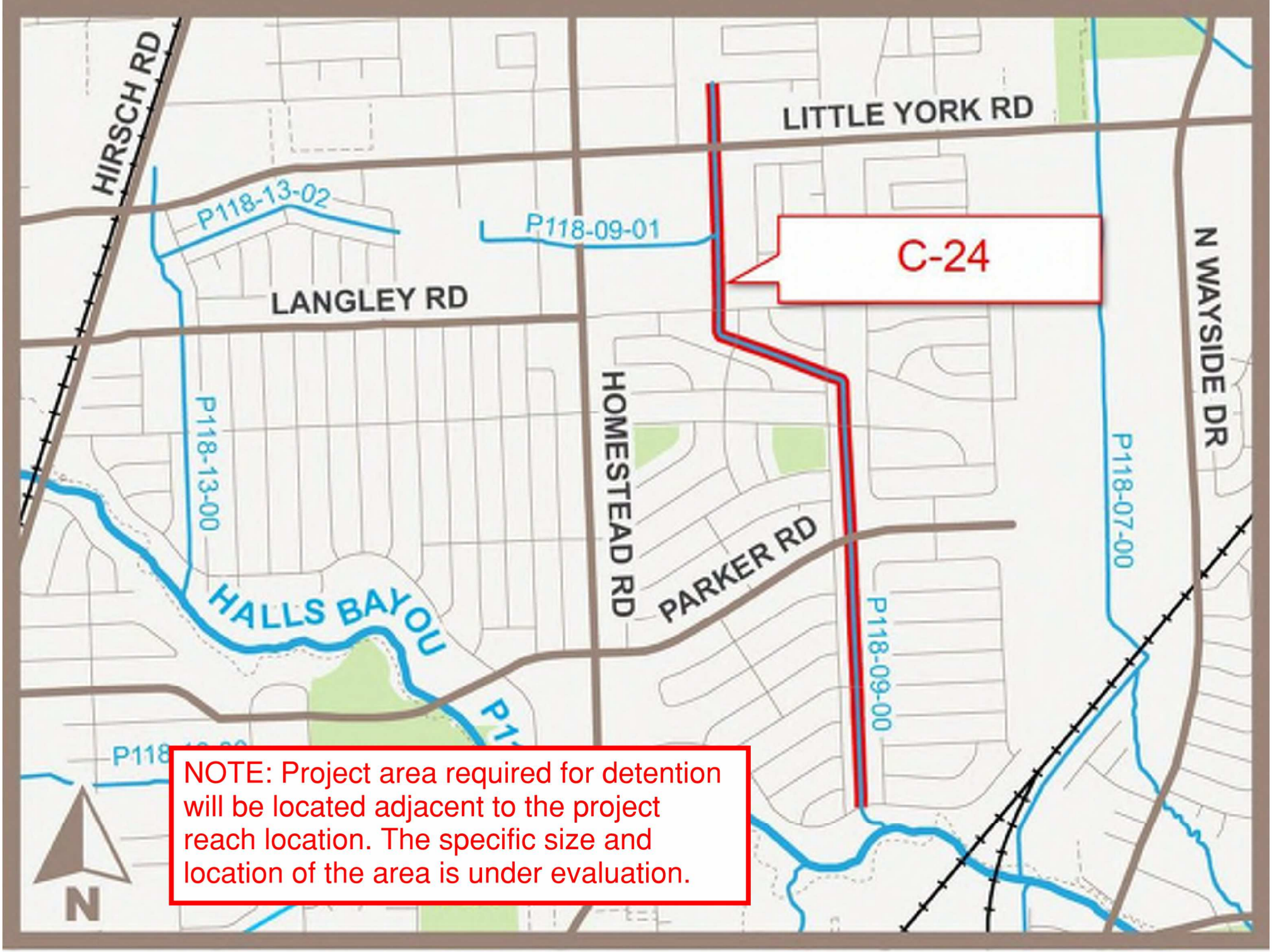

P118-25-00
P118-24-00
P118-22-00
P118-21-00
HALLS BAYOU
P118-00-00
GULF BANK RD
C-26
C-26
P118-23-01
AIRLINE DR
P118-23-00
P118-23-02
HARDY TOLL ROAD
HOPPER RD
Squatty Lyons Park
N
NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
PROJECT REACH


HIRSCH RD
LITTLE YORK RD
P118-13-02
P118-09-01
C-24
LANGLEY RD
N WAYSIDE DR
P118-13-00
HOMESTEAD RD
P118-07-00
PARKER RD
HALLS BAYOU
P118-09-00
NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
N
PROJECT REACH

PROJECT AREA MAP
BOND ID C-01

HALLS BAYOU WATERSHED
CDBG-MIT APPLICATION 2

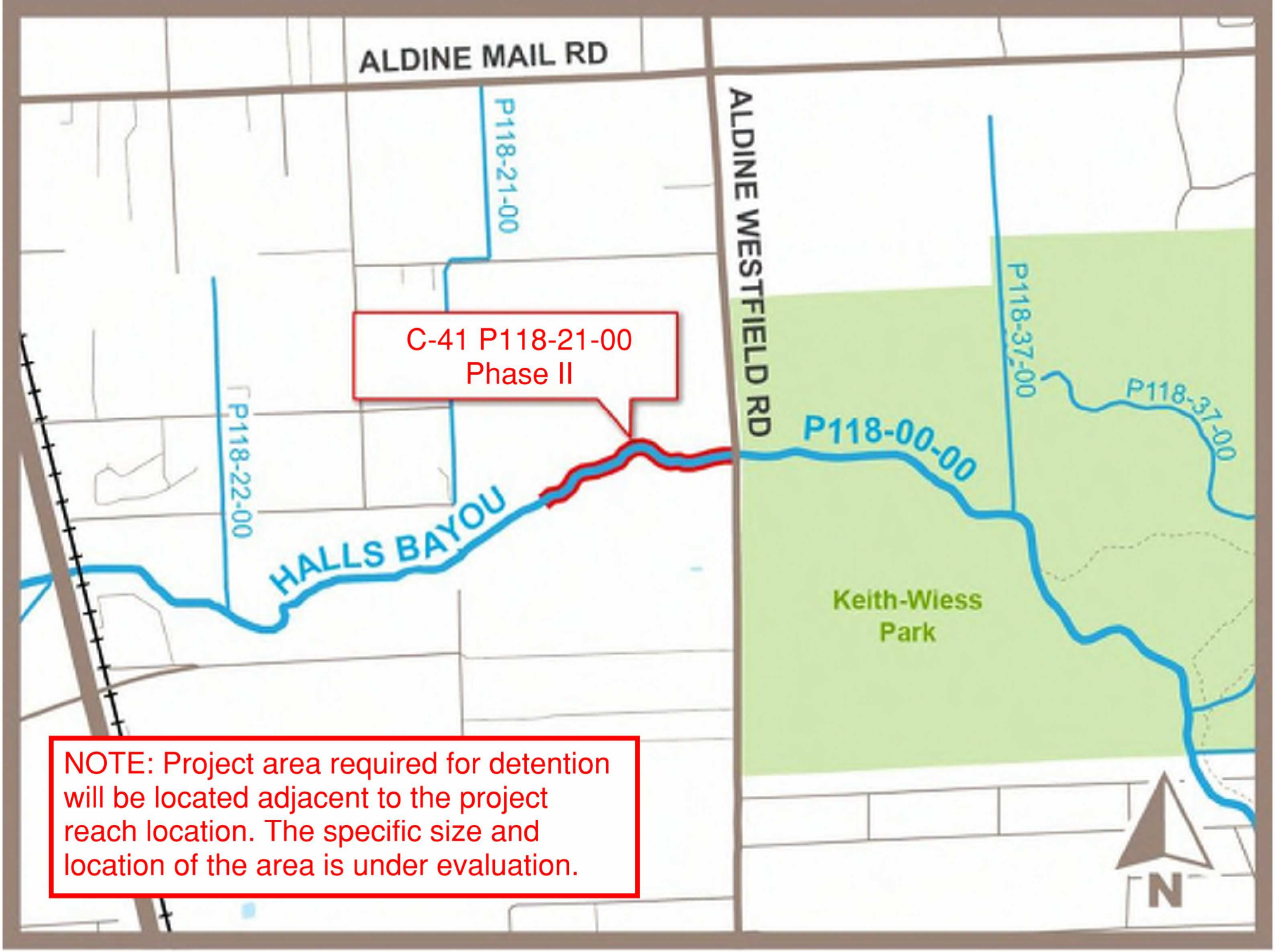
PREPARED: TMM
CHECKED:
APPROVED:

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FREESE NICHOLS

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

DATE: SEPT., 2020
SCALE: AS NOTED

EXHIBIT 1
PAGE 1


ALDINE MAIL RD
ALDINE WESTFIELD RD
P118-21-00
P118-22-00
P118-37-00
P118-37-00
P118-00-00
C-41 P118-21-00
Phase II
HALLS BAYOU
Keith-Wiess
Park
N
NOTE: Project area required for detention will be located adjacent to the project reach location. The specific size and location of the area is under evaluation.
PROJECT REACH

Halls Bayou (P118-00-00) Mainstem Improvements (C-41) Summary Report

Harris County Flood Control District

STATE OF TEXAS
CONNOR R. BISHOP
138205
LICENSED PROFESSIONAL ENGINEER

11/09/2021

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
TBPE Firm No. 2614

HCFCD Bond ID: C-41
Project ID: P118-00-00-E007

Executive Summary

HCFCD authorized LAN in December 2020 to conduct an Alternative Analysis Study on a portion of Halls Bayou (P118-00-00). The purpose of this study is to analyze and describe the existing flooding conditions within the project area, whereupon targeted flood risk mitigation alternatives are developed based on results. The recommended alternative derived from this Alternatives Analysis is intended to be incorporated into a Preliminary Engineering Report (PER), which can efficiently be carried into detailed design.

H&H models were developed for the 50% (2-year), 10% (10-year), 2% (50-year), 1% (100-year), and 0.2% (500-year) design storm events (pre-Atlas 14 update) based on HCFCD criteria using the HEC-HMS and HEC-RAS software. The results of the pre-Atlas 14 500-yr event are widely used as an estimation of the Atlas 14 100-yr conditions.

The alternatives analysis was conducted to determine what conveyance improvements along Halls Bayou could be mitigated by the Keith-Weiss, Hall Park and Bretshire stormwater detention basins. Essentially, the three previously constructed basins will be used to mitigate the proposed channel improvement project. This approach was decided upon prior to the Halls Bayou Mainstem Potential Projects Memo (December 2020).

Baseline Conditions results revealed a 2- to 10-years LOS under Existing Conditions for the project area, while the 50-, 100-, and 500-year events reflect significant roadway and overbank ponding in nearby residential areas. The Existing Conditions model outcome for a 500-year design storm shows that 4,369 structures are mapped within the modeled floodplain, with 2,167 structures shown to be flooded based on estimated finished floor elevations (FFE). Planning level mitigation options developed as part of the Halls Bayou Mainstem Potential Projects Memo were heavily driven by Project funding (CDBG-MIT) and schedule. Therefore, the main goal of this analysis is to develop a low cost, time efficient alternative that provides significant flood reduction in the more frequent storm events. Two of the three options analyzed during the Potential Projects effort were recommended for further evaluation and were subsequently included as part of this detailed analysis.

Of the three alternatives analyzed, Alternative 1 presents the most ideal project given the circumstances surrounding project funding and time to completion. This alternative includes channel excavation along the east bank from just upstream of Hopper Road to just upstream of the Bretshire detention basin (approximately 1.2 miles). The total probable costs of Alternative 1 is $1.84 million, compared to Alternatives 2 and 3 which have probable costs of $2.51 million and $5.24 million, respectively. Alternative 1 removes the 100-year and 500-year floodplain from 974 and 215 structures, respectively, while reducing the overall area of inundation by 275 and 76 acres, respectively. Due to the uncertainty of available funding and only slight additional benefit compared to Alternative 1, Alternative 2 was not recommended at this time, however, it is recommended that the portion of Halls Bayou between Aldine Westfield Road and the Keith-Wiess detention basin be utilized for either conveyance or detention improvements in the future. While Alternative 3 provides additional flood relief for a larger portion of the area compared to Alternatives 1 and 2, it is not recommended to be implemented in the near future due to the additional costs, complexity, and time to completion.

In coordination with HCFCD, LAN recommends moving forward with Alternative 1 and advance the project to the PER stage. It does not require land acquisition or affect significant utilities (oil and gas pipelines) and offers significant flood reduction to the project area in the 10-, 50-, and 100-year storm event. Additionally, Alternative 1 requires less funding and time to complete when compared to Alternatives 2 and 3. This alternative accomplishes the goals of providing a low cost project that can be completed in a short time period compared to other analyzed alternatives.

Table of Contents

1 Introduction

1.1 Purpose

The efforts described in this report are submitted in fulfillment of the services described in Scope of Services and Fee Proposal of the Professional Services Agreement between Lockwood, Andrews & Newnam, Inc. (LAN) and Harris County Flood Control District (HCFCD) dated December 22, 2020. The overall purpose of the detailed baseline conditions hydrology and hydraulics (H&H) analysis for mainstem improvements to P118-00-00 is to develop a starting point for the Alternatives Analysis – which will recommend a potential HCFCD construction project to improve drainage conditions along P118-00-00 and to mitigate flood risks in the contributing drainage areas.

The purpose of this report is to provide a clear and concise summary of the Baseline and Proposed Condition H&H analysis within the study limits along P118-00-00 (Halls Bayou). Refer to **Figure 1-1** for the workflow followed in the baseline conditions analysis.

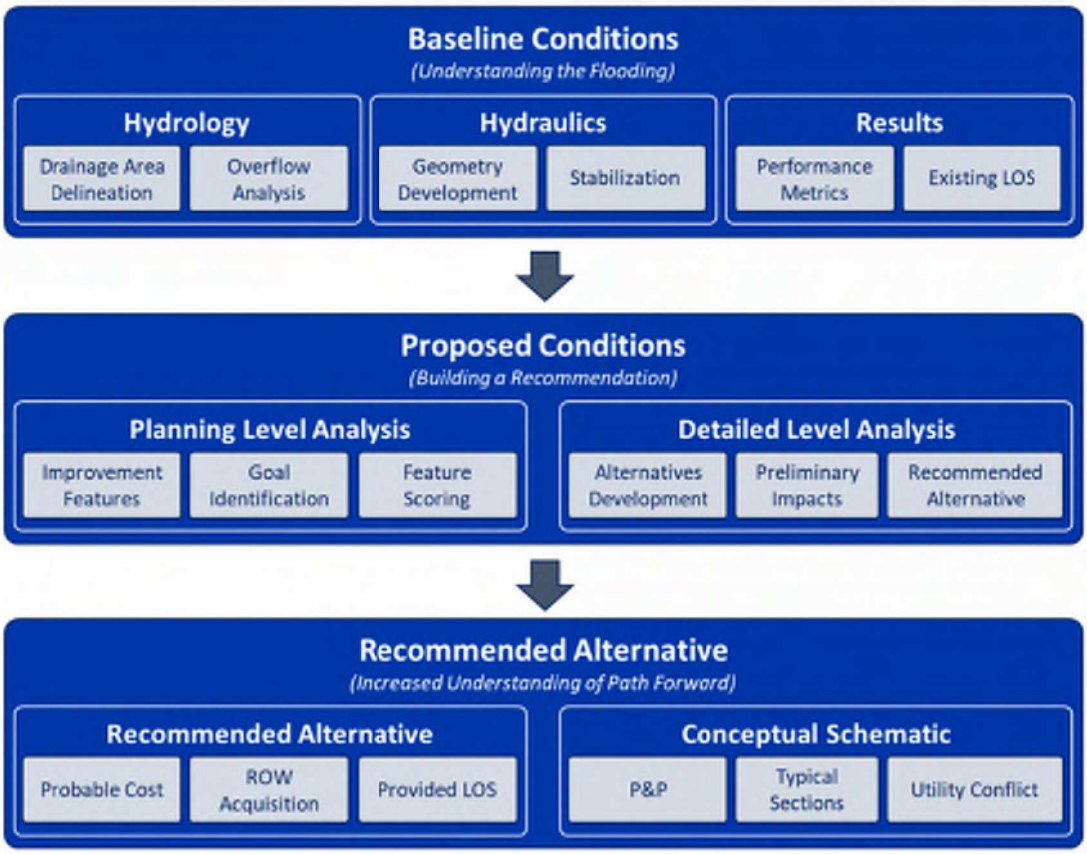


Figure 1-1: Baseline Conditions Workflow

1.2 Background

A portion of P118-00-00 was identified in the 2018 HCFCD Bond Program for a Partnership Project of Right-of-Way (ROW), design, and construction of channel conveyance improvements. The baseline conditions analysis of this Alternatives Analysis Study was the second step completed towards identifying potential improvements for the study area.

LAN submitted a technical memorandum (Halls Bayou Mainstem Potential Projects) to HCFCD in December 2020 that summarized the findings for potential conveyance and detention improvement projects along Halls Bayou (see **Appendix A**). The analysis included three option areas along Halls Bayou that were individually analyzed for hydraulic and structural flooding benefits in addition to project costs and feasibility. It was recommended that two of the three option areas analyzed be further investigated during the Alternatives Analysis stage. The locations of these two reaches are detailed in **Section 1.3**.

1.3 Study Area

The project area is located within the Halls Bayou (HCFCD Unit No. P118-00-00) watershed in the northern portion of Harris County, Texas – refer to **Figure 1-2** and **Exhibit 1**. The project limits were separated into four segments along P118-00-00 and maintain the following extents:

- Segment 1 – Aldine Westfield Road to just upstream of the Keith-Wiess detention basin
- Segment 2 – Bertrand Street to Hopper Road
- Segment 3 – Hopper Road to Little York Road
- Segment 4 – Little York Road to just upstream of the Bretshire detention basin (Shady Lane Park)

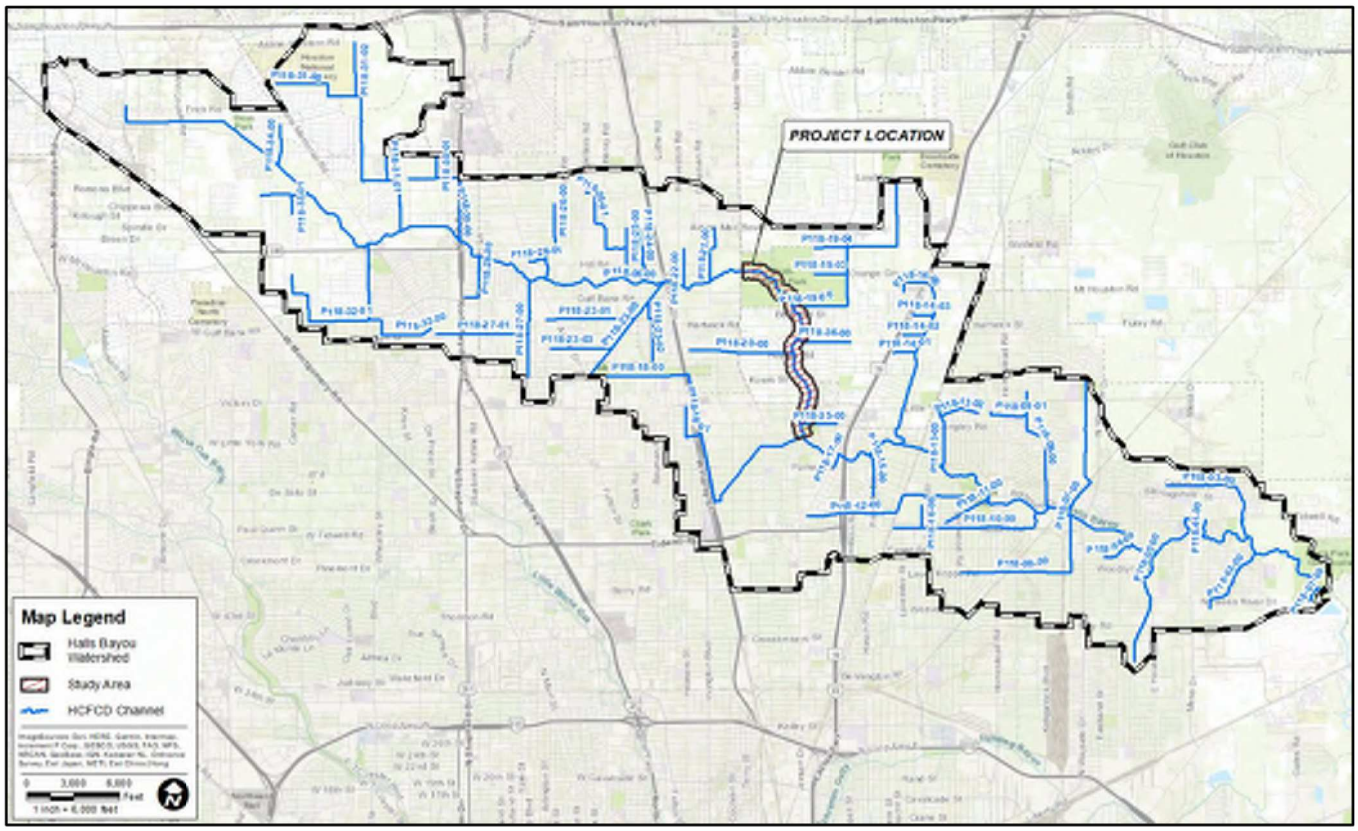


Figure 1-2: Project Area

As mentioned in **Section 1.2**, the Halls Bayou Mainstem Potential Projects effort analyzed three option areas for improvements. These areas and their connection to the Segments listed above are as follows:

- Option 1 = Segment 2 (not recommended for further analysis)
- Option 2 = Segment 3 and 4 (to be evaluated with this analysis)

- Option 3 = Segment 1 (to be evaluated with this analysis)

Figure 1-3 and **Exhibit 2** shows these extents in addition to parcel boundaries and the City of Houston and Harris County limits. These segments were designated based on the Halls Bayou Mainstem Potential Projects Memo mentioned in **Section 1.2**.

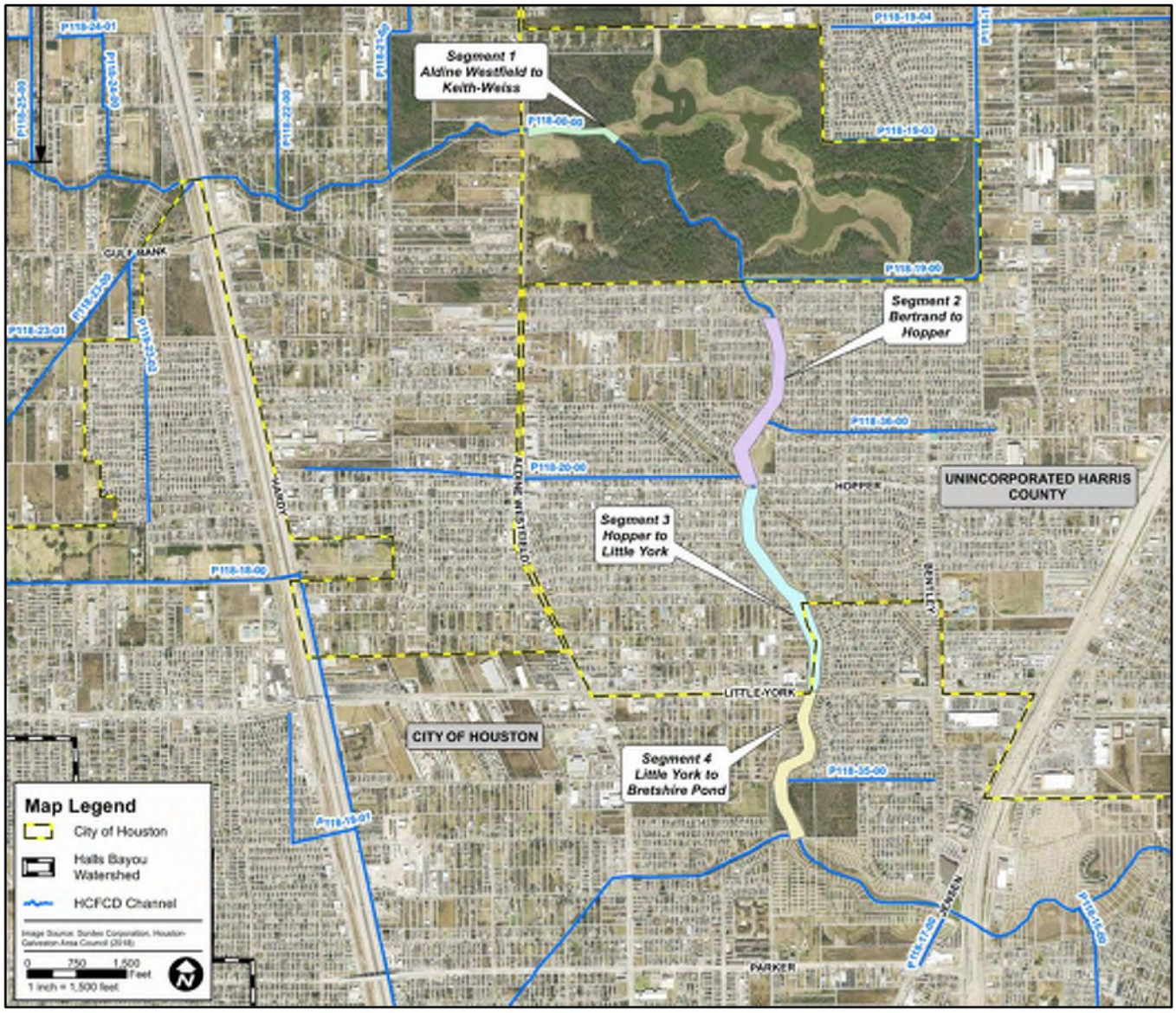


Figure 1-3: Project Area Segments

2 Baseline Conditions Analysis

2.1 Data Collection

H&H models were developed by LAN as part of the HCFCD Halls Bayou Flood Risk Reduction Phasing Study (LAN, September 2018) utilizing Harris County Appraisal District (HCAD) 2004 parcel data, Houston-Galveston Area Council (H-GAC) 2018 aerial imagery, H-GAC 2008 and 2018 Light Detection and Ranging (LiDAR), Federal Emergency Management Agency (FEMA) Effective HEC-RAS and HEC-HMS models, and 2018 Structure Inventory Data from HCFCD. Hydraulic modeling data was also collected from the HEC-RAS models used to complete the Halls Bayou Mainstem Potential Projects Memo. Historic loss data (in the form of heat maps) including All Claims, Repetitive Losses, Hurricane Harvey, and Tropical Storm Imelda losses are included in **Appendix B**.

Data sets used for this analysis include, but are not limited to the following:

- 2006 and 2018 Aerial Imagery - Houston-Galveston Area Council (H-GAC)
- 2018 LiDAR (NUSA) – H-GAC
- Halls Phasing Study Hydrologic and Hydraulic Model
- Mainstem Potential Projects Memo Hydraulic Model
- 2018 Structure Inventory – HCFCD
- Historic flood risk data (losses, all claims, historic events, etc.) - HCFCD

In addition to the data mentioned above, LAN received the Watershed Environmental Baseline (WEB) Map Data Summary Tool (DST) from HCFCD that included spatial data related to environmental features and considerations (see **Exhibit 3**). The goal of this data is to aid in the planning process when developing flood mitigation alternatives.

2.1.1 Prior Studies

Prior studies, including relevant H&H models, analyses, and reports were reviewed in order to account for additional hydraulic insights that may serve to benefit the Baseline Conditions modeling efforts.

- FEMA Effective H&H models (FEMA, June 2007). After Tropical Storm Allison in 2001, FEMA and the HCFCD together developed a countywide study, Tropical Storm Allison Recovery Project (TSARP) to assess the flood risks associated with the major flooding sources and that became the county's Flood Insurance Study (FIS) and Effective Models. As part of the project, FEMA revised the H&H models and remapped the floodplains.
- Halls Bayou Watershed Flood Risk Reduction Phasing Study (LAN, September 2018). The H&H models from the Phasing Study served as the basis for this Baseline Conditions model development.
- Halls Bayou Mainstem Potential Projects Memo (LAN, December 2020).

2.1.2 Site Conditions / Site Visit

On January 14th, 2021, LAN performed a site visit to photograph and document the project area. Major takeaways from the site visit included:

1. Segment 1 (between Aldine Westfield Road and Keith-Weiss) showed signs of bank erosion.
2. Channel banks were in fair condition at most locations within Segments 2-4, with some areas showing bank erosion.
3. Minimal scour at bridge locations.

Refer to **Figures 2-1** to **2-3** and **Appendix C** for photographic documentation.

Figure 2-1: Halls Bayou just downstream of Hopper Road

Figure 2-2: Bretshire Basin

Figure 2-3: Halls Bayou just downstream of Aldine Westfield Road

2.2 HCFCD Facilities and Unit Numbers

The HCFCD facilities within the project area include Halls Bayou (P118-00-00), P118-35-00, P118-20-00, P118-36-00, and P118-19-00. Halls Bayou has been studied by FEMA and is documented near the study area on FEMA FIRM No. 48201C0490L, effective June 18, 2007. The FEMA effective floodplain for the project area of Halls Bayou is included in **Exhibit 4**.

2.3 Right-of-Way

Channel right-of-way (ROW) owned by HCFCD varies throughout the project limits (see **Exhibit 5**), with each segment maintaining the following ROW characteristics:

- Segment 1 – 200’ ROW within a parcel owned by the City of Houston (Keith-Wiess Park and detention basin).
- Segment 2 – 150’ ROW in the northern half of the segment. Per the parcel boundaries, the ROW width in the central and southern portion of the segment appears to range from approximately 175 to 260 feet.
- Segment 3 – ROW ranges from approximately 200 to 275 feet in this area.
- Segment 4 – ROW is approximately 250’ in the northern portion of this area, with increased width in the central and southern areas of the segment. Pinewood Village Park (HCFCD ROW) and Mary Withers Park (City of Houston ROW) are located in the southern portion of this segment.

2.4 Pipelines and Utilities

There are several utilities that cross Halls Bayou throughout the project area, including the following locations:

- Upstream of Bertrand Street
- West of Royal Pine Drive
- Upstream and Downstream of Little York Road

In addition to these utility crossings, there are two major pipeline crossings within the project limits. Each crossing contains several individual pipes, which include the following:

- Crossing #1 – Just east of Brea Crest Street near the P118-36-00 outfall
  - ExxonMobil 8” Refined Product
  - ExxonMobil 10” Refined Product
  - ExxonMobil 8” Highly Volatile Liquid
  - Magellan 20” Crude Oil
- Crossing #2 – Approximately 100 feet downstream of Hopper Road (crosses underneath existing channel)
  - BP Pipelines 12” Crude Oil
  - Explorer Pipeline 10” Refined Liquid Product
  - Sunoco 8” Highly Volatile Liquid
  - Enterprise Products 10” Natural Gas

The location and information pertaining to these pipelines was documented by the Texas Railroad Commission and should be verified through field survey and Subsurface Utility Engineering (SUE) data.

2.5 Land Use

The land use types within the drainage area include primarily residential, commercial, and undeveloped (see **Exhibit 6**). Small residential lots make up the majority of the contributing drainage areas.

2.6 Hydrologic and Hydraulic Analysis

The H&H models developed for Halls Bayou Watershed Flood Risk Reduction Phasing Study were used as the starting point to establish the Baseline Conditions models for this study. These H&H models were revised as needed to establish two modeling scenarios that make up the Baseline Conditions analysis, which include the following:

1. Pre-Existing Conditions – this scenario reflects Halls Bayou conditions without the Keith-Wiess, Bretshire, and Hall Park detention basins (see **Figure 2-4**).
2. Existing Conditions – this scenario reflects the current conditions of Halls Bayou and includes the three detention basins that were constructed between 2008 and 2018 (see **Figure 2-5**).

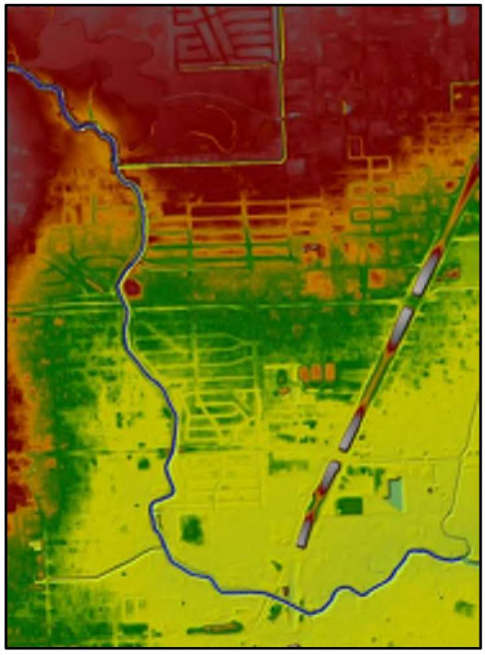


Figure 2-4: Pre-Existing Conditions

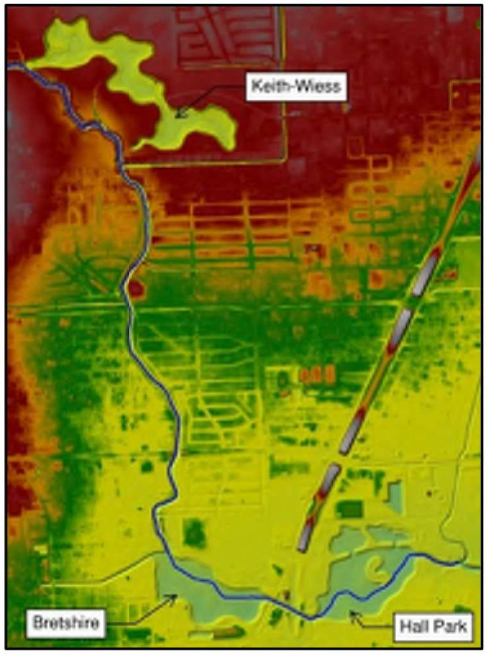


Figure 2-5: Existing Conditions

The Pre-Existing Conditions scenario was developed to measure hydraulic impacts during the Alternative Analysis stage of the project. The proposed improvements include channel conveyance improvements to be paired with stormwater detention basins that were previously constructed (Keith-Wiess, Bretshire, and Hall Park). The Pre-Existing Conditions scenario does not include the detention basis that will mitigate the channel modifications.

2.6.1 Hydrology

The hydrologic model developed for the Halls Bayou Watershed Flood Risk Reduction Phasing Study was not modified for the purpose of this analysis.

The meteorological model was developed to include the 2-, 10-, 50-, 100-, and 500-year design storm based on Harris County Hydrologic Region 2 (HCFCD, December 2009). These precipitation frequency estimates are associated with TP-40 (U.S. Weather Bureau, 1961) and Hydro-35 (NOAA, 1977) and were effective during the initial scoping of this project.

