# Kemah City Council Meeting

October 7, 2020

7:00p.m.

# A G E N D A

## OCTOBER 7, 2020 7:00P.M.

## CITY OF KEMAH - CITY COUNCIL
## AND KEMAH PUBLIC FACILITIES CORPORATION

**Council Chambers, Kemah City Hall,**
**1401 State Hwy 146, Kemah, Texas**

**VIRTUAL MEETING**

**Terri Gale – Mayor**

| Teresa Vazquez-Evans | Wanda Zimmer | Kyle Burks | Robin Collins | Isaac Saldaña |
|---|---|---|---|---|
| Council Position 1 | Council Position 2 | Council Position 3 | Council Position 4 | Council Position 5 |

*In accordance with the Texas Open Meetings Act the agenda is posted for public information, at all times, for at least 72 hours preceding the scheduled time of the meeting on the bulletin board located on the front exterior wall of the City Hall Building, except in case of emergency meetings or emergency items posted in accordance with law.Texas Criminal and Traffic Law Handbook Penal Code Sec. 38.13 Hindering Proceedings by Disorderly Conduct. A person commits an offense if he intentionally hinders an official proceeding by noise or violent or tumultuous behavior or disturbance. Penal Code Section 42.05 Disrupting Meeting or Procession. A person commits an offense if, with intent to prevent or disrupt a lawful meeting, procession, or gathering, he obstructs or interferes with the meeting, procession, or gathering by physical action or verbal utterance.The City Council reserves the right to meet in closed session on any of the below items should the need arise and if applicable, pursuant to authorization by Title 5, Chapter 551 of the Texas Government Code.*

1. **Pledges**

2. **Prayer**

3. **Invitation to Address Council**
*(State law prohibits the Mayor and members of the City Council from commenting on any statement or engaging in dialogue without an appropriate agenda item being posted in accordance with the Texas Open Meetings Law. Comments should be directed to the entire Council, not individual members. Engaging in verbal attacks or comments intended to insult, abuse, malign or slander any individual shall be cause for termination of speaking privileges and expulsion from Council Chambers. Your comments are limited to two (2) minutes.)*

4. **Council Members Comments and Announcements (Items of Community Interest Only)**

5. **Mayor's Comments**

6. **City Administrator Report:**
   - Financials
   - Economic Development
   - Events and Operations

7. **CIP**

8. **Police and Emergency Management Report**
   - Events and Operations
   - Emergency Services

9. **Communications and Marketing Report**

10. **Consent Agenda**
    A. **To approve the preliminary plat for 2401 Park Ave – Corinthian Cove**

11. **Consideration and Possible Action: to schedule a public workshop to discuss the proposed Kemah Conference Center**

12. **Consideration and Possible Action: to define and approve holiday events, including Trunk or Treat and Christmas**

13. **Consideration and Possible Action: to approve the Master Drainage Plan for the City of Kemah**

14. **Consideration and Possible Action: to determine a process and timeline to backfill an open KCDC position**

15. **Consideration and Possible Action: on the approval of an evaluation scoring matrix to be used in the RFP selection process for the schoolhouse and train depot lease.**

16. **Consideration and Possible Action: of City of Kemah's ordinance requirement for annual business registration**

17. **Consideration and Possible Action: to approve an ordinance requiring bars and over 50% alcohol restaurants to have licensed peace officers in their security staff**

18. **Consideration and Possible Action: to revise the configuration, timing, signage, and any other aspects of the bollards, lighting, parking areas, and other safety-related changes for 6th street and the Lighthouse District**

19. **Consideration and Possible Action: to determine staffing of Kemah police officers for certain shifts throughout the week and weekend and supplementing certain shifts with outside agencies to potentially include, but not limited to, Galveston County.**

20. **Council Member Closing Comments**

21. **Mayor's Closing Comments**

22. **Adjourn**

**ONLINE:** https://global.gotomeeting.com/join/711186805

**PHONE:** United States (Toll Free): 1 877 309 2073
United States: +1 (646) 749-3129

**ACCESS CODE:** 711-186-805

## CERTIFICATION

This is to certify that a copy of the Notice of the Regular City Council meeting for **Wednesday, October 7, 2020**, was posted on the bulletin board at City Hall, 1401 Highway 146, Kemah, Texas, on this the 2nd day of October, 2020, prior to 7:00 p.m.

_____ _____

Melissa Chilcote, City Secretary Date

I certify this notice was removed by me from the Kemah City Hall bulletin board on the ____ day of _____, 2020.

# Kemah City Council Agenda Item

## #10A Preliminary Plat Approval for Corinthian Cove

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by:Jimmy/Cris

Subject: Preliminary Plat Approval for Corinthian Cove

Proceeding: Consent

Originating Department: Community Services

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

### SUMMARY / ORIGINATING CAUSE

Applicant has submitted a preliminary plat for a 1.98 acre subdivided into 2 lots at 2401 Park Ave.

### IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY

Staff has reviewed and preliminary plat is recommended for approval.

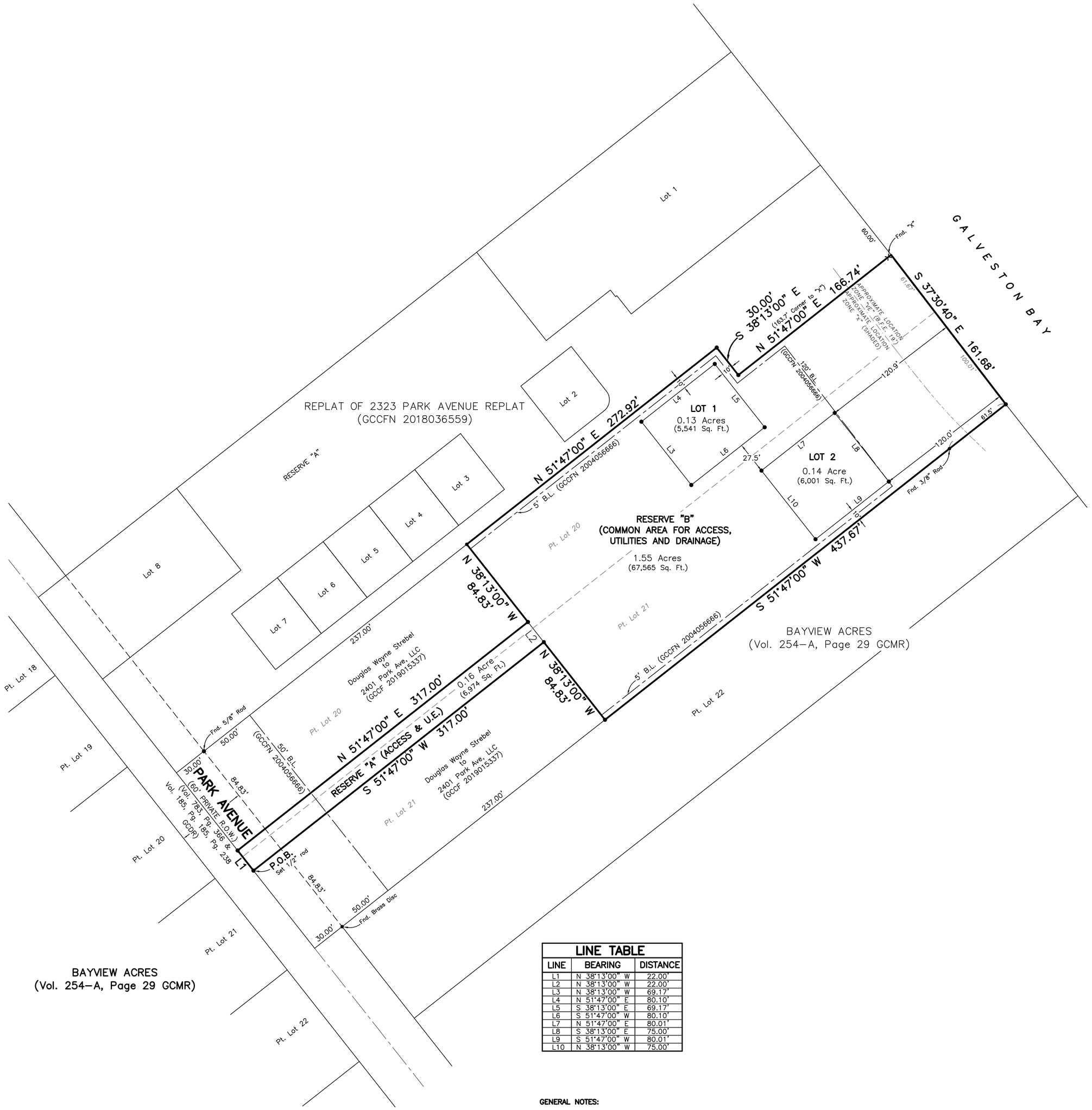
Once approved, a final plat will be submitted to the City for approval. If there are any minor changes a final plat will be presented to Council at the next Council Meeting.

### RECOMMENDATIONS

Approve

### ATTACHMENTS

Preliminary Plat




BAYVIEW ACRES
(Vol. 254-A, Page 29 GCMR)

| LINE TABLE | | |
|---|---|---|
| LINE | BEARING | DISTANCE |
| L1 | N 38°13'00" W | 22.00' |
| L2 | N 38°13'00" W | 22.00' |
| L3 | N 38°13'00" W | 69.17' |
| L4 | N 51°47'00" E | 80.10' |
| L5 | S 38°13'00" E | 69.17' |
| L6 | S 51°47'00" W | 80.10' |
| L7 | N 51°47'00" E | 80.01' |
| L8 | S 38°13'00" E | 75.00' |
| L9 | S 51°47'00" W | 80.01' |
| L10 | N 38°13'00" W | 75.00' |

**GENERAL NOTES:**

1.) This property lies in Zones "X" (Shaded), and "VE" Base Flood Elevation (B.F.E.) 19 feet, defined by FEMA as areas of minimal flooding, as scaled from Flood Insurance Rate Map Community-Panel Number 48167C0044G, effective date August 15, 2019.

2.) This survey has been prepared without the benefit of a current title report or title commitment. This property may be subject to matters of record not reflected hereon which such a title report or title commitment may reveal.

3.) Bearings shown hereon based on BAYVIEW ACRES subdivision, Volume 254-A, Page 29 of the Galveston County Map Records.

4.) The herein subdivided tract or parcel of land lies entirely within the incorporated limits of the City of Kemah, Texas.

5.) The herein subdivided tract or parcel of land lies within the Clear Creek Independent School District.

6.) All building lines shall be as per City of Kemah Ordinances or as shown on plat.

7.) The reason for this plat is to create two Lots and two Reserves.

8.) This plat does not attempt to amend or remove any covenants or restrictions.

9.) All corners are set 1/2" rod with cap stamped "High Tide Surveying" unless otherwise noted.

| | |
|---|---|
| REVISED: | AUGUST 17, 2020 |
| SURVEY DATE: | AUGUST 6, 2020 |
| FILE No.: | 1600-0000-0021-001 |
| DRAFTING: | JTK/ECM |
| JOB No.: | 20-0394 |

GRAPHIC SCALE
50' 0 100' 150'
SCALE: 1" = 50'

**ABBREVIATIONS:**

| | |
|---|---|
| P.O.B. | Point of Beginning |
| B.L. | Building Line |
| U.E. | Utility Easement |
| GCDR | Galveston County Deed Records |
| GCMR | Galveston County Map Records |
| GCCFN | Galveston County Clerk's File Number |
| R.O.W. | Right of Way |

STATE OF TEXAS }{
COUNTY OF GALVESTON }{ KNOW ALL MEN BY THESE PRESENTS

THAT 2401 Park Ave LLC, owners of the property subdivided in the above and foregoing map of **CORINTHIAN COVE** do hereby make subdivision of said property, according to the lines, street, alleys, parks, and easements therein shown, and designate said subdivision as **CORINTHIAN COVE** in the **RAFAEL BASQUEZ SURVEY**, Abstract 32, an addition to the City of Kemah, Galveston County, Texas; and dedicate to public use, as such, the streets, alleys, parks, and easements shown thereon forever except where noted on the map for private streets; and do hereby waive any claims for damages occasioned by the establishing of grades as approved for the streets and alleys dedicated, or occasioned by the alteration of the surface of any portion of the streets or alleys to conform to such grade; and do hereby bind ourselves, our successors and assigns to warrant and forever defend the title to the land so dedicated.

There is also dedicated for utilities an unobstructed aerial easement five feet wide from a plane 20 feet above the ground upward located adjacent to each side of all utility easements shown hereon.

We 2401 Park Ave LLC, do hereby dedicate forever to the public a strip of land 25 feet wide of the centerline of all gullies, ravines, draws, sloughs, or other natural drainage causes shown located in said subdivision as easements for drainage purposes, giving the City of Kemah and/or any other public agency the right to enter upon said easement at any and all times for the purpose of constructing and/or maintaining drainage work and/or structures.

Further, 2401 Park Ave LLC, do hereby relinquish all rights of access to major or larger streets or highways shown hereon except by way of the platted streets shown.

WITNESS MY HAND in _____, Galveston County, Texas, this _____ day of _____, 2020.

_____
Clark G. Thompson, Jr., Member
2401 Park Ave LLC

THE STATE OF TEXAS

COUNTY OF GALVESTON

Before me, the undersigned authority, on this day personally appeared Clark G. Thompson, Jr., Member of 2401 Park Ave LLC, known to me to be the person whose name is subscribed to the above and foregoing instrument, and acknowledged to me that he executed the same for the purposes and considerations therein expressed.

WITNESS MY HAND AND SEAL OF OFFICE this _____ day of _____, 2020.

_____
Notary Public in and for
The State of Texas
My Commission Expires:____

This is to certify that I, Stephen C. Blaskey, a Registered Professional Land Surveyor for the State of Texas, Registration #5856, have platted the above and foregoing subdivision from an actual survey made on the ground and under my direction; that this plat accurately represents the facts as found by that survey made by me, and; that all corners have been, or will be, properly monumented.

**PRELIMINARY**
**NOT TO BE RECORDED**
**FOR ANY PURPOSE**

_____
Stephen C. Blaskey
Registered Professional Land Surveyor 5856

This is to certify that the City Council of the City of Kemah, Texas, on motion made and seconded and adopted, has approved this plat and subdivision of **CORINTHIAN COVE** as shown hereon, and ordered said plat filed on record in the office of the County Clerk of Galveston County, Texas.

IN TESTIMONY WHEREOF, witness the official signatures this _____ day of _____, 2020.

_____
Melissa Chilcote
City Secretary

_____
Terri Gale
Mayor

THE STATE OF TEXAS

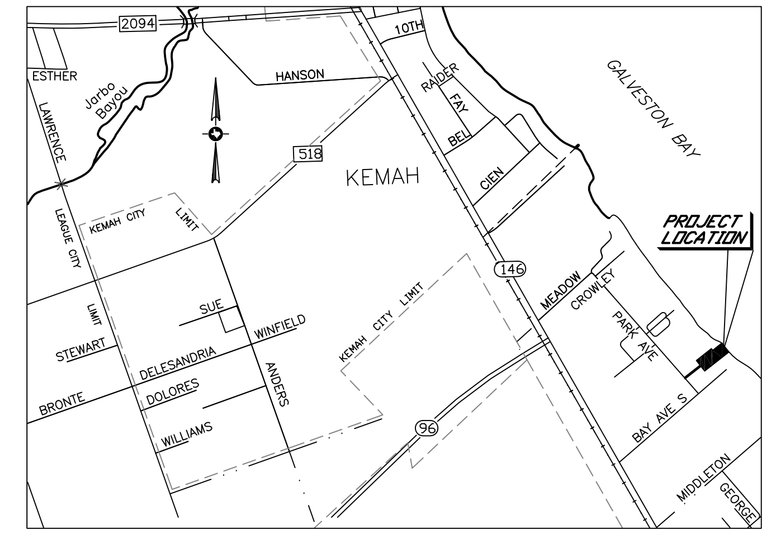
COUNTY OF GALVESTON

I, Dwight Sullivan, County Clerk, Galveston County, Texas, do hereby certify that this written instrument was filed for record in my office on _____, 2020, at __ o'clock, ___.m., and duly recorded on _____, 2020, at __ o'clock, ___.m., in PLAT RECORD _____, MAP NUMBER _____, Galveston County Map Records.

WITNESS MY HAND AND SEAL OF OFFICE at Galveston, Texas, the day and date last above written.

Dwight Sullivan
County Clerk
Galveston County, Texas

By:_____, Deputy




VICINITY MAP
NOT TO SCALE

**PROPERTY DESCRIPTION:**

All that certain 1.98 acres (86,081 Square Feet) tract or parcel of land being a part of Lots 20 and 21 of BAYVIEW ACRES, a subdivision out of the RAFAEL BASQUEZ SURVEY, ABSTRACT 32, in Galveston County, Texas, according to the map or plat thereof recorded in Volume 254-A, Page 29 of the Map Records in the Office of the County Clerk of Galveston County, Texas, and being part of a called 3.21 acre tract described in a General Warranty Deed dated March 25, 2019 from Douglas Wayne Strebel to 2401 Park Ave LLC, a Texas limited liability company, and found of record in Clerk's File Number 2019015337 of the Official Public Records of Galveston County, Texas; and being more fully described by metes and bounds as follows:

BEGINNING at point on the centerline of a permanent easement for private road (Park Avenue) as shown on said plat of BAYVIEW ACRES, and conveyed by Deed executed on April 30th, 1948 from Dorothy Sorrells to the County of Galveston as found of record in Volume 783, Page 366, of the Galveston County Deed Records;

THENCE, N 38°13'00" W along and with the Northerly right-of-way line of Park Avenue, a distance of 22.00 feet to a point for corner;

THENCE, through the interior of aforesaid 2401 Park Ave LLC 3.21 acre tract, the following two (2) courses and distances:

N 51°47'00" E a distance of 317.00 feet to a point for corner;
N 38°13'00" W, a distance of 84.83 feet to a point on the Northerly line of said 2401 Park Ave. LLC 3.21 acre tract;

THENCE, along the Northerly line of said 2401 Park Ave LLC 3.21 acre tract, the following three (3) courses and distances:

N 51°47'00" E a distance of 272.92 feet to a point for corner;
S 38°13'00" E a distance of 30.00 feet to a point for corner;
N 51°47'00" E at a distance of 163.7 feet pass an "X" found in concrete, and continuing for a total distance of 166.74 feet to a point for corner in the water's edge of Galveston Bay;

THENCE, S 37°30'40" E along said Galveston Bay, a distance of 161.68 feet to a point for corner being in the Southeasterly line of said Lot 21;

THENCE, S 51°47'00" W, along the Southeasterly line of said Lot 21, at a distance of 61.5 feet pass a 3/8 inch rod found on line, and continuing for a total distance of 437.67 feet to a point for corner;

THENCE, through the interior of aforesaid 2401 Park Ave LLC 3.21 acre tract, the following two (2) courses and distances:

N 38°13'00" W, a distance of 84.83 feet to a point for corner;
S 51°47'00" W a distance of 317.00 feet to the POINT OF BEGINNING and containing a calculated area of 1.98 acres (86,081 Square Feet) of land.

PRELIMINARY PLAT OF

# CORINTHIAN COVE

A SUBDIVISION OUT OF THE RAFAEL BASQUEZ SURVEY, ABSTRACT 32, BEING A PART OF LOTS 20 AND 21 OF BAYVIEW ACRES, VOLUME 254-A, PAGE 29, G.C.M.R.

CITY OF KEMAH,
GALVESTON COUNTY, TEXAS

1.98 ACRES

2 LOTS, 2 RESERVES

OWNER:
2401 Park Ave LLC
10814 Roaring Brook Lane
Houston, Texas 77024

SURVEYOR:
High Tide Land Surveying, LLC
200 Houston Ave. Suite B
League City, TX 77573

# Kemah City Council Agenda Item

## #11 Kemah Conference Center Public Hearing

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by:Mayor Gale

Subject: to schedule a public workshop to discuss the proposed Kemah Conference Center

Proceeding: Consent

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

**SUMMARY / ORIGINATING CAUSE**

**IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY**

**RECOMMENDATIONS**

Schedule a Workshop for the Confernce Center discussion

**ATTACHMENTS**

# Kemah City Council Agenda Item

## #12 Trunk or Treat and Christmas

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by:Mayor Gale

Subject: to define and approve holiday events, including Trunk or Treat and Christmas

Proceeding: Consideration and Possible Action

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

**SUMMARY / ORIGINATING CAUSE**

**IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY**

**RECOMMENDATIONS**

**ATTACHMENTS**

# Kemah City Council Agenda Item

## #13 Master Drainage Plan

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by:Jessica Koutny

Subject: to approve the Master Drainage Plan for the City of Kemah

Proceeding: Consideration and Possible Action

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

**SUMMARY / ORIGINATING CAUSE**

**IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY**

**RECOMMENDATIONS**

To approve the Master Drainage Plan

**ATTACHMENTS**

# City of Kemah
# Master Drainage Plan

PREPARED FOR:

**City of Kemah**
1401 State Highway 146
Kemah, TX 77565

PREPARED BY:

LJA Engineering, Inc.

3600 W Sam Houston Pkwy S, Suite 600
Houston, TX 77042
PH: (713) 953 – 5200 FAX: (713) 953 – 5026
FIRM REGISTRATION #: F-1386
Job Number: 2335-1901

STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
10/2/2020

**October 2020**

# TABLE OF CONTENTS

**TABLE OF CONTENTS** ..... **II**

**EXECUTIVE SUMMARY** ..... **1-1**

**1.0 INTRODUCTION** ..... **1-1**

1.1. PROJECT PURPOSE AND SCOPE ..... 1-1
1.2. PROJECT LOCATION ..... 1-1
1.3. FLOODPLAIN MAPPING ..... 1-2
1.4. PRIOR STUDIES ..... 1-2
1.5. SUPPORTING INVESTIGATIONS ..... 1-2
*1.5.1. Survey Information ..... 1-2*
*1.5.2. Record Drawings and As-builts ..... 1-3*
*1.5.3. Interviews ..... 1-3*

**2.0 EXISTING CONDITIONS** ..... **2-1**

2.1. TOPOGRAPHY ..... 2-1
2.2. LAND USE ..... 2-2
2.3. EXISTING FACILITIES ..... 2-2
2.4. EXISTING CONDITIONS MODEL, HYDROLOGIC PARAMETERS AND HYDRAULIC MODEL ..... 2-5

**3.0 PROPOSED CONDITION ANALYSIS** ..... **3-1**

3.1. PROPOSED CONDITIONS MODEL ..... 3-1
3.2. CHANGES TO EXISTING CONDITION MODEL ..... 3-1

**4.0 RECOMMENDATIONS** ..... **4-1**

**TABLES**

Table 1 - Land Use Type C Coefficient ..... 2-2
Table 2 - Galveston County Rainfall IDF Coefficients ..... 2-5
Table 3 - Bayview Acres Existing Flows ..... 2-6
Table 4 - Bayview Acres Existing Outfall Capacity ..... 2-6
Table 5 - WinStorm Existing Conditions 2-year Analysis ..... 2-8
Table 6 - Small Watershed Method Input Parameters ..... 2-9
Table 7 - South Kemah Area Parameters for Triangular Hydrograph Method ..... 2-10
Table 8 - South Kemah Peak Flows Using Rational Method ..... 2-11
Table 9 - Bayview Acres Alternative 1 Proposed Outfall Capacity ..... 3-2
Table 10 - Bayview Acres Alternative 2 Proposed Outfall Capacity ..... 3-3
Table 11 - WinStorm Proposed Conditions 2-year Analysis ..... 3-4

**EXHIBITS**

Exhibit 1.0 – Overall Map
Exhibit 1.1 – Bayview Acres Vicinity Map
Exhibit 1.2 – Lighthouse District Vicinity Map
Exhibit 1.3 – Kemah Oaks Vicinity Map
Exhibit 1.4 – South Kemah Vicinity Map
Exhibit 1.5 – West Kemah Vicinity Map
Exhibit 2.1 – Bayview Acres Elevation Map
Exhibit 2.2 – Lighthouse District Elevation Map
Exhibit 2.3 – Kemah Oaks Elevation Map
Exhibit 2.4 – South Kemah Elevation Map
Exhibit 2.5 – West Kemah Elevation Map
Exhibit 3.1 – Bayview Acres – Drainage Area Map – Existing Conditions
Exhibit 3.2 – Bayview Acres – Park Ave Survey Profile
Exhibit 3.3 – Bayview Acres – Proposed Conditions – Alternative 1
Exhibit 3.4 – Bayview Acres – Proposed Conditions – Alternative 2
Exhibit 3.5 – Bayview Acres – Land Use
Exhibit 4.1 – Kemah Oaks – Drainage Area Map
Exhibit 4.2 – Kemah Oaks HGL Profiles
Exhibit 4.3 – Kemah Oaks Proposed Alternatives 1 & 2
Exhibit 5.1 – South Kemah – Drainage Area Map – Existing Conditions
Exhibit 5.2 – South Kemah – Land Use
Exhibit 5.3 – South Kemah – Overall Proposed Alternative 1
Exhibit 5.4 - South Kemah – System A Drainage Improvements
Exhibit 5.5 – South Kemah – System B Drainage Improvements
Exhibit 5.6 – South Kemah – System C Drainage Improvements
Exhibit 5.7 – South Kemah – Regional Detention Alternative 2
Exhibit 6.1 – Jarbo Ditch HEC-RAS Cross-Sections
Exhibit 6.2 - Jarbo Ditch Existing 2-year Inundation Map
Exhibit 6.3 – Jarbo Ditch Existing 5-year Inundation Map
Exhibit 6.4 – Jarbo Ditch Existing 10-year Inundation Map
Exhibit 6.5 – Jarbo Ditch Existing 25-year Inundation Map
Exhibit 6.6 – Jarbo Ditch Existing 50-year Inundation Map
Exhibit 6.7 – Jarbo Ditch Existing 100-year Inundation Map
Exhibit 6.8 – Jarbo Ditch Proposed Channel Improvements
Exhibit 6.9 – Jarbo Ditch Scenario 1 - 2-year Inundation Map
Exhibit 6.10 – Jarbo Ditch Scenario 1 - 5-year Inundation Map
Exhibit 6.11 – Jarbo Ditch Scenario 1 - 10-year Inundation Map
Exhibit 6.12 – Jarbo Ditch Scenario 1 - 25-year Inundation Map
Exhibit 6.13 – Jarbo Ditch Scenario 1 - 50-year Inundation Map
Exhibit 6.14 – Jarbo Ditch Scenario 1 - 100-year Inundation Map
Exhibit 6.15 – Jarbo Ditch Scenario 2 - 2-year Inundation Map
Exhibit 6.16 – Jarbo Ditch Scenario 2 - 5-year Inundation Map
Exhibit 6.17 – Jarbo Ditch Scenario 2 - 10-year Inundation Map
Exhibit 6.18 – Jarbo Ditch Scenario 2 - 25-year Inundation Map
Exhibit 6.19 – Jarbo Ditch Scenario 2 - 50-year Inundation Map
Exhibit 6.20 – Jarbo Ditch Scenario 2 - 100-year Inundation Map

**APPENDICES**

Appendix A – Opinion of Probable Cost
Appendix B – FEMA FIRM Maps
Appendix C – Lighthouse District Master Drainage Study
Appendix D – West Kemah Drainage Study
Appendix E – Sample Interview
Appendix F – Jarbo Ditch Existing HEC-RAS Output & Profiles
Appendix G – Jarbo Ditch Scenario 1 HEC-RAS Output & Profiles
Appendix H – Jarbo Ditch Scenario 2 HEC-RAS Output & Profiles
Appendix I – Bayview Proposed Ditch Calculations
Appendix J – GIS Shapefiles Existing Storm Sewer

# EXECUTIVE SUMMARY

The City of Kemah (City) contracted LJA Engineering, Inc. (LJA) to develop a Master Drainage Plan (MDP) that addresses conveyance and detention improvements necessary to reduce the frequency and severity of flooding throughout the City. The City is in northeast Galveston County adjacent to the Gulf of Mexico. The City limits are bounded by FM 518 and Clear Creek Channel to the north, SH 96 and Bay Ave to the south, Galveston Bay to the east, and Lawrence Road to the west.

The City is served by three primary outfalls: Jarbo Bayou, Clear Creek Channel and Galveston Bay. For this study, the City is broken down into five areas: Bayview Acres, the Lighthouse District, Kemah Oaks, South Kemah, and West Kemah. The area studied for this MDP includes the entire City with focus on the Bayview Area, South Kemah, and Kemah Oaks.

The City is comprised of 1,217 acres or 1.9 square mile area along the coast. The proximity to the coast presents challenges for conveyance to designated outfalls as generally the topography is flat with natural ground elevations within the study area ranging from 22 feet to 0 feet base on LIDAR data obtained from the Houston-Galveston Area Council (HGAC).

Overall, the LIDAR data shows that the overland flows generally travel from south to north across most of the City except for the Bayview Acres area which generally flows west to east. There is an area that potentially overflows in extreme events to the City drainage system from the west in the South Kemah area along Lawrence Road that does need to be accommodated in any drainage improvements within this area. For South Kemah and Kemah Oaks, the flows outfall to Jarbo Ditch which outfalls to Jarbo Bayou and ultimately out to Clear Creek Channel. All West Kemah and most of the Lighthouse District outfall directly to Clear Creek Channel. Bayview Acres and the bay fronting sections of the of the Lighthouse District outfall to Galveston Bay.

Each of the five areas within the City were studied as to the existing drainage issues with varying amounts of available data. In general, it was determined that the existing drainage facilities throughout the City have capacity issues for both conveyance and storage which results in frequent localized flooding. The West Kemah and Lighthouse Districts have been previously studied with recommendations for de-silting of ditches, ditch re-grading, culvert resizing and storm sewer improvements. Kemah Oaks is experiencing frequent flooding due to an undersized storm sewer system and detention facility. Bayview Acres is experiencing frequent flooding due to undersized outfalls and lack of conveyance capacity with the roadside ditches. South Kemah is experiencing flooding due to undersized and inconsistent conveyance systems, lack of outfall depth to Jarbo Ditch and lack of storage capacity.

Because the areas of West Kemah and the Lighthouse District have had past drainage evaluations which provided guidance and recommendations for some drainage improvements to these areas, this study focused on improvements to Bayview Acres, South Kemah, and Kemah Oaks. For each of these three areas, at least two (2) alternatives have been evaluated to improve conveyance and detention (if required). The recommendations for these various drainage areas within the City of Kemah are as follows:

- *Bayview Acres* - Alternative 1, which includes upsizing the existing outfalls at Meadow Ln and Bay Ave as well as providing one (1) additional outfall along the northside of Yacht Club, is recommended for the Bayview Acres area. This alternative is less expensive than Alternative 2, which includes two (2) new outfalls. Although larger outfalls will be required for Yacht Club North and Bay Ave, this alternative prevents the City from acquiring two separate drainage easements and reduces the amount of storm sewer pipe that would need to be maintained by the City. This recommended alternative allows for faster construction since only three (3) outfalls would be

installed rather than 4 outfalls and requires less right of way acquistion. This alternative would also provide a 100-year LOS. The cost of Alternative 1 is **$2,206,590**.

- *Kemah Oaks* - Alternative 2, which expands the Bel Rd linear detention ditch southeast of the subdivision and would provide enough storage to avoid the installation of a stormwater pump station, is recommended for the Kemah Oaks subdivision. The existing Kemah Oaks detention basin can be converted to a dry bottom basin. If the City wishes to proceed with this alternative, this alternative would require further design analysis during final design to analyze and design the overflow spillway, adjust outfalls and evaluate the interaction between the two detention facilities to ensure no adverse impacts to service area of the existing Bel Rd detention facility. The cost of Alternative 2 is **$2,062,850**.

  It is recommended that while Alternative 2 is ultimately implemented, Alternative 4 is pursued by the City to provide some relief to the Kemah Oaks area. Alternative 4 provides an emergency spillway for the Kemah Oaks detention basin and can be implemented within the available capital improvement budget for fiscal year and can provide much needed relief to this area while the City seeks routes to implement the recommendation to improve Jarbo Ditch and Alternative 2 for Kemah Oaks. The cost of Alternative 4 is **$171,650**.

- *South Kemah and Jarbo Ditch* - Alternative 1, which includes conveyance improvements in three specific drainage conveyance routes, is recommended for the South Kemah area. This alternative allows for discharge only to Jarbo Ditch. The cost of Alternative 1 is **$3,884,510**.

  Two scenarios for improvements were evaluated for Jarbo Ditch and it is recommended that both be implemented. While the improvements to Jarbo Ditch can be implemented in phases, Scenario 1 is recommended first to widen the lower section of Jarbo Ditch to a 25-year conveyance capacity which provides the move conveyance for the recommended Alternative 1 for South Kemah. The cost of Scenario 1 is **$4,030,115** which includes land acquisition. It is then recommended that Scenario 2 is implemented, which provides conveyance improvements to the upper section of Jarbo Ditch to the most upstream point. The cost of Scenario 2 is **$1,359,915**, which includes land acquisition.

  Additionally, Alternative 2 for South Kemah is recommended to provide some regional detention storage for the South Kemah area but it is recommended to reevaluate the amount of regional detention required once the Jarbo Bayou study is completed. The current cost of Alternative 2 is **$4,120,010**, although this amount is expected to change after re-evaluating the amount of detention the City would provide in a less frequent, more intense storm event.

- *Lighthouse District and West Kemah* - It is recommended that the City continue implementing the recommendations made from previous drainage evaluation in these two areas. LJA is continuing to investigate if there are critical areas that need immediate improvements to alleviate flooding issues. It is likely that quick fixes beyond the recommendations in the previous report are not available and the City needs to plan to invest in re-constructing the storm sewer systems that are undersized in future capital improvement plans. The City also needs to determine the LOS for storm water drainage that it wishes to provide in these areas, since these areas directly discharge to Clear Creek Channel or to Galveston Bay.

Finally, in addition to the recommended improvements in the five areas within the City, the LJA was asked to review and provided recommendations for updates to Chapter 38 and Chapter 46 regarding stormwater management drainage criteria and floodplain regulations, respectively. Working with City staff, LJA finalized the recommendations for updates to drainage, detention, and floodplain fill criteria

throughout the City for changes to Chapters 38 and 46. The recommended changes to Chapters 38 and 46 were adopted by the City in May and June of 2020, respectively.

The following concerns were addressed in the updates to Chapter 38:

- Adopt Galveston County detention rate requirements.
- Establish requirements to ensure developers are maintaining their on-site stormwater pump stations.
- Establish minimum diameter pipe size for driveway replacements.
- Require further analysis when filling in ditches and replacing with enclosed conduits.
- Establish a criteria for calculating Time of Concentration.
- Incorporate IDF empirical values for rain events.
- Establish minimum LOS criteria.
- Require removing and replacing infrastructure within a developments immediate vicinity if re-development will occur.

The following concerns were addressed in the updates to Chapter 46:

- Provide allowance for maintenance fill for gardens.
- Require drainage plans sealed by an engineer when fill exceeds 60 cubic yards.
- Require notification to Floodplain Administrator for minor fill in the floodplain.
- Set permitting and mitigation requirements for fill in the floodplain.
- Provide requirements to maintain natural flow within the floodplain.

# 1.0 INTRODUCTION

## 1.1. Project Purpose and Scope

The City of Kemah (City) contracted LJA Engineering, Inc. (LJA) to develop a Master Drainage Plan (MDP). The City is adjacent to the Gulf of Mexico, therefore, on-going flooding issues can be attributed to riverine flooding, tidal (storm surge) flooding or a combination of both. As detailed in the authorized proposal, this MDP focuses on riverine flooding only and no analysis was conducted to assess tidal flooding.

This study focuses on assessing the City's storm sewer system existing conditions based on available data (i.e. LiDAR, record and as-built drawings, etc.) and providing alternatives for conveyance improvements which will alleviate the on-going flooding. The MDP also aims to investigate offsite flow from outside the City limits that may also be impacting the City's systems. The scope of work (SOW) for this MDP includes performing a detailed hydrologic and hydraulic analysis of the City of Kemah. Since the City is adjacent to the Gulf of Mexico, the study is broken into five areas since the storm sewer systems behave differently dependent on the point of outfall. Furthermore, LJA has reviewed the City's current drainage criteria, Chapter 38 and 46 in the Code of Ordinances, and will provide recommendations to the City to update the current document to reflect appropriate design standards due to more intense rains as shown by updated data by the National Oceanic Atmospheric Administration (NOAA).

## 1.2. Project Location

The City is in southeast Texas, southeast of Houston in Galveston County. The City limits are bounded by FM 518 and Clear Creek Channel to the north, SH 96 and Bay Ave to the south, Galveston Bay to the east and Lawrence Rd to the west, see **Exhibit 1.0**. The City is served by Jarbo Bayou, Clear Creek Channel and Galveston Bay. This study is broken into five areas: Bayview Acres, Lighthouse District, Kemah Oaks, South Kemah and West Kemah.

*Bayview Acres*

This area is bounded by Solomon Rd to the north, Bay Ave to the south, Galveston Bay to the east and State Highway (SH) 146 to the west, see **Exhibit 1.1**. The area is a mixture of developed and undeveloped land, with development being single family and multi-family residential homes. This area outfalls to Galveston Bay.

*Lighthouse District*

This area is bounded by Clear Creek Channel to the north, 10$^{th}$ St to the south, Galveston Bay to the east and SH 146 St to the west, see **Exhibit 1.2**. The area is fully developed with a mixture of single family residential, multi-family residential and commercial developments. This area outfalls to Galveston Bay and Clear Creek Channel.

*Kemah Oaks*

This area is bounded by Farm-to-Market (FM) 518 to the north, a 57-Acre Park to the south, a Centerpoint Energy (CPE) Fee Strip to the east and Jarbo Ditch to the west, see **Exhibit 1.3**. The area is fully developed with only single family residential homes. This area outfalls to Jarbo Ditch, which is a tributary of Jarbo Bayou.

*South Kemah*

This area is generally bounded by FM 518 to the north, SH 96 to the south, SH 146 to the east and Lawrence Rd to the west, see **Exhibit 1.4.** The area is a mixture of developed and undeveloped land, with

development being single family residential, multi-family residential and commercial developments. This area outfalls to Jarbo Ditch, which is a tributary of Jarbo Bayou.

*West Kemah*

This area is bounded by Grove Rd to the north, FM 2094 to the south, SH 146 to the east and Lazy Ln to the west, see **Exhibit 1.5**. The area is a mixture of developed and undeveloped land, with development being single family residential and commercial developments. This area outfalls to Clear Creek Channel.

## 1.3. Floodplain Mapping

Based on FIRM maps 48167C0042G and 48167C0044G, both effective on August 15, 2019, half of the City is located within Zone AE, also known as the area in the 100-year floodplain and the other half is located within shaded Zone X, also known as the area in the 500-year floodplain. See **Appendix B** for a copy of the FEMA maps. The FIRM map updates adopted in 2019 within the City include both riverine and wave run-up (storm surge) analysis in setting the base flood elevations (BFE) within the community.

## 1.4. Prior Studies

Two prior studies have been done for the City. A master drainage study[1] of the Lighthouse District was conducted in October 2009 (see **Appendix C**). The study concluded that development and re-development contributed to an increase in impervious cover which resulted in an increase in surface runoff. Due to an increase in surface runoff, the storm sewer system in the area was deemed inadequate. The study recommended to re-construct the existing storm sewer system and increase the conveyance capacity. The study also recommended replacing an existing stormwater pump station. Based on record drawings[2] from 2012, the stormwater pump station was replaced with a three (3) pump system, one (1) pump a standby, to convey the increased flows. The stormwater pump station was built for future expansion and allow installation of a fourth pump.

A drainage study[3] of West Kemah was conducted in September 2016 (see **Appendix D**). The drainage study concluded that the existing ditches and culverts were undersized to serve their service area. The study also noted that reverse grades in the system exacerbated the deficiencies in the ditch and culvert system. The study recommended to remove undersized culverts and replace with larger, adequately sized culverts. In addition, the study recommended to desilt and re-grade ditches to re-establish positive flow. The study also identified several ditch segments that required widening to increase the conveyance capacity.

## 1.5. Supporting Investigations

### 1.5.1. Survey Information

As part of this MDP, limited survey information was available to assist in the analysis of this study. A topographic survey of the Kemah Oaks detention basin was conducted by LJA Engineering, Inc. The survey included top of bank, toe, flowline and water mark elevations. Additionally, inlet and outlet pipe inverts in the detention basin were gathered. The purpose of the survey was to confirm the volume storage

[1] LJA Engineering & Surveying, Inc., *"Master Drainage Study"*, for the City of Kemah, October 2009
[2] LJA Engineering & Surveying, Inc., "*City of Kemah Construction Plans For: Storm Water Pump Station*", November 2010
[3] LJA Engineering & Surveying, Inc., "*West Kemah Drainage Study*", for the City of Kemah, September 2016

provided in the basin, since the basin as constructed does not reflect the record drawings[4]. The elevation data for this survey is based on NAVD 88, 2002 adjusted datum.

A limited topographic survey of Bayview Acres conducted in August 2012 by Ted K. Guthrie was provided. The survey included culvert sizes and flowlines and ditch flowlines. Ditch top of bank elevations and widths were not delineated as part of this survey, therefore, ditch cross-sections could not extrapolated from this data to analyze conveyance capacity. The elevation data for this survey is based on NAVD88 datum.

### 1.5.2. Record Drawings and As-builts

The City provided several record drawings and as-builts for several street segments in the study area, however, many of these drawings contained limited topographic information which could aid in the study of the area.

### 1.5.3. Interviews

Several interviews were conducted with City residents that live in the study areas. A template of the interview questions is in **Appendix E**. The purpose the interviews was to gather firsthand historical knowledge of the drainage issues experienced by the residents.

[4] Century Engineering, Inc., "*City of Kemah Construction Documents for Kemah Oaks Subdivision, Section One – Paving, Storm Sewer, Sanitary Sewer, Drainage, Potable Water and Detention*", February 1992

# 2.0 EXISTING CONDITIONS

## 2.1. Topography

The City is comprised of 1,217 acres or 1.9 square mile area in Galveston County, Texas. The topography is relatively flat with natural ground elevations in the study area ranging from 0 feet to 20 feet based on LiDAR.

Overall, the LiDAR data shows that overland flows generally travel from south to north. The LiDAR also shows flows that enters from outside the City limits from the west and south. The flows naturally are conveyed towards Jarbo Bayou, Clear Creek Channel and Galveston Bay.

*Bayview Acres*

Bayview Acres flows from west to east, flowing to Galveston Bay. SH 146 is a high point in the drainage boundary which prevents overland flow from entering the area from the west. The natural ground elevations range from 0 to 18, although at the edge of Galveston Bay, there is an approximately 10-foot drop off, therefore, the land is relatively flat sloping at an approximately 0.40% slope. See **Exhibit 2.1** for a LiDAR elevation map of Bayview Acres.

*Lighthouse District*

The Lighthouse District flows south to north towards Clear Creek Channel. SH 146 is a high point in the drainage boundary which prevents overland flow from entering the area from the west. Overland flows from the south are likely entering this area during heavy rain events since this area is the lowest point in the City. The natural ground elevations range from 0 to 10. The land is relatively flat sloping at an approximate 0.30% slope. See **Exhibit 2.2** for a LiDAR elevation map of the Lighthouse District.

*Kemah Oaks*

The Kemah Oaks Subdivision flows from south to north. The north boundary of the subdivision appears to be a drainage high point preventing overland flow to enter from the south side. The east boundary of the subdivision also appears to be a high point, preventing overland flow from entering from the east. The CPE fee strip appears to be a natural low point which directs stormwater towards FM 518. The subdivision streets are low relative to the lot elevations and FM 518. A sheet flow release point towards the point is located at the intersection of Oak Meadow Dr and Bay Oaks St to theoretically drain the neighborhood during more intense storm events. See **Exhibit 2.3** for a LiDAR elevation map of Kemah Oaks.

*South Kemah*

The South Kemah area generally flows south to north. SH 96 appears to act as a natural high point for the drainage area preventing additional overland flow from entering the drainage boundary, however, the drainage boundaries do extend outside the City limits. The natural ground elevations range from 12 to 22. The land is relatively flat sloping at approximate 0.25-0.30% slope. See **Exhibit 2.4** for a LiDAR elevation map of South Kemah.

*West Kemah*

The West Kemah area flows from south to north, although it is not very well defined due to relative flat grades in the area. A true drainage pattern is not distinguishable, even with contours broken down to the 0.5-ft level. A few high points exist south of the area's boundary, but overall the area ranges between 6.5 to 7.5 ft elevations. It is possible that overland flows from south of FM 2094 may enter the area during an intense rain event and stormwater may move slowly through the area due to poorly defined grades. Low points are located to the north and west of the area, but a defined overland flow path can not be defined. See **Exhibit 2.5** for a LiDAR elevation map of West Kemah.

## 2.2. Land Use

The City is comprised of commercial developments and mostly residential lots. Each individual area, as defined previously, was analyzed based on the existing development. For the development of post developed flows, assumptions were made regarding undeveloped land dependent on the surrounding area.

The land use for Bayview Acres and South Kemah were assigned a C-factor based on the existing composition of the lot. Parcels were gathered from Galveston County Appraisal District (GCAD) and were assigned a land use type and C factor. **Table 1** shows a breakdown of land use type and the associated C coefficient.

**Table 1 - Land Use Type C Coefficient**

| Land Use Type | C |
|---|---|
| SFR <1/4 | 0.55 |
| SFR 1/4 to 1/2 | 0.45 |
| SFR >1/2 | 0.35 |
| MF <20 | 0.65 |
| MF >20 | 0.80 |
| Business | 0.80 |
| Industrial Light | 0.65 |
| Industrial Heavy | 0.75 |
| Industrial RR | 0.30 |
| Parks/Open Area | 0.18 |
| ROW | 0.80 |
| Water | 0.95 |

## 2.3. Existing Facilities

Each studied area has a different drainage system which ultimately conveys flow towards an outfall.

*Bayview Acres*

The Bayview Acres area is comprised of concrete and asphalt roads with grass-lined roadside ditches and reinforced concrete pipe (RCP) culverts. The City owns and maintains three (3) main roads in this area: Bay Ave, Meadow Ln and Park Ave. Based on the record drawings[5], Meadow Ln is a crowned road re-constructed with a longitudinal slope of 0.0% and a cross slope of 2%. The re-construction of Meadow Ln incorporated drainage improvements which included filling in existing ditches and placing an enclosed 24-inch diameter storm sewer with grate inlets and swales on the southeast side of the road. The northwest side of the road remained relatively untouched besides improvements to the existing outfall, which replaced dual 18-inch diameter pipes with a single 30-inch diameter RCP culvert.

Based on existing topo from 2012 (see Section 1.5.1), the majority of Park Ave ditches are graded to flow west to east, except for 400-feet east of the Meadow Ln and Park Ave intersection, which were re-graded as part of the Meadow Ln re-construction. The existing culverts are sized 18-inches and 24-inches in diameter. A profile of the Park Ave ditches was created based on the topo provided, see **Exhibit 3.2**. It

[5] LJA Engineering, Inc., "*City of Kemah Construction Plans For: Cien Road and Meadow Lane Concrete Paving*", November 2016

appears that at the time of the survey, there were segments of ditch which had accumulated silt, thus reducing the conveyance capacity. On Bay Ave, the ditches west of the Bay Ave and Park Ave intersection are graded from west to east. Park Ave and Bay Ave ultimately flow towards an existing 24-inch diameter culvert located in a 15-foot drainage easement and outfalls at Galveston Bay through an 18-inch diameter RCP.

*Lighthouse District*

The Lighthouse District is comprised of concrete and asphalts roads with a combination of grass-lined roadside ditches, RCP culverts, grate inlets with sub-surface storm sewer and grass-lined swales and curb inlets. The storm sewer sizes range from 15-inch to 54-inch in diameter. The storm sewer system appears to convey towards a stormwater pump station, where discharges into an 8-foot x 4-foot RCB. This pump station is located between 1st and 3rd street off Texas Ave and outfalls to Clear Creek Channel. The stormwater pump station is a three (3) pump system, with one (1) pump being a standby. The stormwater pump station was designed to add an additional pump in the future.

*Kemah Oaks*

The Kemah Oaks Subdivision is comprised of curb and gutter streets with curb inlets. The sub-surface storm sewer system conveys flow to an existing detention basin at the southwest corner of the subdivision. The storm sewer system sizes range from 24-inches to 48-inches. The storm sewer trunkline is located within the two main roads in the subdivision, Kemah Oaks Dr and Bay Oaks Dr. A segment of pipe is located along Oak Briar Dr. In general, the other cul-de-sac streets in the subdivision are graded to drain towards the subdivision main streets. The high point is located at the cul-de-sac and stormwater drains towards the street intersections, where it is conveyed to storm sewer via curb inlets with 5-foot openings.

The detention basin is a wet bottom basin with a 42-inch corrugated metal pipe (CMP) that outfalls to Jarbo Ditch. Based on record drawings, the detention basin design included a concrete pilot channel at the basin bottom and the outfall pipe should have matched the lowest flowline in the basin to create a dry bottom basin. The basin bottom was designed with 1% cross slopes towards the concrete pilot channel which ultimately conveyed stormwater to the outfall. Additionally, an emergency spillway at the southwest side of basin was not constructed. The record drawings indicate that the detention basin was designed to provide 23.85 acre-feet of volume storage although only 19.94 acre-feet were required. Based on volume storage analysis performed with AutoCAD Civil 3D, the current volume storage provided in the existing basin is 17.42 acre-feet. The volume storage was based on comparing the lowest top of bank elevation and the permanent pool elevation at the bottom of the basin.

Based on record drawings, the detention basin was designed with a 100-year water surface elevation (WSEL) which exceeded the designed top of curb elevations for several streets. This information conveys that the existing streets are will hold stormwater during an extreme rain event, until the WSEL in the basin reduces to allow additional stormwater to drain into the basin, see **Figure 1** for represented example. Furthermore, **Exhibit 4.2** is a copy of the record drawings marked with the detention designed 100-year WSEL.

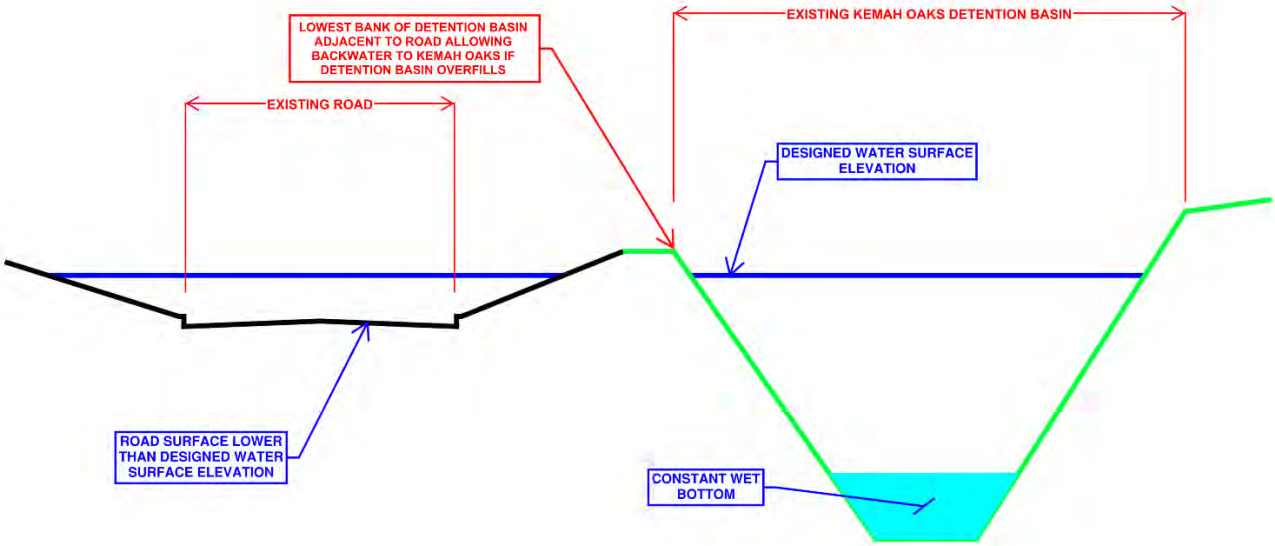



**Figure 1 - Representation of Kemah Oaks Basin 100-yr WSEL Relative to Existing Neighborhood Streets**

*South Kemah*

The South Kemah area is comprised of concrete and asphalts roads with a combination of grass-lined roadside ditches, RCP culverts, grate inlets with sub-surface storm sewer and grass-lined swales and curb inlets. Limited information is available for the existing South Kemah storm sewer infrastructure. The area ultimately appears to drain towards Jarbo Ditch.

*West Kemah*

The West Kemah area is comprised of concrete roads with grass-lined roadside ditches and RCP culverts. The roads were re-constructed in 2014, however, no drainage improvements were incorporated besides the removal of four (4) RCP culverts (18-inch, 2 – 24-inch and 1 – 30-inch) which were replaced with one (1) 6-foot x 4-foot reinforced concrete box (RCB) culvert. Based on the record drawings[6], the proposed roadway longitudinal grades are flat with slopes generally between 0.0 – 0.2%. The road is a crowned road, with 2% cross slopes, which conveys stormwater to roadside ditches. It appears that storm sewer system ultimately outfalls to Clear Creek Channel.

*Jarbo Ditch*

Jarbo Ditch serves the Kemah Oaks and South Kemah areas. Jarbo Ditch is a tributary of Jarbo Bayou and it extends from the South Kemah Dr and Winfield Ln intersection to Jarbo Bayou. An existing HEC-RAS model was not available of Jarbo Ditch or Jarbo Bayou. Based on a ditch cross-section de-lineated from a topographic survey conducted of the Kemah Oaks detention basin, the existing channel appears to have 870 cfs of conveyance capacity using manning's equation.

[6] LJA Engineering, Inc., "*City of Kemah Construction Plans For: West Kemah Street Improvements*", January 2014

## 2.4. Existing Conditions Model, Hydrologic Parameters and Hydraulic Model

In general, for the study areas, Atlas 14 rainfall data was applied to the storm sewer system analysis. The National Oceanic Atmospheric Administration (NOAA) in September 2018 published the NOAA Atlas 14, Volume 11 Precipitation-Frequency Atlas of the United, Texas[7] (Atlas 14), which increased the rainfall values for many areas within the state of Texas, including Galveston County. The Houston-Galveston area were among some of the largest increases in rainfall values, ranging between 15 to 30%. These increases in rainfall are producing larger flows, particularly in the less frequent rainfall events of the 50-, 100- and 500-year events.

Drainage area boundaries for each area were developed using a combination of LiDAR data and available record drawing as-builts. The existing and proposed flows for each drainage area were generated using the rational method. This is an adequate method to calculate the flows for drainage areas that are less than 600 acres. The formula is the following:

$$Q = CIA$$

Q indicates flows, which is measured in cubic feet per second (cfs), C is the runoff coefficient which is unitless, I is intensity defined in inches per hour (in/hr) and A is the drainage area defined in acres. The runoff coefficient used for each area varied depending on the developments in the existing area. To calculate the intensity for each drainage area, a time of concentration was calculated based on a standard formula used by other jurisdictions such as Galveston Drainage District #1 (GDD1), City of Houston (COH) and others. The formula is the following:

$$T_c = 10A^{0.1761} + 15$$

$T_c$ indicates the time of concentration in minutes and A indicates the drainage area in acres. This formula is adequate to use in scenarios with smaller drainage areas since it is a good approximation for time of concentration. The intensity values were calculated based on the following formula:

$$I = \frac{b}{(T_c + d)^e}$$

Intensity (I) is defined in inches per hour. The b, d and e values are empirical values developed based on rainfall data. The rainfall data used is Atlas 14 values. The b, d and e values are presented in **Table 2**.

**Table 2 - Galveston County Rainfall IDF Coefficients**

| Coefficient | 50% (2-year) | 20% (5-year) | 10% (10-year) | 4% (25-year) | 2% (50-year) | 1% (100-year) |
|---|---|---|---|---|---|---|
| **e** | 0.80 | 0.78 | 0.76 | 0.74 | 0.72 | 0.71 |
| **b (in)** | 66.15 | 80.12 | 90.16 | 102.99 | 110.99 | 120.52 |
| **d (min)** | 13.17 | 13.18 | 13.24 | 13.42 | 13.44 | 13.86 |

The conveyance capacity of the existing drainage outfalls was calculated using manning's equation. The formula is the following:

$$Q = \frac{1.49}{n} * A * R^{\frac{2}{3}} * \sqrt{S}$$

[7] "*NOAA Atlas 14 Precipitation-Frequency Atlas of the United States - Volume 11 Version 2.0: Texas*", 2018

Q indicates the flow defined as cubic feet per second. A indicates the cross-sectional area of the pipe. R is the hydraulic radius, which is a function of the wetted perimeter over the cross-sectional area of the pipe. For the simplicity of this analysis, it was assumed that the pipes are flowing full. S is the slope of the pipe.

*Bayview Acres*

Drainage areas for the Bayview Acres area were generated using available LiDAR data. The area was broken into seven (7) sub-drainage boundaries and a flow was generated for each individual area using the rational method (see **Table 3**). Based on analyzing LiDAR information, it was determined that two (2) sub-drainage areas flow to the Meadow Ln outfall and five (5) sub-drainage area boundaries flow to the Bay Ave outfall.

**Table 3 - Bayview Acres Existing Flows**

| DA ID | Area (ac) | C-factor | 2-year Flow (cfs) | 100-year Flow (cfs) |
|---|---|---|---|---|
| DA-1 | 3.82 | 0.35 | 4.46 | 11.59 |
| DA-2 | 7.75 | 0.53 | 13.41 | 34.98 |
| DA-3 | 16.17 | 0.34 | 16.98 | 44.52 |
| DA-4 | 12.47 | 0.37 | 14.52 | 37.99 |
| DA-5 | 10.91 | 0.34 | 11.64 | 30.43 |
| DA-6 | 19.69 | 0.56 | 34.18 | 89.73 |
| DA-7 | 39.02 | 0.36 | 39.46 | 104.14 |

The existing conveyance capacity of the Meadow Ln and Bay Ave outfalls were calculated using Manning's Equation. Drainage IDs 1 and 2 were assigned to the Meadow Ln outfall and drainage IDs 3, 4, 5, 6 and 7 were assigned to the Bay Ave outfall. **Table 4** shows that the existing outfall conveyance capacity versus the amount of flow that the outfall receives. A drainage area map can be found in **Exhibit 3.1**.

**Table 4 - Bayview Acres Existing Outfall Capacity**

| Outfall | DA ID | 2-yr $Q_{peak}$ (cfs) | 100-yr $Q_{peak}$ (cfs) | Pipe Size (in) | $Q_{pipe}$ (cfs) | 2-yr Adequate? | 100-yr Adequate? |
|---|---|---|---|---|---|---|---|
| Meadow Ln | 1, 2 | 18 | 47 | 30 | 29 | **Yes** | **No** |
| Bay Ave | 3, 4, 5, 6, 7 | 117 | 307 | 18 | 23 | **No** | **No** |

The existing Bay Ave outfall is currently providing less than a 2-year LOS. The Meadow Ln outfall is adequately sized for a 2-year LOS, however, is not adequately sized to provide a 100-year LOS. There is insufficient data to properly analyze the conveyance capacity of the existing ditches for Bayview Acres, however, based on 2012 survey data provided by the City, it was determined that at the time of survey, the existing ditches were silted up. A ditch that has silt accumulation will lose its conveyance capacity, thus reducing the LOS of the service area that it serves. A byproduct of silt accumulation is that flow velocities are reduced, thus allowing additional silt to accumulate at the ditch bottom and further reducing the LOS provided to the area.

*Lighthouse District*

The drainage issues in the Lighthouse District are documented in a Master Drainage Study conducted in 2009. Based on LiDAR information, it appears that ponding issues near the Harris Ave and 7th St intersection may be on-going due to a low spot in this area that would require a significant amount of head to push stormwater out. Another issue is that as properties have been re-developed, existing drainage inlets have been left in place and in some cases do not appear located in low spots. It is likely that this area will continue to flood unless significant drainage improvements are conducted as recommended in the 2009 master drainage study conducted of the area.

*Kemah Oaks*

A WinStorm model of the drainage infrastructure within the Kemah Oaks subdivision was created based on record drawings of the existing drainage facilities. As shown in **Exhibit 4.1**, the contributing flows to the area are only from the subdivision. LiDAR demonstrates that the residential lots drainage high is at the back-end property line and the lots are graded to drain to the local streets. Based on field reconnaissance, an earthen swale was placed between the residential lots property lines to facilitate the drainage of water in between lots to the local streets.

The existing storm sewer system was designed in the early 1990s, which used prior rainfall data that does not reflect current standards. Based on flooding records, it appears that Kemah Oaks has experienced consistent flooding issues over the last several years. The existing model developed for this subdivision used pre-Atlas 14 rainfall data to investigate the LOS the existing system currently provides. The overall drainage areas shown on **Exhibit 4.1** were further broken down to the inlet level to develop a full analysis of the area.

WinStorm is a static 1D model, which analyzes the conveyance capacity of the underground drainage system. The program calculates a hydraulic grade line (HGL) which is compared to a critical elevation as assigned by the user. If the HGL exceeds the critical elevation, this indicates a deficiency in the system. The HGL analysis starts at the downstream end with a fixed tailwater assigned based on engineering judgement. For this model, the fixed tailwater for the 2-year and 5-year storm event was set at the top of pipe, which indicates a pipe flowing full. Additionally, the critical elevations were set to the gutter line which is typical of other jurisdictions in proximity to the City. The software generates flows using the rational method as previously discussed. A C-factor of 0.55, which is representative of single-family residential lots less than half (1/2) an acre, was used in the equation.

A series of nodes and runs were used to create a model of the subdivision. Inlets and manholes were assigned nodes and pipes from node to node were assigned as runs. Individual drainage areas were assigned to each inlet node. In general, manholes are not assigned drainage areas or flows, unless the model is done as a manhole level analysis or additional flows, including offsite flows are entering the system.

Based on the 2-yr storm analysis, there are several deficiencies in the system. Multiple critical elevations were exceeded. The software calculated a 2-year HGL which is overlaid on the record drawings, see **Exhibit 4.2**. The record drawings profile shows top of curb elevations only; therefore, clouds and call outs were added for clarification at areas of deficiencies. Node labels were also added to the record drawings. The results state that the existing system is inadequate to provide a 2-year LOS. **Table 5** below has been organized to show the output from the WinStorm analysis. Cells filled in red indicate an area of deficiency. As stated previously, a fixed tailwater of top of pipe was used for this analysis.

**Table 5 - WinStorm Existing Conditions 2-year Analysis**

| Run # | US DA ID | DS DA ID | HGL US (ft) | HGL DS (ft) | Cumulative Q (cfs) | $Q_{capacity}$ | Critical Elev (ft) | CE - $HGL_{US}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | B-1 | OUT | 6.50 | 6.30 | 91.68 | 58.65 | 10.38 | 3.88 |
| 2 | B-2 | B-1 | 6.72 | 6.50 | 91.68 | 58.65 | 10.76 | 4.04 |
| 3 | B-3 | B-2 | 7.23 | 6.72 | 91.68 | 49.57 | 10.61 | 3.38 |
| 4 | B-3A1 | B-3 | 7.28 | 7.23 | 8.82 | 12.09 | 8.95 | 1.67 |
| 5 | B-3A2 | B-3A1 | 7.29 | 7.28 | 4.56 | 13.52 | 8.95 | 1.66 |
| 6 | B-3B | B-3 | 7.33 | 7.23 | 9.15 | 8.87 | 10.00 | 2.67 |
| 7* | B-3B1 | B-3B | 7.35 | 7.33 | 9.15 | 25.30 | 8.95 | 1.60 |
| 8 | B-3B2 | B-3B1 | 7.36 | 7.35 | 4.74 | 13.52 | 8.95 | 1.59 |
| 9 | B-4 | B-3 | 7.97 | 7.23 | 76.85 | 45.43 | 11.22 | 3.25 |
| 10 | B-4A1 | B-4 | 8.02 | 7.97 | 9.06 | 13.06 | 9.10 | 1.08 |
| 11 | B-4A2 | B-4A1 | 8.03 | 8.02 | 4.50 | 13.52 | 9.10 | 1.07 |
| 12 | B-4B | B-4 | 8.08 | 7.97 | 9.43 | 2.87 | 11.20 | 3.12 |
| 13* | B-4B1 | B-4B | 8.09 | 8.08 | 9.43 | 24.00 | 9.10 | 1.01 |
| 14 | B-4B2 | B-4B1 | 8.11 | 8.09 | 4.71 | 13.52 | 9.10 | 0.99 |
| 15 | B-5 | B-4 | 8.45 | 7.97 | 61.35 | 45.43 | 10.97 | 2.52 |
| 16 | B-5A1 | B-5 | 8.58 | 8.45 | 25.30 | 16.99 | 9.50 | 0.92 |
| 17* | B-5A2 | B-5A1 | 8.59 | 8.58 | 6.06 | 25.30 | 8.50 | **-0.09** |
| 18 | B-5A3 | B-5A2 | 8.60 | 8.59 | 4.19 | 13.52 | 8.50 | **-0.10** |
| 19 | B-5AB | B-5A1 | 9.44 | 8.58 | 20.36 | 15.35 | 10.00 | 0.56 |
| 20* | B-5AB1 | B-5AB | 9.45 | 9.44 | 5.83 | 25.30 | 8.93 | **-0.52** |
| 21 | B-5AB2 | B-5AB1 | 9.46 | 9.45 | 4.15 | 13.52 | 8.93 | **-0.53** |
| 22 | B-5AC | B-5AB | 9.78 | 9.44 | 15.07 | 9.78 | 10.95 | 1.17 |
| 23 | B-5AD | B-5AC | 10.15 | 9.78 | 15.07 | 9.50 | 11.00 | 0.85 |
| 24 | B-5AE | B-5AD | 10.16 | 10.15 | 1.91 | 8.61 | 9.71 | **-0.45** |
| 25 | B-5AF | B-5AE | 10.16 | 10.16 | 1.33 | 8.94 | 9.71 | **-0.45** |
| 26 | B-5AD1 | B-5AD | 11.03 | 10.15 | 13.61 | 9.63 | 10.50 | **-0.53** |
| 27* | B-5AD2 | B-5AD1 | 11.06 | 11.03 | 13.61 | 25.30 | 9.20 | **-1.86** |
| 28 | B-5AD3 | B-5AD2 | 11.09 | 11.06 | 7.77 | 13.52 | 9.20 | **-1.89** |
| 29 | B-5B1 | B-5 | 8.60 | 8.45 | 19.63 | 15.04 | 10.25 | 1.65 |
| 30* | B-5B2 | B-5B1 | 8.61 | 8.60 | 6.44 | 25.30 | 9.10 | 0.49 |
| 31* | B-5B3 | B-5B2 | 8.62 | 8.61 | 4.39 | 19.12 | 9.10 | 0.48 |
| 32 | B-5BA | B-5B1 | 10.34 | 8.60 | 14.08 | 9.61 | 10.25 | **-0.09** |
| 33* | B-5BA1 | B-5BA | 10.37 | 10.34 | 14.08 | 40.80 | 9.19 | **-1.18** |
| 34* | B-5BA2 | B-5BA1 | 10.40 | 10.37 | 7.11 | 19.12 | 9.19 | **-1.21** |
| 35 | B-6 | B-5 | 9.65 | 8.45 | 17.56 | 9.60 | 10.25 | 0.60 |
| 36* | B-6A1 | B-6 | 9.66 | 9.65 | 4.94 | 25.30 | 9.21 | **-0.45** |
| 37* | B-6A2 | B-6A1 | 9.66 | 9.66 | 4.10 | 19.12 | 9.21 | **-0.45** |
| 38 | B-7 | B-6 | 9.88 | 9.65 | 13.04 | 9.75 | 10.25 | 0.37 |
| 39* | B-7A1 | B-7 | 9.89 | 9.88 | 3.86 | 25.30 | 9.21 | **-0.68** |
| 40 | B-8 | B-7 | 10.62 | 9.88 | 9.93 | 9.60 | 11.00 | 0.38 |
| 41 | B-9 | B-8 | 10.74 | 10.62 | 9.93 | 9.77 | 11.00 | 0.26 |
| 42 | B-10 | B-9 | 10.81 | 10.74 | 9.93 | 11.76 | 10.34 | **-0.47** |
| 43 | B-11 | B-10 | 10.82 | 10.81 | 5.45 | 13.52 | 10.34 | **-0.48** |

A 100-year analysis was not conducted with WinStorm and requires higher level software and data to model the interaction between a sub-surface and surface system. Since the existing pipes do not currently provide a 2-year LOS, it is likely that the software will produce exaggerated 100-year HGLs which are not

realistic. It is typical that most jurisdictions design the underground storm sewer systems to convey less intense rains and for extreme events to be conveyed via a combination of underground storm sewer and roadway. For roadway conveyance, the goal is to keep stormwater within the City right-of-way (ROW) and prevent structures from flooding.

Based on historical data, the flooding during extreme events is an issue for the Kemah Oaks subdivision. There have been multiple reported flooded structures in the area and most them occurred at street intersections with the main arterial streets, Bay Oaks Ave and Kemah Oaks Ave. Per the record drawings, the intersections were designed to be the low points and as previously mentioned, the 100-year WSEL of the basin was designed to be higher than these points. In addition, the basin was not constructed as originally designed which exacerbates the drainage issues in this subdivision. The existing detention basin is a wet bottom basin which does not contain an emergency spillway.

A topographic survey of the basin was conducted and based on the elevations provided, the detention basin lowest top of bank elevation is 10.3, which is at the Bay Oaks and Oak Meadow Dr intersection. Adjacent to Jarbo Ditch, the top of bank elevations range between 10.9 and 13.3. Since an emergency spillway was not constructed, it is possible that during an intense rain event, when the basin is full, the basin backs up into the subdivision streets due to lack of capacity to store a 100-year storm event. As previously stated, the existing basin volume is 17.42 acre-feet, a 2.52 acre-feet difference from the required volume storage based on the design drawings (19.94 acre-feet).

In addition, results from an existing steady HEC-RAS conditions model conducted of Jarbo Ditch, indicates that Kemah Oaks streets will pond even during less intense storm events since it appears the subdivision streets sit lower than surrounding areas, thus allowing water to accumulate. See **Exhibits 6.2 – 6.7** for inundation maps created from the model.

Due to updated rainfall data, required detention storage required to serve this area is higher. Using the Small Watershed Method (Malcomn's Method), a comparison of 100-year, 24-hour storm event pre-developed and post-developed flow rates were compared. Two hydrographs, one existing and one proposed were used to develop the required detention volume based on the peak flows developed using rational method. The assumptions to compile this data is shown in **Table 6** below.

**Table 6 - Small Watershed Method Input Parameters**

| Storm | Duration | Rainfall Excess (inches) | Exist Peak Q (cfs) | Prop Peak Q (cfs) | Exist C | Prop C |
|---|---|---|---|---|---|---|
| 100-yr | 24-hr | 9.70 | 75.34 | 207.19 | 0.20 | 0.55 |

The input data is pre-Atlas 14 values used to compute existing and proposed peak flows. The rainfall excess is an assumption based on GDD1 criteria. The calculated required volume is 26.65 acre-feet, therefore, based on an existing storage of 17.42 acre-feet, an additional 9.23 acre-feet of storage is required. The storage volume for Kemah Oaks calculates at a storage rate of 0.46 acre-feet per acre.

*South Kemah*

Very limited data is available of the South Kemah area. Drainage area boundaries were delineated using LiDAR elevations. Based on the drainage area, pre-developed and post-developed flows were calculated based on the rational method. Insufficient data is available to develop a detailed existing model of the area. It is recommended that additional topographic survey be gathered to supplement various information missing from the limited library of record drawings. LiDAR does a poor job of capturing actual

roadside ditch data since LiDAR points are built on a 5-foot by 5-foot grid, which does not allow smaller ditch cross-sections to be captured. In addition, the area has multiple culverts which span a considerable length and more detailed invert information is needed to input into the hydraulic model.

A detention analysis of the area was done using parameters set in the GCDD1 drainage criteria manual, see **Table 6** below. The GCDD1 criteria recommends an intensity of 0.56 inch per hour be used to analyze a 100-year, 24-hour event. This value will produce lower peak flows. The Triangular Hydrograph Method was used to calculate the required storage volume for the South Kemah area. A storage rate of 178.67 acre-feet (0.58 acre-feet per acre) will be needed for the South Kemah area to be provided for regional detention in the area. This detention storage only accounts for drainage south of FM 518. It is anticipated that all future developments in the area would require their own on-site detention to store the volume generated between pre-developed and post-developed flows due to the likely inadequate systems which exists in the South Kemah area.

**Table 7 - South Kemah Area Parameters for Triangular Hydrograph Method**

| Drainage Area (acres) | Intensity (in/hr) | Pre-Developed C-factor | Post-Developed C-factor | Pre-Developed 100-yr $Q_{peak}$ (cfs) | Post-Developed 100-yr $Q_{peak}$ (cfs) | Total Basin Inflow Volume (acre-feet) |
|---|---|---|---|---|---|---|
| 306 | 0.56 | 0.30 | 0.72 | 64 | 154 | 306 |

The C-factors used for this calculation assumed a pre-developed c-factor which reflects mostly undeveloped land (approximately 17% impervious area). The post-developed c-factor accounts for a fully developed area, which is approximately 87% impervious area.

A detention basin within the area would in the area would discharge to Jarbo Ditch.

*West Kemah*

A previous analysis of the West Kemah area was conducted in 2016. The LiDAR elevations convey that the area is relatively flat, with hardly any elevation change. The commercial developments and school built on the south side of the West Kemah boundary were built relatively higher than the surrounding area. The 2016 study identified several ditch and culvert improvements that were necessary to improve the conveyance in the area. The streets were rebuilt recently, however, there were limited drainage improvements to the area. Further investigation will be on-going to identify critical areas that may require immediate attention.

*Jarbo Ditch*

An existing condition analysis for Jarbo Ditch was conducted to determine the existing LOS that can be conveyed in the ditch. As described in **Section 2.3**, Jarbo Ditch services the South Kemah and Kemah Oaks area. A total of nineteen (19) sub-drainage areas were delineated for the Jarbo Ditch watershed boundary. The drainage areas were delineated based on LiDAR. On the east side of Jarbo Ditch, there are a few undeveloped tracts with a high point near the middle of the tract that splits the flows towards Jarbo Ditch and SH 146. These tracts are adjacent to existing utility corridors. It was assumed that future development would discharge to Jarbo Ditch. Furthermore, it was assumed that grading in the utility corridors would also be graded towards Jarbo Ditch. This accounted for a worst-case scenario to properly assess the LOS in Jarbo Ditch. Additionally, it was assumed that flows from FM 518, east of the FM 518/Jarbo Ditch intersection, are being discharged to Jarbo Ditch.

Peak flows were generated using the Rational Method. Land use for each sub-drainage area was generated as explained in **Section 2.2**. Time of concentration for each drainage area was calculated using the previously stated formula. Drainage are ID, DA-1, had a calculated larger sub-drainage area of 306 acres, which calculated a low time of concentration number, thus generating a larger flow. The time of concentration for DA-1 was updated to reflect time of concentration as calculated in the TxDOT Hydraulic Design Manual (HDM), which generated a higher time of concentration, thus reducing the peak flow from this sub-drainage area. **Exhibit 5.1** shows the delineated drainage areas that flow to Jarbo Ditch. The calculated peak flows are shown in **Table 8**:

**Table 8 - South Kemah Peak Flows Using Rational Method**

| DA_ID | Area (acre) | Composite C-Factor | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|---|---|
| DA-1 | 309.25 | 0.52 | 225.95 | 314.90 | 658.57 |
| DA-2 | 16.47 | 0.95 | 48.76 | 65.98 | 127.86 |
| DA-3 | 86.50 | 0.33 | 81.26 | 110.35 | 215.84 |
| DA-4 | 35.40 | 0.31 | 32.89 | 44.57 | 86.73 |
| DA-5 | 11.41 | 0.80 | 28.97 | 39.17 | 75.76 |
| DA-6 | 5.47 | 0.80 | 14.39 | 19.44 | 37.47 |
| DA-7 | 36.57 | 0.80 | 87.28 | 118.29 | 230.21 |
| DA-9 | 60.72 | 0.18 | 32.11 | 43.57 | 85.03 |
| DA-11 | 8.14 | 0.81 | 21.30 | 28.79 | 55.59 |
| DA-12 | 2.98 | 0.80 | 8.06 | 10.88 | 20.91 |
| DA-13 | 10.58 | 0.26 | 8.74 | 11.81 | 22.84 |
| DA-14 | 0.37 | 0.80 | 1.09 | 1.46 | 2.79 |
| DA-15 | 57.04 | 0.62 | 103.19 | 139.99 | 273.13 |
| DA-16 | 15.44 | 0.58 | 28.23 | 38.20 | 73.99 |
| DA-17 | 20.81 | 0.23 | 14.89 | 20.15 | 39.10 |
| DA-18 | 0.37 | 0.80 | 1.09 | 1.47 | 2.80 |
| DA-19 | 11.47 | 0.58 | 20.96 | 28.34 | 54.82 |
| DA-20 | 2.19 | 0.80 | 5.99 | 8.08 | 15.50 |
| DA-21 | 8.01 | 0.80 | 20.70 | 27.97 | 54.01 |

The peak flows generated by the rational method were input into a HEC-RAS steady state model. Cross-sections from the existing terrain were generated using 2018 LiDAR data. A topographic survey was not conducted for this investigation which limits the accuracy of the HEC-RAS output. A model is not available for Jarbo Bayou, Jarbo Ditch's discharge point, which also limits the accuracy of the HEC-RAS model. The tailwater assumed for this model was normal depth. It is understood that League City is currently working on a model for Jarbo Bayou, however, that model will not be completed until later in 2020 and thus, it was not available for our use to understand the impacts from Jarbo Bayou. Discharge flows were strategically placed along the existing corridor based on discharge point assumptions.

Based on available record data and existing topography, most of the discharge to Jarbo Ditch occurs prior to the FM 518 and Jarbo Ditch crossing. Historically, residents in both South Kemah and Kemah Oaks have complained of restrictions at this crossing. The HEC-RAS model demonstrates that Jarbo Ditch, only provides a 5-year LOS to the area. Additionally, due to the Kemah Oaks subdivision streets lying lower

than the surrounding area, the model demonstrates that these subdivision streets pond at the 2-year storm event. The model also shows significant ponding issues west of Jarbo Ditch and east of Anders Ln.

Based on the HEC-RAS output, found in **Appendix F**, the FM 518 crossing is acting as one of several restrictors in the ditch which allows water to back up starting at this crossing. Furthermore, another restriction is located upstream of Jarbo Ditch, between the Kemah Oaks detention basin and the 57-acre park since the ditch is not wide enough to provide adequate conveyance for storm events greater than the 5-year event.

The existing condition storm inundation maps for the 2, 5, 10, 25, 50 and 100-year storm events are found in **Exhibits 6.2 – 6.7**.

## 3.0 PROPOSED CONDITION ANALYSIS

The alternative analysis for each area depended largely on the data available to create an existing conditions model to compare versus the recommended proposed conditions. For the Lighthouse District and West Kemah areas, based on previous drainage reports prepared, it is beneficial that the City consider implementing recommendations provided in those drainage reports. There are no small-scale repairs that can improve the performance of the drainage system during an extreme event rainfall. The City can continue implementing a maintenance program that include: de-silting storm sewers, de-silting ditches, re-grading ditches to re-establish positive flow and removing blockages on above surface inlet grates that may reduce the capturing capacity of the inlet.

### 3.1. Proposed Conditions Model

The proposed conditions were modeled based on the criteria described in **Section 2.0**. There was no deviation for Bayview Acres, Kemah Oaks or South Kemah. As previously stated, for South Kemah, additional information is required to fill-in gaps that are missing in the data. The record drawings available for the area are limited and do not provide enough information to allow for the construction of a proper hydraulic model.

The recently updated, Atlas 14 rainfall data was used to calculate peak flows and apply to the hydraulic analysis for the proposed conditions.

### 3.2. Changes to Existing Condition Model

*Bayview Acres*

Two alternatives were explored for this area to increase the LOS. The existing ditches and culverts in the area currently drain to inadequately sized outfalls which are likely causing backwater effects due to the outfalls choking the system. The effects are a reduced LOS in the existing roadside ditches and culverts since water does not drain efficiently, thus causing street flooding and ultimately ponding outside the City ROW.

No regional detention is recommended for either alternative. Since the outfalls discharge into Galveston Bay, detaining stormwater will not provide any benefit for the area. However, it is recommended that the City require future multi-family, industrial or commercial development in the area to provide on-site detention or discharge directly to Galveston Bay to prevent overwhelming the receiving storm sewer system due to increases in runoff.

The roadside ditch sizes presented in **Appendix I** were calculated based on manning's equation and assumed that the normal depth is at top of bank. As explained in **Section 2.4**, peak flows were generated using rational method. Similarly, the outfalls were calculated by applying manning's equation and comparison the pipe capacity to the flow conveyed to the outfall. Further analysis will be required during preliminary engineering and final design to properly conduct an HGL analysis on the recommended improvements, however, the recommendations made here provide a baseline in regards to the drainage improvements needed to increase the LOS for the area.

**<u>Alternative 1</u>**

The following changes are proposed for Alternative 1:

- Remove the existing 30-inch diameter outfall for Meadow Ln and replace with a 42-inch diameter pipe.

    - Drainage areas 1 and 2 (see **Table 9**) would continue to be serviced by this outfall and no additional area is added.
- Combine drainage areas 3, 4 and 5 (see **Table 9**) and install a 54-inch outfall north of the Yacht Club (104 Park Circle).
    - A 20-foot drainage easement would be required to access the outfall for maintenance and construction.
- Remove the existing 18-inch diameter outfall for Bay Ave and replace with a 6-foot by 4-foot RCB.
    - The proposed pipe can be installed within the existing 15-foot drainage easement and the contributing drainage area would be reduced. Only drainage areas 7 would drain to this outfall (see **Table 9**).
- Upsize culverts and widen and re-grade ditches to re-direct flow.
    - Topographic survey will be required to accurately model the needed sizes to increase conveyance of the existing roadside ditch/culvert system. Preliminary sizing of the roadside ditches, assuming that the City owns a 60-foot ROW within Bay Ave and Park Ave, has been provided in **Appendix I**.

**Table 9 - Bayview Acres Alternative 1 Proposed Outfall Capacity**

| Outfall | DA ID | 2-yr $Q_{peak}$ (cfs) | 100-yr $Q_{peak}$ (cfs) | Pipe Size | $Q_{pipe}$ (cfs) | 2-yr Adequate? | 100-yr Adequate? |
|---|---|---|---|---|---|---|---|
| Meadow Ln | 1, 2 | 18 | 47 | 42” | 63 | **Yes** | **Yes** |
| Yacht Club North | 3, 4, 5, 6 | 77 | 203 | 6’ x 4’ | 219 | **Yes** | **Yes** |
| Bay Ave | 7 | 40 | 105 | 54” | 140 | **Yes** | **Yes** |

The cost of Alternative 1, including the cost of land acquisition, is estimated at **$2,206,590**. The outfalls would be sized to provide a 100-year LOS based on Atlas 14 rainfall. A detailed cost estimate of this alternative can be found in **Appendix A**.

**<u>Alternative 2</u>**

The following changes are proposed for Alternative 2:

- Remove the existing 30-inch diameter outfall for Meadow Ln and replace with a 42-inch diameter pipe.
    - Drainage areas 1 and 2 (see **Table 10**) would continue to be serviced by this outfall and no additional area is added.
- Combine drainage areas 3, 4 and 5 (see **Table 10**) and install a 54-inch outfall north of the Yacht Club (104 Park Circle).
    - A 20-foot drainage easement would be required to access the outfall for maintenance and construction.
- Install a 48-inch outfall south of the Yacht Club to serve drainage area 6 (See **Table 10**).
- Remove the existing 18-inch diameter outfall for Bay Ave and replace with 54-inch diameter pipe. (See **Table 10**)
- Upsize the culverts and widen and re-grade ditches to re-direct flow.
    - Topographic survey will be required to accurately model the needed sizes to increase conveyance of the existing roadside ditch/culvert system. Preliminary sizing of the roadside ditches, assuming that the City owns a 60-foot ROW within Bay Ave and Park Ave, has been provided in **Appendix I**.

**Table 10 - Bayview Acres Alternative 2 Proposed Outfall Capacity**

| Outfall | DA ID | 2-yr $Q_{peak}$ (cfs) | 100-yr $Q_{peak}$ (cfs) | Pipe Size | $Q_{pipe}$ (cfs) | 2-yr Adequate? | 100-yr Adequate? |
|---|---|---|---|---|---|---|---|
| Meadow Ln | 1, 2 | 18 | 47 | 42” | 63 | **Yes** | **Yes** |
| Yacht Club North | 3, 4, 5 | 44 | 113 | 54” | 123 | **Yes** | **Yes** |
| Yacht Club South | 6 | 34 | 90 | 48” | 90 | **Yes** | **Yes** |
| Bay Ave | 7 | 40 | 105 | 54” | 140 | **Yes** | **Yes** |

The cost of Alternative 2, including the cost of land acquisition, is estimated at **$2,123,480**. The outfalls would be sized to provide a 100-year LOS. A detailed cost estimate of this alternative can be found in **Appendix A**.

*Kemah Oaks*

Four alternatives were analyzed for the Kemah Oaks area to increase the LOS. As per the existing analysis presented in Section **2.3**, the existing drainage system is inadequately sized to provide a minimum 2-year LOS to the existing subdivision. In addition, the existing detention basin is undersized to provide an adequate LOS needed during an extreme event.

**<u>Alternative 1</u>**

The following changes are proposed for Alternative 1:

- Remove 1,950 linear feet (LF) of 24-inch diameter RCP and 390 LF of 30-inch diameter RCP and replace with 1,550 LF of 30-inch diameter RCP and 790 LF of 36-inch diameter RCP.
    - Full depth concrete pavement repair will be necessary in areas where pipes beneath pavement are being removed and replaced.

The cost of Alternative 1 is **$846,050**. In this scenario, the storm sewer system would be upsized to provide up to a 2-year LOS. **Table 11** reflects the updated “CE – $HGL_{US}$” which shows that the HGL no longer exceeds the critical elevation during a 2-year storm event based on the proposed upsized pipes. A detailed cost estimate of this alternative can be found in **Appendix A**.

## Table 11 - WinStorm Proposed Conditions 2-year Analysis

| Run # | US DA ID | DS DA ID | HGL US (ft) | HGL DS (ft) | Cumulative Q (cfs) | $Q_{capacity}$ | Critical Elevation (ft) | CE - $HGL_{US}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | B-1 | OUT | 6.49 | 6.30 | 91.18 | 58.65 | 10.38 | 3.89 |
| 2 | B-2 | B-1 | 6.71 | 6.49 | 91.18 | 58.65 | 10.76 | 4.05 |
| 3 | B-3 | B-2 | 7.22 | 6.71 | 91.18 | 49.57 | 10.61 | 3.39 |
| 4 | B-3A1 | B-3 | 7.27 | 7.22 | 8.82 | 12.09 | 8.95 | 1.68 |
| 5 | B-3A2 | B-3A1 | 7.28 | 7.27 | 4.56 | 13.52 | 8.95 | 1.67 |
| 6 | B-3B | B-3 | 7.32 | 7.22 | 9.15 | 8.87 | 10.00 | 2.68 |
| 7* | B-3B1 | B-3B | 7.34 | 7.32 | 9.15 | 25.30 | 8.95 | 1.61 |
| 8 | B-3B2 | B-3B1 | 7.35 | 7.34 | 4.74 | 13.52 | 8.95 | 1.60 |
| 9 | B-4 | B-3 | 7.95 | 7.22 | 76.42 | 45.43 | 11.22 | 3.27 |
| 10 | B-4A1 | B-4 | 8.00 | 7.95 | 9.06 | 13.06 | 9.10 | 1.10 |
| 11 | B-4A2 | B-4A1 | 8.01 | 8.00 | 4.50 | 13.52 | 9.10 | 1.09 |
| 12 | B-4B | B-4 | 8.06 | 7.95 | 9.43 | 2.87 | 11.20 | 3.14 |
| 13* | B-4B1 | B-4B | 8.08 | 8.06 | 9.43 | 24.00 | 9.10 | 1.02 |
| 14 | B-4B2 | B-4B1 | 8.09 | 8.08 | 4.71 | 13.52 | 9.10 | 1.01 |
| 15 | B-5 | B-4 | 8.42 | 7.95 | 61.01 | 45.43 | 10.97 | 2.55 |
| 16 | B-5A1 | B-5 | 8.47 | 8.42 | 25.17 | 27.62 | 9.50 | 1.03 |
| 17* | B-5A2 | B-5A1 | 8.47 | 8.47 | 6.06 | 45.87 | 8.50 | 0.03 |
| 18 | B-5A3 | B-5A2 | 8.48 | 8.47 | 4.19 | 24.52 | 8.50 | 0.02 |
| 19 | B-5AB | B-5A1 | 8.80 | 8.47 | 20.29 | 24.96 | 10.00 | 1.20 |
| 20* | B-5AB1 | B-5AB | 8.80 | 8.80 | 5.83 | 45.87 | 8.93 | 0.13 |
| 21 | B-5AB2 | B-5AB1 | 8.80 | 8.80 | 4.15 | 24.52 | 8.93 | 0.13 |
| 22 | B-5AC | B-5AB | 8.83 | 8.80 | 15.05 | 28.82 | 10.95 | 2.12 |
| 23 | B-5AD | B-5AC | 8.88 | 8.83 | 15.05 | 28.02 | 11.00 | 2.12 |
| 24 | B-5AE | B-5AD | 8.88 | 8.88 | 1.91 | 15.62 | 9.71 | 0.83 |
| 25 | B-5AF | B-5AE | 8.88 | 8.88 | 1.33 | 16.22 | 9.71 | 0.83 |
| 26 | B-5AD1 | B-5AD | 8.98 | 8.88 | 13.61 | 28.39 | 10.50 | 1.52 |
| 27* | B-5AD2 | B-5AD1 | 8.99 | 8.98 | 13.61 | 45.87 | 9.20 | 0.21 |
| 28 | B-5AD3 | B-5AD2 | 9.00 | 8.99 | 7.77 | 24.52 | 9.20 | 0.20 |
| 29 | B-5B1 | B-5 | 8.58 | 8.42 | 19.53 | 15.04 | 10.25 | 1.67 |
| 30* | B-5B2 | B-5B1 | 8.58 | 8.58 | 6.44 | 25.30 | 9.10 | 0.52 |
| 31* | B-5B3 | B-5B2 | 8.59 | 8.58 | 4.39 | 19.12 | 9.10 | 0.51 |
| 32 | B-5BA | B-5B1 | 9.10 | 8.58 | 14.08 | 17.42 | 10.25 | 1.15 |
| 33* | B-5BA1 | B-5BA | 9.11 | 9.10 | 14.08 | 73.97 | 9.19 | 0.08 |
| 34* | B-5BA2 | B-5BA1 | 9.12 | 9.11 | 7.11 | 34.67 | 9.19 | 0.07 |
| 35 | B-6 | B-5 | 8.79 | 8.42 | 17.60 | 17.40 | 10.25 | 1.46 |
| 36* | B-6A1 | B-6 | 8.79 | 8.79 | 4.94 | 45.87 | 9.21 | 0.42 |
| 37* | B-6A2 | B-6A1 | 8.80 | 8.79 | 4.10 | 34.67 | 9.21 | 0.41 |
| 38 | B-7 | B-6 | 8.86 | 8.79 | 13.07 | 17.68 | 10.25 | 1.39 |
| 39* | B-7A1 | B-7 | 8.86 | 8.86 | 3.86 | 45.87 | 9.21 | 0.35 |
| 40 | B-8 | B-7 | 9.09 | 8.86 | 9.93 | 17.41 | 11.00 | 1.91 |
| 41 | B-9 | B-8 | 9.12 | 9.09 | 9.93 | 17.71 | 11.00 | 1.88 |
| 42 | B-10 | B-9 | 9.14 | 9.12 | 9.93 | 21.33 | 10.34 | 1.20 |
| 43 | B-11 | B-10 | 9.15 | 9.14 | 5.45 | 24.52 | 10.34 | 1.19 |

**Alternative 2**

The following changes are proposed for Alternative 2:

- Remove 1,950 linear feet (LF) of 24-inch diameter RCP and 390 LF of 30-inch diameter RCP and replace with 1,550 LF of 30-inch diameter RCP and 790 LF of 36-inch diameter RCP.
    - Full depth concrete pavement repair will be necessary in areas where pipes beneath pavement are being removed and replaced.
- Expand the linear detention basin for Bel Rd, southeast of Kemah Oaks subdivision to include an additional 10 acre-feet of detention volume.
    - An emergency spillway would be constructed between the two basins to provide an extreme event structure that would prevent the Kemah Oaks existing detention basin from backing up into the Kemah Oaks streets.
    - A concrete pilot channel would be added to the Bel Rd linear ditch basin to facilitate.

