

# 2023 REGIONAL FLOOD PLAN REGION 6 SAN JACINTO

July 2023

PREPARED FOR THE SAN JACINTO  
REGIONAL FLOOD PLANNING GROUP



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Supplemental Source Documentation**

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**Appendix 5-4AL:  
Halls Bayou CDBG-MIT Application 1 Projects**

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PLANNING  
 ENGINEERING  
 PROGRAM MANAGEMENT

memo

**TEXAS**

AUSTIN  
 COLLEGE STATION  
 CORPUS CHRISTI  
 DALLAS  
 FORT WORTH  
 FRISCO  
 HOUSTON  
 LAREDO  
 MONTGOMERY COUNTY  
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FLINT  
 LANSING

**OKLAHOMA**

NORMAN

Date: December 15, 2020  
 Prepared By: Chris Edwards, P.E., CFM  
 Project #: 120-11994-000, 120-12170-000  
 Project Name: Halls Bayou Implementation Program  
 Subject: Halls Bayou Mainstem Potential Projects

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Lockwood, Andrews & Newnam, Inc. (LAN) was authorized by Harris County Flood Control District (HCFCD) to determine additional projects along the Mainstem of Halls Bayou, that might be considered for upcoming grant funding opportunities. Over the past four months, the following options have been explored:

Channel Improvements:

- Option 1: Bertrand to Hopper (100-year LOS)
- Option 2: Hopper to Bretshire (20-foot expansion)
- Option 3: Aldine-Westfield Road to Keith-Weiss (40-foot expansion)

Regional Detention Basins:

- Option 4: Hardy West
- Option 5: Aldine Westfield
- Option 6: Mary Withers

**Summary/Recommendations:**

We recommend considering Channel Improvement Options 2 and 3, as well Regional Detention Options 4 and 5. These projects provide significant relief from flooding along the Mainstem of Halls Bayou, and do not result in adverse impacts upstream or downstream. The Channel Improvement Options are offset by the inclusion of the existing Regional Basins of Keith Weiss, Bretshire, and Hall Park, as described in more detail below. Options 4 and 5 provide needed detention along the mainstem, are in line with Phase 1 of the Halls Bayou Phasing Study, and can help facilitate future mainstem projects in the area. Option 1, while providing localized flooding relief, offsets benefits seen downstream from Option 2 where a higher number of flooded structures are located. Option 6 may still be considered for a future project, however it will require additional coordination w/ the City of Houston before being fully considered for pursuing grant funding.

Lockwood, Andrews & Newnam, Inc.  
 A LEO A DALY COMPANY  
 2925 Briarpark Drive  
 Suite 400  
 Houston, TX 77042  
 713.266.6900

lan-inc.com

# 1 Channel Improvement Options

The objectives for this analysis were to update the Halls Bayou Baseline Conditions model to reflect conditions prior to the construction of Keith-Weiss, Bretshire, and Hall Park regional detention basins, and to identify channel improvement concepts in the vicinity of those basins that reduce water surface elevations (WSEs) within Halls Bayou without introducing adverse impacts.

Starting from the Baseline Conditions model from the Halls Bayou Phasing Study, the Without Projects Conditions model was created by removing geometry associated with Keith-Weiss, Bretshire, and Hall Park regional detention basins. For Keith-Weiss, the storage area was first converted into a 2D flow area in the Baseline Conditions model to better represent the transfer of water across the large detention basin footprint. Then, in the Without Project Conditions model, the cross sections along Keith Weiss were reverted to the 2007 Effective HEC-RAS model, based on 2001 LiDAR taken prior to the construction of the basin. A comparison of the site is shown below:



FIGURE I: KEITH-WEISS PARK IMAGERY, 2006 AND 2016.

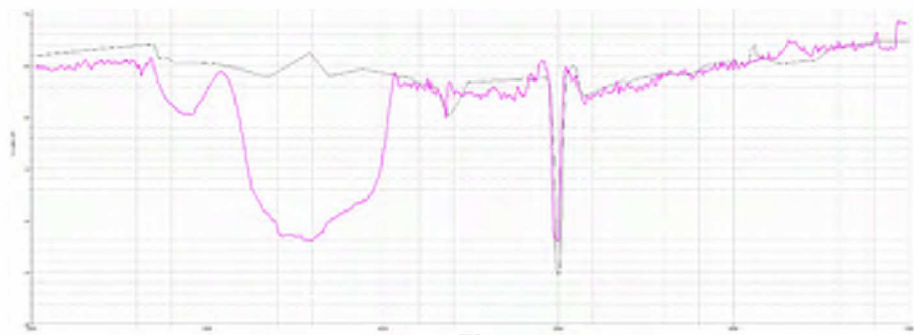


FIGURE II: PRE- VS. POST-CONSTRUCTION AT KEITH-WEISS (PROPOSED IN MAGENTA)

For Bretshire and Hall Park, 35 cross sections from river station 43789 to 37413 were reverted to their pre-basin geometry, as these basins were modeled within the cross sections themselves. Other small adjustments were made to both geometric models to provide additional stability, including updating Htab parameters and adding cross sections near the confluence of P118-26-00 and Halls Bayou. With the geometry updated, the Without Project Conditions model was run for the 10-, 100-, and 500-year pre-Atlas 14 design storm events.

The Baseline Conditions and Without Project Conditions WSEs were compared to better understand the benefits provided by these three basins to Halls Bayou, and to help identify locations for channel conveyance improvements. Near Keith-Weiss, the 500- and 100-year events show maximum depth reductions of 1.65 feet and 2.05 feet, respectively. Near Bretshire/Hall Park, the 500- and 100-year events show maximum depth reductions of 1.15

feet and 2.1 feet, respectively. No adverse impacts were observed from the implementation of these basins.

**TABLE I: REDUCTIONS IN WSE FROM WITHOUT PROJECTS TO BASELINE CONDITIONS**

Location	Reduction in WSE (feet)	
	100-year	500-year
Keith-Weiss	2.05	1.65
Bretshire/Hall Park	2.1	1.15

The following pages describe each Option: their location, geometries, benefits, cost, and other considerations. Performance metrics for each Option are based on a standalone project, however all three Options have also been incorporated into one model to check for adverse impacts. When combined, no adverse impacts are observed when compared to the Without Projects Conditions model. Additionally, these options, when combined, do not significantly change the performance of each individual option.

## 1.1 Option 1 – Bertrand to Hopper (100-year LOS)

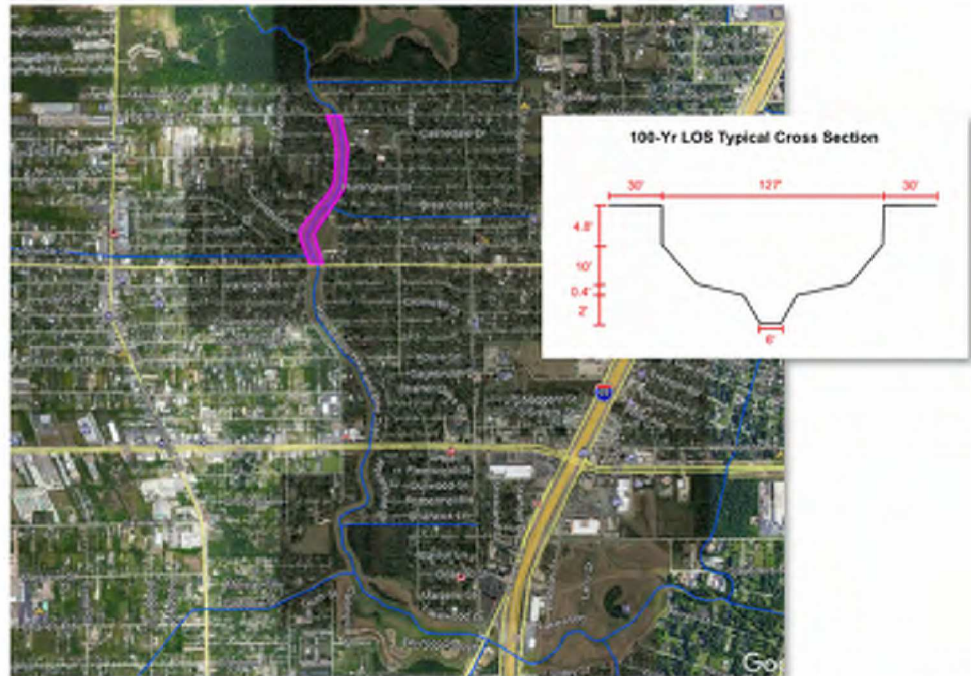


FIGURE 1: OPTION 1 – BERTRAND TO HOPPER PROJECT LOCATION

Proposed channel improvements for Option 1 extend from downstream of Bertrand Street to Hopper Road (see Figure 1-1). The improvements were incorporated from the Halls Phasing Study and provide a 100-year Level-of-Service (LOS) for the channel based on the Halls Bayou Vision Plan. Design elements include a 127-foot wide grass-lined channel, with 4.8-foot tall retaining walls at the banks (added for needed capacity with limited ROW). The 100- and 500-year events show maximum depth reductions of up to 0.6 feet and 0.5 feet just downstream of Bertrand Street, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Without Project Conditions WSEs. The reduction in WSE from Option 1 results in the performance metrics in Table 1 below when compared to the Baseline Conditions model. (Note: the negative metrics in the 500-year indicates that while this project reduces structural impacts locally, it is offset by reductions in structural benefits downstream. There are still no adverse impacts versus the Without Projects Conditions model.)

TABLE 1: OPTION 1 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	3	87	-20
Miles of Road Removed	0.03	0.57	-1.4
Acres of Land Removed	3	50	-13.36

The estimated opinion of probable cost is **\$20 Million**, which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

Some of the challenges with this option are the constructability of the proposed retaining walls on either bank, several utility crossings, as well as limited ROW with Shady Lane and Royal Pine Drive running parallel to the channel. Safety considerations will also need to be addressed with the retaining wall option, especially with the Halls Bayou Hike and Bike Trail on the east bank.

## 1.2 Option 2 – Hopper to Bretshire (20-foot widening)

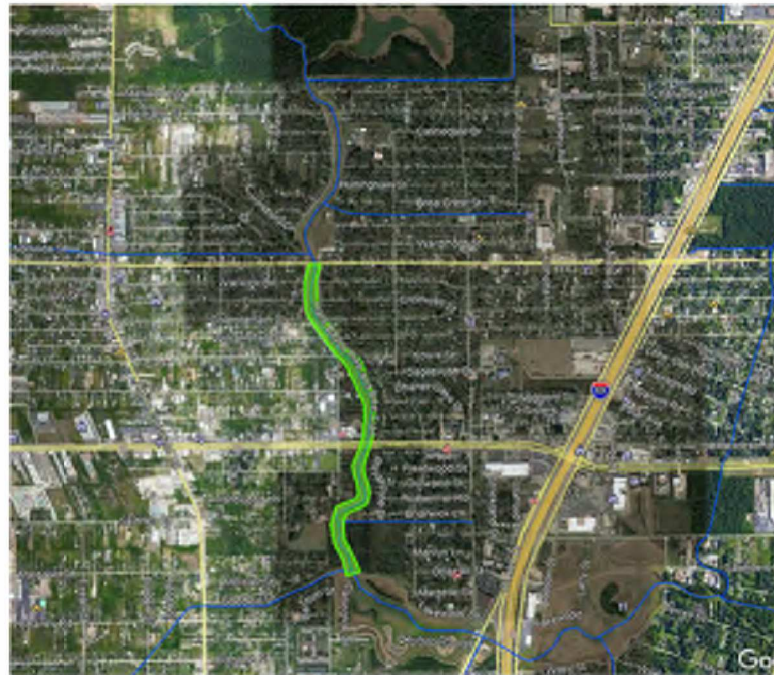


FIGURE 2: OPTION 2 – HOPPER TO BRETSHIRE PROJECT LOCATION

Proposed channel improvements for Option 2 extend from downstream of Hopper Road to the Bretshire Regional Detention Basin. This option is limited to a 20-foot channel widening on the west bank of Halls Bayou. The improvements extend into the existing maintenance berm, with the aim of utilizing Shady Lane for maintenance access for the majority of this option. The 100- and 500-year events show maximum depth reductions of up to 0.8 feet and 0.4 feet just downstream of Little York Road, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Without Project Conditions WSEs. The reduction in WSE from Option 2 results in the performance metrics in Table 2 below when compared to the Baseline Conditions model. (Note: the negative metrics in the 500-year indicates that while this project reduces floodplain impacts locally, it is offset by reductions in floodplain benefits downstream. There are still no adverse impacts versus the Without Projects Conditions model.)

TABLE 2: OPTION 2 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	2	541	70
Miles of Road Removed	0.31	3.64	0
Acres of Land Removed	10	159	-10

The estimated opinion of probable cost is **\$3.5 Million**, which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

This option was created to reduce ROW acquisition needs while still providing WSE reduction benefits. Option 2 results in a greater reduction in structural flooding than Option 1, and at a much lower cost. The size of the existing floodplain is much larger as Halls Bayou nears US69, and therefore channel improvements in this area serve a larger number of businesses and residents.

### 1.3 Option 3 – Aldine Westfield to Keith-Weiss (40-foot widening)

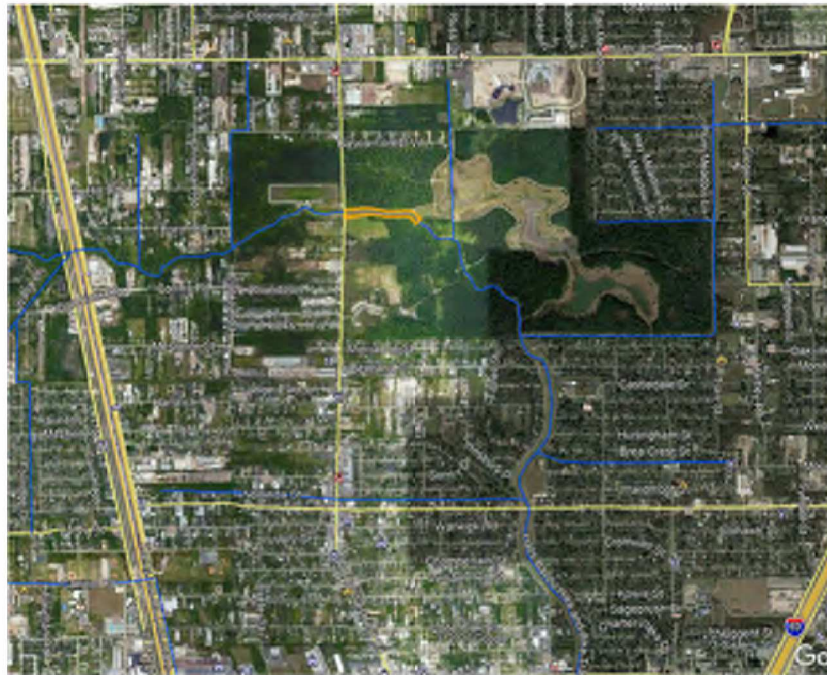


FIGURE 3: OPTION 3 – ALDINE WESTFIELD TO KEITH WEISS PROJECT LOCATION

Proposed channel improvements for Option 3 extend from downstream of Aldine Westfield Road to the Keith-Weiss Regional Detention Basin. This option is limited to a 40-foot channel widening on the north bank of Halls Bayou at this location. ROW acquisition needs in this option are limited to undeveloped property, reducing impacts to businesses and residents. The 100- and 500-year events show maximum depth reductions of up to 0.4 feet and 0.5 feet just upstream of Aldine Westfield Road, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Without Project Conditions WSEs. The reduction in WSE from Option 3 results in the following performance metrics when compared to the Baseline Conditions model:

TABLE 3: OPTION 3 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	8	28	17
Miles of Road Removed	0.11	-0.12	0.33
Acres of Land Removed	4	8	21.73

The estimated opinion of probable cost is **\$800,000**, which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

This option was created to reduce ROW acquisition needs while still providing WSE reduction benefits. The channel expansion on the north bank would extend into City of Houston property. Joint opportunities at this location may help serve both the City and HCFC (e.g. recreational trails, environmental restoration). Feasibility for this option should be further explored in the Alternatives Analysis phase.

## 2 Regional Detention Options

The following regional detention options have also been considered in this planning-level study. These options, unlike the channel conveyance options already discussed, are self-mitigating and do not rely in the existing regional basins to offset any increases in WSE upstream or downstream. Therefore, both performance metrics and WSEs are compared versus the Baseline Conditions model of Halls Bayou.

## 2.1 Option 4 – Hardy West Detention Basin

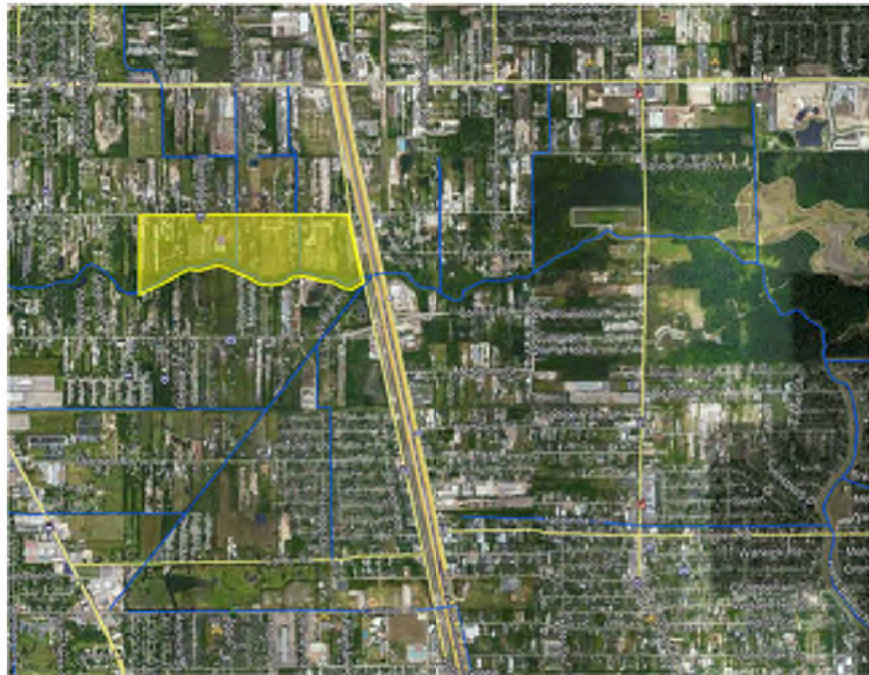


FIGURE 4: OPTION 4 – HARDY WEST DETENTION BASIN PROJECT LOCATION

Hardy West Phase 1 and 2 is a proposed wet-bottom detention basin bound to the east by Hardy Toll Road, to the north by Hill Road, and to the south by Halls Bayou. The improvements were incorporated from the Halls Phasing Study. The total proposed usable area is approximately 76 acres and would require approximately 70 acres of ROW acquisition. The basin provides approximately 700 acre-feet of storage. The 100- and 500-year events show maximum depth reductions of up to 0.4 feet and 0.5 feet near the confluence of P118-25-00, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Baseline Conditions WSEs. The reduction in WSE from Option 4 results in the following performance metrics when compared to the Baseline Conditions model:

TABLE 4: OPTION 4 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	-	202	2
Miles of Road Removed	-	2.0	0.1
Acres of Land Removed	-	87	4

The estimated opinion of probable cost is **\$47 Million** which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

The Hardy West basin provides additional storage along Halls Bayou, essential for future channel improvement projects along Halls Bayou and the surrounding tributaries. It is also included in Phase 1 of the draft Halls Bayou Phasing Study. Localized channel improvements were quickly analyzed to see if additional reductions in WSEs were possible, however any channel work would require additional ROW along Halls Bayou due to the incised nature of the channel at this location.



## 2.2 Option 5 – Aldine Westfield Detention Basin

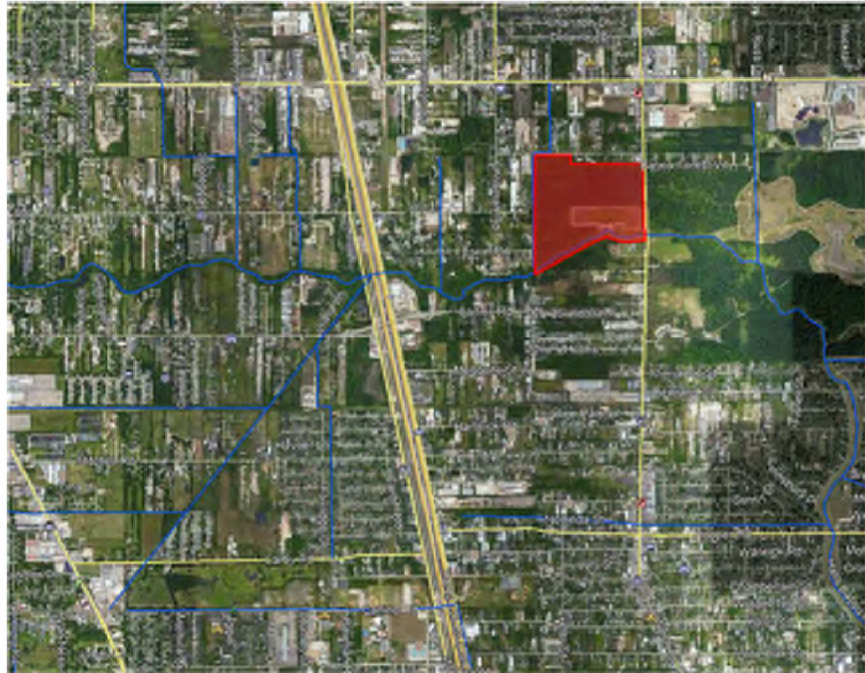


FIGURE 5: OPTION 5 – ALDINE WESTFIELD DETENTION BASIN PROJECT LOCATION

Aldine Westfield is a proposed wet-bottom detention basin bound to the west by P118-21-00, to the east by Aldine Westfield Road, to the north by Isom Street, and to the south by Halls Bayou. The improvements were incorporated from the P118-21-00 Preliminary Engineering Report. The basin provides approximately 572 acre-feet of storage, is 14 feet deep, and provides a 50-foot buffer for maintenance berms, backslope swales, and tree planting. The outfall structure includes two 8’x5’ RCBs and a 100-foot wide concrete weir. Limited channel improvements along Halls Bayou were also included in this option. The 10- and 100-year events show maximum depth reductions of up to 0.5 feet and 0.3 feet just upstream of P118-21-00, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Baseline Conditions WSEs. The reduction in WSE from Option 5 results in the following performance metrics when compared to the Baseline Conditions model:

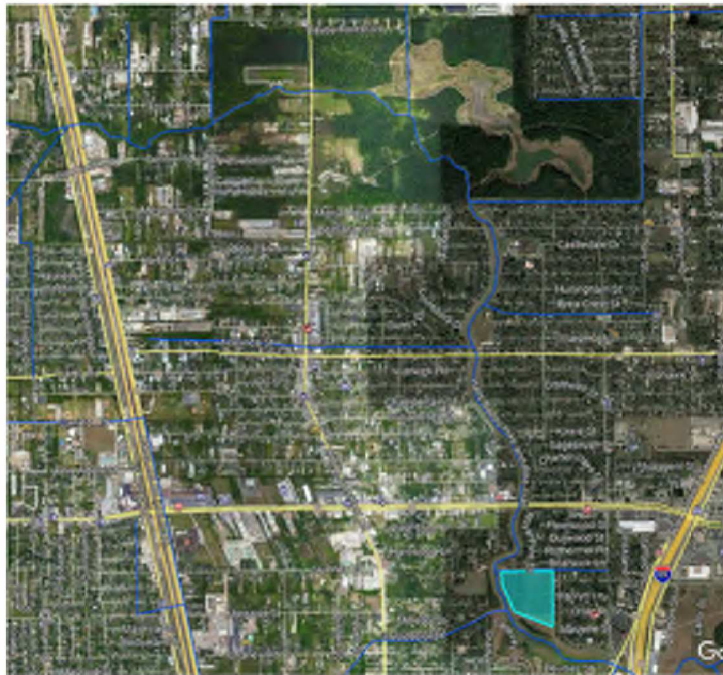
TABLE 5: OPTION 5 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	136	210	-
Miles of Road Removed	1.6	1.3	-
Acres of Land Removed	145	141	-

The estimated opinion of probable cost is **\$20 Million** which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

A portion of the Aldine Westfield basin is currently under design in support of the P118-21-00 Channel Improvements project. The current design provides approximately 170 acre-feet of storage. Option 5 would expand that storage volume, as well as incorporate the existing TxDOT detention basin into one regional basin at this location. Coordination has been ongoing between HCFCD, Harris County, TxDOT, and the City of Houston for this regional basin.

### 2.3 Option 6 – Mary Withers Detention Basin



**FIGURE 6: OPTION 6 – MARY WITHERS DETENTION BASIN PROJECT LOCATION**

Mary Withers is a detention basin briefly considered as HCFC and LAN looked for other storage options in this portion of Halls Bayou. The existing Mary Withers Park is owned and maintained by the City of Houston. A 14-foot deep, 15-acre detention pond at this location could provide approximately 180 acre-feet of storage. This option was also combined with localized channel improvements on Halls Bayou from Little York to Bretshire. The 100- and 500-year events show maximum depth reductions of up to 0.4 feet and 0.2 feet at Little York Road, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Baseline Conditions WSEs. The reduction in WSE from Option 6 results in the following performance metrics when compared to the Baseline Conditions model:

**TABLE 6: OPTION 6 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS**

Performance Metrics	10-year	100-year	500-year
Structures Removed	-	269	59
Miles of Road Removed	-	1.2	0.6
Acres of Land Removed	-	64	21

An Opinion of Probable Cost was not determined for this option, as further negotiations with the City of Houston would be needed before moving forward. However, a general estimate of **\$9 Million** would be appropriate for planning purposes, which includes proposed improvements, planning/engineering/construction costs, and contingency for a similar-sized detention basin.

### 3 2020 Vision Plan vs. Without Projects Condition

In addition to the proposed channel and detention improvements analysis, HCFCD requested LAN compare the Without Projects Condition with the latest Vision Plan from the Halls Bayou Phasing Study. The “Vision Plan” refers to the ultimate 500-year Level-of-Service design for Halls Bayou, which is made up of 58 individual features/projects to be constructed over 12 phases. The purpose of this comparison is to better understand how the Vision Plan works with the addition of Keith-Weiss, Bretshire, and Hall Park basins. Since the initial Mainstem Memo was submitted in July 2020, updates to the Vision Plan have been finalized in the Phasing Study 2020 Update, and therefore this comparison will refer to the latest model. The Without Projects Condition model will also be incorporated into the Halls Bayou Phasing Study as well.

An overall WSE comparison profile is included in Exhibits 7 and 8. From this comparison, the largest increase in benefit from comparing to the Without Projects Condition can be seen near Keith-Weiss Park. Tables 7 and 8 summarize key WSE changes between the different models:

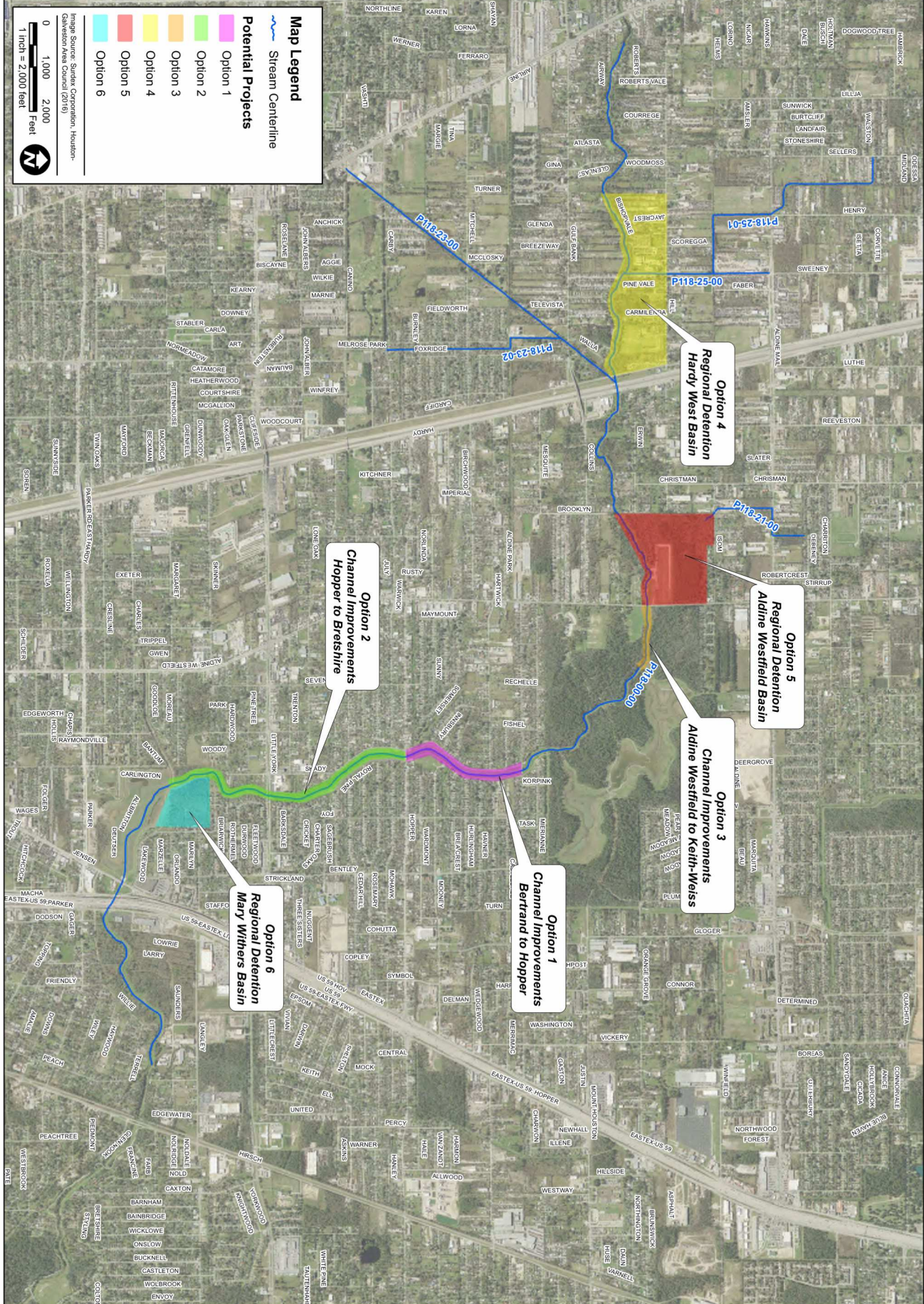
**TABLE 7: WITHOUT PROJECT, BASELINE, AND VISION PLAN 100-YEAR WSE COMPARISON**

River Station	100-Year Water Surface Elevation (feet)		
	Without Projects	Baseline	Vision Plan
60535.46	67.35	66.77	64.04
59423.1	67.00	66.18	63.95
58613.7	66.74	65.73	63.89
57555.5	66.01	64.33	63.13
56513.3	65.09	64.23	61.95
55557.7	64.14	63.98	60.76

**TABLE 8: WITHOUT PROJECT, BASELINE, AND VISION PLAN 500-YEAR WSE COMPARISON**

River Station	500-Year Water Surface Elevation (feet)		
	Without Projects	Baseline	Vision Plan
60535.46	68.45	67.93	65.53
59423.1	68.1	67.45	65.42
58613.7	67.83	67.08	65.33
57555.5	67.23	65.42	64.41
56513.3	66.29	64.84	63.58
55557.7	65.48	64.83	62.84

From this comparison, moving the “baseline” of comparison to the Without Project Condition, prior to the construction of Keith-Weiss, Bretshire, and Hall Park, results in an increased reduction in WSE attributed to the Halls Bayou Vision Plan. This method is also being implemented in the Halls Bayou Phasing Study 2020 Update. Keith-Weiss, Bretshire, and Hall Park, along with the Bond Program projects currently being implemented, will be grouped together into “Phase Zero”, representing on-going work in Halls Bayou over the past 10 years. The Phasing Study then provides a road map for the implementation of future projects up to the completion of the Vision Plan.



**Map Legend**

Stream Centerline

Potential Projects

- Option 1
- Option 2
- Option 3
- Option 4
- Option 5
- Option 6

Map Source: Sunda Corporation, Houston  
 Screenshot Date: 08/19/20

0 1,000 2,000 Feet  
 1 inch = 2,000 feet

**Option 2**  
 Channel Improvements  
 Hopper to Breitshie

**Option 3**  
 Channel Improvements  
 Aldine Westfield to Keith-Weiss

**Option 1**  
 Channel Improvements  
 Bertrand to Hopper

**Option 4**  
 Regional Detention  
 Hardy West Basin

**Option 5**  
 Regional Detention  
 Aldine Westfield Basin

**Option 6**  
 Regional Detention  
 Mary Withers Basin

**HARRIS COUNTY FLOOD CONTROL DISTRICT**  
 9900 Northwest Freeway  
 Houston, Texas 77032

DATE: JUL 2020  
 SCALE: AS NOTED

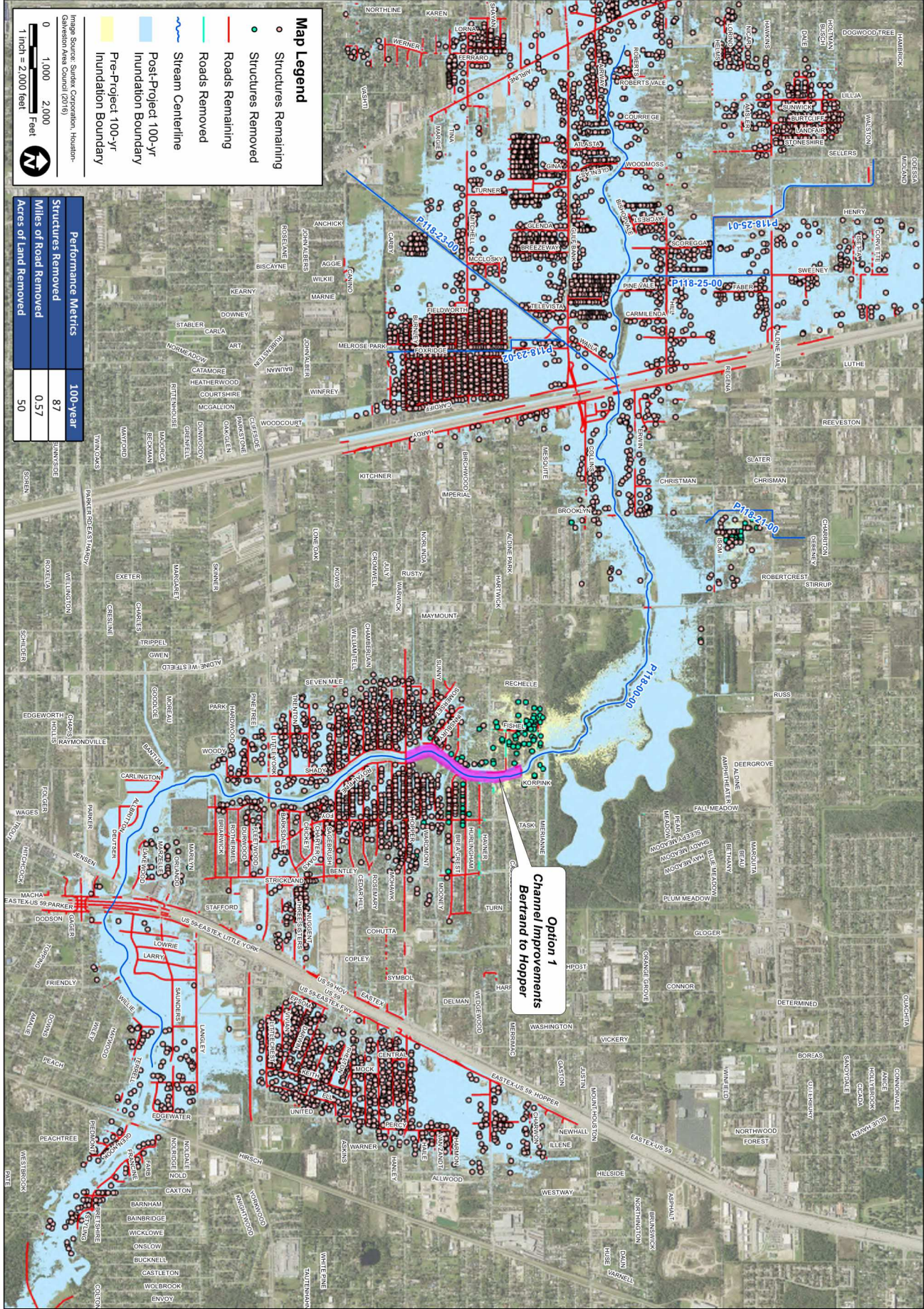
EXHIBIT

**Lockwood, Andrews & Newnam, Inc.**  
 A TETRA & DAVID COMPANY  
 TBE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 T 713.266.6900 • F 713.266.0289  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	LM
CHECKED:	CEE
APPROVED:	CEE

**HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS**

**MAINSTEM OPTIONS OVERVIEW**



**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Map Source: Surber Corporation, Houston  
 Shaded Relief Data: ESRI

1 inch = 2,000 feet

Performance Metrics	
Structures Removed	87
Miles of Road Removed	0.57
Acres of Land Removed	50

**Option 1**  
 Channel Improvements  
 Bertrand to Hopper

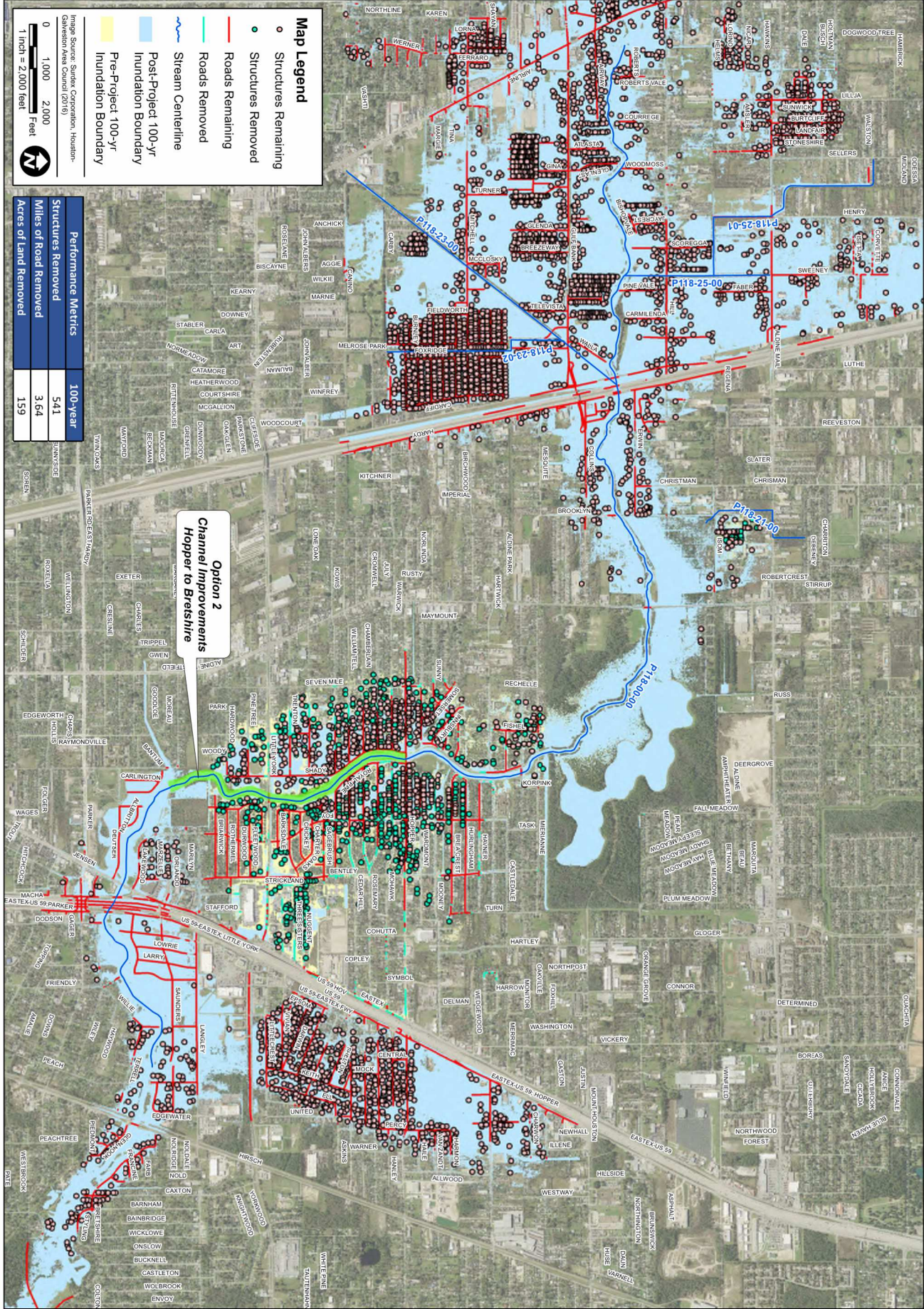
9900 Northwest Freeway  
**HARRIS COUNTY FLOOD CONTROL DISTRICT**  
 Houston, Texas 77032

**Lockwood, Andrews & Newnam, Inc.**  
 A TETRA & DAVID COMPANY  
 TETRA Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2080  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	LM
CHECKED:	CEE
APPROVED:	CEE

**HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS**

**MAINSTEM OPTION 1 PERFORMANCE METRICS MAP (100-YEAR)**



**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Map Source: Surdata Corporation, Houston  
 Shaded Relief Data: ESRI

0 1,000 2,000 Feet  
 1 inch = 2,000 feet

Performance Metrics	
Structures Removed	541
Miles of Road Removed	3.64
Acres of Land Removed	159

**Option 2**  
 Channel Improvements  
 Hopper to Bretshire

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

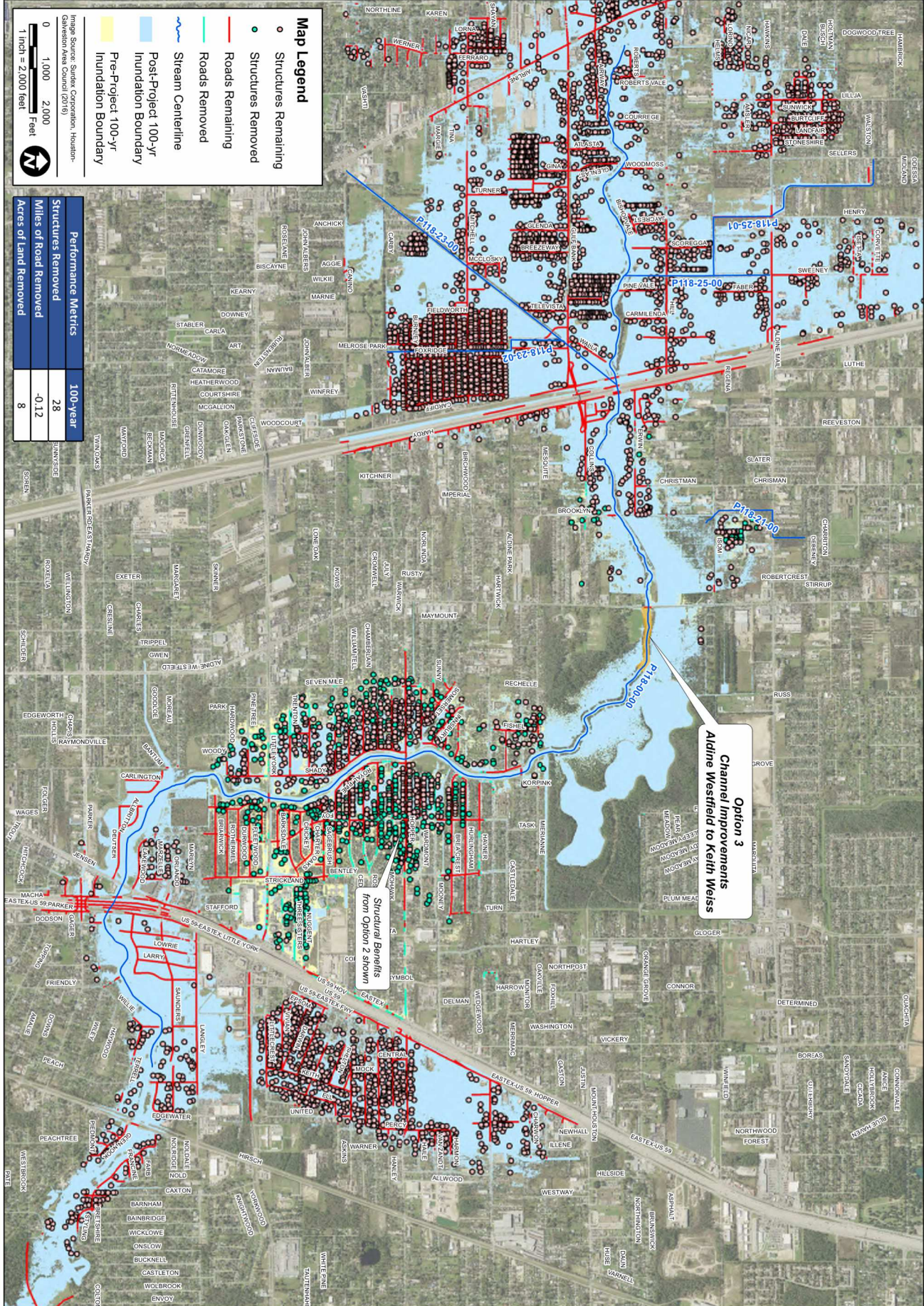
DATE: JUL 2020  
 SCALE: AS NOTED

**Lockwood, Andrews & Newnam, Inc.**  
 A TETRA & DAVID COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2080  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	LM
CHECKED:	CEE
APPROVED:	CEE

**HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS**

**MAINSTEM OPTION 2 PERFORMANCE METRICS MAP (100-YEAR)**



**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Map Source: Sunda Corporation, Houston  
 Shaded Relief: Sunda Corporation (2019)  
 1 inch = 2,000 feet

**Performance Metrics**

Metric	100-year
Structures Removed	28
Miles of Road Removed	-0.12
Acres of Land Removed	8

Structural Benefits from Option 2 shown

Option 3 Channel Improvements Aldine Westfield to Keith Weiss

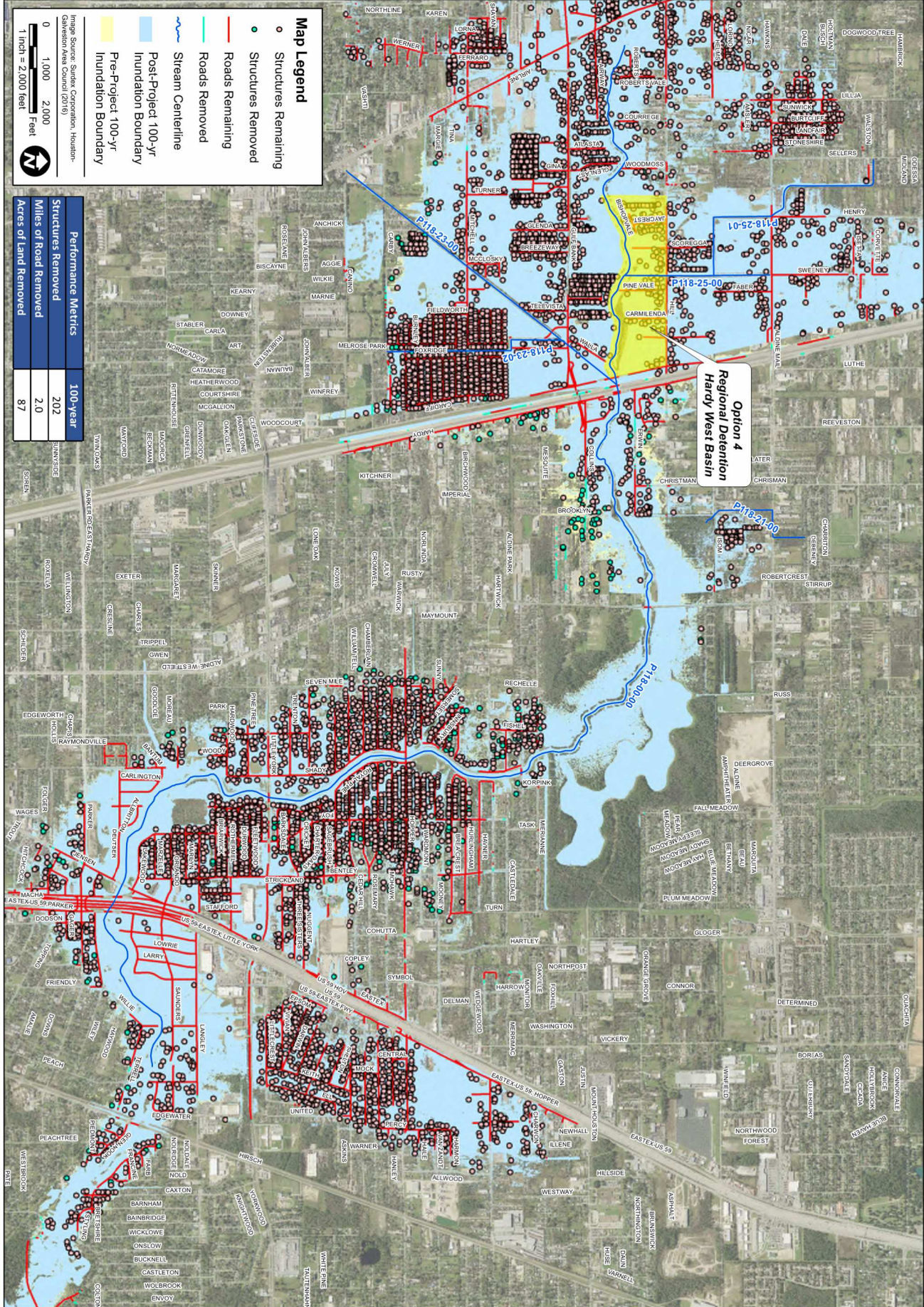
9900 Northwest Freeway  
**HARRIS COUNTY FLOOD CONTROL DISTRICT**  
 Houston, Texas 77032

**Lockwood, Andrews & Newnam, Inc.**  
 A TETRA & DAVID COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2080  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	LM
CHECKED:	CEE
APPROVED:	CEE

**HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS**

**MAINSTEM OPTION 3 PERFORMANCE METRICS MAP (100-YEAR)**



**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Map Scale: 1 inch = 2,000 feet

Performance Metrics		100-year
Structures Removed		202
Miles of Road Removed		2.0
Acres of Land Removed		87

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

DATE: JUL 2020  
 SCALE: AS NOTED

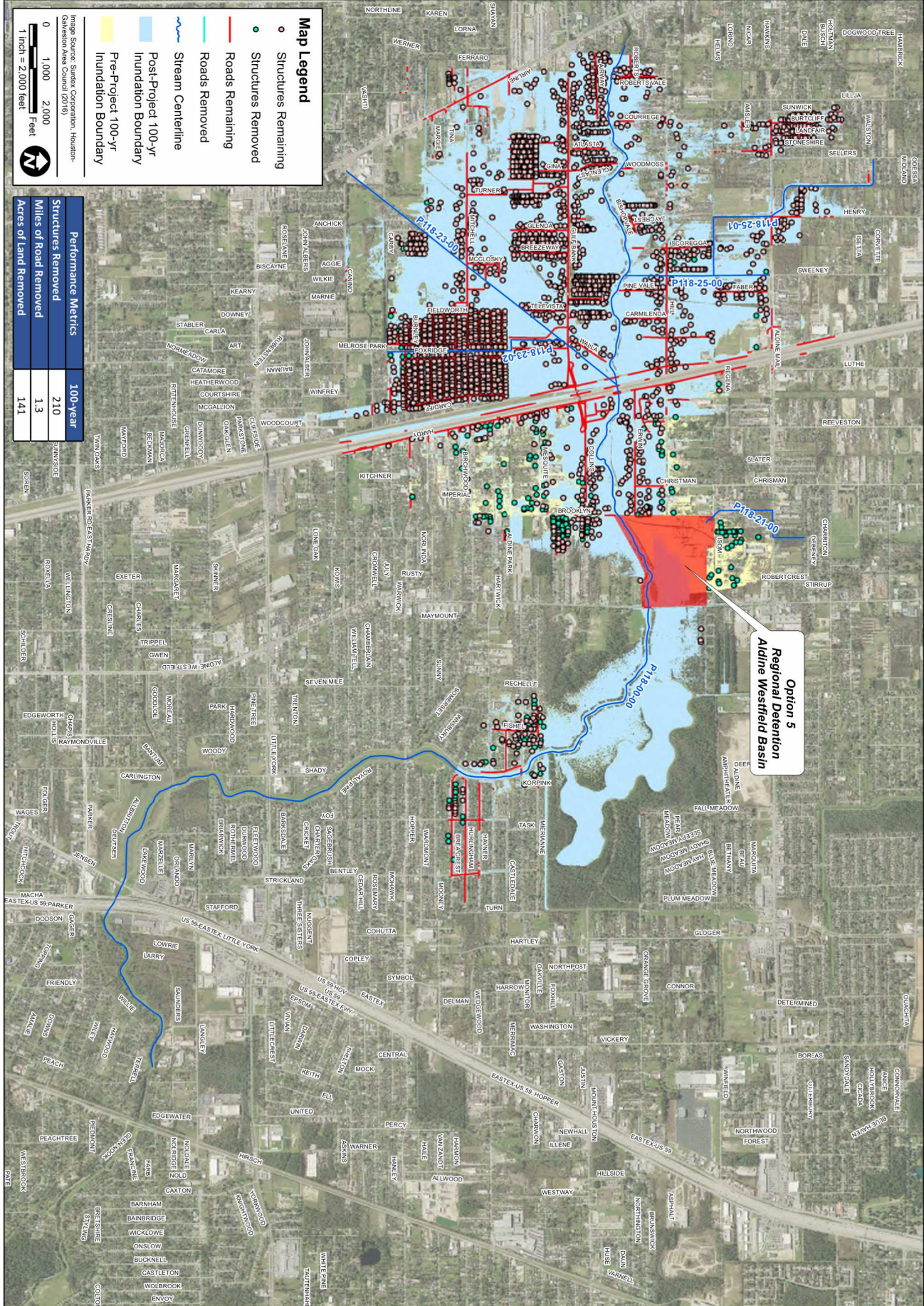
**Lockwood, Andrews & Newnam, Inc.**  
 A TETRA & DAVID COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2081  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	LM
CHECKED:	CEE
APPROVED:	CEE

**HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS**

**MAINSTEM OPTION 4**  
**PERFORMANCE METRICS MAP (100-YEAR)**





**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Map Scale: 1 inch = 2,000 feet

Performance Metrics	
Structures Removed	210
Miles of Road Removed	1.3
Acres of Land Removed	141

**Option 5**  
 Regional Detention  
 Aldine Westfield Basin

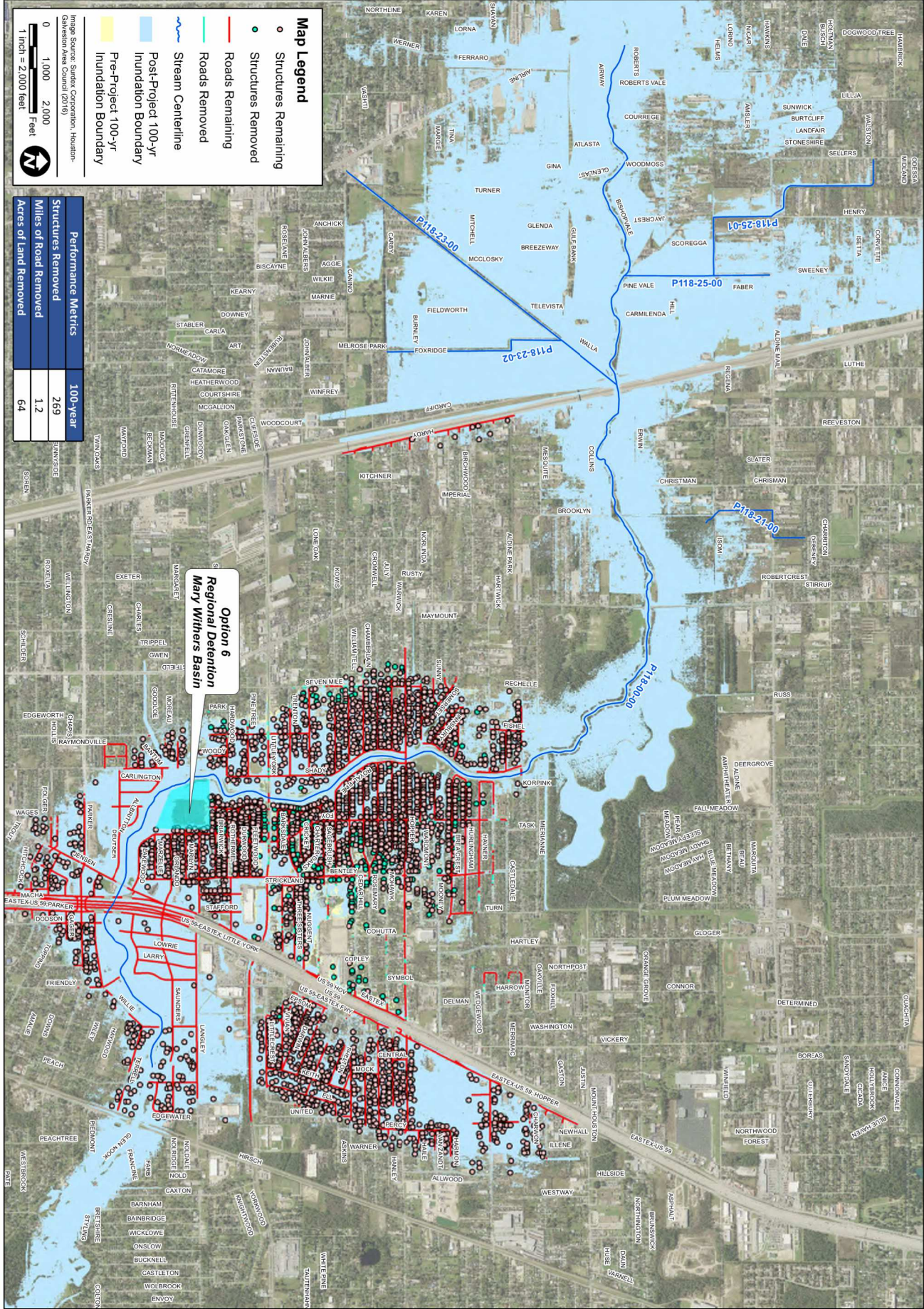
**HARRIS COUNTY FLOOD CONTROL DISTRICT**  
 9900 Northwest Freeway  
 Houston, Texas 77032



**Lockwood, Andrews & Newnam, Inc.**  
 A TETRA & DAVID COMPANY  
 TBE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2080  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	LM
CHECKED:	CEE
APPROVED:	CEE

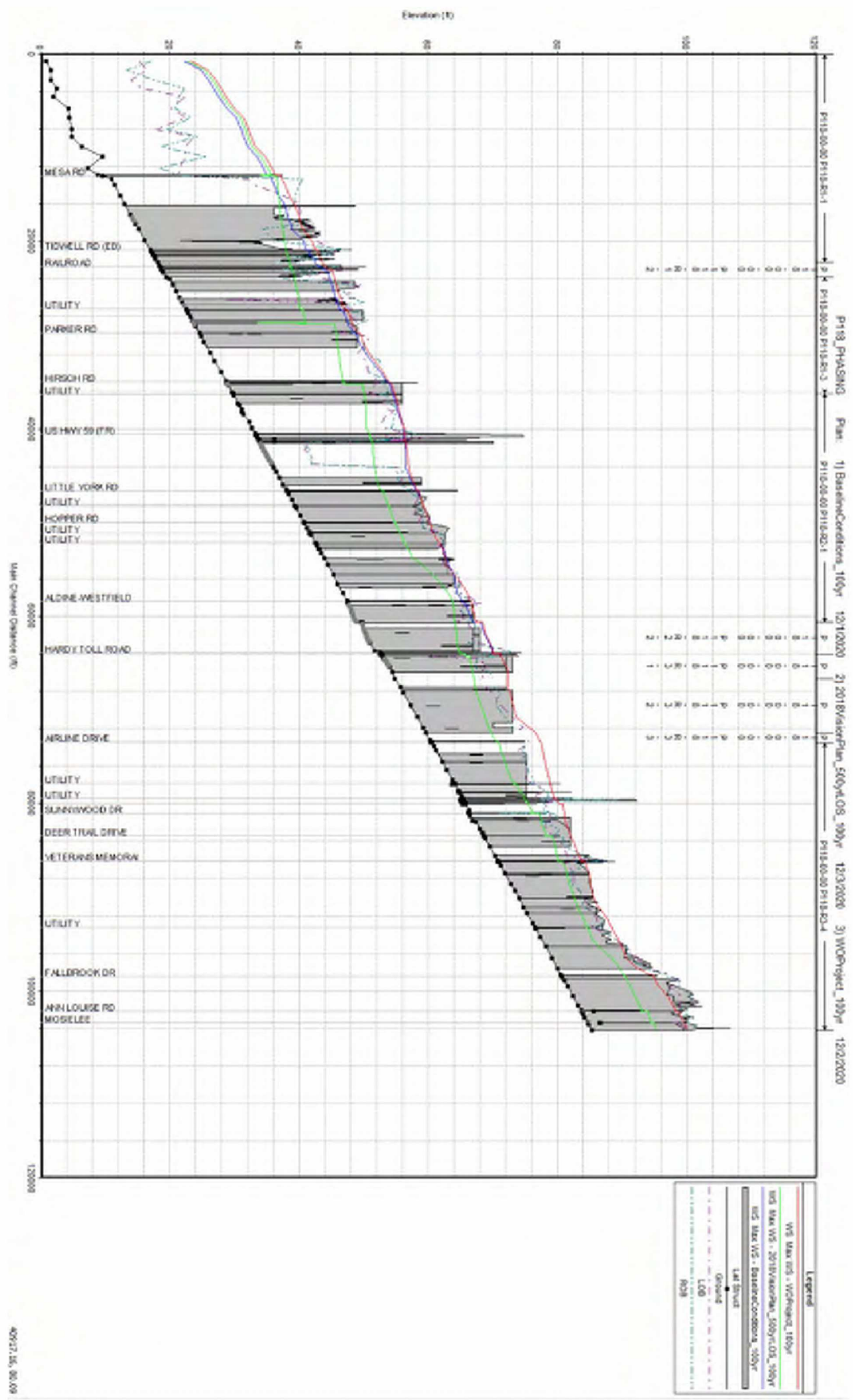
**HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS**

**MAINSTEM OPTION 5 PERFORMANCE METRICS MAP (100-YEAR)**

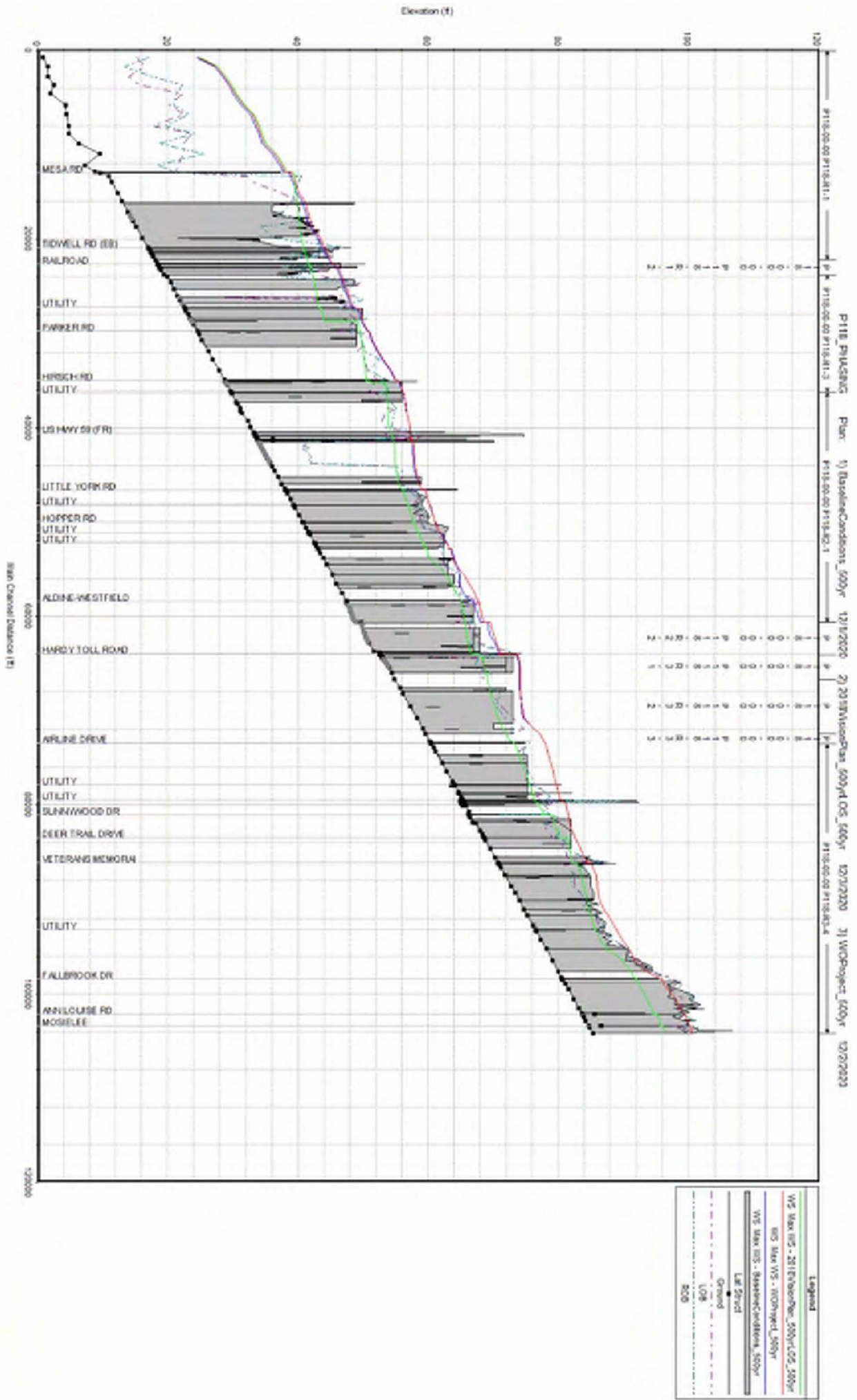


 <p>9900 Northwest Freeway Houston, Texas 77092</p>	 <p>Lockwood, Andrews &amp; Newnam, Inc. A TETRA &amp; DAVID COMPANY TBE Firm No. 2614 2925 Briarpark Drive • Houston, TX 77042-3720 713.266.6900 • F 713.266.2081 www.lan-inc.com • info@lan-inc.com</p>	PREPARED: LM	HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS  MAINSTEM OPTION 6 PERFORMANCE METRICS MAP (100-YEAR)
		CHECKED: CEE	
		APPROVED: CEE	

# EXHIBIT 7 - 100-year WSE Vision Plan Comparison

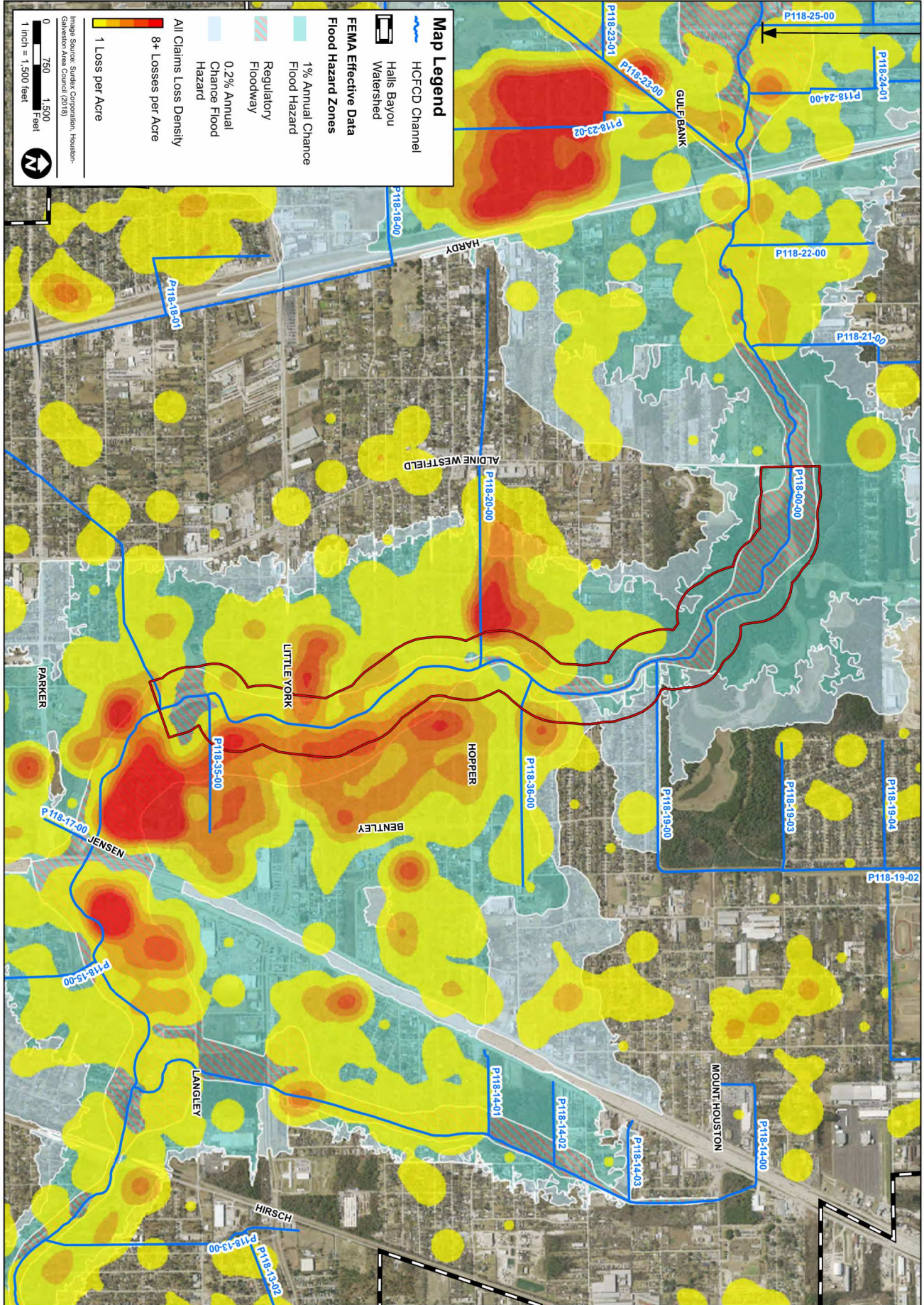


# EXHIBIT 8 - 500-year WSE Vision Plan Comparison



# **APPENDIX B**

## **Historical Loss Heat Maps**



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

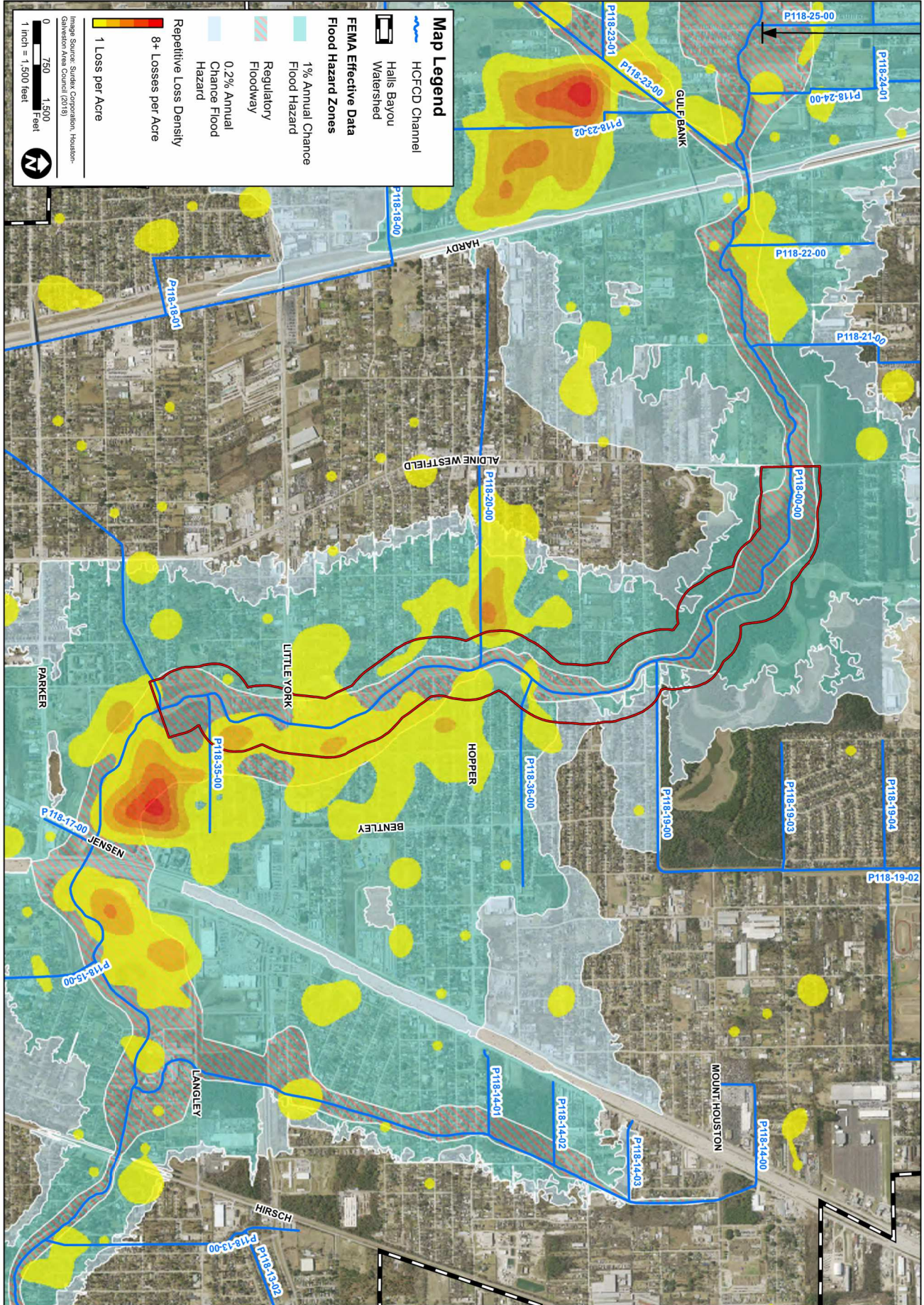
**Lockwood, Andrews & Newnam, Inc.**  
 A TIED & DAILY COMPANY  
 TIDE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.296.6900 • F 713.266.2089  
 www.lan-inc.com • info@lan-inc.com

PREPARED: CRB  
 CHECKED: WWC  
 APPROVED: WWC

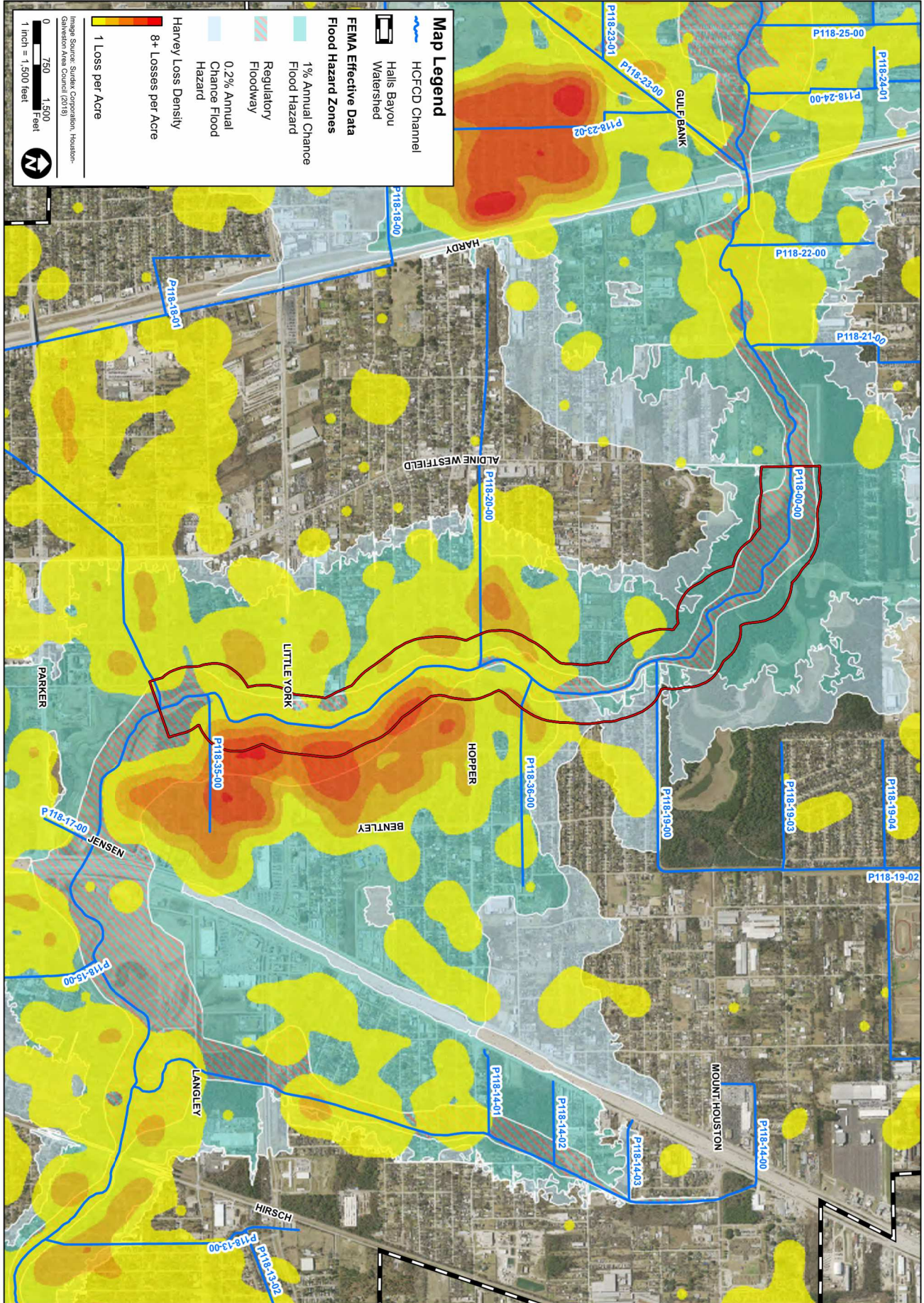
HCFC D HALLS BAYOU WATERSHED  
 P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