In September 2018, the National Oceanic and Atmospheric Administration (NOAA) released the “NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 11 Version 2.0: Texas” (commonly referred to as NOAA Atlas 14). The NOAA Atlas 14 precipitation frequency estimates are planned to supersede previous estimates associated with TP-40 and Hydro-35. The new data is based on records extending through June 2018. In general, the NOAA Atlas 14 data shows increased rainfall values throughout Harris County. Most notably: the 100-year, 24-hour storm event increased from 13.2 inches to 16.9 inches within Halls Bayou.

While this project is based on the older precipitation frequency estimates, the updated NOAA Atlas 14 100-year rainfall depths and resulting water surface elevations (WSELs) can be approximated by the previous effective 500-year storm event included in this study.

2.6.1.1 Drainage Area Delineation

The effective model sub-basins that cover the project area include P118P, P118N2, P118Q, P118R, and P118S (see **Figure 2-6** and **Exhibit 7**). These drainage areas provide appropriate boundary conditions for the dynamic HEC-RAS model.

To confirm the drainage area delineations, LAN developed a Rain-on-Mesh model, where precipitation is applied directly to the surface to determine overland flow paths. This procedure was conducted for the 2- and 100-year storm events. **Figure 2-6** shows the result of a 100-year storm event with HEC-RAS's particle tracing feature to show flow paths and the contributing area draining to Halls Bayou. Flow change locations assigned in the Baseline Conditions Halls Phasing Study HEC-RAS model were maintained for this analysis.

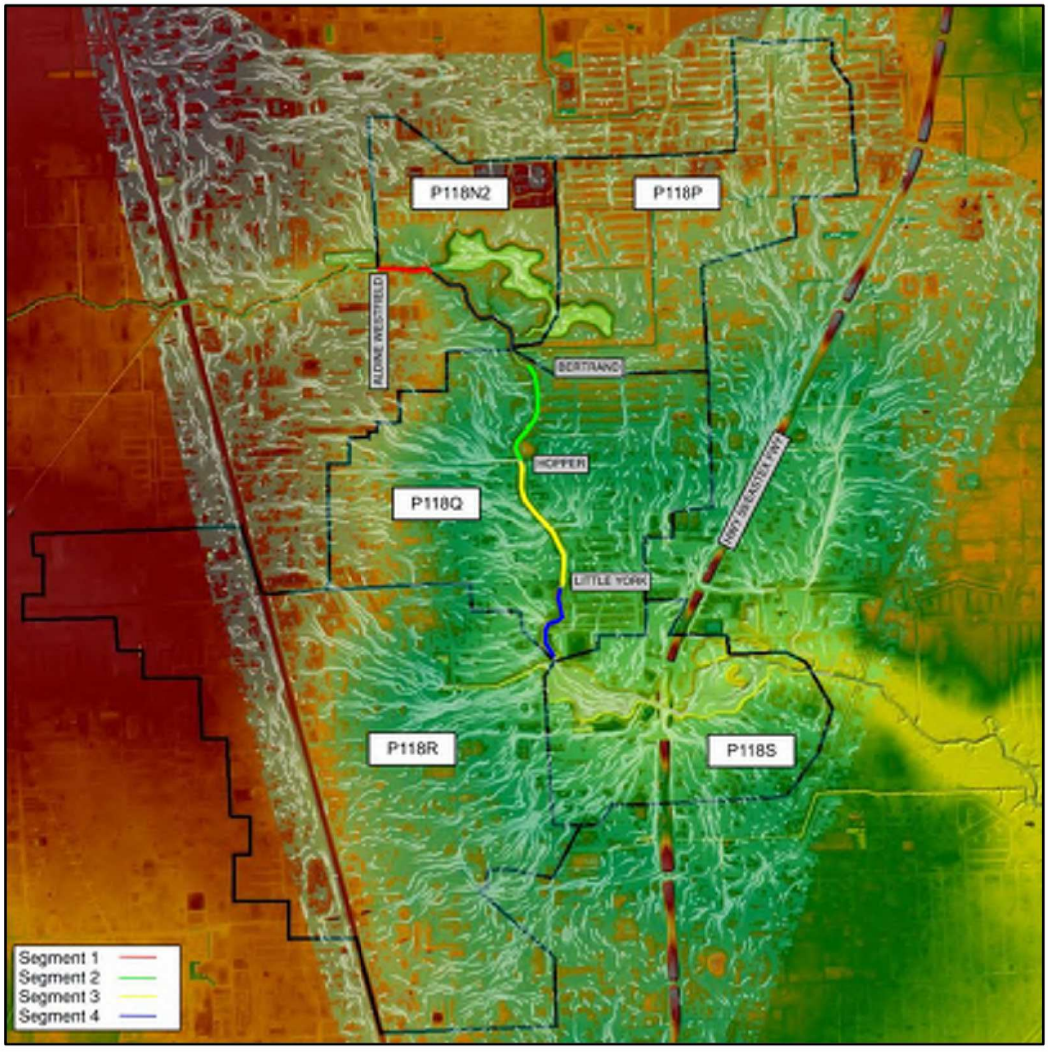


Figure 2-6: Contributing Drainage Areas – HEC-RAS Rain-on-Mesh Model (100-Year Rainfall Event)

2.6.1.2 Hydrograph Development

The hydrology model utilized to establish Baseline Conditions flows came from the Halls Bayou Watershed Flood Risk Reduction Phasing Study, which was based on the FEMA effective HEC-HMS model and updated to reflect more current conditions. HEC-HMS version 3.4 (USACE 2009) was used

throughout the Phasing Study analysis and was consistent with the Effective M3 hydrologic model development. Harris County Appraisal District (HCAD) 2004 parcel data, used in the development of the Halls Federal General Revaluation Report (GRR) and Halls Ahead Vision Studies, and 2018 aerial imagery were referenced to verify and update the land use parameters. Percent impervious and Percent Land Urbanization (DLU) were calculated by digitizing the land use categories from HCAD 2004 parcel data and verified based on 2018 aerial imagery. Time of Concentration (TC) & Storage Coefficient (R) parameters were developed using the HCFCD hydrologic methodology (HCFCD 2009).

Peak runoff values of the contributing drainage areas for each modeled storm event are included in **Table 2-1**. The hydrographs of these drainage areas were subsequently applied to the hydraulic models as internal boundary conditions.

Table 2-1: Contributing Drainage Area Peak Flows

Drainage Area	Area Acres (sq.mi.)	Peak Flow (cfs)				
		2-Year (50%)	10-Year (10%)	50-Year (2%)	100-Year (1%)	500-Year (0.2%)
P118N2	439 (0.69)	181	346	508	591	825
P118P	891 (1.39)	165	331	510	601	875
P118Q	1273 (1.99)	215	434	671	793	1,158
P118R	2292 (3.58)	611	1,191	1,792	2,100	3,003
P118S	688 (1.07)	239	457	677	788	1,109

2.6.2 Hydraulics

The development of the combined 1D/2D Baseline Conditions Models (Pre-Existing and Existing Conditions) focused on four key hydraulic features: (1) 1D cross-sections, (2) 2D flow areas, (3) lateral structures, and (4) boundary conditions. LAN followed the process described in *Section 3: Development of a Combined 1D/2D Mode*l, of the "*HEC-RAS 2D Modeling User's Manual*" (USACE, February 2016) when developing this model.

As a starting point for the Baseline Conditions models, LAN used the 1D unsteady model that was developed as part of the Halls Phasing Study. LAN was scoped to re-evaluate and modify the hydraulic model from the Halls Phasing Study, convert from HEC-RAS Version 5.0.3 to Version 5.0.5, modify the hydraulic 1D model to a combined 1D/2D model, and stabilize the model for the 2-, 10-, 50-, 100-, and 500-year return periods. Additionally, the Halls Phasing Study model (**Figure 2-7**) was truncated from just upstream of Aldine Westfield Road to just upstream of P118-14-00 (**Figure 2-8** and **2-9**). This truncated Halls Phasing Study model served as the starting point when creating the four Baseline Conditions models (Pre-Existing 1D, Pre-Existing 1D/2D, Existing 1D, and Existing 1D/2D). The complete HEC-RAS model layouts for these four models are shown in **Exhibits 8-11**.

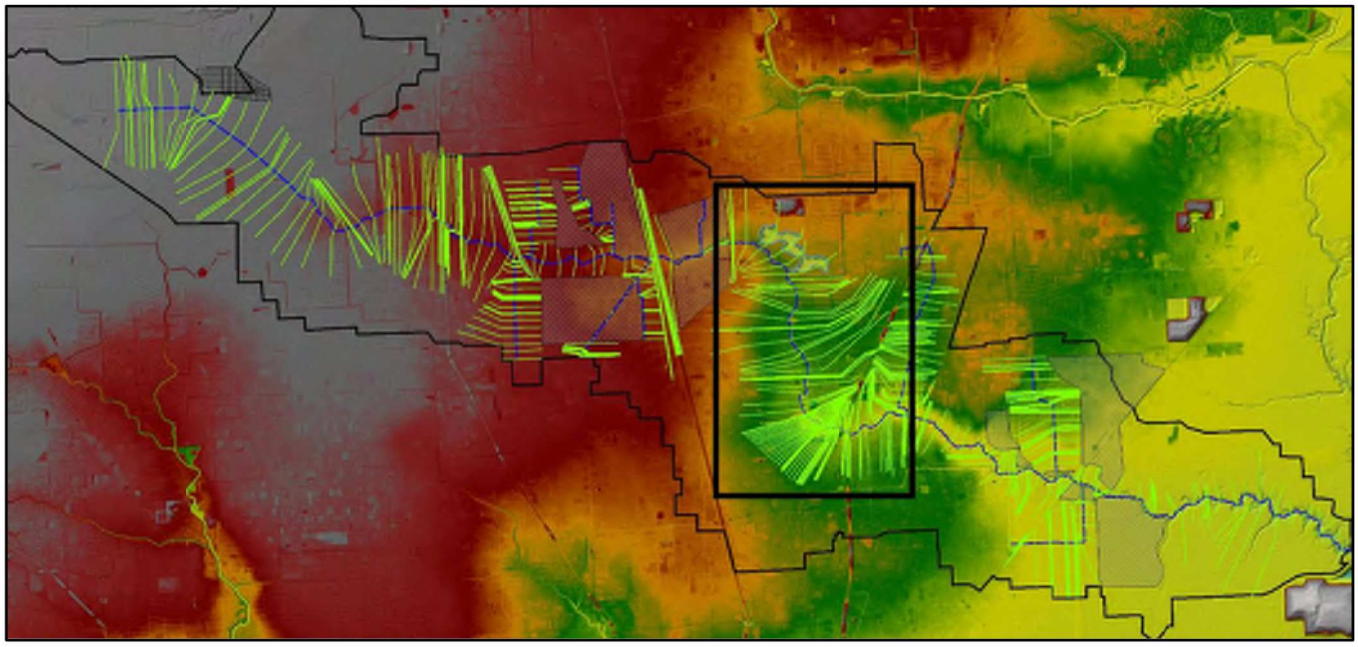


Figure 2-7: Halls Phasing Study HEC-RAS Model

2.6.2.1 1D Cross Section Geometry

Cross sections along Halls Bayou within the Halls Phasing Study model were based primarily on the effective M3 model, which was created using 2001 LiDAR. It is noted in the Phasing Study report that only cross sections showing obvious discrepancies between the 2001 and 2008 LiDAR were revised. For this Baseline Conditions analysis, both the Pre-Existing and Existing Conditions models were created using 2018 H-GAC LiDAR in the overbanks, while the channel cross section data was left unchanged from the Halls Phasing Study model. Roughness values assigned to the 1D cross sections were mostly unchanged from the Halls Phasing Study model, although n-values at the Bretshire and Hall Park detention basins were modified to ensure consistency between the 1D-only and 1D/2D combined models.

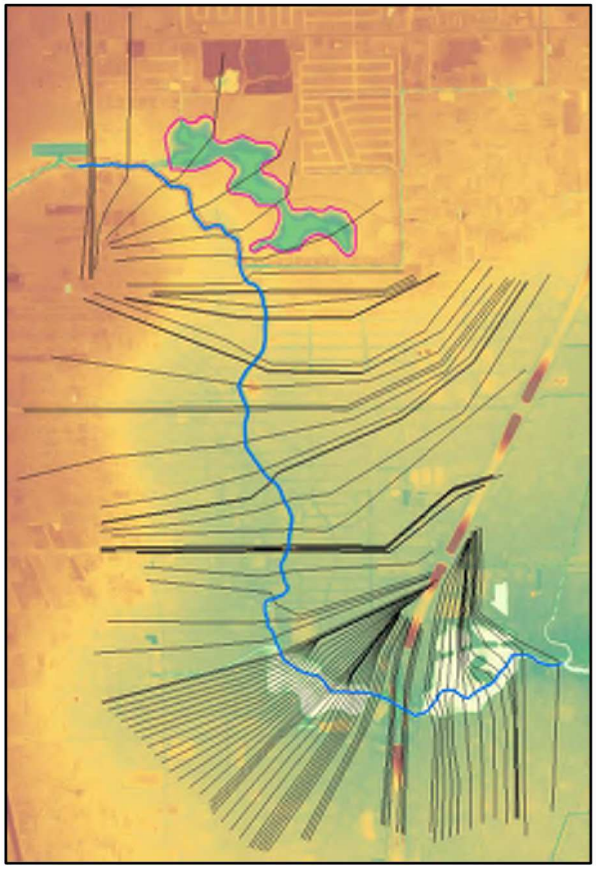


Figure 2-8: 1D Truncated HEC-RAS Model

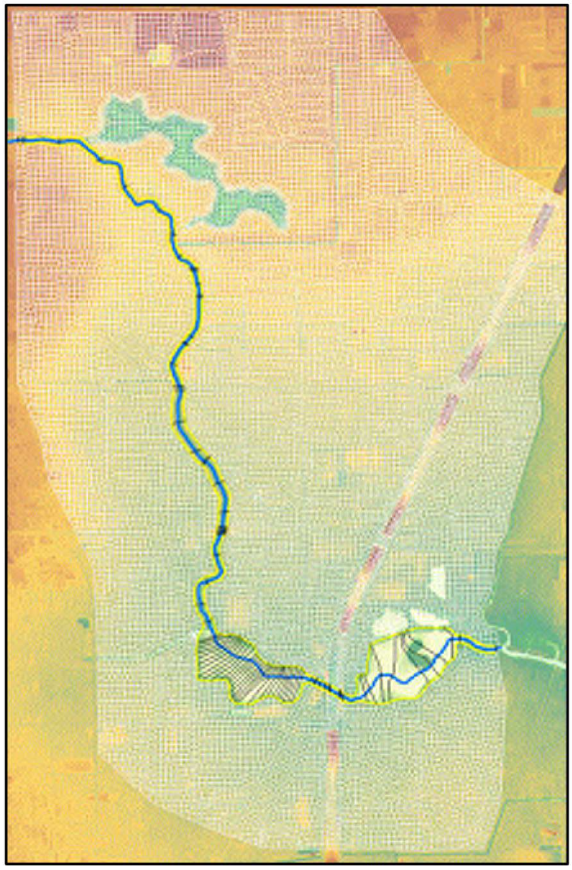


Figure 2-9: 1D/2D Truncated HEC-RAS Model

2.6.2.2 1D/2D Model

Several steps were taken to convert the Phasing Study model to a combined 1D/2D model. As stated in **Section 2.6.2**, the Phasing Study model was first truncated to only include the project area, which significantly decreased simulation time. In addition to the truncated 1D model, a 1D/2D truncated model (**Figure 2-9**) was created to provide increased accuracy of flood depth and inundation extent in the overbank areas. This required that cross sections be shortened to extend to just outside the channel limits in addition to creating lateral weirs along both overbanks throughout the reach so that flow could be transferred to the 2D flow areas. Two 2D flow areas were created (one for each overbank area) using a cell size of 100'x100' for the respective 1D/2D Baseline Conditions models. The 2D mesh as refined to a 50'x50' cell size near the Keith-Wiess detention basin to confirm sheet flow patterns in the 500-year event. As per HCFCD's "2D Modeling Guidelines", break lines were created for all major roadways contained within the new 2D mesh boundaries.

It should be noted that the 1D/2D combined hydraulic model was used for calculating performance metrics (discussed in **Section 2.7.1**) only, while WSEL and flow impacts or comparisons were measured using the 1D only models to maintain consistency with FEMA Effective models.

2.6.2.3 Lateral Structures – 1D/2D Model Interaction

Lateral structures were set in HEC-RAS to connect the 1D river/reach to the 2D flow area (**Figure 2-10**). As the 1D channel fills up and reaches the banks, the lateral structures allow the water to leave the 1D channel and enter the 2D overbanks. LAN placed lateral structures on left and right banks between inline structures (culverts/bridges) along the entire length of the tributaries. For the weir coefficients of the lateral structures and 2D connectors, Table 3-1 of the HEC-RAS 2D Manual recommended 0.2 to 0.5 for flow escaping the main river (USACE, February 2016).

Figure 2-10: HEC-RAS Model – 1D/2D Interaction

2.6.2.4 Tailwater Conditions

Stage and flow results for each storm event from the Interim Impact Analysis Model (discussed in Section 6) were used for downstream boundary conditions for the 1D truncated models. For the 1D/2D models, a stage hydrograph from Halls Bayou was applied to each 2D flow area boundary near the downstream end of the truncated model, while a rating curve was used for the downstream 1D boundary condition. Additional information regarding boundary conditions has been provided within the hydraulic model.

2.6.2.5 Inflow Boundary Conditions

Upstream boundary conditions for the truncated models were generated using flow results from the Halls Phasing Study model. Resulting flow hydrographs of each storm event were applied to the most upstream cross section of each Baseline Conditions scenario.

Internal boundary conditions from the Halls Phasing Study model were modified to more accurately represent the inflow from contributing drainage areas and other HCFCD channels. The total inflow volume did not change from the Phasing Study model, however lateral inflow locations were adjusted. Inflow

hydrographs are applied via boundary conditions using DSS connections to the Halls Phasing Study HEC-HMS model – refer to **Section 2.6.1.2 - "Hydrograph Development"**.

2.6.2.6 Terrain Updates and Adjustments

In February 2018, H-GAC released approximately 10,000 square miles of new, high-resolution LiDAR data of Harris County and the surrounding coastal area. This data is used to support floodplain management and planning, emergency management operations, water quality modeling, and stream restoration. The 2018 LiDAR uses a 1.0-meter cell size and provides more accurate results than the 2008 LiDAR, which uses a 1.5-meter cell size.

When comparing cross section data from the Halls Phasing Study model to the 2018 LiDAR, it is evident that noticeable discrepancies exist between the two data sets. Differences in terrain elevation are primarily seen within the cross section overbanks, as shown in the example cross section in **Figure 2-11**. The application of the 2018 H-GAC LiDAR is warranted especially due to the increased terrain accuracy in the overbanks, which will in turn improve 2D modeling accuracy and therefore provide more accurate flood metrics such as structural flooding and roadway ponding. Additionally, the 2008 H-GAC Lidar did not contain the Bretshire or Hall Park detention basins, which are important hydraulic features of this analysis.

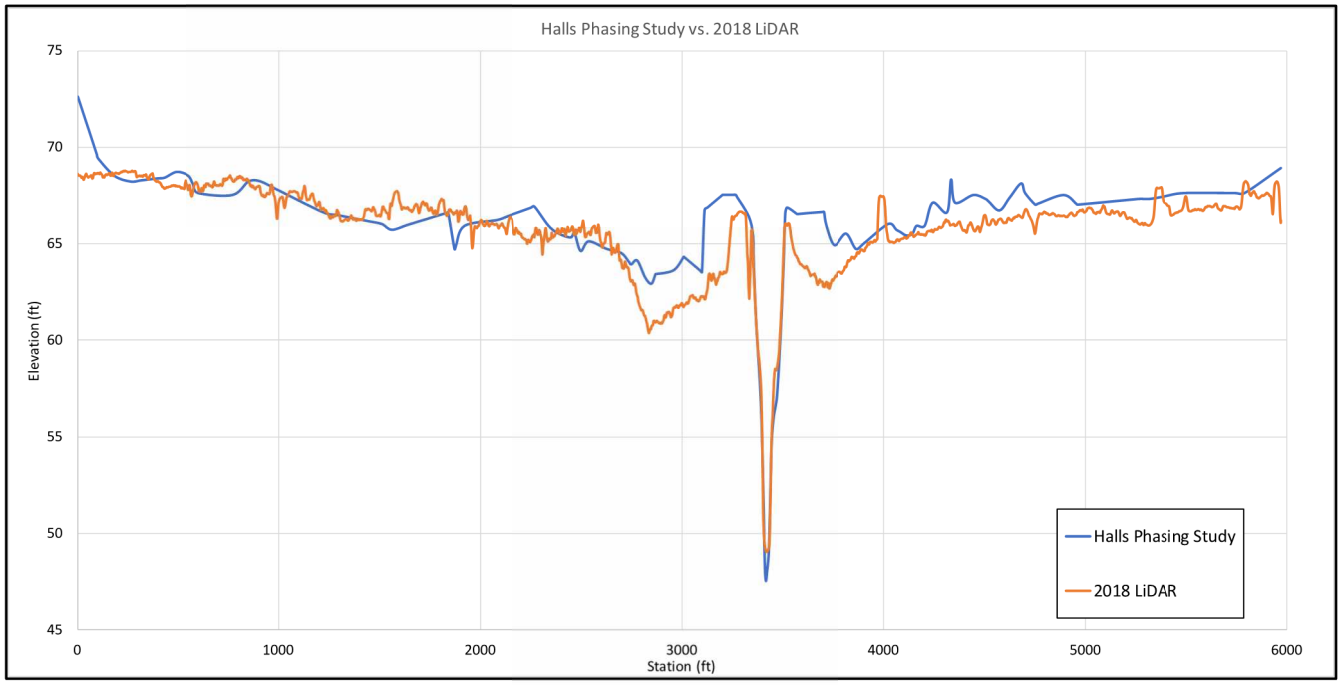


Figure 2-11: Halls Phasing Study Cross Section vs. 2018 LiDAR

As a result of modeling both Pre-Existing and Existing Conditions, it was required that two separate terrains be created within the HEC-RAS model. Details and adjustments for each Baseline Conditions terrain are detailed below:

- Pre-Existing Conditions – Using the 2018 LiDAR as the base terrain, it was required that Keith-Wiess, Bretshire, and Hall Park basins be "filled", as to represent terrain conditions prior to their construction. For Bretshire and Hall Park, this was done by clipping the 2008 LiDAR covering these areas and merging the data on top of the 2018 LiDAR. For Keith-Wiess, it was required that

an imaginary flat surface be created and subsequently merged on the same surface due to the basin being included in the 2008 LiDAR.

- Existing Conditions – This terrain reflects the 2018 LiDAR, which did not require any adjustments prior to modeling in HEC-RAS.

Figure 2-4 and **2-5** in **Section 2.6** show the final terrain data sets used for the hydraulic modeling.

2.7 Baseline Conditions Results

Both the Existing and Pre-Existing Conditions models demonstrate widespread ponding across the catchment in the 100- and 500-year storm event. Maximum ponding extents and depths for all five storm events can be seen in **Exhibits 12-21**. **Exhibits 12-16** also include Historically Flooded Structures that were extracted from historical loss data (All Claims and Repetitive Losses) within the Bretshire and Hall Park basin footprints. Water surface profile comparisons between Pre-Existing and Existing Conditions for all four storm events can be seen in **Appendix D**.

2.7.1 Performance Metrics

The Baseline Conditions HEC-RAS results were used to generate a set of performance metrics to measure proposed improvement alternatives. Metrics include acreage of floodplain, miles of inundated roadway, number of structures in the floodplain, and number of flooded structures based on estimated finished floor elevation (FFE). Miles of roadway measures the length of roadway resulting from an intersection of the maximum inundation boundary with the HGAC StarMaps roadway centerline shapefile. Refer to **Table 2-2** for a summary of the two Baseline Condition's performance metrics for the 2-, 10-, 50-, 100-, and 500-year storm events.

To determine the structure counts in the floodplain, maximum floodplain extents and WSELs were exported from HEC-RAS for all four design storms (2-, 10-, 50-, 100-, and 500-year) to GIS and intersected with the 2018 HCFCD Structural Inventory (SI) data. The SI is a point dataset of building centroids with FFE's populated from either survey or an assumed adjustment based on LiDAR. There are still data points with no assigned FFE data, and in these cases, the associated 2018 LiDAR elevation fields were used and adjusted by adding 0.5 feet to approximate FFE values for use in developing the performance metrics. A structure centroid with a model WSEL value higher than its FFE was considered flooded.

Table 2-2: Baseline Conditions Performance Metrics

Metric	2-Year (50%)		10-Year (10%)		50-year (2%)		100-year (1%)		500-year (0.2%)	
	Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing
Structures in Floodplain	0	0	610	25	2,442	1,893	3,047	2,633	4,555	4,369
Flooded Structures (based on FFE)	0	0	62	0	624	307	1,105	707	2,365	2,167
Miles of Inundated Road	0.1	0.0	15.7	1.6	32.6	24.0	37.5	30.7	56.0	53.0
Acres of Inundated Land (Floodplain)	72	221	612	348	1,515	1,243	1,764	1,525	2,437	2,303

2.7.2 Existing Level of Service

Pre-Existing Condition model results show that this portion of Halls Bayou maintains less than a 10-year Level-of-Service (LOS) throughout most of the reach. With the addition of Keith-Wiess, Bretshire, and Hall Park detention basins, the Existing Conditions results show significant hydraulic benefits and reflect primarily a 10-year LOS throughout the project area. It should be reinstated that these storm events use "Pre-Atlas 14" rainfall data, which should be taken into account when determining the LOS. A summary

of Baseline Conditions WSELs and flows at roadway crossings along Halls Bayou is shown in **Table 2-3** and **2-4**, respectively. Note that the flows included in **Table 2-4** are reported at the time of the peak WSEL.

Table 2-3: Baseline Conditions WSELs (ft) at Roadway Crossings (1D Model Results)

Location	Deck Elevation (ft)	2-Year (50%)		10-Year (10%)		50-year (2%)		100-year (1%)		500-year (0.2%)	
		Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing
Aldine Westfield Road	67.74	61.59	61.12	65.35	64.78	66.68	65.76	67.13	66.20	68.09	67.44
Bertrand Street	66.15	57.94	57.08	61.09	60.80	62.27	62.21	62.64	62.61	63.69	63.67
Hopper Road	60.77	56.62	55.56	59.51	59.13	60.36	60.20	60.66	60.51	61.48	61.37
Little York Road U/S	60.84	55.16	53.76	57.68	56.84	58.69	57.97	59.19	58.45	60.23	59.89
Little York Road D/S	65.16	55.13	53.72	57.65	56.80	58.53	57.91	58.97	58.32	60.07	59.63
Jensen Drive	59.37	52.52	48.80	55.75	53.25	56.98	55.38	57.77	56.21	59.27	58.69
HWY 59	78.32	52.22	48.37	55.19	52.53	56.22	54.46	56.52	55.08	57.83	56.69

Table 2-4: Baseline Conditions Flows (cfs) at Roadway Crossings (1D Model Results)

Location	2-Year (50%)		10-Year (10%)		50-year (2%)		100-year (1%)		500-year (0.2%)	
	Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing	Pre-Existing	Existing
Aldine Westfield Road	2,559	2,559	4,616	4,609	6,040	6,043	6,711	6,712	9,224	9,226
Bertrand Street	2,749	2,457	4,890	4,809	6,330	6,327	7,006	7,017	9,557	9,531
Hopper Road	2,810	2,514	4,983	4,882	6,447	6,442	7,126	7,136	9,688	9,652
Little York Road U/S	2,886	2,583	5,097	4,973	6,596	6,581	7,268	7,275	9,851	9,801
Little York Road D/S	2,887	2,583	5,097	4,973	6,594	6,580	7,257	7,271	9,847	9,801
Jensen Drive	3,419	2,872	5,717	5,418	7,336	7,290	7,942	7,969	10,428	10,303
HWY 59	3,419	2,859	5,711	5,413	7,294	7,164	7,860	7,809	10,355	10,303

2.8 Baseline Conditions Summary

Baseline conditions results revealed that this reach of Halls Bayou is significantly undersized, which subsequently causes widespread street ponding in addition to overbank and structural flooding throughout. As shown in the performance metrics results, the Existing Conditions, 500-year design storm reflects 4,369 structures mapped within the modeled floodplain with 2,167 structures flooded based on estimated finished floor elevations in addition to 53 miles of roadway being inundated.

3 Proposed Conditions Alternatives

All alternatives considered in this Alternatives Analysis Summary Report evaluated flood damage reduction potential under existing development hydrologic conditions. Other planned infrastructure projects that may affect the P118-00-00 service area and total flows are not considered as part of this analysis unless explicitly stated. The Existing Conditions HEC-RAS model was used as a starting point for developing the various Proposed Conditions models, however the Pre-Existing Conditions model was the comparison point for the Impact Analysis.

3.1 Alternatives Development

LAN used the Mainstem Potential Projects Memo as a starting point for developing the proposed alternatives for this analysis. As mentioned in **Sections 1.2 and 1.3**, Options 2 and 3 were recommended for further analysis and subsequently included in the proposed conditions alternatives discussed in **Section 3.3**.

3.2 Planning Level Drainage Improvement Alternatives

The planning level analysis was completed primarily within the Mainstem Potential Projects Memo effort, which developed options based heavily on projected grant funding and time to completion. This alternatives analysis was centered around detailed modeling of the options developed within the Mainstem Potential Projects Memo.

3.3 Detailed Level Alternatives

LAN developed three Alternatives under pre-Atlas 14 conditions, with Alternatives 1 and 2 being derived from the Potential Projects Memo. In developing the alternatives, it should be noted that the HEC-RAS model does not account for local drainage systems (undersized storm sewer, sheet flow paths) and assumes the entire runoff volume of the contributing area is conveyed to the channel.

3.3.1 Alternative 1

Alternative 1 improvements are based on Option 2 from the Potential Projects Memo, and includes widening the existing channel along the left (east) bank from approximately 750' upstream of Hopper Road to just upstream of the Bretshire detention basin (**see Figure 3-1 and Exhibit 22**). The proposed channel excavation begins one foot above the estimated ordinary high water mark (OHWM), contains an intermediate shelf (varying width), and a side slope (5:1, H:V) that ultimately ties into the existing ground elevations near the top of bank (see **Figure 3-2**). Alternative 1 improvements do not propose modifications to existing roadway bridges or pipeline crossings, however slight modification may be required to the existing pedestrian bridge near Kowis Street.

The channel improvements reflect a total excavation volume of approximately 62,500 cubic yards (38.7 ac-ft). The proposed section lies within the existing ROW, however it may be required that portions of the existing Greenway Trail be relocated to accommodate the channel widening. The project costs of Alternative 1 is $1,839,940 and would provide a 10-year LOS for Halls Bayou within the project area.

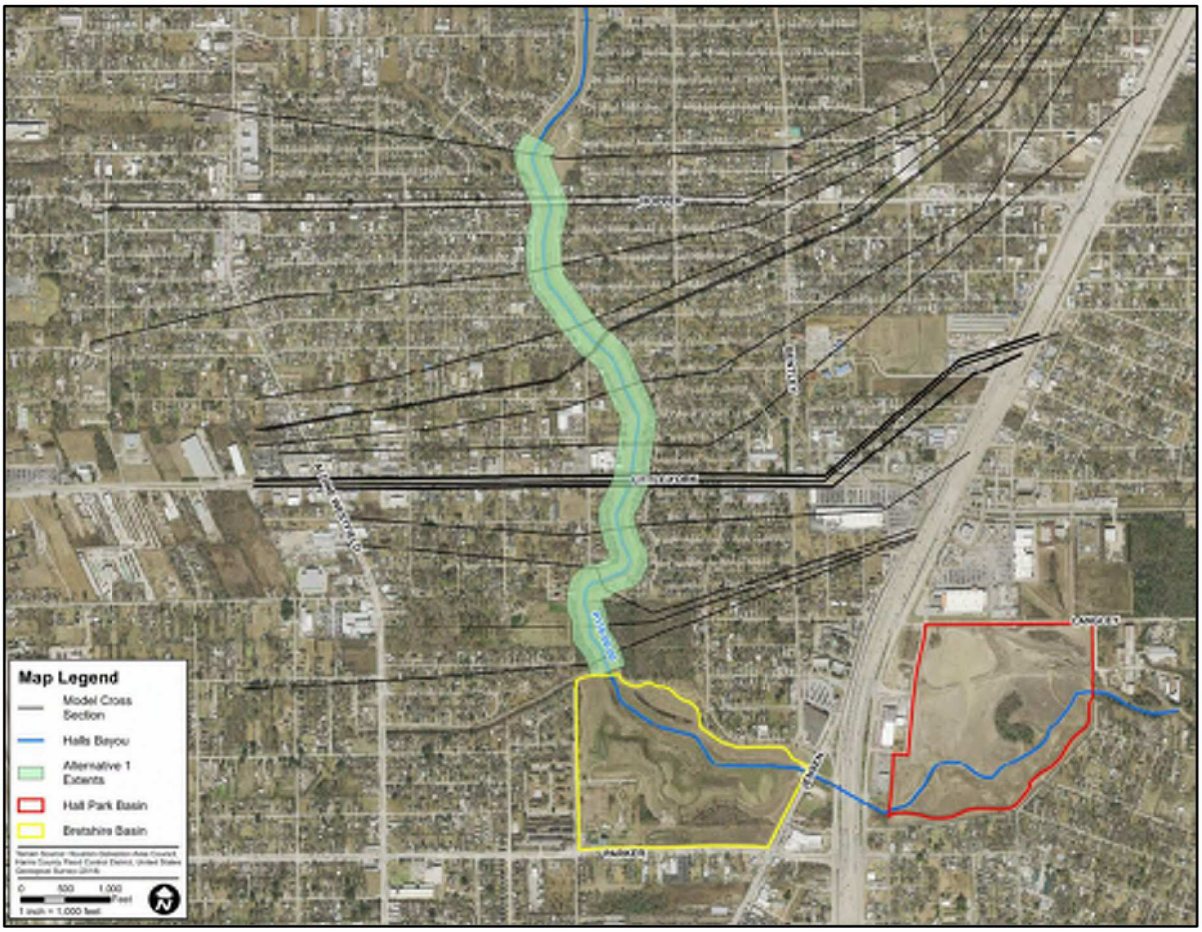


Figure 3-1: Alternative 1 Layout

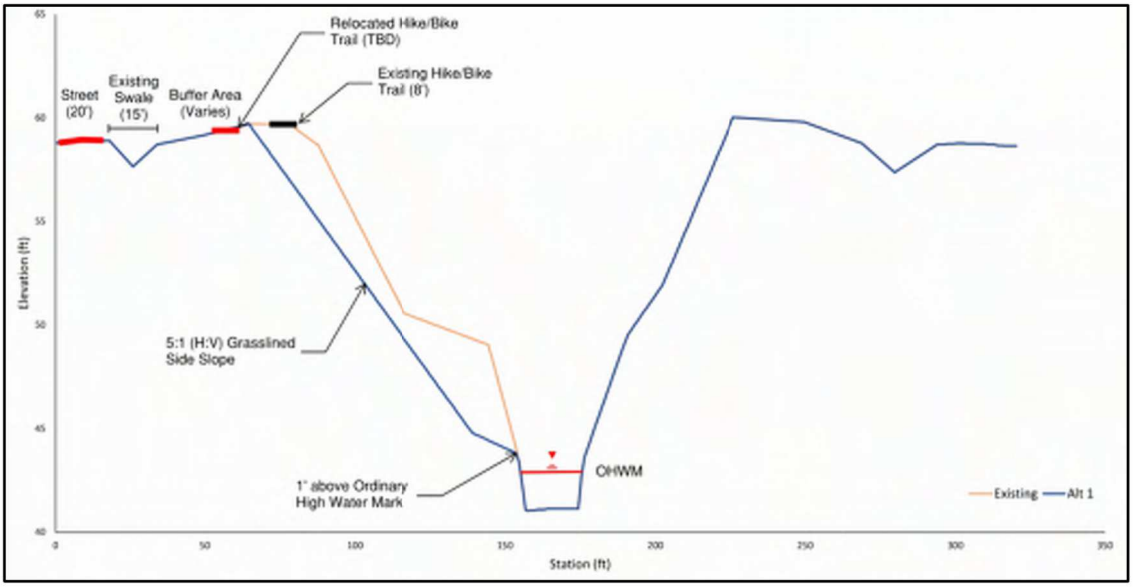


Figure 3-2: Alternative 1 Typical Section

3.3.2 Alternative 2

Alternative 2 consist of the Alternative 1 improvements in addition to channel improvements between Aldine Westfield Road and the Keith-Wiess detention basin (see **Figure 3-3** and **Exhibit 23**). The channel improvements reflect a total excavation volume of approximately 89,000 cubic yards (55.2 ac-ft). A typical section of the improvements between Aldine Westfield Road and the Keith-Wiess detention basin is shown in **Figure 3-4**. The projected costs of Alternative 2 is $2,508,390 and would provide a 10-year LOS for Halls Bayou within the project area.