The purpose of this alternatives is to increase the LOS of the Kemah Oaks storm sewer and detention basin to provide a 100-year LOS. The Bel Rd linear detention ditch would be expanded to allow for a reduction in the WSEL of the Kemah Oaks detention basin, which would reduce the amount of stormwater currently stored in the Kemah Oaks subdivision streets. The emergency spillway would allow for water to flow into the expanded Bel Rd linear detention ditch.

The cost of Alternative 2 is **$2,062,850**, a detailed cost breakdown of this alternative can be found in **Appendix A**. Land acquisition would not be required for this alternative since it is understood that the property the Bel Rd linear detention basin is currently on is owned by the County and an agreement is in place for the City to make use of this site. If this is not the case, the City would be required to purchase additional land to expand the detention.

To further investigate this alternative, it is recommended that the City allow for a survey of foundation slabs of previously flooded properties to ensure that the expanded detention basin is optimized to reduce the WSEL and reduce the risk of structural flooding.

**Alternative 3**

The following changes are proposed for Alternative 3:

- Remove 1,950 linear feet (LF) of 24-inch diameter RCP and 390 LF of 30-inch diameter RCP and replace with 1,550 LF of 30-inch diameter RCP and 790 LF of 36-inch diameter RCP.
    - Full depth concrete pavement repair will be necessary in areas where pipes beneath pavement are being removed and replaced.
- Excavate an additional 9.82 acre-feet within the existing basin.
- Construct an emergency spillway to the Bel Rd linear detention ditch.
- Install a stormwater pump station.
    - A stormwater pump station would be required since the Jarbo Ditch is limited in depth. The existing basin footprint is fixed, therefore, only depth is available to get more increase the volume storage capacity of the basin. It is likely that a small amount of storage would need to be extended along the Bel Rd linear detention ditch.

The cost of Alternative 3 is **$1,780,620**. A detailed cost analysis can be found in **Appendix A.** A service drop and generator would also need to be considered for a stormwater pump station. Ultimately, this alternative would require the long term maintenance of a stormwater pump station, which the City may not want to take on.

**Alternative 4**

The following changes are proposed for Alternative 4:

- Construct an extreme event emergency spillway from the Kemah Oaks existing detention basin.
    - This will prevent stormwater from backing up into the Kemah Oaks subdivision when Jarbo Ditch is not flowing full. Ultimately, as demonstrated by Jarbo Ditch HEC-RAS existing condition analysis, if Jarbo Ditch is flowing full, stormwater will back up into the Kemah Oaks subdivision since it is the lowest point relative to the rest of the Jarbo Ditch service area.
- Remove existing Inlet and 24-inch at the Oak Meadow Dr/Bay Oaks Dr intersection and upsize to convey the difference between the 2-year and 100-year flow.
    - The purpose is to convey stormwater to the detention basin via an underground system, since the system as currently design depends on spilling over the top bank of the basin, thus ponding water in neighborhood streets and causing mobility issues.

The cost of Alternative 4 is **$171,650**. A detailed cost analysis can be found in **Appendix A**. This alternative does not consider any alterations to existing detention basin and is considered a temporary solution until the City is able to get additional funds to expand the detention basin and widen Jarbo Ditch.

*South Kemah*

Two alternatives were explored for the South Kemah area based on the limited amount of data available. Based on previous documented rain events in the area, it is understood that the existing roadside ditch and culvert system that serves most of the area are either undersized, graded to flow incorrectly, silted up or a combination of all three.

**Alternative 1**

It is understood that the existing ditches and culverts are undersized, and that local conveyance is easily overwhelmed during more frequent, less intense storm events. Currently, the City has a preliminary set of plans for the street reconstruction of Anders Ln which include drainage conveyance improvements. LJA recommends that this project is funded and constructed as part of this alternative.

The improvements in the South Kemah area were split into three separate drainage outfalls, also regarded as System A, System B and System C. System drainage improvements were sized based on a 5-year storm event. Furthermore, the hydrology was performed based on assigning C-Factor values to each parcel as currently developed and peak flows were calculated using the rational method.

An HGL analysis was not conducted due to insufficient topographic data available. Pipes were sized based on calculating the capacity of pipe by using manning's equation. If the capacity was exceeded, then the pipe was upsized until the capacity exceeded the 5-year peak flow. Additionally, peak flows were not determined based on a cumulative time of concentration and instead, individual peak flows were added together to create the cumulative flows needed to size each system. These recommendations provide a base to start the design, however, preliminary engineering will need to be conducted prior to the start of design to properly analyze the proposed system and confirm the proposed drainage area as delineated. Preliminary engineering would include full topographic survey, which would be needed to verify where the existing ditch and underground systems flow.

System A

System A provides improvements to Delores St, Delesandri Ln and Winfield Ln and discharges to Jarbo Ditch. The following are the improvements recommended for System A:

- Remove and dispose of 1,250 LF of 18-inch RCP
- Remove and dispose of 1,700 LF of 24-inch RCP
- 825 LF of 7-foot by 4-foot RCB along Windfield Ln
- 1,000 LF of 5-foot by 4-foot along Delesandri Ln
- 420 LF of 30-inch diameter RCP along an existing 20-foot drainage easement.
    - The 20-foot drainage easement has not been confirmed, however, the City believes this easement exists and the cost of easement acquisition was not taken into account.
    - The easement extends from Delores St to Delesandri Ln
- Ditch improvements along Delores St, including driveway repair and culvert replacement

The cost of System A improvements is $1,570,000. A detailed cost is included in **Appendix A**. The opinion of probable cost shows a subtotal of $924,610 for System A, however, this subtotal did not include extra work items, permitting, engineering fees, construction management and a 30-percent contingency, which the aforementioned overall total cost does reflect.

<u>System B</u>

System B improvements encompasses Williams Dr and Lewis Dr. The following are the improvements recommended for System B:

- Remove and dispose of 2,030 LF of 24-inch RCP
- 1,075 LF of 7-foot by 4-foot RCB along an existing 20-foot drainage easement Jarbo Ditch to Anders Ln
    - The City stated that there is an existing drainage easement in this area, therefore, easement acquisition was not considered in the cost.
- Ditch improvements along Lewis Dr and Williams Dr, including driveway repair and culvert replacement
- 200 LF of 6-foot by 3-foot RCB along an existing 20-foot easement.
    - The City stated that there is an existing drainage easement in this area, therefore, easement acquisition was not considered in the cost.

The cost of System B improvements is $1,270,000. A detailed cost is included in **Appendix A**. The opinion of probable cost shows a subtotal of $750,710 for System B, however, this subtotal did not include extra work items, permitting, engineering fees, construction management and a 30-percent contingency, which the aforementioned overall total cost does reflect.

<u>System C</u>

System C improvements encompasses South Kemah Dr. The following are the improvements recommended for System C. A detailed cost is included in **Appendix A**. The opinion of probable cost shows a subtotal of $622,880 for System C, however, this subtotal did not include extra work items, permitting, engineering fees, construction management and a 30-percent contingency, which the aforementioned overall total cost does reflect.

- Remove and dispose of 1,200 LF of 24-inch RCP
- Remove and dispose of 780 LF of 36-inch RCP
- 1,200 LF of 30-inch RCP along South Kemah Dr
- 780 LF of 6-foot by 3-foot RCB along South Kemah Drive
- De-silt existing ditches

The cost of System C improvements is $1,060,000. A detailed cost is included in **Appendix A**. The opinion of probable cost shows a subtotal of $622,880 for System B, however, this subtotal did not include extra

work items, permitting, engineering fees, construction management and a 30-percent contingency, which the aforementioned overall total cost does reflect.

**Alternative 2**

Since entire South Kemah drains into Jarbo Ditch, a regional detention basin alternative was explored for the area. As stated in **Section 2.3**, Jarbo Ditch is an unstudied stream and a topographic survey of the entire ditch is required to complete a proper channel analysis. A preliminary steady state HEC-RAS model was conducted using 2018 LiDAR and assuming a tailwater condition at the confluence with Jarbo Bayou. The existing conditions analysis indicated that Jarbo Ditch has a 5-year LOS based on the existing configuration of the ditch. The existing condition analysis was ran based on the existing land use of South Kemah and assuming a normal depth outfall to Jarbo Bayou. Based on historical imagery, prior to 1990, South Kemah was mostly undeveloped.

This alternative explores regional detention under the assumption that the increase in flows from the development of single-family residential developments (present and future) and business developments (present) has adversely impacted conveyance in the area. To remediate the issue, it is proposed that a regional detention basin is constructed to mitigate the increase in flows from present and future development, as shown on **Exhibit 5.7**. As requested by the City, not all lots were taken under consideration, therefore, any lot not identified in the aforementioned exhibit will require on-site detention at a rate of 0.60 acre-feet per acre to prevent adverse impacts to Jarbo Ditch.

Alternative 2 proposes the following:

- Parcel acquisition for the construction of a detention basin.
    - The opinion of probable cost only considers a portion of the land needed to make the acquisition.
- Excavate a basin which provides nearly 62 acre-feet of storage.
- Construct a 5-foot by 5-foot outfall to Jarbo Ditch, which restricts the flow to pre-developed conditions of the South Kemah area.
- Install ditch interceptor structures along the boundary of the basin to limit erosion control issues for the lifetime of the basin.
- A stormwater pump station may be required to limit the amount of property acquisition likely needed for the construction of the basin.

The cost of this alternative, including property acquisition, is **$4,120,010.** A detailed cost breakdown can be found in **Appendix A.** Additional land acquisition may be needed to accomplish the necessary detention. Additionally, it would be prudent that this Alternative is re-visited prior to design to determine if detaining stormwater for a 100-year storm event is necessary in this area. The scope of work for this MDP did not provide a budget for detailed hydraulic modeling that included tidal influences, therefore, attempting to withhold a 100-year storm event is only a baseline start, however, the City may want to consider only holding for a lesser rain event.

*Jarbo Ditch*

As stated in **Section 2.4**, an existing condition steady state HEC-RAS analysis was conducted on Jarbo Ditch to understand the current LOS it provides its service area. An alternative analysis was not conducted on Jarbo Ditch, instead two viable scenarios were analyzed to provide a short term goal (Scenario 1) and long-term goal (Scenario 2) to increase the LOS provided by this ditch. A proposed conditions steady state HEC-RAS model was prepared for both scenarios and the flows applied to the existing conditions as presented in **Table 8** were also applied to these scenarios. As done with the existing conditions analysis,

a normal depth was assumed as the tailwater for the hydraulic analysis of both scenarios. This study can be further refined once a study for Jarbo Bayou is completed and proposed condition analysis can be meshed with the Jarbo Bayou model. Scenario 1 focused on the following:

- Increase LOS of Jarbo Ditch, starting 1,100 LF south of the FM 518 crossing and ending at the confluence of Jarbo Bayou
    - There is available undeveloped land south and north of this crossing.
- Upsize the FM 518 crossing.
    - The FM 518 crossing is currently a restrictor in the existing model which prevents a limited LOS.

Based on the analysis conducted for Scenario 1, a 25-year LOS was provided to the South Kemah area. This scenario requires the following:

- Acquire 50-feet of additional ROW, north of the FM 518 crossing.
    - The ROW would be acquired to the east of the existing ROW.
    - The proposed channel would be a trapezoidal earthen channel with a 30-foot bottom and a 100-foot top and 4:1 side slopes. It would also include a 20-foot maintenance berm.
- Acquire 40-feet of additional ROW, south of the FM 518 crossing.
    - The ROW acquisition would be limited from the FM 518 crossing to 1,100 LF south of the FM 518 crossing, just north of the existing City maintenance facility.
    - The proposed channel would be a trapezoidal earthen channel with a 25-foot bottom and a 90-foot top and 3:1 side slopes. It would also include a 20-foot maintenance berm.
- Install an additional 8-foot by 7-foot RCB at FM 518.
    - The existing dual 8-foot by 7-foot RCB would remain in place.
- Utility relocations would likely be necessary and a contingency amount was included in the opinion of probable cost.
- Inundation Maps for proposed improvements are shown in **Exhibit 6.9 – 6.14**.

The cost of Scenario 1, which includes land acquisition, is **$4,030,115**. A detailed cost breakdown can be found in **Appendix A**. Scenario 1 widens Jarbo Ditch, although it does not deepen Jarbo Ditch (see **Exhibit 6.8** for proposed ROW acquisition needed in Scenario 1). Based on current known information, Jarbo Ditch is currently at the lowest point and the flowline cannot be lowered. Until the Jarbo Bayou study is completed, it is not known if Jarbo Bayou may be dredged to gain additional depth. The City requested that LJA explore the opportunity of providing regional detention, as presented under South Kemah alternatives, north of the FM 518 crossing; however, due to the limited amount of land available the FM 518 crossing to widen the channel, conveying the full 100-year flow north of the crossing is not possible; therefore, widening the channel for regional detention would not provide any benefit. Also, regional detention this close to the coast can create additional concerns during storm surge events that may exacerbate flooding in the area. As discussed under Alternative 2 of South Kemah, LJA recommends further study that expands the scope of work to conduct a detailed hydraulic model of the area which includes regional detention and tidal influences.

Scenario 2 is a continuation of Jarbo Ditch improvements and assumes that Scenario 1 is built. Upstream of the Scenario 1 improvements, there are severe restrictions regarding available, undeveloped properties. Additionally, there is an elevated portion of land that cannot be used for drainage purposes and this poses additional challenges to accomplish a higher LOS within Jarbo Ditch. Furthermore, this elevated land restricts flows that overtop Jarbo Ditch from spreading to undeveloped land and rather

pushes flow towards developed properties in South Kemah. It is recommended that the City considers lowering this land, although this is not part of the recommendation for Scenario 2.

Scenario 2 requires the following:

- Acquire 60-feet of additional ROW within an existing 88-acre tract.
    - The county and the City own property and ROW within this scenario which allows for a reduction in land acquisition.
    - The channel would be a trapezoidal earthen channel with a 25-foot bottom and a top that ranges between 60 to 90-feet.
        - The reason for the variance is that the channel becomes a lot shallower, approximately 3-4-feet as just north of the 57-acre park.
    - This scenario does not consider any culverts needed within the corridor.
    - An assumption was made regarding potential utility relocations in the corridor, additional data is needed to formalize a plan.
- Inundation Maps for proposed improvements are shown in **Exhibit 6.15 – 6.20**.

The cost of Scenario 2, which includes land acquisition, is **$1,359,915**. A detailed cost breakdown can be found in **Appendix A**. Scenario 2 only widens Jarbo Ditch and does not deepen it (see **Exhibit 6.8** for proposed ROW acquisition needed in Scenario 2). As previously stated, Jarbo Ditch cannot be deepened unless a study of Jarbo Bayou reveals that Jarbo Bayou can and will be deepened which would allow for Jarbo Ditch to be deepened. Scenario 2 will also only provide a 25-year LOS to the Jarbo Ditch service area.

The total cost of Scenarios 1 and 2 is **$5,390,030** which includes a 30% contingency. Ultimately, if the City wishes to provide a 100-year LOS to the Jarbo Ditch service area, it is necessary to acquire additional land to allow for additional box culverts to be installed at the FM 518 crossing. Due to the current configuration of FM 518 and Jarbo Ditch, realignment of the Jarbo Ditch and possibly FM 518 would be required to further increase the capacity of the FM 518 culvert crossing. Even with ROW acquisition, the ROW is constrained, and land acquisition would need to consider the taking of a few properties in the Kemah Oaks subdivision that are adjacent to Jarbo Ditch.

A detailed preliminary engineering study will need to be conducted of Jarbo Ditch. Ultimately, the recommendations made in this MDP relied on limited data and the scope of work did not include the detailed level of modeling needed to fine tune the recommendation. The preliminary engineering study would likely explore a 1D/2D unsteady model, which would integrate the Jarbo Bayou model and create a more accurate representation of the Jarbo Ditch service area.

## 4.0 RECOMMENDATIONS

The following alternatives are recommended for each area:

*Bayview Acres*

Alternative 1 is recommended for the Bayview Acres area. Although larger outfalls will be required for Yacht Club North and Bay Ave, this alternative prevents the City from acquiring two separate drainage easements and reduces the amount of pipe that would need to be maintained. This recommended alternative allows for faster construction since only three (3) outfalls would be installed rather than 4 outfalls.

This alternative would provide a 100-year LOS for the Bayview Acres provided that future development includes detention to mitigate flows to existing conditions.

*Kemah Oaks*

Ultimately, Alternative 2 is recommended for the Kemah Oaks subdivision. This alternative expands the Bel Rd linear detention ditch southeast of the subdivision and would provide enough storage to avoid the installation of a stormwater pump station. The existing Kemah Oaks detention basin can be converted to a dry bottom. If the City wishes to proceed with this alternative, this alternative would require further design analysis during final design to analyze and design the overflow spillway, adjust outfalls and evaluate the interaction between the two detention facilities.

Alternative 4 was included in this MDP based on discussions with the City and short term "band-aid" fixes that could be implemented based on the available budget for the fiscal year. It is recommended that while Alternative 2 is ultimately implemented, Alternative 4 is pursued by the City to provide some relief to the Kemah Oaks area. As discussed in **Section 2.4**, Jarbo Ditch has a 5-year LOS, which has a direct impact to the Kemah Oaks subdivision, however, the emergency overflow would provide much needed relief to this area while the City seeks routes to implement the recommendation to improve Jarbo Ditch.

*South Kemah and Jarbo Ditch*

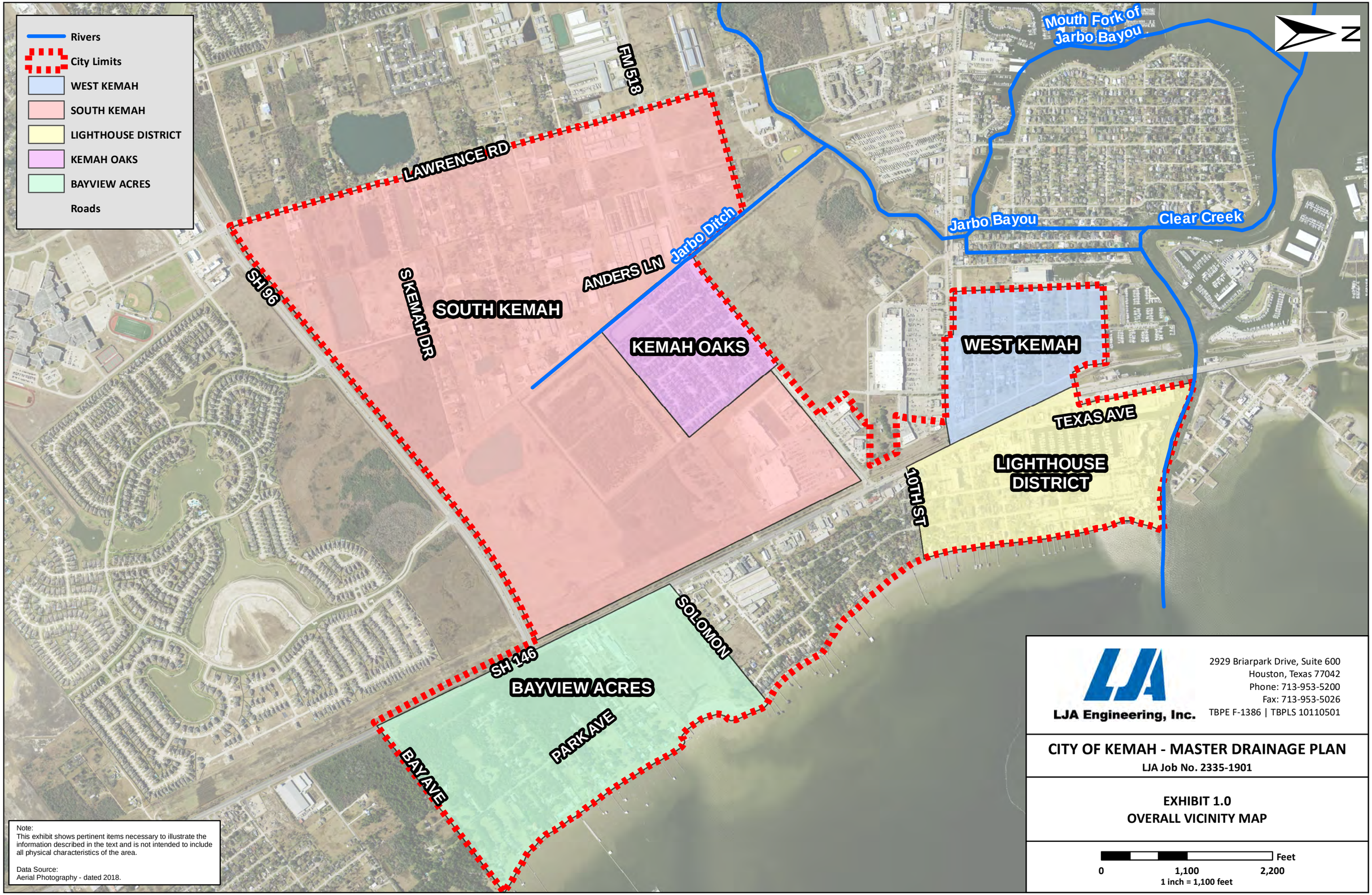
It is recommended that both Alternatives 1 and 2 are implemented for the South Kemah area. As noted, the area has undersized culverts and ditches that do not allow proper conveyance of stormwater to Jarbo Ditch. Additionally, the majority of lots that have been developed thus far within this area did not consider the increase in flows due to their development and constructing a regional detention basin to retro-actively hold the increase in flows prior to releasing to Jarbo Ditch, would help minimize the impact of Jarbo Ditch.

It is also recommended that Scenarios 1 and 2 are implemented for Jarbo Ditch to increase the conveyance capacity for the area and reduce the amount of ponding. Scenario 1 is presented as a short term solution, which would have the greatest impact in the area by increasing the conveyance through FM 518. Scenario 2 could then be implemented when additional funds are acquired. As mentioned previously, it is highly critical that the City conduct a preliminary engineering study of Jarbo Ditch and implement higher level modeling to finalize the recommended design. It will also be beneficial to understand the results and recommendations for Jarbo Bayou, prior to finalizing the recommendation for Jarbo Ditch. LJA recommends that the City allocate additional funds to conduct a proper study of the Jarbo Ditch watershed and incorporate the Jarbo Bayou model being created by League City. Ultimately, the improvements discussed for Scenario 1 and 2 do not incorporate the possible backwater effects from Jarbo Bayou and therefore, the recommendations may reflect a less than 100-year LOS.

*Lighthouse District and West Kemah*

It is recommended that they City continue implementing the recommendations made from previous studies in these two areas. LJA is continuing to investigate if there are critical areas that need immediate improvements to alleviate flooding issues. It is likely that quick fixes beyond the recommendations in the previous report are not available and the City needs to invest in re-constructing the storm sewer systems that are undersized. The City also needs to determine the LOS it wishes to provide in these areas, since these areas directly discharge to Clear Creek Channel or to Galveston Bay.

# EXHIBITS




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 1.0**
**OVERALL VICINITY MAP**

Feet
0 1,100 2,200
1 inch = 1,100 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 1.0 - Overall Vicinity Map.mxd

Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 1.1**
**BAYVIEW ACRES**
**VICINITY MAP**

Feet
0 500 1,000
1 inch = 500 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 1.1 - Bayview Acres Vicinity Map.mxd

Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 1.2 - Lighthouse District Vicinity Map.mxd

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 1.2
## LIGHTHOUSE DISTRICT
## VICINITY MAP

Feet
0 400 800
1 inch = 400 feet

Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

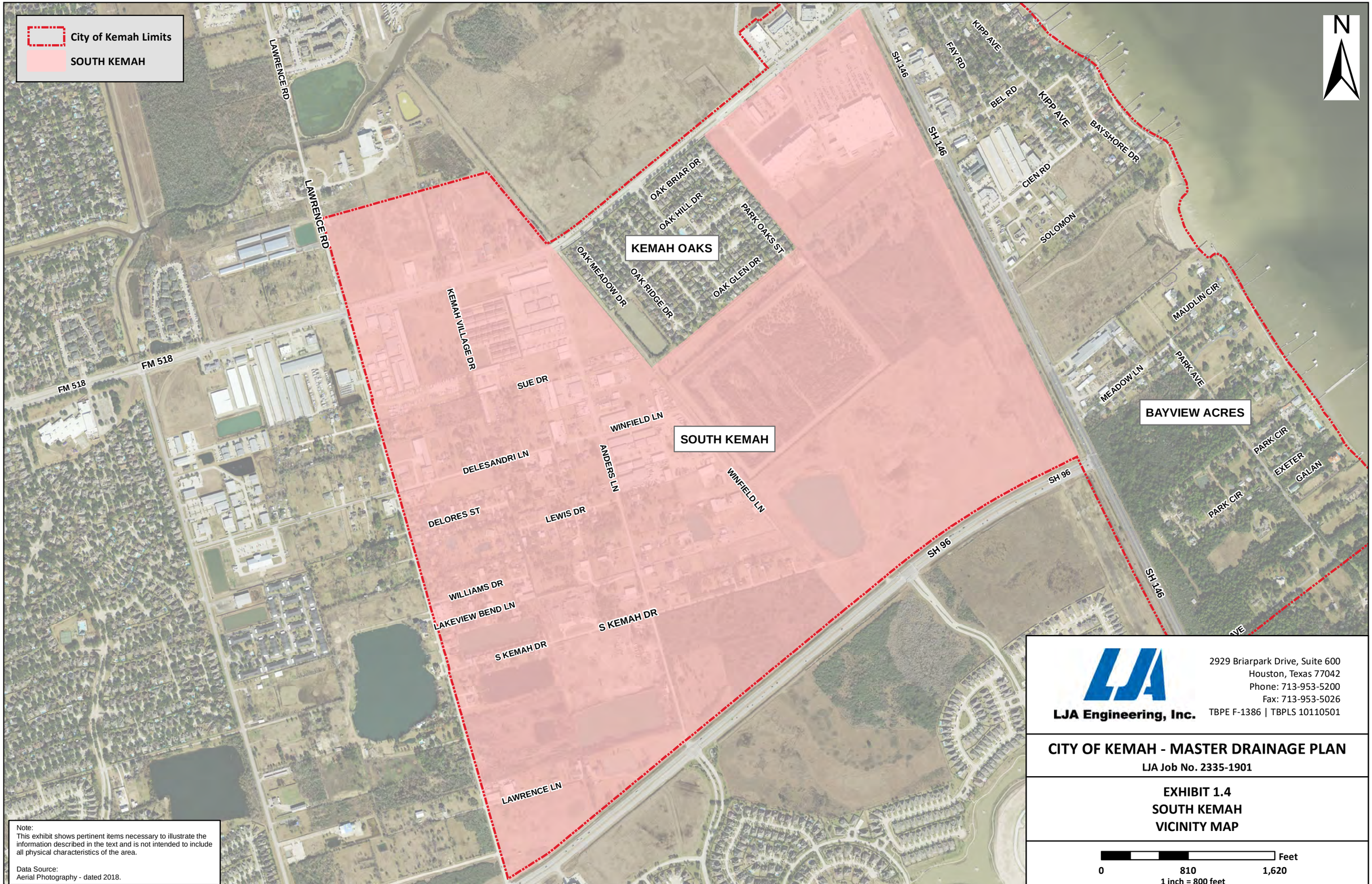
# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 1.3
## KEMAH OAKS
## VICINITY MAP

Feet
0 250 500
1 inch = 250 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 1.3 - Kemah Oaks Vicinity Map.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 1.4 - South Kemah Vicinity Map.mxd

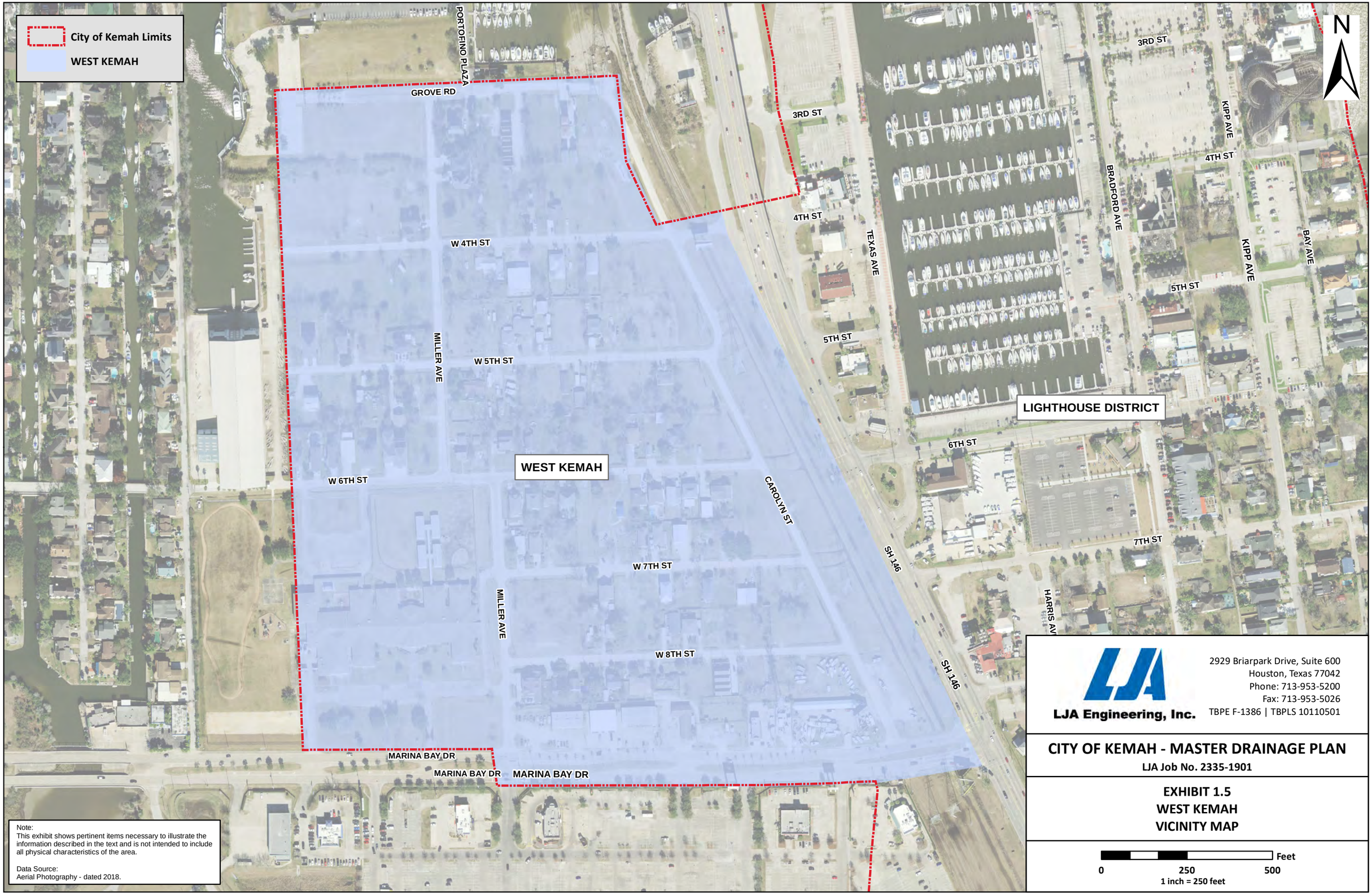
LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 1.4
## SOUTH KEMAH
## VICINITY MAP

Feet
0 810 1,620
1 inch = 800 feet




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

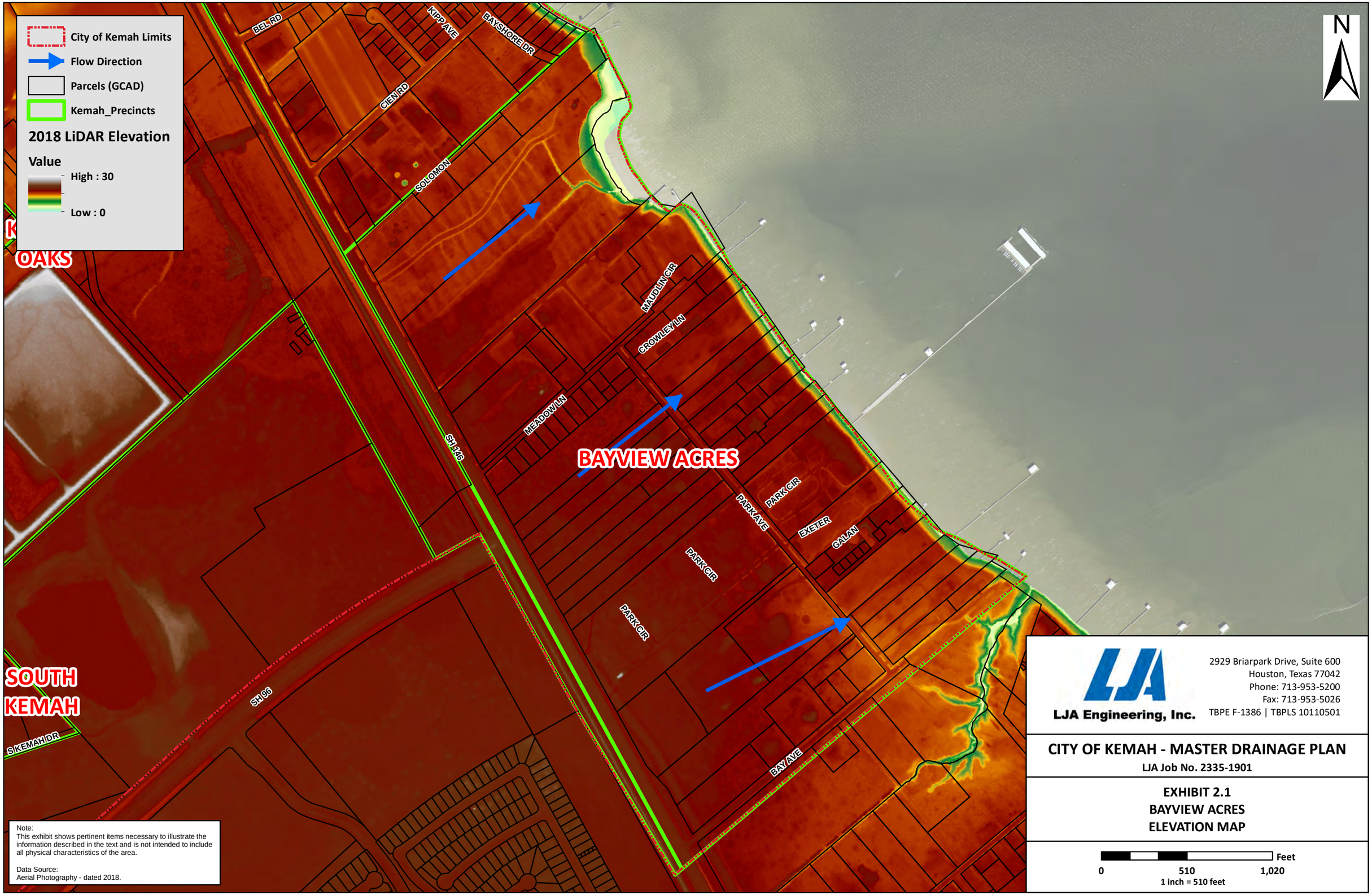
# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 1.5
## WEST KEMAH
## VICINITY MAP

Feet
0 250 500
1 inch = 250 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 1.5 - West Kemah Vicinity Map.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

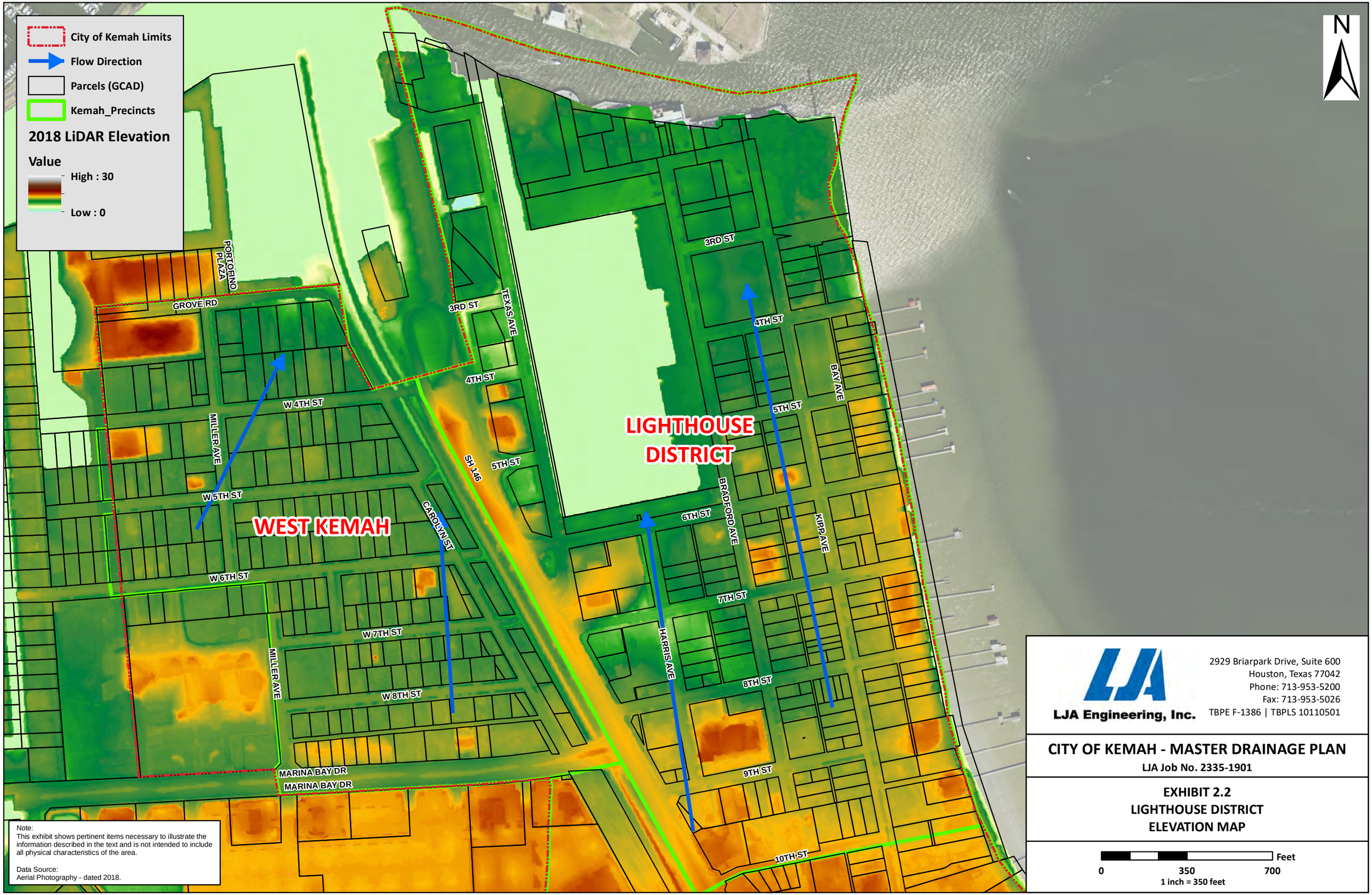
# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 2.1
## BAYVIEW ACRES
## ELEVATION MAP

Feet
0 510 1,020
1 inch = 510 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 2.1 - Bayview Acres Elevation Map.mxd




J:\2335\19011\DOC\EXHIBITS\GIS\Exhibit 2.2 - Lighthouse District Elevation Map.mxd

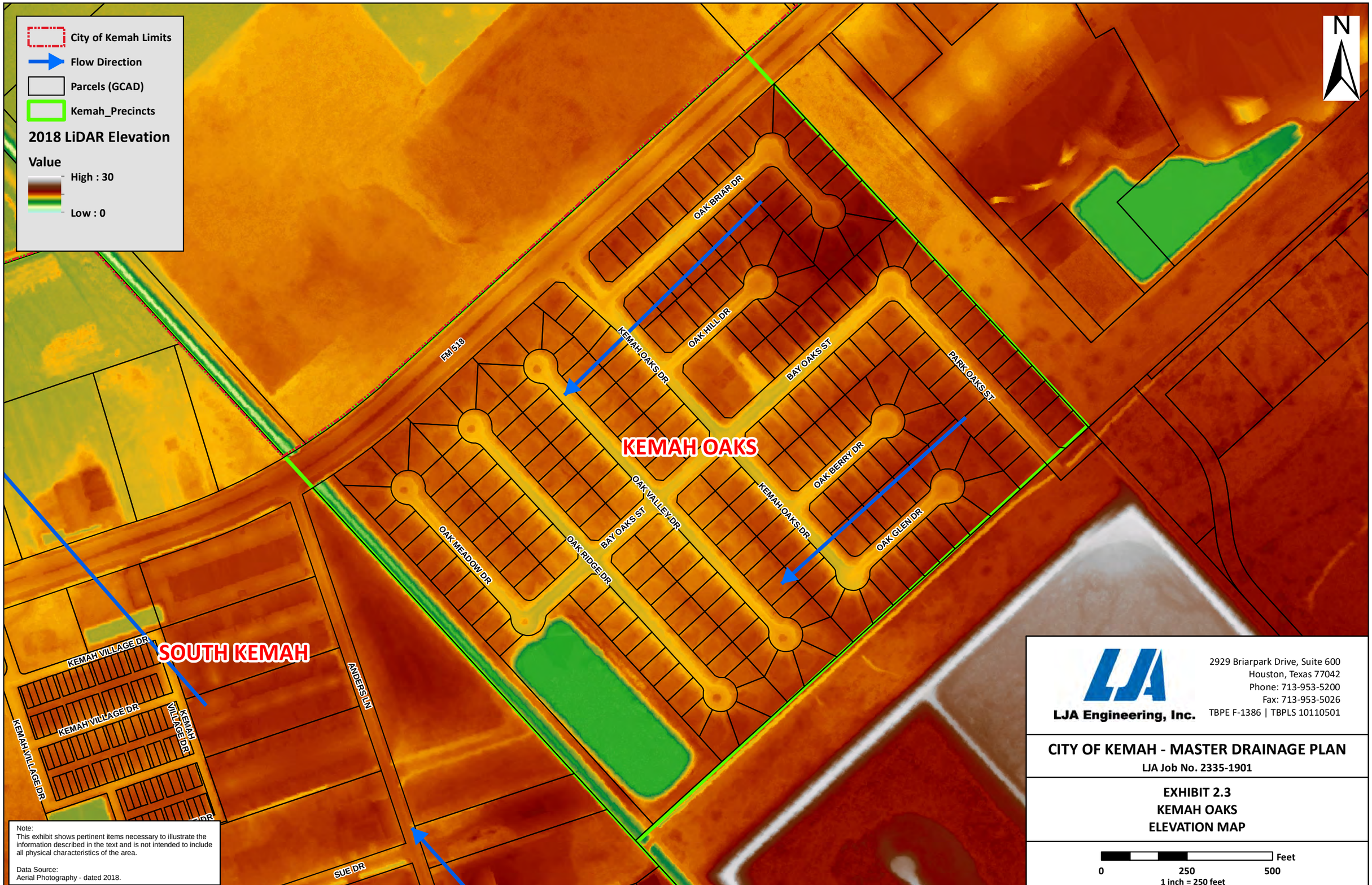
LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 2.2
## LIGHTHOUSE DISTRICT
## ELEVATION MAP

Feet
0 350 700
1 inch = 350 feet




LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

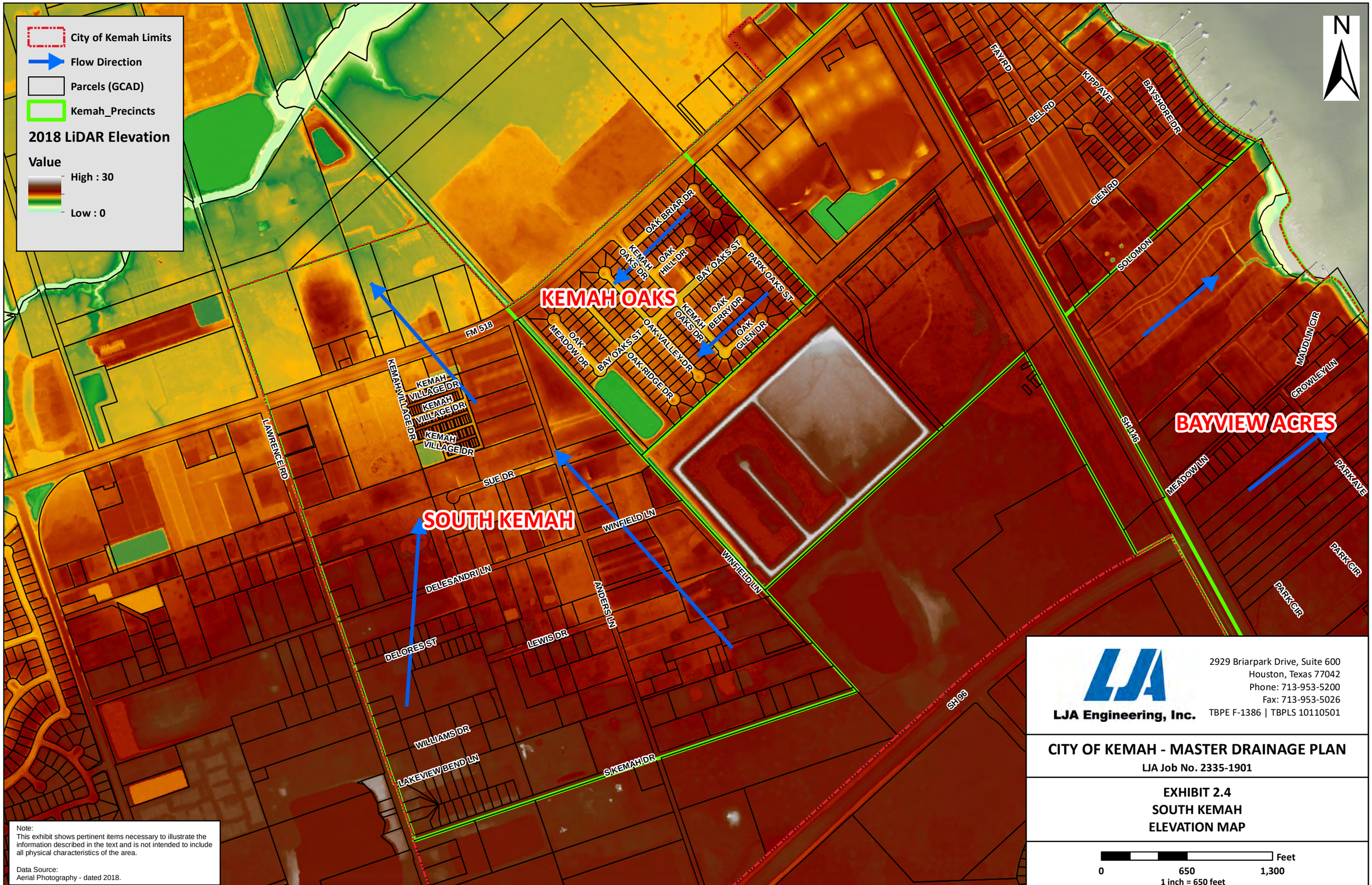
# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 2.3
## KEMAH OAKS
## ELEVATION MAP

Feet
0 250 500
1 inch = 250 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 2.3 - Kemah Oaks Elevation Map.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

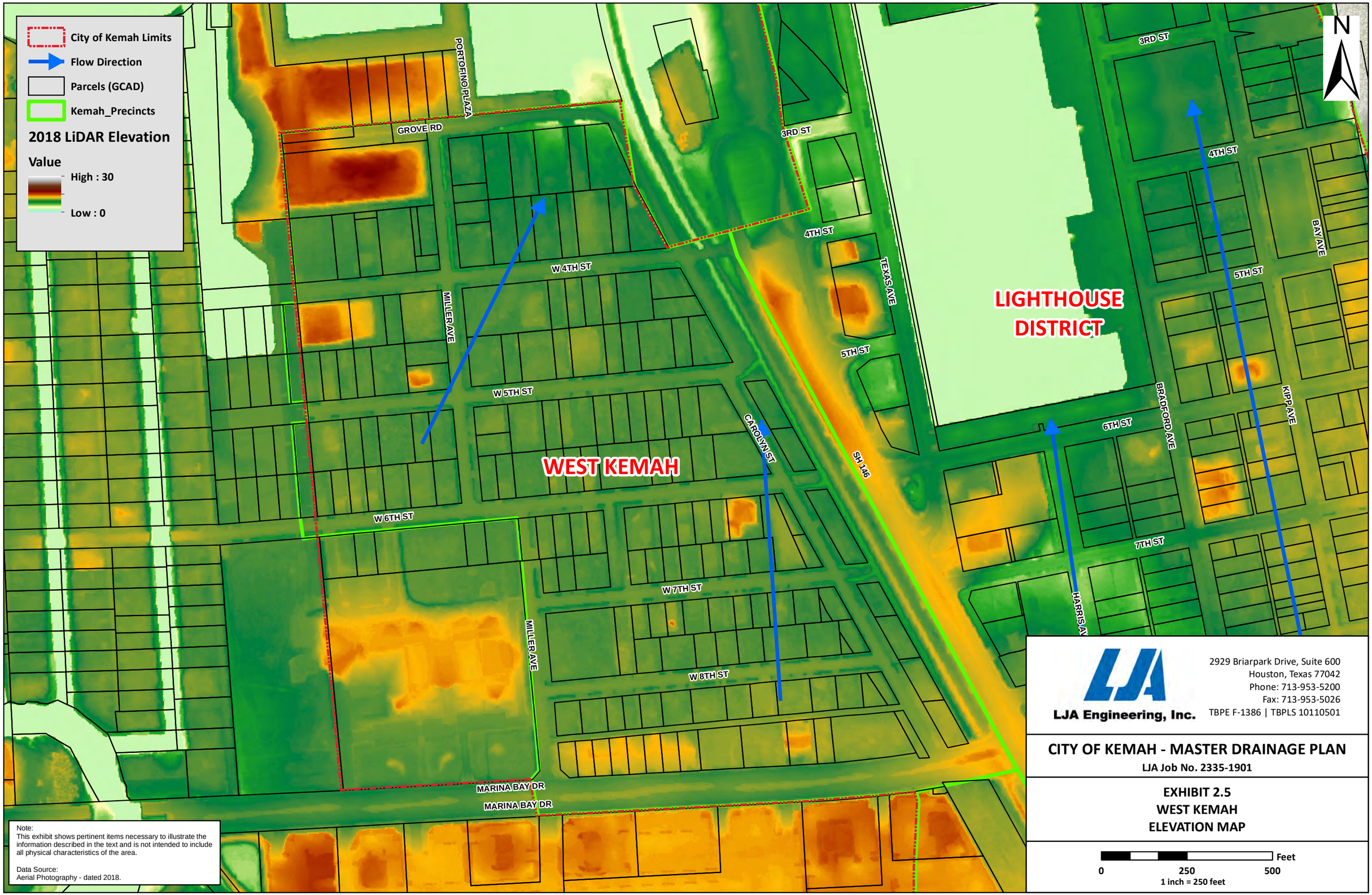
# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 2.4
## SOUTH KEMAH
## ELEVATION MAP

Feet
0 650 1,300
1 inch = 650 feet

J:\2335\1901\DOC\EXHIBIT\GIS\Exhibit 2.4 - South Kemah Elevation Map.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 2.5 - West Kemah Elevation Map.mxd

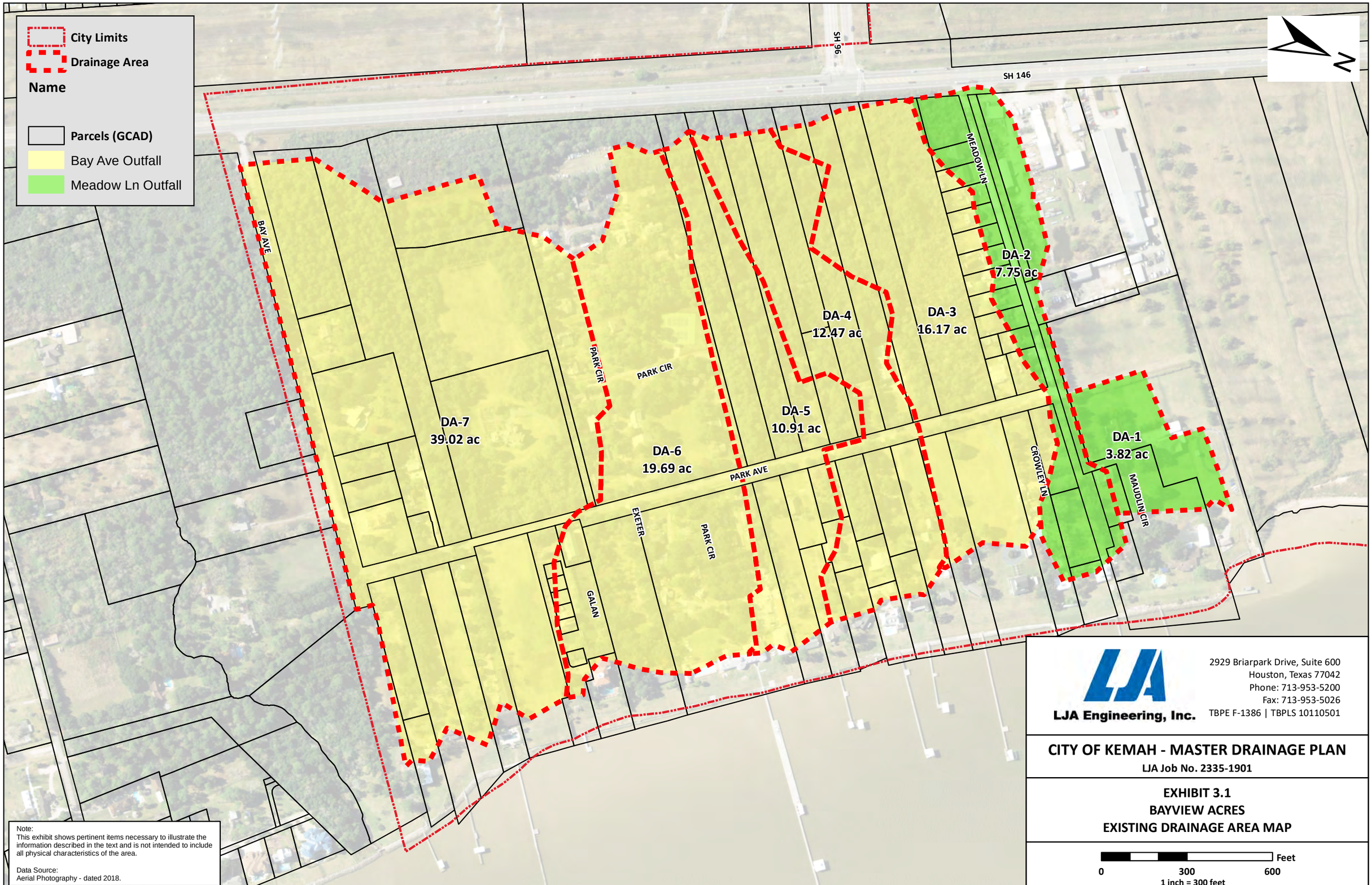
LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 2.5**
**WEST KEMAH**
**ELEVATION MAP**

0 250 500 Feet
1 inch = 250 feet




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

**CITY OF KEMAH - MASTER DRAINAGE PLAN**

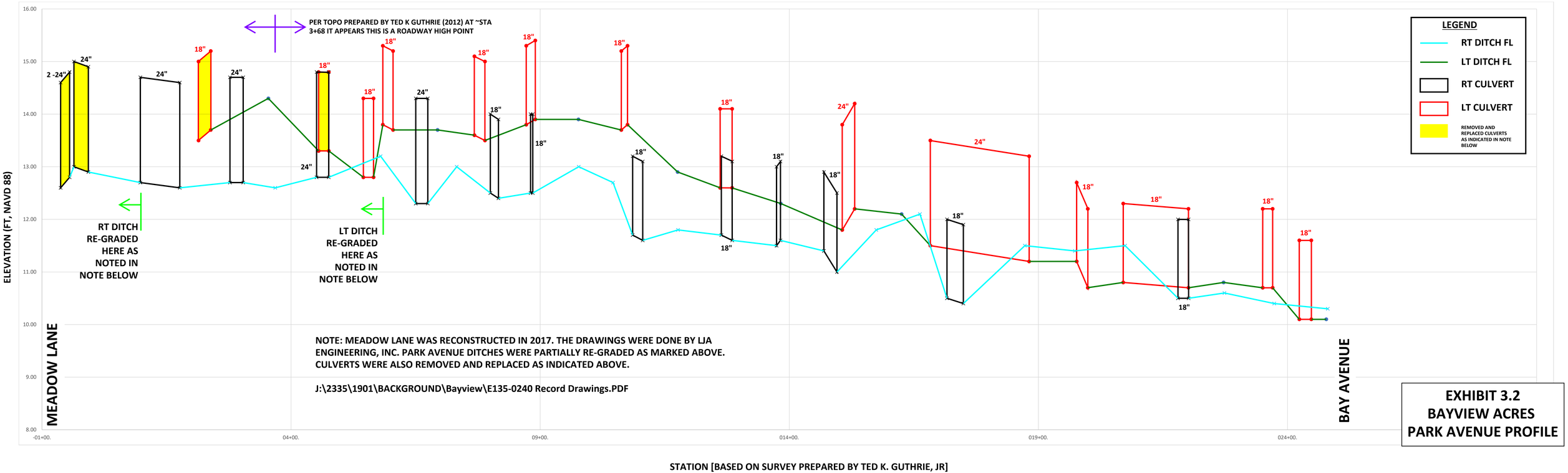
**LJA Job No. 2335-1901**

**EXHIBIT 3.1**
**BAYVIEW ACRES**
**EXISTING DRAINAGE AREA MAP**

Feet
0 300 600
1 inch = 300 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 3.1 - Bayview Acres - Drainage Area Map.mxd

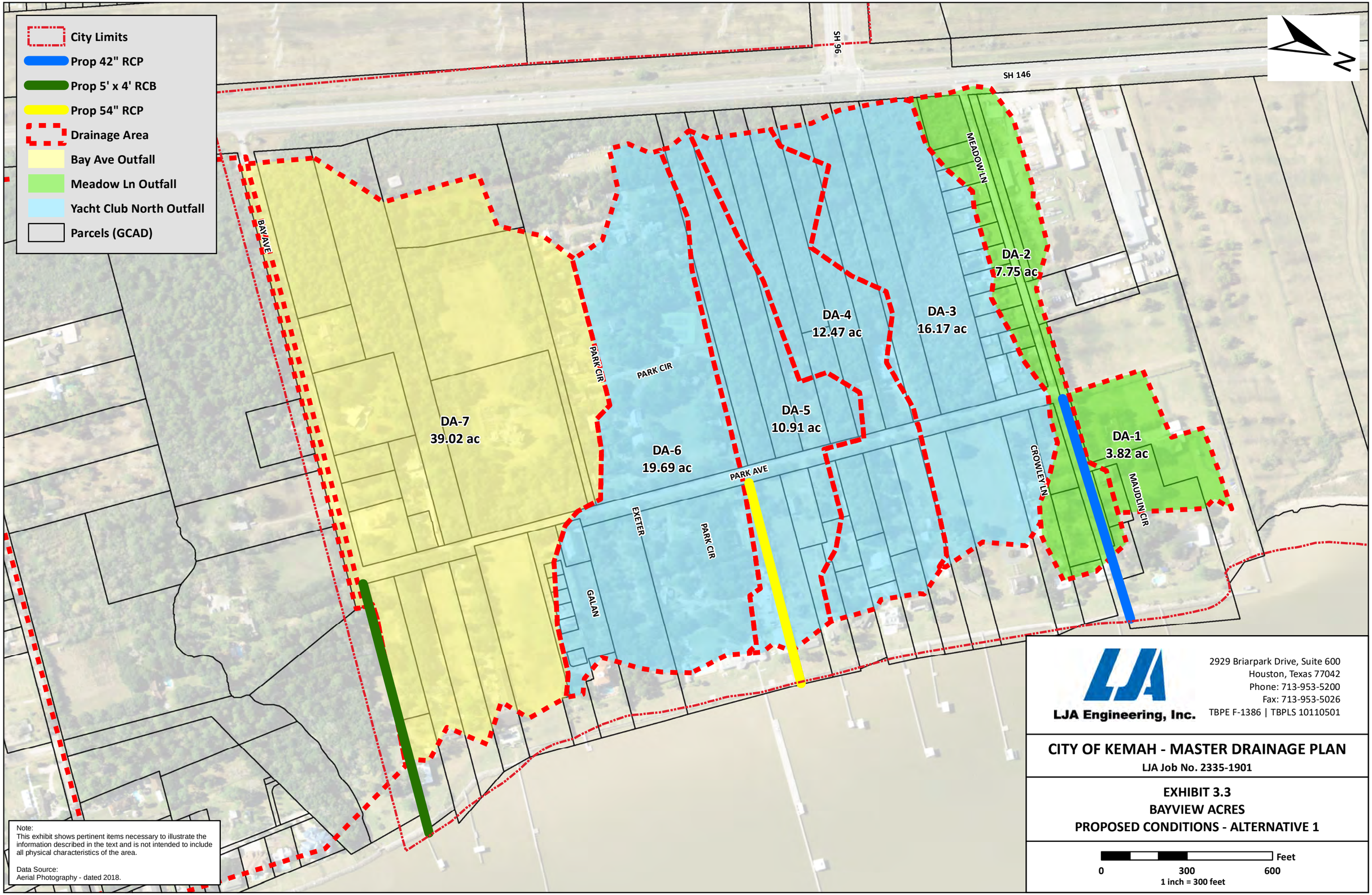
# PARK AVENUE

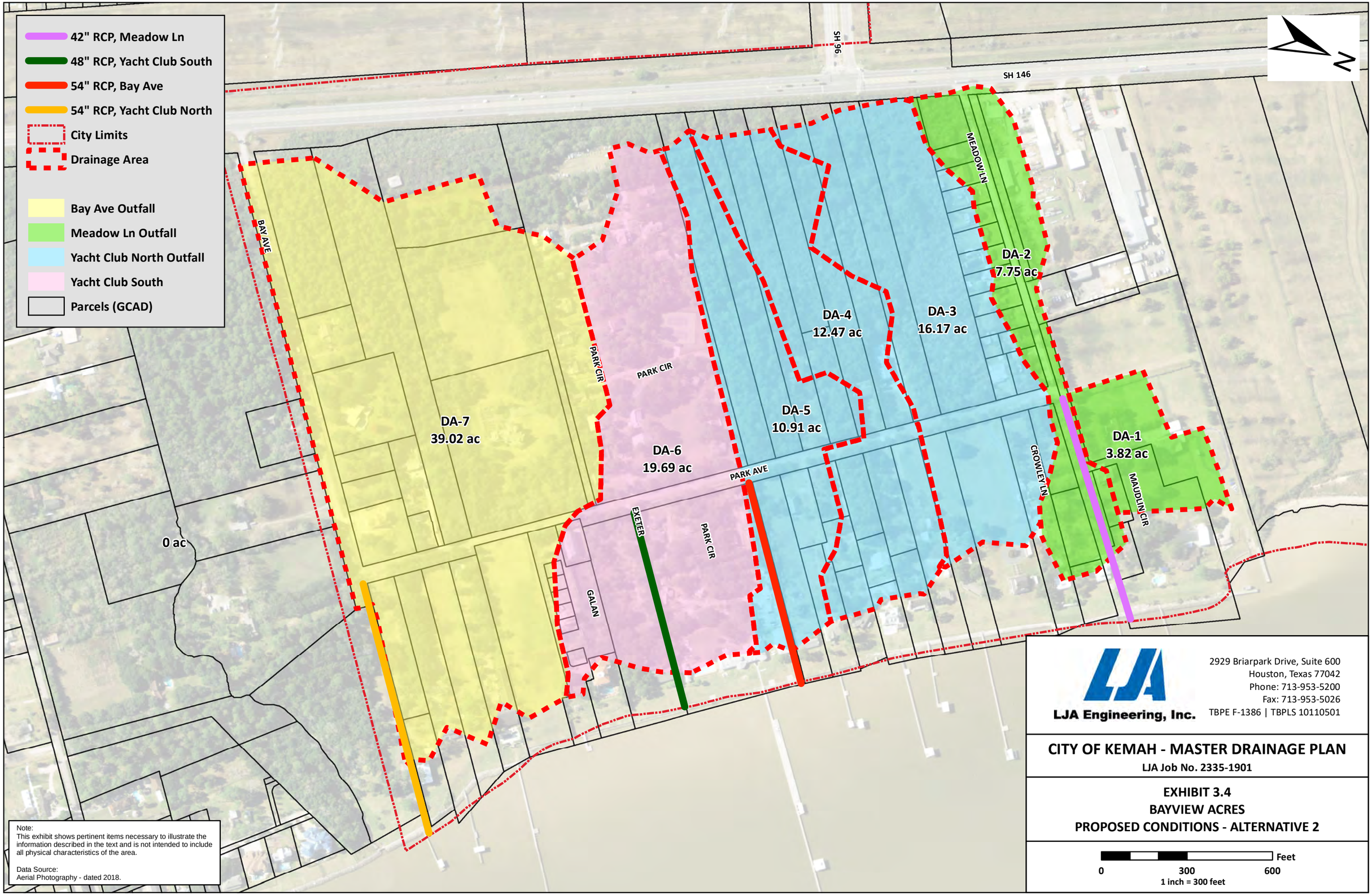



NOTE: MEADOW LANE WAS RECONSTRUCTED IN 2017. THE DRAWINGS WERE DONE BY LJA ENGINEERING, INC. PARK AVENUE DITCHES WERE PARTIALLY RE-GRADED AS MARKED ABOVE. CULVERTS WERE ALSO REMOVED AND REPLACED AS INDICATED ABOVE.

J:\2335\1901\BACKGROUND\Bayview\E135-0240 Record Drawings.PDF

**EXHIBIT 3.2**
**BAYVIEW ACRES**
**PARK AVENUE PROFILE**


City Limits
Prop 42" RCP
Prop 5' x 4' RCB
Prop 54" RCP
Drainage Area
Bay Ave Outfall
Meadow Ln Outfall
Yacht Club North Outfall
Parcels (GCAD)
SH 96
SH 146
BAY AVE
PARK CIR
PARK AVE
EXETER
GALAN
MEADOW LN
CROWLEY LN
MAUDLIN CIR
DA-1
3.82 ac
DA-2
7.75 ac
DA-3
16.17 ac
DA-4
12.47 ac
DA-5
10.91 ac
DA-6
19.69 ac
DA-7
39.02 ac
Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.
Data Source:
Aerial Photography - dated 2018.
LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501
CITY OF KEMAH - MASTER DRAINAGE PLAN
LJA Job No. 2335-1901
EXHIBIT 3.3
BAYVIEW ACRES
PROPOSED CONDITIONS - ALTERNATIVE 1
Feet
0
300
600
1 inch = 300 feet
J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 3.3 - Bayview Acres - Proposed Conditions - Alternative 1.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

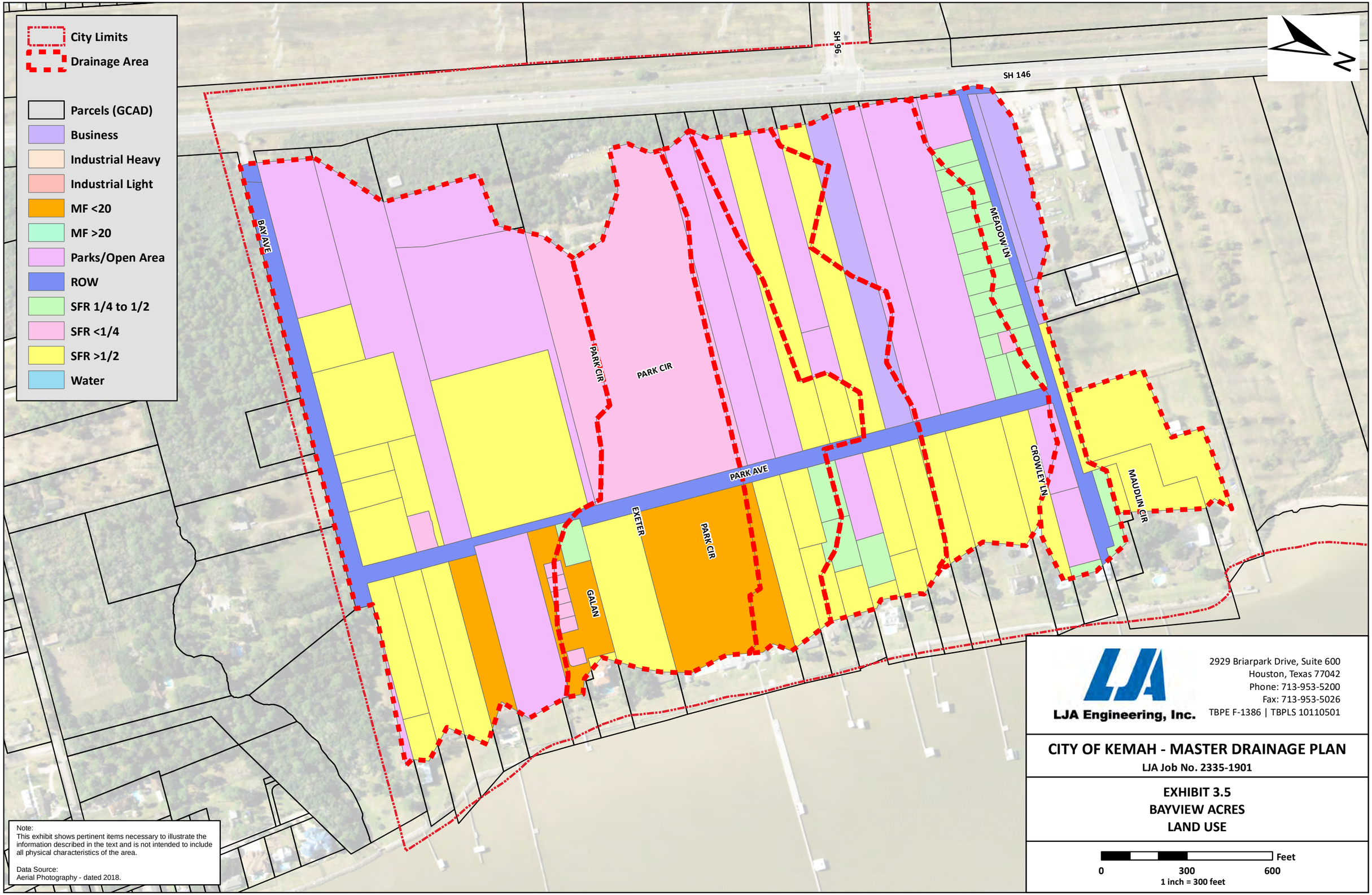
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 3.4**
**BAYVIEW ACRES**
**PROPOSED CONDITIONS - ALTERNATIVE 2**

Feet
0 300 600
1 inch = 300 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 3.4 - Bayview Acres - Proposed Conditions - Alternative 2.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 3.5 - Bayview Acres - Land Use.mxd

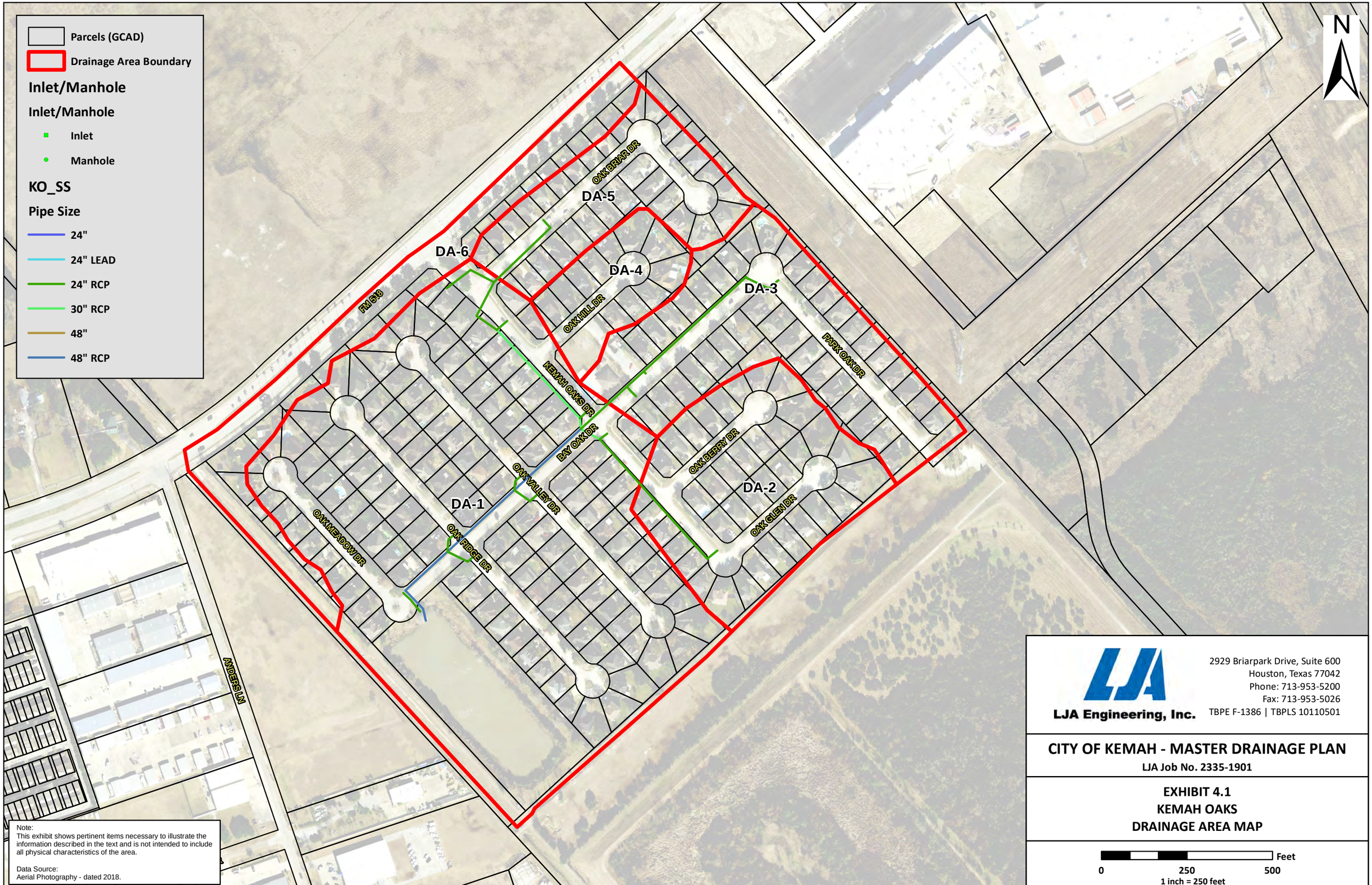
LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 3.5
## BAYVIEW ACRES
## LAND USE

Feet
0 300 600
1 inch = 300 feet




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

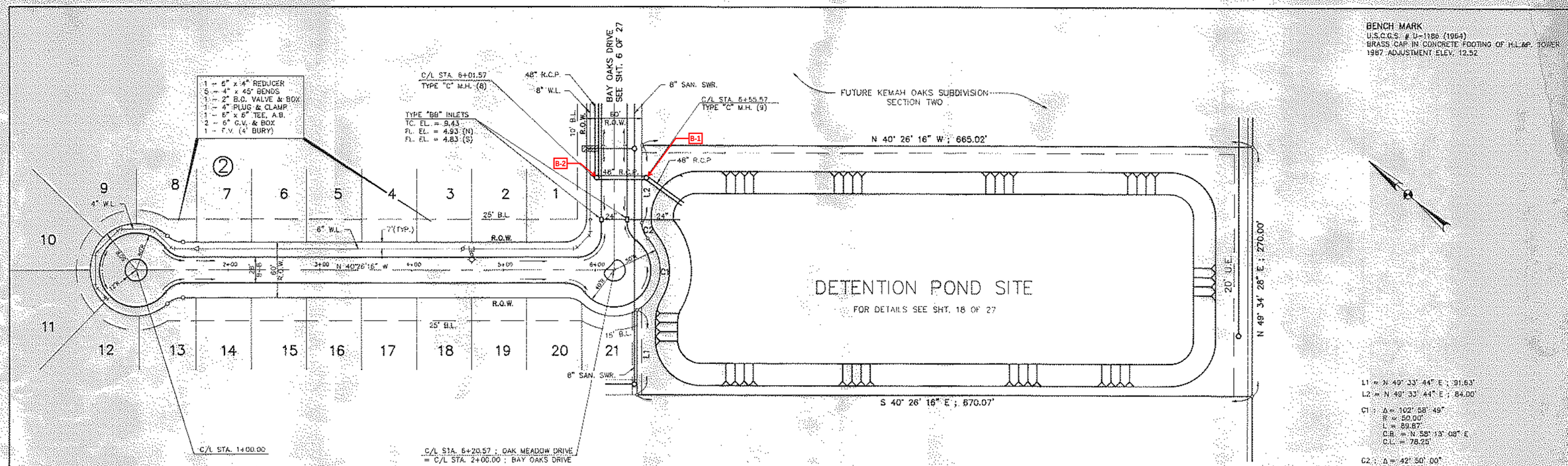
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 4.1**
**KEMAH OAKS**
**DRAINAGE AREA MAP**

Feet
0 250 500
1 inch = 250 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 4.1 - Kemah Oaks Drainage Area Map.mxd




BENCH MARK
U.S.C.G.S. # U-1188 (1954)
BRASS CAP IN CONCRETE FOOTING OF H.L.&P. TOWER
1987 ADJUSTMENT ELEV. 12.52

L1 = N 49° 33' 44" E ; 91.63'
L2 = N 49° 33' 44" E ; 84.00'

C1 : Δ = 102° 58' 49"
R = 50.00'
L = 89.87'
C.B. = N 58° 13' 08" E
C.L. = 78.25'

C2 : Δ = 42° 50' 00"
R = 25.00'
L = 18.69'
C.B. = N 26° 08' 44" E
C.L. = 18.26'

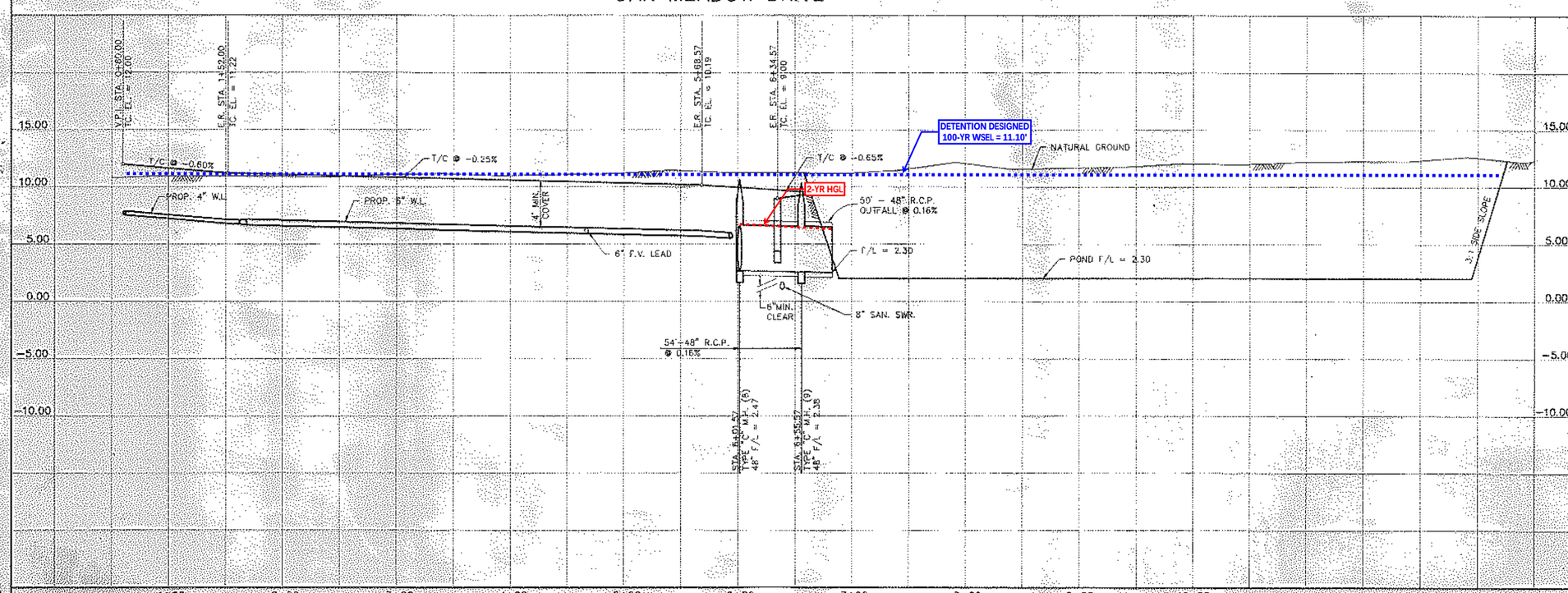



**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 1 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

**THIS EXHIBIT IS NOT TO SCALE**

CENTURY ENGINEERING, INC.
9950 WESTPARK, SUITE 200, HOUSTON, TEXAS 77063 (713) 780-9871

CITY OF KEMAH
KEMAH OAKS SUBDIVISION, SECTION ONE
GALVESTON COUNTY TEXAS
PLAN & PROFILE
OAK MEADOW DRIVE
STA. 1+00.00 TO STA. END

| | | |
|---|---|---|
| File Name: ED1.DWG | Scale: HORIZ. 1"=50' VERT. 1"=5' | Date: FEB. 1992 |
| Designed By: | Checked By: | Job No. 91016-00.0 |
| Drawn By: | Approved By: | Sheet 5 of 27 |

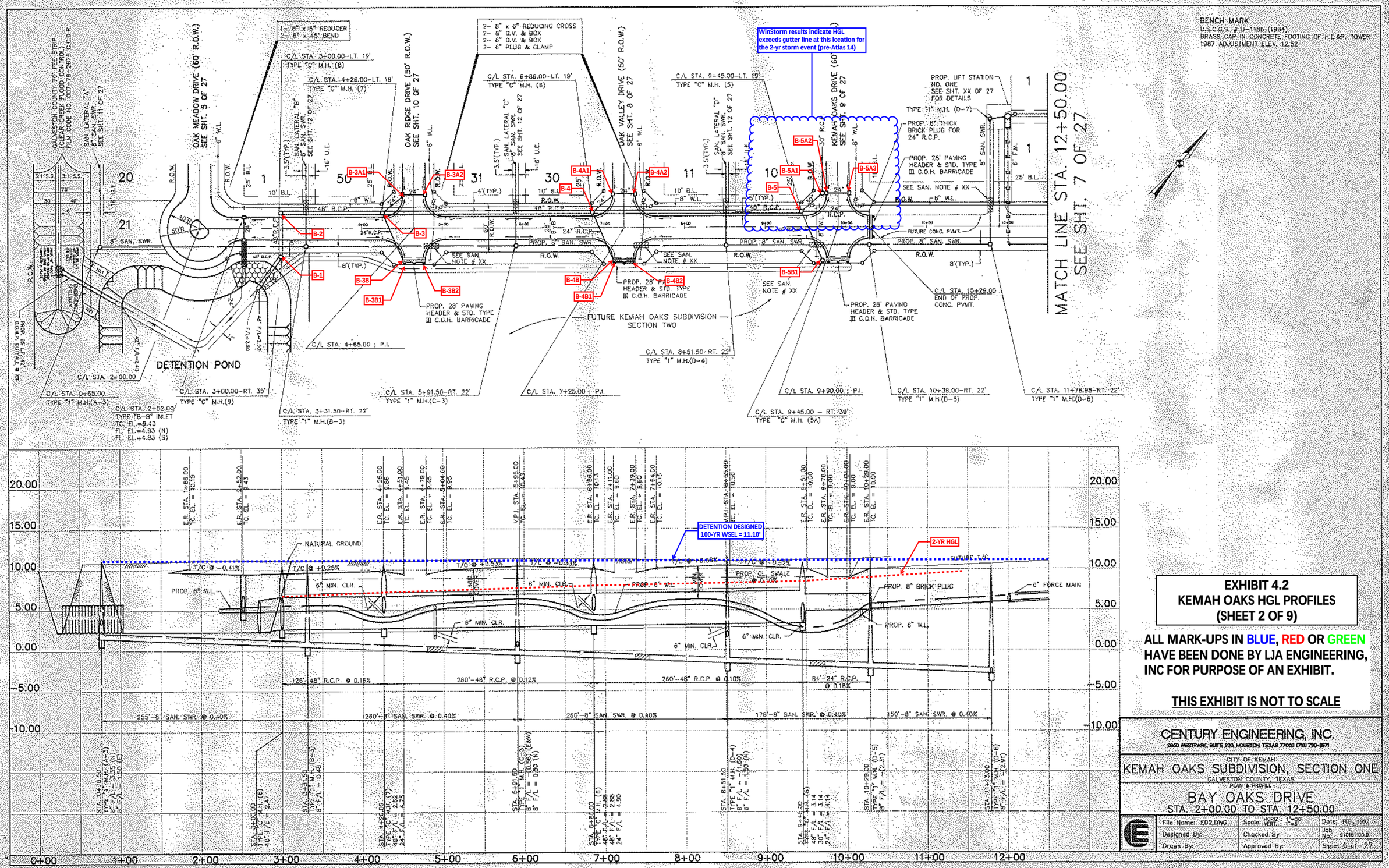



**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 2 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

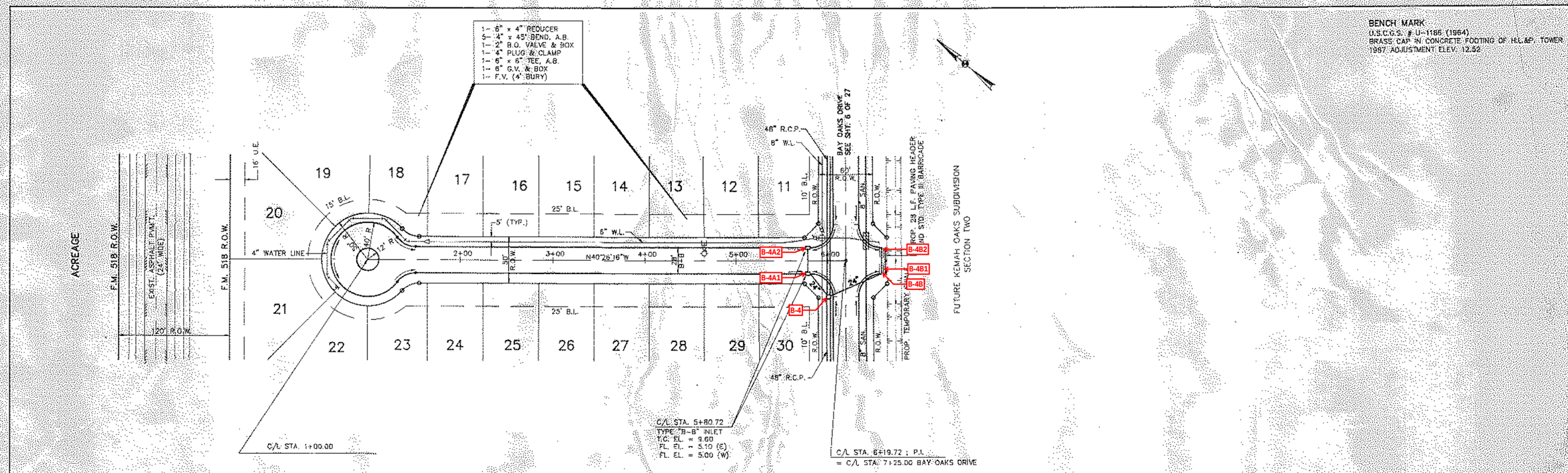
**THIS EXHIBIT IS NOT TO SCALE**

CENTURY ENGINEERING, INC.
9950 WESTPARK, SUITE 200, HOUSTON, TEXAS 77063 (713) 780-8671

CITY OF KEMAH
KEMAH OAKS SUBDIVISION, SECTION ONE
GALVESTON COUNTY, TEXAS
PLAN & PROFILE
BAY OAKS DRIVE
STA. 2+00.00 TO STA. 12+50.00

| | | |
|---|---|---|
| File Name: ED2.DWG | Scale: HORIZ.: 1"=50' VERT.: 1"=5' | Date: FEB. 1992 |
| Designed By: | Checked By: | Job No. 91016-00.0 |
| Drawn By: | Approved By: | Sheet 6 of 27 |

BENCH MARK
U.S.C.G.S. # U-1186 (1964)
BRASS CAP IN CONCRETE FOOTING OF H.L.&P. TOWER
1987 ADJUSTMENT ELEV. 12.52



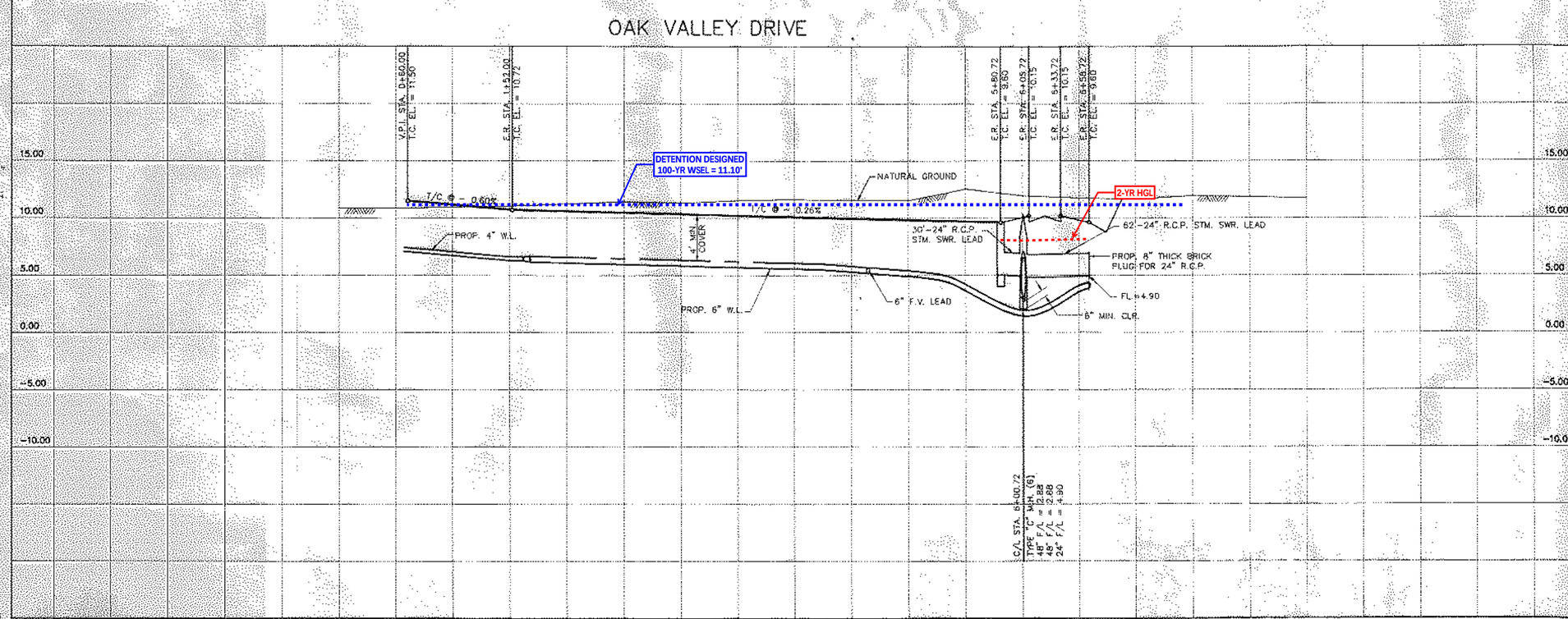




**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 3 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

**THIS EXHIBIT IS NOT TO SCALE**

CENTURY ENGINEERING, INC.
9950 WESTPARK, SUITE 200, HOUSTON, TEXAS 77063 (713) 790-1871

CITY OF KEMAH
KEMAH OAKS SUBDIVISION, SECTION ONE
GALVESTON COUNTY, TEXAS
PLAN & PROFILE
OAK VALLEY DRIVE
STA. 1+00.00 TO STA. 6+19.72

| | | |
|---|---|---|
| File Name: ED5.DWG | Scale: HORIZ. 1"=50 VERT. 1"=5 | Date: FEB., 1992 |
| Designed By: | Checked By: | Job No. 91016-00.0 |
| Drawn By: | Approved By: | Sheet 8 of 27 |