**ALL CLAIMS LOSSES**

EXHIBIT  
 1



 <p><b>HARRIS COUNTY FLOOD CONTROL DISTRICT</b></p> <p>9900 Northwest Freeway Houston, Texas 77092</p>	 <p><b>Lockwood, Andrews &amp; Newnam, Inc.</b> A TIER 1 DAILY COMPANY</p> <p>TBPE Firm No. 2614 2925 Briarpark Drive • Houston, TX 77042-3720 713.296.6900 • F 713.266.2089 www.lan-inc.com • info@lan-inc.com</p>	PREPARED: CRB	<p><b>HCFCD HALLS BAYOU WATERSHED P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS</b></p> <p><b>REPETITIVE LOSSES</b></p>	
		DATE: JULY 2021 SCALE: AS NOTED		CHECKED: WWC
		EXHIBIT 2		APPROVED: WWC



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

DATE: JULY 2021  
 SCALE: AS NOTED

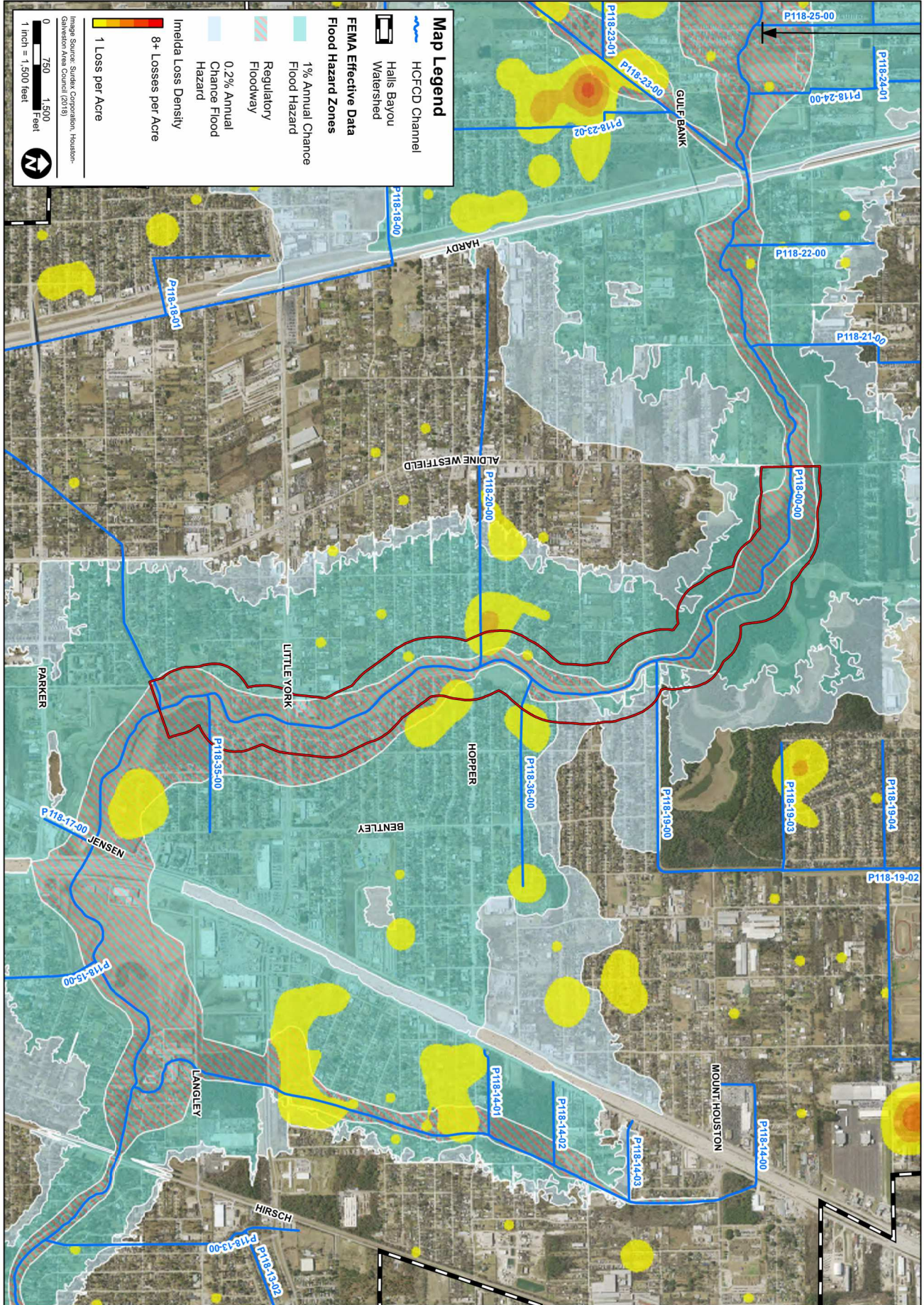
**Lockwood, Andrews & Newnam, Inc.**  
 A TIED & DAILY COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.296.6900 • F 713.266.2089  
 www.lan-inc.com • info@lan-inc.com

PREPARED: CRB  
 CHECKED: WWC  
 APPROVED: WWC

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

HURRICANE HARVEY LOSSES





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

**Lockwood, Andrews & Newnam, Inc.**  
 A TIED & DAILY COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.256.6900 • F 713.266.2089  
 www.lan-inc.com • info@lan-inc.com

PREPARED: CRB  
 CHECKED: WWC  
 APPROVED: WWC

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

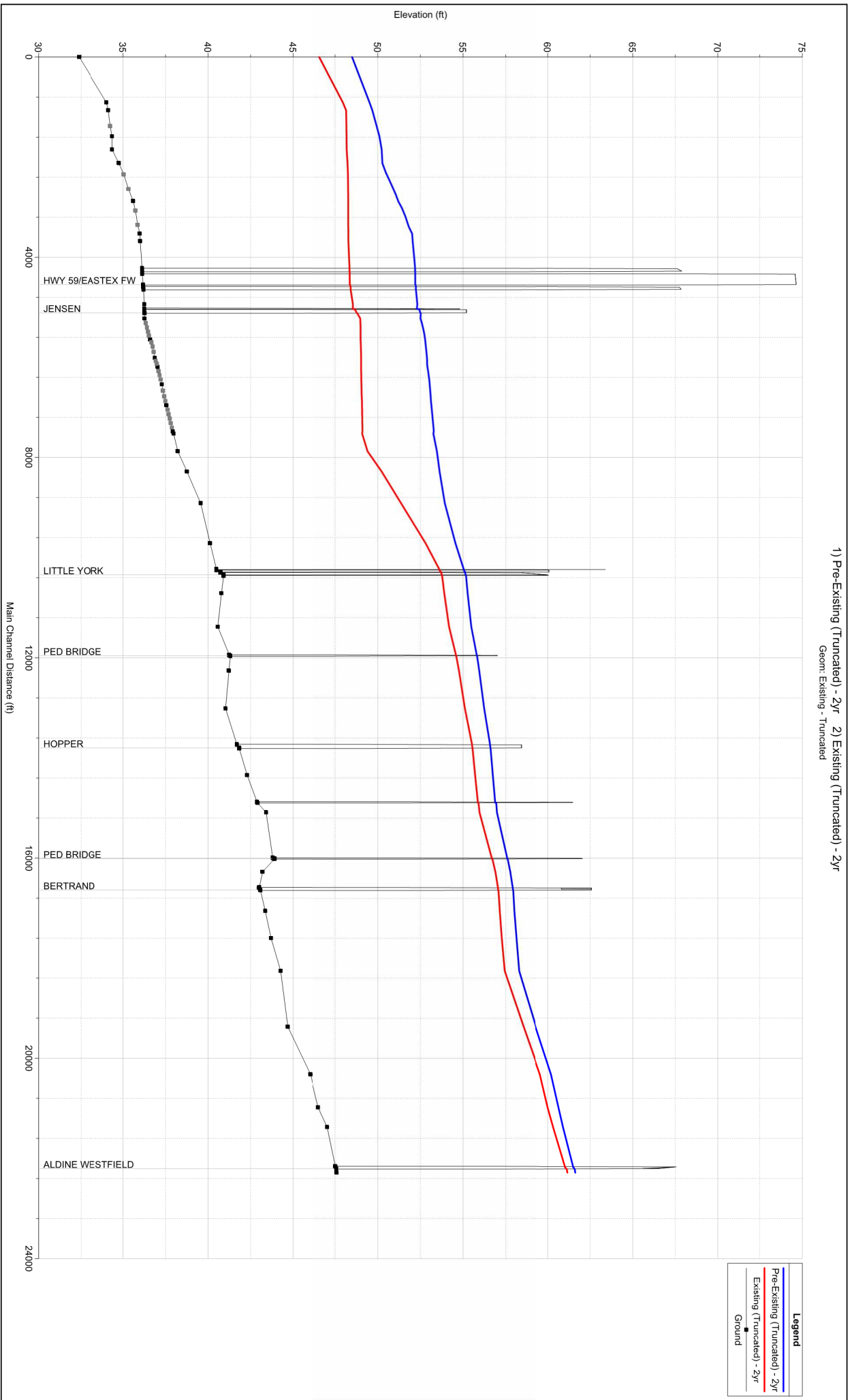
**IMELDA LOSSES**

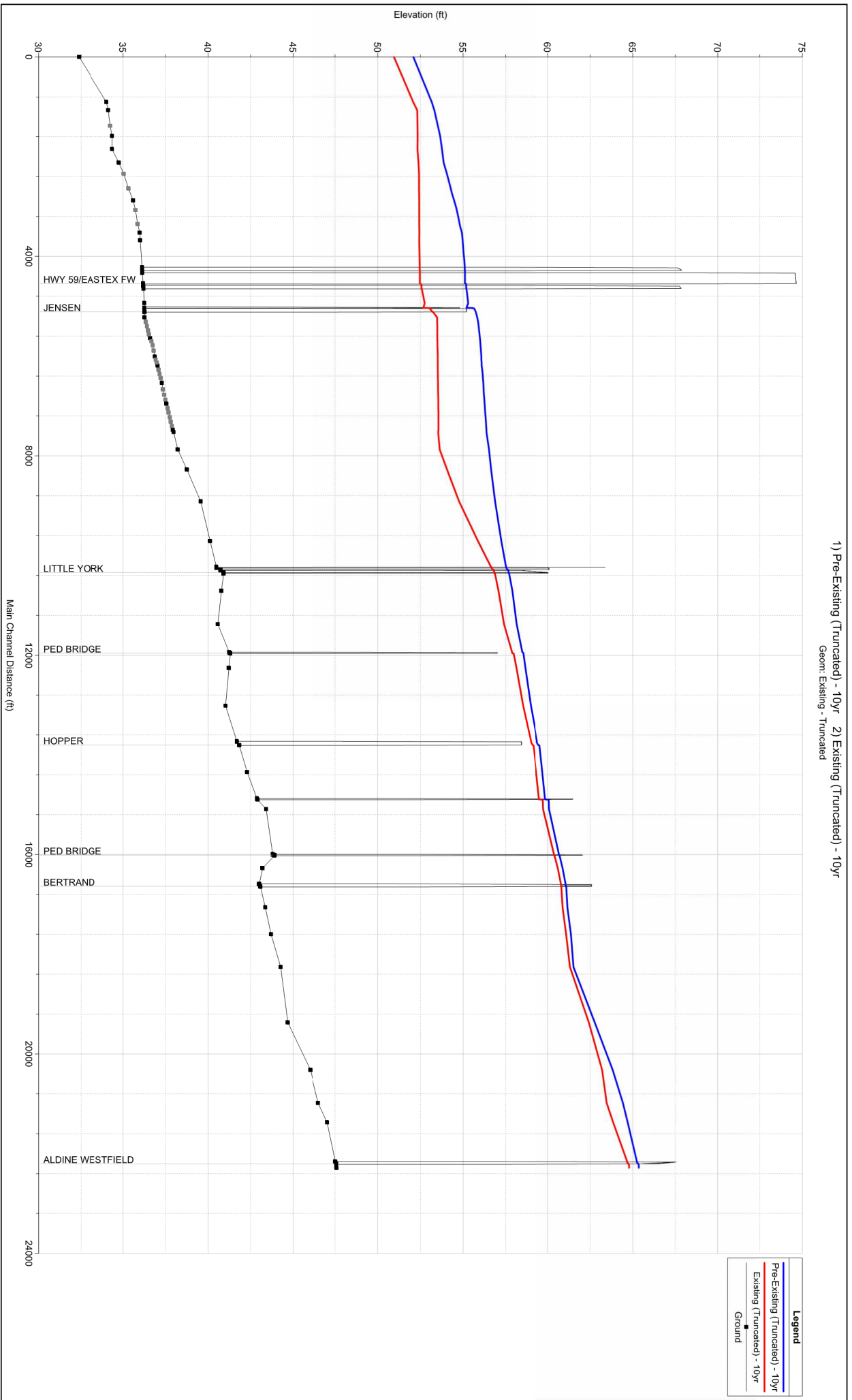
# **APPENDIX C**

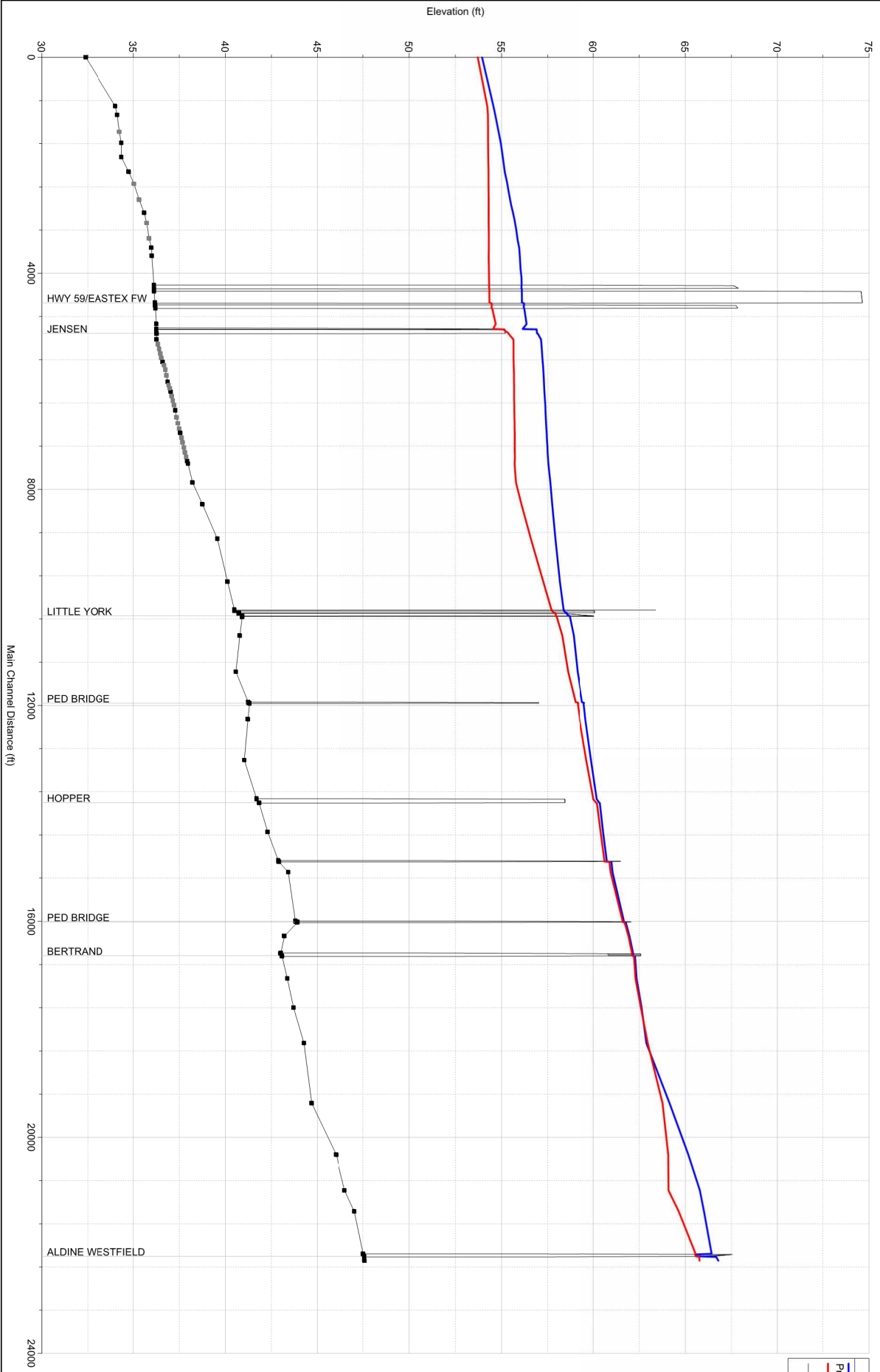
## **Site Visit Photos**

# **APPENDIX D**

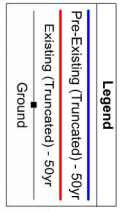
## **Baseline Conditions Water Surface Profiles**

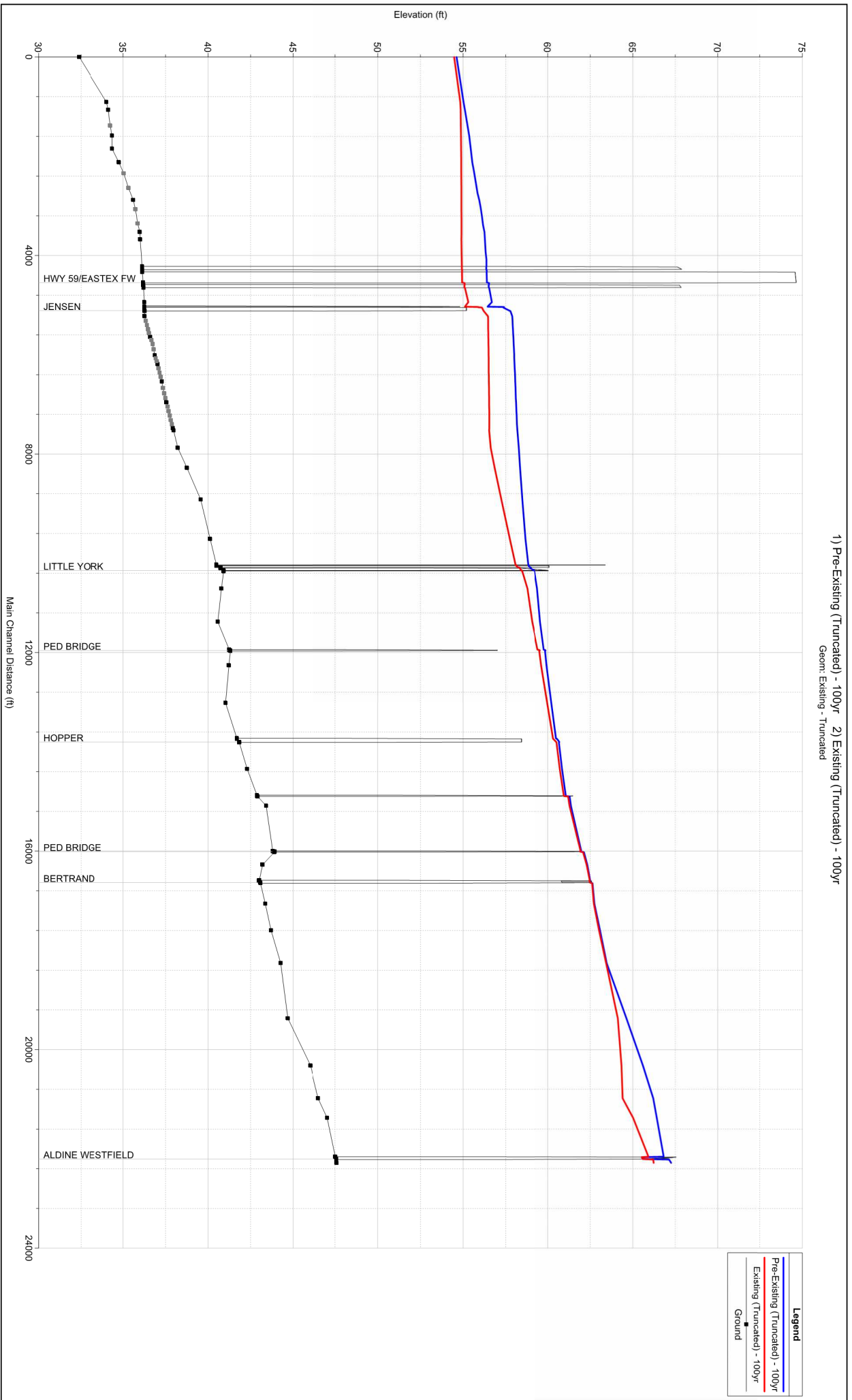




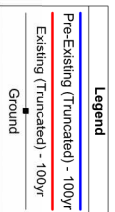


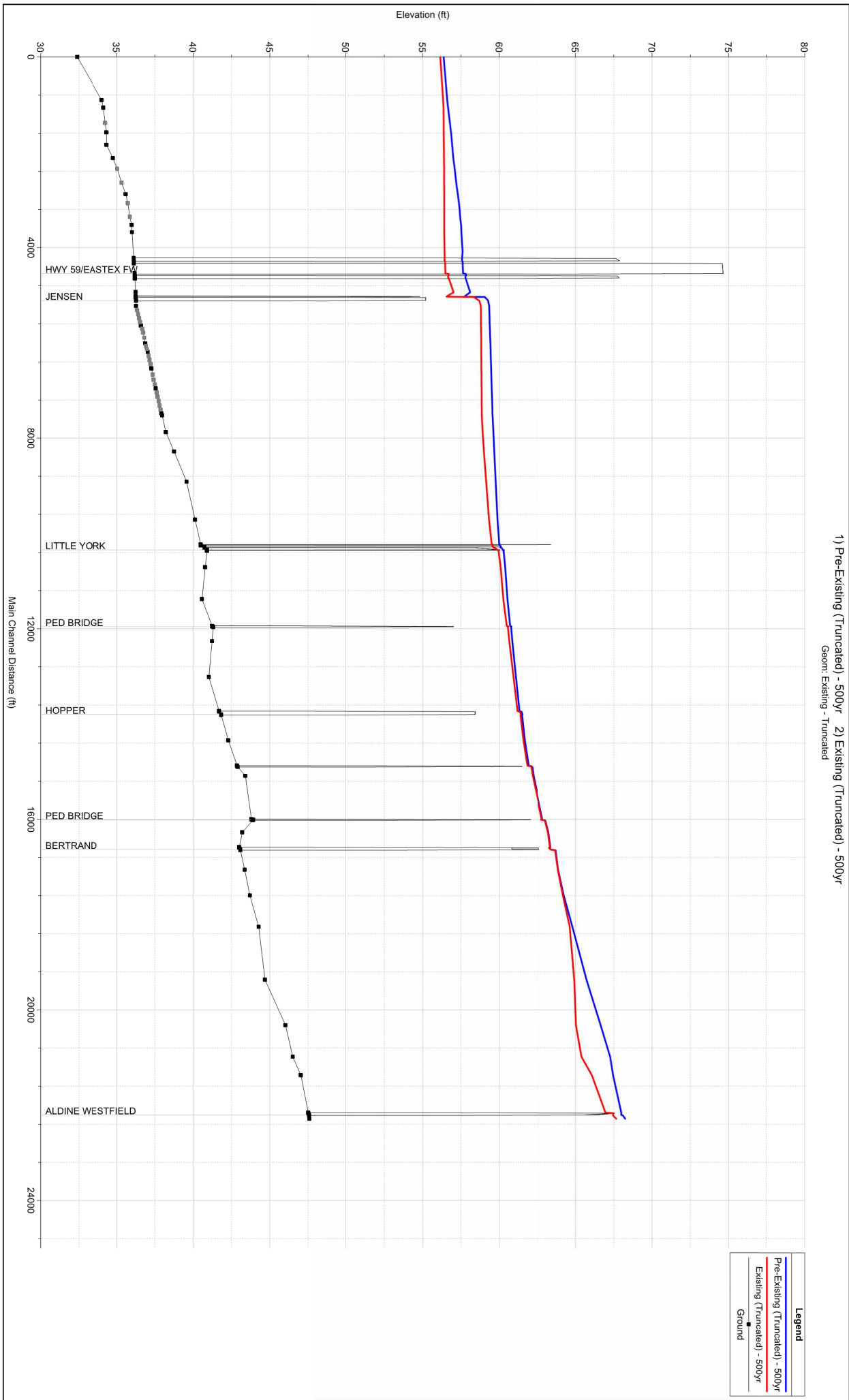
1) Pre-Existing (Truncated) - 50yr 2) Existing (Truncated) - 50yr  
 Geom: Existing - Truncated





1) Pre-Existing (Truncated) - 100Yr 2) Existing (Truncated) - 100Yr  
 Geom: Existing - Truncated

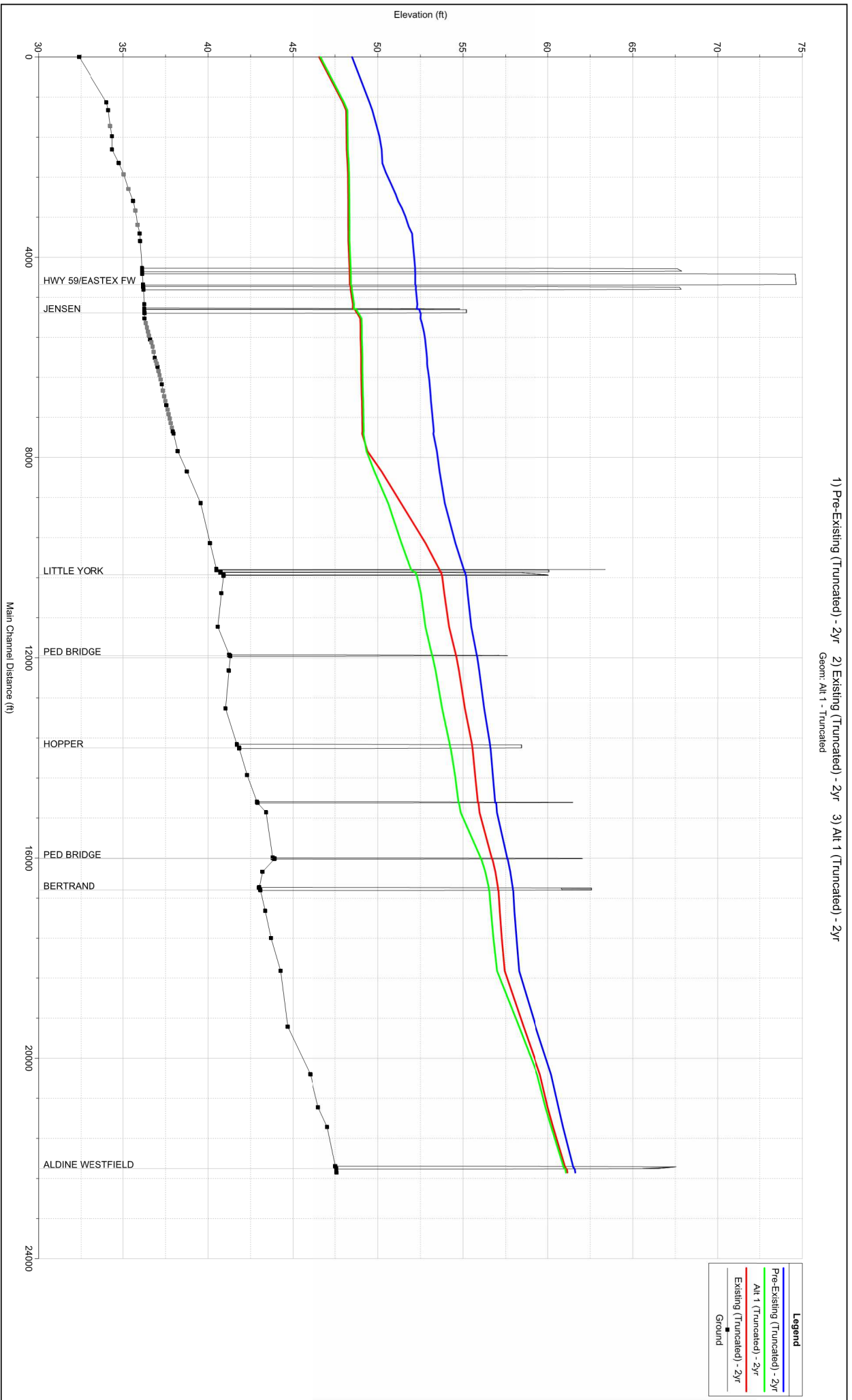




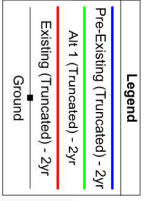


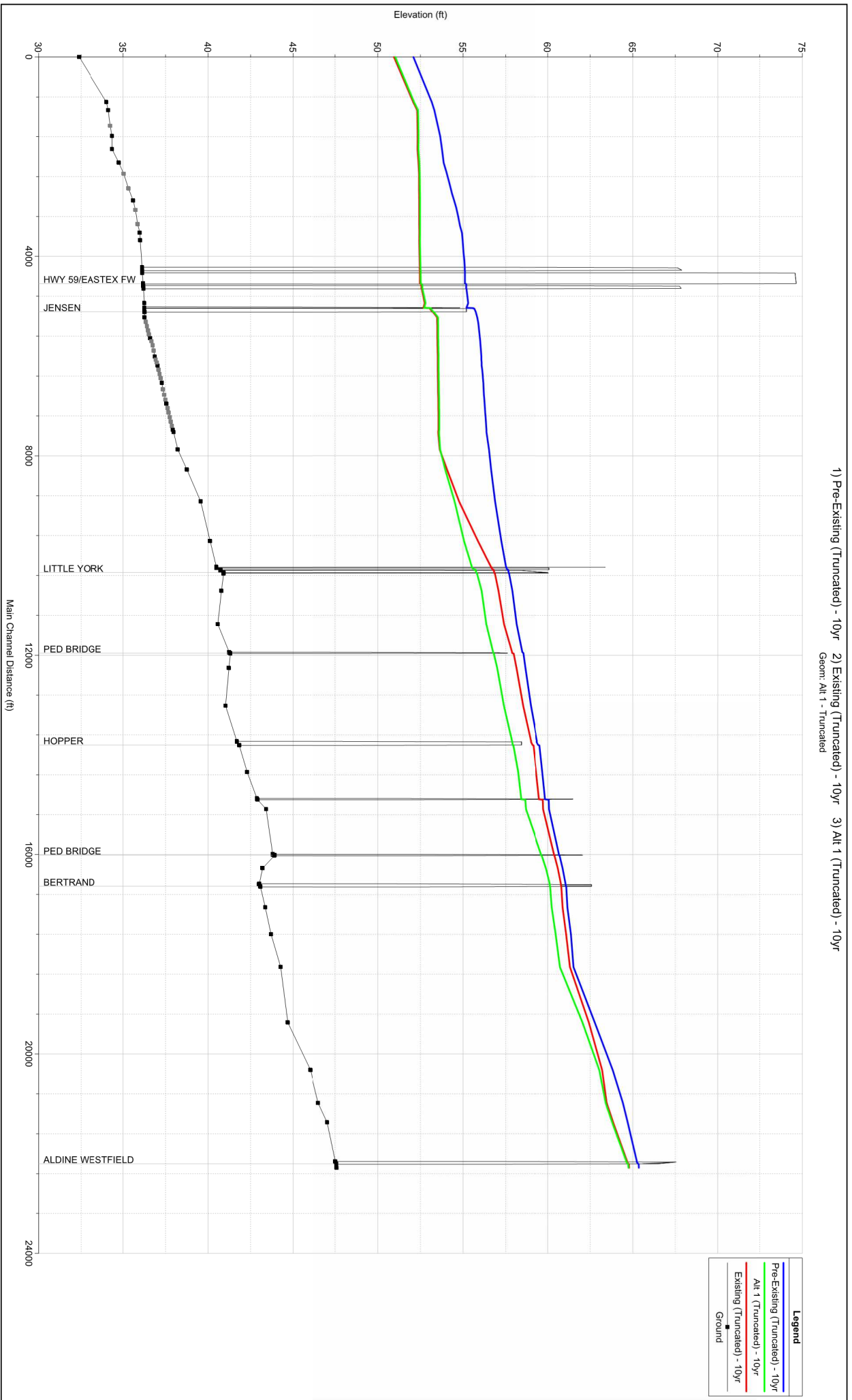
# **APPENDIX E**

**Water Surface Profile Comparisons  
Alternative 1 vs. Baseline Conditions**

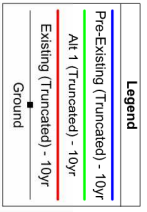


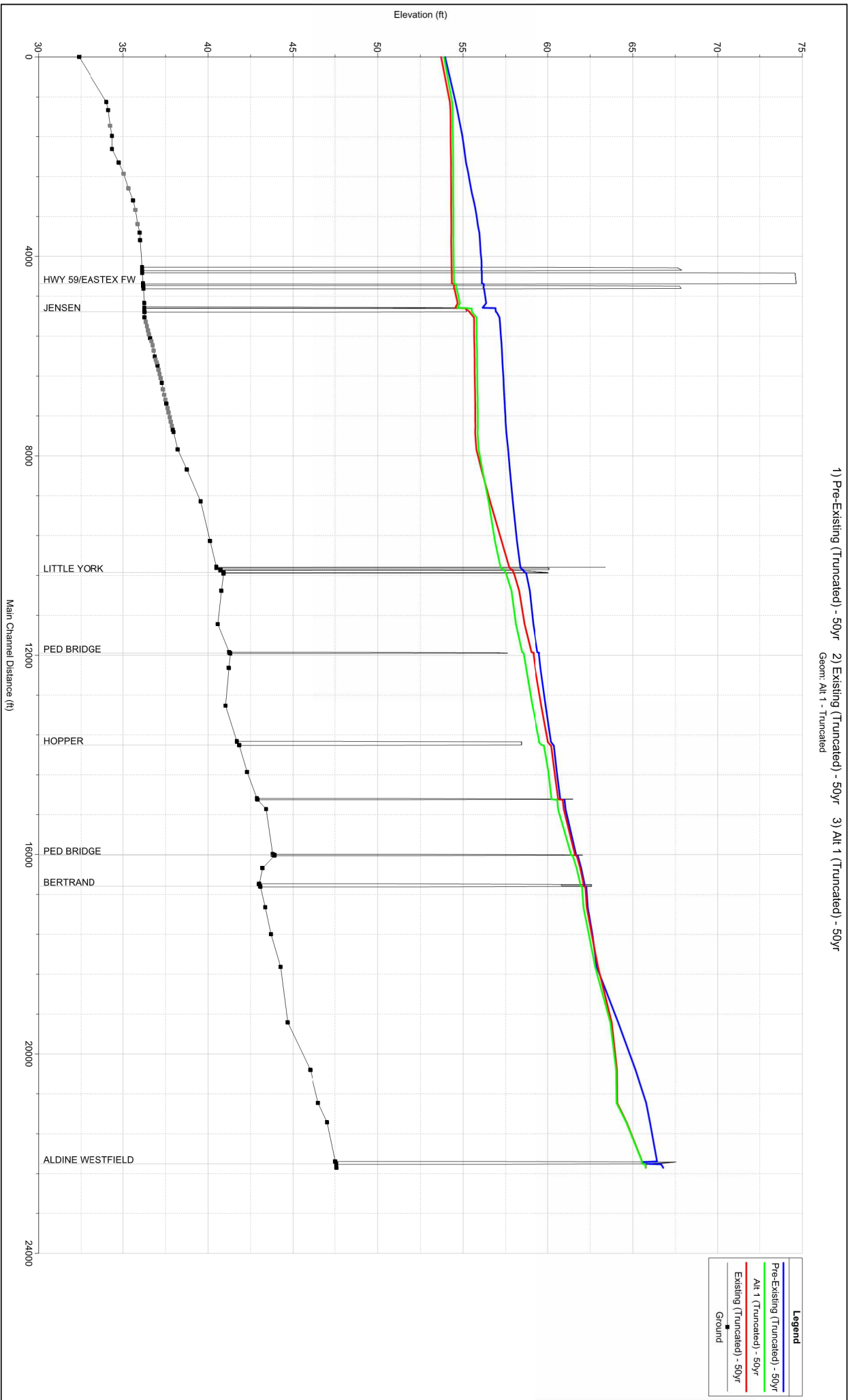
1) Pre-Existing (Truncated) - 2yr 2) Existing (Truncated) - 2yr 3) Alt 1 (Truncated) - 2yr  
 Geom: Alt 1 - Truncated



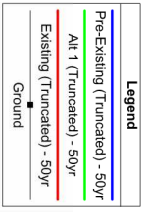


1) Pre-Existing (Truncated) - 10yr 2) Existing (Truncated) - 10yr 3) Alt 1 (Truncated) - 10yr  
 Geom: Alt 1 - Truncated



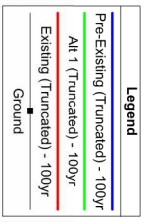


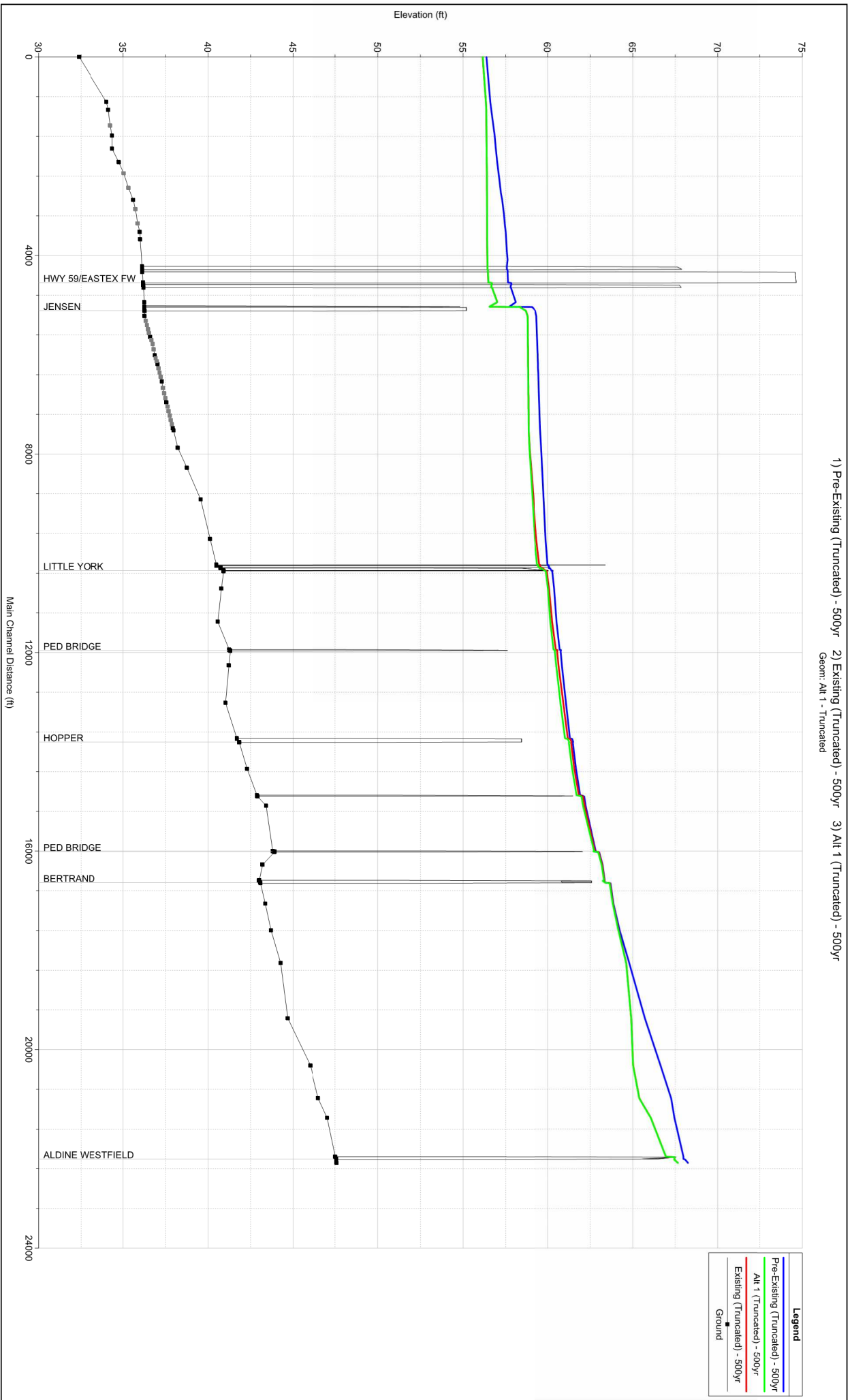
1) Pre-Existing (Truncated) - 50yr 2) Existing (Truncated) - 50yr 3) Alt 1 (Truncated) - 50yr  
 Geom: Alt 1 - Truncated





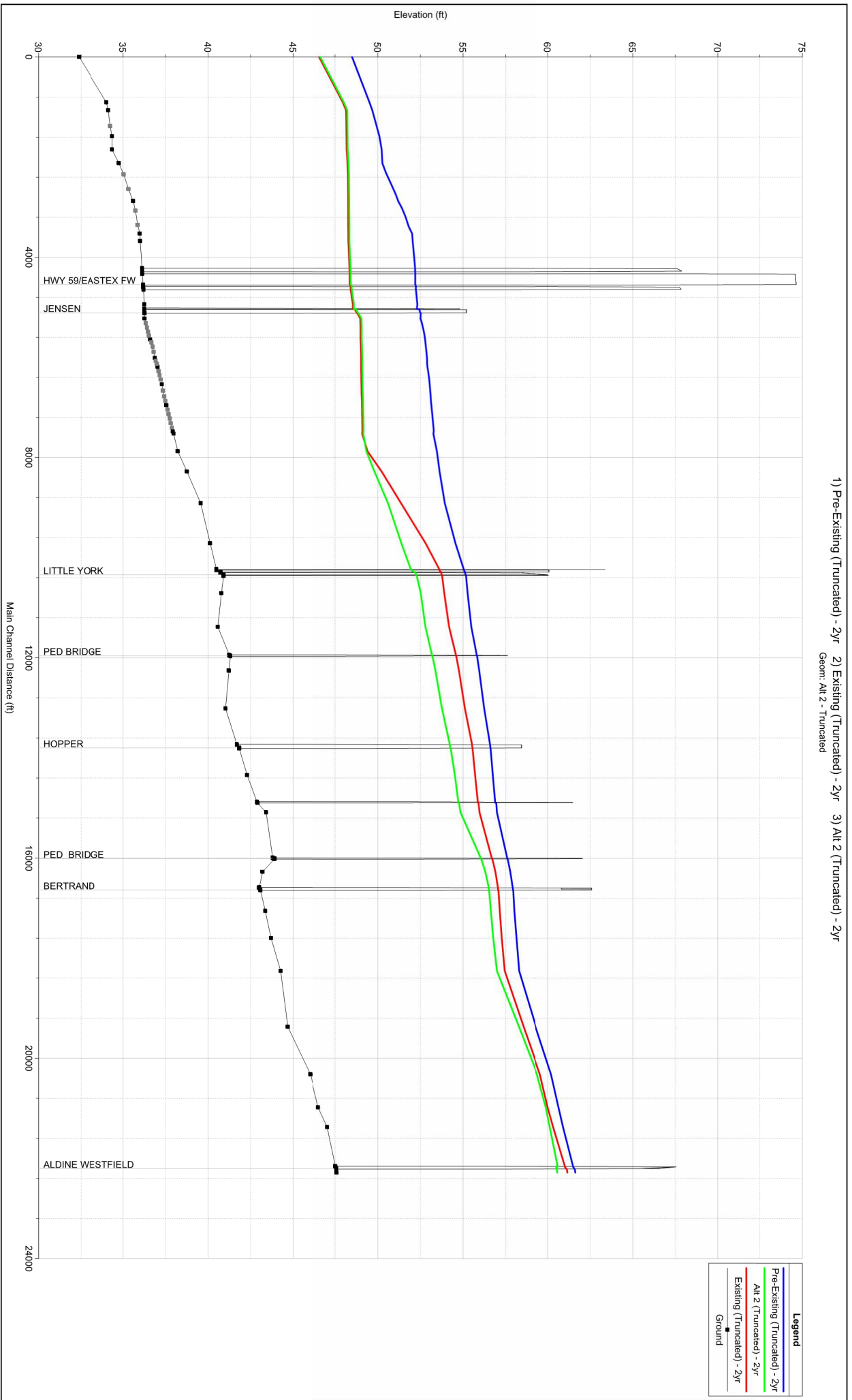
1) Pre-Existing (Truncated) - 100yr 2) Existing (Truncated) - 100yr 3) Alt 1 (Truncated) - 100yr  
 Geom: Alt 1 - Truncated





# **APPENDIX F**

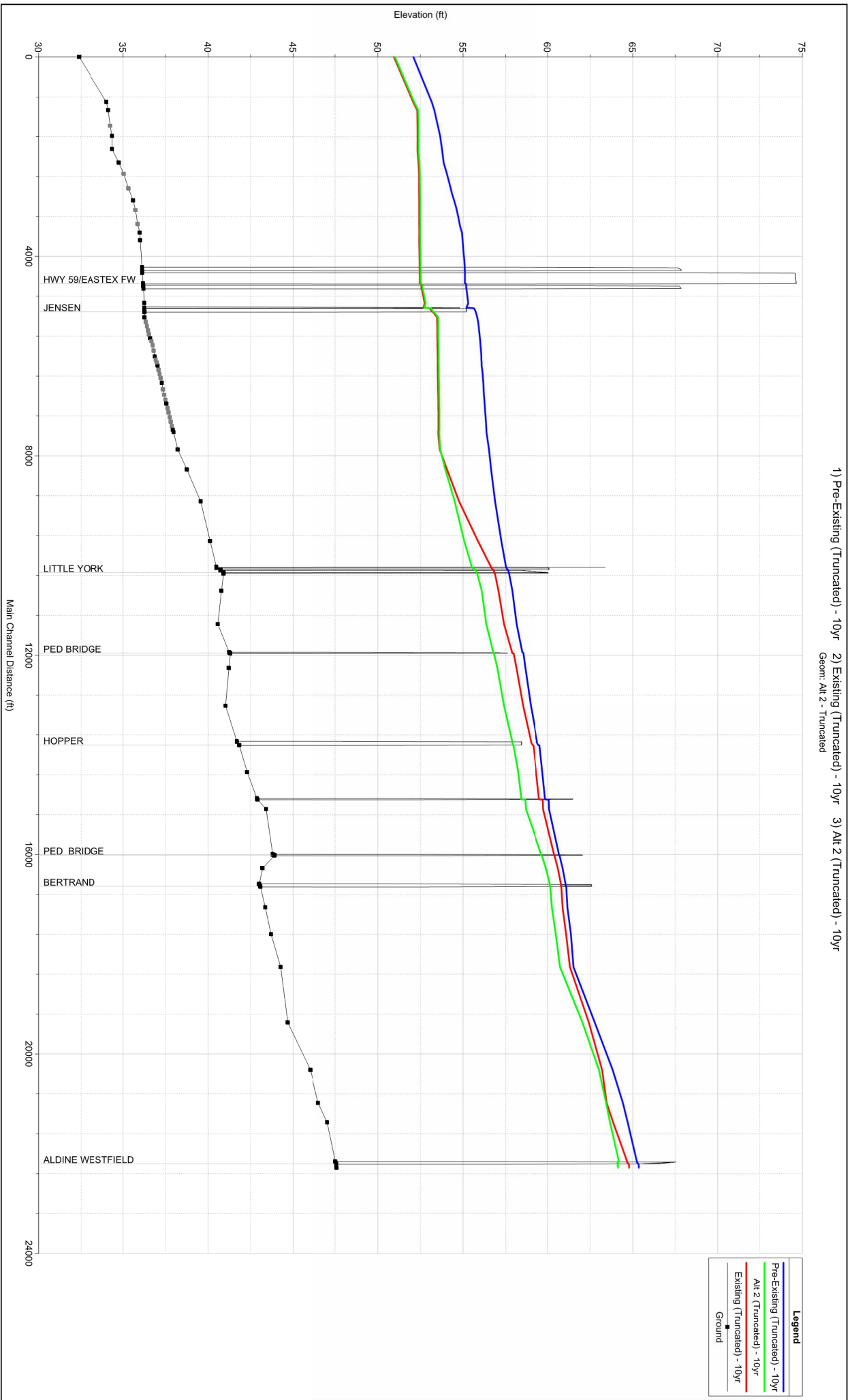
**Water Surface Profile Comparisons  
Alternative 2 vs. Baseline Conditions**



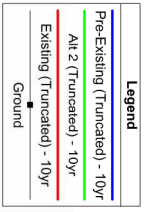
1) Pre-Existing (Truncated) - 2yr 2) Existing (Truncated) - 2yr 3) Alt 2 (Truncated) - 2yr  
 Geom: Alt 2 - Truncated

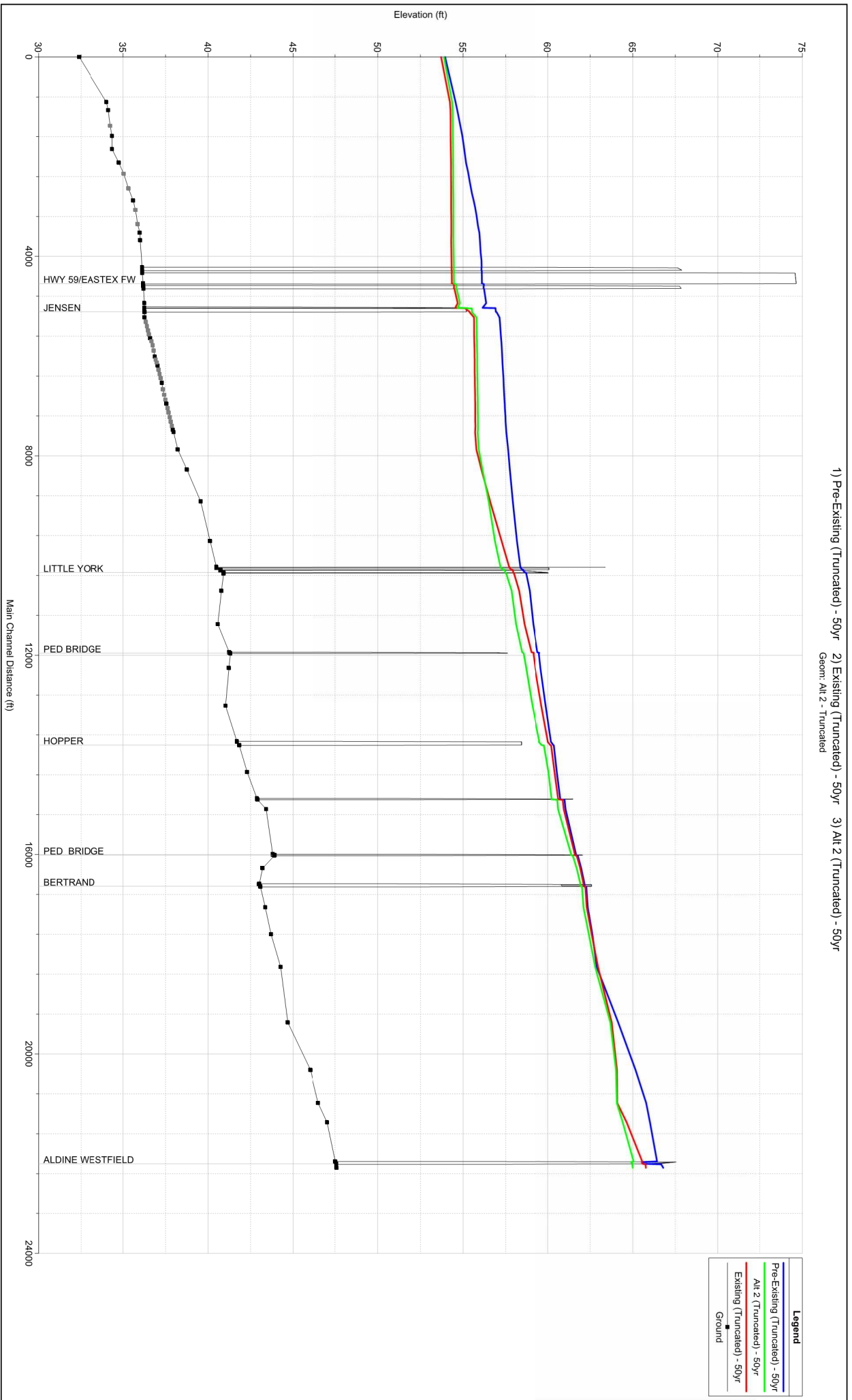
Legend	
Blue line	Pre-Existing (Truncated) - 2yr
Green line	Alt 2 (Truncated) - 2yr
Red line	Existing (Truncated) - 2yr
Black line with squares	Ground





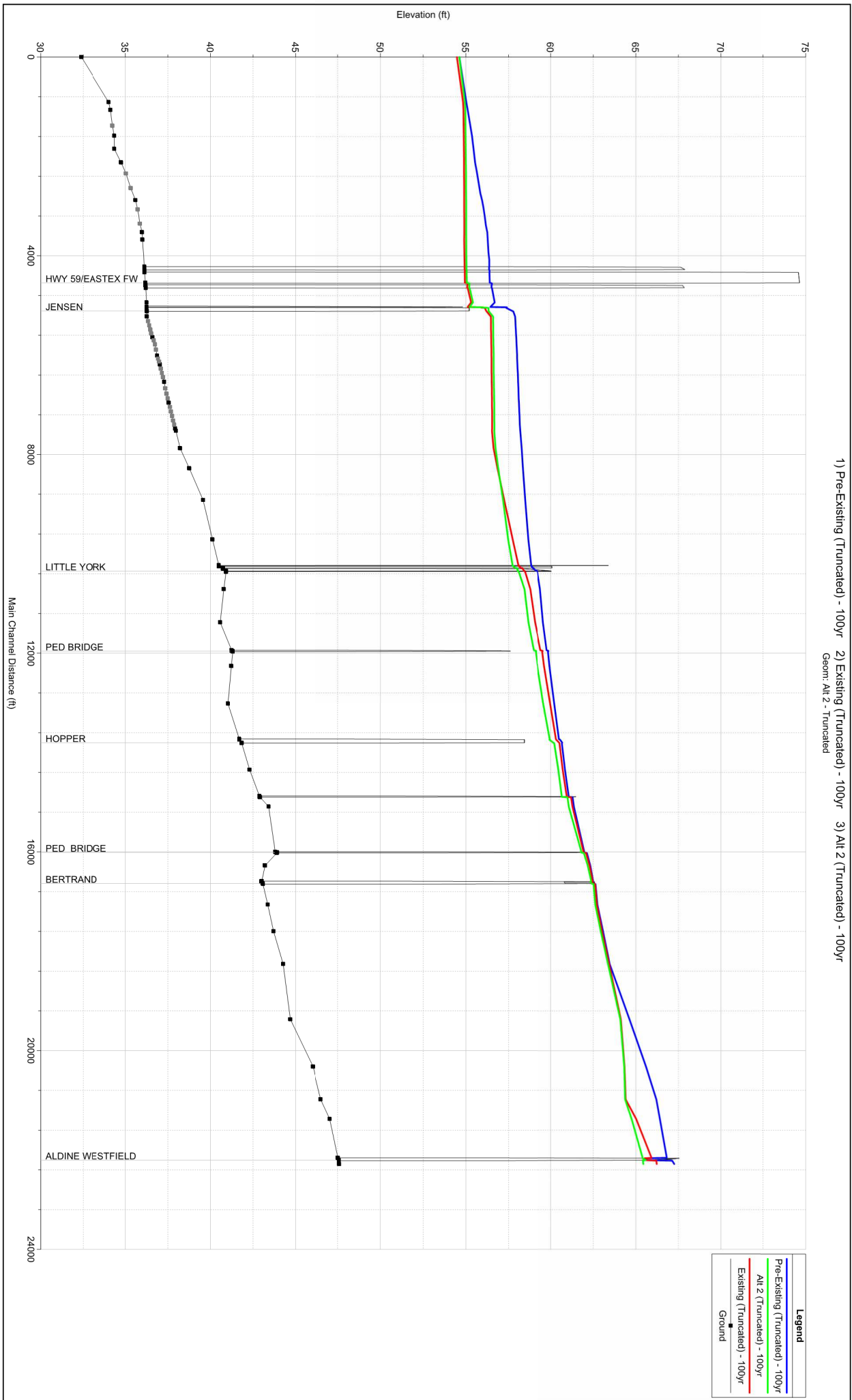
1) Pre-Existing (Truncated) - 10yr 2) Existing (Truncated) - 10yr 3) Alt 2 (Truncated) - 10yr  
 Geom: Alt 2 - Truncated



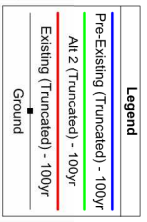


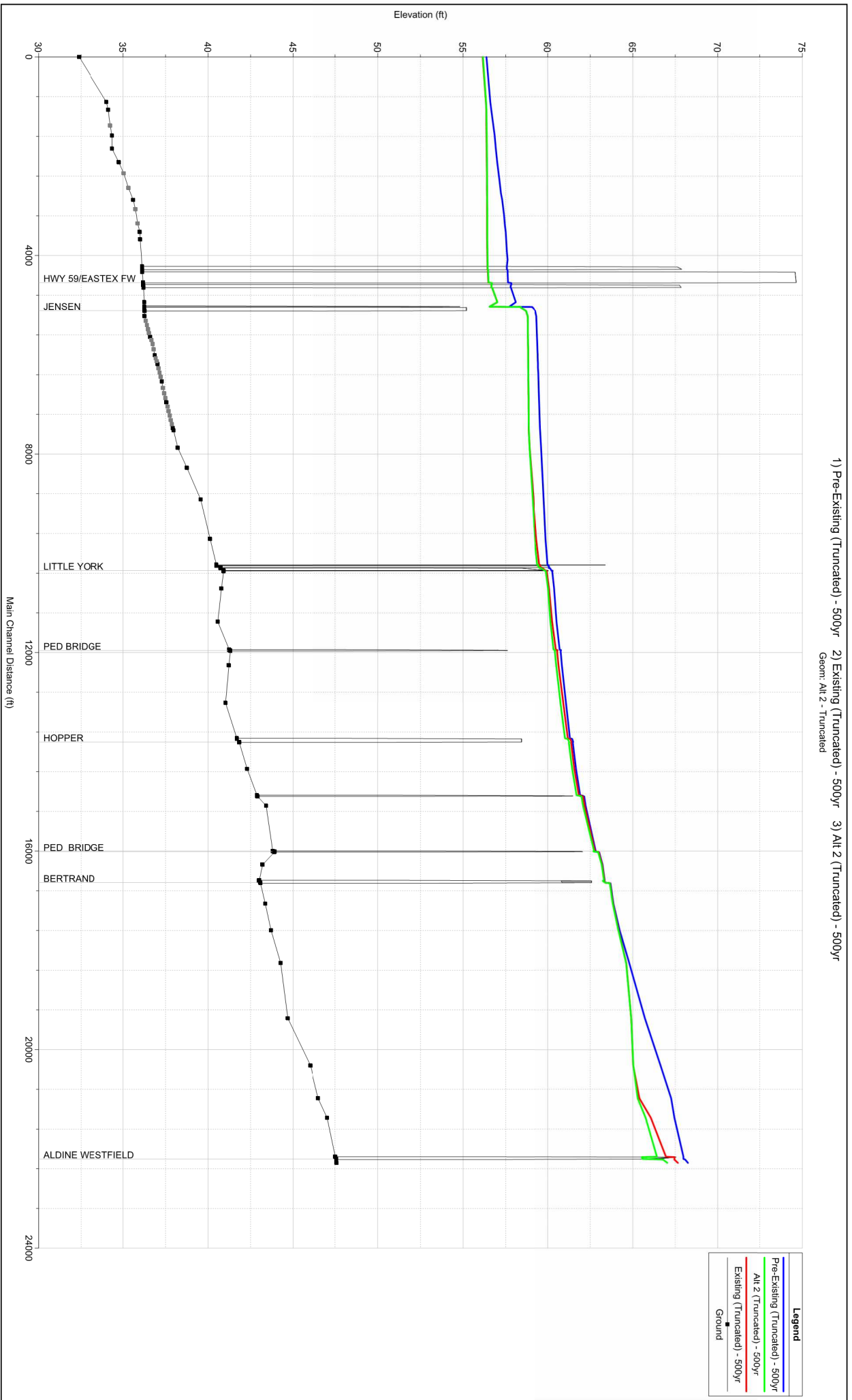
1) Pre-Existing (Truncated) - 50yr 2) Existing (Truncated) - 50yr 3) Alt 2 (Truncated) - 50yr  
 Geom: Alt 2 - Truncated

**Legend**  
 Pre-Existing (Truncated) - 50yr  
 Alt 2 (Truncated) - 50yr  
 Existing (Truncated) - 50yr  
 Ground



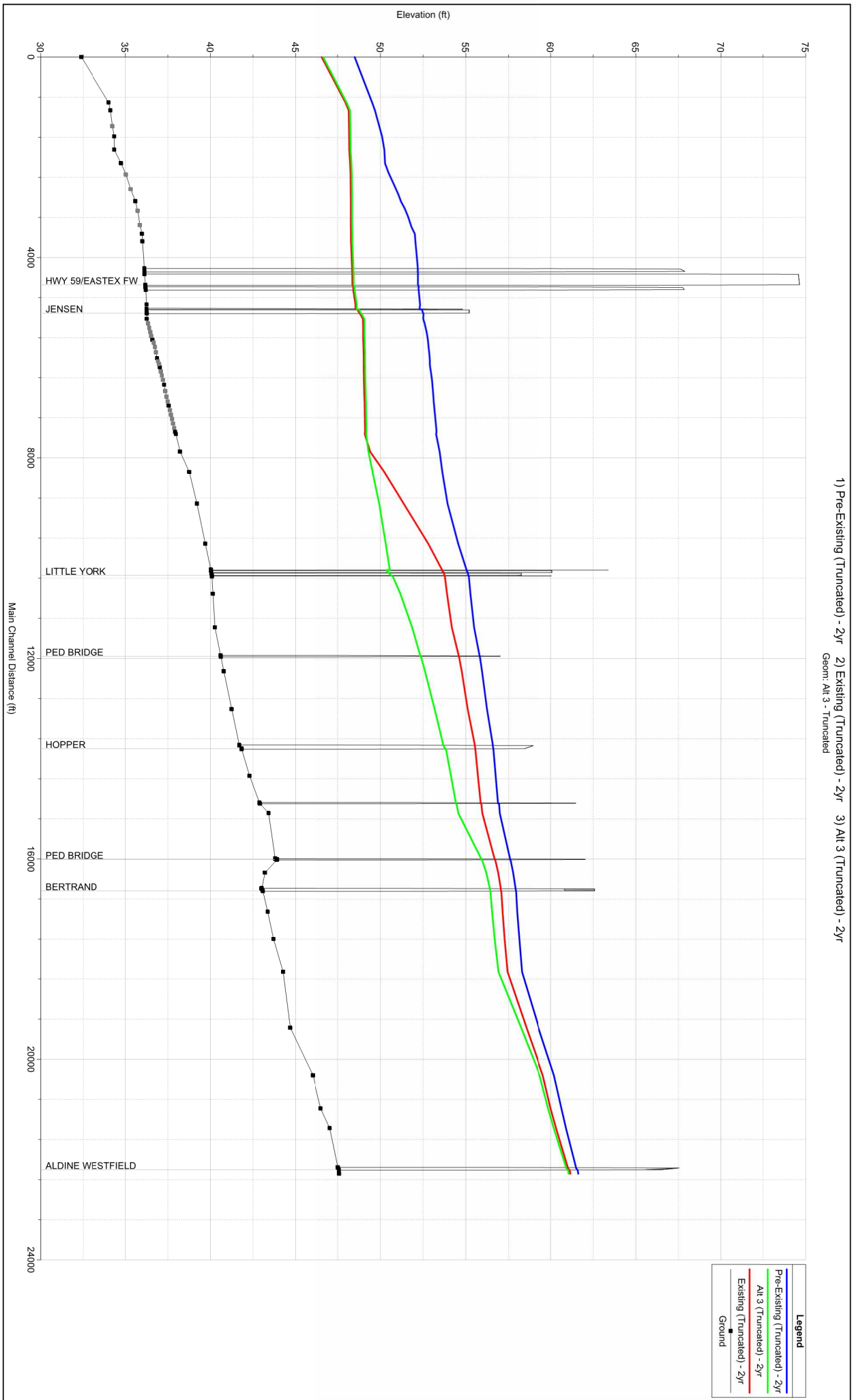
1) Pre-Existing (Truncated) - 100yr 2) Existing (Truncated) - 100yr 3) Alt 2 (Truncated) - 100yr  
 Geom: Alt 2 - Truncated





# **APPENDIX G**

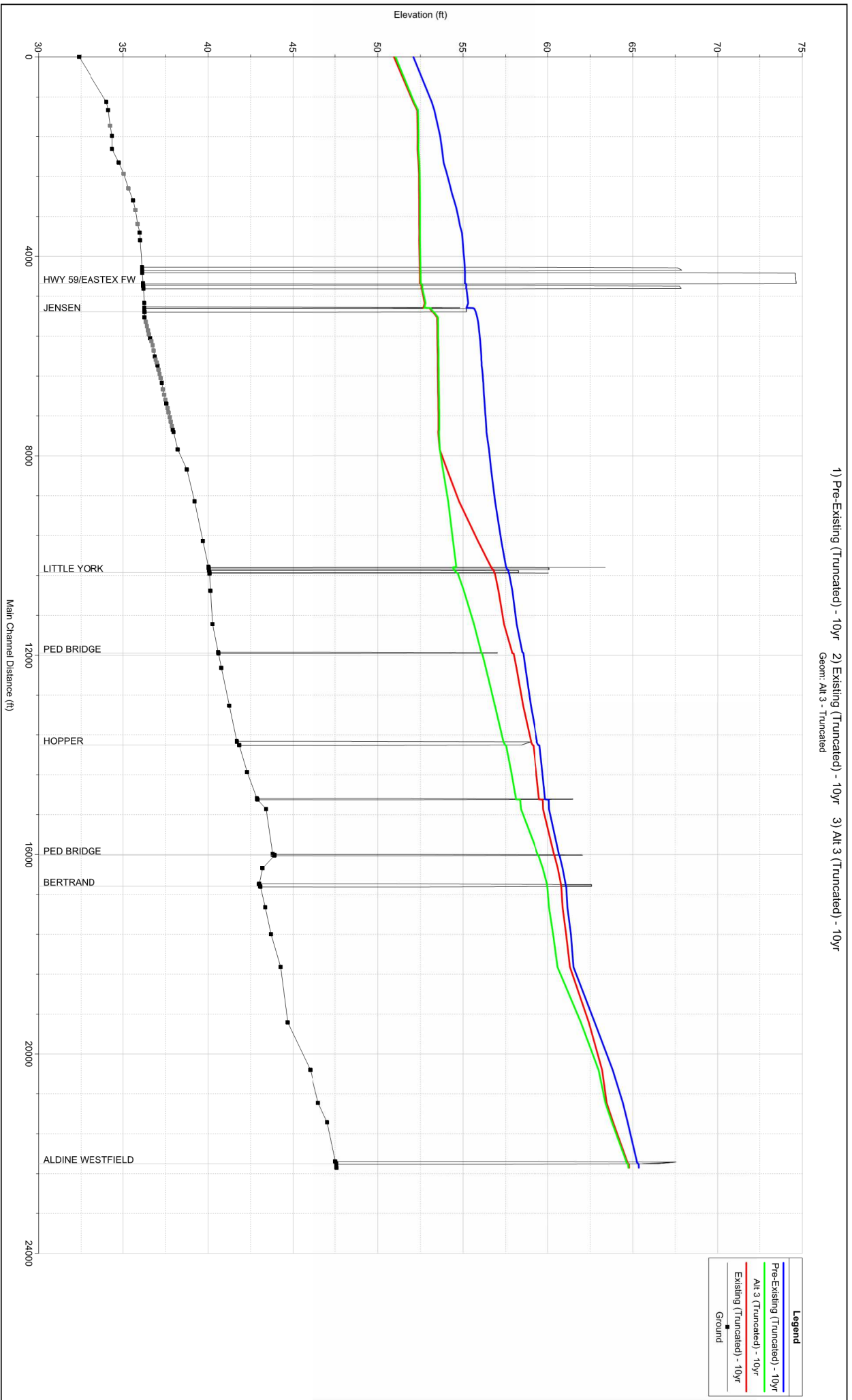
**Water Surface Profile Comparisons  
Alternative 3 vs. Baseline Conditions**



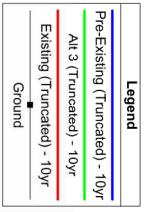
1) Pre-Existing (Truncated) - 2yr 2) Existing (Truncated) - 2yr 3) Alt 3 (Truncated) - 2yr  
 Geom: Alt 3 - Truncated

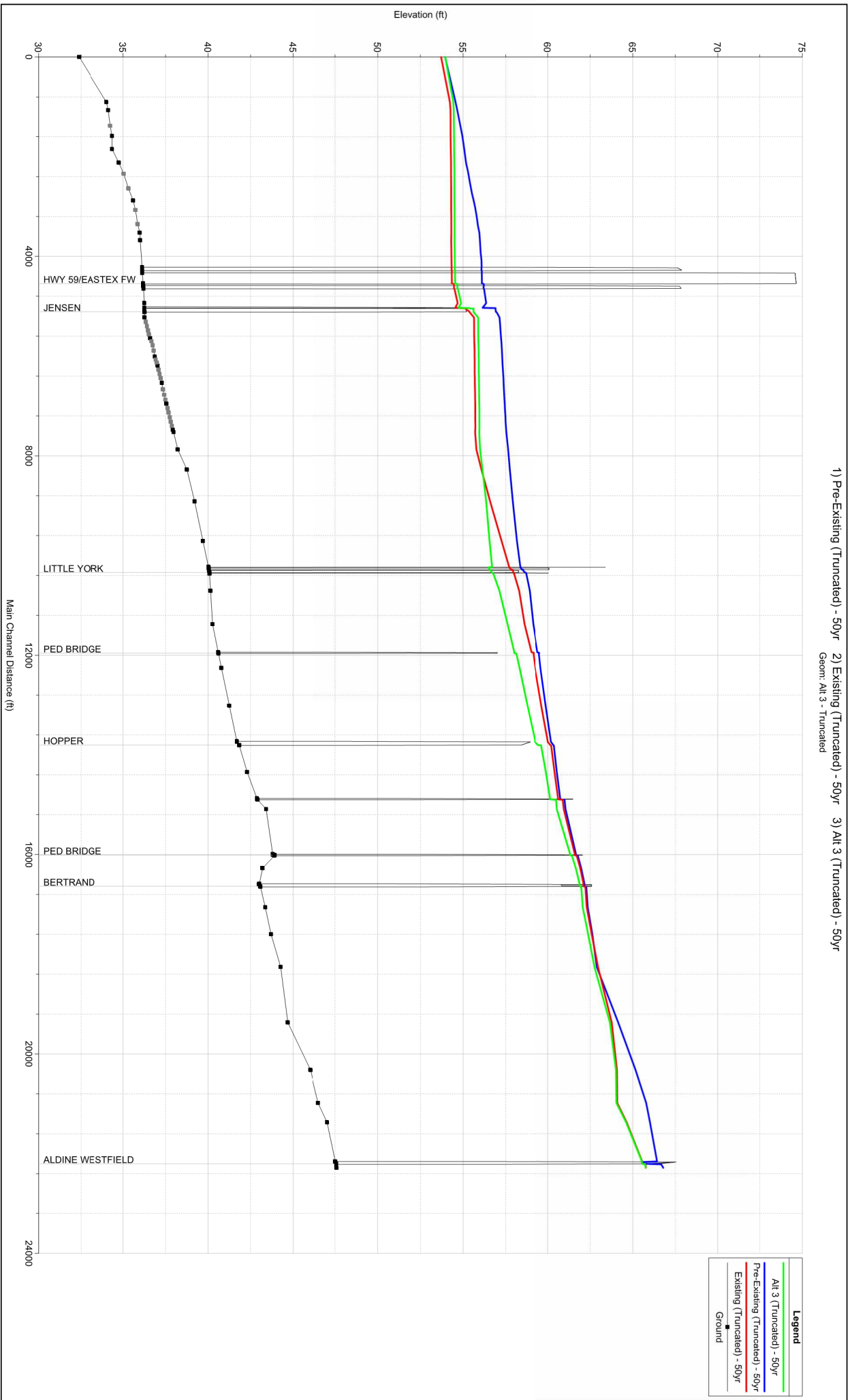
**Legend**

- Pre-Existing (Truncated) - 2yr
- Alt 3 (Truncated) - 2yr
- Existing (Truncated) - 2yr
- Ground

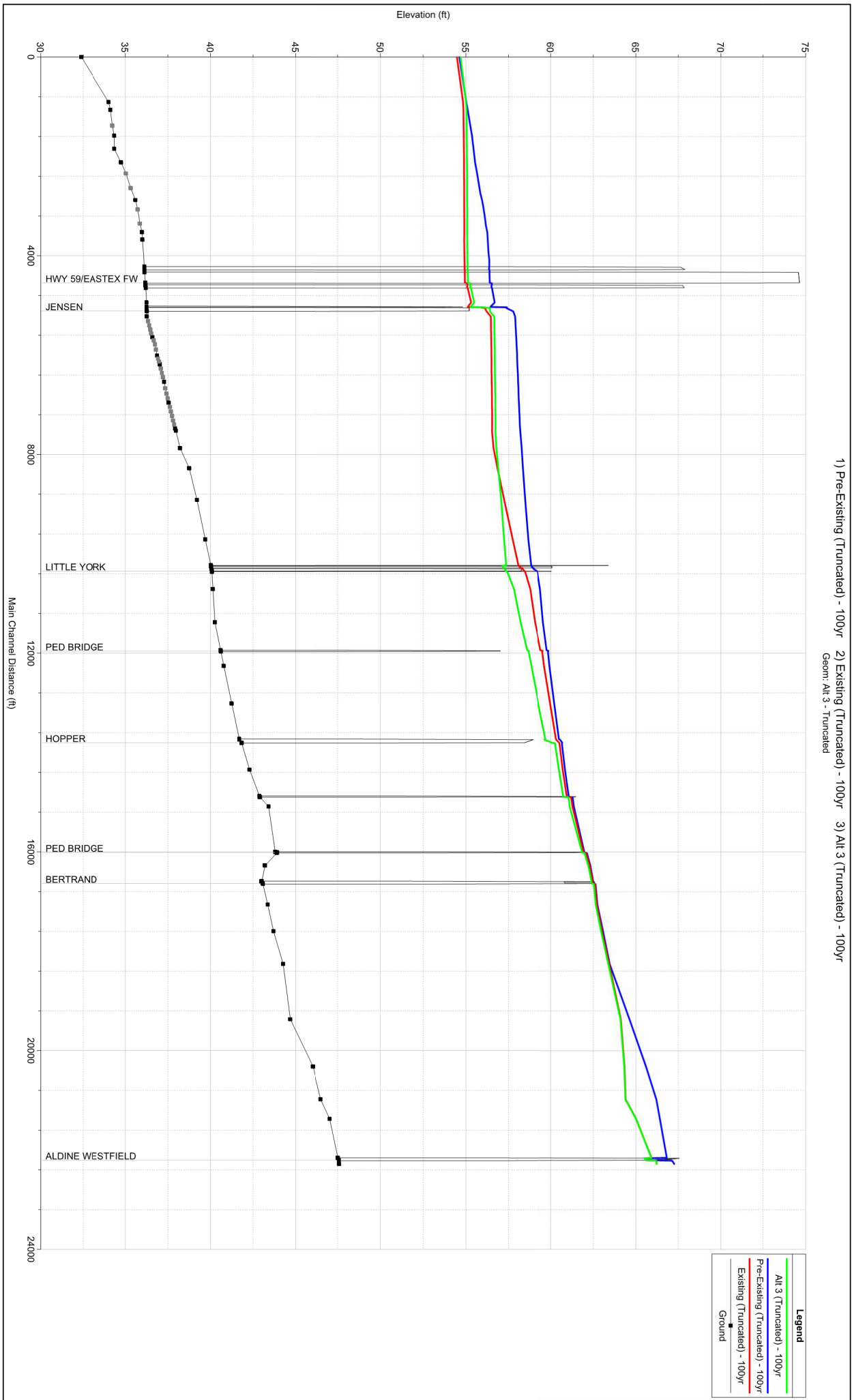


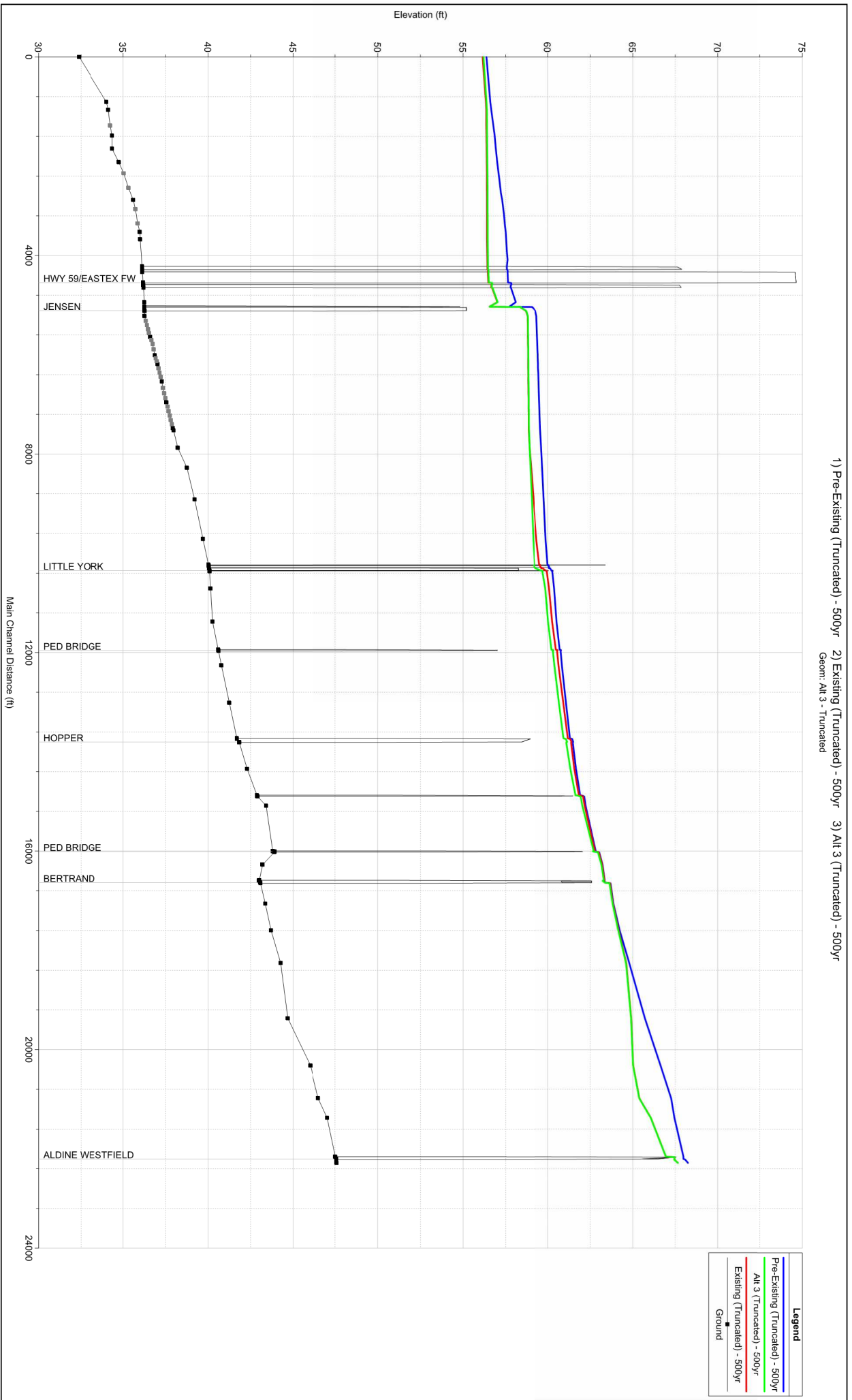
1) Pre-Existing (Truncated) - 10yr 2) Existing (Truncated) - 10yr 3) Alt 3 (Truncated) - 10yr  
 Geom: Alt 3 - Truncated











# **APPENDIX H**

## **HCFCO Project Scoring Documentation**

## Harris County Flood Control District Project Scoring Form

**USERS:**

Only type in cells that are ORANGE shaded.