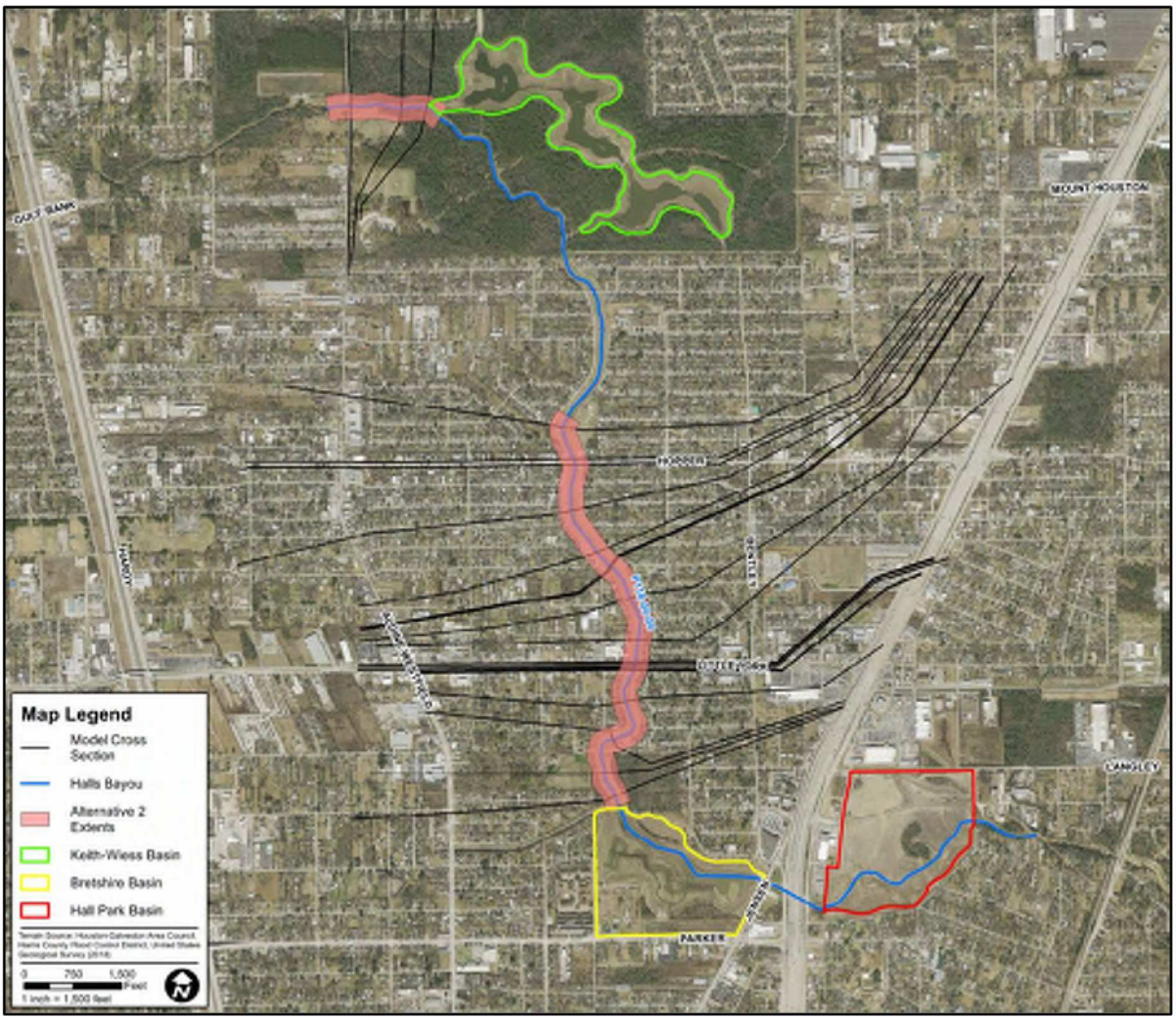


Figure 3-3: Alternative 2 Layout

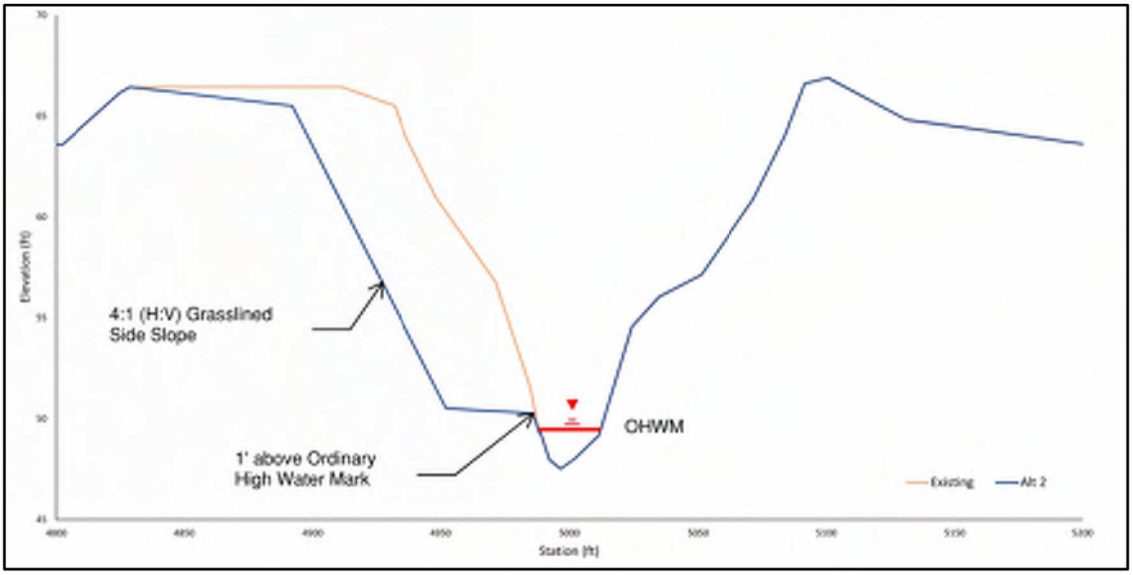


Figure 3-4: Alternative 2 Typical Section (Between Aldine Westfield and Keith-Wiess Basin)

3.3.3 Alternative 3

Alternative 3 includes a complete redesign of the existing channel that begins just downstream of Hopper Road and ends at the Bretshire detention basin (see **Figure 3-5** and **Exhibit 24**). Between Hopper Road and Little York Road, the proposed channel consists of a 15' bottom width (with a pilot channel), an intermediate bench along the left bank, and 4:1 side slopes throughout (see **Figure 3-6**). From Little York to the Bretshire detention basin, the channel consists of a 25'-35' bottom width (with pilot channel), an intermediate bench on both sides of the channel, and 4:1 side slopes throughout. The improvements also include 30' maintenance berms and backslope swales. The proposed section dimensions do not require additional ROW based on existing HCFCD GIS ROW data.

This alternative provides an increased LOS compared to Alternatives 1 and 2, however it requires a greater impact to existing infrastructure such as bridges and utilities. It also may require environmental or USACE permitting as a result of modifications to the existing flowlines and areas below the OHWM. The projected costs of Alternative 3 is $5,241,050 and would provide a 50-year LOS for Halls Bayou within the project area.

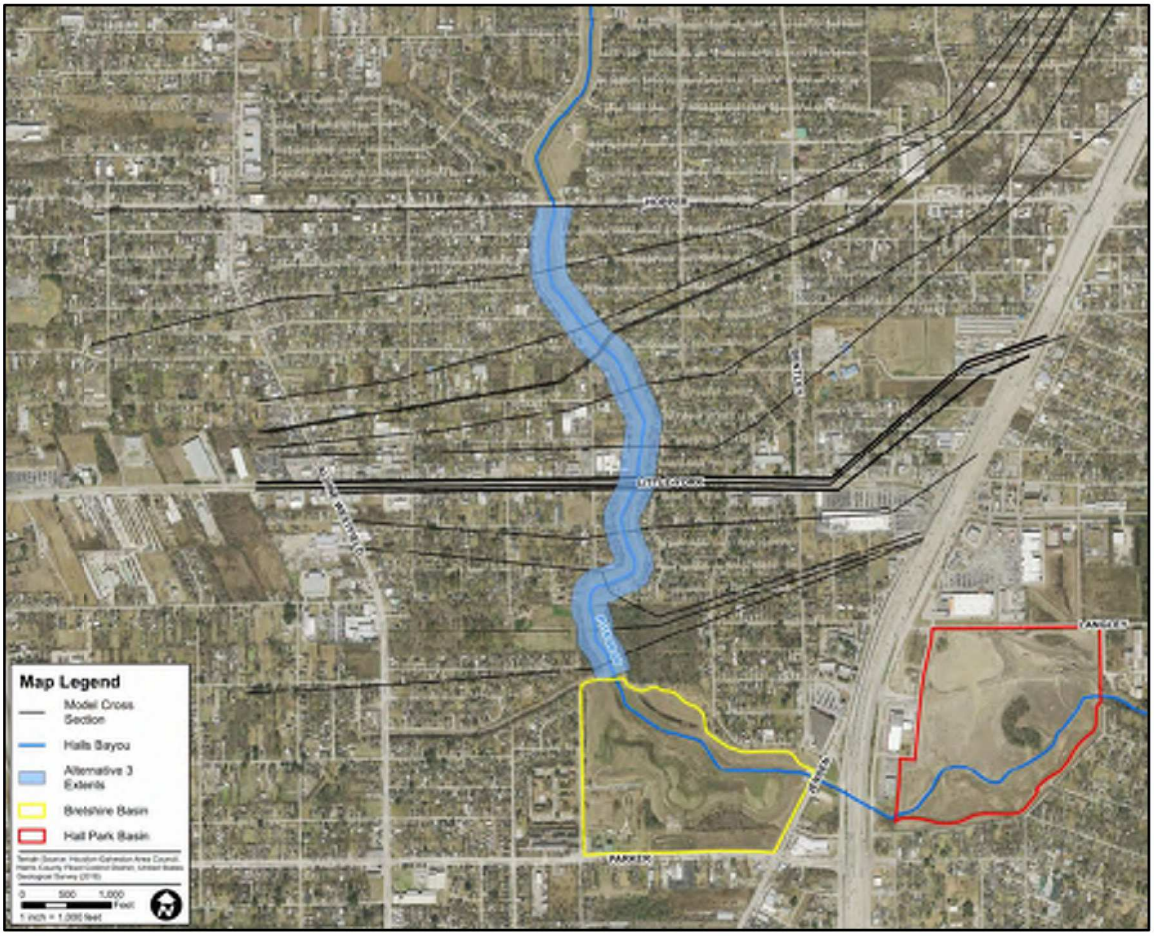


Figure 3-5: Alternative 3 Layout

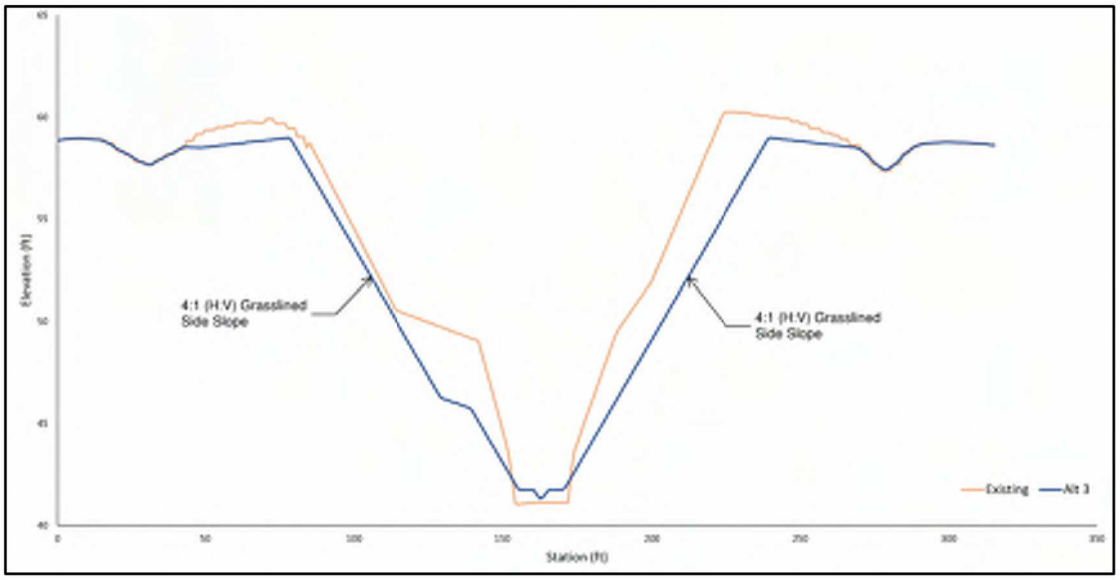


Figure 3-6: Alternative 3 Typical Section

3.4 Features and Enhancements

A portion of the Halls Bayou Greenway Trail is located within the proposed improvement area. The existing greenway trail is located along the left overbank of the channel and extends from the Keith-Wiess detention basin to Jensen Drive. Each alternative developed for this study proposes to remove and replace portions of the existing Greenway Trail as a result of the conveyance improvements. The probable costs of removing and replacing the trail has been included in the Opinions of Probable Construction Costs (OPCCs) outlined in **Section 4.4**. Coordination between HCFCD, the Houston Parks Board, Aldine Management District, and engineering or design firms will be required to finalize the details and design of future enhancements.

4 Alternatives Analysis Results

4.1 Hydraulics

4.1.1 HEC-RAS Geometry

The Existing Conditions model geometry was used as a starting point for the development of each proposed alternative geometry within the HEC-RAS model. Hydrology and other unsteady flow boundary conditions remained consistent from Existing to Proposed Conditions. Channel modifications for each respective alternative were completed by modifying the Existing Conditions cross sections without adding any additional sections or geometric components. Slight modifications to bridges and pipeline crossings were required for the Alternative 3 geometry, however bridge geometries for Alternative 1 and 2 were not modified from Existing Conditions.

4.1.2 Inflow Boundary Conditions

Inflow boundary condition locations remained identical to the Existing Conditions model, which are outlined in **Section 2.6.2.5**.

4.2 Results

The Proposed Conditions HEC-RAS results were used to generate the same performance metrics described in **Section 2.7.1**. Additional hydraulic modeling results including water surface profiles and comparison tables are documented in the sections below and included in appendices.

Alternative 1 improvements provide a 10-year LOS for the project area while significantly reducing the inundation extent for the 50- and 100-year events. **Appendix E** includes water surface profile comparisons of Alternative 1, Existing, and Pre-Existing Conditions. **Exhibits 25-29** show depth grids and performance metrics results for each modeled storm event. Model results show that Alternative 1 removes the 500-year floodplain from 215 structures and 2.2 miles of roadway (see **Table 4-1**). Note that the term “benefited” included in **Table 4-1** refers to structures no longer within the floodplain or structures no longer flooded based on estimated FFE. Water surface profile comparisons between Alternative 1 and Baseline Conditions for the 10- and 500-year event are included in **Figure 4-1** and **4-2**, respectively.

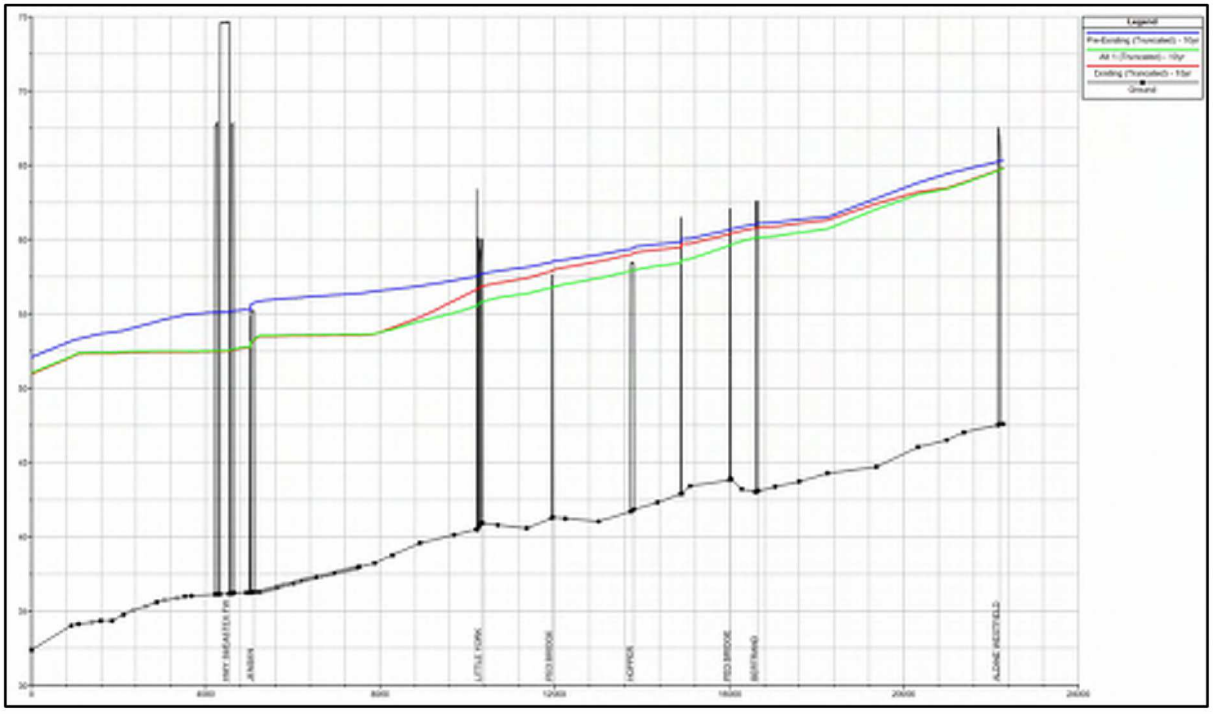


Figure 4-1: Alternative 1 vs. Baseline Conditions WS Profiles (10-Year)

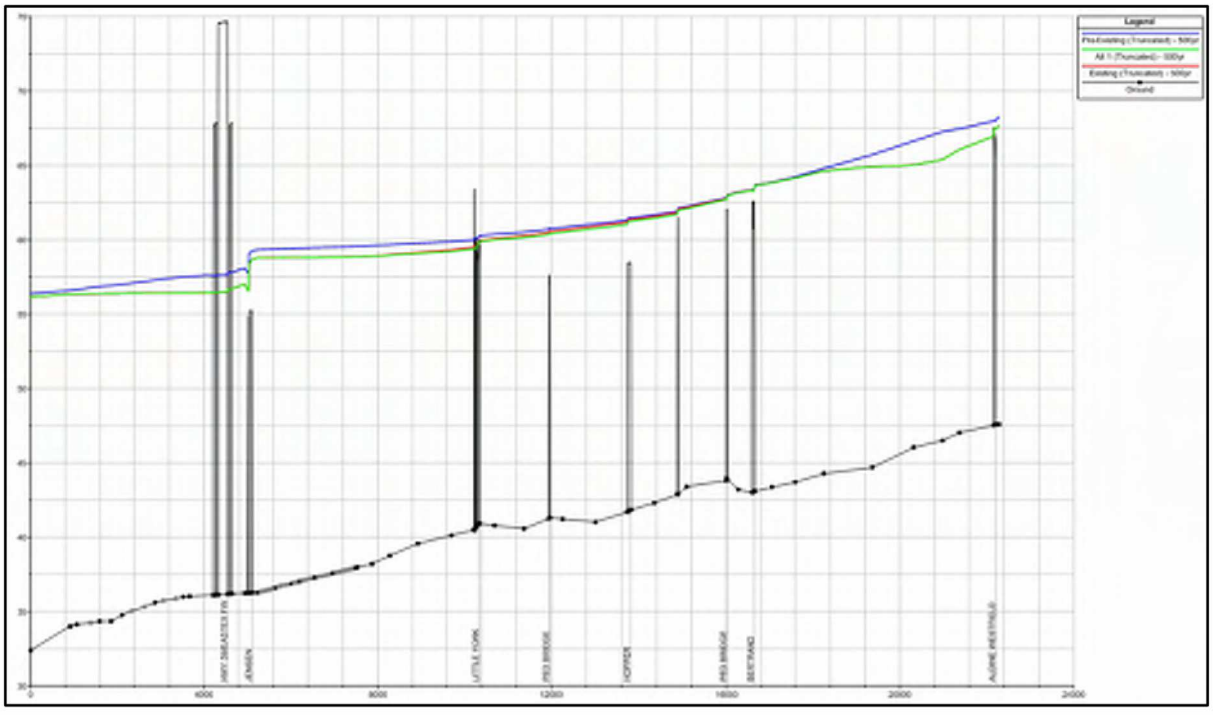


Figure 4-2: Alternative 1 vs. Baseline Conditions WS Profiles (500-Year)

4.2.1 Alternative 2

Alternative 2 improvements provide similar benefits when compared to Alternative 1 in addition to decreases in WSEL between Aldine Westfield Road and the Keith-Wiess detention basin. **Appendix F**

includes water surface profile comparisons of Alternative 2, Existing, and Pre-Existing Conditions. **Exhibits 30-34** show depth grids and performance metrics results for each modeled storm event. Model results show that Alternative 2 removes the 500-year floodplain from 219 structures and 2.3 miles of roadway (see **Table 4-1**).

4.2.2 Alternative 3

Alternative 3 improvements provide nearly a 50-year LOS for the project area and significantly reduces the inundation extent for the 50-year and 100-year events. **Appendix G** includes water surface profile comparisons of Alternative 3, Existing, and Pre-Existing Conditions. **Exhibits 35-39** show depth grids and performance metrics results for each modeled storm event. Model results show that Alternative 3 removes the 500-year floodplain from 408 structures and 4.0 miles of roadway (see **Table 4-1**).

Table 4-1: Alternative Performance Metrics Results (500-year Storm Event)

Alternative	Attributes					
	Cost Information		500yr Metrics			
	Total Estimated Cost	Cost of ROW Acquisition	Inundated Structures Benefited	Flooded Structures Benefited	Miles of Roadway Benefited	Floodplain Removed from Area (ac)
Existing	$ -	$ -	0	0	0.0	0
Alternative 1	$ 1,839,940.00	$ -	215	411	2.2	76
Alternative 2	$ 2,508,390.00	$ -	219	427	2.3	87
Alternative 3	$ 5,241,050.00	$ -	408	849	4.0	130

Tables 4-2, 4-3, and 4-4 include WSEL and flow results from the 10-, 100-, and 500-year storm event at major roadway crossings. Note that the flows listed are recorded at the time of the peak WSEL.

Table 4-2: WSEL (ft) and Flow (cfs) Comparisons (10-year Storm Event)

Location	River Station	10-year									
		Pre-Existing		Existing		Alternative 1		Alternative 2		Alternative 3	
		WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow
Aldine Westfield Road	58359.5	65.35	4,616	64.78	4,609	64.74	4,598	64.12	4,589	64.73	4,593
Bertrand Street	52815.3	61.09	4,890	60.80	4,809	60.14	4,806	60.15	4,810	59.98	4,803
Hopper Road	49980.9	59.51	4,983	59.13	4,882	57.95	4,890	57.96	4,894	57.53	4,888
Little York Road U/S	46560.8	57.68	5,097	56.84	4,973	55.79	4,993	55.80	4,997	54.65	4,989
Little York Road D/S	46515.8	57.65	5,097	56.80	4,973	55.74	4,993	55.75	4,997	54.51	4,989
Jensen Drive	41275.0	55.75	5,717	53.25	5,418	53.30	5,453	53.31	5,459	53.30	5,451
FREEWAY SERVICE RD U/S	40919.3	55.20	5,712	52.58	5,413	52.62	5,444	52.63	5,450	52.62	5,444
HWY 59/EASTEX FWY	40726.2	55.19	5,711	52.53	5,413	52.57	5,443	52.58	5,449	52.57	5,443
FREEWAY SERVICE RD D/S	40550.1	55.11	5,709	52.47	5,413	52.52	5,441	52.53	5,448	52.52	5,442

Table 4-3: WSEL (ft) and Flow (cfs) Comparisons (100-year Storm Event)

Location	River Station	100-year									
		Pre-Existing		Existing		Alternative 1		Alternative 2		Alternative 3	
		WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow
Aldine Westfield Road	58359.5	67.13	6,711	66.20	6,712	66.20	6,713	65.42	6,713	66.20	6,713
Bertrand Street	52815.3	62.64	7,006	62.61	7,017	62.51	7,017	62.52	7,021	62.54	7,014
Hopper Road	49980.9	60.66	7,126	60.51	7,136	60.21	7,141	60.21	7,145	60.25	7,135
Little York Road U/S	46560.8	59.19	7,268	58.45	7,275	58.07	7,272	58.08	7,278	57.38	7,219
Little York Road D/S	46515.8	58.97	7,257	58.32	7,271	57.98	7,266	57.99	7,274	57.25	7,210
Jensen Drive	41275.0	57.77	7,942	56.21	7,969	56.34	8,008	56.34	8,020	56.42	8,057
FREEWAY SERVICE RD U/S	40919.3	56.53	7,860	55.12	7,810	55.22	7,890	55.23	7,905	55.30	8,005
HWY 59/EASTEX FWY	40726.2	56.52	7,860	55.08	7,809	55.19	7,886	55.20	7,899	55.27	8,002
FREEWAY SERVICE RD D/S	40550.1	56.39	7,840	54.95	7,790	55.05	7,874	55.06	7,890	55.12	7,996

Table 4-4: WSEL (ft) and Flow (cfs) Comparisons (500-year Storm Event)

Location	River Station	500-year									
		Pre-Existing		Existing		Alternative 1		Alternative 2		Alternative 3	
		WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow
Aldine Westfield Road	58359.5	68.09	9,224	67.44	9,226	67.44	9,226	66.78	9,226	67.44	9,226
Bertrand Street	52815.3	63.69	9,557	63.67	9,531	63.64	9,529	63.64	9,531	63.63	9,533
Hopper Road	49980.9	61.48	9,688	61.37	9,652	61.24	9,651	61.24	9,654	61.09	9,656
Little York Road U/S	46560.8	60.23	9,851	59.89	9,801	59.83	9,799	59.83	9,803	59.63	9,808
Little York Road D/S	46515.8	60.07	9,847	59.63	9,801	59.54	9,798	59.55	9,803	59.26	9,806
Jensen Drive	41275.0	59.27	10,428	58.69	10,303	58.69	10,300	58.70	10,309	58.70	10,318
FREEWAY SERVICE RD U/S	40919.3	57.81	10,355	56.71	10,303	56.70	9,975	56.71	9,956	56.73	9,870
HWY 59/EASTEX FWY	40726.2	57.83	10,355	56.69	10,303	56.69	9,973	56.70	9,955	56.71	9,869
FREEWAY SERVICE RD D/S	40550.1	57.60	10,312	56.46	9,946	56.46	9,846	56.47	9,860	56.49	9,776

4.3 Right-of-Way Requirement

Each of the proposed alternatives are designed to fit within the existing HCFCD ROW. It should be noted that existing HCFCD ROW boundaries and widths were determined based on GIS data, and actual ROW boundary locations may differ when comparing GIS and field survey information.

4.4 Opinion of Probable Construction Cost

An OPCC for each alternative can be found in **Tables 4-5**, **4-6**, and **4-7**. Unit cost values utilized the latest TxDOT and HCFCD average low bid prices. The costs consider clearing, grubbing, excavation and disposal, culverts, headwalls, turf establishment, partial ROW acquisition, and pipeline relocation. LAN assumes 15% of direct construction costs for Planning, Engineering, and Design, 5% for Mobilization/Demobilization, 10% for Construction Management, and 30% for Contingency.

Table 4-5: Alternative 1 OPCC

Alternative 1 OPCC					
HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
2315-02	Excavation & Off-Site Disposal	CY	62,500	$ 15.00	$ 937,500.00
2120-46	Remove & Disposal of Existing Hike/Bike Trail	SY	4,500	$ 7.50	$ 33,750.00
2741-01	8' Hike/Bike Trail (5,200 LF)	SY	4,650	$ 20.00	$ 93,000.00
2741-01	10' Hike/Bike Trail (900 LF)	SY	1,000	$ 20.00	$ 20,000.00
2120-04	Backslope Interceptor Outfall Modifcation (CMP)	LF	30	$ 45.00	$ 1,350.00
2120-04	Storm Sewer Outfall Modification (CMP)	LF	60	$ 45.00	$ 2,700.00
2464-01	HCFCD Timber Bent (Remove & Replace)	EA	1	$ 4,500.00	$ 4,500.00
3320-01	Pedestrian Bridge Pier Support/Modifications	LS	1	$ 12,000.00	$ 12,000.00
2120-03	Removal & Disposal of Riprap	CY	290	$ 16.00	$ 4,640.00
2632-05	Backslope Interceptor Structure	EA	6	$ 3,500.00	$ 21,000.00
2642-02	24" CMP	LF	300	$ 65.00	$ 19,500.00
					$ 1,149,940.00

	Planning, Engineering, Design (15%)			15%	$ 172,500.00
	Mobilization / Demobilization (5%)			5%	$ 57,500.00
	Construction Management (10%)			10%	$ 115,000.00
	Contingency (30%)			30%	$ 345,000.00
Total:					**$ 1,839,940.00**
				Total ROW Costs	$ -
				Total Cost	**$ 1,839,940.00**

Table 4-6: Alternative 2 OPCC

Alternative 2 OPCC					
HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
2315-02	Excavation & Off-Site Disposal	CY	89,000	$ 15.00	$ 1,335,000.00
2120-46	Remove & Disposal of Existing Hike/Bike Trail	SY	4,500	$ 7.50	$ 33,750.00
2741-01	8' Hike/Bike Trail (5,200 LF)	SY	4,650	$ 20.00	$ 93,000.00
2741-01	10' Hike/Bike Trail (900 LF)	SY	1,000	$ 20.00	$ 20,000.00
2120-04	Backslope Interceptor Outfall Modifcation (CMP)	LF	30	$ 45.00	$ 1,350.00
2120-04	Storm Sewer Outfall Modification (CMP)	LF	60	$ 45.00	$ 2,700.00
2464-01	HCFCD Timber Bent (Remove & Replace)	EA	1	$ 4,500.00	$ 4,500.00
3320-01	Pedestrian Bridge Pier Support/Modifications	LS	1	$ 12,000.00	$ 12,000.00
2120-03	Removal & Disposal of Riprap	CY	290	$ 16.00	$ 4,640.00
2632-05	Backslope Interceptor Structure	EA	9	$ 3,500.00	$ 31,500.00
2642-02	24" CMP	LF	450	$ 65.00	$ 29,250.00
					$ 1,567,690.00

	Planning, Engineering, Design (15%)			15%	$ 235,200.00
	Mobilization / Demobilization (5%)			5%	$ 78,400.00
	Construction Management (10%)			10%	$ 156,800.00
	Contingency (30%)			30%	$ 470,300.00
Total:					**$ 2,508,390.00**
				Total ROW Costs	$ -
				Total Cost	**$ 2,508,390.00**

Table 4-7: Alternative 3 OPCC

Alternative 3 OPCC					
HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
2315-02	Excavation & Off-Site Disposal	CY	103,000	$ 15.00	$ 1,545,000.00
2120-46	Remove & Disposal of Existing Hike/Bike Trail	SY	4,500	$ 7.50	$ 33,750.00
2741-01	8' Hike/Bike Trail (5,200 LF)	SY	4,650	$ 20.00	$ 93,000.00
2741-01	10' Hike/Bike Trail	SY	1,000	$ 20.00	$ 20,000.00
2120-04	Backslope Interceptor Outfall Modifcation	LF	45	$ 45.00	$ 2,025.00
2120-04	Storm Sewer Outfall Modification (CMP)	LF	135	$ 45.00	$ 6,075.00
2120-04	Storm Sewer Outfall Modification (RCB)	LF	30	$ 60.00	$ 1,800.00
-	Bridge Modifications (Little York Road)	EA	2	$ 550,000.00	$ 1,100,000.00
-	Utility Adjustments (Little York Road)	LF	1,310	$ 150.00	$ 196,500.00
2464-01	HCFCD Timber Bent	EA	2	$ 4,500.00	$ 9,000.00
3320-01	Pedestrian Bridge Modifications	LS	1	$ 150,000.00	$ 150,000.00
2120-03	Removal & Disposal of Riprap	CY	1,050	$ 16.00	$ 16,800.00
2378-01	Riprap	SY	120	$ 60.00	$ 7,200.00
2632-05	Backslope Interceptor Structure	EA	14	$ 3,500.00	$ 49,000.00
2642-02	24" CMP	LF	700	$ 65.00	$ 45,500.00
					$ 3,275,650.00

	Planning, Engineering, Design (15%)			15%	$ 491,300.00
	Mobilization / Demobilization (5%)			5%	$ 163,800.00
	Construction Management (10%)			10%	$ 327,600.00
	Contingency (30%)			30%	$ 982,700.00
Total:					**$ 5,241,050.00**
				Total ROW Costs	$ -
				Total Cost	**$ 5,241,050.00**

4.5 Alternatives Scoring

LAN utilized the latest HCFCD prioritization framework (Version 6-8, Revised July 2021) to score each of the proposed alternatives. The scoring summary for each alternative is included in **Appendix H** and **Table 4-8**. Metrics and parameters that contribute to the final score include the following:

- Flood Risk Reduction
- Social Vulnerability Index
- Estimated Costs
- Partnership/Grant Funding
- Maintenance
- Environmental Impacts
- Recreational Enhancements

Based on the factors above, Alternative 1, 2, and 3 reflect the following scores:

- Alternative 1 – 8.46
- Alternative 2 – 8.31
- Alternative 3 – 8.36

Project performance scores were recalculated by adding the construction costs of the three previously constructed detention basins to reflect a more traditional channel conveyance improvement project that would include the costs of channel improvements and detention. HCFCD provided the construction costs

of the Keith-Wiess and Hall Park detention basins, which were approximately $9.8 million and $10.2 million, respectively. The cost of the Bretshire basin was estimated using the costs and detention volume of the Hall Park basin (835 ac-ft according to HCFCD.org) since these two basin designs are similar. The project scores that include the detention basin costs are included in **Table 4-9**.