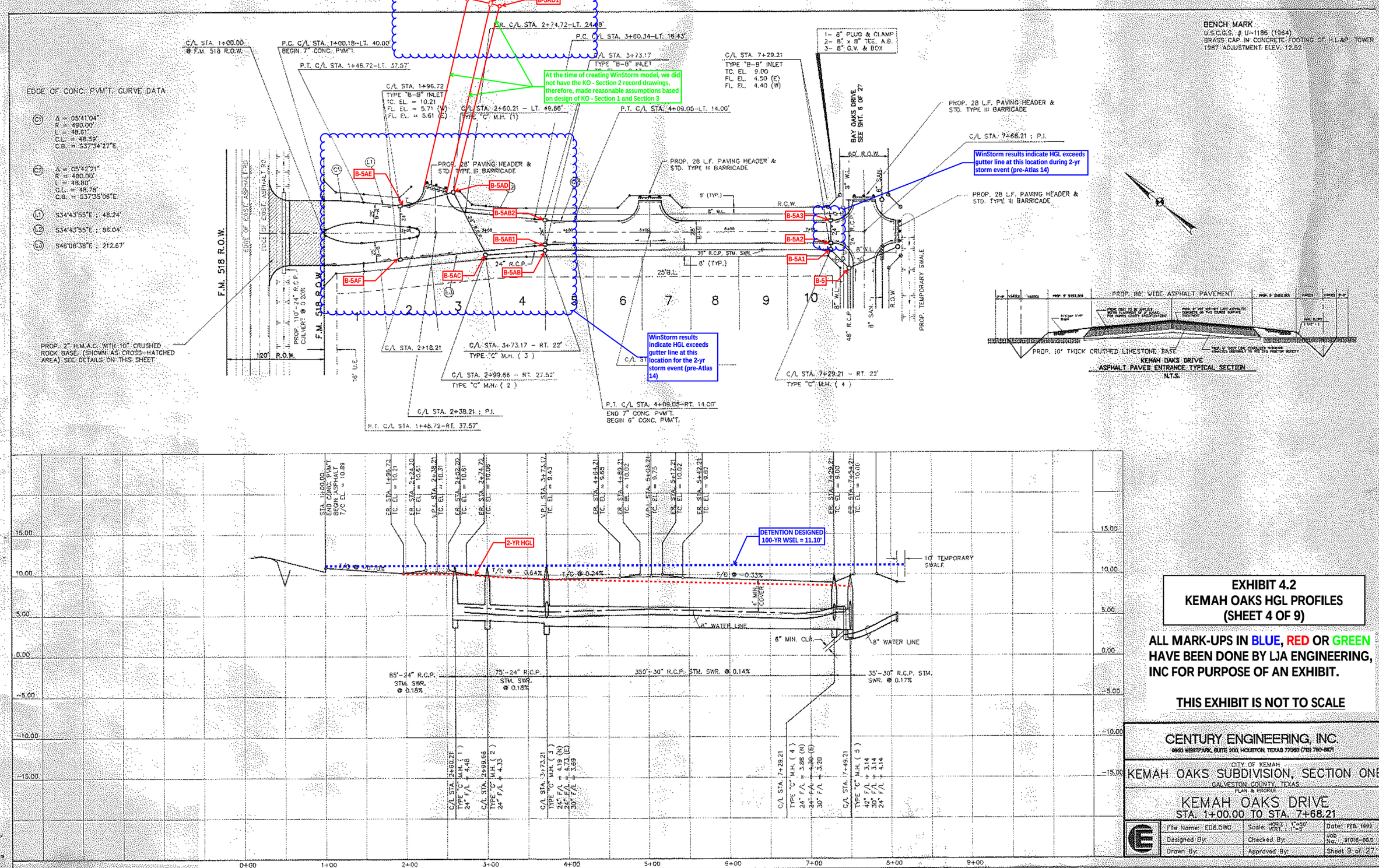



**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 4 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

**THIS EXHIBIT IS NOT TO SCALE**

CENTURY ENGINEERING, INC.
9990 WESTPARK, SUITE 200, HOUSTON, TEXAS 77063 (713) 780-8871

CITY OF KEMAH
KEMAH OAKS SUBDIVISION, SECTION ONE
GALVESTON COUNTY, TEXAS
PLAN & PROFILE
KEMAH OAKS DRIVE
STA. 1+00.00 TO STA. 7+68.21

| | | |
|---|---|---|
| File Name: ED6.DWG | Scale: HORIZ. 1"=30' VERT. 1"=3' | Date: FEB. 1992 |
| Designed By: | Checked By: | Job No.: 9108-00.0 |
| Drawn By: | Approved By: | Sheet 9 of 27 |

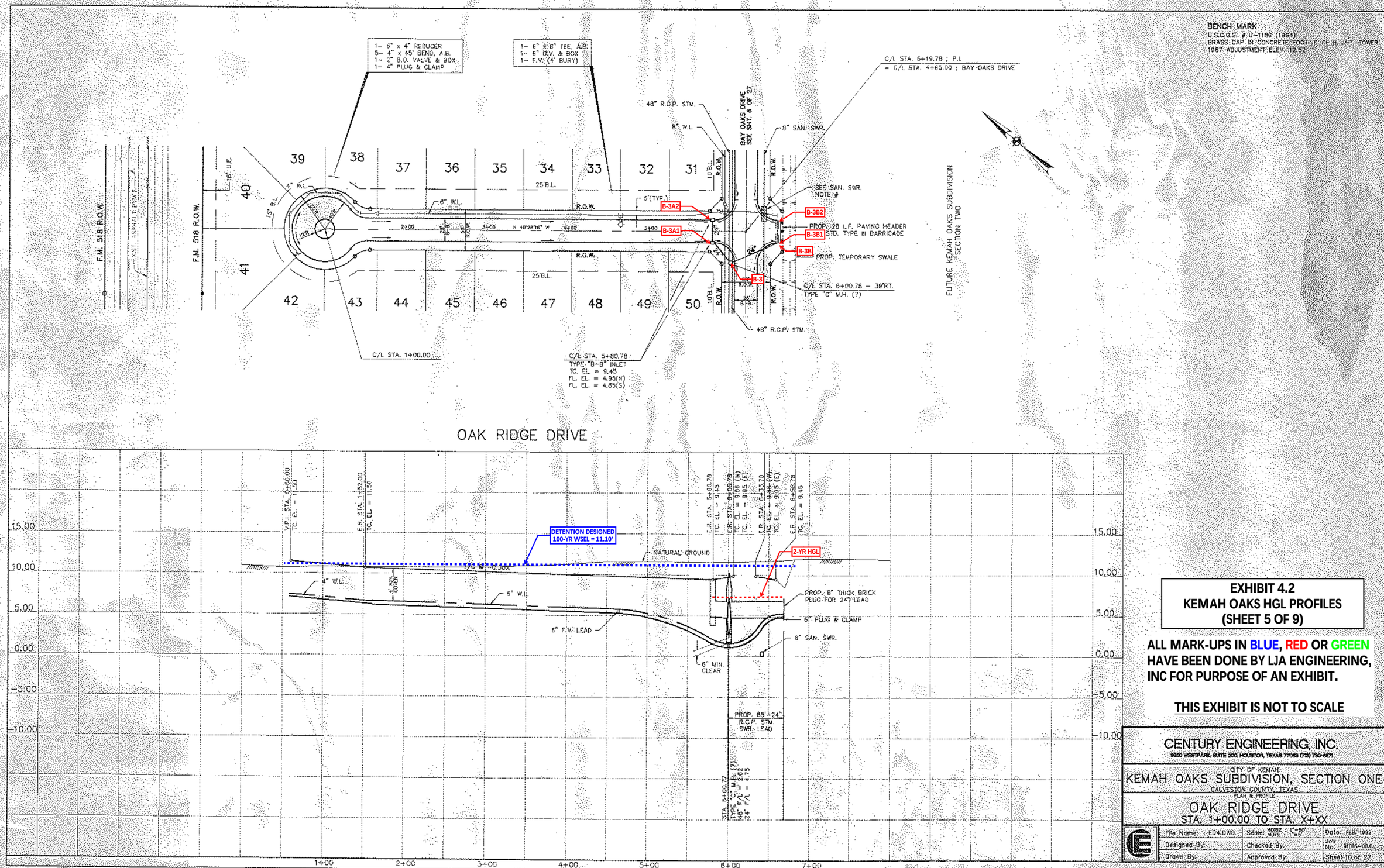



**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 5 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

**THIS EXHIBIT IS NOT TO SCALE**

CENTURY ENGINEERING, INC.
9820 WESTPARK, SUITE 200, HOUSTON, TEXAS 77063 (713) 780-8671

CITY OF KEMAH
KEMAH OAKS SUBDIVISION, SECTION ONE
GALVESTON COUNTY, TEXAS
PLAN & PROFILE

OAK RIDGE DRIVE
STA. 1+00.00 TO STA. X+XX

| | | |
|---|---|---|
| File Name: ED4.DWG | Scale: HORIZ. 1"=50' VERT. 1"=5' | Date: FEB. 1992 |
| Designed By: | Checked By: | Job No. 91016-00.0 |
| Drawn By: | Approved By: | Sheet 10 of 27 |

BENCH MARK
U.S.C.G.S. # U-1186 (1964)
BRASS CAP IN CONCRETE FOOTING OF H.L. & P. TOWER
1987 ADJUSTMENT ELEV. 12.52

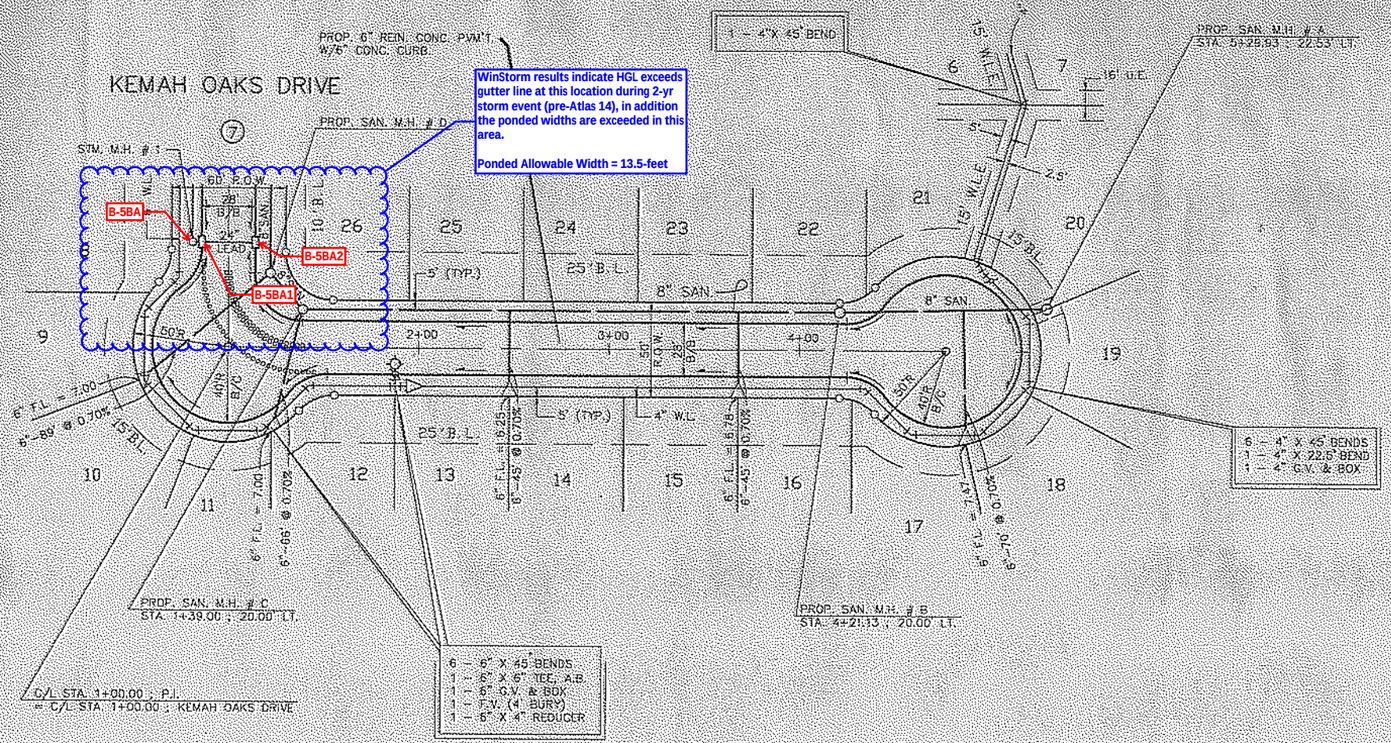
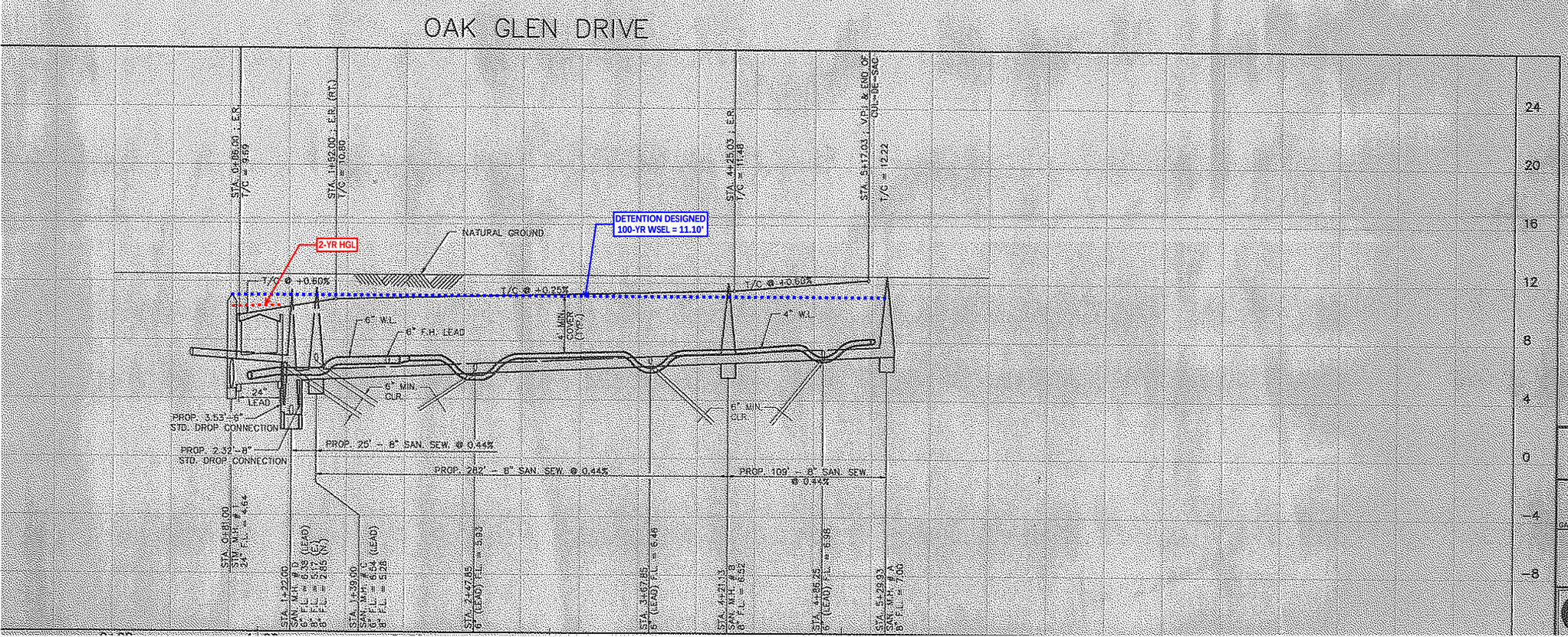



**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 6 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

**THIS EXHIBIT IS NOT TO SCALE**




NOTICE
AT LEAST 48 HOURS BEFORE EXCAVATING IN STREET R.O.W. OR EASEMENTS CALL THE UTILITY COORDINATING COMMITTEE 1-800-669-8344

PRIVATE UTILITY LINES SHOWN

ENTEX, INC.

G.T.E. TELEPHONE COMPANY
VALID FOR ONE YEAR ONLY

HOUSTON LIGHTING & POWER CO.
APPROVAL ONLY FOR ORIGINAL UNDERGROUND FACILITIES UNDERGROUNDED
VALID FOR ONE YEAR ONLY

CITY OF KEMAH, TEXAS

FRANK JONES
DIRECTOR OF PUBLIC WORKS

BEN BLACKLEDGE
MAYOR

CENTURY ENGINEERING, INC.
3330 S. DESIGNER, SUITE 100, HOUSTON, TEXAS 77063 (713) 780-8571

CITY OF KEMAH
KEMAH OAKS SUBDIVISION
SECTION THREE
GALVESTON COUNTY TEXAS

PLAN & PROFILE
OAK GLEN DRIVE
STA. 0+00 TO STA. 5+17.03

| | | |
|---|---|---|
| File Name: PP1.DWG | Scale: HORZ. 1"=40' VERT. 1"=4' | Date: AUGUST 1984 |
| Designed By: KMA | Checked By: KSS | Job No.: 91006-10.0 |
| Drawn By: KMA & LJ | Approved By: KSS | Sheet 6 of 15 |

U.S.C.G.S. # U-1186 (1954)
BRASS CAP IN CONCRETE FOOTING OF H.L. & P. TOWER
1987 ADJUSTMENT ELEV. 12.52

WinStorm results indicate HGL exceeds gutter line at this location during 2-yr storm event (pre-Atlas 14), in addition the ponded widths are exceeded in this area.

Ponded Allowable Width = 13.5-feet

WinStorm results indicate HGL exceeds gutter line at this location during 2-yr storm event (pre-Atlas 14).

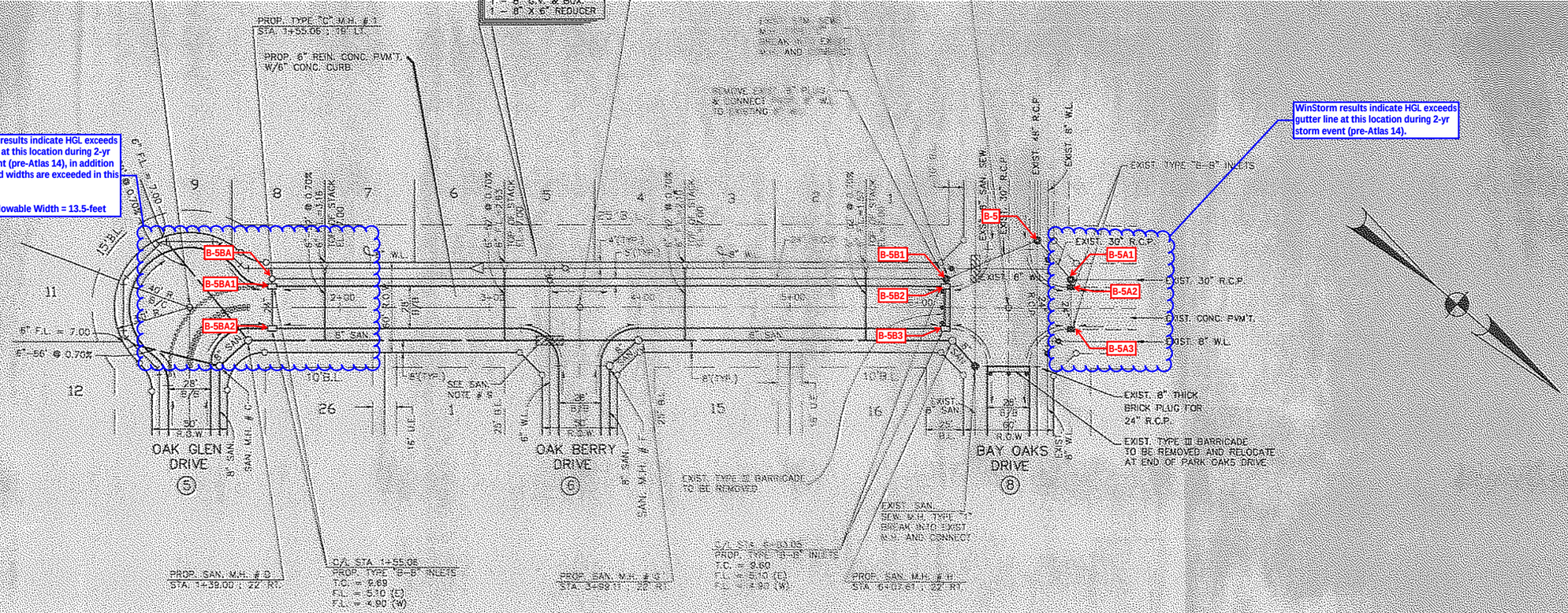
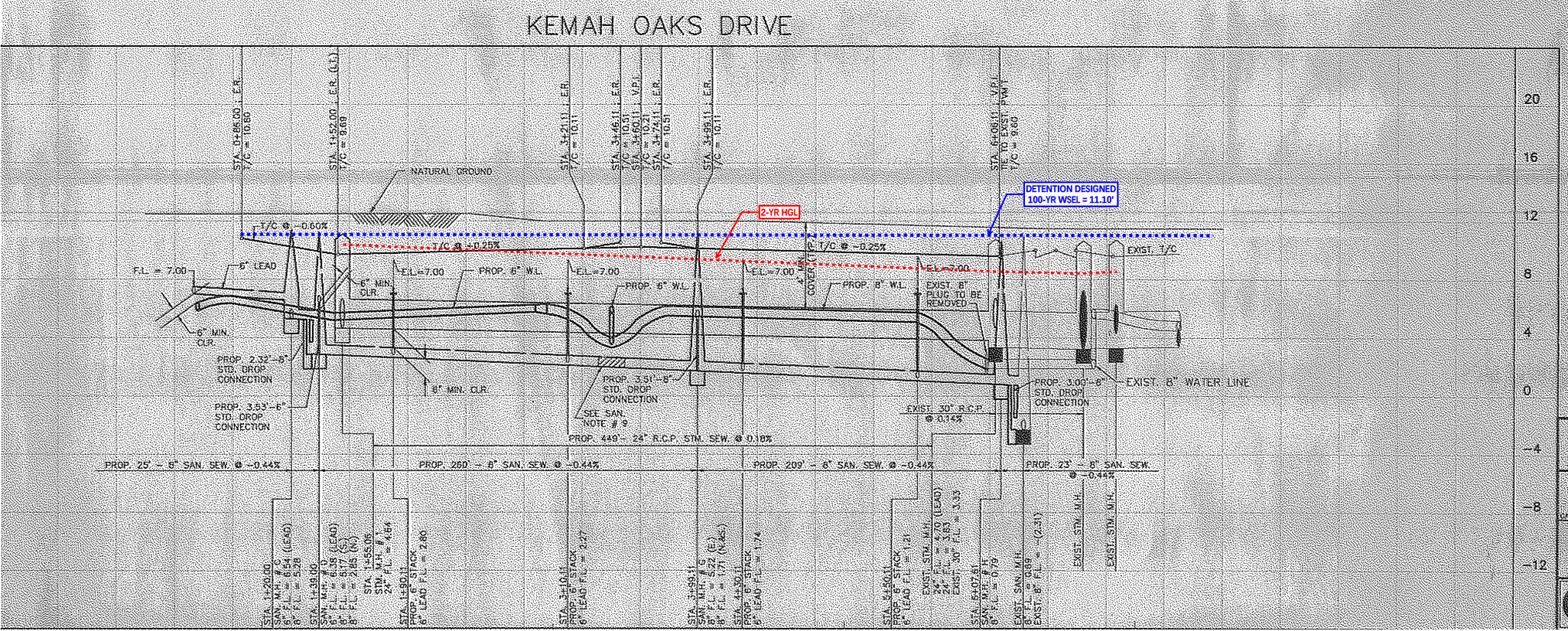



**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 7 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

**THIS EXHIBIT IS NOT TO SCALE**




NOTICE:
AT LEAST 48 HOURS BEFORE EXCAVATING IN STREET R.O.W. OR EASEMENTS CALL THE UTILITY COORDINATING COMMITTEE 1-800-669-8344

PRIVATE UTILITY LINES SHOWN

ENTEX, INC.

G.T.E. TELEPHONE COMPANY
VALID FOR ONE YEAR ONLY

HOUSTON LIGHTING & POWER CO.
APPROVAL ONLY FOR PROPOSED UNDERGROUND FACILITIES UNLESS NOTED.
VALID FOR ONE YEAR ONLY

CITY OF KEMAH, TEXAS

FRANK JONES
DIRECTOR OF PUBLIC WORKS

BEN BLACKLEDGE
MAYOR

CENTURY ENGINEERING, INC.
3000 S. GESSNER, SUITE 100, HOUSTON, TEXAS 77063 (713) 780-8671

CITY OF KEMAH
KEMAH OAKS SUBDIVISION
SECTION THREE
GALVESTON COUNTY TEXAS

PLAN & PROFILE
KEMAH OAKS DRIVE
STA. 0+00 TO STA. 6+06.11

| | | |
|---|---|---|
| File Name: PP3.DWG | Scale: HORZ. 1"=40' VERT. 1"=4' | Date: AUGUST 1994 |
| Designed By: KMA | Checked By: KSS | Job No. 91006-10.0 |
| Drawn By: KMA & L.S. | Approved By: KSS | Sheet 7 of 15 |

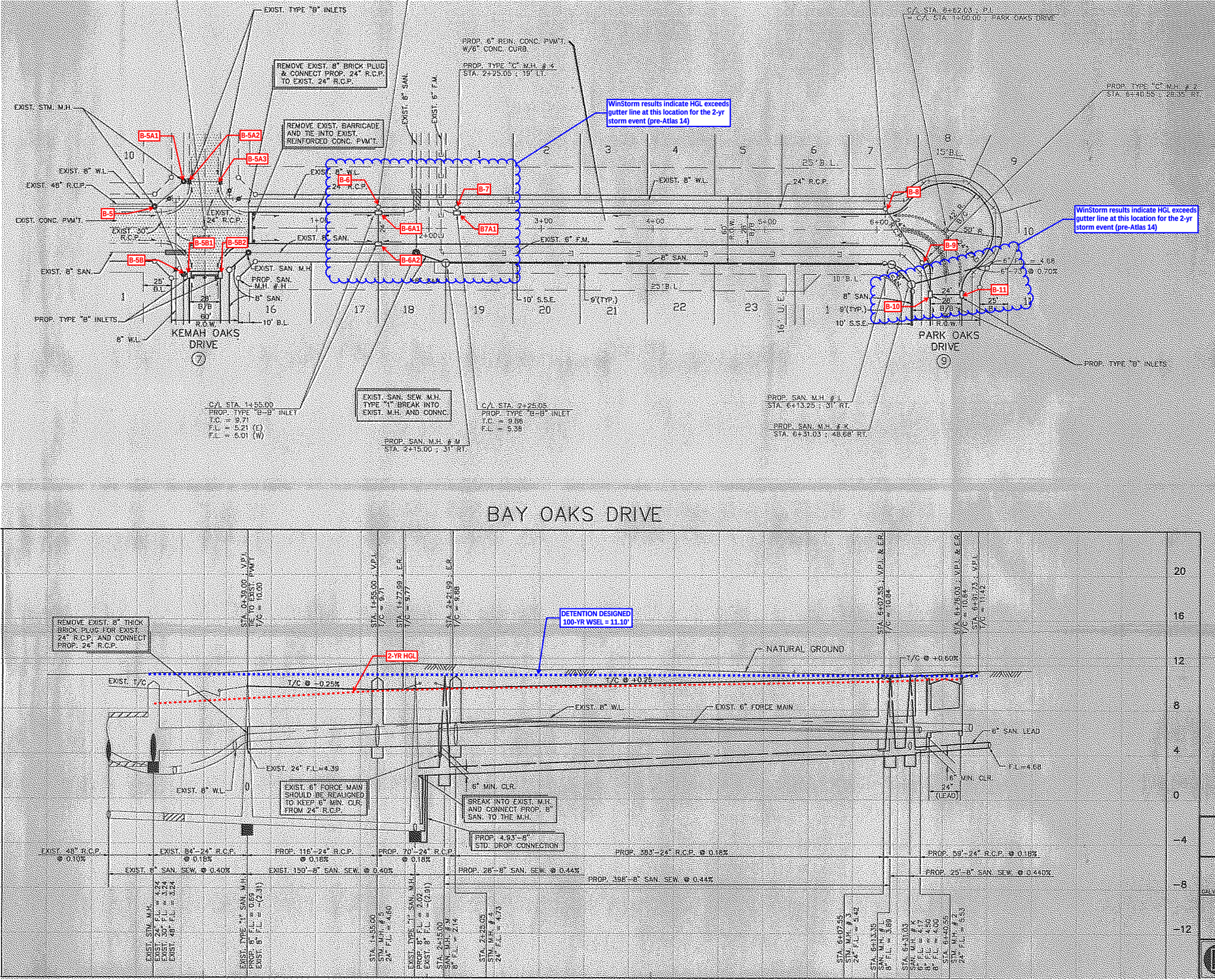



**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 8 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

**THIS EXHIBIT IS NOT TO SCALE**




NOTICE:
AT LEAST 48 HOURS BEFORE EXCAVATING IN STREET R.O.W. OR EASEMENTS CALL THE UTILITY COORDINATING COMMITTEE 1-800-669-8344

PRIVATE UTILITY LINES SHOWN

ENTEX, INC.

G.T.E. TELEPHONE COMPANY
VALID FOR ONE YEAR ONLY

HOUSTON LIGHTING & POWER CO.
APPROVAL ONLY FOR CROSSING UNDERGROUND FACILITIES UNLESS NOTED
VALID FOR ONE YEAR ONLY

CITY OF KEMAH, TEXAS

FRANK JONES
DIRECTOR OF PUBLIC WORKS

BEN BLACKLEDGE
MAYOR

CENTURY ENGINEERING, INC.
3020 B. GESSNER, SUITE 100, HOUSTON, TEXAS 77063 (713) 780-6571

CITY OF KEMAH
KEMAH OAKS SUBDIVISION
SECTION THREE

GALVESTON COUNTY TEXAS

PLAN & PROFILE
BAY OAKS DRIVE
STA. 0+00 TO STA. 7+04.03

| | | | |
|---|---|---|---|
| File Name: PP4.DWG | Scale: HORIZ. 1"=20' VERT. 1"=4' | | Date: AUGUST 1994 |
| Designed By: KMA | Checked By: KSS | | Job No. 91006-10.0 |
| Drawn By: KMA & L.S. | Approved By: KSS | | Sheet 8 of 15 |

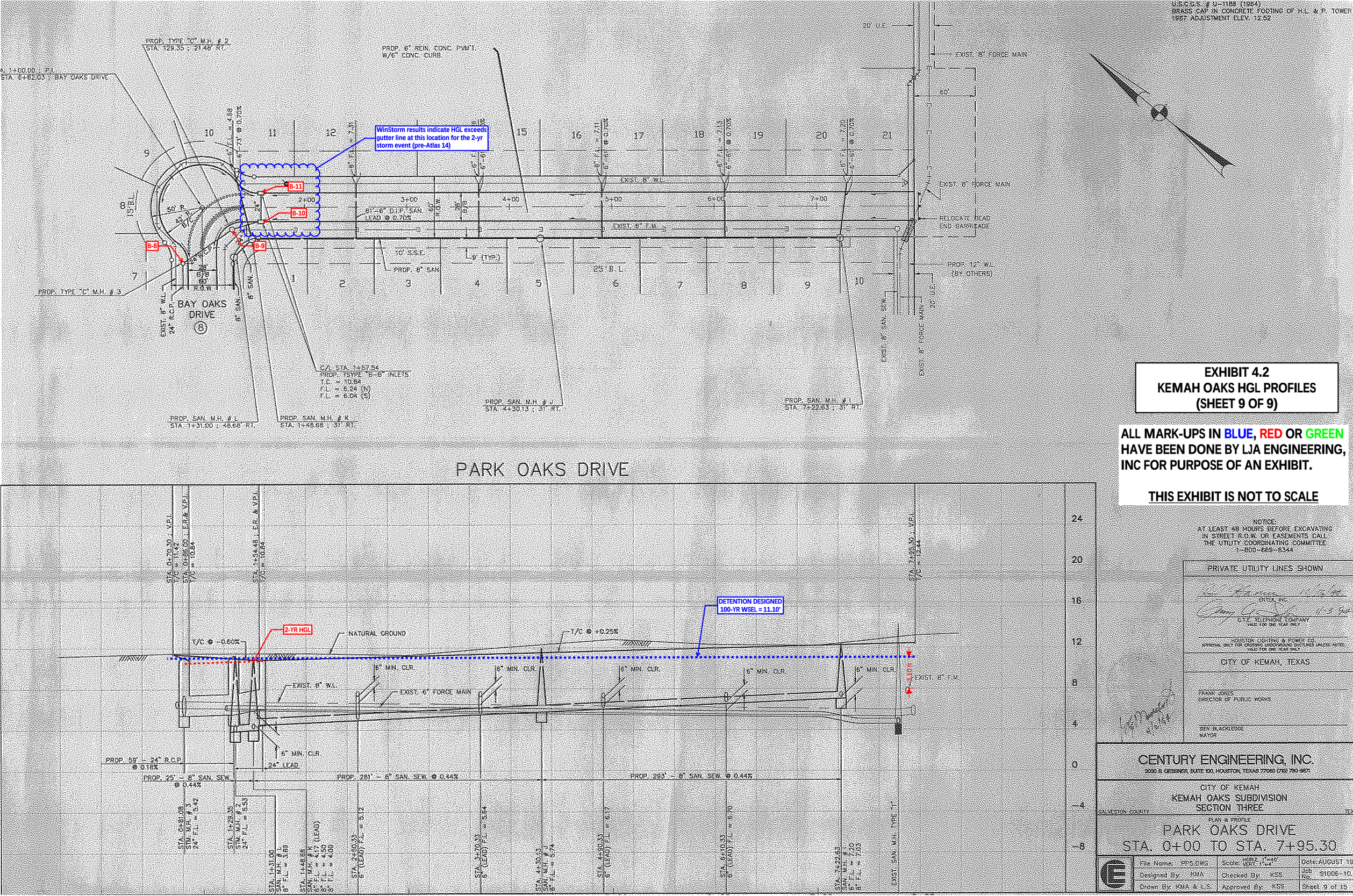



**EXHIBIT 4.2**
**KEMAH OAKS HGL PROFILES**
**(SHEET 9 OF 9)**

**ALL MARK-UPS IN BLUE, RED OR GREEN HAVE BEEN DONE BY LJA ENGINEERING, INC FOR PURPOSE OF AN EXHIBIT.**

**THIS EXHIBIT IS NOT TO SCALE**

NOTICE:
AT LEAST 48 HOURS BEFORE EXCAVATING IN STREET R.O.W. OR EASEMENTS CALL THE UTILITY COORDINATING COMMITTEE 1-800-669-6344

PRIVATE UTILITY LINES SHOWN

ENTEX, INC.

G.T.E. TELEPHONE COMPANY
VALID FOR ONE YEAR ONLY

HOUSTON LIGHTING & POWER CO.
APPROVAL ONLY FOR CROSSING UNDERGROUND OUTLINED UNLESS NOTED.
VALID FOR ONE YEAR ONLY

CITY OF KEMAH, TEXAS

FRANK JONES
DIRECTOR OF PUBLIC WORKS

DEN BLACKLEDGE
MAYOR

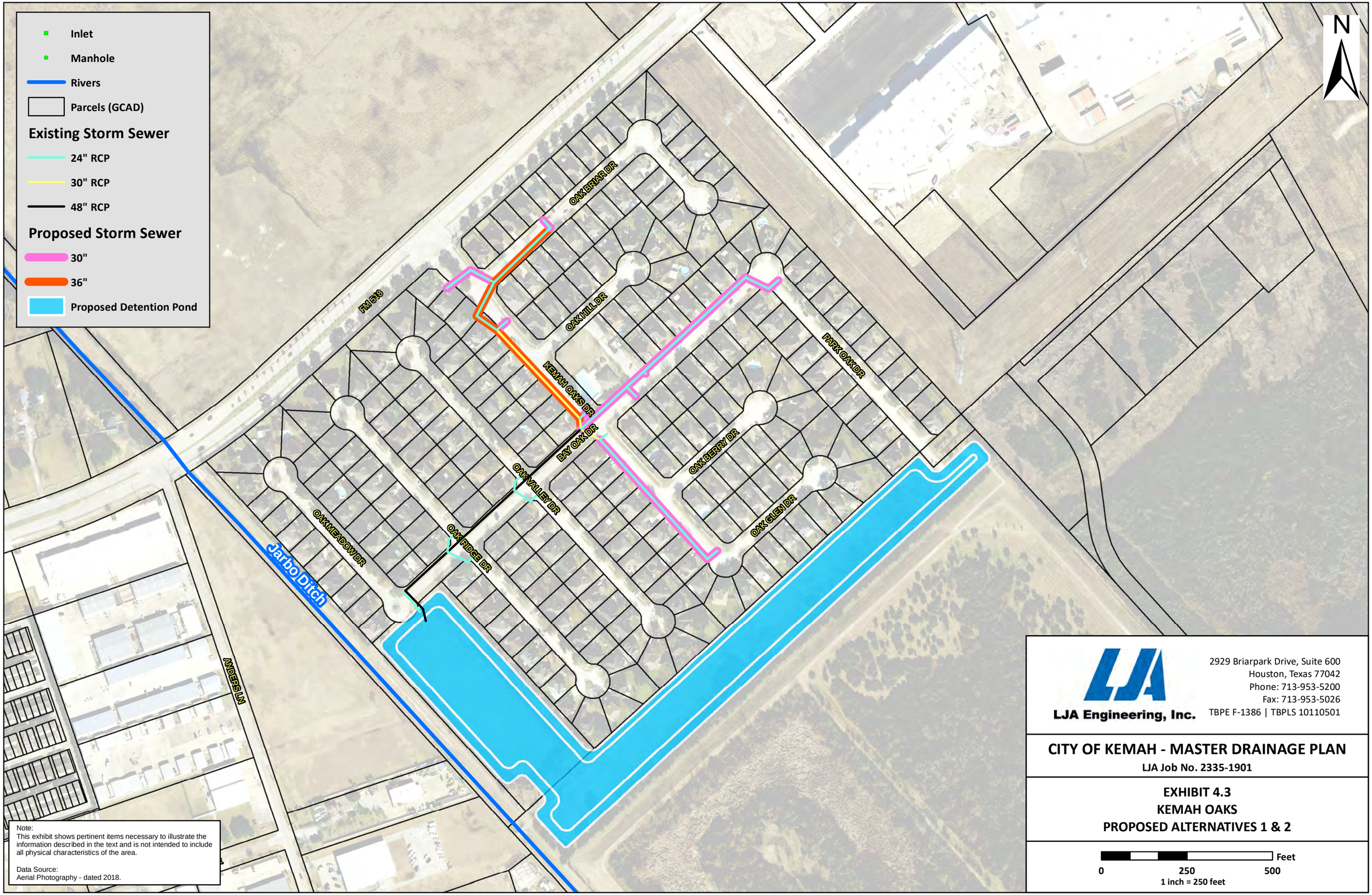
CENTURY ENGINEERING, INC.
3000 B. GESSNER, SUITE 100, HOUSTON, TEXAS 77063 (713) 780-9671

CITY OF KEMAH
KEMAH OAKS SUBDIVISION
SECTION THREE

GALVESTON COUNTY — TEXAS

PLAN & PROFILE
PARK OAKS DRIVE
STA. 0+00 TO STA. 7+95.30

| | | | |
|---|---|---|---|
| File Name: PP5.DWG | Scale: HORIZ. 1"=40' VERT. 1"=4' | | Date: AUGUST 1994 |
| Designed By: KMA | Checked By: KSS | | Job No. 91006-10.0 |
| Drawn By: KMA & LS | Approved By: KSS | | Sheet 9 of 15 |




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

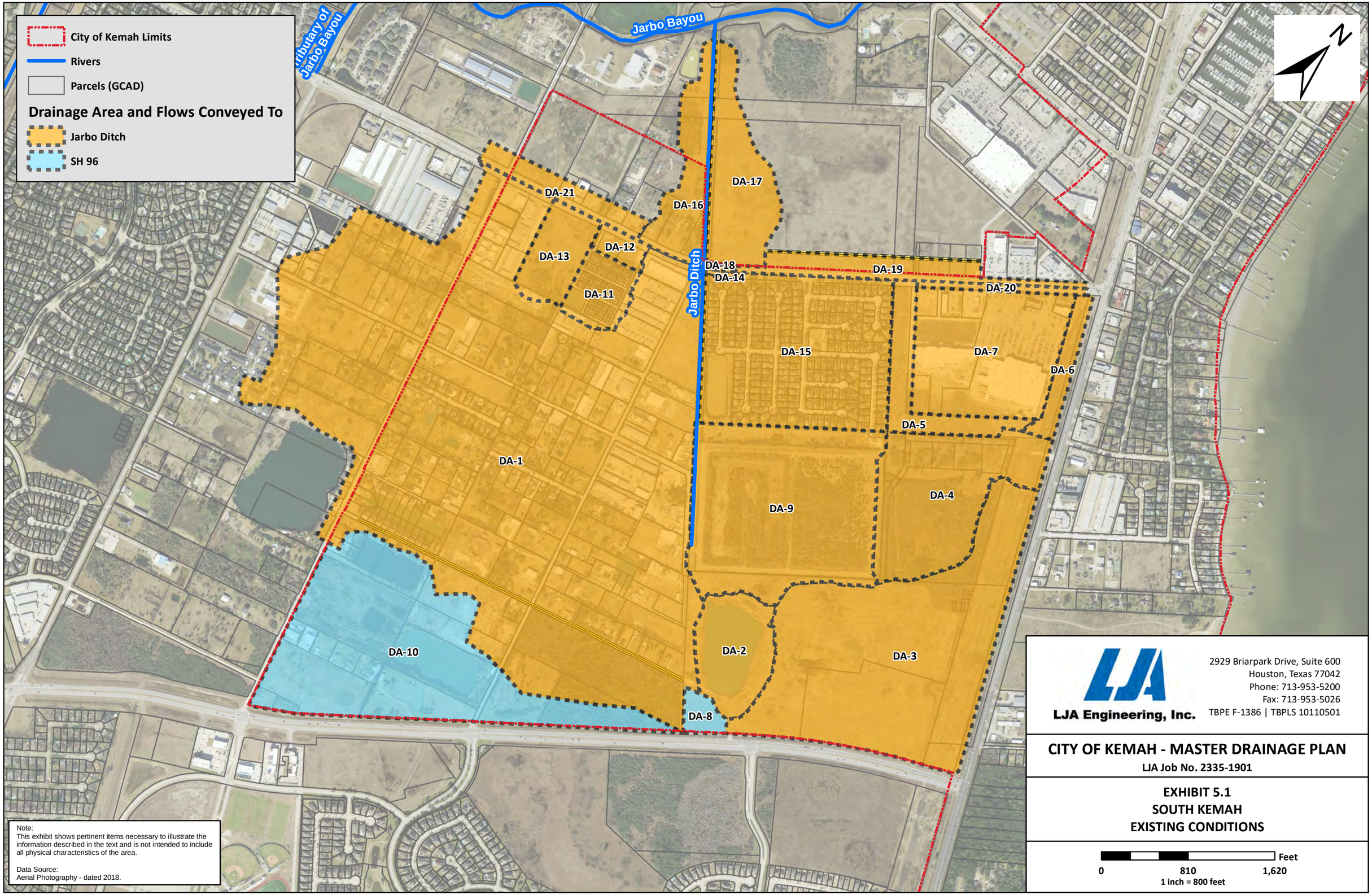
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

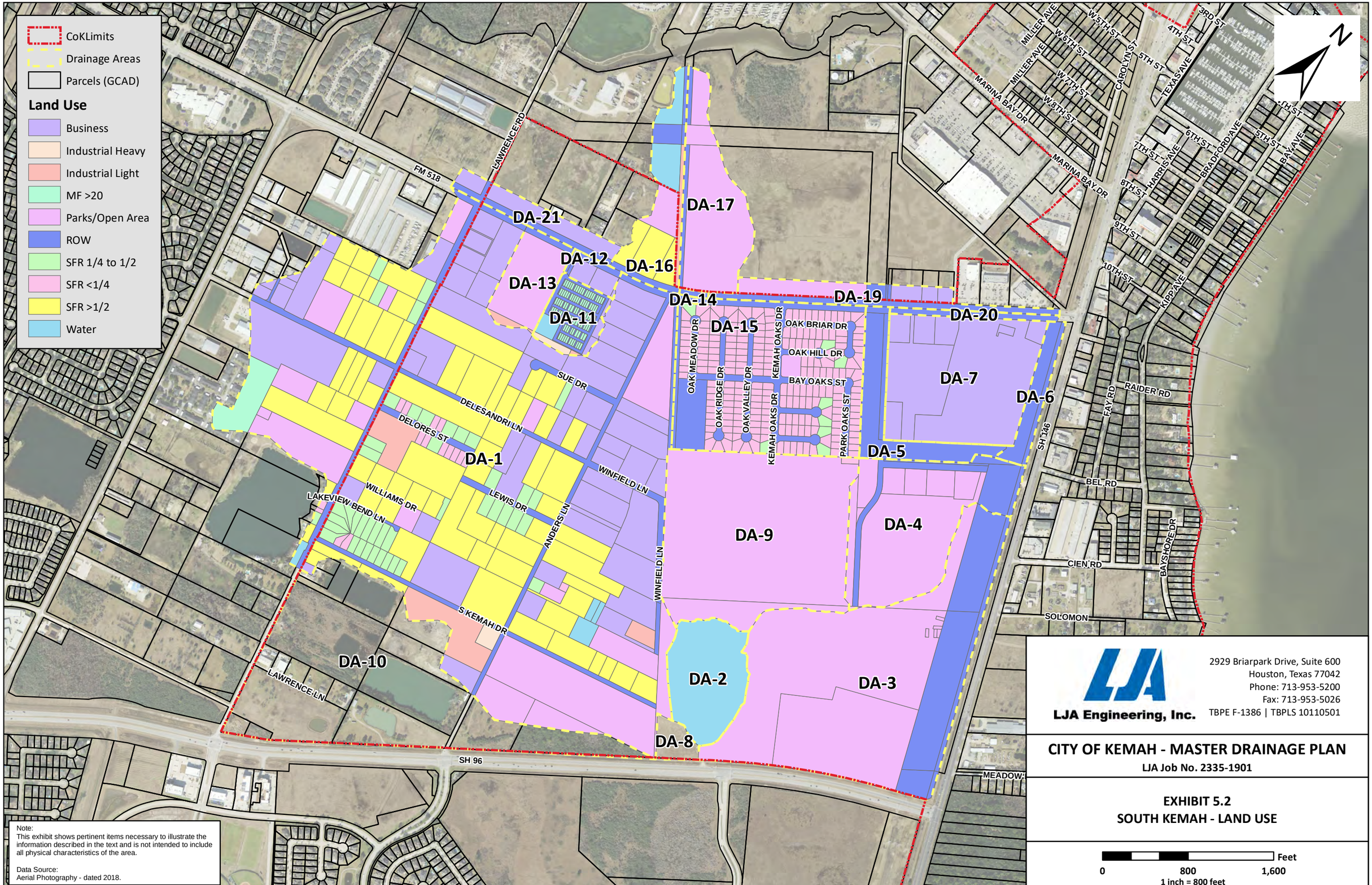
**EXHIBIT 4.3**
**KEMAH OAKS**
**PROPOSED ALTERNATIVES 1 & 2**

Feet
0 250 500
1 inch = 250 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 4.3 - Kemah Oaks Proposed Alternatives 1 & 2.mxd




J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 5.1 - South Kemah Existing Conditions.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

J:\2335\19011\DOC\EXHIBITS\GIS\Exhibit 5.2 - South Kemah Land Use.mxd

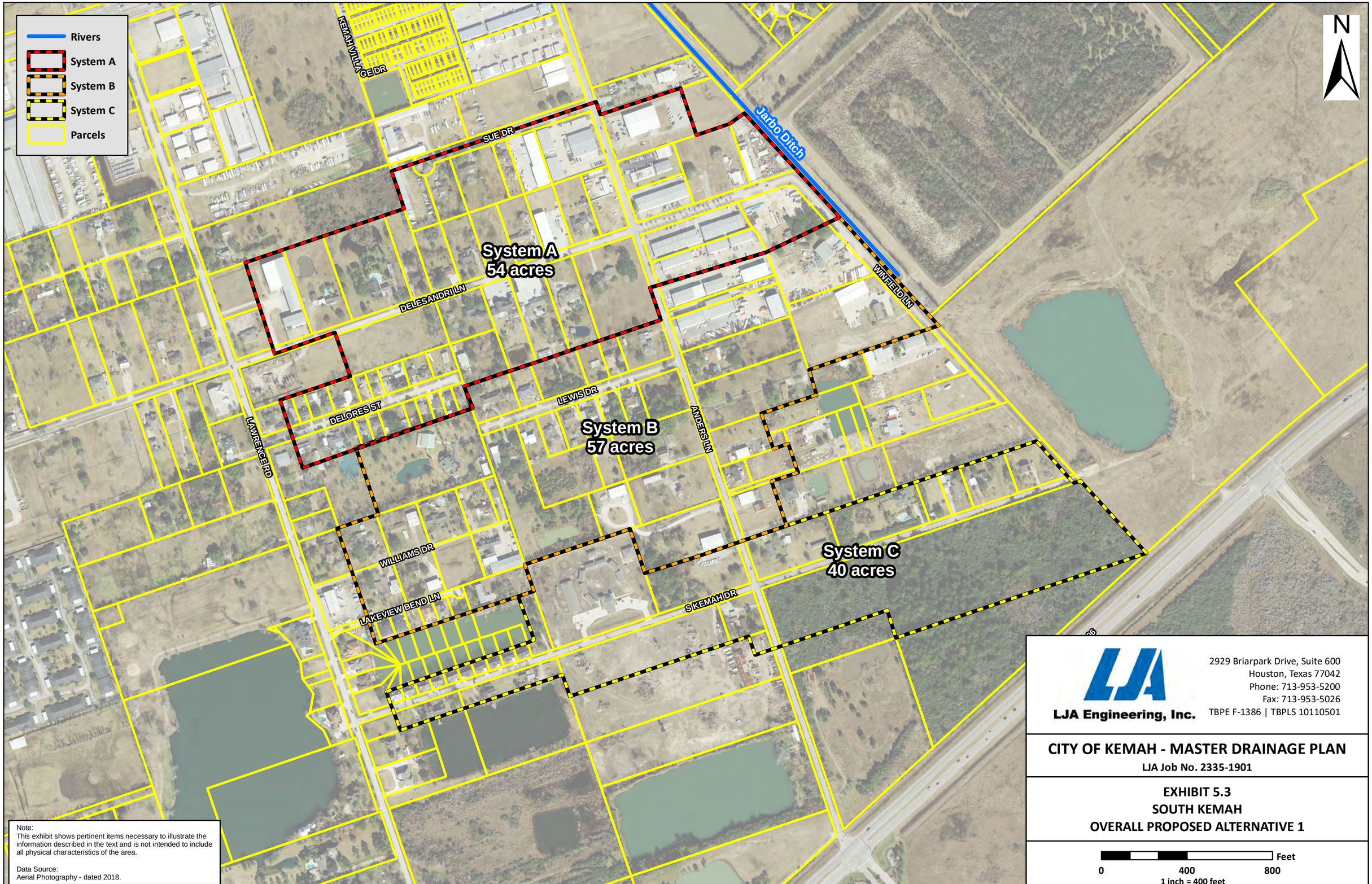
LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 5.2
## SOUTH KEMAH - LAND USE

Feet
0 800 1,600
1 inch = 800 feet




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

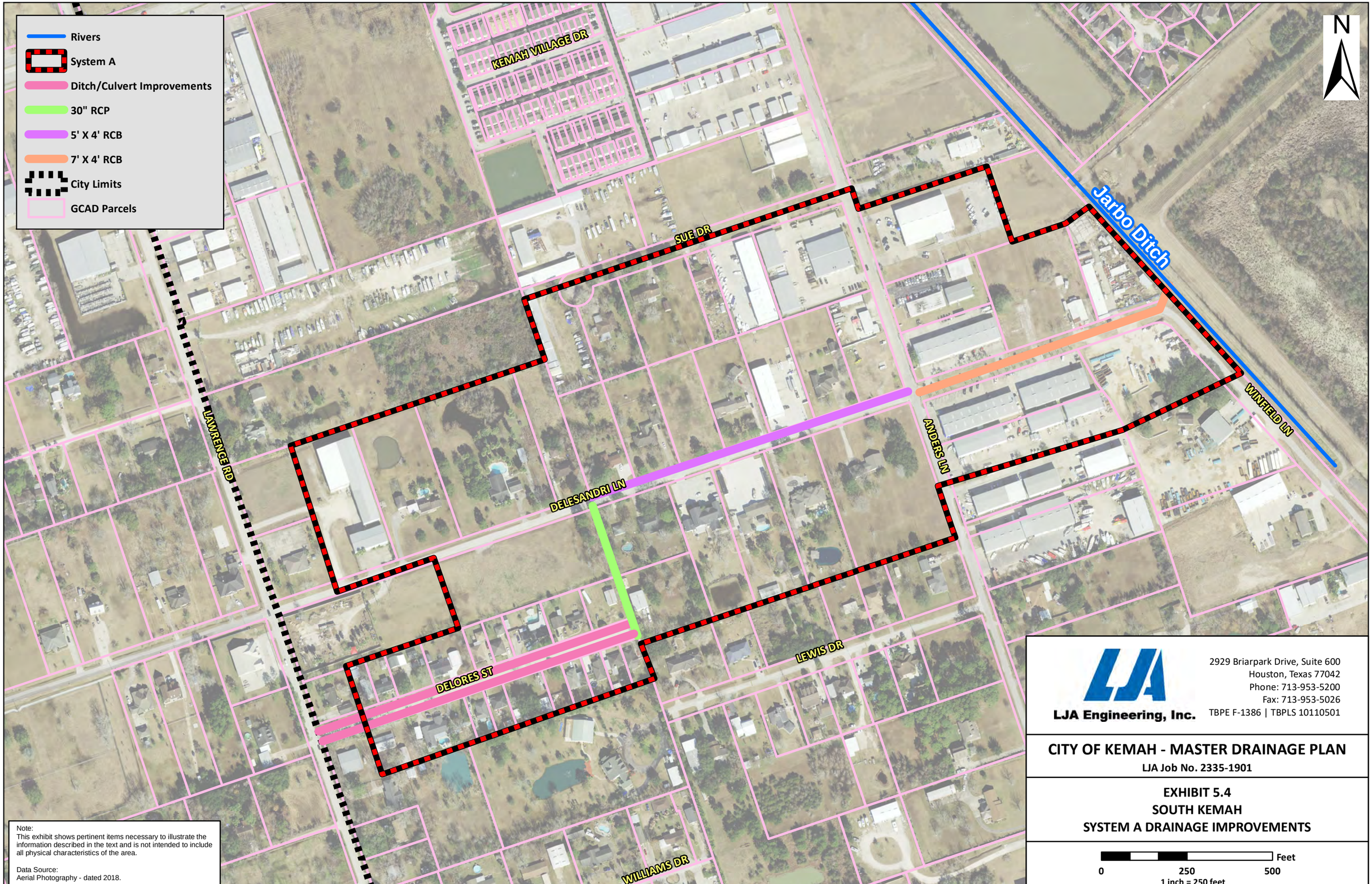
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 5.3**
**SOUTH KEMAH**
**OVERALL PROPOSED ALTERNATIVE 1**

0 400 800 Feet
1 inch = 400 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 5.3 - South Kemah Overall Proposed Alternative 1.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

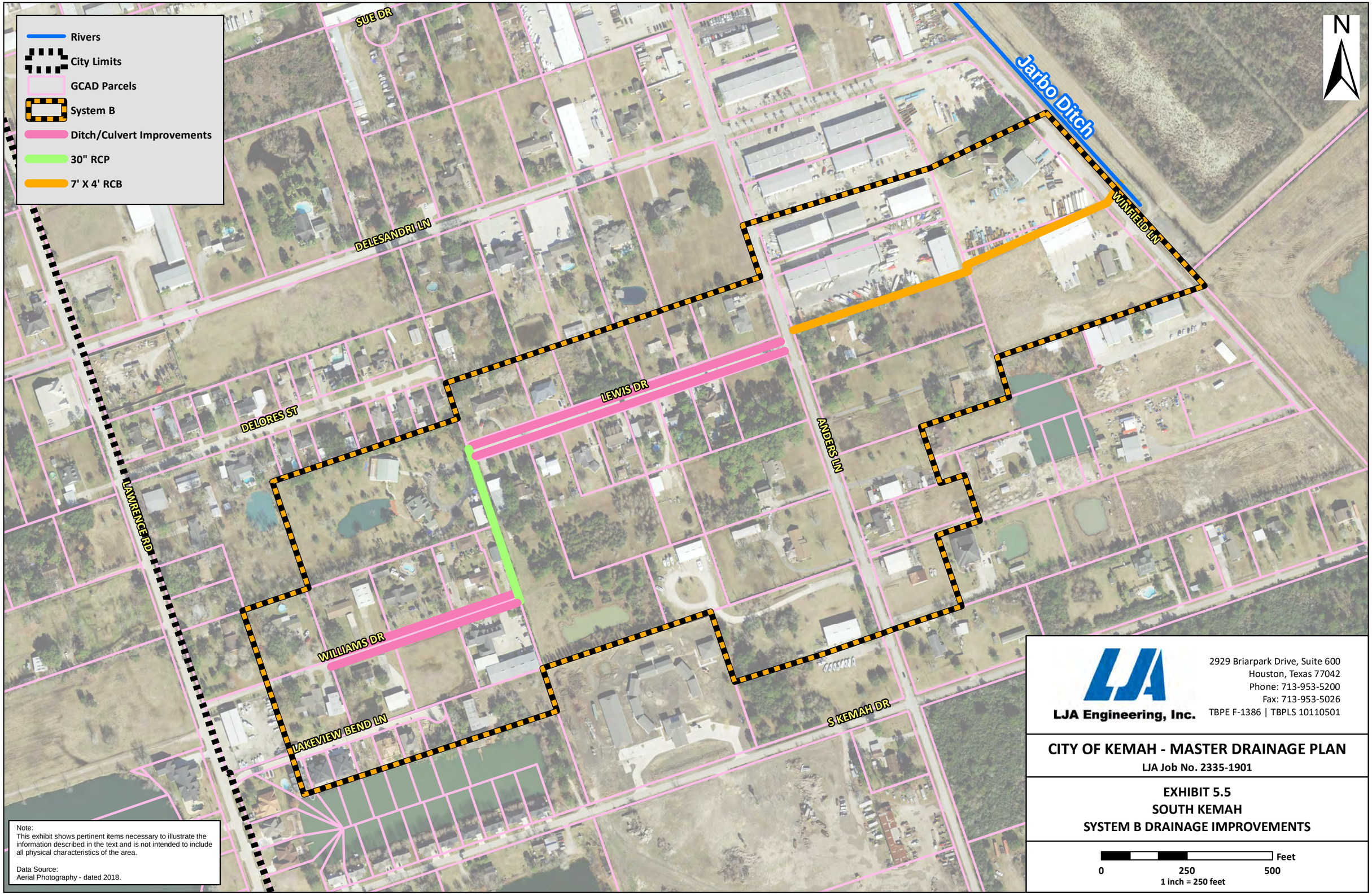
# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 5.4
## SOUTH KEMAH
## SYSTEM A DRAINAGE IMPROVEMENTS

Feet
0 250 500
1 inch = 250 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 5.4 - South Kemah System A Drainage Imprvoements.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

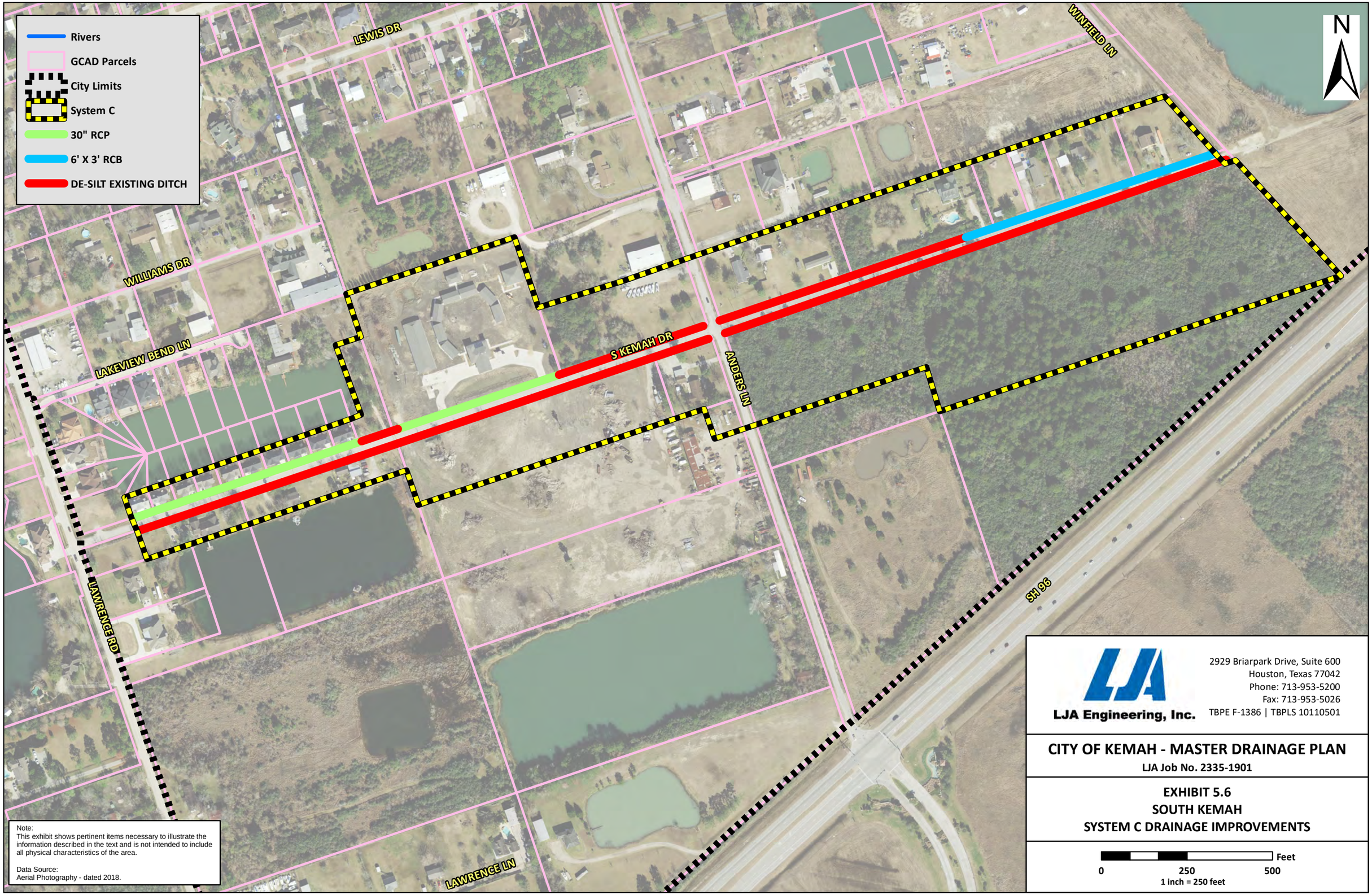
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 5.5**
**SOUTH KEMAH**
**SYSTEM B DRAINAGE IMPROVEMENTS**

Feet
0 250 500
1 inch = 250 feet

J:\2335\19011DOC\EXHIBITS\GIS\Exhibit 5.5 - South Kemah System B Drainage Imprvoements.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

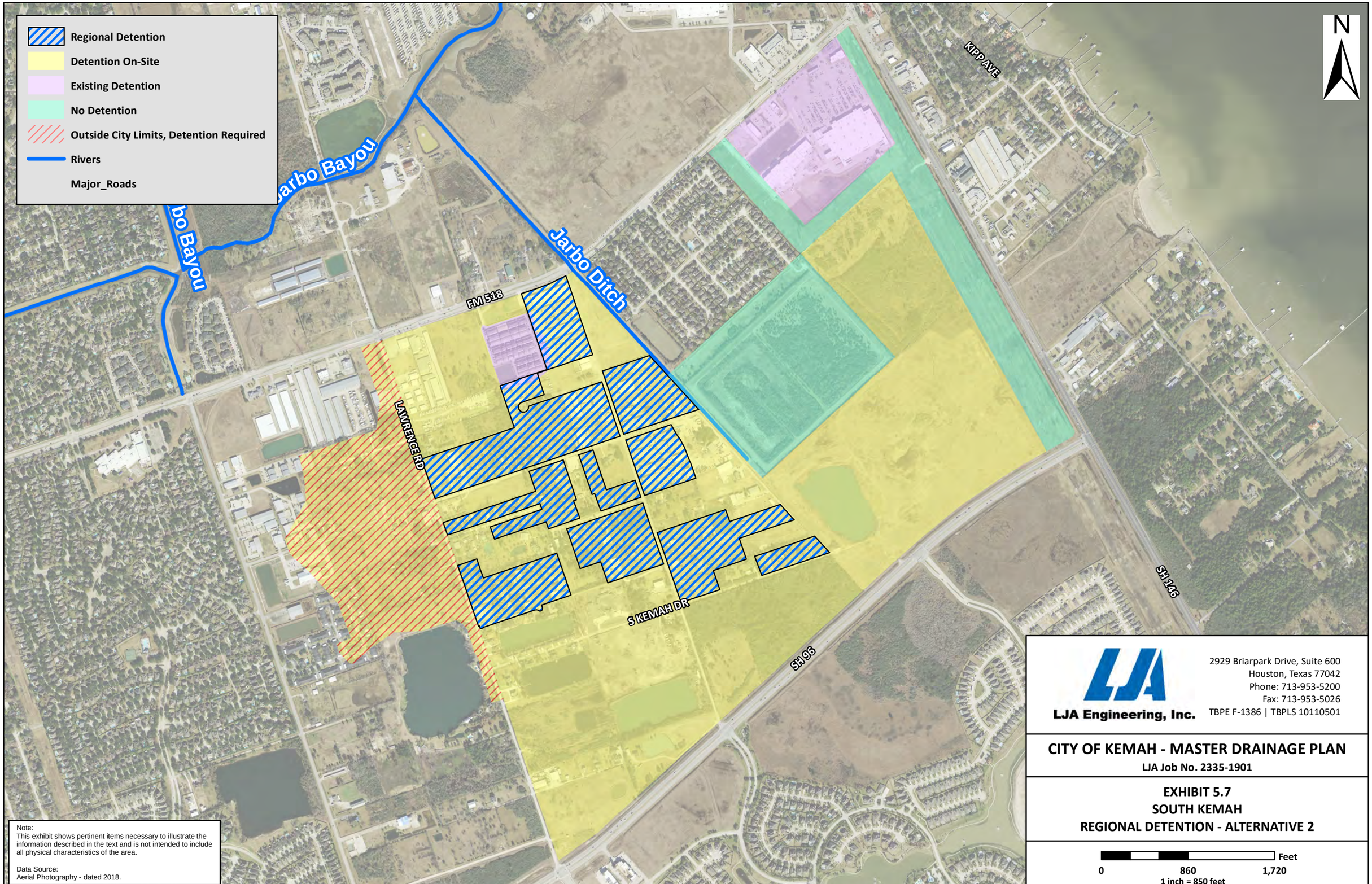
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 5.6**
**SOUTH KEMAH**
**SYSTEM C DRAINAGE IMPROVEMENTS**

Feet
0 250 500
1 inch = 250 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 5.6 - South Kemah System C Drainage Imprvoements.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

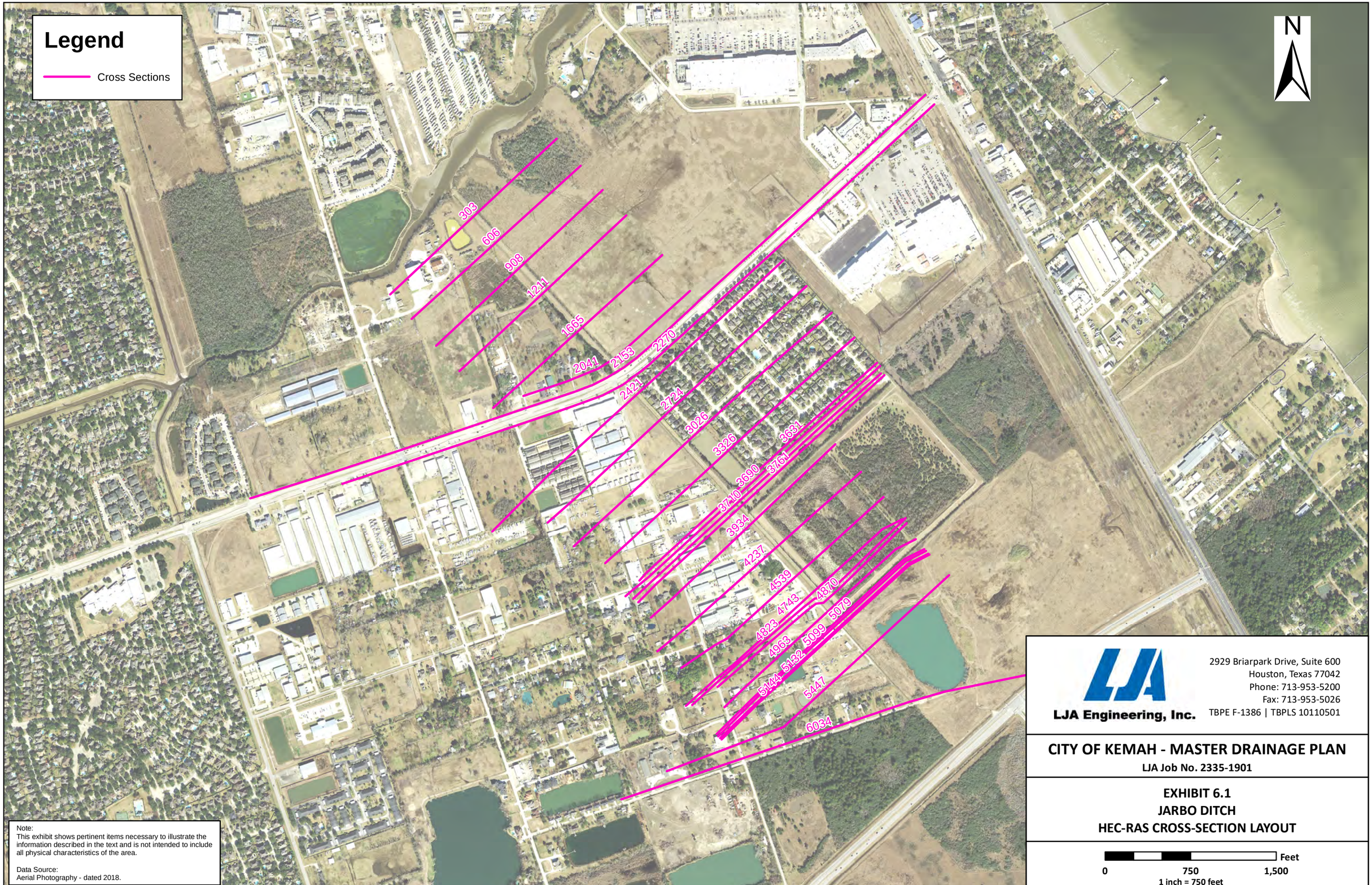
# CITY OF KEMAH - MASTER DRAINAGE PLAN

LJA Job No. 2335-1901

## EXHIBIT 5.7
## SOUTH KEMAH
## REGIONAL DETENTION - ALTERNATIVE 2

Feet
0 860 1,720
1 inch = 850 feet

J:\2335\1901\DOC\EXHIBITS\GIS\Exhibit 5.7 - South Kemah Regional Detention Alternative 2.mxd




LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

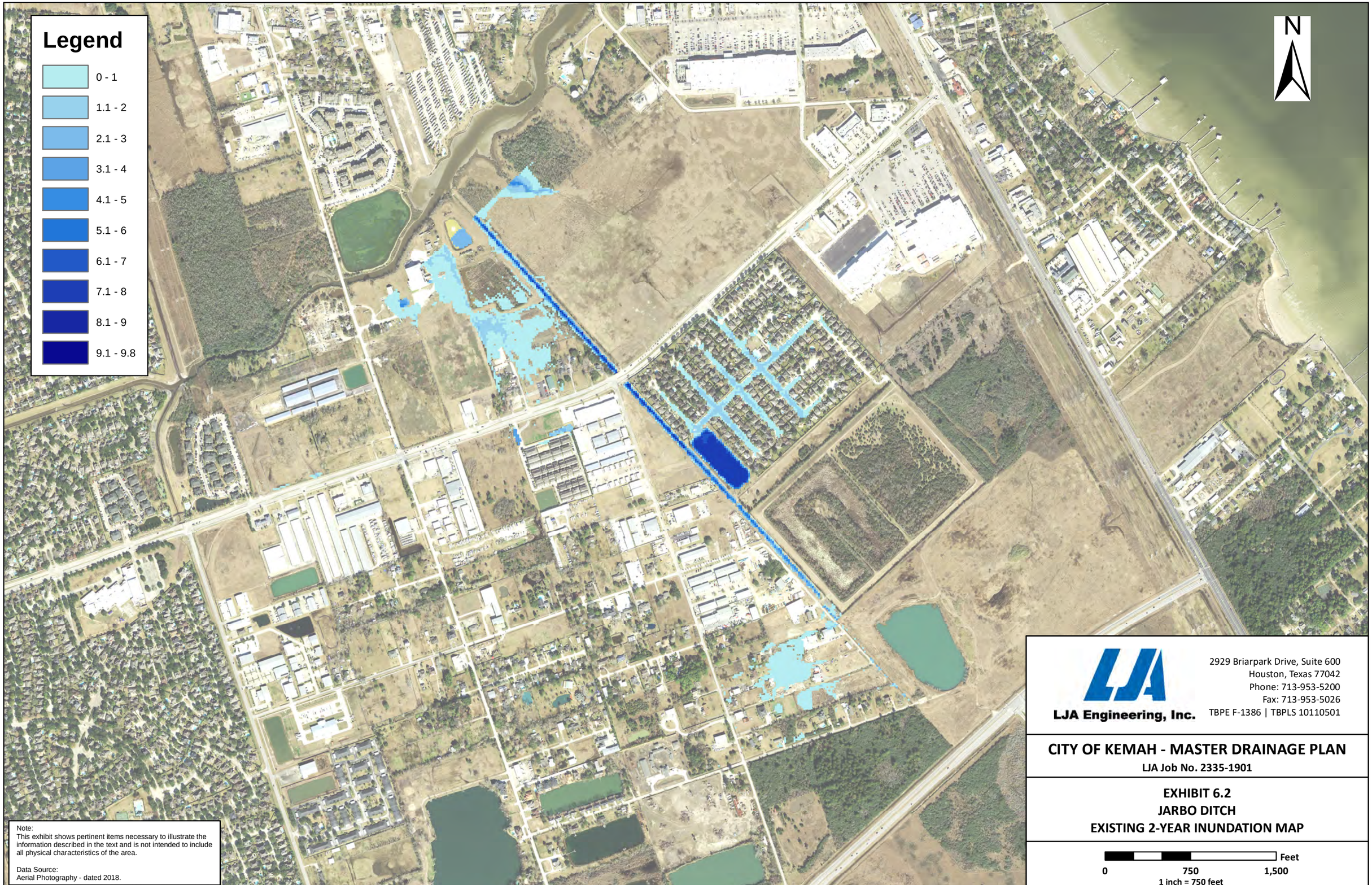
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.1
## JARBO DITCH
## HEC-RAS CROSS-SECTION LAYOUT

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

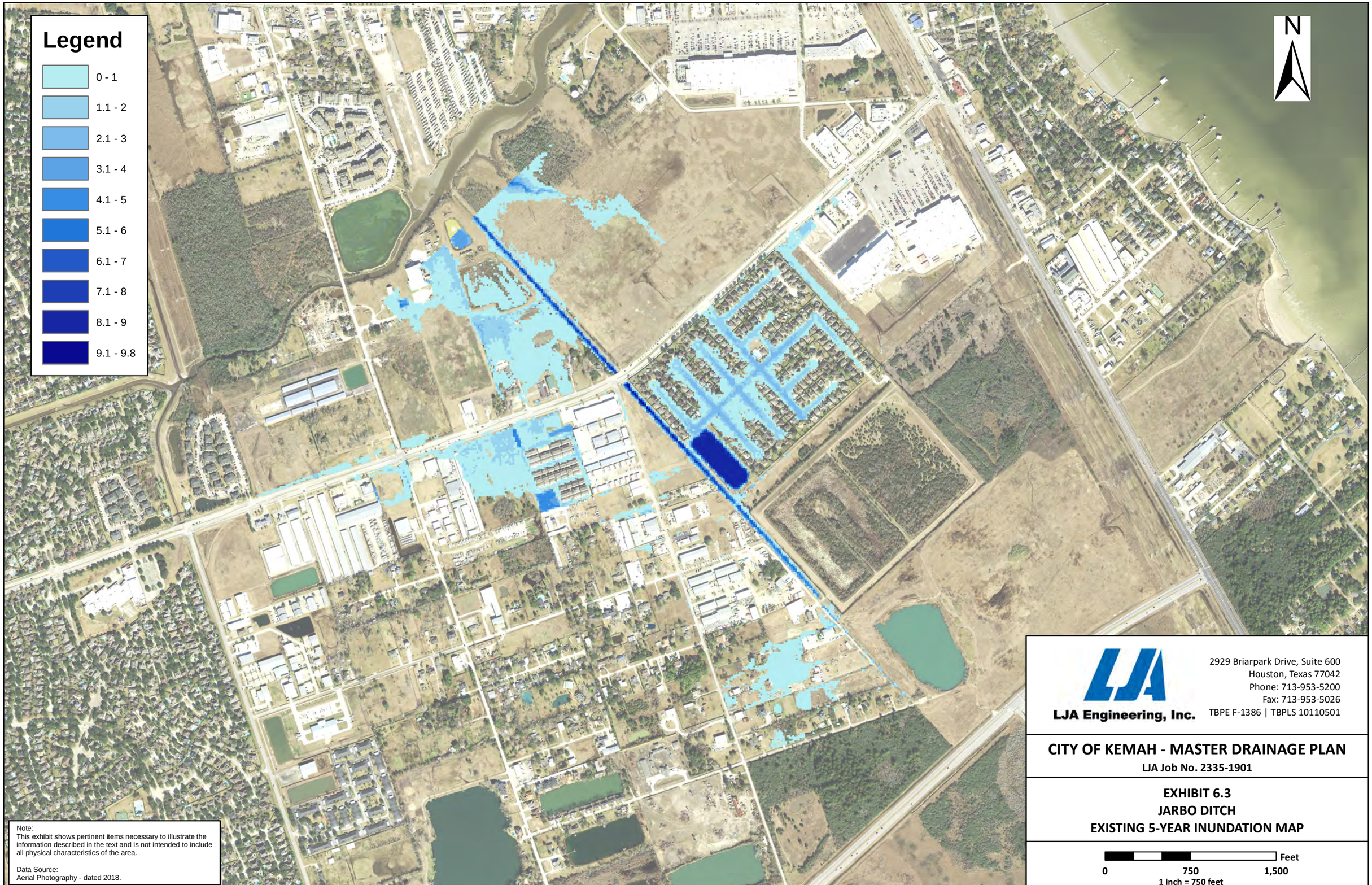
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.2
## JARBO DITCH
## EXISTING 2-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

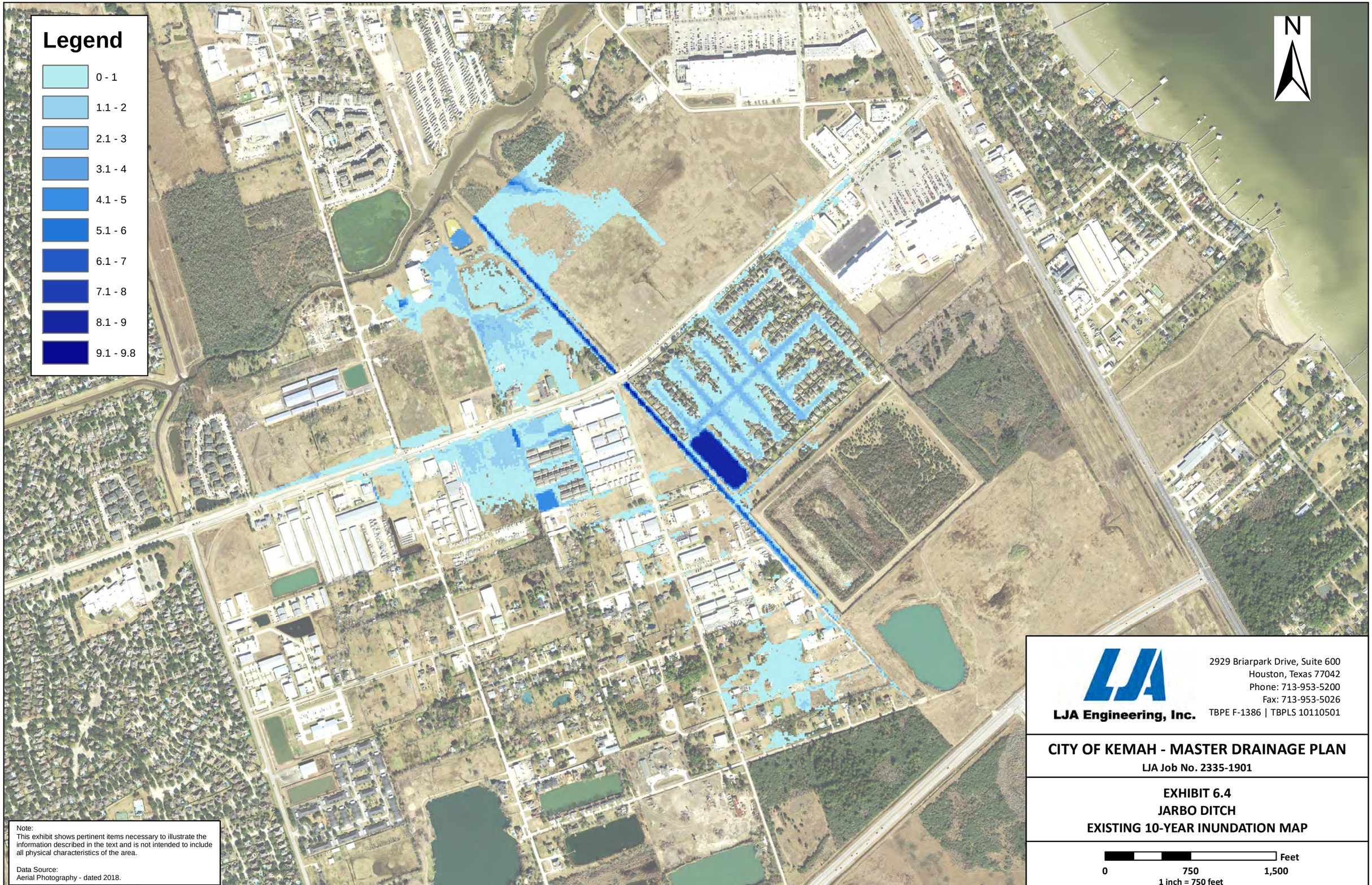
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.3
## JARBO DITCH
## EXISTING 5-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

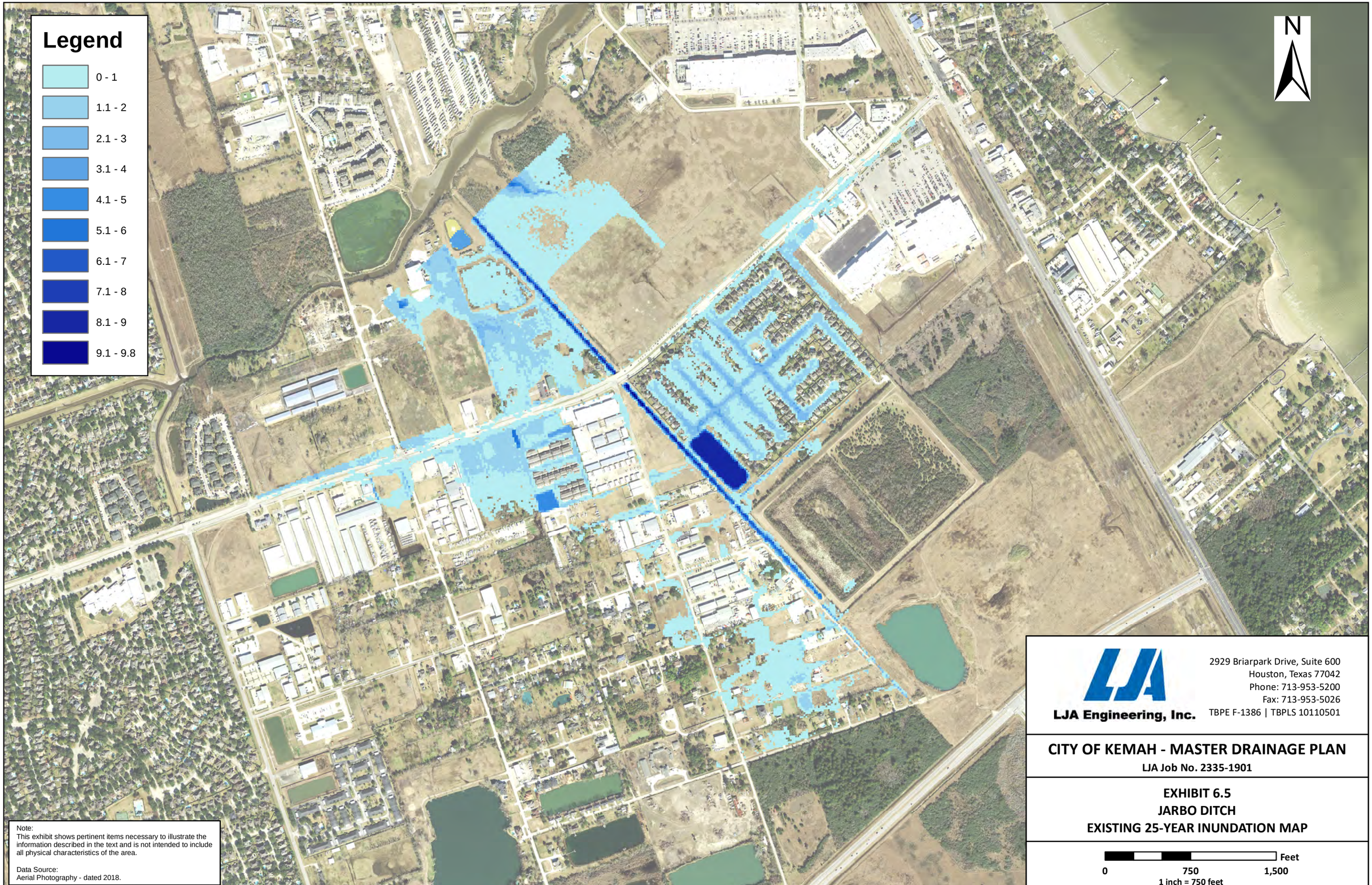
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.4
## JARBO DITCH
## EXISTING 10-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

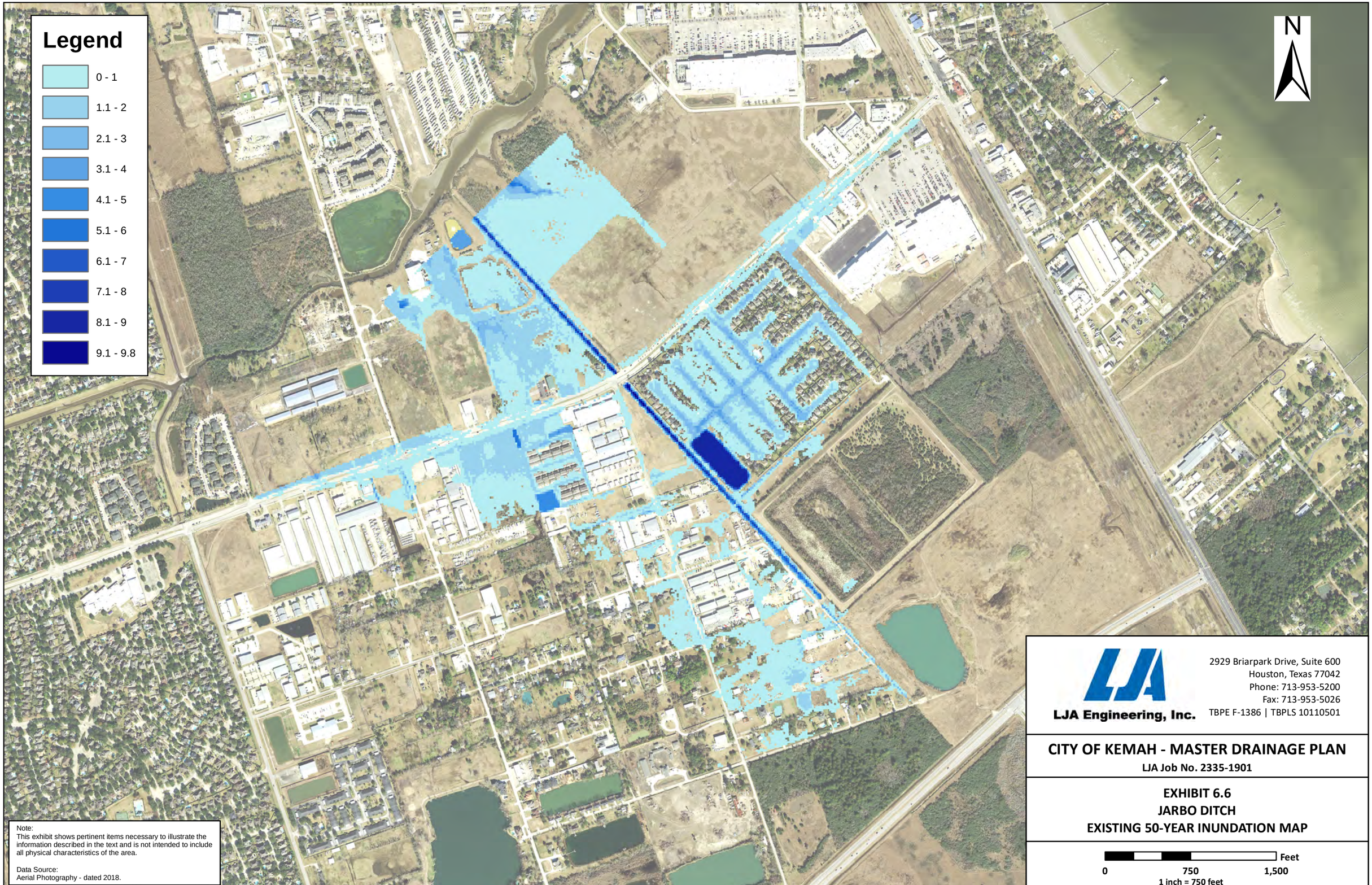
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.5
## JARBO DITCH
## EXISTING 25-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

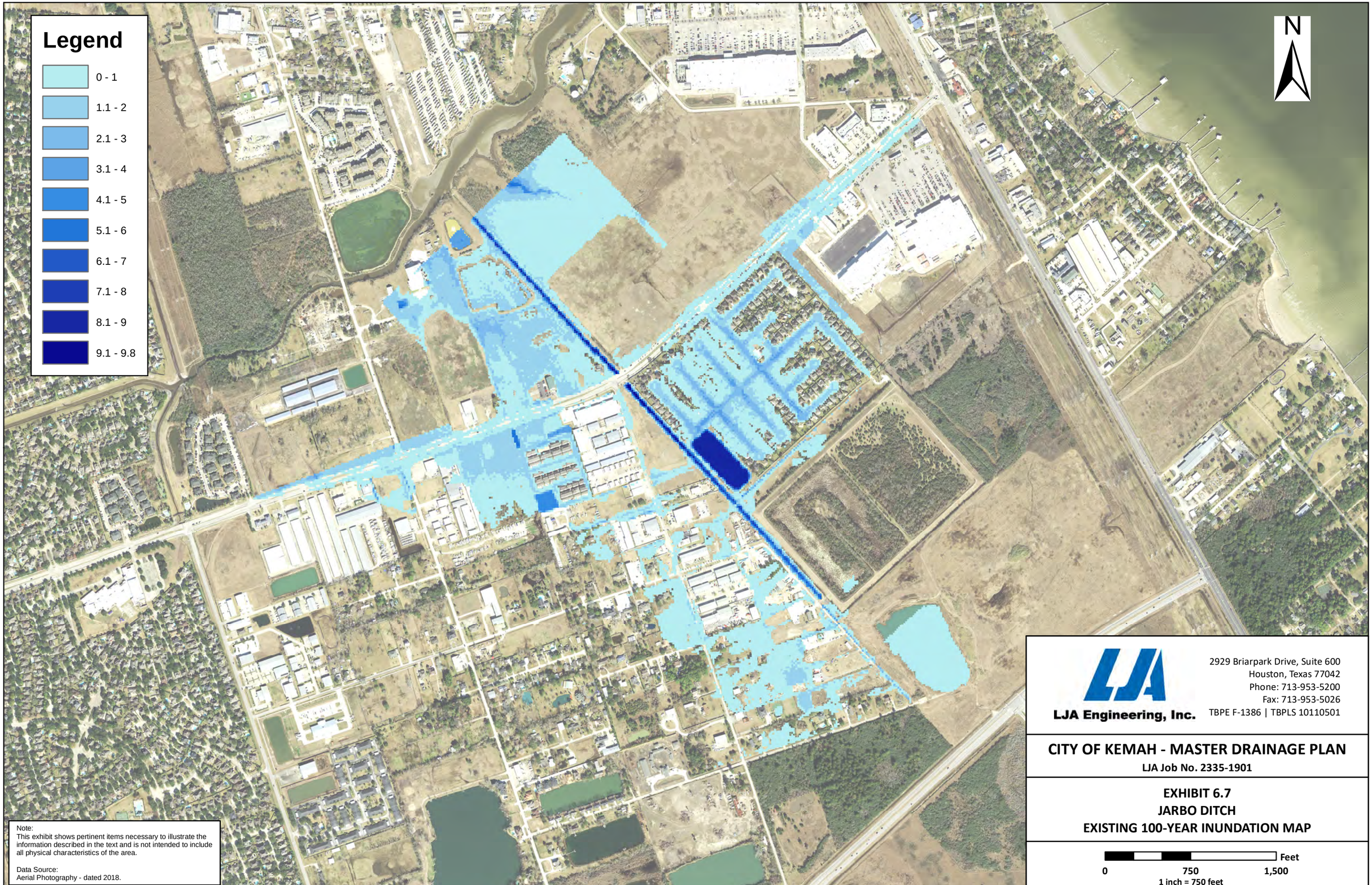
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.6
## JARBO DITCH
## EXISTING 50-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