GREY cells are automatic calculations (Do not type in these cells).

\* YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the

**NOTES:**

Prioritization Scoring Framework VERSION: July 28, 2021 (6-8)

<b>TOTAL PROJECT SCORE:</b>	<b>8.46</b>
<b>Project Area:</b>	Alt #1
<b>Project ID:</b>	P118-00-00 (C-41)
<b>Project Name:</b>	Mainstem Improvements
<b>Project Manager:</b>	William Conlan
<b>Project Watershed:</b>	(P) Halls Bayou

1. What is the <b>OVERALL</b> project cost?	\$ 1,839,940	USD.	\$ 1,839,940	DISTRICT COST (After Partnership / Grant)
2. Does the project have potential for <b>PARTNERSHIP</b> or <b>GRANT</b> funding?	No funding partner or grant.			
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?	0% <i>If unknown, enter "0%"</i>			
3a. How many structures are subject to flooding in the <b>BASELINE</b> (existing) condition?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	25	1893	2633
3b. How many structures are proposed to have the <b>FULL BENEFIT</b> of floodplain removal for the respective events?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	25	1203	974
3c. How many structures have a proposed <b>PARTIAL BENEFIT</b> floodplain depth reduction <b>GREATER</b> than 0.25-feet?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	0	622	1353
4. How many linear feet of channel in the Project area have a <b>ROW WIDTH</b> less than 110-ft wide?	0	FEET	0.00	MILES
5. What is the <b>CDC Social Vulnerability Index (SVI)</b> of the observed Project Area?	Area (Acres)	Percentage	Project Area: Alt #1	
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?	0	0%	<b>4125 acres</b>	
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?	0	0%		
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?	279	7%		
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?	3846	93%		
6. What is the qualitative expectation of the projects need for <b>LONG TERM MAINTENANCE</b> ?	No requirements for special maintenance have been identified.			
7. What is/are the project's potential <b>ENVIRONMENTAL</b> impacts?	Less than 0.1 acres of wetlands expected to be impacted or wetland impacts are not known			
Is there any knowledge of <b>CULTURAL ARTIFACTS</b> ?	No			
8a. What is the projects potential to offer <b>RECREATIONAL FEATURES</b> as a benefit?	A possible partner has been identified for potential recreational features over 50% of the Project			
8b. What is the projects potential to offer <b>ENVIRONMENTAL ENHANCEMENTS</b> as a benefit?	50% of the Project is not expected to have environmental enhancement			

Note: Project cost does not include the cost of the three previously constructed detention basins.

## Harris County Flood Control District Project Scoring Form

**USERS:**

Only type in cells that are ORANGE shaded.

GREY cells are automatic calculations (Do not type in these cells).

\* YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the

**NOTES:**

Prioritization Scoring Framework VERSION: July 28, 2021 (6-8)

<b>TOTAL PROJECT SCORE:</b>	<b>8.31</b>
Project Area:	Alt #2
Project ID:	P118-00-00 (C-41)
Project Name:	Mainstem Improvements
Project Manager:	William Conlan
Project Watershed:	(P) Halls Bayou

1. What is the <b>OVERALL</b> project cost?	\$ 2,508,390	USD.	\$ 2,508,390	DISTRICT COST (After Partnership / Grant)
2. Does the project have potential for <b>PARTNERSHIP</b> or <b>GRANT</b> funding?	No funding partner or grant.			
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?	0% <i>If unknown, enter "0%"</i>			
3a. How many structures are subject to flooding in the <b>BASELINE</b> (existing) condition?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	25	1893	2633
3b. How many structures are proposed to have the <b>FULL BENEFIT</b> of floodplain removal for the respective events?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	25	1206	980
3c. How many structures have a proposed <b>PARTIAL BENEFIT</b> floodplain depth reduction <b>GREATER</b> than 0.25-feet?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	0	641	1365
4. How many linear feet of channel in the Project area have a <b>ROW WIDTH</b> less than 110-ft wide?	0	FEET	0.00	MILES
5. What is the <b>CDC Social Vulnerability Index (SVI)</b> of the observed Project Area?	Area (Acres)	Percentage	Project Area: Alt #2	
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?	0	0%	<b>4125 acres</b>	
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?	0	0%		
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?	279	7%		
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?	3846	93%		
6. What is the qualitative expectation of the projects need for <b>LONG TERM MAINTENANCE</b> ?	No requirements for special maintenance have been identified.			
7. What is/are the project's potential <b>ENVIRONMENTAL</b> impacts?	0.1 to 0.5 acres of wetlands expected to be impacted			
Is there any knowledge of <b>CULTURAL ARTIFACTS</b> ?	No			
8a. What is the projects potential to offer <b>RECREATIONAL FEATURES</b> as a benefit?	50% of the Project has potential for recreational features			
8b. What is the projects potential to offer <b>ENVIRONMENTAL ENHANCEMENTS</b> as a benefit?	50% of the Project is not expected to have environmental enhancement			

Note: Project cost does not include the cost of the three previously constructed detention basins.

## Harris County Flood Control District Project Scoring Form

**USERS:**

Only type in cells that are ORANGE shaded.

GREY cells are automatic calculations (Do not type in these cells).

\* YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the

**NOTES:**

Prioritization Scoring Framework VERSION: July 28, 2021 (6-8)

<b>TOTAL PROJECT SCORE:</b>	<b>8.36</b>
Project Area:	Alt #3
Project ID:	P118-00-00 (C-41)
Project Name:	Mainstem Improvements
Project Manager:	William Conlan
Project Watershed:	(P) Halls Bayou

1. What is the <b>OVERALL</b> project cost?	\$ 5,241,050	USD.	\$ 5,241,050	DISTRICT COST (After Partnership / Grant)
2. Does the project have potential for <b>PARTNERSHIP</b> or <b>GRANT</b> funding?	No funding partner or grant.			
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?	0% <span style="color: red;">If unknown, enter "0%"</span>			
3a. How many structures are subject to flooding in the <b>BASELINE</b> (existing) condition?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	25	1893	2633
3b. How many structures are proposed to have the <b>FULL BENEFIT</b> of floodplain removal for the respective events?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	25	1809	1840
3c. How many structures have a proposed <b>PARTIAL BENEFIT</b> floodplain depth reduction <b>GREATER</b> than 0.25-feet?	EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)
	# of Structures	0	42	654
4. How many linear feet of channel in the Project area have a <b>ROW WIDTH</b> less than 110-ft wide?	0	FEET	0.00	MILES
5. What is the <b>CDC Social Vulnerability Index (SVI)</b> of the observed Project Area?	Area (Acres)	Percentage	Project Area: Alt #3	
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?	0	0%	<b>4125 acres</b>	
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?	0	0%		
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?	279	7%		
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?	3846	93%		
6. What is the qualitative expectation of the projects need for <b>LONG TERM MAINTENANCE</b> ?	No requirements for special maintenance have been identified.			
7. What is/are the project's potential <b>ENVIRONMENTAL</b> impacts?	0.5 to 2 acres of wetlands expected to be impacted			
Is there any knowledge of <b>CULTURAL ARTIFACTS</b> ?	No			
8a. What is the projects potential to offer <b>RECREATIONAL FEATURES</b> as a benefit?	50% of the Project has potential for recreational features			
8b. What is the projects potential to offer <b>ENVIRONMENTAL ENHANCEMENTS</b> as a benefit?	50% of the Project has potential for environmental enhancements			

Note: Project cost does not include the cost of the three previously constructed detention basins.

## Harris County Flood Control District Project Scoring Form

### **Mainstem Improvements**

**SCORING CRITERIA:**      **1**      **2**      **3**      **4**      **5**      **6**      **7**      **8**

*Weight:*      25%      20%      20%      10%      10%      5%      5%      5%

Project Area:	Project ID:	Flood Risk (100-Year Event) Reduction	Existing Conditions Drainage LOS	Social Vulnerability Index (SVI)	Project Efficiency	Partnership Funding	Long Term Maintenance Costs	Minimize Environmental Impacts	Potential for Multiple Benefits	TOTAL SCORE
Alt #1	P118-00-00 (C-41)	2.50	2.00	1.96	1.00	0.00	0.50	0.40	0.10	<b>8.46</b>
Alt #2	P118-00-00 (C-41)	2.50	2.00	1.96	1.00	0.00	0.50	0.30	0.05	<b>8.31</b>
Alt #3	P118-00-00 (C-41)	2.50	2.00	1.96	1.00	0.00	0.50	0.20	0.20	<b>8.36</b>

Note: Project cost does not include the cost of the three previously constructed detention basins.

## Harris County Flood Control District Scoring Form

USERS:	Only type in cells that are ORANGE shaded.				NOTES:							
GREY cells are automatic calculations (Do not type in these cells).					YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the							
*					PRIORITY Scoring Framework VERSION:				July 28, 2021 (6-8)			
<b>TOTAL PROJECT SCORE:</b>					<b>7.55</b>							
1. What is the <b>OVERALL</b> project cost?					\$	29,711,478	USD.	\$	29,711,478	DISTRICT COST (After Partnership / Grant)		
2. Does the project have potential for <b>PARTNERSHIP</b> or <b>GRANT</b> funding?					No funding partner or grant.							
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?					0%					If unknown, enter "0%"		
3a. How many structures are subject to flooding in the <b>BASELINE</b> (existing) condition?					EVENT		10-yr (10%)		50-yr (2%)		100-yr (1%)	
					# of Structures		25		1893		2633	
3b. How many structures are proposed to have the <b>FULL BENEFIT</b> of floodplain removal for the respective events?					EVENT		10-yr (10%)		50-yr (2%)		100-yr (1%)	
					# of Structures		25		1203		974	
3c. How many structures have a proposed <b>PARTIAL BENEFIT</b> floodplain depth reduction <b>GREATER</b> than 0.25-feet?					EVENT		10-yr (10%)		50-yr (2%)		100-yr (1%)	
					# of Structures		0		622		1353	
4. How many linear feet of channel in the Project area have a <b>ROW WIDTH</b> less than 110-ft wide?					0		FEET		0.00		MILES	
5. What is the <b>CDC Social Vulnerability Index (SVI)</b> of the observed Project Area?					Area (Acres)		Percentage		Project Area: Alt #1			
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?					0		0%		<b>4125 acres</b>			
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?					0		0%					
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?					279		7%					
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?					3846		93%					
6. What is the qualitative expectation of the projects need for <b>LONG TERM MAINTENANCE</b> ?					Project is expected to require maintenance outside of District's regular maintenance practices and will incur some additional costs.							
7. What is/are the project's potential <b>ENVIRONMENTAL</b> impacts?					0.1 to 0.5 acres of wetlands expected to be impacted							
Is there any knowledge of <b>CULTURAL ARTIFACTS</b> ?					No							
8a. What is the projects potential to offer <b>RECREATIONAL FEATURES</b> as a benefit?					50% of the Project has potential for recreational features							
8b. What is the projects potential to offer <b>ENVIRONMENTAL ENHANCEMENTS</b> as a benefit?					50% of the Project is not expected to have environmental enhancement							

Note: Construction costs of Keith-Wiess, Bretshire, and Hall Park detention is included.



## Harris County Flood Control District Scoring Form

USERS:	Only type in cells that are ORANGE shaded.				NOTES:					
GREY cells are automatic calculations (Do not type in these cells).										
* YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the					Prioritization Scoring Framework VERSION: July 28, 2021 (6-8)					
<b>TOTAL PROJECT SCORE:</b>					<b>7.54</b>					
1. What is the <b>OVERALL</b> project cost?					\$	30,379,928	USD.	\$	30,379,928	DISTRICT COST (After Partnership / Grant)
2. Does the project have potential for <b>PARTNERSHIP</b> or <b>GRANT</b> funding?					No funding partner or grant.					
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?					0% <i>If unknown, enter "0%"</i>					
3a. How many structures are subject to flooding in the <b>BASELINE</b> (existing) condition?					EVENT		10-yr (10%)		100-yr (1%)	
					# of Structures		25		2633	
3b. How many structures are proposed to have the <b>FULL BENEFIT</b> of floodplain removal for the respective events?					EVENT		10-yr (10%)		100-yr (1%)	
					# of Structures		25		980	
3c. How many structures have a proposed <b>PARTIAL BENEFIT</b> floodplain depth reduction <b>GREATER</b> than 0.25-feet?					EVENT		10-yr (10%)		100-yr (1%)	
					# of Structures		0		1365	
4. How many linear feet of channel in the Project area have a <b>ROW WIDTH</b> less than 110-ft wide?					0		FEET		0.00	
5. What is the <b>CDC Social Vulnerability Index (SVI)</b> of the observed Project Area?					Area (Acres)		Percentage		Project Area: Alt #2	
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?					0		0%		<b>4125 acres</b>	
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?					0		0%			
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?					279		7%			
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?					3846		93%			
6. What is the qualitative expectation of the projects need for <b>LONG TERM MAINTENANCE</b> ?					Project is expected to require maintenance outside of District's regular maintenance practices and will incur some additional costs.					
7. What is/are the project's potential <b>ENVIRONMENTAL</b> impacts?					0.1 to 0.5 acres of wetlands expected to be impacted					
Is there any knowledge of <b>CULTURAL ARTIFACTS</b> ?					No					
8a. What is the projects potential to offer <b>RECREATIONAL FEATURES</b> as a benefit?					50% of the Project has potential for recreational features					
8b. What is the projects potential to offer <b>ENVIRONMENTAL ENHANCEMENTS</b> as a benefit?					50% of the Project is not expected to have environmental enhancement					

Note: Construction costs of Keith-Wiess, Bretshire, and Hall Park detention is included.

## Harris County Flood Control District Scoring Form

USERS:	Only type in cells that are ORANGE shaded.				NOTES:					
GREY cells are automatic calculations (Do not type in these cells).					YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the					
<b>* YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the</b>					Prioritization Scoring Framework VERSION:				July 28, 2021 (6-8)	
<b>TOTAL PROJECT SCORE:</b>					<b>7.40</b>					
1. What is the <b>OVERALL</b> project cost?					\$	33,112,588	USD.	\$	33,112,588	DISTRICT COST (After Partnership / Grant)
2. Does the project have potential for <b>PARTNERSHIP</b> or <b>GRANT</b> funding?					No funding partner or grant.					
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?					0% If unknown, enter "0%"					
3a. How many structures are subject to flooding in the <b>BASELINE</b> (existing) condition?					EVENT		10-yr (10%)		100-yr (1%)	
					# of Structures		25	1893	2633	
3b. How many structures are proposed to have the <b>FULL BENEFIT</b> of floodplain removal for the respective events?					EVENT		10-yr (10%)		100-yr (1%)	
					# of Structures		25	1809	1840	
3c. How many structures have a proposed <b>PARTIAL BENEFIT</b> floodplain depth reduction <b>GREATER</b> than 0.25-feet?					EVENT		10-yr (10%)		100-yr (1%)	
					# of Structures		0	42	654	
4. How many linear feet of channel in the Project area have a <b>ROW WIDTH</b> less than 110-ft wide?					0		FEET		0.00	
5. What is the <b>CDC Social Vulnerability Index (SVI)</b> of the observed Project Area?					Area (Acres)		Percentage		Project Area: Alt #3	
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?					0		0%		<b>4125 acres</b>	
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?					0		0%			
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?					279		7%			
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?					3846		93%			
6. What is the qualitative expectation of the projects need for <b>LONG TERM MAINTENANCE</b> ?					Project is expected to require maintenance outside of District's regular maintenance practices and will incur some additional costs.					
7. What is/are the project's potential <b>ENVIRONMENTAL</b> impacts?					2 to 5 acres of wetlands expected to be impacted					
Is there any knowledge of <b>CULTURAL ARTIFACTS</b> ?					No					
8a. What is the projects potential to offer <b>RECREATIONAL FEATURES</b> as a benefit?					50% of the Project has potential for recreational features					
8b. What is the projects potential to offer <b>ENVIRONMENTAL ENHANCEMENTS</b> as a benefit?					50% of the Project is not expected to have environmental enhancement					

Note: Construction costs of Keith-Wiess, Bretshire, and Hall Park detention is included.

## Harris County Flood Control District Project Scoring Form

### **Halls Bayou - Mainstem Improvements**

**SCORING CRITERIA:**

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
<b>Weight:</b>	<i>25%</i>	<i>20%</i>	<i>20%</i>	<i>10%</i>	<i>10%</i>	<i>5%</i>	<i>5%</i>	<i>5%</i>

Project Area:	Project ID:	Flood Risk (100-Year Event) Reduction	Existing Conditions Drainage LOS	Social Vulnerability Index (SVI)	Project Efficiency	Partnership Funding	Long Term Maintenance Costs	Minimize Environmental Impacts	Potential for Multiple Benefits	TOTAL SCORE
Alt #1	P118-00-00 (C-41)	2.50	2.00	1.96	0.44	0.00	0.30	0.30	0.05	<b>7.55</b>
Alt #2	P118-00-00 (C-41)	2.50	2.00	1.96	0.43	0.00	0.30	0.30	0.05	<b>7.54</b>
Alt #3	P118-00-00 (C-41)	2.50	2.00	1.96	0.49	0.00	0.30	0.10	0.05	<b>7.40</b>

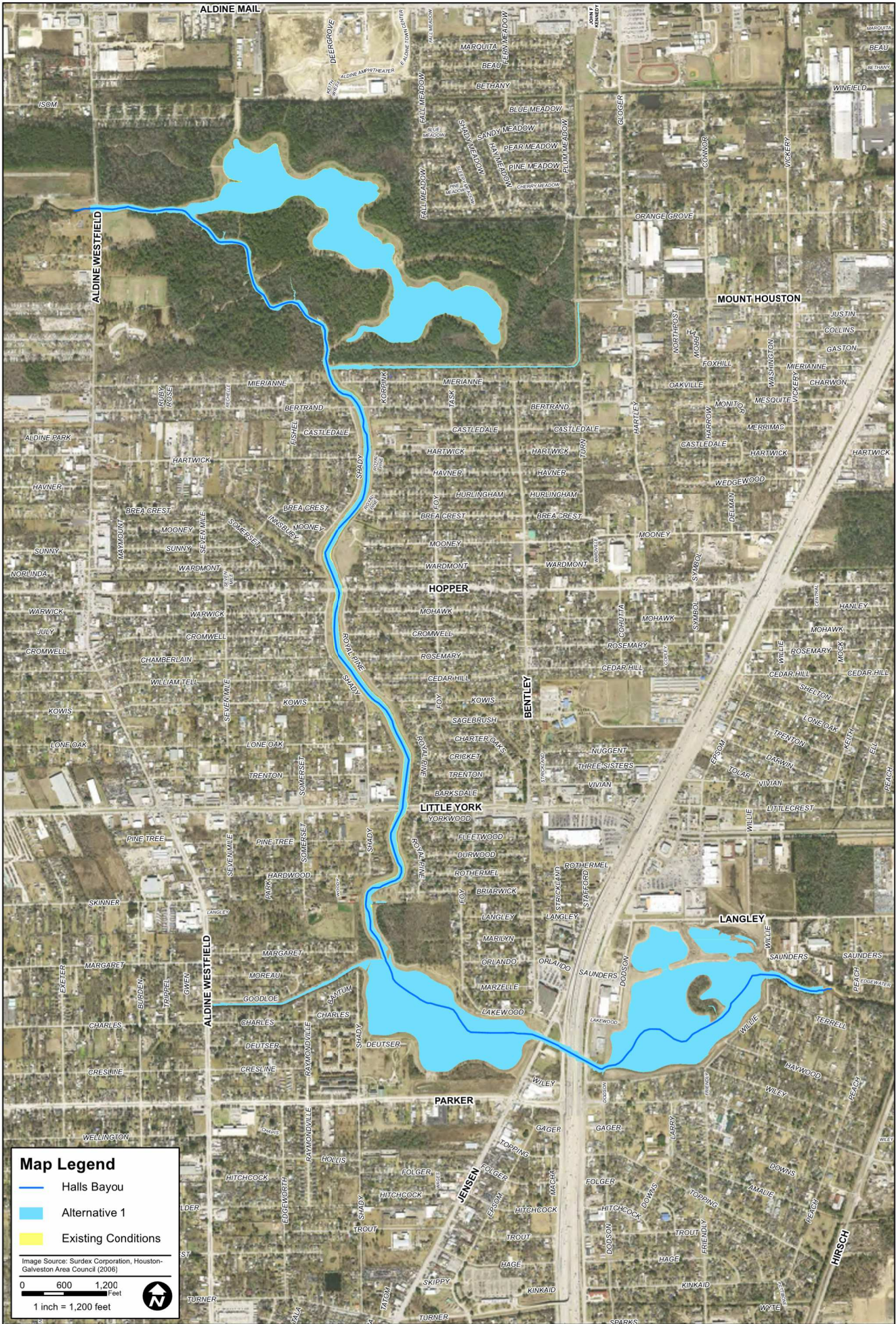
Note: These project scores include the construction costs of the three previously constructed detention basins (Keith-Wiess, Bretshire, and Hall Park).

Note: Construction costs of Keith-Wiess, Bretshire, and Hall Park detention is included.

# **APPENDIX I**

**Inundation Comparison Maps**

**Alternative 1**



**Map Legend**

- Halls Bayou
- Alternative 1
- Existing Conditions

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

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: JULY 2021  
SCALE: AS NOTED



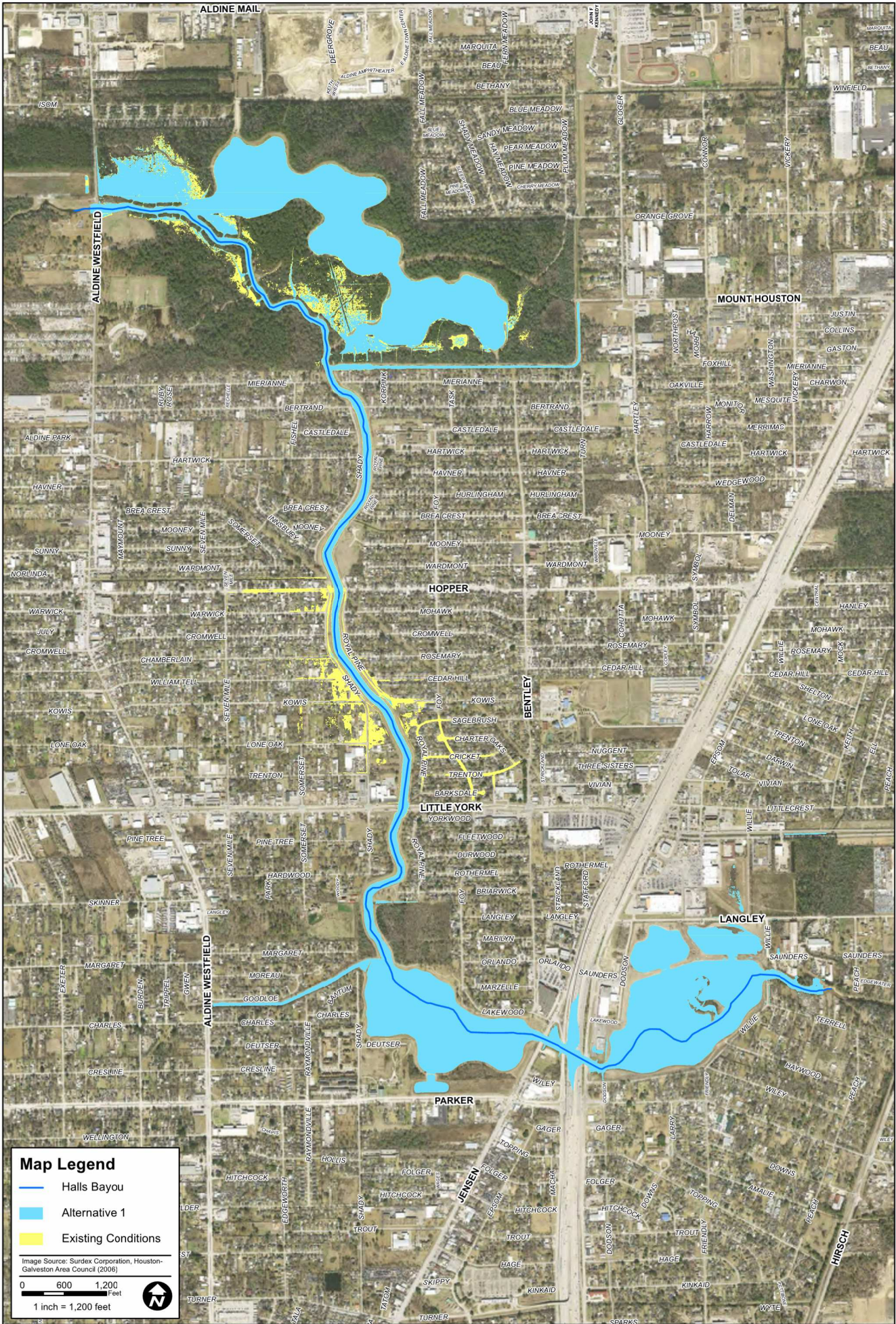
**lan** Lockwood, Andrews & Newnam, Inc.  
A LEO A DALY COMPANY

TBPE Firm No. 2614  
2925 Briarpark Drive • Houston, TX 77042-3720  
T 713.266.6900 • F 713.266.2089  
www.lan-inc.com • info@lan-inc.com

PREPARED: CRB  
CHECKED: WWC  
APPROVED: WWC

**HCFCF HALLS BAYOU WATERSHED  
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

**FLOODPLAIN COMPARISON  
ALTERNATIVE 1 vs. EXISTING (2-YEAR)**



**Map Legend**

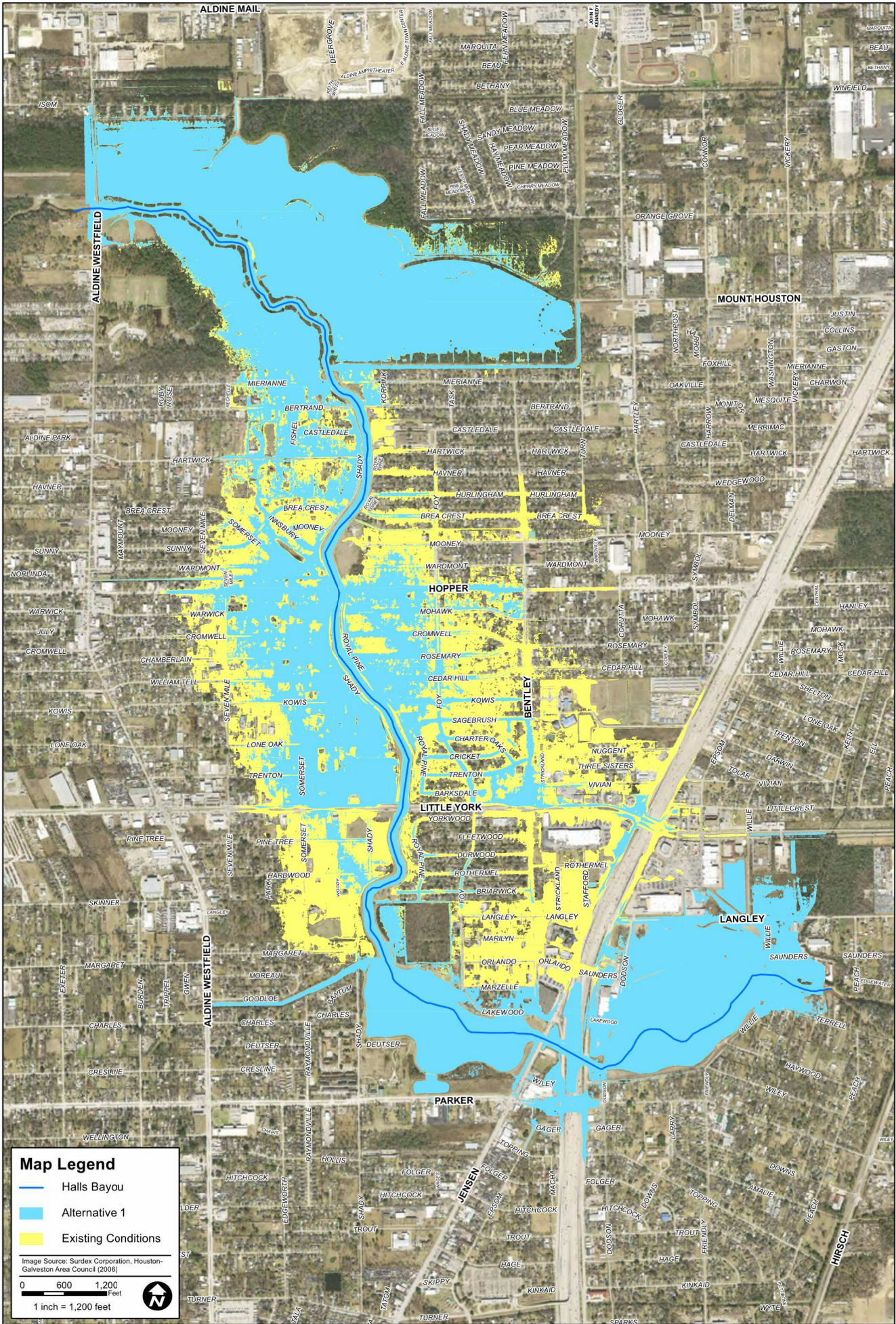
- Halls Bayou
- Alternative 1
- Existing Conditions

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

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: JULY 2021 SCALE: AS NOTED	 <b>FLOOD CONTROL DISTRICT</b> <small>9100 Northwest Freeway Houston, Texas 77036</small>	 <b>Lockwood, Andrews &amp; Newnam, Inc.</b> <small>A LEQ &amp; G&amp;L COMPANY</small> <small>TBPE Firm No. 2614 2925 Briarpark Drive • Houston, TX 77042-3720 T 713.286.6900 • F 713.286.2089 www.lan-inc.com • info@lan-inc.com</small>	PREPARED: CRB CHECKED: WWC APPROVED: WWC	<b>HCFCF HALLS BAYOU WATERSHED</b> <b>P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS</b> <b>FLOODPLAIN COMPARISON</b> <b>ALTERNATIVE 1 vs. EXISTING (10-YEAR)</b>
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**Map Legend**

- Halls Bayou
- Alternative 1
- Existing Conditions

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

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: JULY 2021  
SCALE: AS NOTED



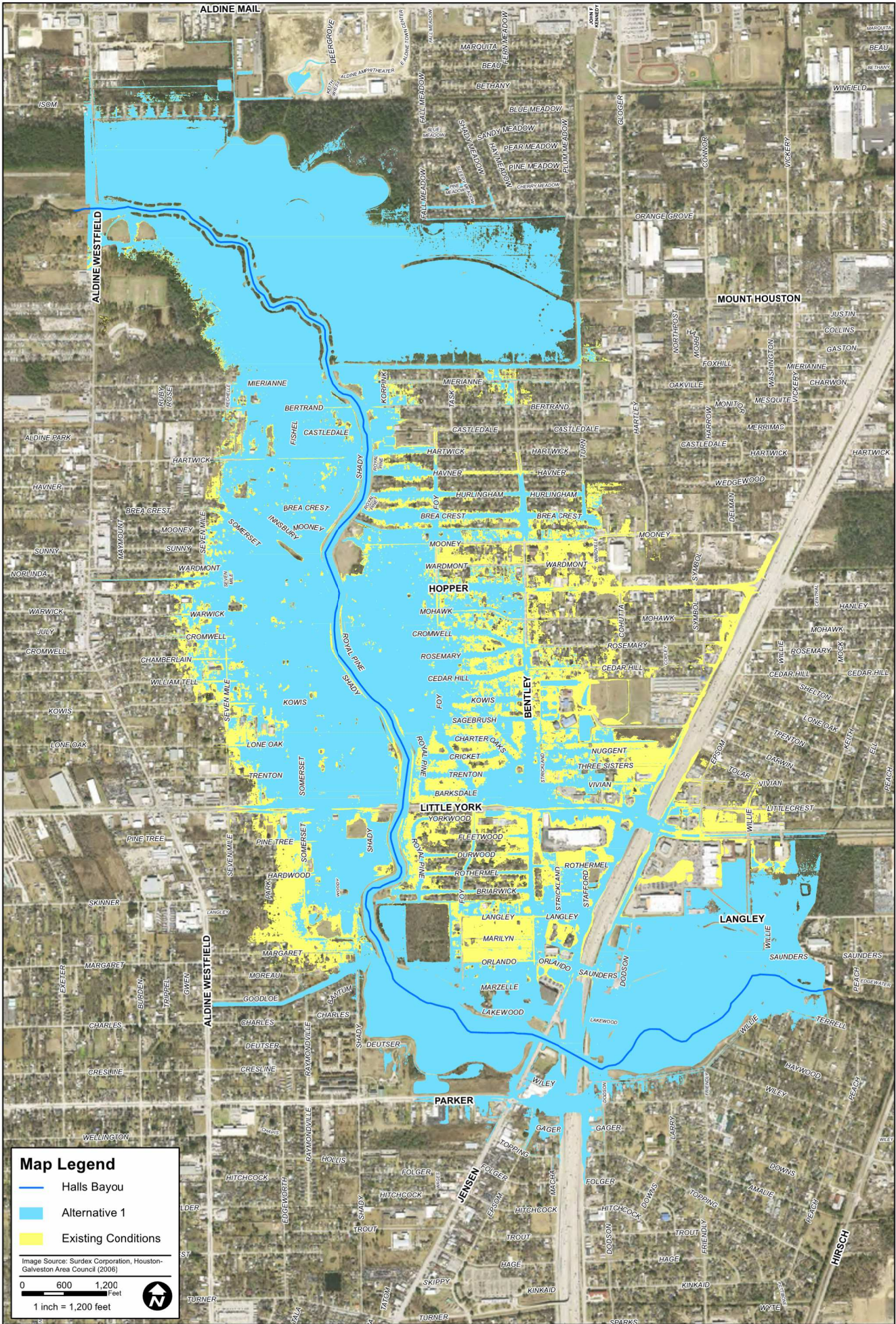
**lan** Lockwood, Andrews & Newnam, Inc.  
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T 713.286.6900 • F 713.286.2089  
www.lan-inc.com • info@lan-inc.com

PREPARED: CRB  
CHECKED: WWC  
APPROVED: WWC

**HCFCF HALLS BAYOU WATERSHED  
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

**FLOODPLAIN COMPARISON  
ALTERNATIVE 1 vs. EXISTING (50-YEAR)**



**Map Legend**

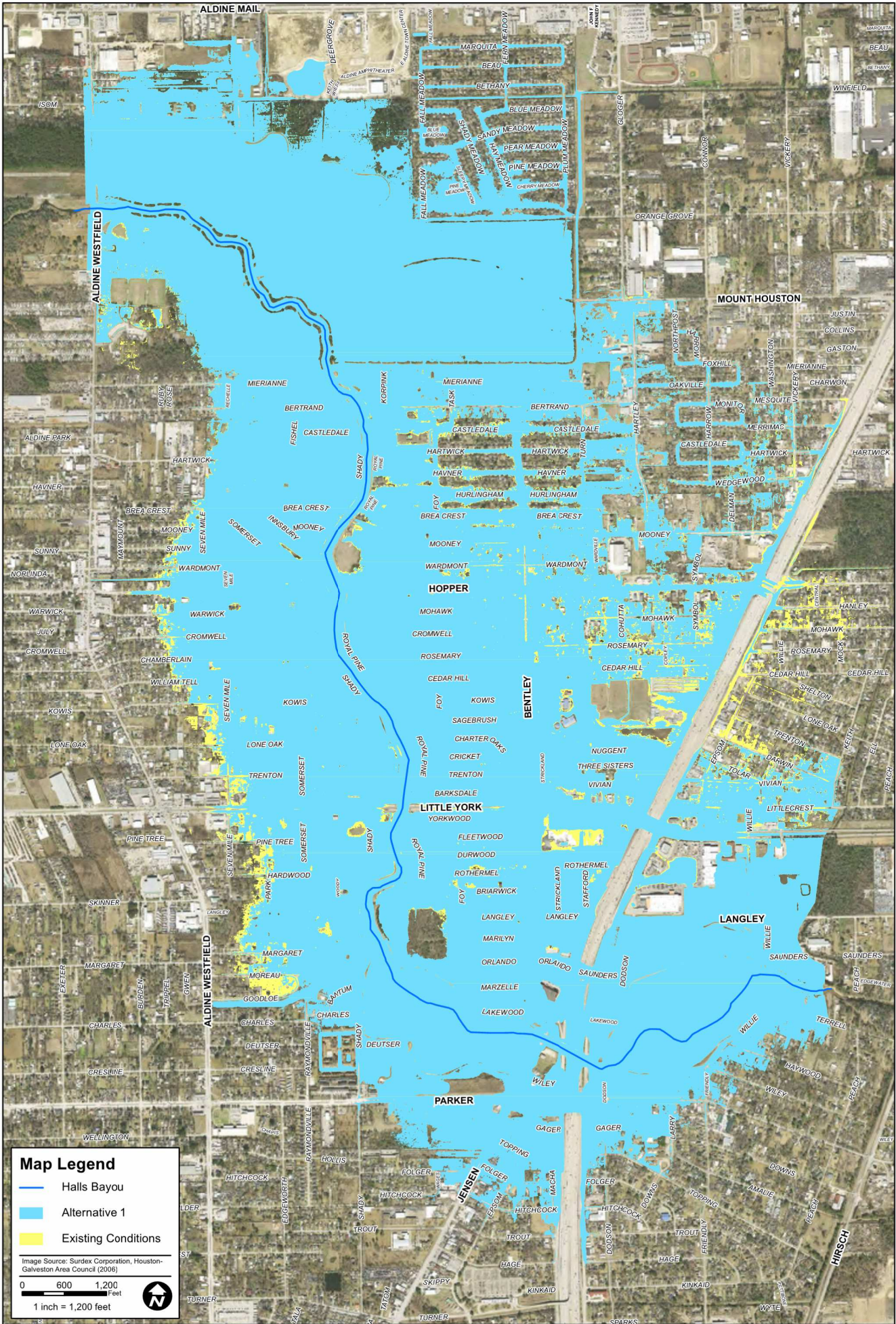
- Halls Bayou
- Alternative 1
- Existing Conditions

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

0 600 1,200 Feet

1 inch = 1,200 feet





**Map Legend**

- Halls Bayou
- Alternative 1
- Existing Conditions

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

0 600 1,200 Feet

1 inch = 1,200 feet

DATE: JULY 2021  
SCALE: AS NOTED



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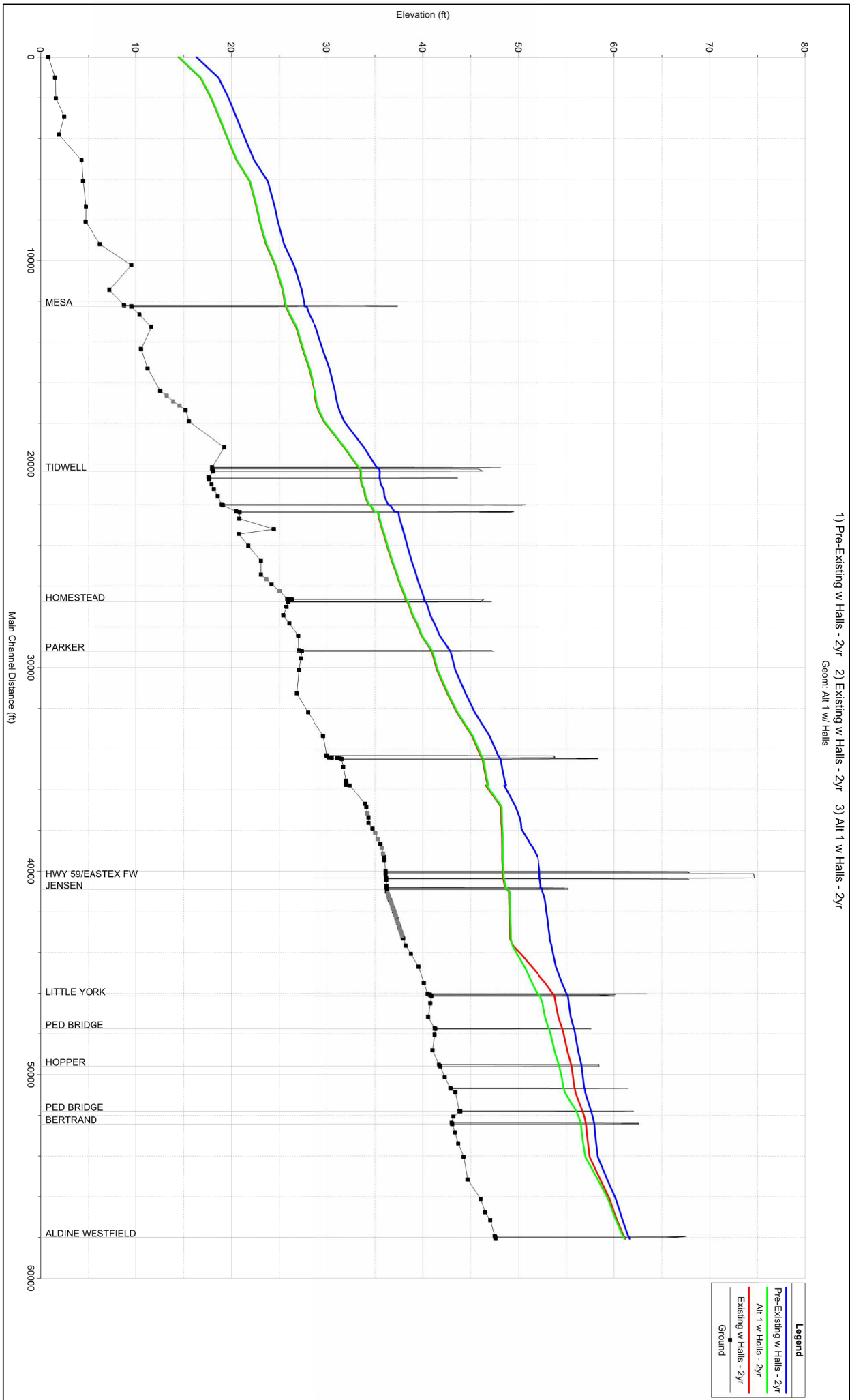
PREPARED: CRB  
CHECKED: WWC  
APPROVED: WWC

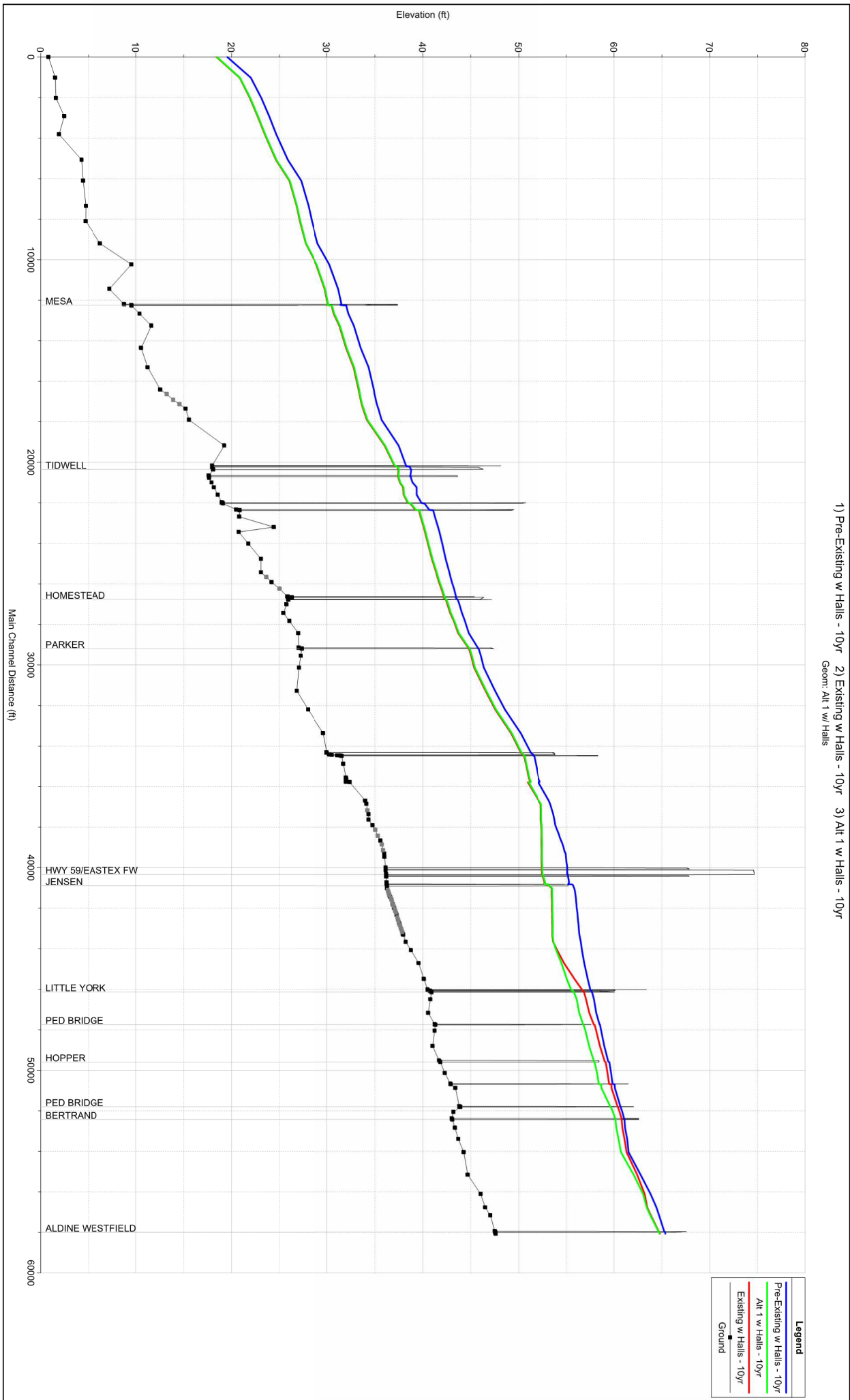
**HCFCF HALLS BAYOU WATERSHED  
P118-00-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

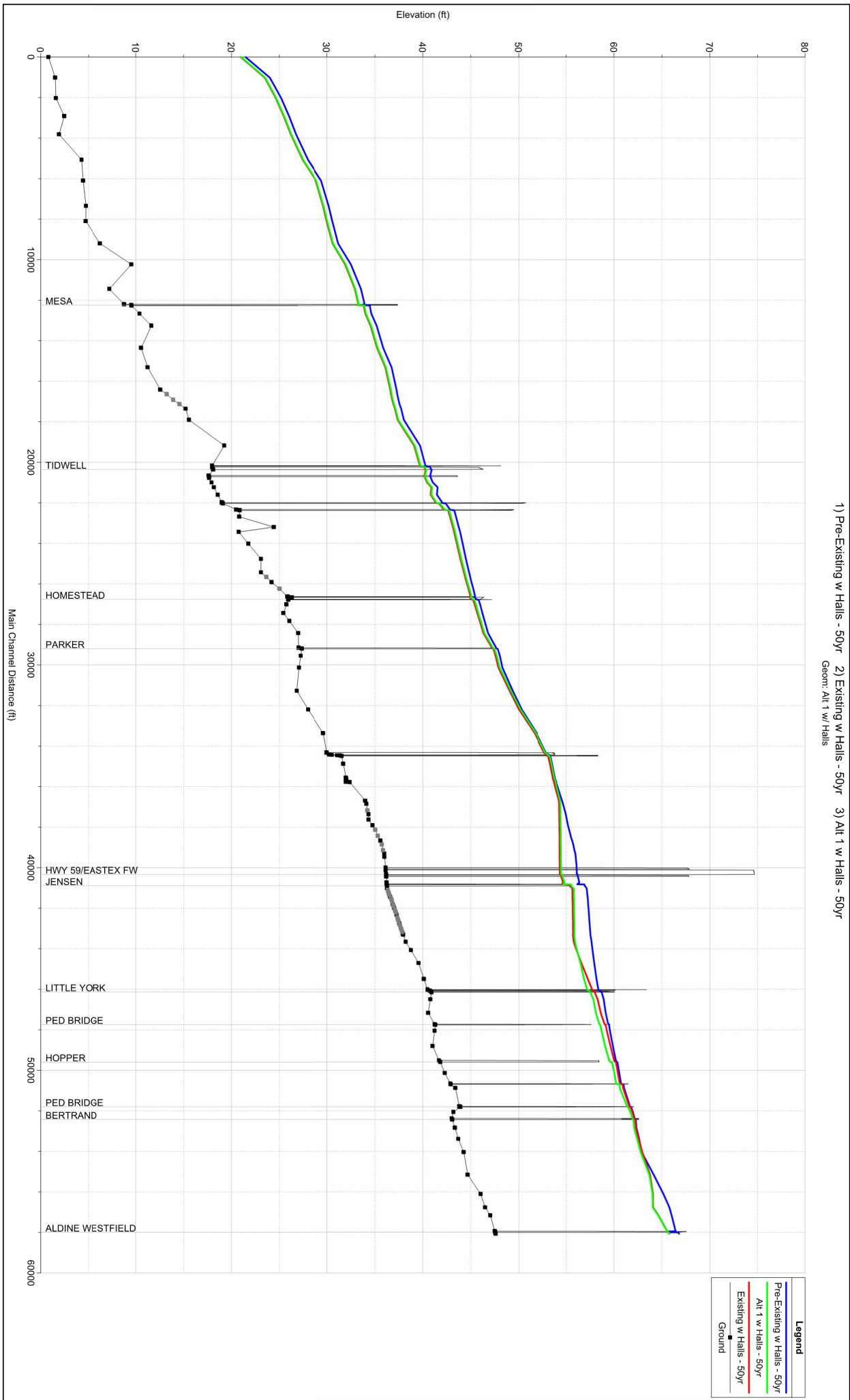
**FLOODPLAIN COMPARISON  
ALTERNATIVE 1 vs. EXISTING (500-YEAR)**

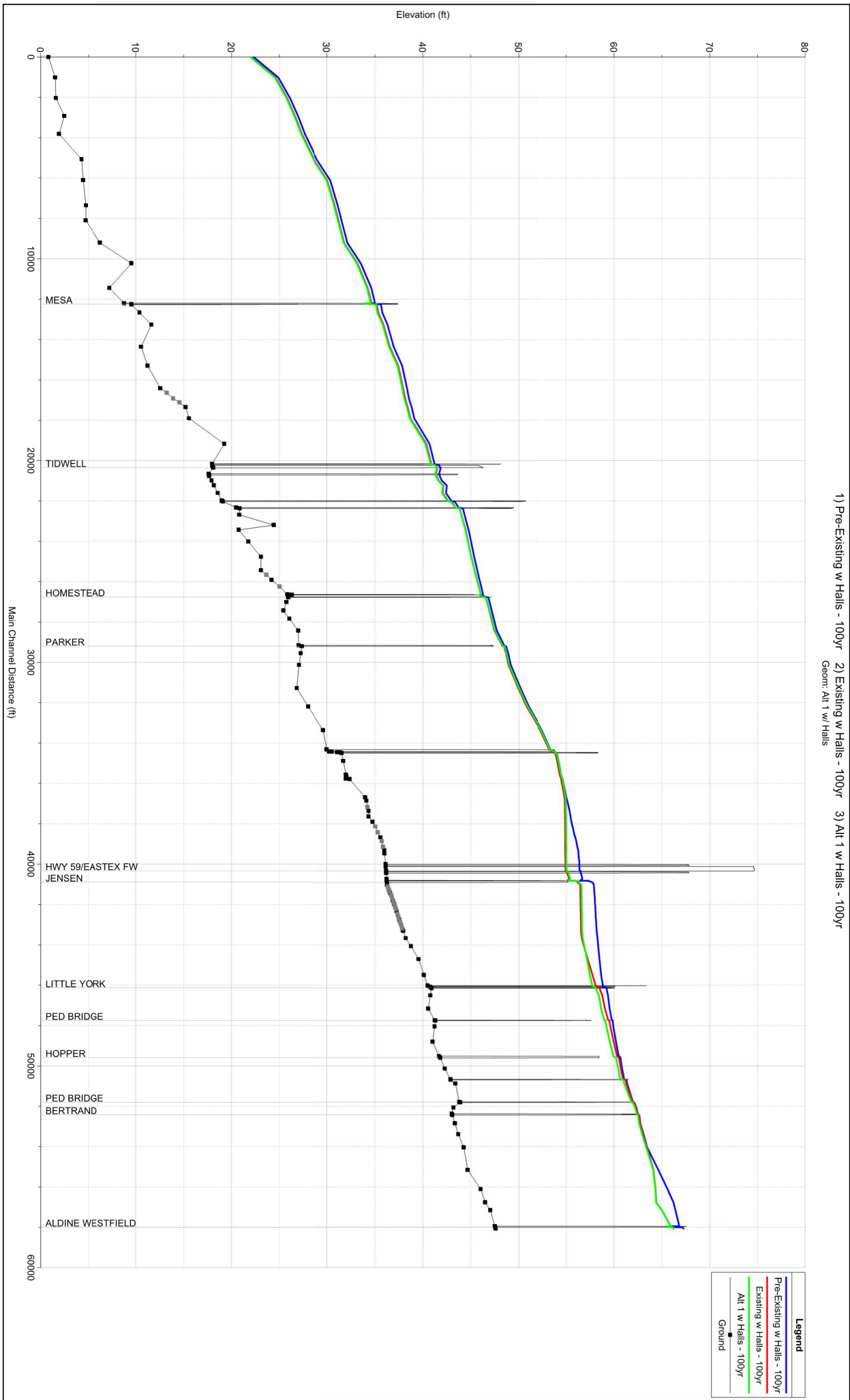
# **APPENDIX J**

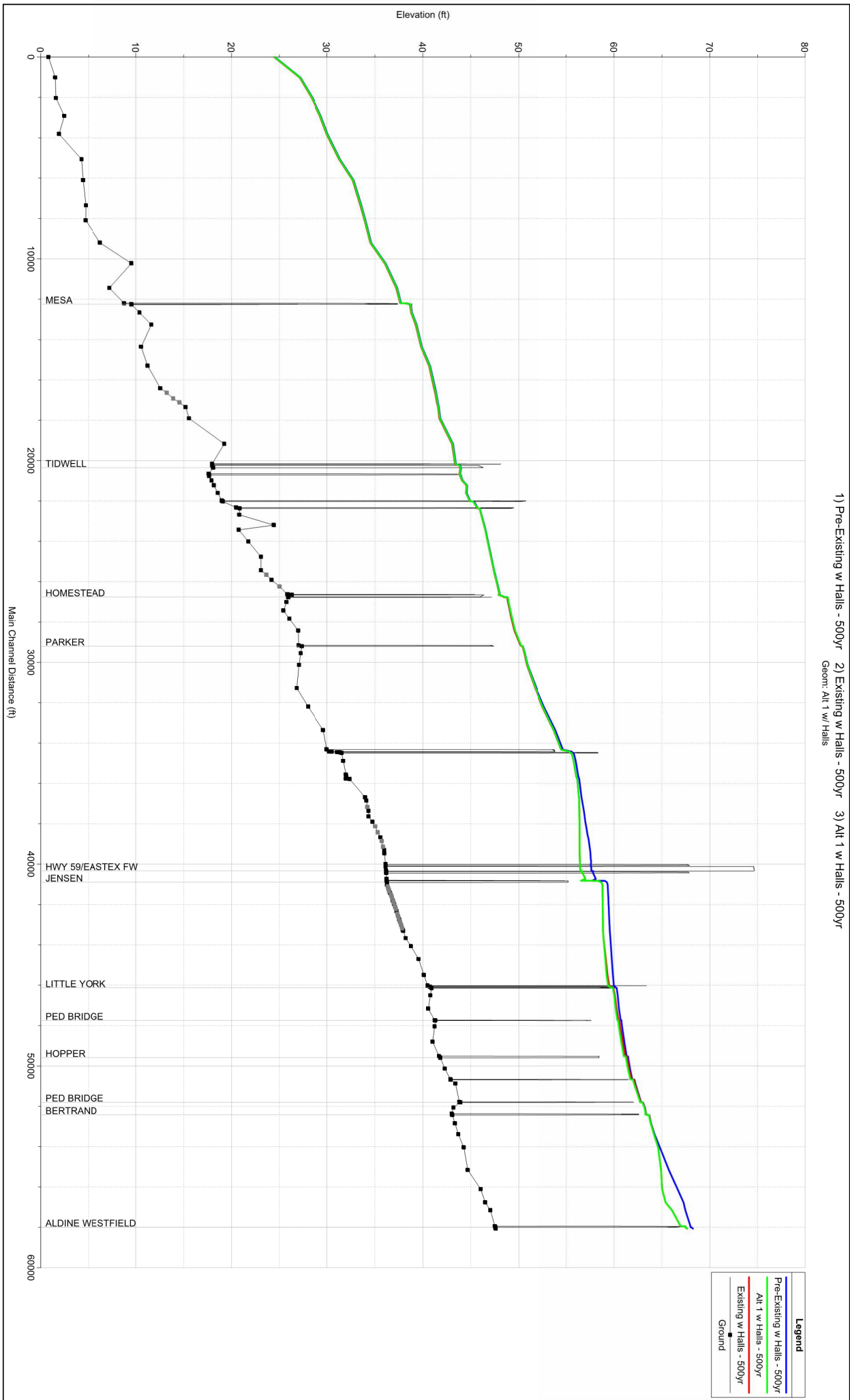
**P118-00-00 Water Surface Profiles  
(Preliminary Impact Analysis)**