Table 4-8: HCFCD Project Scoring

SCORING CRITERIA:		1	2	3	4	5	6	7	8	
Weight:		25%	20%	20%	10%	10%	5%	5%	5%	
Project Area:	Project ID:	Flood Risk (100-Year Event) Reduction	Existing Conditions Drainage LOS	Social Vulnerability Index (SVI)	Project Efficiency	Partnership Funding	Long Term Maintenance Costs	Minimize Environmental Impacts	Potential for Multiple Benefits	TOTAL SCORE
Alt #1	P118-00-00 (C-41)	2.50	2.00	1.96	1.00	0.00	0.50	0.40	0.10	**8.46**
Alt #2	P118-00-00 (C-41)	2.50	2.00	1.96	1.00	0.00	0.50	0.30	0.05	**8.31**
Alt #3	P118-00-00 (C-41)	2.50	2.00	1.96	1.00	0.00	0.50	0.20	0.20	**8.36**

Table 4-9: HCFCD Project Scoring (With Detention Basin Costs)

SCORING CRITERIA:		1	2	3	4	5	6	7	8	
Weight:		25%	20%	20%	10%	10%	5%	5%	5%	
Project Area:	Project ID:	Flood Risk (100-Year Event) Reduction	Existing Conditions Drainage LOS	Social Vulnerability Index (SVI)	Project Efficiency	Partnership Funding	Long Term Maintenance Costs	Minimize Environmental Impacts	Potential for Multiple Benefits	TOTAL SCORE
Alt #1	P118-00-00 (C-41)	2.50	2.00	1.96	0.44	0.00	0.30	0.30	0.05	**7.55**
Alt #2	P118-00-00 (C-41)	2.50	2.00	1.96	0.43	0.00	0.30	0.30	0.05	**7.54**
Alt #3	P118-00-00 (C-41)	2.50	2.00	1.96	0.49	0.00	0.30	0.10	0.05	**7.40**

Note: These project scores include the construction costs of the three previously constructed detention basins (Keith-Wiess, Bretshire, and Hall Park).

5 Recommended Alternative

Prior to the start of this analysis, it was determined that projected funding and time to completion would play a key role in developing the recommended alternative. The main goal of the Mainstem Potential Projects Memo was to develop high level alternatives that do not exceed the estimated funding available for this mainstem improvement project, which was allocated $3.9 million as Bond Project C-41. Since the Potential Projects effort was completed, the certainty of additional project funding has become a concern, and therefore it was agreed upon during the project review meetings that Alternative 1 (**Figure 5-1**) was the most suitable alternative that presents an efficient project both on a cost and schedule basis.

Based on the information provided above and in **Section 4**, it is recommended that Alternative 1 be selected as a flood mitigation project for the portion of Halls Bayou presented in this study. Due to the uncertainty of available funding and only slight additional benefit compared to Alternative 1, Alternative 2 was not recommended at this time, however, it is recommended that the portion of Halls Bayou between Aldine Westfield Road and the Keith-Wiess detention basin be utilized for either conveyance or detention improvements in the future. While Alternative 3 provides additional flood relief for a larger portion of the area compared to Alternatives 1 and 2, it is not recommended to be implemented in the near future due to the additional costs, complexity, and time to completion.

Inundation comparisons for each modeled storm event under Alternative 1 conditions are included in **Appendix I**.

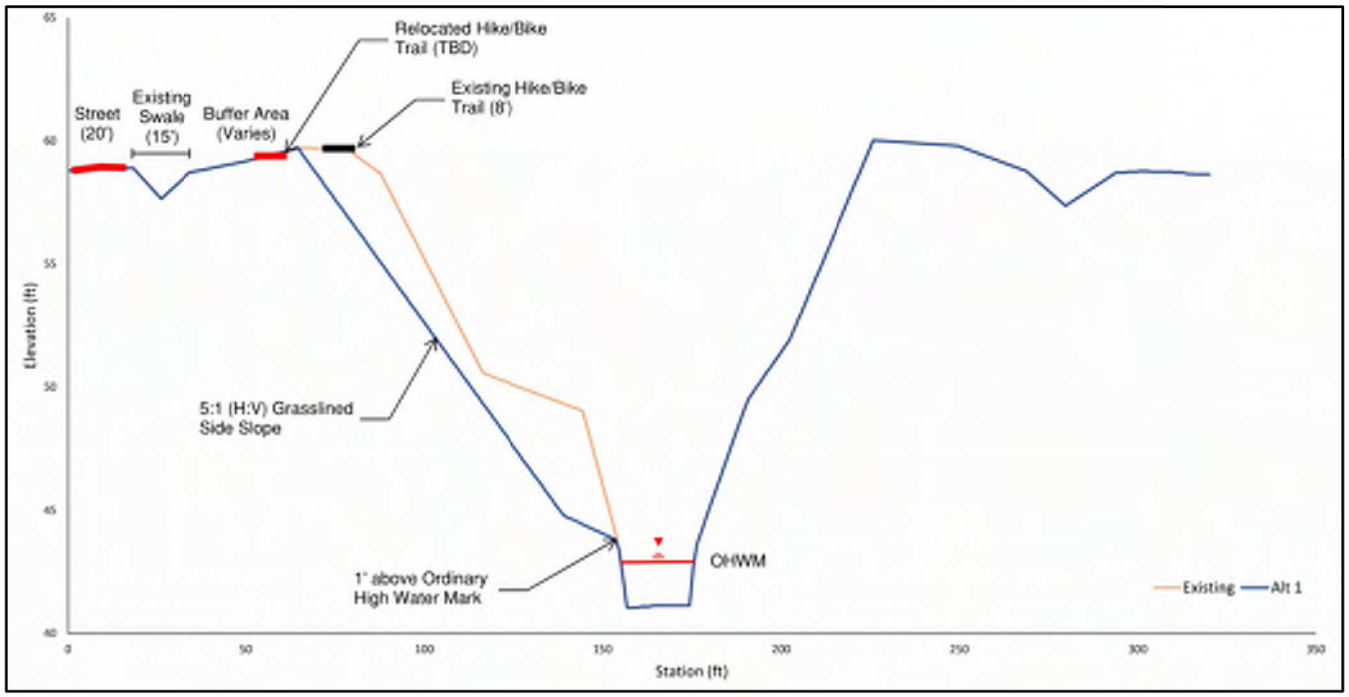


Figure 5-1: Alternative 1 Typical Section

6 Impacts Analysis on Halls Bayou

To identify impacts along the mainstem of Halls Bayou, a preliminary assessment of potential impacts was performed for each proposed alternative. This preliminary analysis will focus on the effect that the recommended alternative will potentially have on P118-00-00 WSEL pre- and post-project.

To conduct the preliminary impacts analysis, LAN created a truncated version of the Halls Phasing Study HEC-RAS model that included the modeling updates and strategies discussed in **Section 2.6.2** (see **Figure 6-1**). The truncated model was re-integrated into the Halls Phasing Study HEC-RAS model to demonstrate no impacts to downstream along Halls Bayou. A similar model was created for each Alternative to determine if any WSEL impacts exist downstream along Halls Bayou. As mentioned in **Section 2.6**, the proposed (Alternative 1, 2, and 3) condition WSELs will be compared to Pre-Existing condition WSELs for this analysis. Water surface profiles showing comparisons between Pre-Existing, Existing, and Proposed Condition are included in **Appendix J**, while **Table 6-1** shows WSELs at several locations along Halls Bayou (downstream of the project area) for each modeling scenario.

Figure 6-1: Preliminary Impact Analysis HEC-RAS Model Layout

Table 6-1: WSEL and Flow Results Along Halls Bayou

Halls Bayou River Station	500-year Results									
	Pre-Existing		Existing		Alternative 1		Alternative 2		Alternative 3	
	WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow
43789.5	59.55	10,387	58.85	10,273	58.85	10,267	58.85	10,276	58.86	10,287
36341.47	56.37	10,143	56.15	9,924	56.16	9,854	56.17	9,867	56.20	9,740
31824.3	51.83	10,513	51.72	10,042	51.76	10,134	51.76	10,148	51.78	10,182
13937.2	39.36	17,285	39.26	17,107	39.31	17,217	39.33	17,238	39.30	17,196
678.7	24.54	18,760	24.46	18,594	24.50	18,680	24.52	18,704	24.49	18,651

As shown in **Table 6-1** above, each alternative reflects nearly identical results along Halls Bayou (downstream of the project area) for the 500-year storm event. As mentioned in **Section 2.6**, the results of the recommended alternative will be compared to Pre-Existing Conditions when measuring hydraulic impacts. When compared to Alternatives 2 and 3, Alternative 1 reflects slightly lower WSELs along Halls Bayou in the pre-Atlas 14 500-year event, which closely represents the 100-year event under the latest Atlas 14 rainfall conditions. Overall, the preliminary impact analysis reflects that Alternative 1 WSELs are below Pre-Existing Conditions WSELs, while providing slightly more benefit to areas along Halls Bayou downstream of the Hall Park detention basin when compared to Alternatives 2 and 3.

7 Additional Services

7.1 Environmental and Cultural Considerations

A high-level desktop evaluation of environmental data was provided by HCFCD through the Watershed Environmental Baseline Data Summary Tool (WEB-DST). The information identified existing wetlands, potential wetlands, endangered species, pipelines, hazardous material point sources, oil and gas wells, and landfills.

In addition to the WEB-DST data, Hollaway Environmental + Communication Services, Inc. was contracted to assist LAN with identifying potential environmental and cultural concerns. Hollaway completed a Wetland Delineation Report, a Threatened & Endangered Species Habitat Assessment, and a Phase 1 ESA, which can be found in **Appendix K**, **Appendix L**, and **Appendix M**, respectively. Additionally, BGE, Inc. conducted a cultural resources desktop assessment, which can be found in **Appendix N**. Determinations and/or recommendations will be incorporated into the final design of the selected alternative. Initial findings do not reflect impacts to Alternative 1 as the proposed improvements do not impact the OHWM.

7.2 Adjacent Projects (Active/Planned)

7.2.1 Kowis Street Improvements

On July 30th, 2021, LAN received construction plans from HCFCD detailing roadway and drainage improvements along Kowis Street from Bentley Street to Cedar Hill Lane. These plans were developed by Cobb Fendley and submitted for interim review on July 27th, 2021. After revieing the plan set, LAN determined that the proposed outfall (discharging into Halls Bayou) located just downstream of the pedestrian bridge will be impacted as part of the recommended Alternative 1 presented in this report. As a result of the Alternative 1 channel widening, the proposed 60" RCP and timber bent will eventually require modifications. Additionally, the proposed sidewalk that is shown to intersect the existing Halls Bayou Greenway Trail will require modification due to the relocation of the Greenway Trail (see **Figure 5-1**). LAN recommends a proactive approach that includes slight adjustments to the Kowis Street plan set to accommodate the future Alternative 1 improvements along Halls Bayou, such as interim asphalt connection between the road ROW and current Greenway Trail, and a CMP Collar near the ultimate channel side slope with temporary extension to the current channel side slope outfall location. LAN provided construction plan review mark-ups back to the HCFCD Watershed Coordinator's office on August 11th, 2021

8 Summary and Conclusions

HCFCD authorized LAN in December 2020 to conduct an Alternative Analysis Study on a portion of Halls Bayou (P118-00-00). The purpose of this study is to analyze and describe the existing flooding conditions within the project area, whereupon targeted flood risk mitigation alternatives are developed based on results. The recommended alternative derived from this Alternatives Analysis is intended to be incorporated into a Preliminary Engineering Report (PER), which can efficiently be carried into detailed design.

H&H models were developed for the 50% (2-year), 10% (10-year), 2% (50-year), 1% (100-year), and 0.2% (500-year) design storm events (pre-Atlas 14 update) based on HCFCD criteria using the HEC-HMS and HEC-RAS software. The results of the pre-Atlas 14 500-yr event are widely used as an estimation of the Atlas 14 100-yr conditions.

The alternatives analysis was conducted to determine what conveyance improvements along Halls Bayou could be mitigated by the Keith-Weiss, Hall Park and Bretshire stormwater detention basins. Essentially, the three previously constructed basins will be used to mitigate the proposed channel improvement project. This approach was decided upon prior to the Halls Bayou Mainstem Potential Projects Memo (December 2020).

Baseline Conditions results revealed a 2- to 10-years LOS under Existing Conditions for the project area, while the 50-, 100-, and 500-year events reflect significant roadway and overbank ponding in nearby residential areas. The Existing Conditions model outcome for a 500-year design storm shows that 4,369 structures are mapped within the modeled floodplain, with 2,167 structures shown to be flooded based on estimated finished floor elevations (FFE). Planning level mitigation options developed as part of the Halls Bayou Mainstem Potential Projects Memo were heavily driven by Project funding (CDBG-MIT) and schedule. Therefore, the main goal of this analysis is to develop a low cost, time efficient alternative that provides significant flood reduction in the more frequent storm events. Two of the three options analyzed during the Potential Projects effort were recommended for further evaluation and were subsequently included as part of this detailed analysis.

Of the three alternatives analyzed, Alternative 1 presents the most ideal project given the circumstances surrounding project funding and time to completion. This alternative includes channel excavation along the east bank from just upstream of Hopper Road to just upstream of the Bretshire detention basin (approximately 1.2 miles). The total probable costs of Alternative 1 is $1.84 million, compared to Alternatives 2 and 3 which have probable costs of $2.51 million and $5.24 million, respectively. Alternative 1 removes the 100-year and 500-year floodplain from 974 and 215 structures, respectively, while reducing the overall area of inundation by 275 and 76 acres, respectively. Due to the uncertainty of available funding and only slight additional benefit compared to Alternative 1, Alternative 2 was not recommended at this time, however, it is recommended that the portion of Halls Bayou between Aldine Westfield Road and the Keith-Wiess detention basin be utilized for either conveyance or detention improvements in the future. While Alternative 3 provides additional flood relief for a larger portion of the area compared to Alternatives 1 and 2, it is not recommended to be implemented in the near future due to the additional costs, complexity, and time to completion.

In coordination with HCFCD, LAN recommends moving forward with Alternative 1 and advance the project to the PER stage. It does not require land acquisition or affect significant utilities (oil and gas pipelines) and offers significant flood reduction to the project area in the 10-, 50-, and 100-year storm event. Additionally, Alternative 1 requires less funding and time to complete when compared to Alternatives 2 and 3. This alternative accomplishes the goals of providing a low cost project that can be completed in a short time period compared to other analyzed alternatives.

9 References

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United States Army Corps of Engineers (USACE). (2016). “HEC-RAS River Analysis System Version 5.0 2D Modeling Users Manual,” Institute for Water Resources, Hydrologic Engineering Center, Davis, CA. updated February 2016.

10 List of Exhibits

11 Appendices

Appendix A – Halls Bayou Mainstem Potential Projects Memo

Appendix B – Historical Loss Heat Maps

Appendix C – Site Visit Photos

Appendix D – Baseline Conditions Water Surface Profiles

Appendix E – Water Surface Profile Comparisons – Alternative 1 vs. Baseline Conditions

Appendix F – Water Surface Profile Comparisons – Alternative 2 vs. Baseline Conditions

Appendix G – Water Surface Profile Comparisons – Alternative 3 vs. Baseline Conditions

Appendix H – HCFCD Project Scoring Documentation

Appendix I – Inundation Comparison Maps - Alternative 1

Appendix J – P118-00-00 Water Surface Profiles (Preliminary Impact Analysis)

Appendix K – Wetland Delineation Report

Appendix L – Threatened & Endangered Species Habitat Assessment

Appendix M – Phase 1 ESA

Appendix N – Cultural Resource Desktop Assessment

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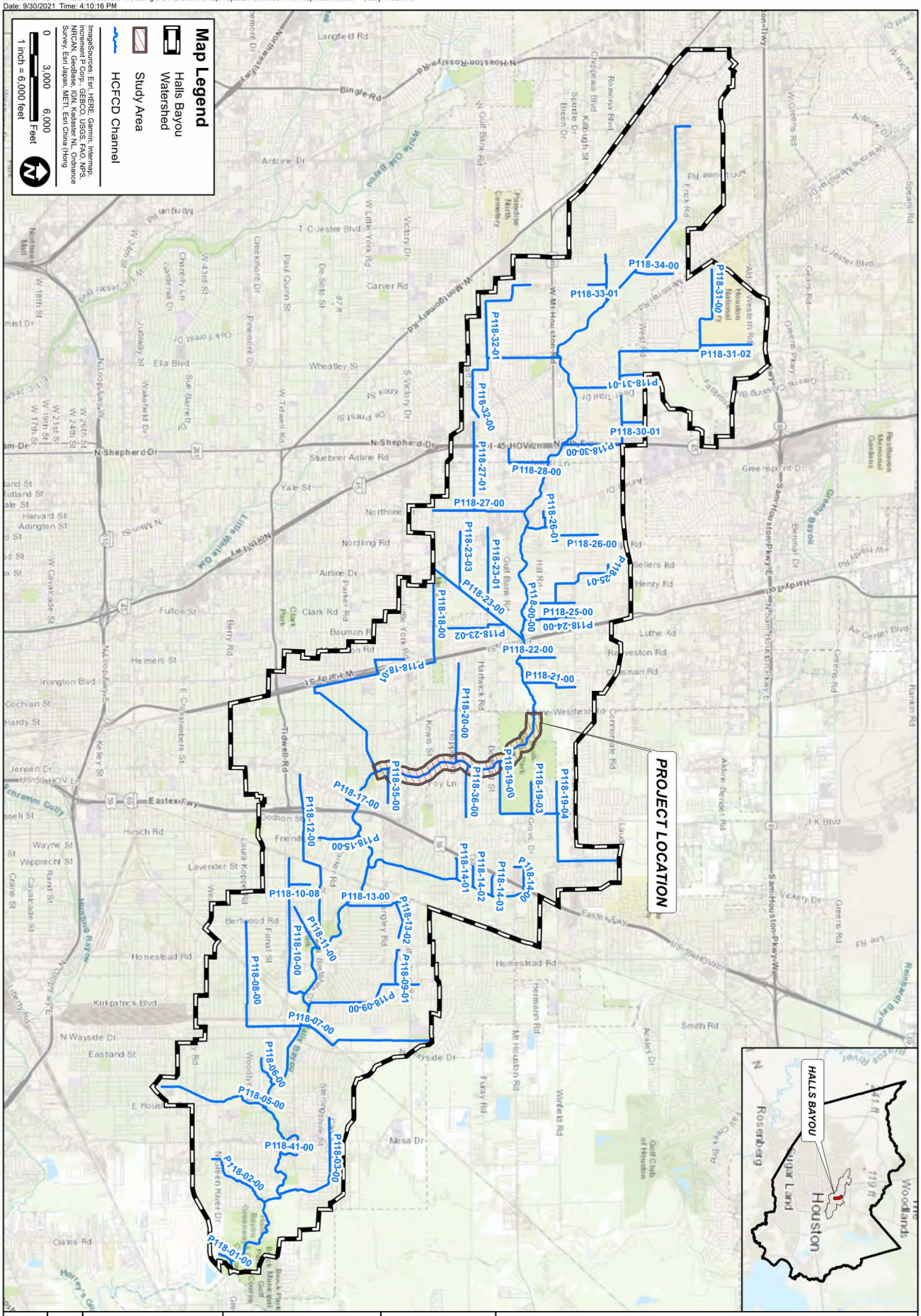

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P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

STUDY AREA

EXHIBIT 1

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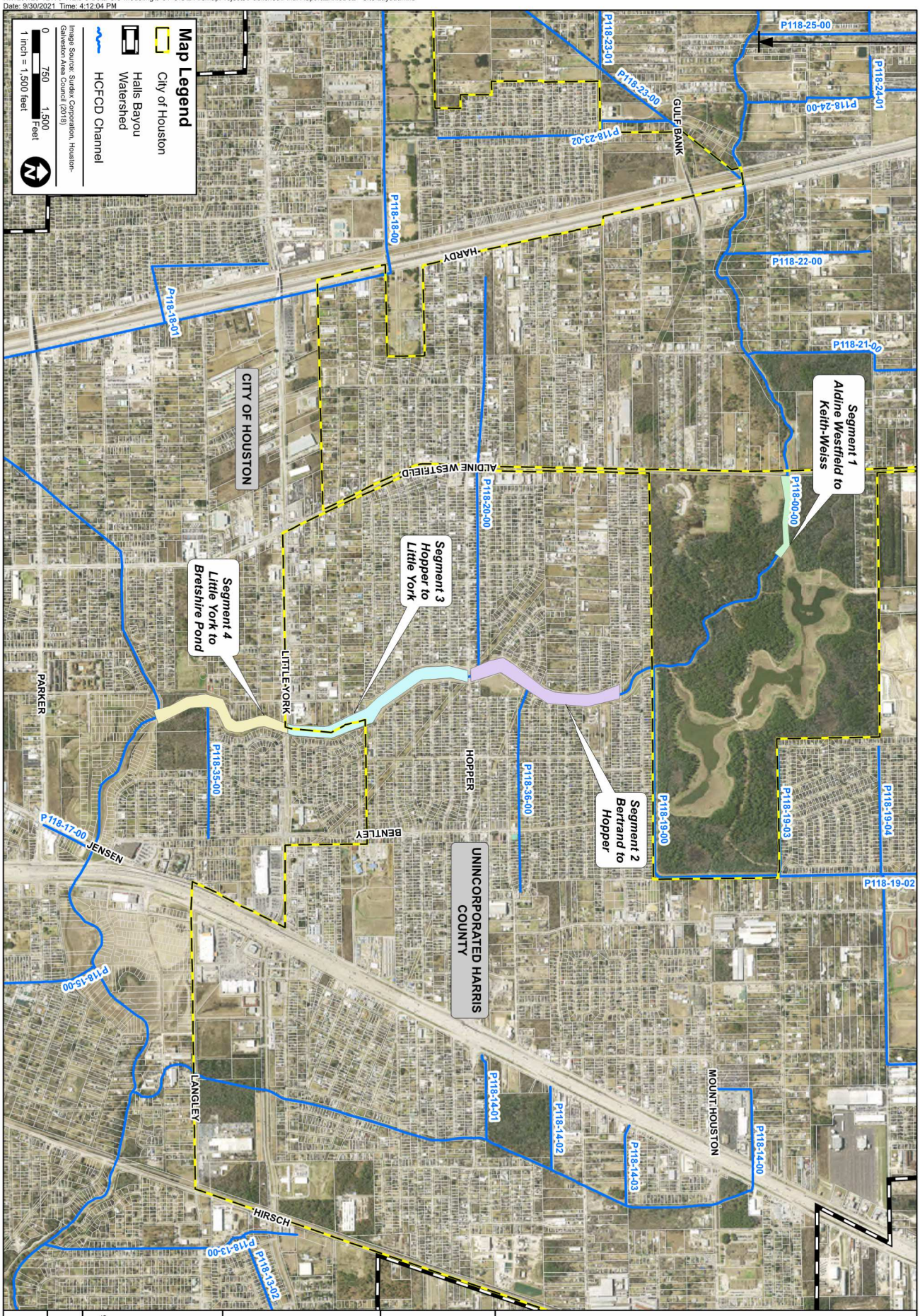

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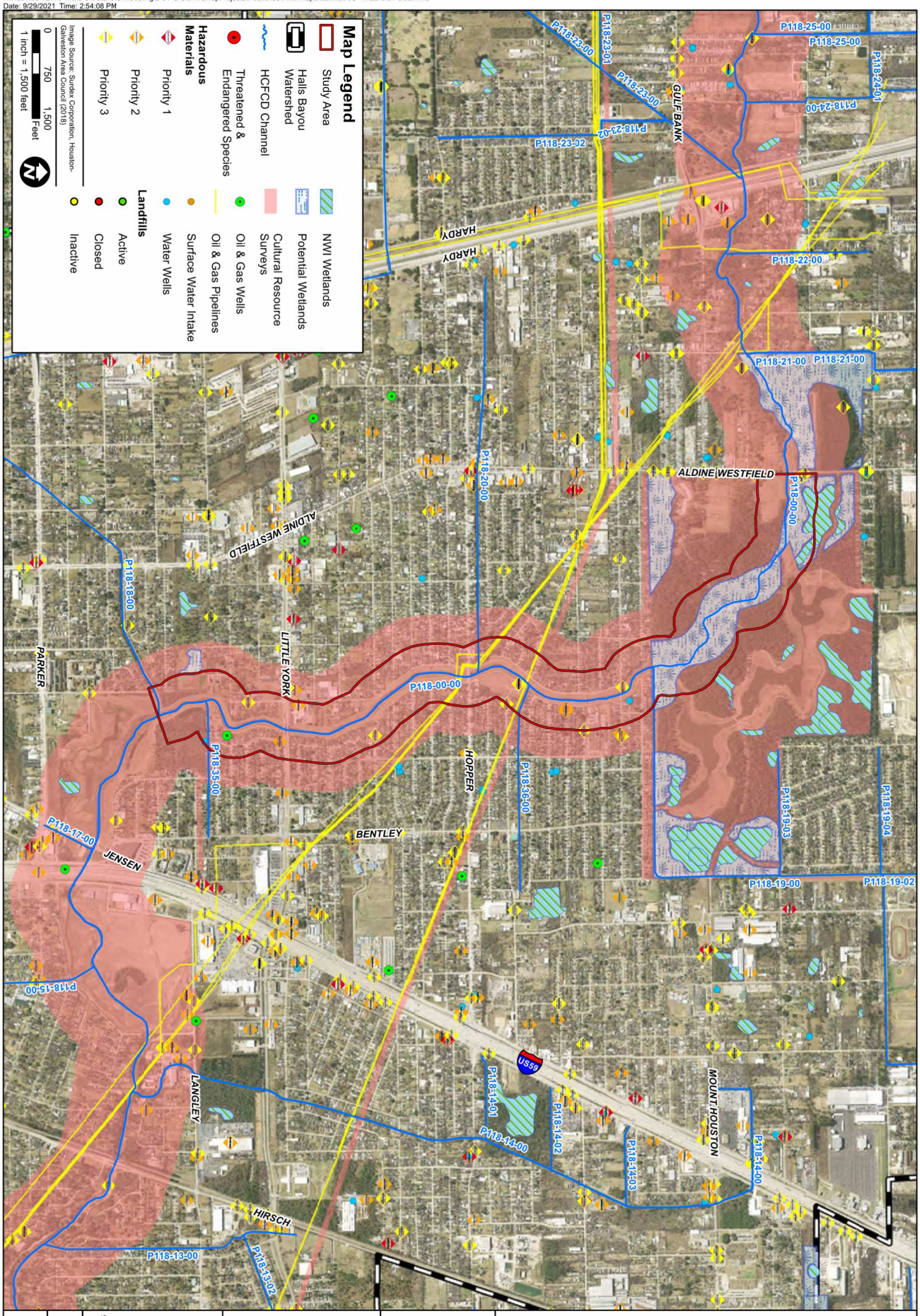

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WATERSHED ENVIRONMENTAL BASELINE (WEB) MAP DATA SUMMARY TOOL (DST) DATA

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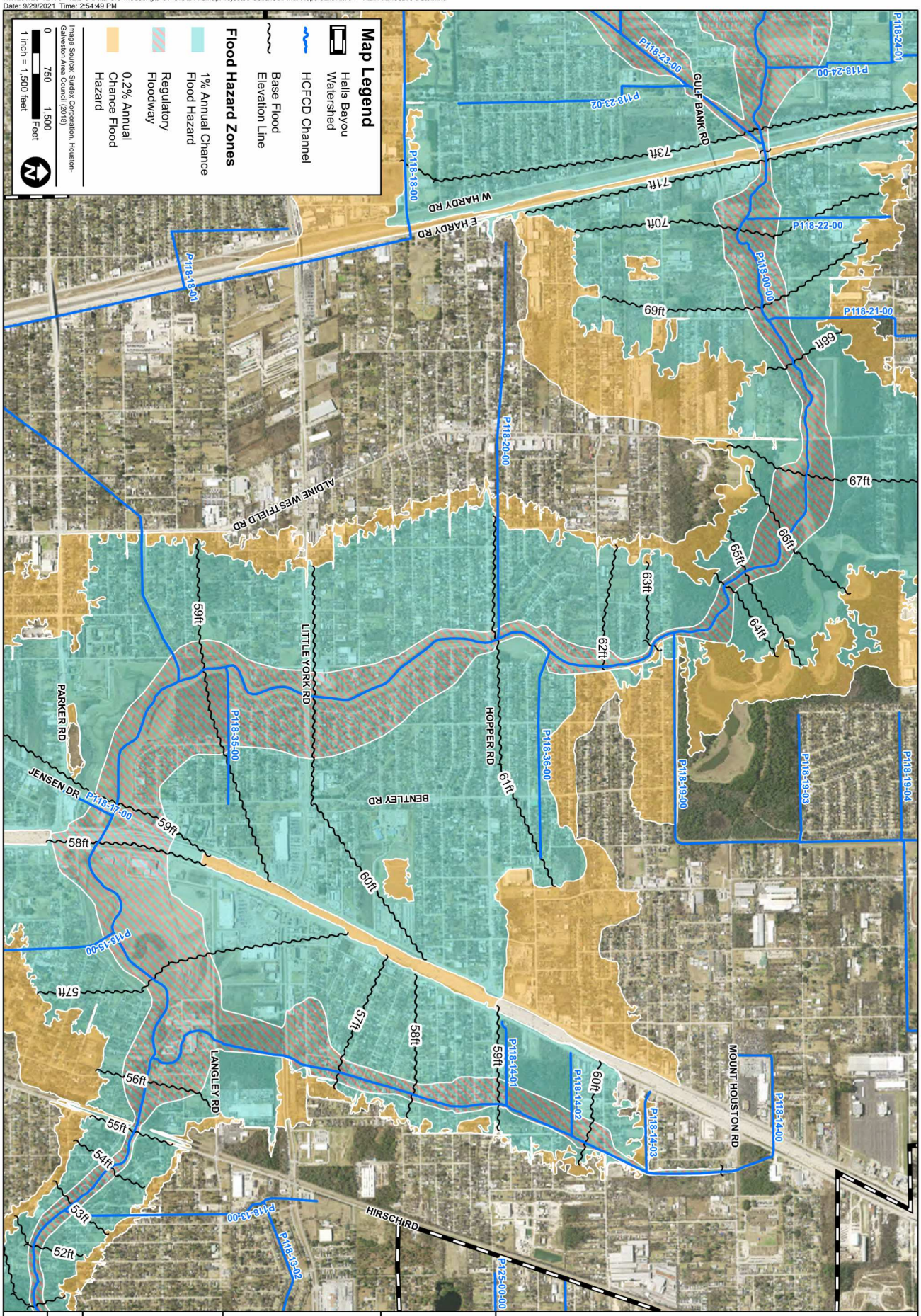

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FEMA EFFECTIVE FLOODPLAIN

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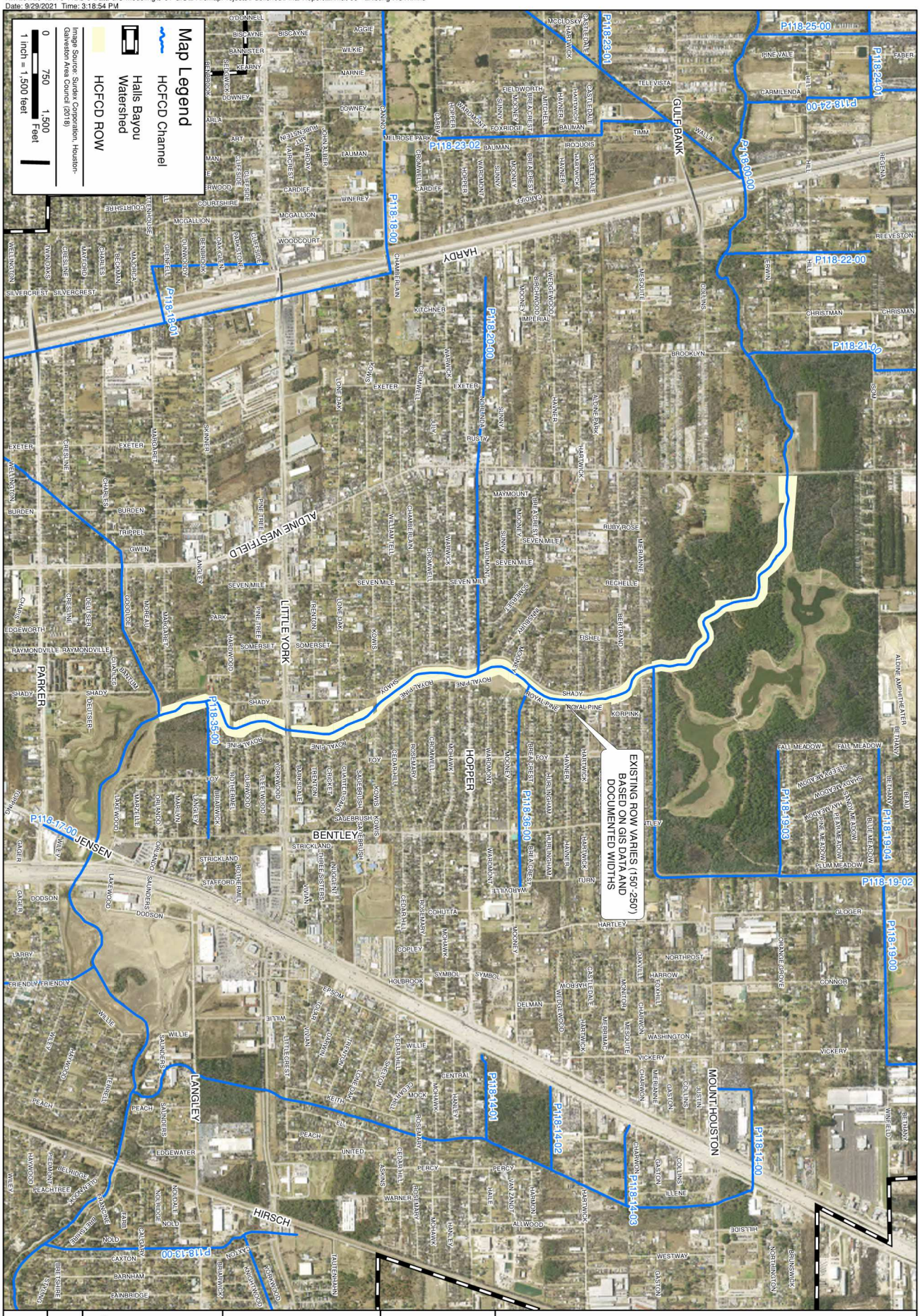