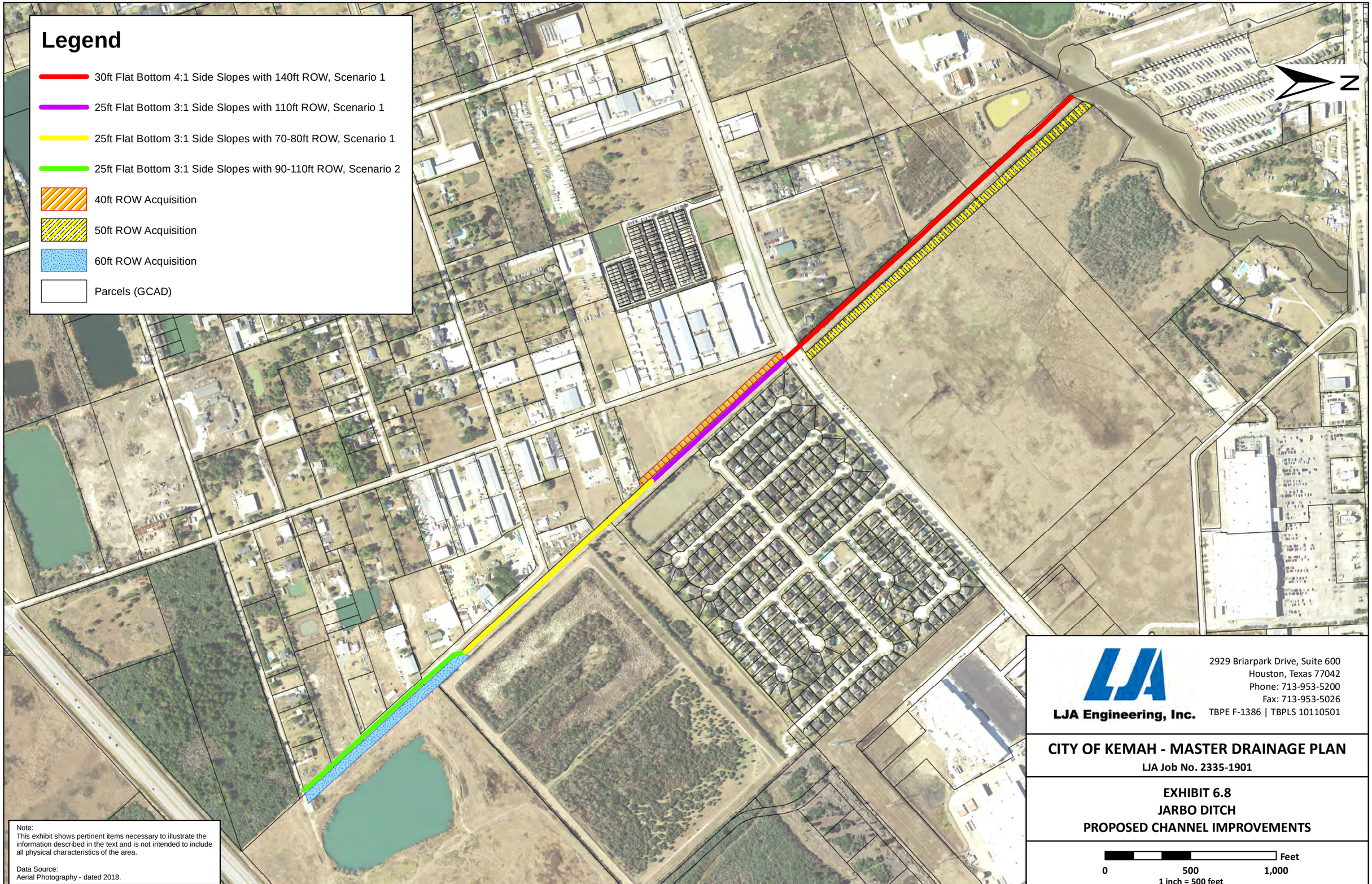
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.7
## JARBO DITCH
## EXISTING 100-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

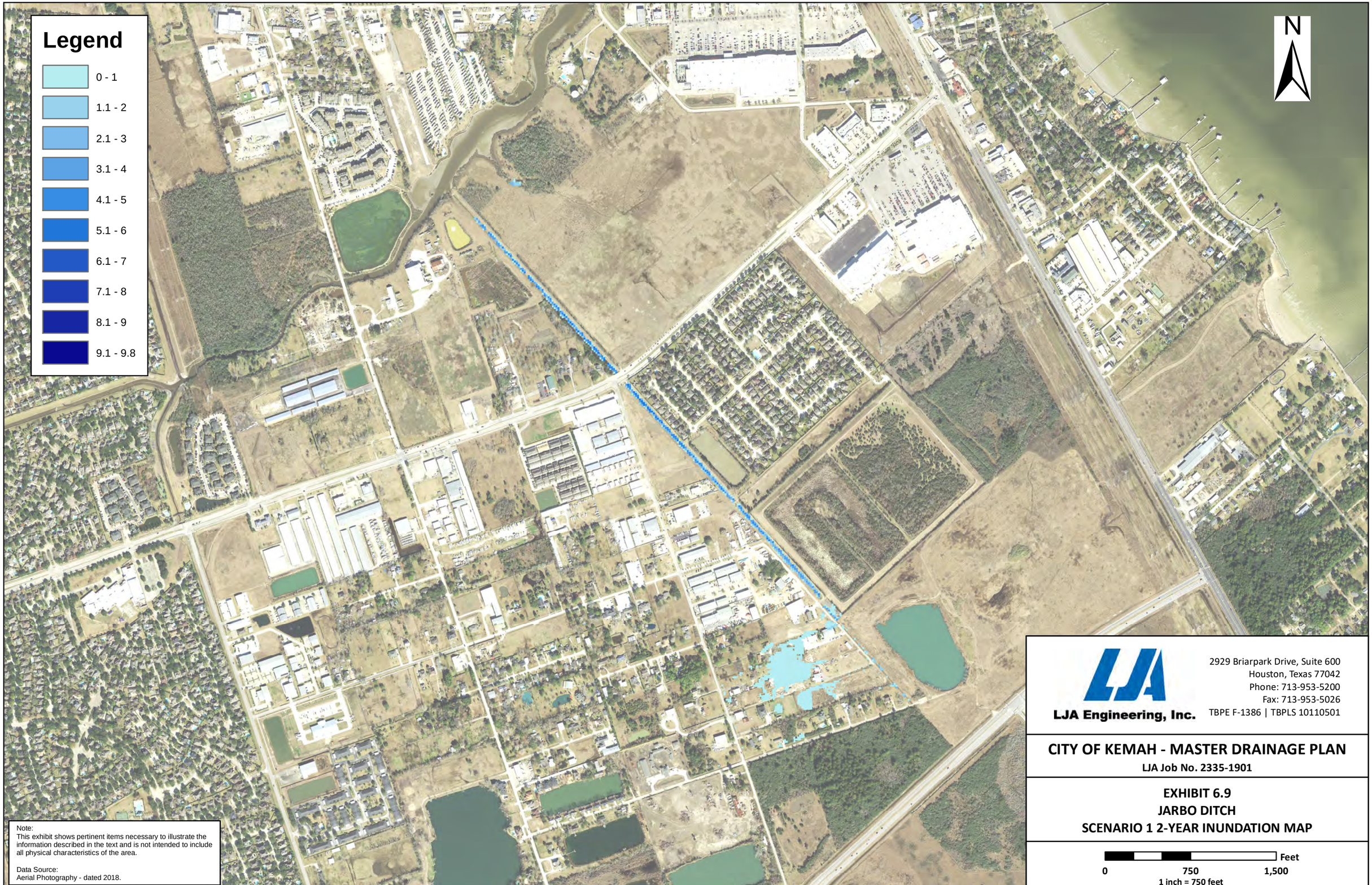
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 6.8**
**JARBO DITCH**
**PROPOSED CHANNEL IMPROVEMENTS**

Feet
0 500 1,000
1 inch = 500 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

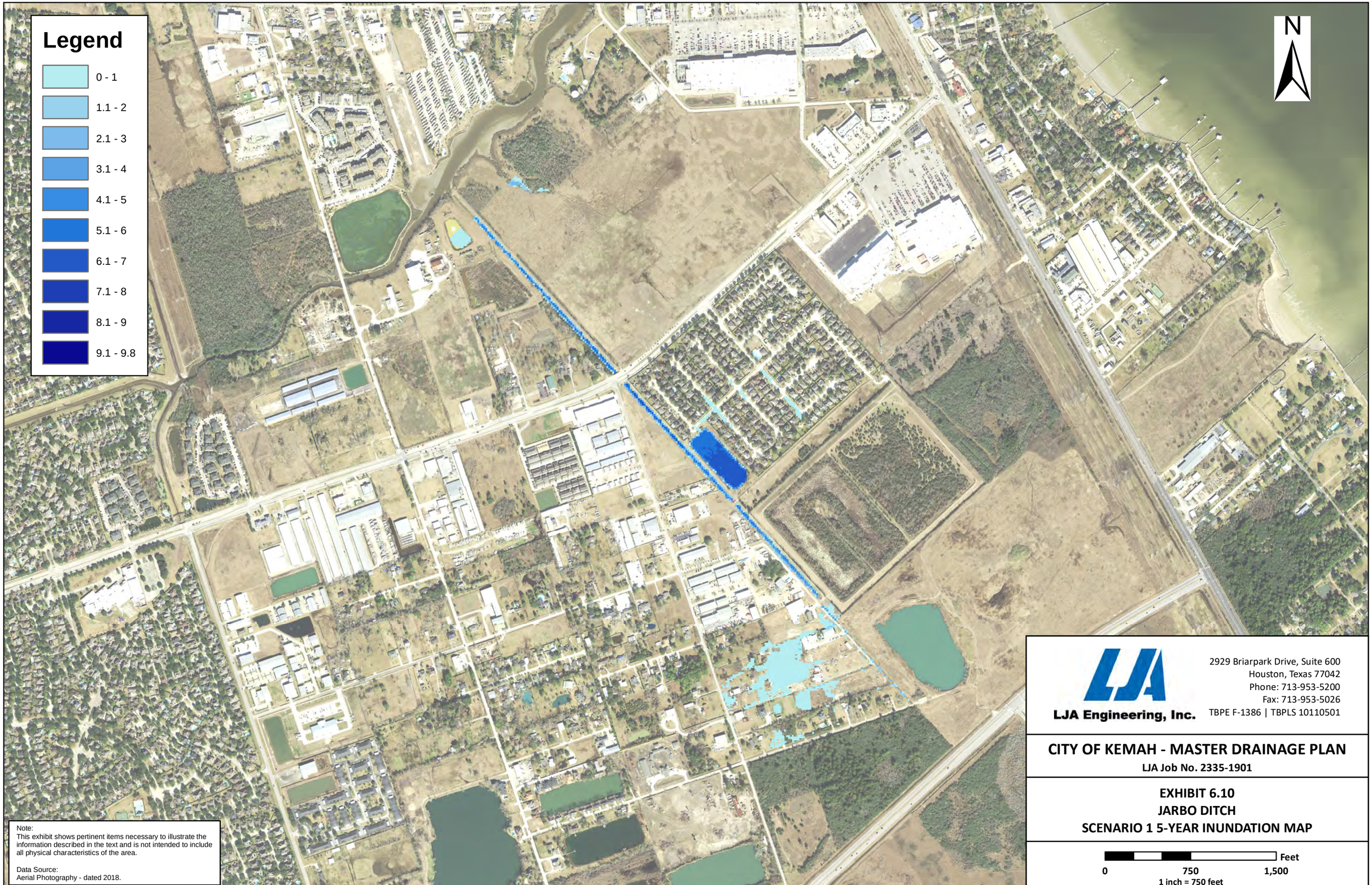
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.9
## JARBO DITCH
## SCENARIO 1 2-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

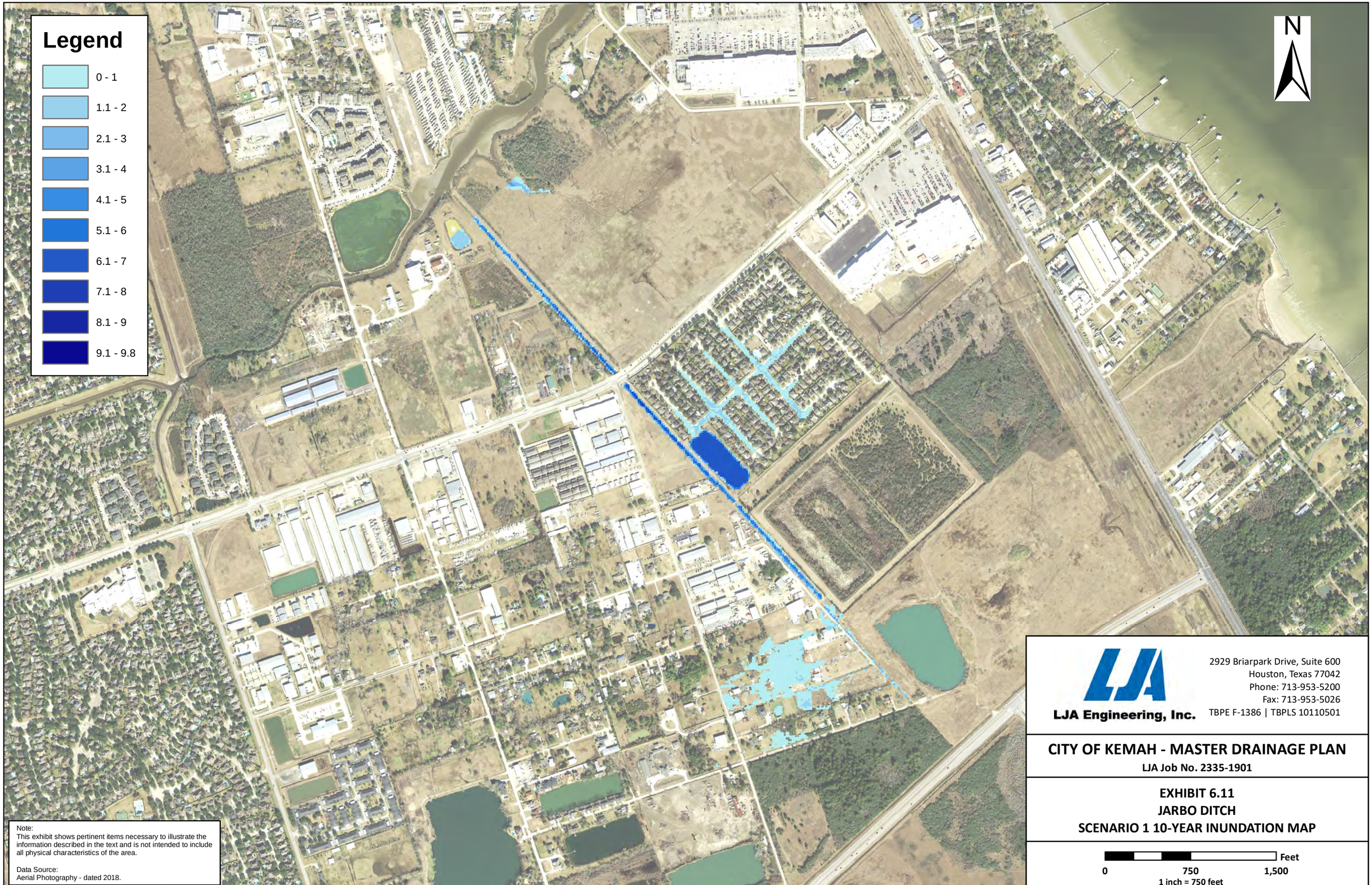
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.10
## JARBO DITCH
## SCENARIO 1 5-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

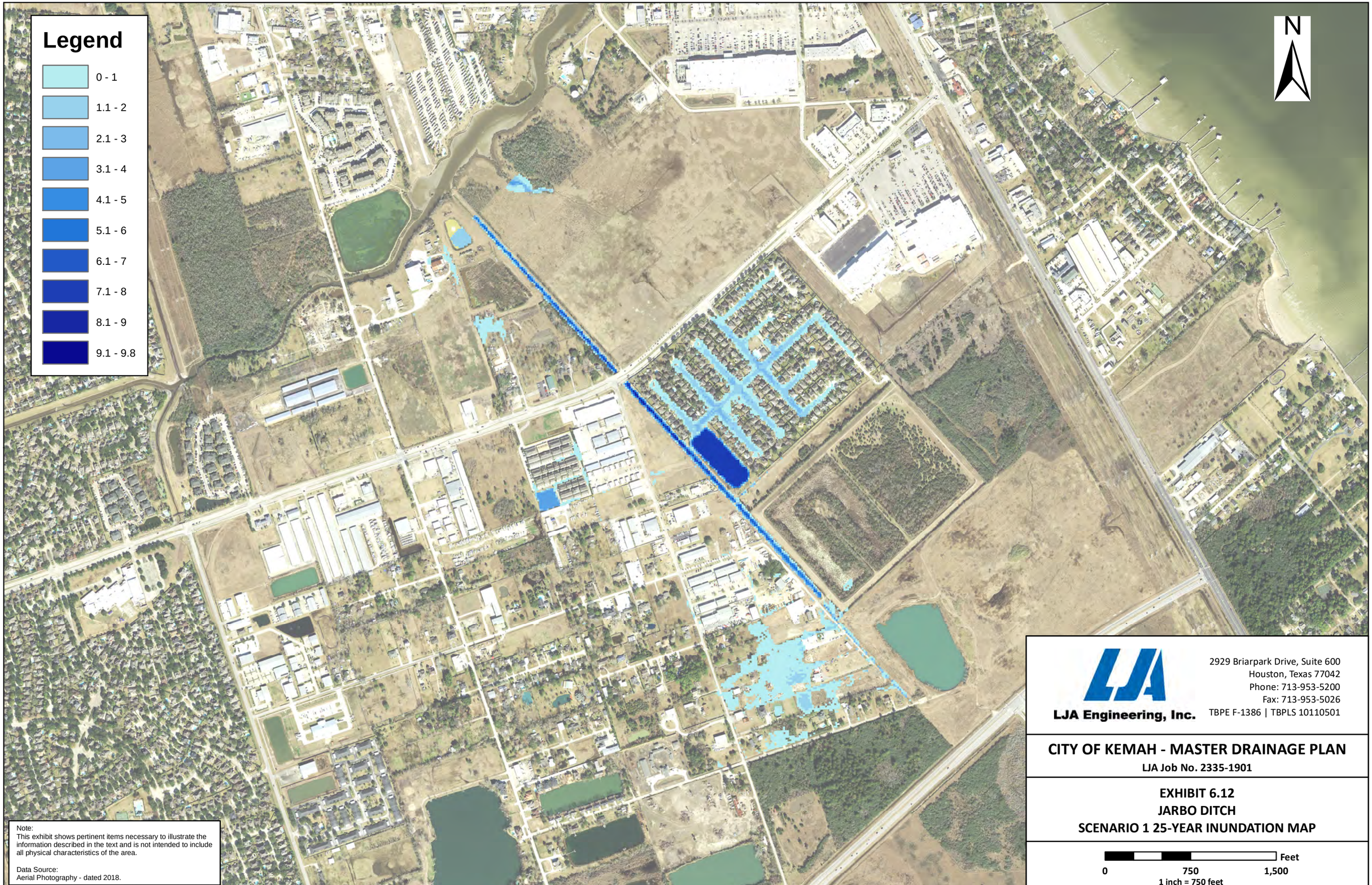
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.11
## JARBO DITCH
## SCENARIO 1 10-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

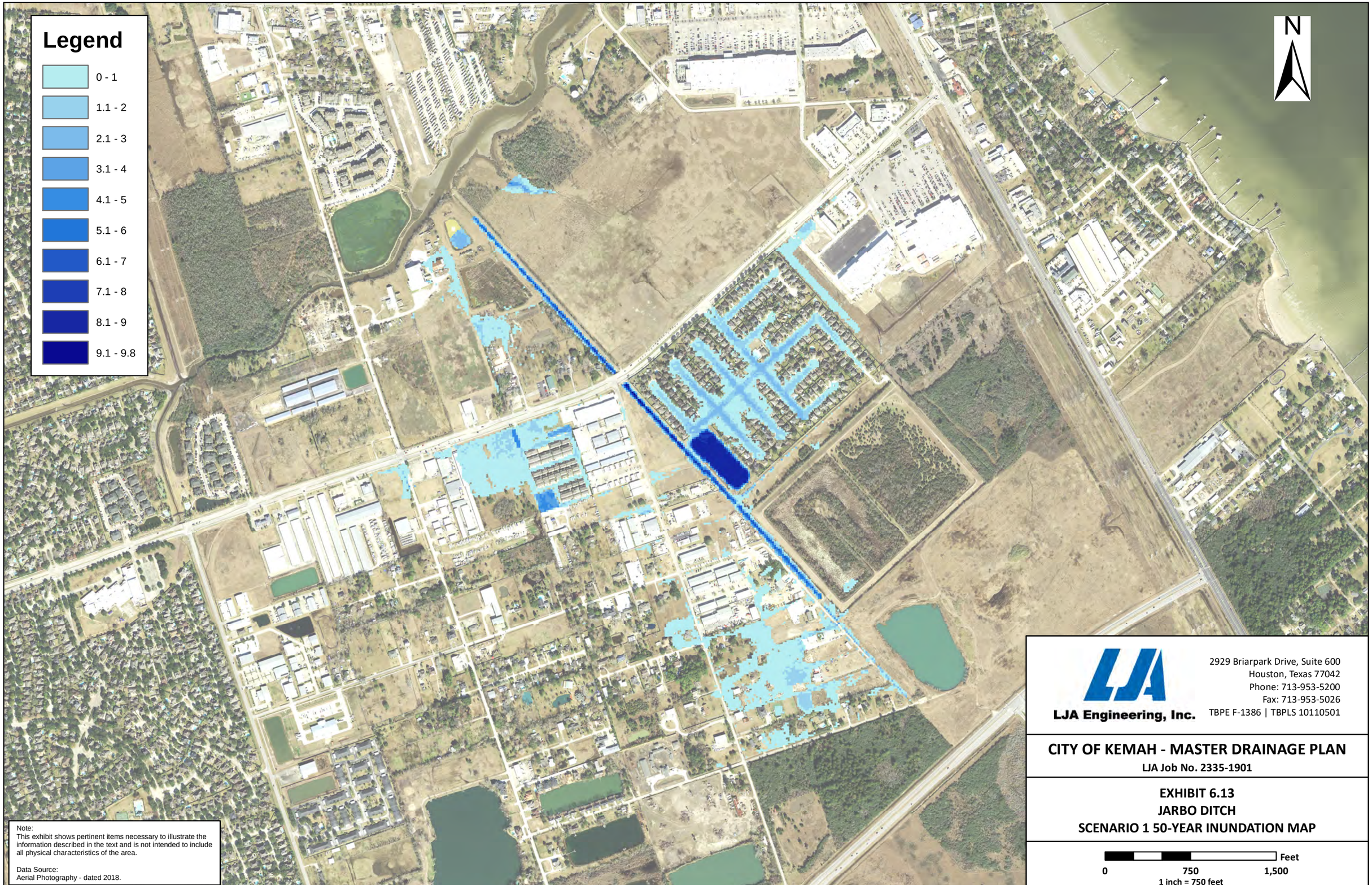
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.12
## JARBO DITCH
## SCENARIO 1 25-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

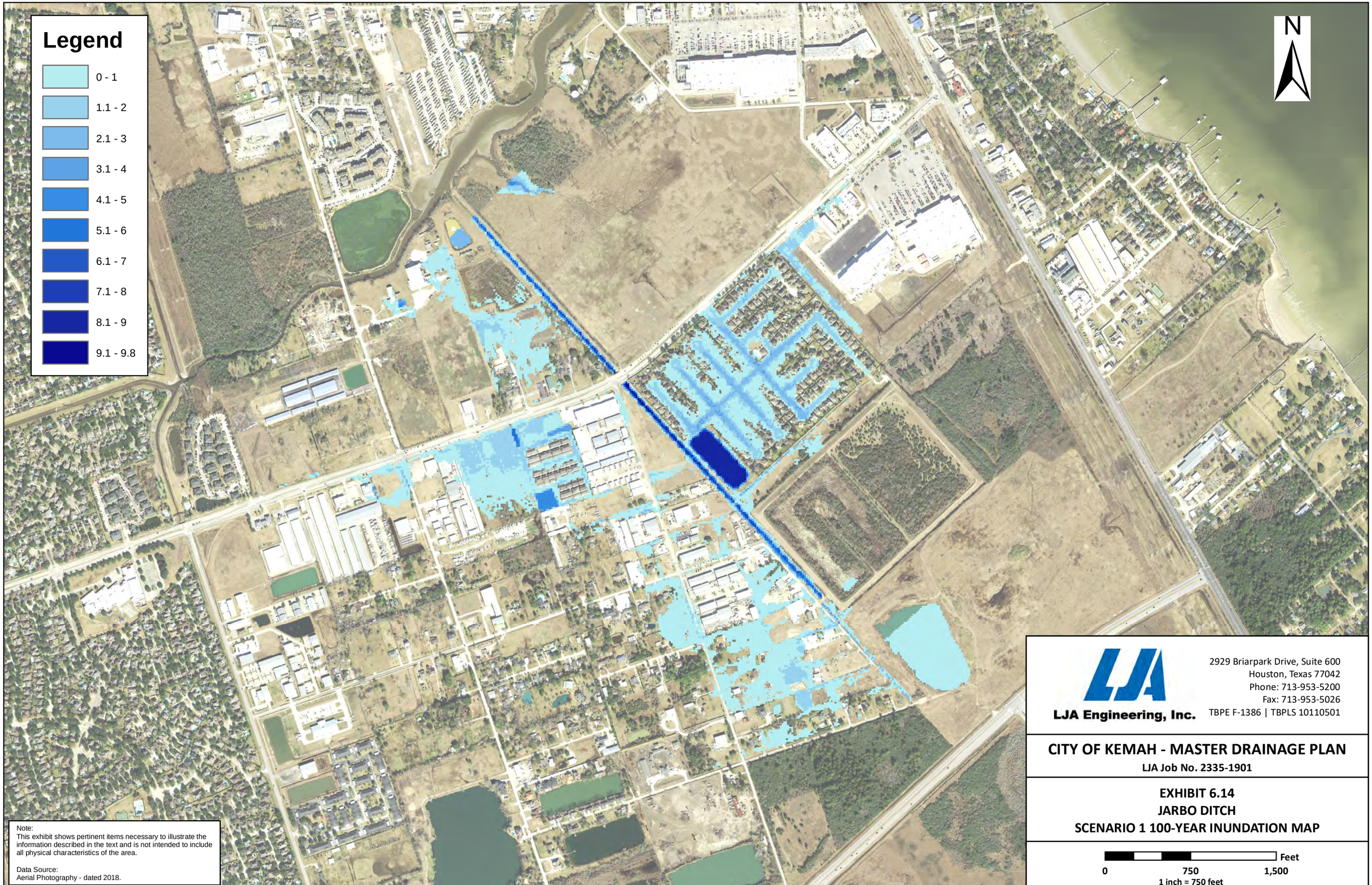
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.13
## JARBO DITCH
## SCENARIO 1 50-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

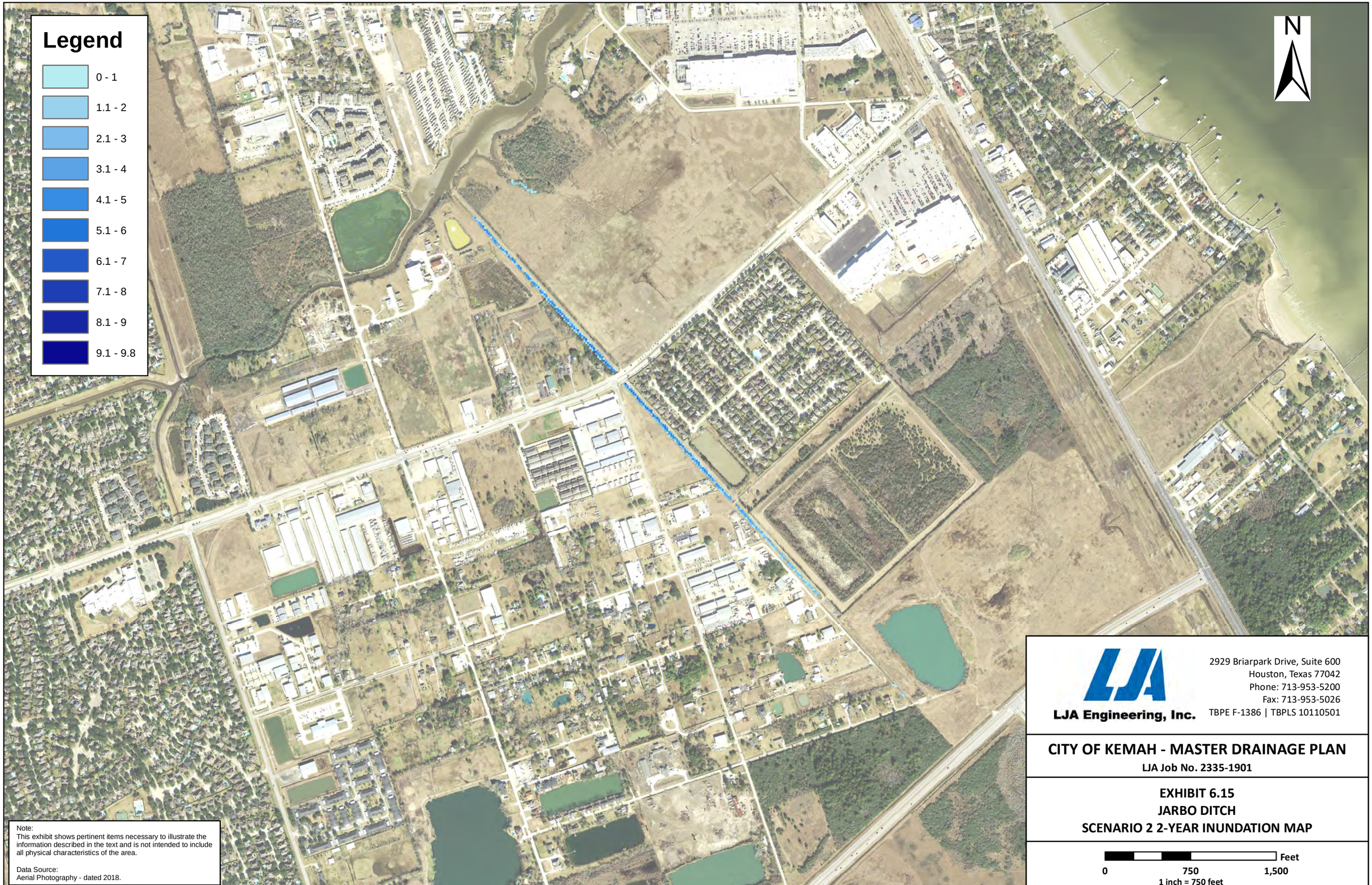
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 6.14**
**JARBO DITCH**
**SCENARIO 1 100-YEAR INUNDATION MAP**

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

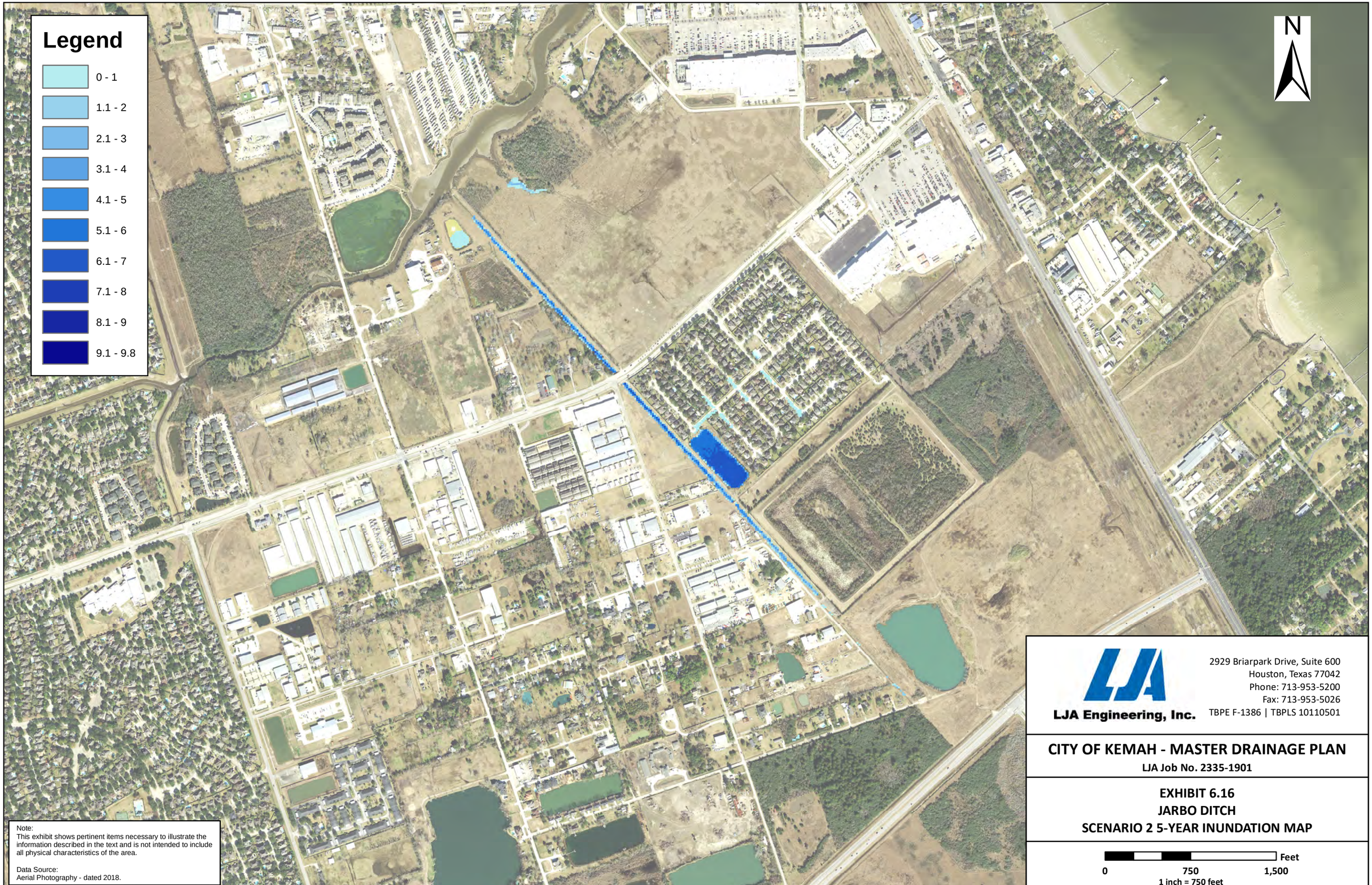
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.15
## JARBO DITCH
## SCENARIO 2 2-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

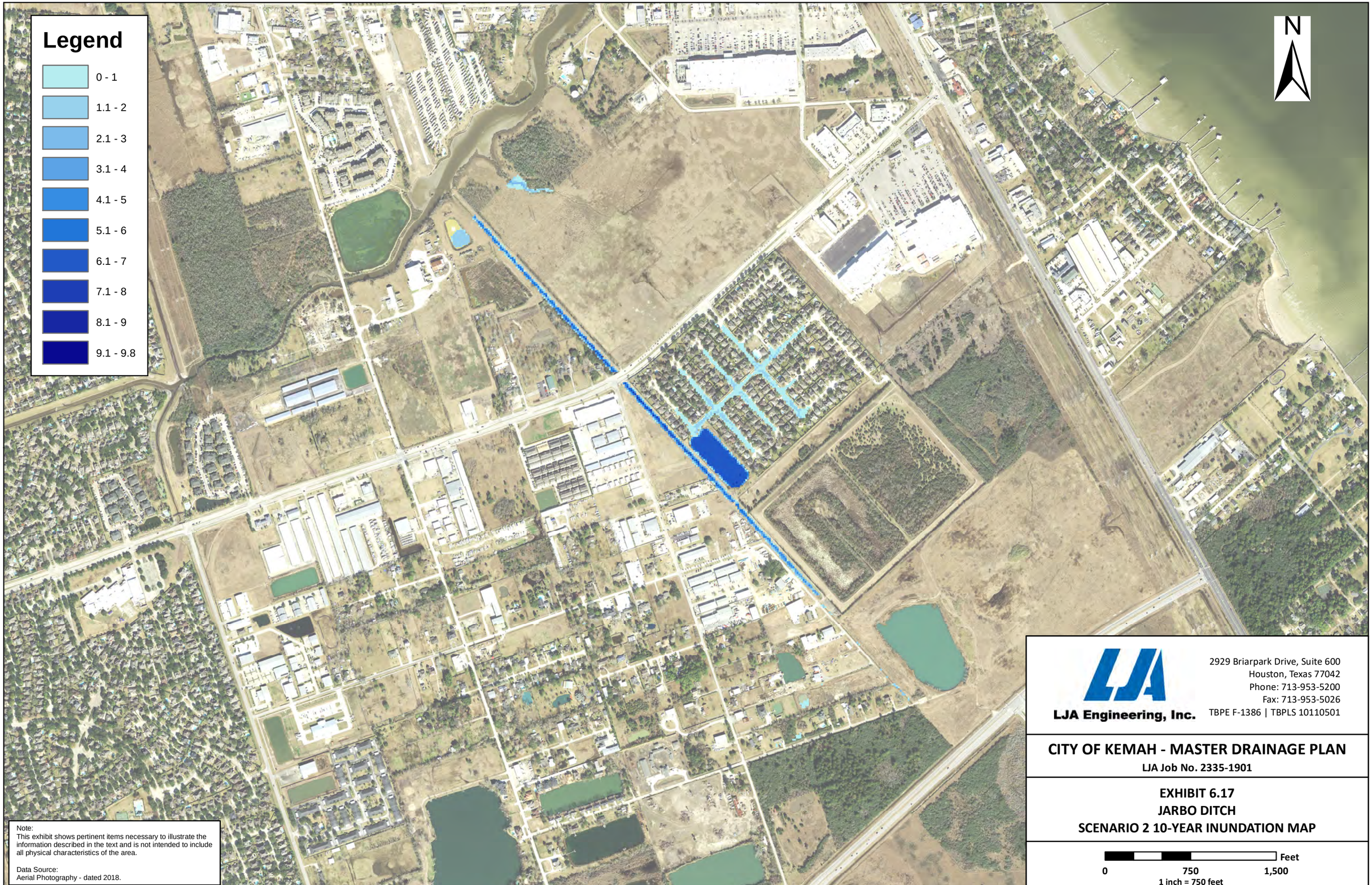
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.16
## JARBO DITCH
## SCENARIO 2 5-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

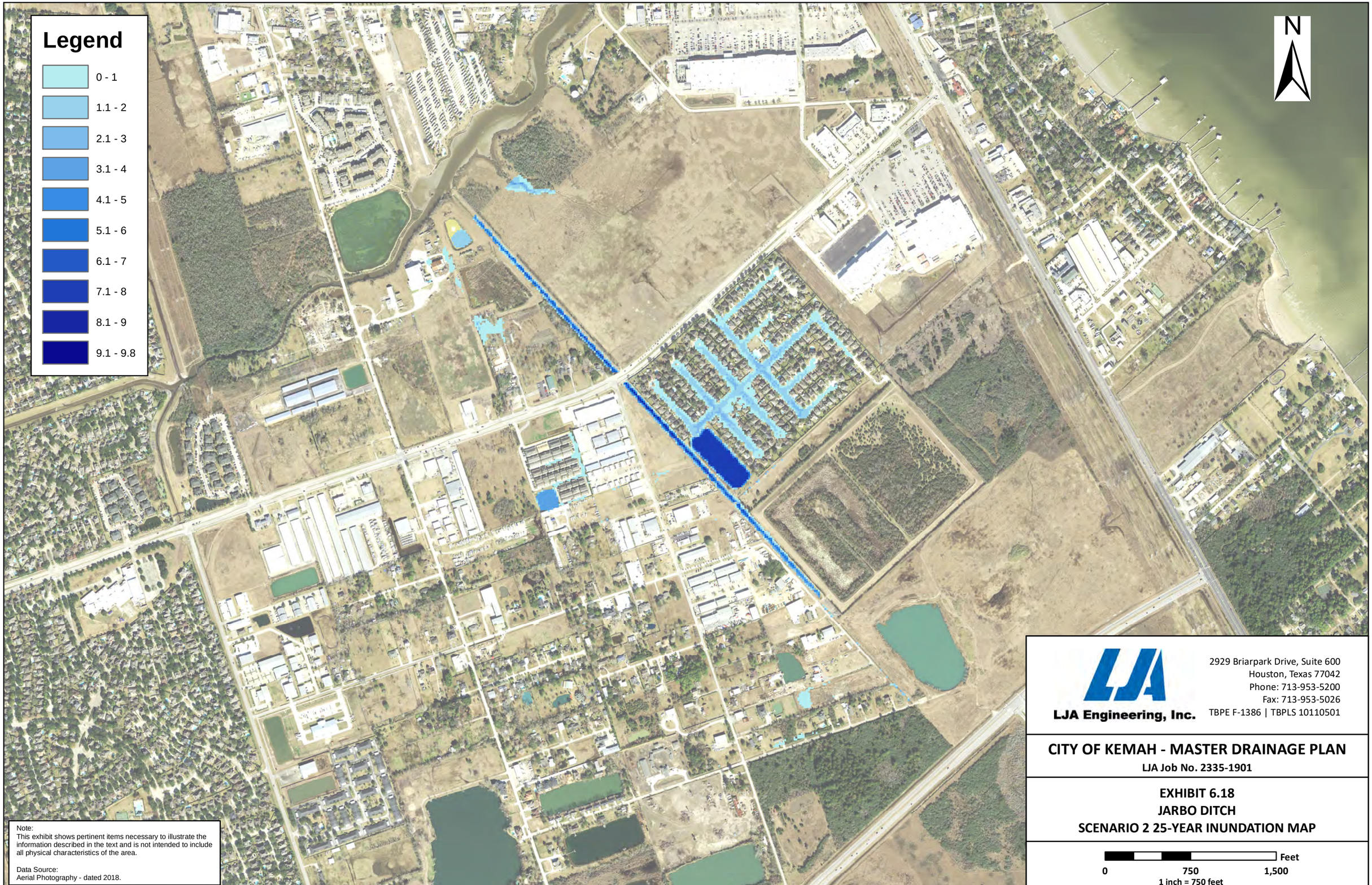
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.17
## JARBO DITCH
## SCENARIO 2 10-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

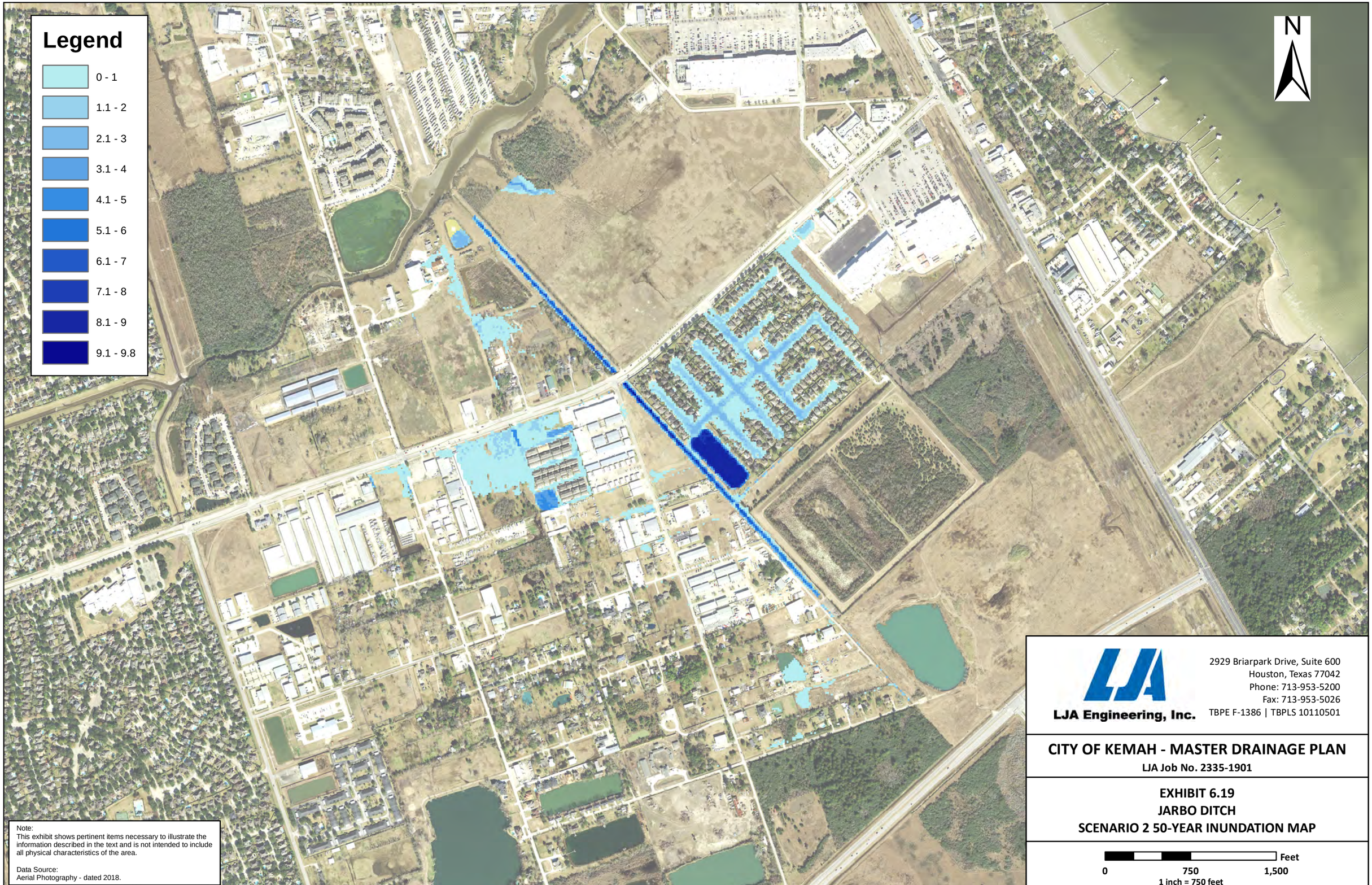
**CITY OF KEMAH - MASTER DRAINAGE PLAN**

**LJA Job No. 2335-1901**

**EXHIBIT 6.18**
**JARBO DITCH**
**SCENARIO 2 25-YEAR INUNDATION MAP**

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

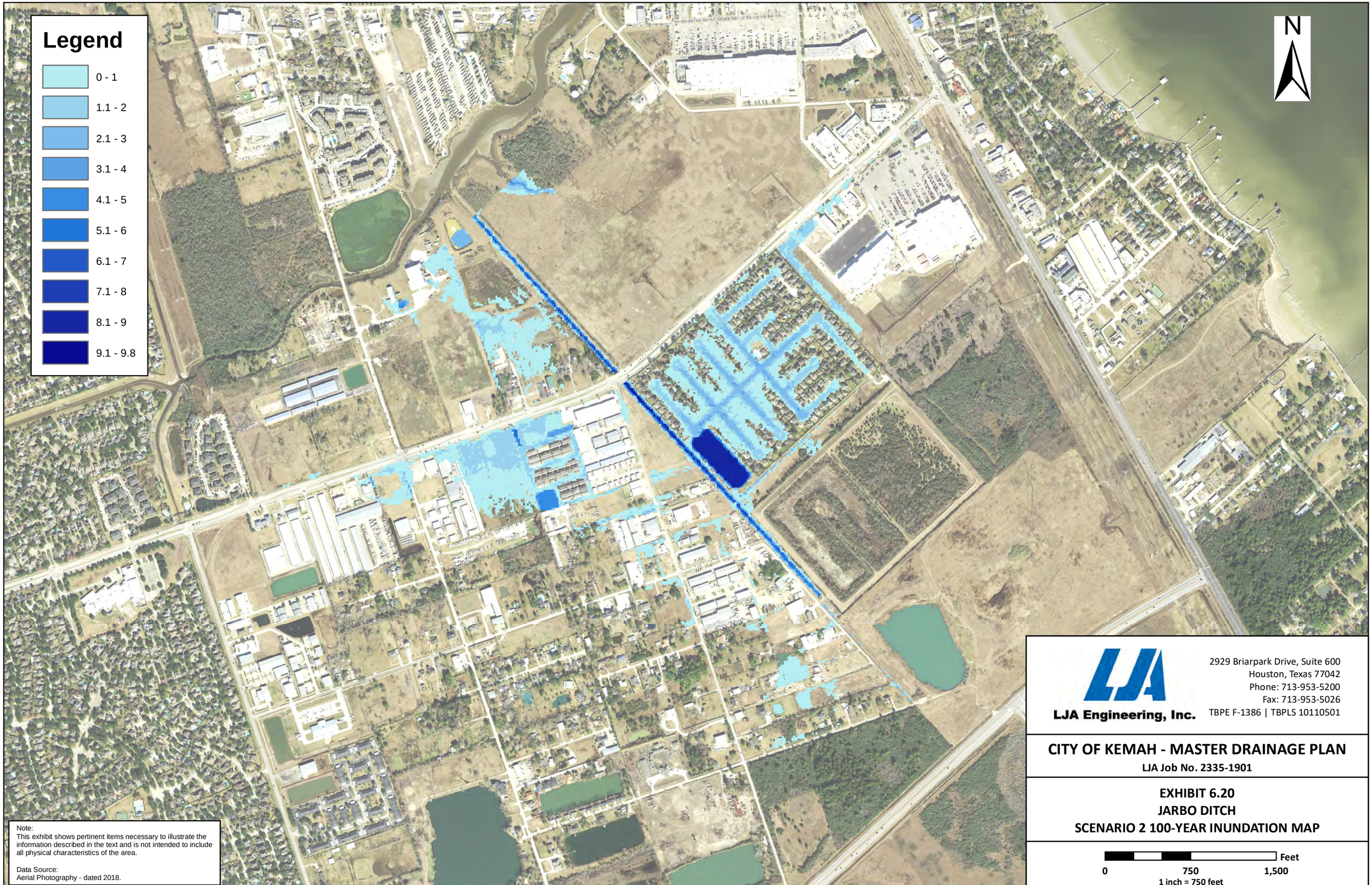
# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.19
## JARBO DITCH
## SCENARIO 2 50-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd




Note:
This exhibit shows pertinent items necessary to illustrate the information described in the text and is not intended to include all physical characteristics of the area.

Data Source:
Aerial Photography - dated 2018.

LJA Engineering, Inc.
2929 Briarpark Drive, Suite 600
Houston, Texas 77042
Phone: 713-953-5200
Fax: 713-953-5026
TBPE F-1386 | TBPLS 10110501

# CITY OF KEMAH - MASTER DRAINAGE PLAN

**LJA Job No. 2335-1901**

## EXHIBIT 6.20
## JARBO DITCH
## SCENARIO 2 100-YEAR INUNDATION MAP

Feet
0 750 1,500
1 inch = 750 feet

J:\2335\1901\DOC\EXHIBITS\GIS\2020-07-29 SKemah Drainage_10.5.mxd

# APPENDIX A
# OPINION OF PROBABLE COST

# BAYVIEW ACRES
# ALTERNATIVE 1
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**Bayview Acres - Alternative 1**
**Opinion of Probable Cost**

| Item | Unit | Quantity | | Unit Price | | Total Cost |
|---|---|---|---|---|---|---|
| Mobilization | % | 5% | $ | 1,281,000 | $ | 64,050 |
| **STORM SEWER** | | | | | | |
| Remove and Dispose - 18" RCP | LF | 60 | $ | 9 | $ | 540 |
| Remove and Dispose - 24" RCP | LF | 340 | $ | 10 | $ | 3,400 |
| Remove and Dispose - 30" RCP | LF | 800 | $ | 12 | $ | 9,600 |
| Storm Pipe 42" RC Pipe (CL III) | LF | 850 | $ | 140 | $ | 119,000 |
| Storm Pipe 54" RC Pipe (CL III) | LF | 720 | $ | 210 | $ | 151,200 |
| Concrete Box Culvert (6 ft x 4 ft) | LF | 960 | $ | 450 | $ | 432,000 |
| Cement Stabilized Sand Backfill | CY | 2500 | $ | 25 | $ | 62,500 |
| Ditch Widening and Regrading | LF | 8000 | $ | 20 | $ | 160,000 |
| Culvert Resizing and Driveway Reconstruction | LS | 1 | $ | 300,000 | $ | 300,000 |
| **GENERAL ITEMS** | | | | | | |
| Groundwater Control | LF | 2530 | $ | 20 | $ | 50,600 |
| Trench Safety System | LF | 2530 | $ | 2 | $ | 5,060 |
| **MISCELLANEOUS ITEMS** | | | | | | |
| Extra Work Items | % | 4% | $ | 1,281,000 | $ | 51,240 |
| SW3P, Bonds & Permits | % | 5% | $ | 1,281,000 | $ | 64,050 |
| Planning, Engineering & Design | % | 15% | $ | 1,281,000 | $ | 192,150 |
| Construction Management | % | 10% | $ | 1,281,000 | $ | 128,100 |
| Easement Acquisition | SF | 14400 | $ | 2.00 | $ | 28,800 |
| Contingency | % | 30% | $ | 1,281,000 | $ | 384,300 |
| **Total** | | | | | **$** | **2,206,590** |

# BAYVIEW ACRES
# ALTERNATIVE 2
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**Bayview Acres - Alternative 2**
**Opinion of Probable Cost**

| Item | Unit | Quantity | | Unit Price | | Total Cost |
|---|---|---|---|---|---|---|
| Mobilization | % | 5% | $ | 1,214,000 | $ | 60,700 |
| **STORM SYSTEM** | | | | | | |
| Remove and Dispose - 18" RCP | LF | 60 | $ | 9 | $ | 540 |
| Remove and Dispose - 24" RCP | LF | 340 | $ | 10 | $ | 3,400 |
| Remove and Dispose - 30" RCP | LF | 800 | $ | 12 | $ | 9,600 |
| Storm Pipe 42" RC Pipe (CL III) | LF | 850 | $ | 140 | $ | 119,000 |
| Storm Pipe 48" RC Pipe (CL III) | LF | 760 | $ | 140 | $ | 106,400 |
| Storm Pipe 54" RC Pipe (CL III) | LF | 1680 | $ | 210 | $ | 352,800 |
| Cement Stabilized Sand Backfill | CY | 4100 | $ | 25 | $ | 102,500 |
| Ditch Widening and Regrading | LF | 8000 | $ | 20 | $ | 160,000 |
| Culvert Resizing and Driveway Reconstruction | LS | 1 | $ | 300,000 | $ | 300,000 |
| **GENERAL ITEMS** | | | | | | |
| Groundwater Control | LF | 3290 | $ | 20 | $ | 65,800 |
| Trench Safety System | LF | 3290 | $ | 2 | $ | 6,580 |
| **MISCELLANEOUS ITEMS** | | | | | | |
| Extra Work Items | % | 4% | $ | 1,214,000 | $ | 48,560 |
| SW3P, Bonds & Permits | % | 5% | $ | 1,214,000 | $ | 60,700 |
| Planning, Engineering & Design | % | 15% | $ | 1,214,000 | $ | 182,100 |
| Construction Management | % | 10% | $ | 1,214,000 | $ | 121,400 |
| Easement Acquisition | SF | 29600 | $ | 2.00 | $ | 59,200 |
| Contingency | % | 30% | $ | 1,214,000 | $ | 364,200 |
| **Total** | | | | | **$** | **2,123,480** |

# KEMAH OAKS
# ALTERNATIVE 1
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**Kemah Oaks Subdivision - Alternative 1**
**Opinion of Probable Cost**

| Item | Unit | Quantity | Unit Price | Total Cost |
|---|---|---|---|---|
| Mobilization | % | 5% | $ 501,000 | $ 25,050 |
| **STORM SEWER** | | | | |
| Remove and Dispose - 24" RCP | LF | 1950 | $ 10 | $ 19,500 |
| Remove and Dispose - 30" RCP | LF | 390 | $ 12 | $ 4,680 |
| Storm Pipe 30" RC Pipe (CL III) | LF | 1550 | $ 90 | $ 139,500 |
| Storm Pipe 36" RC Pipe (CL III) | LF | 790 | $ 120 | $ 94,800 |
| Cement Stabilized Sand Backfill | CY | 1000 | $ 125 | $ 125,000 |
| **GENERAL ITEMS** | | | | |
| Site Restoration | LF | 1,820 | $ 10 | $ 18,200 |
| Groundwater Control | LF | 2340 | $ 20 | $ 46,800 |
| Trench Safety System | LF | 2340 | $ 2 | $ 4,680 |
| Traffic Control | LS | 1 | $ 20,000 | $ 20,000 |
| Full Depth Pavement Repair (7"), including subgrade and concrete curbs, all depths | SY | 320 | $ 85 | $ 27,200 |
| **MISCELLANEOUS ITEMS** | | | | |
| Extra Work Items | % | 4% | $ 501,000 | $ 20,040 |
| SW3P, Bonds & Permits | % | 5% | $ 501,000 | $ 25,050 |
| Planning, Engineering & Design | % | 15% | $ 501,000 | $ 75,150 |
| Construction Management | % | 10% | $ 501,000 | $ 50,100 |
| Contingency | % | 30% | $ 501,000 | $ 150,300 |
| **Total** | | | | **$ 846,050** |

# KEMAH OAKS
# ALTERNATIVE 2
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**Kemah Oaks Subdivision - Alternative 2**
**Opinion of Probable Cost**

| Item | Unit | Quantity | Unit Price | Total Cost |
|---|---|---|---|---|
| Mobilization | % | 5% | $ 1,221,000 | $ 61,050 |
| **STORM SEWER ITEMS** | | | | |
| Remove and Dispose - 24" RCP | LF | 1950 | $ 10 | $ 19,500 |
| Remove and Dispose - 30" RCP | LF | 390 | $ 12 | $ 4,680 |
| Storm Pipe 30" RC Pipe (CL III) | LF | 1550 | $ 90 | $ 139,500 |
| Storm Pipe 36" RC Pipe (CL III) | LF | 790 | $ 120 | $ 94,800 |
| Cement Stabilized Sand Backfill | CY | 1000 | $ 25 | $ 25,000 |
| **DETENTION ITEMS** | | | | |
| Excavation and Off-Site Disposal (Detention) | CY | 60000 | $ 8 | $ 480,000 |
| Hydromulch | AC | 10 | $ 2,000 | $ 20,000 |
| Ditch Interceptor Structure (Class A) | EA | 3 | $ 3,000 | $ 9,000 |
| Concrete Pilot Channel (Class A) | CY | 210 | $ 600 | $ 126,000 |
| Outfall and Emergency Overflow | LS | 1 | $ 50,000 | $ 50,000 |
| **GENERAL ITEMS** | | | | |
| Site Restoration | LF | 1,820 | $ 10 | $ 18,200 |
| Utility Relocations | LS | 1 | $ 135,000 | $ 135,000 |
| Groundwater Control | LF | 2340 | $ 20 | $ 46,800 |
| Trench Safety System | LF | 2340 | $ 2 | $ 4,680 |
| Traffic Control | LS | 1 | $ 20,000 | $ 20,000 |
| Full Depth Pavement Repair (7"), including subgrade and concrete curbs, all depths | SY | 320 | $ 85 | $ 27,200 |
| **MISCELLANEOUS ITEMS** | | | | |
| Extra Work Items | % | 4% | $ 1,221,000 | $ 48,840 |
| SW3P, Bonds & Permits | % | 5% | $ 1,221,000 | $ 61,050 |
| Planning, Engineering & Design | % | 15% | $ 1,221,000 | $ 183,150 |
| Construction Management | % | 10% | $ 1,221,000 | $ 122,100 |
| Contingency | % | 30% | $ 1,221,000 | $ 366,300 |
| **Total** | | | | **$ 2,062,850** |

# KEMAH OAKS
# ALTERNATIVE 3
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**Kemah Oaks Subdivision - Alternative 3**
**Opinion of Probable Cost**

| Item | Unit | Quantity | Unit Price | Total Cost |
|---|---|---|---|---|
| Mobilization | % | 5% | $ 1,054,000 | $ 52,700 |
| **STORM SEWER ITEMS** | | | | |
| Remove and Dispose - 24" RCP | LF | 1950 | $ 10 | $ 19,500 |
| Remove and Dispose - 30" RCP | LF | 390 | $ 12 | $ 4,680 |
| Storm Pipe 30" RC Pipe (CL III) | LF | 1550 | $ 90 | $ 139,500 |
| Storm Pipe 36" RC Pipe (CL III) | LF | 790 | $ 120 | $ 94,800 |
| Cement Stabilized Sand Backfill | CY | 1000 | $ 125 | $ 125,000 |
| **DETENTION ITEMS** | | | | |
| Excavation and Off-Site Disposal (Detention) | CY | 19500 | $ 8 | $ 156,000 |
| Hydromulch | AC | 2 | $ 2,000 | $ 4,000 |
| Ditch Interceptor Structure (Class A) | EA | 3 | $ 3,000 | $ 9,000 |
| Concrete Pilot Channel (Class A) | CY | 140 | $ 600 | $ 84,000 |
| Stormwater pump station | LS | 1 | $ 300,000 | $ 300,000 |
| **GENERAL ITEMS** | | | | |
| Site Restoration | LF | 1,820 | $ 10 | $ 18,200 |
| Groundwater Control | LF | 2340 | $ 20 | $ 46,800 |
| Trench Safety System | LF | 2340 | $ 2 | $ 4,680 |
| Traffic Control | LS | 1 | $ 20,000 | $ 20,000 |
| Full Depth Pavement Repair (7"), including subgrade and concrete curbs, all depths | SY | 320 | $ 85 | $ 27,200 |
| **MISCELLANEOUS ITEMS** | | | | |
| Extra Work Items | % | 4% | $ 1,054,000 | $ 42,160 |
| SW3P, Bonds & Permits | % | 5% | $ 1,054,000 | $ 52,700 |
| Planning, Engineering & Design | % | 15% | $ 1,054,000 | $ 158,100 |
| Construction Management | % | 10% | $ 1,054,000 | $ 105,400 |
| Contingency | % | 30% | $ 1,054,000 | $ 316,200 |
| **Total** | | | | **$ 1,780,620** |

# KEMAH OAKS
# ALTERNATIVE 4
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**Kemah Oaks Subdivision - Alternative 4**
**Opinion of Probable Cost**

| Item | Unit | Quantity | Unit Price | Total Cost |
|---|---|---|---|---|
| Mobilization | % | 5% | $ 102,000 | $ 5,100 |
| **STORM SEWER** | | | | |
| Remove and Dispose - 24" RCP | LF | 60 | $ 10 | $ 600 |
| Remove and Dispose - Inlet | EA | 1 | $ 500 | $ 500 |
| Type C-2A Inlet | EA | 2 | $ 7,500 | $ 15,000 |
| Concrete Box Culvert (6 ft x 4 ft) | LF | 60 | $ 450 | $ 27,000 |
| 5" Concrete Slope Paving | SY | 560 | $ 80 | $ 44,800 |
| Cement Stabilized Sand Backfill | CY | 54 | $ 25 | $ 1,350 |
| **GENERAL ITEMS** | | | | |
| Site Restoration | LF | 60 | $ 10 | $ 600 |
| Groundwater Control | LF | 60 | $ 20 | $ 1,200 |
| Trench Safety System | LF | 60 | $ 2 | $ 120 |
| Traffic Control | LS | 1 | $ 5,000 | $ 5,000 |
| Full Depth Pavement Repair (7"), including subgrade and concrete curbs, all depths | SY | 60 | $ 85 | $ 5,100 |
| **MISCELLANEOUS ITEMS** | | | | |
| Extra Work Items | % | 4% | $ 102,000 | $ 4,080 |
| SW3P, Bonds & Permits | % | 5% | $ 102,000 | $ 5,100 |
| Planning, Engineering & Design | % | 15% | $ 102,000 | $ 15,300 |
| Construction Management | % | 10% | $ 102,000 | $ 10,200 |
| Contingency | % | 30% | $ 102,000 | $ 30,600 |
| **Total** | | | | **$ 171,650** |

# SOUTH KEMAH
# ALTERNATIVE 1
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**South Kemah Area - Alternative 1**
**Opinion of Probable Cost**

| Item | Unit | Quantity | | Unit Price | | Total Cost |
|---|---|---|---|---|---|---|
| Mobilization | % | 5% | $ | 2,299,000 | $ | 114,950 |
| | | **SYSTEM A** | | | | |
| **DEMOLITION** | | | | | | |
| Remove and Dispose - 18" RCP | LF | 1250 | $ | 10 | $ | 12,500 |
| Remove and Dispose - 24" RCP | LF | 1700 | $ | 10 | $ | 17,000 |
| Removing Concrete (Driveways) | SY | 240 | $ | 10 | $ | 2,400 |
| **STORM WATER ITEMS** | | | | | | |
| Storm Pipe 30" RC Pipe (CL III) | LF | 420 | $ | 90 | $ | 37,800 |
| Concrete Box Culvert (5 ft x 4 ft) | LF | 1000 | $ | 350 | $ | 350,000 |
| Concrete Box Culvert (7 ft x 4 ft) | LF | 825 | $ | 450 | $ | 371,250 |
| Cement Stabilized Sand Backfill | CY | 1400 | $ | 25 | $ | 35,000 |
| Excavation and Off-Site Disposal (Ditch) | CY | 1270 | $ | 8 | $ | 10,160 |
| Hydromulch | AC | 1 | $ | 2,000 | $ | 2,000 |
| **GENERAL ITEMS** | | | | | | |
| Groundwater Control | LF | 2250 | $ | 20 | $ | 45,000 |
| Trench Safety System | LF | 2250 | $ | 2 | $ | 4,500 |
| Traffic Control | LS | 1 | $ | 25,000 | $ | 25,000 |
| Concrete Driveway Repair | SY | 240 | $ | 50 | $ | 12,000 |
| | | | | **SUBTOTAL - SYSTEM A** | **$** | **924,610** |
| | | **SYSTEM B** | | | | |
| **DEMOLITION** | | | | | | |
| Remove and Dispose - 24" RCP | LF | 2030 | $ | 10 | $ | 20,300 |
| Removing Concrete (Driveways) | SY | 450 | $ | 10 | $ | 4,500 |
| **STORM WATER ITEMS** | | | | | | |
| Storm Pipe 24" RC Pipe (CL III) | LF | 220 | $ | 70 | $ | 15,400 |
| Storm Pipe 30" RC Pipe (CL III) | LF | 140 | $ | 90 | $ | 12,600 |
| Concrete Box Culvert (6 ft x 3 ft) | LF | 200 | $ | 400 | $ | 80,000 |
| Concrete Box Culvert (7 ft x 4 ft) | LF | 1075 | $ | 450 | $ | 483,750 |
| Cement Stabilized Sand Backfill | CY | 980 | $ | 25 | $ | 24,500 |
| Excavation and Off-Site Disposal (Ditch) | CY | 3010 | $ | 8 | $ | 24,080 |
| Hydromulch | AC | 1 | $ | 2,000 | $ | 2,000 |

**Appendix A**
**City of Kemah - Master Drainage Plan**
**South Kemah Area - Alternative 1**
**Opinion of Probable Cost**

| | | | | | | |
|---|---|---|---|---|---|---|
| **GENERAL ITEMS** | | | | | | |
| Groundwater Control | LF | 1640 | $ | 20 | $ | 32,800 |
| Trench Safety System | LF | 1640 | $ | 2 | $ | 3,280 |
| Traffic Control | LS | 1 | $ | 25,000 | $ | 25,000 |
| Concrete Driveway Repair | SY | 450 | $ | 50 | $ | 22,500 |
| | | | **SUBTOTAL - SYSTEM B** | | **$** | **750,710** |
| | | **SYSTEM C** | | | | |
| **DEMOLITION** | | | | | | |
| Remove and Dispose - 24" RCP | LF | 1200 | $ | 10 | $ | 12,000 |
| Remove and Dispose - 36" RCP | LF | 780 | $ | 10 | $ | 7,800 |
| Removing Concrete (Driveways) | SY | 210 | $ | 10 | $ | 2,100 |
| Remove and Dispose Inlets (All Sizes) | EA | 14 | $ | 500 | $ | 7,000 |
| **STORM WATER ITEMS** | | | | | | |
| Storm Pipe 30" RC Pipe (CL III) | LF | 1200 | $ | 90 | $ | 108,000 |
| De-Silt Ditches | LF | 4640 | $ | 15 | $ | 69,600 |
| Concrete Box Culvert (6 ft x 3 ft) | LF | 780 | $ | 400 | $ | 312,000 |
| Cement Stabilized Sand Backfill | CY | 1270 | $ | 25 | $ | 31,750 |
| Type A Inlet | EA | 14 | $ | 2,000 | $ | 28,000 |
| **GENERAL ITEMS** | | | | | | |
| Groundwater Control | LF | 1200 | $ | 20 | $ | 24,000 |
| Trench Safety System | LF | 1200 | $ | 2 | $ | 2,400 |
| Traffic Control | LS | 1 | $ | 5,000 | $ | 5,000 |
| Concrete Driveway (Residential) | SF | 1890 | $ | 7 | $ | 13,230 |
| | | | **SUBTOTAL - SYSTEM C** | | **$** | **622,880** |
| **MISCELLANEOUS ITEMS** | | | | | | |
| Extra Work Items | % | 4% | $ | 2,299,000 | $ | 91,960 |
| SW3P, Bonds & Permits | % | 5% | $ | 2,299,000 | $ | 114,950 |
| Planning, Engineering & Design | % | 15% | $ | 2,299,000 | $ | 344,850 |
| Construction Management | % | 10% | $ | 2,299,000 | $ | 229,900 |
| Contingency | % | 30% | $ | 2,299,000 | $ | 689,700 |
| **Total** | | | | | **$** | **3,884,510** |

# SOUTH KEMAH
# ALTERNATIVE 2
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**South Kemah Area - Alternative 1**
**Opinion of Probable Cost**

| Item | Unit | Quantity | | Unit Price | | Total Cost |
|---|---|---|---|---|---|---|
| Mobilization | % | 5% | $ | 1,665,000 | $ | 83,250 |
| **STORM SEWER** | | | | | | |
| Concrete Box Culvert (5 ft x 5 ft) | LF | 30 | $ | 350 | $ | 10,500 |
| Concrete Box Culvert (9 ft x 6 ft) | LF | 100 | $ | 850 | $ | 85,000 |
| Cement Stabilized Sand Backfill | CY | 100 | $ | 25 | $ | 2,500 |
| **DETENTION POND** | | | | | | |
| Class C Concrete Headwall | CY | 20 | $ | 800 | $ | 16,000 |
| Concrete Rip Rap (Class B) | CY | 10 | $ | 250 | $ | 2,500 |
| Excavation and Off-Site Disposal (Detention) | CY | 120000 | $ | 8 | $ | 960,000 |
| Concrete Pilot Channel (Class A) | CY | 80 | $ | 600 | $ | 48,000 |
| Hydromulch | AC | 6 | $ | 2,000 | $ | 12,000 |
| Ditch Interceptor Structure (Class A) | EA | 5 | $ | 3,000 | $ | 15,000 |
| Stormwater Pump Station | LS | 1 | $ | 500,000 | $ | 500,000 |
| **GENERAL ITEMS** | | | | | | |
| Groundwater Control | LF | 130 | $ | 20 | $ | 2,600 |
| Trench Safety System | LF | 130 | $ | 2 | $ | 260 |
| Traffic Control | LS | 1 | $ | 10,000 | $ | 10,000 |
| **MISCELLANEOUS ITEMS** | | | | | | |
| Extra Work Items | % | 4% | $ | 1,665,000 | $ | 66,600 |
| SW3P, Bonds & Permits | % | 5% | $ | 1,665,000 | $ | 83,250 |
| Planning, Engineering & Design | % | 15% | $ | 1,665,000 | $ | 249,750 |
| Construction Management | % | 10% | $ | 1,665,000 | $ | 166,500 |
| **Parcel Acquisition** | **SF** | **261360** | **$** | **5** | **$** | **1,306,800** |
| Contingency | % | 30% | $ | 1,665,000 | $ | 499,500 |
| | **Total** | | | | **$** | **4,120,010** |

# JARBO DITCH
# SCENARIO 1
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**Jarbo Ditch - Scenario 1**
**Opinion of Probable Cost**

| Item | Unit | Quantity | | Unit Price | | Total Cost |
|---|---|---|---|---|---|---|
| Mobilization | % | 5% | $ | 907,000 | $ | 45,350 |
| **STORM SEWER** | | | | | | |
| Concrete Box Culvert (8 ft x 7 ft) | LF | 130 | $ | 650 | $ | 84,500 |
| Cement Stabilized Sand Backfill | CY | 100 | $ | 25 | $ | 2,500 |
| **CHANNEL** | | | | | | |
| Class C Concrete Headwall | CY | 100 | $ | 800 | $ | 80,000 |
| Concrete Rip Rap (Class B) | CY | 170 | $ | 250 | $ | 42,500 |
| Excavation and Off-Site Disposal (Channel) | CY | 32000 | $ | 13 | $ | 416,000 |
| Hydromulch | AC | 8 | $ | 2,000 | $ | 16,000 |
| Ditch Interceptor Structure (Class A) | EA | 10 | $ | 3,000 | $ | 30,000 |
| 5" Concrete Slope Paving | SY | 1060 | $ | 80 | $ | 84,800 |
| Concrete Retaining Wall | SF | 400 | $ | 75 | $ | 30,000 |
| Backslope Drainage System Swales | LF | 6600 | $ | 5 | $ | 33,000 |
| Crushed Limestone Flexible Base, 6" Thickness | SY | 3700 | $ | 20 | $ | 74,000 |
| **GENERAL ITEMS** | | | | | | |
| Groundwater Control | LF | 130 | $ | 20 | $ | 2,600 |
| Trench Safety System | LF | 130 | $ | 2 | $ | 260 |
| Traffic Control | LS | 1 | $ | 10,000 | $ | 10,000 |
| Full Depth Pavement Repair (11"), including subgrade and concrete curbs, all depths | SY | 145 | $ | 125 | $ | 18,125 |
| Utility Relocations (Estimate) | LS | 1 | $ | 500,000 | $ | 500,000 |
| **MISCELLANEOUS ITEMS** | | | | | | |
| Extra Work Items | % | 4% | $ | 907,000 | $ | 36,280 |
| SW3P, Bonds & Permits | % | 5% | $ | 907,000 | $ | 45,350 |
| Planning, Engineering & Design | % | 15% | $ | 907,000 | $ | 136,050 |
| Construction Management | % | 10% | $ | 907,000 | $ | 90,700 |
| **Parcel Acquisition** | **SF** | **198000** | **$** | **10** | **$** | **1,980,000** |
| Contingency | % | 30% | $ | 907,000 | $ | 272,100 |
| **Total** | | | | | **$** | **4,030,115** |

# JARBO DITCH
# SCENARIO 2
# OPINION OF PROBABLE COST

**Appendix A**
**City of Kemah - Master Drainage Plan**
**Jarbo Ditch - Scenario 2**
**Opinion of Probable Cost**

| Item | Unit | Quantity | | Unit Price | | Total Cost |
|---|---|---|---|---|---|---|
| Mobilization | % | 5% | $ | 291,000 | $ | 14,550 |
| **CHANNEL** | | | | | | |
| Excavation and Off-Site Disposal (Channel) | CY | 10000 | $ | 13 | $ | 130,000 |
| Hydromulch | AC | 5 | $ | 2,000 | $ | 10,000 |
| Ditch Interceptor Structure (Class A) | EA | 8 | $ | 3,000 | $ | 24,000 |
| Concrete Retaining Wall | SF | 400 | $ | 75 | $ | 30,000 |
| Backslope Drainage System Swales | LF | 5400 | $ | 5 | $ | 27,000 |
| Crushed Limestone Flexible Base, 6" Thickness | SY | 3000 | $ | 20 | $ | 60,000 |
| **GENERAL ITEMS** | | | | | | |
| Traffic Control | LS | 1 | $ | 10,000 | $ | 10,000 |
| Full Depth Pavement Repair (11"), including subgrade and concrete curbs, all depths | SY | 145 | $ | 125 | $ | 18,125 |
| Utility Relocations (Estimate) | LS | 1 | $ | 250,000 | $ | 250,000 |
| **MISCELLANEOUS ITEMS** | | | | | | |
| Extra Work Items | % | 4% | $ | 291,000 | $ | 11,640 |
| SW3P, Bonds & Permits | % | 5% | $ | 291,000 | $ | 14,550 |
| Planning, Engineering & Design | % | 15% | $ | 291,000 | $ | 43,650 |
| Construction Management | % | 10% | $ | 291,000 | $ | 29,100 |
| **Parcel Acquisition** | **SF** | **60000** | **$** | **10** | **$** | **600,000** |
| Contingency | % | 30% | $ | 291,000 | $ | 87,300 |
| **Total** | | | | | **$** | **1,359,915** |

# APPENDIX B
# FEMA MAPS

# NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

**Coastal Base Flood Elevations** shown on this map apply only landward of 0.0' North American Vertical Datum of 1988. Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

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

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was STATE PLANE TEXAS SOUTH CENTRAL FIPS 4204. The **horizontal datum** was the North American Datum of 1983 (NAD 83), GRS1980 Spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

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

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

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at https://www.ngs.noaa.gov/.

**Base Map** information shown on this FIRM was derived from Galveston Central Appraisal District, NOAA, National Geodetic Survey, Texas Natural Resources Information System, U.S. Fish and Wildlife Service and the U.S. Geological Survey and were provided in digital format using source material at a scale of 1:20,000 or better.

Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

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

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Information eXchange** at 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letter of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Information eXchange may also be reached by Fax at 1-800-358-9620 and their website at https://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at https://www.fema.gov/national-flood-insurance-program.

The AE Zone category has been divided by a Limit of Moderate Wave Action (LiMWA). The LiMWA represents the approximate landward limit of the 1.5-foot breaking wave. The effects of wave hazards between the VE Zone and the LiMWA (or between the shoreline and the LiMWA for areas where VE Zones are not identified) will be similar to, but less severe than those in the VE Zone.

# LEGEND

**SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD**

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

| | |
|---|---|
| **ZONE A** | No Base Flood Elevations determined. |
| **ZONE AE** | Base Flood Elevations determined. |
| **ZONE AH** | Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined. |
| **ZONE AO** | Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined. |
| **ZONE AR** | Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood. |
| **ZONE A99** | Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined. |
| **ZONE V** | Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined. |
| **ZONE VE** | Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined. |

**FLOODWAY AREAS IN ZONE AE**

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

**OTHER FLOOD AREAS**

| | |
|---|---|
| **ZONE X** | Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood. |

**OTHER AREAS**

| | |
|---|---|
| **ZONE X** | Areas determined to be outside the 0.2% annual chance floodplain. |
| **ZONE D** | Areas in which flood hazards are undetermined, but possible. |

Floodplain Boundary
Floodway Boundary
Zone D Boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
Limit of Moderate Wave Action
~~513~~ Base Flood Elevation line and value; elevation in feet*
(EL 987) Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

Cross section line
Transect line
Culvert
Bridge
Footbridge
45° 02' 08", 93° 02' 12" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
4989000FT 1000-meter Universal Transverse Mercator grid ticks, zone 15
5000-foot grid values: Texas State Plane Coordinate System, (FIPS Zone 4204), Lambert Conformal Conic
DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5 River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
**AUGUST 15, 2019**

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

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

**MAP SCALE 1" = 500'**

250 0 500 1000 FEET
150 0 150 300 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

**PANEL 0042G**

# FIRM
## FLOOD INSURANCE RATE MAP

## GALVESTON COUNTY, TEXAS
### AND INCORPORATED AREAS

**PANEL 42 OF 600**
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| CLEAR LAKE SHORES, CITY OF | 485461 | 0042 | G |
| GALVESTON COUNTY | 485470 | 0042 | G |
| KEMAH, CITY OF | 485481 | 0042 | G |

**MAP NUMBER**
**48167C0042G**

**EFFECTIVE DATE**
**AUGUST 15, 2019**

Federal Emergency Management Agency

# NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (**BFEs**) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

**Coastal Base Flood Elevations** shown on this map apply only landward of 0.0' North American Vertical Datum of 1988. Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

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

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was STATE PLANE TEXAS SOUTH CENTRAL FIPS 4204. The **horizontal datum** was the North American Datum of 1983 (NAD 83), GRS1980 Spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

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

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

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at https://www.ngs.noaa.gov/.

**Base Map** information shown on this FIRM was derived from Galveston Central Appraisal District, NOAA, National Geodetic Survey, Texas Natural Resources Information System, U.S. Fish and Wildlife Service and the U.S. Geological Survey and were provided in digital format using source material at a scale of 1:20,000 or better.

Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

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

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Information eXchange** at 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letter of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Information eXchange may also be reached by Fax at 1-800-358-9620 and their website at https://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at https://www.fema.gov/national-flood-insurance-program.

# LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

| | |
|---|---|
| **ZONE A** | No Base Flood Elevations determined. |
| **ZONE AE** | Base Flood Elevations determined. |
| **ZONE AH** | Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined. |
| **ZONE AO** | Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined. |
| **ZONE AR** | Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood. |
| **ZONE A99** | Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined. |
| **ZONE V** | Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined. |
| **ZONE VE** | Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined. |

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

| | |
|---|---|
| **ZONE X** | Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood. |

OTHER AREAS

| | |
|---|---|
| **ZONE X** | Areas determined to be outside the 0.2% annual chance floodplain. |
| **ZONE D** | Areas in which flood hazards are undetermined, but possible. |

Floodplain Boundary
Floodway Boundary
Zone D Boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities
Limit of Moderate Wave Action
~~513~~ Base Flood Elevation line and value; elevation in feet*
(EL 987) Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

Cross section line
Transect line
Culvert
Bridge
Footbridge
45° 02' 08", 93° 02' 12" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
$^{49}89^{000m}$ N 1000-meter Universal Transverse Mercator grid ticks, zone 15
4989000FT 5000-foot grid values: Texas State Plane Coordinate System, (FIPS Zone 4204), Lambert Conformal Conic
DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5 River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
AUGUST 15, 2019

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

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

**MAP SCALE 1" = 500'**

250 0 500 1000 FEET
150 0 150 300 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

**PANEL 0044G**

# FIRM
## FLOOD INSURANCE RATE MAP

## GALVESTON COUNTY, TEXAS
### AND INCORPORATED AREAS

**PANEL 44 OF 600**
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| GALVESTON COUNTY | 485470 | 0044 | G |
| KEMAH, CITY OF | 485481 | 0044 | G |
| LEAGUE CITY, CITY OF | 485488 | 0044 | G |

**MAP NUMBER**
**48167C0044G**

**EFFECTIVE DATE**
**AUGUST 15, 2019**

Federal Emergency Management Agency

# APPENDIX C
# LIGHTHOUSE DISTRICT MASTER DRAINAGE STUDY

# Report

# Master Drainage Study

STATE OF TEXAS
CHARLES W. BEERE
34611
LICENSED
PROFESSIONAL ENGINEER

11/02/09

OCTOBER 2009

LJA Project No. E135-0090

[redacted]


**LJA Engineering & Surveying, Inc.**

East Houston Office
11821 East Freeway, Suite 400
Houston, Texas 77029
Ph: 713.450.1300
Firm Registration No.: F-1386

# TABLE OF CONTENTS

I. INTRODUCTION ..... 1
*Purpose and Scope* ..... 1
*Data Sources* ..... 1
*Background Information* ..... 1

II. BACKGROUND CONSIDERATIONS ..... 3
*Base Map Development* ..... 3
*Land Use Update* ..... 3
*Hydrologic Parameters* ..... 3
*Drainage Areas* ..... 4
*Facilities* ..... 4
Storm Sewer System ..... 4
Pump Station ..... 5

III. DESIGN CRITERIA ..... 6
*Methodology* ..... 6
*Rational Method* ..... 6
*Runoff Coefficient* ..... 7
*Time of Concentration* ..... 7
*Intensity- Duration Values* ..... 7

IV. DRAINAGE PLAN ..... 8
*Storm Sewers* ..... 8
*Pump Station* ..... 9

V. RECOMMENDATIONS ..... 10

## EXHIBITS

| Exhibit No. | Exhibit Title |
|---|---|
| 1 | Study Area |
| 2 | Drainage Areas and Sub-Areas |
| 3 | Proposed Storm Sewer Alternative "A" |
| 4 | Proposed Storm Sewer Alternative "B" |
| 5 | Typical Roadway Plan w/ Trunk Storm Sewer |
| 6 | Typical Roadway Plan w/ Collector Storm Sewers Only |

## APPENDICES

| | |
|---|---|
| Appendix A | Drainage System – Alternative A |
| Appendix B | Drainage System – Alternative B |
| Appendix C | Drainage System – Alternative "A" Construction Cost Estimate |
| Appendix D | Drainage System – Alternative "B" Construction Cost Estimate |

# I. INTRODUCTION

### *Purpose and Scope*

On June 15, 2009, LJA Engineering and Surveying, Inc. was authorized, by action of the City Council for the City of Kemah, to prepare a Master Drainage Study for the marina area business district of the City served by the City's existing drainage pump station. The marina area business district is generally bounded by Clear Creek on the north, Galveston Bay on the east, Tenth Street on the south, and by State Highway 146 on the west. Exhibit 1 shows the planned study area.

The City of Kemah Master Drainage Plan for the marina business district was completed with the intent to gather previous information regarding the study area, provide analysis, review current and anticipated development, determine the extent and operation of the existing drainage system(s), address existing drainage conditions, develop proposed improvements to correct and/or reduce flooding in the area, and generate costs associated with the necessary improvements.

### *Data Sources*

Data was gathered from a variety of sources including earlier drainage projects, street improvement projects, Texas Department of Transportation plans, aerial photography, TSARP photogrammetry, field reconnaissance, from discussions and correspondence with area entities, and observations of citizens and City personnel.

### *Background Information*

Over the course of the last 20 years, the City of Kemah, in general and especially within the marina area, has seen commercial development and some residential development. Most of the commercial development (which includes parking facilities) has been through redevelopment of existing property. In most cases single family housing has been lost to the commercial development.

The City of Kemah has the sole responsibility to provide and maintain storm sewers and their outfalls. However, many of the storm sewers in various locations within the marina area have been constructed by the developer during the redevelopment of various properties. Some of these drainage facilities either remain the developer's responsibility for maintenance while others have become the City's responsibility for maintenance.

Drainage controls in and around the marina area of the City of Kemah include most every type of drainage structure currently used in the practice of storm water management. Included in the overall drainage controls for the City are natural drainage channels; improved earthen ditches; roadside ditches with culverts of various shapes, sizes, and materials; piped roadside ditches; storm sewer systems; detention facilities (mostly private); and a storm water pump station.

# II. BACKGROUND CONSIDERATIONS

### *Base Map Development*

The base map for the study was developed from existing information. The base map utilizes an aerial of the study area supplemented by data from the FEMA flood plain map for Galveston County – Kemah area, the 7th Street Paving and Drainage project, previous surveys associated with the storm water pump station facility, and additional site reconnaissance coupled with spot topographic survey data.

No existing storm sewer map was found for the City of Kemah. Previous survey information was coupled with the field reconnaissance in an attempt to determine the existing storm sewer size and location along 6th Street and Texas Avenue.

Texas Department of Transportation plans indicate little to none of the State Highway 146 drainage enters into the City of Kemah system but is self contained with discharge to the Clear Creek Channel. The two systems appear to combine downstream of the City's stormwater pump station.

### *Land Use Update*

The land use was developed based upon the latest aerial maps (2006) supplemented by field reconnaissance. The final land plan for the study was also affected by the changes observed from a previous drainage investigation undertaken with the 7th Street Paving and Drainage project. The study area has become increasingly more impervious as older single family residences are replaced with commercial establishments and/or parking facilities. Even in areas along Galveston Bay where single family residences are replaced with new single family residences, most new residences contain a larger foot print with greater under roof area and thus are more impervious. Generally the study area will become more impervious and the analysis part of the study will reflect greater runoff.

### *Hydrologic Parameters*

Hydrologic parameters for each sub-drainage area were updated using the anticipated and updated land use database. The land use categories were assigned a numerical runoff coefficient quantified by the percent development and percent impervious. The land use plan was merged with the sub-drainage area boundaries to obtain a database consistent with the existing and/or anticipated land use within each sub-drainage area. A composite percent development and percent imperviousness was computed for each sub-drainage area.

### *Drainage Areas*

The study area was determined to contain several areas not connected to the existing system served by the stormwater pump station. The marina area, boardwalk area, and the transition area (south of the boardwalk, east of the marina, north of mid block between 5th and 6th Streets, and Galveston Bay) are not served by the storm water pump station thus are not included in the drainage evaluation.

The stormwater pump station drainage system is comprised of approximately 48.5 acres. The overall drainage area can be subdivided into approximately 71 subareas or sub-drainage areas. The number of sub-drainage areas has increased over the years due to the alteration of the land use from its original concept of single family residential to commercial/parking. The original concept of sheet flow drainage from the rear of each lot to the front of each lot has been altered by the development. Exhibit 2 provides an overview of each sub-drainage area contained within the study area.

### *Facilities*

*Storm Sewer System*

The existing storm sewer system is comprised of numerous small diameter collector storm sewers, piped road side ditches, and some remaining open roadside ditches. A trunk storm sewer extends from the existing pump station at Texas and 2nd Street to approximately 7th Street and Bradford.

The trunk sewer is comprised of an older section from the pump station to 6th near Harris. The older section is believed to be 54-inches from beginning to end. A portion of the system is currently flooded. The system generally extends along the west side of Texas from 2nd Street to 3rd Street and is believed to angle across Texas to the east side then along the east side of Texas to 6th Street. The 54-inch storm sewer extends along the north side of 6th Street to mid block between Texas and Harris. A major blockage of some type exists between the existing storm water pump station fore bay (existing manhole at Texas Avenue and 2nd Street) and the existing manhole at Texas and 3rd Street. The two manholes connect the 54-inch storm sewer along the west side of Texas Avenue. The manhole at Texas Avenue and 2nd Street is dry with little evidence of siltation. The manhole at 3rd Street and Texas Avenue is flooded with evidence of major siltation. Siltation, due to system backup, was noted as far upstream as 6th Street and Harris Street.

The newer section of trunk storm sewer was constructed with the City's roadway improvements along 7th Street in 2002. The trunk sewer is comprised of 8'x4' box culverts along the south side of 6th Street from mid block between Texas and

Harris to Harris, a 6'x4' box culvert along Harris from 6th to 7th Streets , and a 54-inch pipe storm sewer along 7th Street to Bradford. Three 30-inch pipe storm sewers connect the new trunk sewer with the old trunk sewer across 6th Street.

*Pump Station*

The existing pump station is comprised of small forebay and at the time of the field reconnaissance a single storm water pump. The existing station has capacity and condition limitations which affect the overall performance and ability of the storm sewer system.

# III. DESIGN CRITERIA

### *Methodology*

Typically, for areas up to 200 acres served by storm sewers or roadside ditches, peak discharges are based upon the Rational Method.