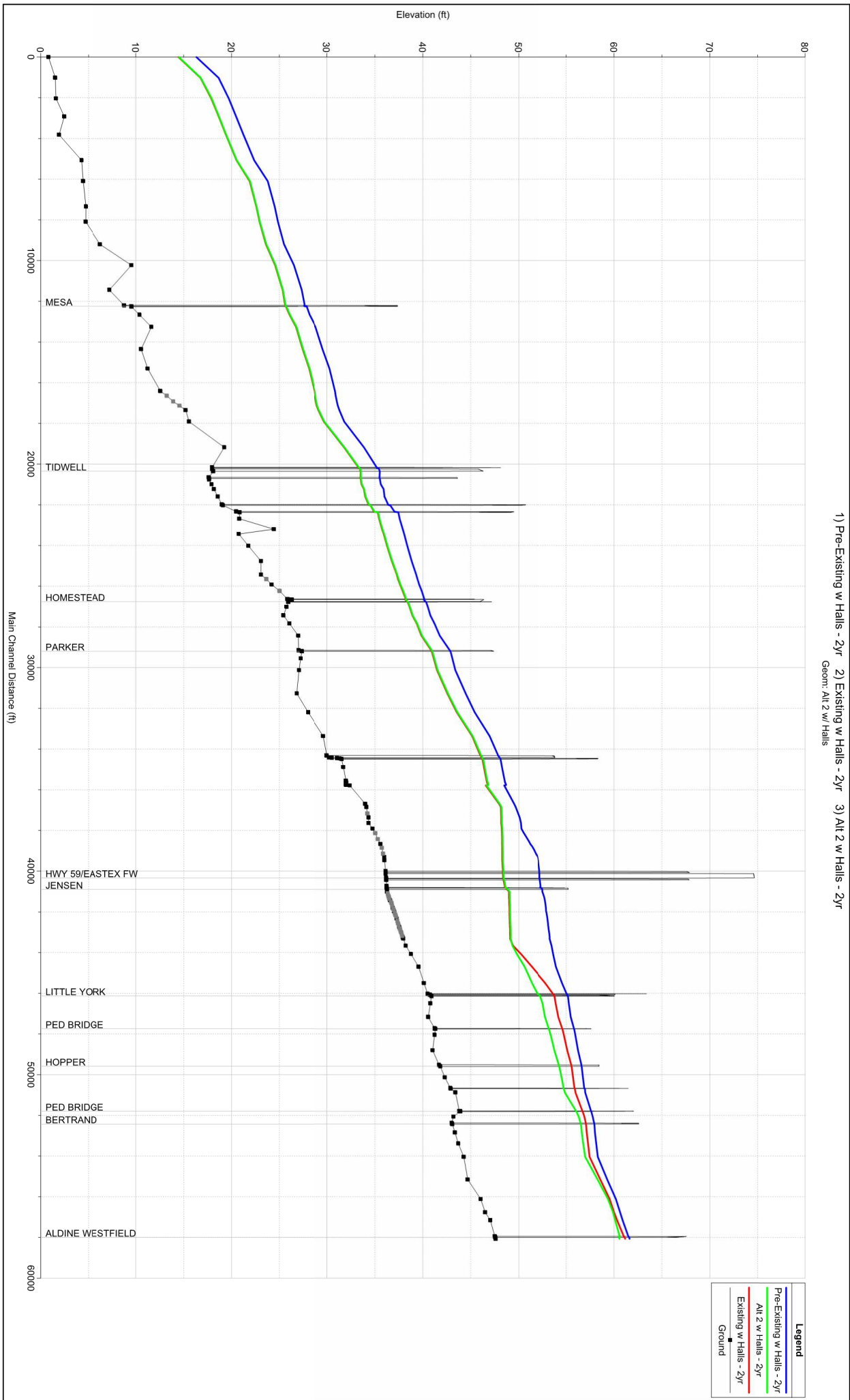




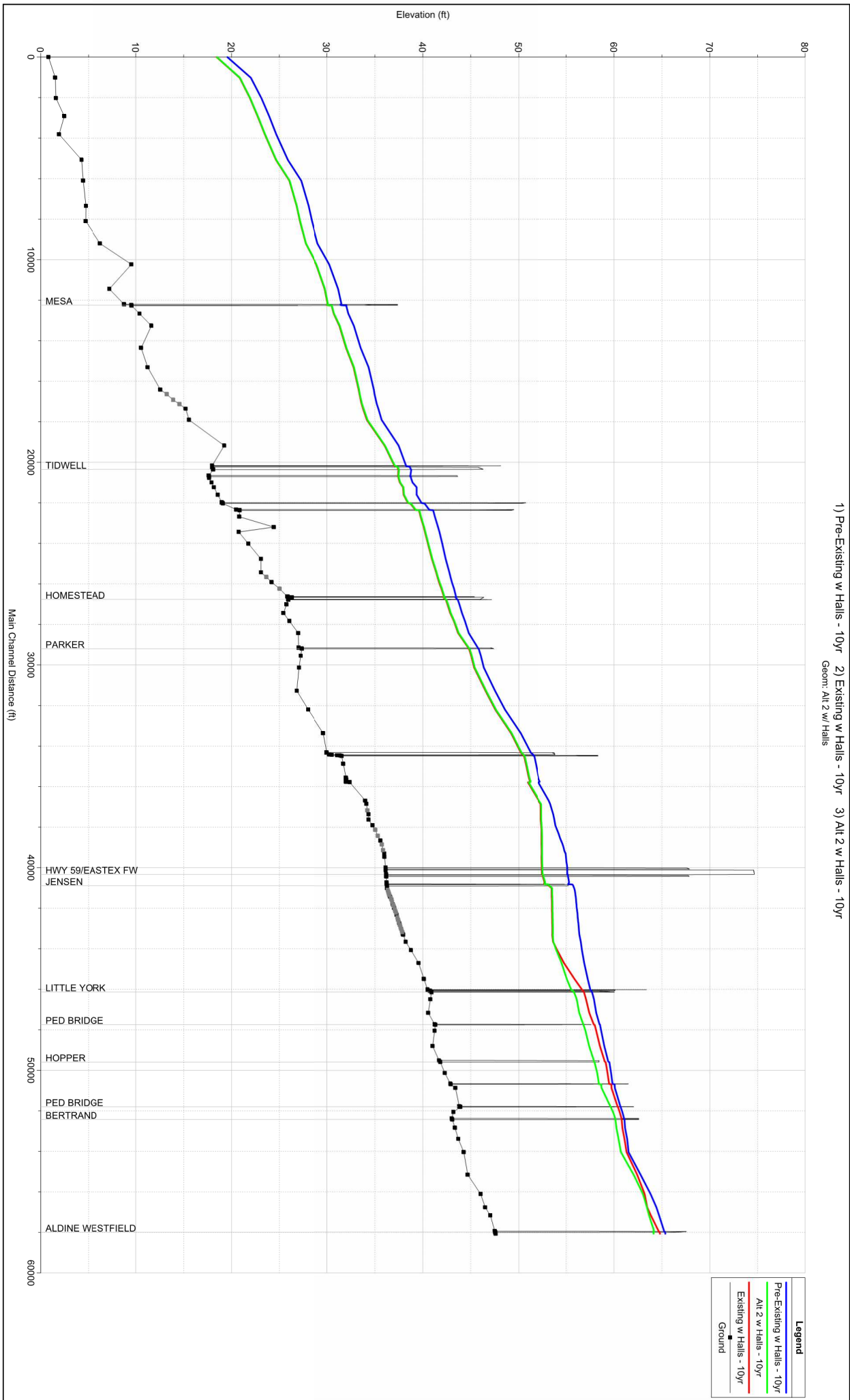


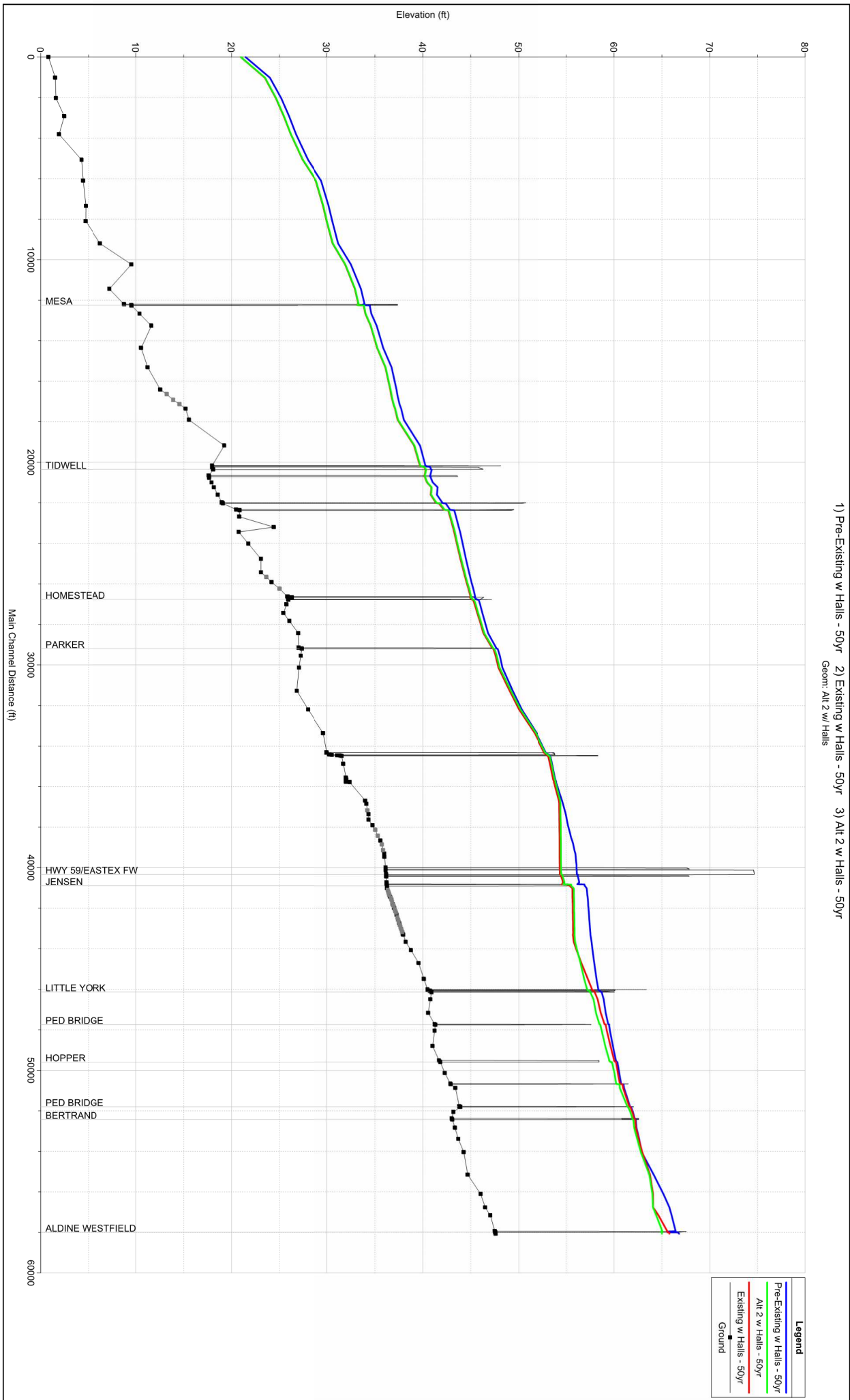


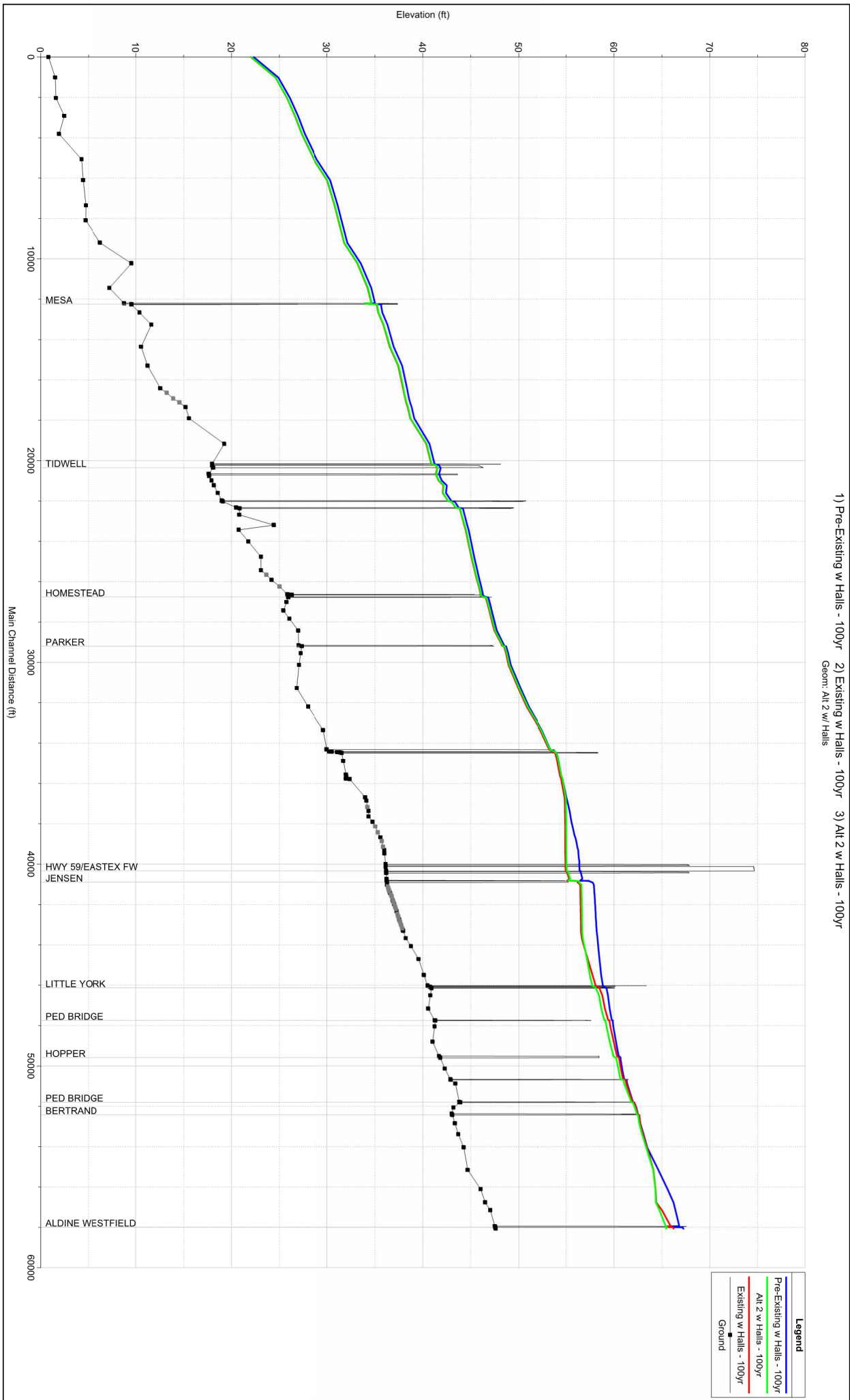


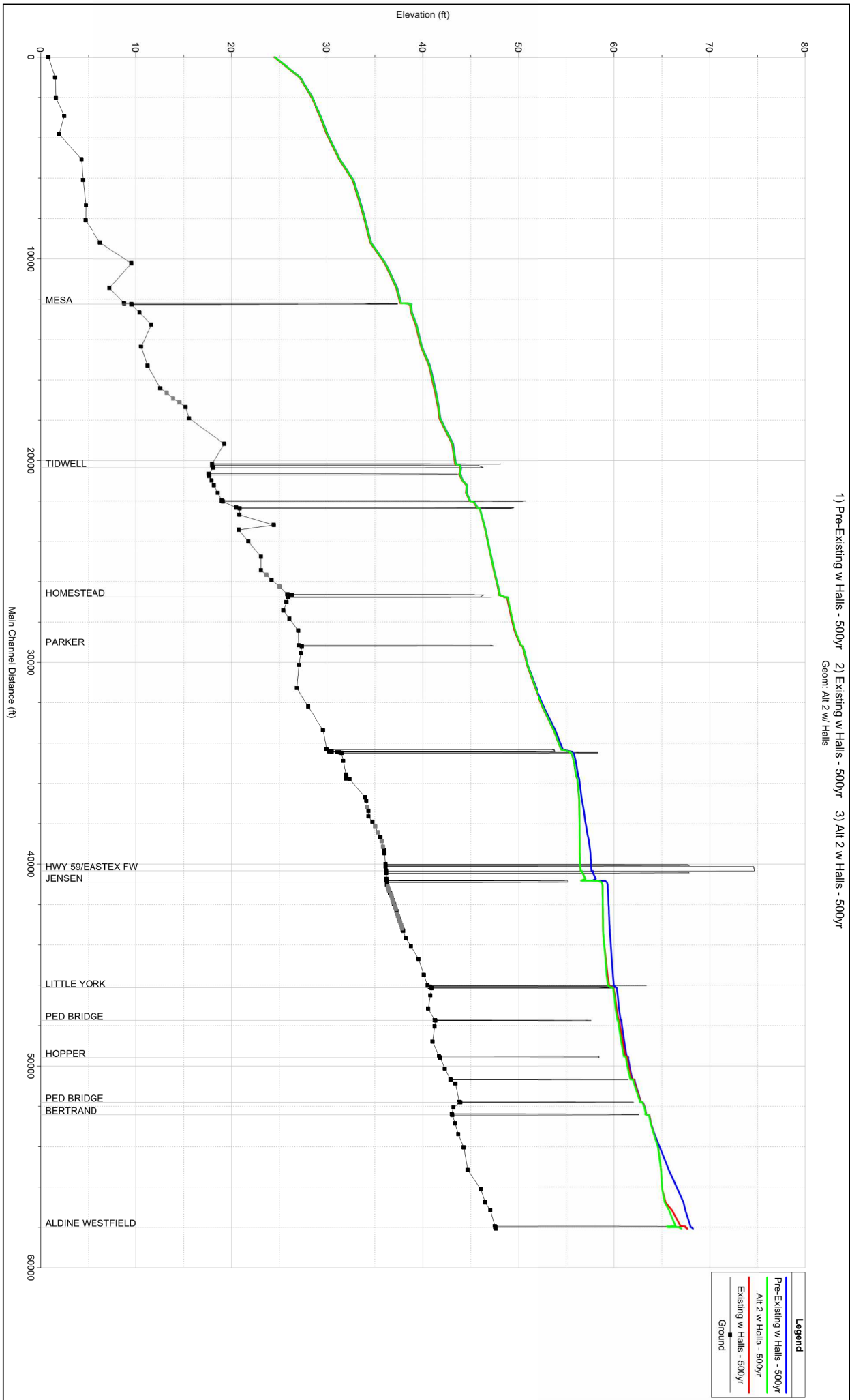






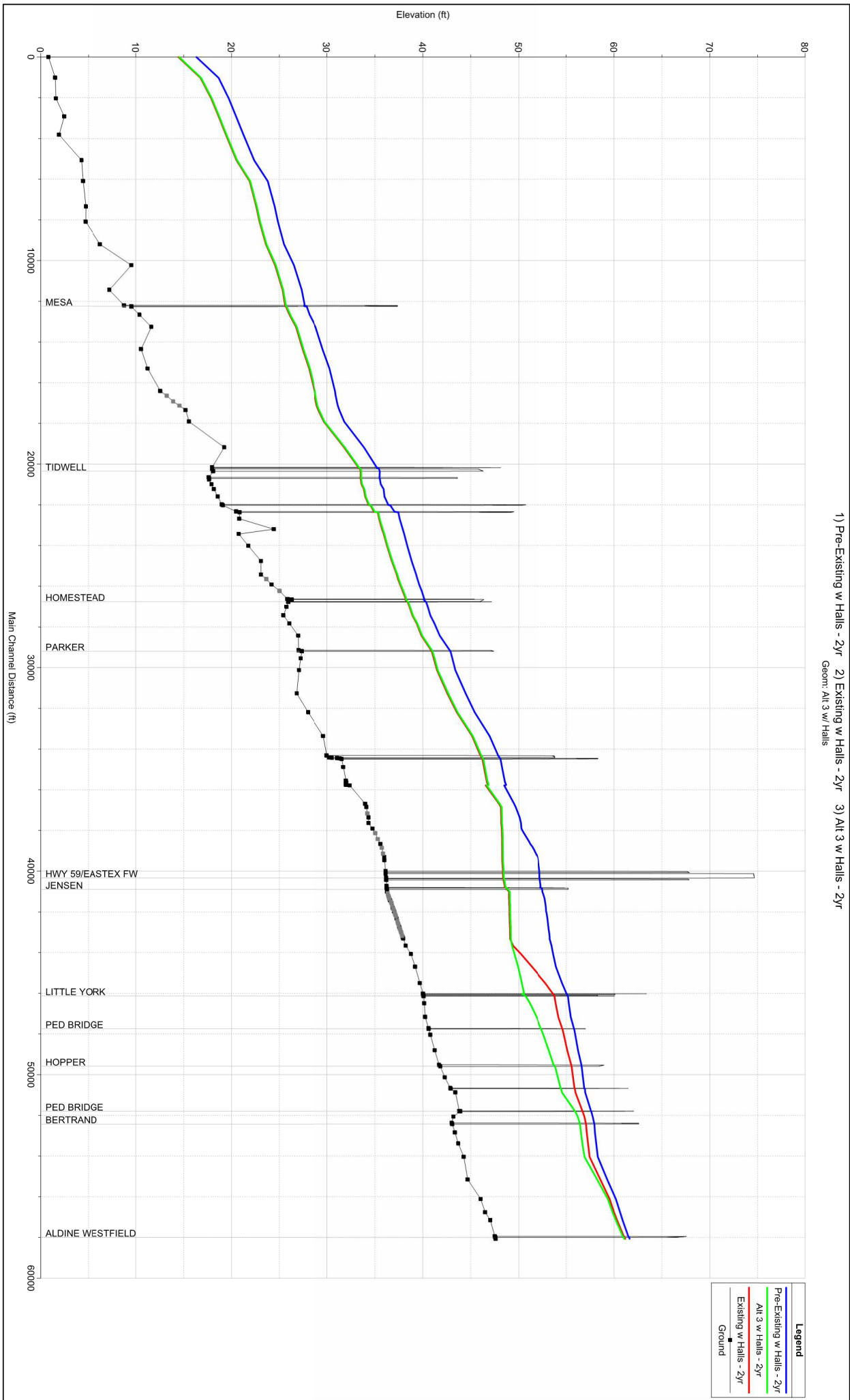


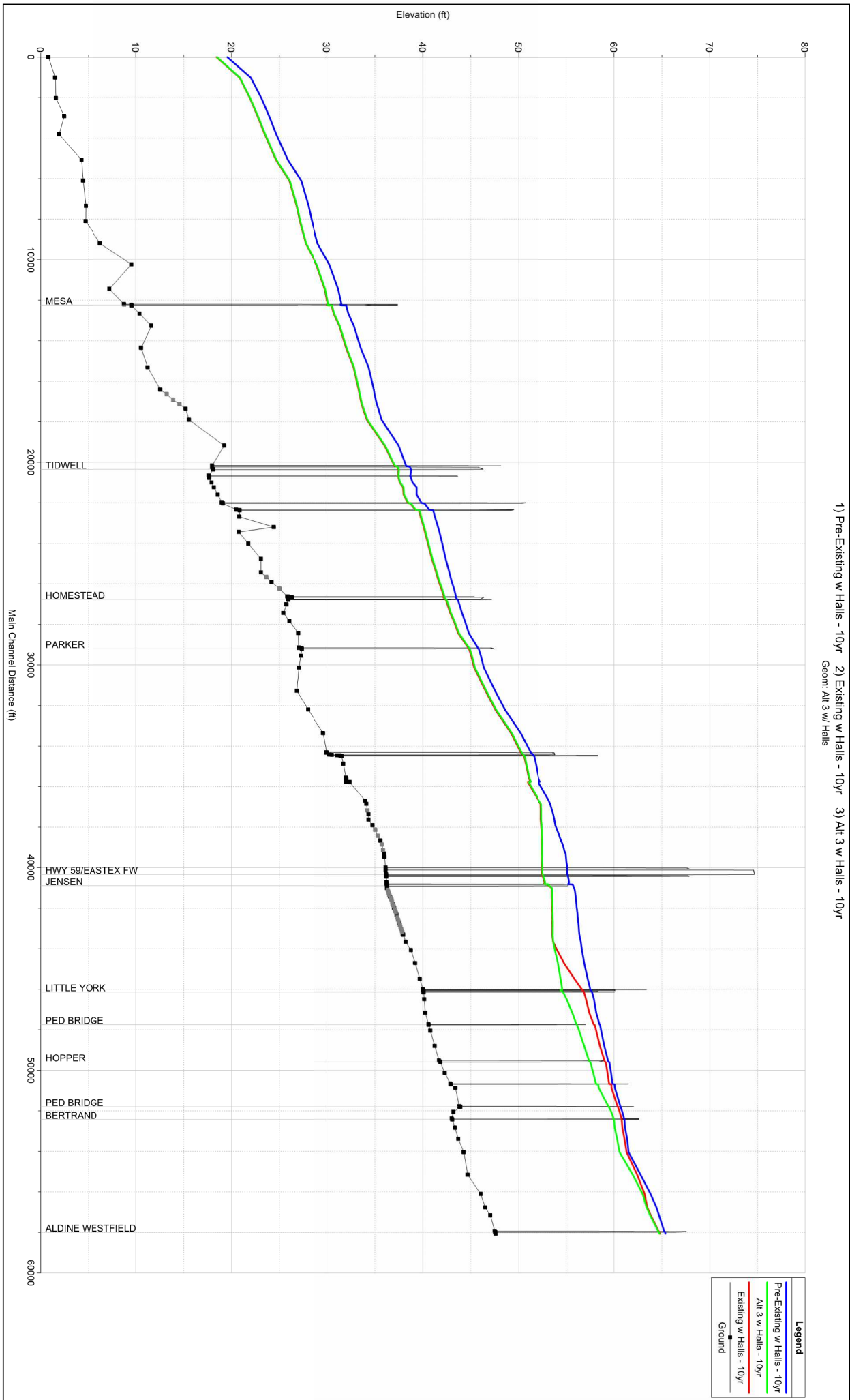


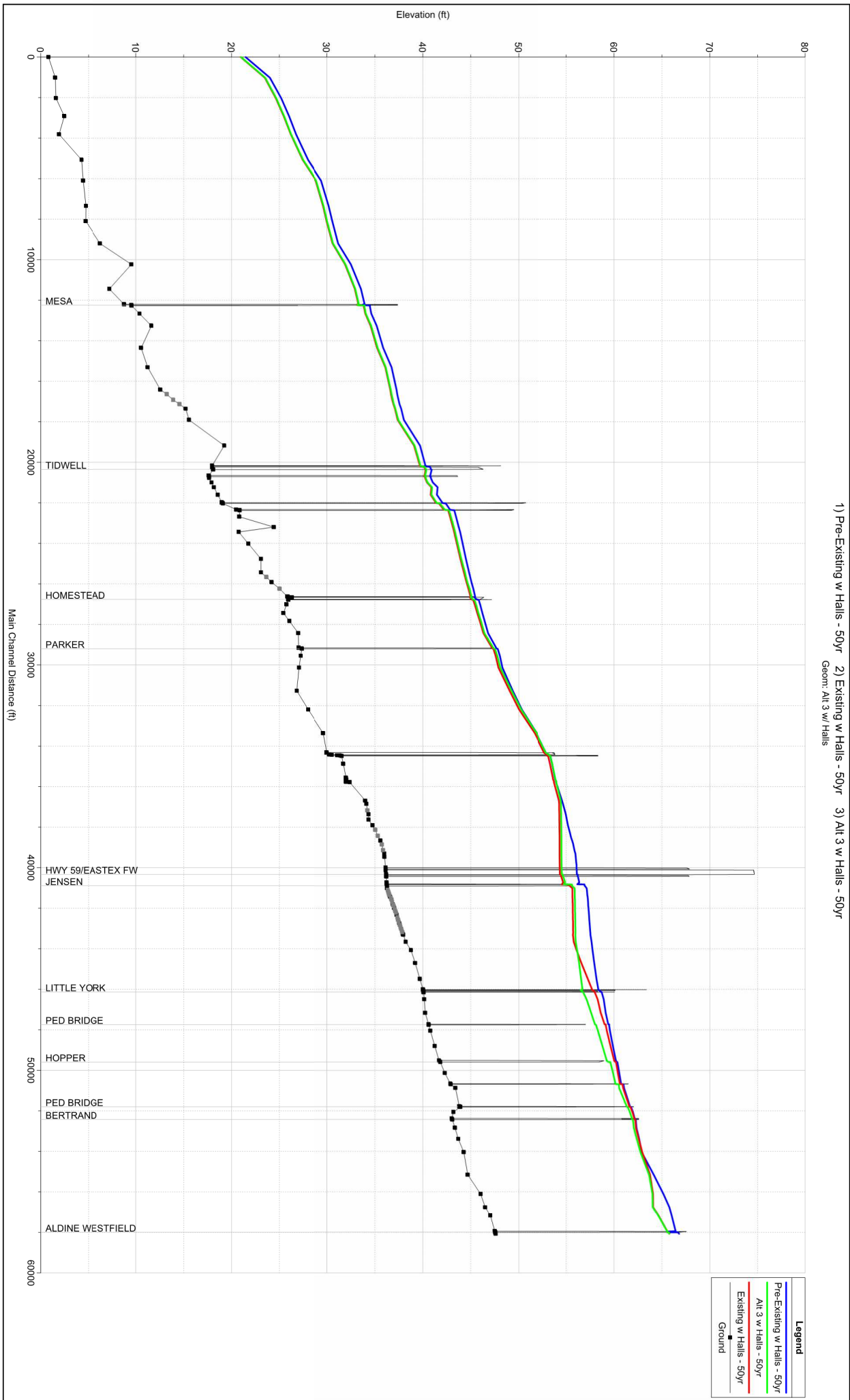


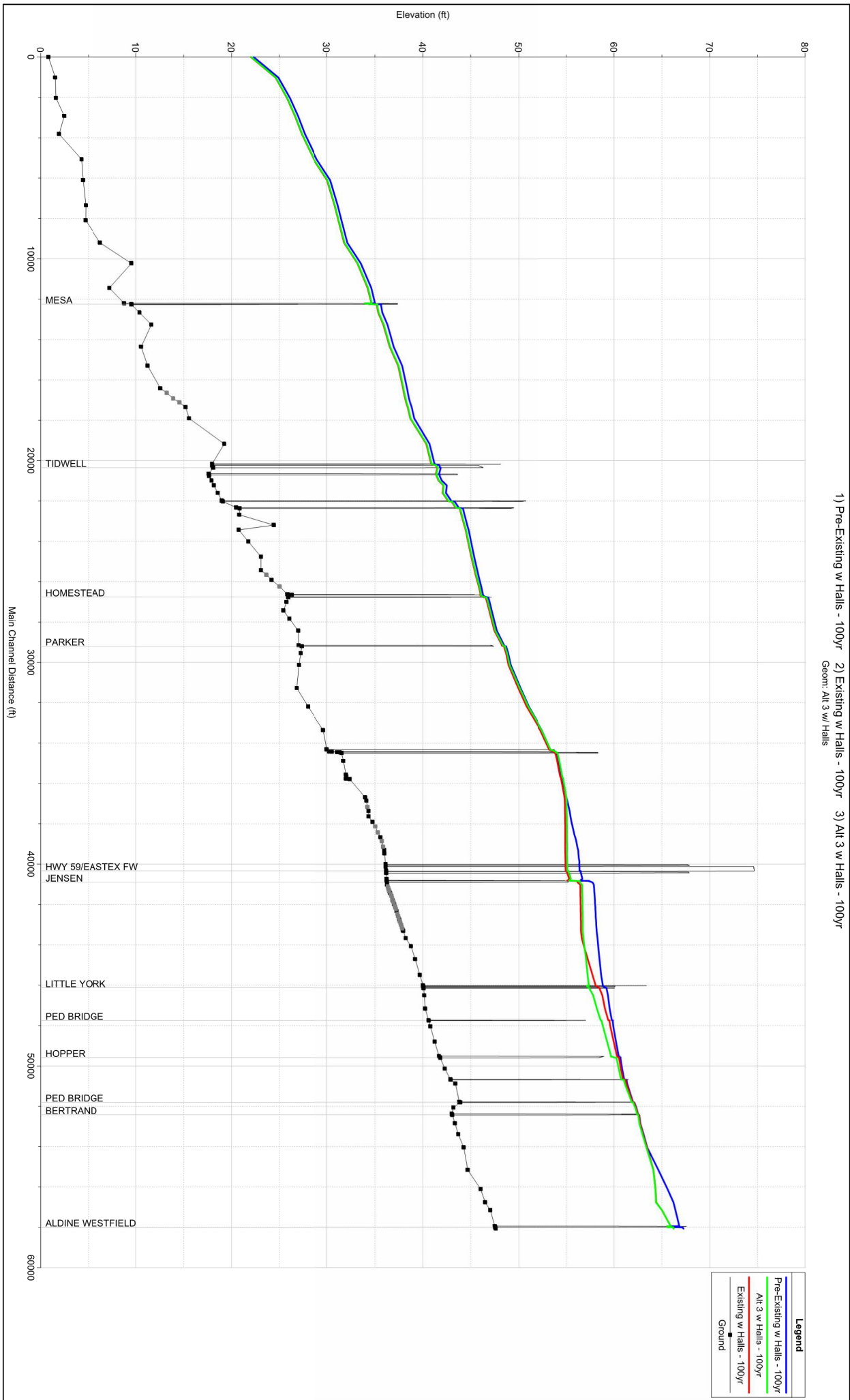
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 Geom: Alt 2 w/ Halls

Legend	
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Red line	Existing w/ Halls - 500yr
Black line with squares	Ground



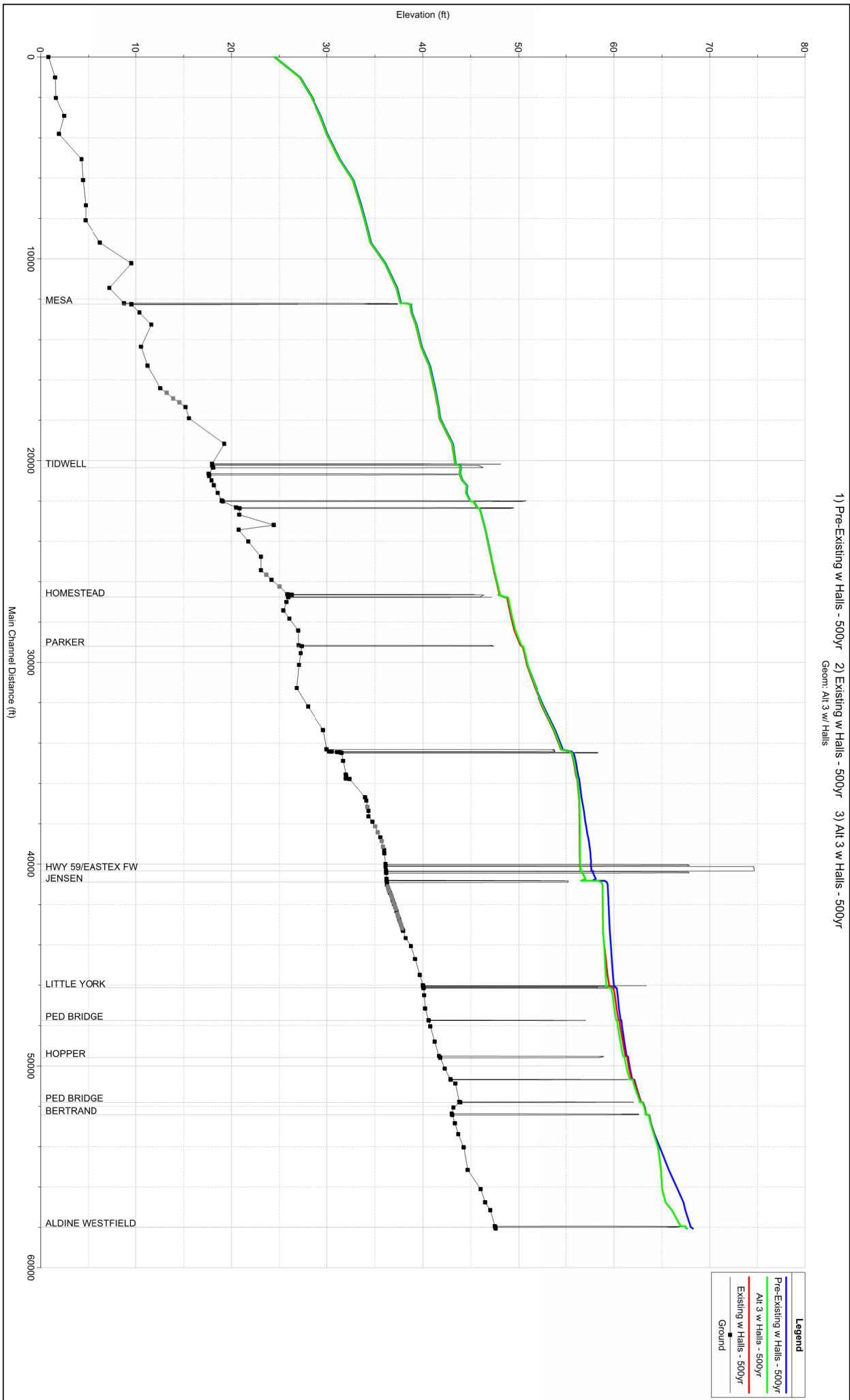






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 Geom: Alt 3 w/ Halls





1) Pre-Existing w/ Halls - 500yr 2) Existing w/ Halls - 500yr 3) Alt 3 w/ Halls - 500yr  
 Geom: Alt 3 w/ Halls

Legend	
Blue line	Pre-Existing w/ Halls - 500yr
Green line	Alt 3 w/ Halls - 500yr
Red line	Existing w/ Halls - 500yr
Black line with squares	Ground

# **APPENDIX K**

## **Wetland Delineation Report**

# **APPENDIX L**

## **Threatened & Endangered Species Habitat Assessment**

# **APPENDIX M**

**Phase 1 ESA**

# **APPENDIX N**

## **Cultural Resource Desktop Assessment**



July 13, 2021

Kelly G. Brezovar, PWS  
Hollaway Environmental + Communications  
2500 Summer Street, Suite 1130  
Houston, TX 77007

**RE: Cultural Resources Desktop Assessment**

Halls Bayou Watershed Bond Project C-41, HCFCD Project ID # P118-00-00-E007  
Harris County, Texas

Dear Mrs. Brezovar:

BGE has conducted a cultural resources desktop assessment for the proposed Halls Bayou Watershed Bond Project C-41, HCFCD Project ID # P118-00-00-E007, in Harris County, Texas. The objective of this desktop assessment is to inform the Harris County Flood Control District (HCFCD) of the presence or absence of recorded cultural resources within and near the project, to assess the potential for encountering unrecorded cultural resources, and to provide a recommendation on the need for additional cultural resources assessments.

BGE conducted an archival records and background review of the project area, which included consultation of the Texas Archeological Sites Atlas and the Texas Freedom Colonies Atlas. BGE also conducted a review of the soils present within the project and consulted the Potential Archeological Liability Map (PALM) for the project area. The results of the desktop assessment indicated that the project will not have any impact on any known cultural resources, and that the area where the project is located has been previously investigated for cultural resources via a reconnaissance survey. Furthermore, the project corridor only encompasses the existing channel and its banks. The project footprint extends only to the sloping banks of Halls Bayou.

Based on the results of this desktop assessment and the project footprint provided by Hollaway and HCFCD, BGE does not recommend a cultural resources survey to be performed prior to project construction.

Should you require any additional information or have any questions, please feel free to contact Ernesto Maycotte at (281) 509-4676 or by email at [emaycotte@bgeinc.com](mailto:emaycotte@bgeinc.com).

Respectfully,

A handwritten signature in black ink, appearing to be 'EM' or similar initials.

Ernesto Maycotte, MBA, RPA  
Principal Investigator  
BGE, Inc.

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**Cultural Resources Desktop Assessment for the  
Halls Bayou Watershed Bond Project C-41  
HCFCFCD Project ID # P118-00-00-E007  
HARRIS COUNTY, TEXAS**

Prepared for:

Hollaway Environmental + Communications  
2500 Summer Street, Suite 1130  
Houston, Texas 77007

On behalf of:

Harris County Flood Control District  
9900 Northwest Freeway  
Houston, Texas 77092

Prepared by:

BGE, Inc.  
10777 Westheimer, Suite 400  
Houston, Texas 77042



July 13, 2021

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## INTRODUCTION

BGE, Inc. (BGE) was contracted by Hollaway Environmental + Communications (Hollaway), on behalf of the Harris County Flood Control District (HCFCFCD) to conduct a cultural resources desktop assessment for the proposed Halls Bayou Watershed Bond Project C-41, HCFCFCD Project ID # P118-00-00-E007 (project), in Harris County, Texas. The objective of this desktop assessment is to inform HCFCFCD of the presence or absence of recorded cultural resources (archaeological and historic properties) within and near the project, to assess the potential for encountering unrecorded cultural resources, and to provide a recommendation on the need for additional cultural resources assessments.

## PROJECT DESCRIPTION AND LOCATION

The project consists of channel improvements to a section of Halls Bayou (P118-00-00) measuring approximately 3,428 meters (m; 11,247 feet [ft]) in length. The project is divided in two segments; one segment on the northern end of the project where Halls Bayou runs west to east, and a second segment where Halls Bayou runs north to south. For the purpose of this desktop assessment, the segment on the north is designated as Segment A, while the segment running north to south is designated as Segment B (**Figure 1**). Segment A measures approximately 436 m (1,429 ft) in length. Segment B measures approximately 2,992 m (9,818 ft) in length. The width of the project corridor varies from approximately 22 m (71 ft) to approximately 80 m (263 ft). The project covers an area of approximately 20 hectares (ha; 50 acres [ac]). The project corridor only encompasses the existing channel and its banks, entirely within the HCFCFCD right-of-way (ROW).

The project is located in north-central Harris County, Texas, approximately 12 kilometers (km; 7.5 miles [mi]) north of downtown Houston. Segment A is located immediately east of Aldine Westfield Road and continues through Keith-Weiss Park. Segment B commences on the south end of Keith-Weiss Park and continues south until its terminus approximately 966 m (3,168 ft) northeast of the intersection of Aldine Westfield Road and Parker Road. The project is situated within the *Humble, TX*, and the *Settegast, TX* United States Geological Survey (USGS) topographic quadrangles (**Figure 2**).

## REGULATORY CONTEXT

Harris County is considered a political subdivision of the State of Texas and because the project will involve five or more acres of ground-disturbing activity, the HCFCFCD is required under the Antiquities Code of Texas (ACT) and its Rules of Practice and Procedure (Texas Administrative Code, Title 13, Chapter 26) to notify the Texas Historical Commission (THC) prior to commencing project activities. Moreover, Halls Bayou is considered a Water of the United States (WOTUS) under Section 404 of the Clean Water Act (CWA), administered by the United States Corps of Engineers, Galveston District (USACE). As such, project activities may be subject to USACE review and coordination to secure compliance with Section 106 of the National Historic Preservation Act (NHPA).



Figure 1: Vicinity map

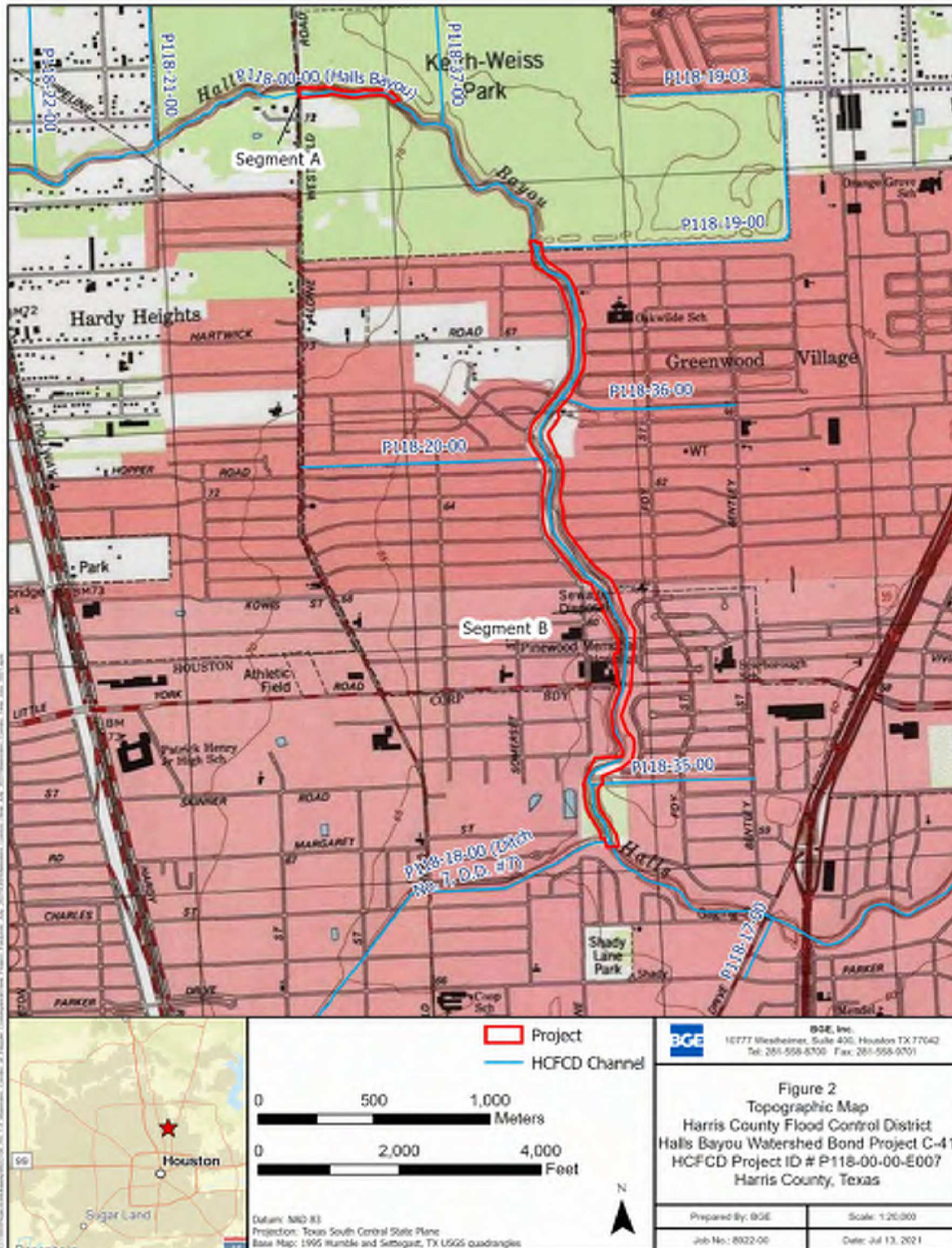


Figure 2: Topographic map

## NATURAL ENVIRONMENT

### ENVIRONMENTAL SETTING

The project is situated within the Northern Humid Gulf Coastal Prairies sub-region of the greater Western Gulf Coastal Plain ecoregion of Texas. The Western Gulf Coastal Plains are characterized by relatively flat topography. Native vegetation consisted of grassland, with some forests present along streams. Historic plant communities included big bluestem (*Andropogon gerardii*) and little bluestem (*Schizachyrium scoparium*), yellow Indiangrass (*Sorghastrum nutans*), brownseed paspalum (*Paspalum plicatulum*), gulf muhly (*Muhlenbergia capillaris*), and switchgrass (*Panicum virgatum*). Urban and industrial land uses (including oil and gas production) are common within the ecoregion, with development intensifying in recent decades (Griffith et al. 2007). The Northern Humid Gulf Coastal Prairies sub-region is characterized as a gently sloping coastal plain underlain by Quaternary-age (2.6 million years ago to Present) deltaic sands, silts, clays, and gravels. Pimple mounds found across prairie terraces in the region were presumably caused by ant and termite populations in the hotter and drier climate prior to the Holocene epoch (11,650 years ago to Present; Saucier 1994; Griffith et al. 2007). The project is situated within the City of Houston metropolitan area. Segment A is located within Keith-Weiss Park, where the native vegetation described above may still be present. Segment B is located within a heavily urbanized area and is surrounded by residential neighborhoods. Halls Bayou has been channelized within Segment B. The presence of native vegetation within Segment B is unlikely.

### GEOLOGY

The project is underlain by the Lissie Formation of Middle Pleistocene-age (781,000 to 126,000 years ago; Barnes et al. 1992). The Lissie Formation has a mostly flat and featureless surface, except for multiple pimple mounds and shallow depressions (USGS 2018). The Lissie Formation includes three levels, which consist of undifferentiated (in terms of origin and texture) alluvium, fine-grained channel facies of alluvial sand, silt and clay, and fine-grained overbank facies of alluvial silt and clay (Wermund and Moore 1993). The formation is composed of sand, silt, clay, and minor gravels (USGS 2021).

### SOILS

Soils within the project are mapped as Clodine fine sandy loam and Clodine-Urban Land Complex (Soil Survey Staff 2021; **Figure 3**). The geoarcheological potential of the Clodine soil series, as established by James Abbott (2001) in his study of the geoarcheology of the Houston Highway District for the Texas Department of Transportation, is *Low-Moderate*. Most of Segment A is situated within the Clodine fine sandy loam, while virtually all of Segment B is situated within the Clodine-Urban Land Complex.

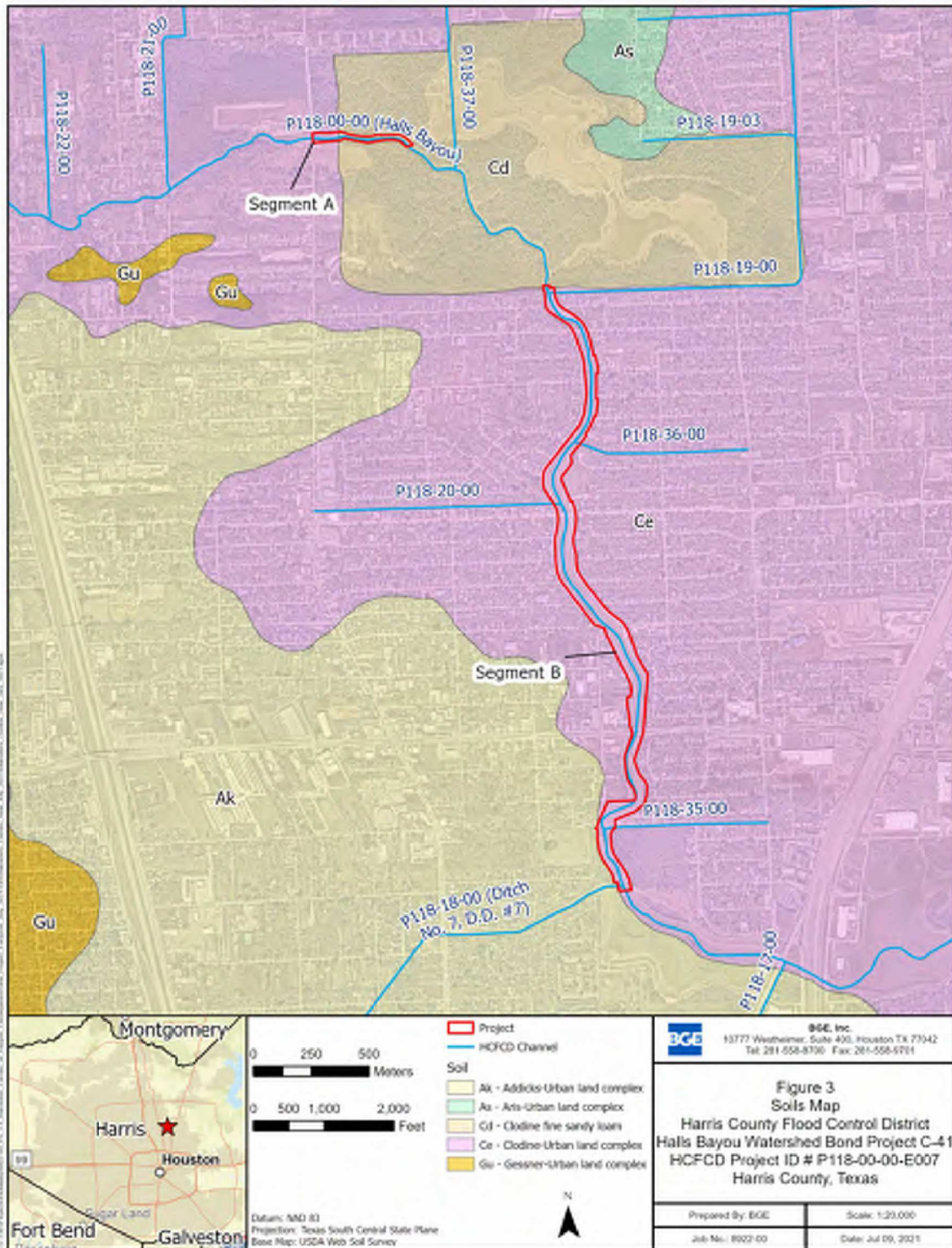


Figure 3: Soils map

## REGIONAL CULTURAL HISTORY

The earliest definitive evidence of human occupation in Southeast Texas is attributed to the Paleoindian period (ca. 11,500 to 8,000 years before present [B.P.]; Ricklis 2004). The first half of the period is typified by the production of distinctive fluted, lanceolate projectile points (Clovis and Folsom) traditionally associated with a specialized subsistence strategy based on the consumption of Pleistocene megafauna (i.e., bison and mammoths) that would have roamed the open grasslands (Bousman et al. 2004; Willey 1966). The latter half of the Paleoindian period is distinguished by the appearance of unfluted lanceolate dart points (San Patrice, Scottsbluff, Plainview, and Angostura). Points from the Paleoindian period are uncommon across Southeast Texas and are often found in isolated surficial finds or mixed deposits (Ricklis 2004).

The Archaic period (ca. 8000 to 1850 B.P.) is marked by the intensification of foraging that developed during the latter half of the Paleoindian. Climatic fluctuations resulting in periodic rises in sea level (and consequently variable resource availability) characterize the period (Story 1990). There is a shift in tool technology to predominantly local, low-grade lithic materials, which in turn led to the production of less carefully fashioned tools than during the Paleoindian period (Story 1990). Archaic tool technologies are more functionally varied, with an increased number of styles tied to certain geographic areas (Story 1990). Few Early Archaic (ca. 8000 to 6000 B.P.) sites have been found in well stratified or preserved contexts. The early Archaic was dominated by expanding stem point types, including early side-notched points (Keithville, Neches River, and Trinity), and later massive barbed (Bell and Calf Creek), unstemmed (Tortugas) and stemmed (Wells) points (Patterson 1996; Ricklis 2004). The transition to the Middle Archaic subperiod (ca. 6000 to 3450 B.P.) is marked by a decreased grinding of point basal edges, and an increased emphasis on thinner and smaller dart points, such as Yarbrough, Bulverde, Travis, and Pedernales types (Patterson 1996; Ricklis 2004). As the climate became drier during this period, hunter-gatherers tended to broaden their food types. Another Middle Archaic shift was the rise of cemeteries in the western part of the region (Ricklis 2004). The most notable cemetery dating to the Middle Archaic is the Ernest Witte Site (41AU36; Ricklis 2004), in Austin County. By the Late Archaic subperiod (ca. 3450 to 1850 B.P.), cemeteries became an essential part of the cultural tradition, populations increased, and consequently become less mobile and established defined territories (Ricklis 2004; Story 1990).

The introduction of pottery to Southeast Texas marks the transition into the Early Ceramic period (1850 to 1250 B.P.). It is generally accepted that ceramic technology came to Southeast Texas as the result of cultural diffusion from Louisiana and the Lower Mississippi Valley. The earliest pottery in the region is found along the upper Texas coast and is characterized by thick vessel walls that are contorted, poorly wedged, and untempered (characteristic of the Tchefuncte cast) (Ricklis 2004). Ceramics were not introduced to inland Southeast Texas until much later. Goose Creek sandy paste pottery is the main ceramic type identified in the region, manufactured from the Early Ceramic period through the Historic period (Patterson 1996). Due to a lack of quality lithic materials smaller dart points (especially those made of bone) were common during the Early Ceramic period (Patterson 1996; Story 1990).

The Late Prehistoric period (1250 to 450 B.P.) is marked by the transition towards small, expanded stem, bifacial arrow point types (Patterson 1996; Ricklis 2004). The first half of this period is characterized by the introduction of the bow and arrow, and the dominance of the Scallorn arrow points. Lithic technology during the second half of this period is characterized by Perdiz arrow points, blade-cores, thin bifacial knives, unifacial end scrapers, expanded base drills, and prismatic blades (Ricklis 2004). These changes were driven by changes in the environment that brought bison back into the region, which caused the groups to develop technologies suited for procuring and processing bison (Ricklis 2004; Story 1990).

The Protohistoric period (450 to 250 B.P./1500 to 1700 A.D.) is marked by the advent of European contact. In 1519, Francisco de Garay, the Spanish governor of Jamaica, sent Alonso Álvarez de Pineda on an exploratory expedition to the Gulf Coast (Chipman 1992). Pineda and his men mapped the shoreline along the coast of northeastern Mexico and Texas with relative accuracy (Chipman 1992; Freeman 1990). In 1528, two makeshift barges carrying several dozen Spaniards wrecked on the Texas coast near Galveston Island. The group were members of a failed expedition led by Pánfilo de Narváez to colonize Florida (Chipman 1987). For Native American groups, this period constituted continuations of Late Prehistoric tool and subsistence adaptations observed by encroaching Europeans (Turner et al. 2011). Spanish interest in Texas was reinvigorated by news that French explorer René-Robert Cavalier, Sieur de la Salle had landed at Matagorda Bay in 1685 (Foster 2015). The French incursion into territory claimed by Spain renewed the latter's interest in colonizing Texas. Alonso de León consequently led a series of expeditions and in 1690 established Mission San Francisco de los Tejas in East Texas between the Trinity and Neches rivers (Bolton 1912). Mission San Francisco de los Tejas was abandoned in 1693 due to rising tensions between the occupying Spanish soldiers and local Hasinai groups.

The Early Historic period (250 to 150 B.P./1700 to 1800 A.D.) represents a renewed interest in Texas by the Spanish, and the development of Texas as a Spanish Colony. In 1716, Louis Juchereau de Saint-Denis, accompanied by Captain Domingo Ramón and Spanish soldiers, priests, and settlers, founded four missions and a *presidio* in East Texas and present-day Louisiana, and Mission San Antonio de Valero soon followed (ca. 1718) to serve as a halfway point between the East Texas missions and those in the Rio Grande Valley (Campbell 2003). Attempts to formalize Spanish control over East Texas intensified during the 1740s and 1750s (Freeman 1990). In 1756, mission Nuestra Señora de la Luz was established to protect Spanish interests in East Texas. In 1773, East Texas was abandoned by the Spanish, who drew the east-most boundary lines for Spanish settlement at San Antonio. However, Spanish settlers, who were already residing in East Texas, persuaded the King of Spain to return to the area. Initially, a new mission, Nuestra Señora del Pilar de Bucareli, was established in 1774. The residents eventually abandoned the mission due to floods, fires, and Comanche attacks, and reestablished their community in modern-day Nacogdoches (Freeman 1990).

The Late Historic period (150 B.P. to present/1800 to present) is marked by waning Spanish influence in Texas, and a growing Anglo-American influence. This transition began in 1803, when the Spanish ceded their claim to the Louisiana Territory to the French, who in turn sold it to the United States (Freeman 1990). The Mexican fight for independence from Spain broke out in 1810 (Henderson 2009). During these tumultuous times, American and French colonists started to settle

East Texas and supported Mexican Republicans in their fight against Spain (Freeman 1990). In 1821, Agustin de Iturbide joined forces with Vicente Guerrero and enacted his *Plan de Iguala*, which cemented Mexico's independence from Spain. Economically devastated as a result of the war for independence, residents from the area that made up the Mexican state of Coahuila y Texas largely abandoned the region in search of employment and better opportunities (De Leon 2010). With the region left largely uninhabited, the Mexican government became increasingly fearful of encroachment from the United States and established a colonization program meant to preserve the land as Mexican territory. In 1821, Stephen F. Austin utilized this program and gained approval to create a colony in Texas that includes territory from 19 present day Texas counties, including Harris County (southeastern most portion of the colony; Freeman 1990). The area that now includes Harris County, was the first to be settled by the original 300 Anglo-Texas settlers in 1824 when Baron de Bastrop issued out the grants. John Richardson Harris, whom Harris County is named after, received one league of land that was located at the junction of Buffalo and Bray Bayous. John Richardson Harris is known for constructing the first steam sawmill in Texas, as well as founding the town of Harrisburg (Feik et al. 1977). The large influx of Anglo-Americans began to worry the Mexican government. In April 1830, President Bustamante issued a decree banning future immigration from the United States (Campbell 1989; Freeman 1990). Furthermore, the law forbade the further introduction of slaves into Texas. To enforce the law, the Mexican government established a customs house and military post at Anahuac (Freeman 1990). In January 1835, when President Antonio Lopez de Santa Anna sent soldiers to the Galveston area to establish Fort Anahuac to collect taxes. Fighting erupted in October 1835 in Gonzales (Campbell 1989). Although most of the early battles (i.e. Gonzales, Goliad, The Alamo) of the Texas Revolution were fought south and west of the region, the final battles of the region were fought in southeast Texas. On March 1, 1836, a convention was held in Washington on the Brazos that led to the drafting of a constitution and the declaration of Texas Independence from Mexico (Campbell 1989). Later that year, Santa Anna was captured and forced to sign the treaty that granted Texas Independence (Freeman 1990).

Harris County was formed in 1836. Originally called Harrisburg County, the county was renamed Harris in 1839, and consisted of lands previously incorporated in the Mexican Harrisburg municipality and Galveston Island. The Anglo population in Texas swelled at this point, due to the attractiveness of cheap arable land in east Texas. In the northern part of Harris County, new German migrants started to arrive in large numbers during the 1840s (Feik et al. 1977). This trend would increase after the annexation of Texas and the signing of the Treaty of Guadalupe-Hidalgo in 1845 and 1847 respectively (Freeman 1990). The institution of slavery also shot up in this period, which resulted in an increase in African American slave populations increasing from 5,000 to 38,753 between 1836 and 1847 (Campbell 1989). Prosperity for southeast Texas would come to an end after the Civil War. After declaring secession from the Union on February 1, 1861, Texas joined the Confederate States of America (Wooster 2014). After the defeat of the confederacy in May of 1865, the Union army occupied Texas during what is known as the Reconstruction era (Freeman 1990). Development of Harris County continued into the 20th Century, where railroad building continued with the creation of a freight terminal in the northwestern portion of the county by the Trinity and Brazos Valley Railway. The community of Tomball developed around this freight terminal and became one of the most populated towns in the county (Feik et al. 1977).



During the early 20th Century, the economy switched again to a reliance on lumber, coal, lignite, and an emerging oil industry (Freeman 1990). In Harris County, oil was first discovered at Humble's Moonshine Hill in 1904. Along the Cypress Creek area in Harris County, rice cultivation began. Rice cultivation was popular in this area because the great flat fields throughout the area were perfect for its cultivation. This led to much of the area being irrigated with water valves and rice elevators (Feik et al. 1977).

## ARCHIVAL RECORDS AND BACKGROUND REVIEW

### CULTURAL RESOURCES RECORDS REVIEW

BGE conducted a review of data available in the Texas Archeological Sites Atlas (TASA) and the Texas Freedom Colonies Atlas to identify recorded archeological and historic sites, previous cultural resources investigations, cemeteries, historical markers, neighborhood surveys, National Register of Historic Places (NRHP) properties or districts, and freedom colonies within 1 km (0.6 mi) of the project, which constitutes the Study Area (**Figure 4**). This review indicated that the project does not intersect any recorded archeological or historic sites or any other cultural resources. Within the Study Area, three historic sites have been recorded (**Table 1**). All three sites were recorded in 1997 during the Keith-Wiess Park Flood Detention Basin survey conducted by Moore Archeological Consulting, Inc. for the HCFCFCD. All three sites have been determined to be *ineligible* for inclusion in the NRHP (TARL & THC 2021). The project will have no impact on these sites. No other cultural resources have been recorded within the Study Area. Also, no freedom colonies are located within the Study Area (Roberts 2021).

**Table 1:** Sites within the Study Area

Trinomial	Type of Site	Year Recorded	Eligibility	Archeological Investigation	Sponsor Agency
41HR805	Historic	1997	Ineligible	Keith-Wiess Park Flood Detention Basin Survey	HCFCFCD
41HR806	Historic	1997	Ineligible	Keith-Wiess Park Flood Detention Basin Survey	HCFCFCD
41HR807	Historic	1997	Ineligible	Keith-Wiess Park Flood Detention Basin Survey	HCFCFCD

The information in the TASA also indicated that nine archeological investigations have been conducted within the Study Area since 1983 (**Table 2; Figure 4**). All previous archeological investigations were conducted under an ACT permit. Five of the nine investigations were conducted on behalf of HCFCFCD. The spatial information for the Keith-Wiess Park Flood Detention Basin Survey, which recorded the three sites within the Study Area, is not included in the TASA, therefore it is not shown on Figure 4.

**Table 2:** Archeological investigations within the Study Area

ACT Permit No.	Fieldwork Year	Project Name	Sponsor Agency	Investigative Firm	Sites*
348	1983	N/A	HCRS	N/A	N/A
1641	1996	N/A	Texas Water Development Board	N/A	N/A

ACT Permit No.	Fieldwork Year	Project Name	Sponsor Agency	Investigative Firm	Sites*
1798	1997	Keith-Wiess Park Flood Detention Basin Survey	HCFCF	Moore Archeological Consulting, Inc.	41HR805 41HR806 41HR807
3215	2003	Bretshire Place and Lakewood Estates Subdivision Survey	HCFCF	Moore Archeological Consulting, Inc.	N/A
3216	2003	Hall Park and Farrington Place Subdivision Survey	HCFCF	Moore Archeological Consulting, Inc.	N/A
3777	2005	Little York Road Retention Pond Survey	Texas Department of Transportation	Moore Archeological Consulting, Inc.	N/A
3947	2005	Flood Damage Reduction and Ecosystem Restoration Concepts Survey, Halls Bayou	HCFCF	Atkins	N/A
7181	2015	Halls Bayou Hike and Bike Trail Survey	Houston Parks and Recreation Department	Moore Archeological Consulting, Inc.	N/A
8863	2020	Halls Bayou Project - HCFCF P118-21-00-E011 Survey	HCFCF	Moore Archeological Consulting, Inc.	N/A

\* Sites recorded within Study Area.

The Flood Damage Reduction and Ecosystem Restoration Concepts survey, conducted by Atkins in 2005 for the HCFCF, consisted of a “reconnaissance survey of a 2,000-foot-wide study area centered on Halls Bayou” (TARL & THC 2021; Norton 2015). This survey, labeled with its ACT Permit No. (3947) on Figure 4, consisted of a background records search and a pedestrian reconnaissance survey (no shovel testing) that included the current project in its entirety, as corroborated by a map included in the report of investigations prepared for that survey (**Figure 5; Norton 2015**). Figure 4 reflects the information as currently presented in the TASA. BGE believes that the location of the Flood Damage Reduction and Ecosystem Restoration Concepts survey (ACT 3947) as presented in the TASA is incorrect, possibly due to a coordinate system inaccuracy, and has submitted an error report to the TASA administrators.

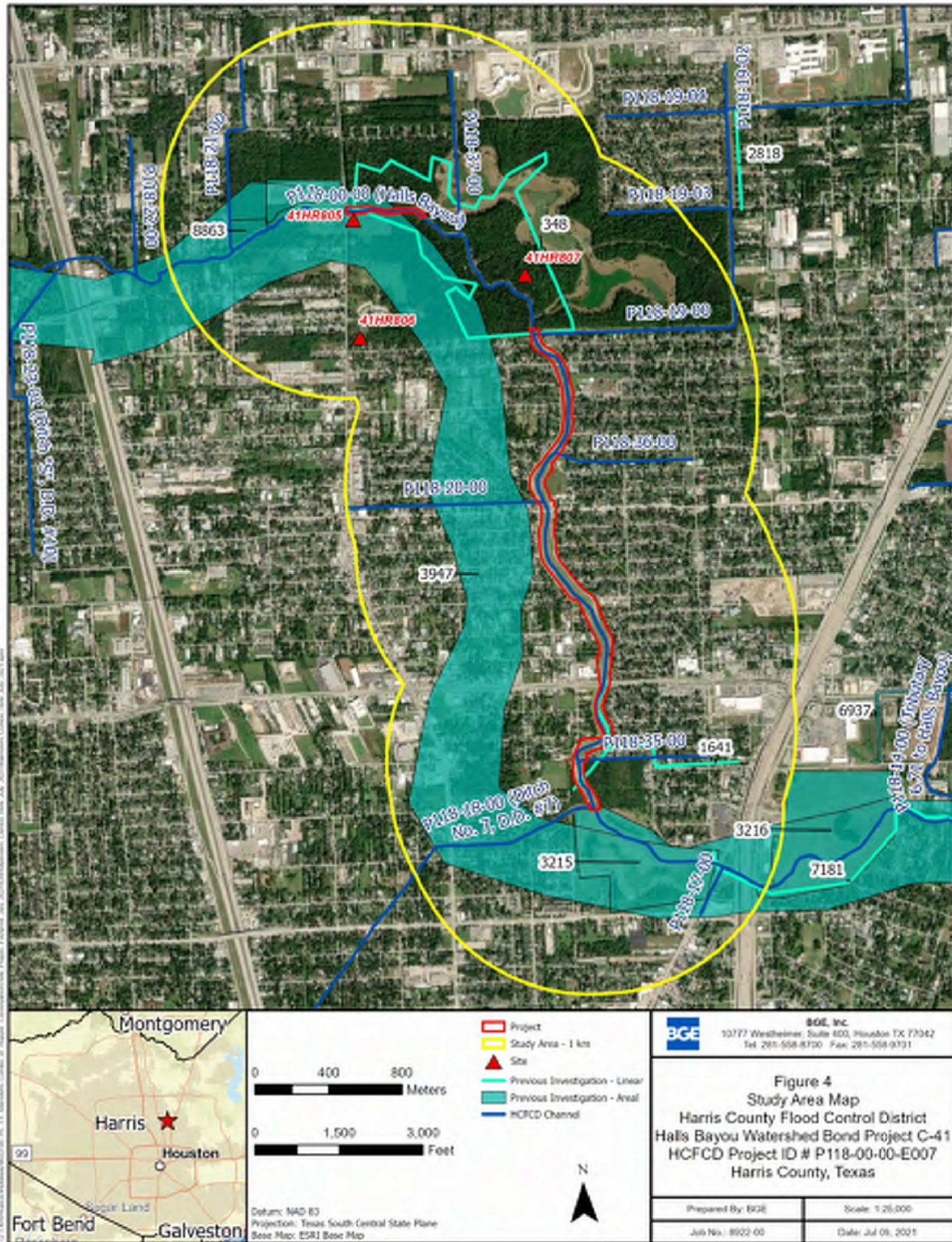


Figure 4: Study Area map

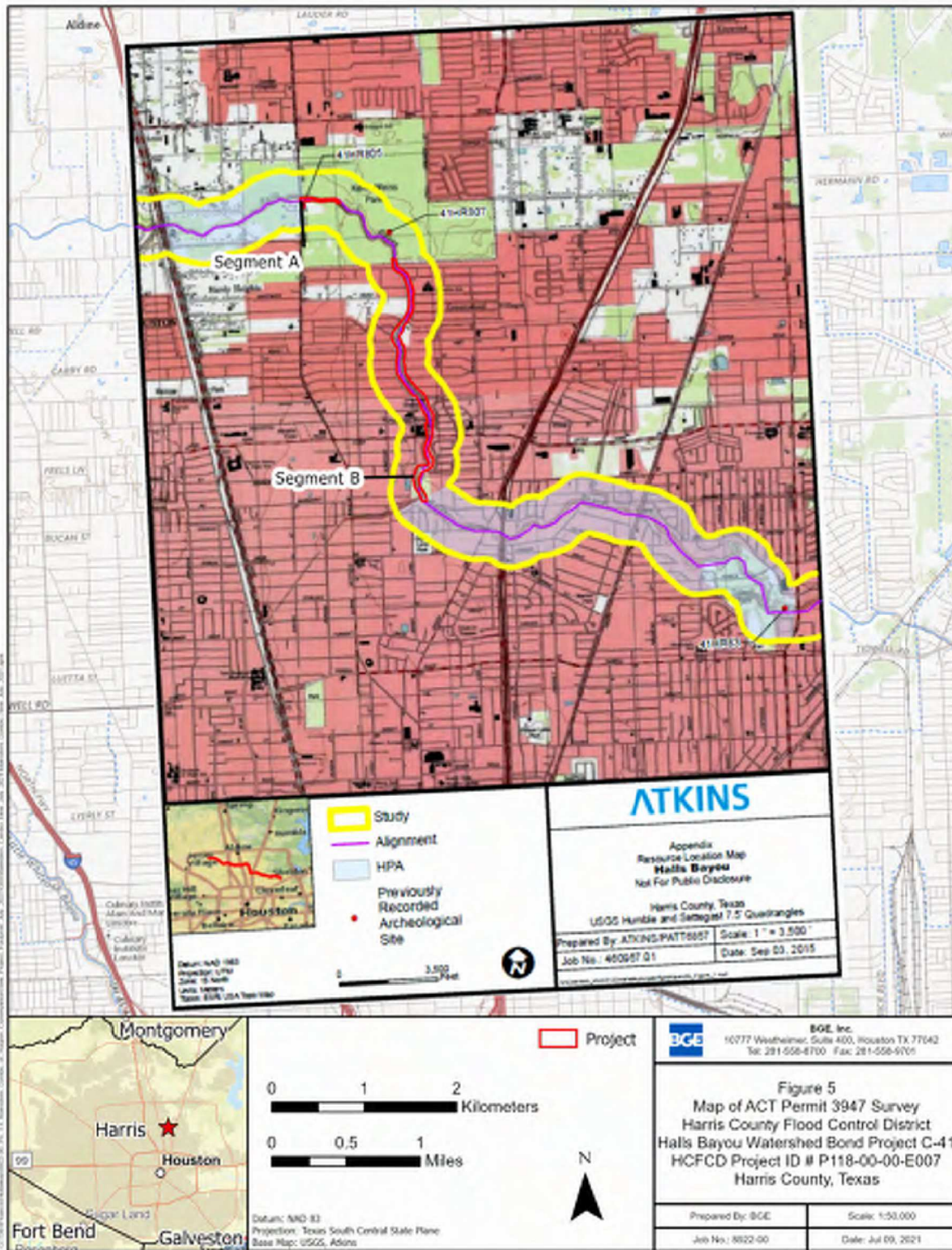


Figure 5: Map of ACT permit 3947 survey

## **POTENTIAL ARCHEOLOGICAL LIABILITY MAP**

BGE reviewed the Potential Archeological Liability Map (PALM) developed by the Texas Department of Transportation (TxDOT) for the Houston District. TxDOT developed PALM as a tool to estimate the integrity potential of prehistoric sites possibly located within different geographic areas and make survey recommendations based on that potential. Most of Segment A is located in what PALM defines as Area Value 1 (**Figure 6**), where a surface survey is recommended, and deep reconnaissance is also recommended if deep impacts are anticipated. The westernmost portion of Segment A, as well as all of Segment B, are located in Area Value 4, where no survey is recommended.

As mentioned before, the project corridor only encompasses the existing channel and its banks, entirely within the HCFCD ROW. Therefore, even though Segment A is located within PALM Area Value 1, surface survey and deep reconnaissance do not seem possible due to the limited project footprint extending only to the sloping banks of Halls Bayou (**Figure 7**).

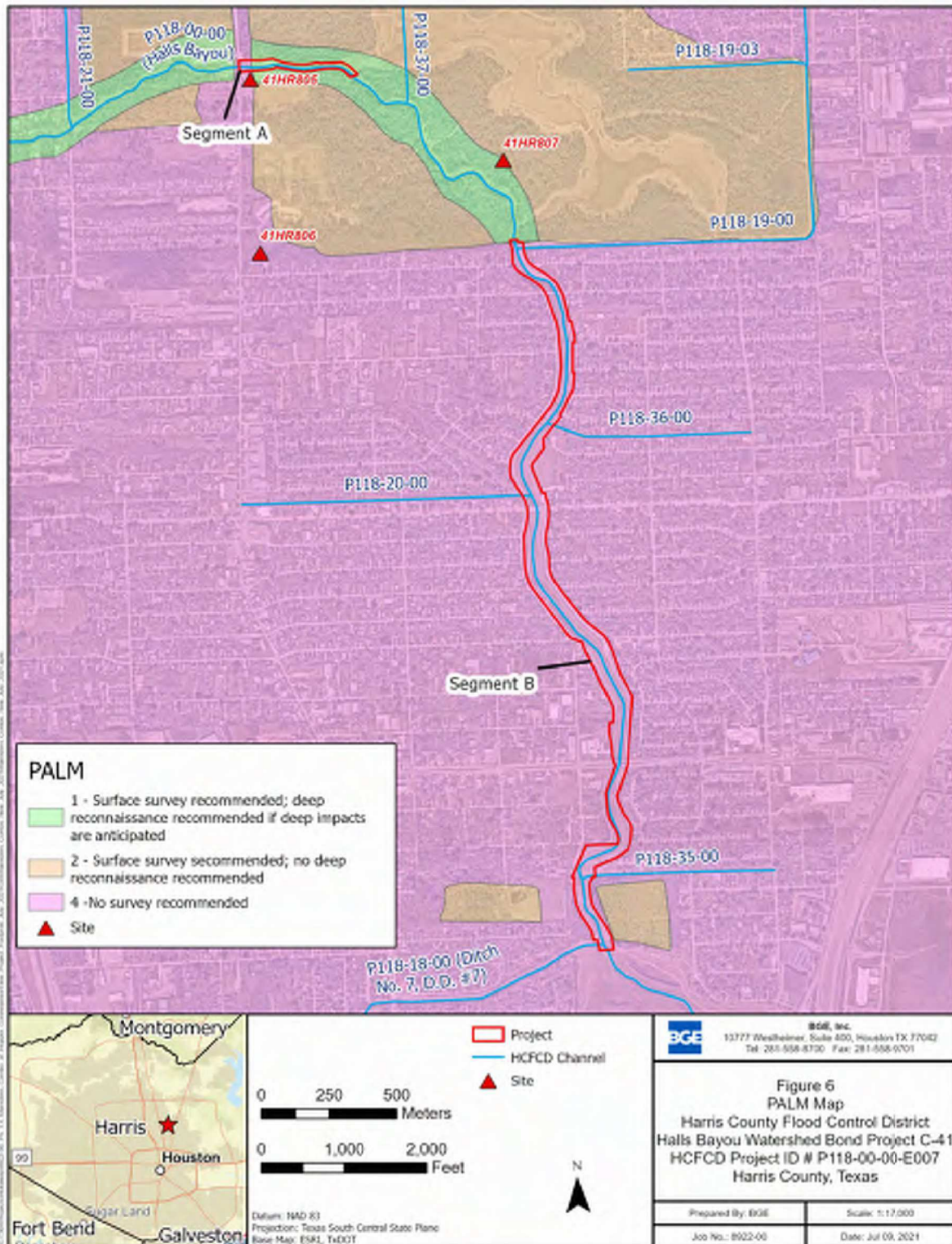


Figure 6: PALM map

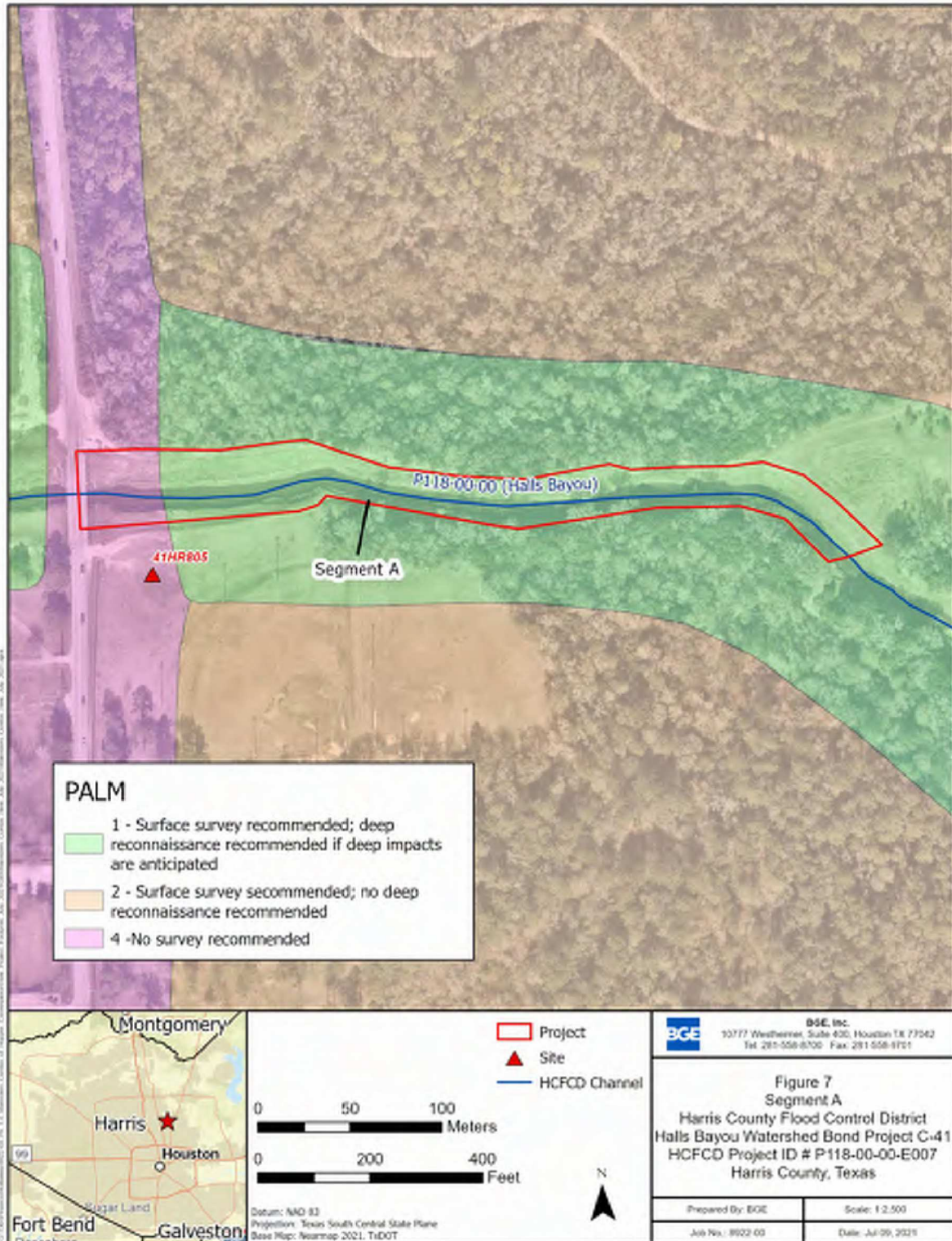


Figure 7: Segment A



## **SUMMARY AND MANAGEMENT RECOMMENDATIONS**

This cultural resources desktop assessment for the proposed Halls Bayou Watershed Bond Project C-41, HCFCD Project ID # P118-00-00-E007, indicated that the project will not have any impact on any known cultural resources, and that the area where the project is located has been previously investigated for cultural resources via a reconnaissance survey. Furthermore, the project corridor only encompasses the existing channel and its banks, entirely within the HCFCD ROW. The project footprint extends only to the sloping banks of Halls Bayou.

Based on the results of this desktop assessment and the project footprint provided by Hollaway and HCFCD, BGE does not recommend a cultural resources survey to be performed prior to project construction.

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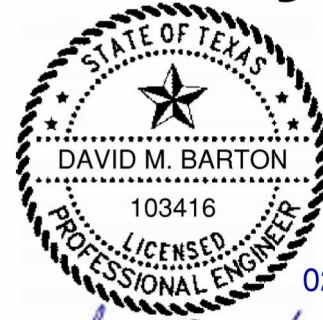
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# Hardy West Alternatives Analysis Summary Report

Harris County Flood Control District



02/15/2022

*David M. Barton*



Lockwood, Andrews  
& Newnam, Inc.

A LEO A DALY COMPANY

TBPE Firm No. 2614

## Executive Summary

The Harris County Flood Control District (HCFCD) authorized Lockwood, Andrews & Newnam, Inc. (LAN) in February 2020 to conduct an Alternative Analysis Study on the Hardy West detention basin along Halls Bayou (HCFCD Unit No. P118-00-00). The purpose of this study is to analyze and describe the existing flooding conditions within the project area, whereupon targeted flood risk mitigation alternatives are developed based on results. The recommended alternative derived from this Alternatives Analysis is intended to be incorporated into a Preliminary Engineering Report (PER), which can efficiently be carried into detailed design.

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

Baseline Conditions results revealed a less than 10-year Level-of-Service (LOS) for Halls Bayou in the project area. The Existing Conditions model outcome for a 500-year design storm shows that 2,855 structures are mapped within the modeled floodplain, with 2,119 structures shown to be inundated based on estimated finished floor elevations (FFE). Three proposed alternatives were developed using the Halls Bayou Mainstem Potential Projects Memorandum (LAN, July 2020) as a starting point. Hardy West was also identified in the Halls Bayou Watershed Flood Risk Reduction Phasing Study (LAN, January 2021) as a recommended project for the first phase of the Vision Plan implementation.

In coordination with HCFCD, LAN recommends Alternative 3 to carry for advancement to a PER Study. Compared to Alternatives 1 and 2, Alternative 3 provides the best cost to benefit ratio, being less expensive and requiring less ROW acquisition, while still providing benefit to Halls Bayou and the surrounding area.

Alternative 1 consists of one large pond bounded by Halls Bayou to the south, Hill Road to the north, and Hardy Toll Road to the east. The basin is 12 feet deep and has an 80-acre footprint, providing a storage volume of 680 ac-ft, including 1 foot of freeboard. Alternative 1 provides the most storage and has the greatest benefits along with the highest cost at \$51.4 million. Alternatives 1 and 2 require approximately 96 acres of right-of-way.

Alternative 2 consists of two ponds separated by P118-25-00 bounded by Halls Bayou to the south, Hill Road to the north, and Hardy Toll Road to the east. The east and west basins are 12 and 11 feet deep, respectively, and have a total pond footprint of 77-acres, providing a storage volume of 625 ac-ft, including 1 foot of freeboard. Alternative 2 provides slightly less storage and benefits than Alternative 1, and costs approximately \$49.3 million.

Alternative 3 consists of two ponds offset from Hill Road and separated by P118-25-00 bounded by Halls Bayou to the south, Woodmoss Road to the west, and Hardy Toll Road to the east. The east and west basins are 12 and 11 feet deep, respectively, and have a total pond footprint of 55 acres, providing a storage volume of 400 ac-ft, including 1 foot of freeboard. While Alternatives 1 and 2 provide slightly more benefits than Alternative 3, Alternative 3 still provides benefit to Halls Bayou, requires 26 less acres of right-of-way than the other two alternatives, and is approximately \$16 million and \$13.9 million less than Alternatives 1 and 2, respectively. Alternative 3 provides a 10-year (pre-Atlas 14 update) level-of-service (LOS), and results in no adverse impacts to Halls Bayou and the surrounding region, up to and including the 500-year storm event (pre-Atlas 14 update).

For the performance metrics, all structures north of Aldine Mail Route Road near P118-25-00/01 and north of Isom Street near P118-21-00 have been excluded. Water surface elevations in these areas are



# Hardy West Alternatives Analysis Summary Report

controlled by the tributaries and overflow from Greens Bayou, with very little benefit observed from the Hardy West improvements. Other improvement projects for these tributaries are currently in development by HCFCD to address flooding in these areas.

LAN and HCFCD identified the need for preliminary modeling for several projects in the 2021 CDBG-MIT updated project prioritization list. The goals of these projects are to better identify benefits and maximize benefits for detention projects by coupling with localized channel improvements. For one project evaluation, “Mainstem – Hardy West 2”, incorporating channel improvements to the Hardy West Alternative 3 model was analyzed. LAN recommends further exploring the addition of channel improvements to Alternative 3 to maximize benefits in the area. The Mainstem – Hardy West 2 memo can be referenced in **Appendix K**.

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# Hardy West Alternatives Analysis Summary Report

## 1 Introduction

### 1.1 Purpose

The efforts described in this report are submitted in fulfillment of the services described in Scope of Services and Fee Proposal of the Professional Services Agreement between Lockwood, Andrews & Newnam, Inc. (LAN) and Harris County Flood Control District (HCFCD) dated February 25<sup>th</sup>, 2020. The overall purpose of the detailed baseline conditions hydrology and hydraulics (H&H) analysis for Hardy West is to develop a starting point for the Alternatives Analysis – which will recommend a potential HCFCD construction project to improve drainage conditions along Halls Bayou and to mitigate flood risks in the contributing drainage area.

The purpose of this memorandum is to provide a clear and concise summary of the H&H analyses for Hardy West and modification of the baseline models. Refer to **Figure 1-1** for the workflow followed in the baseline conditions analysis.

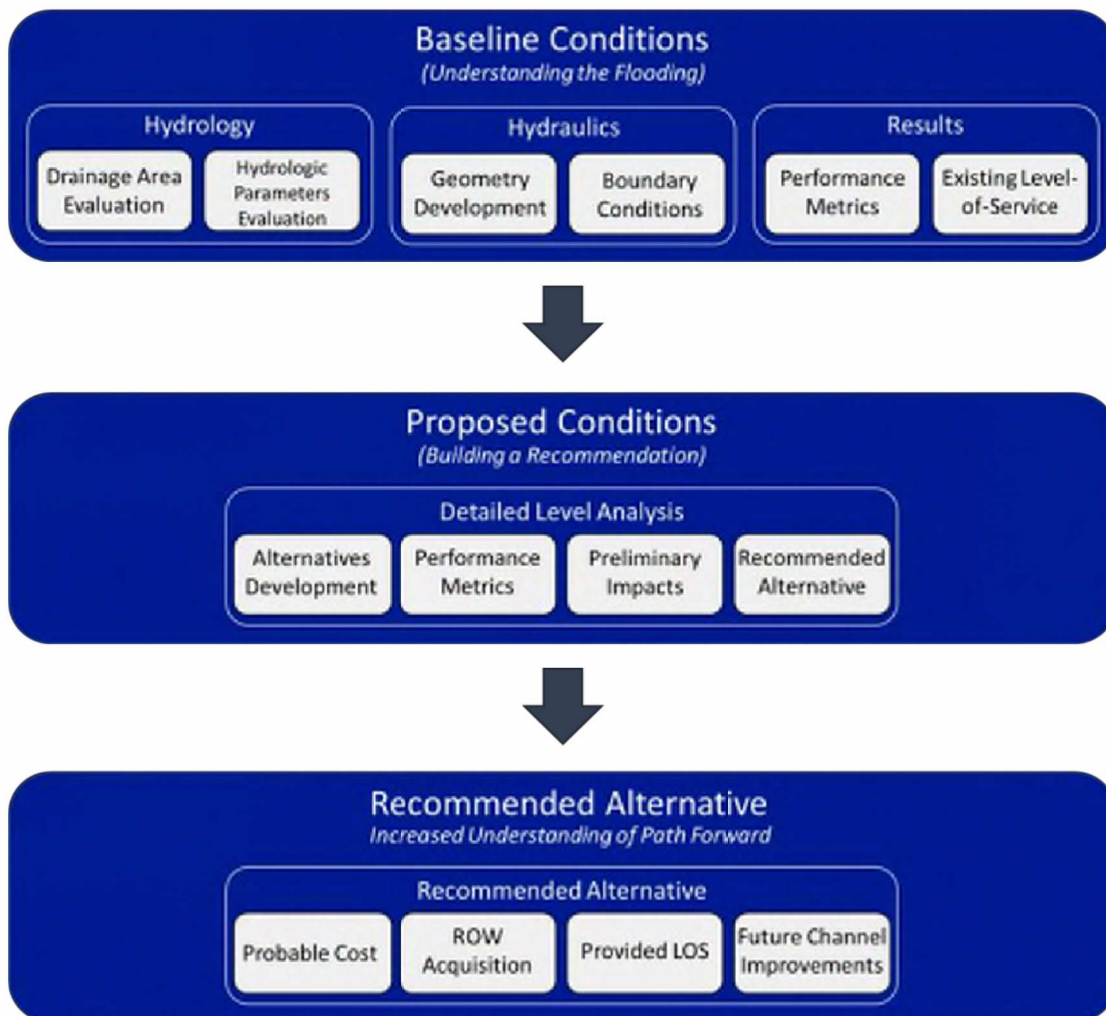


Figure 1-1: Alternatives Analysis Workflow

## 1.2 Background

In January 2021, LAN completed the Halls Bayou Watershed Flood Risk Reduction Phasing Study which updated the 2013 Halls Ahead Study Vision Plan and developed a phasing strategy for identified bond projects. This Alternatives Analysis study is the next step towards getting Phase 1 of the bond projects constructed. This Analysis, when complete, will describe and analyze a series of potential flood risk mitigation projects, evaluate project performance metrics, recommend a project solution, assess mitigation potential for adverse impacts downstream, summarize key findings, and deliver concept plans for stakeholder communication.

## 1.3 Study Area

Hardy West Detention Basin is located within the Halls Bayou (HCFCD Unit No. P118-00-00) watershed in the northern portion of Harris County, Texas – refer to **Exhibit 1**. The project limits encompass the proposed footprint of the pond, bounded by Hill Road on the north, Halls Bayou on the south, and Hardy Toll Road on the east. The Federal Emergency Management Agency (FEMA) effective floodplain (shown in **Exhibit 2** and **Figure 1-2**) extends approximately 6,000 feet to several miles wide. The land use, as shown in **Exhibit 3**, consists primarily of residential land cover.

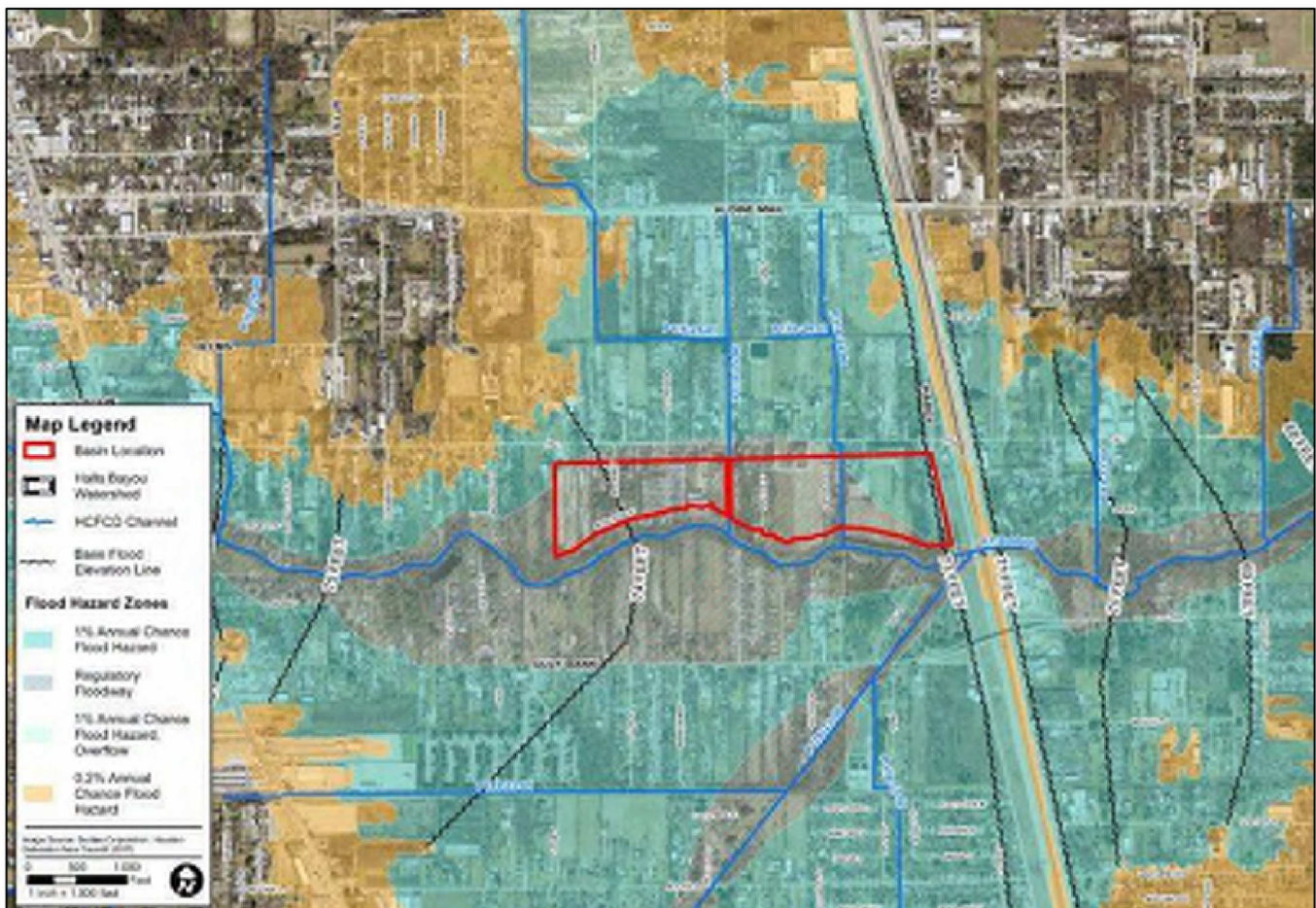


Figure 1-2: FEMA Effective Floodplain

## 2 Baseline Conditions Analysis

### 2.1 Data Collection

The starting H&H models for Halls Bayou were obtained from the HCFCD Halls Bayou Watershed Flood Risk Reduction Phasing Study (LAN, January 2021). Hydrologic Engineering Center (HEC) Hydrologic Modeling System (HMS) version 3.4 and River Analysis System (RAS) version 5.0.3 models were developed by LAN as part of the Phasing Study utilizing the following:

- Harris County Appraisal District (HCAD) 2004 parcel data
- Houston-Galveston Area Council (H-GAC) 2017 aerial imagery
- H-GAC 2018 Land Cover
- United States Geological Survey's (USGS) National Land Cover Database (NLCD) percent impervious data from 2006 to 2011
- H-GAC 2008 and 2018 Light Detection and Ranging (LIDAR)
- Channel survey data from Baseline Corporation Professional Surveyors
- FEMA Effective HEC-RAS and HEC-HMS models
- 2017 Structure Inventory Data from HCFCD

Available HCFCD Right-of-Way (ROW) information can be seen in [Exhibit 4](#).