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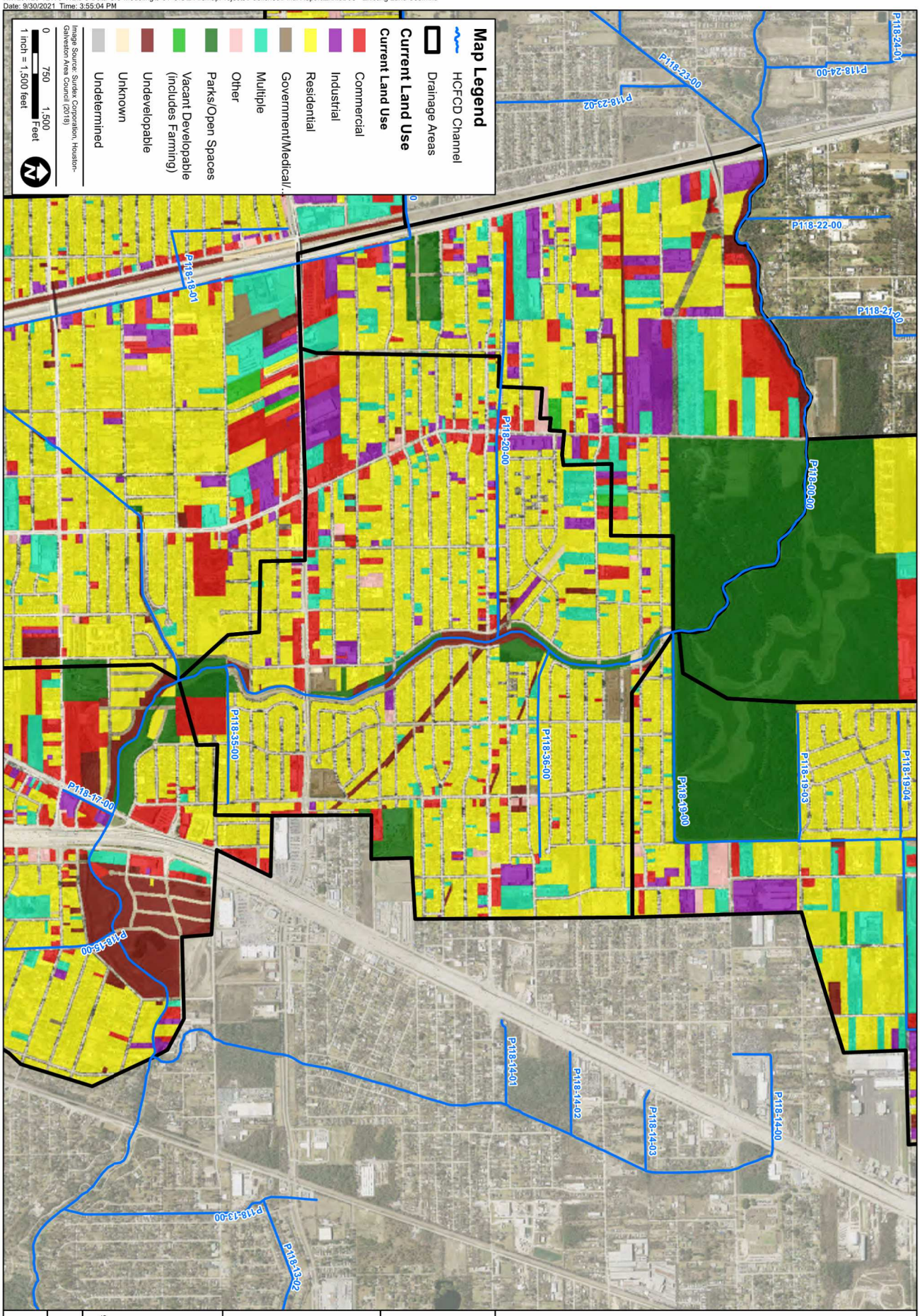

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EXISTING LAND USE (H-GAC)

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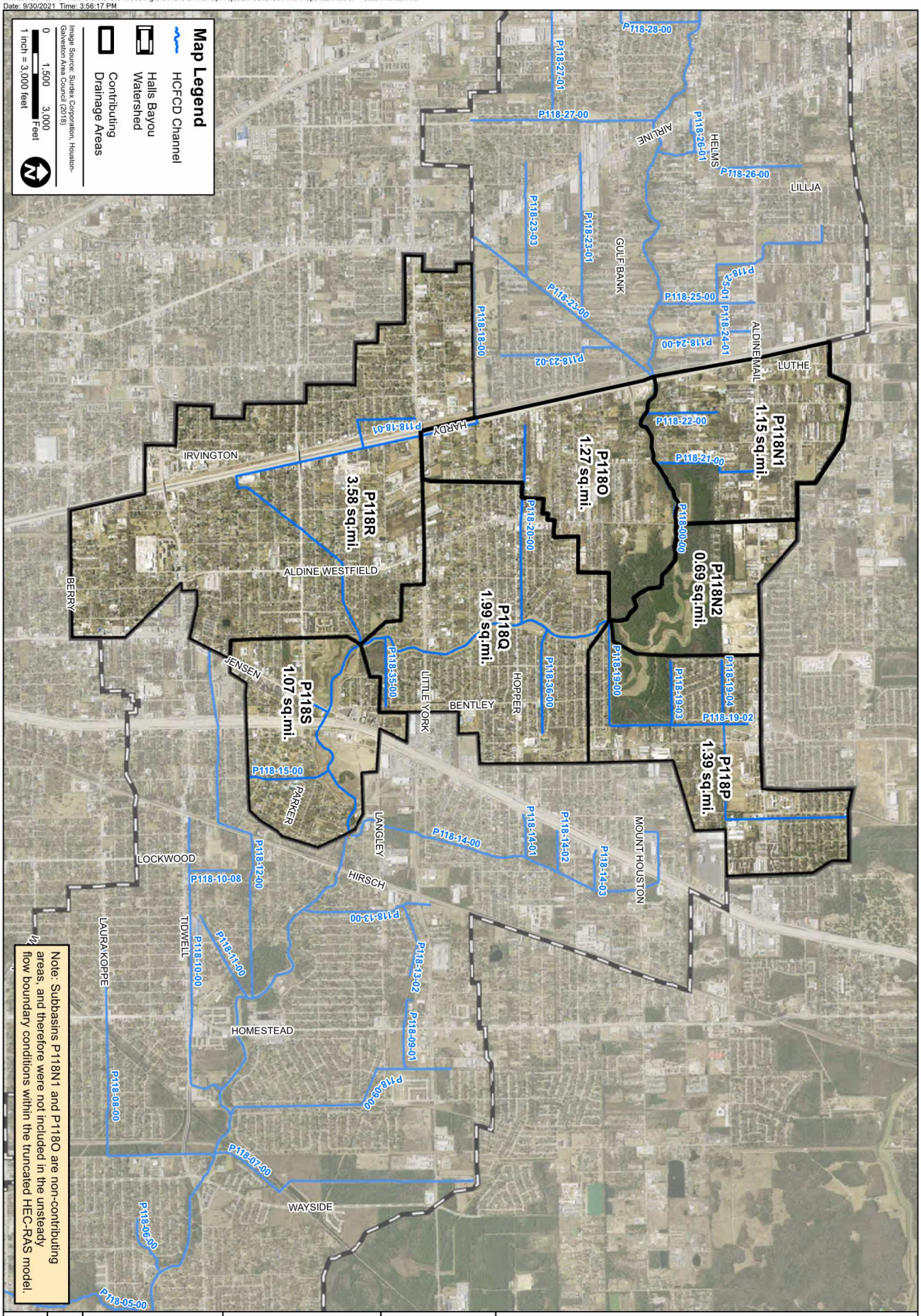

Note: Subbasins P118N1 and P118O are non-contributing areas, and therefore were not included in the unsteady flow boundary conditions within the truncated HEC-RAS model.

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CONTRIBUTING DRAINAGE AREAS

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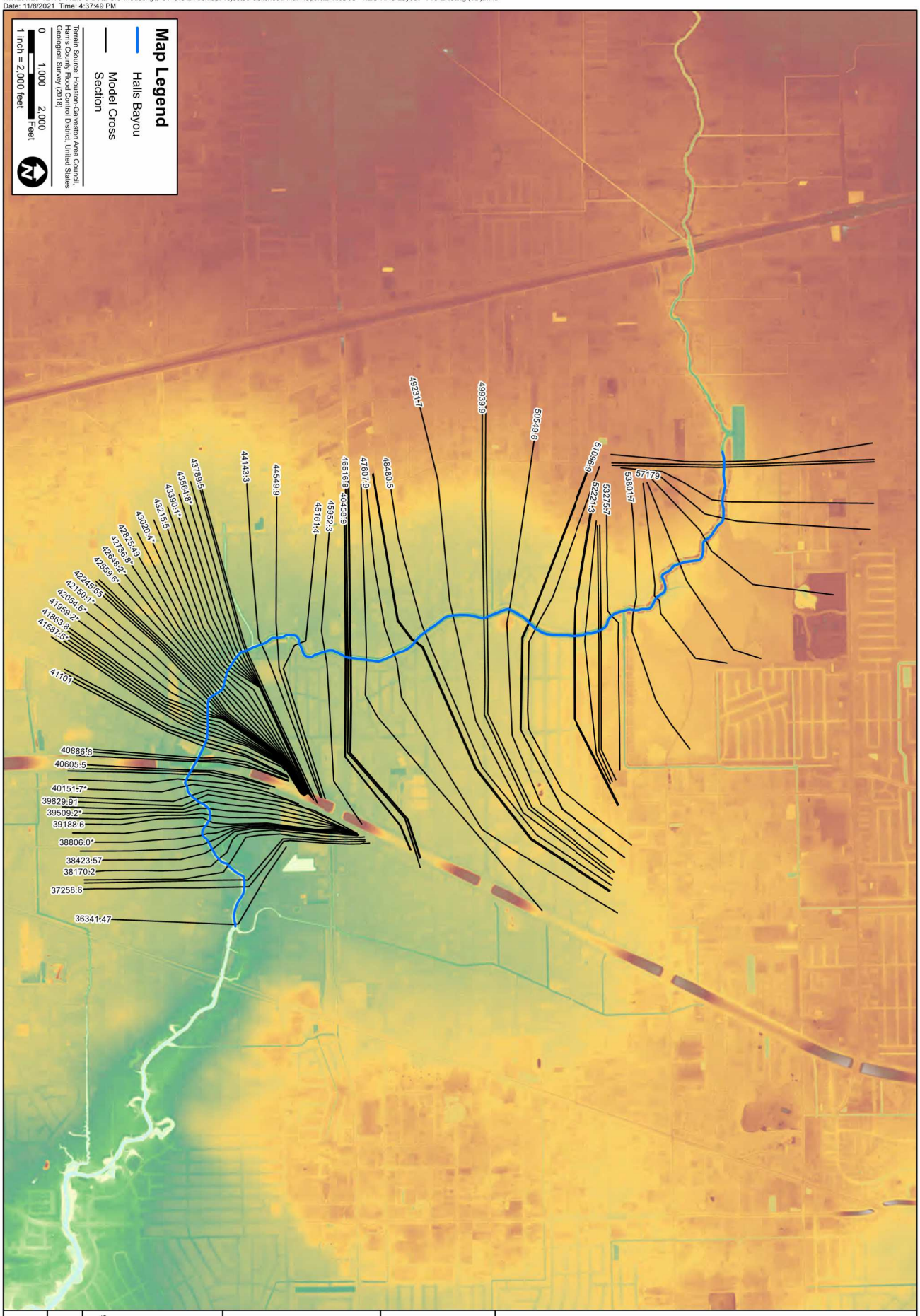

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HEC-RAS MODEL LAYOUT
PRE-EXISTING CONDITIONS (1D)

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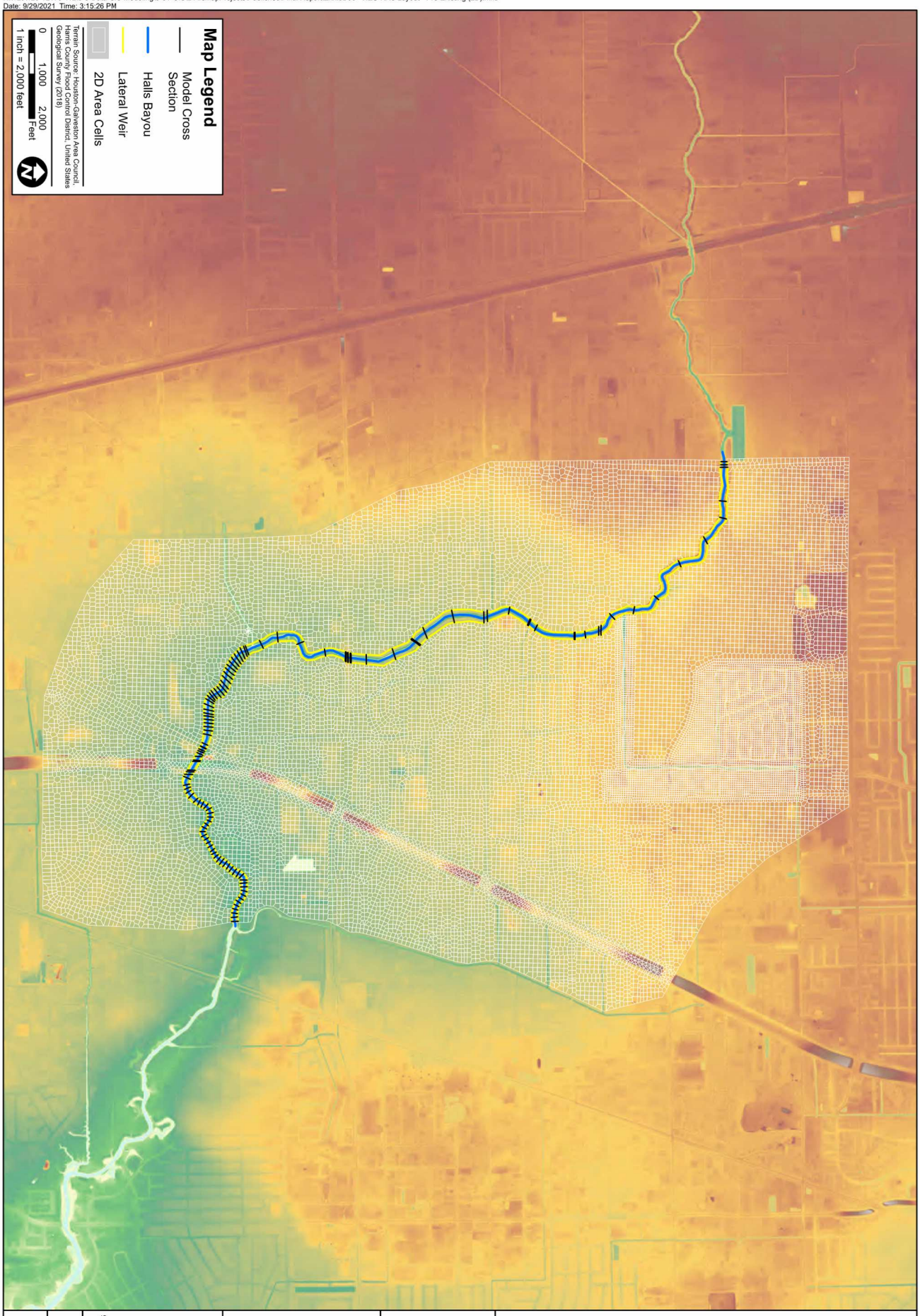

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HEC-RAS MODEL LAYOUT
PRE-EXISTING CONDITIONS (1D/2D)

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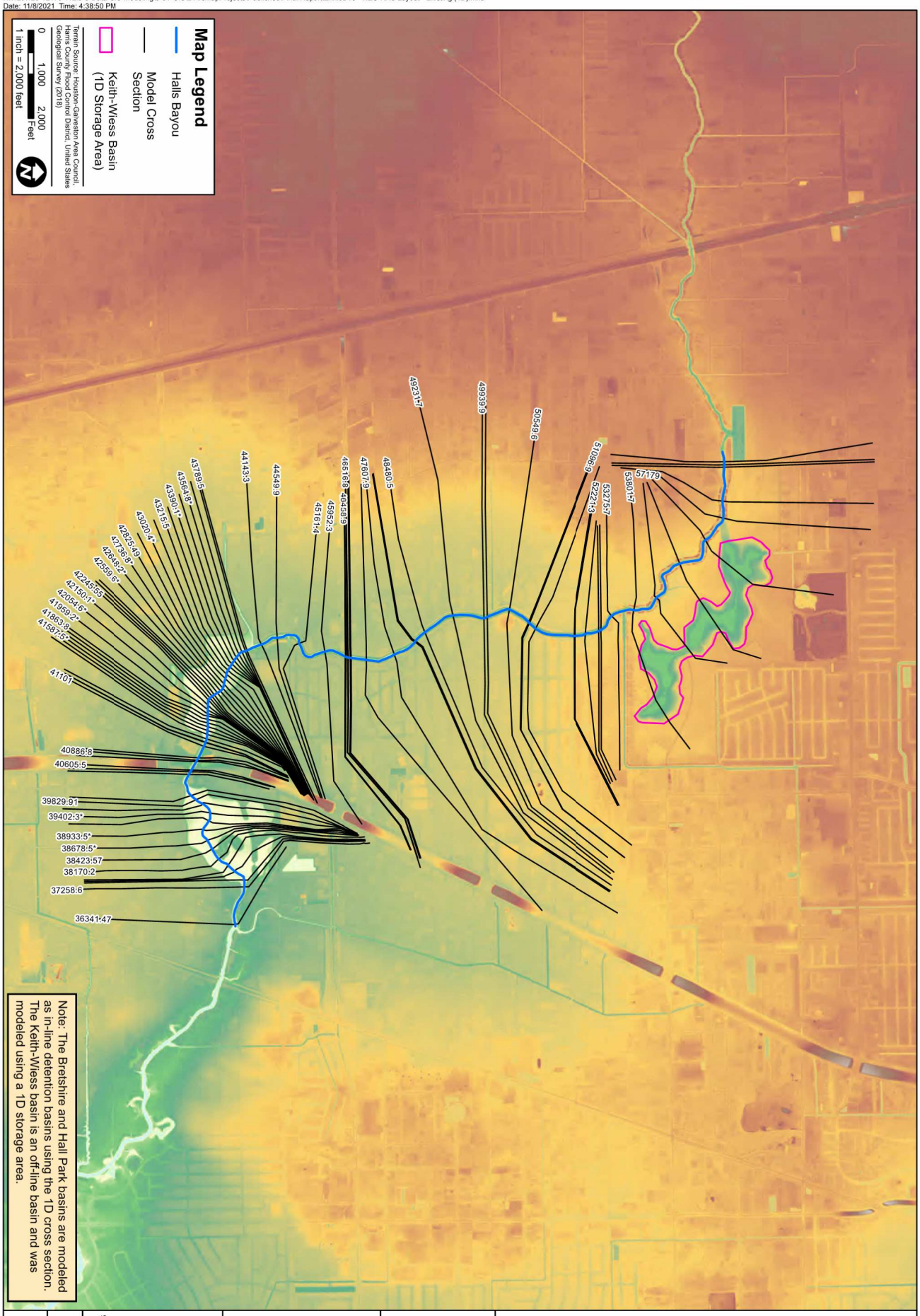

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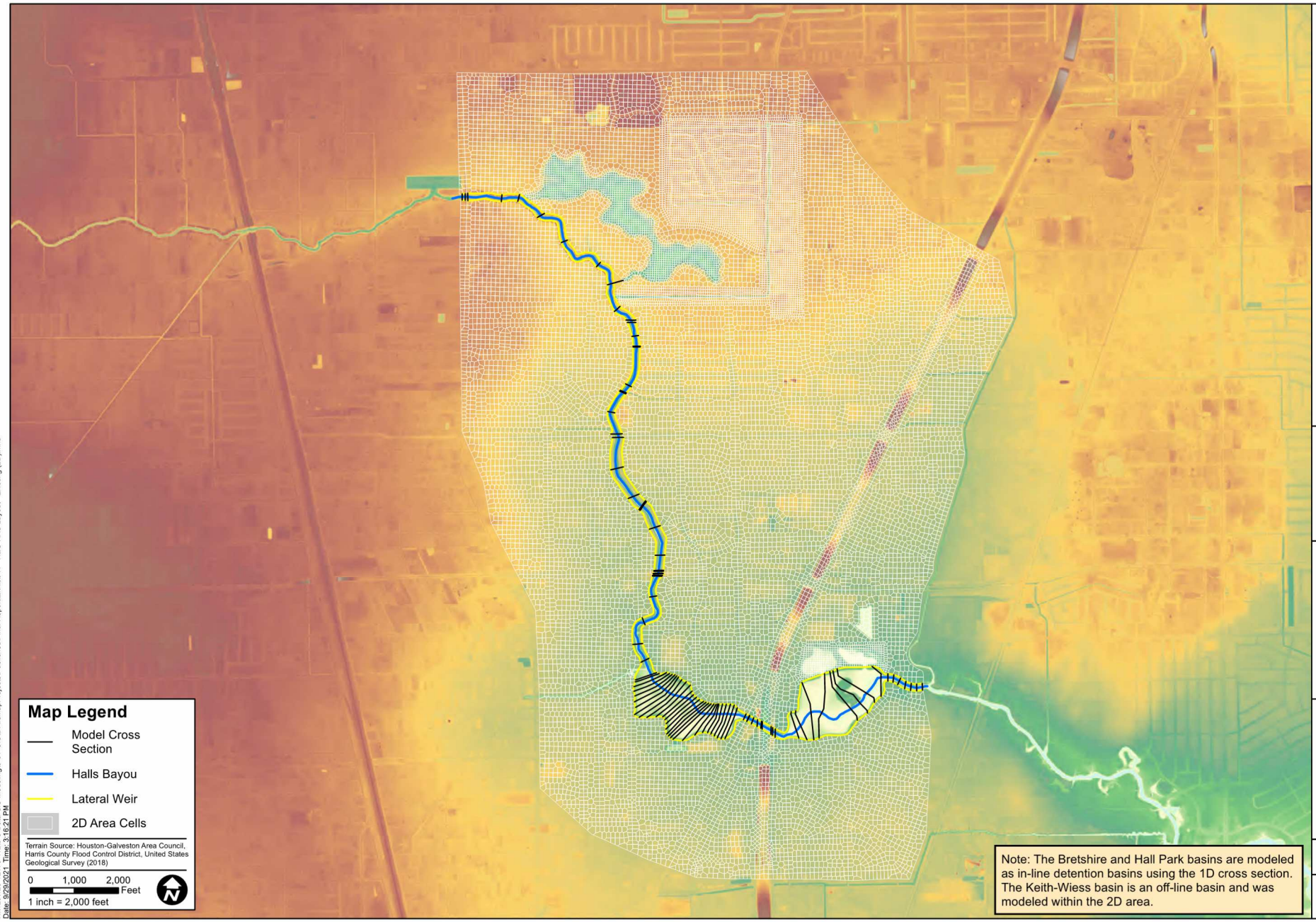
HEC-RAS MODEL LAYOUT EXISTING CONDITIONS (1D)



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HEC-RAS MODEL LAYOUT
EXISTING CONDITIONS (1D/2D)

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11

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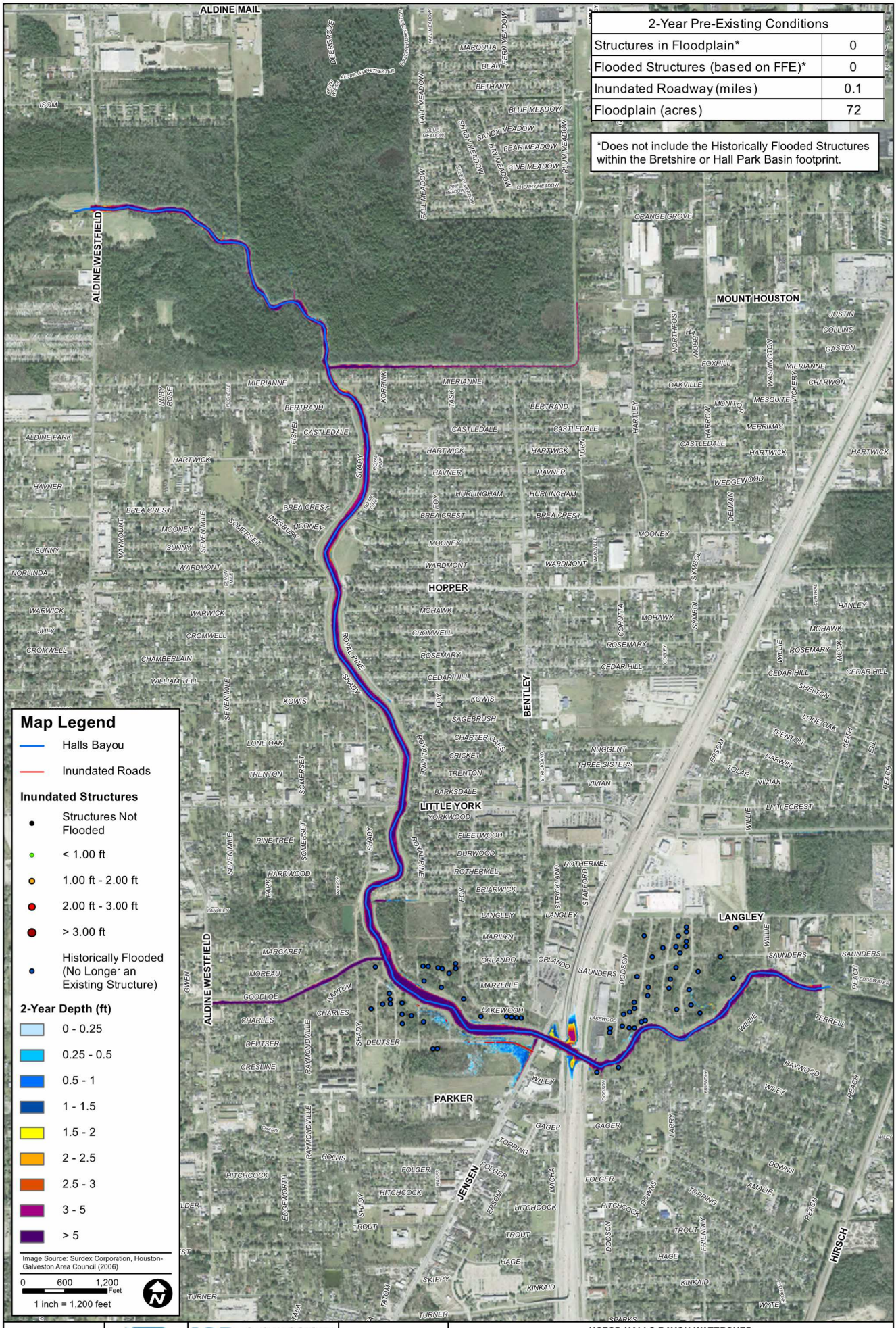

2-Year Pre-Existing Conditions	
Structures in Floodplain*	0
Flooded Structures (based on FFE)*	0
Inundated Roadway (miles)	0.1
Floodplain (acres)	72

*Does not include the Historically Flooded Structures within the Bretshire or Hall Park Basin footprint.

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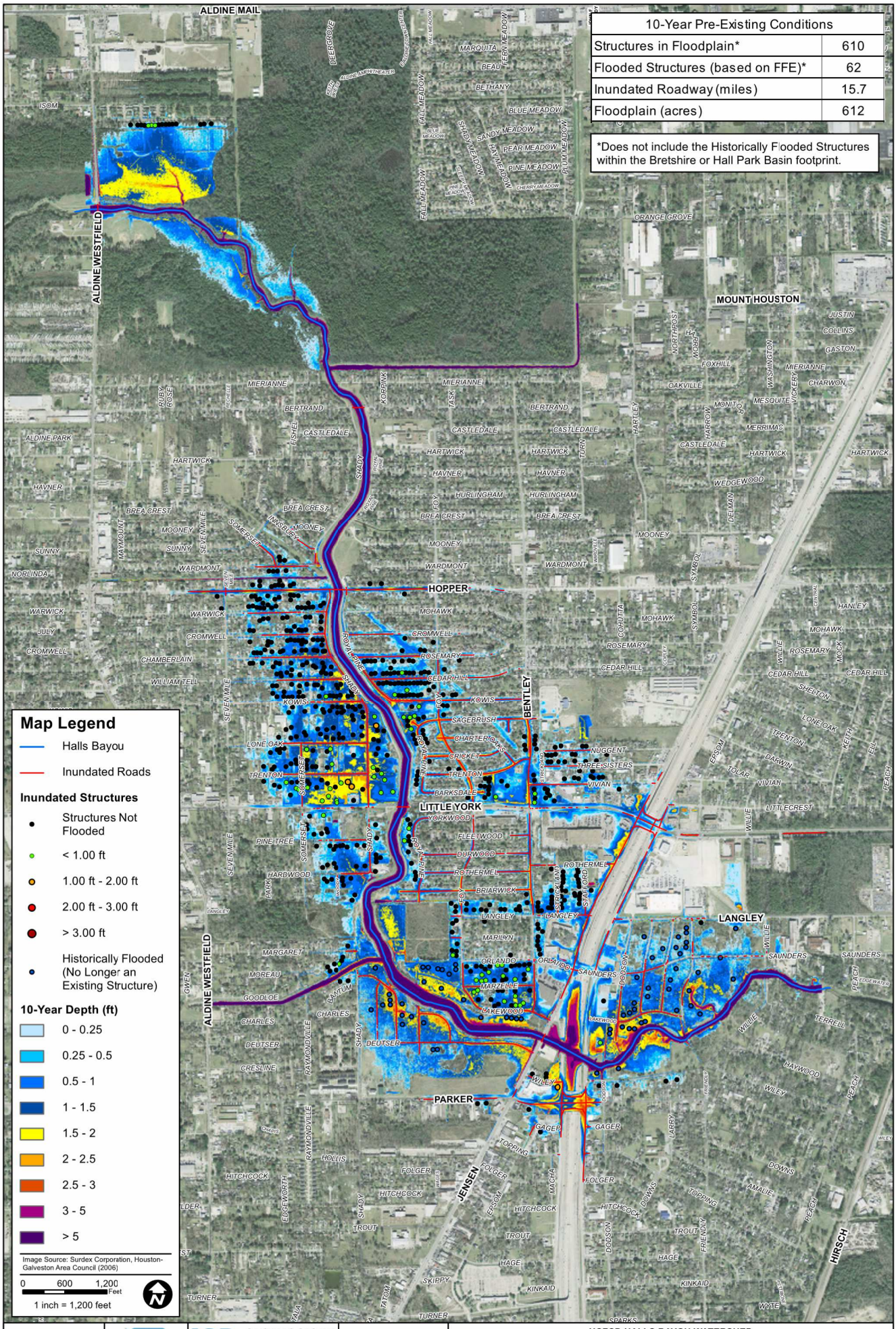
PRE-EXISTING CONDITIONS PERFORMANCE METRICS (2-YEAR)



Map Legend

- Halls Bayou
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft
- Historically Flooded (No Longer an Existing Structure)

10-Year Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 5
- > 5

Image Source: Surdex Corporation, Houston-Galveston Area Council (2006)

0 600 1,200 Feet

1 inch = 1,200 feet

10-Year Pre-Existing Conditions	
Structures in Floodplain*	610
Flooded Structures (based on FFE)*	62
Inundated Roadway (miles)	15.7
Floodplain (acres)	612

*Does not include the Historically Flooded Structures within the Bretshire or Hall Park Basin footprint.