### *Rational Method*

The hydrologic method use to calculate peak flow rates for the drainage area was the Rational Method. The Rational Method equations are as follows:

$Q = CIA$

where:

$Q$ = maximum rate of runoff, in cfs
$C$ = runoff coefficient (weighted average)
$i$ = average rainfall intensity, in inches/hour
$A$= drainage area, in acres

### *Runoff Coefficient*

The runoff coefficient (C) is determined using typical Engineering Design Criteria for drainage systems utilized by other municipalities within the greater Houston area. The runoff coefficients vary based upon land use. Since the drainage area consists of pavement, residential areas, and commercial, the following C values were used to represent the land use within the drainage area.

| *Drainage Area Description* | *Runoff Coefficient* |
|---|---|
| Pavement/Roofs | 0.95 |
| Residential – lots less than 5,000 sf | 0.70 |
| Residential – lots 5,000 sf to 8,000 sf | 0.60 |
| Residential – lots 8,000 sf to 0.25 ac | 0.50 |
| Residential – Multi Family | 0.75 |
| Parks/Open Areas | 0.20 |
| Commercial | 0.90 |

Weighted composite C values were computed for the sub-drainage areas within the watershed. The composite values give equal weight to each sub-drainage area as a part of the whole drainage area. The composite values are dependant

upon each sub-drainage areas type of development and its impact upon the overall drainage system's coefficient.

### *Time of Concentration*

The time of concentration for storm sewers and/or roadside ditches shall be the time of concentration of the previous upstream contribution area plus the time of flow in the pipe or ditch. Typically for undeveloped areas the time of concentration of the first analysis point shall consist of the inlet time plus a 15 minute initial concentration time. Typically for developed areas the time of concentration of the first analysis point shall consist of the inlet time plus a 10 minute initial concentration time,

### *Intensity – Duration Values*

The time of concentration of runoff is used to determine the rainfall intensity component of the Rational Method formula. Typically intensity-duration curves are used for storm sewer and roadside ditch design. The curves are derived from the National Weather Service publications HYDRO-35 and Technical Paper No. 40 along with the U.S.G.S. WRI Report 98-4044. The curves are a family of curves for various rainfall events-the 3-year, 5-year, 10-year, 25-year, and 100-year events. Typically, storm sewers within the greater Houston area are designed to handle the 3-year frequency events runoff. The 3-year event, which is equivalent to a rainfall intensity of having a 33% probability of being exceeded in any given rainfall event, was selected for the analysis within this report. Rainfall intensity for the 3-year event is 6.2 inches per hour at an initial time of concentration of 10 minutes and is 5.3 inches per hour at an initial time of concentration of 15 minutes.

# IV. DRAINAGE PLAN

Development within the study area has had significant impact on the ability of the existing drainage system to convey storm water away from especially low elevation areas such as Harris and 7th Street. The study area has experienced an increase in the imperviousness as a part of redevelopment and consequently most rainfall events result in more runoff than most of the existing system is capable of handling. The exception is the storm sewers installed in 2002 with the 7th Street roadway project. These storm sewers have sufficient capacity to handle the additional runoff. The overall condition, single operational unit, lack of firm pumping capacity, along with the lack of pump protection (debris racks) dictate the storm water pump station be replaced.

### *Storm Sewers*

Two storm sewer drainage plan alternatives were developed to provide drainage to the study area. Both proposed storm sewer alternatives utilize all of the 2002 constructed storm sewers. Much of the two storm sewer alternatives are the same. The lower reach of both storm sewer systems, between the pump station and the intersection of Harris and 7th Street is exactly identical in size, location, and cost. The same is true of the upper reach from Bradford and 9th Street to upper terminus near 10th Street and Kipp Street. The middle portion of each trunk sewer provides the primary differences of routing between the two alternatives. The trunk sewer of Alternative "A", shown on Exhibit 3, travels a more central to the overall drainage area for the middle reach route. The central portion of trunk sewer for Alternative "B", as shown on Exhibit 4, lies closer to businesses fronting along State Highway 146. The entire drainage area is served by both alternatives by slightly different collector storm sewers. Exhibits 5 and 6 provide a typical roadway cross section of storm water systems combined with upgraded piped ditch drainage. Both plans require the replacement of the existing storm water pump station to be effective.

*Alternative "A"*

The routing of trunk storm sewer Alternative "A" proceeds east along 7th Street (existing sewer to remain), thence south along Bradford to 9th Street. The route is more central to the overall drainage area. However, the previously constructed storm sewer stub across 7th Street at Bradford is now two small needing to be a 48-inch in lieu of the constructed 36-inch. The proposed Alternative "A" would construct approximately 3,003 linear feet of storm sewer ranging from 8'x4' box culverts to 24-inch pipe storm sewers. The trunk storm sewer for Alternative "A" also requires 15 manholes with an expected construction cost of $1,116,000.00. The alternative requires five collector storm sewers consisting of approximately 2,672 linear feet of storm sewer ranging from 24-inch to 48-inch along with twenty one manholes. The expected construction cost for the collector storm sewers is $283,728.00. The overall estimated construction cost for the trunk and

collection sewers for Alternative "A" is $1,399,728.00. The proposed storm water pump station cost must be added to the sewer costs for a complete project cost.

*Alternative "B"*

The routing of trunk storm sewer Alternative "B" proceeds south along Harris Street thence east along 9th Street to Bradford. The route is more westerly (closer to businesses along State Highway 146) of the overall drainage area. Again, 7th Street would need to be crossed but this time at Bradford with a new, previously not planned, 54-inch storm sewer. The proposed Alternative "B" would construct approximately 3,615 linear feet of storm sewer ranging from 8'x4' box culverts to 24-inch pipe storm sewers. The trunk storm sewer for Alternative "B" also requires fifteen manholes with an expected construction cost of $1,192,758.00. The alternative requires five collector storm sewers consisting of approximately 2,327 linear feet of storm sewer ranging from 24-inch to 54-inch along with twenty manholes. The expected construction cost for the collector storm sewers is $243,348.00. The overall estimated construction cost for the trunk and collection sewers for Alternative "B" is $1,436,106.00. The proposed storm water pump station cost must be added to the sewer costs for a complete project cost.

### *Pump Station*

A replacement for the existing pump station would be a multiple pump facility consisting of three pumps each capable of 18,000 gallons per minute (120 cubic feet per second). The proposed pump station would replace the existing facility within the public right-of-way of 2nd Street between Texas and State Highway 146. The new station will require forebay improvements, a trash rack (pump protection), and downstream channel rectification besides the new pumping units and appurtenances. The estimated construction cost for the storm water pump station is $1,066,395.00.

# V. RECOMMENDATIONS

Two things are clear based upon data collected for the project. First, if the existing or future storm sewers were connected directly to the Clear Creek Channel or the Marina, water would begin to pool in the low area of Harris Street (near 7th Street) during any event of water surface elevations from the bay in excess of two (2) feet. Water would pool even during non-rainfall events. Secondly, most of the marina bulkhead is slightly below elevation 5.0. Therefore, water surfaces at or above elevation 5.0 overflow from the Clear Creek Channel and/or the Marina would begin to enter the storm sewer system. The overflow would set up a sort of "do loop" where water would circulate between the storm sewer to pump station to channel/marina to storm sewer. Consequently, the storm sewer and pump station would only be effective for those events not accompanied by high water levels within the Clear Creek Channel and/or Marina.

Development within the study area has had significant impact on the ability of the existing drainage system to convey storm water away from especially low elevation areas – Harris and 7th Street. The study area has experienced an increase in the imperviousness as a part of redevelopment and consequently most rainfall events result in more runoff than the existing system is capable of handling. The condition is exasperated currently by a blockage within the main trunk storm sewer on Texas between 2nd Street and 3rd Street. The extent and reason for the blockage is unknown but siltation due to the blockage extends upstream for over one thousand feet to the area of 6th Street and Harris. The blockage creates flooding conditions, especially along Harris Street at 7th Street, for even the slightest rainfall event. The blockage should be removed and the existing storm sewer de-silted.

The existing storm water pump station is in poor condition with only one pump available for service at the time of the field reconnaissance. The pump station should be replaced in order to provide adequate storm water removal from the existing and/or proposed storm water sewer system.

The existing trunk storm sewer and collection storm system should be expanded and replaced to provide drainage within the study area. Either alternative would provide the City with an adequate drainage system. Alternative "A", which is slightly cheaper, would require cutting the 7th Street pavement at two locations (Bradford and Harris Streets). Alternative "B" would require cutting the 7th Street pavement only at Harris Street. Alternative "B" will provide greater flexibility to the City; especially should the City select to phase the construction over an extended period of time. Table 1 provides an estimated project cost for the recommended project.

# Table 1
# City of Kemah
# Recommended Drainage Project
# Probable Costs

***Construction Costs (Estimated)***

| | | |
|---|---|---|
| Trunk & Collector Sewers (Alternative "B") | | |
| Collector Sewer A (trunk sewer) | $ | 993,965.00 |
| Collector Sewer B | | 29,250.00 |
| Collector Sewer C | | 53,520.00 |
| Collector Sewer D | | 36,320.00 |
| Collector Sewer E | | 71,060.00 |
| Collector Sewer F | | 12,640.00 |
| Storm Water Pump Station | | 927,300.00 |
| ***Total Construction Costs*** | ***$*** | ***2,124,055.00*** |
| ***Construction Contingency*** | | ***378,446.00*** |
| ***Total Construction Costs*** | ***$*** | ***2,502,501.00*** |

***Non-Construction Costs (Estimated)***

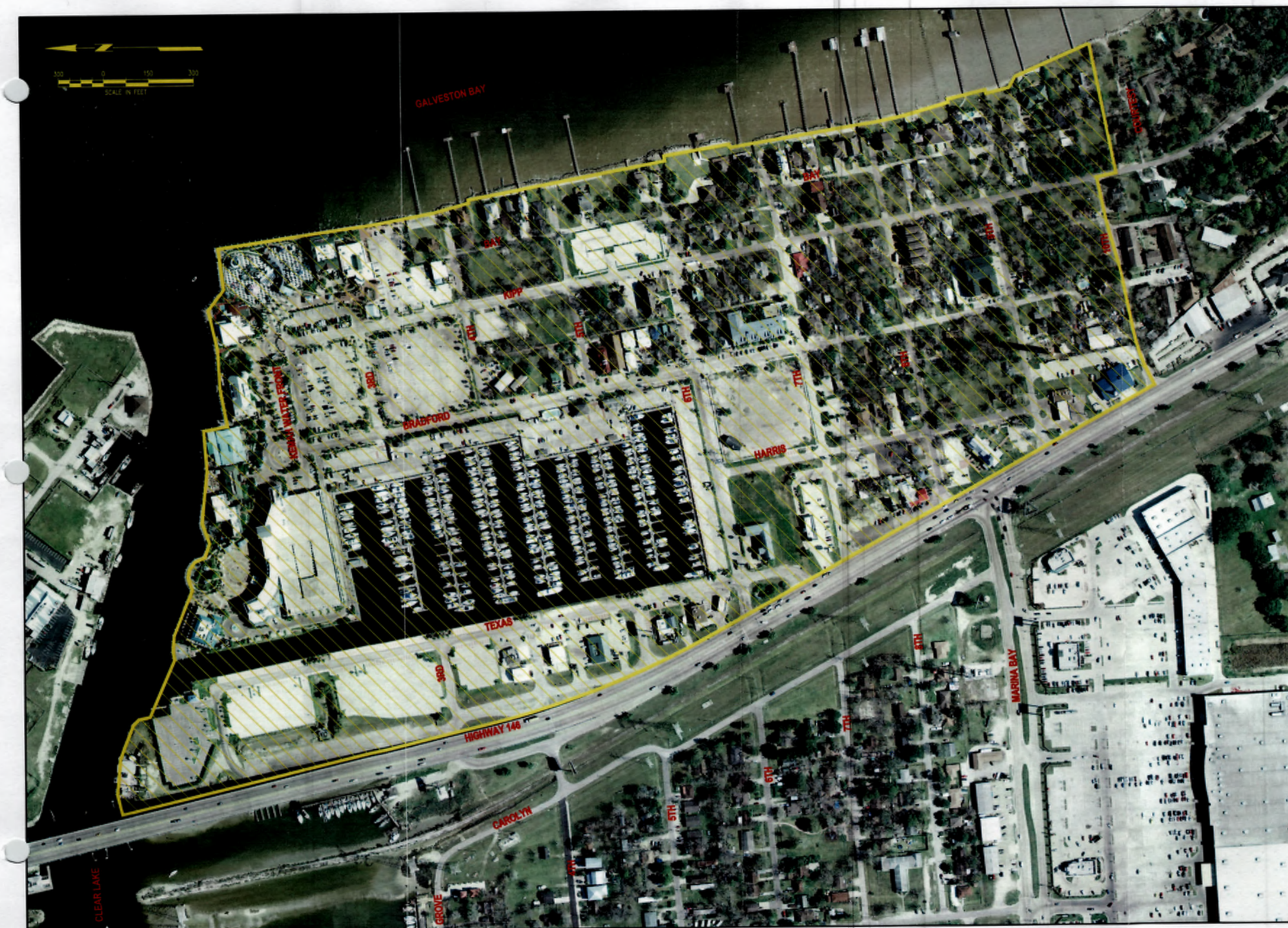
| | | |
|---|---|---|
| Engineering | | |
| Preliminary & Design | $ | 170,170.00 |
| Bidding | | 10,650.00 |
| Construction | | 31,900.00 |
| Surveys | | 67,500.00 |
| Geotechnical | | 20,000.00 |
| Materials Testing | | 30,000.00 |
| Project Representative | | 125,000.00 |
| Miscellaneous | | 5,000.00 |
| ***Total Non-Construction Costs*** | ***$*** | ***460,220.00*** |
| ***Non-Construction Contingency*** | ***$*** | ***46,020.00*** |
| ***Total Non-Construction Costs*** | ***$*** | ***506,240.00*** |
| ***Total Project Costs*** | ***$*** | ***3,008,741.00*** |

The project can be phase constructed to allow the City to construct different portions of the overall project as funding becomes available. The phased construction must proceed in an orderly manner to ensure the facilities will provide the intended service. The following are the prescribed order for the phased construction:

1. Storm Water Pump Station

2. Collection System A (trunk storm sewer)
   The trunk sewer can also be phased from downstream to upstream.

3. Collection Systems B, C, D, E, & F
   The collection systems can also be phased dependant upon completion of System A




**LEGEND**

DRAINAGE AREA & SUB-AREA DIVIDE

**CITY OF KEMAH**
**MASTER DRAINAGE STUDY**

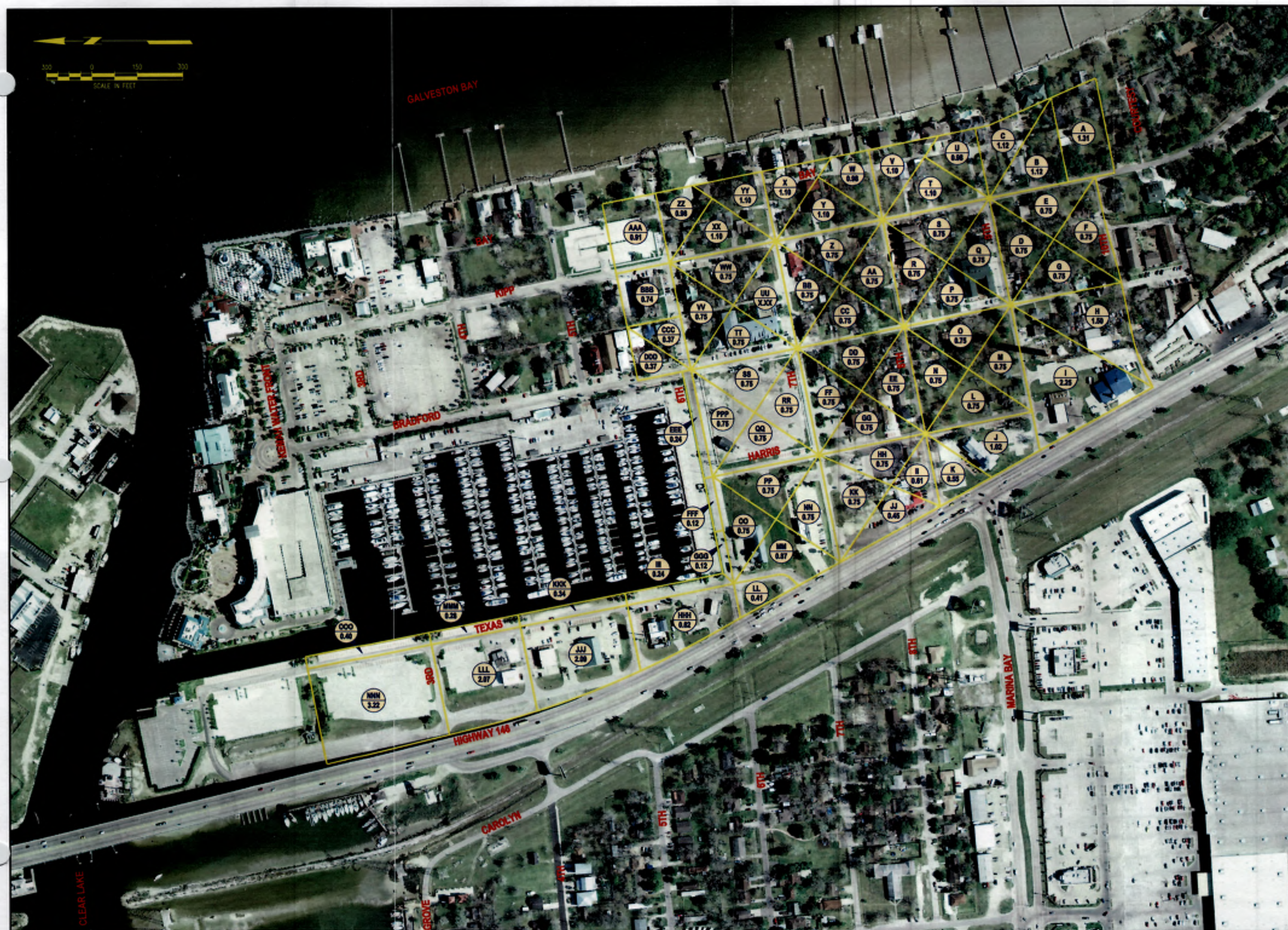
**STUDY AREA**

LJA Engineering & Surveying, Inc.
11821 East Freeway
Suite 400
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385

SCALE: 1" = 300' | JOB No. E135-0080 | EXHIBIT No. 1

135-009-EXH 1 THRU 4 (11X17-1:1)

08/31/09




## LEGEND

DRAINAGE AREA & SUB-AREA DIVIDE

AAA 0.91 — SUB-AREA DESIGNATION / AREA IN ACRES

# CITY OF KEMAH
## MASTER DRAINAGE STUDY

## DRAINAGE AREAS AND SUB-AREAS

LJA Engineering & Surveying, Inc.
11821 East Freeway
Suite 400
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1386

SCALE: 1" = 300' | JOB No. E135-0090 | EXHIBIT No. 2

08/31/09

135-009-EXH 1 TMU 4 (1100/-1:1)

**LEGEND**

- PROPOSED TRUNK STORM SEWER
- PROPOSED COLLECTOR STORM SEWER
- A-20 PROPOSED STORM SEWER MANHOLE

# CITY OF KEMAH
## MASTER DRAINAGE STUDY

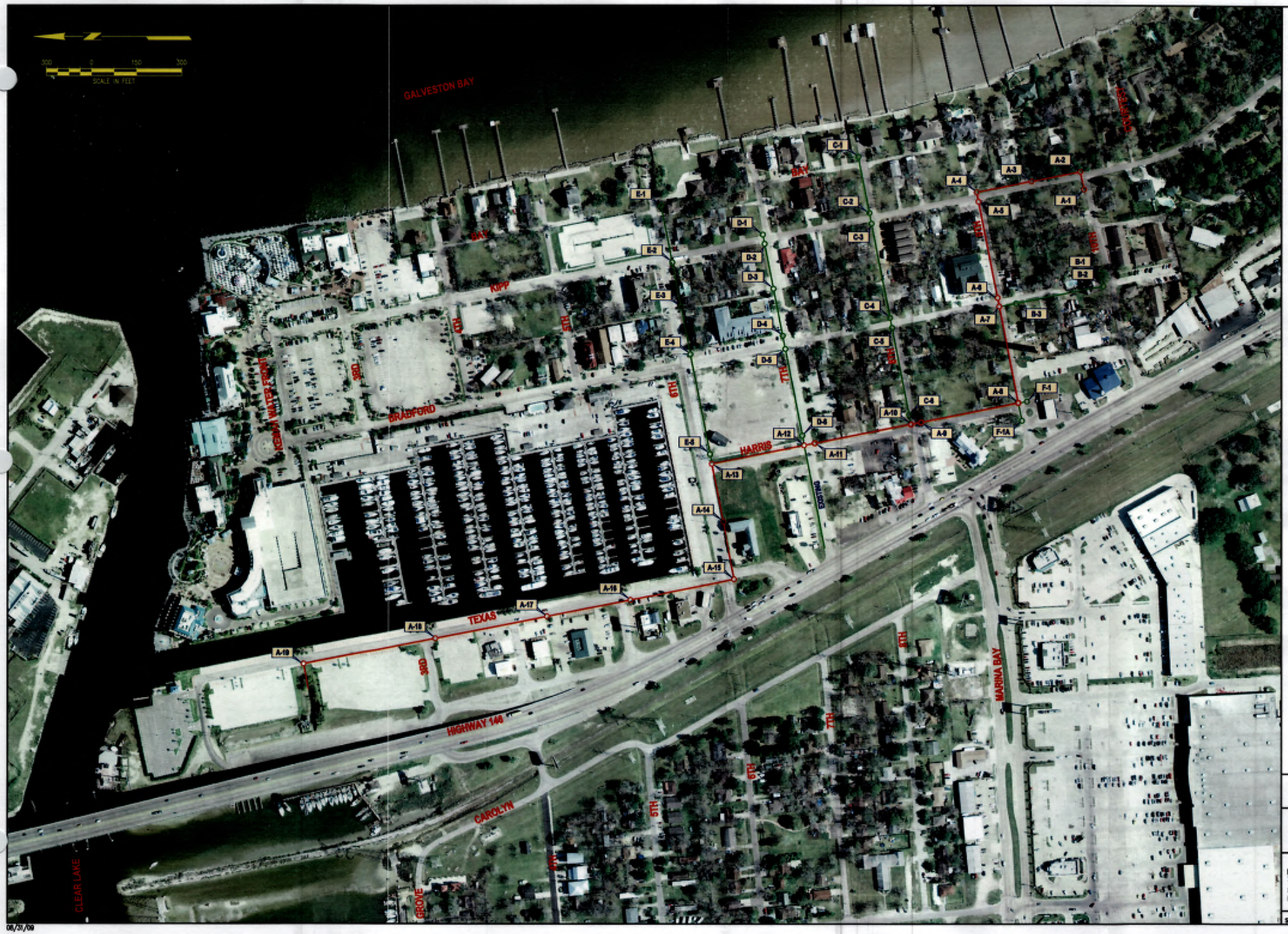
## PROPOSED STORM SEWER ALTERNATIVE "A"

LJA Engineering & Surveying, Inc.
11821 East Freeway
Suite 400
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385

SCALE: 1" = 300' | JOB No. E135-0090 | EXHIBIT No. 3

08/31/09

135-009-EXH 1 THRU 4 (11X17-1:1)




**LEGEND**

- PROPOSED TRUNK STORM SEWER
- PROPOSED COLLECTOR STORM SEWER
- A-20 PROPOSED STORM SEWER MANHOLE

**CITY OF KEMAH**
**MASTER DRAINAGE STUDY**

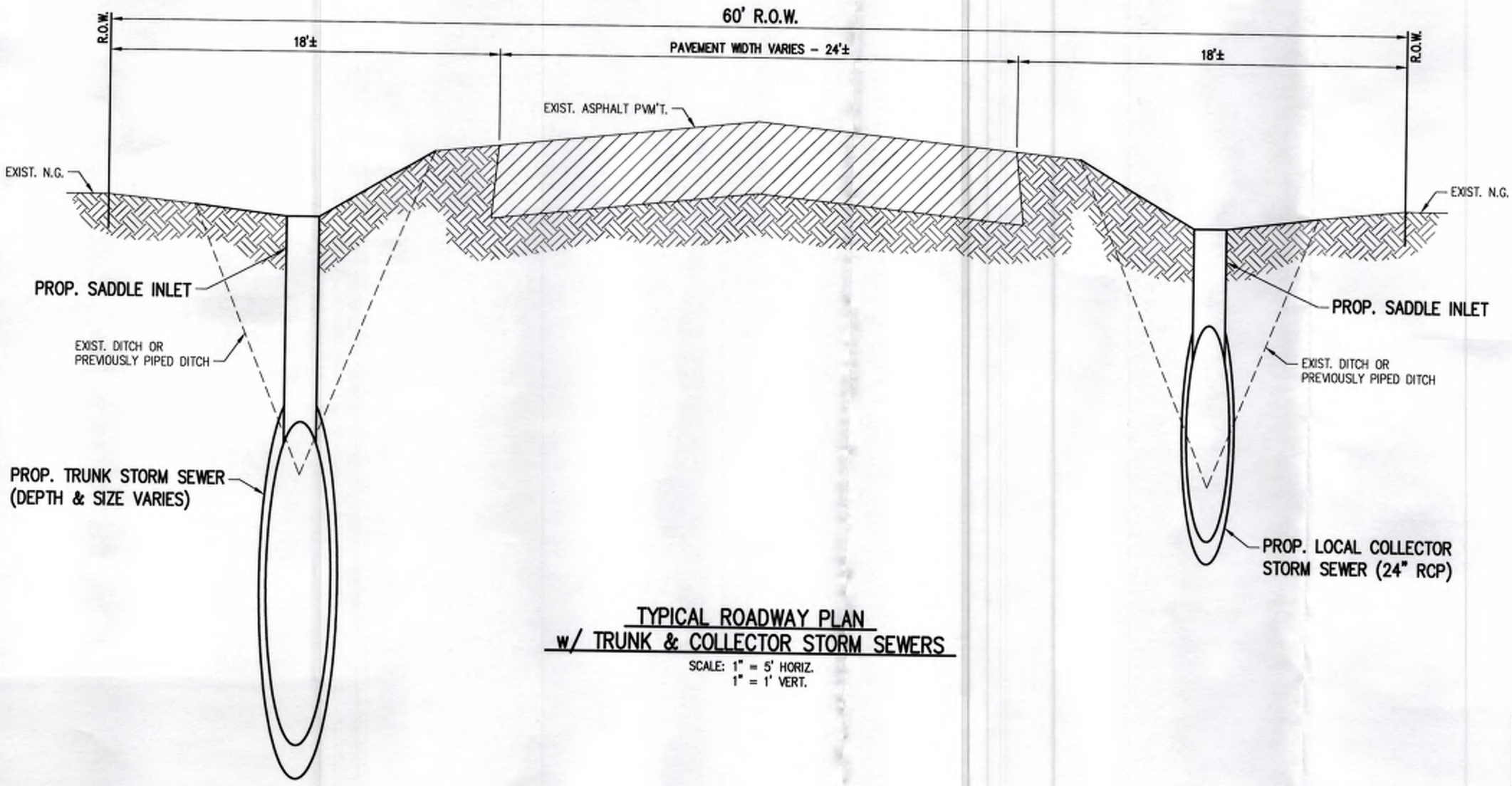
**PROPOSED STORM SEWER ALTERNATIVE "B"**

LJA Engineering & Surveying, Inc.
11821 East Freeway
Suite 400
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1305

SCALE: 1" = 300' | JOB No. 135-0080 | EXHIBIT No. 4

08/31/09

135-009-EXH 1 THRU 4 (11007-fc1)




## TYPICAL ROADWAY PLAN w/ TRUNK & COLLECTOR STORM SEWERS

SCALE: 1" = 5' HORIZ.
1" = 1' VERT.

08/27/09

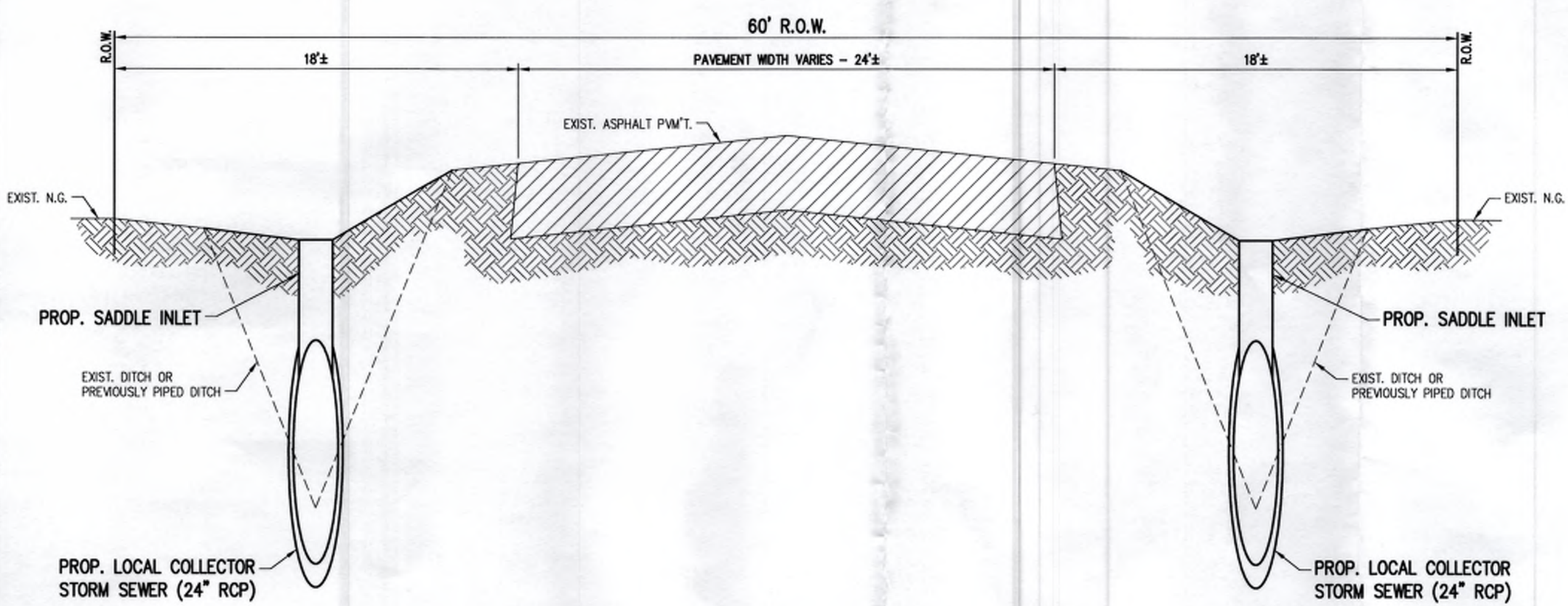
**CITY OF KEMAH**
**MASTER DRAINAGE STUDY**

**TYPICAL ROADWAY PLAN w/ TRUNK STORM SEWER**

LJA Engineering & Surveying, Inc.
11821 East Freeway
Suite 400
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385

SCALE: 1" = 5' HORIZ. 1" = 1' VERT. | JOB No. 0135-0090 | EXHIBIT No. 5

135-009-0045 TYP SECT (11X17-1:5)




## TYPICAL ROADWAY PLAN
## w/ COLLECTOR STORM SEWERS ONLY

SCALE: 1" = 5' HORIZ.
1" = 1' VERT.

**CITY OF KEMAH**
**MASTER DRAINAGE STUDY**

**TYPICAL ROADWAY PLAN w/ COLLECTOR STORM SEWERS ONLY**

LJA Engineering & Surveying, Inc.
11821 East Freeway
Suite 400
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385

SCALE: 1" = 5' HORIZ. 1" = 1' VERT. JOB No. E135-0090 EXHIBIT No. 6

08/27/09

135-009-E246 TYP SECT (11X17-1:5)

APPENDIX A

**CITY OF KEMAH**
**Drainage System - Alternative "A"**

| Mark Number | FROM Sta | TO Sta | Area (ac) | TOTAL AREA (ac) | TIME (Min.) | RUNOFF COEF. "C" (weighted) | Intensity I (in/hr) | Runoff Qd (cfs) | REACH Length (ft) | LINE SIZE | LINE Mann. Const. | LINE SLOPE (%) | DESIGN Qc (cfs) | DESIGN V (fps) | RATIO Qd/Qc | SLOPE FALL (ft) | OTHER LOSSES (ft) | FLOWLINE UP-STR. (ft) | FLOWLINE DN-STR. (ft) | ACTUAL VEL. (fps) | SLOPE HYDGRD % | Change in HGL (ft) | UP-STR. H.G.L. (ft) | DN-STR. H.G.L. (ft) | UP-STR. N.G. (ft) | DEPTH BELOW (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | A-1 | A-2 | 0.57 | 0.57 | 15.27 | 0.60 | 5.24 | 1.79 | 30 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.19 | 0.05 | 0.00 | 2.46 | 2.41 | 2.7 | 0.03 | 0.01 | 1.46 | 1.46 | 10.00 | 8.54 |
| A | A-2 | A-3 | 1.31 | 1.88 | 15.44 | 0.46 | 5.21 | 4.51 | 180 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.47 | 0.31 | 0.00 | 2.41 | 2.11 | 3.3 | 0.07 | 0.13 | 1.46 | 1.33 | 9.00 | 7.54 |
| A | A-3 | A-4 | 1.19 | 3.07 | 16.44 | 0.44 | 5.06 | 6.84 | 170 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.72 | 0.29 | 0.00 | 2.11 | 1.82 | 3.4 | 0.07 | 0.12 | 1.33 | 1.21 | 9.00 | 7.67 |
| A | A-4 | A-5 | 2.99 | 6.06 | 17.38 | 0.60 | 4.92 | 17.91 | 53 | 30" | 0.013 | 0.22 | 19.0 | 3.0 | 0.94 | 0.12 | 0.50 | 1.32 | 1.20 | 3.8 | 0.08 | 0.04 | 1.21 | 1.17 | 9.00 | 7.79 |
| A | A-5 | A-6 | 0.25 | 6.31 | 17.68 | 0.60 | 4.88 | 18.49 | 325 | 30" | 0.013 | 0.22 | 19.0 | 3.0 | 0.97 | 0.72 | 0.00 | 1.20 | 0.49 | 3.8 | 0.08 | 0.26 | 1.17 | 0.91 | 9.00 | 7.83 |
| A | A-6 | A-7 | 2.81 | 9.12 | 19.48 | 0.63 | 4.65 | 26.70 | 25 | 42" | 0.013 | 0.08 | 29.0 | 3.0 | 0.92 | 0.02 | 1.00 | -0.51 | -0.53 | 3.0 | 0.08 | 0.02 | 0.91 | 0.89 | 9.00 | 8.09 |
| A | A-7 | A-8 | 0.73 | 9.85 | 19.62 | 0.62 | 4.63 | 28.28 | 330 | 42" | 0.013 | 0.08 | 29.0 | 3.0 | 0.98 | 0.26 | 0.00 | -0.53 | -0.80 | 3.0 | 0.08 | 0.26 | 0.89 | 0.62 | 8.00 | 7.11 |
| A | A-8 | A-9 | 2.84 | 12.69 | 21.45 | 0.62 | 4.41 | 34.73 | 25 | 48" | 0.013 | 0.07 | 36.0 | 3.0 | 0.96 | 0.02 | 0.50 | -1.30 | -1.32 | 3.0 | 0.08 | 0.02 | 0.62 | 0.60 | 9.00 | 8.38 |
| A | A-9 | A-10 | 2.23 | 14.92 | 21.59 | 0.61 | 4.40 | 40.03 | 330 | 48" | 0.013 | 0.08 | 40.0 | 3.2 | 1.00 | 0.26 | 0.00 | -1.32 | -1.58 | 3.3 | 0.08 | 0.26 | 0.60 | 0.34 | 6.50 | 5.90 |
| A | A-10 | A-11 | 0.17 | 15.09 | 23.31 | 0.61 | 4.21 | 38.79 | 25 | 48" | 0.013 | 0.08 | 40.0 | 3.2 | 0.97 | 0.02 | 0.00 | -1.58 | -1.60 | 3.3 | 0.10 | 0.03 | 0.34 | 0.32 | 6.50 | 6.16 |
| A | A-11 | A-12 | 7.12 | 22.21 | 23.44 | 0.61 | 4.20 | 56.92 | 296 | 54" | 0.013 | 0.10 | 64.0 | 3.8 | 0.89 | 0.30 | 0.50 | -2.10 | -2.40 | 3.8 | 0.10 | 0.30 | 0.32 | 0.02 | 2.50 | 2.18 |
| A | A-12 | A-13 | 0.17 | 22.38 | 24.74 | 0.61 | 4.07 | 55.60 | 23 | 54" | 0.013 | 0.10 | 54.0 | 3.8 | 1.03 | 0.02 | 0.00 | -2.40 | -2.42 | 3.8 | 0.11 | 0.03 | 0.02 | -0.01 | 2.50 | 2.48 |
| A | A-13 | A-14 | 12.94 | 35.32 | 24.84 | 0.62 | 4.06 | 88.98 | 313 | 6'X4' | 0.013 | 0.10 | 98.0 | 4.1 | 0.91 | 0.31 | 0.00 | -2.42 | -2.73 | 3.7 | 0.06 | 0.19 | -0.01 | -0.19 | 4.00 | 4.01 |
| A | A-14 | A-15 | 7.12 | 42.44 | 26.11 | 0.64 | 3.95 | 107.17 | 199 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.70 | 0.24 | 0.00 | -2.73 | -2.97 | 3.5 | 0.04 | 0.08 | -0.19 | -0.27 | 5.00 | 5.19 |
| A | A-15 | A-16 | 0.00 | 42.44 | 26.80 | 0.64 | 3.88 | 105.51 | 190 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.69 | 0.23 | 0.00 | -2.97 | -3.20 | 3.5 | 0.04 | 0.08 | -0.27 | -0.35 | 6.00 | 6.27 |
| A | A-16 | A-17 | 0.41 | 42.85 | 27.46 | 0.64 | 3.83 | 104.98 | 380 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.69 | 0.46 | 0.00 | -3.20 | -3.65 | 3.5 | 0.04 | 0.15 | -0.35 | -0.50 | 4.50 | 4.85 |
| A | A-17 | A-18 | 0.86 | 43.71 | 28.78 | 0.65 | 3.72 | 105.68 | 365 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.69 | 0.44 | 0.00 | -3.65 | -4.09 | 3.5 | 0.04 | 0.15 | -0.50 | -0.65 | 4.00 | 4.50 |
| A | A-18 | A-19 | 2.43 | 46.14 | 30.05 | 0.66 | 3.62 | 110.27 | 300 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.72 | 0.36 | 0.00 | -4.09 | -4.45 | 3.7 | 0.04 | 0.12 | -0.65 | -0.77 | 4.00 | 4.65 |
| A | A-19 | A-20 | 2.35 | 48.49 | 31.09 | 0.67 | 3.54 | 115.13 | 415 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.75 | 0.50 | 0.00 | -4.45 | -4.95 | 3.8 | 0.05 | 0.21 | -0.77 | -0.98 | 4.00 | 4.77 |
| A | A-20 | Outfall | 0.00 | 48.49 | 32.53 | 0.69 | 3.44 | 115.17 | 50 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.75 | 0.06 | 0.00 | -4.95 | -5.01 | 3.9 | 0.05 | 0.03 | -0.98 | -1.00 | 4.00 | 4.98 |
| B | B-1 | B-2 | 0.17 | 0.17 | 10.00 | 0.60 | 6.23 | 0.64 | 40 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.07 | 0.07 | 0.00 | 1.68 | 1.62 | 2.7 | 0.07 | 0.03 | 1.22 | 1.19 | 10.00 | 8.78 |
| B | B-2 | B-3 | 0.39 | 0.56 | 10.22 | 0.65 | 6.18 | 2.25 | 350 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.24 | 0.60 | 0.00 | 1.62 | 1.02 | 2.8 | 0.08 | 0.28 | 1.19 | 0.91 | 10.00 | 8.81 |
| B | B-3 | A-7 | 0.17 | 0.73 | 12.17 | 0.64 | 5.78 | 2.70 | 30 | 24 | 0.013 | 0.17 | 9.5 | 3.0 | 0.28 | 0.05 | 0.00 | 1.02 | 0.97 | 2.8 | 0.08 | 0.02 | 0.91 | 0.89 | 8.00 | 7.09 |
| C | C-1 | C-2 | 0.74 | 0.74 | 10.00 | 0.69 | 6.23 | 3.18 | 30 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.33 | 0.05 | 0.00 | 1.06 | 1.01 | 3.0 | 0.08 | 0.02 | 0.84 | 0.82 | 10.00 | 9.16 |
| C | C-2 | C-3 | 0.08 | 0.82 | 10.17 | 0.68 | 6.20 | 3.45 | 155 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.36 | 0.26 | 0.00 | 1.01 | 0.74 | 3.0 | 0.11 | 0.17 | 0.82 | 0.65 | 10.00 | 9.18 |
| C | C-3 | C-4 | 1.24 | 2.06 | 11.03 | 0.54 | 6.01 | 6.69 | 23 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.70 | 0.04 | 0.00 | 0.74 | 0.71 | 3.3 | 0.14 | 0.03 | 0.65 | 0.61 | 10.00 | 9.35 |
| C | C-4 | A-9 | 0.17 | 2.23 | 11.16 | 0.54 | 5.98 | 7.21 | 15 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.76 | 0.03 | 0.00 | 0.71 | 0.68 | 3.3 | 0.07 | 0.01 | 0.61 | 0.60 | 6.00 | 5.39 |
| D | D-1 | D-2 | 2.82 | 2.82 | 10.00 | 0.64 | 6.23 | 11.25 | 46 | 24" | 0.013 | 0.20 | 10.5 | 3.3 | 1.07 | 0.09 | 0.00 | 4.10 | 4.01 | 3.3 | 0.07 | 0.03 | 0.62 | 0.59 | 10.00 | 9.38 |
| D | D-2 | D-3 | 0.08 | 2.90 | 10.23 | 0.64 | 6.18 | 11.47 | 157 | 24" | 0.013 | 0.74 | 20.0 | 6.3 | 0.57 | 1.16 | 0.00 | 4.01 | 2.85 | 7.0 | 0.07 | 0.11 | 0.59 | 0.48 | 10.00 | 9.41 |
| D | D-3 | D-4 | 1.98 | 4.88 | 10.65 | 0.63 | 6.09 | 18.72 | 138 | 24" | 0.013 | 0.74 | 20.0 | 6.3 | 0.94 | 1.02 | 0.00 | 2.85 | 1.83 | 6.3 | 0.07 | 0.10 | 0.48 | 0.38 | 9.00 | 8.52 |
| D | D-4 | A-11 | 2.24 | 7.12 | 11.01 | 0.62 | 6.01 | 26.55 | 58 | 24 | 0.013 | 0.74 | 20.0 | 6.3 | 1.33 | 0.43 | 0.00 | 1.83 | 1.40 | 6.3 | 0.07 | 0.04 | 0.38 | 0.34 | 8.00 | 7.62 |
| E | E-1 | E-2 | 1.52 | 1.52 | 10.00 | 0.60 | 6.23 | 5.68 | 160 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.60 | 0.27 | 0.00 | 0.48 | 0.21 | 3.0 | 0.07 | 0.11 | 0.38 | 0.27 | 10.00 | 9.62 |
| E | E-2 | E-3 | 1.52 | 3.04 | 10.89 | 0.60 | 6.04 | 11.02 | 200 | 30" | 0.013 | 0.13 | 15.0 | 3.0 | 0.73 | 0.26 | 0.50 | -0.29 | -0.55 | 3.0 | 0.08 | 0.16 | 0.27 | 0.11 | 10.00 | 9.73 |
| E | E-3 | E-4 | 1.49 | 4.53 | 12.00 | 0.61 | 5.81 | 16.07 | 160 | 30" | 0.013 | 0.18 | 17.0 | 3.5 | 0.95 | 0.29 | 0.00 | -0.55 | -0.84 | 3.5 | 0.08 | 0.13 | 0.11 | -0.02 | 7.00 | 6.89 |
| E | E-4 | E-5 | 1.49 | 6.02 | 12.76 | 0.62 | 5.67 | 21.16 | 320 | 36" | 0.013 | 0.11 | 22.0 | 3.2 | 0.96 | 0.35 | 0.50 | -1.34 | -1.69 | 3.2 | 0.05 | 0.16 | -0.02 | -0.18 | 6.00 | 6.02 |
| E | E-5 | A-14 | 1.73 | 7.75 | 14.43 | 0.71 | 5.38 | 29.58 | 30 | 42" | 0.013 | 0.13 | 36.0 | 3.7 | 0.82 | 0.04 | 0.50 | -2.19 | -2.23 | 3.8 | 0.05 | 0.02 | -0.18 | -0.19 | 4.00 | 4.18 |
| F | F-1 | F-2 | 3.19 | 3.19 | 10.00 | 0.70 | 6.23 | 13.92 | 20 | 30" | 0.013 | 0.13 | 15.0 | 3.0 | 0.93 | 0.03 | 0.00 | 0.12 | 0.09 | 3.0 | 0.05 | 0.01 | 0.74 | 0.73 | 3.00 | 2.26 |
| F | F-2 | F-3 | 0.22 | 3.41 | 10.11 | 0.68 | 6.21 | 14.39 | 340 | 30" | 0.013 | 0.18 | 17.0 | 3.5 | 0.85 | 0.61 | 0.00 | 0.09 | -0.52 | 3.5 | 0.10 | 0.34 | 0.73 | 0.39 | 3.00 | 2.27 |
| F | F-3 | F-4 | 4.33 | 7.74 | 11.73 | 0.63 | 5.87 | 28.61 | 30 | 42" | 0.013 | 0.08 | 29.0 | 3.0 | 0.99 | 0.02 | 1.00 | -1.52 | -1.54 | 3.0 | 0.10 | 0.03 | 0.39 | 0.36 | 7.00 | 6.61 |
| F | F-4 | F-5 | 0.31 | 8.05 | 11.90 | 0.63 | 5.83 | 29.59 | 330 | 42" | 0.013 | 0.10 | 32.0 | 3.3 | 0.92 | 0.33 | 0.00 | -1.54 | -1.87 | 3.3 | 0.10 | 0.33 | 0.36 | 0.03 | 9.00 | 8.64 |
| F | F-5 | A-13 | 4.89 | 12.94 | 13.56 | 0.63 | 5.52 | 45.04 | 40 | 48" | 0.013 | 0.12 | 50.0 | 3.8 | 0.90 | 0.05 | 0.50 | -2.37 | -2.42 | 3.8 | 0.10 | 0.04 | 0.03 | -0.01 | 9.00 | 8.97 |

APPENDIX B

**CITY OF KEMAH**
**Drainage System - Alternative B**

| Mark Number | FROM Sta | TO Sta | Area (ac) | TOTAL AREA (ac) | TIME (Min.) | RUNOFF COEF. "C" (weighted) | Intensity I (in/hr) | Runoff Qd (cfs) | REACH Length (ft) | LINE SIZE | LINE Mann. Const. | LINE SLOPE (%) | DESIGN Qc (cfs) | DESIGN V (fps) | RATIO Qd/Qc | SLOPE FALL (ft) | OTHER LOSSES (ft) | FLOWLINE UP-STR. (ft) | FLOWLINE DN-STR. (ft) | ACTUAL VEL. (fps) | SLOPE HYDGRD % | Change in HGL (ft) | UP-STR. H.G.L. (ft) | DN-STR. H.G.L. (ft) | UP-STR. N.G. (ft) | DEPTH BELOW (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | A-1 | A-2 | 0.57 | 0.57 | 15.27 | 0.60 | 5.24 | 1.79 | 30 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.19 | 0.05 | 0.00 | 2.77 | 2.72 | 2.7 | 0.03 | 0.01 | 1.75 | 1.74 | 10.00 | 8.25 |
| A | A-2 | A-3 | 1.31 | 1.88 | 15.44 | 0.46 | 5.21 | 4.51 | 180 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.47 | 0.31 | 0.00 | 2.72 | 2.41 | 3.3 | 0.07 | 0.13 | 1.74 | 1.62 | 9.00 | 7.26 |
| A | A-3 | A-4 | 1.19 | 3.07 | 16.44 | 0.44 | 5.06 | 6.84 | 170 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.72 | 0.29 | 0.00 | 2.41 | 2.12 | 3.4 | 0.07 | 0.12 | 1.62 | 1.50 | 9.00 | 7.38 |
| A | A-4 | A-5 | 2.99 | 6.06 | 17.38 | 0.60 | 4.92 | 17.91 | 53 | 30" | 0.013 | 0.22 | 19.0 | 3.0 | 0.94 | 0.12 | 0.50 | 1.62 | 1.50 | 3.8 | 0.08 | 0.04 | 1.50 | 1.46 | 9.00 | 7.50 |
| A | A-5 | A-6 | 0.25 | 6.31 | 17.68 | 0.60 | 4.88 | 18.49 | 325 | 30" | 0.013 | 0.22 | 19.0 | 3.0 | 0.97 | 0.72 | 0.00 | 1.50 | 0.79 | 3.8 | 0.08 | 0.26 | 1.46 | 1.20 | 9.00 | 7.54 |
| A | A-6 | A-7 | 2.81 | 9.12 | 19.48 | 0.63 | 4.65 | 26.70 | 25 | 42" | 0.013 | 0.08 | 29.0 | 3.0 | 0.92 | 0.02 | 1.00 | -0.21 | -0.23 | 3.0 | 0.08 | 0.02 | 1.20 | 1.18 | 8.00 | 6.80 |
| A | A-7 | A-8 | 0.73 | 9.85 | 19.62 | 0.62 | 4.63 | 28.28 | 330 | 42" | 0.013 | 0.08 | 29.0 | 3.0 | 0.98 | 0.26 | 0.00 | -0.23 | -0.50 | 3.0 | 0.08 | 0.26 | 1.18 | 0.91 | 6.00 | 4.82 |
| A | A-8 | A-9 | 3.41 | 13.26 | 21.45 | 0.62 | 4.41 | 36.29 | 340 | 48" | 0.013 | 0.08 | 41.0 | 3.0 | 0.89 | 0.27 | 0.50 | -1.00 | -1.27 | 3.0 | 0.08 | 0.27 | 0.91 | 0.64 | 6.00 | 5.09 |
| A | A-9 | A-10 | 4.33 | 17.59 | 23.34 | 0.61 | 4.21 | 45.19 | 25 | 48" | 0.013 | 0.10 | 46.0 | 3.6 | 0.98 | 0.03 | 0.00 | -1.27 | -1.29 | 3.6 | 0.08 | 0.02 | 0.64 | 0.62 | 6.00 | 5.36 |
| A | A-10 | A-11 | 0.31 | 17.90 | 23.46 | 0.61 | 4.20 | 45.85 | 330 | 48" | 0.013 | 0.10 | 46.0 | 3.2 | 1.00 | 0.33 | 0.00 | -1.29 | -1.62 | 3.3 | 0.10 | 0.33 | 0.62 | 0.29 | 4.00 | 3.38 |
| A | A-11 | A-12 | 4.89 | 22.79 | 25.18 | 0.61 | 4.03 | 56.05 | 296 | 54" | 0.013 | 0.10 | 64.0 | 3.8 | 0.88 | 0.30 | 0.50 | -2.12 | -2.42 | 3.8 | 0.10 | 0.30 | 0.29 | -0.01 | 2.00 | 1.71 |
| A | A-12 | A-13 | 11.90 | 34.69 | 26.47 | 0.62 | 3.91 | 84.17 | 313 | 6'X4' | 0.013 | 0.10 | 98.0 | 4.1 | 0.86 | 0.31 | 0.00 | -2.42 | -2.73 | 3.7 | 0.08 | 0.19 | -0.01 | -0.19 | 4.00 | 4.01 |
| A | A-13 | A-14 | 7.75 | 42.44 | 27.75 | 0.64 | 3.80 | 103.32 | 199 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.68 | 0.24 | 0.00 | -2.73 | -2.97 | 3.5 | 0.04 | 0.08 | -0.19 | -0.27 | 5.00 | 5.19 |
| A | A-14 | A-15 | 0.00 | 42.44 | 28.44 | 0.64 | 3.75 | 101.78 | 190 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.67 | 0.23 | 0.00 | -2.97 | -3.20 | 3.5 | 0.04 | 0.08 | -0.27 | -0.35 | 6.00 | 6.27 |
| A | A-15 | A-16 | 0.41 | 42.85 | 29.10 | 0.64 | 3.69 | 101.32 | 380 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.66 | 0.46 | 0.00 | -3.20 | -3.65 | 3.5 | 0.04 | 0.15 | -0.35 | -0.50 | 4.50 | 4.85 |
| A | A-16 | A-17 | 0.86 | 43.71 | 30.42 | 0.65 | 3.59 | 102.09 | 365 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.67 | 0.44 | 0.00 | -3.65 | -4.09 | 3.5 | 0.04 | 0.15 | -0.50 | -0.65 | 4.00 | 4.50 |
| A | A-17 | A-18 | 2.43 | 46.14 | 31.88 | 0.66 | 3.50 | 106.62 | 300 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.70 | 0.36 | 0.00 | -4.09 | -4.45 | 3.7 | 0.04 | 0.12 | -0.65 | -0.77 | 4.00 | 4.65 |
| A | A-18 | A-19 | 2.35 | 48.49 | 32.73 | 0.67 | 3.43 | 111.41 | 415 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.73 | 0.50 | 0.00 | -4.45 | -4.95 | 3.8 | 0.05 | 0.21 | -0.77 | -0.98 | 4.00 | 4.77 |
| A | A-19 | Outfall | 0.00 | 48.49 | 34.17 | 0.69 | 3.33 | 111.55 | 50 | 8'X4' | 0.013 | 0.12 | 153.0 | 4.8 | 0.73 | 0.06 | 0.00 | -4.95 | -5.01 | 3.9 | 0.05 | 0.03 | -0.98 | -1.00 | 4.00 | 4.98 |
| B | B-1 | B-2 | 0.17 | 0.17 | 10.00 | 0.60 | 6.23 | 0.64 | 40 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.07 | 0.07 | 0.00 | 0.48 | 0.41 | 2.7 | 0.07 | 0.03 | 1.79 | 1.76 | 10.00 | 8.21 |
| B | B-2 | B-3 | 0.39 | 0.56 | 10.22 | 0.65 | 6.18 | 2.25 | 350 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.24 | 0.60 | 0.00 | 0.41 | -0.18 | 2.8 | 0.08 | 0.28 | 1.76 | 1.48 | 10.00 | 8.24 |
| B | B-3 | A-7 | 0.17 | 0.73 | 12.17 | 0.64 | 5.78 | 2.70 | 30 | 24 | 0.013 | 0.17 | 9.5 | 3.0 | 0.28 | 0.05 | 0.00 | -0.18 | -0.23 | 2.8 | 0.08 | 0.02 | 1.48 | 1.46 | 8.00 | 6.52 |
| C | C-1 | C-2 | 0.74 | 0.74 | 10.00 | 0.69 | 6.23 | 3.18 | 30 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.33 | 0.05 | 0.00 | 0.34 | 0.29 | 3.0 | 0.08 | 0.02 | 1.15 | 1.13 | 10.00 | 8.85 |
| C | C-2 | C-3 | 0.08 | 0.82 | 10.17 | 0.68 | 6.20 | 3.45 | 155 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.36 | 0.26 | 0.00 | 0.29 | 0.02 | 3.0 | 0.11 | 0.17 | 1.13 | 0.95 | 10.00 | 8.87 |
| C | C-3 | C-4 | 1.24 | 2.06 | 11.03 | 0.54 | 6.01 | 6.69 | 23 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.70 | 0.04 | 0.00 | 0.02 | -0.02 | 3.3 | 0.14 | 0.03 | 0.95 | 0.92 | 10.00 | 9.05 |
| C | C-4 | C-5 | 0.17 | 2.23 | 11.16 | 0.54 | 5.98 | 7.21 | 15 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.76 | 0.03 | 0.00 | -0.02 | -0.04 | 3.3 | 0.07 | 0.01 | 0.92 | 0.91 | 6.00 | 5.08 |
| C | C-5 | C-6 | 1.50 | 3.73 | 11.24 | 0.61 | 5.97 | 13.58 | 330 | 30" | 0.013 | 0.22 | 19.0 | 3.0 | 0.71 | 0.73 | 0.50 | -0.54 | -1.27 | 3.0 | 0.08 | 0.26 | 0.90 | 0.64 | 8.00 | 7.10 |
| C | C-6 | A-10 | 0.60 | 4.33 | 13.07 | 0.61 | 5.61 | 14.82 | 25 | 36" | 0.013 | 0.10 | 22.0 | 3.0 | 0.67 | 0.03 | 0.00 | -1.27 | -1.29 | 3.3 | 0.10 | 0.03 | 0.64 | 0.62 | 8.00 | 7.38 |
| D | D-1 | D-2 | 2.82 | 2.82 | 10.00 | 0.64 | 6.23 | 11.25 | 46 | 24" | 0.013 | 0.20 | 10.5 | 3.3 | 1.07 | 0.09 | 0.00 | 3.11 | 3.01 | 3.3 | 0.07 | 0.03 | 0.89 | 0.86 | 10.00 | 9.11 |
| D | D-2 | D-3 | 0.08 | 2.90 | 10.23 | 0.64 | 6.18 | 11.47 | 157 | 24" | 0.013 | 0.74 | 20.0 | 6.3 | 0.57 | 1.16 | 0.00 | 3.01 | 1.85 | 7.0 | 0.07 | 0.11 | 0.86 | 0.75 | 10.00 | 9.14 |
| D | D-3 | D-4 | 1.98 | 4.88 | 10.65 | 0.63 | 6.09 | 18.72 | 138 | 24" | 0.013 | 0.74 | 20.0 | 6.3 | 0.94 | 1.02 | 0.00 | 1.85 | 0.83 | 6.3 | 0.07 | 0.10 | 0.75 | 0.65 | 9.00 | 8.25 |
| D | D-4 | D-5 | 2.24 | 7.12 | 11.01 | 0.62 | 6.01 | 26.55 | 58 | 24" | 0.013 | 0.74 | 20.0 | 6.3 | 1.33 | 0.43 | 0.00 | 0.83 | 0.40 | 6.3 | 0.07 | 0.04 | 0.65 | 0.61 | 8.00 | 7.35 |
| D | D-5 | D-6 | 0.75 | 7.87 | 11.17 | 0.65 | 5.98 | 30.60 | 296 | 54" | 0.013 | 0.10 | 64.0 | 3.8 | 0.48 | 0.30 | 2.50 | -2.10 | -2.40 | 3.7 | 0.10 | 0.30 | 0.61 | 0.31 | 6.00 | 5.39 |
| D | D-6 | A-12 | 4.03 | 11.90 | 12.46 | 0.65 | 5.72 | 44.28 | 23 | 54" | 0.013 | 0.10 | 64.0 | 3.8 | 0.69 | 0.02 | 0.00 | -2.40 | -2.42 | 3.8 | 0.10 | 0.02 | 0.31 | 0.29 | 2.00 | 1.69 |
| E | E-1 | E-2 | 1.52 | 1.52 | 10.00 | 0.60 | 6.23 | 5.68 | 160 | 24" | 0.013 | 0.17 | 9.5 | 3.0 | 0.60 | 0.27 | 0.00 | -0.02 | -0.29 | 3.0 | 0.07 | 0.11 | 0.38 | 0.27 | 10.00 | 9.62 |
| E | E-2 | E-3 | 1.52 | 3.04 | 10.89 | 0.60 | 6.04 | 11.02 | 200 | 30" | 0.013 | 0.13 | 15.0 | 3.0 | 0.73 | 0.26 | 0.50 | -0.79 | -1.05 | 3.0 | 0.08 | 0.16 | 0.27 | 0.11 | 10.00 | 9.73 |
| E | E-3 | E-4 | 1.49 | 4.53 | 12.00 | 0.61 | 5.81 | 16.07 | 160 | 30" | 0.013 | 0.18 | 17.0 | 3.5 | 0.95 | 0.29 | 0.00 | -1.05 | -1.34 | 3.5 | 0.08 | 0.13 | 0.11 | -0.02 | 8.00 | 7.89 |
| E | E-4 | E-5 | 1.49 | 6.02 | 12.76 | 0.62 | 5.67 | 21.16 | 320 | 36" | 0.013 | 0.11 | 22.0 | 3.2 | 0.96 | 0.35 | 0.50 | -1.84 | -2.19 | 3.2 | 0.05 | 0.16 | -0.02 | -0.18 | 6.00 | 6.02 |
| E | E-5 | A-13 | 1.73 | 7.75 | 14.43 | 0.71 | 5.38 | 29.58 | 30 | 42" | 0.013 | 0.13 | 36.0 | 3.7 | 0.82 | 0.04 | 0.50 | -2.69 | -2.73 | 3.8 | 0.05 | 0.02 | -0.18 | -0.19 | 4.00 | 4.18 |
| F | F-1 | A-8 | 3.19 | 3.19 | 10.00 | 0.70 | 6.23 | 13.92 | 25 | 30" | 0.013 | 0.13 | 15.0 | 3.0 | 0.93 | 0.03 | 0.00 | -0.96 | -1.00 | 3.0 | 0.05 | 0.01 | 0.95 | 0.94 | 9.00 | 8.05 |
| F | F-1A | A-8 | 0.22 | 3.41 | 10.14 | 0.68 | 6.20 | 14.38 | 25 | 30" | 0.013 | 0.18 | 17.0 | 3.5 | 0.85 | 0.05 | 0.00 | -0.95 | -1.00 | 3.5 | 0.10 | 0.03 | 0.94 | 0.91 | 9.00 | 8.06 |

# APPENDIX C

**CITY OF KEMAH**
**DRAINAGE SYSTEM - ALTERNATIVE "A"**
**CONSTRUCTION COST ESTIMATE**

***System A***

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes [1] | EA | 15 | $1,500.00 | $22,500.00 |
| 2 | Inlets | EA | 48 | $800.00 | $38,400.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 380 | $40.00 | $15,200.00 |
| 4 | 30" Reinf. Conc. Pipe | LF | 378 | $50.00 | $18,900.00 |
| 5 | 42" Reinf. Conc. Pipe | LF | 355 | $80.00 | $28,400.00 |
| 6 | 48" Reinf. Conc. Pipe | LF | 380 | $95.00 | $36,100.00 |
| 7 | 54" Reinf. Conc. Pipe [2] | LF | 0 | $115.00 | $0.00 |
| 8 | 6' x 4' Box Culvert [3] | LF | 0 | $420.00 | $0.00 |
| 9 | 8' x 4' Box Culvert [4] | LF | 1510 | $450.00 | $679,500.00 |
| 10 | Remove & Replace Roadway Pvmt. | SY | 500 | $70.00 | $35,000.00 |
| 11 | Remove & Replace Driveway Pvmt. | SY | 800 | $70.00 | $56,000.00 |

| | |
|---|---|
| ***Subtotal System A Construction Cost*** | ***$930,000.00*** |
| ***Contingency (20%)*** | ***$186,000.00*** |
| ***Total System A Construction Cost*** | ***$1,116,000.00*** |

[1] Total is 20 manholes with 5 manholes existing
[2] Total is 319 lf with all 319 lf existing
[3] Total is 319 lf with all 319 lf existing
[4] Total is 1899 lf with 389 lf existing

***System B***

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 3 | $1,500.00 | $4,500.00 |
| 2 | Inlets | EA | 6 | $800.00 | $4,800.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 420 | $40.00 | $16,800.00 |
| 4 | Remove & Replace Roadway Pvmt. | SY | 30 | $70.00 | $2,100.00 |
| 5 | Remove & Replace Driveway Pvmt. | SY | 15 | $70.00 | $1,050.00 |

| | |
|---|---|
| ***Subtotal System B Construction Cost*** | ***$29,250.00*** |
| ***Contingency (20%)*** | ***$5,850.00*** |
| ***Total System B Construction Cost*** | ***$35,100.00*** |

*System C*

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 4 | $1,500.00 | $6,000.00 |
| 2 | Inlets | EA | 9 | $800.00 | $7,200.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 223 | $40.00 | $8,920.00 |
| 4 | Remove & Replace Roadway Pvmt. | SY | 55 | $70.00 | $3,850.00 |
| 5 | Remove & Replace Driveway Pvmt. | SY | 20 | $70.00 | $1,400.00 |
| | ***Subtotal System C Construction Cost*** | | | | ***$27,370.00*** |
| | ***Contingency (20%)*** | | | | ***$5,474.00*** |
| | ***Total System C Construction Cost*** | | | | ***$32,844.00*** |

*System D*

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 4 | $1,500.00 | $6,000.00 |
| 2 | Inlets | EA | 9 | $800.00 | $7,200.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 399 | $40.00 | $15,960.00 |
| 4 | Remove & Replace Roadway Pvmt. | SY | 50 | $70.00 | $3,500.00 |
| 5 | Remove & Replace Driveway Pvmt. | SY | 18 | $70.00 | $1,260.00 |
| | ***Subtotal System D Construction Cost*** | | | | ***$33,920.00*** |
| | ***Contingency (20%)*** | | | | ***$6,784.00*** |
| | ***Total System D Construction Cost*** | | | | ***$40,704.00*** |

*System E*

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 5 | $1,500.00 | $7,500.00 |
| 2 | Inlets | EA | 12 | $800.00 | $9,600.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 160 | $40.00 | $6,400.00 |
| 4 | 30" Reinf. Conc. Pipe | LF | 360 | $50.00 | $18,000.00 |
| 5 | 36" Reinf. Conc. Pipe | LF | 320 | $70.00 | $22,400.00 |
| 6 | 42" Reinf. Conc. Pipe | LF | 30 | $80.00 | $2,400.00 |
| 7 | Remove & Replace Roadway Pvmt. | SY | 50 | $70.00 | $3,500.00 |
| 8 | Remove & Replace Driveway Pvmt. | SY | 18 | $70.00 | $1,260.00 |
| | ***Subtotal System E Construction Cost*** | | | | ***$71,060.00*** |
| | ***Contingency (20%)*** | | | | ***$14,212.00*** |
| | ***Total System E Construction Cost*** | | | | ***$85,272.00*** |

***System F***

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 5 | $1,500.00 | $7,500.00 |
| 2 | Inlets | EA | 12 | $800.00 | $9,600.00 |
| 3 | 30" Reinf. Conc. Pipe | LF | 360 | $50.00 | $18,000.00 |
| 4 | 42" Reinf. Conc. Pipe | LF | 360 | $80.00 | $28,800.00 |
| 5 | 48" Reinf. Conc. Pipe | LF | 40 | $95.00 | $3,800.00 |
| 6 | Remove & Replace Roadway Pvmt. | SY | 32 | $70.00 | $2,240.00 |
| 7 | Remove & Replace Driveway Pvmt. | SY | 70 | $70.00 | $4,900.00 |
| | ***Subtotal System F Construction Cost*** | | | | ***$74,840.00*** |
| | ***Contingency (20%)*** | | | | ***$14,968.00*** |
| | ***Total System F Construction Cost*** | | | | ***$89,808.00*** |

***Storm Water Pump Station***

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Site Work | | | | |
| | Finish Grading | LS | 1 | $15,500.00 | $15,500.00 |
| | Rip Rap | SY | 795 | $40.00 | $31,800.00 |
| 2 | Structure | | | | |
| | Concrete | LS | 1 | $216,000.00 | $216,000.00 |
| | Bar Screen | EA | 1 | $16,000.00 | $16,000.00 |
| 3 | Pumps | LS | 1 | $285,000.00 | $285,000.00 |
| 4 | Controls | LS | 1 | $55,000.00 | $55,000.00 |
| 5 | Electrical | LS | 1 | $125,000.00 | $125,000.00 |
| 6 | Piping & Valves | LS | 1 | $80,000.00 | $80,000.00 |
| 7 | Demolition | LS | 1 | $58,000.00 | $58,000.00 |
| 8 | Channel Rectification | LS | 1 | $45,000.00 | $45,000.00 |
| | ***Subtotal Storm Water Pump Station Construction Cost*** | | | | ***$927,300.00*** |
| | ***Contingency (15%)*** | | | | ***$139,095.00*** |
| | ***Total Storm Water Pump Station Construction Co:*** | | | | ***$1,066,395.00*** |

***Total Alternative "A" Construction Cost*** ***$2,466,123.00***

# APPENDIX D

**CITY OF KEMAH**
**DRAINAGE SYSTEM - ALTERNATIVE "B"**
**CONSTRUCTION COST ESTIMATE**

***System A***

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes [1] | EA | 15 | $1,500.00 | $22,500.00 |
| 2 | Inlets | EA | 48 | $800.00 | $38,400.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 380 | $40.00 | $15,200.00 |
| 4 | 30" Reinf. Conc. Pipe | LF | 378 | $50.00 | $18,900.00 |
| 5 | 42" Reinf. Conc. Pipe | LF | 355 | $80.00 | $28,400.00 |
| 6 | 48" Reinf. Conc. Pipe | LF | 695 | $95.00 | $66,025.00 |
| 7 | 54" Reinf. Conc. Pipe | LF | 296 | $115.00 | $34,040.00 |
| 8 | 6' x 4' Box Culvert [2] | LF | 0 | $420.00 | $0.00 |
| 9 | 8' x 4' Box Culvert [3] | LF | 1510 | $450.00 | $679,500.00 |
| 10 | Remove & Replace Roadway Pvmt. | SY | 500 | $70.00 | $35,000.00 |
| 11 | Remove & Replace Driveway Pvmt. | SY | 800 | $70.00 | $56,000.00 |
| | ***Subtotal System A Construction Cost*** | | | | ***$993,965.00*** |
| | ***Contingency (20%)*** | | | | ***$198,793.00*** |
| | ***Total System A Construction Cost*** | | | | ***$1,192,758.00*** |

[1] Total is 19 manholes with 4 manholes existing
[2] Total is 319 lf with all 319 lf existing
[3] Total is 1899 lf with 389 lf existing

***System B***

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 3 | $1,500.00 | $4,500.00 |
| 2 | Inlets | EA | 6 | $800.00 | $4,800.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 420 | $40.00 | $16,800.00 |
| 4 | Remove & Replace Roadway Pvmt. | SY | 30 | $70.00 | $2,100.00 |
| 5 | Remove & Replace Driveway Pvmt. | SY | 15 | $70.00 | $1,050.00 |
| | ***Subtotal System B Construction Cost*** | | | | ***$29,250.00*** |
| | ***Contingency (20%)*** | | | | ***$5,850.00*** |
| | ***Total System B Construction Cost*** | | | | ***$35,100.00*** |

*System C*

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 6 | $1,500.00 | $9,000.00 |
| 2 | Inlets | EA | 12 | $800.00 | $9,600.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 233 | $40.00 | $9,320.00 |
| 4 | 30" Reinf. Conc. Pipe | LF | 330 | $50.00 | $16,500.00 |
| 5 | 36" Reinf. Conc. Pipe | LF | 25 | $70.00 | $1,750.00 |
| 6 | Remove & Replace Roadway Pvmt. | SY | 75 | $70.00 | $5,250.00 |
| 7 | Remove & Replace Driveway Pvmt. | SY | 30 | $70.00 | $2,100.00 |
| | ***Subtotal System C Construction Cost*** | | | | ***$53,520.00*** |
| | ***Contingency (20%)*** | | | | ***$10,704.00*** |
| | ***Total System C Construction Cost*** | | | | ***$64,224.00*** |

*System D*

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes [1] | EA | 4 | $1,500.00 | $6,000.00 |
| 2 | Inlets | EA | 12 | $800.00 | $9,600.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 399 | $40.00 | $15,960.00 |
| 4 | 54" Reinf. Conc. Pipe [2] | LF | 0 | $40.00 | $0.00 |
| 5 | Remove & Replace Roadway Pvmt. | SY | 50 | $70.00 | $3,500.00 |
| 6 | Remove & Replace Driveway Pvmt. | SY | 18 | $70.00 | $1,260.00 |
| | ***Subtotal System D Construction Cost*** | | | | ***$36,320.00*** |
| | ***Contingency (20%)*** | | | | ***$7,264.00*** |
| | ***Total System D Construction Cost*** | | | | ***$43,584.00*** |

[1] Total is 6 manholes with 2 manholes existing
[2] Total is 319 lf with all 319 lf existing

*System E*

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 5 | $1,500.00 | $7,500.00 |
| 2 | Inlets | EA | 12 | $800.00 | $9,600.00 |
| 3 | 24" Reinf. Conc. Pipe | LF | 160 | $40.00 | $6,400.00 |
| 4 | 30" Reinf. Conc. Pipe | LF | 360 | $50.00 | $18,000.00 |
| 5 | 36" Reinf. Conc. Pipe | LF | 320 | $70.00 | $22,400.00 |
| 6 | 42" Reinf. Conc. Pipe | LF | 30 | $80.00 | $2,400.00 |
| 7 | Remove & Replace Roadway Pvmt. | SY | 50 | $70.00 | $3,500.00 |
| 8 | Remove & Replace Driveway Pvmt. | SY | 18 | $70.00 | $1,260.00 |
| | ***Subtotal System E Construction Cost*** | | | | ***$71,060.00*** |
| | ***Contingency (20%)*** | | | | ***$14,212.00*** |
| | ***Total System E Construction Cost*** | | | | ***$85,272.00*** |

*System F*

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Manholes | EA | 2 | $1,500.00 | $3,000.00 |
| 2 | 30" Reinf. Conc. Pipe | LF | 50 | $50.00 | $2,500.00 |
| 3 | Remove & Replace Roadway Pvmt. | SY | 32 | $70.00 | $2,240.00 |
| 4 | Remove & Replace Driveway Pvmt. | SY | 70 | $70.00 | $4,900.00 |

| | |
|---|---|
| ***Subtotal System F Construction Cost*** | ***$12,640.00*** |
| ***Contingency (20%)*** | ***$2,528.00*** |
| ***Total System F Construction Cost*** | ***$15,168.00*** |

*Storm Water Pump Station*

| Item No. | Description | Unit | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Site Work | | | | |
| | Finish Grading | LS | 1 | $15,500.00 | $15,500.00 |
| | Rip Rap | SY | 795 | $40.00 | $31,800.00 |
| 2 | Structure | | | | |
| | Concrete | LS | 1 | $216,000.00 | $216,000.00 |
| | Bar Screen | EA | 1 | $16,000.00 | $16,000.00 |
| 3 | Pumps | LS | 1 | $285,000.00 | $285,000.00 |
| 4 | Controls | LS | 1 | $55,000.00 | $55,000.00 |
| 5 | Electrical | LS | 1 | $125,000.00 | $125,000.00 |
| 6 | Piping & Valves | LS | 1 | $80,000.00 | $80,000.00 |
| 7 | Demolition | LS | 1 | $58,000.00 | $58,000.00 |
| 8 | Channel Rectification | LS | 1 | $45,000.00 | $45,000.00 |

| | |
|---|---|
| ***Subtotal Storm Water Pump Station Construction Cost*** | ***$927,300.00*** |
| ***Contingency (15%)*** | ***$139,095.00*** |
| ***Total Storm Water Pump Station Construction Cost*** | ***$1,066,395.00*** |

***Total Alternative "B" Construction Cost*** ***$2,502,501.00***

# APPENDIX D
# WEST KEMAH DRAINAGE STUDY

# CITY OF KEMAH

# WEST KEMAH DRAINAGE STUDY

CITY OF KEMAH
1401 STATE HIGHWAY 146
KEMAH, TEXAS 77565

**LJA Engineering & Surveying, Inc.**
East Houston Office
11821 East Freeway Suite 360
Houston, Texas 77029
713-450-1300

**LJA Engineering, Inc.**

11821 East Freeway
Suite 360
Houston, Texas 77029
TBPE № F-1386

Phone 713.450.1300
Fax 713.450.1385
www.ljaengineering.com

September 28, 2016

Jimmy Thompson
City Engineer
City of Kemah
1401 State Hwy 146
Kemah, Texas 77565

Re: West Kemah Drainage Study

Dear Mr. Thompson:

The specific scope of this project is to analyze the existing drainage conditions within a section of the City of Kemah. Specifically, West Kemah, has existing drainage conditions that were not planned, maintained, or developed at the same time. This has led to a drainage system that is currently undersized and with flowlines that do not help the water drain to the bay in an efficient manner. In some areas of West Kemah, the water becomes stagnant and does not drain but instead backs up until it evaporates overtime. This analysis provides the city a future plan to redevelop the drainage system with proper sizes and flowlines that will ensure this section of the City will drain properly under the given assumptions. It also provides probable construction cost estimates for the city's use in budgeting the proposed capital improvements that will need to be incorporated into the budget. This analysis is based on current field surveys and known pipeline depths from best available records. Excavation of the existing conditions once in construction could uncover variables that were not known about.

**Methods and Means**

Flow was developed for the drainage study based on the Rational Method. The chosen intensity of rainfall was based on a 2 year storm event from the City of Houston's Infrastructure Design Manual, table 9.1 rainfall intensity parameters, of b = 75.01, d = 16.2, and e = .8315. The watershed coefficient was based on City of Houston's Infrastructure Design Manual Land Use Type Chart, within the storm water design requirements chapter 9, where C = 0.45 for lots ¼ to ½ acre.

Rational Method
Q = I * (CA)
C = watershed coefficient
A = area (acres)
I = rainfall intensity (inches per hour)

Once a flow was developed for a 2 year storm event, the size of the ditches and reinforced concrete pipe was calculated from Manning's Equation below.

Manning's Equation:
V = (K/n) R^(2/3) Sf^(1/2)
Where: K = 1.49 for English units,
1.00 for metric units
V = velocity (ft./sec or m/sec)
R = hydraulic radius (ft. or m) (area/wetted perimeter)
Sf = channel slope (ft-ft)
n = 0.013 for concrete pipes
0.045 for Earthen Section

Then once the sizes were calculated, the most advantageous route for redirecting the storm water was designed in order to minimize probable construction cost. This meant directing as much water as possible into the ditch along Carolyn Street while not impacting the known pipeline locations. This allows for much less length of pipe and smaller pipe throughout all of West Kemah. If the water could not be directed to Carolyn a much larger collection pipe would have to be installed along Miller that would incur the city more construction cost to achieve the same result. Also due to pipeline elevations and flowline depths certain pipes had to be converted to arch pipe and doubled up to guarantee the same flow would be maintained.

With the impending expansion of TxDot Highway 146, drainage considerations had to be taken for the neighborhood to see if TxDot would impact or add flow to the drainage system. Mr. Elie Arkhoury informed us that the expansion would take all increased runoff from the increased impervious cover and drain or detain it on its own. The new highway will be designed to not flow excess storm water to the west of the railroad tracks that run parallel with Carolyn Street. No

special consideration needed to be taken for the West Kemah Drainage Study in relation to the TxDot Expansion of 146.

**Probable Construction Cost Estimates**

All eight construction costs totals and a length of ditch and pipe associated with them

| | Pipe Length | Ditch Length | Cost |
|---|---|---|---|
| Grove Street | 382 | 174 | $218,165 |
| 4th Street | 2464 | 586 | $409,548 |
| 5th Street | 2624 | 894 | $395,840 |
| 6th Street | 1984 | 1290 | $354,543 |
| 7th Street | 995 | 1070 | $217,024 |
| 8th Street | 1031 | 1250 | $202,149 |
| Miller Avenue | 1180 | 2420 | $325,465 |
| Carolyn Street | 551 | 4435 | $320,062 |

**Results**

All eight streets will need to be completely reworked and flowlines set accordingly for this drainage plan to be effective. The City may so elect to construct this plan in a manner that constructs certain streets at a time but will need to construct the streets from the bottom flowline and up with elevations getting higher as it goes. Based upon the probable construction cost the total is 2.44 million dollars.

Sincerely,

Mark Havran, PE
Project Manager

Attachments

# WEST KEMAH

# LAYOUTS & COSTS

**West Kemah Carolyn Street Drainage Rehabilitation**

Length Ditch 4435 Ft

Length Reinforced Concrete Pipe 551 Ft

| Item No. | Description | Est Qty | Units | Unit Price | Total Price Per Item |
|---|---|---|---|---|---|
| 1 | Excavate Existing Concrete for Depth of Flowline | 750 | SY | $17 | $12,750 |
| 2 | Cut for Storm Pipe Finish and Grade | 4693 | CY | $10 | $46,930 |
| 3 | Embankment for Storm Pipe Finished Grade | 115 | CY | $7 | $805 |
| 4 | 8-inch Subgrade Manipulation | 825 | SY | $6 | $4,950 |
| 5 | Lime for Stabilized Sub-grade 6% by Dryweight (27 lb/sy) | 12 | TON | $165 | $1,980 |
| 6 | Cement Stabilized Sand | 266 | CY | $35 | $9,310 |
| 7 | Bank Sand | 23 | CY | $15 | $345 |
| 8 | 7-inch Reinforced Concrete | 170 | SY | $120 | $20,400 |
| 9 | Dirt Work/Ditch Realignment | 4435 | LF | $15 | $66,525 |
| 10 | Surface Restoration Gravel/Limestone | 278 | SY | $60 | $16,680 |
| 11 | 18 Inch Reinforced Concrete Pipe | 74 | LF | $50 | $3,700 |
| 12 | 18 Inch Reinforced Concrete Arch Pipe | 106 | LF | $68 | $7,208 |
| 13 | 24 Inch Reinforced Concrete Arch Pipe | 161 | LF | $105 | $16,905 |
| 14 | 24 Inch Reinforced Concrete Pipe | 144 | LF | $75 | $10,800 |
| 15 | 30 Inch Reinforced Concrete Arch Pipe | 66 | LF | $155 | $10,230 |
| 16 | Traffic Control During Construction | 3 | Months | $4,000 | $12,000 |
| 17 | Permanent Traffic Markings | 1 | LS | $3,000 | $3,000 |
| 18 | Traffic Sign Relocation and Replacement | 7 | EA | $100 | $700 |
| 19 | Hydromulch Turf Establishment | 2 | ACRES | $3,250 | $6,500 |
| 20 | SWPPP | 1 | LS | $5,000 | $5,000 |
| 21 | Pipeline Matting and Protection | 1 | LS | $10,000 | $10,000 |
| **Sub Total** | | | | | **$266,718** |
| **Contingency (20%)** | | | | | **$53,344** |
| **Total** | | | | | **$320,062** |

*This cost estimate uses best available information from pipeline representatives. It does not gurantee that future unforeseen depths that are not known at this time will not affect the future flowlines or cost of the work to be performed.

**This is a probable cost for construction along Carolyn alone and does not include engineering.

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24A-CAROLYN-001 A | 1.47 | 1.44 | 40 |
| 24A-CAROLYN-001 B | 1.47 | 1.44 | 40 |
| 18-CAROLYN-002 A | 3.57 | 3.54 | 37 |
| 18-CAROLYN-002 B | 3.57 | 3.54 | 37 |
| 30A-CAROLYN-003 A | 2.34 | 2.31 | 33 |
| 30A-CAROLYN-003 B | 2.34 | 2.31 | 33 |
| 24-CAROLYN-004 | 3.40 | 3.38 | 26 |
| 18A-5TH-027 A | 3.70 | 3.64 | 53 |
| 18A-5TH-027 B | 3.70 | 3.64 | 53 |

50 0 50 100
SCALE IN FEET

LEGEND

- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT
- INLET
- FLOW

# CITY OF KEMAH

## CAROLYN STREET

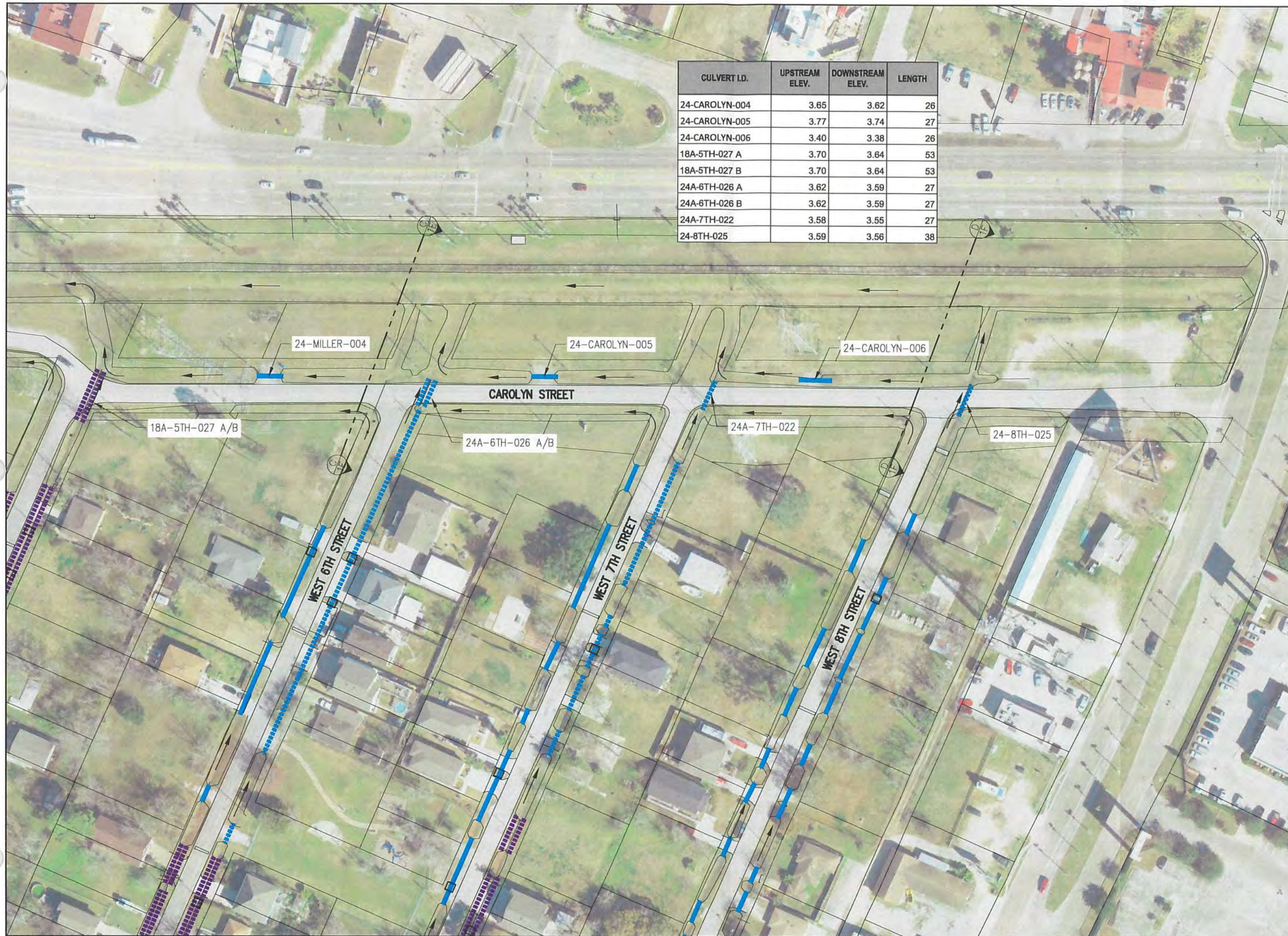

**LJA Engineering, Inc.**
11821 East Freeway
Suite # 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386


SCALE: AS SHOWN JOB No. E135-0280 EXHIBIT No. 01A

09/28/16

H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-01-Carolyn 1.dwg (XREF: Base)

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-CAROLYN-004 | 3.65 | 3.62 | 26 |
| 24-CAROLYN-005 | 3.77 | 3.74 | 27 |
| 24-CAROLYN-006 | 3.40 | 3.38 | 26 |
| 18A-5TH-027 A | 3.70 | 3.64 | 53 |
| 18A-5TH-027 B | 3.70 | 3.64 | 53 |
| 24A-6TH-026 A | 3.62 | 3.59 | 27 |
| 24A-6TH-026 B | 3.62 | 3.59 | 27 |
| 24A-7TH-022 | 3.58 | 3.55 | 27 |
| 24-8TH-025 | 3.59 | 3.56 | 38 |




50 0 50 100
SCALE IN FEET

LEGEND

- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT
- INLET
- FLOW

# CITY OF KEMAH

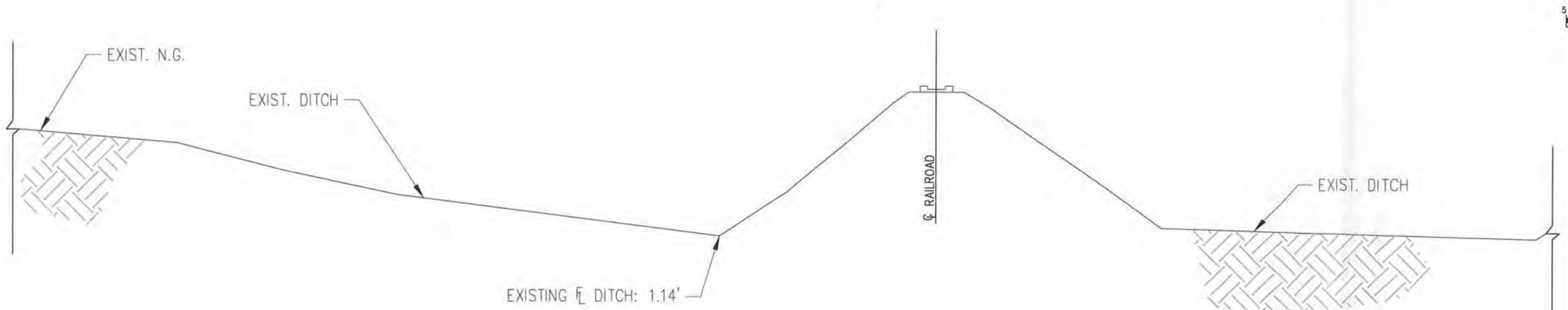
## CAROLYN STREET

**LJA Engineering, Inc.**
11821 East Freeway
Suite # 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

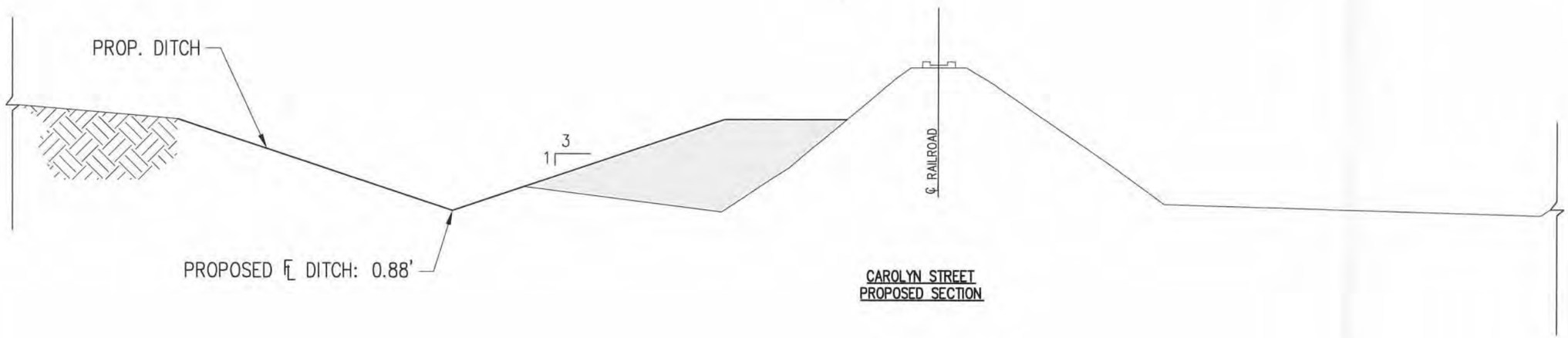
SCALE: AS SHOWN JOB No. E135-0280 EXHIBIT No. 01B

09/28/16

H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-01-Carolyn 2.dwg (XREF: Base)




CAROLYN STREET
EXISTING SECTION




CAROLYN STREET
PROPOSED SECTION

SECTION A/1C
SCALE: 1":10'

5 0 5 10
SCALE IN FEET

LEGEND

FILL

**CITY OF KEMAH**

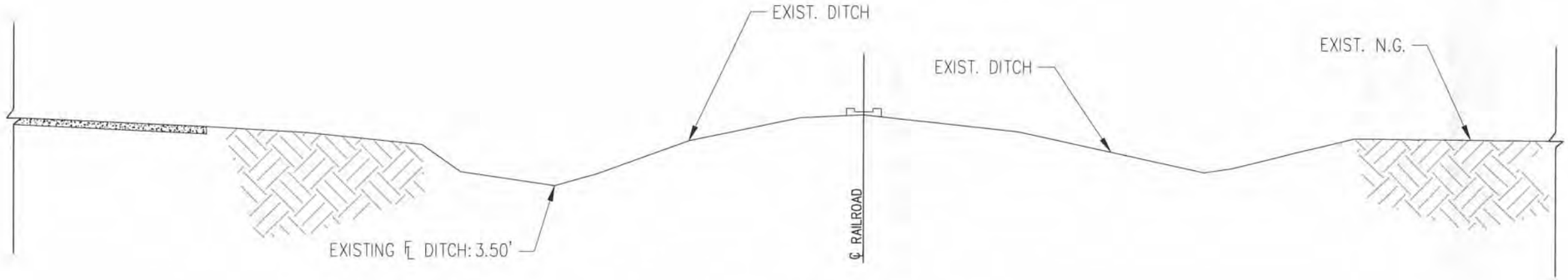
**CAROLYN DITCH SECTION "A"**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

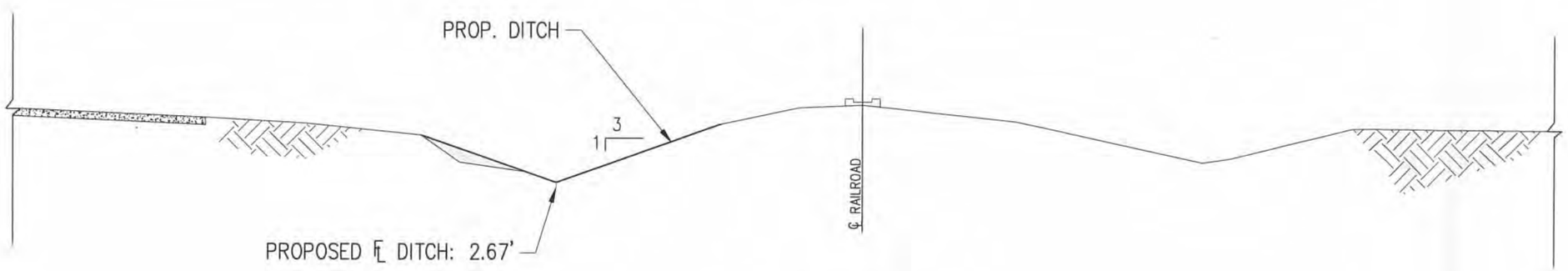
| SCALE: 1":10' | JOB No. E135-0280 | EXHIBIT No. 01C |
|---|---|---|

H:\ACAD\Clients\135\0280\Carolyn Exhibit 1C.dwg (XREF)

09/28/16




CAROLYN STREET
EXISTING SECTION




CAROLYN STREET
PROPOSED SECTION

SECTION B/10
SCALE: N.T.S.