#### 2.1.1 Prior Studies

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

- FEMA Effective H&H models (FEMA, June 2014). After Tropical Storm Allison in 2001, the FEMA and the HCFCD together developed a countywide study, Tropical Storm Allison Recovery Project (TSARP) to assess the flood risks associated with the major flooding sources and that became a Flood Insurance Study (FIS) and Effective Model. As part of the project FEMA revised the H&H models and remapped the floodplains. This Effective Model is used as a go by model for the 2013 Halls Ahead Vision Plan program.
- Halls Ahead Vision Plan Engineering Appendix (BGE, August 2013). The Halls Ahead program is an accelerated flood damage reduction study, designed to be a guide for future HCFCD projects and facilities in the Halls Bayou watershed. The H&H models from the Vision Plan served as the basis for the Phasing Study.
- Halls Bayou Watershed Flood Risk Reduction Phasing Study (LAN, January 2021). The Halls Phasing Study is an update and phasing strategy for the BGE 2013 Vision Plan. The H&H models from the Phasing Study served as the basis for this Baseline Conditions model development.
- Halls Bayou Mainstem Potential Projects Memorandum (LAN, July 2020). The potential projects study was completed to analyze projects along the mainstem of Halls Bayou that might be considered for upcoming grant funding opportunities – see [Appendix D](#).
- P118-25-00/01 Alternatives Analysis Summary Report (LAN, January 2020). The alternative analysis is a study that analyzes and describes the existing flooding conditions within the P118-25-00/01 catchment area, whereupon targeted flood risk mitigation alternatives are developed based on results.

#### 2.1.2 Site Conditions / Site Visits

On January 15, 2021, LAN performed a site visit to photograph and document the project area. One significant finding included a wastewater treatment plant (WWTP) facility serving the Rose Wood Mobile

# Hardy West Alternatives Analysis Summary Report

Home Community; however, this facility is located on the south side of Halls Bayou and will not be a potential constraint. The site visit findings, such as channel condition, were consistent with and confirmed the data being used in this Alternatives Analysis. Refer to **Figures 2-1** through **2-3** and **Appendix A** for photographic documentation.



**Figure 2-1: Rapids in Halls Bayou just upstream of P118-25-00 and Halls Bayou confluence**



**Figure 2-2: Halls Bayou looking upstream from Hardy Toll Road bridge**



**Figure 2-3: Halls Bayou looking downstream toward Hardy Toll Road bridge**

## 2.1.3 Historical Flooding

LAN analyzed historical flood losses from FEMA repetitive loss claims, claims from Hurricane Harvey (2017), and Hurricane Imelda (2019). Claims were compiled into heat maps and compared to determine historical problem areas (see **Appendix B**). Overall, the claims data agreed that the main problem areas are just downstream of tributary P118-26-00 along Halls Bayou, within the footprint of the Hardy West basin location along Halls Bayou, and along tributary P118-23-02. **Figure 2-4** below shows the heat map of all loss claims compiled together for analysis.



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## 2.1.4 HCFCD Watershed Environmental Baseline (WEB) Program

The HCFCD WEB program was created to document the baseline environmental conditions of Harris County's watersheds. The program has integrated data from multiple sources for planning-level desktop analyses, including potential wetlands, cultural resource sites, threatened and endangered species locations, hazardous and toxic materials sites, pipelines, oil and gas well locations, stream habitat quality assessments, and FEMA floodplains. The WEB desktop analysis for this project is included in **Exhibit 5**.

In the WEB desktop analysis for Hardy West, two (2) pipelines were identified running parallel to W Hardy Toll Road and to the edge of the footprint of the Hardy West detention basin. The sizes of the pipelines are 6.63" and 20" in diameter and are owned by ExxonMobil and Magellan, respectively. The pipelines are currently located just outside the footprint of the Hardy West detention basin, and it is anticipated that there will be no environmental permitting or pipeline relocations.

## 2.2 Hydrology and Hydraulics

The methodology used to study the Hardy West project area involved H&H analysis and modeling in HEC-HMS and HEC-RAS. The hydrologic results presented in this report were completed using HEC-HMS Version 3.4, and the hydraulic results were modeled with HEC-RAS Version 5.0.5 for the Hardy West model. The Baseline Conditions model will establish an existing condition for conducting a flood risk assessment within the Hardy West project area.

### 2.2.1 Hydrology

The meteorological model was developed to include the 2-, 10-, 50-, 100-, and 500-year design storm events (pre-Atlas 14 update) based on Harris County Hydrologic Region 2 (HCFCD, December 2009). The effective model sub-basins covering the project area are named P118L1 and P118L2. The HEC-HMS 3.4 model from the Halls Phasing study, also used in the "Halls Bayou Mainstem Potential Projects" memorandum, was used in this project.

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

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

#### 2.2.1.1 Hydrologic Parameters

Land use categories used in the 2021 Phasing Study (based on 2016 aerial imagery) were verified based on 2021 aerial imagery; no new developments were identified within the project area. LAN evaluated all other hydrologic parameters manually and determined no change was necessary from the Phasing study and the "Halls Bayou Mainstem Potential Projects" memorandum. Halls Bayou sub-basins in the vicinity of the project area are shown in **Exhibit 6**.

### 2.2.2 Hydraulics

As a starting point for the Baseline Conditions model, LAN used a fully 1D/2D unsteady HEC-RAS 5.0.3 model of Halls Bayou from the Halls Bayou Phasing Study, which was also used in the "Halls Bayou Mainstem Potential Projects" memorandum. The model was converted from HEC-RAS Version 5.0.3 to



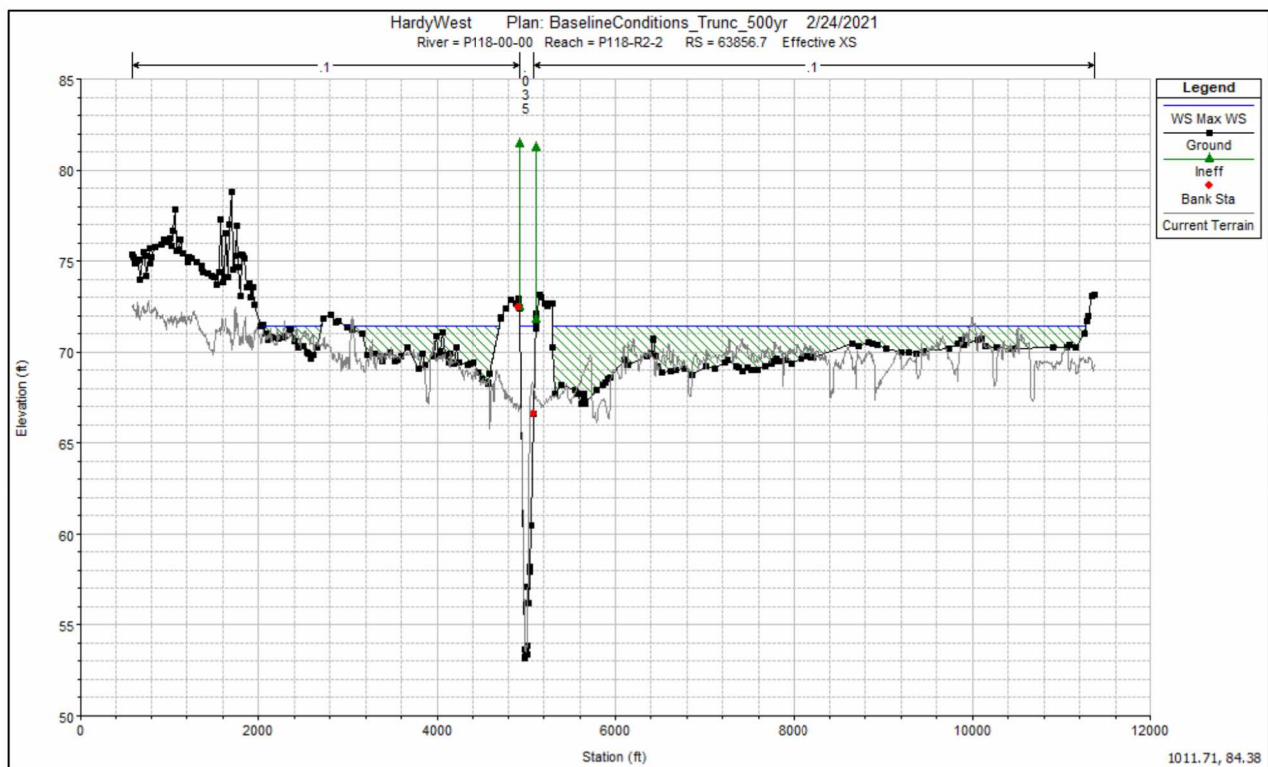


# Hardy West Alternatives Analysis Summary Report

Minor adjustments were made and will be described in the following sections. **Exhibit 7** shows the final HEC-RAS 1D model geometry for the baseline conditions.

## 2.2.2.1 1D Channel Geometry

In the Halls Phasing study, channel cross sections for the 1D unsteady model were taken from the Effective HCFCD Model & Map Management System (M3) model which was based on 2001 LiDAR and corrected in areas with large discrepancies when compared to the 2008 LiDAR. In this Alternatives Analysis model, reach lengths along the Halls mainstem were checked and several were updated including cross sections at river stations 67511.6, 65955.8, 65434.6, 64399.74, 64220.7, 63960.4, and 63856.7. Three cross sections were added along the Halls mainstem. The cross section at RS 63756.7 was added to serve as the second downstream bounding cross section from the Hardy Toll Road bridge at RS 63908.2. Cross sections at RS 68670 and RS 66190 were added to produce a more direct and accurate comparison between Baseline and Proposed Conditions, further discussed in Section 4.1.1. Cross sections at RS 66869 and RS 66774 were added just upstream and downstream of the P118-25-00 junction with Halls Bayou to create model stability. Furthermore, the junction at P118-25-00 was updated to a storage area connection to ensure flow is accurately conveyed between the 1D channels and 2D flow areas. Manning's n values were checked with recommended values and updated as needed. Manning's n values of 0.99 representing ineffective flow areas were updated, and actual ineffective flow areas were placed where needed – see **Figure 2-6** below.



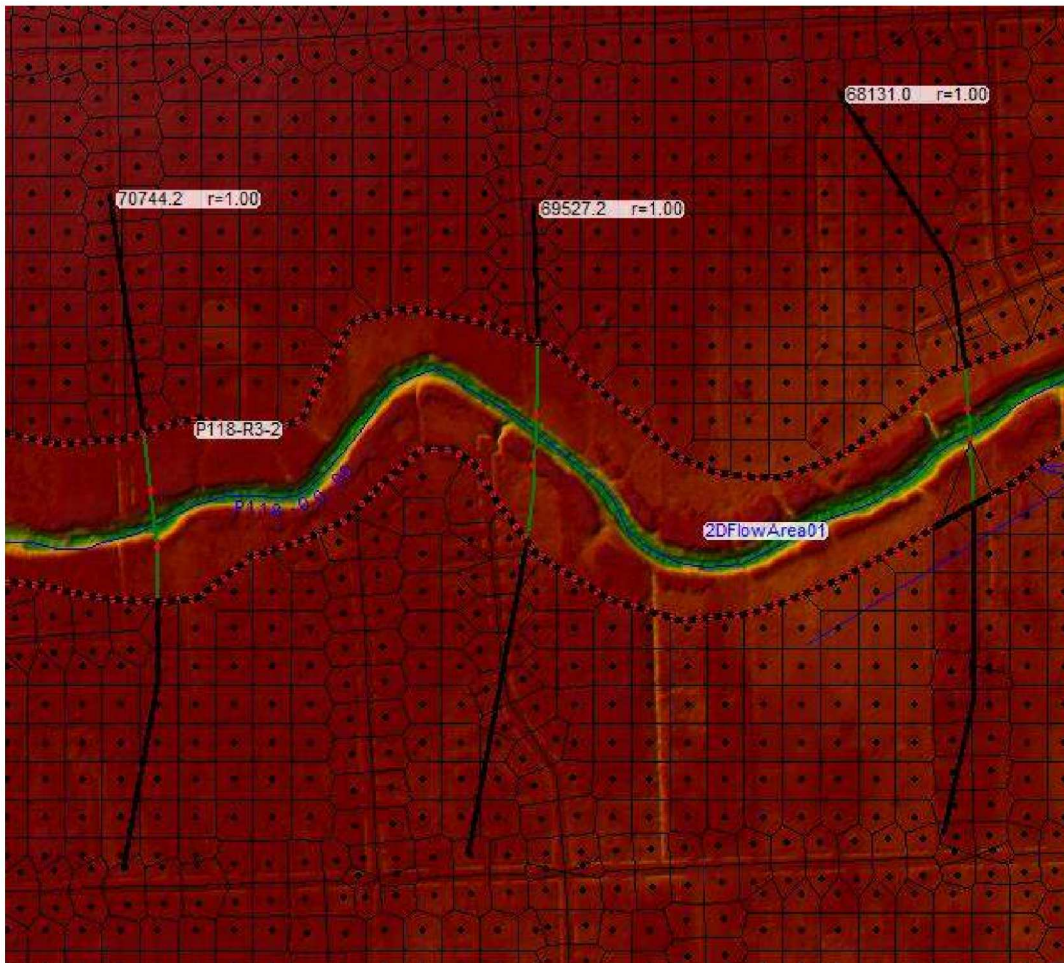
**Figure 2-6: Cross section**

## 2.2.2.2 2D Flow Areas

The 2D flow areas from the Halls Phasing Study model were used and slightly modified in this Alternatives Analysis. 2D flow areas from the P118-25-00/01 Standalone model were imported as part of the model

# Hardy West Alternatives Analysis Summary Report

geometry. 2D flow areas upstream of Hardy Toll Road along Halls Bayou in the vicinity of the project area were extended much closer to Halls Bayou channel banks for increased accuracy of overland and channel flow. Blocked obstructions were set in the cross-sections where they overlapped with the 2D area to prevent HEC-RAS from double counting storage in the 1D overbank (see **Figure 2-7** below).



**Figure 2-7: 2D Flow Areas along Halls Bayou**

Manning's n values were assigned to the various land cover classifications from the 2018 H-GAC Land Cover within the 2D flow areas. The n values were assigned based on the recommended Manning's n values from the HCFCD Two-Dimensional Modeling Guidelines (July, 2018) – see **Table 2-1** below.

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**Table 2-1: Recommended n-Value Assignments per H-GAC Land Classifications**

Land Classification	Recommended Manning's n Value
Open Water	0.02
Developed High Intensity	0.03
Developed Med Intensity	0.18
Developed Low Intensity	0.16
Developed Open Space	0.06
Barren Lands	0.2
Forest/Shrubs	0.25
Pasture/Grasslands	0.22
Cultivated Crops	0.17
Wetlands	0.08
Building	10

### 2.2.2.3 Lateral Structures – 1D/2D Model Interaction

Lateral structures were set in HEC-RAS to connect the 1D river/reach to the 2D flow area. As the 1D channel fills up and reaches the banks, the lateral structures allow the water to leave the 1D channel and enter the 2D overbanks. LAN modified lateral structures from the Halls Phasing Study on left and right banks between inline structures along Halls Bayou, where needed. For the weir coefficients of the lateral structures and 2D connectors, Table 3-1 of the HEC-RAS 2D Manual recommended 0.2 to 0.5 for flow escaping the main river (USACE, February 2016).

### 2.2.2.4 Boundary Conditions

The downstream boundary condition was set as a rating curve based on the rating curve established in the Phasing Study model for the same cross section (RS 58436.86) for each storm event. The upstream boundary condition was set as a flow hydrograph taken from the Phasing study model at the same cross section (RS 72405.2) for each storm event. Five boundary conditions from the Standalone P118-25-00/01 model were imported as part of the model geometry. These boundary conditions include three overflow boundary condition hydrographs for each storm event representing overflow from P138-00-00 into the project area and two overflow boundary condition hydrographs for each storm event representing overflow from P118-26-00 into the project area – see **Figure 2-8** below for the 500-year flows. Overflow from P118-27-00 coming into the P118-23-00 project area was also set as a boundary condition for each storm event – see **Figure 2-9** below for the 500-year flows. See **Appendix R** for the 500-year Greens Bayou overflow, and flow from P118-26-00 and P118-27-00 into the Hardy West project area.

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Figure 2-8: 500-Year Flow from P118-26-00 into Hardy West Project Area



Figure 2-9: 500-Year Flow from P118-27-00 into Hardy West Project Area

## 2.2.3 2018 LiDAR Update and Re-Evaluation

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

The raw difference (2018 minus 2008, see **Figure 2-10**) indicates the majority of open areas fall within the margin of error. There has been some development within the last 10 years, including the expansion of Aldine Mail Route, which is evident in the difference grid. Some areas along the channels exhibit differences greater than one foot but less than 4 feet. In some sections of Halls Bayou, differences of 4 feet are seen. This is likely due to several factors including the difference in resolution, the fact that channels are in vegetated areas (where the original margin of error is higher), and possible erosion over the 10-year period. It is not an indicator of any significant topographic disparities.

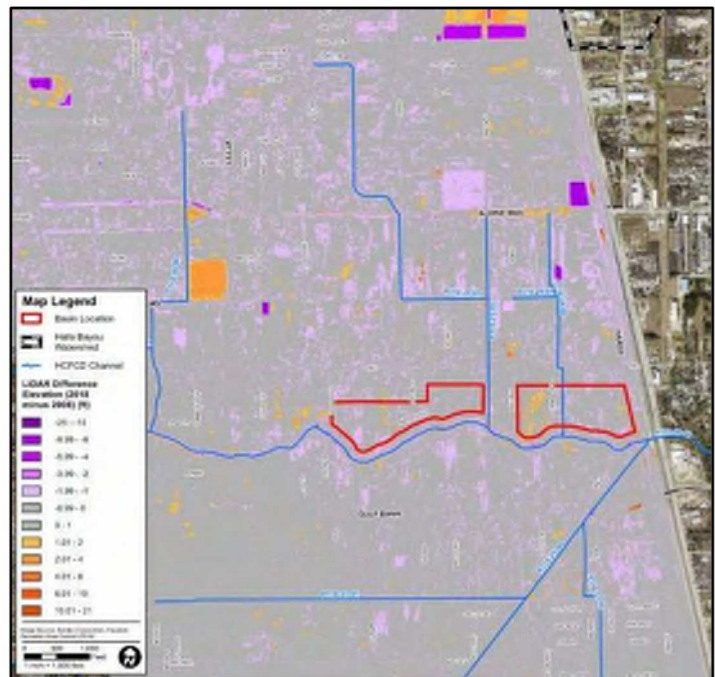


Figure 2-10: 2018 and 2008 LiDAR Difference Grid

When the standard deviation between the two LIDAR datasets is calculated, the overall differences fall within the margin of error. Most areas along the channel outside the margin of error fall within a standard

# Hardy West Alternatives Analysis Summary Report

deviation of 4-6 inches. There are no significant differences between the two LiDAR datasets within the Hardy West project area.

While it is recommended that future projects use the 2018 LiDAR to incorporate terrain changes and increased accuracy, the 2008 LiDAR is sufficient for current hydrologic and hydraulic studies.

## 2.3 Baseline Conditions Results

The Baseline Conditions model demonstrated widespread ponding across the project area. Maximum ponding extents and depths for all four storm events can be seen in **Exhibits 8** through **12**. Water surface profiles for all four storm events can be seen in **Appendix C**.

### 2.3.1 Performance Metrics

The HEC-RAS results were used to generate a set of performance metrics to measure proposed improvement alternatives. Metrics include acreage of floodplain, miles of inundated roadway, number of structures in the floodplain, and number of flooded structures based on finished floor elevation (FFE). To determine the structure counts in the floodplain, maximum floodplain extents were exported from HEC-RAS for all five design storms (2-, 10-, 50-, 100-, and 500-year) to GIS and intersected with the 2017 HCFCD structural inventory (SI) data. The SI is a point dataset of building centroids with FFE's populated from either survey or an assumed adjustment based on LiDAR. There are still data points with no assigned FFE data, and in these cases, the associated 2008 LiDAR elevation fields were used and adjusted by adding 0.5 feet to approximate FFE values for use in developing the performance metrics.

Flooded structure counts and the degree of inundation were generated by exporting WSEL raster of the maximum ponding from HEC-RAS and extracting raster values to the SI points. A structure with a model WSEL value higher than its FFE was considered flooded. Miles of roadway measures the length of roadway resulting from an intersection of the maximum inundation boundary with the HGAC STAR Map roadway centerline shapefile. Refer to **Table 2-2** for a summary of the Baseline Conditions performance metrics for the 2-, 10-, 50-, 100-, and 500-year storm events. Performance metrics for all baseline plans and storm events can also be found between **Exhibits 8** through **12**.

**Table 2-2: Baseline Conditions Summary Performance Metrics**

Metric	2-year Floodplain	10-year Floodplain	50-year Floodplain	100-year Floodplain	500-year Floodplain
Structures in Floodplain	316	907	1914	2113	2855
Flooded Structures (based on FFE)	77	291	809	1308	2119
Miles of Inundated Roadway	2.7	11.8	20.5	22.8	30.2
Acres of Inundated Land (Floodplain)	246	684	1235	1387	1817

For the performance metrics, all structures, roads, and floodplain acreage north of Aldine Mail Route Road have been excluded from the calculations. This topic is further discussed in Section 4.3.

### 2.3.2 Existing Level-of-Service

Existing Level-of-Service (LOS) was evaluated by comparing Service Elevations (minimum elevation of the right and left channel overbank; ROB and LOB, respectively) for each cross-section with modeled WSEL for a 2-, 10-, 50-, 100-, and 500-year return period. Hardy Toll Road bridge along with the Missouri Pacific Railroad act as flow restrictors, ultimately causing significant flooding extents on the west side of Hardy Toll Road. The Hardy Toll Road bridge opening and the entire stretch of Halls Bayou in the Hardy

# Hardy West Alternatives Analysis Summary Report

West project are undersized, creating a less than 10-year LOS in this section of channel. Detention storage provided by Hardy West detention basin could significantly reduce the floodplain from Halls Bayou along with mitigating any potential channel improvements. Also, in larger storm events, a significant amount of stormwater from P138-00-00 overflows into tributaries P118-25-00 and P118-25-01 and Halls Bayou, primarily just upstream of Hardy Toll Road, contributing to the poor LOS in the section of Halls Bayou. WSEL profile plots are shown in **Appendix C**.

## 3 Proposed Conditions Analysis

All alternatives considered in this Alternatives Analysis Summary Report evaluated flood damage reduction potential under existing (Baseline) hydrologic conditions. Other planned infrastructure projects that may affect the Hardy West project area are not considered as part of this analysis unless explicitly stated. The Baseline Conditions model was used as a starting point for developing the various Proposed Conditions models.

### 3.1 Alternatives Development

LAN used the Mainstem Potential Projects Memo as a starting point for developing the three proposed alternatives for this analysis. Hardy West was also identified in the Halls Bayou Phasing Study as a recommended project for the first phase of the Vision Plan implementation.

### 3.2 Detailed Alternatives Analysis

LAN developed three (3) Alternatives under pre-Atlas 14 conditions. The purpose of the Hardy West pond is to provide flooding relief and additional storage to mainstem Halls Bayou. The three Alternative layouts can be seen in **Exhibits 13** through **15**. **Table 3-1** below summarizes the modeled alternatives.

**Table 3-1: Alternatives Summary Table**

Alternative	Detention Storage Provided (ac-ft)	Total Cost
Alternative 1	680	\$ 51,380,000
Alternative 2	625	\$ 49,250,000
Alternative 3	400	\$ 35,360,000

#### 3.2.1 Alternative 1

Alternative 1 consists of one large pond bounded by Halls Bayou to the south, Hill Road to the north, and Hardy Toll Road to the east (see **Figure 3-1**). The basin is an offline detention basin, 12 feet deep, and has an 80-acre footprint, providing a storage volume of 680 ac-ft, including 1 foot of freeboard. The basin specifications include a 50-foot maintenance berm and 5:1 side slopes. In this alternative, 900 feet and 1,000 feet of the downstream ends of P118-25-00 and P118-24-00, respectively, will be removed, and both tributaries will flow into the basin at Hill Road. The proposed outfall structure consists of a 48-inch diameter outfall pipe and a weir at approximately 300-feet wide and 2 feet deep; both outlets are located at the downstream end of the pond. The basin is offset from Halls Bayou by approximately 160 feet to account for future channel improvements outlined in the Vision Plan. The entirety of the Alternative 1 basin footprint is located within a HCFCD buy-out area of interest. Detailed hydraulic calculations are shown in **Appendix Q**. Comparison WSEL profiles between Baseline Conditions and Alternative 1 for all five storm events are attached – see **Appendix E**.

These modifications have a project total cost of \$51.4 million and would provide a 10-year LOS to this region of Halls Bayou. Approximately 96 acres of ROW would need to be acquired for Alternative 1, which includes 71 full parcel acquisitions. An estimated 106 structures lie within the proposed ROW limits. ROW acquisition costs alone are approximately \$19.7 million for Alternative 1. The Alternative 1 layout is shown in **Exhibit 13** and below in **Figure 3-1**. The detailed estimate of probable costs for Alternative 1 can be seen in **Appendix J**.



# Hardy West Alternatives Analysis Summary Report



Figure 3-1: Alternative 1 Layout

# Hardy West Alternatives Analysis Summary Report

## 3.2.2 Alternative 2

Alternative 2 consists of two ponds separated by P118-25-00 bounded by Halls Bayou to the south, Hill Road to the north, and Hardy Toll Road to the east (see **Figure 3-2**). The east and west basins are 12 and 11 feet deep, respectively, and have a total pond footprint of 77 acres, providing a storage volume of 625 ac-ft, including 1 foot of freeboard; both basins are offline detention. The basin specifications include a 50-foot maintenance berm and 5:1 side slopes. In this alternative, 1,000 feet of the downstream end of P118-24-00 will be removed and will flow into the basin at Hill Road. P118-25-00 will not be affected by Alternative 2 and will continue to flow into Halls Bayou at the confluence. The proposed outfall structure for the east pond consists of a 48-inch diameter outfall pipe and a weir at approximately 300 feet wide and 2 feet deep; both outlets are located at the downstream end of the east pond. The proposed outfall structure for the west pond consists of a 48-inch diameter outfall pipe and a weir at approximately 300-foot wide and 1 foot deep; the weir is located at the upstream end of the west pond and the outfall pipe is toward the downstream end of the west pond. The basins are offset from Halls Bayou by approximately 160 feet to account for future channel improvements outlined in the Vision Plan. The entirety of the Alternative 2 basin footprint is located within a HCFCDD buy-out area of interest. Detailed hydraulic calculations are shown in **Appendix Q**. Comparison WSEL profiles between Baseline Conditions and Alternative 1 for all five storm events are attached – see **Appendix F**.

These modifications have a project total cost of \$49.3 million and would provide a 10-year LOS to this region of Halls Bayou. Approximately 96 acres of ROW would need to be acquired for Alternative 2, which includes 71 full parcel acquisitions. An estimated 106 structures lie within the proposed ROW limits. ROW acquisition costs alone are approximately \$19.7 million for Alternative 2. The Alternative 2 layout is shown in **Exhibit 14** and below in **Figure 3-2**. The detailed estimate of probable costs for Alternative 2 can be seen in **Appendix J**.



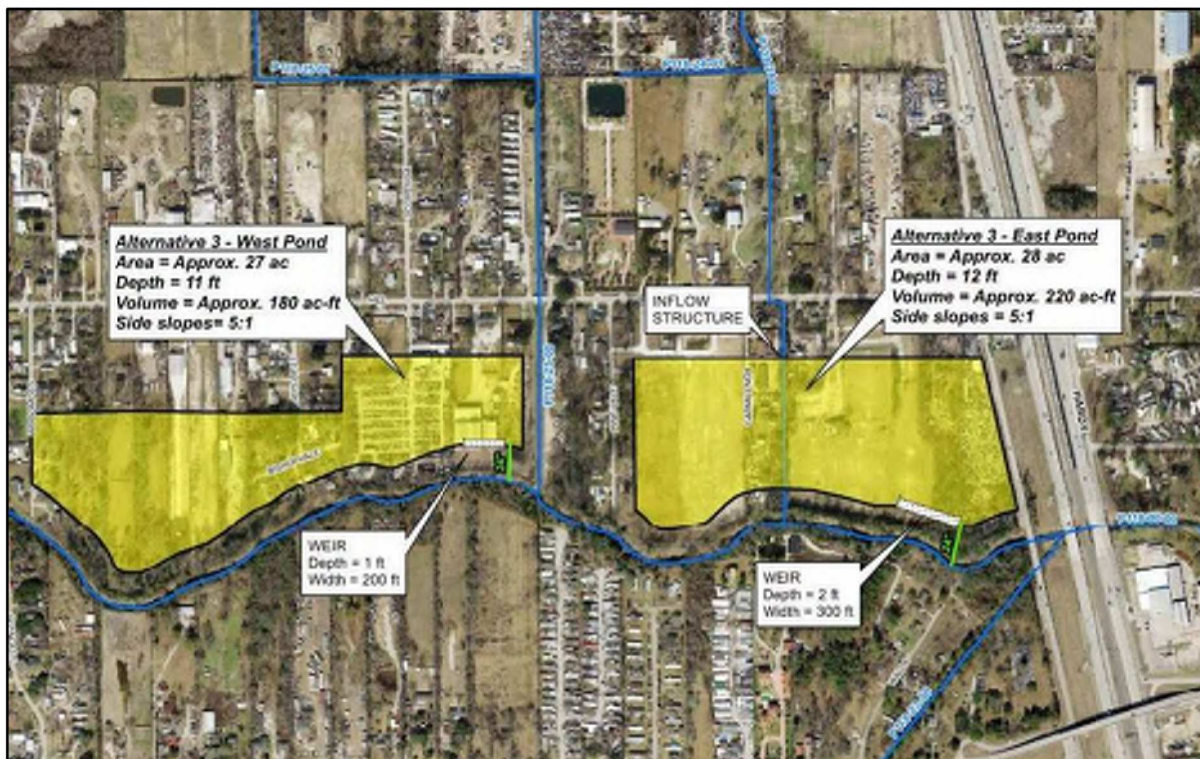
Figure 3-2: Alternative 2 Layout

# Hardy West Alternatives Analysis Summary Report

## 3.2.3 Alternative 3

Alternative 3 consists of two ponds offset from Hill Road and separated by P118-25-00 bounded by Halls Bayou to the south, Woodmoss Road to the west, and Hardy Toll Road to the east (see **Figure 3-3**). The basin footprint is shaped to avoid as many structures as possible and includes open areas and structures that have flooded more frequently in the past. The east and west basins are 12 and 11 feet deep, respectively, and have a total pond footprint of 55 acres, providing a storage volume of 400 ac-ft, including 1 foot of freeboard. The basin specifications include a 50-foot maintenance berm and 5:1 side slopes. In this alternative, 775 feet of the downstream end of P118-24-00 will be removed and will flow into the basin 200 feet south of Hill Road. P118-25-00 will not be affected by Alternative 3 and will continue to flow into Halls Bayou at the confluence. The proposed outfall structure for the east pond consists of a 24-inch diameter outfall pipe and a weir at approximately 300-feet wide and 2 feet deep; both outlets are located at the downstream end of the east pond. The proposed outfall structure for the west pond consists of a 24-inch diameter outfall pipe and a weir at approximately 200-feet wide and 1 foot deep; both outlets are located at the downstream end of the west pond. The basins are offset from Halls Bayou by approximately 160 feet to account for future channel improvements outlined in the Vision Plan. The majority of the Alternative 3 basin footprint is located within a HCFCD buy-out area of interest. Detailed hydraulic calculations are shown in **Appendix Q**. Comparison WSEL profiles between Baseline Conditions and Alternative 1 for all five storm events are attached – see **Appendix G**.

These modifications have a project total cost of \$35.4 million and would provide a 10-year LOS to this region of Halls Bayou. Approximately 70 acres of ROW would need to be acquired for Alternative 3, which includes 24 full parcel acquisitions and 17 partial parcel acquisitions. An estimated 36 structures lie within the proposed ROW limits. ROW acquisition costs alone are approximately \$15.8 million for Alternative 3. The Alternative 3 layout is shown in **Exhibit 15** and below in **Figure 3-3**. The detailed estimate of probable costs for Alternative 3 can be seen in **Appendix J**.



**Figure 3-3: Alternative 3 Layout**

## 4 Alternatives Analysis Results

### 4.1 Hydraulics

#### 4.1.1 HEC-RAS Geometry

The Existing Conditions model geometry was used as a starting point for the development of each proposed alternative geometry within the HEC-RAS model. Hydrology and other unsteady flow boundary conditions remained consistent from Existing to Proposed Conditions. Cross sections at RS 68670 and RS 66190 were added to each of the Alternatives for increased accuracy in lateral structure placement and to allow for separate lateral structure parameters. Weir coefficients were set at 2.0 for flow going into the proposed basin 2D flow area for each Alternative. For Alternative 1, approximately 720 feet of the downstream end of P118-25-00 was removed, and a 2D Area Connector was added. Cross sections at RS 805 and RS 772 were added to the downstream end of P118-25-00 in Alternative 1 for model stability. The Recommended Alternative HEC-RAS geometry can be seen in **Exhibit 16**.

#### 4.1.2 Inflow Boundary Conditions

Inflow boundary condition locations remained identical to the Existing Conditions model, which are outlined in Section 2.2.2.4.

### 4.2 Results

#### 4.2.1 Alternative 1

Alternative 1 improvements provide a 10-year LOS for the project area while significantly reducing WSELs in Halls Bayou upstream of Hardy Toll Road for all storm events. **Appendix E** includes water surface profile comparisons of Alternative 1 and Existing Conditions. **Exhibits 17** through **21** show depth grids and performance metrics results for each modeled storm event. Model results show that Alternative 1 removes the 500-year floodplain from 49 structures and 1.3 miles of roadway (see **Table 4-1**), and an estimated 106 structural buyouts. When calculating the performance metrics for proposed conditions, the structures within the pond footprints that will be structural buyouts are not included as benefit. The 10- and 100-year events show maximum depth reductions of up to 1.18 feet and 0.84 feet, respectively, compared to the Baseline Conditions model. There is a slight increase in water surface elevation in the 50- and 100-year storm events of 0.06 feet and 0.05 feet along tributary P118-21-00; this slight increase can be deemed insignificant. The water surface elevations here are controlled by the tributary itself, and the model geometry does not reflect the latest P118-21-00 conditions, as a Preliminary Engineering Report (PER) has recently been completed for P118-21-00. Alternative 1 results in no adverse impacts to Halls Bayou up to and including the 500-year storm event.

#### 4.2.2 Alternative 2

Alternative 2 improvements provide similar benefits when compared to Alternative 1, with slightly greater WSEL reductions in the 2- and 10-year storm events and slightly less WSEL reductions in the 50-, 100-, and 500-year storm events. **Appendix F** includes water surface profile comparisons of Alternative 2 and Existing Conditions. **Exhibits 22** through **26** show depth grids and performance metrics results for each modeled storm event. Model results show that Alternative 2 removes the 500-year floodplain from 45 structures and 1.2 miles of roadway (see **Table 4-1**), and an estimated 106 structural buyouts. When calculating the performance metrics for proposed conditions, the structures within the pond footprints that will be structural buyouts are not included as benefit. The 10- and 100-year events show maximum depth reductions of up to 1.3 feet and 0.58 feet, respectively, compared to the Baseline Conditions model. There is a slight increase in water surface elevation in the 50- and 100-year storm events of 0.06 feet and 0.04 feet along tributary P118-21-00; this slight increase can be deemed insignificant. The water

# Hardy West Alternatives Analysis Summary Report

There is a slight increase in water surface elevation in the 50- and 100-year storm events of 0.06 feet and 0.04 feet along tributary P118-21-00: this slight increase can be deemed insignificant. The water surface elevations here are controlled by the tributary itself, and the model geometry does not reflect the latest P118-21-00 conditions. Alternative 2 results in no adverse impacts to Halls Bayou up to and including the 500-year storm event.

## 4.2.3 Alternative 3

Alternative 3 improvements provide a less than 10-year LOS for the project area while reducing WSELs in Halls Bayou upstream of Hardy Toll Road for all storm events. **Appendix G** includes water surface profile comparisons of Alternative 3 and Existing Conditions. **Exhibits 27** through **31** show depth grids and performance metrics results for each modeled storm event. Model results show that Alternative 3 removes the 500-year floodplain from 41 structures and 0.8 miles of roadway (see **Table 4-1**), and an estimated 36 structural buyouts. When calculating the performance metrics for proposed conditions, the structures within the pond footprints that will be structural buyouts are not included as benefit. The 10- and 100-year events show maximum depth reductions of up to 0.76 feet and 0.6 feet, respectively, compared to the Baseline Conditions model. There is a slight increase in water surface elevation in the 50- and 100-year storm events of 0.05 feet and 0.03 feet along tributary P118-21-00. The water surface elevations here are controlled by the tributary itself, and the model geometry does not reflect the latest P118-21-00 conditions. There is also a less than 0.01-foot increase in WSEL on the upstream end of P118-25-01 in the 50- and 100-year storm events; however, the model geometry does not reflect the latest P118-25-01 conditions, as this tributary project is currently being further refined in the PER phase. Several other outside improvement projects are ongoing in the surrounding area as well. These slight increases can be deemed insignificant. Alternative 3 results in no adverse impacts to Halls Bayou up to and including the 500-year storm event.

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

Alternative	Attributes						
	Cost Information		500yr Metrics				
	Total Estimated Cost	Cost of ROW Acquisition	Inundated Structures Benefitted	Flooded Structures Benefitted	Miles of Roadway Benefitted	Floodplain Removed form Area (ac)	Structural Buyouts
Baseline	\$ -	\$ -	0	0	0	0	0
Alternative 1	\$ 51,378,815.98	\$ 19,679,107.65	49	63	1.3	94	106
Alternative 2	\$ 49,250,705.98	\$ 19,679,107.65	45	57	1.2	89	106
Alternative 3	\$ 35,355,798.62	\$ 15,799,525.29	41	51	0.8	66	36

**Table 4-2** includes WSEL and flow results from the 500-year storm event at the Hardy Toll Road and bridge crossings.

**Table 4-2: WSEL (ft) and Flow (cfs) Comparisons (500-year Storm Event)**

Location	River Station	500-year							
		Baseline		Alternative 1		Alternative 2		Alternative 3	
		WSEL	Flow	WSEL	Flow	WSEL	Flow	WSEL	Flow
Hardy Road	64247.2	73.68	4,696	73.48	4,975	73.50	4,913	73.53	4,893
West Hardy Toll Road	64059.0	73.51	8,202	73.33	8,083	73.34	8,094	73.37	8,118
Missouri Pacific Railroad	63985.4	71.59	8,202	71.53	8,083	71.54	8,094	71.55	8,118
East Hardy Toll Road	63908.2	71.51	8,202	71.45	8,083	71.45	8,094	71.47	8,118

## 4.3 Performance Metrics Revisions

For the performance metrics, all structures, roads, and floodplain acreage north of Aldine Mail Route Road have been excluded from the calculations. There are three primary reasons for removing structures in that area from the performance metrics calculations:

- There is very little benefit north of Aldine Mail Route Road in the Hardy West Alternatives.
- The tributary projects including P118-25-00/01 and P118-26-00 will improve the conditions in those northern neighborhoods such as Oak Glen Place, Colonial Hills, and Aldine Village, and will have a much greater impact on the area than the Hardy West Alternatives.
- There is a substantial amount of overflow cascading south from P138-00-00. When the P138-00-00 overflow is removed, there is a significant reduction in ponding north of Aldine Mail Route Road.

All structures, roads, and floodplain acreage north of Isom Street near P118-21-00 have also been excluded from the performance metrics. P118-21-00 is beyond the Hardy West project limits, the WSELs in P118-21-00 are not controlled by Halls Bayou, and there is little to no benefit in that area. The inundation floodplain north of Aldine Mail Route Road and north of Isom Street are still shown on the performance metrics exhibits, but not included in the reported numbers in the tables.

When calculating the performance metrics for proposed conditions, the structures within the pond footprints that will be structural buyouts are not included as benefit. Performance metrics results tables for each storm event and each Alternative can be seen in **Exhibits 17** through **31**.

## 4.4 Opinion of Probable Construction Cost

An OPCC for each alternative can be found in **Tables 4-3**, **4-4**, and **4-5**. Unit cost values utilized the latest TxDOT and HCFCD average low bid prices. The costs consider clearing, grubbing, excavation and disposal, turf establishment, backslope drainage system swales, concrete interceptor structures, culverts, headwalls and wingwalls, concrete lining, riprap, and ROW acquisition. LAN assumes 10% of direct construction costs for Planning, Engineering, and Design, 5% for Mobilization/Demobilization, 10% for Construction Management, and 30% for Contingency.

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**Table 4-3: Alternative 1 OPCC**

Hardy West Alternatives Analysis OPCC						
Alternative	HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Alternative 1	2233-01	Clearing and Grubbing	AC	79.8	\$ 4,000.00	\$ 319,200.00
	2315-02	Excavation & Off-Site Disposal	CY	1,224,517	\$ 15.00	\$ 18,367,755.00
	2921-01	Turf Establishment	AC	79.8	\$ 3,000.00	\$ 239,400.00
	2315-06	Backslope Drainage System Swales	LF	10,400	\$ 2.00	\$ 20,800.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	13,333	\$ 85.00	\$ 1,133,333.33
	2376-06	Concrete Interceptor Structure	SY	156	\$ 120.00	\$ 18,720.00
	2632-70	Headwalls and Wingwalls	CY	90	\$ 950.00	\$ 85,500.00
	2378-01	Riprap, Gradation No. 1	SY	1,340	\$ 100.00	\$ 134,000.00
	2642-02	24" CMP	LF	1,040	\$ 90.00	\$ 93,600.00
	2611-06	48" RCP	LF	200	\$ 195.00	\$ 39,000.00
<b>Subtotal:</b>						<b>\$ 20,451,308.33</b>

	Planning, Engineering, and Design (10% of DCC):	\$ 2,045,200.00
	Mobilization/Demobilization (5% of DCC):	\$ 1,022,600.00
	Construction Management (10% of DCC):	\$ 2,045,200.00
	Contingency (30% of DCC):	\$ 6,135,400.00
	<b>ROW Acquisition:</b>	<b>\$ 19,679,107.65</b>
<b>Total:</b>		<b>\$ 51,378,900.00</b>

**Table 4-4: Alternative 2 OPCC**

Hardy West Alternatives Analysis OPCC						
Alternative	HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Alternative 2	2233-01	Clearing and Grubbing	AC	77.4	\$ 4,000.00	\$ 309,600.00
	2315-02	Excavation & Off-Site Disposal	CY	1,124,491	\$ 15.00	\$ 16,867,365.00
	2921-01	Turf Establishment	AC	77.4	\$ 3,000.00	\$ 232,200.00
	2315-06	Backslope Drainage System Swales	LF	11,600	\$ 2.00	\$ 23,200.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	13,333	\$ 85.00	\$ 1,133,333.33
	2376-06	Concrete Interceptor Structure	SY	180	\$ 120.00	\$ 21,600.00
	2632-70	Headwalls and Wingwalls	CY	180	\$ 950.00	\$ 171,000.00
	2378-01	Riprap, Gradation No. 1	SY	1,340	\$ 100.00	\$ 134,000.00
	2642-02	24" CMP	LF	1,200	\$ 90.00	\$ 108,000.00
	2611-06	48" RCP	LF	400	\$ 195.00	\$ 78,000.00
<b>Subtotal:</b>						<b>\$ 19,078,298.33</b>

	Planning, Engineering, and Design (10% of DCC):	\$ 1,907,900.00
	Mobilization/Demobilization (5% of DCC):	\$ 954,000.00
	Construction Management (10% of DCC):	\$ 1,907,900.00
	Contingency (30% of DCC):	\$ 5,723,500.00
	<b>ROW Acquisition:</b>	<b>\$ 19,679,107.65</b>
<b>Total:</b>		<b>\$ 49,250,800.00</b>

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Table 4-5: Alternative 3 OPCC

Hardy West Alternatives Analysis OPCC						
Alternative	HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Alternative 3	2233-01	Clearing and Grubbing	AC	55.2	\$ 4,000.00	\$ 220,800.00
	2315-02	Excavation & Off-Site Disposal	CY	717,932	\$ 15.00	\$ 10,768,980.00
	2921-01	Turf Establishment	AC	55.2	\$ 3,000.00	\$ 165,600.00
	2315-06	Backslope Drainage System Swales	LF	11,100	\$ 2.00	\$ 22,200.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	11,333	\$ 85.00	\$ 963,333.33
	2376-06	Concrete Interceptor Structure	SY	168	\$ 120.00	\$ 20,160.00
	2632-70	Headwalls and Wingwalls	CY	180	\$ 950.00	\$ 171,000.00
	2378-01	Riprap, Gradation No. 1	SY	1,120	\$ 100.00	\$ 112,000.00
	2642-02	24" CMP	LF	1,120	\$ 90.00	\$ 100,800.00
	2611-02	24" RCP	LF	400	\$ 180.00	\$ 72,000.00
						Subtotal:

	Planning, Engineering, and Design (10% of DCC):	\$ 1,261,700.00
	Mobilization/Demobilization (5% of DCC):	\$ 630,900.00
	Construction Management (10% of DCC):	\$ 1,261,700.00
	Contingency (30% of DCC):	\$ 3,785,100.00
	<b>ROW Acquisition:</b>	<b>\$ 15,799,525.29</b>
	<b>Total:</b>	<b>\$ 35,355,800.00</b>

## 4.5 Alternatives Scoring

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

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

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

- Alternative 1 – 7.75
- Alternative 2 – 7.60
- Alternative 3 – 7.23

Structures in the floodplain within the proposed pond footprints in Baseline Conditions are included as benefit in the Proposed Conditions scoring framework numbers, as these structures will be bought out and removed.



## 5 Recommended Alternative

Through coordination with HCFCD, LAN recommends Alternative 3 to carry for advancement to a PER Study. Alternative 3 offers the best balance between costs and benefits compared to Alternatives 1 and 2. While Alternatives 1 and 2 provide slightly more benefit to this area of Halls Bayou, Alternative 3 costs approximately \$16 million and \$13.9 million less than Alternatives 1 and 2, respectively, while still providing benefit to the surrounding area. The Alternative 3 detention basin provides a 10-year level of service to the adjacent section of Halls Bayou. Comparison water surface profiles between Baseline Conditions and the Recommended Alternative along Halls Bayou are shown in **Appendix G**.

As with Baseline Conditions, performance metrics include acreage of floodplain, miles of inundated roadway, number of structures in the floodplain, and number of flooded structures based on FFE for the 2-, 10-, 50-, 100-, and 500-year storm events. The use of performance metrics allows for a quantitative evaluation of potential flood damage reduction benefits. Refer to **Table 5-1** for a summary of the Recommended Alternative 3 performance metrics. There are approximately 36 structures within the footprint of the Alternative 3 pond; they are not included in the “Structures No Longer in Floodplain” count below. These structures will be acquired and bought out. The 100- and 500-year events show maximum depth reductions of up to 0.33 feet and 0.57 feet within Halls Bayou, respectively, compared to the Baseline Conditions model. Ponding depth comparisons between baseline conditions and the recommended alternative for the 2-, 10-, 50-, 100-, and 500-year storm events can be seen in **Exhibits 27** through **31**. Detailed hydraulic calculations are shown in **Appendix Q**.

**Table 5-1: Baseline Conditions vs. Recommended Alternative Performance Metrics**

Performance Metric	2-year Floodplain	10-year Floodplain	50-year Floodplain	100-year Floodplain	500-year Floodplain
Structures No Longer in Floodplain	-	131	113	57	41
Structures No Longer Flooded (based on FFE)	-	36	154	156	51
Structural Buyouts	36	36	36	36	36
Miles of Roadway No Longer in Floodplain	-	2.9	0.9	0.9	0.8
Acres of Land No Longer in Floodplain	-	137	96	82	66

### 5.1 Right-of-Way Requirement

For the Recommended Alternative 3, approximately 70 acres of ROW would need to be acquired, including 24 full parcel acquisitions and 17 partial parcel acquisitions. Refer to **Appendix H** for a listing of affected parcels. An estimated 36 structures lie within the proposed ROW limits – refer to **Exhibit 32**. All 36 structures are located within the 100-year FEMA floodplain, where 30 of which are also located within the regulatory floodway. ROW acquisition costs alone are approximately \$15.8 million for the Recommended Alternative 3.

The project area is also within the Federal Aviation Association (FAA) 5-mile separation area, and wet-bottom detention basin designs in the airport hazard zone require FAA coordination and approval.

### 5.2 CDBG-MIT Project Evaluations – Mainstem Hardy West 2

LAN and HCFCD identified the need for preliminary modeling for several projects in the 2021 CDBG-MIT updated project prioritization list. The goals of these projects are to better identify benefits and maximize benefits for detention projects by coupling with localized channel improvements. For one project evaluation, “Mainstem – Hardy West 2”, incorporating channel improvements to the Hardy West

# Hardy West Alternatives Analysis Summary Report

Alternative 3 model was analyzed. Coupling channel improvements with the Alternative 3 detention basin reduces WSELs in Halls Bayou by an additional 0.4 feet and 0.75 feet in the 100- and 500-year storm events, respectively. Although channel improvements are not part of the Hardy West Alternatives Analysis, LAN recommends further exploring the addition of channel improvements to Alternative 3 to maximize benefits in the area. The Mainstem – Hardy West 2 memo can be referenced in **Appendix K**.

## 6 Preliminary Impact Analysis

A preliminary assessment of potential impacts was performed on Halls Bayou as a result of the Recommended Alternative. The impacts model for Halls Bayou was developed based on the latest Halls Bayou model from the HCFCD Halls Bayou Phasing Study. This analysis focused on the effect that the Recommended Alternative will potentially have on WSELs along Halls Bayou.

To conduct the preliminary impacts analysis, LAN imported the downstream portion of the P118-00-00 Halls Phasing HEC-RAS model into the standalone model of Hardy West. Geometries were created for both Baseline and Alternative 3 conditions, with the respective boundary conditions and hydrology changes. The corresponding model was run in HEC-RAS 5.0.5. The Recommended Alternative resulted in maximum WSEL decreases of 0.54 feet and 0.3 feet in the section of channel adjacent to the pond in the 100- and 500-year storm events, respectively. Downstream of the Hardy West pond, WSELs show an average decrease of 0.08 feet and 0.03 feet in the 100- and 500-year storm events, respectively. The Recommended Alternative 3 shows no adverse impacts to Halls Bayou in the 10-, 100-, or 500-year storm event. As discussed in Section 4.2.3, there is a less than 0.01-foot increase in WSEL on the upstream end of P118-25-01 in the 50- and 100-year storm events; however, the model geometry does not reflect the latest P118-25-01 conditions, as this tributary project is currently being further refined in the PER phase. There is one other location in the 100-year storm event where a slight increase of less than 0.05 feet is shown in WSEL significantly downstream of this project on tributary P118-08-00. This however is attributed to model instability at the P118-08-00 junction and is not a reflection of improvements made at Hardy West. On Halls Bayou, there are no adverse impacts, and the hydrograph in the channel shows no flow impacts or significant changes in timing. Therefore, impacts along P118-08-00 can be disregarded, or further refined during future project phases. Refer to **Appendix L** for a WSEL comparison profile plot along Halls Bayou.

Overall, the Recommended Alternative 3 is effective in reducing WSELs along Halls Bayou. LAN recommends considering this option in the PER and design phases of the project for the final Drainage Impact Analysis to ensure no adverse impacts.

## 7 Additional Services

### 7.1 Environmental and Cultural Considerations

A high-level desktop evaluation of environmental data was provided by HCFCD through the WEB-DST. The information identified existing wetlands, potential wetlands, endangered species, pipelines, hazardous material point sources, oil and gas wells, and landfills, as discussed in Section 2.1.4.

In addition to the WEB-DST data, Hollaway Environmental + Communication Services, Inc. was contracted to assist LAN with identifying potential environmental and cultural concerns. Hollaway completed a Waters of the United States (WOTUS) Report, a Threatened & Endangered Species Habitat Assessment, and a Phase 1 Environmental Site Assessment Report, which can be found in **Appendix M**, **Appendix N**, and **Appendix O**, respectively. Additionally, BGE, Inc. conducted a cultural resources desktop assessment, which can be found in **Appendix P**.

Several wetlands and aquatic features will be impacted by the recommended alternative – discussion, recommendation, and exhibits can be found in the WOTUS Report in **Appendix M**. Also, based on the Threatened & Endangered Species Habitat Assessment, there is potential for three state listed threatened species to occur within the project area – details are discussed in **Appendix N**. Determinations and/or recommendations will be incorporated into the final design of the selected alternative.

## 8 Summary and Conclusions

The Harris County Flood Control District (HCFCD) authorized Lockwood, Andrews & Newnam, Inc. (LAN) to conduct an Alternatives Analysis Study on the Hardy West detention basin, located within the Halls Bayou (HCFCD Unit No. P118-00-00) watershed. The purpose of this study is to analyze and describe the existing flooding conditions within the Hardy West project area, whereupon targeted flood risk mitigation alternatives are developed based on results. The Recommended Alternative ultimately derived from the Alternatives Analysis is intended to be incorporated into a PER, which can efficiently be carried into detailed design.

H&H models were developed for the 50%, 10%, 2%, 1%, and 0.2% design storm events (pre-Atlas 14 update) based on HCFCD criteria using the HEC-HMS and HEC-RAS software in prior studies including the Halls Phasing Study and the Halls Bayou Mainstem Potential Projects Memorandum. These models were reviewed, and the hydraulic model was updated where necessary.

Baseline conditions results revealed the existing less than 10-year LOS for this section of Halls Bayou is mainly driven by the Hardy Toll Road bridge along with the Missouri Pacific Railroad acting as flow restrictors, Halls Bayou being undersized, and significant overflow from P138-00-00 into the Halls Bayou Watershed. The HEC-RAS results were used and processed in GIS to generate a set of performance metrics to ultimately measure proposed improvement alternatives. Overall, the floodplain mapping between this model and the previous Phasing study model agree for this area with slight increases in WSELs at the Hardy Toll Road bridge due to updates of ineffective flow areas. The model outcome for a 500-year design storm shows 2,855 structures in the floodplain, with 2,119 structures being flooded.

Three proposed alternatives were developed using the Mainstem Potential Projects Memo as a starting point. Hardy West was also identified in the Halls Bayou Phasing Study as a recommended project for the first phase of the Vision Plan implementation.

For the performance metrics, all structures north of Aldine Mail Route Road near P118-25-00/01 and north of Isom Street near P118-21-00 have been excluded. Water surface elevations in these areas are controlled by the tributaries and overflow from Greens Bayou, with very little benefit observed from the Hardy West improvements. Other improvement projects for these tributaries are currently in development by HCFCD to address flooding in these areas.

In coordination with HCFCD, LAN recommends Alternative 3 to carry for advancement to a PER Study. Alternative 3 consists of two ponds offset from Hill Road and separated by P118-25-00 bounded by Halls Bayou to the south, Woodmoss Road to the west, and Hardy Toll Road to the east. The east and west basins are 12 and 11 feet deep, respectively, and have a total pond footprint of 55 acres, providing a storage volume of 400 ac-ft, including 1 foot of freeboard. While Alternatives 1 and 2 provide slightly more benefits than Alternative 3, Alternative 3 still provides benefit to Halls Bayou, requires 26 less acres of right-of-way than the other two alternatives, and is approximately \$16 million and \$13.9 million less than Alternatives 1 and 2, respectively. Alternative 3 provides a 10-year (pre-Atlas 14 update) LOS, and results in no adverse impacts to Halls Bayou and the surrounding region, up to and including the 500-year storm event (pre-Atlas 14 update).

LAN and HCFCD identified the need for preliminary modeling for several projects in the 2021 CDBG-MIT updated project prioritization list. The goals of these projects are to better identify benefits and maximize benefits for detention projects by coupling with localized channel improvements. For one project evaluation, "Mainstem – Hardy West 2", incorporating channel improvements to the Hardy West Alternative 3 model was analyzed. LAN recommends further exploring the addition of channel improvements to Alternative 3 to maximize benefits in the area.

## 9 List of Exhibits

Exhibit 1 – Vicinity Map

Exhibit 2 – FEMA Effective Floodplain

Exhibit 3 – Baseline Conditions Land Use

Exhibit 4 – Existing HCFCD ROW

Exhibit 5 – Watershed Environmental Baseline (WEB) Map Data Summary Tool (DST) Data

Exhibit 6 – Phasing Study Drainage Areas

Exhibit 7 – Baseline HEC-RAS Model Geometry

Exhibit 8 – 2-Year Baseline Conditions Performance Metrics

Exhibit 9 – 10-Year Baseline Conditions Performance Metrics

Exhibit 10 – 50-Year Baseline Conditions Performance Metrics

Exhibit 11 – 100-Year Baseline Conditions Performance Metrics

Exhibit 12 – 500-Year Baseline Conditions Performance Metrics

Exhibit 13 – Alternative 1 Layout

Exhibit 14 – Alternative 2 Layout

Exhibit 15 – Alternative 3 Layout

Exhibit 16 – HEC-RAS Geometry Recommended Alternative

Exhibit 17 – 2-Year Alternative 1 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 18 – 10-Year Alternative 1 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 19 – 50-Year Alternative 1 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 20 – 100-Year Alternative 1 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 21 – 500-Year Alternative 1 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 22 – 2-Year Alternative 2 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 23 – 10-Year Alternative 2 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 24 – 50-Year Alternative 2 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 25 – 100-Year Alternative 2 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 26 – 500-Year Alternative 2 vs. Baseline Conditions Comparison Performance Metrics

Exhibit 27 – 2-Year Alternative 3 (Recommended Alternative) vs. Baseline Conditions Comparison Performance Metrics

# Hardy West Alternatives Analysis Summary Report

Exhibit 28 – 10-Year Alternative 3 (Recommended Alternative) vs. Baseline Conditions Comparison Performance Metrics

Exhibit 29 – 50-Year Alternative 3 (Recommended Alternative) vs. Baseline Conditions Comparison Performance Metrics

Exhibit 30 – 100-Year Alternative 3 (Recommended Alternative) vs. Baseline Conditions Comparison Performance Metrics

Exhibit 31 – 500-Year Alternative 3 (Recommended Alternative) vs. Baseline Conditions Comparison Performance Metrics

Exhibit 32 – Proposed ROW Alternative 3 (Recommended Alternative)

## 10 Appendices

Appendix A – Site Visit Photo Documentation

Appendix B – Historical Losses Heat Maps

Appendix C – Baseline Conditions Water Surface Profiles

Appendix D – Halls Bayou Mainstem Potential Projects Memo

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

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

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

Appendix H – Proposed ROW for Recommended Alternative

Appendix I – HCFCD Project Scoring Documentation

Appendix J – Detailed Opinion of Probable Cost

Appendix K – Excerpt from CDBG-MIT Project Evaluations – Mainstem Hardy West 2 Memo by LAN dated November 2021

Appendix L – Impact Analysis vs. Recommended Alternative Water Surface Profile Comparisons

Appendix M – Waters of the United States Report

Appendix N – Threatened & Endangered Species Habitat Assessment

Appendix O – Phase 1 Environmental Site Assessment Report

Appendix P – Cultural Resource Desktop Assessment

Appendix Q – Detailed Hydraulic Calculations

Appendix R – Boundary Conditions – 500-Year Storm Event



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**Headquarters**

2925 Briarpark Drive  
Suite 400  
Houston, TX 77042  
713.266.6900

[Info@lan-inc.com](mailto:Info@lan-inc.com)

**Texas**

Austin  
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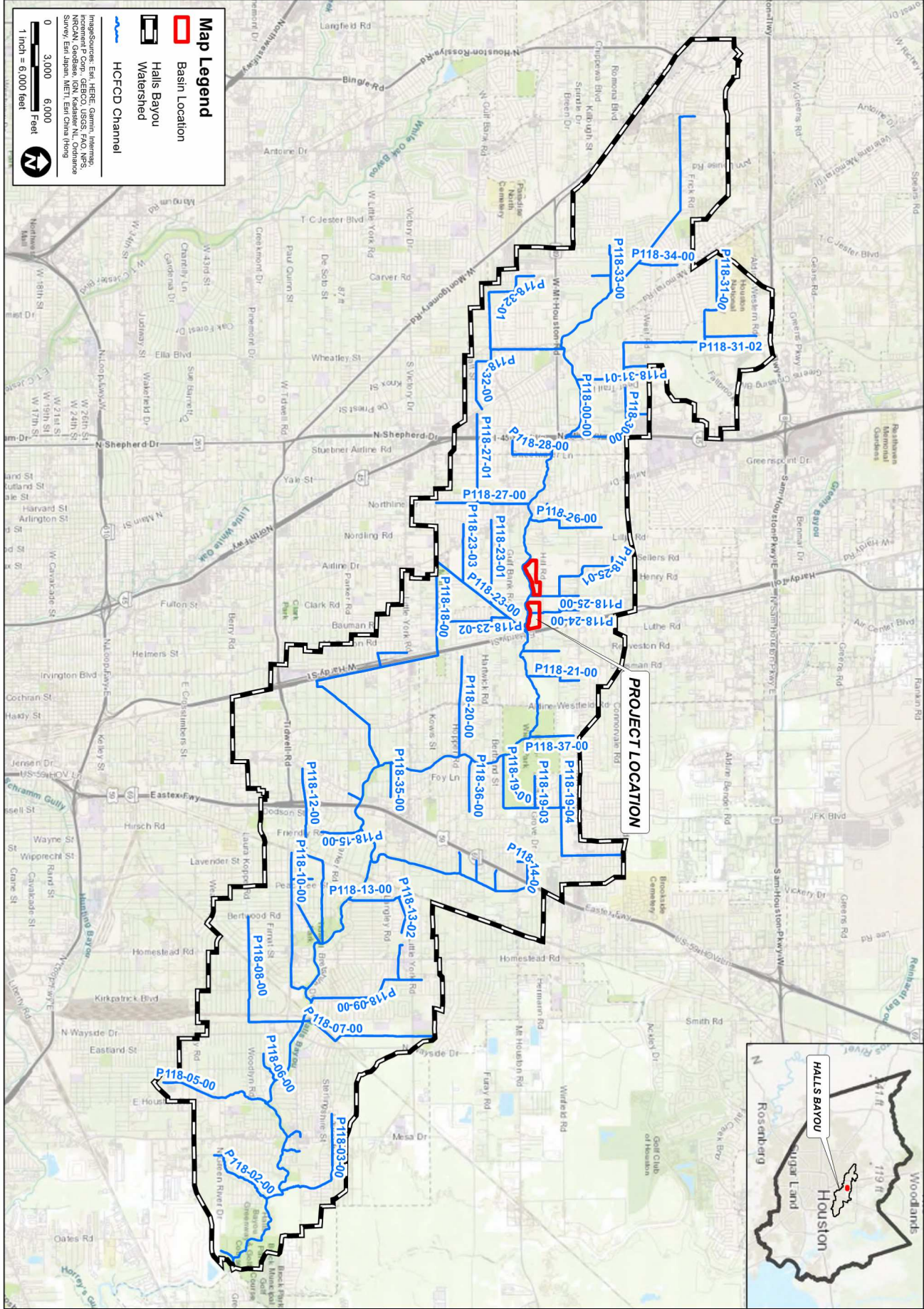


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# Exhibits



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9900 Northwest Freeway  
Houston, Texas 77092

**Lockwood, Andrews & Newnam, Inc.**  
 A LEAD & DAILY COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77062-3202  
 713.296.6900 • F 713.266.2088  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	BJI
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**HCFC D HALLS BAYOU WATERSHED HARDY WEST ALTERNATIVES ANALYSIS**

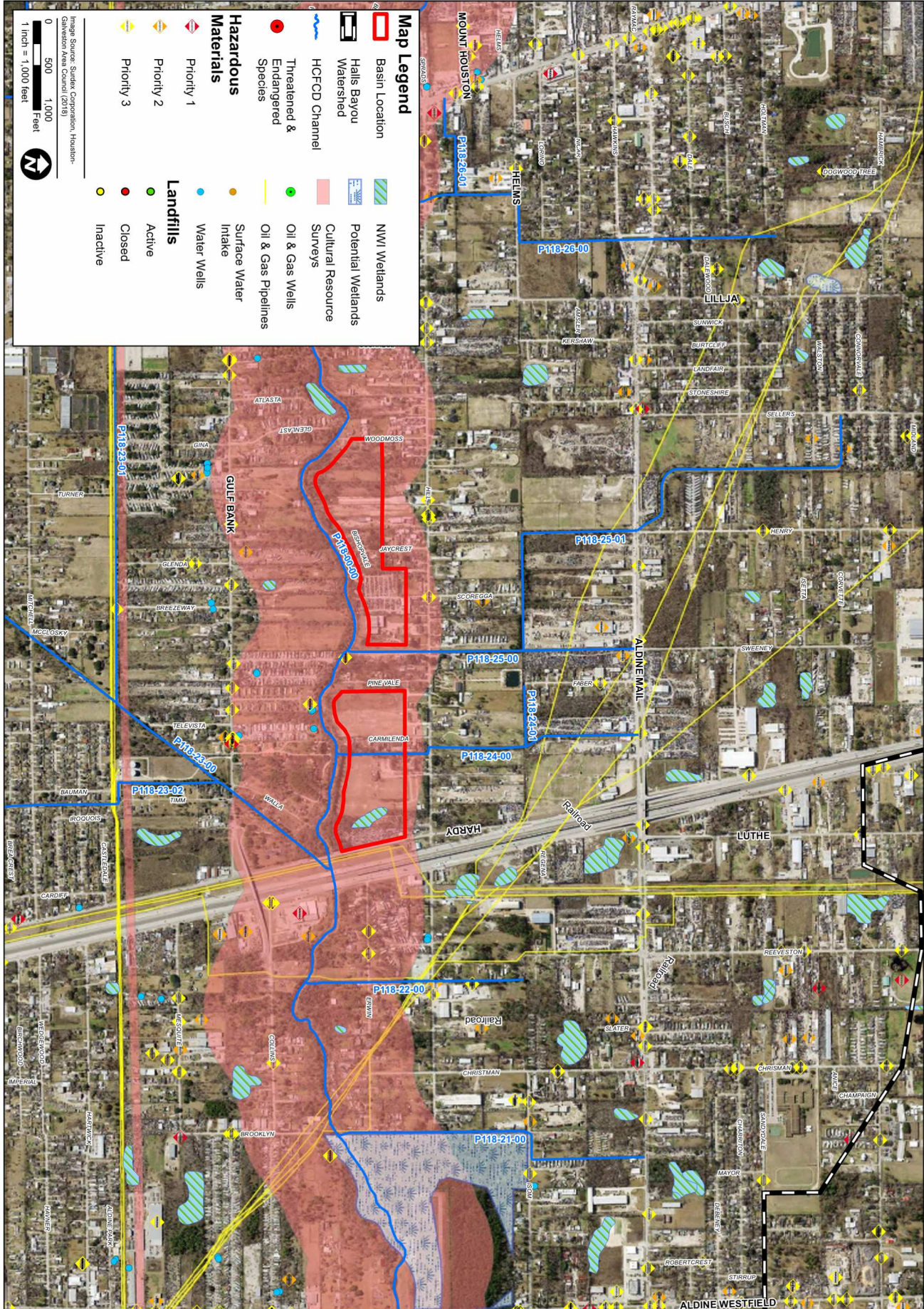
VICINITY MAP

EXHIBIT 1










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 A LEO A DALY COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.296.6900 • F 713.296.2089  
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 HARDY WEST ALTERNATIVES ANALYSIS**  
**WATERSHED ENVIRONMENTAL BASELINE (WEB) MAP  
 DATA SUMMARY TOOL (DST) DATA**

EXHIBIT  
5

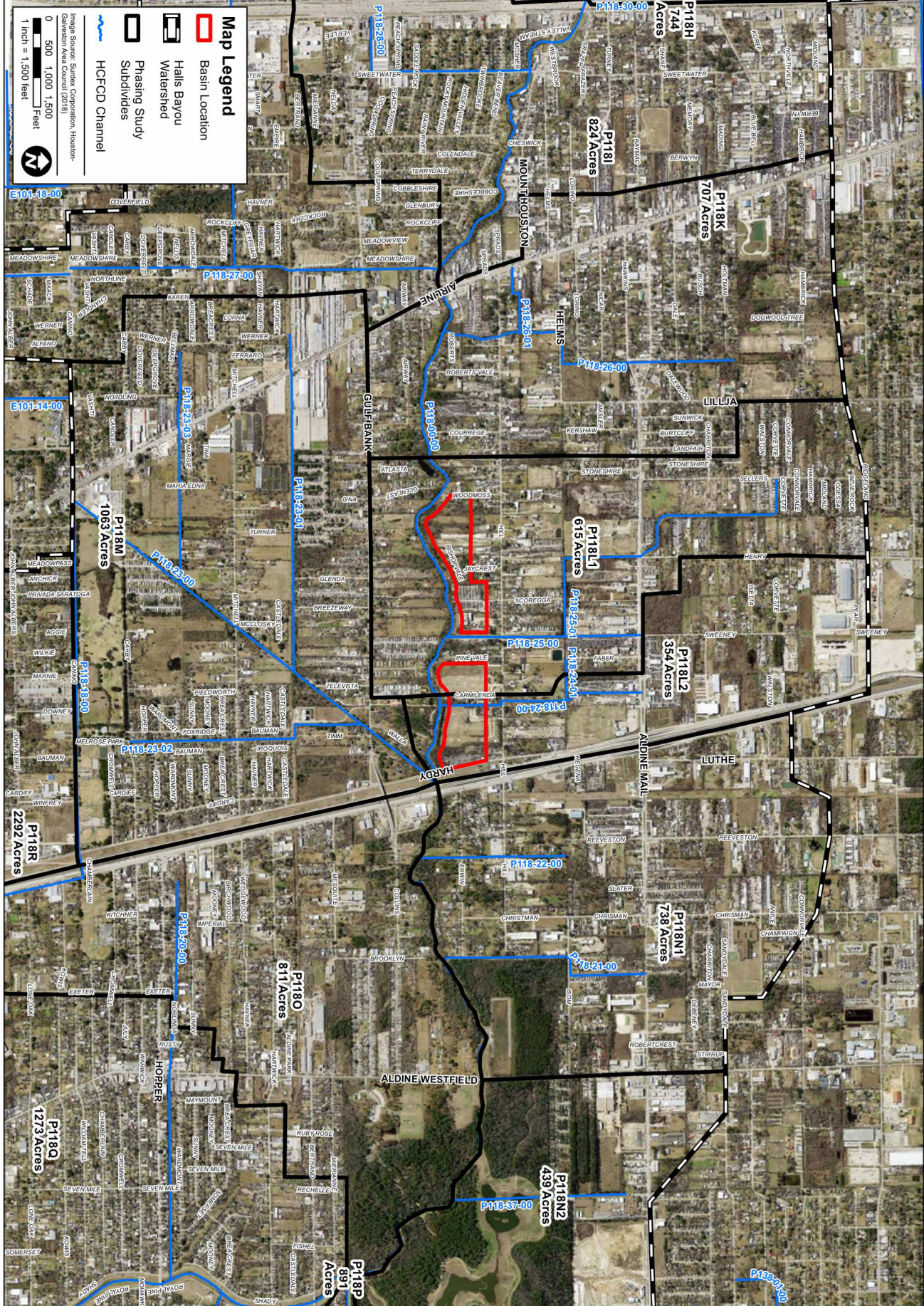


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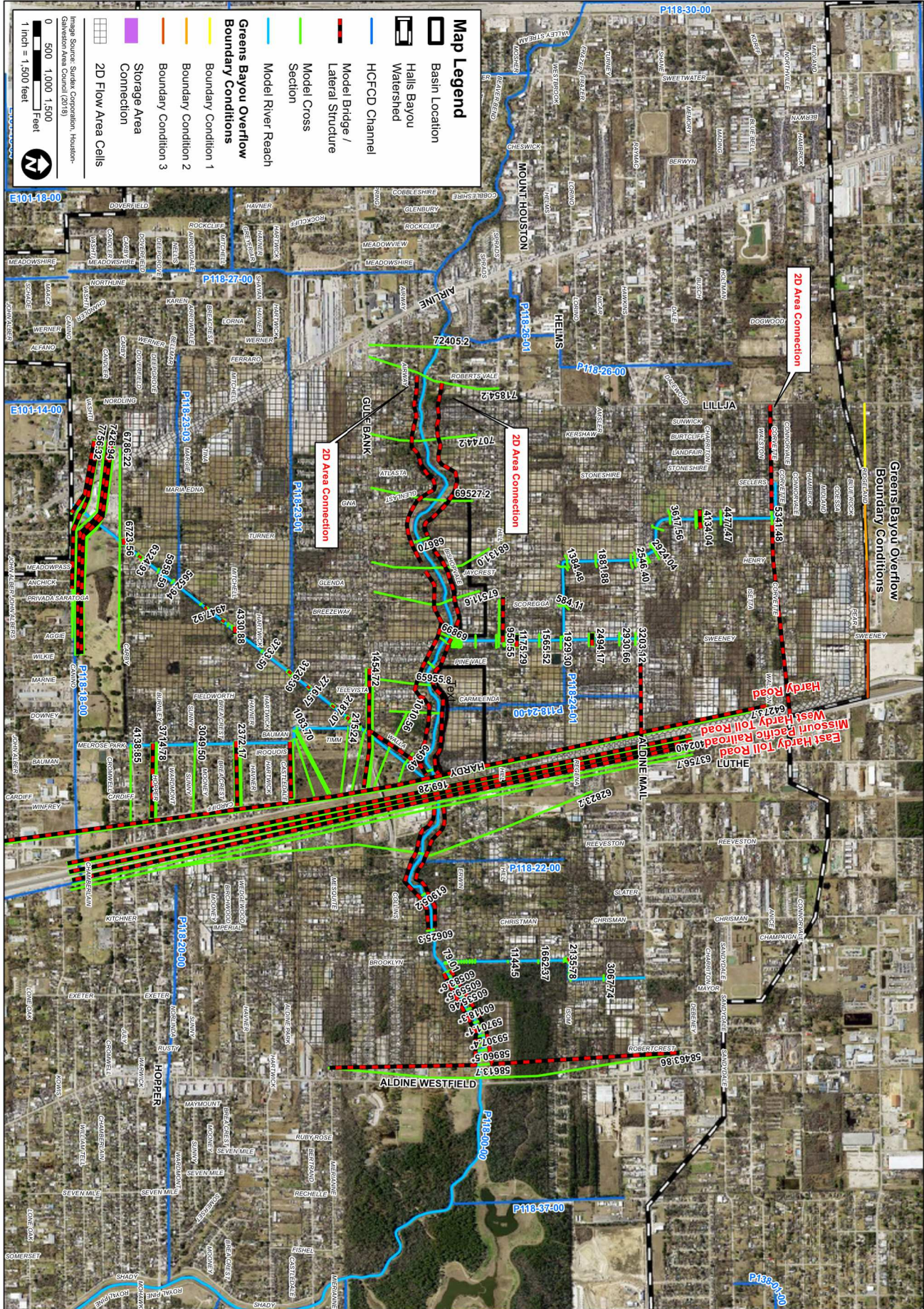


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 A LEAD & DAILY COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2088  
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**PHASING STUDY DRAINAGE AREAS**





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 A LEO A DALY COMPANY  
 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2889  
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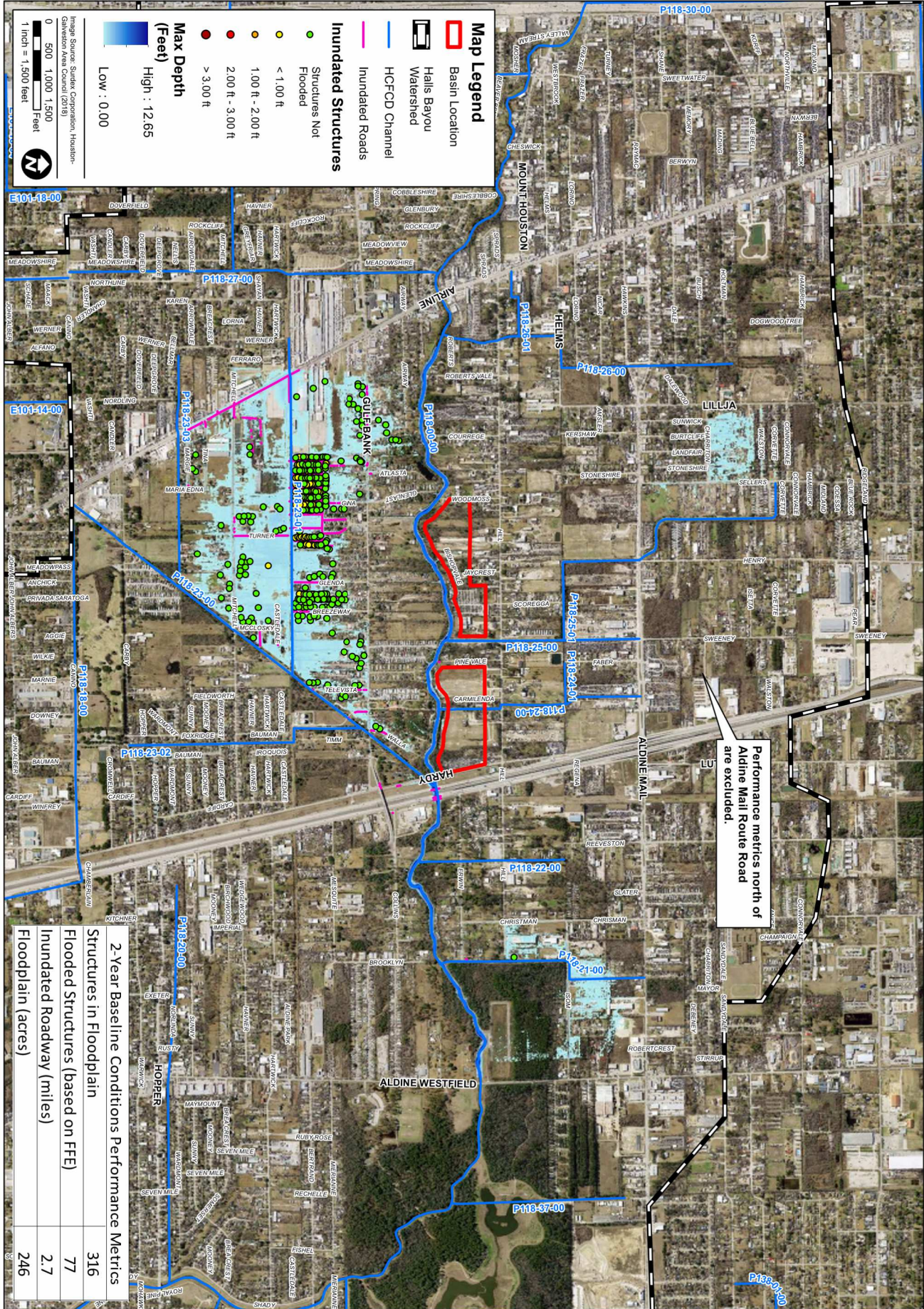
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 HARDY WEST ALTERNATIVES ANALYSIS

**BASELINE HEC-RAS MODEL GEOMETRY**

EXHIBIT  
 7

DATE: SEPT 2021  
 SCALE: AS NOTED



2-Year Baseline Conditions Performance Metrics	
Structures in Floodplain	316
Flooded Structures (based on FFE)	77
Inundated Roadway (miles)	2.7
Floodplain (acres)	246

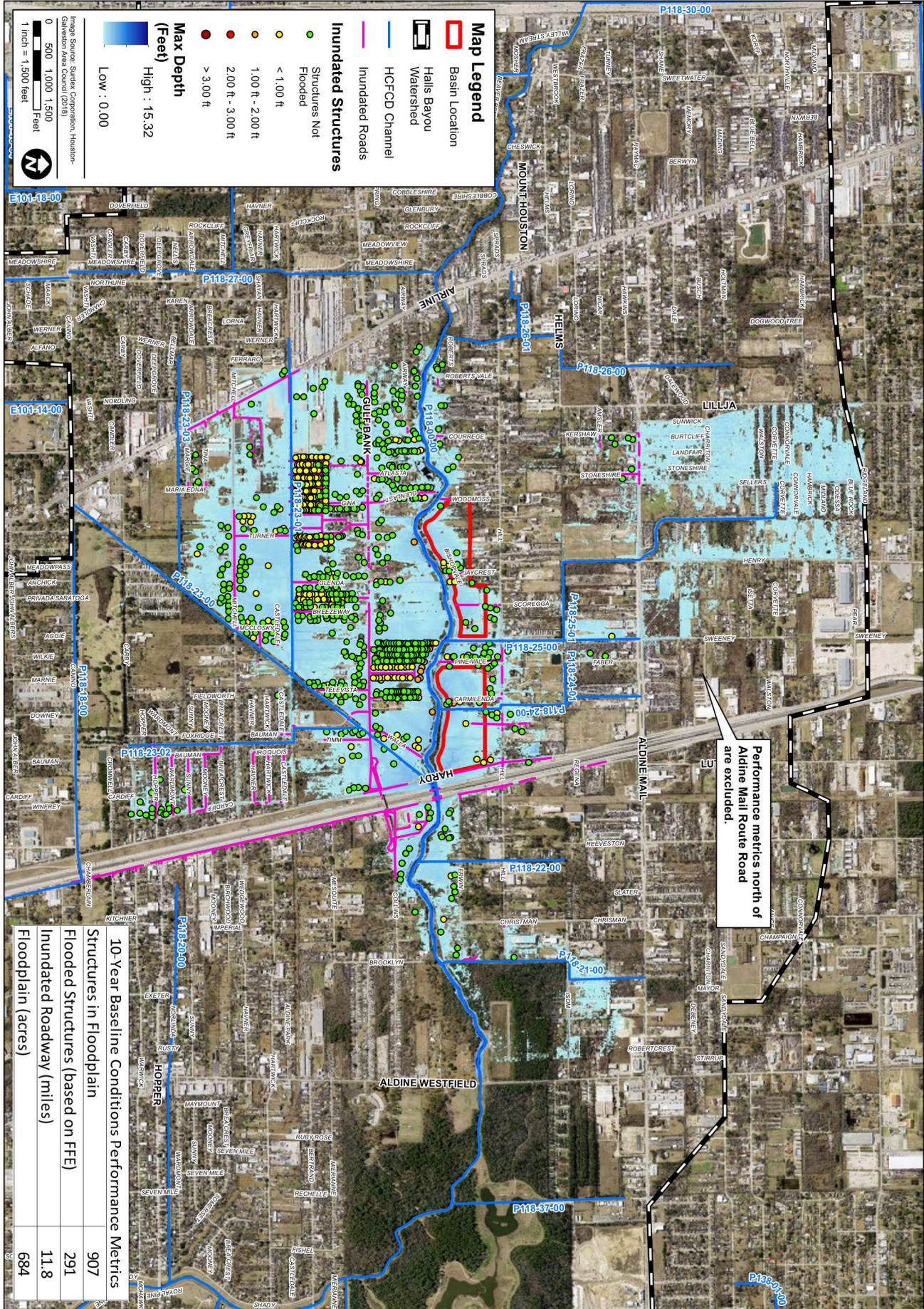
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 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.296.6900 • F 713.296.2089  
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 HARDY WEST ALTERNATIVES ANALYSIS  
**2-YEAR BASELINE CONDITIONS  
 PERFORMANCE METRICS**



10-Year Baseline Conditions Performance Metrics	
Structures in Floodplain	907
Flooded Structures (based on FFE)	291
Inundated Roadway (miles)	11.8
Floodplain (acres)	684

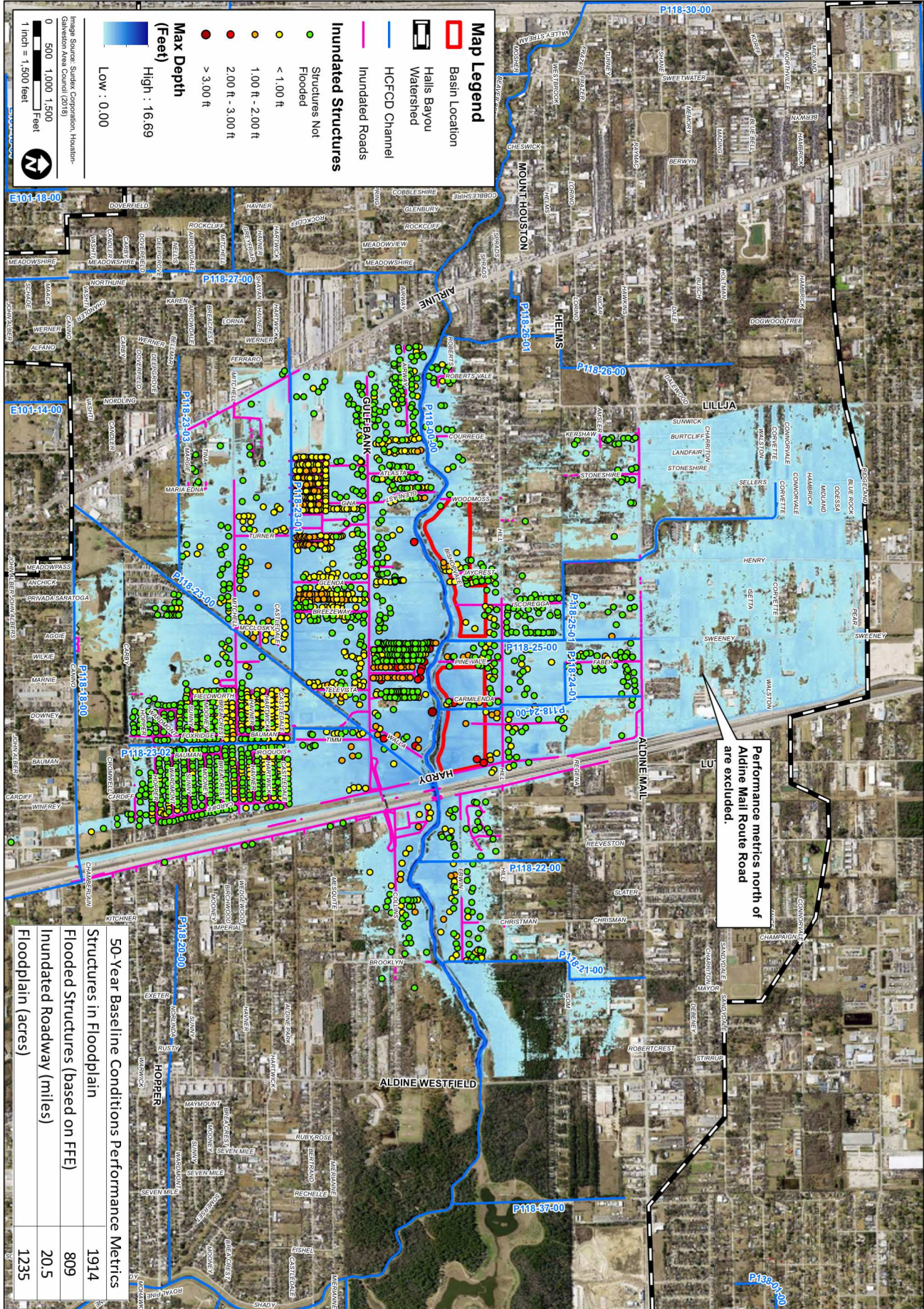
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 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.296.6900 • F 713.296.2089  
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**HCFCD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS  
 10-YEAR BASELINE CONDITIONS  
 PERFORMANCE METRICS**



**Map Legend**

- Basin Location
- Halls Bayou Watershed
- Inundated Roads
- HCFCFD Channel
- Inundated Structures
- Structures Not Flooded

**Inundated Structures (Feet)**

- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

**Max Depth (Feet)**

High : 16.69  
Low : 0.00

Scale: 1 inch = 1,500 feet

North Arrow

Image Source: Sures Corporation, Houston, Submission Area Count: (2018)

Performance metrics north of Aldine Mail Route Road are excluded.