DATE: OCT 2021
SCALE: AS NOTED

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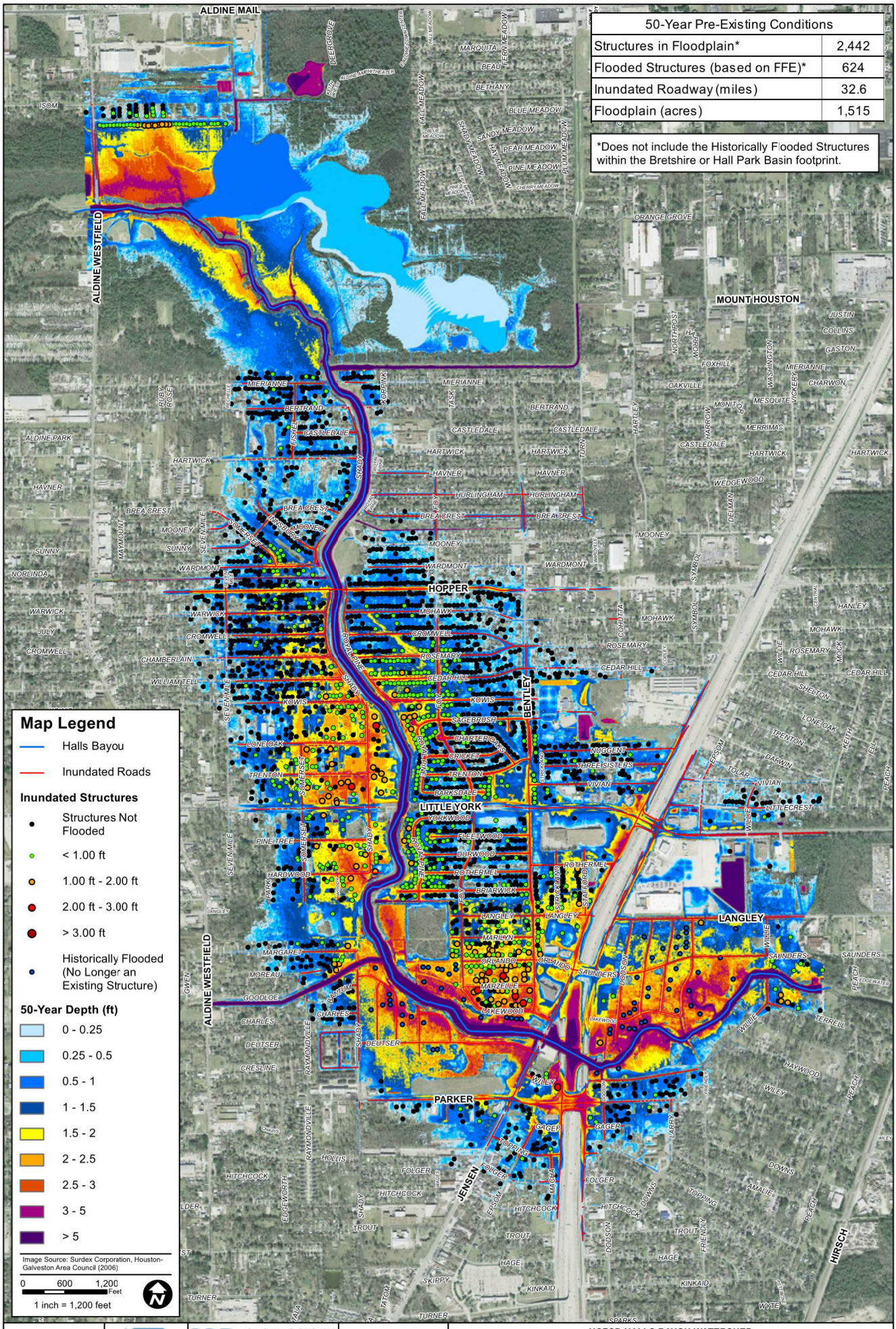
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

PRE-EXISTING CONDITIONS PERFORMANCE METRICS (10-YEAR)



50-Year Pre-Existing Conditions	
Structures in Floodplain*	2,442
Flooded Structures (based on FFE)*	624
Inundated Roadway (miles)	32.6
Floodplain (acres)	1,515

*Does not include the Historically Flooded Structures within the Bretshire or Hall Park Basin footprint.

Map Legend

- Halls Bayou
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft
- Historically Flooded (No Longer an Existing Structure)

50-Year Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 5
- > 5

Image Source: Surdex Corporation, Houston-Galveston Area Council (2006)

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 14

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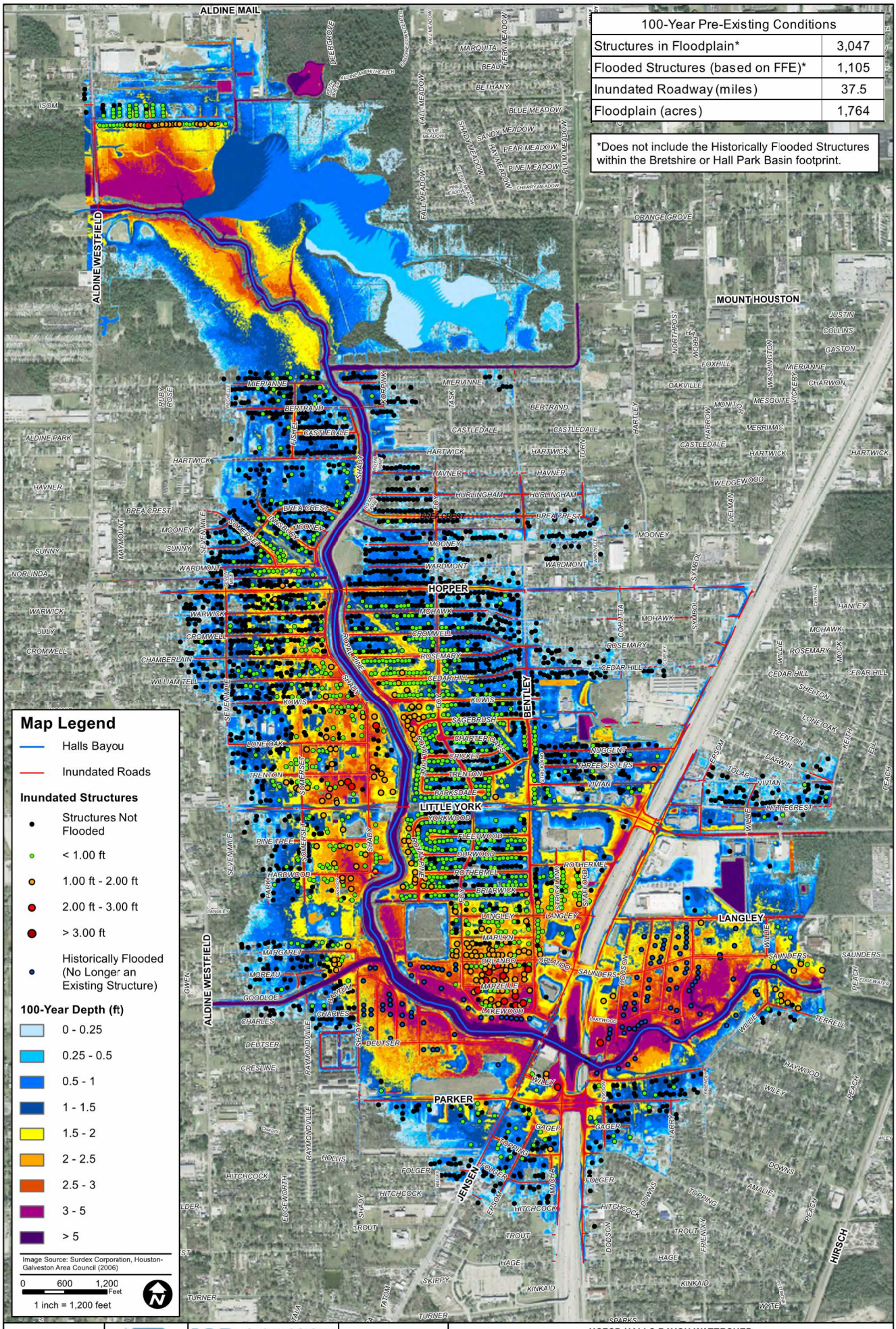
PRE-EXISTING CONDITIONS PERFORMANCE METRICS (50-YEAR)



100-Year Pre-Existing Conditions	
Structures in Floodplain*	3,047
Flooded Structures (based on FFE)*	1,105
Inundated Roadway (miles)	37.5
Floodplain (acres)	1,764

*Does not include the Historically Flooded Structures within the Bretshire or Hall Park Basin footprint.

Map Legend

- Halls Bayou
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft
- Historically Flooded (No Longer an Existing Structure)

100-Year Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 5
- > 5

Image Source: Surdex Corporation, Houston-Galveston Area Council (2006)

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: OCT 2021
SCALE: AS NOTED

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APPROVED: WWC

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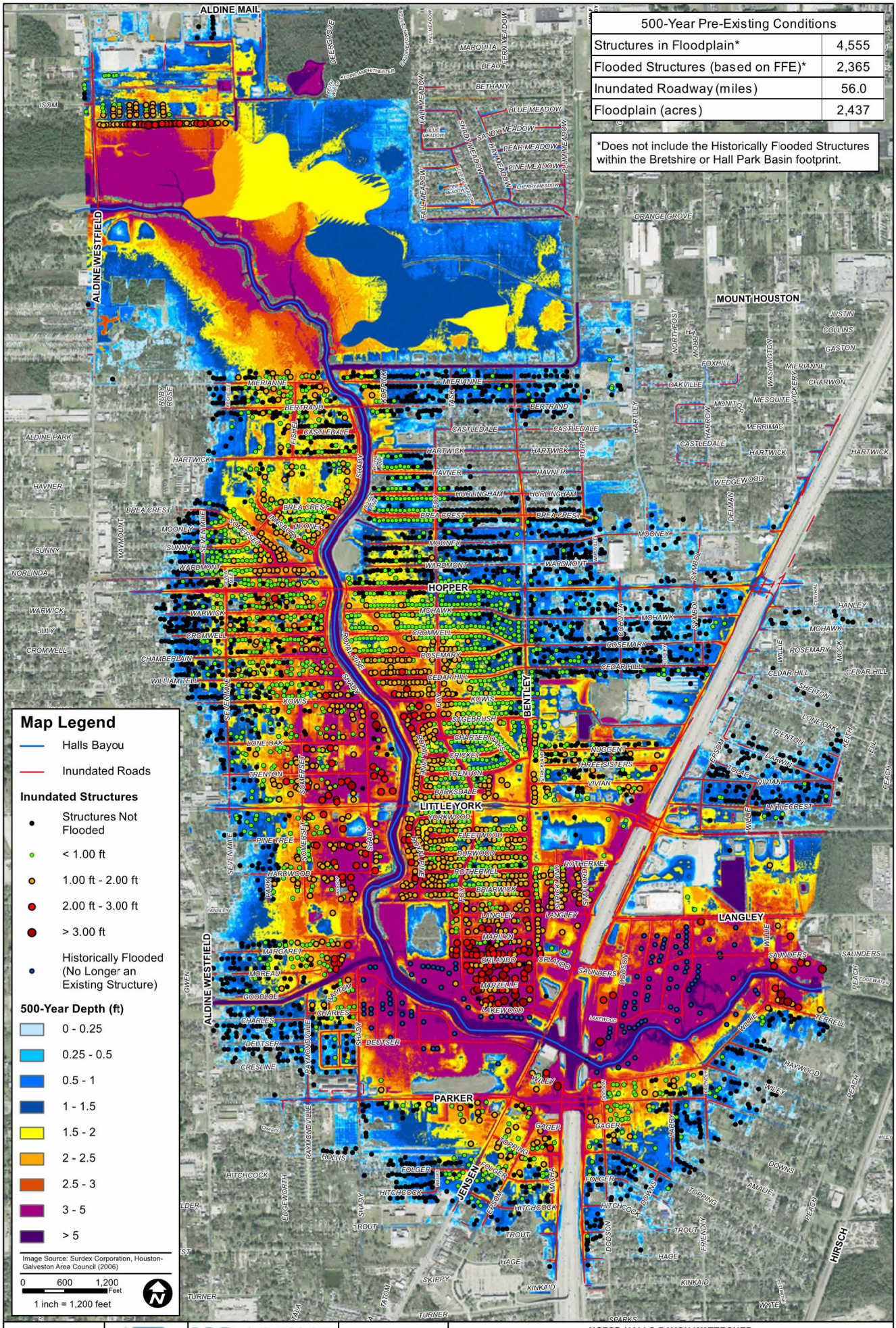
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

PRE-EXISTING CONDITIONS PERFORMANCE METRICS (100-YEAR)



500-Year Pre-Existing Conditions	
Structures in Floodplain*	4,555
Flooded Structures (based on FFE)*	2,365
Inundated Roadway (miles)	56.0
Floodplain (acres)	2,437

*Does not include the Historically Flooded Structures within the Bretshire or Hall Park Basin footprint.

Map Legend

- Halls Bayou
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft
- Historically Flooded (No Longer an Existing Structure)

500-Year Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 5
- > 5

Image Source: Surdex Corporation, Houston-Galveston Area Council (2006)

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 16

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
TBPE Firm No. 2614
2925 Briarpark Drive • Houston, TX 77042-3720
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PREPARED: CRB
CHECKED: WWC
APPROVED: WWC

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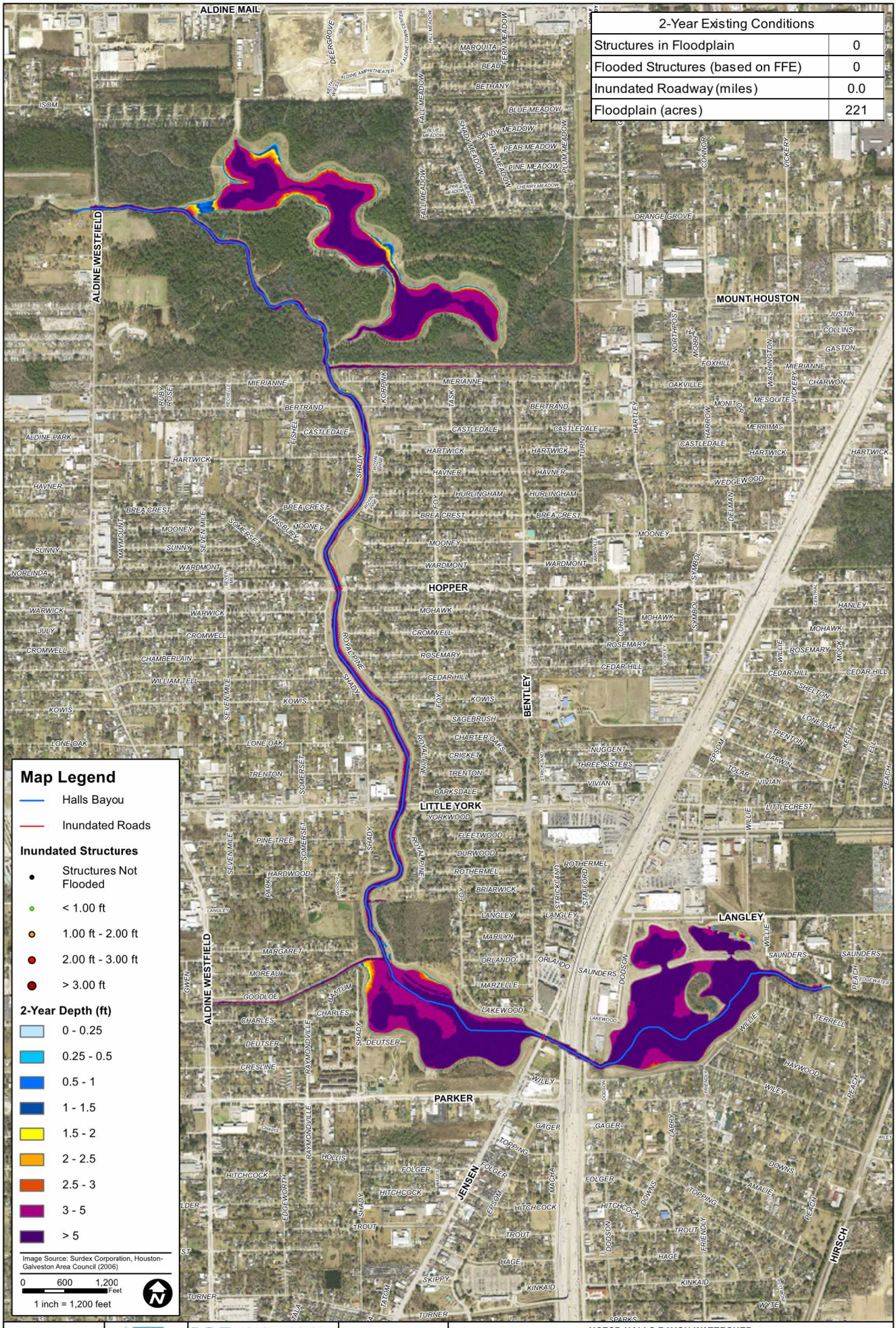
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

PRE-EXISTING CONDITIONS PERFORMANCE METRICS (500-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 17

HARRIS COUNTY FLOOD CONTROL DISTRICT
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Houston, Texas 77092

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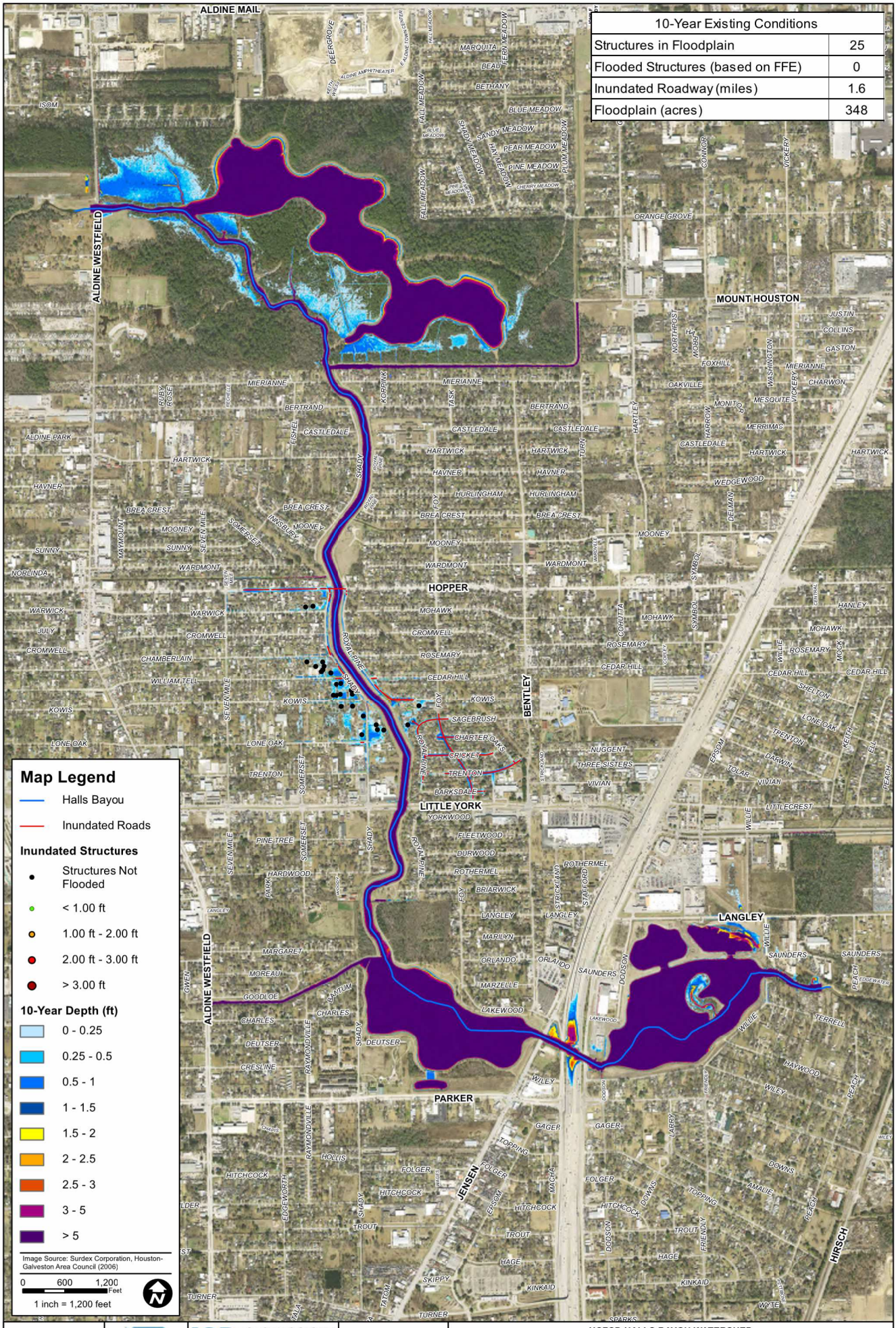
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

EXISTING CONDITIONS PERFORMANCE METRICS (2-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 18

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
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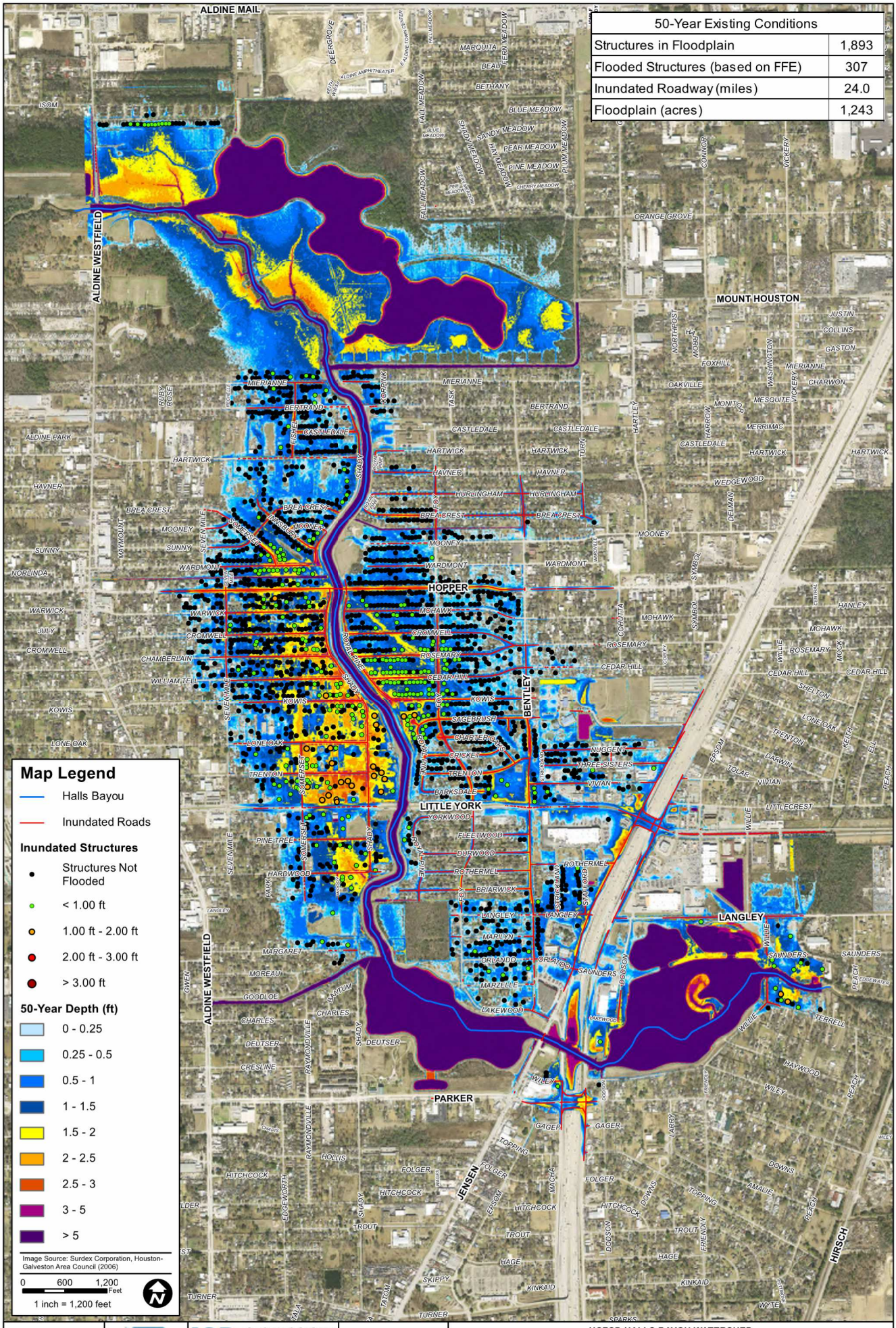
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

EXISTING CONDITIONS PERFORMANCE METRICS (10-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 19

HARRIS COUNTY FLOOD CONTROL DISTRICT
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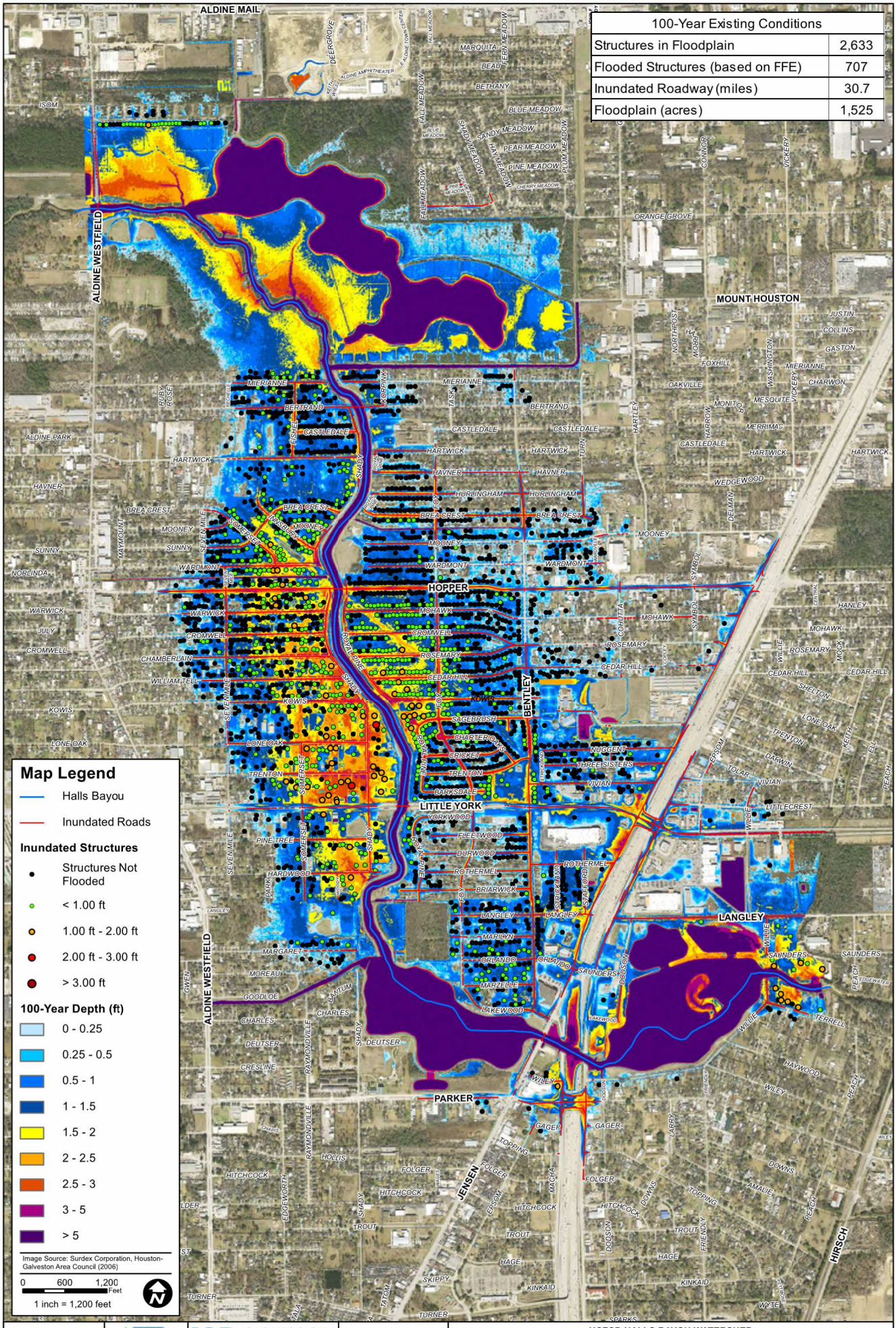
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

EXISTING CONDITIONS PERFORMANCE METRICS (50-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 20

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CHECKED: WWC
APPROVED: WWC

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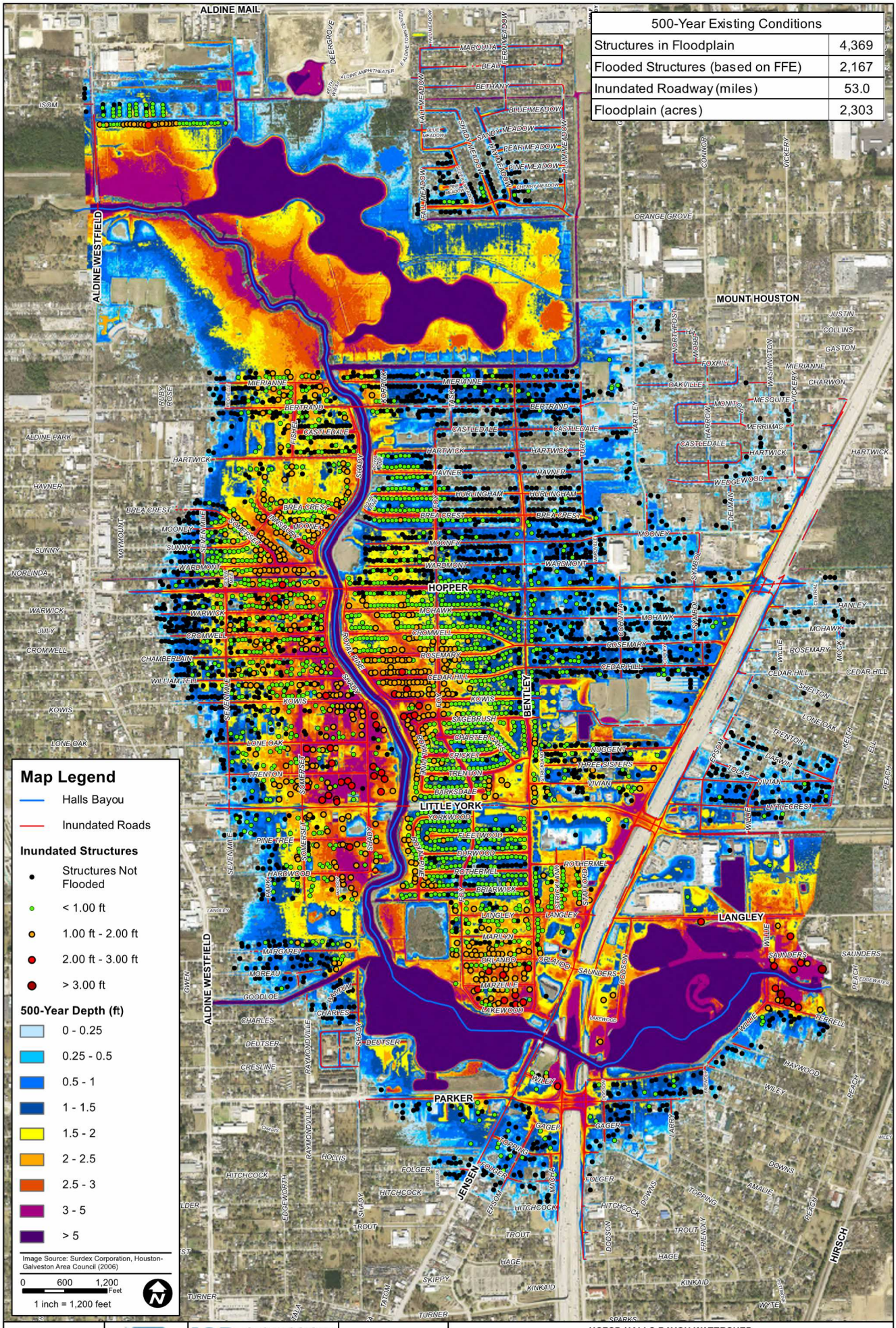
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

EXISTING CONDITIONS PERFORMANCE METRICS (100-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 21

HARRIS COUNTY FLOOD CONTROL DISTRICT
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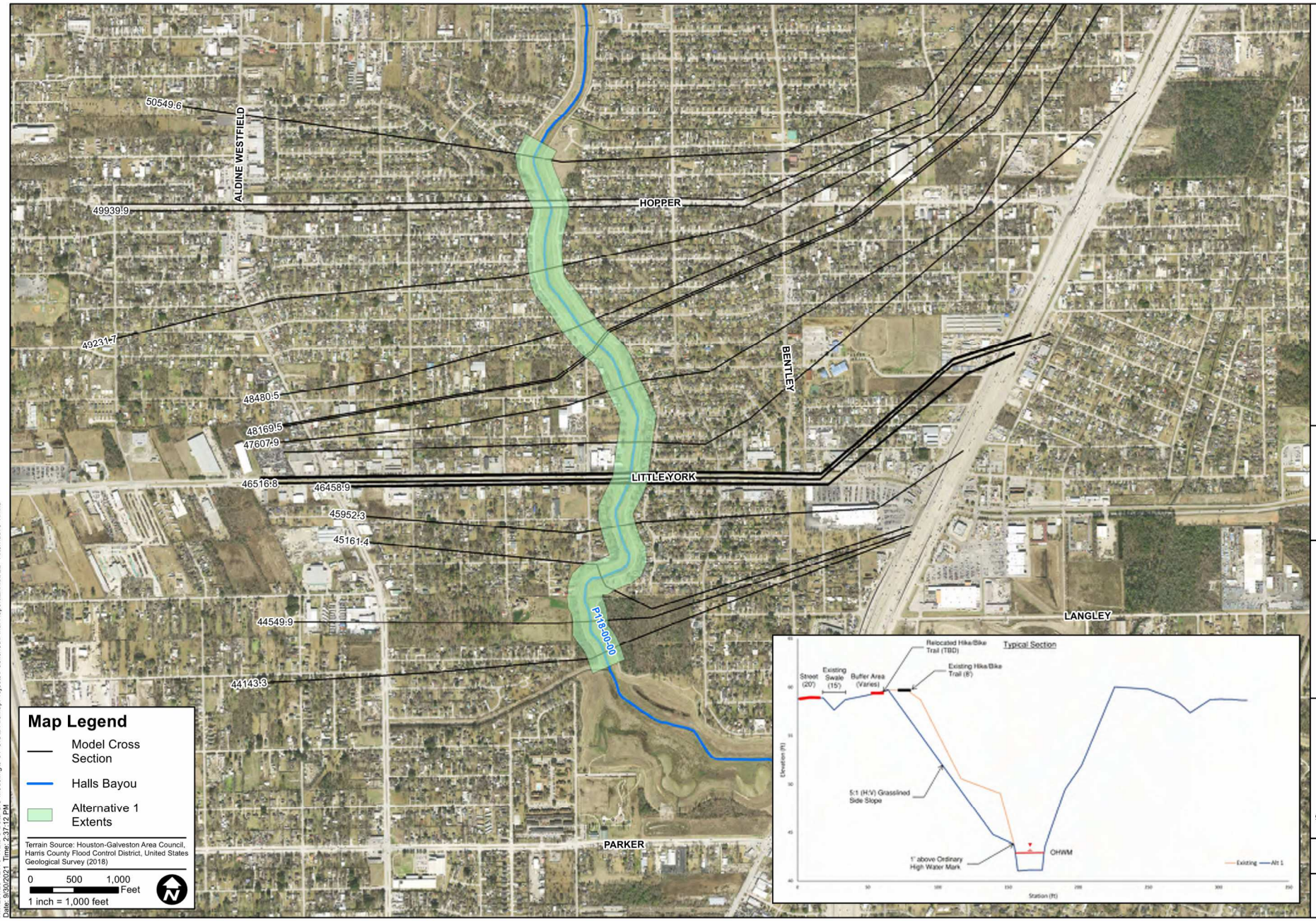
PREPARED: CRB
CHECKED: WWC
APPROVED: WWC

HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

EXISTING CONDITIONS PERFORMANCE METRICS (500-YEAR)



HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 1 LAYOUT

PREPARED: CRB	CHECKED: WWC	APPROVED: WWC

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HARRIS COUNTY FLOOD CONTROL DISTRICT
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DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT
22

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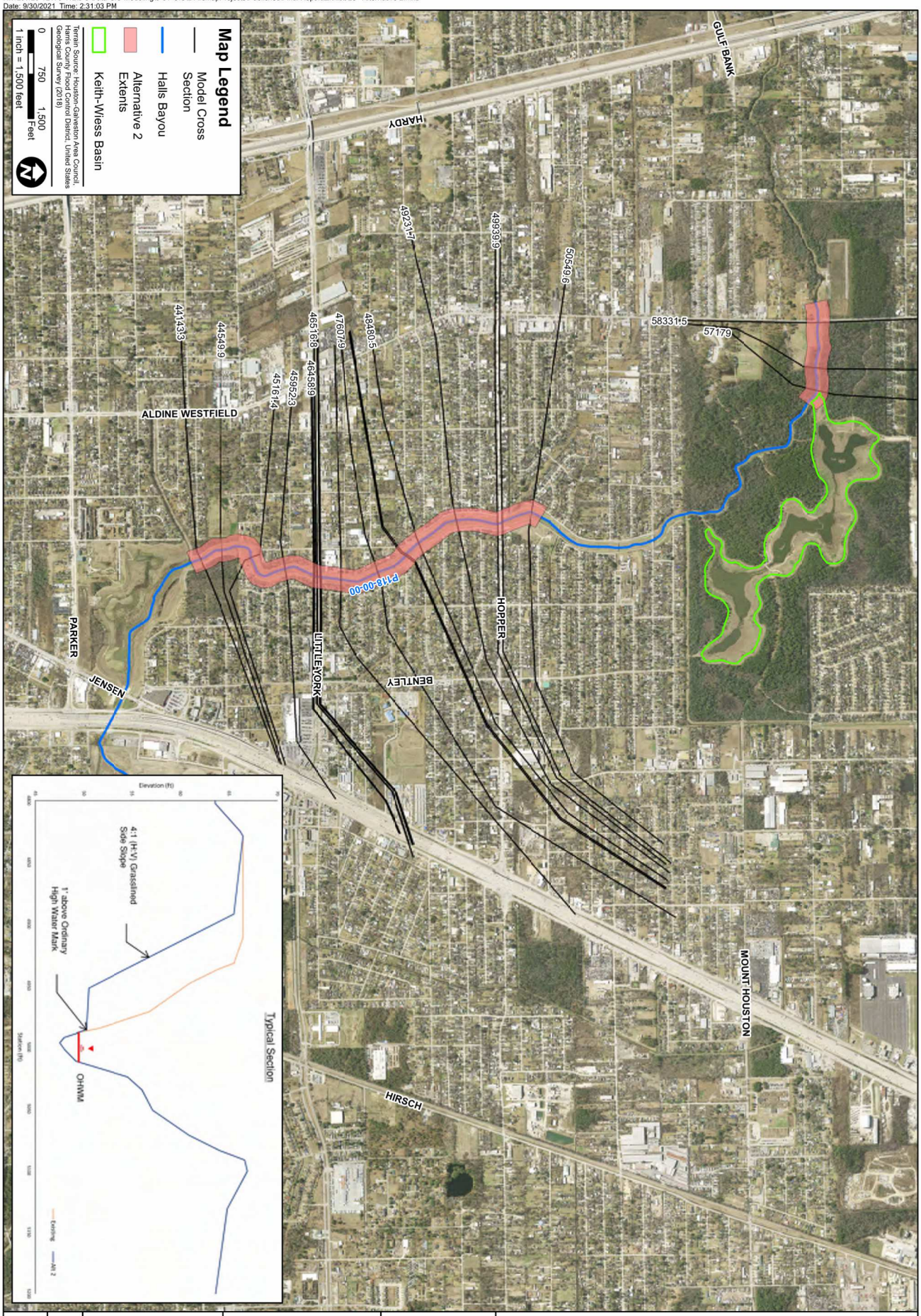
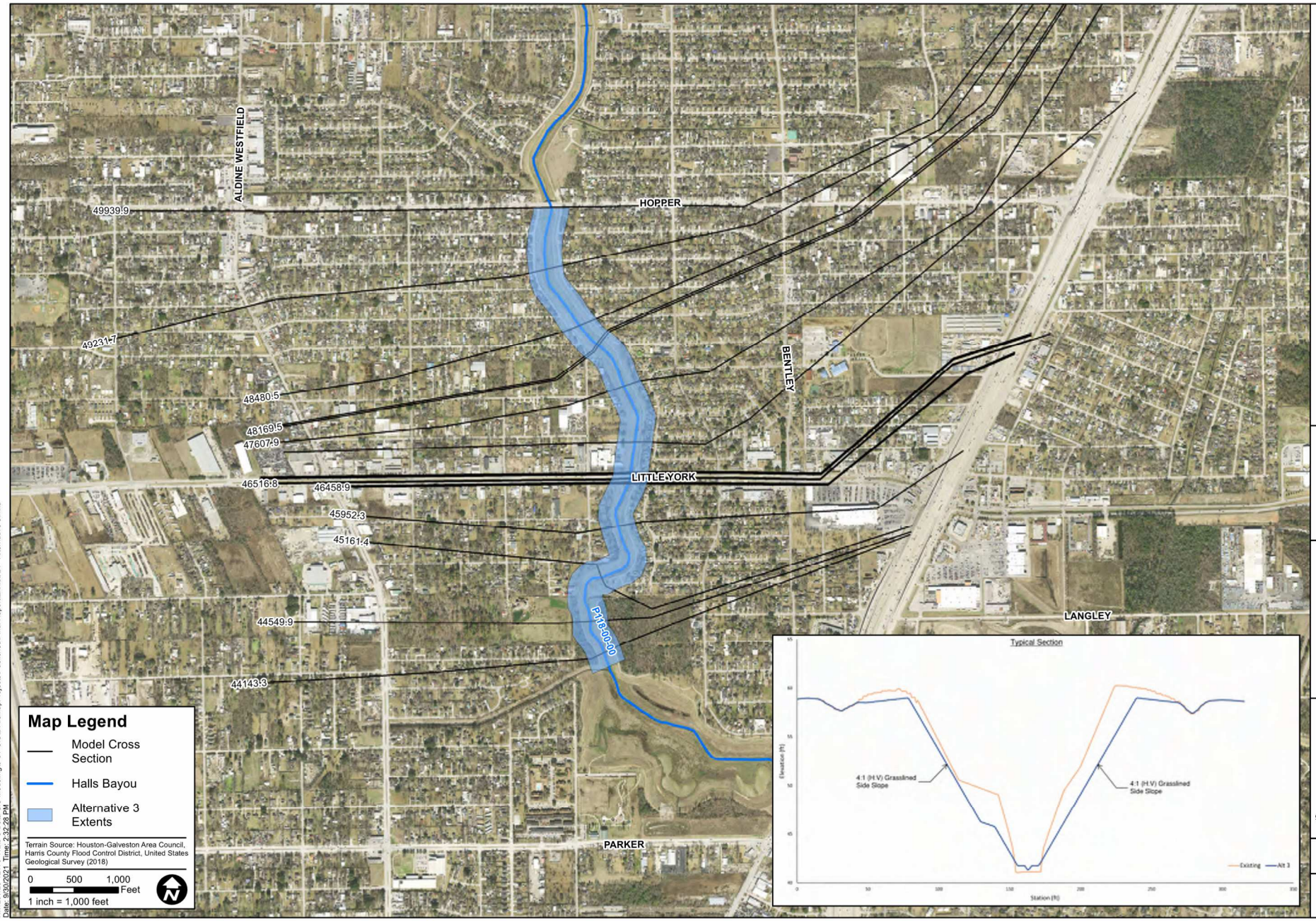


EXHIBIT 23	DATE: OCT 2021 SCALE: AS NOTED	HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092	Lockwood, Andrews & Newnam, Inc. A LEO A DALY COMPANY TBPE Firm No. 2614 2925 Briarpark Drive • Houston, TX 77042-3720 T 713.266.6900 • F 713.266.2089 www.lan-inc.com • info@lan-inc.com	PREPARED: CRB CHECKED: WWC APPROVED: WWC	HCFCD HALLS BAYOU WATERSHED P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS ALTERNATIVE 2 LAYOUT



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HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 3 LAYOUT

PREPARED: CRB
CHECKED: WWC
APPROVED: WWC

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HARRIS COUNTY FLOOD CONTROL DISTRICT
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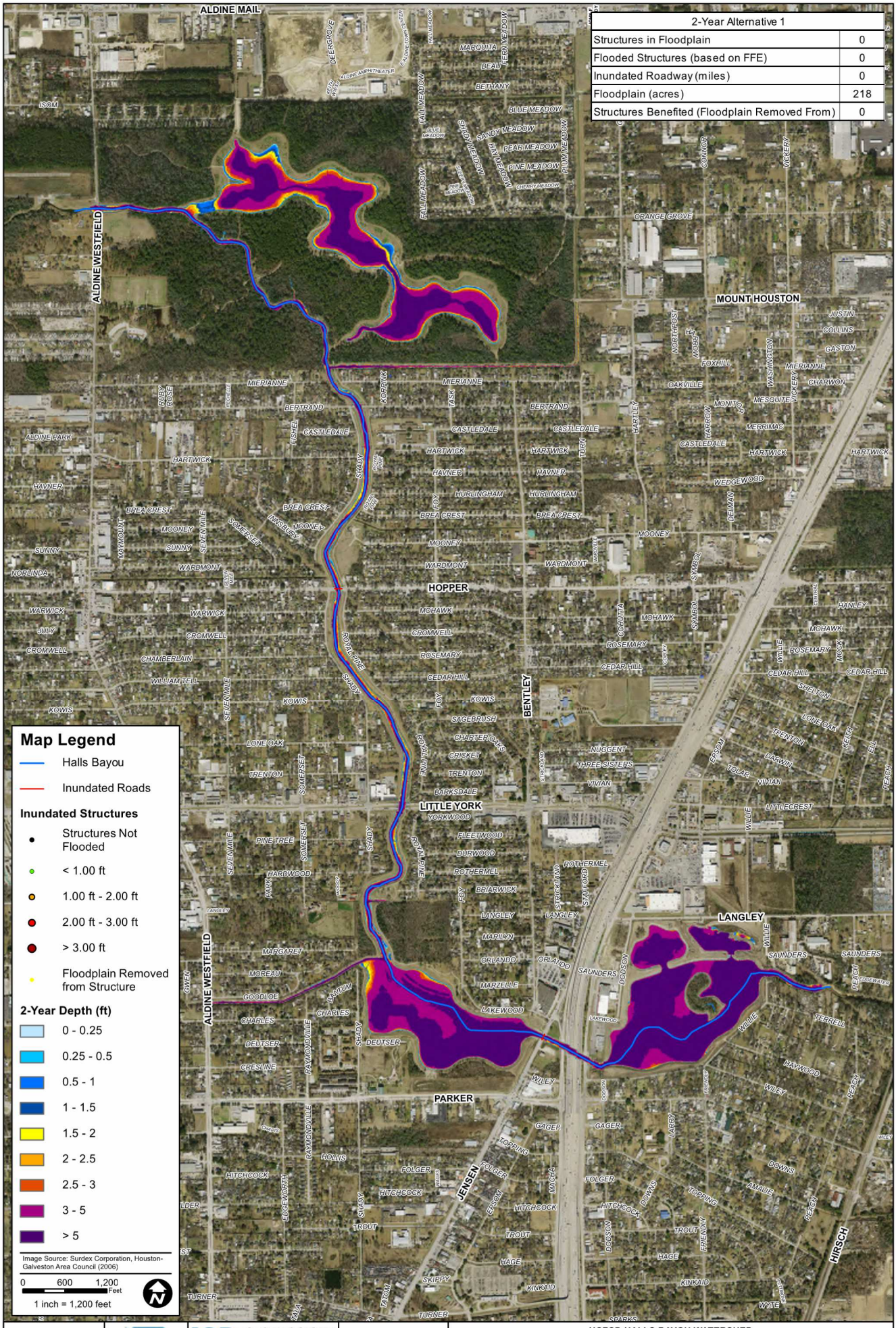
DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT
24



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 25

HARRIS COUNTY FLOOD CONTROL DISTRICT
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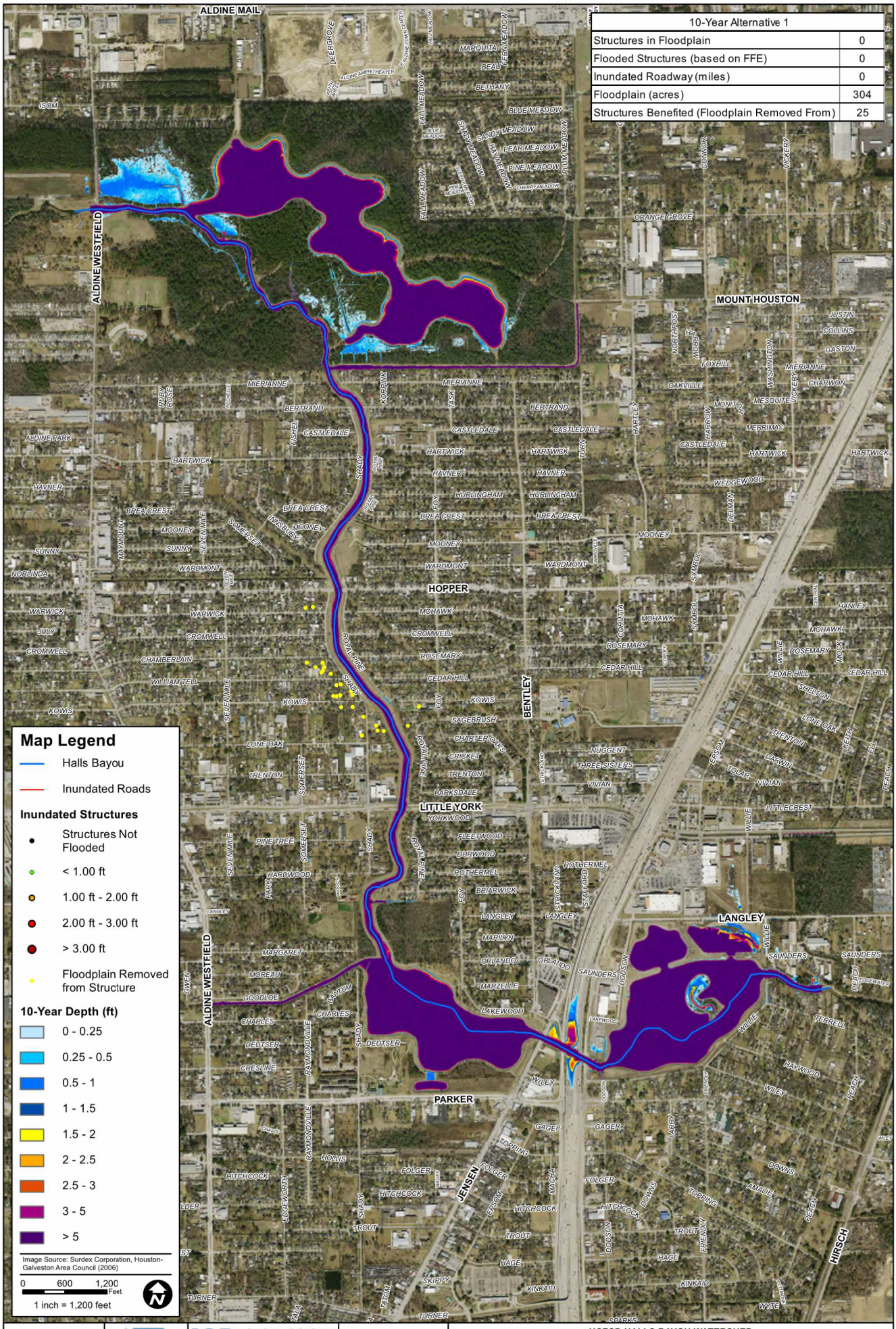
PREPARED: CRB
CHECKED: WWC
APPROVED: WWC

HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 1
PERFORMANCE METRICS (2-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 26

HARRIS COUNTY FLOOD CONTROL DISTRICT
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PREPARED: CRB
CHECKED: WWC
APPROVED: WWC

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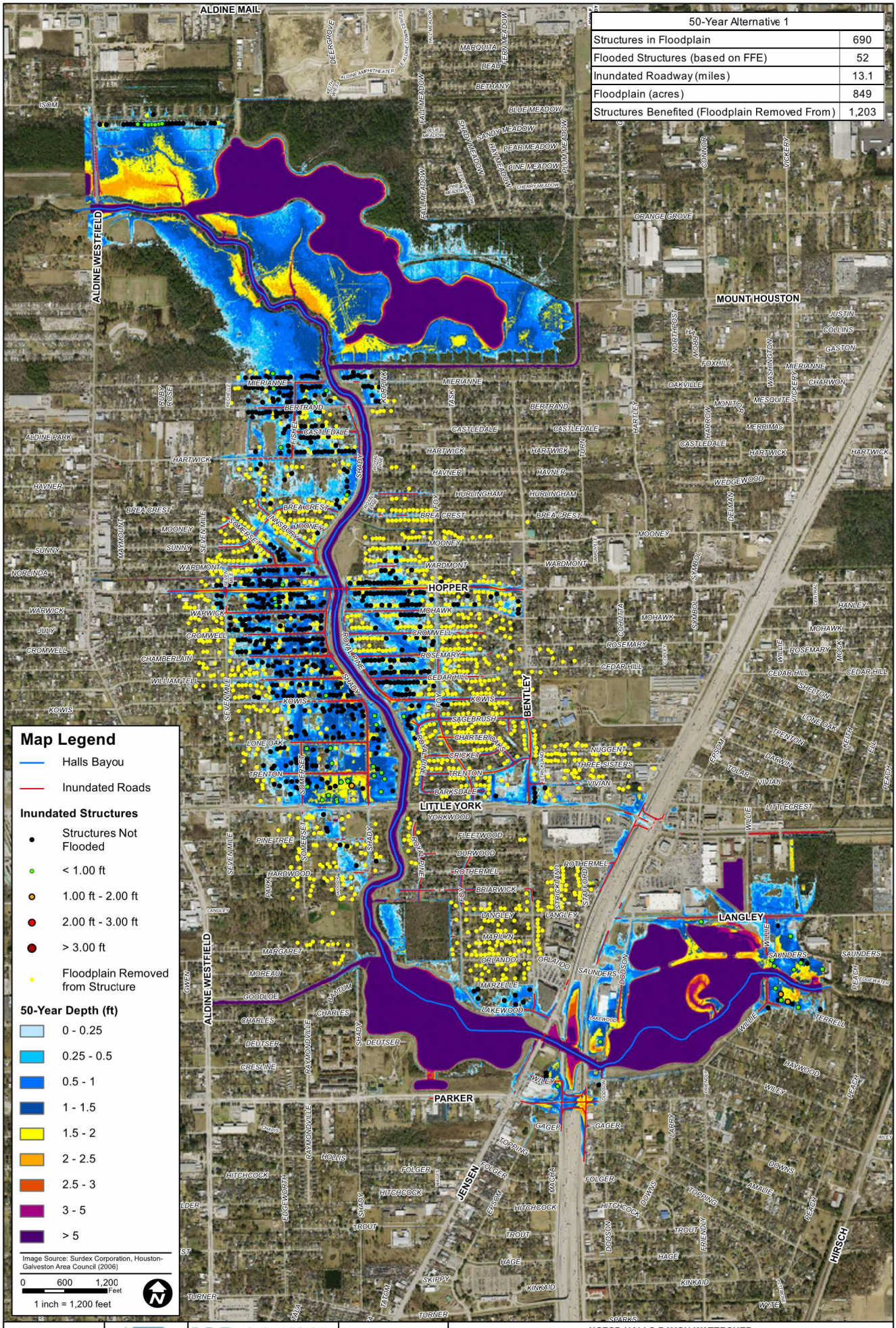
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 1
PERFORMANCE METRICS (10-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 27

HARRIS COUNTY FLOOD CONTROL DISTRICT
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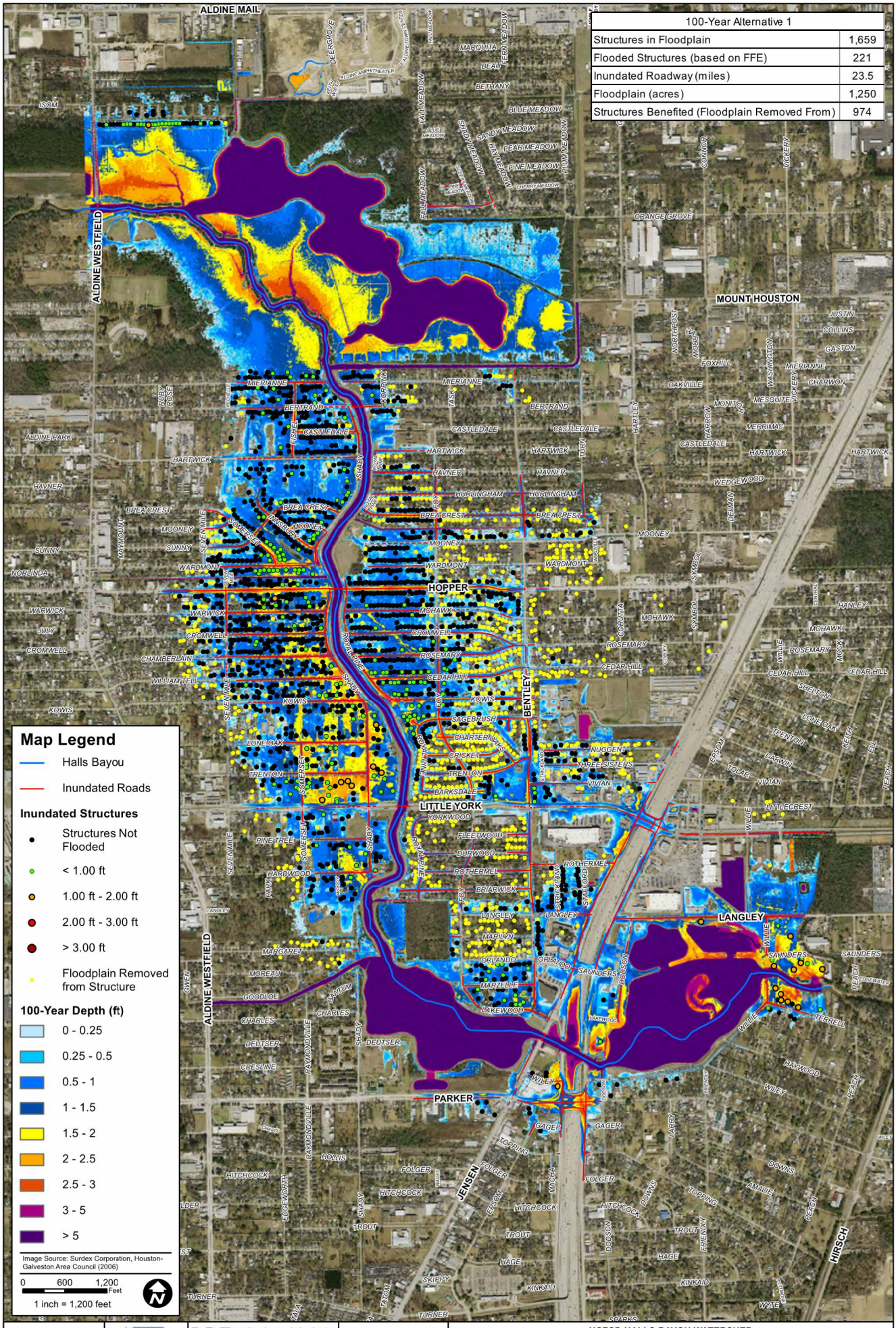
PREPARED: CRB
CHECKED: WWC
APPROVED: WWC

HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 1
PERFORMANCE METRICS (50-YEAR)



100-Year Alternative 1	
Structures in Floodplain	1,659
Flooded Structures (based on FFE)	221
Inundated Roadway (miles)	23.5
Floodplain (acres)	1,250
Structures Benefited (Floodplain Removed From)	974

DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 28

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
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www.lan-inc.com • info@lan-inc.com

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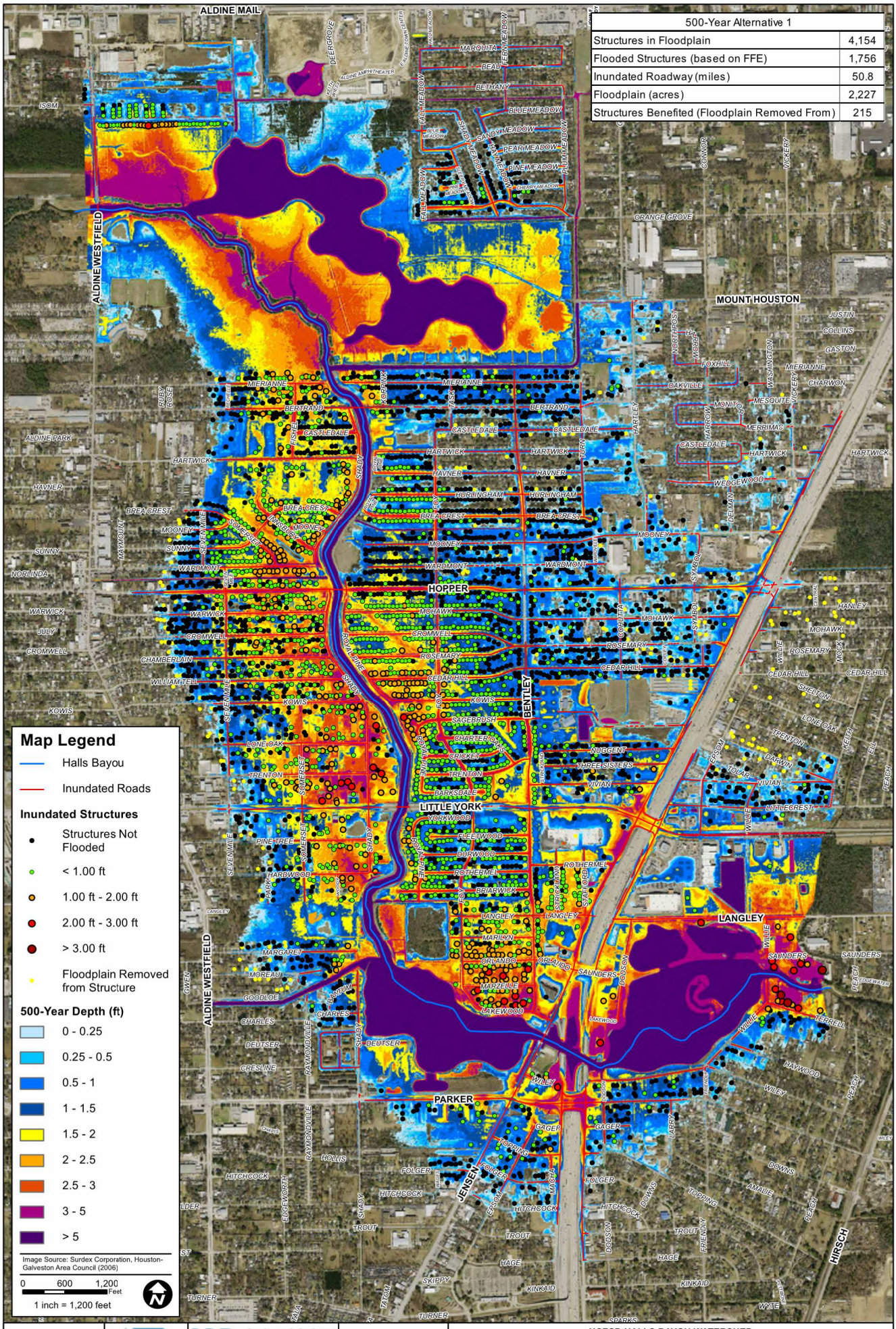
APPROVED: WWC

HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 1
PERFORMANCE METRICS (100-YEAR)



500-Year Alternative 1	
Structures in Floodplain	4,154
Flooded Structures (based on FFE)	1,756
Inundated Roadway (miles)	50.8
Floodplain (acres)	2,227
Structures Benefited (Floodplain Removed From)	215

DATE: OCT 2021
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EXHIBIT
29

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

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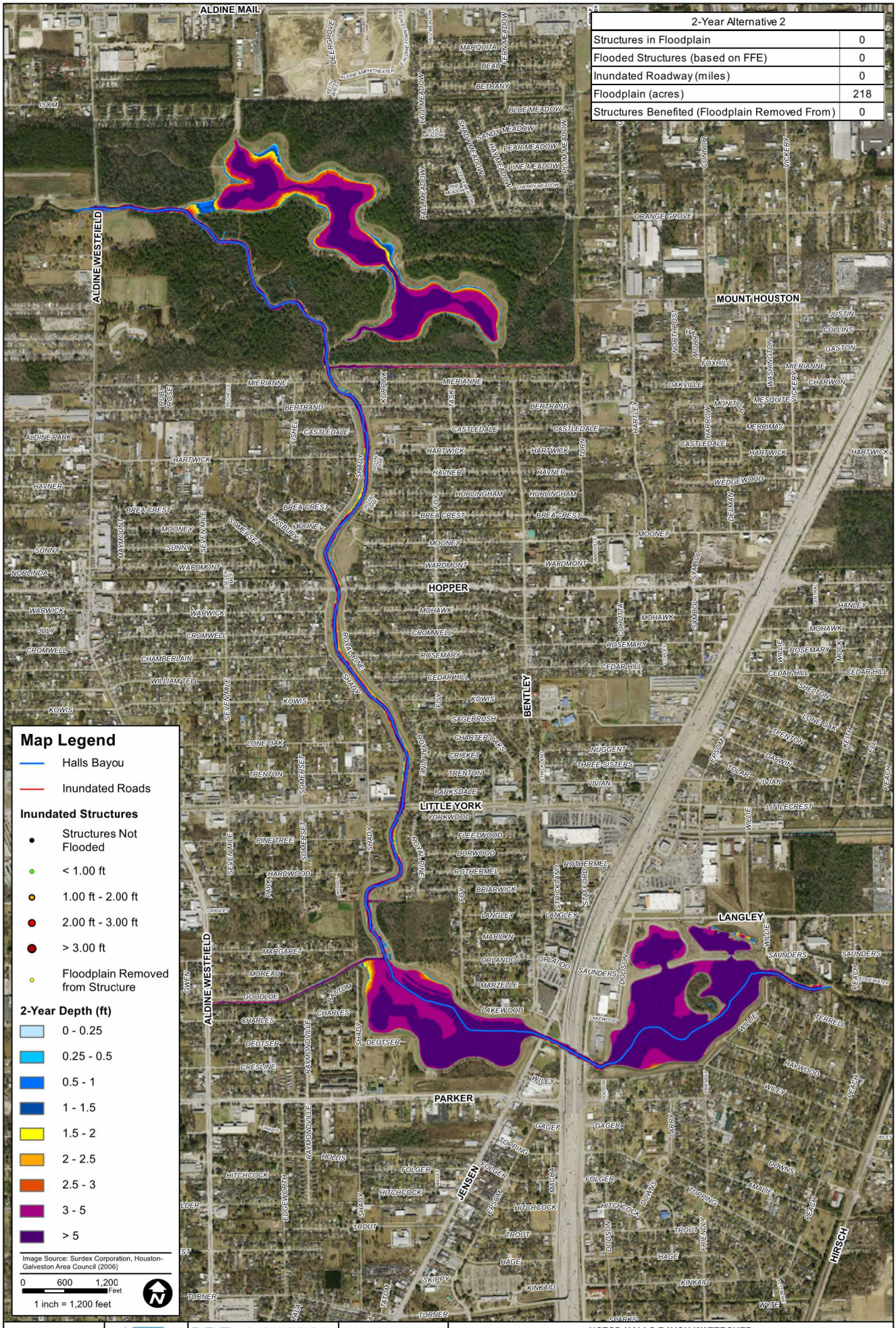
HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 1
PERFORMANCE METRICS (500-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 30

HARRIS COUNTY FLOOD CONTROL DISTRICT
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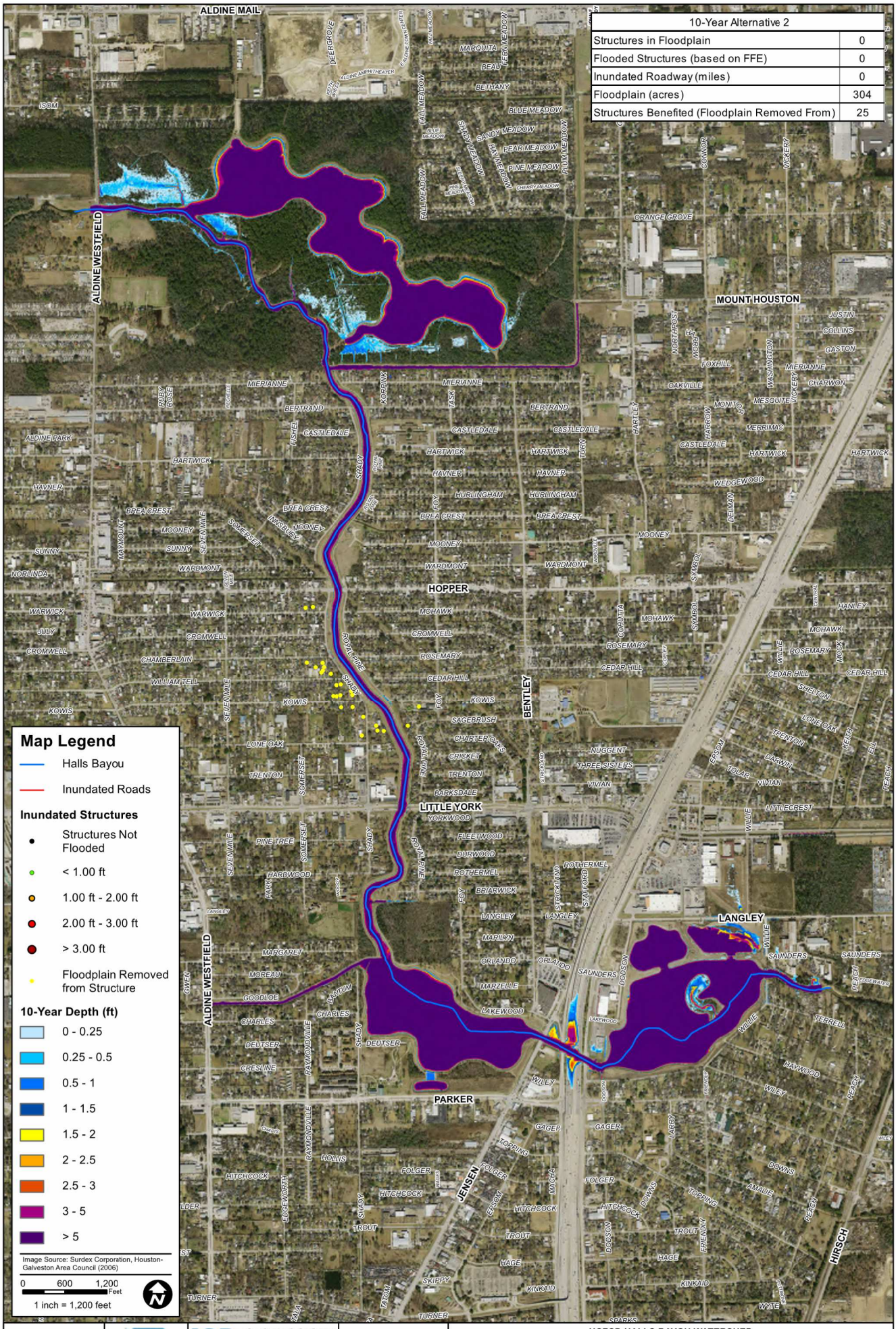
HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 2
PERFORMANCE METRICS (2-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 31