5 0 5 10
SCALE IN FEET

LEGEND

FILL

**CITY OF KEMAH**

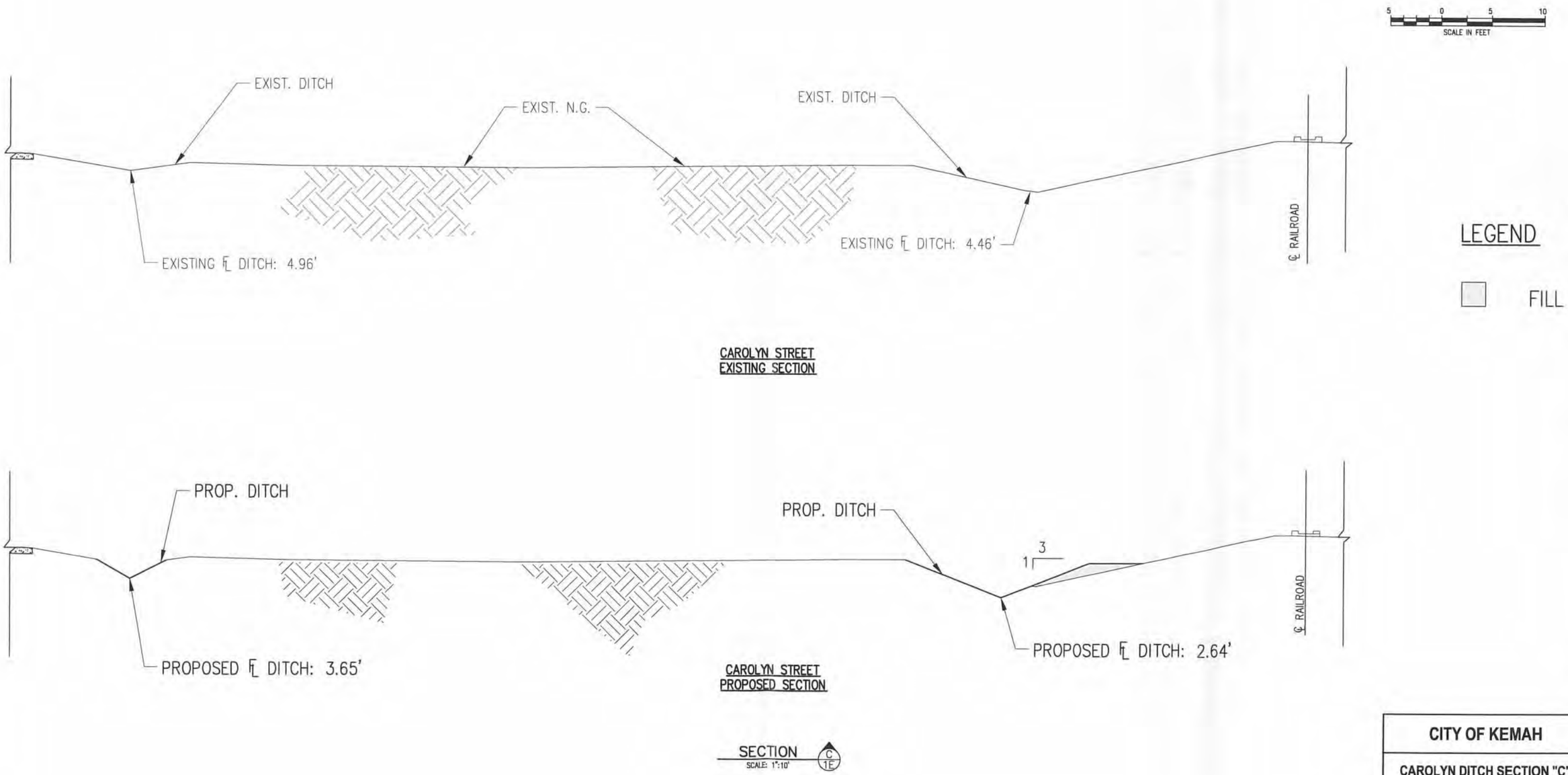
**CAROLYN DITCH SECTION "B"**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

| SCALE: N.T.S. | JOB No. E135-0280 | EXHIBIT No. 01D |
|---|---|---|

H:\ACAD\Clients\135\0280\Carolyn Exhibit 1D.dwg (XREF)

09/28/16




**CITY OF KEMAH**

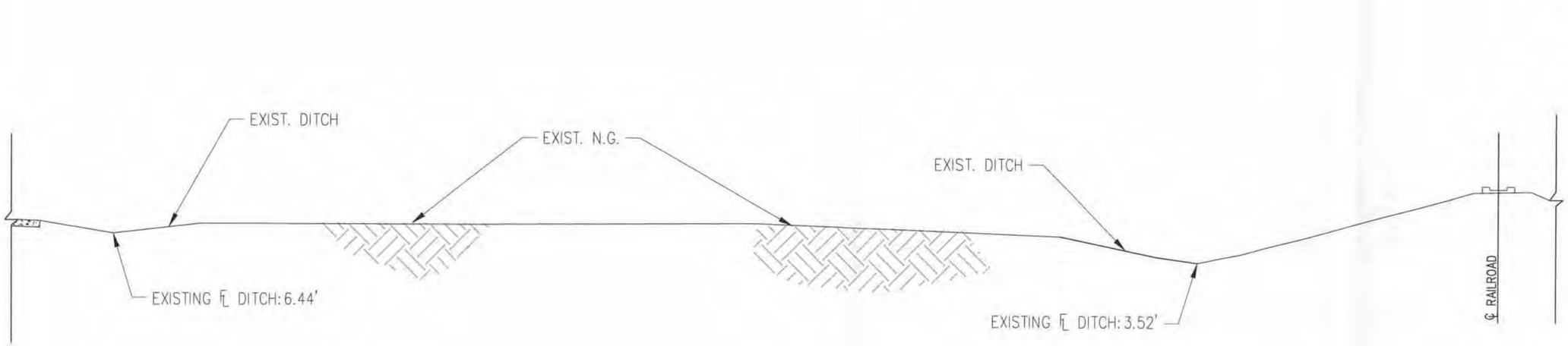
**CAROLYN DITCH SECTION "C"**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

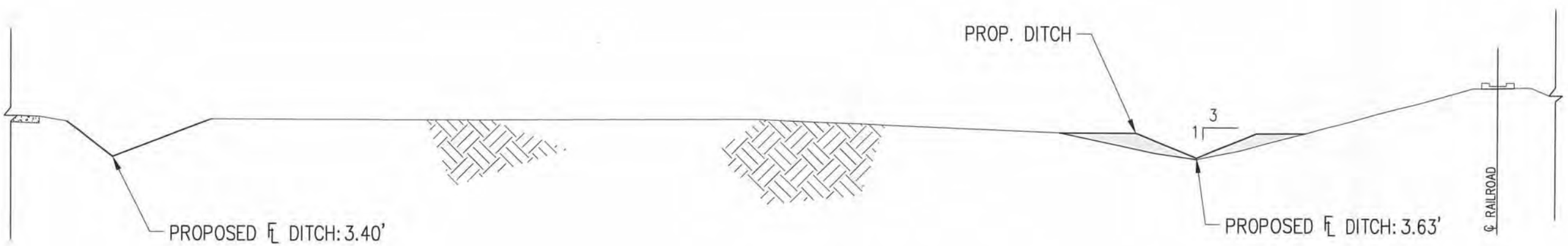
| SCALE: 1":10' | JOB No. E135-0280 | EXHIBIT No. 01E |
|---|---|---|

09/28/16

H:\ACAD\Clients\135\0280\Carolyn Exhibit 1E.dwg (XREF)




CAROLYN STREET
EXISTING SECTION




CAROLYN STREET
PROPOSED SECTION

SECTION D/1F
SCALE: 1":10'

5 0 5 10
SCALE IN FEET

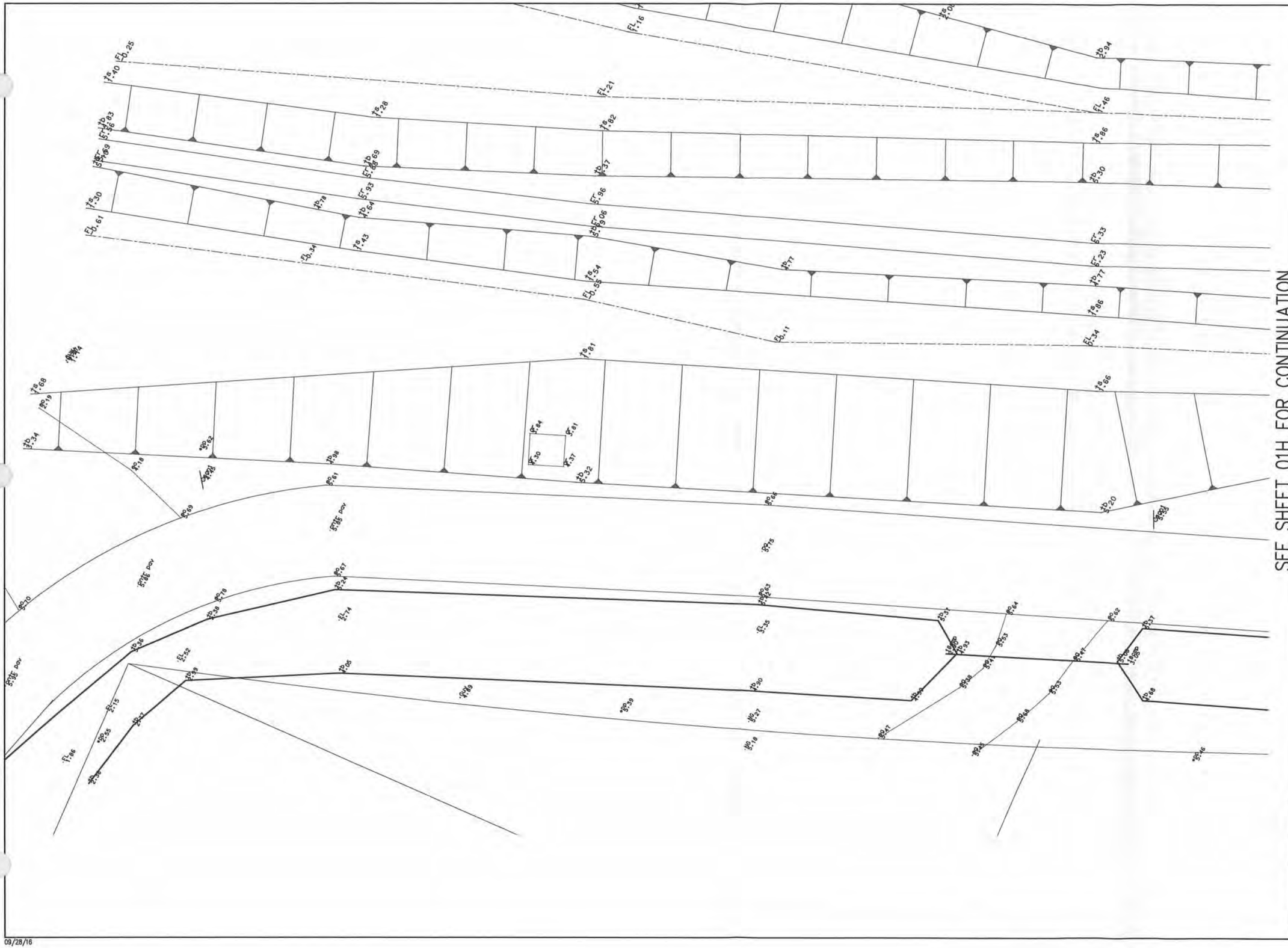
LEGEND

FILL

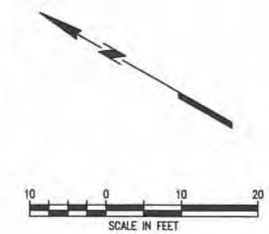
| CITY OF KEMAH | |
|---|---|
| CAROLYN DITCH SECTION "D" | |
| LJA Engineering, Inc. | |
| 11821 East Freeway<br>Suite 360<br>Houston, Texas 77029 | Phone 713.450.1300<br>Fax 713.450.1385<br>FRN - F-1386 |
| SCALE: 1":10' | JOB No. E135-0280 / EXHIBIT No. 01F |

09/28/16

H:\ACAD\Clients\135\0280\Carolyn Exhibit 1F.dwg (XREF)



SEE SHEET 01H FOR CONTINUATION




INDEX:

PP–POWER POLE
RR–RAILROAD
TB–TOP OF BANK
TS–TOE SLOPE
FL–FLOW LINE
EC–EDGE OF CONCRETE
EG–EDGE OF GRAVEL
NG–NATURAL GROUND
GUY–GUIDEWIRE

**CITY OF KEMAH**

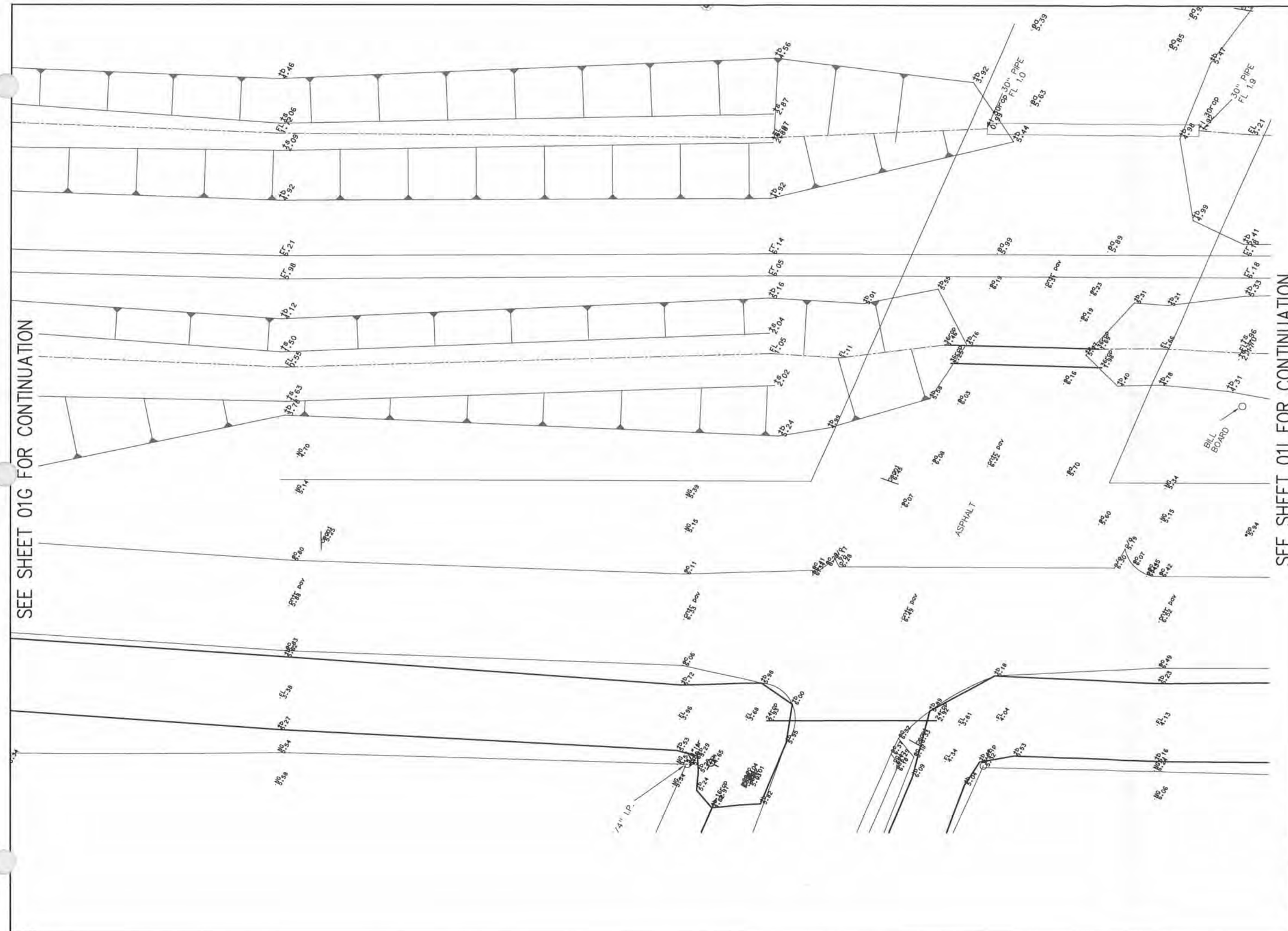
**CAROLYN TOPOGRAPHY SECTION**
**1 of 8**


**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386


SCALE: 1":20' | JOB No. E135-0280 | EXHIBIT No. 01G

H:\ACAD\Clients\135\0280\Carolyn Topo Exhibit.dwg (XREF: Base)

09/28/16




10 0 10 20
SCALE IN FEET

INDEX:

PP–POWER POLE
RR–RAILROAD
TB–TOP OF BANK
TS–TOE SLOPE
FL–FLOW LINE
EC–EDGE OF CONCRETE
EG–EDGE OF GRAVEL
NG–NATURAL GROUND
GUY–GUIDEWIRE

**CITY OF KEMAH**

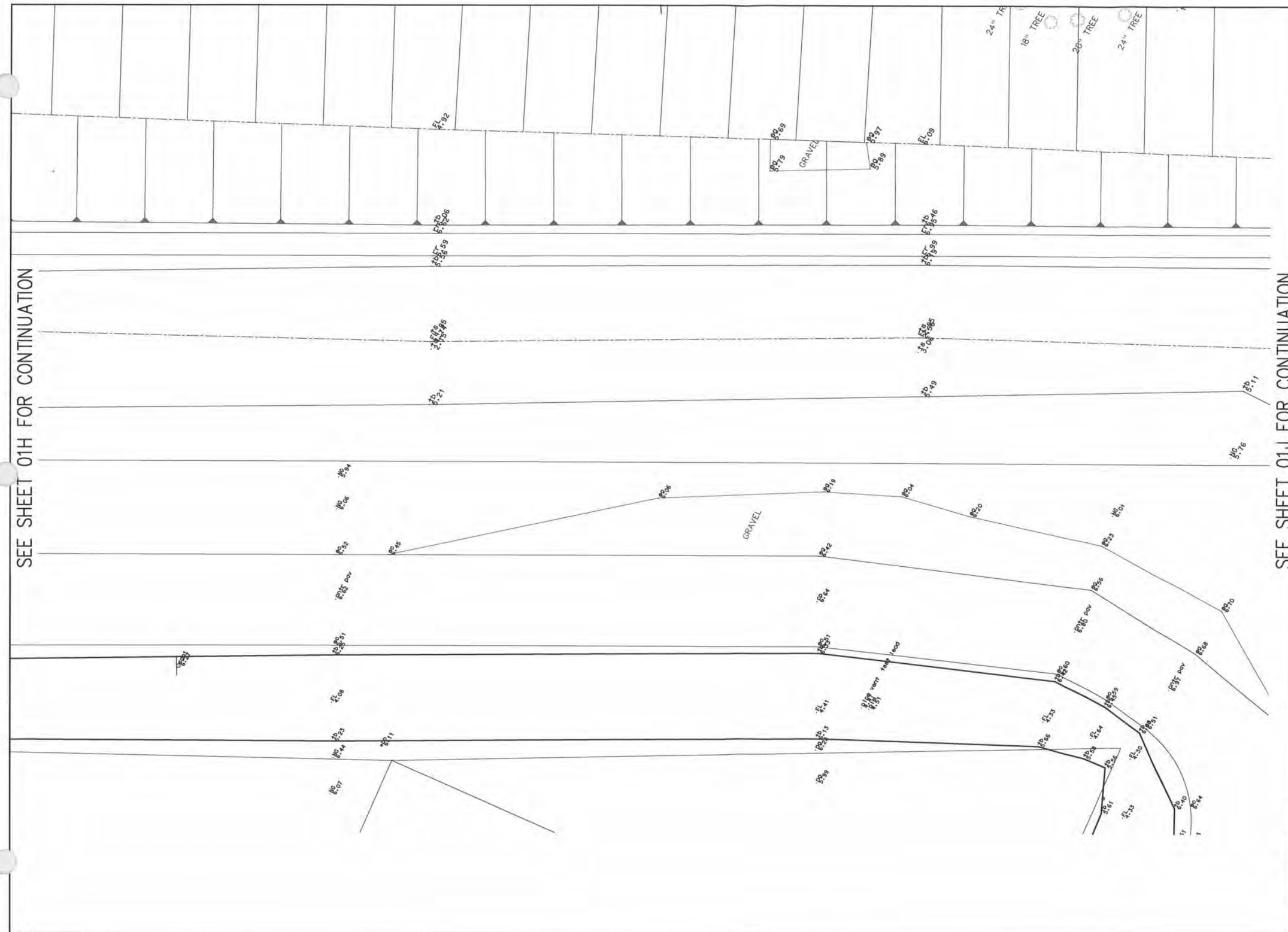
**CAROLYN TOPOGRAPHY SECTION**
**2 of 8**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: 1":20' | JOB No. E135-0280 | EXHIBIT No. 01H

H:\ACAD\Clients\135\0280\Carolyn Topo Exhibit.dwg (XREF: Base)

09/28/16




INDEX:

PP–POWER POLE
RR–RAILROAD
TB–TOP OF BANK
TS–TOE SLOPE
FL–FLOW LINE
EC–EDGE OF CONCRETE
EG–EDGE OF GRAVEL
NG–NATURAL GROUND
GUY–GUIDEWIRE

**CITY OF KEMAH**

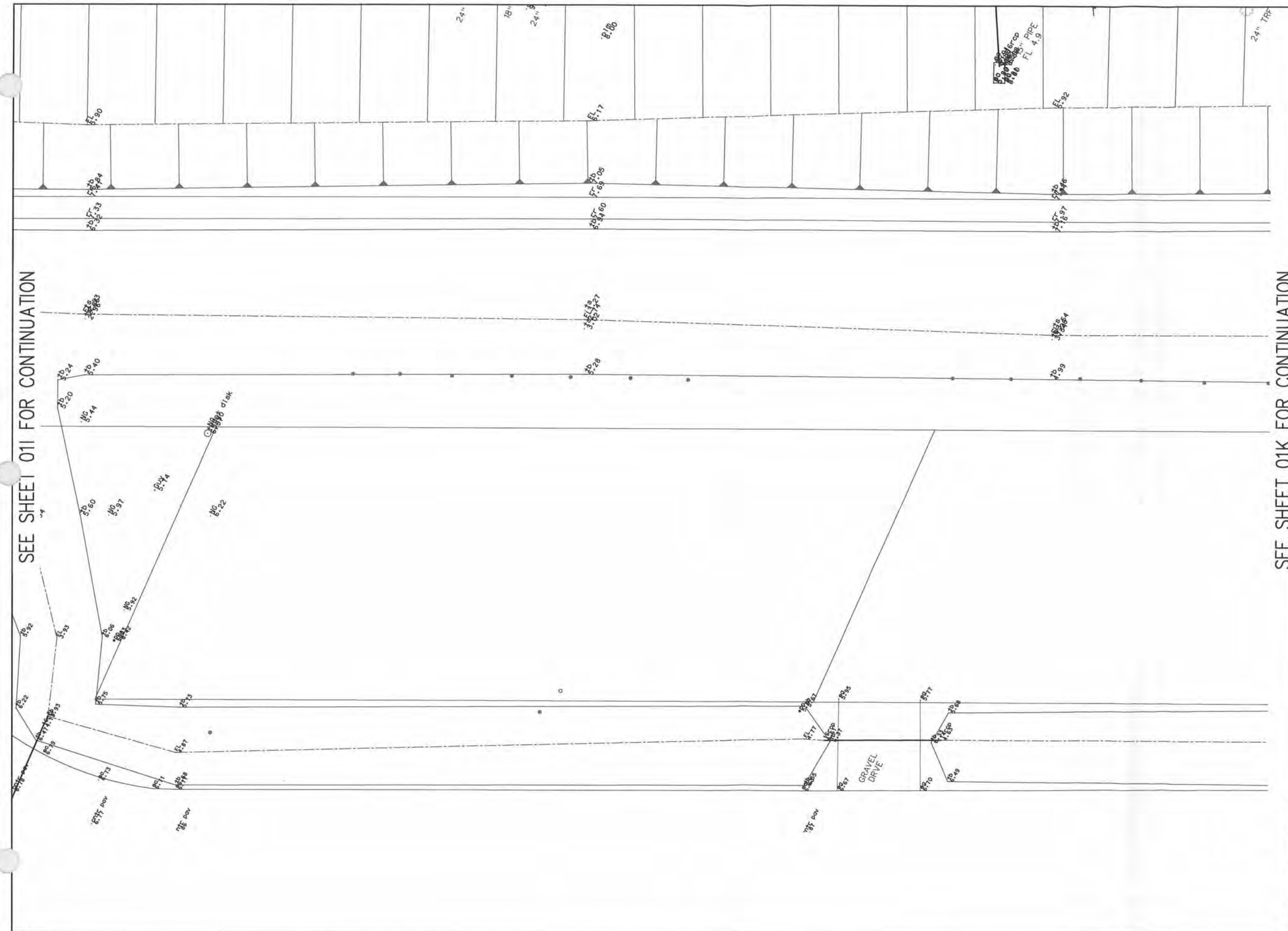
**CAROLYN TOPOGRAPHY SECTION**
**3 of 8**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: 1"=20' | JOB No. E135-0280 | EXHIBIT No. 011

H:\ACAD\Clients\135\0280\Carolyn Topo Exhibit.dwg (XREF: Base)

09/28/16




INDEX:

PP–POWER POLE
RR–RAILROAD
TB–TOP OF BANK
TS–TOE SLOPE
FL–FLOW LINE
EC–EDGE OF CONCRETE
EG–EDGE OF GRAVEL
NG–NATURAL GROUND
GUY–GUIDEWIRE

**CITY OF KEMAH**

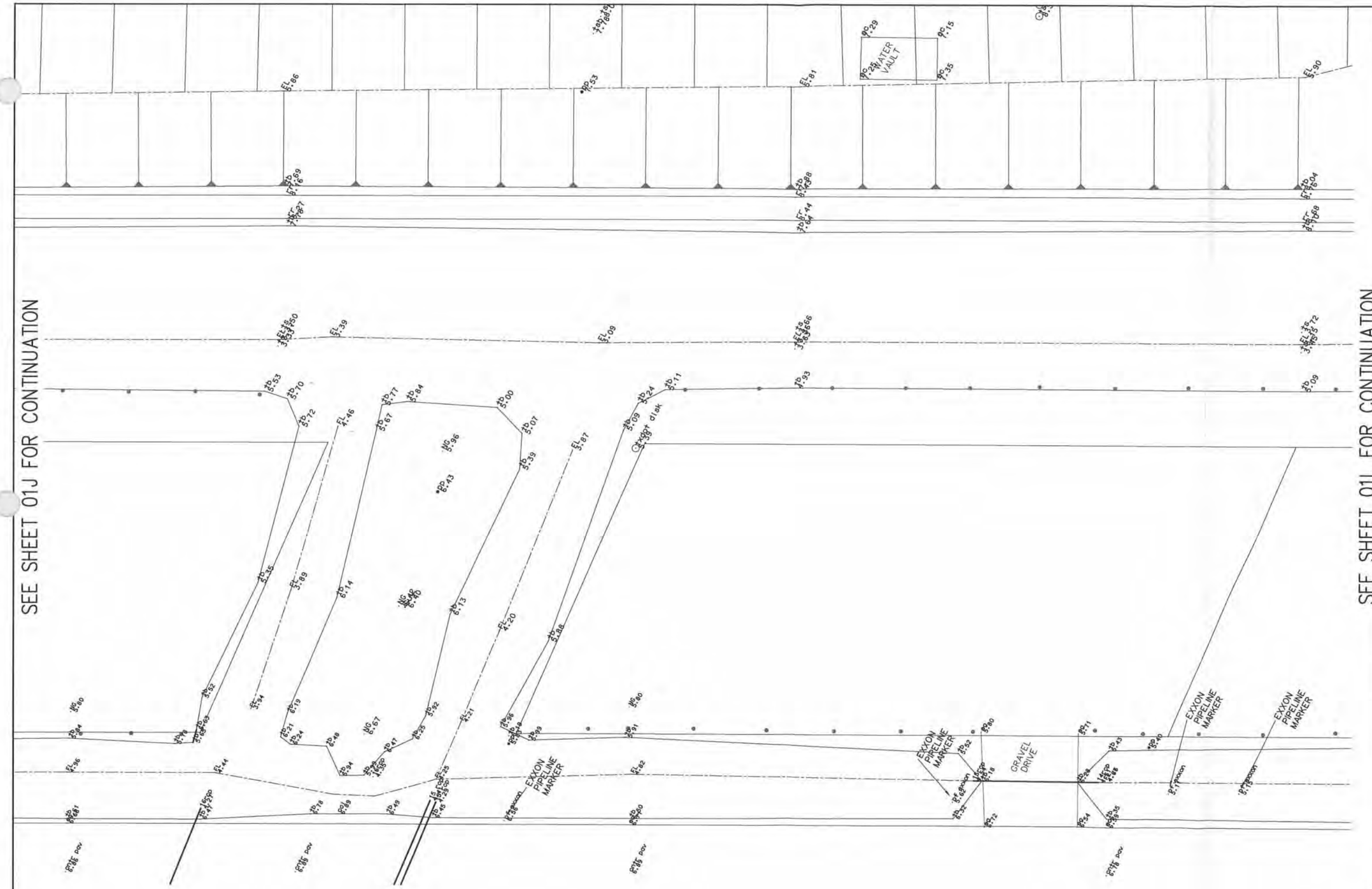
**CAROLYN TOPOGRAPHY SECTION**
**4 of 8**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: 1":20' | JOB No. E135-0280 | EXHIBIT No. 01J

09/28/16

H:\ACAD\Clients\135\0280\Carolyn Topo Exhibit.dwg (XREF: Base)




INDEX:

PP–POWER POLE
RR–RAILROAD
TB–TOP OF BANK
TS–TOE SLOPE
FL–FLOW LINE
EC–EDGE OF CONCRETE
EG–EDGE OF GRAVEL
NG–NATURAL GROUND
GUY–GUIDEWIRE

**CITY OF KEMAH**

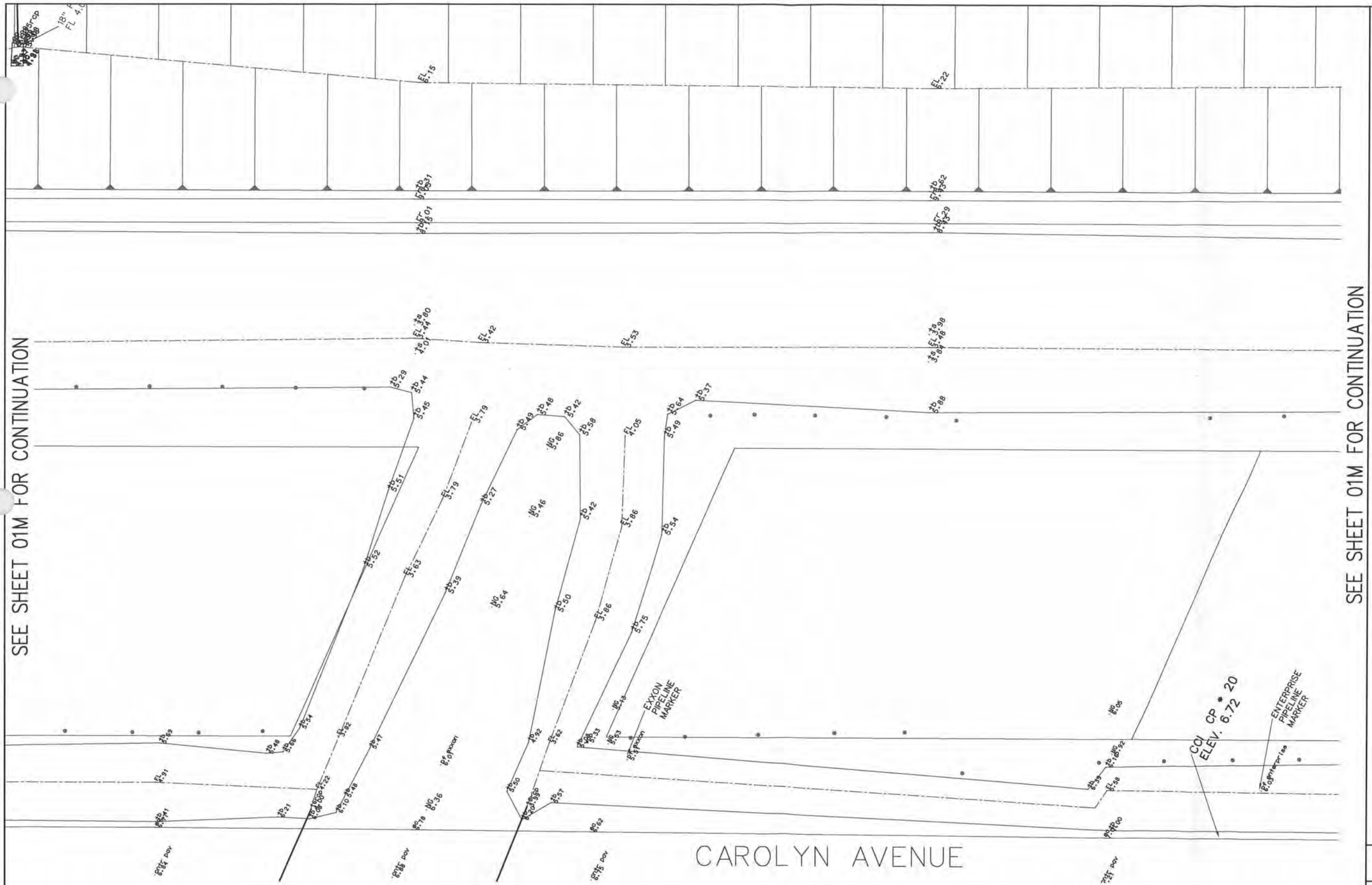
**CAROLYN TOPOGRAPHY SECTION**
**5 of 8**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: 1"=20' | JOB No. E135-0280 | EXHIBIT No. 01K

09/28/16

H:\ACAD\Clients\135\0280\Carolyn Topo Exhibit.dwg (XREF: Base)




10 0 10 20
SCALE IN FEET

INDEX:

PP–POWER POLE
RR–RAILROAD
TB–TOP OF BANK
TS–TOE SLOPE
FL–FLOW LINE
EC–EDGE OF CONCRETE
EG–EDGE OF GRAVEL
NG–NATURAL GROUND
GUY–GUIDEWIRE

**CITY OF KEMAH**

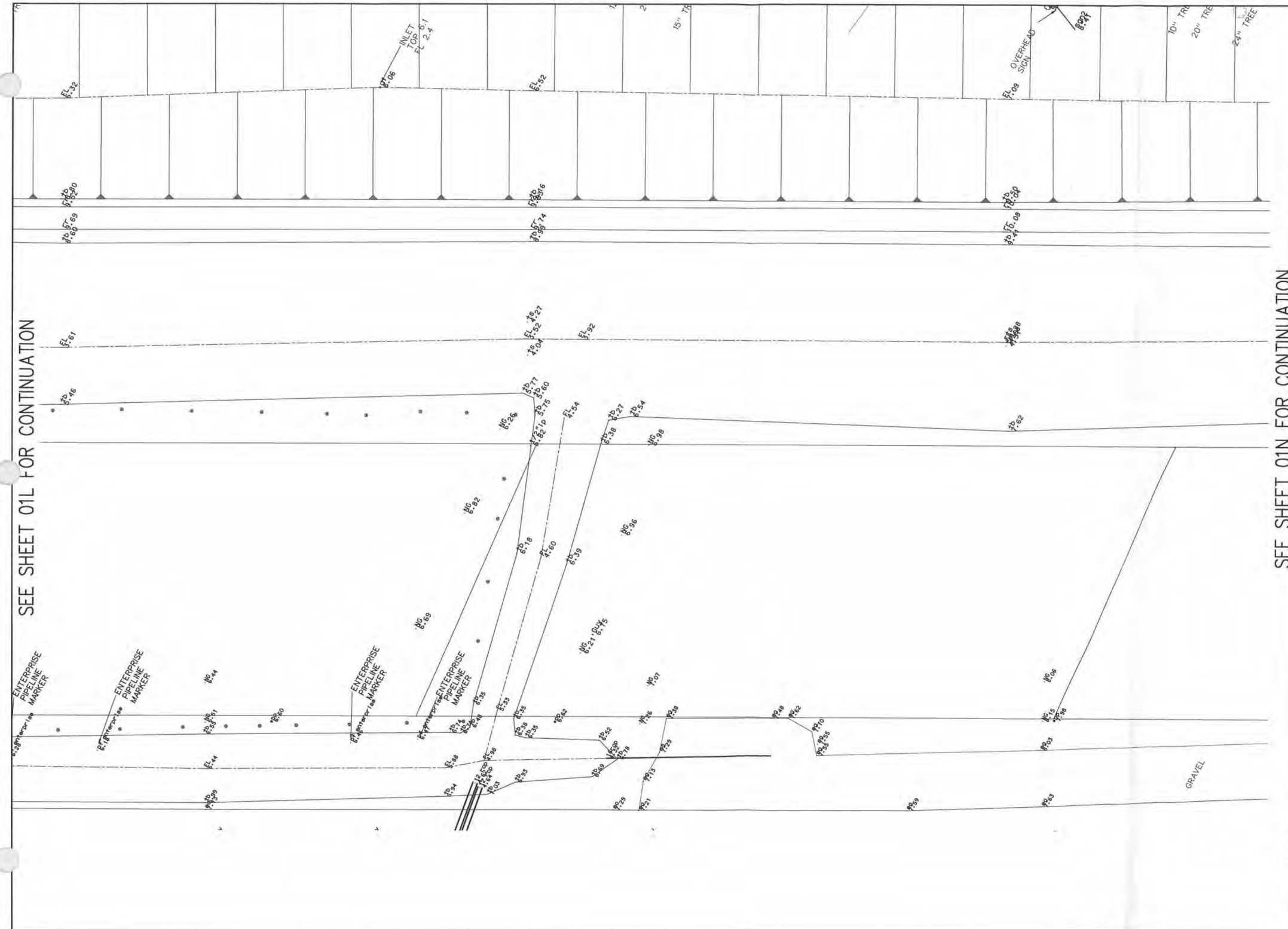
**CAROLYN TOPOGRAPHY SECTION**
**6 of 8**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: 1":20' | JOB No. E135-0280 | EXHIBIT No. 01L

H:\ACAD\Clients\135\0280\Carolyn Topo Exhibit.dwg (XREF: Base)

09/28/16




INDEX:

PP–POWER POLE
RR–RAILROAD
TB–TOP OF BANK
TS–TOE SLOPE
FL–FLOW LINE
EC–EDGE OF CONCRETE
EG–EDGE OF GRAVEL
NG–NATURAL GROUND
GUY–GUIDEWIRE

**CITY OF KEMAH**

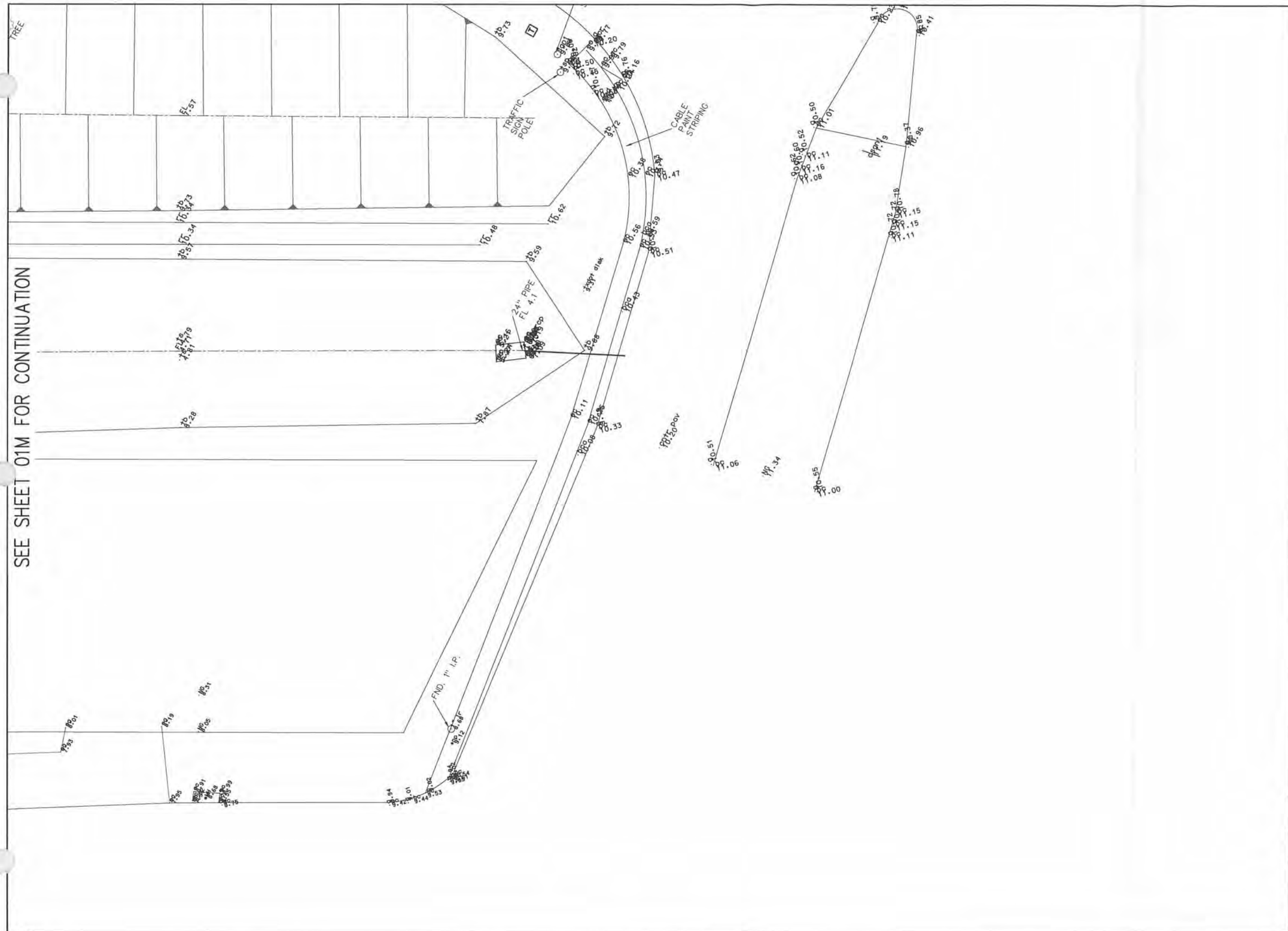
**CAROLYN TOPOGRAPHY SECTION**
**7 of 8**

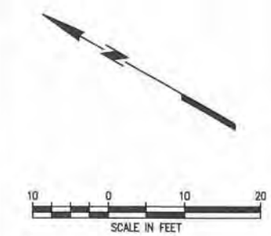
**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: 1"=20' | JOB No. E135–0280 | EXHIBIT No. 01M

H:\ACAD\Clients\135\0280\Carolyn Topo Exhibit.dwg (XREF: Base)

09/28/16




INDEX:

PP–POWER POLE
RR–RAILROAD
TB–TOP OF BANK
TS–TOE SLOPE
FL–FLOW LINE
EC–EDGE OF CONCRETE
EG–EDGE OF GRAVEL
NG–NATURAL GROUND
GUY–GUIDEWIRE

**CITY OF KEMAH**

**CAROLYN TOPOGRAPHY SECTION**
**8 of 8**

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: 1":20' | JOB No. E135-0280 | EXHIBIT No. 01N

09/28/16

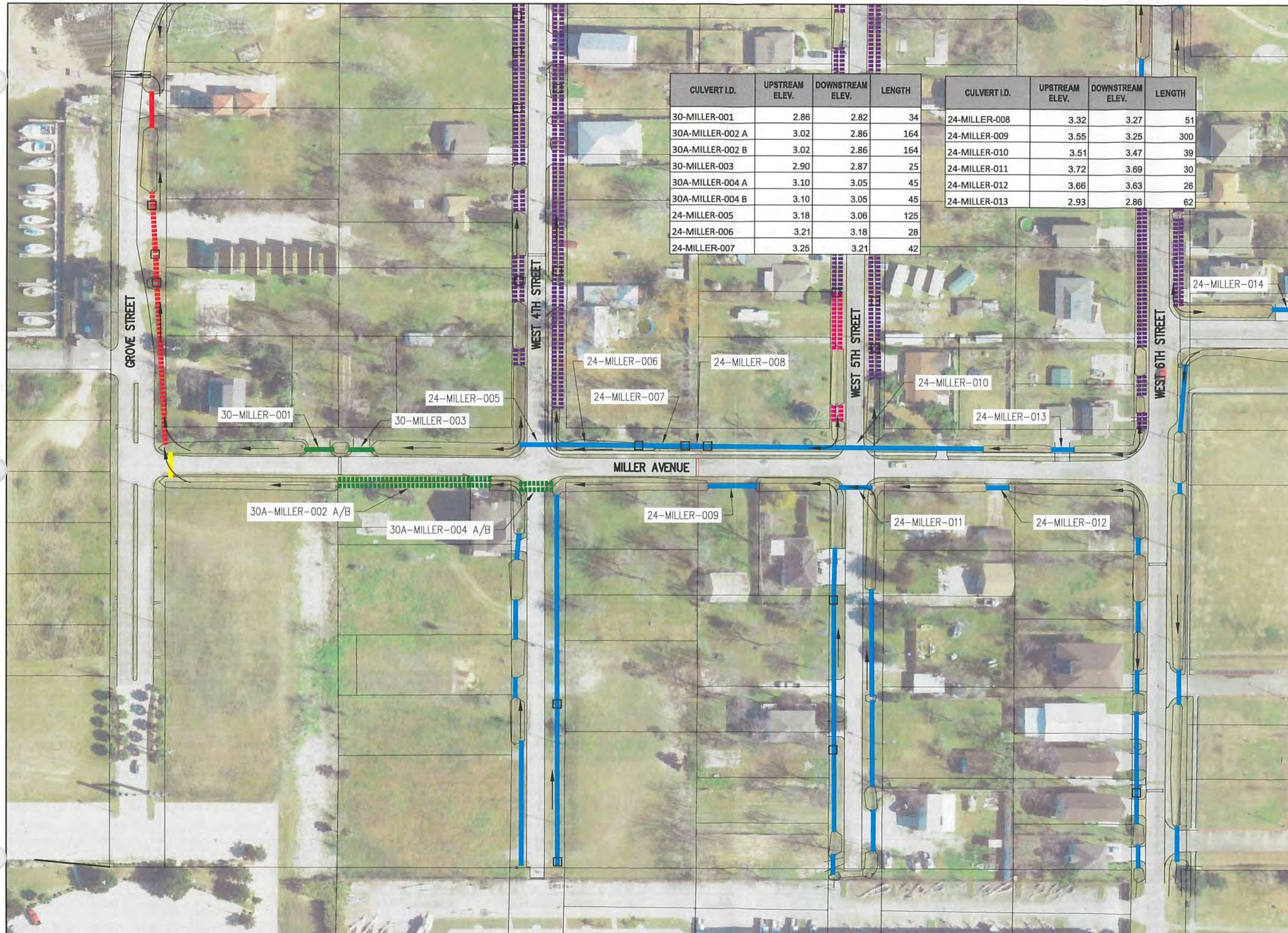
H:\ACAD\Clients\135\0280\Carolyn Topo Exhibit.dwg (XREF: Base)

## West Kemah Miller Avenue Drainage Rehabilitation

Length Ditch 2420 Ft
Length Reinforced Concrete Pipe 1180 Ft

| Item No. | Description | Est Qty | Units | Unit Price | Total Price Per Item |
|---|---|---|---|---|---|
| 1 | Excavate Existing Concrete for Depth of Flowline | 115 | SY | $17 | $1,955 |
| 2 | Cut for Storm Pipe Finish and Grade | 2829 | CY | $11 | $31,119 |
| 3 | Embankment for Storm Pipe Finished Grade | 236 | CY | $7 | $1,652 |
| 4 | 8-inch Subgrade Manipulation | 140 | SY | $6 | $840 |
| 5 | Lime for Stabilized Sub-grade 6% by Dryweight (27 lb/sy) | 2 | TON | $165 | $330 |
| 6 | Cement Stabilized Sand | 795 | CY | $35 | $27,825 |
| 7 | 7-Inch Reinforced Concrete | 115 | SY | $120 | $13,800 |
| 8 | 6-Inch Reinforced Concrete Driveways | 78 | SY | $100 | $7,800 |
| 9 | 2-Inch Asphalt Surface & 8-Inch Asphalt Base | 10 | SY | $75 | $750 |
| 10 | Drain Inlet | 4 | EA | $2,500 | $10,000 |
| 11 | 24 Inch Reinforced Concrete Pipe | 703 | LF | $75 | $52,725 |
| 12 | 30 Inch Reinforced Concrete Arch Pipe | 418 | LF | $155 | $64,790 |
| 13 | 30 Inch Reinforced Concrete Pipe | 59 | LF | $115 | $6,785 |
| 14 | Traffic Control During Construction | 3 | Months | $4,000 | $12,000 |
| 15 | Permanent Traffic Markings | 1 | LS | $3,000 | $3,000 |
| 16 | Traffic Sign Relocation and Replacement | 13 | EA | $100 | $1,300 |
| 17 | Hydromulch Turf Establishment | 0.6 | ACRES | $3,250 | $1,950 |
| 18 | SWPPP | 1 | LS | $5,000 | $5,000 |
| 19 | 4.5-Inch Sidewalk Remove and Replace & Includes Ramp | 360 | SY | $75 | $27,000 |
| 20 | Mailbox Remove & Relocate | 2 | EA | $300 | $600 |
| **Sub Total** | | | | | **$271,221** |
| **Contingency (20%)** | | | | | **$54,244** |
| **Total** | | | | | **$325,465** |

*This cost estimate uses best available information from pipeline representatives. It does not gurantee that future unforeseen depths that are not known at this time will not affect the future flowlines or cost of the work to be performed.
**This is a probable cost for construction along Miller Avenue alone and does not include engineering.




| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 30-MILLER-001 | 2.86 | 2.82 | 34 |
| 30A-MILLER-002 A | 3.02 | 2.86 | 164 |
| 30A-MILLER-002 B | 3.02 | 2.86 | 164 |
| 30-MILLER-003 | 2.90 | 2.87 | 25 |
| 30A-MILLER-004 A | 3.10 | 3.05 | 45 |
| 30A-MILLER-004 B | 3.10 | 3.05 | 45 |
| 24-MILLER-005 | 3.18 | 3.06 | 125 |
| 24-MILLER-006 | 3.21 | 3.18 | 28 |
| 24-MILLER-007 | 3.25 | 3.21 | 42 |

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-MILLER-008 | 3.32 | 3.27 | 51 |
| 24-MILLER-009 | 3.55 | 3.25 | 300 |
| 24-MILLER-010 | 3.51 | 3.47 | 39 |
| 24-MILLER-011 | 3.72 | 3.69 | 30 |
| 24-MILLER-012 | 3.66 | 3.63 | 26 |
| 24-MILLER-013 | 2.93 | 2.86 | 62 |

N

50 0 50 100
SCALE IN FEET

LEGEND

- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT

INLET

FLOW

# CITY OF KEMAH

## MILLER AVENUE

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: AS SHOWN | JOB No. E135-0280 | EXHIBIT No. 02A

H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-02-Miller 1.dwg (XREF: Base)

09/28/16

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-MILLER-009 | 3.55 | 3.25 | 300 |
| 24-MILLER-010 | 3.51 | 3.47 | 39 |
| 24-MILLER-011 | 3.72 | 3.69 | 30 |
| 24-MILLER-012 | 3.66 | 3.63 | 26 |
| 24-MILLER-013 | 2.93 | 2.86 | 62 |

50 0 50 100
SCALE IN FEET

LEGEND
- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT
- INLET
- FLOW

# CITY OF KEMAH

## MILLER AVENUE

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: AS SHOWN | JOB No. E135-0280 | EXHIBIT No. 02B

H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-02-Miller 2.dwg (XREF: Base)

09/28/16

## West Kemah Grove Street Drainage Rehabilitation

| | |
|---|---|
| Length Ditch | 174 Ft |
| Length Reinforced Concrete Pipe | 382 Ft |

| Item No. | Description | Est Qty | Units | Unit Price | Total Price Per Item |
|---|---|---|---|---|---|
| 1 | Excavate Existing Concrete for Depth of Flowline | 445 | SY | $17 | $7,565 |
| 2 | Cut for Storm Pipe Finish and Grade | 85 | CY | $10 | $850 |
| 3 | Embankment for Storm Pipe Finished Grade | 23 | CY | $7 | $161 |
| 4 | 8-Inch Subgrade Manipulation | 530 | SY | $6 | $3,180 |
| 5 | Lime for Stabilized Sub-grade 6% by Dryweight (27 lb/sy) | 6 | TON | $165 | $990 |
| 6 | Cement Stabilized Sand | 254 | CY | $35 | $8,890 |
| 7 | 7-Inch Reinforced Concrete | 445 | SY | $120 | $53,400 |
| 8 | 6-Inch Reinforced Concrete Driveways | 25 | SY | $100 | $2,500 |
| 9 | 2-Inch Asphalt Surface & 8-Inch Asphalt Base | 12 | SY | $75 | $900 |
| 10 | Dirt Work/Ditch Realignment | 174 | LF | $15 | $2,610 |
| 11 | Drain Inlet | 3 | EA | $2,500 | $7,500 |
| 12 | 36 Inch Reinforced Concrete Pipe | 58 | LF | $130 | $7,540 |
| 13 | 42 Inch Reinforced Concrete Arch Pipe | 281 | LF | $203 | $57,043 |
| 14 | 42 Inch Reinforced Concrete Pipe | 43 | LF | $150 | $6,450 |
| 15 | Traffic Control During Construction | 3 | Months | $4,000 | $12,000 |
| 16 | Permanent Traffic Markings | 1 | LS | $3,000 | $3,000 |
| 17 | Traffic Sign Relocation and Replacement | 5 | EA | $100 | $500 |
| 18 | Hydromulch Turf Establishment | 0.1 | ACRES | $3,250 | $325 |
| 19 | SWPPP | 1 | LS | $5,000 | $5,000 |
| 20 | Rip Rap remove and replace | 1 | LS | $500 | $500 |
| 21 | Mailbox Remove & Relocate | 3 | EA | 300 | $900 |
| 22 | Curb | | | | |
| **Sub Total** | | | | | **$181,804** |
| **Contingency (20%)** | | | | | **$36,361** |
| **Total** | | | | | **$218,165** |

*This cost estimate uses best available information from pipeline representatives. It does not gurantee that future unforeseen depths that are not known at this time will not affect the future flowlines or cost of the work to be performed.
**This is a probable cost for construction along Grove Street alone and does not include engineering.

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 36-GROVE-001 | 1.12 | 1.06 | 58 |
| 42A-GROVE-002 | 1.06 | 0.88 | 180 |
| 42A-GROVE-003 | 0.88 | 0.85 | 32 |
| 42A-GROVE-004 | 0.85 | 0.80 | 49 |
| 42A-GROVE-005 | 0.77 | 0.75 | 20 |
| 42-GROVE-006 | 0.68 | 0.64 | 43 |

50 0 50 100
SCALE IN FEET

LEGEND

- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT
- INLET
- FLOW

# CITY OF KEMAH

## GROVE STREET

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: AS SHOWN | JOB No. E135-0280 | EXHIBIT No. 03

09/28/16

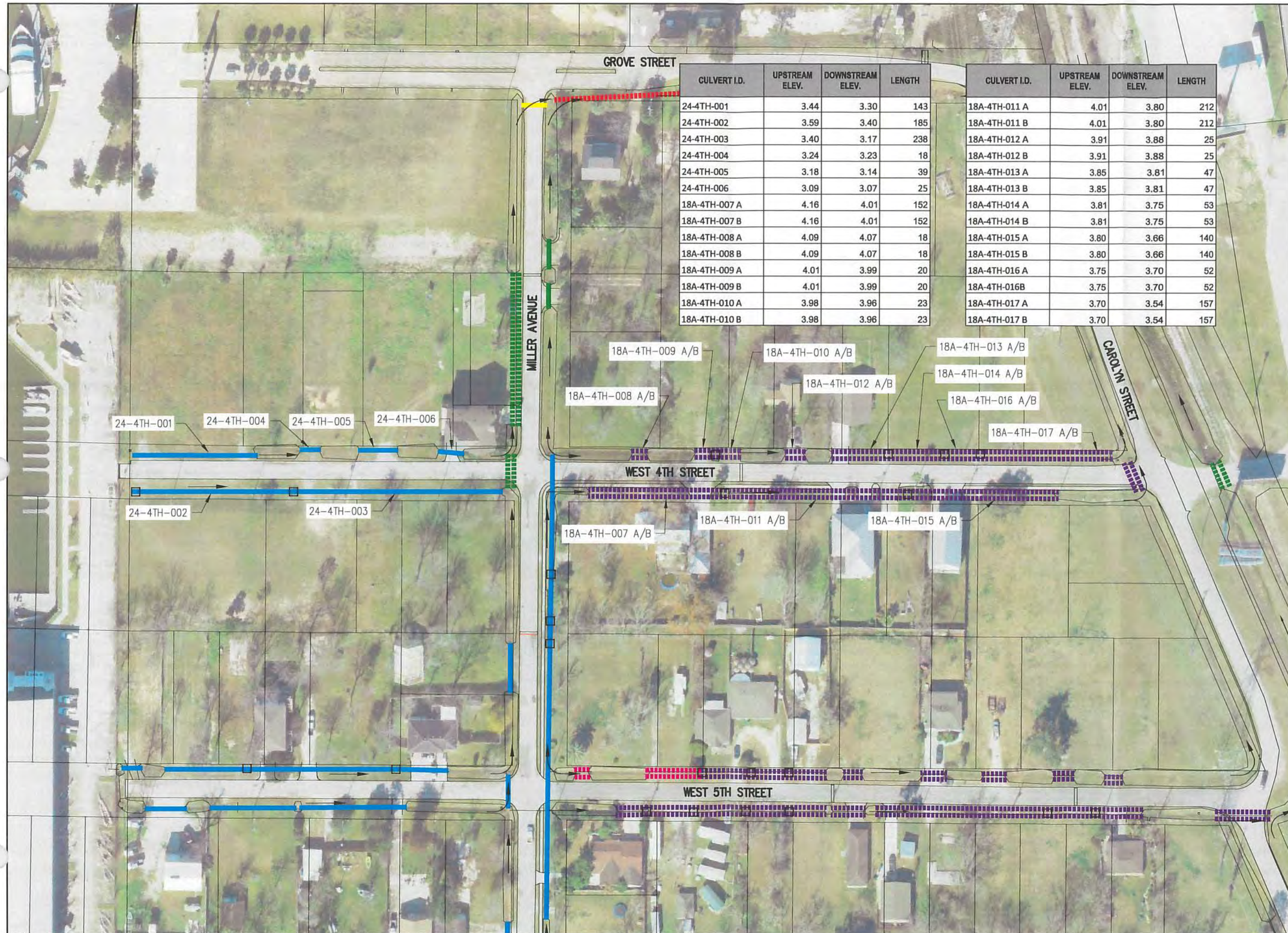
H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-03-Grove.dwg (XREF: Base)

## West Kemah 4th Street Drainage Rehabilitation

| | | |
|---|---|---|
| Length Ditch | 586 | Ft |
| Length Reinforced Concrete Pipe | 2464 | Ft |

| Item No. | Description | Est Qty | Units | Unit Price | Total Price Per Item |
|---|---|---|---|---|---|
| 1 | Excavate Existing Concrete for Depth of Flowline | 23 | SY | $17 | $391 |
| 2 | Cut for Storm Pipe Finish and Grade | 404 | CY | $10 | $4,040 |
| 3 | Embankment for Storm Pipe Finished Grade | 28 | CY | $7 | $196 |
| 4 | 8-inch Subgrade Manipulation | 28 | SY | $6 | $168 |
| 5 | Lime for Stabilized Sub-grade 6% by Dryweight (27 lb/sy) | 2 | TON | $165 | $330 |
| 6 | Cement Stabilized Sand | 1980 | CY | $35 | $69,300 |
| 7 | 7-Inch Reinforced Concrete | 23 | SY | $120 | $2,760 |
| 8 | 6-Inch Reinforced Concrete Driveways | 107 | SY | $100 | $10,700 |
| 9 | 2-Inch Asphalt Surface & 8-Inch Asphalt Base | 37 | EA | $75 | $2,775.00 |
| 10 | Dirt Work/Ditch Realignment | 586 | LF | $15 | $8,790.00 |
| 11 | Drain Inlet | 7 | EA | $2,500 | $17,500 |
| 12 | 18 Inch Reinforced Concrete Arch Pipe | 1798 | LF | $68 | $121,365 |
| 13 | 24 Inch Reinforced Concrete Pipe | 666 | LF | $75 | $49,950 |
| 14 | Traffic Control During Construction | 3 | Months | $4,000 | $12,000 |
| 15 | Permanent Traffic Markings | 1 | LS | $3,000 | $3,000 |
| 16 | Traffic Sign Relocation and Replacement | 4 | EA | $100 | $400 |
| 17 | Hydromulch Turf Establishment | 0.5 | ACRES | $3,250 | $1,625 |
| 18 | SWPPP | 1 | LS | $5,000 | $5,000 |
| 19 | 4.5-Inch Sidewalk Remove and Replace | 360 | SY | $70 | $25,200 |
| 20 | Mailbox Remove & Relocate | 1 | EA | $300 | $300 |
| 21 | 100 W 4th Street Residential Landscaping Replacement/Repair | 1 | LS | $3,500 | $3,500 |
| 22 | 40 W 4th Street Residential Landscaping Replacement/Repair | 1 | LS | $2,000 | $2,000 |
| **Sub Total** | | | | | **$341,290** |
| **Contingency (20%)** | | | | | **$68,258** |
| **Total** | | | | | **$409,548** |

*This cost estimate uses best available information from pipeline representatives. It does not gurantee that future unforeseen depths that are not known at this time will not affect the future flowlines or cost of the work to be performed.
**This is a probable cost for construction along 4th Street alone and does not include engineering.




| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-4TH-001 | 3.44 | 3.30 | 143 |
| 24-4TH-002 | 3.59 | 3.40 | 185 |
| 24-4TH-003 | 3.40 | 3.17 | 238 |
| 24-4TH-004 | 3.24 | 3.23 | 18 |
| 24-4TH-005 | 3.18 | 3.14 | 39 |
| 24-4TH-006 | 3.09 | 3.07 | 25 |
| 18A-4TH-007 A | 4.16 | 4.01 | 152 |
| 18A-4TH-007 B | 4.16 | 4.01 | 152 |
| 18A-4TH-008 A | 4.09 | 4.07 | 18 |
| 18A-4TH-008 B | 4.09 | 4.07 | 18 |
| 18A-4TH-009 A | 4.01 | 3.99 | 20 |
| 18A-4TH-009 B | 4.01 | 3.99 | 20 |
| 18A-4TH-010 A | 3.98 | 3.96 | 23 |
| 18A-4TH-010 B | 3.98 | 3.96 | 23 |

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 18A-4TH-011 A | 4.01 | 3.80 | 212 |
| 18A-4TH-011 B | 4.01 | 3.80 | 212 |
| 18A-4TH-012 A | 3.91 | 3.88 | 25 |
| 18A-4TH-012 B | 3.91 | 3.88 | 25 |
| 18A-4TH-013 A | 3.85 | 3.81 | 47 |
| 18A-4TH-013 B | 3.85 | 3.81 | 47 |
| 18A-4TH-014 A | 3.81 | 3.75 | 53 |
| 18A-4TH-014 B | 3.81 | 3.75 | 53 |
| 18A-4TH-015 A | 3.80 | 3.66 | 140 |
| 18A-4TH-015 B | 3.80 | 3.66 | 140 |
| 18A-4TH-016 A | 3.75 | 3.70 | 52 |
| 18A-4TH-016B | 3.75 | 3.70 | 52 |
| 18A-4TH-017 A | 3.70 | 3.54 | 157 |
| 18A-4TH-017 B | 3.70 | 3.54 | 157 |

50 0 50 100
SCALE IN FEET

LEGEND

- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT
- INLET
- FLOW

# CITY OF KEMAH

## WEST 4TH STREET

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: AS SHOWN | JOB No. E135-0280 | EXHIBIT No. 04

09/28/16

H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-04-4th street.dwg (XREF: Base)

**West Kemah 5th Street Drainage Rehabilitation**

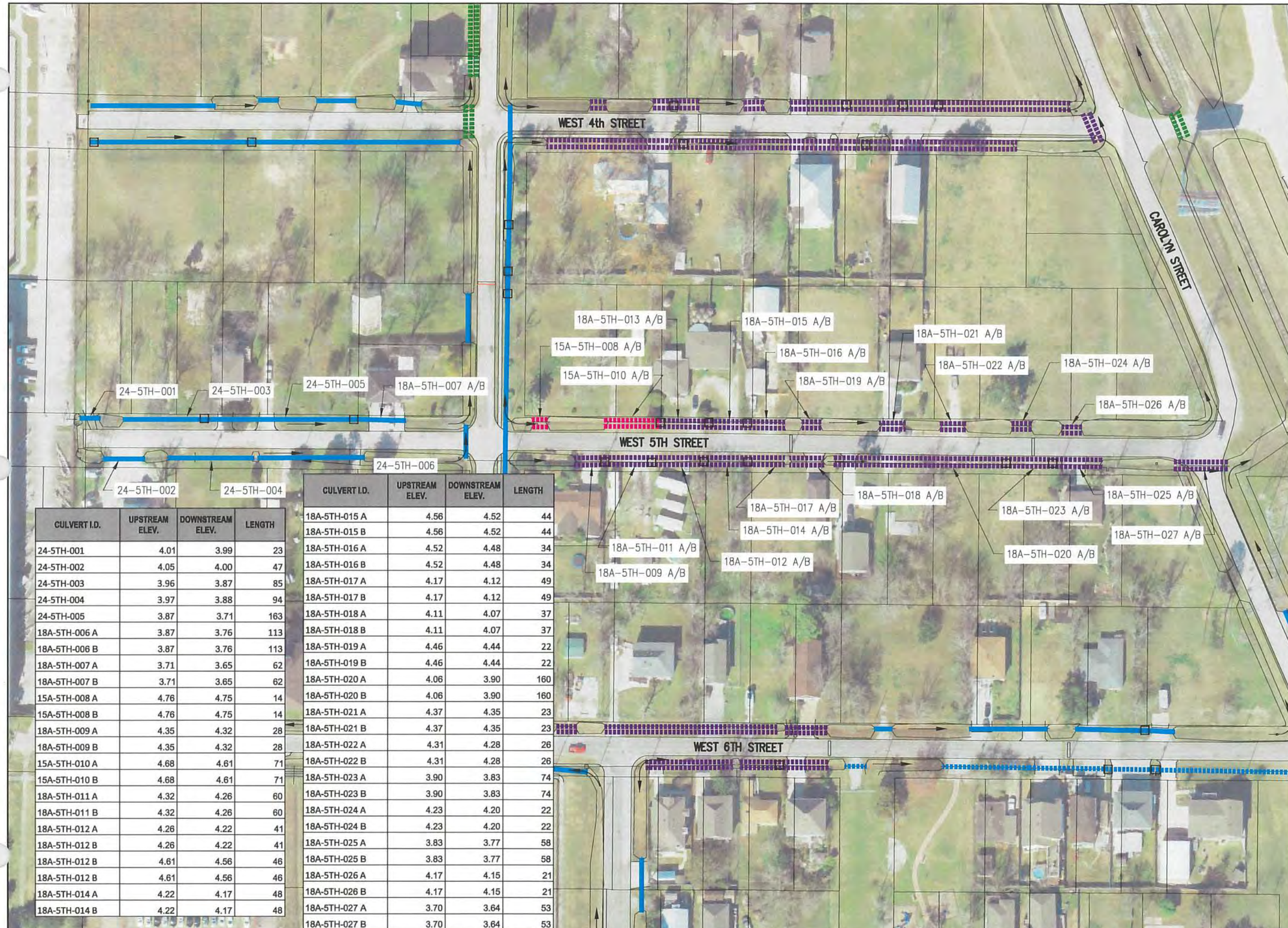
| | |
|---|---|
| Length Ditch | 894 Ft |
| Length Reinforced Concrete Pipe | 2624 Ft |

| Item No. | Description | Est Qty | Units | Unit Price | Total Price Per Item |
|---|---|---|---|---|---|
| 1 | Cut for Storm Pipe Finish and Grade | 1304 | CY | $10 | $13,040 |
| 2 | Embankment for Storm Pipe Finished Grade | 73 | CY | $7 | $511 |
| 3 | Cement Stabilized Sand | 2031 | CY | $35 | $71,085 |
| 4 | 6-Inch Reinforced Concrete Driveways | 78 | SY | $100 | $7,800 |
| 5 | 2-Inch Asphalt Surface & 8-Inch Asphalt Base | 18 | SY | $75 | $1,350 |
| 6 | Drain Inlet | 11 | EA | $2,500 | $27,500 |
| 7 | 15 Inch Reinforced Concrete Arch Pipe | 170 | LF | $80 | $13,600 |
| 8 | 18 Inch Reinforced Concrete Arch Pipe | 2042 | LF | $68 | $138,856 |
| 9 | 24 Inch Reinforced Concrete Pipe | 412 | LF | $75 | $30,900 |
| 10 | Traffic Control During Construction | 3 | Months | $4,000 | $12,000 |
| 11 | Permanent Traffic Markings | 1 | LS | $3,000 | $3,000 |
| 12 | Traffic Sign Relocation and Replacement | 2 | EA | $100 | $200 |
| 13 | Hydromulch Turf Establishment | 0.5 | ACRES | $3,250 | $1,625 |
| 14 | SWPPP | 1 | LS | $5,000 | $5,000 |
| 15 | Mailbox Remove & Relocate | 10 | EA | $300 | $3,000 |
| 16 | 160 W 5th Street Residential Landscaping Replacement/Repair | 1 | LS | $400 | $400 |

| | |
|---|---|
| **Sub Total** | **$329,867** |
| **Contingency (20%)** | **$65,973** |
| **Total** | **$395,840** |

*This cost estimate uses best available information from pipeline representatives. It does not gurantee that future unforeseen depths that are not known at this time will not affect the future flowlines or cost of the work to be performed.

**This is a probable cost for construction along 5th Street alone and does not include engineering.




| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-5TH-001 | 4.01 | 3.99 | 23 |
| 24-5TH-002 | 4.05 | 4.00 | 47 |
| 24-5TH-003 | 3.96 | 3.87 | 85 |
| 24-5TH-004 | 3.97 | 3.88 | 94 |
| 24-5TH-005 | 3.87 | 3.71 | 163 |
| 18A-5TH-006 A | 3.87 | 3.76 | 113 |
| 18A-5TH-006 B | 3.87 | 3.76 | 113 |
| 18A-5TH-007 A | 3.71 | 3.65 | 62 |
| 18A-5TH-007 B | 3.71 | 3.65 | 62 |
| 15A-5TH-008 A | 4.76 | 4.75 | 14 |
| 15A-5TH-008 B | 4.76 | 4.75 | 14 |
| 18A-5TH-009 A | 4.35 | 4.32 | 28 |
| 18A-5TH-009 B | 4.35 | 4.32 | 28 |
| 15A-5TH-010 A | 4.68 | 4.61 | 71 |
| 15A-5TH-010 B | 4.68 | 4.61 | 71 |
| 18A-5TH-011 A | 4.32 | 4.26 | 60 |
| 18A-5TH-011 B | 4.32 | 4.26 | 60 |
| 18A-5TH-012 A | 4.26 | 4.22 | 41 |
| 18A-5TH-012 B | 4.26 | 4.22 | 41 |
| 18A-5TH-012 B | 4.61 | 4.56 | 46 |
| 18A-5TH-012 B | 4.61 | 4.56 | 46 |
| 18A-5TH-014 A | 4.22 | 4.17 | 48 |
| 18A-5TH-014 B | 4.22 | 4.17 | 48 |

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 18A-5TH-015 A | 4.56 | 4.52 | 44 |
| 18A-5TH-015 B | 4.56 | 4.52 | 44 |
| 18A-5TH-016 A | 4.52 | 4.48 | 34 |
| 18A-5TH-016 B | 4.52 | 4.48 | 34 |
| 18A-5TH-017 A | 4.17 | 4.12 | 49 |
| 18A-5TH-017 B | 4.17 | 4.12 | 49 |
| 18A-5TH-018 A | 4.11 | 4.07 | 37 |
| 18A-5TH-018 B | 4.11 | 4.07 | 37 |
| 18A-5TH-019 A | 4.46 | 4.44 | 22 |
| 18A-5TH-019 B | 4.46 | 4.44 | 22 |
| 18A-5TH-020 A | 4.06 | 3.90 | 160 |
| 18A-5TH-020 B | 4.06 | 3.90 | 160 |
| 18A-5TH-021 A | 4.37 | 4.35 | 23 |
| 18A-5TH-021 B | 4.37 | 4.35 | 23 |
| 18A-5TH-022 A | 4.31 | 4.28 | 26 |
| 18A-5TH-022 B | 4.31 | 4.28 | 26 |
| 18A-5TH-023 A | 3.90 | 3.83 | 74 |
| 18A-5TH-023 B | 3.90 | 3.83 | 74 |
| 18A-5TH-024 A | 4.23 | 4.20 | 22 |
| 18A-5TH-024 B | 4.23 | 4.20 | 22 |
| 18A-5TH-025 A | 3.83 | 3.77 | 58 |
| 18A-5TH-025 B | 3.83 | 3.77 | 58 |
| 18A-5TH-026 A | 4.17 | 4.15 | 21 |
| 18A-5TH-026 B | 4.17 | 4.15 | 21 |
| 18A-5TH-027 A | 3.70 | 3.64 | 53 |
| 18A-5TH-027 B | 3.70 | 3.64 | 53 |

50 0 50 100
SCALE IN FEET

LEGEND
- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT
- INLET
- FLOW

# CITY OF KEMAH

## WEST 5TH STREET

LJA Engineering, Inc.
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: AS SHOWN | JOB No. E135-0280 | EXHIBIT No. 05

09/28/16

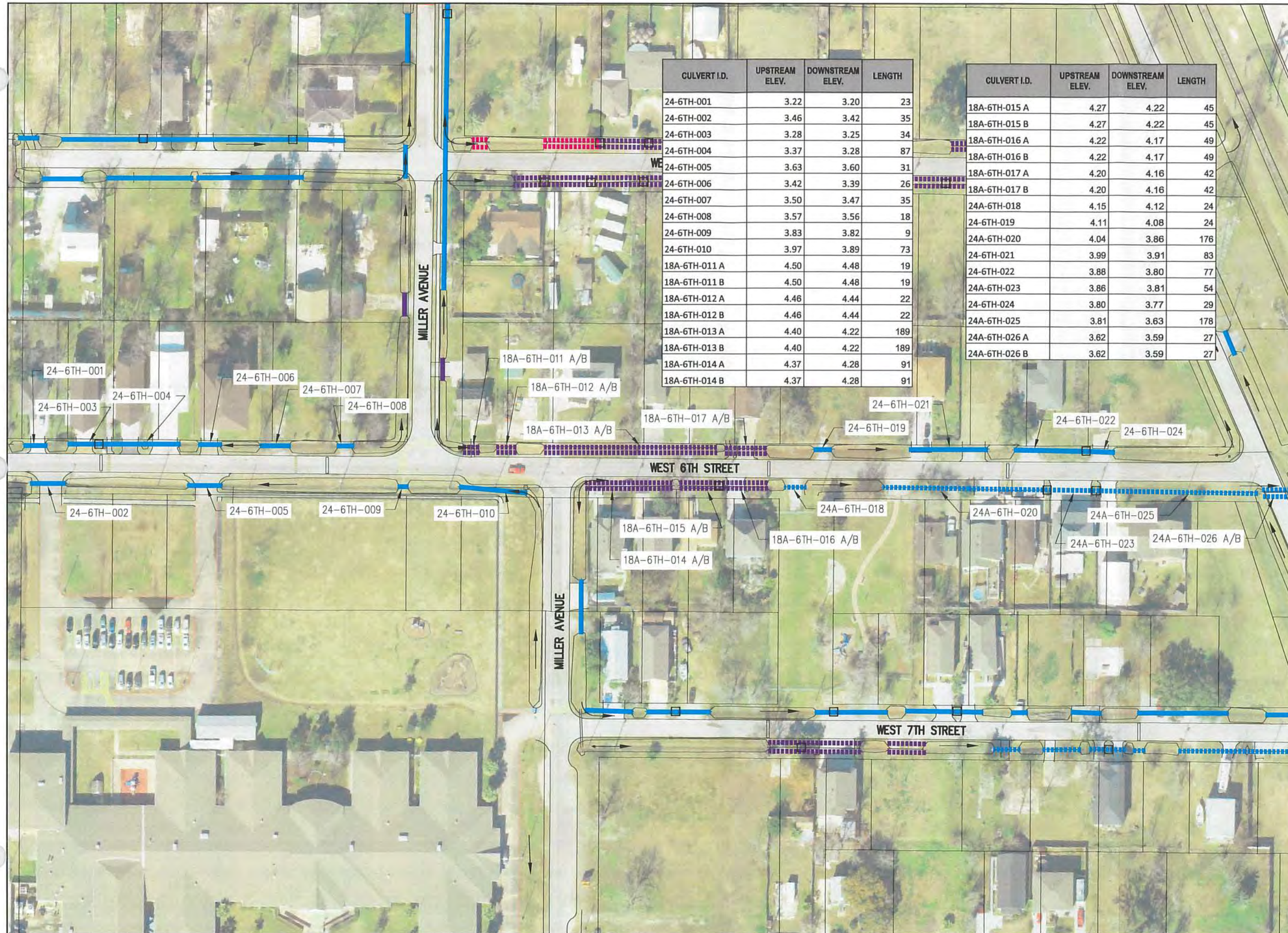
H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-05-5th street.dwg (XREF: Base)

**West Kemah 6th Street Drainage Rehabilitation**

Length Ditch 1290 Ft
Length Reinforced Concrete Pipe 1984 Ft

| Item No. | Description | Est Qty | Units | Unit Price | Total Price Per Item |
|---|---|---|---|---|---|
| 1 | Cut for Storm Pipe Finish and Grade | 354 | CY | $10 | $3,540 |
| 2 | Embankment for Storm Pipe Finished Grade | 315 | CY | $7 | $2,205 |
| 3 | Cement Stabilized Sand | 1606 | CY | $35 | $56,210 |
| 4 | 6-Inch Reinforced Concrete Driveways | 211 | SY | $100 | $21,100 |
| 5 | 2-Inch Asphalt Surface & 8-Inch Asphalt Base | 130 | SY | $75 | $9,750 |
| 6 | 7-Inch Reinforced Concrete | 41 | SY | $120 | $4,920 |
| 7 | Drain Inlet | 5 | EA | $2,500 | $12,500 |
| 8 | 18 Inch Reinforced Concrete Arch Pipe | 914 | LF | $68 | $61,695 |
| 9 | 24 Inch Reinforced Concrete Arch Pipe | 486 | LF | $101 | $49,208 |
| 10 | 24 Inch Reinforced Concrete Pipe | 584 | LF | $75 | $43,800 |
| 11 | Traffic Control During Construction | 3 | Months | $4,000 | $12,000 |
| 12 | Permanent Traffic Markings | 1 | LS | $3,000 | $3,000 |
| 13 | Traffic Sign Relocation and Replacement | 10 | EA | $100 | $1,000 |
| 14 | Hydromulch Turf Establishment | 0.5 | ACRES | $3,250 | $1,625 |
| 15 | SWPPP | 1 | LS | $5,000 | $5,000 |
| 16 | Mailbox Remove & Relocate | 11 | EA | $300 | $3,300 |
| 17 | 223 W 6th Street Residential Landscaping Replacement/Repair | 1 | LS | $700 | $700 |
| 18 | 219 W 6th Street Residential Landscaping Replacement/Repair | 1 | LS | $1,200 | $1,200 |
| 19 | 125 W 6th Street Residential Landscaping Replacement/Repair | 1 | LS | $700 | $700 |
| 20 | 40 W 6th Street Residential Landscaping Replacement/Repair | 1 | LS | $2,000 | $2,000 |
| **Sub Total** | | | | | **$295,453** |
| **Contingency (20%)** | | | | | **$59,091** |
| **Total** | | | | | **$354,543** |

*This cost estimate uses best available information from pipeline representatives. It does not gurantee that future unforeseen depths that are not known at this time will not affect the future flowlines or cost of the work to be performed.
**This is a probable cost for construction along 6th Street alone and does not include engineering.




| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-6TH-001 | 3.22 | 3.20 | 23 |
| 24-6TH-002 | 3.46 | 3.42 | 35 |
| 24-6TH-003 | 3.28 | 3.25 | 34 |
| 24-6TH-004 | 3.37 | 3.28 | 87 |
| 24-6TH-005 | 3.63 | 3.60 | 31 |
| 24-6TH-006 | 3.42 | 3.39 | 26 |
| 24-6TH-007 | 3.50 | 3.47 | 35 |
| 24-6TH-008 | 3.57 | 3.56 | 18 |
| 24-6TH-009 | 3.83 | 3.82 | 9 |
| 24-6TH-010 | 3.97 | 3.89 | 73 |
| 18A-6TH-011 A | 4.50 | 4.48 | 19 |
| 18A-6TH-011 B | 4.50 | 4.48 | 19 |
| 18A-6TH-012 A | 4.46 | 4.44 | 22 |
| 18A-6TH-012 B | 4.46 | 4.44 | 22 |
| 18A-6TH-013 A | 4.40 | 4.22 | 189 |
| 18A-6TH-013 B | 4.40 | 4.22 | 189 |
| 18A-6TH-014 A | 4.37 | 4.28 | 91 |
| 18A-6TH-014 B | 4.37 | 4.28 | 91 |

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 18A-6TH-015 A | 4.27 | 4.22 | 45 |
| 18A-6TH-015 B | 4.27 | 4.22 | 45 |
| 18A-6TH-016 A | 4.22 | 4.17 | 49 |
| 18A-6TH-016 B | 4.22 | 4.17 | 49 |
| 18A-6TH-017 A | 4.20 | 4.16 | 42 |
| 18A-6TH-017 B | 4.20 | 4.16 | 42 |
| 24A-6TH-018 | 4.15 | 4.12 | 24 |
| 24-6TH-019 | 4.11 | 4.08 | 24 |
| 24A-6TH-020 | 4.04 | 3.86 | 176 |
| 24-6TH-021 | 3.99 | 3.91 | 83 |
| 24-6TH-022 | 3.88 | 3.80 | 77 |
| 24A-6TH-023 | 3.86 | 3.81 | 54 |
| 24-6TH-024 | 3.80 | 3.77 | 29 |
| 24A-6TH-025 | 3.81 | 3.63 | 178 |
| 24A-6TH-026 A | 3.62 | 3.59 | 27 |
| 24A-6TH-026 B | 3.62 | 3.59 | 27 |

50 0 50 100
SCALE IN FEET

LEGEND
- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT

INLET
FLOW

# CITY OF KEMAH

## WEST 6TH STREET

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: AS SHOWN | JOB No. E135-0280 | EXHIBIT No. 06

09/28/16

H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-06-6th street.dwg (XREF: Base)

**West Kemah 7th Street Drainage Rehabilitation**

| | |
|---|---|
| Length Ditch | 1070 Ft |
| Length Reinforced Concrete Pipe | 995 Ft |

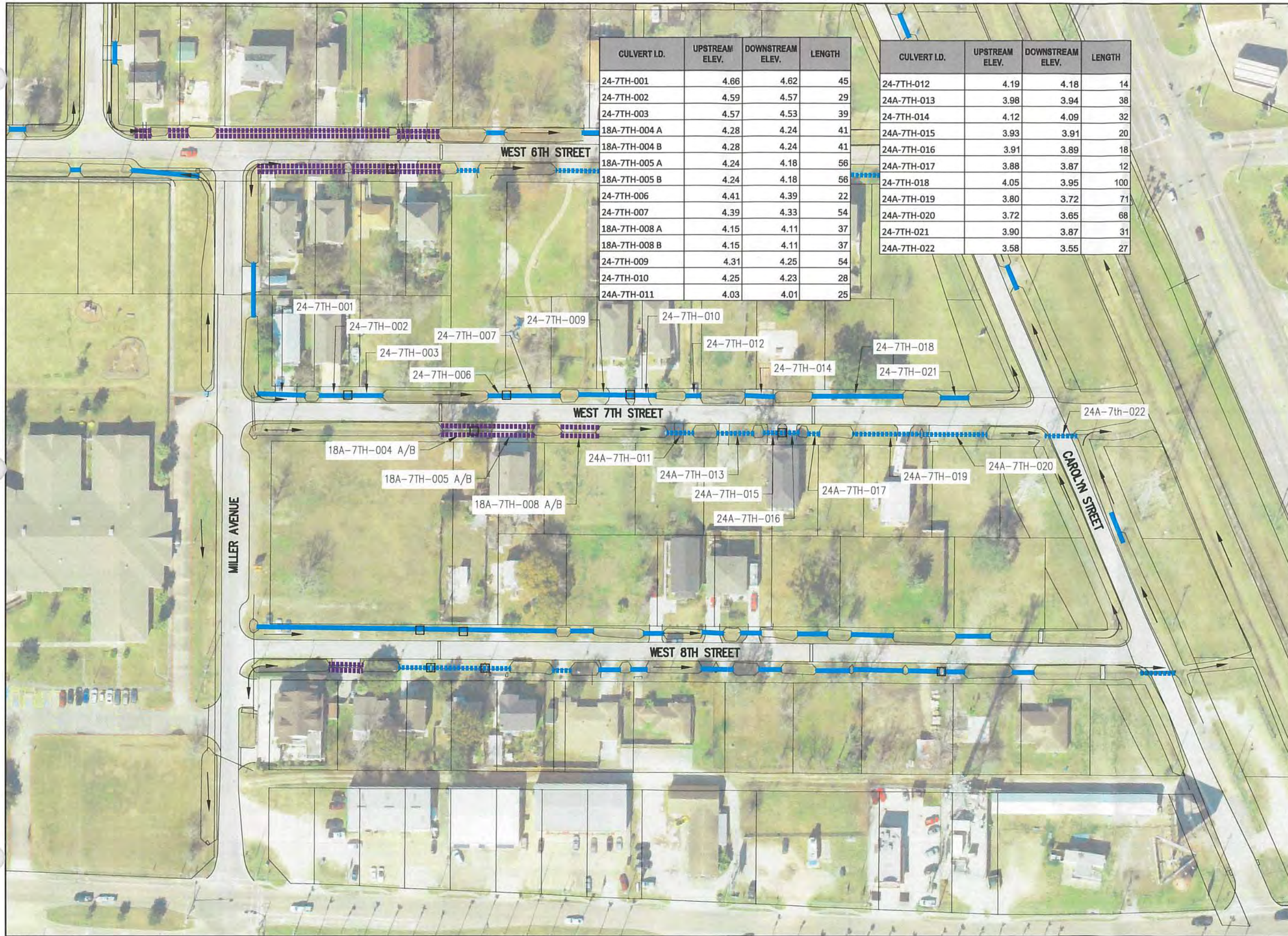
| Item No. | Description | Est Qty | Units | Unit Price | Total Price Per Item |
|---|---|---|---|---|---|
| 1 | Excavate Existing Concrete for Depth of Flowline | 180 | SY | $17 | $3,060 |
| 2 | Cut for Storm Pipe Finish and Grade | 248 | CY | $10 | $2,480 |
| 3 | Embankment for Storm Pipe Finished Grade | 21 | CY | $7 | $147 |
| 4 | 8-inch Subgrade Manipulation | 180 | SY | $6 | $1,080 |
| 5 | Lime for Stabilized Sub-grade 6% by Dryweight (27 lb/sy) | 3 | TON | $165 | $495 |
| 6 | Cement Stabilized Sand | 806 | CY | $35 | $28,210 |
| 7 | 6-Inch Reinforced Concrete Driveways | 149 | SY | $100 | $14,875 |
| 8 | 2-Inch Asphalt Surface & 8-Inch Asphalt Base | 161 | SY | $75 | $12,078 |
| 9 | Drain Inlet | 5 | EA | $2,500 | $12,500 |
| 10 | 18 Inch Reinforced Concrete Arch Pipe | 268 | LF | $68 | $18,224 |
| 11 | 24 Inch Reinforced Concrete Arch Pipe | 279 | LF | $101 | $28,179 |
| 12 | 24 Inch Reinforced Concrete Pipe | 448 | LF | $75 | $33,600 |
| 13 | Traffic Control During Construction | 3 | Months | $4,000 | $12,000 |
| 14 | Permanent Traffic Markings | 1 | LS | $3,000 | $3,000 |
| 15 | Traffic Sign Relocation and Replacement | 2 | EA | $100 | $200 |
| 16 | Hydromulch Turf Establishment | 0.5 | ACRES | $3,250 | $1,625 |
| 17 | SWPPP | 1 | LS | $5,000 | $5,000 |
| 18 | Mailbox Remove & Relocate | 2 | EA | $300 | $600 |
| 19 | 100 West 7th Street Residential Landscaping Replacement/Repair | 1 | LS | $1,000 | $1,000 |
| 20 | Handicap Signs, Concrete wheel stops, and paint | 1 | LS | $2,500 | $2,500 |
| **Sub Total** | | | | | **$180,853** |
| **Contingency (20%)** | | | | | **$36,171** |
| **Total** | | | | | **$217,024** |

*This cost estimate uses best available information from pipeline representatives. It does not gurantee that future unforeseen depths that are not known at this time will not affect the future flowlines or cost of the work to be performed.