**50-Year Baseline Conditions Performance Metrics**

Structures in Floodplain	1914
Flooded Structures (based on FFE)	809
Inundated Roadway (miles)	20.5
Floodplain (acres)	1235

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SCALE: AS NOTED

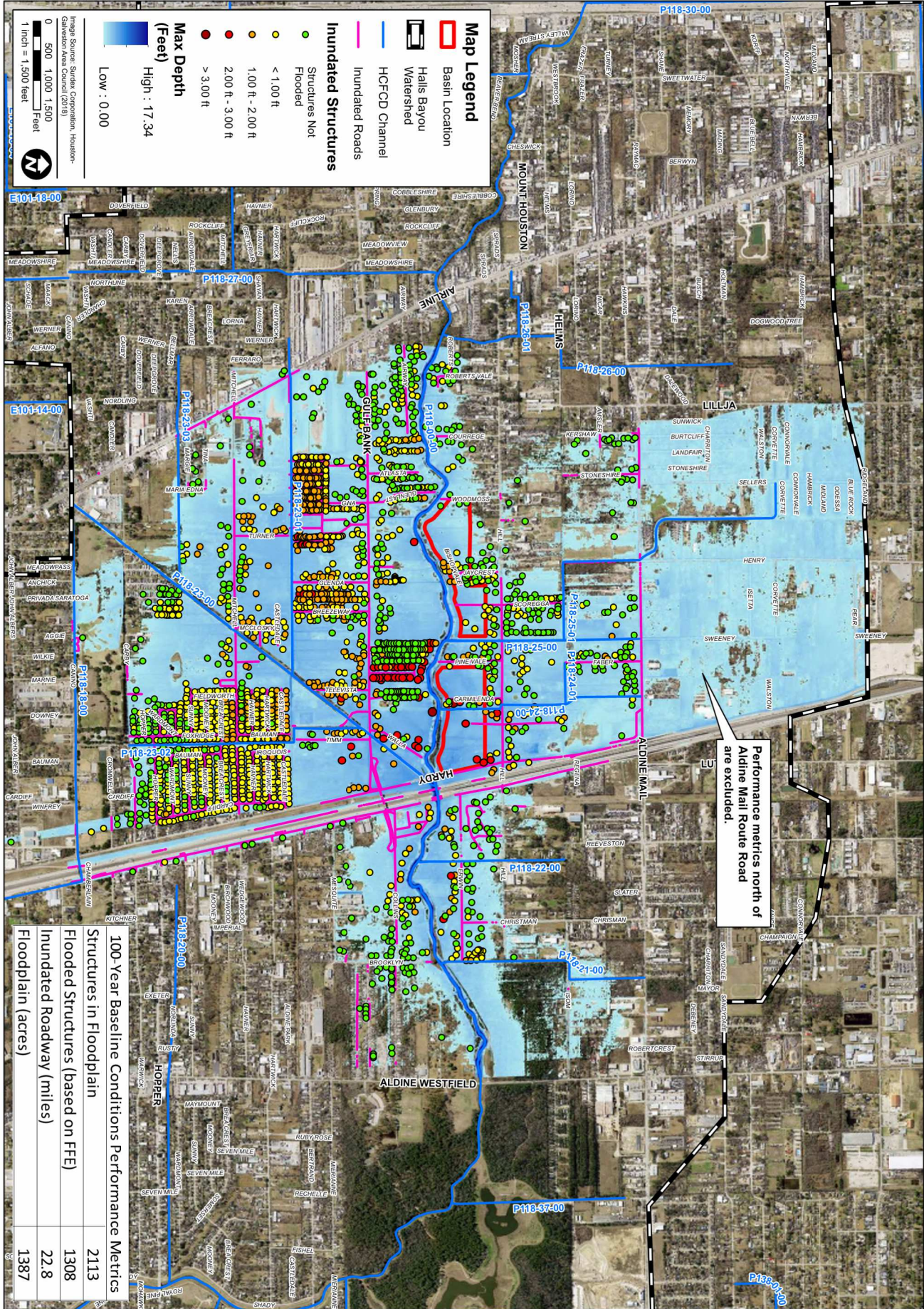
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 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.296.6900 • F 713.296.2089  
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**HCFCFD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**50-YEAR BASELINE CONDITIONS  
 PERFORMANCE METRICS**



100-Year Baseline Conditions Performance Metrics	
Structures in Floodplain	2113
Flooded Structures (based on FFE)	1308
Inundated Roadway (miles)	22.8
Floodplain (acres)	1387

Performance metrics north of Aldine Mail Route Road are excluded.

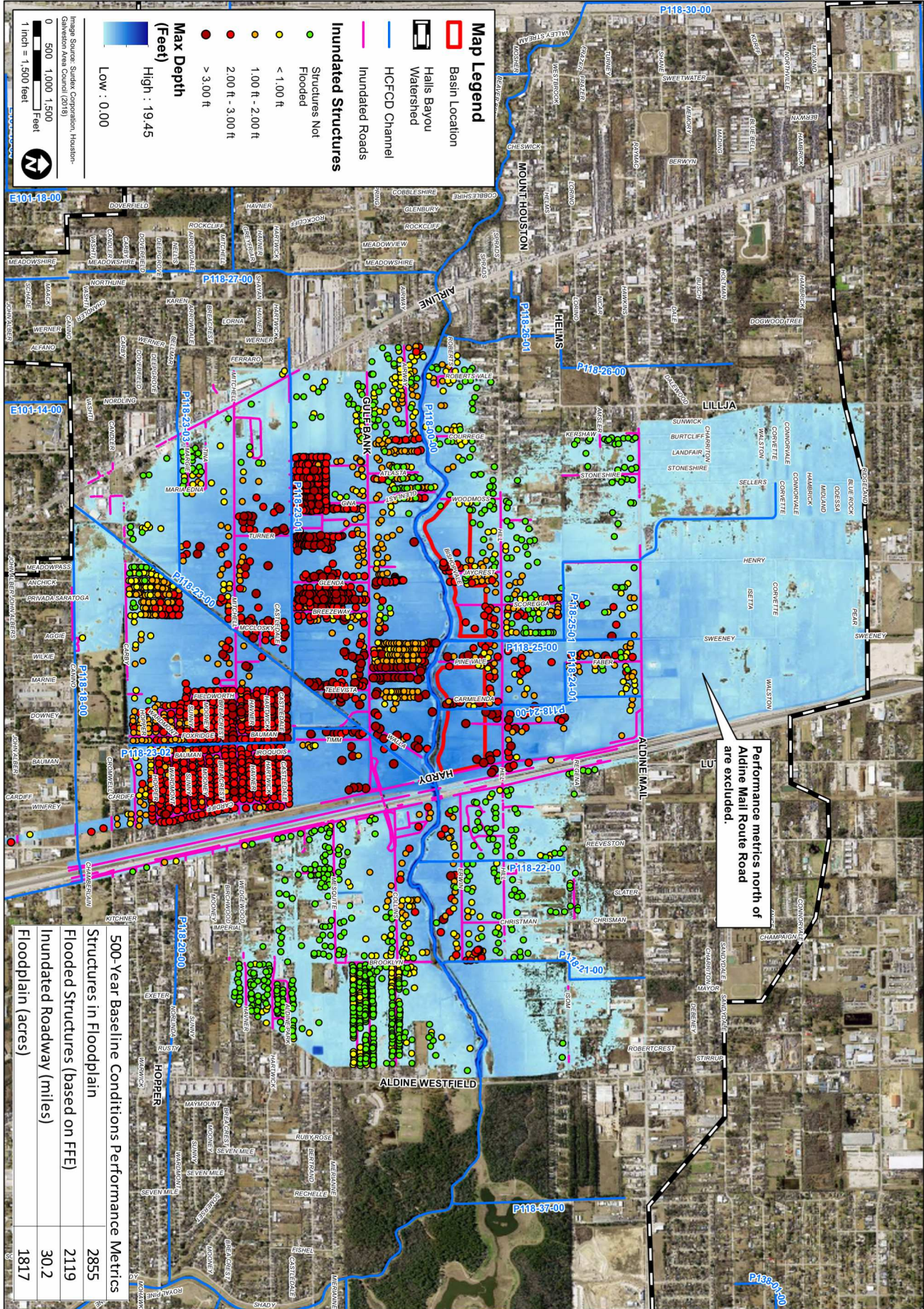
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 TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2081  
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**HCFC D HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**100-YEAR BASELINE CONDITIONS  
 PERFORMANCE METRICS**



**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads
- Inundated Structures
- Structures Not Flooded

**Inundated Structures**

- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

**Max Depth (Feet)**

High : 19.45  
Low : 0.00

Scale: 1 inch = 1,500 feet

North Arrow

Source: Sunders Corporation, Houston, Submission Date: 02/18

Performance metrics north of Aldine Mail Route Road are excluded.

500-Year Baseline Conditions Performance Metrics	
Structures in Floodplain	2855
Flooded Structures (based on FFE)	2119
Inundated Roadway (miles)	30.2
Floodplain (acres)	1817

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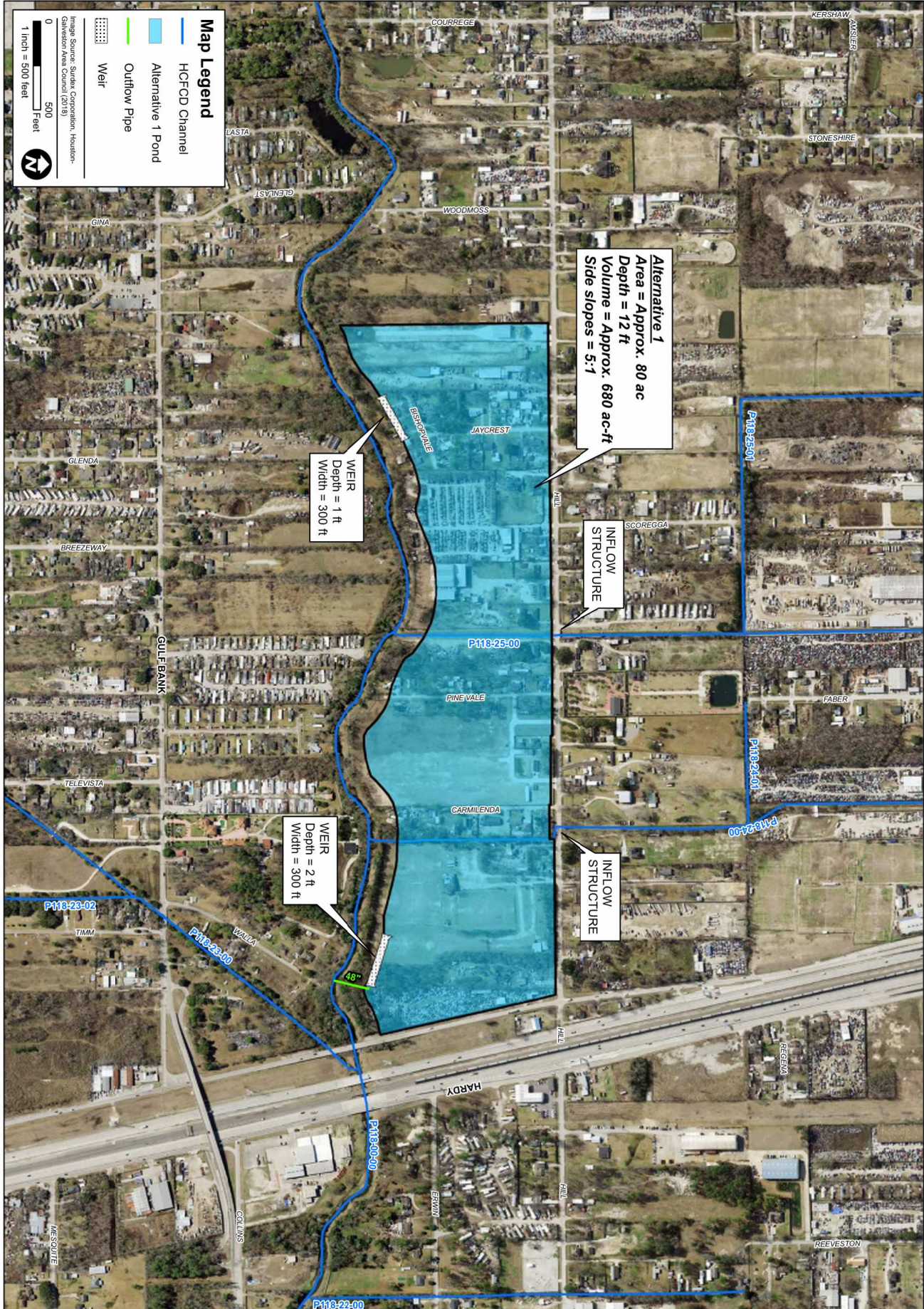
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**HCFCD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**500-YEAR BASELINE CONDITIONS  
 PERFORMANCE METRICS**



13

EXHIBIT

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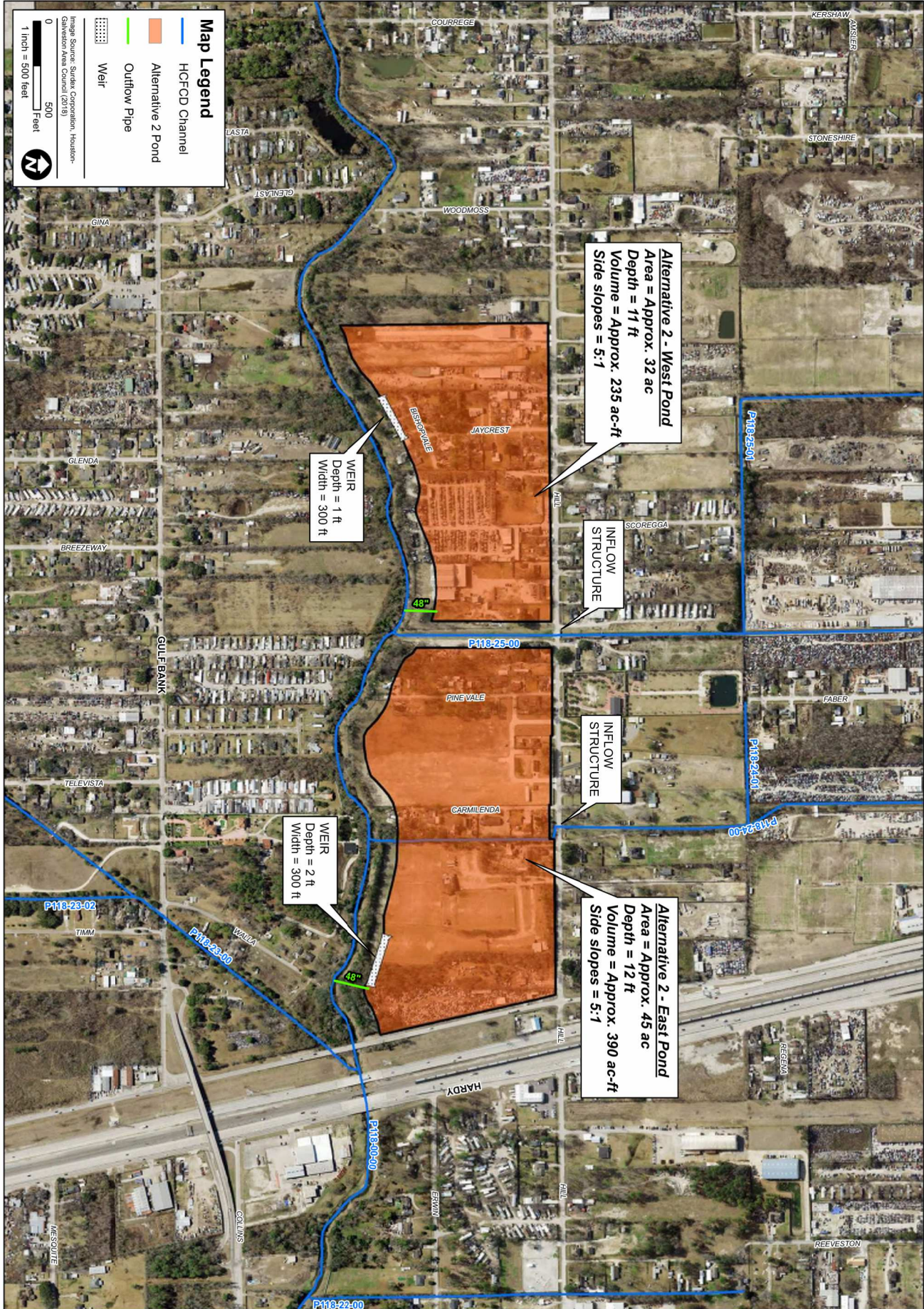
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 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.2889  
 www.lan-inc.com • info@lan-inc.com

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HCFCDD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS

ALTERNATIVE 1 LAYOUT



Map Legend

- HCFCD Channel
- Alternative 2 Pond
- Outflow Pipe
- Weir

Map Source: Surdex Corporation, Houston-Saltwater Area Council (2019)

Scale: 1 inch = 500 feet

North Arrow

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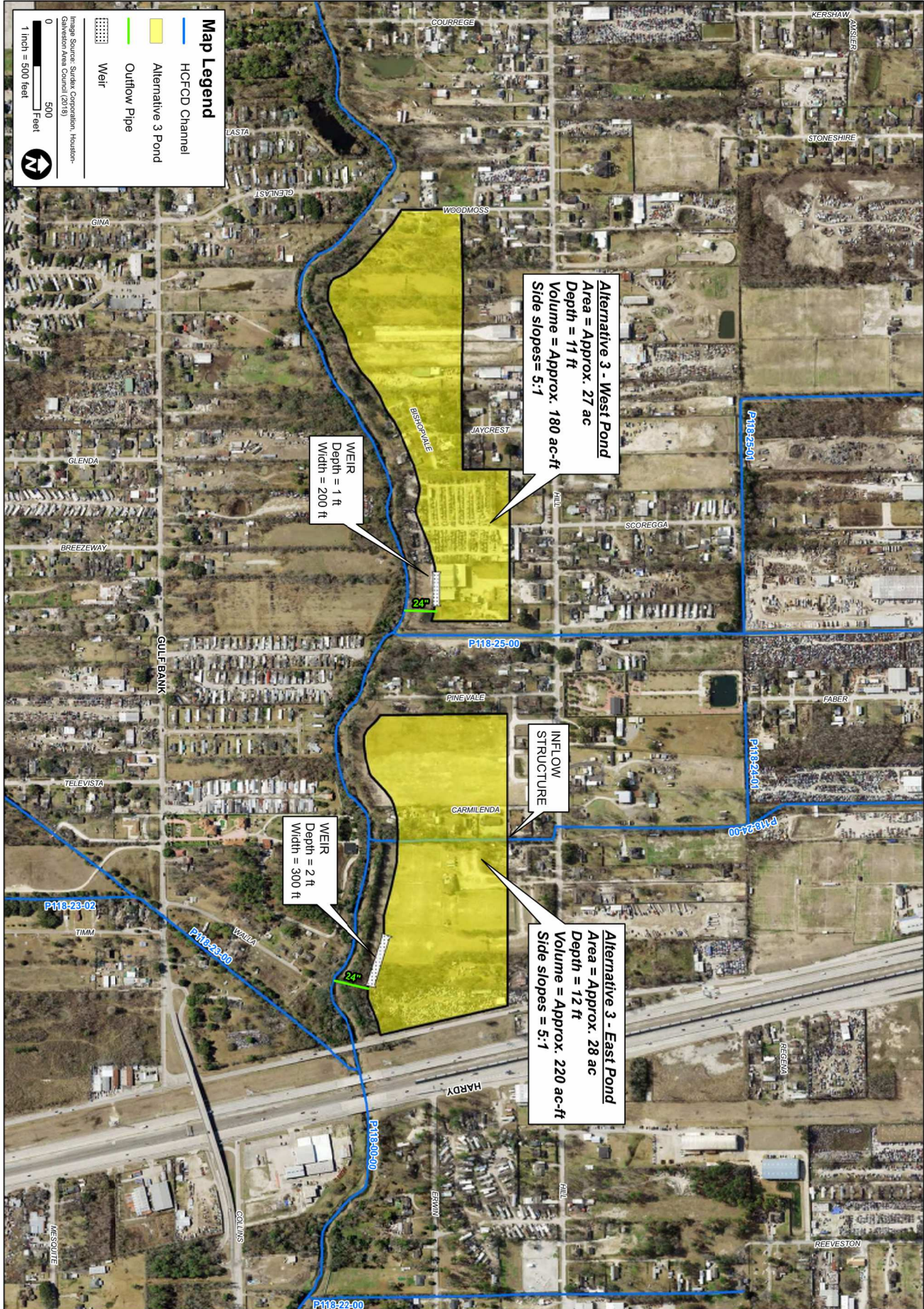
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 713.266.6900 • F 713.266.2889  
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HCFCD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS

**ALTERNATIVE 2 LAYOUT**





**Map Legend**

- HCFCDD Channel
- Alternative 3 Pond
- Outflow Pipe
- Weir

Map Source: Sunders Corporation, Houston -  
 Submission Year: Council (2019)

1 inch = 500 feet

**Alternative 3 - West Pond**  
 Area = Approx. 27 ac  
 Depth = 11 ft  
 Volume = Approx. 180 ac-ft  
 Side slopes = 5:1

**WEIR**  
 Depth = 1 ft  
 Width = 200 ft

**INFLOW STRUCTURE**

**WEIR**  
 Depth = 2 ft  
 Width = 300 ft

**Alternative 3 - East Pond**  
 Area = Approx. 28 ac  
 Depth = 12 ft  
 Volume = Approx. 220 ac-ft  
 Side slopes = 5:1

**HARRIS COUNTY FLOOD CONTROL DISTRICT**

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DATE: SEPT 2021  
 SCALE: AS NOTED

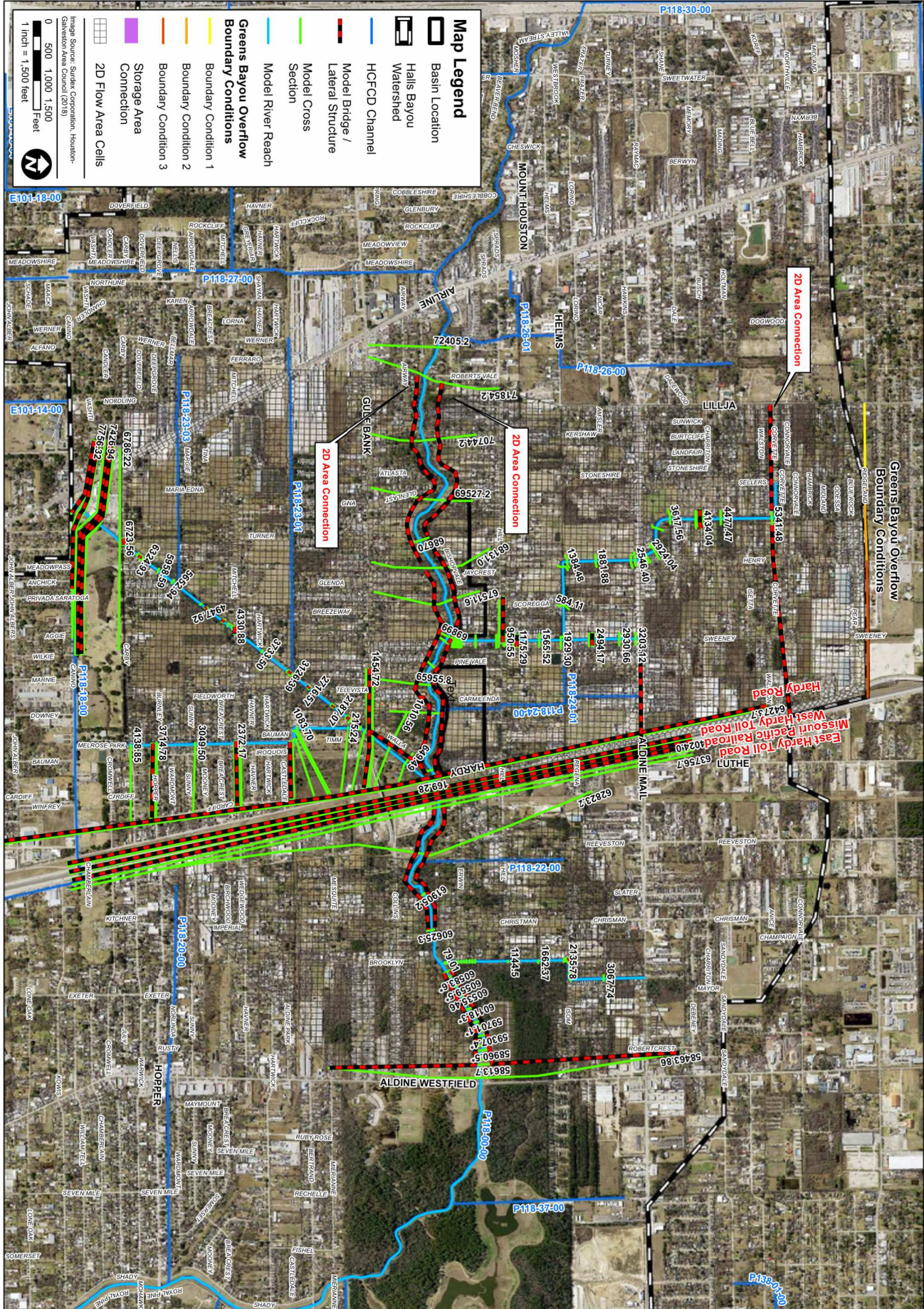
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TBPE Firm No. 2614  
 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.266.6900 • F 713.266.0289  
 www.lan-inc.com • info@lan-inc.com

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APPROVED:	DMB

**HCFCDD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**ALTERNATIVE 3 LAYOUT  
 (RECOMMENDED ALTERNATIVE)**



**HARRIS COUNTY FLOOD CONTROL DISTRICT**  
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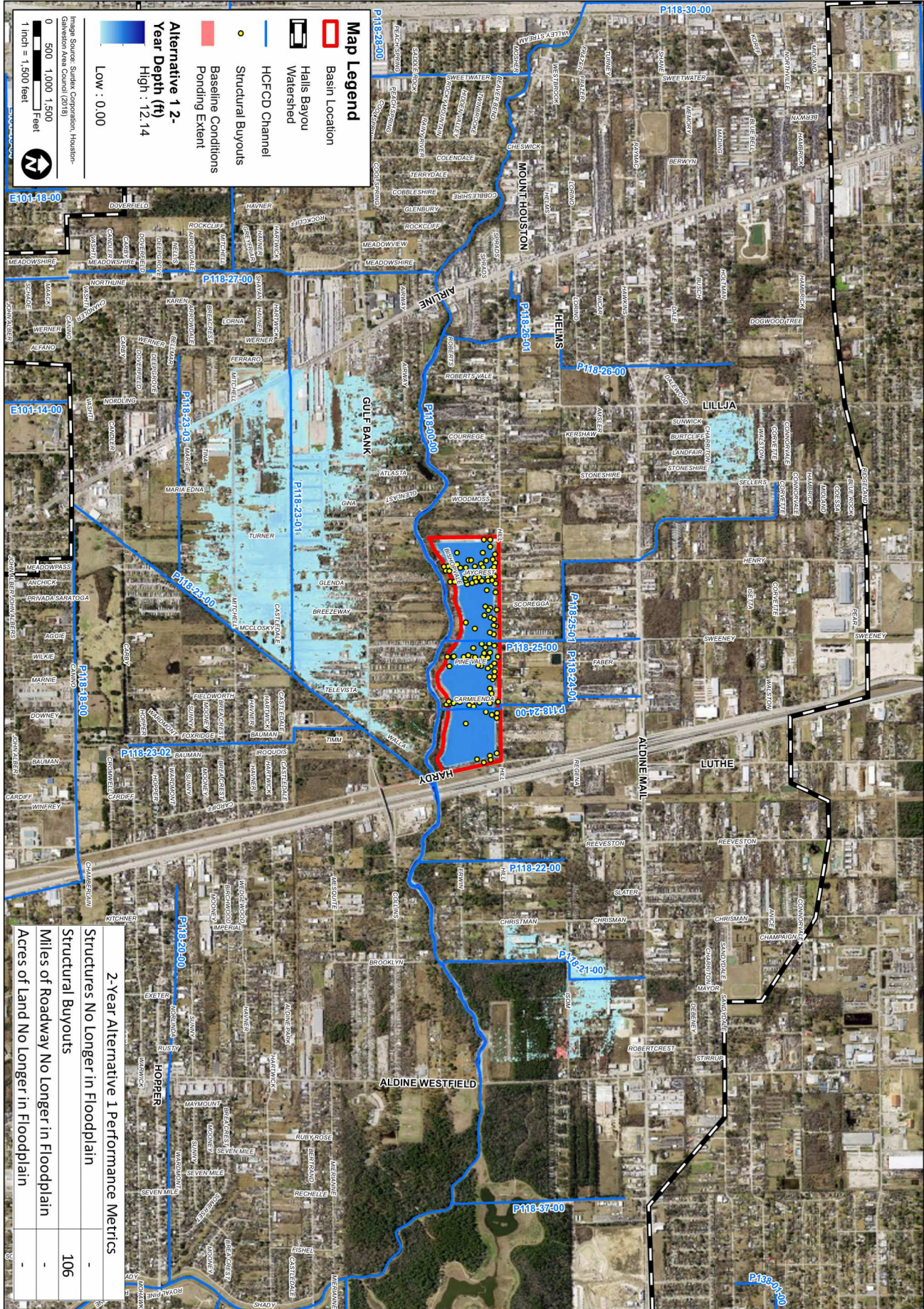
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CHECKED:	DMB
APPROVED:	DMB

**HCFCFD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**RECOMMENDED ALTERNATIVE  
 HEC-RAS MODEL GEOMETRY**

DATE: SEPT 2021  
 SCALE: AS NOTED

EXHIBIT  
 7



**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HCFCO Channel
- Structural Byways
- Baseline Conditions
- Ponding Extent

**Alternative 1-2 Year Depth (ft)**  
 High : 12.14  
 Low : 0.00

Scale: 1 inch = 1,500 feet

2-Year Alternative 1 Performance Metrics	
Structures No Longer in Floodplain	-
Structural Byways	106
Miles of Roadway No Longer in Floodplain	-
Acres of Land No Longer in Floodplain	-

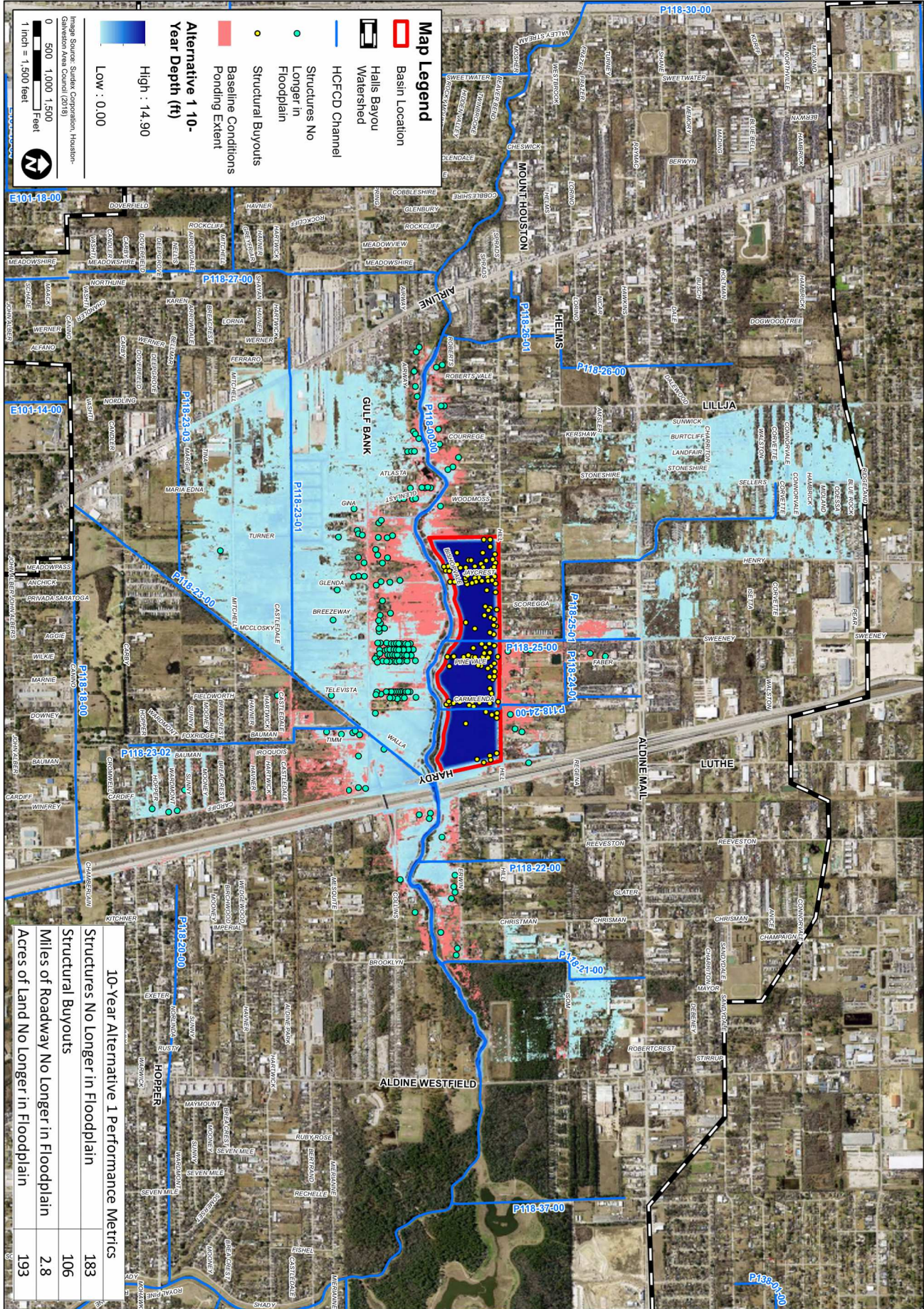
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 2925 Briarpark Drive • Houston, TX 77042-3720  
 713.296.6900 • F 713.296.2089  
 www.lan-inc.com • info@lan-inc.com

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 APPROVED: DMB

**HCFCO HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**2-YEAR ALTERNATIVE 1 vs. BASELINE CONDITIONS  
 PERFORMANCE METRICS**



**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HCFCO Channel
- Structures No Longer in Floodplain
- Structural Byuouts
- Baseline Conditions Ponding Extent

**Alternative 1 10-Year Depth (ft)**

High : 14.90  
Low : 0.00

Scale: 1 inch = 1,500 feet

10-Year Alternative 1 Performance Metrics	
Structures No Longer in Floodplain	183
Structural Byuouts	106
Miles of Roadway No Longer in Floodplain	2.8
Acres of Land No Longer in Floodplain	193

**HARRIS COUNTY FLOOD CONTROL DISTRICT**

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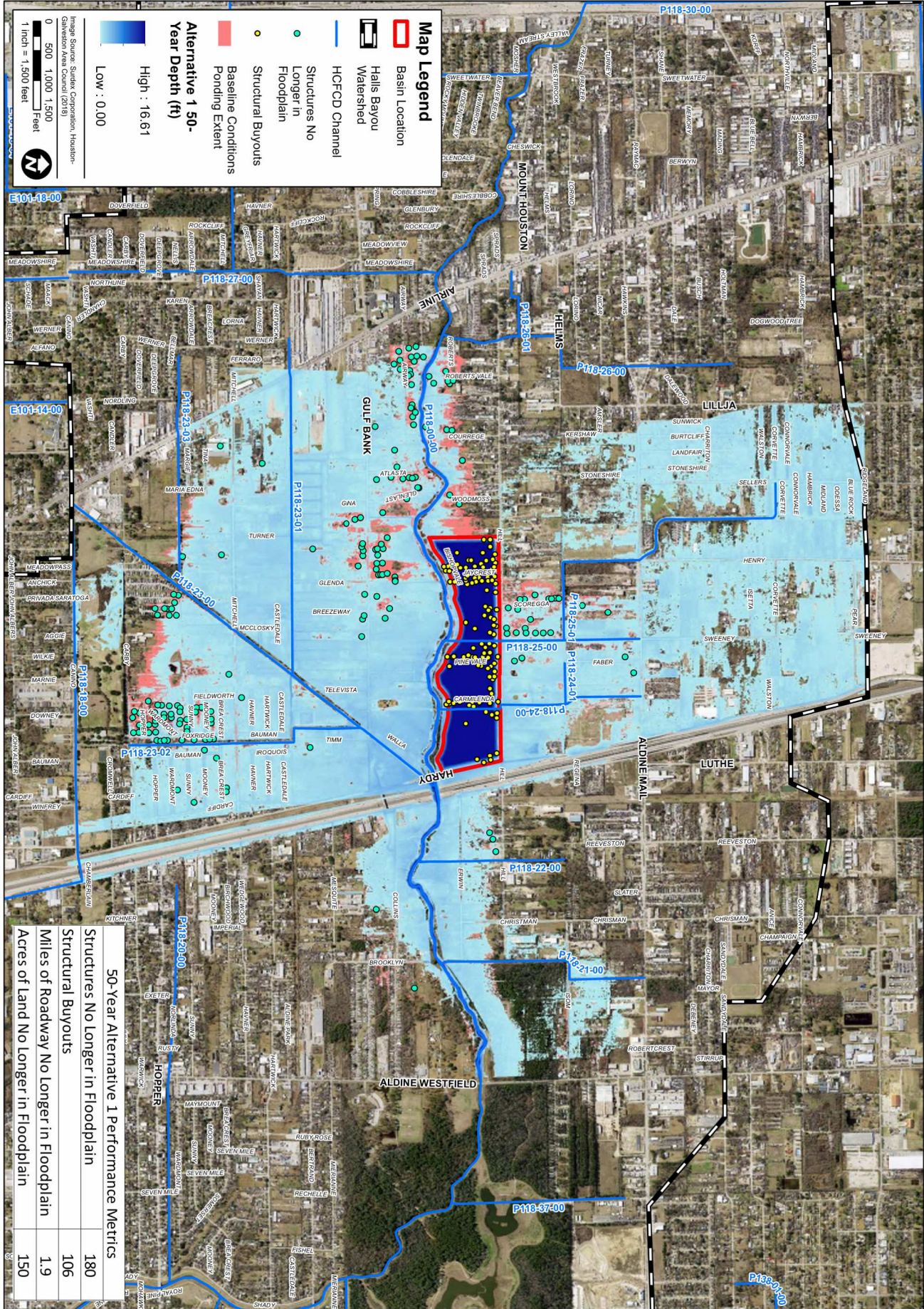
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CHECKED:	DMB
APPROVED:	DMB

**HCFCO HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**10-YEAR ALTERNATIVE 1 vs. BASELINE CONDITIONS  
 PERFORMANCE METRICS**



50-Year Alternative 1 Performance Metrics	
Structures No Longer in Floodplain	180
Structural Byuouts	106
Miles of Roadway No Longer in Floodplain	1.9
Acres of Land No Longer in Floodplain	150

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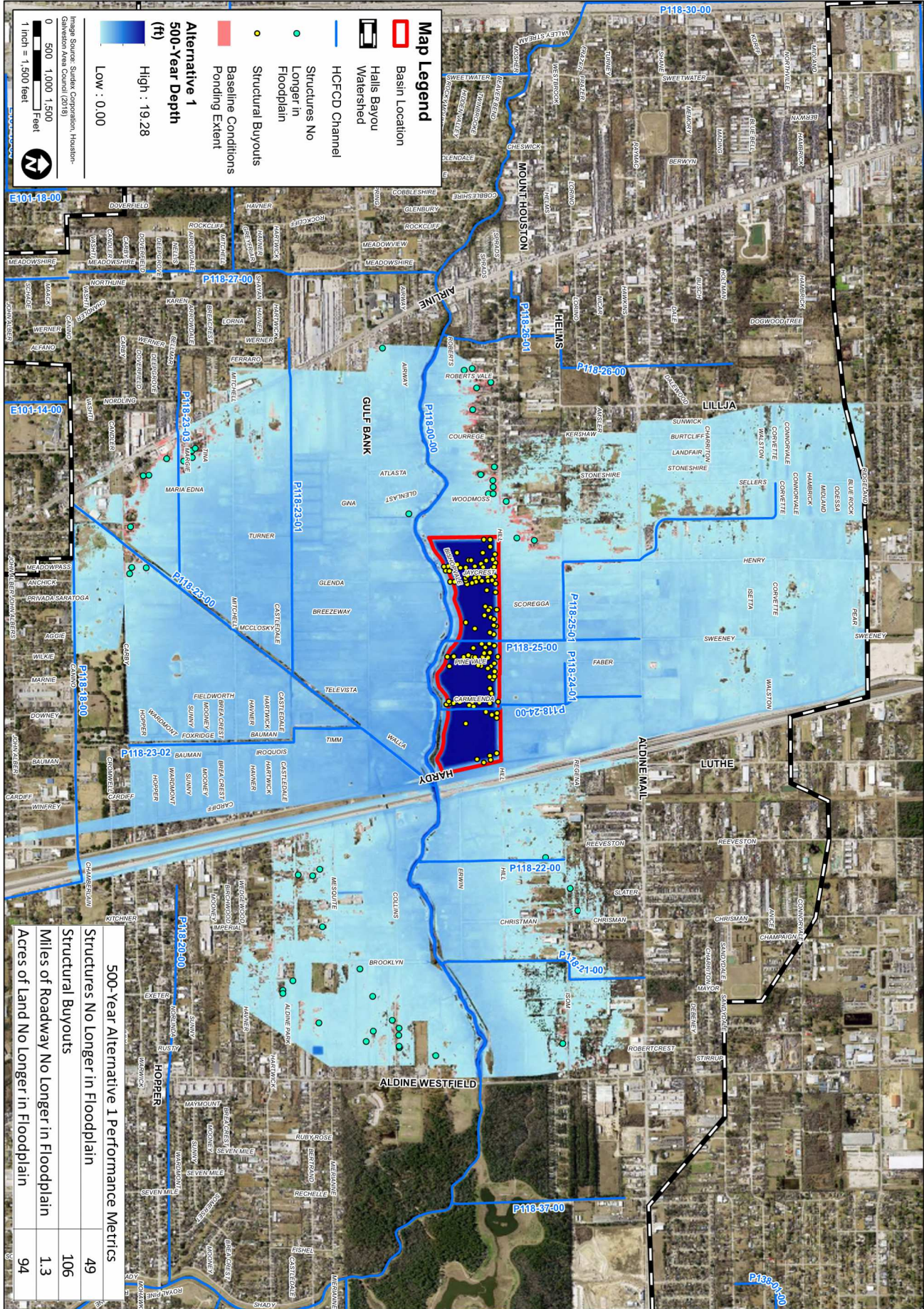


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 APPROVED: DMB

**HCFCO HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**  
**50-YEAR ALTERNATIVE 1 vs. BASELINE CONDITIONS  
 PERFORMANCE METRICS**





**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HCFCO Channel
- Structures No Longer in Floodplain
- Structural Bypasses
- Baseline Conditions Ponding Extent

**Alternative 1 500-Year Depth (ft)**

Low : 0.00  
High : 19.28

Scale: 1 inch = 1,500 feet

500-Year Alternative 1 Performance Metrics	
Structures No Longer in Floodplain	49
Structural Bypasses	106
Miles of Roadway No Longer in Floodplain	1.3
Acres of Land No Longer in Floodplain	94

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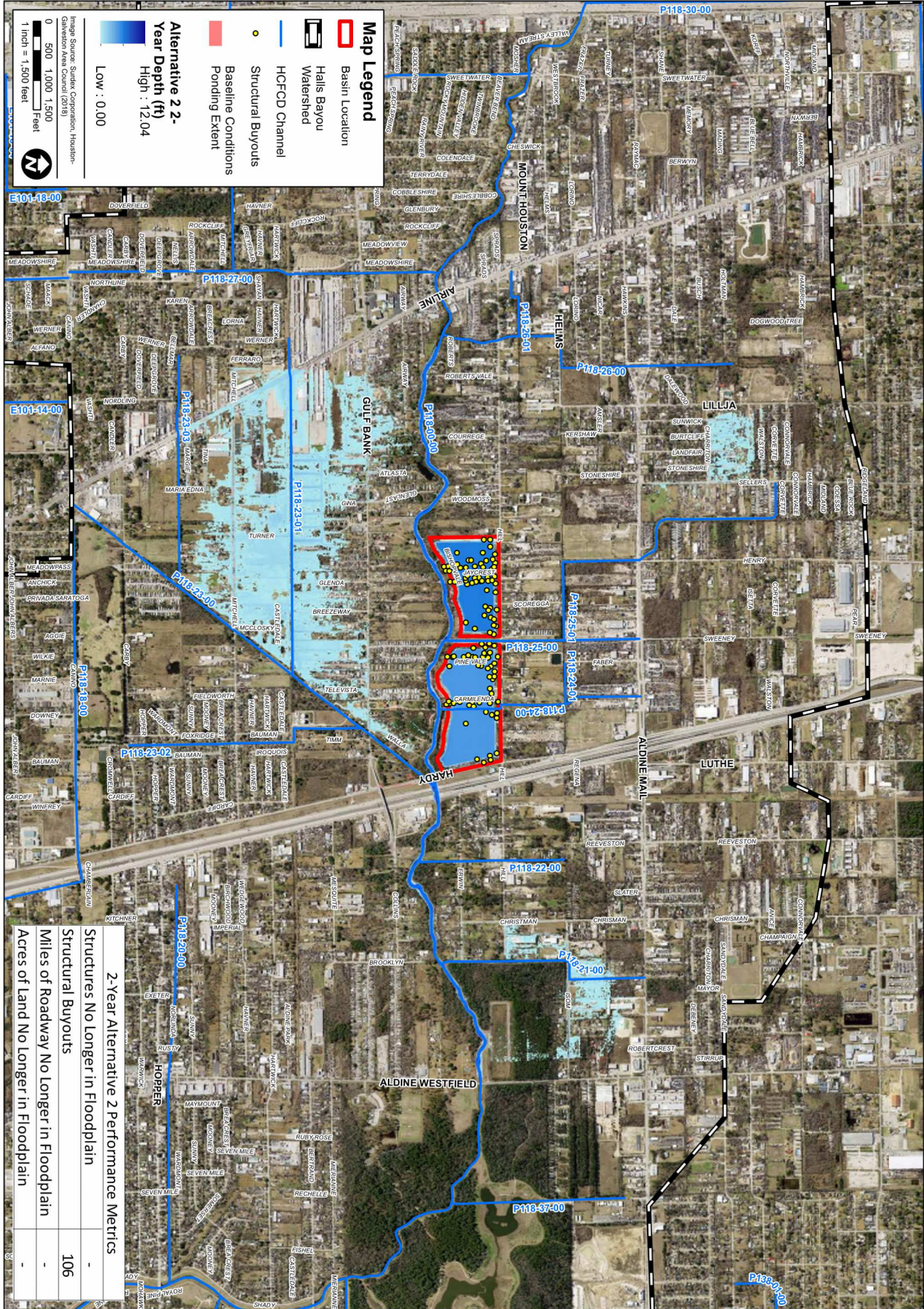
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**HCFCO HALLS BAYOU WATERSHED HARDY WEST ALTERNATIVES ANALYSIS**

**500-YEAR ALTERNATIVE 1 vs. BASELINE CONDITIONS PERFORMANCE METRICS**



2-Year Alternative 2 Performance Metrics	
Structures No Longer in Floodplain	-
Structural Buyouts	106
Miles of Roadway No Longer in Floodplain	-
Acres of Land No Longer in Floodplain	-

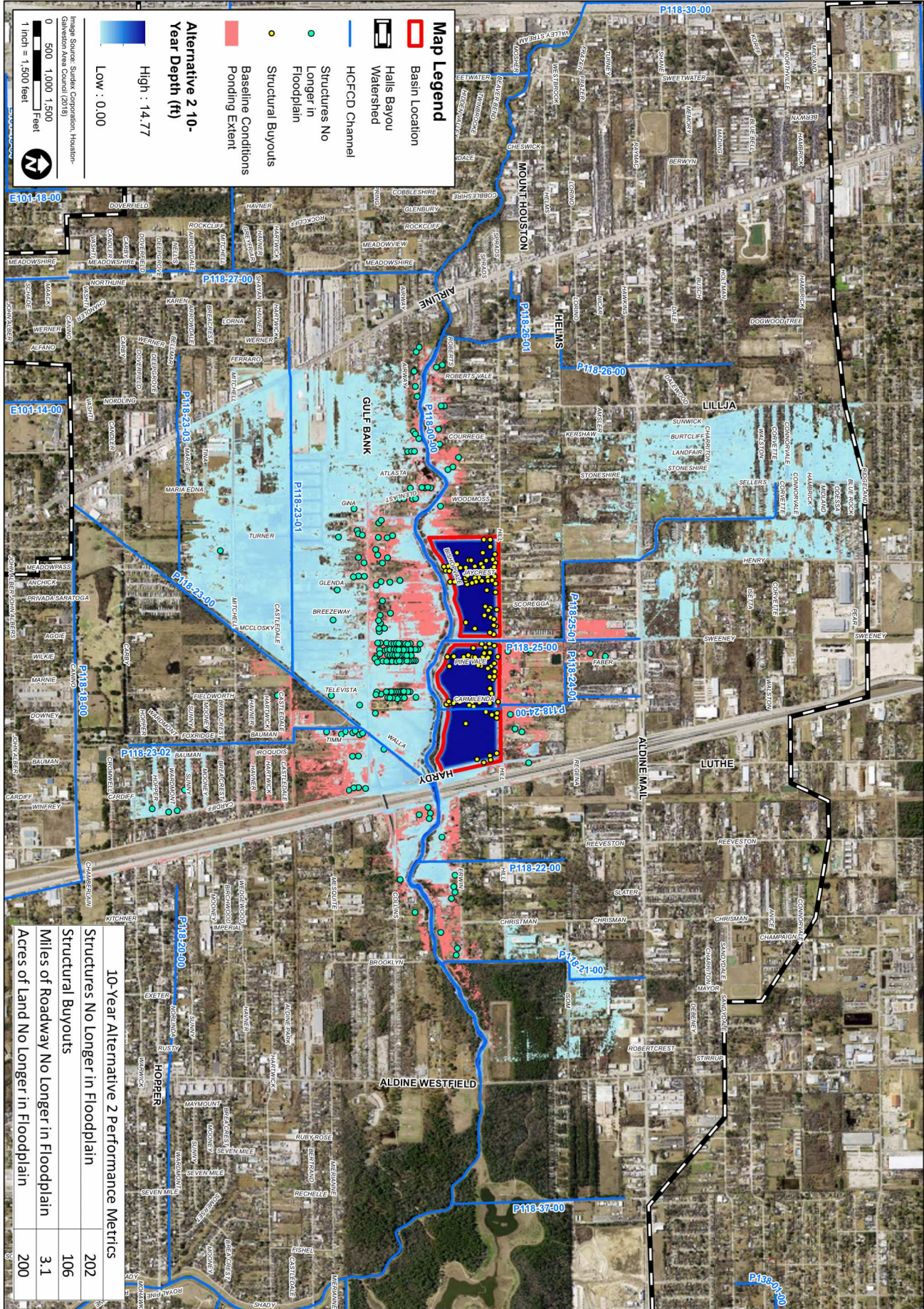
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 APPROVED: DMB

**HCFC-D HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**  
**2-YEAR ALTERNATIVE 2 vs. BASELINE CONDITIONS  
 PERFORMANCE METRICS**





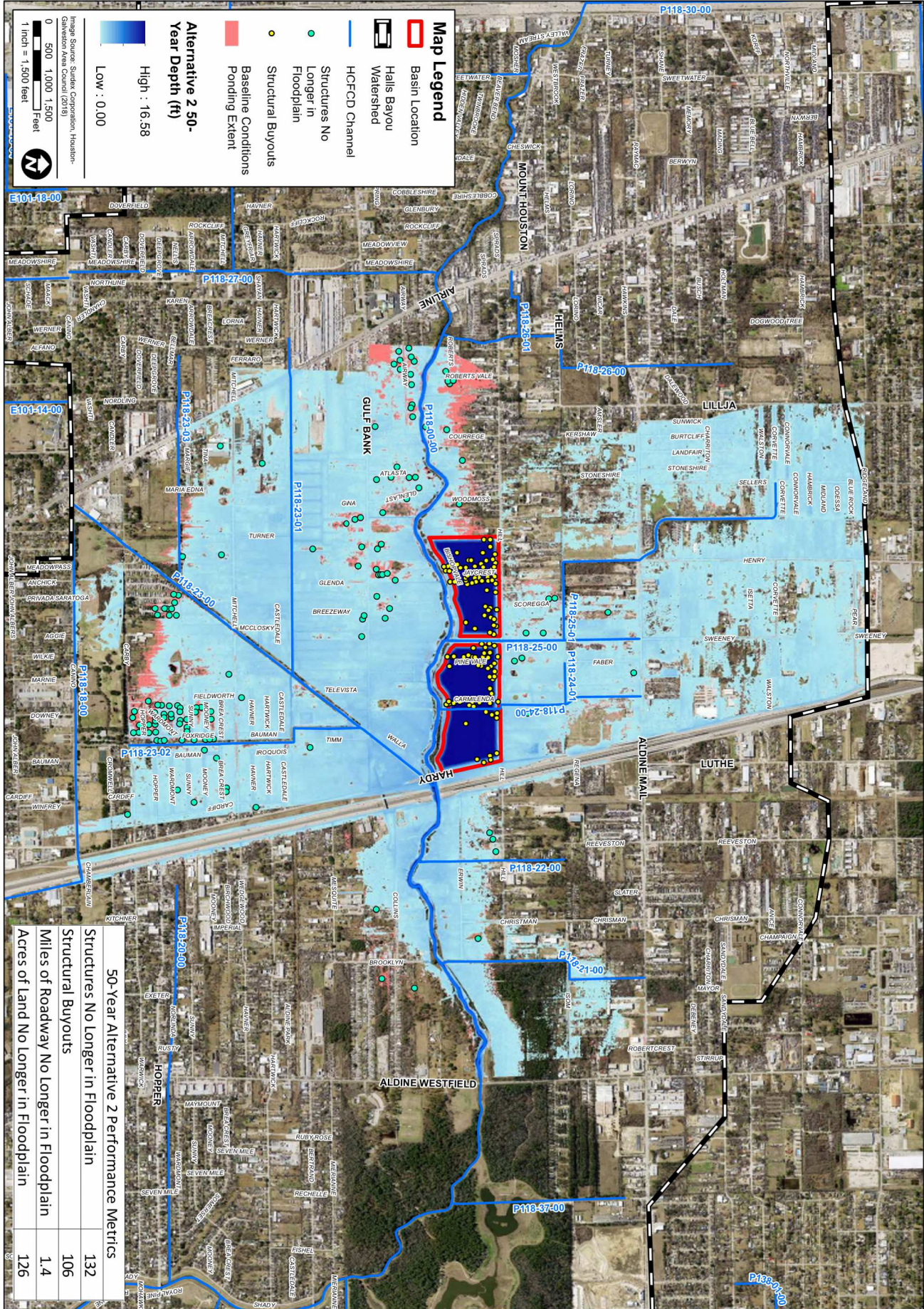
10-Year Alternative 2 Performance Metrics	
Structures No Longer in Floodplain	202
Structural Byouts	106
Miles of Roadway No Longer in Floodplain	3.1
Acres of Land No Longer in Floodplain	200

DATE: SEPT 2021  
 SCALE: AS NOTED



PREPARED: BJI  
 CHECKED: DMB  
 APPROVED: DMB

**HCFC D HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**  
**10-YEAR ALTERNATIVE 2 vs. BASELINE CONDITIONS  
 PERFORMANCE METRICS**



**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HCFCFD Channel
- Structures No Longer in Floodplain
- Structural Byuouts
- Baseline Conditions Ponding Extent

**Alternative 2 50-Year Depth (ft)**

High : 16.58  
 Low : 0.00

Scale: 1 inch = 1,500 feet

North Arrow

Map Source: Sutter Corporation, Houston  
 Submission Area: Council (2018)

50-Year Alternative 2 Performance Metrics	
Structures No Longer in Floodplain	132
Structural Byuouts	106
Miles of Roadway No Longer in Floodplain	1.4
Acres of Land No Longer in Floodplain	126

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 SCALE: AS NOTED

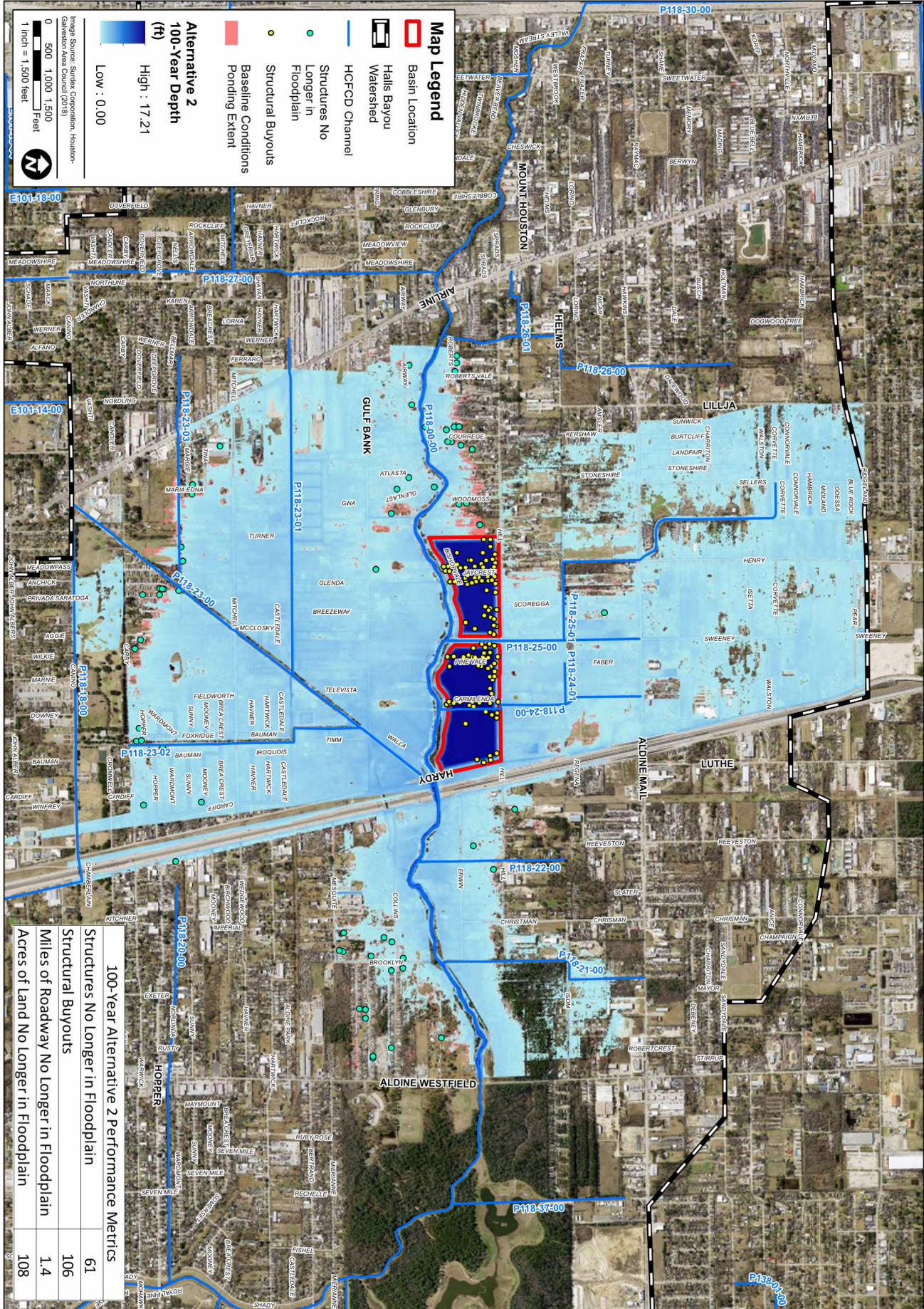
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**HCFCFD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**50-YEAR ALTERNATIVE 2 vs. BASELINE CONDITIONS  
 PERFORMANCE METRICS**



100-Year Alternative 2 Performance Metrics	
Structures No Longer in Floodplain	61
Structural Byuouts	106
Miles of Roadway No Longer in Floodplain	1.4
Acres of Land No Longer in Floodplain	108

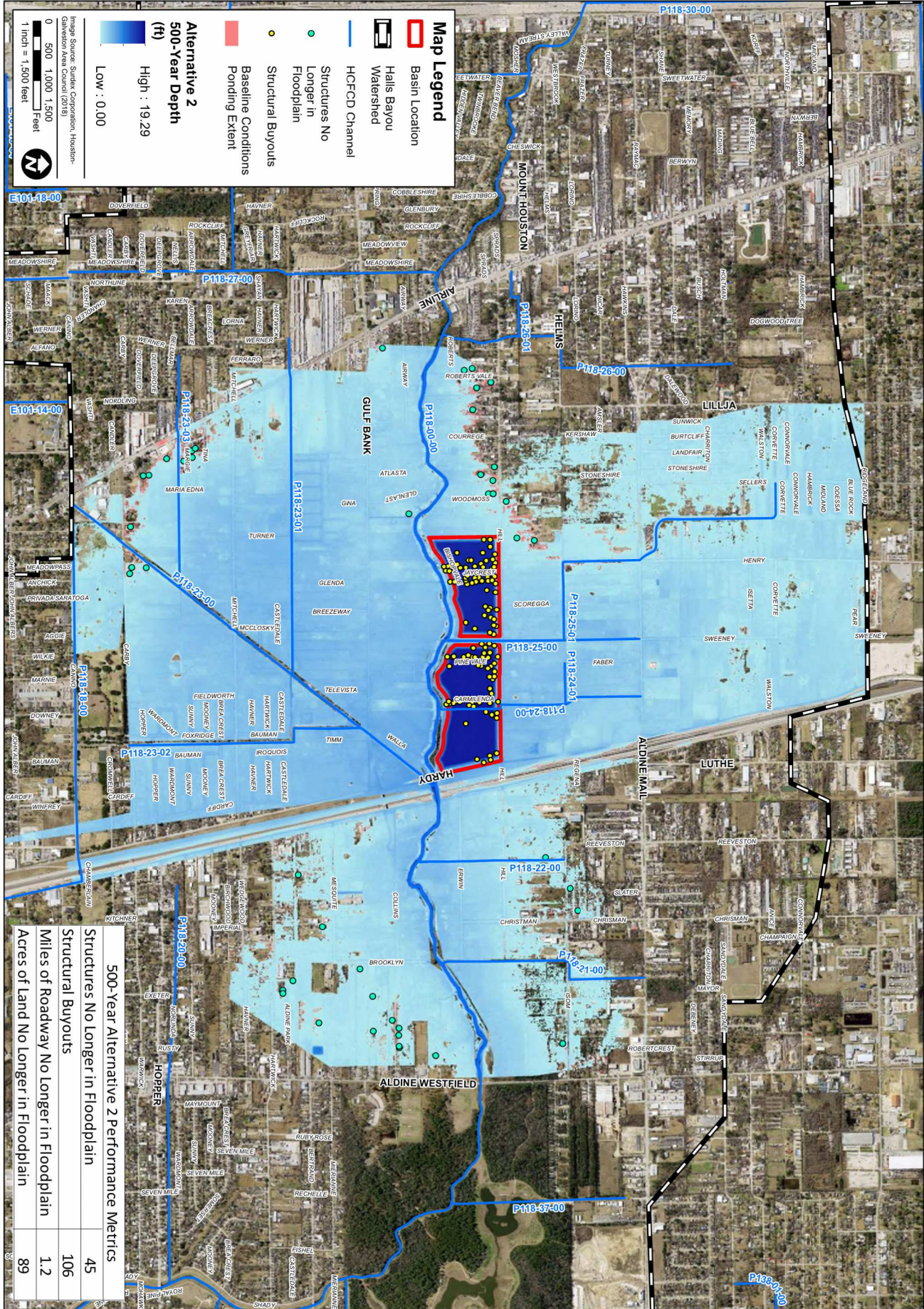
DATE: SEPT 2021  
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 2925 Blairpark Drive • Houston, TX 77042-3720  
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 APPROVED: DMB

**HCFCFD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**  
**100-YEAR ALTERNATIVE 2 vs. BASELINE CONDITIONS  
 PERFORMANCE METRICS**



500-Year Alternative 2 Performance Metrics	
Structures No Longer in Floodplain	45
Structural Bypasses	106
Miles of Roadway No Longer in Floodplain	1.2
Acres of Land No Longer in Floodplain	89

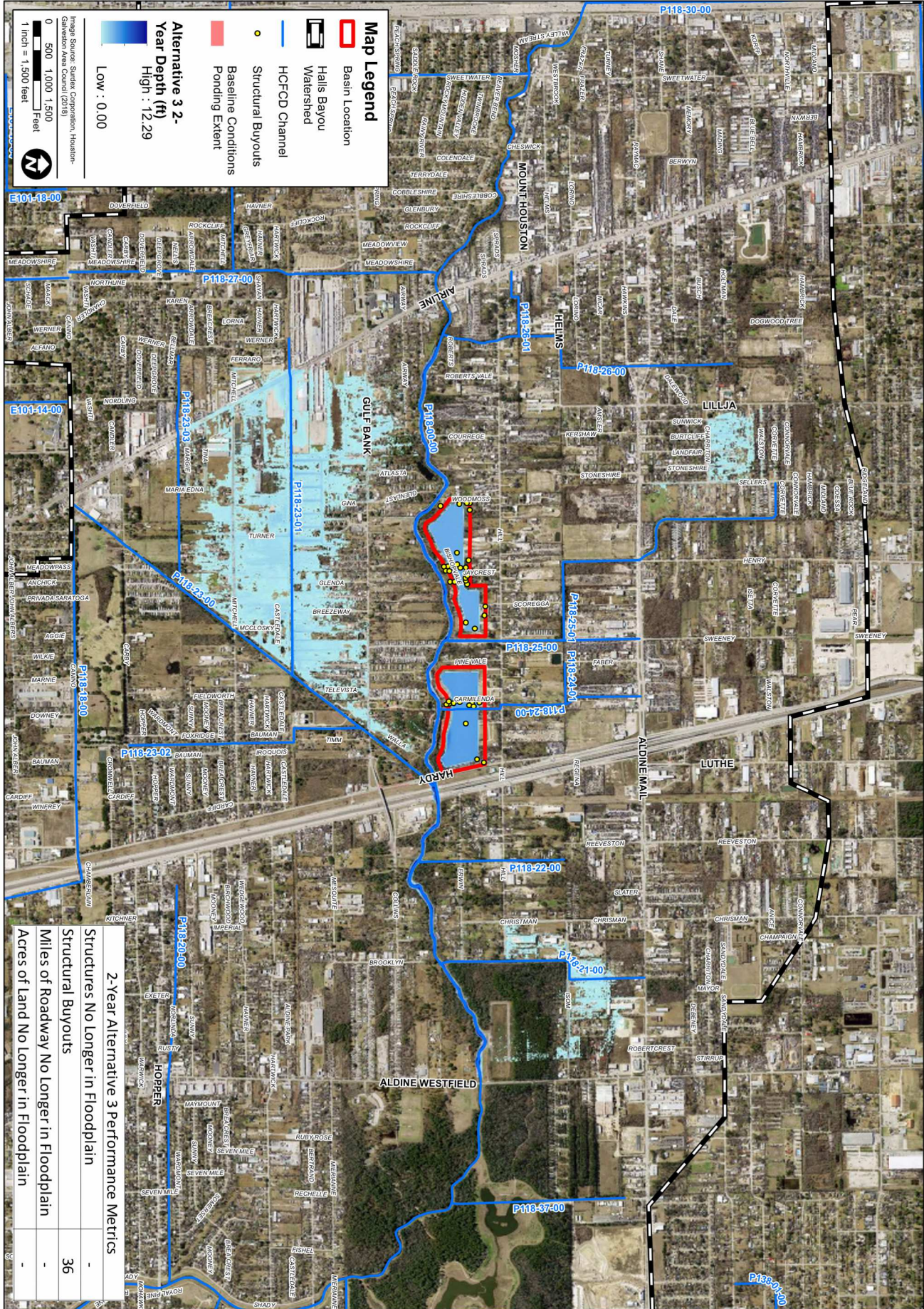
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 CHECKED: DMB  
 APPROVED: DMB

**HCFC D HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**  
**500-YEAR ALTERNATIVE 2 vs. BASELINE CONDITIONS  
 PERFORMANCE METRICS**



**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HC/CD Channel
- Structural Buypouts
- Baseline Conditions
- Ponding Extent