HARRIS COUNTY FLOOD CONTROL DISTRICT
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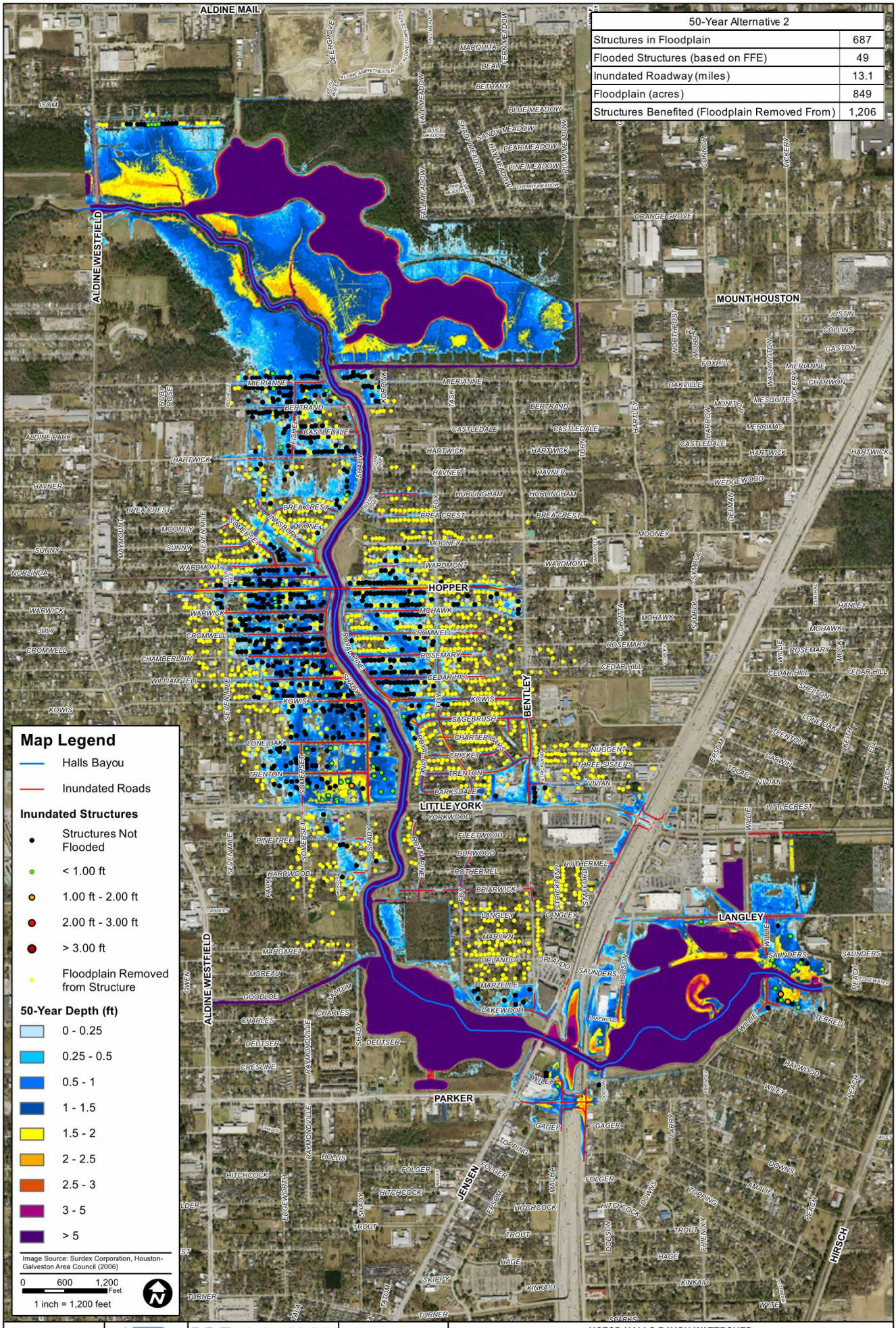
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 2
PERFORMANCE METRICS (10-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 32

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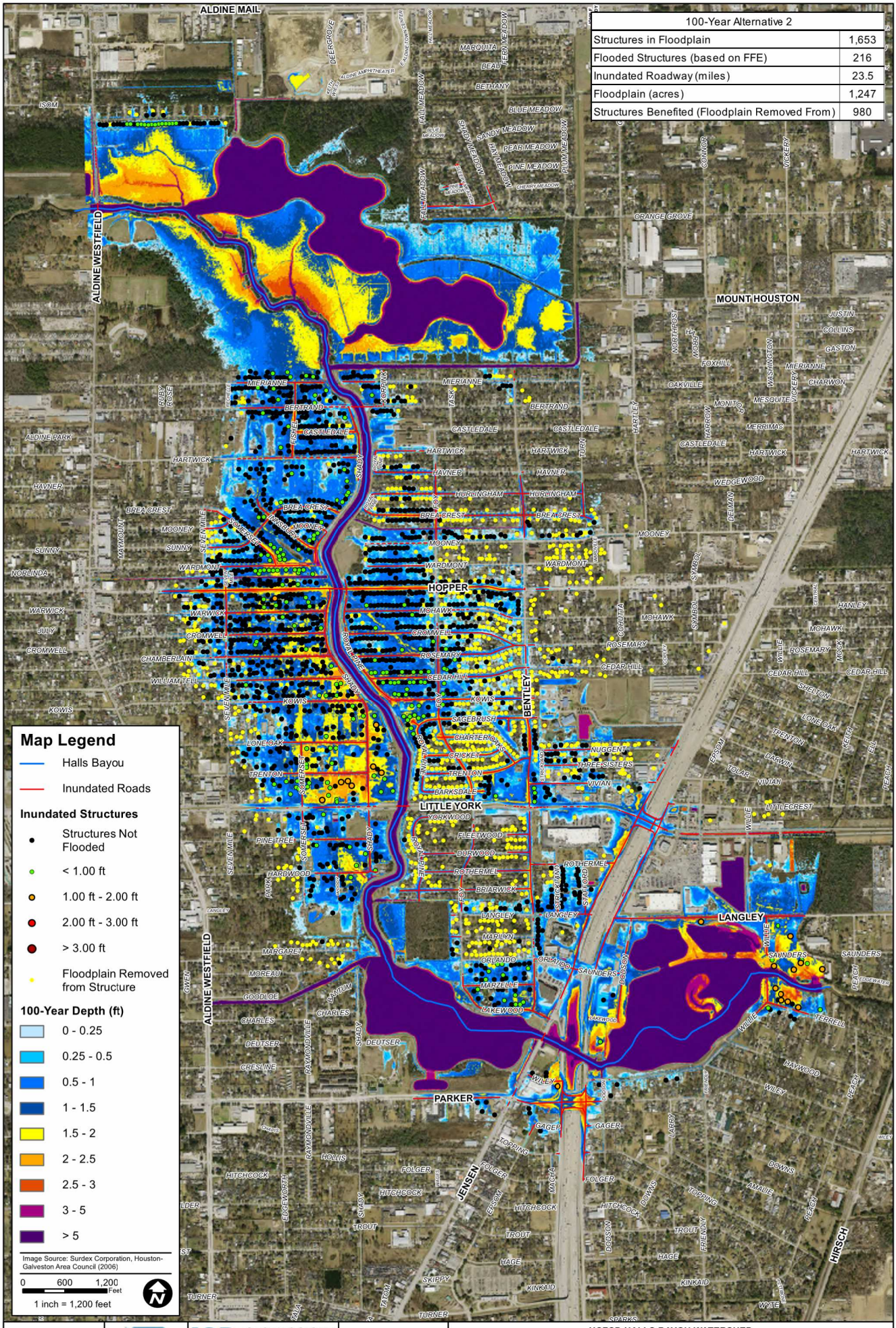
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 2
PERFORMANCE METRICS (50-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

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HARRIS COUNTY FLOOD CONTROL DISTRICT
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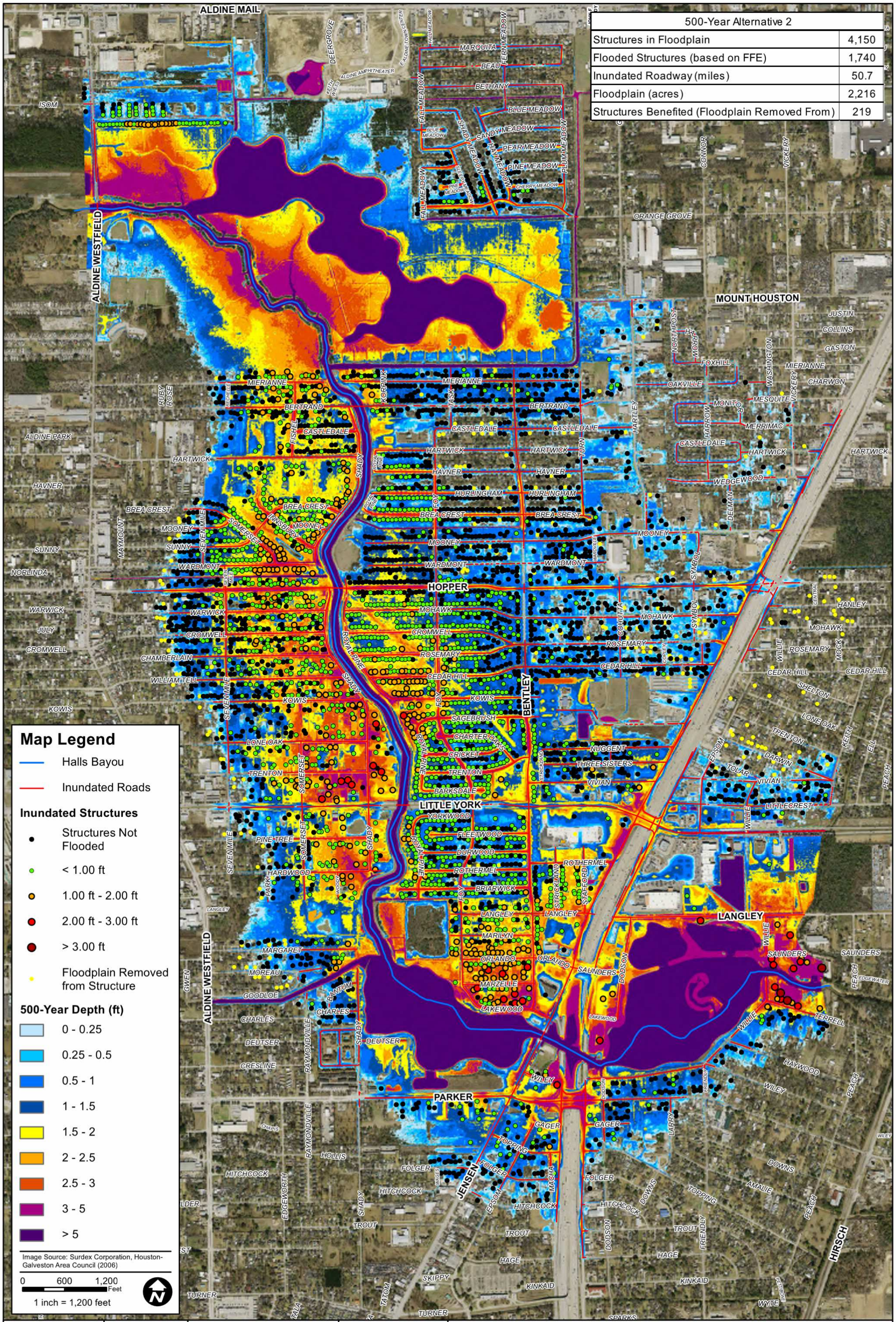
APPROVED: WWC

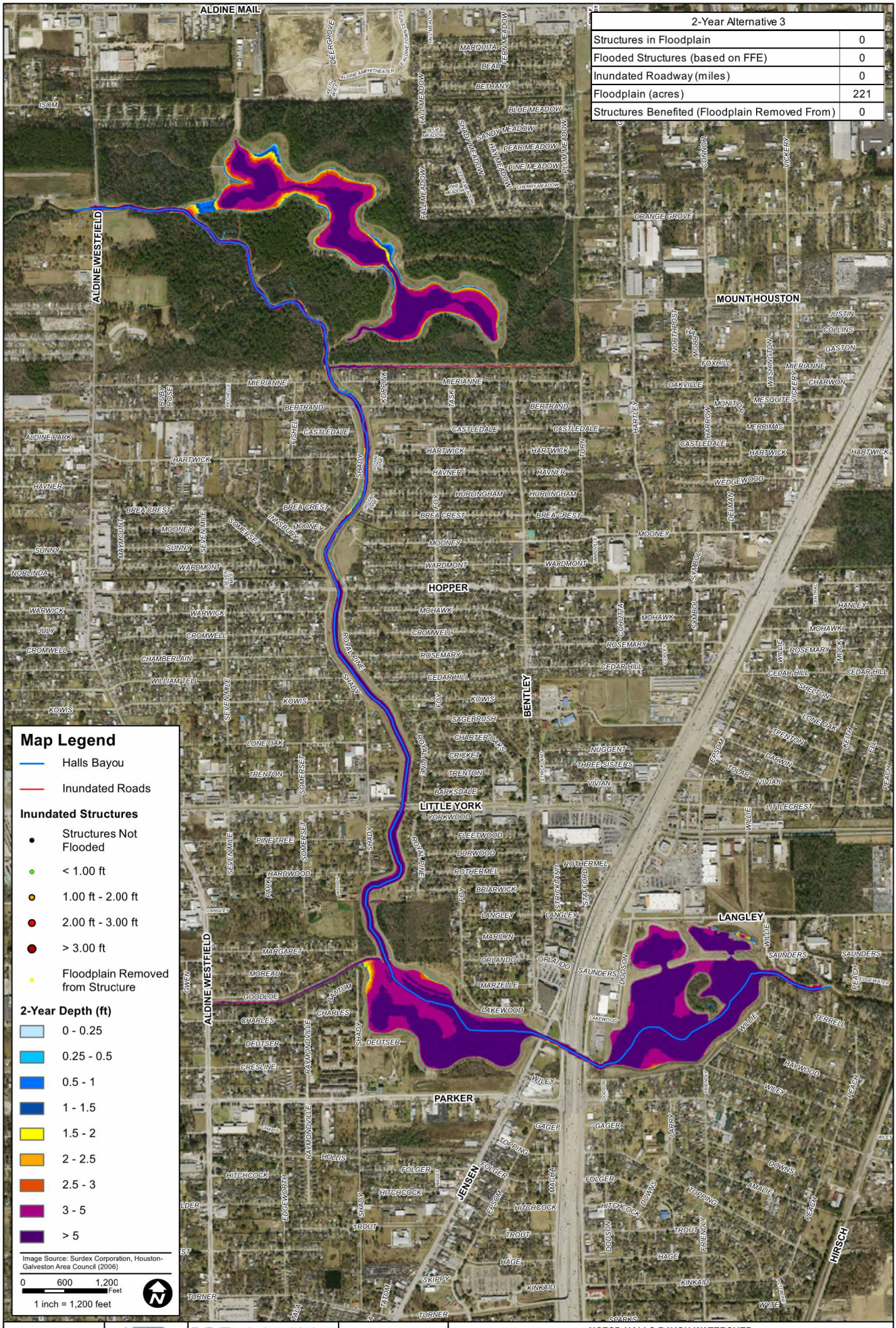
HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 2
PERFORMANCE METRICS (100-YEAR)

500-Year Alternative 2	
Structures in Floodplain	4,150
Flooded Structures (based on FFE)	1,740
Inundated Roadway (miles)	50.7
Floodplain (acres)	2,216
Structures Benefited (Floodplain Removed From)	219



DATE: OCT 2021 SCALE: AS NOTED	HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092	Lockwood, Andrews & Newnam, Inc. A LEO A DALY COMPANY TBPE Firm No. 2614 2925 Briarpark Drive • Houston, TX 77042-3720 T 713.266.6900 • F 713.266.2089 www.lan-inc.com • info@lan-inc.com	PREPARED: CRB CHECKED: WWC APPROVED: WWC	HCFCD HALLS BAYOU WATERSHED P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS ALTERNATIVE 2 PERFORMANCE METRICS (500-YEAR)
EXHIBIT 34				



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 35

HARRIS COUNTY FLOOD CONTROL DISTRICT
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Houston, Texas 77092

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PREPARED: CRB
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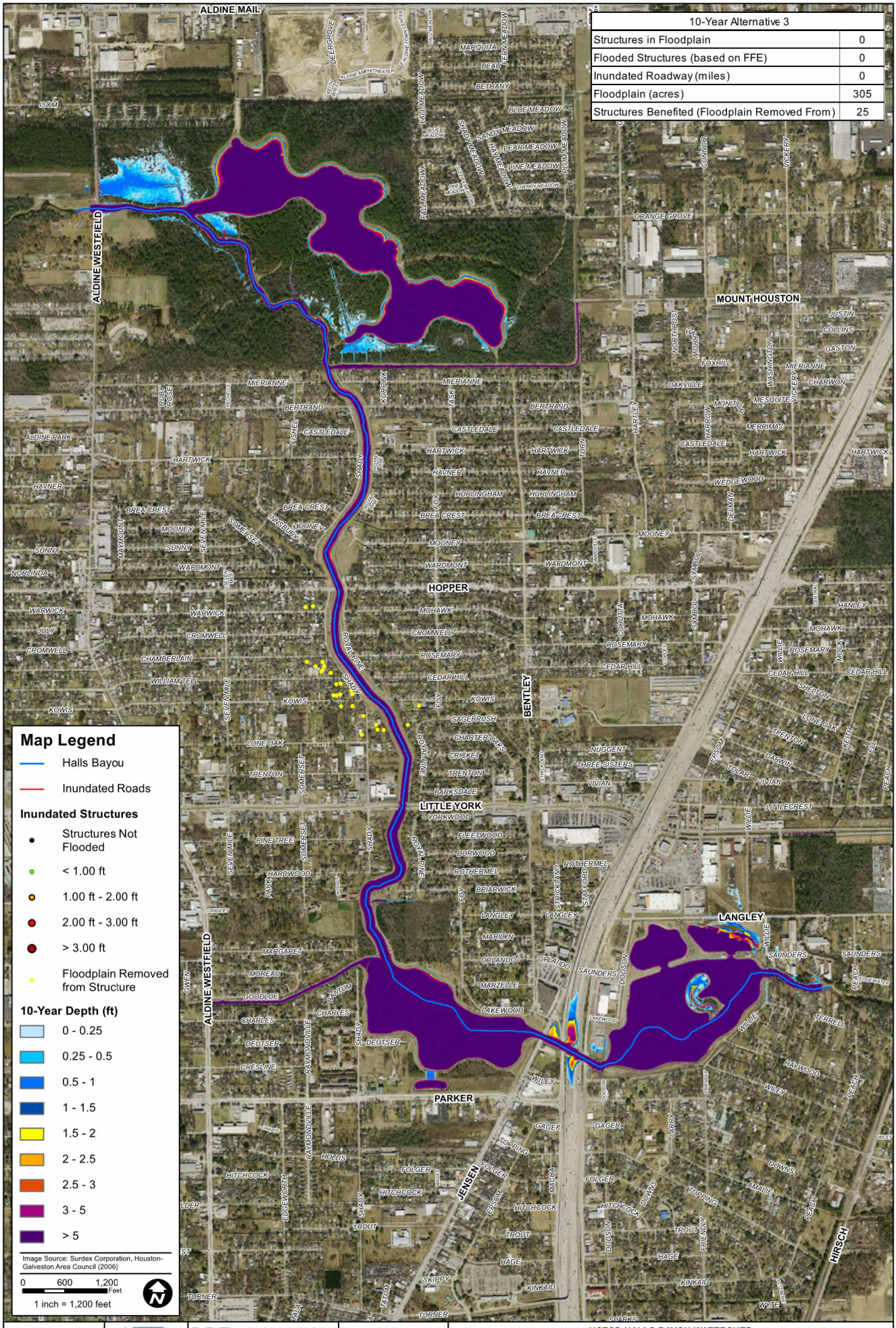
APPROVED: WWC

HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 3
PERFORMANCE METRICS (2-YEAR)



DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 36

HARRIS COUNTY FLOOD CONTROL DISTRICT
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PREPARED: CRB
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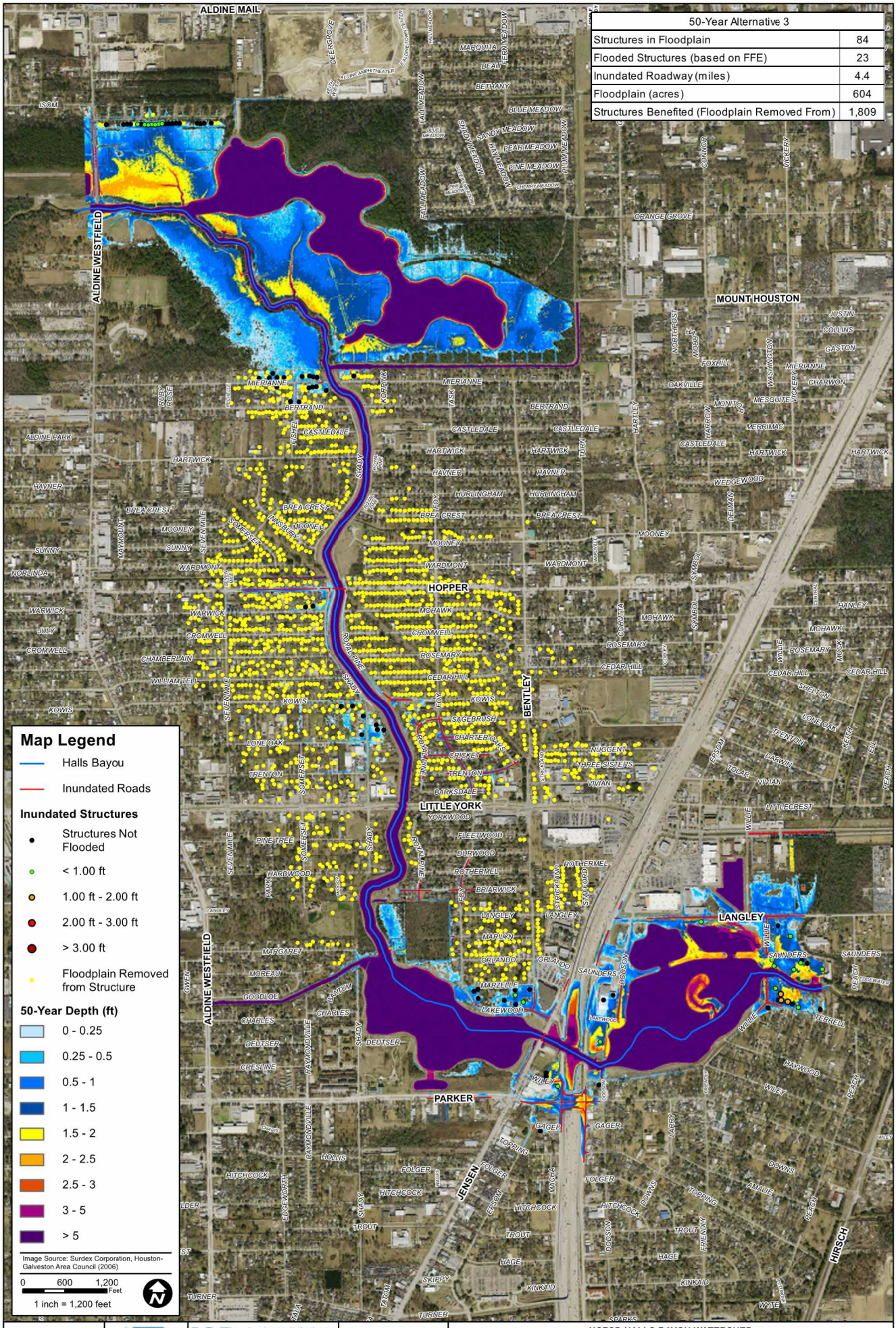
APPROVED: WWC

HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 3
PERFORMANCE METRICS (10-YEAR)



50-Year Alternative 3	
Structures in Floodplain	84
Flooded Structures (based on FFE)	23
Inundated Roadway (miles)	4.4
Floodplain (acres)	604
Structures Benefited (Floodplain Removed From)	1,809

Map Legend

- Halls Bayou
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft
- Floodplain Removed from Structure

50-Year Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 5
- > 5

Image Source: Surdex Corporation, Houston-Galveston Area Council (2006)

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 37

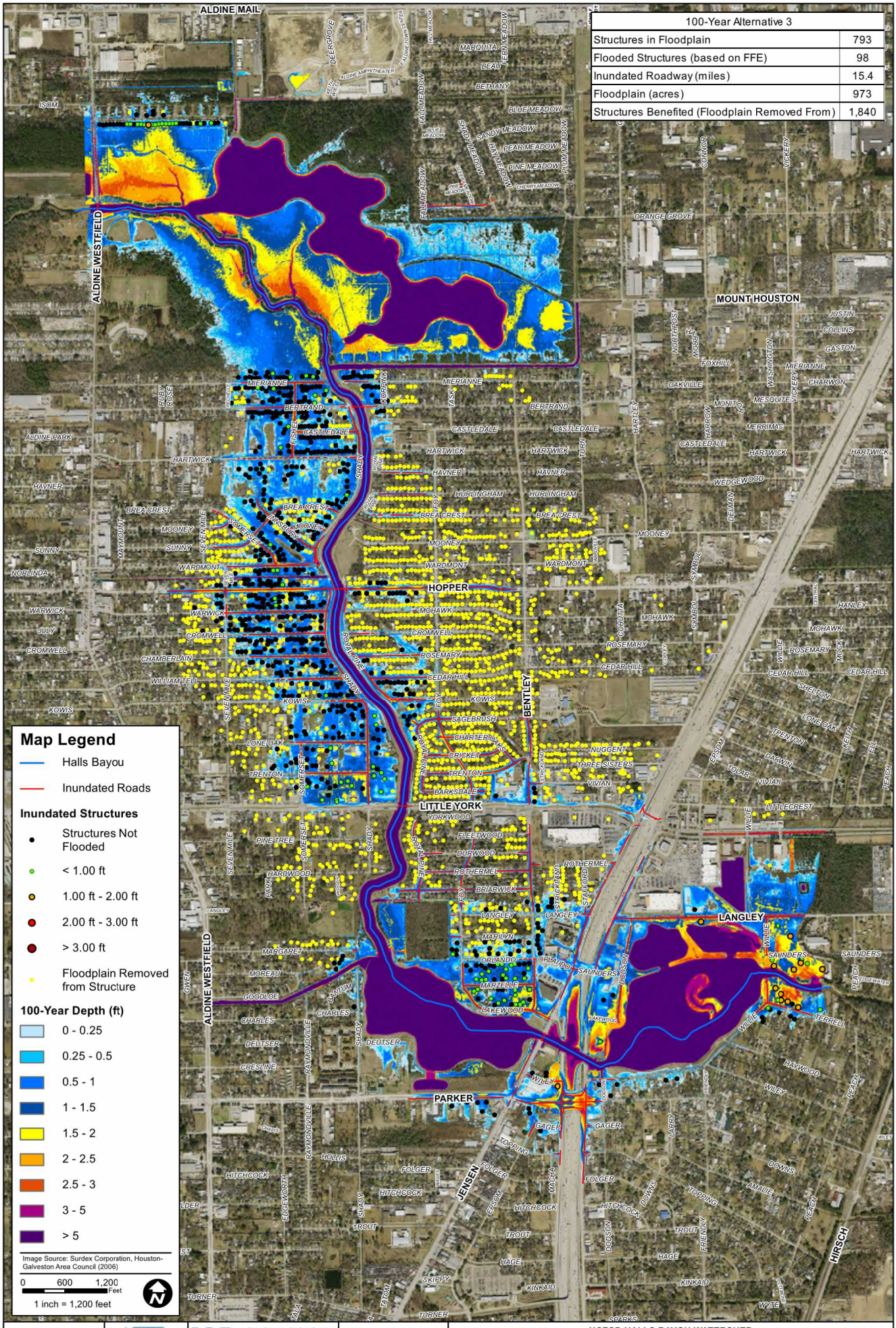
HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
TBPE Firm No. 2614
2925 Briarpark Drive • Houston, TX 77042-3720
T 713.266.6900 • F 713.266.2089
www.lan-inc.com • info@lan-inc.com

PREPARED: CRB
CHECKED: WWC
APPROVED: WWC

HCFCD HALLS BAYOU WATERSHED
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALTERNATIVE 3
PERFORMANCE METRICS (50-YEAR)



100-Year Alternative 3	
Structures in Floodplain	793
Flooded Structures (based on FFE)	98
Inundated Roadway (miles)	15.4
Floodplain (acres)	973
Structures Benefited (Floodplain Removed From)	1,840

DATE: OUT 2021
SCALE: AS NOTED

EXHIBIT
38

HARRIS COUNTY FLOOD CONTROL DISTRICT
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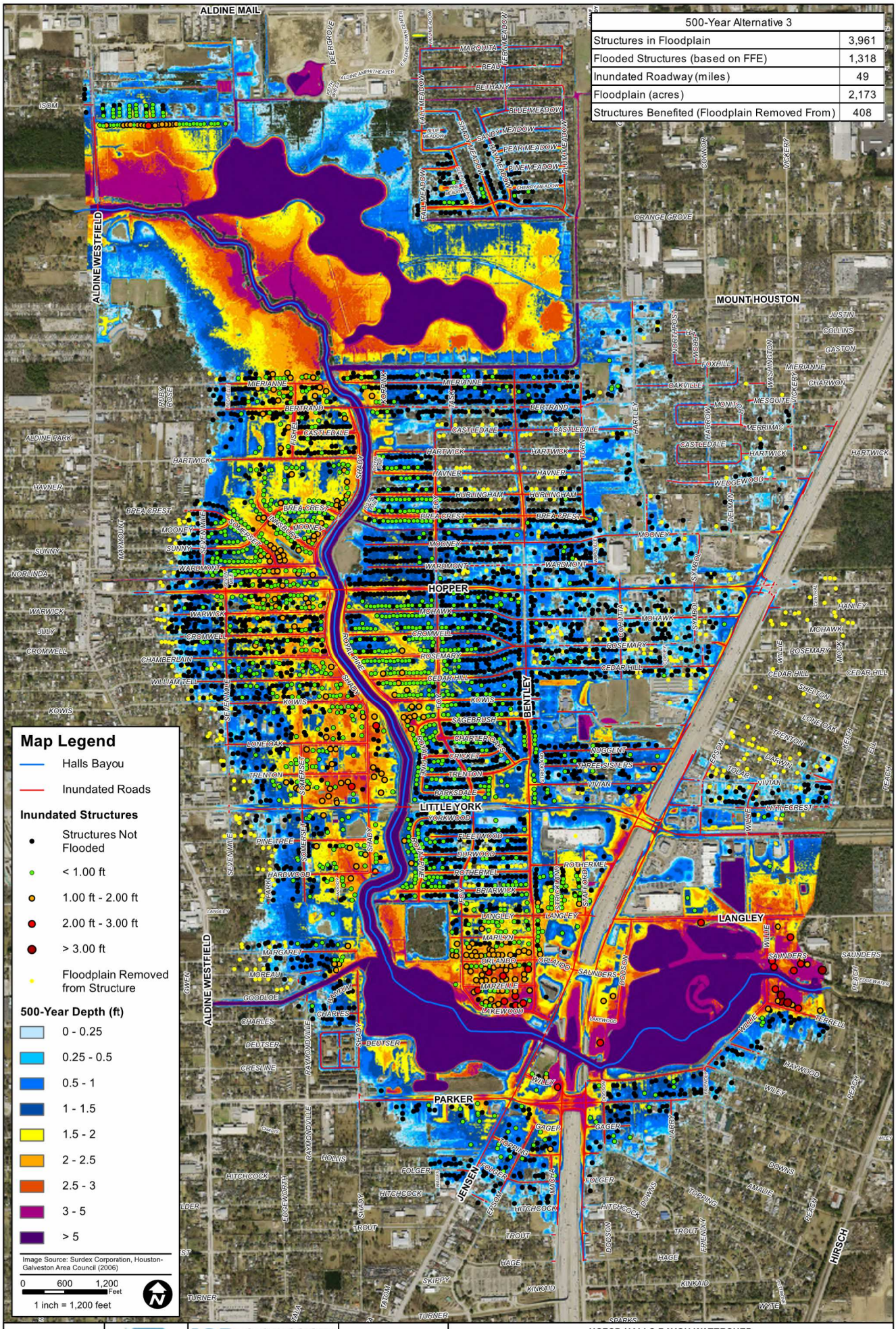
ALTERNATIVE 3
PERFORMANCE METRICS (100-YEAR)



500-Year Alternative 3	
Structures in Floodplain	3,961
Flooded Structures (based on FFE)	1,318
Inundated Roadway (miles)	49
Floodplain (acres)	2,173
Structures Benefited (Floodplain Removed From)	408

Map Legend

- Halls Bayou
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft
- Floodplain Removed from Structure

500-Year Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 5
- > 5

Image Source: Surdex Corporation, Houston-Galveston Area Council (2006)

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: OCT 2021
SCALE: AS NOTED

EXHIBIT 39

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ALTERNATIVE 3
PERFORMANCE METRICS (500-YEAR)