**This is a probable cost for construction along 7th Street alone and does not include engineering.

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-7TH-001 | 4.66 | 4.62 | 45 |
| 24-7TH-002 | 4.59 | 4.57 | 29 |
| 24-7TH-003 | 4.57 | 4.53 | 39 |
| 18A-7TH-004 A | 4.28 | 4.24 | 41 |
| 18A-7TH-004 B | 4.28 | 4.24 | 41 |
| 18A-7TH-005 A | 4.24 | 4.18 | 56 |
| 18A-7TH-005 B | 4.24 | 4.18 | 56 |
| 24-7TH-006 | 4.41 | 4.39 | 22 |
| 24-7TH-007 | 4.39 | 4.33 | 54 |
| 18A-7TH-008 A | 4.15 | 4.11 | 37 |
| 18A-7TH-008 B | 4.15 | 4.11 | 37 |
| 24-7TH-009 | 4.31 | 4.25 | 54 |
| 24-7TH-010 | 4.25 | 4.23 | 28 |
| 24A-7TH-011 | 4.03 | 4.01 | 25 |

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-7TH-012 | 4.19 | 4.18 | 14 |
| 24A-7TH-013 | 3.98 | 3.94 | 38 |
| 24-7TH-014 | 4.12 | 4.09 | 32 |
| 24A-7TH-015 | 3.93 | 3.91 | 20 |
| 24A-7TH-016 | 3.91 | 3.89 | 18 |
| 24A-7TH-017 | 3.88 | 3.87 | 12 |
| 24-7TH-018 | 4.05 | 3.95 | 100 |
| 24A-7TH-019 | 3.80 | 3.72 | 71 |
| 24A-7TH-020 | 3.72 | 3.65 | 68 |
| 24-7TH-021 | 3.90 | 3.87 | 31 |
| 24A-7TH-022 | 3.58 | 3.55 | 27 |




50 0 50 100
SCALE IN FEET

LEGEND

- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT
- INLET
- FLOW

# CITY OF KEMAH

## WEST 7TH STREET

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: AS SHOWN | JOB No. E135-0280 | EXHIBIT No. 07

09/28/16

H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-07-7th street.dwg (XREF: Base)

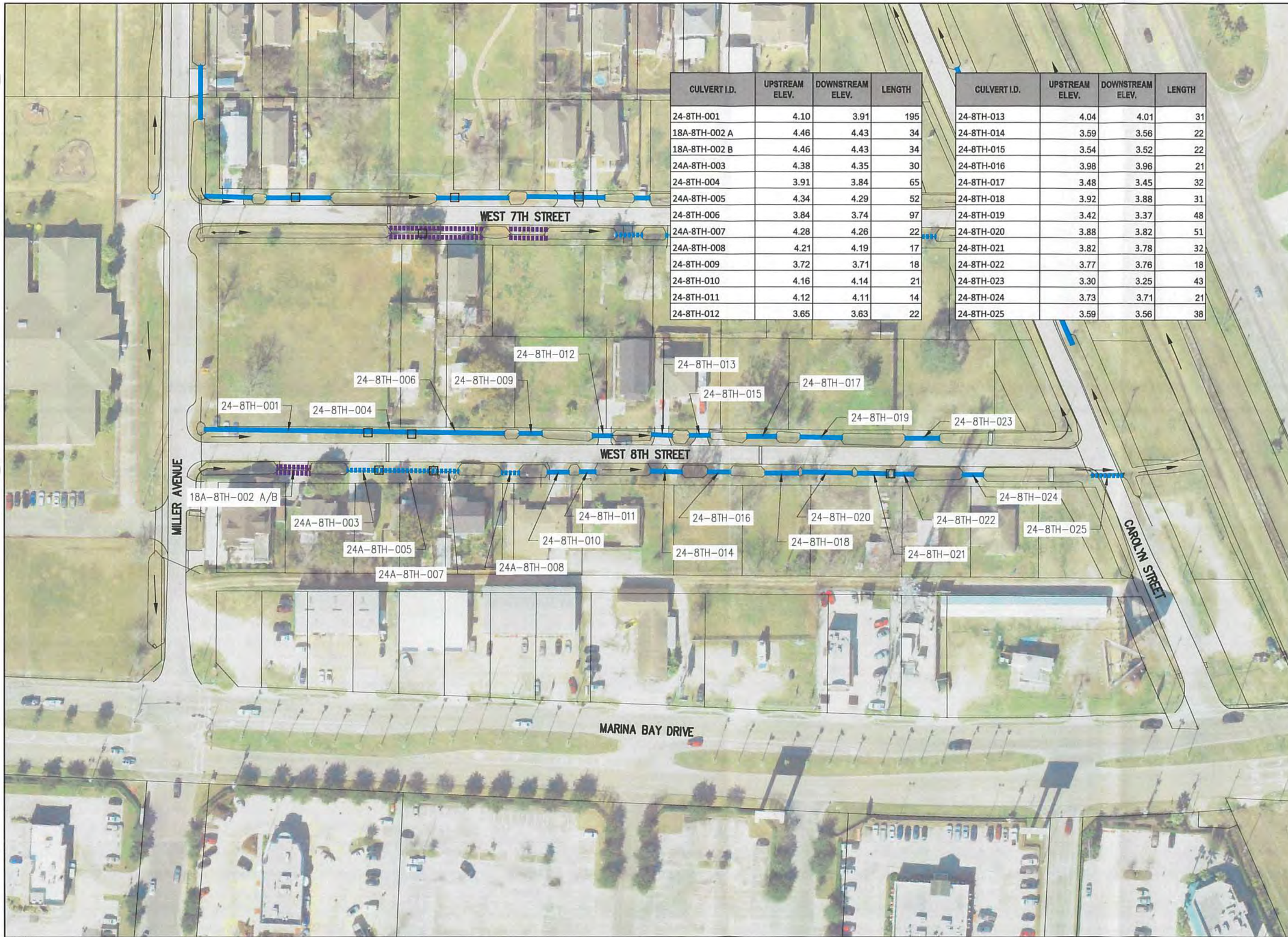
**West Kemah 8th Street Drainage Rehabilitation**

| | |
|---|---|
| Length Ditch | 1250 Ft |
| Length Reinforced Concrete Pipe | 1031 Ft |

| Item No. | Description | Est Qty | Units | Unit Price | Total Price Per Item |
|---|---|---|---|---|---|
| 1 | Cut for Storm Pipe Finish and Grade | 410 | CY | $10 | $4,100 |
| 2 | Embankment for Storm Pipe Finished Grade | 41 | CY | $7 | $287 |
| 3 | Cement Stabilized Sand | 847 | CY | $35 | $29,645 |
| 4 | 6-Inch Reinforced Concrete Driveways | 57 | SY | $100 | $5,700 |
| 5 | 2-Inch Asphalt Surface & 8-Inch Asphalt Base | 153 | SY | $75 | $11,475 |
| 6 | Drain Inlet | 5 | EA | $2,500 | $12,500 |
| 7 | 18 Inch Reinforced Concrete Arch Pipe | 68 | LF | 68 | $4,624 |
| 8 | 24 Inch Reinforced Concrete Arch Pipe | 121 | LF | $101.25 | $12,251 |
| 9 | 24 Inch Reinforced Concrete Pipe | 842 | LF | $75 | $63,150 |
| 10 | Traffic Control During Construction | 3 | Months | $4,000 | $12,000 |
| 11 | Permanent Traffic Markings | 1 | LS | $3,000 | $3,000 |
| 12 | Traffic Sign Relocation and Replacement | 1 | EA | $100 | $100 |
| 13 | Hydromulch Turf Establishment | 0.5 | ACRES | $3,250 | $1,625 |
| 14 | SWPPP | 1 | LS | $5,000 | $5,000 |
| 15 | Mailbox Remove & Relocate | 8 | EA | $300 | $2,400 |
| 16 | Remove & Relocate Pedestrian Bridge | 2 | LS | $300 | $600 |
| **Sub Total** | | | | | **$168,457** |
| **Contingency (20%)** | | | | | **$33,691** |
| **Total** | | | | | **$202,149** |

*This cost estimate uses best available information from pipeline representatives. It does not gurantee that future unforeseen depths that are not known at this time will not affect the future flowlines or cost of the work to be performed.

**This is a probable cost for construction along 8th Street alone and does not include engineering.




| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-8TH-001 | 4.10 | 3.91 | 195 |
| 18A-8TH-002 A | 4.46 | 4.43 | 34 |
| 18A-8TH-002 B | 4.46 | 4.43 | 34 |
| 24A-8TH-003 | 4.38 | 4.35 | 30 |
| 24-8TH-004 | 3.91 | 3.84 | 65 |
| 24A-8TH-005 | 4.34 | 4.29 | 52 |
| 24-8TH-006 | 3.84 | 3.74 | 97 |
| 24A-8TH-007 | 4.28 | 4.26 | 22 |
| 24A-8TH-008 | 4.21 | 4.19 | 17 |
| 24-8TH-009 | 3.72 | 3.71 | 18 |
| 24-8TH-010 | 4.16 | 4.14 | 21 |
| 24-8TH-011 | 4.12 | 4.11 | 14 |
| 24-8TH-012 | 3.65 | 3.63 | 22 |

| CULVERT I.D. | UPSTREAM ELEV. | DOWNSTREAM ELEV. | LENGTH |
|---|---|---|---|
| 24-8TH-013 | 4.04 | 4.01 | 31 |
| 24-8TH-014 | 3.59 | 3.56 | 22 |
| 24-8TH-015 | 3.54 | 3.52 | 22 |
| 24-8TH-016 | 3.98 | 3.96 | 21 |
| 24-8TH-017 | 3.48 | 3.45 | 32 |
| 24-8TH-018 | 3.92 | 3.88 | 31 |
| 24-8TH-019 | 3.42 | 3.37 | 48 |
| 24-8TH-020 | 3.88 | 3.82 | 51 |
| 24-8TH-021 | 3.82 | 3.78 | 32 |
| 24-8TH-022 | 3.77 | 3.76 | 18 |
| 24-8TH-023 | 3.30 | 3.25 | 43 |
| 24-8TH-024 | 3.73 | 3.71 | 21 |
| 24-8TH-025 | 3.59 | 3.56 | 38 |

50 0 50 100
SCALE IN FEET

LEGEND

- 15" CULVERT
- 15" ARCH CULVERT
- 18" CULVERT
- 18" ARCH CULVERT
- 24" CULVERT
- 24" ARCH CULVERT
- 30" CULVERT
- 30" ARCH CULVERT
- 36" CULVERT
- 36" ARCH CULVERT
- 42" CULVERT
- 42" ARCH CULVERT
- INLET
- FLOW

# CITY OF KEMAH

## WEST 8TH STREET

**LJA Engineering, Inc.**
11821 East Freeway
Suite 360
Houston, Texas 77029
Phone 713.450.1300
Fax 713.450.1385
FRN - F-1386

SCALE: AS SHOWN | JOB No. E135-0280 | EXHIBIT No. 08

09/28/16

H:\ACAD\Clients\135\0280\Cost Estimate Exhibits\EX-08-8th street.dwg (XREF: Base)

# APPENDIX E
# SAMPLE QUESTIONAIRE

Kemah MDP
Flooding Questionnaire for Public Use

1. What flooding situations have you experienced?

2. To your knowledge, how frequent have these situations occurred?

3. Have you experienced issues with accessibility during times of flooding? If so, where? (i.e. road overtopping, ditch overflow, etc.)

4. Have you taken steps to reduce the impacts of flooding on your property and/or prepared for flooding? What steps have been taken in your area or neighborhood to reduce flood risk?

5. Within the limits of the City of Kemah are there any other areas that you find of concern? If so, where and why?

# APPENDIX F
# EXISTING HEC-RAS OUTPUT AND PROFILES

HEC-RAS Plan: Existing (no ineff) River: Jarbo_Ditch Reach: JB

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| JB | 6034 | 2-year | 61.00 | 13.51 | 15.92 | | 15.93 | 0.000847 | 1.45 | 119.76 | 536.34 | 0.22 |
| JB | 6034 | 5-year | 82.00 | 13.51 | 16.02 | | 16.03 | 0.000696 | 1.22 | 185.54 | 715.02 | 0.20 |
| JB | 6034 | 10-year | 98.00 | 13.51 | 16.09 | | 16.10 | 0.000609 | 1.06 | 240.63 | 849.46 | 0.18 |
| JB | 6034 | 25-year | 121.00 | 13.51 | 16.17 | | 16.17 | 0.000525 | 1.00 | 306.92 | 954.90 | 0.17 |
| JB | 6034 | 50-year | 138.00 | 13.51 | 16.22 | | 16.22 | 0.000485 | 0.98 | 355.52 | 1014.80 | 0.16 |
| JB | 6034 | 100-year | 157.00 | 13.51 | 16.27 | | 16.27 | 0.000437 | 0.94 | 408.37 | 1083.81 | 0.15 |
| | | | | | | | | | | | | |
| JB | 5447 | 2-year | 157.00 | 12.55 | 15.07 | | 15.10 | 0.001836 | 2.21 | 150.09 | 276.79 | 0.33 |
| JB | 5447 | 5-year | 214.00 | 12.55 | 15.20 | | 15.23 | 0.001901 | 2.30 | 190.76 | 319.52 | 0.33 |
| JB | 5447 | 10-year | 259.00 | 12.55 | 15.30 | | 15.33 | 0.001929 | 2.33 | 225.20 | 373.26 | 0.34 |
| JB | 5447 | 25-year | 321.00 | 12.55 | 15.41 | | 15.44 | 0.001959 | 2.36 | 270.69 | 457.94 | 0.34 |
| JB | 5447 | 50-year | 370.00 | 12.55 | 15.49 | | 15.52 | 0.001925 | 2.36 | 309.81 | 534.05 | 0.34 |
| JB | 5447 | 100-year | 423.00 | 12.55 | 15.56 | | 15.59 | 0.001926 | 2.35 | 350.94 | 596.41 | 0.34 |
| | | | | | | | | | | | | |
| JB | 5144 | 2-year | 157.00 | 12.26 | 14.75 | | 14.76 | 0.000726 | 1.41 | 251.27 | 469.78 | 0.21 |
| JB | 5144 | 5-year | 214.00 | 12.26 | 14.87 | | 14.88 | 0.000767 | 1.49 | 310.05 | 493.50 | 0.21 |
| JB | 5144 | 10-year | 259.00 | 12.26 | 14.94 | | 14.96 | 0.000843 | 1.59 | 347.04 | 505.74 | 0.22 |
| JB | 5144 | 25-year | 321.00 | 12.26 | 15.04 | | 15.05 | 0.000906 | 1.58 | 397.20 | 563.59 | 0.23 |
| JB | 5144 | 50-year | 370.00 | 12.26 | 15.10 | | 15.11 | 0.000971 | 1.68 | 431.48 | 580.15 | 0.24 |
| JB | 5144 | 100-year | 423.00 | 12.26 | 15.16 | | 15.17 | 0.001026 | 1.77 | 465.63 | 594.58 | 0.25 |
| | | | | | | | | | | | | |
| JB | 5132 | 2-year | 157.00 | 12.21 | 14.74 | | 14.75 | 0.000867 | 1.43 | 249.72 | 529.91 | 0.22 |
| JB | 5132 | 5-year | 214.00 | 12.21 | 14.86 | | 14.87 | 0.000896 | 1.46 | 317.04 | 573.37 | 0.23 |
| JB | 5132 | 10-year | 259.00 | 12.21 | 14.94 | | 14.95 | 0.000941 | 1.51 | 359.82 | 585.03 | 0.23 |
| JB | 5132 | 25-year | 321.00 | 12.21 | 15.03 | | 15.04 | 0.000944 | 1.53 | 416.04 | 621.72 | 0.23 |
| JB | 5132 | 50-year | 370.00 | 12.21 | 15.09 | | 15.10 | 0.000976 | 1.59 | 454.17 | 651.44 | 0.24 |
| JB | 5132 | 100-year | 423.00 | 12.21 | 15.15 | | 15.16 | 0.001012 | 1.65 | 492.28 | 663.72 | 0.24 |
| | | | | | | | | | | | | |
| JB | 5099 | 2-year | 157.00 | 12.14 | 14.69 | | 14.71 | 0.001312 | 1.90 | 194.78 | 445.37 | 0.28 |
| JB | 5099 | 5-year | 214.00 | 12.14 | 14.82 | | 14.84 | 0.001327 | 1.95 | 255.68 | 543.26 | 0.28 |
| JB | 5099 | 10-year | 259.00 | 12.14 | 14.89 | | 14.91 | 0.001389 | 1.97 | 297.62 | 605.56 | 0.29 |
| JB | 5099 | 25-year | 321.00 | 12.14 | 14.98 | | 15.00 | 0.001441 | 1.93 | 357.44 | 643.91 | 0.29 |
| JB | 5099 | 50-year | 370.00 | 12.14 | 15.04 | | 15.06 | 0.001494 | 1.85 | 397.10 | 673.15 | 0.29 |
| JB | 5099 | 100-year | 423.00 | 12.14 | 15.10 | | 15.12 | 0.001528 | 1.83 | 436.32 | 692.22 | 0.29 |
| | | | | | | | | | | | | |
| JB | 5079 | 2-year | 157.00 | 12.00 | 14.68 | | 14.69 | 0.000812 | 1.54 | 233.19 | 484.97 | 0.22 |
| JB | 5079 | 5-year | 214.00 | 12.00 | 14.80 | | 14.81 | 0.000890 | 1.62 | 299.52 | 610.56 | 0.23 |
| JB | 5079 | 10-year | 259.00 | 12.00 | 14.87 | | 14.88 | 0.000954 | 1.68 | 345.13 | 679.74 | 0.24 |
| JB | 5079 | 25-year | 321.00 | 12.00 | 14.96 | | 14.98 | 0.000976 | 1.66 | 414.63 | 802.58 | 0.24 |
| JB | 5079 | 50-year | 370.00 | 12.00 | 15.02 | | 15.04 | 0.001019 | 1.65 | 463.87 | 874.24 | 0.25 |
| JB | 5079 | 100-year | 423.00 | 12.00 | 15.08 | | 15.09 | 0.001054 | 1.64 | 514.81 | 917.10 | 0.25 |
| | | | | | | | | | | | | |
| JB | 4963 | 2-year | 222.00 | 11.06 | 14.53 | | 14.56 | 0.001537 | 1.74 | 250.62 | 654.44 | 0.29 |
| JB | 4963 | 5-year | 302.00 | 11.06 | 14.65 | | 14.67 | 0.001497 | 1.83 | 336.23 | 811.87 | 0.29 |
| JB | 4963 | 10-year | 365.00 | 11.06 | 14.70 | | 14.73 | 0.001636 | 1.97 | 384.78 | 870.05 | 0.31 |
| JB | 4963 | 25-year | 452.00 | 11.06 | 14.79 | | 14.82 | 0.001724 | 2.10 | 462.79 | 937.24 | 0.32 |
| JB | 4963 | 50-year | 520.00 | 11.06 | 14.85 | | 14.88 | 0.001722 | 2.14 | 515.61 | 959.28 | 0.32 |
| JB | 4963 | 100-year | 594.00 | 11.06 | 14.90 | | 14.93 | 0.001758 | 2.21 | 566.01 | 987.69 | 0.33 |
| | | | | | | | | | | | | |
| JB | 4870 | 2-year | 222.00 | 10.60 | 14.12 | 14.12 | 14.29 | 0.005917 | 4.02 | 105.23 | 318.72 | 0.59 |
| JB | 4870 | 5-year | 302.00 | 10.60 | 14.22 | 14.22 | 14.39 | 0.007561 | 4.19 | 146.52 | 451.71 | 0.65 |
| JB | 4870 | 10-year | 365.00 | 10.60 | 14.31 | 14.28 | 14.44 | 0.006975 | 3.94 | 193.15 | 543.71 | 0.63 |
| JB | 4870 | 25-year | 452.00 | 10.60 | 14.39 | 14.34 | 14.52 | 0.007881 | 4.19 | 237.84 | 704.82 | 0.67 |
| JB | 4870 | 50-year | 520.00 | 10.60 | 14.44 | | 14.57 | 0.008017 | 4.26 | 278.39 | 753.96 | 0.67 |
| JB | 4870 | 100-year | 594.00 | 10.60 | 14.48 | | 14.61 | 0.008373 | 4.39 | 308.18 | 768.93 | 0.69 |
| | | | | | | | | | | | | |
| JB | 4823 | 2-year | 222.00 | 9.72 | 12.66 | 12.66 | 13.32 | 0.014823 | 6.66 | 36.79 | 31.80 | 0.95 |
| JB | 4823 | 5-year | 302.00 | 9.72 | 13.04 | 13.04 | 13.71 | 0.013686 | 6.83 | 50.93 | 41.01 | 0.93 |
| JB | 4823 | 10-year | 365.00 | 9.72 | 13.31 | 13.31 | 13.96 | 0.012652 | 6.81 | 63.06 | 55.18 | 0.90 |
| JB | 4823 | 25-year | 452.00 | 9.72 | 13.83 | 13.83 | 14.15 | 0.007124 | 5.29 | 141.15 | 288.66 | 0.68 |
| JB | 4823 | 50-year | 520.00 | 9.72 | 13.99 | 13.99 | 14.24 | 0.006099 | 4.87 | 198.24 | 423.97 | 0.63 |
| JB | 4823 | 100-year | 594.00 | 9.72 | 14.21 | | 14.34 | 0.004143 | 3.91 | 316.33 | 614.66 | 0.52 |
| | | | | | | | | | | | | |
| JB | 4743 | 2-year | 222.00 | 7.79 | 12.08 | | 12.19 | 0.001291 | 2.63 | 84.27 | 35.87 | 0.30 |
| JB | 4743 | 5-year | 302.00 | 7.79 | 12.99 | | 13.09 | 0.000915 | 2.53 | 119.56 | 41.79 | 0.26 |
| JB | 4743 | 10-year | 365.00 | 7.79 | 13.29 | | 13.41 | 0.001032 | 2.75 | 133.19 | 53.69 | 0.28 |
| JB | 4743 | 25-year | 452.00 | 7.79 | 13.62 | | 13.76 | 0.001211 | 2.99 | 175.12 | 207.12 | 0.31 |
| JB | 4743 | 50-year | 520.00 | 7.79 | 13.86 | | 13.98 | 0.001218 | 2.99 | 245.69 | 399.52 | 0.31 |
| JB | 4743 | 100-year | 594.00 | 7.79 | 14.07 | | 14.18 | 0.001152 | 2.90 | 354.28 | 633.81 | 0.30 |
| | | | | | | | | | | | | |
| JB | 4539 | 2-year | 222.00 | 7.44 | 11.93 | | 11.99 | 0.000634 | 1.99 | 111.77 | 42.88 | 0.22 |
| JB | 4539 | 5-year | 302.00 | 7.44 | 12.87 | | 12.93 | 0.000578 | 1.93 | 156.72 | 62.81 | 0.21 |
| JB | 4539 | 10-year | 365.00 | 7.44 | 13.17 | | 13.23 | 0.000631 | 2.09 | 178.24 | 89.11 | 0.22 |
| JB | 4539 | 25-year | 452.00 | 7.44 | 13.48 | | 13.56 | 0.000699 | 2.28 | 221.77 | 215.73 | 0.23 |
| JB | 4539 | 50-year | 520.00 | 7.44 | 13.70 | | 13.78 | 0.000726 | 2.36 | 282.91 | 356.60 | 0.24 |
| JB | 4539 | 100-year | 594.00 | 7.44 | 13.91 | | 13.98 | 0.000730 | 2.38 | 368.60 | 467.28 | 0.24 |

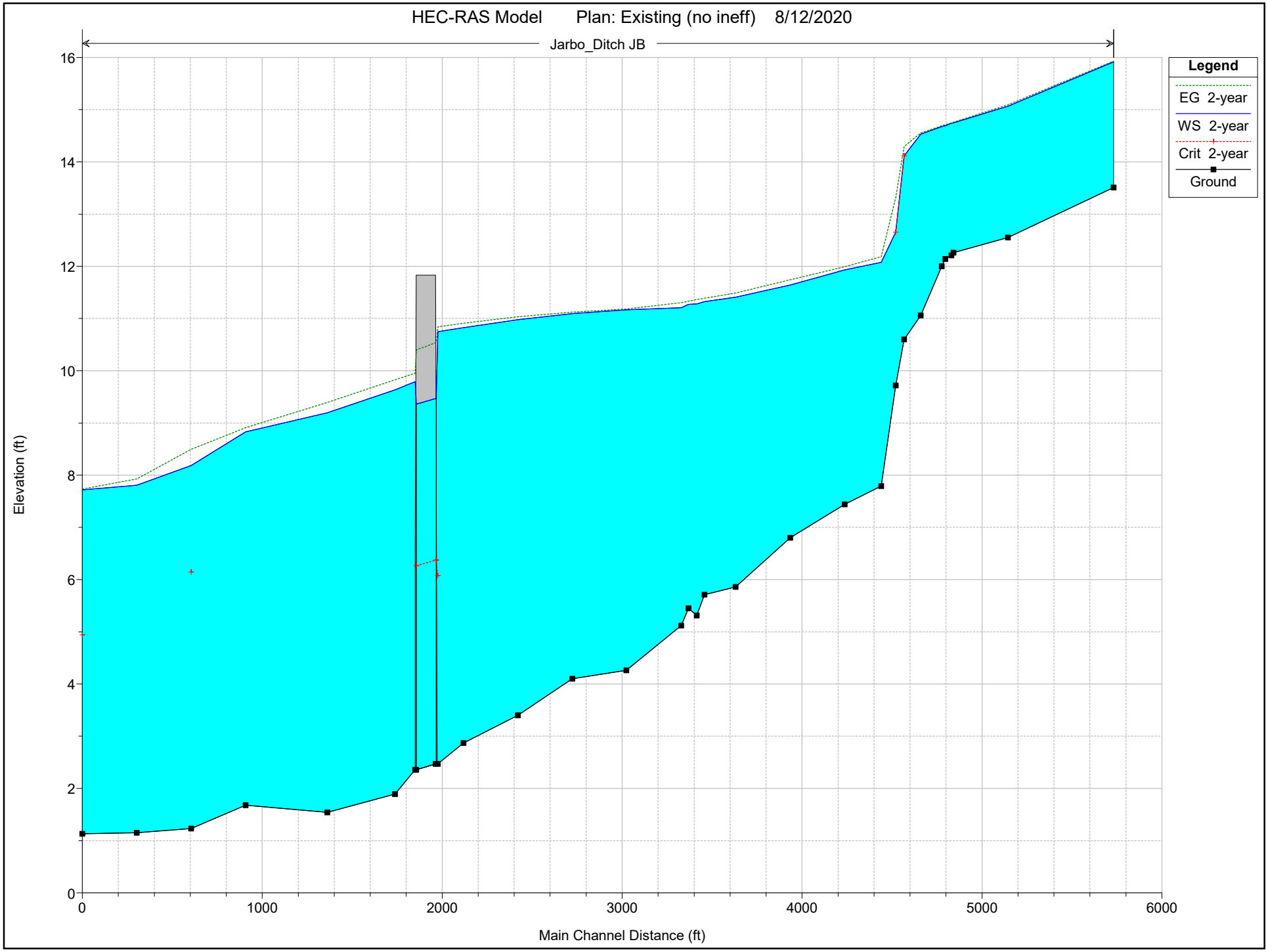
HEC-RAS Plan: Existing (no ineff) River: Jarbo_Ditch Reach: JB (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| | | | | | | | | | | | | |
| JB | 4237 | 2-year | 312.00 | 6.80 | 11.64 | | 11.74 | 0.001014 | 2.50 | 124.58 | 48.24 | 0.27 |
| JB | 4237 | 5-year | 428.00 | 6.80 | 12.63 | | 12.72 | 0.000789 | 2.33 | 190.96 | 91.92 | 0.25 |
| JB | 4237 | 10-year | 519.00 | 6.80 | 12.90 | | 13.00 | 0.000881 | 2.54 | 220.48 | 127.18 | 0.26 |
| JB | 4237 | 25-year | 647.00 | 6.80 | 13.17 | | 13.29 | 0.001029 | 2.83 | 279.75 | 335.28 | 0.29 |
| JB | 4237 | 50-year | 747.00 | 6.80 | 13.38 | | 13.50 | 0.001072 | 2.90 | 361.23 | 414.25 | 0.29 |
| JB | 4237 | 100-year | 858.00 | 6.80 | 13.58 | | 13.69 | 0.001196 | 2.88 | 449.48 | 496.66 | 0.30 |
| | | | | | | | | | | | | |
| JB | 3934 | 2-year | 312.00 | 5.86 | 11.41 | | 11.49 | 0.000668 | 2.29 | 136.19 | 43.50 | 0.23 |
| JB | 3934 | 5-year | 428.00 | 5.86 | 12.42 | | 12.50 | 0.000671 | 2.27 | 190.61 | 86.92 | 0.23 |
| JB | 3934 | 10-year | 519.00 | 5.86 | 12.65 | | 12.75 | 0.000789 | 2.54 | 214.97 | 126.90 | 0.25 |
| JB | 3934 | 25-year | 647.00 | 5.86 | 12.85 | | 12.98 | 0.001018 | 2.94 | 249.95 | 234.04 | 0.29 |
| JB | 3934 | 50-year | 747.00 | 5.86 | 13.01 | | 13.16 | 0.001161 | 3.16 | 297.45 | 367.63 | 0.31 |
| JB | 3934 | 100-year | 858.00 | 5.86 | 13.13 | | 13.30 | 0.001362 | 3.40 | 348.57 | 508.28 | 0.33 |
| | | | | | | | | | | | | |
| JB | 3761 | 2-year | 312.00 | 5.71 | 11.33 | | 11.39 | 0.000461 | 2.02 | 154.35 | 44.87 | 0.19 |
| JB | 3761 | 5-year | 428.00 | 5.71 | 12.33 | | 12.40 | 0.000456 | 2.01 | 224.21 | 114.32 | 0.19 |
| JB | 3761 | 10-year | 519.00 | 5.71 | 12.55 | | 12.63 | 0.000538 | 2.26 | 256.90 | 211.91 | 0.21 |
| JB | 3761 | 25-year | 647.00 | 5.71 | 12.73 | | 12.83 | 0.000693 | 2.64 | 316.96 | 540.46 | 0.24 |
| JB | 3761 | 50-year | 747.00 | 5.71 | 12.88 | | 12.99 | 0.000744 | 2.80 | 421.16 | 769.74 | 0.25 |
| JB | 3761 | 100-year | 858.00 | 5.71 | 12.98 | | 13.11 | 0.000823 | 3.00 | 507.45 | 948.94 | 0.26 |
| | | | | | | | | | | | | |
| JB | 3710 | 2-year | 312.00 | 5.31 | 11.28 | | 11.36 | 0.000634 | 2.35 | 133.00 | 38.69 | 0.22 |
| JB | 3710 | 5-year | 428.00 | 5.31 | 12.29 | | 12.37 | 0.000722 | 2.28 | 205.86 | 169.86 | 0.23 |
| JB | 3710 | 10-year | 519.00 | 5.31 | 12.51 | | 12.60 | 0.000791 | 2.50 | 260.72 | 373.40 | 0.25 |
| JB | 3710 | 25-year | 647.00 | 5.31 | 12.68 | | 12.79 | 0.000938 | 2.82 | 346.78 | 640.80 | 0.27 |
| JB | 3710 | 50-year | 747.00 | 5.31 | 12.85 | | 12.96 | 0.000918 | 2.89 | 486.55 | 1012.93 | 0.27 |
| JB | 3710 | 100-year | 858.00 | 5.31 | 12.95 | | 13.06 | 0.000955 | 3.00 | 603.44 | 1227.38 | 0.28 |
| | | | | | | | | | | | | |
| JB | 3690 | 2-year | 312.00 | 5.45 | 11.27 | | 11.33 | 0.000480 | 1.95 | 160.05 | 51.22 | 0.19 |
| JB | 3690 | 5-year | 428.00 | 5.45 | 12.28 | | 12.34 | 0.000398 | 1.94 | 239.39 | 167.92 | 0.18 |
| JB | 3690 | 10-year | 519.00 | 5.45 | 12.50 | | 12.57 | 0.000464 | 2.18 | 290.96 | 320.45 | 0.20 |
| JB | 3690 | 25-year | 647.00 | 5.45 | 12.66 | | 12.75 | 0.000586 | 2.52 | 352.61 | 441.79 | 0.22 |
| JB | 3690 | 50-year | 747.00 | 5.45 | 12.82 | | 12.92 | 0.000634 | 2.69 | 443.41 | 707.78 | 0.23 |
| JB | 3690 | 100-year | 858.00 | 5.45 | 12.91 | | 13.02 | 0.000738 | 2.94 | 512.02 | 867.24 | 0.25 |
| | | | | | | | | | | | | |
| JB | 3631 | 2-year | 416.00 | 5.12 | 11.21 | | 11.30 | 0.000698 | 2.47 | 168.54 | 49.85 | 0.24 |
| JB | 3631 | 5-year | 568.00 | 5.12 | 12.22 | | 12.31 | 0.000764 | 2.47 | 247.02 | 192.46 | 0.25 |
| JB | 3631 | 10-year | 688.00 | 5.12 | 12.42 | | 12.54 | 0.000874 | 2.76 | 294.57 | 280.39 | 0.27 |
| JB | 3631 | 25-year | 855.00 | 5.12 | 12.56 | | 12.71 | 0.001127 | 3.22 | 338.78 | 344.38 | 0.30 |
| JB | 3631 | 50-year | 987.00 | 5.12 | 12.70 | | 12.88 | 0.001244 | 3.47 | 392.42 | 428.95 | 0.32 |
| JB | 3631 | 100-year | 1131.00 | 5.12 | 12.76 | | 12.97 | 0.001518 | 3.88 | 416.75 | 464.80 | 0.36 |
| | | | | | | | | | | | | |
| JB | 3326 | 2-year | 416.00 | 4.26 | 11.17 | | 11.18 | 0.000178 | 1.35 | 569.23 | 434.90 | 0.12 |
| JB | 3326 | 5-year | 568.00 | 4.26 | 12.22 | | 12.23 | 0.000077 | 0.97 | 1128.66 | 718.61 | 0.08 |
| JB | 3326 | 10-year | 688.00 | 4.26 | 12.43 | | 12.44 | 0.000092 | 1.08 | 1296.09 | 901.41 | 0.09 |
| JB | 3326 | 25-year | 855.00 | 4.26 | 12.57 | | 12.59 | 0.000122 | 1.25 | 1438.47 | 1068.18 | 0.10 |
| JB | 3326 | 50-year | 987.00 | 4.26 | 12.71 | | 12.72 | 0.000155 | 1.41 | 1592.25 | 1200.59 | 0.12 |
| JB | 3326 | 100-year | 1131.00 | 4.26 | 12.76 | | 12.78 | 0.000195 | 1.57 | 1658.72 | 1243.08 | 0.13 |
| | | | | | | | | | | | | |
| JB | 3026 | 2-year | 499.00 | 4.10 | 11.10 | | 11.12 | 0.000233 | 1.59 | 604.26 | 468.01 | 0.14 |
| JB | 3026 | 5-year | 685.00 | 4.10 | 12.20 | | 12.21 | 0.000099 | 1.09 | 1555.56 | 1471.24 | 0.09 |
| JB | 3026 | 10-year | 831.00 | 4.10 | 12.40 | | 12.41 | 0.000107 | 1.12 | 1882.54 | 1689.34 | 0.10 |
| JB | 3026 | 25-year | 1035.00 | 4.10 | 12.54 | | 12.55 | 0.000127 | 1.21 | 2121.11 | 1765.71 | 0.10 |
| JB | 3026 | 50-year | 1197.00 | 4.10 | 12.67 | | 12.68 | 0.000131 | 1.25 | 2363.41 | 1907.26 | 0.11 |
| JB | 3026 | 100-year | 1375.00 | 4.10 | 12.72 | | 12.73 | 0.000159 | 1.38 | 2451.68 | 1964.24 | 0.12 |
| | | | | | | | | | | | | |
| JB | 2724 | 2-year | 499.00 | 3.40 | 10.98 | | 11.03 | 0.000351 | 2.03 | 394.77 | 477.17 | 0.17 |
| JB | 2724 | 5-year | 685.00 | 3.40 | 12.16 | | 12.17 | 0.000122 | 1.24 | 1239.11 | 989.92 | 0.10 |
| JB | 2724 | 10-year | 831.00 | 3.40 | 12.36 | | 12.37 | 0.000137 | 1.30 | 1454.02 | 1152.67 | 0.11 |
| JB | 2724 | 25-year | 1035.00 | 3.40 | 12.48 | | 12.50 | 0.000180 | 1.50 | 1604.58 | 1227.10 | 0.13 |
| JB | 2724 | 50-year | 1197.00 | 3.40 | 12.61 | | 12.63 | 0.000199 | 1.57 | 1768.40 | 1322.69 | 0.13 |
| JB | 2724 | 100-year | 1375.00 | 3.40 | 12.65 | | 12.67 | 0.000251 | 1.77 | 1810.37 | 1347.07 | 0.15 |
| | | | | | | | | | | | | |
| JB | 2421 | 2-year | 524.00 | 2.87 | 10.82 | | 10.91 | 0.000454 | 2.37 | 232.52 | 112.17 | 0.20 |
| JB | 2421 | 5-year | 719.00 | 2.87 | 12.11 | | 12.13 | 0.000165 | 1.50 | 1200.67 | 1368.49 | 0.12 |
| JB | 2421 | 10-year | 874.00 | 2.87 | 12.31 | | 12.33 | 0.000167 | 1.51 | 1503.95 | 1683.48 | 0.12 |
| JB | 2421 | 25-year | 1089.00 | 2.87 | 12.42 | | 12.44 | 0.000209 | 1.69 | 1707.63 | 1907.43 | 0.14 |
| JB | 2421 | 50-year | 1259.00 | 2.87 | 12.54 | | 12.57 | 0.000232 | 1.78 | 1958.05 | 2169.44 | 0.14 |
| JB | 2421 | 100-year | 1447.00 | 2.87 | 12.55 | | 12.58 | 0.000299 | 2.02 | 1982.16 | 2188.36 | 0.16 |
| | | | | | | | | | | | | |
| JB | 2270 | 2-year | 700.00 | 2.47 | 10.75 | 6.08 | 10.84 | 0.000418 | 2.50 | 337.25 | 449.61 | 0.19 |
| JB | 2270 | 5-year | 957.00 | 2.47 | 12.09 | 6.71 | 12.10 | 0.000080 | 1.08 | 2640.06 | 3032.94 | 0.09 |
| JB | 2270 | 10-year | 1160.00 | 2.47 | 12.29 | 7.16 | 12.30 | 0.000077 | 1.06 | 3294.67 | 3590.36 | 0.08 |
| JB | 2270 | 25-year | 1442.00 | 2.47 | 12.40 | 7.72 | 12.41 | 0.000095 | 1.18 | 3724.12 | 4250.83 | 0.09 |
| JB | 2270 | 50-year | 1664.00 | 2.47 | 12.53 | 8.12 | 12.53 | 0.000100 | 1.20 | 4280.69 | 4900.83 | 0.10 |

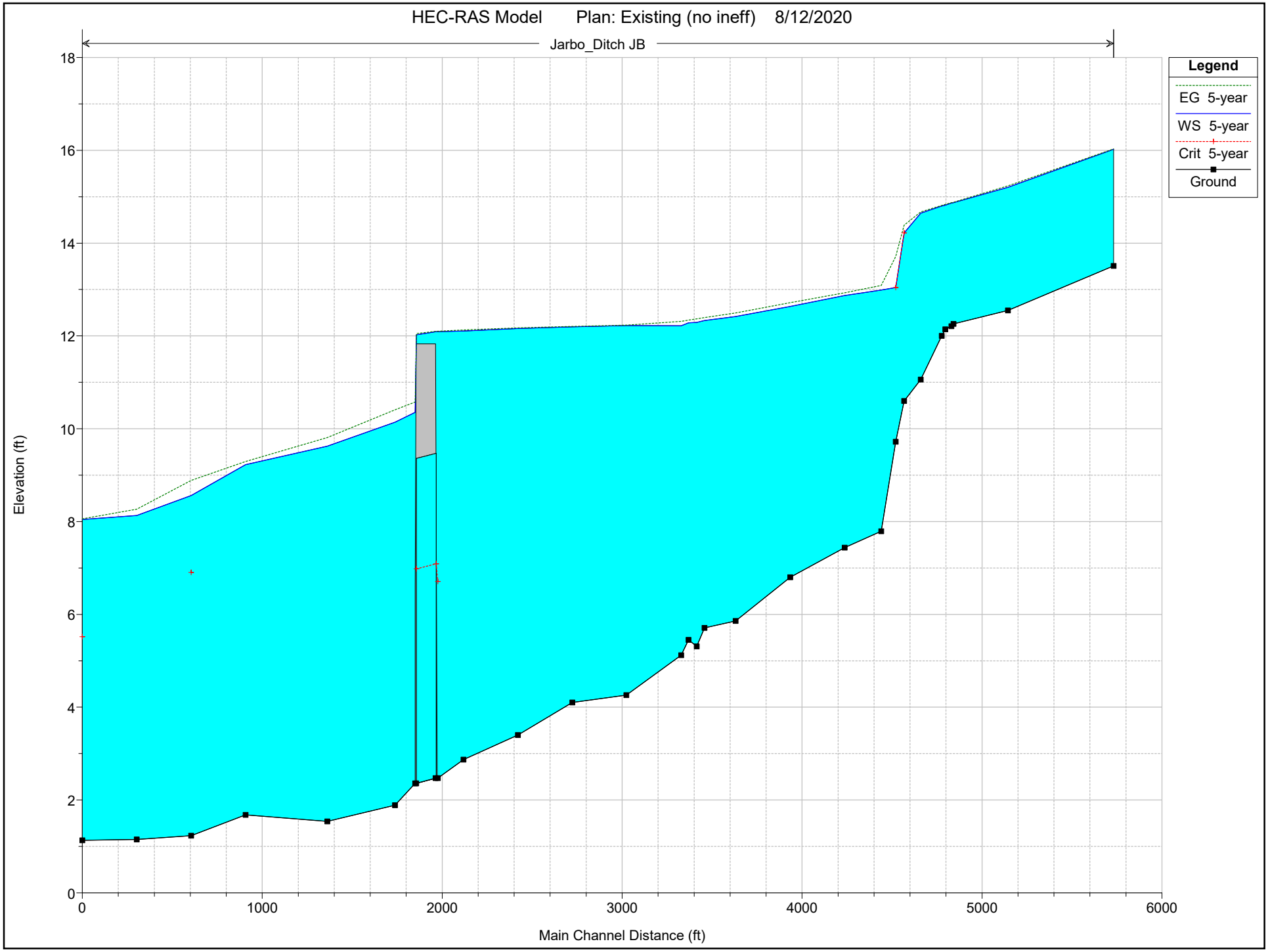
HEC-RAS Plan: Existing (no ineff) River: Jarbo_Ditch Reach: JB (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| JB | 2270 | 100-year | 1908.00 | 2.47 | 12.53 | 8.53 | 12.54 | 0.000130 | 1.37 | 4311.00 | 4932.97 | 0.11 |
| | | | | | | | | | | | | |
| JB | 2209 | | Culvert | | | | | | | | | |
| | | | | | | | | | | | | |
| JB | 2153 | 2-year | 743.00 | 2.36 | 9.79 | | 9.95 | 0.000850 | 3.22 | 231.71 | 60.60 | 0.27 |
| JB | 2153 | 5-year | 1015.00 | 2.36 | 10.35 | | 10.57 | 0.001097 | 3.81 | 319.93 | 351.70 | 0.31 |
| JB | 2153 | 10-year | 1229.00 | 2.36 | 10.69 | 7.49 | 10.91 | 0.001125 | 3.95 | 540.42 | 1190.63 | 0.31 |
| JB | 2153 | 25-year | 1528.00 | 2.36 | 11.25 | | 11.31 | 0.000500 | 2.69 | 1955.03 | 4014.44 | 0.21 |
| JB | 2153 | 50-year | 1762.00 | 2.36 | 11.51 | | 11.53 | 0.000317 | 2.10 | 3138.01 | 5038.81 | 0.17 |
| JB | 2153 | 100-year | 2020.00 | 2.36 | 11.71 | | 11.73 | 0.000224 | 1.73 | 4231.28 | 5553.58 | 0.14 |
| | | | | | | | | | | | | |
| JB | 2041 | 2-year | 745.00 | 1.89 | 9.63 | | 9.83 | 0.001092 | 3.52 | 212.92 | 78.84 | 0.30 |
| JB | 2041 | 5-year | 1019.00 | 1.89 | 10.14 | | 10.41 | 0.001476 | 4.17 | 279.81 | 188.90 | 0.35 |
| JB | 2041 | 10-year | 1234.00 | 1.89 | 10.36 | | 10.69 | 0.001822 | 4.69 | 328.30 | 257.85 | 0.40 |
| JB | 2041 | 25-year | 1533.00 | 1.89 | 10.60 | | 11.00 | 0.002266 | 5.29 | 397.84 | 314.30 | 0.44 |
| JB | 2041 | 50-year | 1768.00 | 1.89 | 10.77 | | 11.21 | 0.002594 | 5.64 | 461.00 | 396.83 | 0.47 |
| JB | 2041 | 100-year | 2027.00 | 1.89 | 10.98 | 9.00 | 11.41 | 0.002977 | 5.79 | 555.05 | 521.45 | 0.50 |
| | | | | | | | | | | | | |
| JB | 1665 | 2-year | 752.00 | 1.54 | 9.20 | | 9.39 | 0.001212 | 3.59 | 247.06 | 363.28 | 0.32 |
| JB | 1665 | 5-year | 1028.00 | 1.54 | 9.62 | | 9.81 | 0.001572 | 3.75 | 465.67 | 625.26 | 0.36 |
| JB | 1665 | 10-year | 1245.00 | 1.54 | 9.82 | | 10.01 | 0.001573 | 3.88 | 599.95 | 709.52 | 0.36 |
| JB | 1665 | 25-year | 1547.00 | 1.54 | 10.05 | | 10.23 | 0.001599 | 4.04 | 766.11 | 762.36 | 0.36 |
| JB | 1665 | 50-year | 1784.00 | 1.54 | 10.20 | | 10.37 | 0.001627 | 4.16 | 883.54 | 836.53 | 0.37 |
| JB | 1665 | 100-year | 2045.00 | 1.54 | 10.34 | | 10.52 | 0.001659 | 4.27 | 1013.85 | 931.26 | 0.37 |
| | | | | | | | | | | | | |
| JB | 1211 | 2-year | 763.00 | 1.68 | 8.83 | | 8.91 | 0.000816 | 2.68 | 520.84 | 541.24 | 0.26 |
| JB | 1211 | 5-year | 1043.00 | 1.68 | 9.23 | | 9.30 | 0.000763 | 2.64 | 769.92 | 713.33 | 0.25 |
| JB | 1211 | 10-year | 1263.00 | 1.68 | 9.41 | | 9.48 | 0.000807 | 2.78 | 902.12 | 762.71 | 0.26 |
| JB | 1211 | 25-year | 1569.00 | 1.68 | 9.59 | | 9.67 | 0.000899 | 3.03 | 1042.67 | 792.81 | 0.27 |
| JB | 1211 | 50-year | 1810.00 | 1.68 | 9.69 | | 9.78 | 0.000994 | 3.24 | 1125.71 | 802.51 | 0.29 |
| JB | 1211 | 100-year | 2074.00 | 1.68 | 9.79 | | 9.89 | 0.001093 | 3.46 | 1209.29 | 808.43 | 0.31 |
| | | | | | | | | | | | | |
| JB | 908 | 2-year | 771.00 | 1.23 | 8.18 | 6.15 | 8.49 | 0.002378 | 4.54 | 201.72 | 267.21 | 0.43 |
| JB | 908 | 5-year | 1054.00 | 1.23 | 8.56 | 6.90 | 8.89 | 0.002443 | 4.94 | 379.25 | 707.03 | 0.45 |
| JB | 908 | 10-year | 1276.00 | 1.23 | 8.74 | 7.39 | 9.06 | 0.002455 | 5.11 | 530.31 | 981.26 | 0.45 |
| JB | 908 | 25-year | 1585.00 | 1.23 | 8.95 | 8.83 | 9.23 | 0.002362 | 5.18 | 769.18 | 1347.79 | 0.45 |
| JB | 908 | 50-year | 1829.00 | 1.23 | 9.09 | 8.92 | 9.33 | 0.002171 | 5.08 | 983.59 | 1553.67 | 0.43 |
| JB | 908 | 100-year | 2095.00 | 1.23 | 9.22 | 9.02 | 9.43 | 0.002071 | 5.06 | 1182.30 | 1600.64 | 0.42 |
| | | | | | | | | | | | | |
| JB | 606 | 2-year | 777.00 | 1.15 | 7.81 | | 7.93 | 0.001258 | 3.18 | 425.46 | 492.18 | 0.31 |
| JB | 606 | 5-year | 1061.00 | 1.15 | 8.13 | | 8.27 | 0.001471 | 3.57 | 645.23 | 887.39 | 0.34 |
| JB | 606 | 10-year | 1285.00 | 1.15 | 8.37 | | 8.47 | 0.001275 | 3.28 | 883.49 | 1097.26 | 0.32 |
| JB | 606 | 25-year | 1596.00 | 1.15 | 8.59 | | 8.68 | 0.001190 | 3.29 | 1178.33 | 1643.60 | 0.31 |
| JB | 606 | 50-year | 1840.00 | 1.15 | 8.77 | | 8.84 | 0.001044 | 3.19 | 1502.00 | 1888.77 | 0.29 |
| JB | 606 | 100-year | 2108.00 | 1.15 | 8.92 | | 8.99 | 0.000926 | 3.08 | 1792.97 | 1909.12 | 0.28 |
| | | | | | | | | | | | | |
| JB | 303 | 2-year | 786.00 | 1.13 | 7.72 | 4.94 | 7.73 | 0.000302 | 1.53 | 1093.14 | 1082.09 | 0.15 |
| JB | 303 | 5-year | 1073.00 | 1.13 | 8.04 | 5.52 | 8.06 | 0.000301 | 1.63 | 1487.37 | 1302.87 | 0.16 |
| JB | 303 | 10-year | 1300.00 | 1.13 | 8.27 | 5.67 | 8.28 | 0.000301 | 1.70 | 1798.43 | 1452.96 | 0.16 |
| JB | 303 | 25-year | 1614.00 | 1.13 | 8.48 | 6.08 | 8.50 | 0.000301 | 1.77 | 2113.72 | 1496.88 | 0.16 |
| JB | 303 | 50-year | 1862.00 | 1.13 | 8.66 | 6.27 | 8.67 | 0.000301 | 1.82 | 2381.12 | 1525.85 | 0.16 |
| JB | 303 | 100-year | 2133.00 | 1.13 | 8.81 | 6.46 | 8.83 | 0.000301 | 1.87 | 2614.52 | 1548.15 | 0.16 |

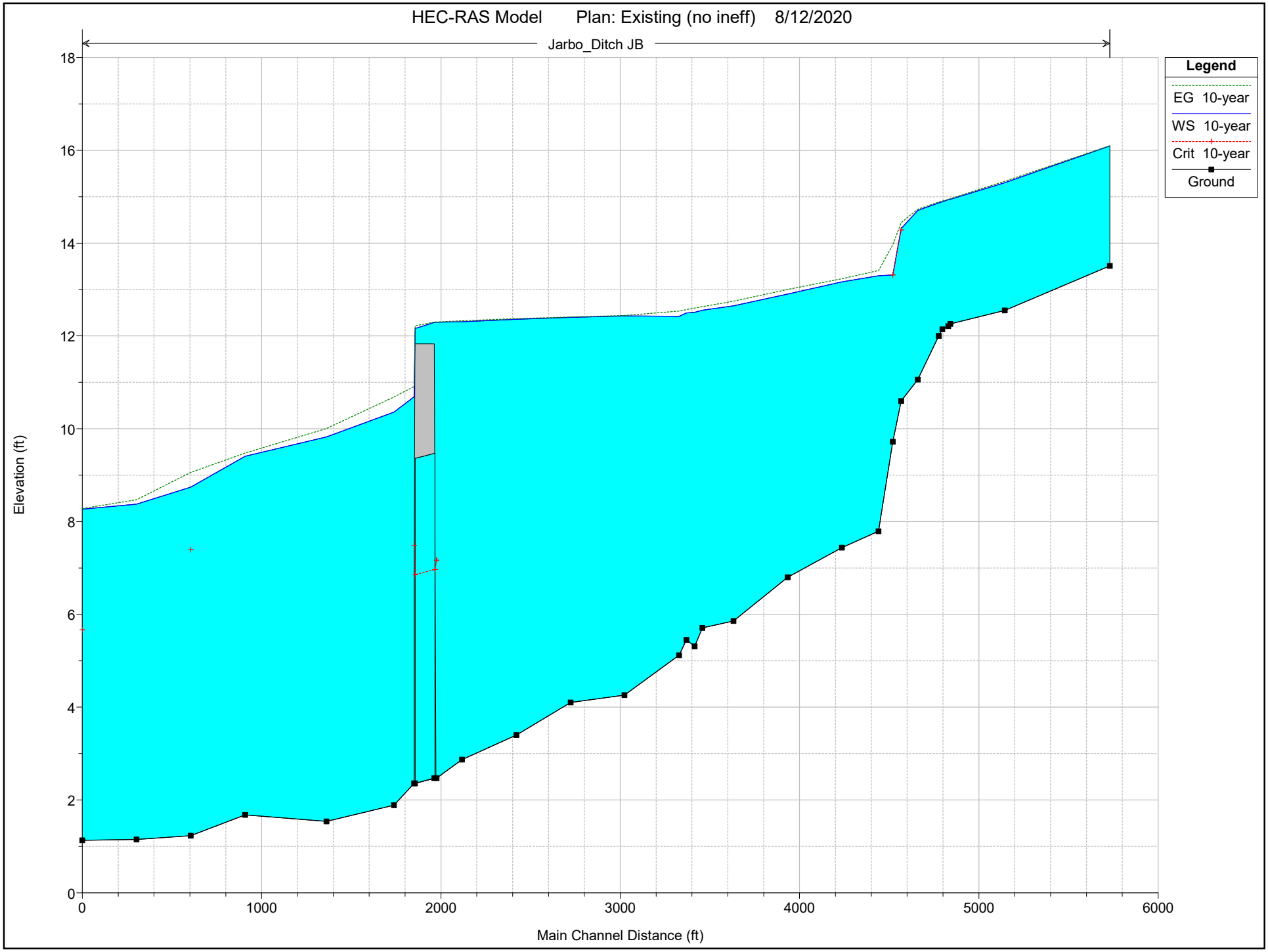
# Existing 2-year Water Surface Profile



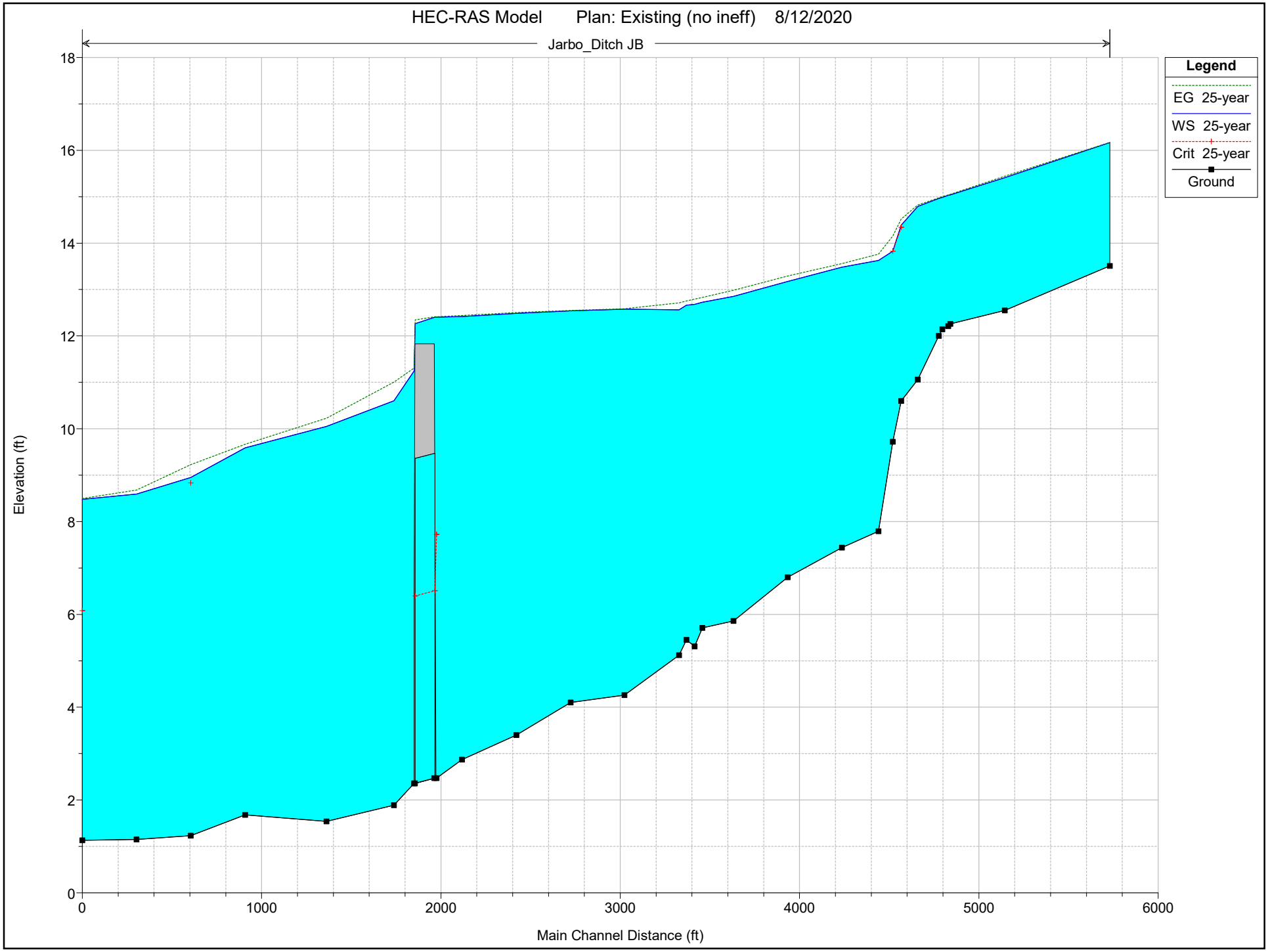
# Existing 5-year Water Surface Profile



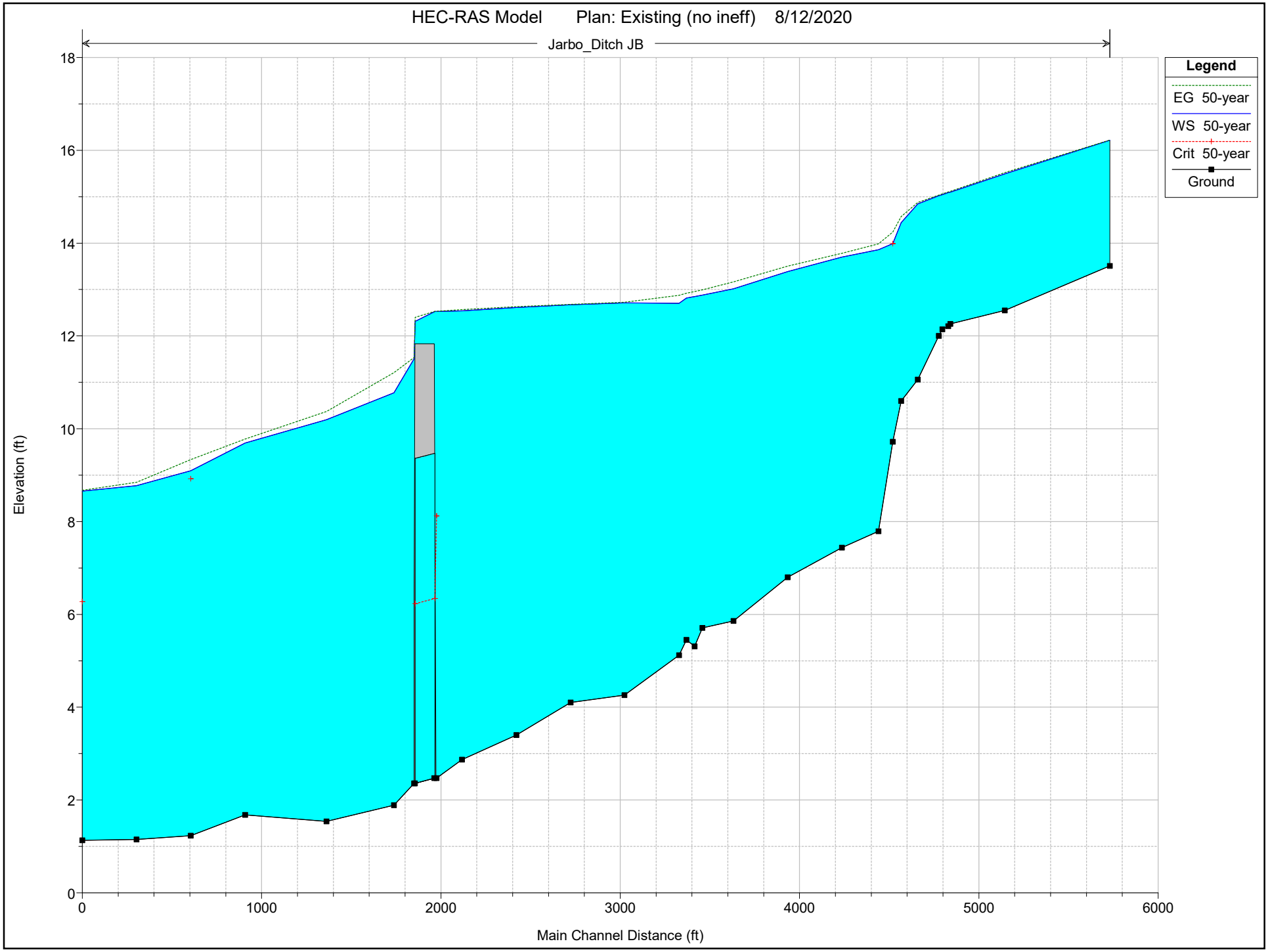
# Existing 10-year Water Surface Profile



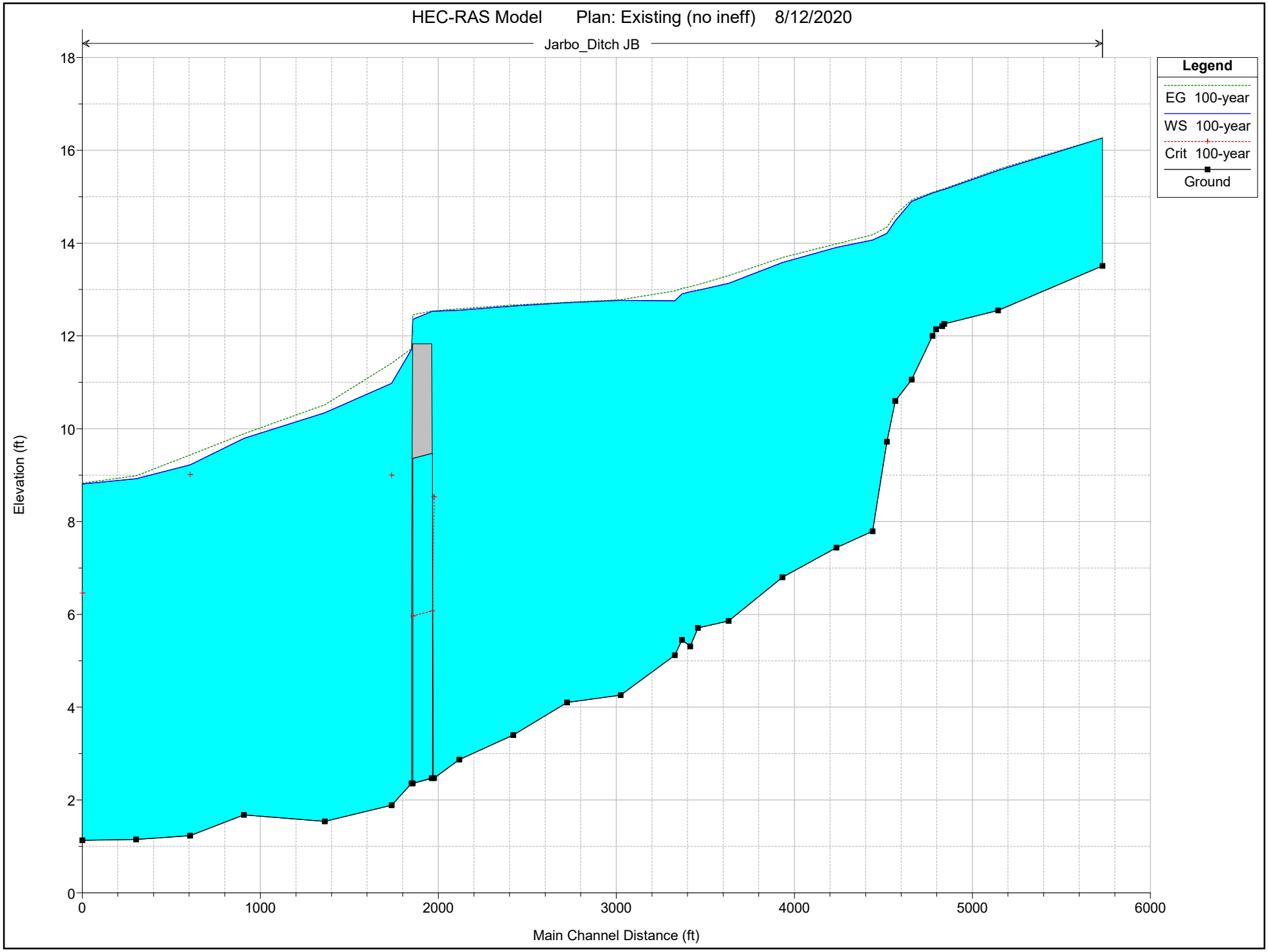
# Existing 25-year Water Surface Profile



# Existing 50-year Water Surface Profile



# Existing 100-year Water Surface Profile



# APPENDIX G
# SCENARIO 1 HEC-RAS OUTPUT AND PROFILES

HEC-RAS Plan: Prop Scen 1 River: Jarbo_Ditch Reach: JB

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| JB | 6034 | 2-year | 61.00 | 13.51 | 15.89 | 15.07 | 15.91 | 0.001018 | 1.61 | 106.81 | 501.99 | 0.24 |
| JB | 6034 | 5-year | 82.00 | 13.51 | 16.00 | | 16.01 | 0.000829 | 1.30 | 170.49 | 666.27 | 0.21 |
| JB | 6034 | 10-year | 98.00 | 13.51 | 16.07 | | 16.08 | 0.000709 | 1.16 | 223.42 | 813.92 | 0.20 |
| JB | 6034 | 25-year | 121.00 | 13.51 | 16.15 | | 16.16 | 0.000578 | 1.06 | 293.48 | 927.53 | 0.18 |
| JB | 6034 | 50-year | 138.00 | 13.51 | 16.21 | | 16.21 | 0.000517 | 1.02 | 346.07 | 1005.01 | 0.17 |
| JB | 6034 | 100-year | 157.00 | 13.51 | 16.26 | | 16.26 | 0.000472 | 0.98 | 395.79 | 1068.97 | 0.16 |
| | | | | | | | | | | | | |
| JB | 5447 | 2-year | 157.00 | 12.55 | 15.05 | | 15.08 | 0.001620 | 2.05 | 146.79 | 275.10 | 0.31 |
| JB | 5447 | 5-year | 214.00 | 12.55 | 15.20 | | 15.23 | 0.001669 | 2.14 | 188.76 | 316.47 | 0.31 |
| JB | 5447 | 10-year | 259.00 | 12.55 | 15.29 | | 15.32 | 0.001730 | 2.19 | 221.65 | 370.32 | 0.32 |
| JB | 5447 | 25-year | 321.00 | 12.55 | 15.41 | | 15.44 | 0.001785 | 2.24 | 269.22 | 455.31 | 0.32 |
| JB | 5447 | 50-year | 370.00 | 12.55 | 15.48 | | 15.51 | 0.001824 | 2.28 | 305.58 | 526.87 | 0.33 |
| JB | 5447 | 100-year | 423.00 | 12.55 | 15.56 | | 15.59 | 0.001855 | 2.29 | 347.36 | 593.68 | 0.33 |
| | | | | | | | | | | | | |
| JB | 5144 | 2-year | 157.00 | 12.26 | 14.78 | | 14.79 | 0.000634 | 1.33 | 264.32 | 474.40 | 0.19 |
| JB | 5144 | 5-year | 214.00 | 12.26 | 14.90 | | 14.91 | 0.000709 | 1.44 | 322.29 | 497.17 | 0.21 |
| JB | 5144 | 10-year | 259.00 | 12.26 | 14.97 | | 14.98 | 0.000767 | 1.49 | 359.89 | 513.77 | 0.21 |
| JB | 5144 | 25-year | 321.00 | 12.26 | 15.06 | | 15.07 | 0.000846 | 1.54 | 409.63 | 570.71 | 0.22 |
| JB | 5144 | 50-year | 370.00 | 12.26 | 15.12 | | 15.13 | 0.000905 | 1.64 | 442.40 | 585.05 | 0.23 |
| JB | 5144 | 100-year | 423.00 | 12.26 | 15.18 | | 15.19 | 0.000960 | 1.73 | 476.68 | 598.60 | 0.24 |
| | | | | | | | | | | | | |
| JB | 5132 | 2-year | 157.00 | 12.21 | 14.77 | | 14.78 | 0.000748 | 1.33 | 265.24 | 540.99 | 0.21 |
| JB | 5132 | 5-year | 214.00 | 12.21 | 14.89 | | 14.90 | 0.000813 | 1.39 | 331.77 | 577.79 | 0.21 |
| JB | 5132 | 10-year | 259.00 | 12.21 | 14.96 | | 14.97 | 0.000832 | 1.42 | 375.13 | 589.27 | 0.22 |
| JB | 5132 | 25-year | 321.00 | 12.21 | 15.05 | | 15.06 | 0.000856 | 1.47 | 430.39 | 637.07 | 0.22 |
| JB | 5132 | 50-year | 370.00 | 12.21 | 15.11 | | 15.12 | 0.000901 | 1.54 | 466.96 | 656.50 | 0.23 |
| JB | 5132 | 100-year | 423.00 | 12.21 | 15.17 | | 15.18 | 0.000939 | 1.60 | 505.13 | 667.87 | 0.24 |
| | | | | | | | | | | | | |
| JB | 5099 | 2-year | 157.00 | 12.14 | 14.73 | | 14.75 | 0.001091 | 1.74 | 211.94 | 479.15 | 0.25 |
| JB | 5099 | 5-year | 214.00 | 12.14 | 14.85 | | 14.86 | 0.001139 | 1.80 | 273.56 | 568.65 | 0.26 |
| JB | 5099 | 10-year | 259.00 | 12.14 | 14.92 | | 14.94 | 0.001198 | 1.82 | 317.88 | 619.51 | 0.27 |
| JB | 5099 | 25-year | 321.00 | 12.14 | 15.01 | | 15.03 | 0.001271 | 1.78 | 376.09 | 653.29 | 0.27 |
| JB | 5099 | 50-year | 370.00 | 12.14 | 15.07 | | 15.08 | 0.001347 | 1.73 | 413.48 | 679.29 | 0.28 |
| JB | 5099 | 100-year | 423.00 | 12.14 | 15.13 | | 15.14 | 0.001390 | 1.73 | 452.72 | 706.26 | 0.28 |
| | | | | | | | | | | | | |
| JB | 5079 | 2-year | 157.00 | 12.00 | 14.71 | | 14.72 | 0.001146 | 1.83 | 247.19 | 519.11 | 0.26 |
| JB | 5079 | 5-year | 214.00 | 12.00 | 14.82 | | 14.84 | 0.001209 | 1.89 | 314.87 | 627.57 | 0.27 |
| JB | 5079 | 10-year | 259.00 | 12.00 | 14.90 | | 14.91 | 0.001258 | 1.93 | 363.56 | 708.39 | 0.27 |
| JB | 5079 | 25-year | 321.00 | 12.00 | 14.99 | | 15.00 | 0.001272 | 1.87 | 433.83 | 830.80 | 0.27 |
| JB | 5079 | 50-year | 370.00 | 12.00 | 15.04 | | 15.06 | 0.001313 | 1.86 | 481.14 | 887.39 | 0.28 |
| JB | 5079 | 100-year | 423.00 | 12.00 | 15.10 | | 15.11 | 0.001336 | 1.84 | 532.78 | 939.70 | 0.28 |
| | | | | | | | | | | | | |
| JB | 4963 | 2-year | 222.00 | 11.06 | 14.52 | | 14.55 | 0.001813 | 1.88 | 243.85 | 640.25 | 0.32 |
| JB | 4963 | 5-year | 302.00 | 11.06 | 14.63 | | 14.66 | 0.001804 | 1.99 | 324.24 | 794.03 | 0.32 |
| JB | 4963 | 10-year | 365.00 | 11.06 | 14.69 | | 14.73 | 0.001917 | 2.12 | 375.19 | 858.99 | 0.33 |
| JB | 4963 | 25-year | 452.00 | 11.06 | 14.77 | | 14.80 | 0.002134 | 2.31 | 440.50 | 928.32 | 0.36 |
| JB | 4963 | 50-year | 520.00 | 11.06 | 14.81 | | 14.85 | 0.002255 | 2.42 | 481.12 | 945.21 | 0.37 |
| JB | 4963 | 100-year | 594.00 | 11.06 | 14.86 | | 14.90 | 0.002249 | 2.47 | 533.76 | 967.08 | 0.37 |
| | | | | | | | | | | | | |
| JB | 4870 | 2-year | 222.00 | 10.60 | 14.09 | 14.09 | 14.26 | 0.005659 | 3.97 | 98.68 | 289.80 | 0.57 |
| JB | 4870 | 5-year | 302.00 | 10.60 | 14.20 | 14.20 | 14.35 | 0.006864 | 4.01 | 138.87 | 434.77 | 0.62 |
| JB | 4870 | 10-year | 365.00 | 10.60 | 14.26 | 14.26 | 14.41 | 0.007646 | 4.18 | 162.65 | 485.68 | 0.66 |
| JB | 4870 | 25-year | 452.00 | 10.60 | 14.38 | | 14.48 | 0.006073 | 3.67 | 233.81 | 696.93 | 0.59 |
| JB | 4870 | 50-year | 520.00 | 10.60 | 14.44 | | 14.53 | 0.005531 | 3.54 | 280.24 | 754.94 | 0.56 |
| JB | 4870 | 100-year | 594.00 | 10.60 | 14.46 | | 14.57 | 0.006474 | 3.85 | 294.85 | 762.62 | 0.61 |
| | | | | | | | | | | | | |
| JB | 4823 | 2-year | 222.00 | 9.72 | 12.65 | 12.65 | 13.36 | 0.015747 | 6.86 | 36.58 | 31.63 | 0.98 |
| JB | 4823 | 5-year | 302.00 | 9.72 | 13.06 | 13.06 | 13.80 | 0.014581 | 7.07 | 51.59 | 41.36 | 0.96 |
| JB | 4823 | 10-year | 365.00 | 9.72 | 13.73 | 13.73 | 14.06 | 0.006364 | 5.02 | 117.41 | 235.87 | 0.65 |
| JB | 4823 | 25-year | 452.00 | 9.72 | 13.89 | 13.89 | 14.18 | 0.006284 | 4.98 | 162.26 | 336.61 | 0.64 |
| JB | 4823 | 50-year | 520.00 | 9.72 | 13.99 | 13.99 | 14.24 | 0.006253 | 4.93 | 197.64 | 422.29 | 0.64 |
| JB | 4823 | 100-year | 594.00 | 9.72 | 14.20 | | 14.33 | 0.004113 | 3.91 | 306.09 | 605.26 | 0.52 |
| | | | | | | | | | | | | |
| JB | 4743 | 2-year | 222.00 | 7.79 | 11.73 | | 11.88 | 0.001981 | 3.07 | 72.31 | 33.78 | 0.37 |
| JB | 4743 | 5-year | 302.00 | 7.79 | 12.33 | | 12.49 | 0.001796 | 3.23 | 93.48 | 37.50 | 0.36 |
| JB | 4743 | 10-year | 365.00 | 7.79 | 12.81 | | 12.98 | 0.001579 | 3.25 | 112.43 | 40.63 | 0.34 |
| JB | 4743 | 25-year | 452.00 | 7.79 | 13.45 | | 13.61 | 0.001395 | 3.22 | 145.57 | 130.50 | 0.33 |
| JB | 4743 | 50-year | 520.00 | 7.79 | 13.77 | | 13.91 | 0.001338 | 3.13 | 213.38 | 336.83 | 0.32 |
| JB | 4743 | 100-year | 594.00 | 7.79 | 14.06 | | 14.16 | 0.001106 | 2.84 | 349.33 | 628.22 | 0.29 |
| | | | | | | | | | | | | |
| JB | 4539 | 2-year | 222.00 | 7.44 | 11.49 | | 11.58 | 0.001059 | 2.38 | 93.33 | 40.21 | 0.28 |
| JB | 4539 | 5-year | 302.00 | 7.44 | 12.11 | | 12.21 | 0.000977 | 2.53 | 119.49 | 44.17 | 0.27 |
| JB | 4539 | 10-year | 365.00 | 7.44 | 12.62 | | 12.72 | 0.000879 | 2.55 | 143.13 | 48.22 | 0.26 |
| JB | 4539 | 25-year | 452.00 | 7.44 | 13.28 | | 13.37 | 0.000868 | 2.48 | 188.99 | 110.98 | 0.26 |
| JB | 4539 | 50-year | 520.00 | 7.44 | 13.59 | | 13.68 | 0.000831 | 2.51 | 247.85 | 271.67 | 0.26 |
| JB | 4539 | 100-year | 594.00 | 7.44 | 13.88 | | 13.97 | 0.000784 | 2.46 | 358.62 | 456.12 | 0.25 |

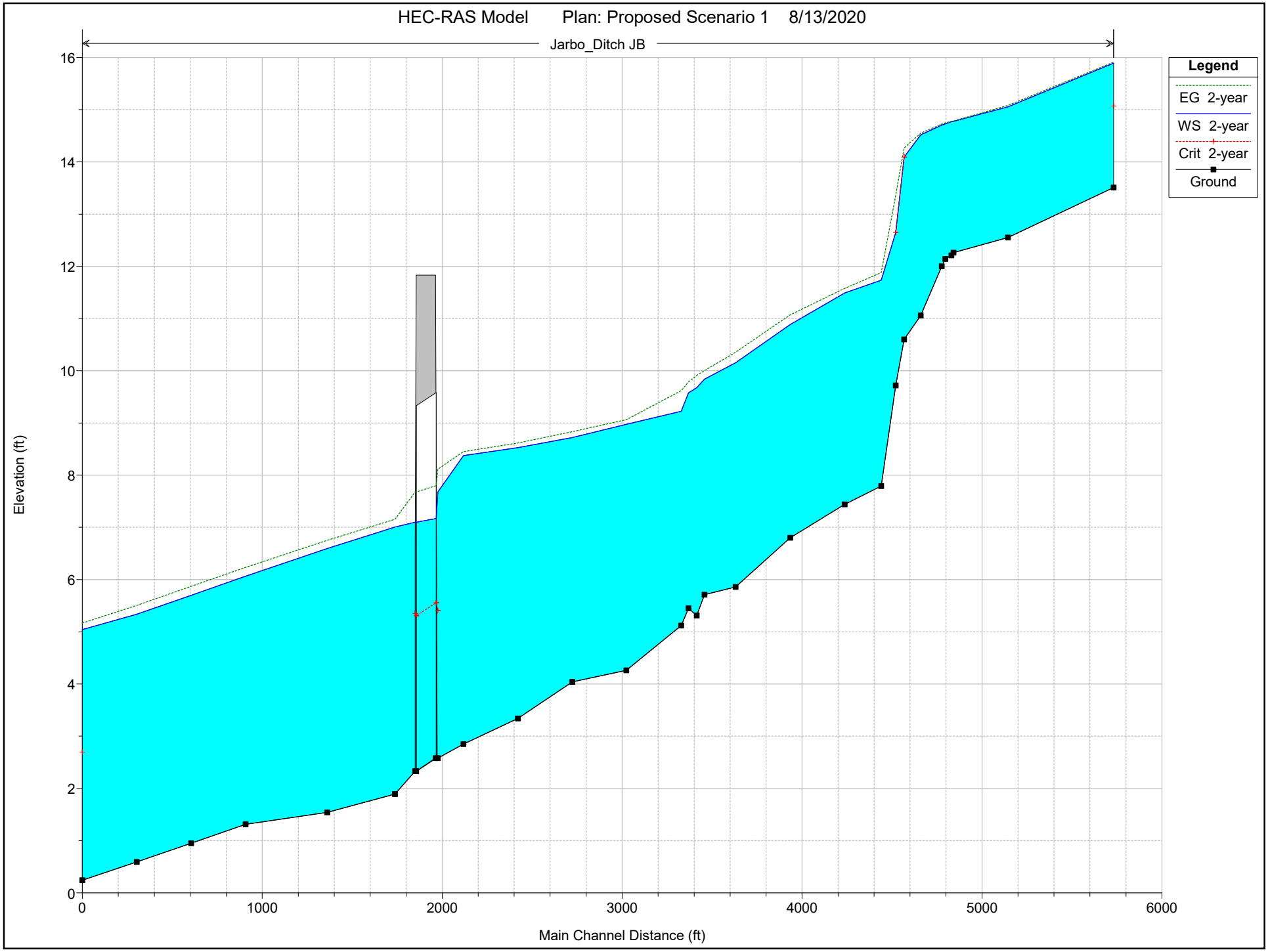
HEC-RAS Plan: Prop Scen 1 River: Jarbo_Ditch Reach: JB (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| | | | | | | | | | | | | |
| JB | 4237 | 2-year | 312.00 | 6.80 | 10.89 | | 11.07 | 0.002397 | 3.44 | 90.64 | 41.55 | 0.41 |
| JB | 4237 | 5-year | 428.00 | 6.80 | 11.56 | | 11.75 | 0.002086 | 3.55 | 120.49 | 47.45 | 0.39 |
| JB | 4237 | 10-year | 519.00 | 6.80 | 12.11 | | 12.30 | 0.002051 | 3.47 | 150.25 | 65.65 | 0.39 |
| JB | 4237 | 25-year | 647.00 | 6.80 | 12.86 | | 13.02 | 0.001430 | 3.23 | 215.14 | 122.72 | 0.33 |
| JB | 4237 | 50-year | 747.00 | 6.80 | 13.19 | | 13.35 | 0.001339 | 3.23 | 287.16 | 353.22 | 0.33 |
| JB | 4237 | 100-year | 858.00 | 6.80 | 13.54 | | 13.65 | 0.001283 | 2.97 | 428.07 | 468.51 | 0.31 |
| | | | | | | | | | | | | |
| JB | 3934 | 2-year | 312.00 | 5.86 | 10.15 | | 10.35 | 0.002327 | 3.60 | 86.57 | 35.87 | 0.41 |
| JB | 3934 | 5-year | 428.00 | 5.86 | 10.94 | | 11.15 | 0.001905 | 3.67 | 116.61 | 40.34 | 0.38 |
| JB | 3934 | 10-year | 519.00 | 5.86 | 11.53 | | 11.74 | 0.001678 | 3.67 | 141.37 | 44.45 | 0.36 |
| JB | 3934 | 25-year | 647.00 | 5.86 | 12.37 | | 12.56 | 0.001605 | 3.49 | 186.67 | 80.64 | 0.35 |
| JB | 3934 | 50-year | 747.00 | 5.86 | 12.71 | | 12.91 | 0.001560 | 3.59 | 223.22 | 142.90 | 0.35 |
| JB | 3934 | 100-year | 858.00 | 5.86 | 13.01 | | 13.22 | 0.001588 | 3.70 | 295.13 | 360.05 | 0.36 |
| | | | | | | | | | | | | |
| JB | 3761 | 2-year | 312.00 | 5.71 | 9.84 | | 10.01 | 0.001669 | 3.27 | 95.39 | 35.52 | 0.35 |
| JB | 3761 | 5-year | 428.00 | 5.71 | 10.68 | | 10.86 | 0.001427 | 3.37 | 127.08 | 40.13 | 0.33 |
| JB | 3761 | 10-year | 519.00 | 5.71 | 11.29 | | 11.47 | 0.001300 | 3.39 | 152.87 | 44.45 | 0.32 |
| JB | 3761 | 25-year | 647.00 | 5.71 | 12.14 | | 12.30 | 0.001261 | 3.23 | 204.93 | 89.75 | 0.32 |
| JB | 3761 | 50-year | 747.00 | 5.71 | 12.50 | | 12.67 | 0.001178 | 3.32 | 246.70 | 170.39 | 0.31 |
| JB | 3761 | 100-year | 858.00 | 5.71 | 12.81 | | 12.98 | 0.001098 | 3.37 | 369.84 | 678.71 | 0.30 |
| | | | | | | | | | | | | |
| JB | 3710 | 2-year | 312.00 | 5.31 | 9.67 | | 9.91 | 0.002450 | 3.92 | 79.67 | 29.77 | 0.42 |
| JB | 3710 | 5-year | 428.00 | 5.31 | 10.52 | | 10.77 | 0.002056 | 4.02 | 106.39 | 33.26 | 0.40 |
| JB | 3710 | 10-year | 519.00 | 5.31 | 11.14 | | 11.40 | 0.001906 | 4.06 | 127.99 | 37.38 | 0.39 |
| JB | 3710 | 25-year | 647.00 | 5.31 | 12.00 | | 12.23 | 0.001765 | 3.91 | 169.66 | 87.12 | 0.37 |
| JB | 3710 | 50-year | 747.00 | 5.31 | 12.36 | | 12.60 | 0.001601 | 3.99 | 219.04 | 211.12 | 0.36 |
| JB | 3710 | 100-year | 858.00 | 5.31 | 12.71 | 9.96 | 12.92 | 0.001355 | 3.89 | 363.63 | 708.89 | 0.34 |
| | | | | | | | | | | | | |
| JB | 3690 | 2-year | 312.00 | 5.45 | 9.58 | | 9.79 | 0.002670 | 3.68 | 84.81 | 37.98 | 0.43 |
| JB | 3690 | 5-year | 428.00 | 5.45 | 10.48 | | 10.67 | 0.001855 | 3.50 | 122.22 | 44.80 | 0.37 |
| JB | 3690 | 10-year | 519.00 | 5.45 | 11.12 | | 11.30 | 0.001513 | 3.40 | 152.52 | 50.10 | 0.34 |
| JB | 3690 | 25-year | 647.00 | 5.45 | 11.98 | | 12.15 | 0.001194 | 3.23 | 201.88 | 93.69 | 0.31 |
| JB | 3690 | 50-year | 747.00 | 5.45 | 12.35 | | 12.52 | 0.001107 | 3.30 | 253.22 | 212.63 | 0.30 |
| JB | 3690 | 100-year | 858.00 | 5.45 | 12.69 | | 12.85 | 0.000976 | 3.29 | 368.40 | 510.07 | 0.29 |
| | | | | | | | | | | | | |
| JB | 3631 | 2-year | 416.00 | 5.12 | 9.22 | | 9.62 | 0.005087 | 5.03 | 82.66 | 37.48 | 0.60 |
| JB | 3631 | 5-year | 568.00 | 5.12 | 10.22 | | 10.55 | 0.003053 | 4.62 | 122.89 | 42.99 | 0.48 |
| JB | 3631 | 10-year | 688.00 | 5.12 | 10.89 | | 11.20 | 0.002468 | 4.50 | 152.96 | 47.48 | 0.44 |
| JB | 3631 | 25-year | 855.00 | 5.12 | 11.78 | | 12.07 | 0.001963 | 4.31 | 199.62 | 63.43 | 0.40 |
| JB | 3631 | 50-year | 987.00 | 5.12 | 12.13 | | 12.44 | 0.001988 | 4.50 | 231.78 | 149.16 | 0.41 |
| JB | 3631 | 100-year | 1131.00 | 5.12 | 12.46 | | 12.78 | 0.001879 | 4.60 | 305.00 | 303.45 | 0.40 |
| | | | | | | | | | | | | |
| JB | 3326 | 2-year | 416.00 | 4.26 | 8.97 | | 9.06 | 0.000714 | 2.43 | 171.06 | 53.19 | 0.24 |
| JB | 3326 | 5-year | 568.00 | 4.26 | 10.05 | | 10.15 | 0.000564 | 2.44 | 249.10 | 308.57 | 0.22 |
| JB | 3326 | 10-year | 688.00 | 4.26 | 10.84 | | 10.89 | 0.000362 | 2.10 | 532.01 | 410.25 | 0.18 |
| JB | 3326 | 25-year | 855.00 | 4.26 | 11.83 | | 11.86 | 0.000189 | 1.64 | 1005.24 | 551.14 | 0.13 |
| JB | 3326 | 50-year | 987.00 | 4.26 | 12.20 | | 12.23 | 0.000174 | 1.62 | 1234.81 | 712.64 | 0.13 |
| JB | 3326 | 100-year | 1131.00 | 4.26 | 12.54 | | 12.57 | 0.000170 | 1.64 | 1530.34 | 1052.01 | 0.13 |
| | | | | | | | | | | | | |
| JB | 3026 | 2-year | 499.00 | 4.04 | 8.72 | | 8.83 | 0.000808 | 2.68 | 185.93 | 54.63 | 0.26 |
| JB | 3026 | 5-year | 685.00 | 4.04 | 9.86 | | 9.97 | 0.000621 | 2.65 | 318.08 | 220.13 | 0.23 |
| JB | 3026 | 10-year | 831.00 | 4.04 | 10.69 | | 10.77 | 0.000452 | 2.43 | 559.65 | 381.83 | 0.20 |
| JB | 3026 | 25-year | 1035.00 | 4.04 | 11.74 | | 11.79 | 0.000277 | 2.06 | 1148.20 | 989.93 | 0.16 |
| JB | 3026 | 50-year | 1197.00 | 4.04 | 12.12 | | 12.17 | 0.000246 | 1.98 | 1604.80 | 1396.60 | 0.15 |
| JB | 3026 | 100-year | 1375.00 | 4.04 | 12.47 | | 12.51 | 0.000215 | 1.91 | 2165.77 | 1735.40 | 0.14 |
| | | | | | | | | | | | | |
| JB | 2724 | 2-year | 499.00 | 3.34 | 8.53 | | 8.62 | 0.000598 | 2.43 | 205.60 | 55.93 | 0.22 |
| JB | 2724 | 5-year | 685.00 | 3.34 | 9.70 | | 9.79 | 0.000502 | 2.49 | 275.44 | 63.55 | 0.21 |
| JB | 2724 | 10-year | 831.00 | 3.34 | 10.54 | | 10.64 | 0.000428 | 2.46 | 381.26 | 237.65 | 0.20 |
| JB | 2724 | 25-year | 1035.00 | 3.34 | 11.66 | | 11.71 | 0.000229 | 1.95 | 974.15 | 757.62 | 0.15 |
| JB | 2724 | 50-year | 1197.00 | 3.34 | 12.06 | | 12.10 | 0.000197 | 1.86 | 1312.05 | 940.05 | 0.14 |
| JB | 2724 | 100-year | 1375.00 | 3.34 | 12.42 | | 12.45 | 0.000173 | 1.77 | 1697.03 | 1211.85 | 0.13 |
| | | | | | | | | | | | | |
| JB | 2421 | 2-year | 524.00 | 2.85 | 8.37 | | 8.45 | 0.000479 | 2.26 | 231.51 | 59.24 | 0.20 |
| JB | 2421 | 5-year | 719.00 | 2.85 | 9.57 | | 9.65 | 0.000415 | 2.34 | 306.80 | 66.74 | 0.19 |
| JB | 2421 | 10-year | 874.00 | 2.85 | 10.43 | | 10.51 | 0.000377 | 2.39 | 366.39 | 75.17 | 0.19 |
| JB | 2421 | 25-year | 1089.00 | 2.85 | 11.56 | | 11.63 | 0.000284 | 2.23 | 740.62 | 988.60 | 0.16 |
| JB | 2421 | 50-year | 1259.00 | 2.85 | 11.98 | | 12.03 | 0.000232 | 2.07 | 1236.11 | 1304.55 | 0.15 |
| JB | 2421 | 100-year | 1447.00 | 2.85 | 12.36 | | 12.40 | 0.000182 | 1.88 | 1804.55 | 1817.37 | 0.13 |
| | | | | | | | | | | | | |
| JB | 2270 | 2-year | 700.00 | 2.58 | 7.68 | 5.40 | 8.11 | 0.001762 | 5.28 | 132.61 | 73.78 | 0.41 |
| JB | 2270 | 5-year | 957.00 | 2.58 | 8.68 | 6.06 | 9.25 | 0.001810 | 6.03 | 158.68 | 82.33 | 0.43 |
| JB | 2270 | 10-year | 1160.00 | 2.58 | 9.39 | 6.53 | 10.05 | 0.001847 | 6.55 | 177.02 | 88.34 | 0.44 |
| JB | 2270 | 25-year | 1442.00 | 2.58 | 10.29 | 7.15 | 11.09 | 0.001882 | 7.19 | 200.58 | 100.59 | 0.46 |
| JB | 2270 | 50-year | 1664.00 | 2.58 | 11.96 | 7.61 | 11.99 | 0.000140 | 1.63 | 2562.86 | 2759.33 | 0.12 |