**Alternative 3 2-Year Depth (ft)**  
 High : 12.29  
 Low : 0.00

Scale: 1 inch = 1,500 feet

2-Year Alternative 3 Performance Metrics	
Structures No Longer in Floodplain	-
Structural Buypouts	36
Miles of Roadway No Longer in Floodplain	-
Acres of Land No Longer in Floodplain	-

**HARRIS COUNTY FLOOD CONTROL DISTRICT**

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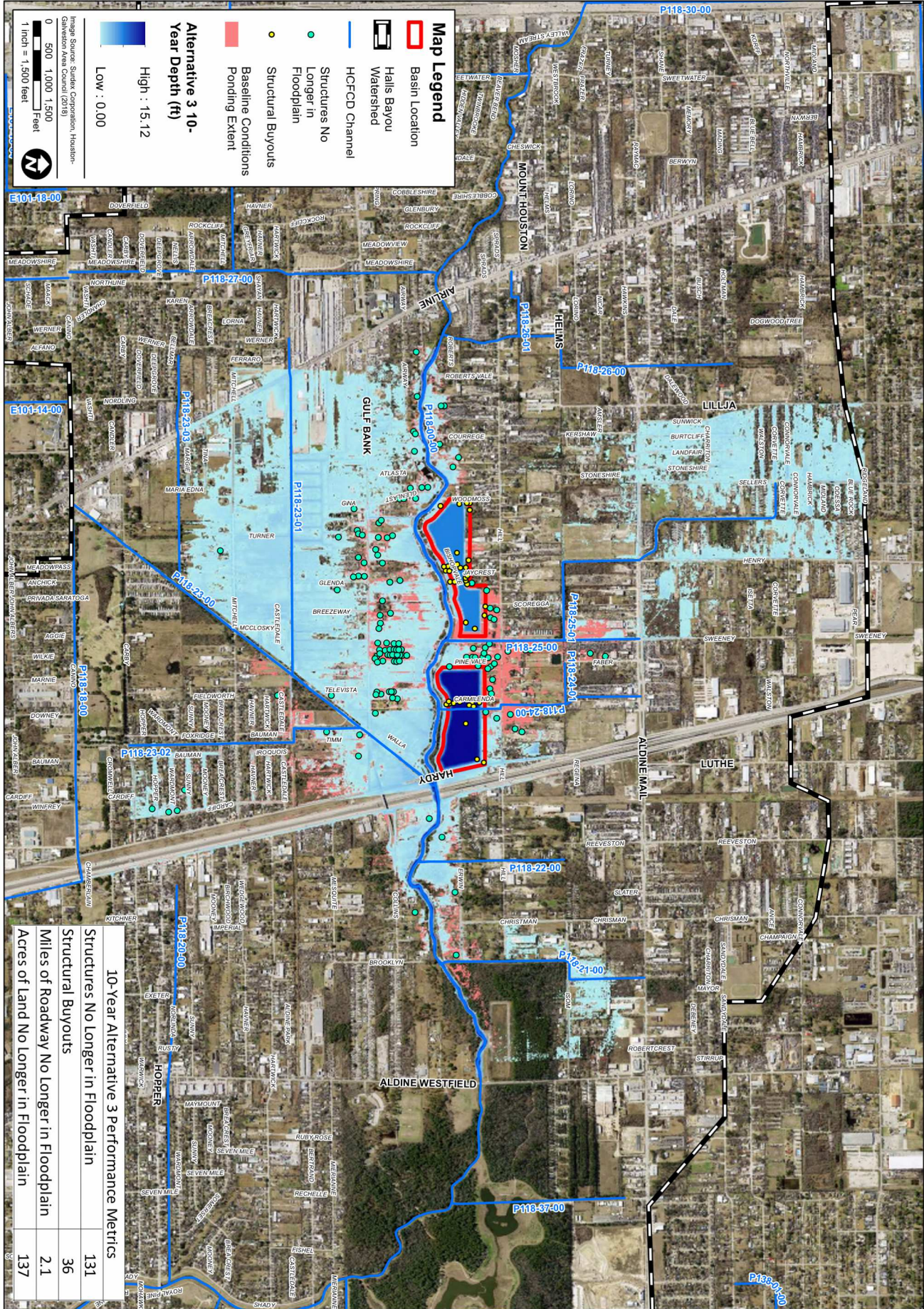
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APPROVED:	DMB

**HC/CD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS**

**2-YEAR ALTERNATIVE 3 (RECOMMENDED ALTERNATIVE)  
 vs. BASELINE CONDITIONS PERFORMANCE METRICS**



10-Year Alternative 3 Performance Metrics	
Structures No Longer in Floodplain	131
Structural Byouts	36
Miles of Roadway No Longer in Floodplain	2.1
Acres of Land No Longer in Floodplain	137

**HARRIS COUNTY FLOOD CONTROL DISTRICT**  
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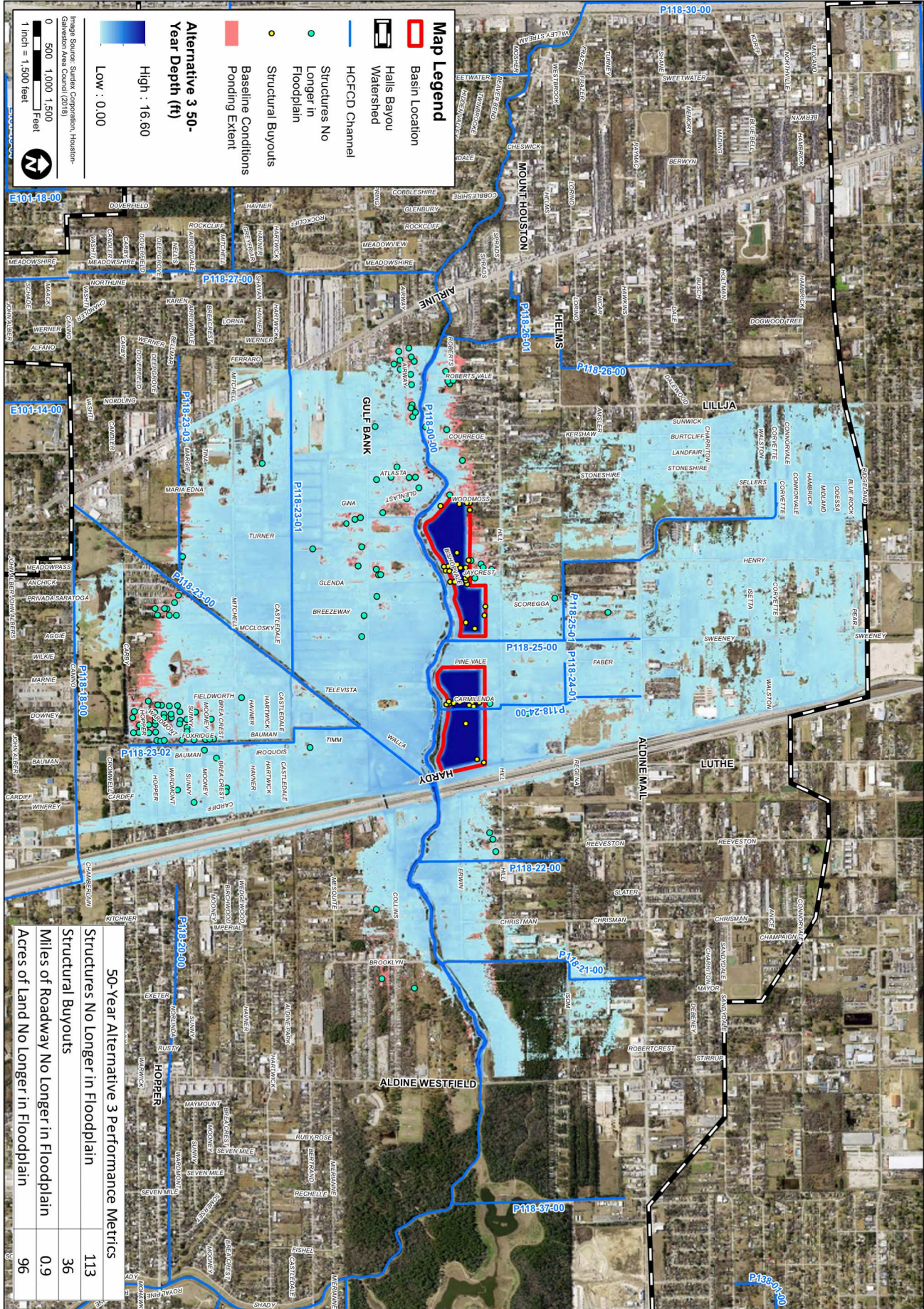
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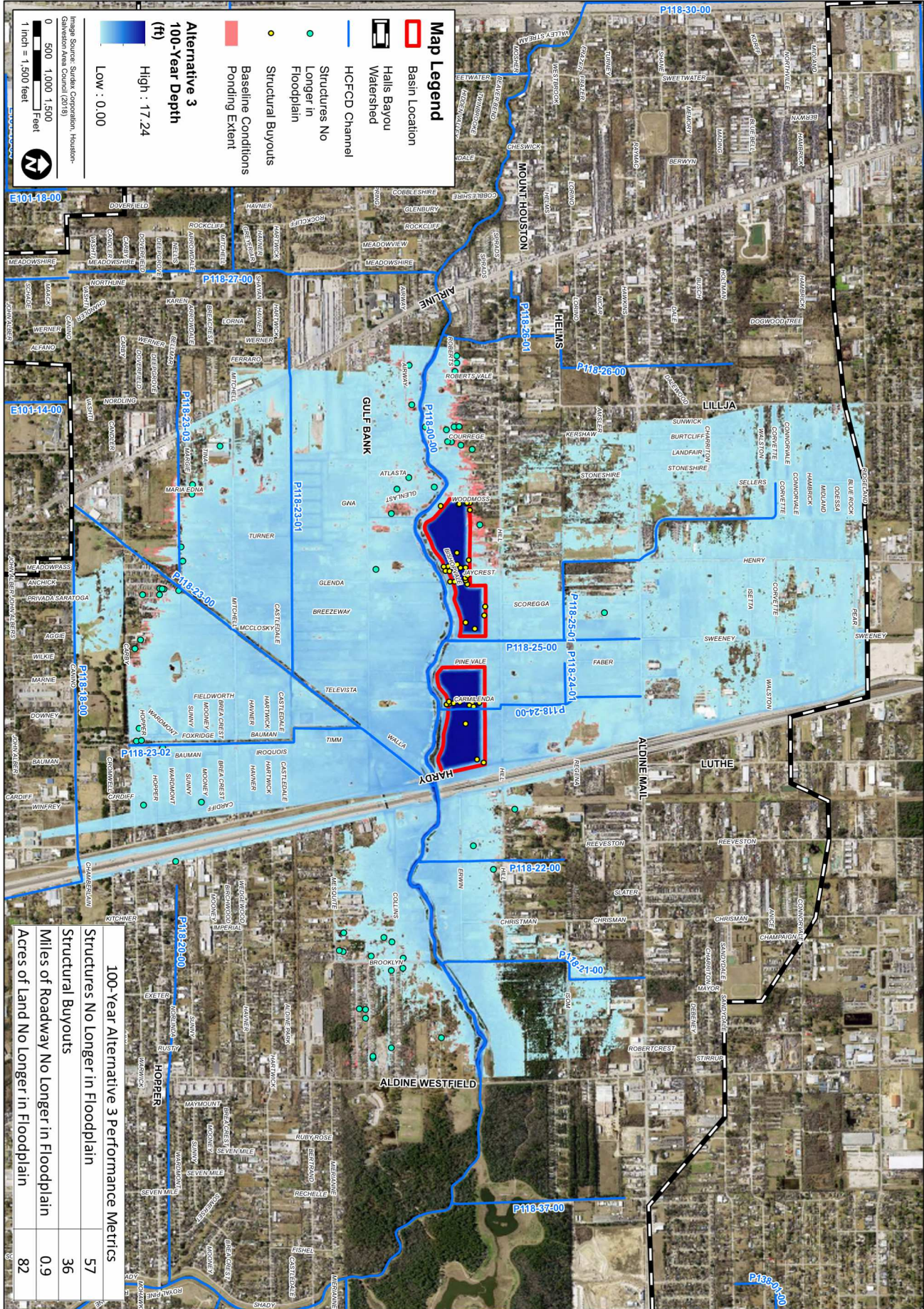
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APPROVED:	DMB

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 HARDY WEST ALTERNATIVES ANALYSIS**

**10-YEAR ALTERNATIVE 3 (RECOMMENDED ALTERNATIVE)  
 vs. BASELINE CONDITIONS PERFORMANCE METRICS**

DATE: SEPT 2021  
 SCALE: AS NOTED  
 EXHIBIT 28





100-Year Alternative 3 Performance Metrics	
Structures No Longer in Floodplain	57
Structural Bypasses	36
Miles of Roadway No Longer in Floodplain	0.9
Acres of Land No Longer in Floodplain	82

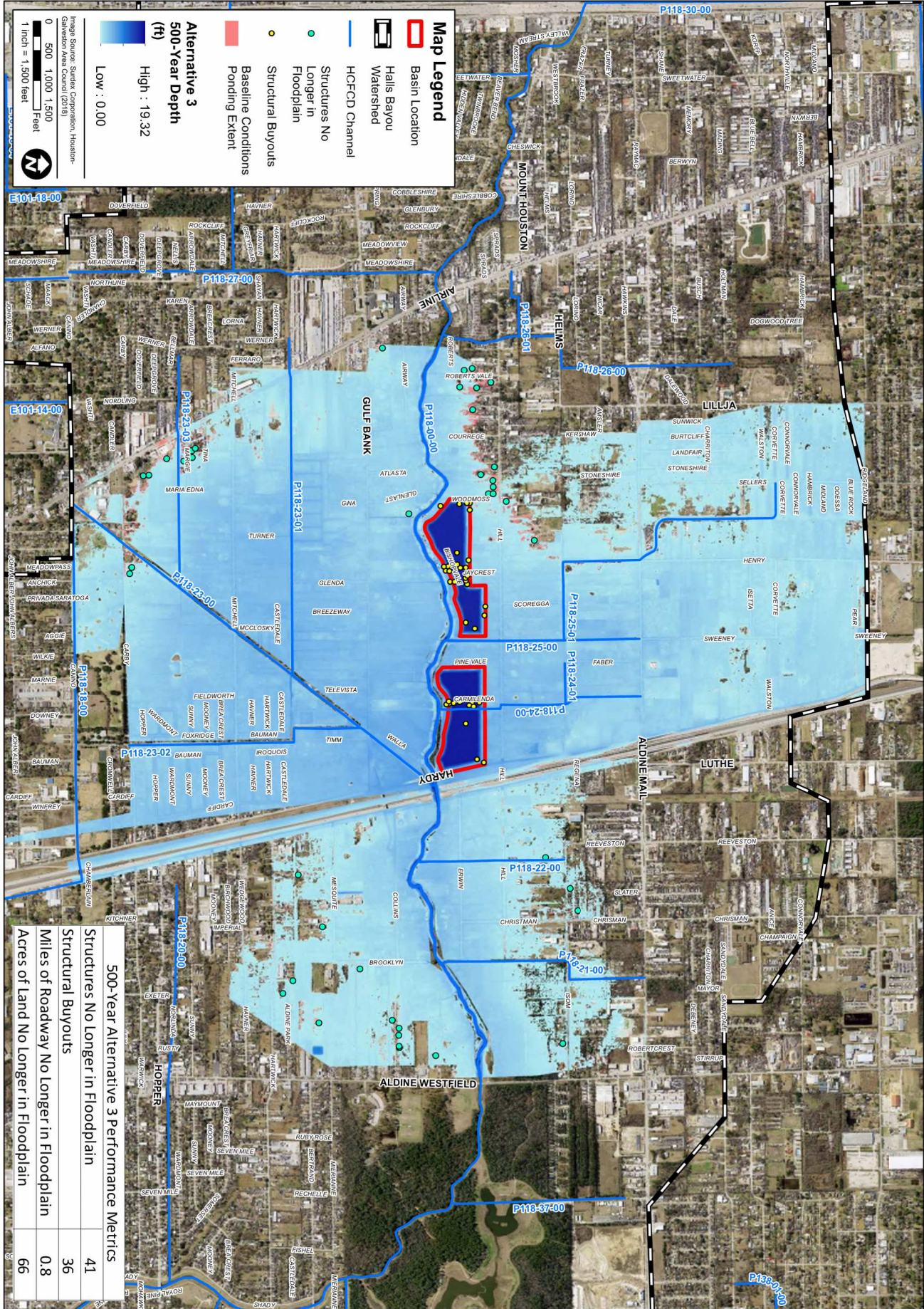
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APPROVED:	DMB

**HCFC D HALLS BAYOU WATERSHED HARDY WEST ALTERNATIVES ANALYSIS**  
**100-YEAR ALTERNATIVE 3 (RECOMMENDED ALTERNATIVE) vs. BASELINE CONDITIONS PERFORMANCE METRICS**





**Map Legend**

- █ Basin Location
- █ Halls Bayou Watershed
- █ HCFCFD Channel
- Structures No Longer in Floodplain
- Structural Bypasses
- █ Baseline Conditions Ponding Extent

**Alternative 3 500-Year Depth (ft)**

Low : 0.00  
High : 19.32

Scale: 1 inch = 1,500 feet

500-Year Alternative 3 Performance Metrics	
Structures No Longer in Floodplain	41
Structural Bypasses	36
Miles of Roadway No Longer in Floodplain	0.8
Acres of Land No Longer in Floodplain	66

**HARRIS COUNTY FLOOD CONTROL DISTRICT**

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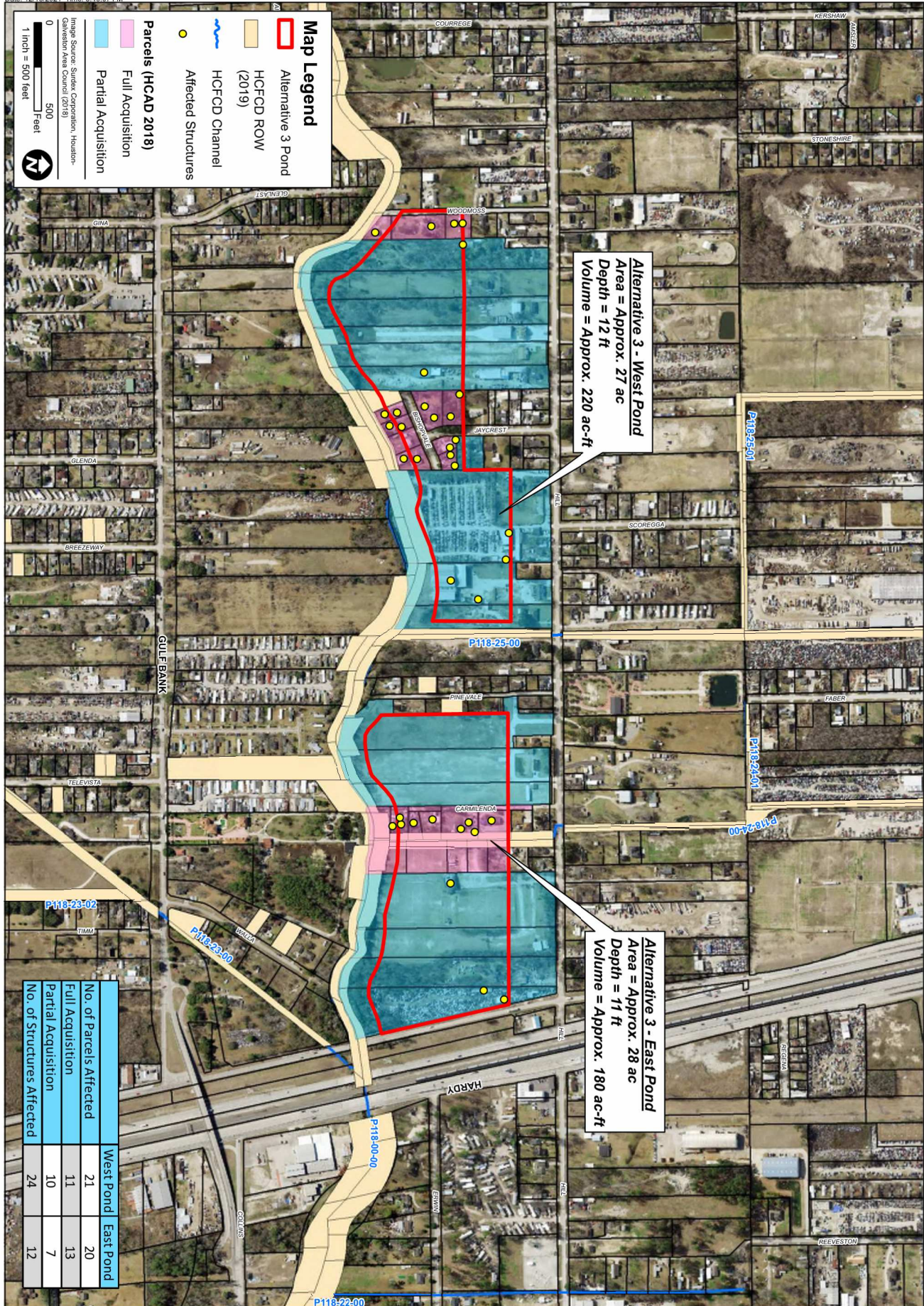
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**HCFCFD HALLS BAYOU WATERSHED HARDY WEST ALTERNATIVES ANALYSIS**

**500-YEAR ALTERNATIVE 3 (RECOMMENDED ALTERNATIVE) vs. BASELINE CONDITIONS PERFORMANCE METRICS**



**Alternative 3 - West Pond**  
 Area = Approx. 27 ac  
 Depth = 12 ft  
 Volume = Approx. 220 ac-ft

**Alternative 3 - East Pond**  
 Area = Approx. 28 ac  
 Depth = 11 ft  
 Volume = Approx. 180 ac-ft

**Map Legend**

- Alternative 3 Pond
- HCFCFCD ROW (2019)
- HCFCFCD Channel
- Affected Structures
- Parcels (HCAD 2018)
- Full Acquisition
- Partial Acquisition

Image Source: Sutter Corporation, Houston-Salveston Area Council (2018)

Scale: 1 inch = 500 feet

	West Pond	East Pond
No. of Parcels Affected	21	20
Full Acquisition	11	13
Partial Acquisition	10	7
No. of Structures Affected	24	12

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 HARDY WEST ALTERNATIVES ANALYSIS

**PROPOSED ROW  
 ALTERNATIVE 3 (RECOMMENDED)**

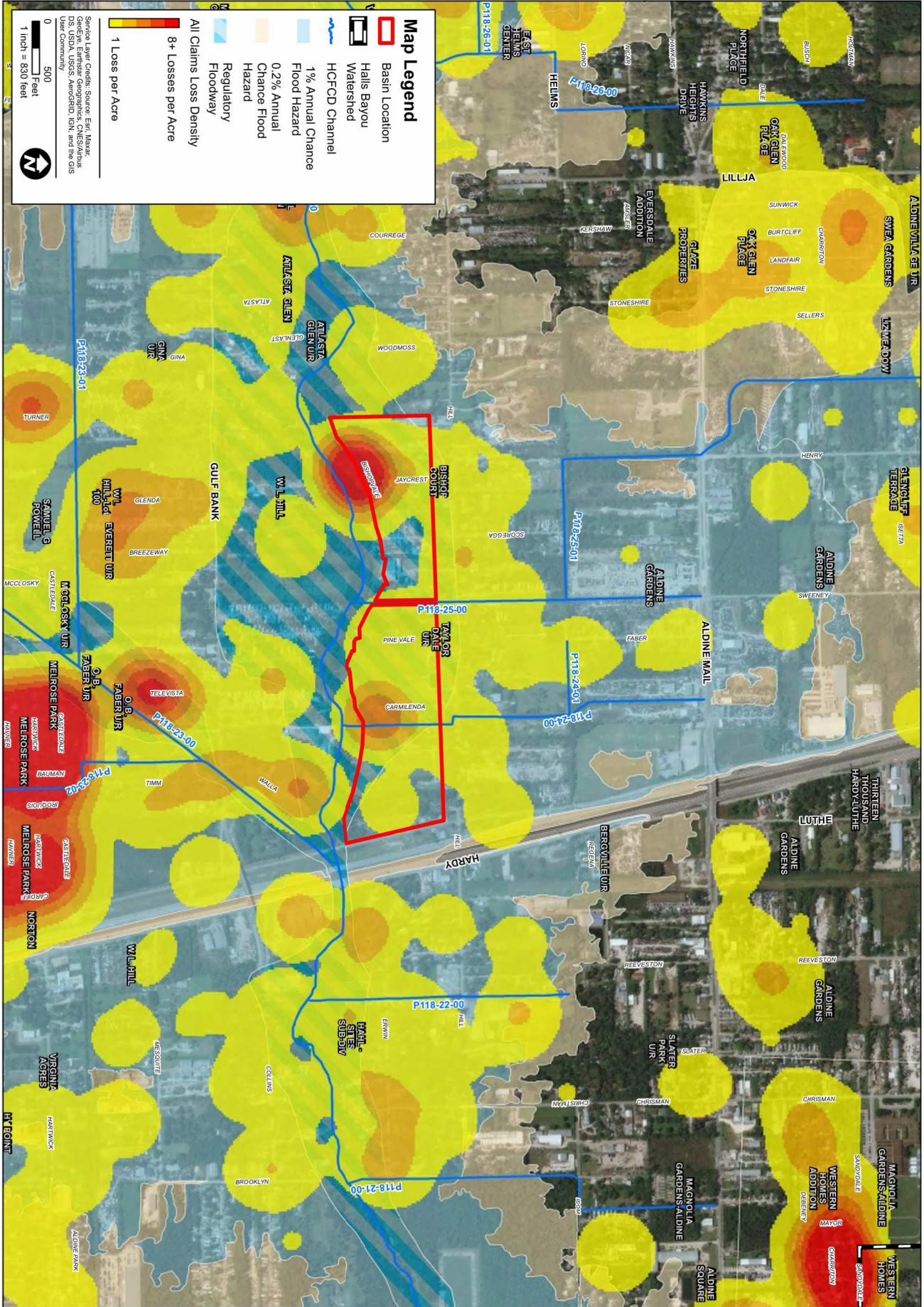
# **Appendices**

# **Appendix A**

Site Visit Photo Documentation

# **Appendix B**

Historical Losses Heat Maps



**HARRIS COUNTY FLOOD CONTROL DISTRICT**  
 9900 Northwest Freeway  
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DATE: DEC 2020  
 SCALE: AS NOTED

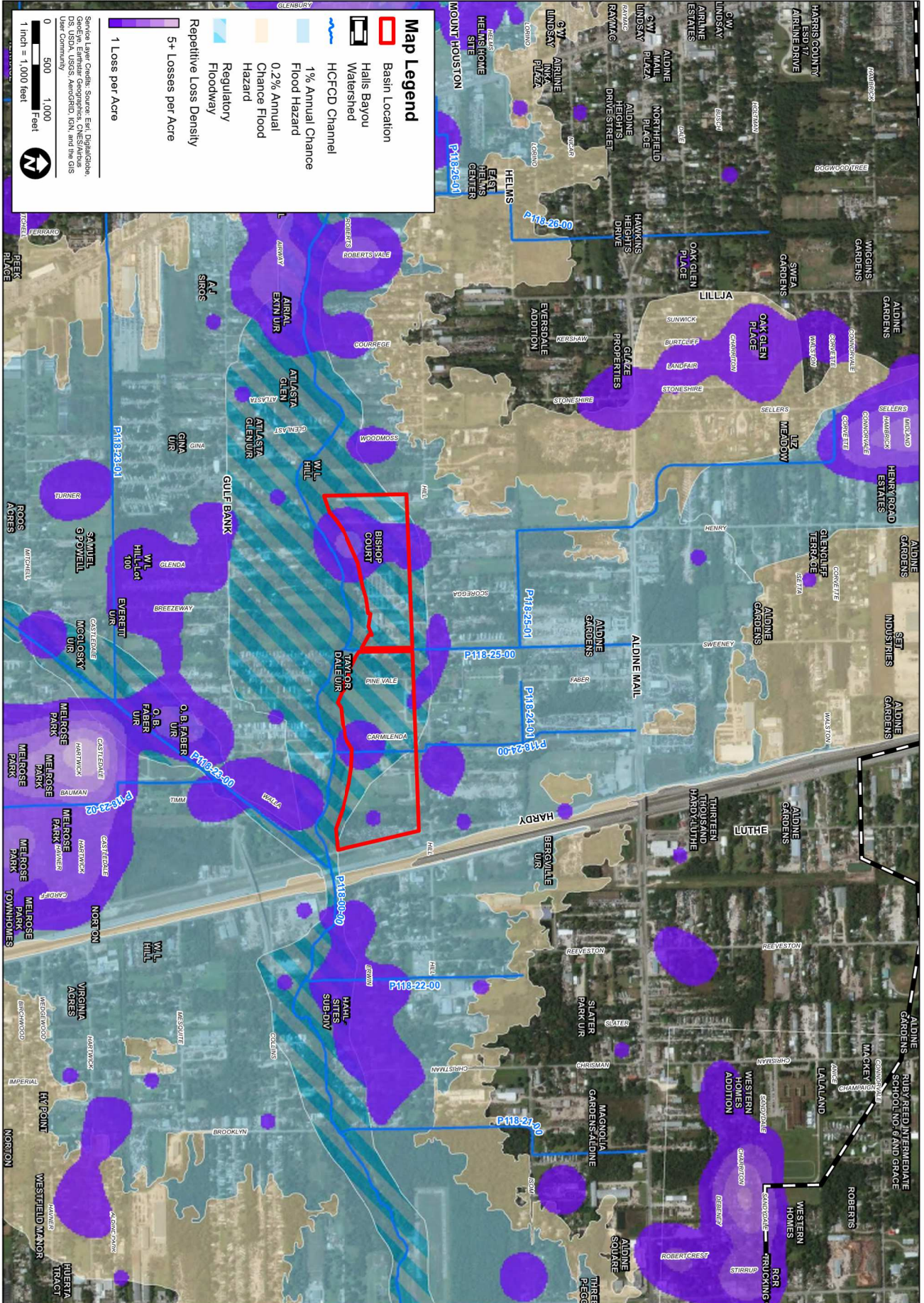
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PREPARED: PSK
CHECKED: CEE
APPROVED: CEE

HCFC D HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

ALL CLAIMS LOSS DATA



**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HC/FCD Channel
- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Regulatory Floodway
- Repetitive Loss Density
- 5+ Losses per Acre
- 1 Loss per Acre

Scale: 1 inch = 1,000 feet

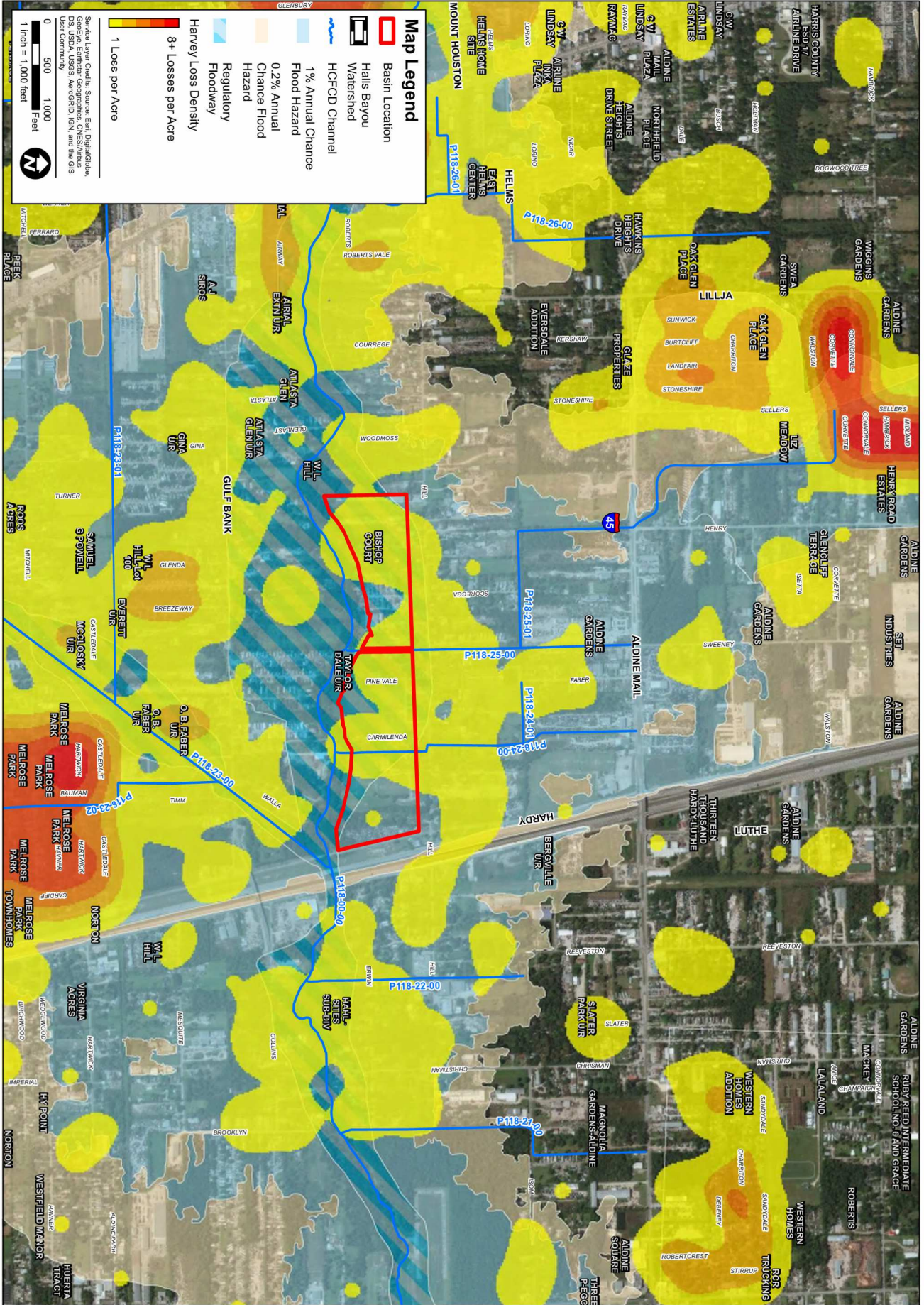
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APPROVED:	CEE

**HC/FCD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

**REPETITIVE LOSS DATA**



**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HCFC D Channel
- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Regulatory Hazard
- Floodway
- Harvey Loss Density
- 8+ Losses per Acre
- 1 Loss per Acre

1 inch = 1,000 feet

0 500 1,000 Feet

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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DATE: DEC 2020  
 SCALE: AS NOTED

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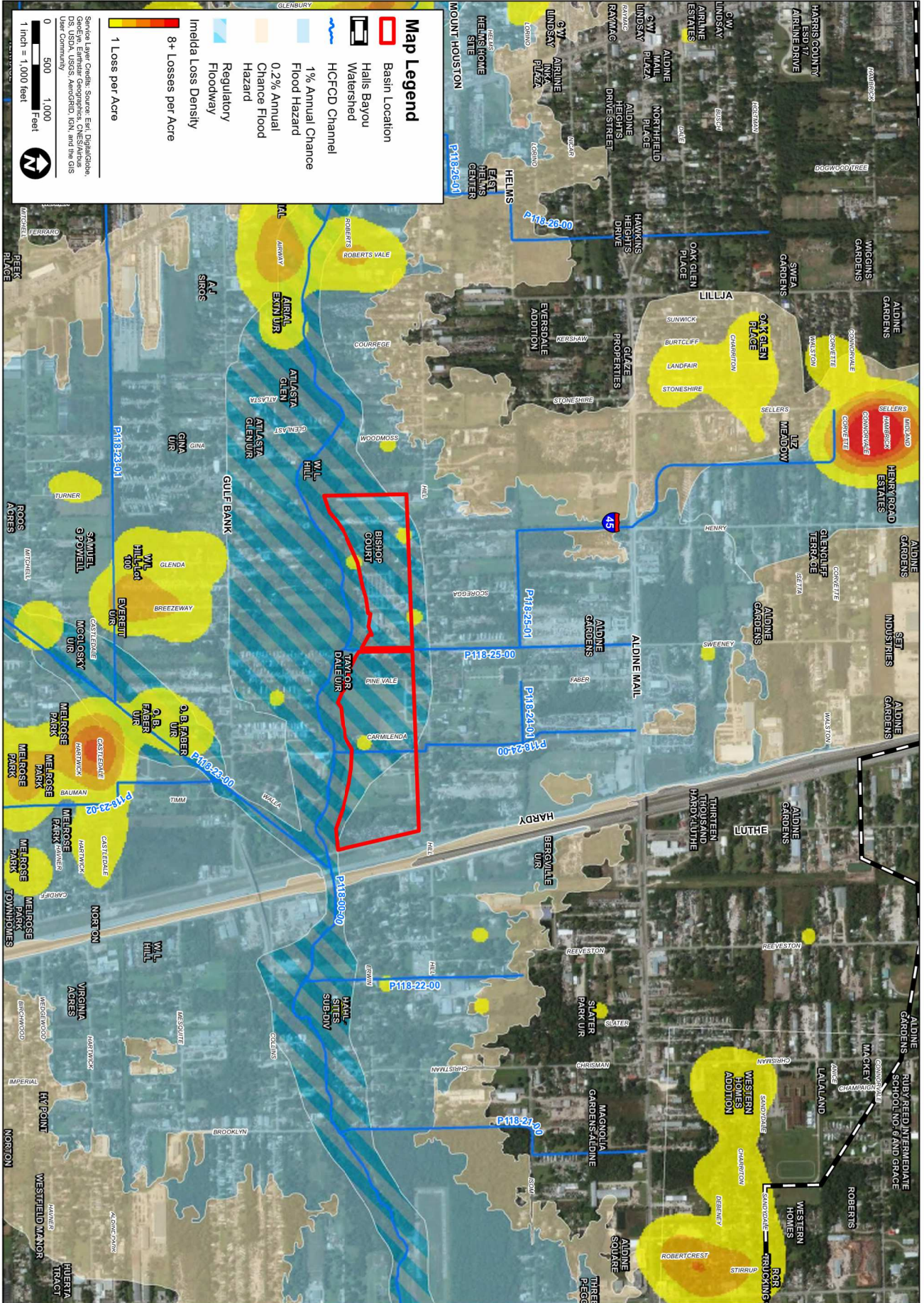
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APPROVED: DMB

HCFC D Halls Bayou Watershed  
 HARDY WEST ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

HARVEY LOSS DATA





**Map Legend**

- Basin Location
- Halls Bayou Watershed
- HCFCDD Channel
- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Regulatory Floodway Hazard
- Floodway
- Imelda Loss Density
- 1 Loss per Acre
- 8+ Losses per Acre

Scale: 1 inch = 1,000 feet

North Arrow

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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DATE: DEC 2020  
 SCALE: AS NOTED

EXHIBIT

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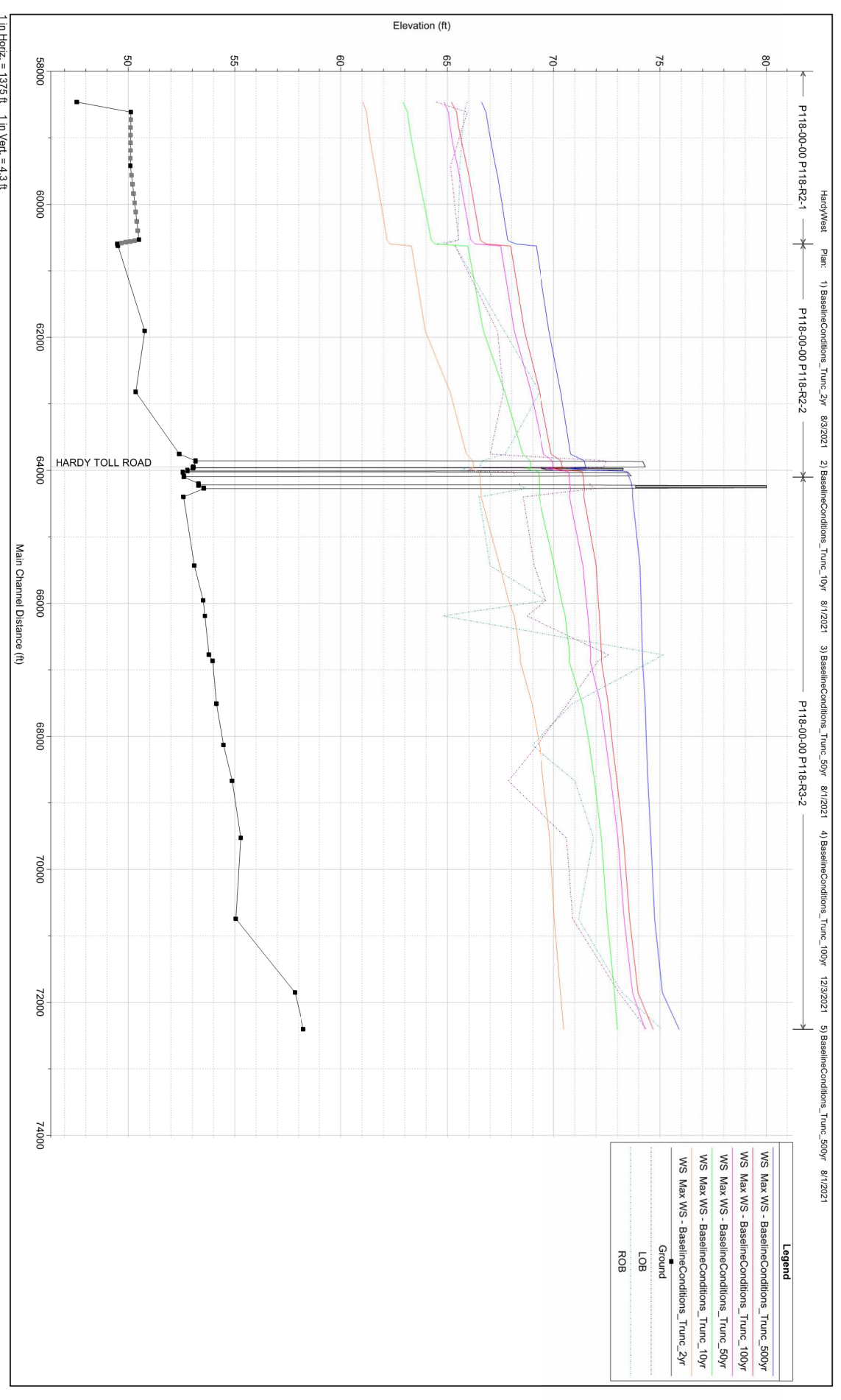
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APPROVED: CEE

HCFCDD HALLS BAYOU WATERSHED  
 HARDY WEST ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

LOSS DATA - IMELDA

# **Appendix C**

Baseline Conditions Water Surface Profiles



HardyWest Plan: 1) BaselineConditions\_Trunc\_2yr 8/3/2021 2) BaselineConditions\_Trunc\_10yr 8/1/2021 3) BaselineConditions\_Trunc\_50yr 8/1/2021 4) BaselineConditions\_Trunc\_100yr 12/3/2021 5) BaselineConditions\_Trunc\_500yr 8/1/2021

P118-00-00 P118-R2-1 P118-00-00 P118-R2-2 P118-00-00 P118-R3-2

Legend	
WS Max WS - BaselineConditions_Trunc_500yr	(Solid blue line)
WS Max WS - BaselineConditions_Trunc_100yr	(Solid green line)
WS Max WS - BaselineConditions_Trunc_50yr	(Solid red line)
WS Max WS - BaselineConditions_Trunc_10yr	(Solid purple line)
WS Max WS - BaselineConditions_Trunc_2yr	(Dotted orange line)
Ground	(Black line with square markers)
LOB	(Dashed black line)
ROB	(Dotted black line)

1 in Horiz. = 1375 ft 1 in Vert. = 4.3 ft

# **Appendix D**

Halls Bayou Mainstem Potential Project Memo



PLANNING  
 ENGINEERING  
 PROGRAM MANAGEMENT

memo

**TEXAS**

AUSTIN  
 COLLEGE STATION  
 CORPUS CHRISTI  
 DALLAS  
 FORT WORTH  
 FRISCO  
 HOUSTON  
 LAREDO  
 MONTGOMERY COUNTY  
 SAN ANTONIO  
 SAN MARCOS  
 WACO

**CALIFORNIA**

LOS ANGELES  
 ORANGE  
 SAN JOSE

**FLORIDA**

MIAMI

**ILLINOIS**

CHICAGO

**MICHIGAN**

FLINT  
 LANSING

**OKLAHOMA**

NORMAN

Date: December 15, 2020  
 Prepared By: Chris Edwards, P.E., CFM  
 Project #: 120-11994-000, 120-12170-000  
 Project Name: Halls Bayou Implementation Program  
 Subject: Halls Bayou Mainstem Potential Projects

---

Lockwood, Andrews & Newnam, Inc. (LAN) was authorized by Harris County Flood Control District (HCFCD) to determine additional projects along the Mainstem of Halls Bayou, that might be considered for upcoming grant funding opportunities. Over the past four months, the following options have been explored:

Channel Improvements:

- Option 1: Bertrand to Hopper (100-year LOS)
- Option 2: Hopper to Bretshire (20-foot expansion)
- Option 3: Aldine-Westfield Road to Keith-Weiss (40-foot expansion)

Regional Detention Basins:

- Option 4: Hardy West
- Option 5: Aldine Westfield
- Option 6: Mary Withers

**Summary/Recommendations:**

We recommend considering Channel Improvement Options 2 and 3, as well Regional Detention Options 4 and 5. These projects provide significant relief from flooding along the Mainstem of Halls Bayou, and do not result in adverse impacts upstream or downstream. The Channel Improvement Options are offset by the inclusion of the existing Regional Basins of Keith Weiss, Bretshire, and Hall Park, as described in more detail below. Options 4 and 5 provide needed detention along the mainstem, are in line with Phase 1 of the Halls Bayou Phasing Study, and can help facilitate future mainstem projects in the area. Option 1, while providing localized flooding relief, offsets benefits seen downstream from Option 2 where a higher number of flooded structures are located. Option 6 may still be considered for a future project, however it will require additional coordination w/ the City of Houston before being fully considered for pursuing grant funding.

Lockwood, Andrews & Newnam, Inc.  
 A LEO A DALY COMPANY  
 2925 Briarpark Drive  
 Suite 400  
 Houston, TX 77042  
 713.266.6900

lan-inc.com

# 1 Channel Improvement Options

The objectives for this analysis were to update the Halls Bayou Baseline Conditions model to reflect conditions prior to the construction of Keith-Weiss, Bretshire, and Hall Park regional detention basins, and to identify channel improvement concepts in the vicinity of those basins that reduce water surface elevations (WSEs) within Halls Bayou without introducing adverse impacts.

Starting from the Baseline Conditions model from the Halls Bayou Phasing Study, the Without Projects Conditions model was created by removing geometry associated with Keith-Weiss, Bretshire, and Hall Park regional detention basins. For Keith-Weiss, the storage area was first converted into a 2D flow area in the Baseline Conditions model to better represent the transfer of water across the large detention basin footprint. Then, in the Without Project Conditions model, the cross sections along Keith Weiss were reverted to the 2007 Effective HEC-RAS model, based on 2001 LiDAR taken prior to the construction of the basin. A comparison of the site is shown below:



FIGURE I: KEITH-WEISS PARK IMAGERY, 2006 AND 2016.

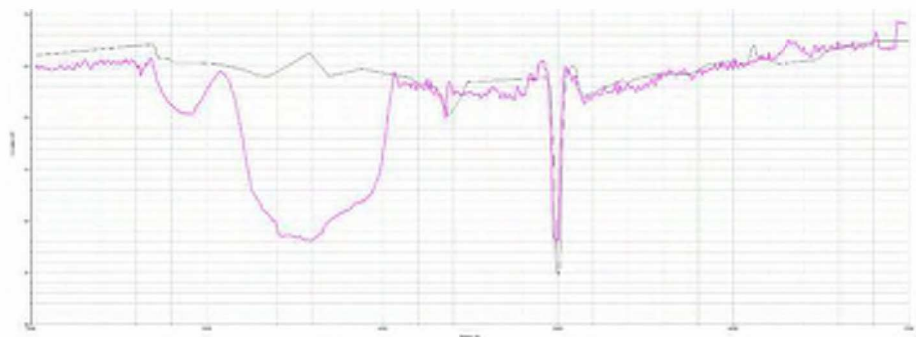


FIGURE II: PRE- VS. POST-CONSTRUCTION AT KEITH-WEISS (PROPOSED IN MAGENTA)

For Bretshire and Hall Park, 35 cross sections from river station 43789 to 37413 were reverted to their pre-basin geometry, as these basins were modeled within the cross sections themselves. Other small adjustments were made to both geometric models to provide additional stability, including updating Htab parameters and adding cross sections near the confluence of P118-26-00 and Halls Bayou. With the geometry updated, the Without Project Conditions model was run for the 10-, 100-, and 500-year pre-Atlas 14 design storm events.

The Baseline Conditions and Without Project Conditions WSEs were compared to better understand the benefits provided by these three basins to Halls Bayou, and to help identify locations for channel conveyance improvements. Near Keith-Weiss, the 500- and 100-year events show maximum depth reductions of 1.65 feet and 2.05 feet, respectively. Near Bretshire/Hall Park, the 500- and 100-year events show maximum depth reductions of 1.15

feet and 2.1 feet, respectively. No adverse impacts were observed from the implementation of these basins.

**TABLE I: REDUCTIONS IN WSE FROM WITHOUT PROJECTS TO BASELINE CONDITIONS**

Location	Reduction in WSE (feet)	
	100-year	500-year
Keith-Weiss	2.05	1.65
Bretshire/Hall Park	2.1	1.15

The following pages describe each Option: their location, geometries, benefits, cost, and other considerations. Performance metrics for each Option are based on a standalone project, however all three Options have also been incorporated into one model to check for adverse impacts. When combined, no adverse impacts are observed when compared to the Without Projects Conditions model. Additionally, these options, when combined, do not significantly change the performance of each individual option.

## 1.1 Option 1 – Bertrand to Hopper (100-year LOS)

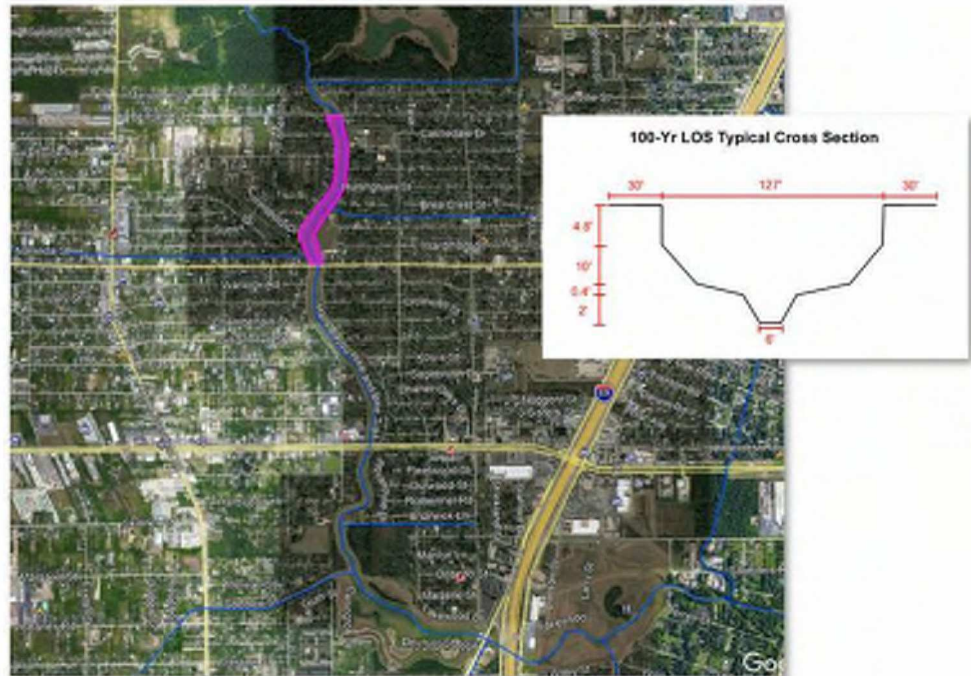


FIGURE 1: OPTION 1 – BERTRAND TO HOPPER PROJECT LOCATION

Proposed channel improvements for Option 1 extend from downstream of Bertrand Street to Hopper Road (see Figure 1-1). The improvements were incorporated from the Halls Phasing Study and provide a 100-year Level-of-Service (LOS) for the channel based on the Halls Bayou Vision Plan. Design elements include a 127-foot wide grass-lined channel, with 4.8-foot tall retaining walls at the banks (added for needed capacity with limited ROW). The 100- and 500-year events show maximum depth reductions of up to 0.6 feet and 0.5 feet just downstream of Bertrand Street, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Without Project Conditions WSEs. The reduction in WSE from Option 1 results in the performance metrics in Table 1 below when compared to the Baseline Conditions model. (Note: the negative metrics in the 500-year indicates that while this project reduces structural impacts locally, it is offset by reductions in structural benefits downstream. There are still no adverse impacts versus the Without Projects Conditions model.)

TABLE 1: OPTION 1 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	3	87	-20
Miles of Road Removed	0.03	0.57	-1.4
Acres of Land Removed	3	50	-13.36

The estimated opinion of probable cost is **\$20 Million**, which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

Some of the challenges with this option are the constructability of the proposed retaining walls on either bank, several utility crossings, as well as limited ROW with Shady Lane and Royal Pine Drive running parallel to the channel. Safety considerations will also need to be addressed with the retaining wall option, especially with the Halls Bayou Hike and Bike Trail on the east bank.



## 1.2 Option 2 – Hopper to Bretshire (20-foot widening)

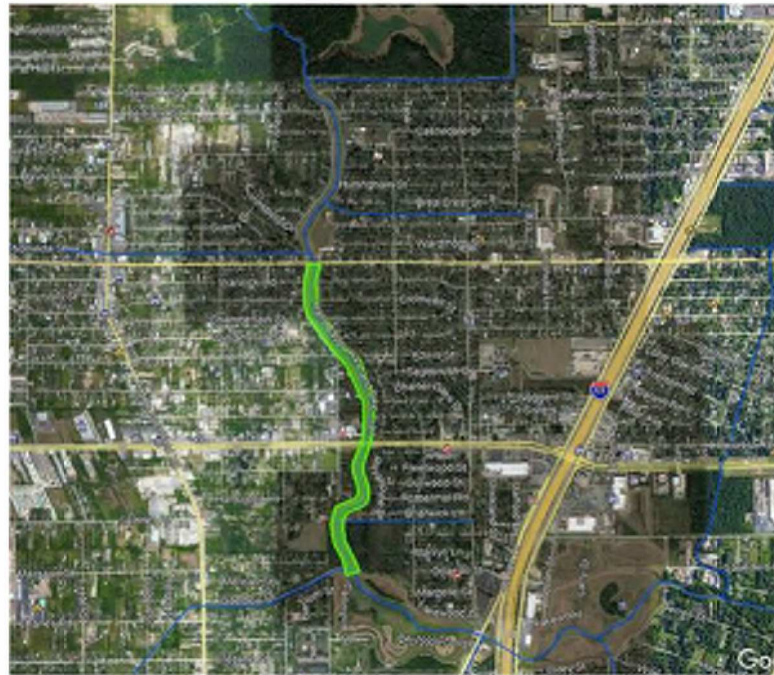


FIGURE 2: OPTION 2 – HOPPER TO BRETSHIRE PROJECT LOCATION

Proposed channel improvements for Option 2 extend from downstream of Hopper Road to the Bretshire Regional Detention Basin. This option is limited to a 20-foot channel widening on the west bank of Halls Bayou. The improvements extend into the existing maintenance berm, with the aim of utilizing Shady Lane for maintenance access for the majority of this option. The 100- and 500-year events show maximum depth reductions of up to 0.8 feet and 0.4 feet just downstream of Little York Road, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Without Project Conditions WSEs. The reduction in WSE from Option 2 results in the performance metrics in Table 2 below when compared to the Baseline Conditions model. (Note: the negative metrics in the 500-year indicates that while this project reduces floodplain impacts locally, it is offset by reductions in floodplain benefits downstream. There are still no adverse impacts versus the Without Projects Conditions model.)

TABLE 2: OPTION 2 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	2	541	70
Miles of Road Removed	0.31	3.64	0
Acres of Land Removed	10	159	-10

The estimated opinion of probable cost is **\$3.5 Million**, which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

This option was created to reduce ROW acquisition needs while still providing WSE reduction benefits. Option 2 results in a greater reduction in structural flooding than Option 1, and at a much lower cost. The size of the existing floodplain is much larger as Halls Bayou nears US69, and therefore channel improvements in this area serve a larger number of businesses and residents.

### 1.3 Option 3 – Aldine Westfield to Keith-Weiss (40-foot widening)

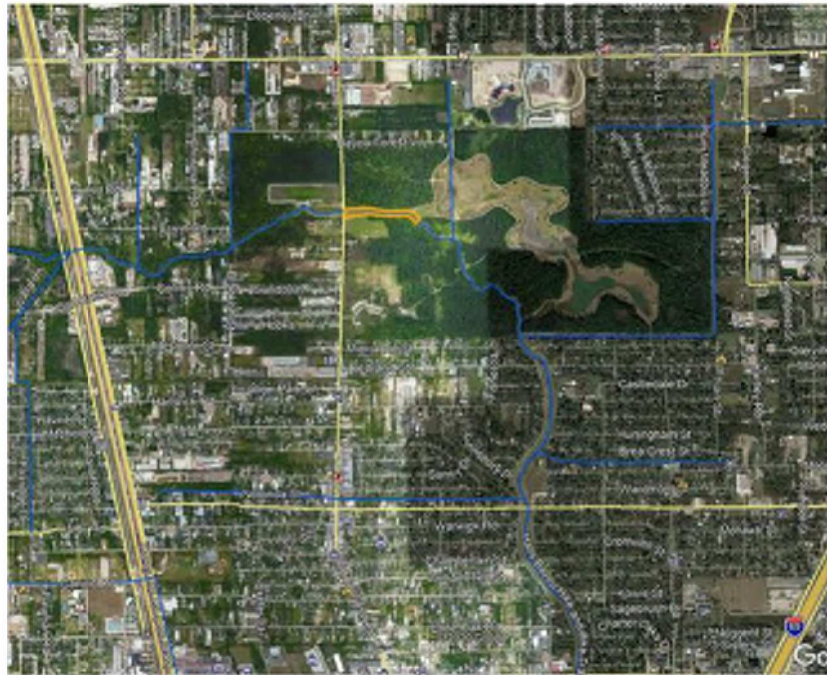


FIGURE 3: OPTION 3 – ALDINE WESTFIELD TO KEITH WEISS PROJECT LOCATION

Proposed channel improvements for Option 3 extend from downstream of Aldine Westfield Road to the Keith-Weiss Regional Detention Basin. This option is limited to a 40-foot channel widening on the north bank of Halls Bayou at this location. ROW acquisition needs in this option are limited to undeveloped property, reducing impacts to businesses and residents. The 100- and 500-year events show maximum depth reductions of up to 0.4 feet and 0.5 feet just upstream of Aldine Westfield Road, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Without Project Conditions WSEs. The reduction in WSE from Option 3 results in the following performance metrics when compared to the Baseline Conditions model:

TABLE 3: OPTION 3 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	8	28	17
Miles of Road Removed	0.11	-0.12	0.33
Acres of Land Removed	4	8	21.73

The estimated opinion of probable cost is **\$800,000**, which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

This option was created to reduce ROW acquisition needs while still providing WSE reduction benefits. The channel expansion on the north bank would extend into City of Houston property. Joint opportunities at this location may help serve both the City and HCFC (e.g. recreational trails, environmental restoration). Feasibility for this option should be further explored in the Alternatives Analysis phase.

## 2 Regional Detention Options

The following regional detention options have also been considered in this planning-level study. These options, unlike the channel conveyance options already discussed, are self-mitigating and do not rely in the existing regional basins to offset any increases in WSE upstream or downstream. Therefore, both performance metrics and WSEs are compared versus the Baseline Conditions model of Halls Bayou.

## 2.1 Option 4 – Hardy West Detention Basin

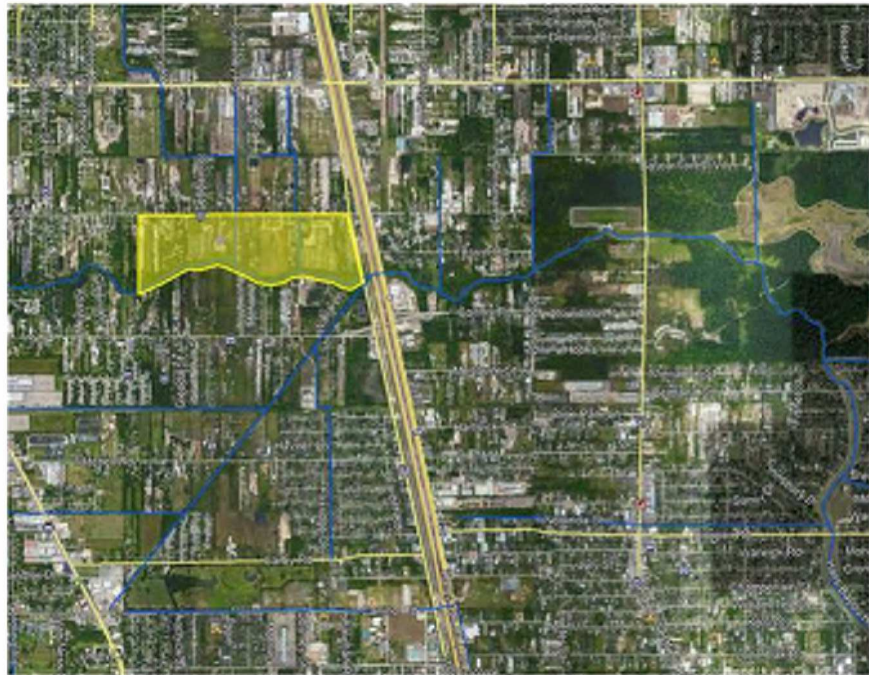


FIGURE 4: OPTION 4 – HARDY WEST DETENTION BASIN PROJECT LOCATION

Hardy West Phase 1 and 2 is a proposed wet-bottom detention basin bound to the east by Hardy Toll Road, to the north by Hill Road, and to the south by Halls Bayou. The improvements were incorporated from the Halls Phasing Study. The total proposed usable area is approximately 76 acres and would require approximately 70 acres of ROW acquisition. The basin provides approximately 700 acre-feet of storage. The 100- and 500-year events show maximum depth reductions of up to 0.4 feet and 0.5 feet near the confluence of P118-25-00, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Baseline Conditions WSEs. The reduction in WSE from Option 4 results in the following performance metrics when compared to the Baseline Conditions model:

TABLE 4: OPTION 4 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	-	202	2
Miles of Road Removed	-	2.0	0.1
Acres of Land Removed	-	87	4

The estimated opinion of probable cost is **\$47 Million** which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

The Hardy West basin provides additional storage along Halls Bayou, essential for future channel improvement projects along Halls Bayou and the surrounding tributaries. It is also included in Phase 1 of the draft Halls Bayou Phasing Study. Localized channel improvements were quickly analyzed to see if additional reductions in WSEs were possible, however any channel work would require additional ROW along Halls Bayou due to the incised nature of the channel at this location.

## 2.2 Option 5 – Aldine Westfield Detention Basin

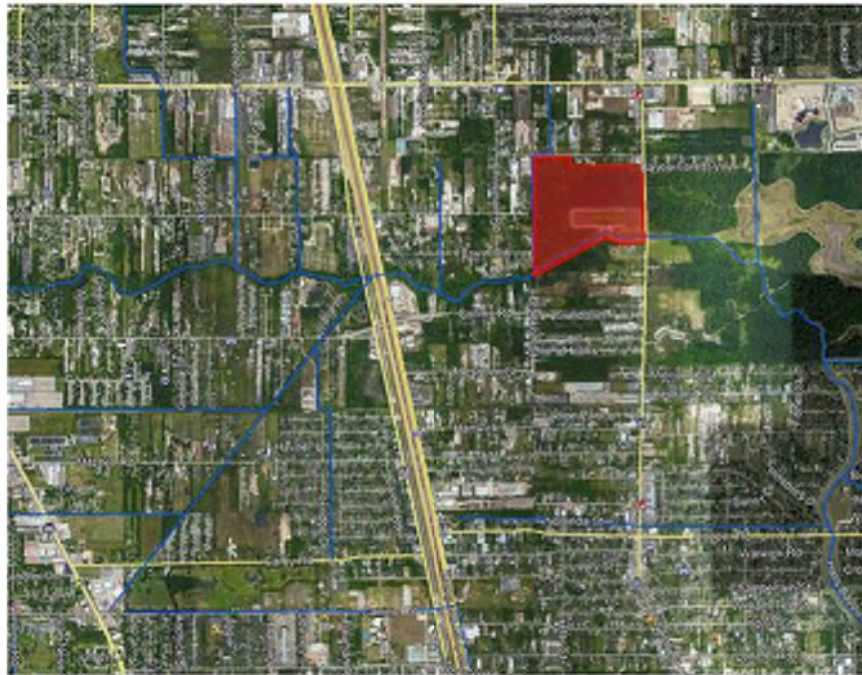


FIGURE 5: OPTION 5 – ALDINE WESTFIELD DETENTION BASIN PROJECT LOCATION

Aldine Westfield is a proposed wet-bottom detention basin bound to the west by P118-21-00, to the east by Aldine Westfield Road, to the north by Isom Street, and to the south by Halls Bayou. The improvements were incorporated from the P118-21-00 Preliminary Engineering Report. The basin provides approximately 572 acre-feet of storage, is 14 feet deep, and provides a 50-foot buffer for maintenance berms, backslope swales, and tree planting. The outfall structure includes two 8'x5' RCBs and a 100-foot wide concrete weir. Limited channel improvements along Halls Bayou were also included in this option. The 10- and 100-year events show maximum depth reductions of up to 0.5 feet and 0.3 feet just upstream of P118-21-00, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Baseline Conditions WSEs. The reduction in WSE from Option 5 results in the following performance metrics when compared to the Baseline Conditions model:

TABLE 5: OPTION 5 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	136	210	-
Miles of Road Removed	1.6	1.3	-
Acres of Land Removed	145	141	-

The estimated opinion of probable cost is **\$20 Million** which includes proposed improvements, ROW, planning/engineering/construction costs, and contingency.

A portion of the Aldine Westfield basin is currently under design in support of the P118-21-00 Channel Improvements project. The current design provides approximately 170 acre-feet of storage. Option 5 would expand that storage volume, as well as incorporate the existing TxDOT detention basin into one regional basin at this location. Coordination has been ongoing between HCFCD, Harris County, TxDOT, and the City of Houston for this regional basin.

### 2.3 Option 6 – Mary Withers Detention Basin

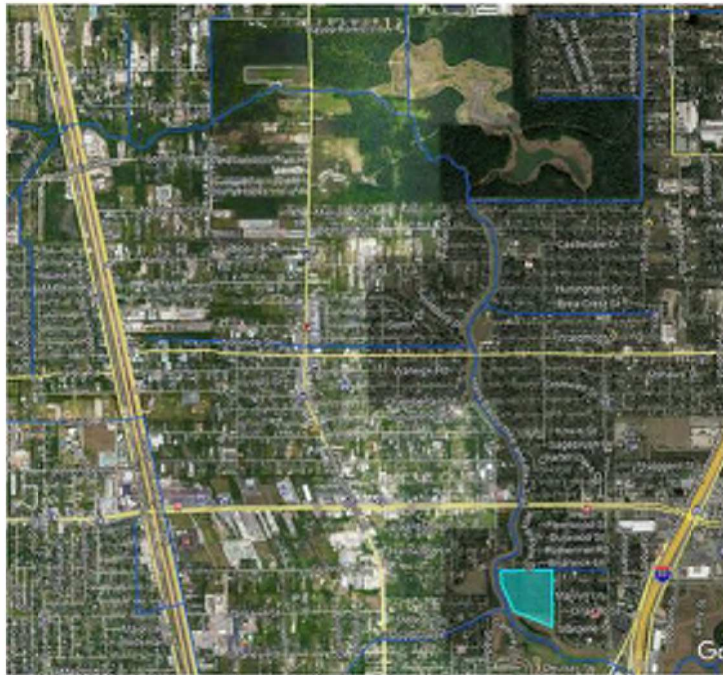


FIGURE 6: OPTION 6 – MARY WITHERS DETENTION BASIN PROJECT LOCATION

Mary Withers is a detention basin briefly considered as HCFC and LAN looked for other storage options in this portion of Halls Bayou. The existing Mary Withers Park is owned and maintained by the City of Houston. A 14-foot deep, 15-acre detention pond at this location could provide approximately 180 acre-feet of storage. This option was also combined with localized channel improvements on Halls Bayou from Little York to Bretshire. The 100- and 500-year events show maximum depth reductions of up to 0.4 feet and 0.2 feet at Little York Road, respectively, compared to the Baseline Conditions model. There are no adverse impacts when compared to the Baseline Conditions WSEs. The reduction in WSE from Option 6 results in the following performance metrics when compared to the Baseline Conditions model:

TABLE 6: OPTION 6 PERFORMANCE METRICS VERSUS BASELINE CONDITIONS

Performance Metrics	10-year	100-year	500-year
Structures Removed	-	269	59
Miles of Road Removed	-	1.2	0.6
Acres of Land Removed	-	64	21

An Opinion of Probable Cost was not determined for this option, as further negotiations with the City of Houston would be needed before moving forward. However, a general estimate of **\$9 Million** would be appropriate for planning purposes, which includes proposed improvements, planning/engineering/construction costs, and contingency for a similar-sized detention basin.

### 3 2020 Vision Plan vs. Without Projects Condition

In addition to the proposed channel and detention improvements analysis, HCFCD requested LAN compare the Without Projects Condition with the latest Vision Plan from the Halls Bayou Phasing Study. The “Vision Plan” refers to the ultimate 500-year Level-of-Service design for Halls Bayou, which is made up of 58 individual features/projects to be constructed over 12 phases. The purpose of this comparison is to better understand how the Vision Plan works with the addition of Keith-Weiss, Bretshire, and Hall Park basins. Since the initial Mainstem Memo was submitted in July 2020, updates to the Vision Plan have been finalized in the Phasing Study 2020 Update, and therefore this comparison will refer to the latest model. The Without Projects Condition model will also be incorporated into the Halls Bayou Phasing Study as well.

An overall WSE comparison profile is included in Exhibits 7 and 8. From this comparison, the largest increase in benefit from comparing to the Without Projects Condition can be seen near Keith-Weiss Park. Tables 7 and 8 summarize key WSE changes between the different models:

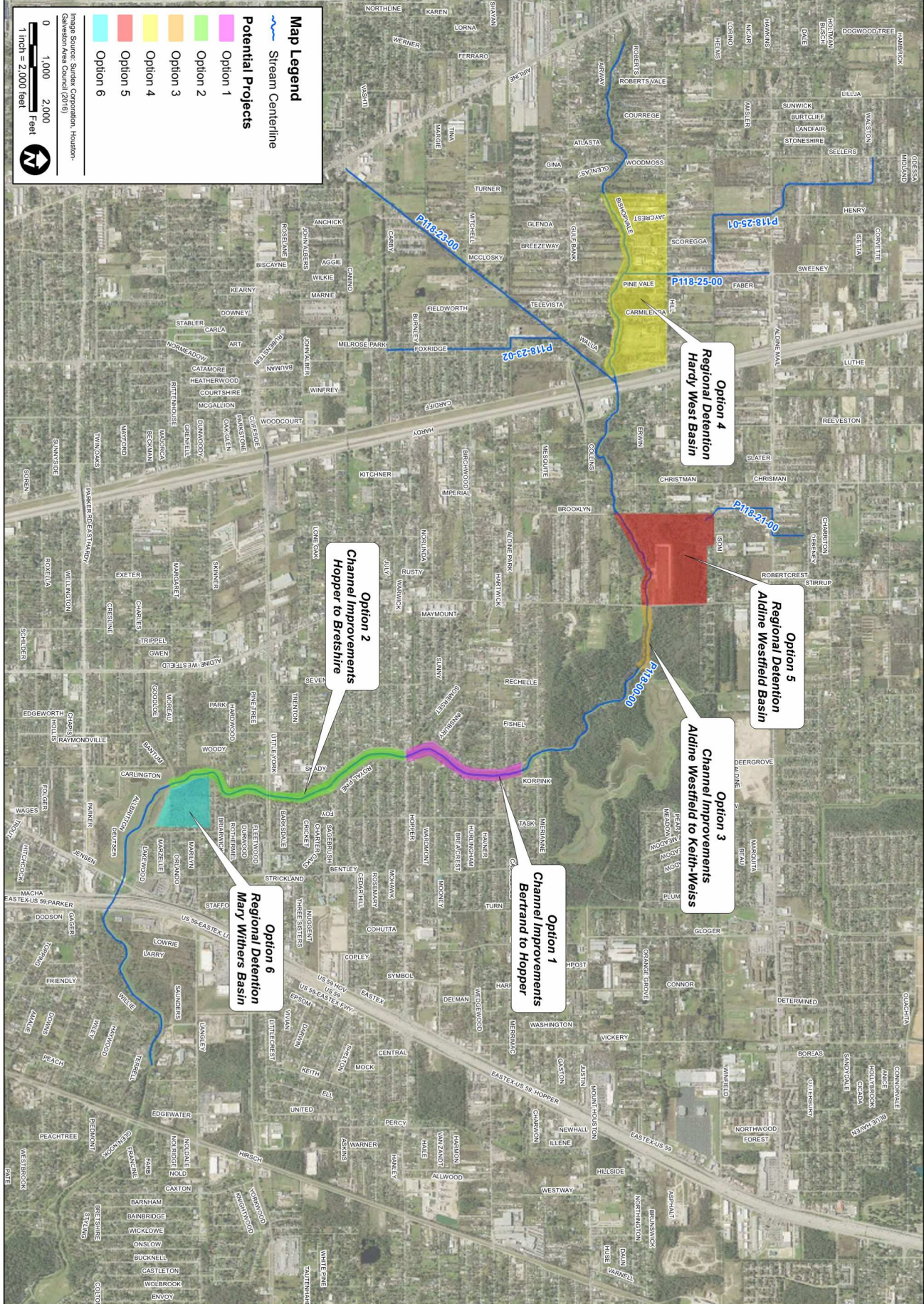
**TABLE 7: WITHOUT PROJECT, BASELINE, AND VISION PLAN 100-YEAR WSE COMPARISON**

River Station	100-Year Water Surface Elevation (feet)		
	Without Projects	Baseline	Vision Plan
60535.46	67.35	66.77	64.04
59423.1	67.00	66.18	63.95
58613.7	66.74	65.73	63.89
57555.5	66.01	64.33	63.13
56513.3	65.09	64.23	61.95
55557.7	64.14	63.98	60.76

**TABLE 8: WITHOUT PROJECT, BASELINE, AND VISION PLAN 500-YEAR WSE COMPARISON**

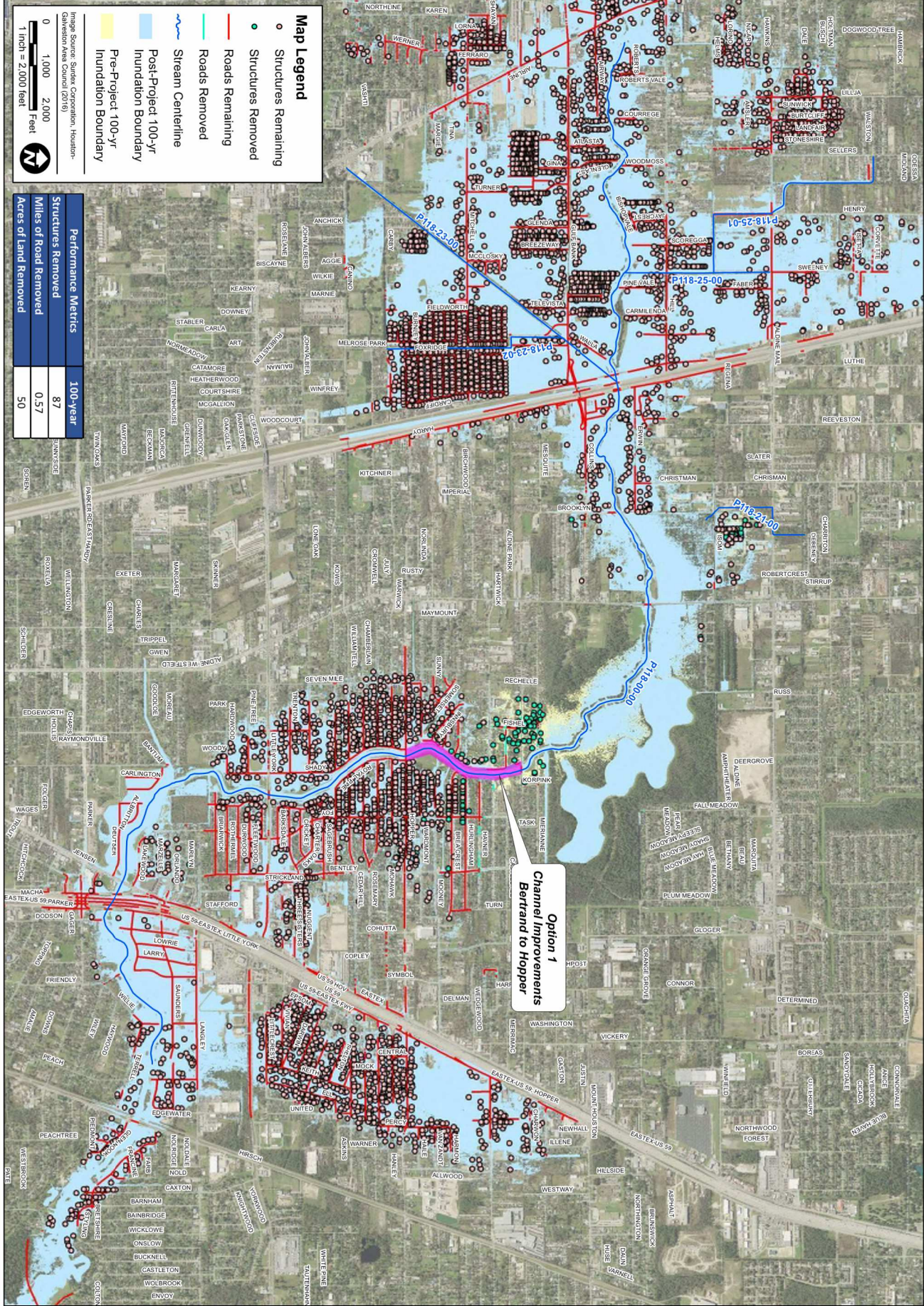
River Station	500-Year Water Surface Elevation (feet)		
	Without Projects	Baseline	Vision Plan
60535.46	68.45	67.93	65.53
59423.1	68.1	67.45	65.42
58613.7	67.83	67.08	65.33
57555.5	67.23	65.42	64.41
56513.3	66.29	64.84	63.58
55557.7	65.48	64.83	62.84

From this comparison, moving the “baseline” of comparison to the Without Project Condition, prior to the construction of Keith-Weiss, Bretshire, and Hall Park, results in an increased reduction in WSE attributed to the Halls Bayou Vision Plan. This method is also being implemented in the Halls Bayou Phasing Study 2020 Update. Keith-Weiss, Bretshire, and Hall Park, along with the Bond Program projects currently being implemented, will be grouped together into “Phase Zero”, representing on-going work in Halls Bayou over the past 10 years. The Phasing Study then provides a road map for the implementation of future projects up to the completion of the Vision Plan.



<p>9900 Northwest Freeway  <b>HARRIS COUNTY</b>  <b>FLOOD CONTROL DISTRICT</b>          Houston, Texas 77092</p>	<p><b>Lockwood, Andrews &amp; Newnam, Inc.</b>          A LEO A DALY COMPANY          TBPE Firm No. 2614          2925 Briarpark Drive • Houston, TX 77042-3720          T 713.266.6900 • F 713.266.0281          www.lan-inc.com • info@lan-inc.com</p>	<p>PREPARED: LM</p>	<p><b>HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS</b></p> <p><b>MAINSTEM OPTIONS OVERVIEW</b></p>
		<p>CHECKED: CEE</p>	
		<p>APPROVED: CEE</p>	
<p>DATE: JUL 2020          SCALE: AS NOTED</p>	<p>EXHIBIT</p>		





**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Map Source: Surdes Corporation, Houston  
 Shaded Relief: ESRI (2019)  
 1 inch = 2,000 feet

**Performance Metrics**

	100-year
Structures Removed	87
Miles of Road Removed	0.57
Acres of Land Removed	50

**Option 1  
 Channel Improvements  
 Bertrand to Hopper**

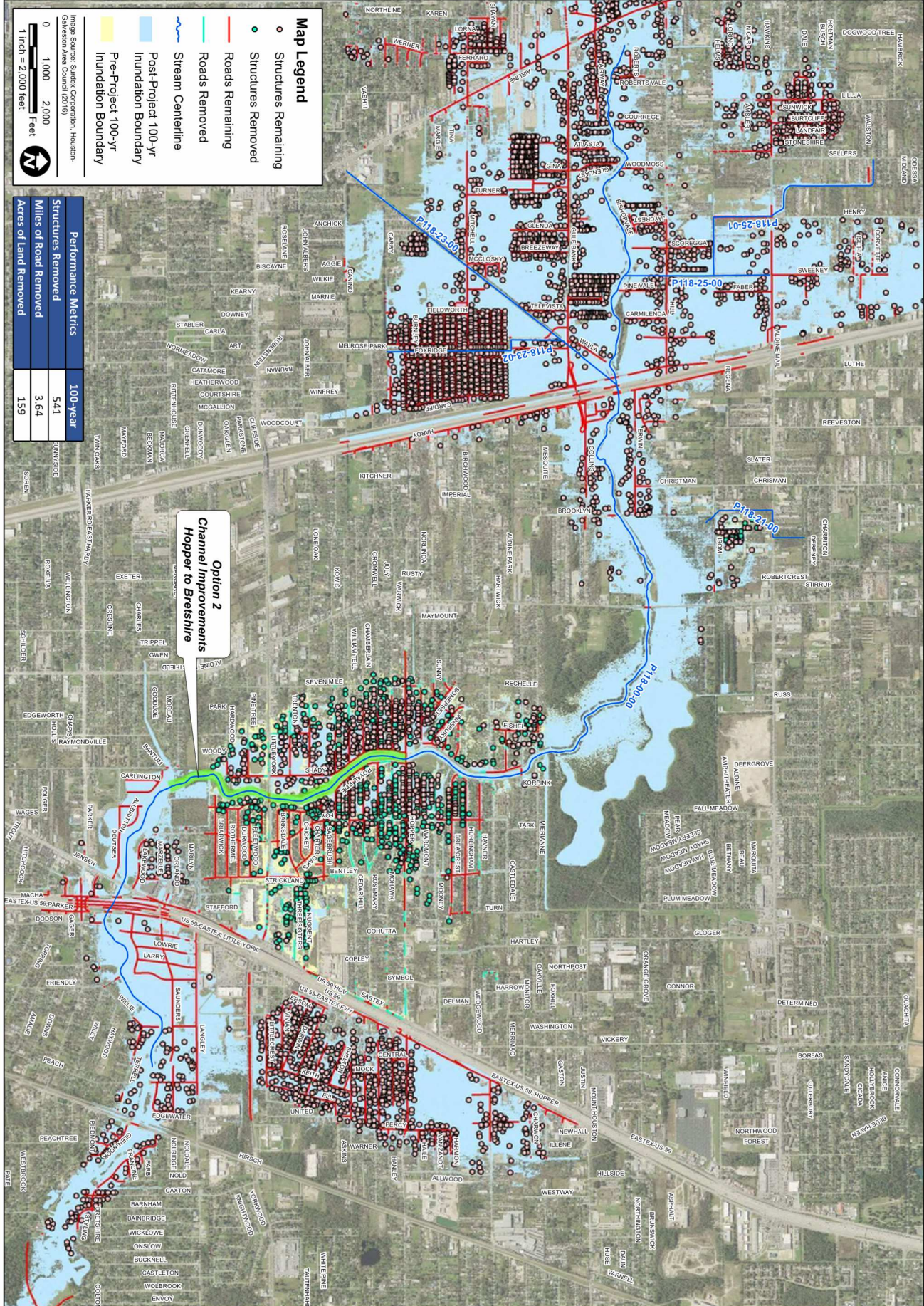
9900 Northwest Freeway  
**HARRIS COUNTY FLOOD CONTROL DISTRICT**  
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 713.266.6900 • F 713.266.0289  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	LM
CHECKED:	CEE
APPROVED:	CEE

**HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS**

**MAINSTEM OPTION 1  
 PERFORMANCE METRICS MAP (100-YEAR)**



**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

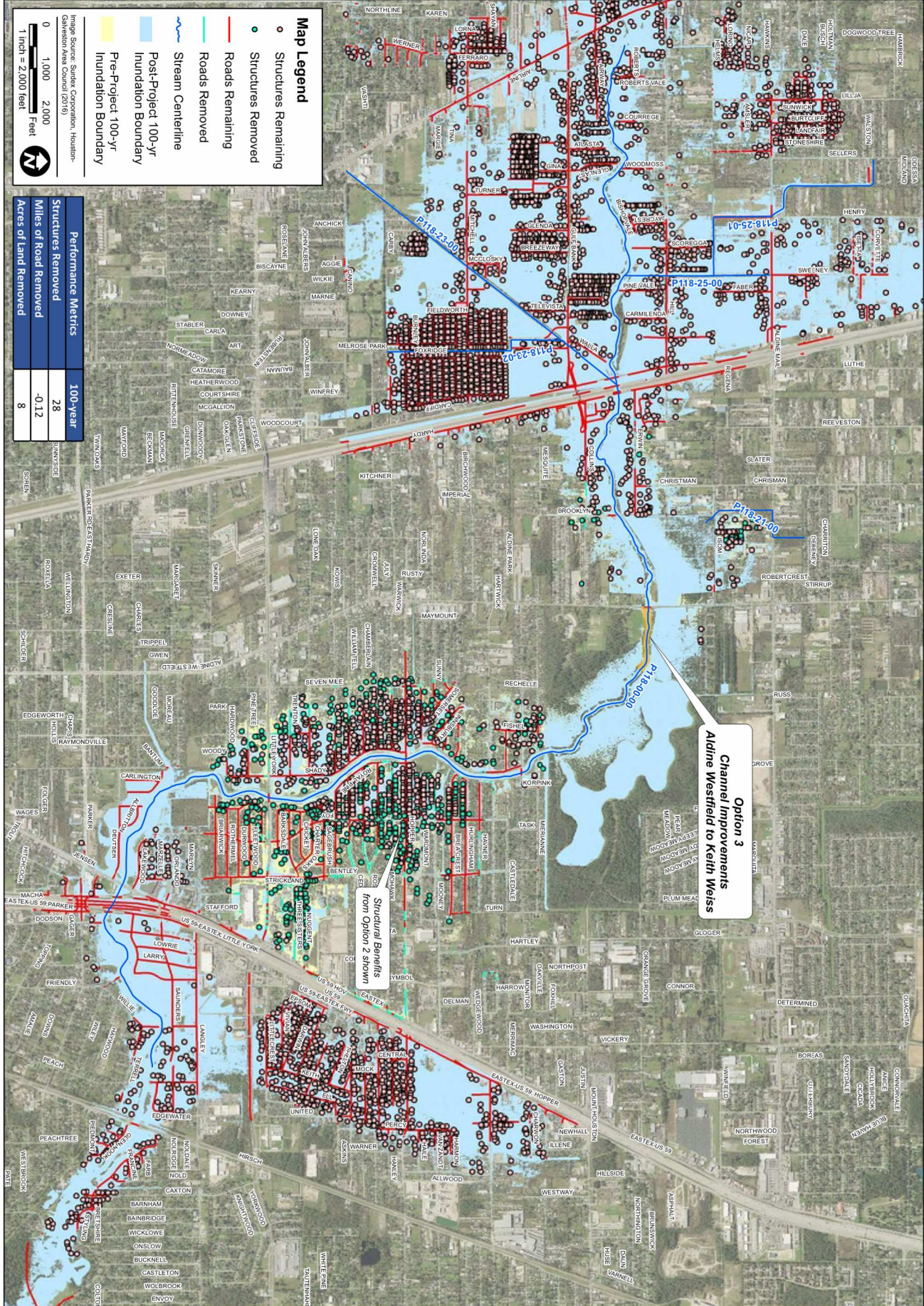
Map Scale:  
 0 1,000 2,000 Feet  
 1 inch = 2,000 feet

**Performance Metrics**

Metric	100-year
Structures Removed	541
Miles of Road Removed	3.64
Acres of Land Removed	159

**Option 2  
 Channel Improvements  
 Hopper to Bretshire**

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		CHECKED: CEE	
		APPROVED: CEE	
DATE: JUL 2020 SCALE: AS NOTED	EXHIBIT		



**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Map Source: Swire Corporation, Houston  
 Shaded Relief: ESRI (2019)  
 1 inch = 2,000 feet

**Performance Metrics**

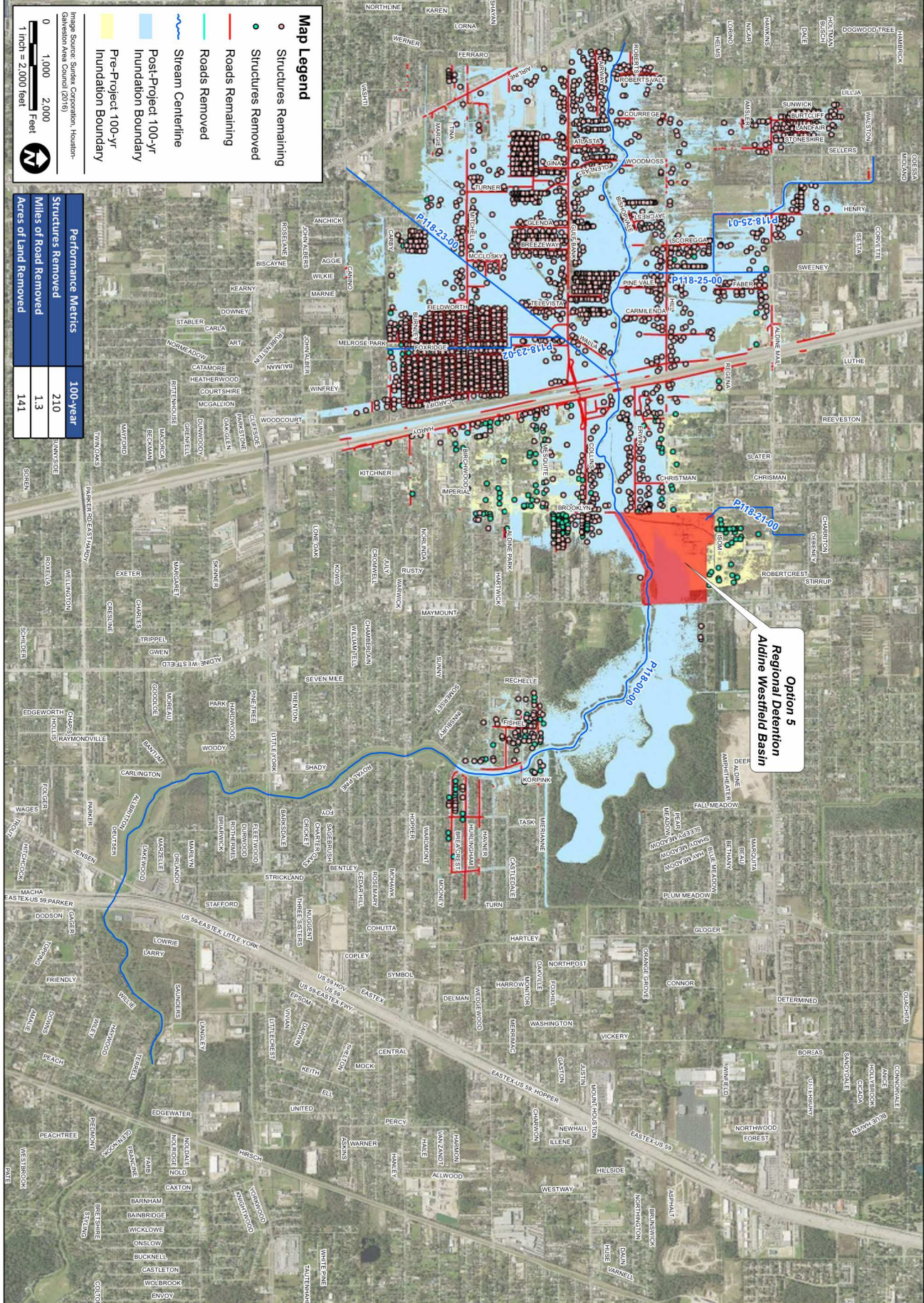
Miles of Road Removed	100-year
28	28
-0.12	-0.12
8	8

Structural Benefits from Option 2 shown

Option 3 Channel Improvements Aldine Westfield to Keith Weiss

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		CHECKED: CEE	
		APPROVED: CEE	
EXHIBIT	DATE: JUL 2020 SCALE: AS NOTED		





**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Scale: 1 inch = 2,000 feet

**Performance Metrics**

Metric	100-year
Structures Removed	210
Miles of Road Removed	1.3
Acres of Land Removed	141

**Option 5  
Regional Detention  
Aldine Westfield Basin**

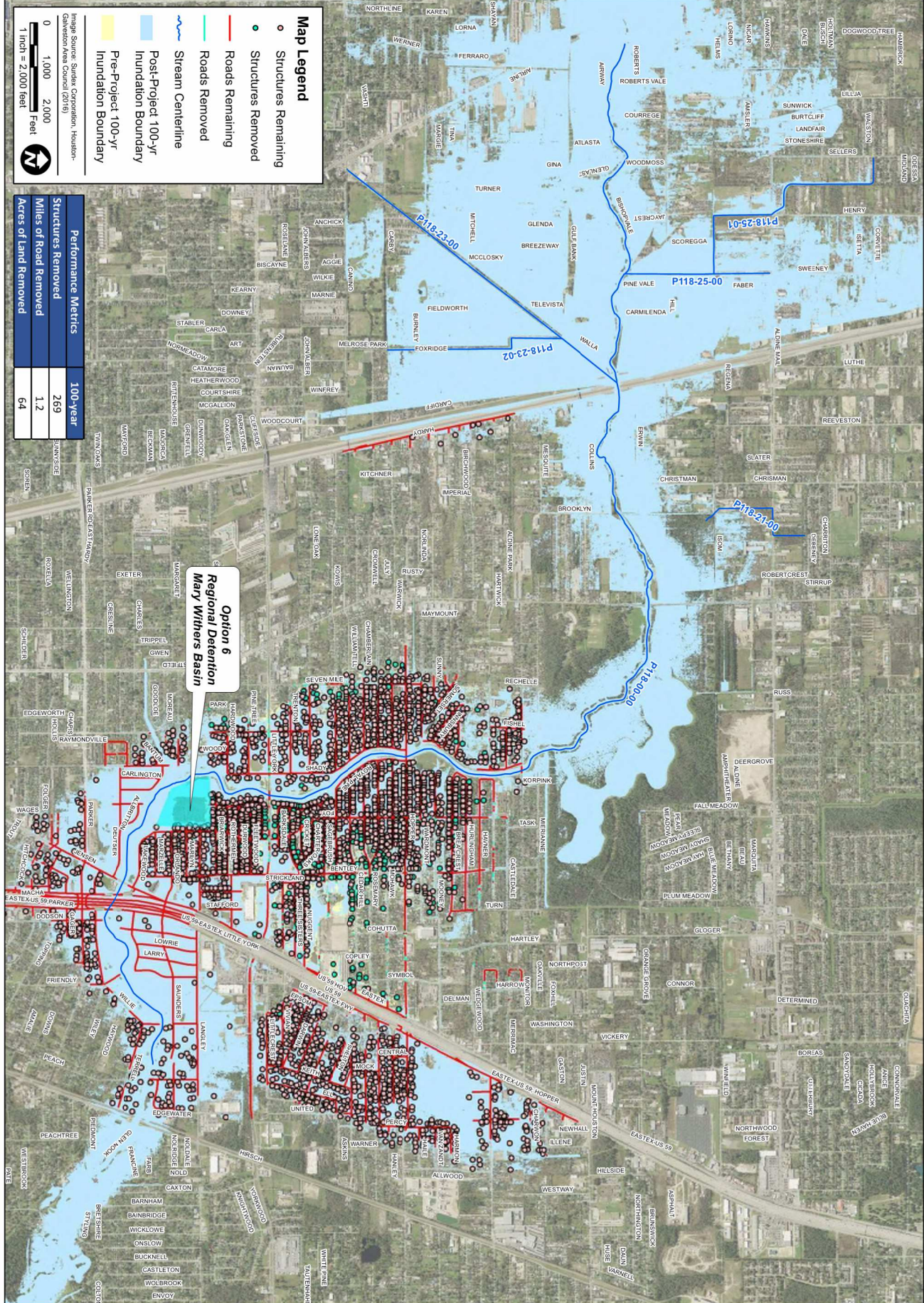
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 713.266.6900 • F 713.266.2081  
 www.lan-inc.com • info@lan-inc.com

PREPARED:	LM
CHECKED:	CEE
APPROVED:	CEE

**HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS**

**MAINSTEM OPTION 5  
PERFORMANCE METRICS MAP (100-YEAR)**



**Map Legend**

- Structures Remaining
- Structures Removed
- Roads Remaining
- Roads Removed
- Stream Centerline
- Post-Project 100-yr Inundation Boundary
- Pre-Project 100-yr Inundation Boundary

Map Source: Sunda Corporation, Houston  
 Screenshot Date: 8/19/19  
 1 inch = 2,000 feet

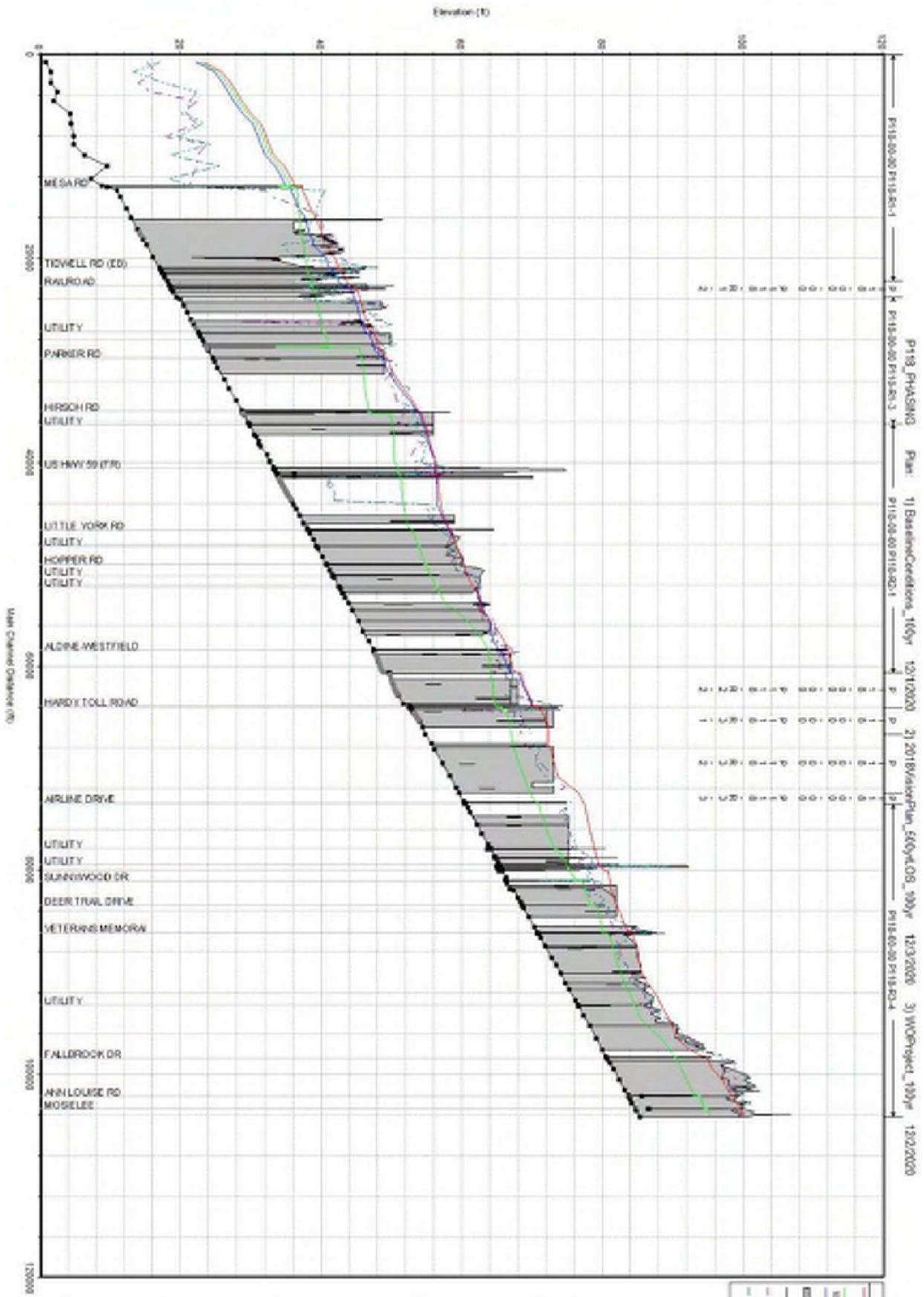
**Performance Metrics**

	100-year
Structures Removed	259
Miles of Road Removed	1.2
Acres of Land Removed	64

**Option 6**  
 Regional Detention  
 Mary Withers Basin

<p><b>HARRIS COUNTY FLOOD CONTROL DISTRICT</b>                  9900 Northwest Freeway                  Houston, Texas 77032</p>	<p><b>Lockwood, Andrews &amp; Newnam, Inc.</b>                  A LEO A DALY COMPANY                  TBPE Firm No. 2614                  2925 Briarpark Drive • Houston, TX 77042-3720                  713.266.6900 • F 713.266.2081                  www.lan-inc.com • info@lan-inc.com</p>	PREPARED: LM	<p><b>HALLS MAINSTEM STORMWATER DETENTION BASIN AND CHANNEL IMPROVEMENTS</b></p> <p><b>MAINSTEM OPTION 6</b>                  PERFORMANCE METRICS MAP (100-YEAR)</p>
		CHECKED: CEE	
		APPROVED: CEE	
EXHIBIT	DATE: JUL 2020 SCALE: AS NOTED		

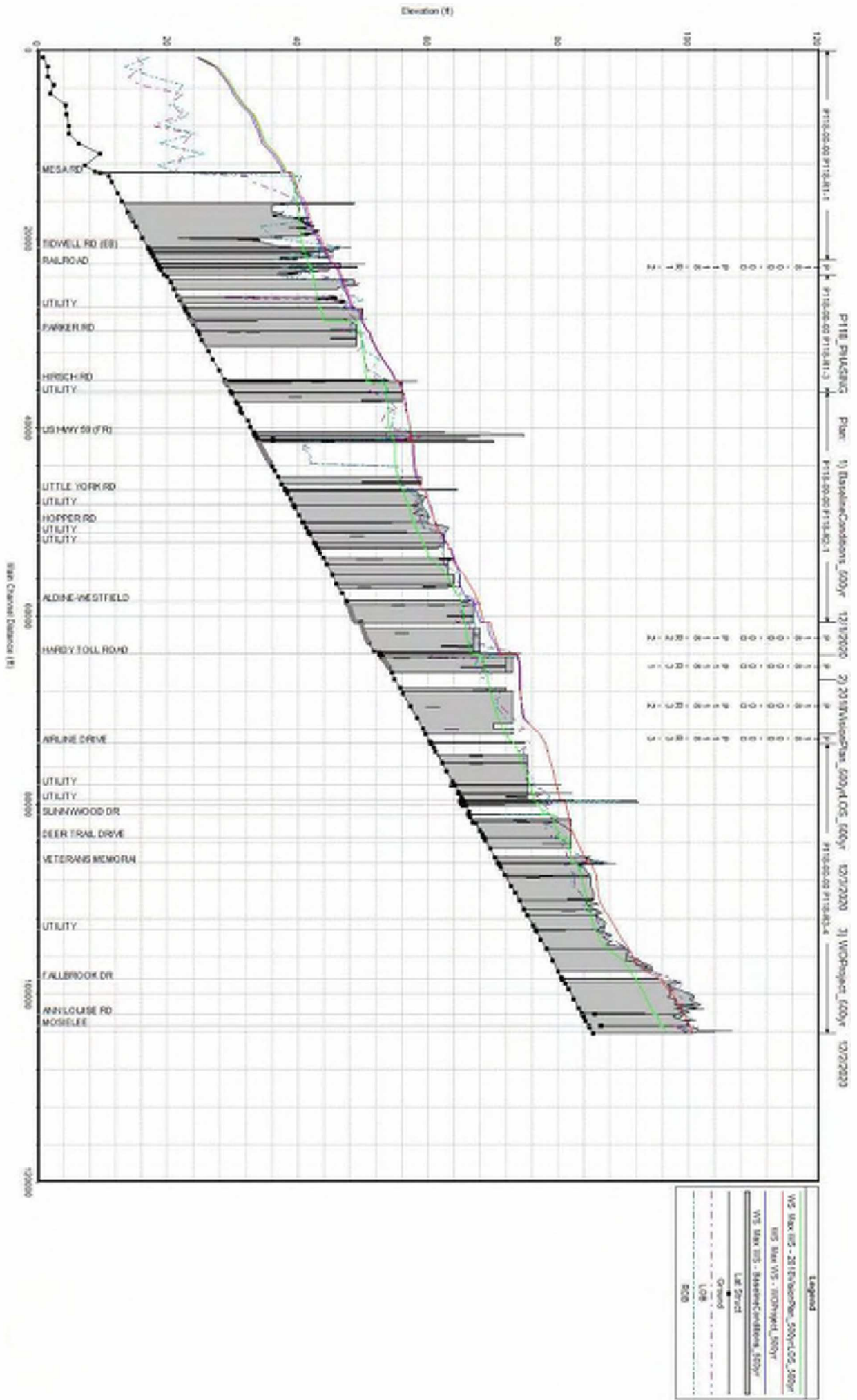
# EXHIBIT 7 - 100-year WSE Vision Plan Comparison



**Legend**

- WSE Max 100 - WCPProject\_100yr
- WSE Max 100 - 2018WaterPlan\_500yrLOE\_100yr
- WSE Max 100 - Base/Conditions\_100yr
- L&S
- Ground
- NOE

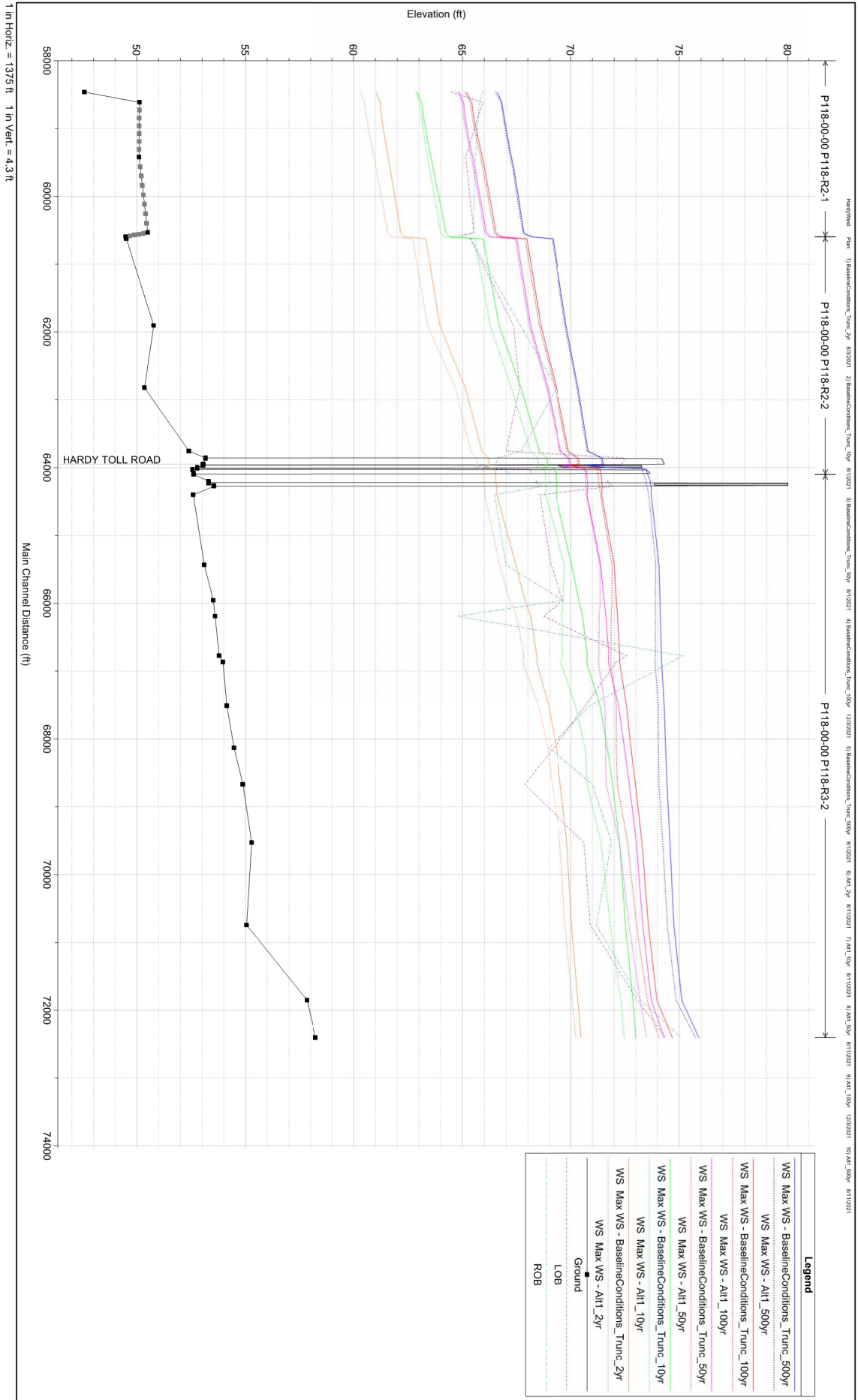
# EXHIBIT 8 - 500-year WSE Vision Plan Comparison





# **Appendix E**

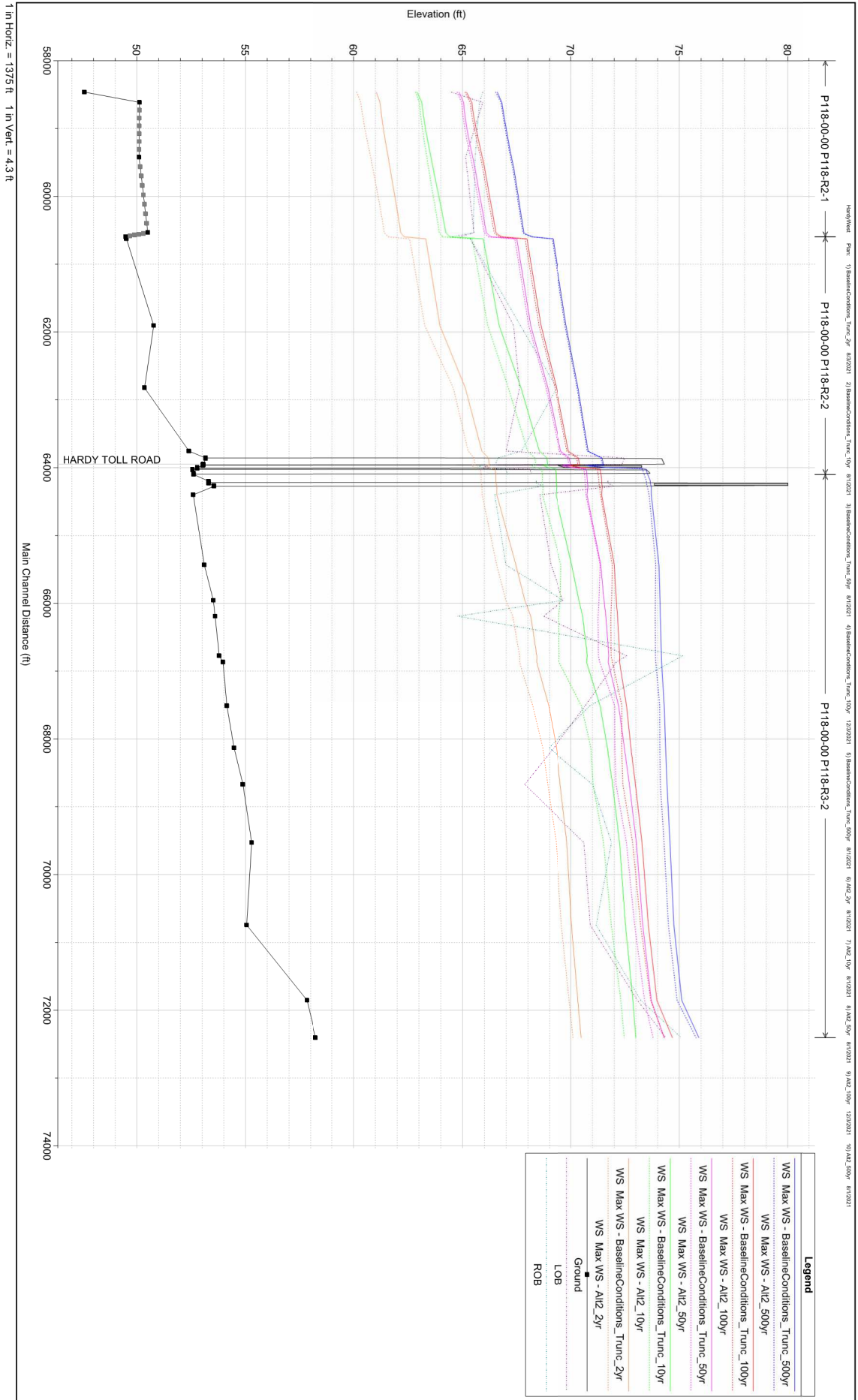
Water Surface Profile Comparisons – Alternative 1 vs. Baseline Conditions



Legend	
WS Max WS - BaselineConditions_Trunc_500yr	.....
WS Max WS - Alt1_500yr	.....
WS Max WS - BaselineConditions_Trunc_100yr	.....
WS Max WS - Alt1_100yr	.....
WS Max WS - BaselineConditions_Trunc_50yr	.....
WS Max WS - Alt1_50yr	.....
WS Max WS - BaselineConditions_Trunc_10yr	.....
WS Max WS - Alt1_10yr	.....
WS Max WS - BaselineConditions_Trunc_2yr	.....
WS Max WS - Alt1_2yr	.....
Ground	.....
LOB	.....
ROB	.....

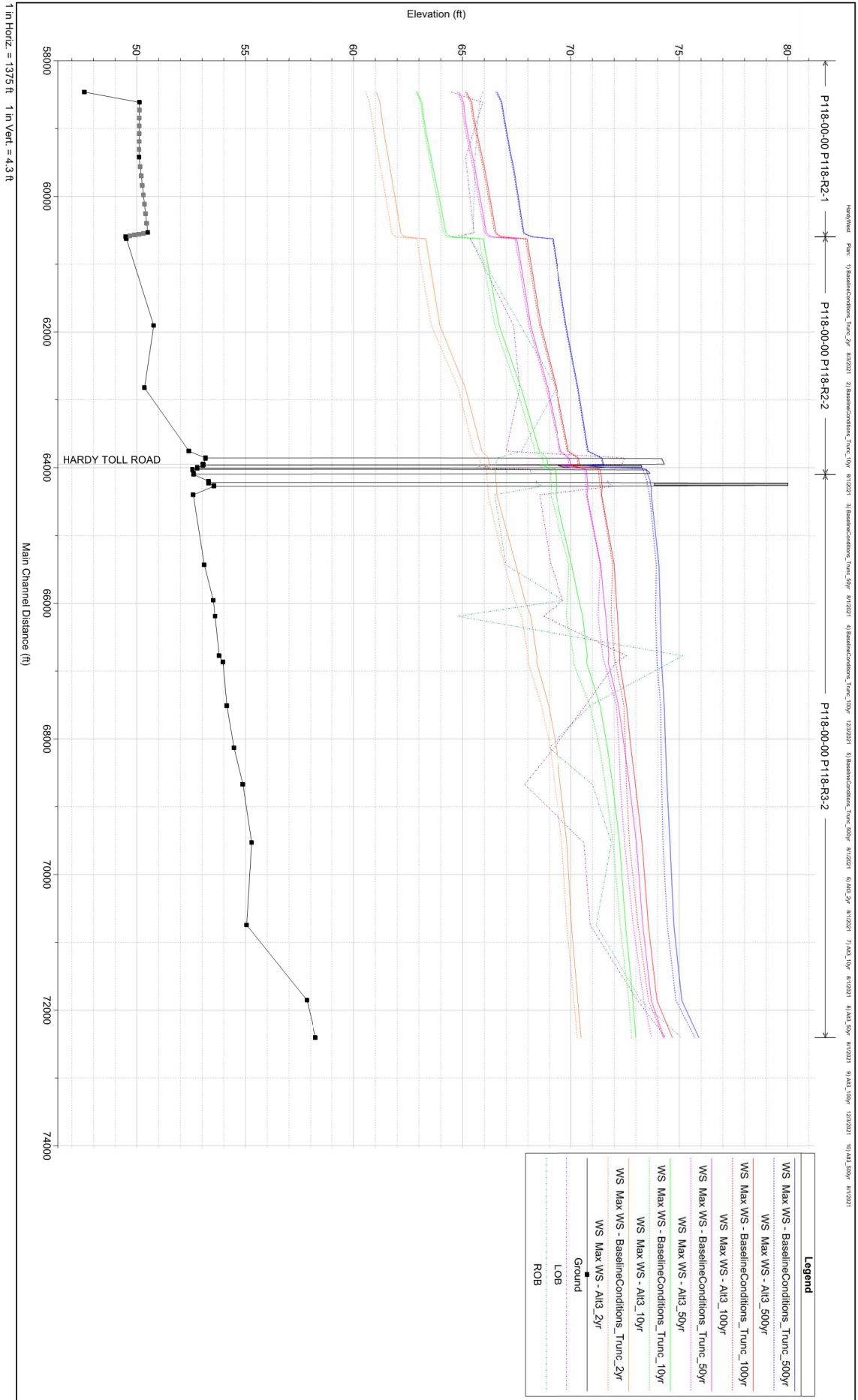
# **Appendix F**

Water Surface Profile Comparisons – Alternative 2 vs. Baseline Conditions



# **Appendix G**

Water Surface Profile Comparisons – Alternative 3 (Recommended) vs.  
Baseline Conditions



# **Appendix H**

Proposed ROW for Recommended Alternative

**Hardy West Detention Basin Alternative 3 - ROW Acquisition Costs**

*Valuation Data based on 2021 HCAD Number <http://hcad.org/> (Real Property Records)*

HCAD #	Parcel Area	Parcel Area within ROW	Parcel Area Used	Current Owner	Address	Property Type	Valuations (as of June 2021)	Multiplier	Full Acquisition Cost	Partial Acquisition Cost	Full or Partial	Relocation	Total ROW Acquisition Cost
(#)	(sq)	(sq)	(%)	(#)	(#)	(#)	(\$)	(#)	(\$)	(\$)		(\$)	(\$)
0552280120001	2.90	1.83	63%	CAMPUZANO DAVID	726 HILL RD	Commercial	\$ 516,655.00	3	\$ 1,549,395.00	\$ 976,633.43	Partial	\$ 2,500.00	\$ 1,029,133.43
0552280120002	3.77	2.25	60%	MUNOZ JOHN SR	810 HILL RD	RSF	\$ 324,383.00	3	\$ 973,008.00	\$ 580,301.47	Partial	\$ 2,500.00	\$ 632,801.47
0552280120003	3.78	2.33	62%	CAMPUZANO J GUSTAVO	806 HILL RD	Residential - Mobile Homes	\$ 100,000.00	1.15	\$ 115,000.00	\$ 70,917.75	Partial	\$ -	\$ 70,917.75
0552280130002	5.10	3.36	66%	LDI CONNIE W	720 HILL RD	RSF	\$ 144,308.00	3	\$ 433,924.00	\$ 285,251.14	Partial	\$ -	\$ 285,251.14
0552280130002	4.85	3.11	64%	PIETSCH AARON LEO & TANVA	722 HILL RD	Residential - Auxiliary Buildings	\$ 86,997.00	3	\$ 260,871.00	\$ 167,459.27	Partial	\$ -	\$ 167,459.27
0552280140001	4.99	3.33	67%	SEYMORE JERRY Z	712 HILL RD	RSF	\$ 453,657.00	3	\$ 1,360,971.00	\$ 560,256.46	Partial	\$ 25,000.00	\$ 934,238.26
0552290000033	4.72	3.68	78%	HERNANDEZ NESTOR	1214 HILL RD	Commercial	\$ 239,636.00	3	\$ 718,908.00	\$ 509,238.26	Partial	\$ -	\$ 509,238.26
0552290000034	4.27	3.24	76%	CASTILLO MARIA C	1202 HILL RD	Other Commercial	\$ 177,471.00	3	\$ 532,413.00	\$ 403,963.55	Partial	\$ -	\$ 403,963.55
0552290000036	0.50	0.50	100%	HARRIS COUNTY ELOOD CONTROL DISTRICT	0 HILL RD	Other Exempt (Government)	\$ -	3	\$ -	\$ -	Full	\$ -	\$ -
0552290000037	7.90	5.98	76%	CASTILLO MARIA C	1120 HILL RD	Commercial	\$ 383,313.00	3	\$ 1,149,939.00	\$ 871,412.75	Partial	\$ 52,500.00	\$ 923,912.75
0552290000039	0.68	0.68	100%	LAGUNAS PROSPERO	13602 CARWILLELINDA ST	Commercial	\$ 207,485.00	3	\$ 622,455.00	\$ 622,455.00	Full	\$ -	\$ 622,455.00
0552290000040	0.56	0.56	100%	EKINS REBEKAH	13506 CARWILLELINDA ST	Vacant Lots/Tracts (Not in City)	\$ 11,828.00	3	\$ 35,484.00	\$ 35,484.00	Full	\$ -	\$ 35,484.00
0552290000041	3.18	2.48	78%	CAMPUZANO J GUSTAVO	1042 HILL RD	Residential - Mobile Homes	\$ 54,000.00	3	\$ 162,000.00	\$ 126,452.91	Partial	\$ -	\$ 126,452.91
0552290000043	0.42	0.42	100%	FERNANDEZ CARLOS	13514 CARWILLELINDA ST	RSF	\$ 40,657.00	1.15	\$ 46,755.55	\$ 46,755.55	Full	\$ -	\$ 46,755.55
0552290000044	5.21	4.16	80%	CAMPUZANO J GUSTAVO	1038 HILL RD	RSF	\$ 155,000.00	3	\$ 465,000.00	\$ 371,072.37	Partial	\$ 141,244.45	\$ 188,000.00
0552290000049	5.57	4.65	84%	CAMPUS SIMON III	1028 HILL RD	Vacant Lots/Tracts (Not in City)	\$ 203,141.00	3	\$ 609,423.00	\$ 406,721.21	Partial	\$ -	\$ 406,721.21
0552290000050	2.65	1.92	72%	MET HOLDING GROUP LLC	922 HILL RD	Commercial	\$ 187,196.00	3	\$ 561,588.00	\$ 406,721.21	Partial	\$ -	\$ 406,721.21
0552290000053	10.22	7.99	79%	YANES HECTOR R	904 HILL RD	Commercial	\$ 1,139,132.00	3	\$ 3,417,396.00	\$ 2,701,681.63	Partial	\$ 100,000.00	\$ 2,801,681.63
0552290000152	0.50	0.50	100%	CASTILLO MARIA C	1120 HILL RD	Vacant Commercial	\$ 17,969.00	3	\$ 53,907.00	\$ 53,907.00	Full	\$ -	\$ 53,907.00
0552290000154	0.50	0.50	100%	CASTILLO MARIA	1120 HILL RD	Vacant Commercial	\$ 17,969.00	3	\$ 53,907.00	\$ 53,907.00	Full	\$ -	\$ 53,907.00
0552290000156	0.98	0.98	100%	CASTILLO MARIA	1120 HILL RD	Vacant Commercial	\$ 30,253.00	3	\$ 90,759.00	\$ 90,759.00	Full	\$ -	\$ 90,759.00
0552290000202	4.66	4.23	91%	KE INUS I	1218 HILL RD	Commercial	\$ 171,171.00	3	\$ 513,513.00	\$ 465,802.10	Partial	\$ 200,000.00	\$ 665,802.10
0552290000235	0.93	0.93	100%	FRANCO MELIDA G	13602 CARWILLELINDA ST	RSF	\$ 188,956.00	1.15	\$ 216,264.40	\$ 216,264.40	Full	\$ -	\$ 216,264.40
0552290000236	0.44	0.44	100%	EKINS REBEKAH	13506 CARWILLELINDA ST	RSF	\$ 91,658.00	1.15	\$ 105,406.70	\$ 105,406.70	Full	\$ -	\$ 105,406.70
0552290000237	0.13	0.13	100%	GALINDO-GARCIA FABIANA A	13602 CARWILLELINDA ST	Vacant Commercial	\$ 825.00	3	\$ 2,475.00	\$ 2,475.00	Full	\$ -	\$ 2,475.00
0552290000238	0.21	0.21	100%	TAMPEZ ROLANDO CAVAZOS & MARIA C	13510 CARWILLELINDA ST	RSF	\$ 1,368.00	3	\$ 4,104.00	\$ 4,104.00	Full	\$ -	\$ 4,104.00
0552290000270	0.26	0.26	100%	TAMPEZ ROLANDO CAVAZOS & MARIA C	13510 CARWILLELINDA ST	RSF	\$ 23,585.00	3	\$ 70,749.00	\$ 70,749.00	Full	\$ 25,000.00	\$ 95,749.00
0920450000007	0.51	0.51	100%	SERRA USHEL M.	13607 JAYCREST DR	RSF	\$ 187,334.00	1.15	\$ 215,434.10	\$ 215,434.10	Full	\$ -	\$ 215,434.10
0920450000009	0.68	0.68	100%	TAYLOR LINDA J	13603 JAYCREST DR	RSF	\$ 160,160.00	1.15	\$ 184,184.00	\$ 184,184.00	Full	\$ -	\$ 184,184.00
0920460000007	0.66	0.16	24%	MARTINEZ JORGE L & MARIA F	13614 JAYCREST DR	RSF	\$ 201,037.00	1.15	\$ 231,192.55	\$ 54,850.56	Partial	\$ 8,000.00	\$ 192,184.00
0920460000009	0.24	0.24	100%	QUINTANA J SANTOS & OBDULIA	839 BISHOPVALE DR	RSF	\$ 105,702.00	1.15	\$ 121,557.30	\$ 121,557.30	Full	\$ 91,442.70	\$ 213,000.00
0920460000010	0.24	0.24	100%	SALAS JESSICA	835 BISHOPVALE DR	Residential - Mobile Homes	\$ 34,162.00	1.15	\$ 39,286.30	\$ 39,286.30	Full	\$ 25,000.00	\$ 64,286.30
0920470000002	0.34	0.34	100%	THERO IDIUTIA	822 BISHOPVALE DR	RSF	\$ 140,390.00	1.15	\$ 162,079.85	\$ 162,079.85	Full	\$ -	\$ 162,079.85
0920470000003	0.31	0.31	100%	FRANCS LINDA T	826 BISHOPVALE DR	RSF	\$ 136,300.00	1.15	\$ 155,745.00	\$ 155,745.00	Full	\$ 42,755.00	\$ 188,000.00
0920470000005	0.40	0.40	100%	FRANCS KENNETH C JR	830 BISHOPVALE DR	Residential - Auxiliary Buildings	\$ 16,437.00	1.15	\$ 18,902.55	\$ 18,902.55	Full	\$ 25,000.00	\$ 43,902.55
0920470000008	0.47	0.47	100%	FRANCS KENNETH C III	838 BISHOPVALE DR	RSF	\$ 228,927.00	1.15	\$ 263,266.05	\$ 263,266.05	Full	\$ 8,000.00	\$ 271,266.05
0920470000009	0.47	0.47	100%	HARRELL FARON B & SANDRA R	10514 WOODMOSS DR	RSF	\$ 162,385.00	1.15	\$ 186,742.75	\$ 186,742.75	Full	\$ -	\$ 186,742.75
0920470000005	0.95	0.95	100%	MARILLIO MARCELIANO	10506 WOODMOSS DR	RSF	\$ 218,536.00	1.15	\$ 251,316.40	\$ 251,316.40	Full	\$ 8,000.00	\$ 259,316.40
0920470000011	0.40	0.40	100%	FRANCSA RADELIA	10530 WOODMOSS DR	Residential - Mobile Homes	\$ 18,399.00	1.15	\$ 21,158.85	\$ 21,158.85	Full	\$ -	\$ 21,158.85
				<b>Total:</b>									

General notes:

- (1) The estimates shown above are to be used for planning purposes only and are not based on actual appraisals or other cost guides.
- (2) \$180,000 for a replacement home is a general estimate based on current market conditions.
- (3) Adding a 3.0 multiplier/15% contingency provides a general estimate. Actual values will be based on a fair market value appraisals according to USPAP guidelines.
- (4) Relocation costs are calculated on a case by case basis according to UDA guidelines. Estimates shown above are based on examples from other projects and past experience, but actual amounts will vary.



# **Appendix I**

HCFCO Project Scoring Documentation

**Harris County Flood Control District Project Scoring Form**  
**Hardy West Alternatives Analysis**

**SCORING CRITERIA:**      **1**      **2**      **3**      **4**      **5**      **6**      **7**      **8**

*Weight:*      *25%*      *20%*      *20%*      *10%*      *10%*      *5%*      *5%*      *5%*

Project Area:	Project ID:	Flood Risk (100-Year Event) Reduction	Existing Conditions Drainage LOS	Social Vulnerability Index (SVI)	Project Efficiency	Partnership Funding	Long Term Maintenance Costs	Minimize Environmental Impacts	Potential for Multiple Benefits	TOTAL SCORE
Alt #1	P118-00-00	2.50	2.00	2.00	0.25	0.00	0.50	0.30	0.20	<b>7.75</b>
Alt #2	P118-00-00	2.50	2.00	2.00	0.25	0.00	0.50	0.30	0.05	<b>7.60</b>
Alt #3	P118-00-00	1.99	2.00	2.00	0.24	0.00	0.50	0.30	0.20	<b>7.23</b>

**Harris County Flood Control District Project Scoring Form**

<b>USERS:</b> Only type in cells that are ORANGE shaded. GREY cells are automatic calculations (Do not type in these cells)		<b>NOTES:</b>													
* YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the		Prioritization Scoring Framework VERSION: July 27, 2021 (6-8)													
<b>TOTAL PROJECT SCORE:</b>		<b>7.75</b>													
Project Area:		Alt #1													
Project ID:		P118-00-00													
Project Name:		Hardy West Alternatives Analysis													
Project Manager:		David Barton, P.E., CFM													
Project Watershed:		(P) Halls Bayou													
1. What is the OVERALL project cost?	\$ 51,378,816 USD.	\$ 51,378,816	DISTRICT COST (After Partnership / Grant)												
2. Does the project have potential for PARTNERSHIP or GRANT funding?	No funding partner or grant.														
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?	0% If unknown, enter "0%"														
3a. How many structures are subject to flooding in the BASELINE (existing) condition?	<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>907</td> <td>1914</td> <td>2113</td> </tr> </table>			EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	907	1914	2113				
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)												
# of Structures	907	1914	2113												
3b. How many structures are proposed to have the FULL BENEFIT of floodplain removal for the respective events?	<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>233</td> <td>271</td> <td>183</td> </tr> </table>			EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	233	271	183				
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)												
# of Structures	233	271	183												
3c. How many structures have a proposed PARTIAL BENEFIT floodplain depth reduction GREATER than 0.25-feet?	<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>135</td> <td>675</td> <td>1001</td> </tr> </table>			EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	135	675	1001				
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)												
# of Structures	135	675	1001												
4. How many linear feet of channel in the Project area have a ROW WIDTH less than 110-ft wide?	1,280	FEEET	0.24 MILES												
5. What is the CDC Social Vulnerability Index (SVI) of the observed Project Area?	<table border="1"> <tr> <td>Area (Acres)</td> <td>Percentage</td> <td>Project Area: Alt #1</td> </tr> <tr> <td>5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?</td> <td>0%</td> <td rowspan="4">96 acres</td> </tr> <tr> <td>5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?</td> <td>0</td> </tr> <tr> <td>5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?</td> <td>0</td> </tr> <tr> <td>5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?</td> <td>96</td> </tr> </table>			Area (Acres)	Percentage	Project Area: Alt #1	5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?	0%	96 acres	5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?	0	5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?	0	5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?	96
Area (Acres)	Percentage	Project Area: Alt #1													
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?	0%	96 acres													
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?	0														
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?	0														
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?	96														
6. What is the qualitative expectation of the projects need for LONG TERM MAINTENANCE?	No requirements for special maintenance have been identified.														
7. What is/are the project's potential ENVIRONMENTAL impacts?	0.1 to 0.5 acres of wetlands expected to be impacted														
Is there any knowledge of CULTURAL ARTIFACTS?	No														
8a. What is the projects potential to offer RECREATIONAL FEATURES as a benefit?	50% of the Project has potential for recreational features														
8b. What is the projects potential to offer ENVIRONMENTAL ENHANCEMENTS as a benefit?	50% of the Project has potential for environmental enhancements														

P118-00-00, PM: David Barton, P.E., CFM	Alt #1	(P) Halls Bayou	Form Answers		Project Score:	7.75		
<b>PRIORITIZATION FRAMEWORK SCORING CRITERIA</b>								
<b>Structure Flooding Reduction Scoring Criteria:</b>						<b>SCORE</b>	<b>WEIGHT</b>	<b>WEIGHTED SCORE</b>
1	Structures Fully Benefited	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)	TOTAL	10.00	25%	2.50
	Structures Fully Benefited	0.025	0.005	0.0025	7.638			
	Structures Partially Benefited (Min. 0.25' depth)	5.825	1.355	0.458	4.927	10.00		
		0.0125	0.0025	0.00125				
		1.688	1.688	1.251				
<b>Existing Conditions Drainage Level of Service Scoring Criteria:</b>						<b>SCORE</b>	<b>WEIGHT</b>	<b>WEIGHTED SCORE</b>
2	Structures in Existing Floodplain	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)	TOTAL	10.00	20%	2.00
	Channel Length	0.025	0.005	0.0025	37.528	10.0		
		22.675	9.570	5.283				
		1.280	0.24		0.2			
<b>Social Vulnerability Index (SVI) for Project Area:</b>						<b>SCORE</b>	<b>WEIGHT</b>	<b>WEIGHTED SCORE</b>
3	SVI indicates low level of vulnerability (less than 0.25)	0	0.10%			10.00	20%	2.00
	SVI indicates moderate to high level of vulnerability (Between 0.2501 and 0.5)	4	0.10%					
	SVI indicates high level of vulnerability (Greater than 0.7501)	7	0.07%					
		10	100.00%					
<b>Project Efficiency Scoring Criteria:</b>						<b>SCORE</b>	<b>WEIGHT</b>	<b>WEIGHTED SCORE</b>
4	Structures Fully Benefited	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)	TOTAL	2.54	10%	0.25
	Structures Partially Benefited (Min. 0.25' depth)	1.206	0.281	0.095	1.582	2.54		
		0.5	0.7	0.05				
		0.349	0.349	0.259	0.957			
<b>Partnership Funding Scoring Criteria:</b>						<b>SCORE</b>	<b>WEIGHT</b>	<b>WEIGHTED SCORE</b>
5	No funding partner or grant.	0				0.00	10%	0.00
	Potential for partnership/ grant is Unknown or expected to be less than 5% of Project Cost	2						
	Partnership or Grant funding is expected to cover 5% - 30% of Project Costs	4						
	Partnership or Grant funding is expected to cover 30% - 60% of Project Costs	6						
	Partnership or Grant funding is expected to cover 60% - 90% of Project Costs	8						
	Partnership or Grant funding is expected to cover 90% or more of Project Costs	10						
<b>Long Term Maintenance Costs Scoring Criteria:</b>						<b>SCORE</b>	<b>WEIGHT</b>	<b>WEIGHTED SCORE</b>
6	Project is expected to require extensive or specialized maintenance that will incur costs and will incur some additional costs.	0				10.00	5%	0.50
	Project is expected to require maintenance outside of District's regular maintenance practices and will incur some additional costs.	6						
	No requirements for special maintenance have been identified.	10						
<b>Minimize Environmental Impacts Scoring Criteria:</b>						<b>SCORE</b>	<b>WEIGHT</b>	<b>WEIGHTED SCORE</b>
7	No known wetland impacts	10				6.00	5%	0.30
	Less than 0.1 acres of wetlands expected to be impacted or wetland impacts are not known	8						
	0.1 to 0.5 acres of wetlands expected to be impacted	6						
	0.5 to 2 acres of wetlands expected to be impacted	4						
	2 to 5 acres of wetlands expected to be impacted	2						
	More than 5 acres of wetlands expected to be impacted	0						
<b>Potential for Multiple Benefits Scoring Criteria:</b>						<b>SCORE</b>	<b>WEIGHT</b>	<b>WEIGHTED SCORE</b>
8	50% of the Project is not expected to have potential for recreational features	0				4.00	5%	0.20
	50% of the Project has potential for recreational features	1						
	A possible partner has been identified for potential recreational features over 50% of the Project	2						
	A partner is expected to commit funding for potential recreational features over 50% of the Project	3						
	50% of the Project is not expected to have environmental enhancement	0						
	50% of the Project has potential for environmental enhancements	3						
	A possible partner has been identified for potential environmental enhancements over 50% of the Project	4						
	A partner is expected to commit funding for potential environmental enhancements over 50% of the Project	7						

**Harris County Flood Control District Project Scoring Form**

<b>USERS:</b> Only type in cells that are ORANGE shaded. GREY cells are automatic calculations (Do not type in these cells)		<b>NOTES:</b>														
* YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the		Prioritization Scoring Framework VERSION: July 27, 2021 (6-8)														
<b>TOTAL PROJECT SCORE:</b>		<b>7.60</b>														
Project Area:		Alt #2														
Project ID:		P118-00-00														
Project Name:		Hardy West Alternatives Analysis														
Project Manager:		David Barton, P.E., CFM														
Project Watershed:		(P) Halls Bayou														
1. What is the OVERALL project cost?	\$ 49,250,706 USD.	\$ 49,250,706	DISTRICT COST (After Partnership / Grant)													
2. Does the project have potential for PARTNERSHIP or GRANT funding?	No funding partner or grant.															
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?	0% If unknown, enter "0%"															
3a. How many structures are subject to flooding in the BASELINE (existing) condition?	<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>907</td> <td>1914</td> <td>2113</td> </tr> </table>			EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	907	1914	2113					
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)													
# of Structures	907	1914	2113													
3b. How many structures are proposed to have the FULL BENEFIT of floodplain removal for the respective events?	<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>255</td> <td>225</td> <td>163</td> </tr> </table>			EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	255	225	163					
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)													
# of Structures	255	225	163													
3c. How many structures have a proposed PARTIAL BENEFIT floodplain depth reduction GREATER than 0.25-feet?	<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>116</td> <td>591</td> <td>629</td> </tr> </table>			EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	116	591	629					
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)													
# of Structures	116	591	629													
4. How many linear feet of channel in the Project area have a ROW WIDTH less than 110-ft wide?	1,280	FEEET	0.24 MILES													
5. What is the CDC Social Vulnerability Index (SVI) of the observed Project Area?	<table border="1"> <tr> <td>Area (Acres)</td> <td>Percentage</td> <td rowspan="4">Project Area: Alt #2</td> </tr> <tr> <td>5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?</td> <td>0%</td> </tr> <tr> <td>5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?</td> <td>0</td> </tr> <tr> <td>5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?</td> <td>0</td> </tr> <tr> <td>5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?</td> <td>96</td> <td>100%</td> <td>96 acres</td> </tr> </table>			Area (Acres)	Percentage	Project Area: Alt #2	5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?	0%	5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?	0	5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?	0	5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?	96	100%	96 acres
Area (Acres)	Percentage	Project Area: Alt #2														
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?	0%															
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?	0															
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?	0															
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?	96	100%	96 acres													
6. What is the qualitative expectation of the projects need for LONG TERM MAINTENANCE?	No requirements for special maintenance have been identified.															
7. What is/are the project's potential ENVIRONMENTAL impacts?	0.1 to 0.5 acres of wetlands expected to be impacted															
Is there any knowledge of CULTURAL ARTIFACTS?	No															
8a. What is the projects potential to offer RECREATIONAL FEATURES as a benefit?	50% of the Project has potential for recreational features															
8b. What is the projects potential to offer ENVIRONMENTAL ENHANCEMENTS as a benefit?	50% of the Project is not expected to have environmental enhancement															

P118-00-00, PM: David Barton, P.E., CFM	Alt #2	(P) Halls Bayou	Project Score:	7.60				
<b>PRIORITIZATION FRAMEWORK SCORING CRITERIA</b>								
<b>Form Answers</b>								
<b>1</b>	<b>Structure Flooding Reduction Scoring Criteria:</b>	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)	TOTAL	SCORE	WEIGHT	WEIGHTED SCORE
	Structures Fully Benefitted	0.025	0.005	0.0025	7.908		25%	2.50
	Structures Partially Benefitted (Min. 0.25' depth)	6.375	1.125	0.408		10.00		
		0.0125	0.0025	0.00125				
		1.450	1.478	0.785	3.714			
<b>2</b>	<b>Existing Conditions Drainage Level of Service Scoring Criteria:</b>	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)	TOTAL	SCORE	WEIGHT	WEIGHTED SCORE
	Structures in Existing Floodplain	0.025	0.005	0.0025	37.528		20%	2.00
	Channel Length	22.675	9.570	5.283		10.0		
		1.280	0.24		0.2			
<b>3</b>	<b>Social Vulnerability Index (SVI) for Project Area:</b>	PERCENTAGE OF SERVICE AREA						
	SVI indicates low level of vulnerability (less than 0.25)	0	0.10%					
	SVI indicates low to moderate level of vulnerability (between 0.2501 and 0.5)	4	0.13%					
	SVI indicates moderate to high level of vulnerability (between 0.5001 and 0.75)	7	0.07%					
	SVI indicates high level of vulnerability (Greater than 0.7501)	10	100.00%					
<b>4</b>	<b>Project Efficiency Scoring Criteria:</b>	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)	TOTAL	SCORE	WEIGHT	WEIGHTED SCORE
	Structures Fully Benefitted	1	0.2	0.1	1.708	2.51	10%	0.25
	Structures Partially Benefitted (Min. 0.25' depth)	1.377	0.243	0.088		\$ 266,000	Structure Value	
		0.5	0.7	0.05	0.802	#####	District Cost	
		0.313	0.319	0.170		0.0054	PEF	
<b>5</b>	<b>Partnership Funding Scoring Criteria:</b>	No funding partner or grant.						
	Potential for partnership/ grant is Unknown or expected to be less than 5% of Project Cost	0				0.00	10%	0.00
	Partnership or Grant funding is expected to cover 5% - 30% of Project Costs	2						
	Partnership or Grant funding is expected to cover 30% - 60% of Project Costs	6						
	Partnership or Grant funding is expected to cover 60% - 90% of Project Costs	8						
	Partnership or Grant funding is expected to cover 90% or more of Project Costs	10						
<b>6</b>	<b>Long Term Maintenance Costs Scoring Criteria:</b>	No requirements for special maintenance have been identified.						
	Project is expected to require extensive or specialized maintenance that will incur costs	0				10.00	5%	0.50
	Project is expected to require maintenance outside of District's regular maintenance practices and will incur some additional costs.	6						
	No requirements for special maintenance have been identified.	10						
<b>7</b>	<b>Minimize Environmental Impacts Scoring Criteria:</b>	0.1 to 0.5 acres of wetlands expected to be impacted						
	No known wetland impacts	10				6.00	5%	0.30
	Less than 0.1 acres of wetlands expected to be impacted or wetland impacts are not known	8						
	0.1 to 0.5 acres of wetlands expected to be impacted	6						
	0.5 to 2 acres of wetlands expected to be impacted	4						
	2 to 5 acres of wetlands expected to be impacted	2						
	More than 5 acres of wetlands expected to be impacted	0						
<b>8</b>	<b>Potential for Multiple Benefits Scoring Criteria:</b>	50% of the Project has potential for recreational features						
	50% of the Project is not expected to have potential for recreational features	0				1.00	5%	0.05
	50% of the Project has potential for recreational features	1						
	A possible partner has been identified for potential recreational features over 50% of the Project	2						
	A partner is expected to commit funding for potential recreational features over 50% of the Project	3						
	50% of the Project is not expected to have environmental enhancement	0						
	50% of the Project has potential for environmental enhancements	3						
	A possible partner has been identified for potential environmental enhancements over 50% of the Project	4						
	A partner is expected to commit funding for potential environmental enhancements over 50% of the Project	7						

**Harris County Flood Control District Project Scoring Form**

<b>USERS:</b> Only type in cells that are ORANGE shaded. GREY cells are automatic calculations (Do not type in these cells)		<b>NOTES:</b>									
* YELLOW cells have dropdown for easy data input. Click on cell, then use drop down just outside the cell, to the		Prioritization Scoring Framework VERSION: July 27, 2021 (6-8)									
<b>TOTAL PROJECT SCORE:</b>		<b>7.23</b>									
1. What is the OVERALL project cost?		\$ 35,355,799 USD.	DISTRICT COST (After Partnership / Grant)								
2. Does the project have potential for PARTNERSHIP or GRANT funding?		No funding partner or grant.									
2a. If estimated partner share is known, what is the estimated partner share responsibility of project cost?		0% If unknown, enter "0%"									
3a. How many structures are subject to flooding in the BASELINE (existing) condition?		<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>907</td> <td>1914</td> <td>2113</td> </tr> </table>		EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	907	1914	2113
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)								
# of Structures	907	1914	2113								
3b. How many structures are proposed to have the FULL BENEFIT of floodplain removal for the respective events?		<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>153</td> <td>146</td> <td>91</td> </tr> </table>		EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	153	146	91
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)								
# of Structures	153	146	91								
3c. How many structures have a proposed PARTIAL BENEFIT floodplain depth reduction GREATER than 0.25-feet?		<table border="1"> <tr> <td>EVENT</td> <td>10-yr (10%)</td> <td>50-yr (2%)</td> <td>100-yr (1%)</td> </tr> <tr> <td># of Structures</td> <td>170</td> <td>319</td> <td>213</td> </tr> </table>		EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)	# of Structures	170	319	213
EVENT	10-yr (10%)	50-yr (2%)	100-yr (1%)								
# of Structures	170	319	213								
4. How many linear feet of channel in the Project area have a ROW WIDTH less than 110-ft wide?		2,060 FEET 0.39 MILES									
5. What is the CDC Social Vulnerability Index (SVI) of the observed Project Area?		Area (Acres) Percentage Project Area: Alt #3									
5.a. Amount of Project Area with an SVI indicated as low level of vulnerability (0.25 or less)?		0 0%									
5.b. Amount of Project Area with an SVI indicated as low to moderate level of vulnerability (0.2501 to 0.5)?		0 0%									
5.c. Amount of Project Area with an SVI indicated as moderate to high level of vulnerability (0.5001 to 0.75)?		0 0%									
5.d. Amount of Project Area with an SVI indicated as high level of vulnerability (0.7501 or more)?		70 100%									
6. What is the qualitative expectation of the projects need for LONG TERM MAINTENANCE?		No requirements for special maintenance have been identified.									
7. What is/are the project's potential ENVIRONMENTAL impacts?		0.1 to 0.5 acres of wetlands expected to be impacted									
Is there any knowledge of CULTURAL ARTIFACTS?		No									
8a. What is the projects potential to offer RECREATIONAL FEATURES as a benefit?		50% of the Project has potential for recreational features									
8b. What is the projects potential to offer ENVIRONMENTAL ENHANCEMENTS as a benefit?		50% of the Project has potential for environmental enhancements									

P118-00-00, PM: David Barton, P.E., CFM	Alt #3	(P) Halls Bayou	Project Score:	7.23
<b>PRIORITIZATION FRAMEWORK SCORING CRITERIA</b>				
			<b>Form Answers</b>	
<b>1</b>	<b>Structure Flooding Reduction Scoring Criteria:</b>			
	Structures Fully Benefitted	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)
		0.025	0.005	0.0025
		3.825	0.730	0.228
		0.0125	0.0025	0.00125
		2.125	0.798	0.266
		TOTAL		4.783
		SCORE		7.97
<b>2</b>	<b>Existing Conditions Drainage Level of Service Scoring Criteria:</b>			
	Structures in Existing Floodplain	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)
		0.025	0.005	0.0025
		22.675	9.570	5.283
	Channel Length	2.060	0.39	
		TOTAL		37.528
		SCORE		10.0
		TOTAL		0.4
		SCORE		10.00
		TOTAL		2.00
		SCORE		2.00
<b>3</b>	<b>Social Vulnerability Index (SVI) for Project Area:</b>			
	SVI indicates low level of vulnerability (less than 0.25)	0	0.10%	0.10%
	SVI indicates low to moderate level of vulnerability (between 0.2501 and 0.5)	4	0.13%	0.13%
	SVI indicates moderate to high level of vulnerability (between 0.5001 and 0.75)	7	0.07%	0.07%
	SVI indicates high level of vulnerability (Greater than 0.7501)	10	100.00%	100.00%
		TOTAL		1.439
		SCORE		2.40
		TOTAL		\$ 266,000
		SCORE		#####
		TOTAL		0.0075
		SCORE		10%
		TOTAL		0.00
		SCORE		0.24
<b>4</b>	<b>Project Efficiency Scoring Criteria:</b>			
	Structures Fully Benefitted	10-Yr. (10%)	50-Yr. (2%)	100-Yr. (1%)
		1.151	0.220	0.1
		0.5	0.7	0.066
		0.639	0.240	0.080
		TOTAL		1.439
		SCORE		2.40
		TOTAL		\$ 266,000
		SCORE		#####
		TOTAL		0.0075
		SCORE		10%
		TOTAL		0.00
		SCORE		0.24
<b>5</b>	<b>Partnership Funding Scoring Criteria:</b>			
	No funding partner or grant	0		
	Potential for partnership/ grant is Unknown or expected to be less than 5% of Project Cost	2		
	Partnership or Grant funding is expected to cover 5% - 30% of Project Costs	4		
	Partnership or Grant funding is expected to cover 30% - 60% of Project Costs	6		
	Partnership or Grant funding is expected to cover 60% - 90% of Project Costs	8		
	Partnership or Grant funding is expected to cover 90% or more of Project Costs	10		
		TOTAL		10
		SCORE		10.00
		TOTAL		5%
		SCORE		0.50
<b>6</b>	<b>Long Term Maintenance Costs Scoring Criteria:</b>			
	Project is expected to require extensive or specialized maintenance that will incur costs	0		
	Project is expected to require maintenance outside of District's regular maintenance practices and will incur some additional costs	6		
	No requirements for special maintenance have been identified.	10		
		TOTAL		10
		SCORE		10.00
		TOTAL		5%
		SCORE		0.50
<b>7</b>	<b>Minimize Environmental Impacts Scoring Criteria:</b>			
	No known wetland impacts	10		
	Less than 0.1 acres of wetlands expected to be impacted or wetland impacts are not known	8		
	0.1 to 0.5 acres of wetlands expected to be impacted	6		
	0.5 to 2 acres of wetlands expected to be impacted	4		
	2 to 5 acres of wetlands expected to be impacted	2		
	More than 5 acres of wetlands expected to be impacted	0		
		TOTAL		10
		SCORE		6.00
		TOTAL		5%
		SCORE		0.30
<b>8</b>	<b>Potential for Multiple Benefits Scoring Criteria:</b>			
	50% of the Project is not expected to have potential for recreational features	0		
	50% of the Project has potential for recreational features	1		
	A possible partner has been identified for potential recreational features over 50% of the Project	2		
	A partner is expected to commit funding for potential recreational features over 50% of the Project	3		
		TOTAL		3
		SCORE		4.00
		TOTAL		5%
		SCORE		0.20



# **Appendix J**

Detailed Opinion of Probable Cost

**Hardy West Alternatives Analysis Preliminary Cost Summary**

Alternative	HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Alternative 1	2233-01	Clearing and Grubbing	AC	79.8	\$ 4,000.00	\$ 319,200.00
	2315-02	Excavation & Off-Site Disposal	CY	1,224,517	\$ 15.00	\$ 18,367,755.00
	2921-01	Turf Establishment	AC	79.8	\$ 3,000.00	\$ 239,400.00
	2315-06	Backslope Drainage System Swales	LF	10,400	\$ 2.00	\$ 20,800.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	13,333	\$ 85.00	\$ 1,133,333.33
	2376-06	Concrete Interceptor Structure	SY	156	\$ 120.00	\$ 18,720.00
	2632-70	Headwalls and Wingwalls	CY	90	\$ 950.00	\$ 85,500.00
	2378-01	Riprap, Gradation No. 1	SY	1,340	\$ 100.00	\$ 134,000.00
	2642-02	24" CMP	LF	1,040	\$ 90.00	\$ 93,600.00
	2611-06	48" RCP	LF	200	\$ 195.00	\$ 39,000.00
<b>Subtotal:</b>						<b>\$ 20,451,308.33</b>

	Planning, Engineering, and Design (10% of DCC):	\$ 2,045,200.00
	Mobilization/Demobilization (5% of DCC):	\$ 1,022,600.00
	Construction Management (10% of DCC):	\$ 2,045,200.00
	Contingency (30% of DCC):	\$ 6,135,400.00
	<b>ROW Acquisition:</b>	<b>\$ 19,679,107.65</b>
	<b>Total:</b>	<b>\$ 51,378,900.00</b>

Hardy West Alternatives Analysis Preliminary Cost Summary						
Alternative	HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Alternative 2	2233-01	Clearing and Grubbing	AC	77.4	\$ 4,000.00	\$ 309,600.00
	2315-02	Excavation & Off-Site Disposal	CY	1,124,491	\$ 15.00	\$ 16,867,365.00
	2921-01	Turf Establishment	AC	77.4	\$ 3,000.00	\$ 232,200.00
	2315-06	Backslope Drainage System Swales	LF	11,600	\$ 2.00	\$ 23,200.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	13,333	\$ 85.00	\$ 1,133,333.33
	2376-06	Concrete Interceptor Structure	SY	180	\$ 120.00	\$ 21,600.00
	2632-70	Headwalls and Wingwalls	CY	180	\$ 950.00	\$ 171,000.00
	2378-01	Riprap, Gradation No. 1	SY	1,340	\$ 100.00	\$ 134,000.00
	2642-02	24" CMP	LF	1,200	\$ 90.00	\$ 108,000.00
	2611-06	48" RCP	LF	400	\$ 195.00	\$ 78,000.00
Subtotal:						\$ 19,078,298.33

	Planning, Engineering, and Design (10% of DCC):	\$ 1,907,900.00
	Mobilization/Demobilization (5% of DCC):	\$ 954,000.00
	Construction Management (10% of DCC):	\$ 1,907,900.00
	Contingency (30% of DCC):	\$ 5,723,500.00
	<b>ROW Acquisition:</b>	<b>\$ 19,679,107.65</b>
	<b>Total:</b>	<b>\$ 49,250,800.00</b>

**Hardy West Alternatives Analysis Preliminary Cost Summary**

Alternative	HCFCD Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Alternative 3	2233-01	Clearing and Grubbing	AC	55.2	\$ 4,000.00	\$ 220,800.00
	2315-02	Excavation & Off-Site Disposal	CY	717,932	\$ 15.00	\$ 10,768,980.00
	2921-01	Turf Establishment	AC	55.2	\$ 3,000.00	\$ 165,600.00
	2315-06	Backslope Drainage System Swales	LF	11,100	\$ 2.00	\$ 22,200.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	11,333	\$ 85.00	\$ 963,333.33
	2376-06	Concrete Interceptor Structure	SY	168	\$ 120.00	\$ 20,160.00
	2632-70	Headwalls and Wingwalls	CY	180	\$ 950.00	\$ 171,000.00
	2378-01	Riprap, Gradation No. 1	SY	1,120	\$ 100.00	\$ 112,000.00
	2642-02	24" CMP	LF	1,120	\$ 90.00	\$ 100,800.00
	2611-02	24" RCP	LF	400	\$ 180.00	\$ 72,000.00
<b>Subtotal:</b>						<b>\$ 12,616,873.33</b>

	Planning, Engineering, and Design (10% of DCC):	\$ 1,261,700.00
	Mobilization/Demobilization (5% of DCC):	\$ 630,900.00
	Construction Management (10% of DCC):	\$ 1,261,700.00
	Contingency (30% of DCC):	\$ 3,785,100.00
	<b>ROW Acquisition:</b>	<b>\$ 15,799,525.29</b>
	<b>Total:</b>	<b>\$ 35,355,800.00</b>