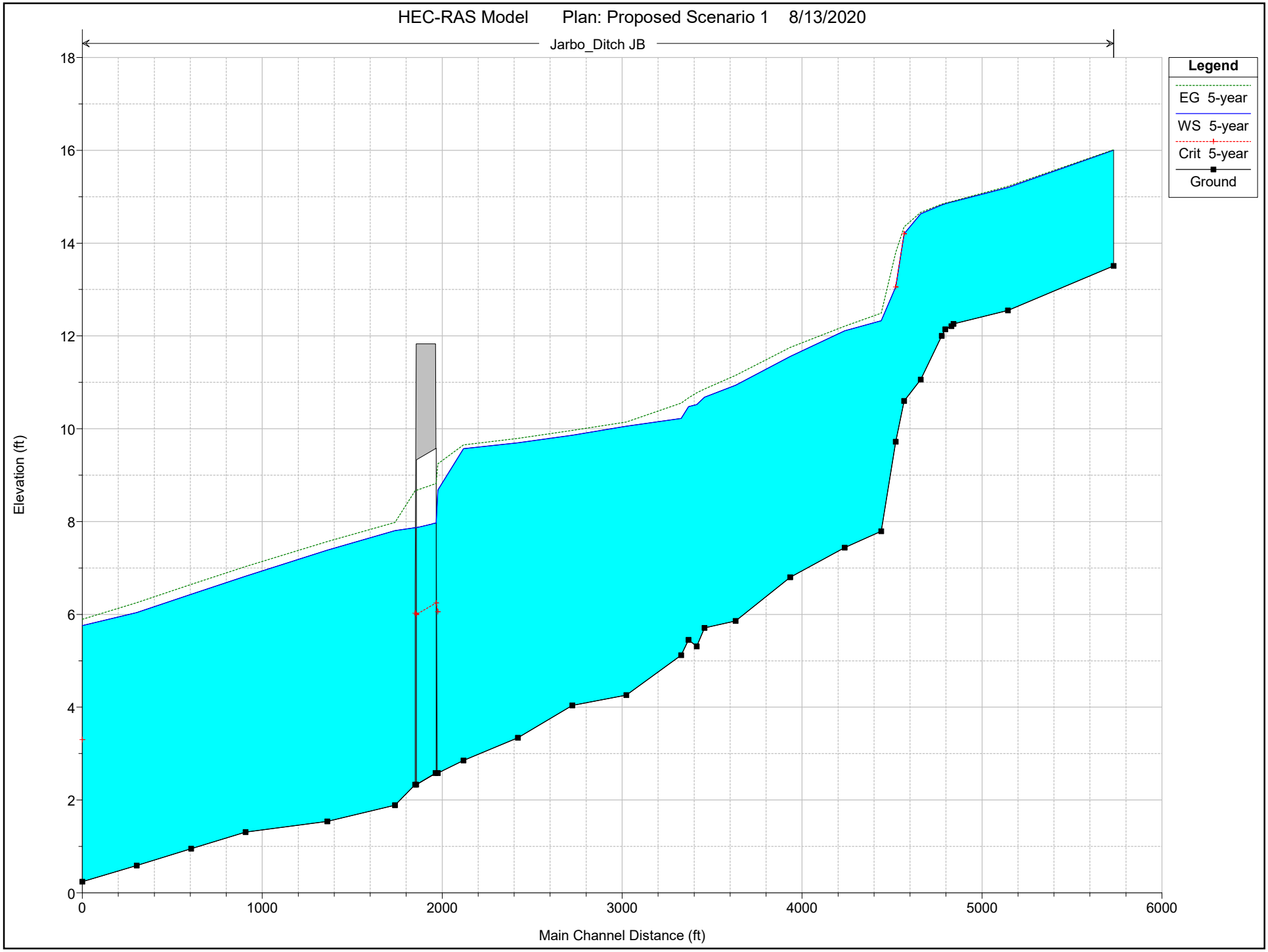
HEC-RAS Plan: Prop Scen 1 River: Jarbo_Ditch Reach: JB (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| JB | 2270 | 100-year | 1908.00 | 2.58 | 12.34 | 8.09 | 12.36 | 0.000098 | 1.39 | 3809.52 | 3912.85 | 0.10 |
| | | | | | | | | | | | | |
| JB | 2209 | | Culvert | | | | | | | | | |
| | | | | | | | | | | | | |
| JB | 2153 | 2-year | 743.00 | 2.33 | 7.10 | 5.35 | 7.68 | 0.002637 | 6.10 | 121.77 | 70.00 | 0.50 |
| JB | 2153 | 5-year | 1015.00 | 2.33 | 7.87 | 6.03 | 8.67 | 0.002963 | 7.16 | 141.77 | 76.50 | 0.54 |
| JB | 2153 | 10-year | 1229.00 | 2.33 | 8.37 | 6.53 | 9.35 | 0.003245 | 7.94 | 154.75 | 80.72 | 0.57 |
| JB | 2153 | 25-year | 1528.00 | 2.33 | 8.96 | 7.17 | 10.21 | 0.003656 | 8.98 | 170.15 | 85.72 | 0.62 |
| JB | 2153 | 50-year | 1762.00 | 2.33 | 9.35 | 7.64 | 10.84 | 0.004002 | 9.77 | 180.37 | 89.04 | 0.65 |
| JB | 2153 | 100-year | 2020.00 | 2.33 | 9.68 | 8.14 | 11.46 | 0.004502 | 10.69 | 188.99 | 95.34 | 0.70 |
| | | | | | | | | | | | | |
| JB | 2041 | 2-year | 745.00 | 1.89 | 7.01 | | 7.16 | 0.001056 | 3.10 | 240.64 | 70.49 | 0.30 |
| JB | 2041 | 5-year | 1019.00 | 1.89 | 7.80 | | 7.98 | 0.001079 | 3.40 | 299.47 | 77.27 | 0.30 |
| JB | 2041 | 10-year | 1234.00 | 1.89 | 8.32 | | 8.53 | 0.001108 | 3.62 | 340.90 | 81.70 | 0.31 |
| JB | 2041 | 25-year | 1533.00 | 1.89 | 8.95 | | 9.19 | 0.001151 | 3.89 | 393.79 | 87.06 | 0.32 |
| JB | 2041 | 50-year | 1768.00 | 1.89 | 9.37 | | 9.63 | 0.001195 | 4.10 | 431.24 | 90.67 | 0.33 |
| JB | 2041 | 100-year | 2027.00 | 1.89 | 9.74 | | 10.03 | 0.001279 | 4.36 | 469.59 | 137.65 | 0.35 |
| | | | | | | | | | | | | |
| JB | 1665 | 2-year | 752.00 | 1.54 | 6.60 | | 6.75 | 0.001094 | 3.15 | 238.87 | 70.01 | 0.30 |
| JB | 1665 | 5-year | 1028.00 | 1.54 | 7.38 | | 7.57 | 0.001124 | 3.47 | 296.35 | 76.60 | 0.31 |
| JB | 1665 | 10-year | 1245.00 | 1.54 | 7.89 | | 8.10 | 0.001165 | 3.70 | 336.14 | 80.84 | 0.32 |
| JB | 1665 | 25-year | 1547.00 | 1.54 | 8.49 | | 8.74 | 0.001227 | 4.00 | 386.37 | 85.90 | 0.33 |
| JB | 1665 | 50-year | 1784.00 | 1.54 | 8.89 | | 9.17 | 0.001290 | 4.24 | 421.27 | 95.54 | 0.34 |
| JB | 1665 | 100-year | 2045.00 | 1.54 | 9.22 | | 9.53 | 0.001375 | 4.49 | 500.61 | 427.53 | 0.36 |
| | | | | | | | | | | | | |
| JB | 1211 | 2-year | 763.00 | 1.31 | 6.06 | | 6.23 | 0.001194 | 3.28 | 232.29 | 68.18 | 0.31 |
| JB | 1211 | 5-year | 1043.00 | 1.31 | 6.82 | | 7.03 | 0.001251 | 3.64 | 286.40 | 74.51 | 0.33 |
| JB | 1211 | 10-year | 1263.00 | 1.31 | 7.30 | | 7.54 | 0.001320 | 3.91 | 323.79 | 85.73 | 0.34 |
| JB | 1211 | 25-year | 1569.00 | 1.31 | 7.86 | | 8.14 | 0.001405 | 4.24 | 382.18 | 143.15 | 0.36 |
| JB | 1211 | 50-year | 1810.00 | 1.31 | 8.26 | | 8.55 | 0.001413 | 4.38 | 478.59 | 382.86 | 0.36 |
| JB | 1211 | 100-year | 2074.00 | 1.31 | 8.66 | | 8.92 | 0.001252 | 4.27 | 672.93 | 525.36 | 0.34 |
| | | | | | | | | | | | | |
| JB | 908 | 2-year | 771.00 | 0.95 | 5.70 | | 5.87 | 0.001203 | 3.30 | 233.52 | 68.43 | 0.32 |
| JB | 908 | 5-year | 1054.00 | 0.95 | 6.43 | | 6.65 | 0.001281 | 3.69 | 285.97 | 74.37 | 0.33 |
| JB | 908 | 10-year | 1276.00 | 0.95 | 6.88 | | 7.13 | 0.001377 | 3.99 | 319.88 | 77.97 | 0.35 |
| JB | 908 | 25-year | 1585.00 | 0.95 | 7.40 | | 7.70 | 0.001518 | 4.39 | 361.39 | 82.16 | 0.37 |
| JB | 908 | 50-year | 1829.00 | 0.95 | 7.75 | | 8.09 | 0.001624 | 4.67 | 396.68 | 112.56 | 0.38 |
| JB | 908 | 100-year | 2095.00 | 0.95 | 8.09 | | 8.46 | 0.001733 | 4.95 | 442.26 | 181.80 | 0.40 |
| | | | | | | | | | | | | |
| JB | 606 | 2-year | 777.00 | 0.59 | 5.33 | | 5.50 | 0.001211 | 3.30 | 235.19 | 69.19 | 0.32 |
| JB | 606 | 5-year | 1061.00 | 0.59 | 6.04 | | 6.25 | 0.001308 | 3.71 | 291.14 | 100.90 | 0.33 |
| JB | 606 | 10-year | 1285.00 | 0.59 | 6.45 | | 6.70 | 0.001431 | 4.03 | 335.48 | 116.16 | 0.35 |
| JB | 606 | 25-year | 1596.00 | 0.59 | 6.92 | | 7.22 | 0.001599 | 4.45 | 401.73 | 162.78 | 0.38 |
| JB | 606 | 50-year | 1840.00 | 0.59 | 7.24 | | 7.59 | 0.001709 | 4.72 | 465.49 | 230.35 | 0.39 |
| JB | 606 | 100-year | 2108.00 | 0.59 | 7.56 | | 7.93 | 0.001774 | 5.00 | 560.71 | 392.68 | 0.40 |
| | | | | | | | | | | | | |
| JB | 303 | 2-year | 786.00 | 0.24 | 5.04 | 2.70 | 5.17 | 0.000957 | 2.95 | 314.43 | 132.61 | 0.28 |
| JB | 303 | 5-year | 1073.00 | 0.24 | 5.76 | 3.30 | 5.89 | 0.000956 | 3.19 | 434.61 | 199.99 | 0.29 |
| JB | 303 | 10-year | 1300.00 | 0.24 | 6.17 | 3.65 | 6.32 | 0.000957 | 3.32 | 523.50 | 225.57 | 0.29 |
| JB | 303 | 25-year | 1614.00 | 0.24 | 6.66 | 4.03 | 6.81 | 0.000956 | 3.46 | 652.75 | 320.32 | 0.29 |
| JB | 303 | 50-year | 1862.00 | 0.24 | 7.00 | 4.34 | 7.15 | 0.000956 | 3.55 | 797.26 | 539.35 | 0.29 |
| JB | 303 | 100-year | 2133.00 | 0.24 | 7.33 | 4.57 | 7.48 | 0.000956 | 3.67 | 1003.81 | 754.92 | 0.30 |

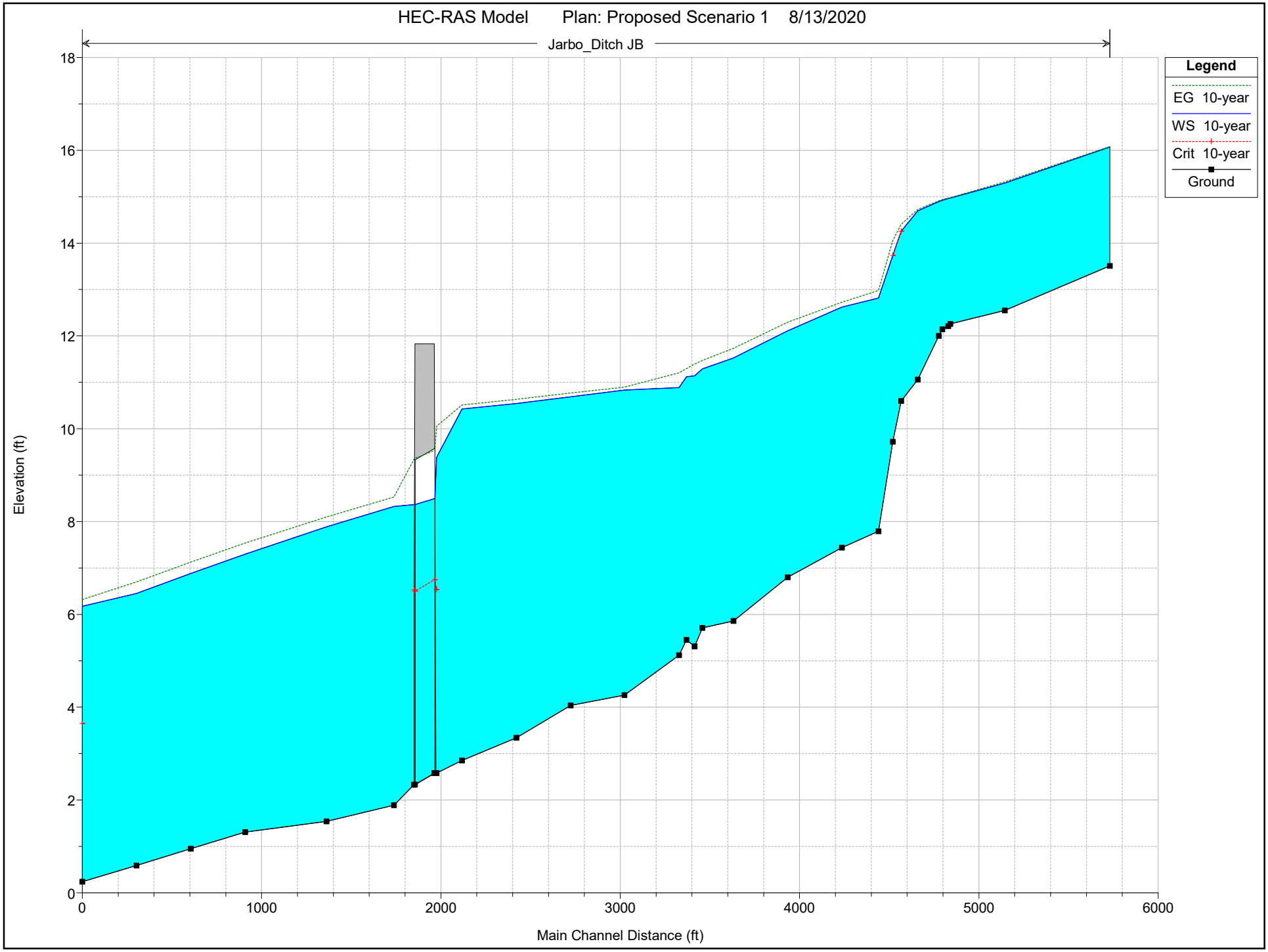
# Scenario 1 2-year Water Surface Profile



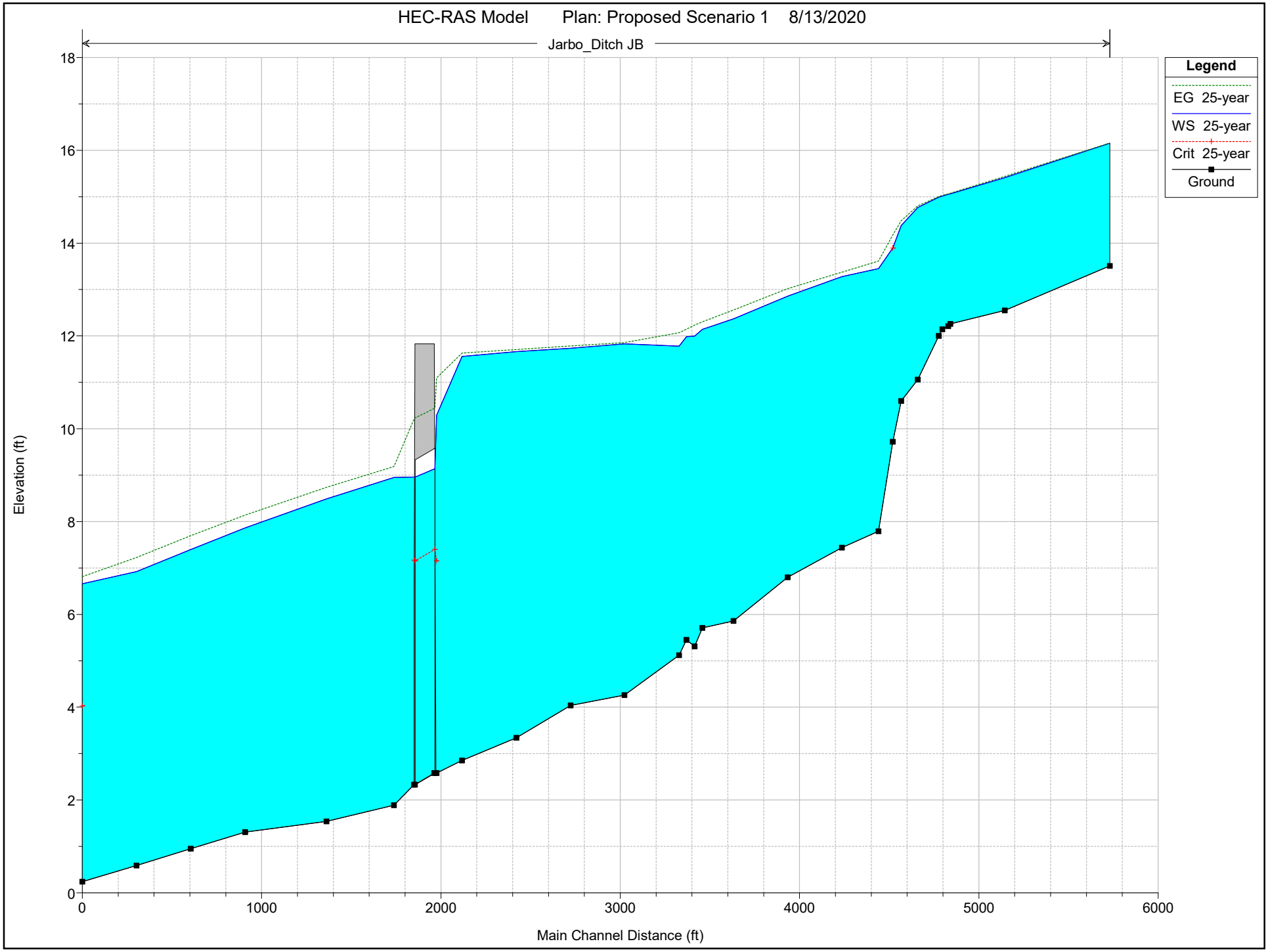
# Scenario 1 5-year Water Surface Profile



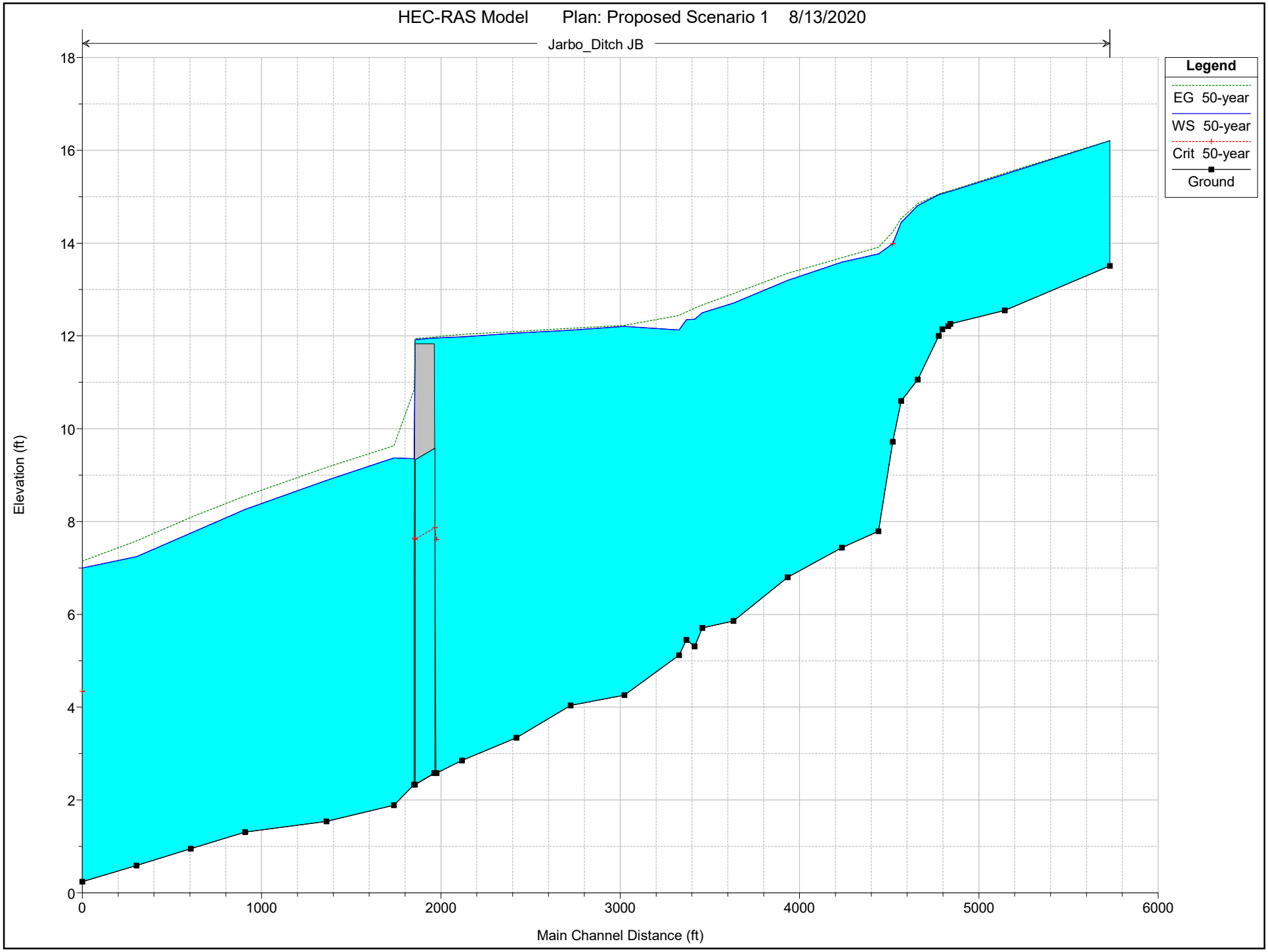
# Scenario 1 10-year Water Surface Profile



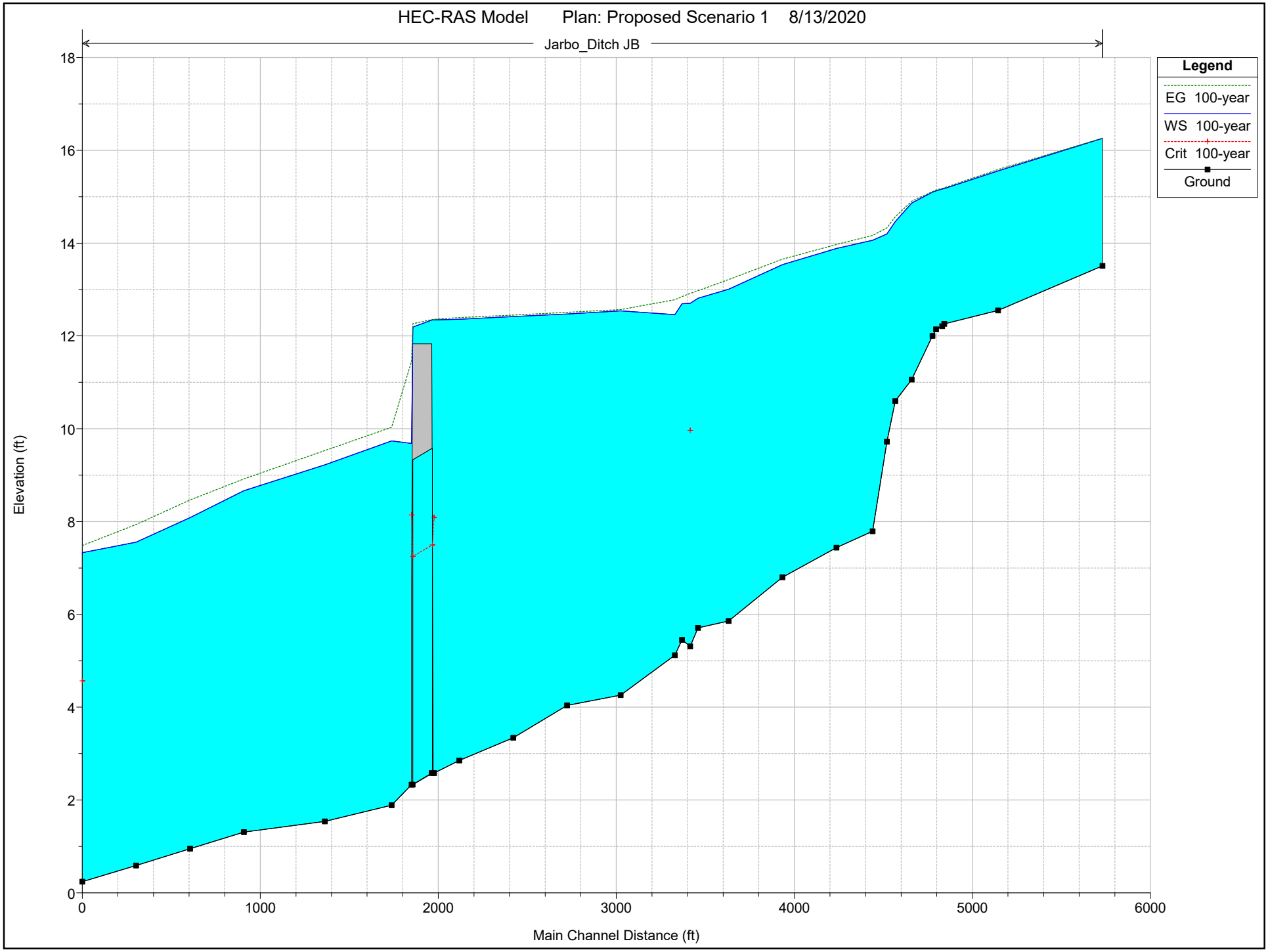
# Scenario 1 25-year Water Surface Profile



# Scenario 1 50-year Water Surface Profile



# Scenario 1 100-year Water Surface Profile



# APPENDIX H
# SCENARIO 2 HEC-RAS OUTPUT AND PROFILES

HEC-RAS Plan: Prop Scen 2 River: Jarbo_Ditch Reach: JB

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| JB | 6034 | 2-year | 61.00 | 14.29 | 15.57 | | 15.61 | 0.001183 | 1.55 | 41.86 | 73.93 | 0.26 |
| JB | 6034 | 5-year | 82.00 | 14.29 | 15.79 | | 15.82 | 0.000989 | 1.55 | 86.41 | 399.41 | 0.24 |
| JB | 6034 | 10-year | 98.00 | 14.29 | 15.89 | | 15.91 | 0.000823 | 1.47 | 134.62 | 526.35 | 0.22 |
| JB | 6034 | 25-year | 121.00 | 14.29 | 15.96 | | 15.99 | 0.000820 | 1.51 | 177.93 | 621.32 | 0.22 |
| JB | 6034 | 50-year | 138.00 | 14.29 | 16.01 | 15.22 | 16.03 | 0.000812 | 1.52 | 209.66 | 713.64 | 0.22 |
| JB | 6034 | 100-year | 157.00 | 14.29 | 16.07 | 15.29 | 16.09 | 0.000778 | 1.51 | 250.33 | 816.79 | 0.22 |
| | | | | | | | | | | | | |
| JB | 5447 | 2-year | 157.00 | 12.11 | 13.76 | | 13.91 | 0.004710 | 3.15 | 49.90 | 35.93 | 0.47 |
| JB | 5447 | 5-year | 214.00 | 12.11 | 14.10 | | 14.28 | 0.004457 | 3.41 | 63.47 | 45.19 | 0.47 |
| JB | 5447 | 10-year | 259.00 | 12.11 | 14.35 | | 14.53 | 0.004174 | 3.52 | 82.18 | 130.11 | 0.46 |
| JB | 5447 | 25-year | 321.00 | 12.11 | 14.64 | | 14.79 | 0.003269 | 3.34 | 126.54 | 170.08 | 0.42 |
| JB | 5447 | 50-year | 370.00 | 12.11 | 14.82 | | 14.95 | 0.002761 | 3.19 | 164.92 | 238.95 | 0.39 |
| JB | 5447 | 100-year | 423.00 | 12.11 | 14.97 | | 15.09 | 0.002492 | 3.12 | 203.78 | 282.86 | 0.37 |
| | | | | | | | | | | | | |
| JB | 5144 | 2-year | 157.00 | 10.98 | 12.96 | | 13.06 | 0.001812 | 2.46 | 64.08 | 41.83 | 0.34 |
| JB | 5144 | 5-year | 214.00 | 10.98 | 13.36 | | 13.47 | 0.001727 | 2.66 | 82.06 | 48.69 | 0.34 |
| JB | 5144 | 10-year | 259.00 | 10.98 | 13.64 | | 13.76 | 0.001670 | 2.77 | 96.00 | 52.14 | 0.34 |
| JB | 5144 | 25-year | 321.00 | 10.98 | 13.98 | | 14.11 | 0.001604 | 2.91 | 114.97 | 57.90 | 0.34 |
| JB | 5144 | 50-year | 370.00 | 10.98 | 14.25 | | 14.37 | 0.001405 | 2.89 | 164.27 | 295.07 | 0.32 |
| JB | 5144 | 100-year | 423.00 | 10.98 | 14.51 | | 14.61 | 0.001070 | 2.66 | 261.81 | 448.46 | 0.29 |
| | | | | | | | | | | | | |
| JB | 5132 | 2-year | 157.00 | 10.94 | 12.94 | | 13.04 | 0.001765 | 2.44 | 64.67 | 43.15 | 0.34 |
| JB | 5132 | 5-year | 214.00 | 10.94 | 13.34 | | 13.45 | 0.001681 | 2.64 | 82.83 | 47.99 | 0.34 |
| JB | 5132 | 10-year | 259.00 | 10.94 | 13.62 | | 13.73 | 0.001630 | 2.77 | 96.50 | 50.81 | 0.34 |
| JB | 5132 | 25-year | 321.00 | 10.94 | 13.96 | | 14.09 | 0.001575 | 2.91 | 114.84 | 55.09 | 0.34 |
| JB | 5132 | 50-year | 370.00 | 10.94 | 14.23 | | 14.35 | 0.001453 | 2.92 | 156.54 | 257.22 | 0.33 |
| JB | 5132 | 100-year | 423.00 | 10.94 | 14.49 | | 14.59 | 0.001162 | 2.73 | 249.49 | 460.52 | 0.30 |
| | | | | | | | | | | | | |
| JB | 5099 | 2-year | 157.00 | 10.82 | 12.89 | | 12.98 | 0.001636 | 2.41 | 65.35 | 40.76 | 0.33 |
| JB | 5099 | 5-year | 214.00 | 10.82 | 13.29 | | 13.39 | 0.001598 | 2.63 | 82.85 | 46.72 | 0.33 |
| JB | 5099 | 10-year | 259.00 | 10.82 | 13.56 | | 13.68 | 0.001569 | 2.76 | 96.26 | 49.94 | 0.33 |
| JB | 5099 | 25-year | 321.00 | 10.82 | 13.91 | | 14.04 | 0.001530 | 2.91 | 114.29 | 53.97 | 0.33 |
| JB | 5099 | 50-year | 370.00 | 10.82 | 14.17 | | 14.31 | 0.001456 | 2.97 | 145.32 | 227.09 | 0.33 |
| JB | 5099 | 100-year | 423.00 | 10.82 | 14.44 | | 14.55 | 0.001216 | 2.85 | 214.26 | 331.74 | 0.30 |
| | | | | | | | | | | | | |
| JB | 5079 | 2-year | 157.00 | 10.73 | 12.84 | | 12.93 | 0.003782 | 2.39 | 65.61 | 38.78 | 0.32 |
| JB | 5079 | 5-year | 214.00 | 10.73 | 13.24 | | 13.35 | 0.003921 | 2.63 | 83.00 | 47.43 | 0.33 |
| JB | 5079 | 10-year | 259.00 | 10.73 | 13.51 | | 13.63 | 0.003992 | 2.78 | 97.58 | 62.98 | 0.33 |
| JB | 5079 | 25-year | 321.00 | 10.73 | 13.87 | | 13.99 | 0.003924 | 2.91 | 123.08 | 78.15 | 0.33 |
| JB | 5079 | 50-year | 370.00 | 10.73 | 14.13 | | 14.26 | 0.003732 | 2.94 | 155.07 | 240.55 | 0.32 |
| JB | 5079 | 100-year | 423.00 | 10.73 | 14.41 | | 14.51 | 0.003026 | 2.74 | 234.03 | 363.81 | 0.29 |
| | | | | | | | | | | | | |
| JB | 4963 | 2-year | 222.00 | 10.30 | 12.25 | | 12.46 | 0.004041 | 3.68 | 60.28 | 37.25 | 0.51 |
| JB | 4963 | 5-year | 302.00 | 10.30 | 12.59 | | 12.86 | 0.004169 | 4.11 | 73.53 | 39.42 | 0.53 |
| JB | 4963 | 10-year | 365.00 | 10.30 | 12.83 | | 13.13 | 0.004260 | 4.39 | 83.12 | 40.92 | 0.54 |
| JB | 4963 | 25-year | 452.00 | 10.30 | 13.16 | | 13.50 | 0.004228 | 4.68 | 96.65 | 42.99 | 0.55 |
| JB | 4963 | 50-year | 520.00 | 10.30 | 13.43 | | 13.78 | 0.004019 | 4.79 | 108.49 | 44.72 | 0.54 |
| JB | 4963 | 100-year | 594.00 | 10.30 | 13.71 | | 14.08 | 0.003794 | 4.89 | 121.53 | 46.55 | 0.53 |
| | | | | | | | | | | | | |
| JB | 4870 | 2-year | 222.00 | 9.96 | 11.75 | | 12.01 | 0.005645 | 4.13 | 53.78 | 36.02 | 0.60 |
| JB | 4870 | 5-year | 302.00 | 9.96 | 12.06 | | 12.39 | 0.005910 | 4.63 | 65.28 | 38.08 | 0.62 |
| JB | 4870 | 10-year | 365.00 | 9.96 | 12.27 | 11.72 | 12.65 | 0.006130 | 4.97 | 73.45 | 39.51 | 0.64 |
| JB | 4870 | 25-year | 452.00 | 9.96 | 12.63 | | 13.04 | 0.005512 | 5.11 | 88.38 | 41.99 | 0.62 |
| JB | 4870 | 50-year | 520.00 | 9.96 | 12.98 | | 13.38 | 0.004649 | 5.03 | 103.47 | 44.36 | 0.58 |
| JB | 4870 | 100-year | 594.00 | 9.96 | 13.33 | | 13.72 | 0.004052 | 4.98 | 119.21 | 46.64 | 0.55 |
| | | | | | | | | | | | | |
| JB | 4823 | 2-year | 222.00 | 9.62 | 11.00 | 11.00 | 11.55 | 0.017694 | 5.96 | 37.25 | 34.00 | 1.00 |
| JB | 4823 | 5-year | 302.00 | 9.62 | 11.26 | 11.26 | 11.92 | 0.016849 | 6.51 | 46.42 | 35.76 | 1.01 |
| JB | 4823 | 10-year | 365.00 | 9.62 | 11.46 | 11.45 | 12.18 | 0.015979 | 6.79 | 53.72 | 37.23 | 1.00 |
| JB | 4823 | 25-year | 452.00 | 9.62 | 12.42 | | 12.78 | 0.005034 | 4.87 | 95.29 | 52.09 | 0.59 |
| JB | 4823 | 50-year | 520.00 | 9.62 | 12.83 | | 13.16 | 0.003849 | 4.63 | 118.49 | 60.54 | 0.53 |
| JB | 4823 | 100-year | 594.00 | 9.62 | 13.22 | | 13.53 | 0.003167 | 4.50 | 143.46 | 68.32 | 0.49 |
| | | | | | | | | | | | | |
| JB | 4743 | 2-year | 222.00 | 7.81 | 10.40 | | 10.50 | 0.001438 | 2.57 | 86.25 | 41.91 | 0.32 |
| JB | 4743 | 5-year | 302.00 | 7.81 | 11.14 | | 11.24 | 0.001054 | 2.53 | 119.14 | 46.80 | 0.28 |
| JB | 4743 | 10-year | 365.00 | 7.81 | 11.71 | | 11.81 | 0.000846 | 2.48 | 147.20 | 50.59 | 0.26 |
| JB | 4743 | 25-year | 452.00 | 7.81 | 12.50 | | 12.59 | 0.000645 | 2.39 | 188.93 | 55.76 | 0.23 |
| JB | 4743 | 50-year | 520.00 | 7.81 | 12.89 | | 12.99 | 0.000623 | 2.46 | 211.50 | 58.36 | 0.23 |
| JB | 4743 | 100-year | 594.00 | 7.81 | 13.27 | | 13.37 | 0.000616 | 2.54 | 233.92 | 66.05 | 0.23 |
| | | | | | | | | | | | | |
| JB | 4539 | 2-year | 222.00 | 7.32 | 10.17 | | 10.25 | 0.001022 | 2.29 | 96.80 | 43.22 | 0.27 |
| JB | 4539 | 5-year | 302.00 | 7.32 | 10.97 | | 11.05 | 0.000750 | 2.26 | 133.70 | 48.29 | 0.24 |
| JB | 4539 | 10-year | 365.00 | 7.32 | 11.58 | | 11.66 | 0.000612 | 2.22 | 164.28 | 52.12 | 0.22 |
| JB | 4539 | 25-year | 452.00 | 7.32 | 12.40 | | 12.47 | 0.000480 | 2.16 | 208.94 | 57.34 | 0.20 |
| JB | 4539 | 50-year | 520.00 | 7.32 | 12.79 | | 12.87 | 0.000473 | 2.24 | 232.32 | 62.01 | 0.20 |
| JB | 4539 | 100-year | 594.00 | 7.32 | 13.17 | | 13.25 | 0.000475 | 2.33 | 259.33 | 91.03 | 0.20 |

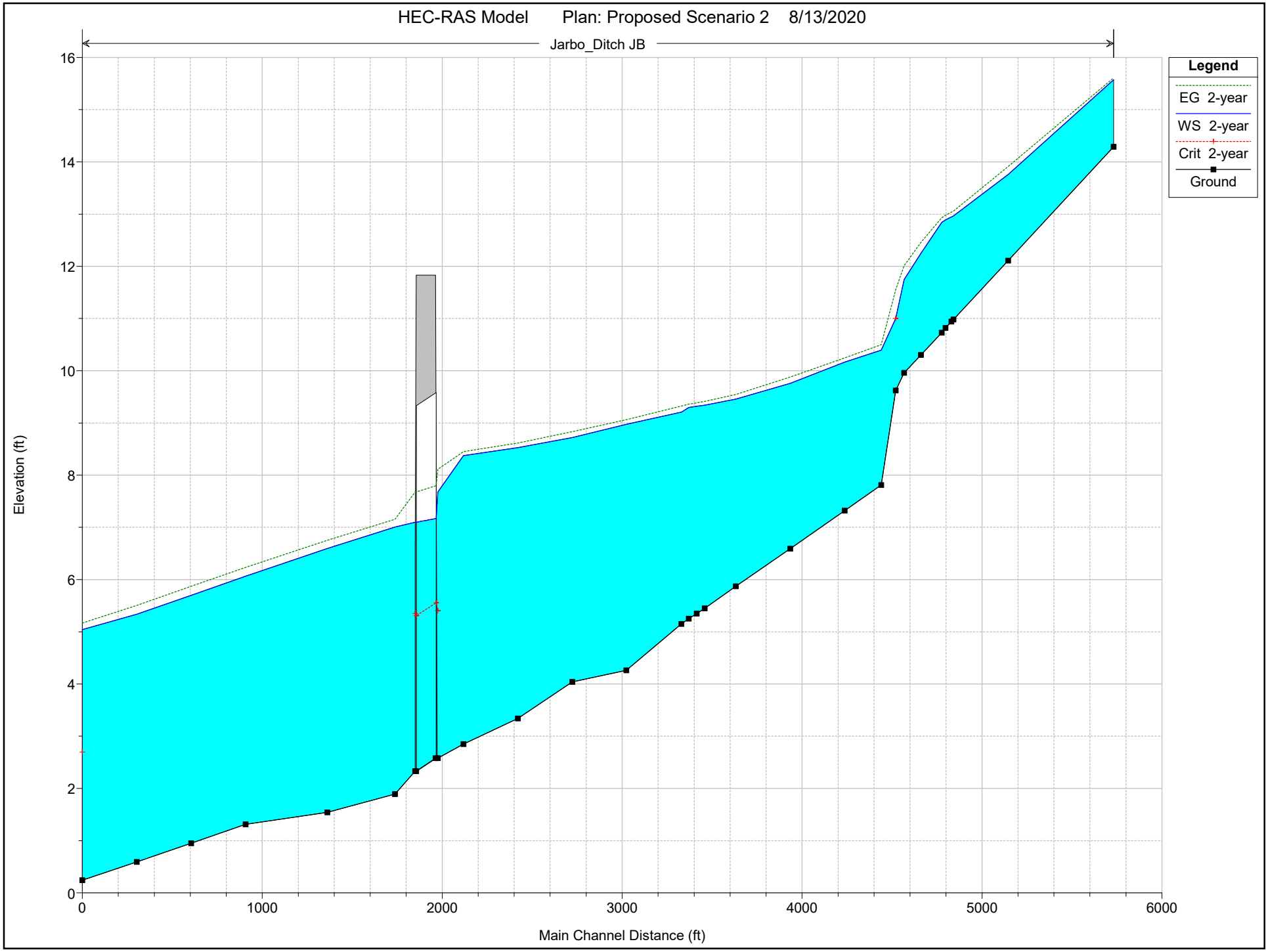
HEC-RAS Plan: Prop Scen 2 River: Jarbo_Ditch Reach: JB (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| | | | | | | | | | | | | |
| JB | 4237 | 2-year | 312.00 | 6.59 | 9.76 | | 9.88 | 0.001351 | 2.81 | 111.21 | 45.20 | 0.32 |
| JB | 4237 | 5-year | 428.00 | 6.59 | 10.66 | | 10.78 | 0.001004 | 2.77 | 154.63 | 51.19 | 0.28 |
| JB | 4237 | 10-year | 519.00 | 6.59 | 11.31 | | 11.43 | 0.000859 | 2.73 | 189.92 | 56.97 | 0.26 |
| JB | 4237 | 25-year | 647.00 | 6.59 | 12.18 | | 12.29 | 0.000691 | 2.67 | 243.22 | 70.81 | 0.24 |
| JB | 4237 | 50-year | 747.00 | 6.59 | 12.57 | | 12.69 | 0.000697 | 2.78 | 274.75 | 87.69 | 0.24 |
| JB | 4237 | 100-year | 858.00 | 6.59 | 12.94 | | 13.07 | 0.000721 | 2.90 | 314.53 | 132.68 | 0.25 |
| | | | | | | | | | | | | |
| JB | 3934 | 2-year | 312.00 | 5.87 | 9.46 | | 9.55 | 0.000870 | 2.41 | 129.59 | 47.54 | 0.26 |
| JB | 3934 | 5-year | 428.00 | 5.87 | 10.44 | | 10.53 | 0.000655 | 2.39 | 179.31 | 53.71 | 0.23 |
| JB | 3934 | 10-year | 519.00 | 5.87 | 11.13 | | 11.21 | 0.000561 | 2.38 | 217.65 | 58.03 | 0.22 |
| JB | 3934 | 25-year | 647.00 | 5.87 | 12.02 | | 12.11 | 0.000470 | 2.38 | 272.20 | 63.70 | 0.20 |
| JB | 3934 | 50-year | 747.00 | 5.87 | 12.40 | | 12.50 | 0.000538 | 2.52 | 298.30 | 88.25 | 0.21 |
| JB | 3934 | 100-year | 858.00 | 5.87 | 12.75 | | 12.86 | 0.000620 | 2.67 | 339.71 | 174.92 | 0.22 |
| | | | | | | | | | | | | |
| JB | 3761 | 2-year | 312.00 | 5.45 | 9.34 | | 9.41 | 0.000639 | 2.16 | 144.59 | 49.54 | 0.22 |
| JB | 3761 | 5-year | 428.00 | 5.45 | 10.35 | | 10.42 | 0.000500 | 2.16 | 197.95 | 56.10 | 0.20 |
| JB | 3761 | 10-year | 519.00 | 5.45 | 11.05 | | 11.12 | 0.000437 | 2.17 | 238.73 | 60.64 | 0.19 |
| JB | 3761 | 25-year | 647.00 | 5.45 | 11.96 | | 12.03 | 0.000370 | 2.18 | 298.82 | 76.60 | 0.18 |
| JB | 3761 | 50-year | 747.00 | 5.45 | 12.33 | | 12.41 | 0.000420 | 2.31 | 333.41 | 119.83 | 0.19 |
| JB | 3761 | 100-year | 858.00 | 5.45 | 12.67 | | 12.76 | 0.000497 | 2.43 | 400.60 | 388.88 | 0.21 |
| | | | | | | | | | | | | |
| JB | 3710 | 2-year | 312.00 | 5.35 | 9.32 | | 9.39 | 0.000578 | 2.08 | 150.26 | 50.64 | 0.21 |
| JB | 3710 | 5-year | 428.00 | 5.35 | 10.33 | | 10.40 | 0.000455 | 2.09 | 204.98 | 57.10 | 0.19 |
| JB | 3710 | 10-year | 519.00 | 5.35 | 11.04 | | 11.10 | 0.000402 | 2.10 | 246.63 | 61.75 | 0.19 |
| JB | 3710 | 25-year | 647.00 | 5.35 | 11.95 | | 12.02 | 0.000348 | 2.12 | 308.05 | 88.02 | 0.18 |
| JB | 3710 | 50-year | 747.00 | 5.35 | 12.32 | | 12.39 | 0.000375 | 2.24 | 354.10 | 181.35 | 0.18 |
| JB | 3710 | 100-year | 858.00 | 5.35 | 12.65 | | 12.74 | 0.000372 | 2.33 | 474.12 | 593.68 | 0.18 |
| | | | | | | | | | | | | |
| JB | 3690 | 2-year | 312.00 | 5.25 | 9.29 | | 9.36 | 0.000550 | 2.05 | 152.50 | 50.59 | 0.21 |
| JB | 3690 | 5-year | 428.00 | 5.25 | 10.32 | | 10.38 | 0.000437 | 2.06 | 207.44 | 57.04 | 0.19 |
| JB | 3690 | 10-year | 519.00 | 5.25 | 11.02 | | 11.09 | 0.000387 | 2.08 | 249.12 | 61.53 | 0.18 |
| JB | 3690 | 25-year | 647.00 | 5.25 | 11.93 | | 12.00 | 0.000341 | 2.10 | 308.87 | 90.52 | 0.17 |
| JB | 3690 | 50-year | 747.00 | 5.25 | 12.30 | | 12.38 | 0.000352 | 2.22 | 359.14 | 195.54 | 0.18 |
| JB | 3690 | 100-year | 858.00 | 5.25 | 12.64 | | 12.72 | 0.000349 | 2.32 | 469.24 | 473.95 | 0.18 |
| | | | | | | | | | | | | |
| JB | 3631 | 2-year | 416.00 | 5.15 | 9.21 | | 9.32 | 0.000971 | 2.72 | 153.07 | 50.77 | 0.28 |
| JB | 3631 | 5-year | 568.00 | 5.15 | 10.24 | | 10.35 | 0.000765 | 2.72 | 208.88 | 57.80 | 0.25 |
| JB | 3631 | 10-year | 688.00 | 5.15 | 10.94 | | 11.06 | 0.000675 | 2.74 | 251.38 | 62.63 | 0.24 |
| JB | 3631 | 25-year | 855.00 | 5.15 | 11.86 | | 11.98 | 0.000587 | 2.74 | 312.12 | 75.34 | 0.23 |
| JB | 3631 | 50-year | 987.00 | 5.15 | 12.22 | | 12.35 | 0.000624 | 2.92 | 351.08 | 163.27 | 0.24 |
| JB | 3631 | 100-year | 1131.00 | 5.15 | 12.55 | | 12.69 | 0.000644 | 3.06 | 434.24 | 333.56 | 0.24 |
| | | | | | | | | | | | | |
| JB | 3326 | 2-year | 416.00 | 4.26 | 8.97 | | 9.06 | 0.000714 | 2.43 | 171.06 | 53.19 | 0.24 |
| JB | 3326 | 5-year | 568.00 | 4.26 | 10.05 | | 10.15 | 0.000564 | 2.44 | 249.10 | 308.57 | 0.22 |
| JB | 3326 | 10-year | 688.00 | 4.26 | 10.84 | | 10.89 | 0.000362 | 2.10 | 532.01 | 410.25 | 0.18 |
| JB | 3326 | 25-year | 855.00 | 4.26 | 11.83 | | 11.86 | 0.000189 | 1.64 | 1005.24 | 551.14 | 0.13 |
| JB | 3326 | 50-year | 987.00 | 4.26 | 12.20 | | 12.23 | 0.000174 | 1.62 | 1234.81 | 712.64 | 0.13 |
| JB | 3326 | 100-year | 1131.00 | 4.26 | 12.54 | | 12.57 | 0.000170 | 1.64 | 1530.11 | 1051.81 | 0.13 |
| | | | | | | | | | | | | |
| JB | 3026 | 2-year | 499.00 | 4.04 | 8.72 | | 8.83 | 0.000808 | 2.68 | 185.93 | 54.63 | 0.26 |
| JB | 3026 | 5-year | 685.00 | 4.04 | 9.86 | | 9.97 | 0.000621 | 2.65 | 318.08 | 220.13 | 0.23 |
| JB | 3026 | 10-year | 831.00 | 4.04 | 10.69 | | 10.77 | 0.000452 | 2.43 | 559.65 | 381.83 | 0.20 |
| JB | 3026 | 25-year | 1035.00 | 4.04 | 11.74 | | 11.79 | 0.000277 | 2.06 | 1148.20 | 989.93 | 0.16 |
| JB | 3026 | 50-year | 1197.00 | 4.04 | 12.12 | | 12.17 | 0.000246 | 1.98 | 1604.80 | 1396.60 | 0.15 |
| JB | 3026 | 100-year | 1375.00 | 4.04 | 12.47 | | 12.51 | 0.000215 | 1.91 | 2165.35 | 1735.31 | 0.14 |
| | | | | | | | | | | | | |
| JB | 2724 | 2-year | 499.00 | 3.34 | 8.53 | | 8.62 | 0.000598 | 2.43 | 205.60 | 55.93 | 0.22 |
| JB | 2724 | 5-year | 685.00 | 3.34 | 9.70 | | 9.79 | 0.000502 | 2.49 | 275.44 | 63.55 | 0.21 |
| JB | 2724 | 10-year | 831.00 | 3.34 | 10.54 | | 10.64 | 0.000428 | 2.46 | 381.26 | 237.65 | 0.20 |
| JB | 2724 | 25-year | 1035.00 | 3.34 | 11.66 | | 11.71 | 0.000229 | 1.95 | 974.15 | 757.62 | 0.15 |
| JB | 2724 | 50-year | 1197.00 | 3.34 | 12.06 | | 12.10 | 0.000197 | 1.86 | 1312.05 | 940.05 | 0.14 |
| JB | 2724 | 100-year | 1375.00 | 3.34 | 12.42 | | 12.45 | 0.000173 | 1.78 | 1696.72 | 1211.72 | 0.13 |
| | | | | | | | | | | | | |
| JB | 2421 | 2-year | 524.00 | 2.85 | 8.37 | | 8.45 | 0.000479 | 2.26 | 231.51 | 59.24 | 0.20 |
| JB | 2421 | 5-year | 719.00 | 2.85 | 9.57 | | 9.65 | 0.000415 | 2.34 | 306.80 | 66.74 | 0.19 |
| JB | 2421 | 10-year | 874.00 | 2.85 | 10.43 | | 10.51 | 0.000377 | 2.39 | 366.39 | 75.17 | 0.19 |
| JB | 2421 | 25-year | 1089.00 | 2.85 | 11.56 | | 11.63 | 0.000284 | 2.23 | 740.62 | 988.60 | 0.16 |
| JB | 2421 | 50-year | 1259.00 | 2.85 | 11.98 | | 12.03 | 0.000232 | 2.07 | 1236.11 | 1304.55 | 0.15 |
| JB | 2421 | 100-year | 1447.00 | 2.85 | 12.36 | | 12.39 | 0.000182 | 1.88 | 1804.03 | 1816.87 | 0.13 |
| | | | | | | | | | | | | |
| JB | 2270 | 2-year | 700.00 | 2.58 | 7.68 | 5.40 | 8.11 | 0.001762 | 5.28 | 132.61 | 73.78 | 0.41 |
| JB | 2270 | 5-year | 957.00 | 2.58 | 8.68 | 6.06 | 9.25 | 0.001810 | 6.03 | 158.68 | 82.33 | 0.43 |
| JB | 2270 | 10-year | 1160.00 | 2.58 | 9.39 | 6.53 | 10.05 | 0.001847 | 6.55 | 177.01 | 88.34 | 0.44 |
| JB | 2270 | 25-year | 1442.00 | 2.58 | 10.29 | 7.15 | 11.09 | 0.001882 | 7.19 | 200.58 | 100.59 | 0.46 |
| JB | 2270 | 50-year | 1664.00 | 2.58 | 11.96 | 7.61 | 11.99 | 0.000140 | 1.63 | 2562.86 | 2759.33 | 0.12 |

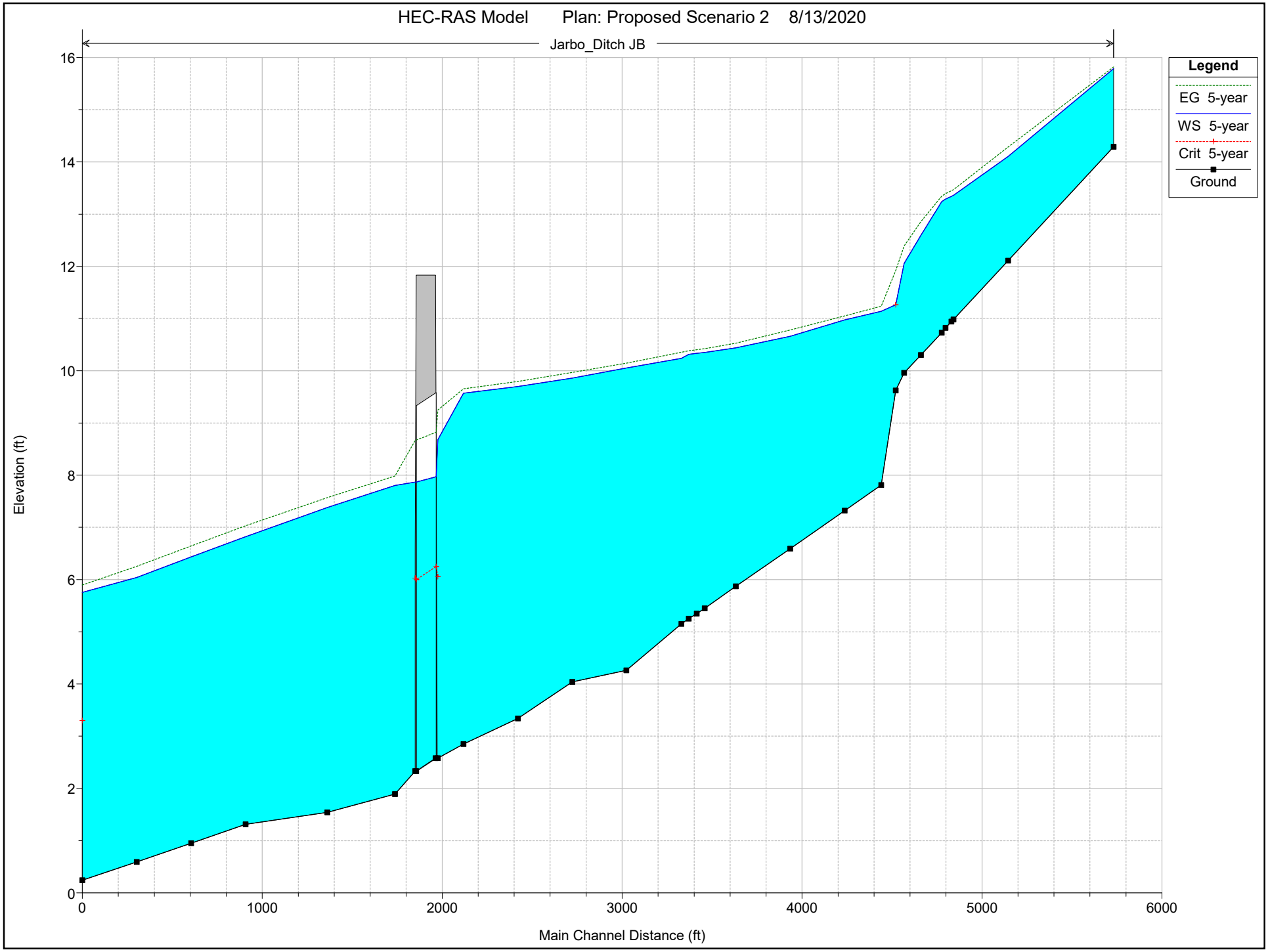
HEC-RAS Plan: Prop Scen 2 River: Jarbo_Ditch Reach: JB (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| JB | 2270 | 100-year | 1908.00 | 2.58 | 12.34 | 8.09 | 12.36 | 0.000098 | 1.39 | 3808.37 | 3911.31 | 0.10 |
| | | | | | | | | | | | | |
| JB | 2209 | | Culvert | | | | | | | | | |
| | | | | | | | | | | | | |
| JB | 2153 | 2-year | 743.00 | 2.33 | 7.10 | 5.35 | 7.68 | 0.002637 | 6.10 | 121.77 | 70.00 | 0.50 |
| JB | 2153 | 5-year | 1015.00 | 2.33 | 7.87 | 6.03 | 8.67 | 0.002963 | 7.16 | 141.77 | 76.50 | 0.54 |
| JB | 2153 | 10-year | 1229.00 | 2.33 | 8.37 | 6.53 | 9.35 | 0.003245 | 7.94 | 154.75 | 80.72 | 0.57 |
| JB | 2153 | 25-year | 1528.00 | 2.33 | 8.96 | 7.17 | 10.21 | 0.003656 | 8.98 | 170.15 | 85.72 | 0.62 |
| JB | 2153 | 50-year | 1762.00 | 2.33 | 9.35 | 7.64 | 10.84 | 0.004002 | 9.77 | 180.37 | 89.04 | 0.65 |
| JB | 2153 | 100-year | 2020.00 | 2.33 | 9.68 | 8.14 | 11.46 | 0.004502 | 10.69 | 188.99 | 95.34 | 0.70 |
| | | | | | | | | | | | | |
| JB | 2041 | 2-year | 745.00 | 1.89 | 7.01 | | 7.16 | 0.001056 | 3.10 | 240.64 | 70.49 | 0.30 |
| JB | 2041 | 5-year | 1019.00 | 1.89 | 7.80 | | 7.98 | 0.001079 | 3.40 | 299.47 | 77.27 | 0.30 |
| JB | 2041 | 10-year | 1234.00 | 1.89 | 8.32 | | 8.53 | 0.001108 | 3.62 | 340.90 | 81.70 | 0.31 |
| JB | 2041 | 25-year | 1533.00 | 1.89 | 8.95 | | 9.19 | 0.001151 | 3.89 | 393.79 | 87.06 | 0.32 |
| JB | 2041 | 50-year | 1768.00 | 1.89 | 9.37 | | 9.63 | 0.001195 | 4.10 | 431.24 | 90.67 | 0.33 |
| JB | 2041 | 100-year | 2027.00 | 1.89 | 9.74 | | 10.03 | 0.001279 | 4.36 | 469.59 | 137.65 | 0.35 |
| | | | | | | | | | | | | |
| JB | 1665 | 2-year | 752.00 | 1.54 | 6.60 | | 6.75 | 0.001094 | 3.15 | 238.87 | 70.01 | 0.30 |
| JB | 1665 | 5-year | 1028.00 | 1.54 | 7.38 | | 7.57 | 0.001124 | 3.47 | 296.35 | 76.60 | 0.31 |
| JB | 1665 | 10-year | 1245.00 | 1.54 | 7.89 | | 8.10 | 0.001165 | 3.70 | 336.14 | 80.84 | 0.32 |
| JB | 1665 | 25-year | 1547.00 | 1.54 | 8.49 | | 8.74 | 0.001227 | 4.00 | 386.37 | 85.90 | 0.33 |
| JB | 1665 | 50-year | 1784.00 | 1.54 | 8.89 | | 9.17 | 0.001290 | 4.24 | 421.27 | 95.54 | 0.34 |
| JB | 1665 | 100-year | 2045.00 | 1.54 | 9.22 | | 9.53 | 0.001375 | 4.49 | 500.62 | 427.53 | 0.36 |
| | | | | | | | | | | | | |
| JB | 1211 | 2-year | 763.00 | 1.31 | 6.06 | | 6.23 | 0.001194 | 3.28 | 232.29 | 68.18 | 0.31 |
| JB | 1211 | 5-year | 1043.00 | 1.31 | 6.82 | | 7.03 | 0.001251 | 3.64 | 286.40 | 74.51 | 0.33 |
| JB | 1211 | 10-year | 1263.00 | 1.31 | 7.30 | | 7.54 | 0.001320 | 3.91 | 323.79 | 85.72 | 0.34 |
| JB | 1211 | 25-year | 1569.00 | 1.31 | 7.86 | | 8.14 | 0.001405 | 4.24 | 382.18 | 143.15 | 0.36 |
| JB | 1211 | 50-year | 1810.00 | 1.31 | 8.26 | | 8.55 | 0.001413 | 4.38 | 478.59 | 382.86 | 0.36 |
| JB | 1211 | 100-year | 2074.00 | 1.31 | 8.66 | | 8.92 | 0.001252 | 4.27 | 672.94 | 525.36 | 0.34 |
| | | | | | | | | | | | | |
| JB | 908 | 2-year | 771.00 | 0.95 | 5.70 | | 5.87 | 0.001203 | 3.30 | 233.52 | 68.43 | 0.32 |
| JB | 908 | 5-year | 1054.00 | 0.95 | 6.43 | | 6.65 | 0.001281 | 3.69 | 285.97 | 74.37 | 0.33 |
| JB | 908 | 10-year | 1276.00 | 0.95 | 6.88 | | 7.13 | 0.001377 | 3.99 | 319.87 | 77.97 | 0.35 |
| JB | 908 | 25-year | 1585.00 | 0.95 | 7.40 | | 7.70 | 0.001518 | 4.39 | 361.39 | 82.16 | 0.37 |
| JB | 908 | 50-year | 1829.00 | 0.95 | 7.75 | | 8.09 | 0.001624 | 4.67 | 396.68 | 112.56 | 0.38 |
| JB | 908 | 100-year | 2095.00 | 0.95 | 8.09 | | 8.46 | 0.001733 | 4.95 | 442.26 | 181.81 | 0.40 |
| | | | | | | | | | | | | |
| JB | 606 | 2-year | 777.00 | 0.59 | 5.33 | | 5.50 | 0.001211 | 3.30 | 235.19 | 69.19 | 0.32 |
| JB | 606 | 5-year | 1061.00 | 0.59 | 6.04 | | 6.25 | 0.001308 | 3.71 | 291.14 | 100.89 | 0.33 |
| JB | 606 | 10-year | 1285.00 | 0.59 | 6.45 | | 6.70 | 0.001431 | 4.03 | 335.48 | 116.16 | 0.35 |
| JB | 606 | 25-year | 1596.00 | 0.59 | 6.92 | | 7.22 | 0.001599 | 4.45 | 401.73 | 162.78 | 0.38 |
| JB | 606 | 50-year | 1840.00 | 0.59 | 7.24 | | 7.59 | 0.001709 | 4.72 | 465.49 | 230.35 | 0.39 |
| JB | 606 | 100-year | 2108.00 | 0.59 | 7.56 | | 7.93 | 0.001773 | 5.00 | 560.72 | 392.69 | 0.40 |
| | | | | | | | | | | | | |
| JB | 303 | 2-year | 786.00 | 0.24 | 5.04 | 2.70 | 5.17 | 0.000957 | 2.95 | 314.43 | 132.61 | 0.28 |
| JB | 303 | 5-year | 1073.00 | 0.24 | 5.76 | 3.30 | 5.89 | 0.000956 | 3.19 | 434.61 | 199.99 | 0.29 |
| JB | 303 | 10-year | 1300.00 | 0.24 | 6.17 | 3.65 | 6.32 | 0.000957 | 3.32 | 523.49 | 225.56 | 0.29 |
| JB | 303 | 25-year | 1614.00 | 0.24 | 6.66 | 4.03 | 6.81 | 0.000956 | 3.46 | 652.75 | 320.32 | 0.29 |
| JB | 303 | 50-year | 1862.00 | 0.24 | 7.00 | 4.33 | 7.15 | 0.000956 | 3.55 | 797.22 | 539.22 | 0.29 |
| JB | 303 | 100-year | 2133.00 | 0.24 | 7.33 | 4.58 | 7.48 | 0.000956 | 3.67 | 1003.81 | 754.93 | 0.30 |

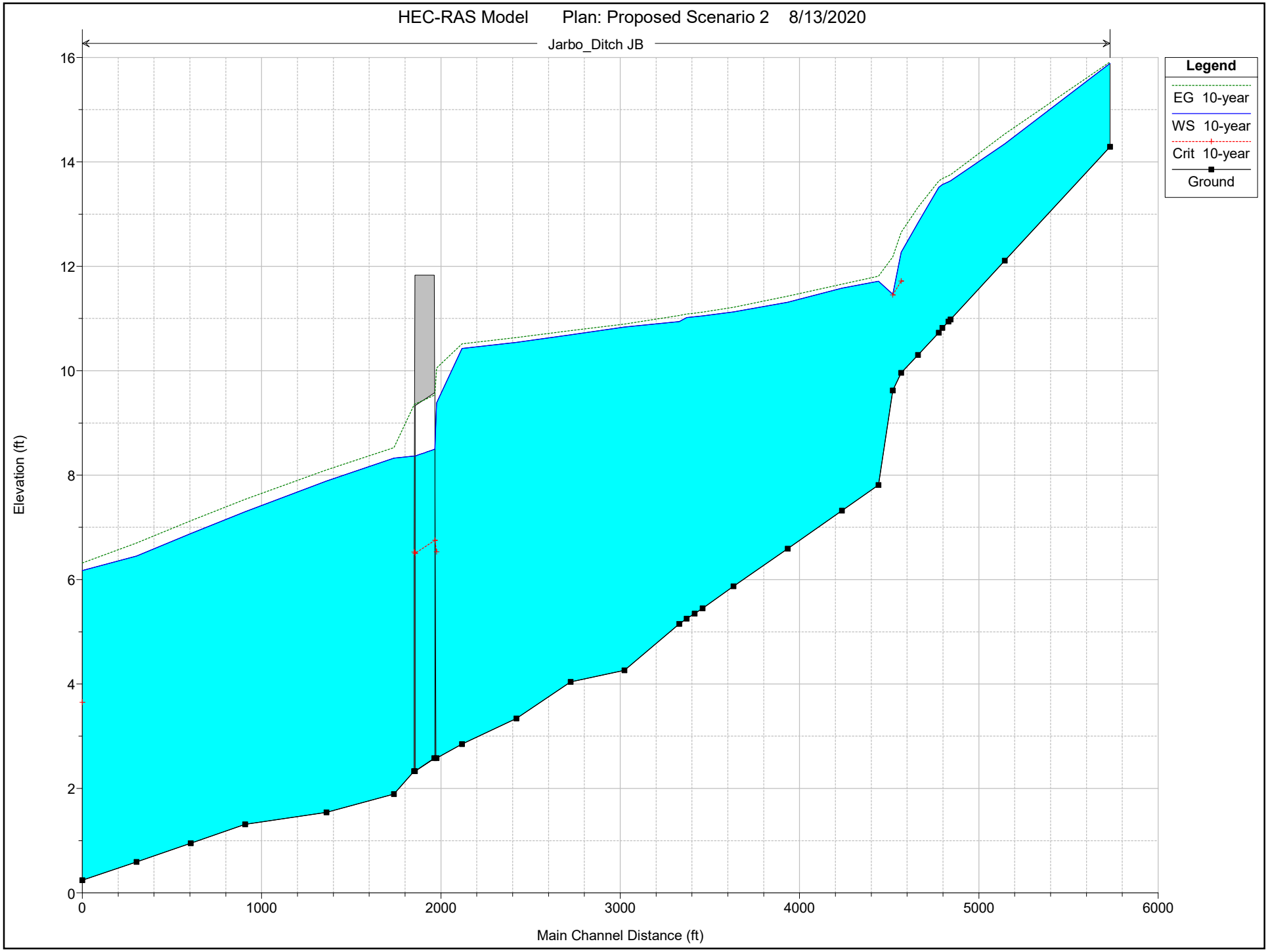
# Scenario 2 2-year Water Surface Profile



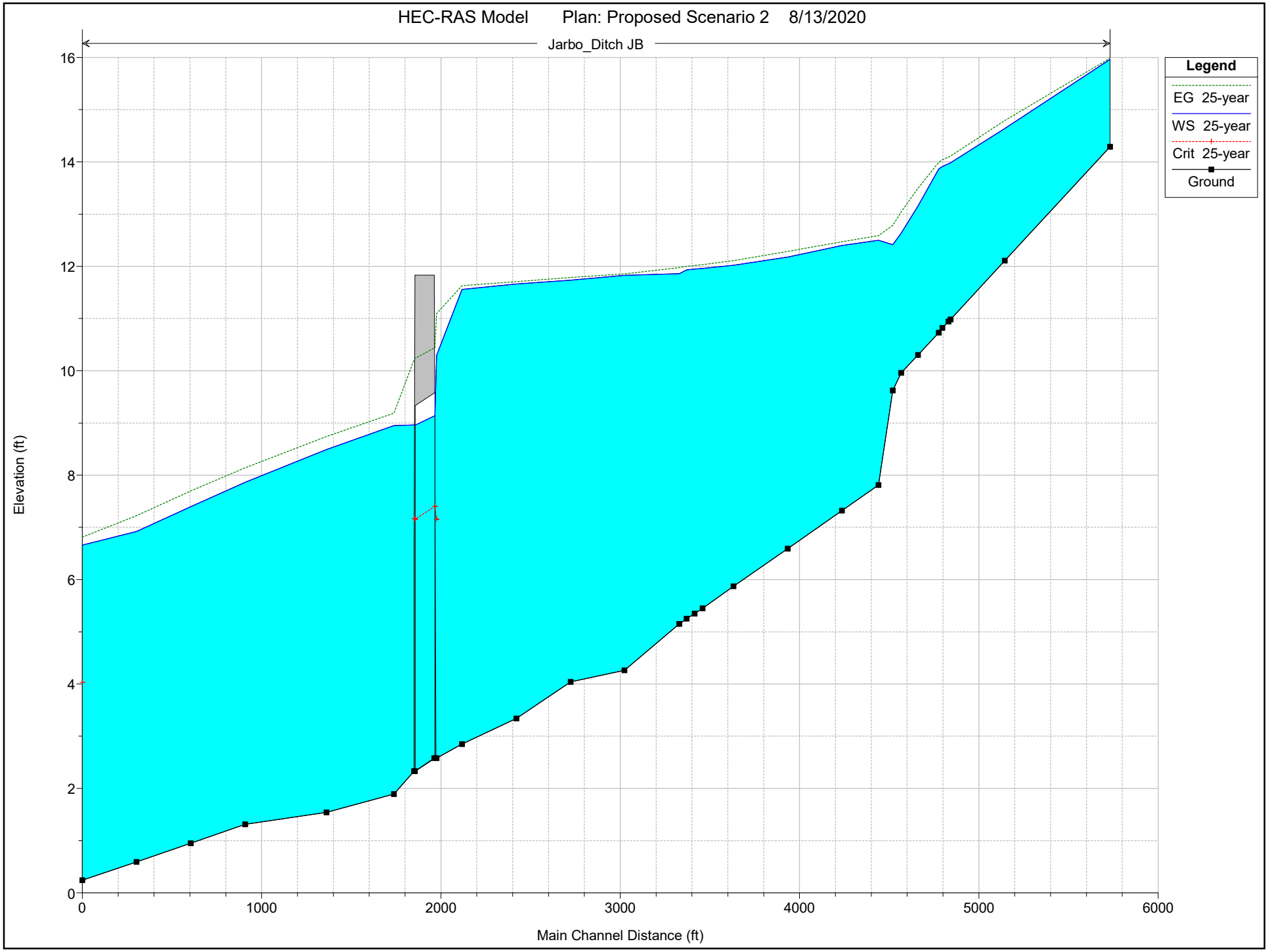
# Scenario 2 5-year Water Surface Profile



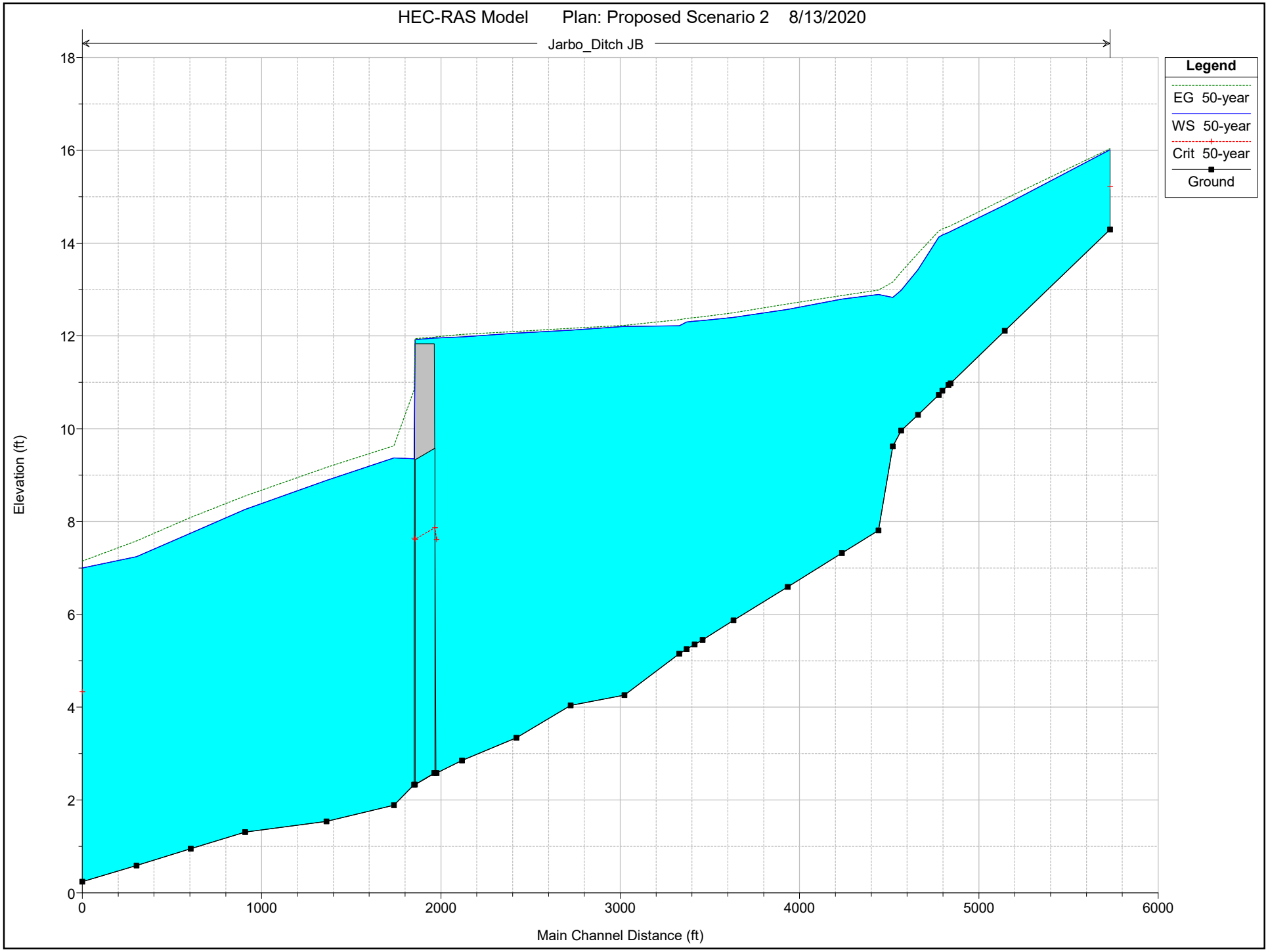
# Scenario 2 10-year Water Surface Profile



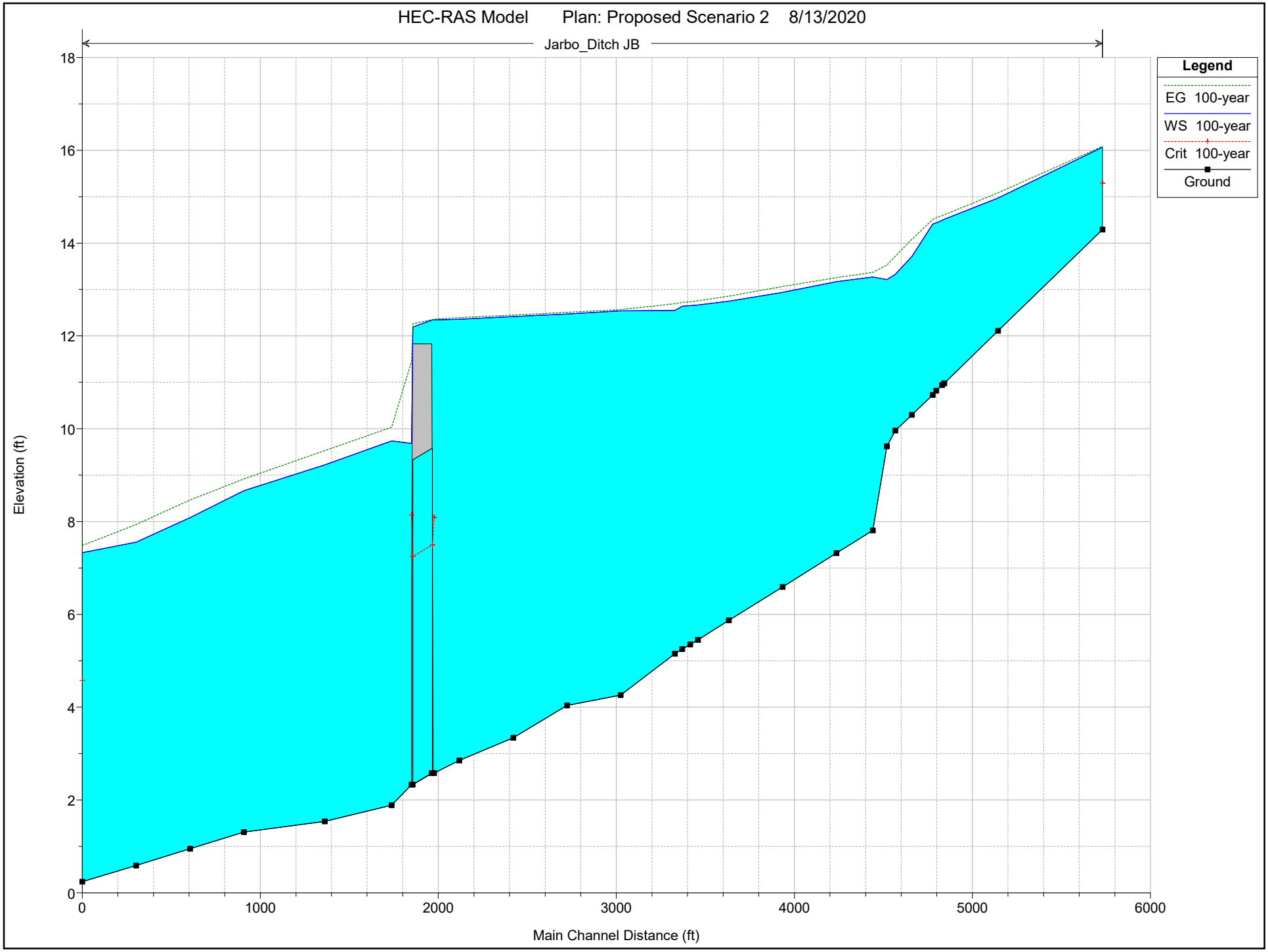
# Scenario 2 25-year Water Surface Profile



# Scenario 2 50-year Water Surface Profile



# Scenario 2 100-year Water Surface Profile



# APPENDIX I
# BAYVIEW PROPOSED DITCH CALCULATIONS

**Appendix I - Bayview Proposed Ditch Calculations**

| Type | Bottom Width (ft) | Depth (ft) | Left Side Slope (ft to ft) | Left Side Slope (ft/ft) | Length, Left Side (ft) | Right Side Slope (ft to ft) | Right Side Slope (ft/ft) | Length, Right Side (ft) | Top Width (ft) | Wetted Perimeter (ft) | Area ($ft^2$) | Hydraulic Radius (ft) | Ditch Surface | n | Ditch Slope (ft/ft) | $Q_{DITCH}$ (cfs) (PER SIDE) | Associated DA-IDs | $\Sigma Q_2$ (cfs) | $\Sigma Q_{100}$ (cfs) | V (fps) | Road Width (ft) | Shoulder Width (ft) | ROW Necessary (ft) | Existing ROW (ft) | Sufficient ROW? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ALTERNATIVE 1 and 2 - BAY AREA DITCH CONVEYANCE [DA-7]** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Trapezoid | 2.0 | 2.75 | 2.50 to 1.00 | 0.40 | 7.06 | 3.00 to 1.00 | 0.33 | 8.40 | 17.1 | 17.5 | 26.3 | 1.51 | Grass-Lined | 0.040 | 0.002 | 57.55 | DA-7 | 39.46 | 104.14 | 2.19 | 22.0 | 1.0 | 58.3 | 60 | Yes |
| **ALTERNATIVE 1 - YACHT CLUB NORTH CONVEYANCE [DA-3 - DA-6]** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Trapezoid | 4.0 | 2.50 | 2.50 to 1.00 | 0.40 | 6.42 | 2.50 to 1.00 | 0.40 | 6.42 | 16.5 | 16.8 | 25.6 | 1.52 | Grass-Lined | 0.040 | 0.002 | 56.48 | DA-6 | 34.18 | 89.73 | 2.20 | 22.0 | 1.0 | 57.0 | 60 | Yes |
| Trapezoid | 4.0 | 1.75 | 3.00 to 1.00 | 0.33 | 5.35 | 3.00 to 1.00 | 0.33 | 5.35 | 14.5 | 14.7 | 16.2 | 1.10 | Grass-Lined | 0.040 | 0.002 | 28.76 | DA-3 | 16.98 | 44.52 | 1.78 | 22.0 | 1.0 | 53.0 | 60 | Yes |
| Trapezoid | 4.0 | 2.15 | 3.00 to 1.00 | 0.33 | 6.57 | 3.00 to 1.00 | 0.33 | 6.57 | 16.9 | 17.1 | 22.5 | 1.31 | Grass-Lined | 0.040 | 0.002 | 44.83 | DA-3, DA-4 | 31.50 | 82.52 | 2.00 | 22.0 | 1.0 | 57.8 | 60 | Yes |
| Trapezoid | 5.0 | 2.50 | 2.50 to 1.00 | 0.40 | 6.42 | 2.50 to 1.00 | 0.40 | 6.42 | 17.5 | 17.8 | 28.1 | 1.58 | Grass-Lined | 0.040 | 0.002 | 63.47 | DA-3, DA-4, DA-5 | 43.14 | 112.95 | 2.26 | 22.0 | 1.0 | 59.0 | 60 | Yes |
| **ALTERNATIVE 2 - YACHT CLUB NORTH CONVEYANCE [DA-5 - DA-6]** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Trapezoid | 4.0 | 2.50 | 2.50 to 1.00 | 0.40 | 6.42 | 2.50 to 1.00 | 0.40 | 6.42 | 16.5 | 16.8 | 25.6 | 1.52 | Grass-Lined | 0.040 | 0.002 | 56.48 | DA-6 | 34.18 | 89.73 | 2.20 | 22.0 | 1.0 | 57.0 | 60 | Yes |
| Trapezoid | 4.0 | 2.00 | 3.00 to 1.00 | 0.33 | 6.11 | 3.00 to 1.00 | 0.33 | 6.11 | 16.0 | 16.2 | 20.0 | 1.23 | Grass-Lined | 0.040 | 0.002 | 38.30 | DA-5 | 11.64 | 30.43 | 1.92 | 22.0 | 1.0 | 56.0 | 60 | Yes |
| **ALTERNATIVE 2 - YACHT CLUB SOUTH CONVEYANCE [DA-3 - DA-4]** | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | 0.0 | | Yes |
| Trapezoid | 2.0 | 2.50 | 3.00 to 1.00 | 0.33 | 7.64 | 3.00 to 1.00 | 0.33 | 7.64 | 17.0 | 17.3 | 23.8 | 1.37 | Grass-Lined | 0.040 | 0.002 | 48.91 | DA-3, DA-4 | 31.50 | 82.52 | 2.06 | 22.0 | 1.0 | 58.0 | 60 | Yes |
| | | | | | | | | | | | | | | | | | | | | | | | 0.0 | | Yes |

# Kemah City Council Agenda Item

## #14 Backfill KCDC Position

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by:Mayor Gale

Subject: to determine a process and timeline to backfill an open KCDC position

Proceeding: Consent

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

**SUMMARY / ORIGINATING CAUSE**

Les Hart will not be on KCDC Board and that vacancy will need to be filled.

**IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY**

**RECOMMENDATIONS**

To discuss a process for filling the KCDC Position.

**ATTACHMENTS**

# Kemah City Council Agenda Item

## #15 RFP evaluation scoring matrix

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by: Teresa Vazquez-Evans

Subject: on the approval of an evaluation scoring matrix to be used in the RFP selection process for the schoolhouse and train depot lease.

Proceeding: Consideration and Possible Action

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

**SUMMARY / ORIGINATING CAUSE**

**IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY**

**RECOMMENDATIONS**

**ATTACHMENTS**

# Kemah City Council Agenda Item

## #16 Ordinance 1086 – Business Registration

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by: Teresa Vazquez-Evans

Subject: of City of Kemah's ordinance requirement for annual business registration

Proceeding: Consideration and Possible Action

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

**SUMMARY / ORIGINATING CAUSE**

**IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY**

**RECOMMENDATIONS**

**ATTACHMENTS**

Ordinance 1086 – Business Registration

**ORDINANCE NO. 1086**

**AN ORDINANCE REQUIRING THE REGISTRATION OF A BUSINESS CONDUCTED IN A COMMERCIAL BUILDING OR STRUCTURE IN THE CITY OF KEMAH, TEXAS**

WHEREAS, the City of Kemah, Texas, deems it to be in the public interest to require the registration of any business, conducted in a commercial building or structure in the City;

**NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF KEMAH, TEXAS, THAT:**

**SECTION ONE:** Any business that occupies any commercial building or commercial structure shall register annually with the CITY SECRETARY. "BUSINESS is a person, firm or corporation that sells goods or provides services. A "COMMERCIAL BUILDING" or "COMMERCIAL STRUCTURE" is a structure used for commercial BUSINESS purposes and it may include a structure that once served a purely residential purpose. Such registration shall require the payment of an administrative fee reasonably related to the cost of such regulation: $75.00 per application, renewable annually. The certificate of registration shall be represented by a Certificate of Occupancy and shall indicate that it is valid only for the calendar year it was issued.

**SECTION TWO:** It shall be unlawful for any BUSINESS to operate within the CITY in a COMMERCIAL BUILDING OR STRUCTURE without evidence of current (calendar year) registration under this ordinance visibly displayed on premises. It shall be unlawful for any BUSINESS to operate within the City in a COMMERCIAL BUILDING OR STRUCTURE unless the address on the registration certificate accurately corresponds with the address of the site where the business is being conducted. In other words, should a registered business move from one regulated location to another within the CITY, the original registration shall be void and a new registration and certificate shall be required before the BUSINESS is validly registered hereunder. Issuance of a Certificate of Occupancy shall not constitute any endorsement by the CITY or approval of the BUSINESS or business practices of the applicant and it shall be unlawful for the applicant to imply that the BUSINESS has been endorsed or recommended by the CITY. It shall be unlawful for any COMMERCIAL BUILDING OR STRUCTURE to obtain a registration, e.g., Certificate of Occupancy without first being inspected annually by the City Fire Marshal and City Building Inspector to verify that Life/Safety provisions and the Approved Use and Occupancy of the COMMERCIAL BUILDING OR STRUCTURE for the respective BUSINESS use. The applicable inspections shall indicate that the COMMERCIAL BUILDING OR STRUCTURE and BUSINESS use is in compliance with applicable codes. Applicable codes; Means those adopted codes in effect at the time the COMMERCIAL BUILDING OR STRUCTURE was constructed, erected, built, re-modeled or modified for the BUSINESS use. Applicable codes shall not be intended to omit any life/safety provisions applicable to the BUSINESS use required by law.

**SECTION THREE:** Any person, firm or corporation violating or failing to comply with any provision of this ordinance shall be guilty of a misdemeanor punishable by fine to the maximum allowable amount by law. Each day shall be a separate violation.

**AND IT IS SO ORDERED.**

**PASSED AND APPROVED ON FIRST READING THIS 2nd DAY OF JANUARY, 2013**

**PASSED AND APPROVED ON SECOND AND FINAL READING THIS 16th DAY OF JANUARY, 2013.**

Wayne Rast

**MAYOR**
CITY OF KEMAH, TEXAS

ATTEST:

Marisela Garcia

**CITY SECRETARY**
CITY OF KEMAH, TEXAS

# Kemah City Council Agenda Item

## #17 Licensed Peace Officer at Bars with over 50% alcohol

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by: Mayor Gale

Subject: to approve an ordinance requiring bars and over 50% alcohol restaurants to have licensed peace officers in their security staff

Proceeding: Consideration and Possible Action

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

**SUMMARY / ORIGINATING CAUSE**

**IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY**

**RECOMMENDATIONS**

**ATTACHMENTS**

# Kemah City Council Agenda Item

## #18 Lighthouse District Safety

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by: Mayor Gale

Subject: to revise the configuration, timing, signage, and any other aspects of the bollards, lighting, parking areas, and other safety-related changes for 6th street and the Lighthouse District

Proceeding: Consent

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

### SUMMARY / ORIGINATING CAUSE

At the Council Meeting on September 24th, the Council agreed to put more precautions in place in the Lighthouse District for safety measures as well as make this a reoccurring agenda item

### IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY

### RECOMMENDATIONS

### ATTACHMENTS

# Kemah City Council Agenda Item

## #19 Police Department Staffing

***Once form is complete and departmental clearances are obtained, this form should be forwarded to the City Secretary as soon as possible prior to the date that the item is expected to be placed on the City Council agenda.***

Date requested for Council consideration: 10/07/2020

Prepared by: Kyle Burks

Subject: to determine staffing of Kemah police officers for certain shifts throughout the week and weekend and supplementing certain shifts with outside agencies to potentially include, but not limited to, Galveston County.

Proceeding: Consideration and Possible Action

Originating Department: Admin

Plan Reference: 17SP- or 17OP-

Texas Ethics Commission Form 1295 required? *n/a*

If YES, is copy of Form attached? Contract Identification Number on Form:

City Attorney Review: *n/a*

Expenditure Required: Amount Budgeted:

Appropriation Required: Source of Funds:

Finance Approval: n/a

City Administrator Approval:

**SUMMARY / ORIGINATING CAUSE**

**IMMINENT CONSEQUENCES / BENEFIT TO COMMUNITY**

**RECOMMENDATIONS**

**ATTACHMENTS**