

2023 REGIONAL FLOOD PLAN REGION 6 SAN JACINTO

January 2023

PREPARED FOR THE SAN JACINTO
REGIONAL FLOOD PLANNING GROUP

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PRELIMINARY ENGINEERING REPORT

For

P118-25-00 and Tributaries Conveyance and Detention Improvements

HCFCFD Project ID P118-25-00-E001

Prepared For:

Harris County Flood Control District (HCFCFD)



Prepared By:

R.G. Miller Engineers
TBPE Firm #F-487
16340 Park Ten Place, Suite 350
Houston, Texas 77084
Phone: (713) 461-9600

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1.0 Executive Summary

R.G. Miller Engineers, Inc. (RGME) was authorized in July 2020 by Harris County Flood Control District (HCFCD) to prepare the “Halls Bayou Tributary Unit No. P118-25-00/01: Preliminary Engineering Report (PER) and Design”.

The purpose of the PER is to provide a feasibility analysis and preliminary design of the recommended drainage Alternative 3b as presented in the “Alternative Analysis Summary Report (AASR)” prepared by LAN for Halls Bayou Tributary Unit No. P118-25-00/01. This alternative includes a proposed detention basin, widening of the existing channels, and extension of channel P118-25-01.

HCFCD tributaries Unit Nos. P118-25-00 and P118-25-01 are located within the Halls Bayou (HCFCD Unit No. P118-00-00) watershed in the northern portion of Harris County. The project area is generally bounded by Hardy Toll Road to the east, Sellers Rd to the west, Hill Rd to the south, and Hollyvale Drive to the north. See [Exhibit 1](#) – Vicinity and Location Maps for reference.

The project is located within the 100-Year FEMA floodplain with some portions lying within the 500-Year floodplain. The project area has experienced significant flooding in the past. The channels were originally designed based on the TP-40 and Hydro-35 rainfall frequency. Comparing to TP-40 and Hydro-35, the recently released NOAA Atlas 14 shows notable increase in rainfall rate and increases the overflows from P118-26-00 and P138-00-00 to the project area and increases the risk of flooding in the project area. Based on the results of analyzing the improvements outlined as Alternative 3b as presented in the “AASR”, RGME determined said improvements were insufficient to meet HCFCD criteria necessary for accomplishing the project goals. RGME worked to expand on Alternative 3b with flood mitigation improvements that called for an increase in the size of the proposed detention pond. The recommended flood mitigation improvements discussed in this report shows a decrease in water surface elevation (WSEL) in the project area by means of adding a 40 ac-ft detention basin, extending P118-25-01 approximately 2,300 ft, and increasing the existing channel cross-section to convey more water downstream. Due to overlapping construction and design timing between the improvements outlined in this report and other proposed improvements made along Halls Bayou, an interim restrictor (sheet piling) is proposed at the proposed project outfall at Hill Road. This restrictor is needed to avoid an increase in WSEL throughout the watershed downstream until the other Halls Bayou improvements can be completed. The No Adverse Impact Study found as [Appendix F](#) determines that the proposed design will meet the Harris County Flood Control District standards for 2-yr, 10-yr, 100-yr, and 500-yr storm events. Right-of-Way (ROW) and Topographic Survey, a Phase 1 Environmental Site Assessment, and a Geotechnical Report were performed to help assess the feasibility of the recommended flood mitigation improvements as outlined in this report.

The preliminary direct construction cost for P118-25-00/01 is approximately \$7,734,632, the preliminary ROW acquisition cost is about \$15,200,000, and the pipeline relocation is about \$1,733,037. The overall cost is approximately \$24,667,669, and with a 20% contingency (not applied to the preliminary ROW acquisition) is approximately \$26,561,202.76. Refer to [Table 1](#) for a detailed breakdown of the preliminary cost estimate.

2.0 Introduction

2.1 Authorization

R.G. Miller Engineers, Inc. (RGME) was authorized to proceed with preparing and delivering the Preliminary Engineering Report for the Harris County Flood Control District (HCFCD) channel conveyance improvements and stormwater detention basin on P118-25-00 and P118-25-01 on August 3rd, 2020.

2.2 Location

HCFCD Tributaries Unit Nos. P118-25-00 and P118-25-01 are located within the Halls Bayou (HCFCD Unit No. P118-00-00) watershed in the northern portion of Harris County. The project area is generally bound by Hardy Toll Road to the east, Sellers Rd to the west, Hill Rd to the south, and Hollyvale Drive to the north. Please refer to [Exhibits 1 and 2](#) for project location.

2.3 Purpose and Scope

The purpose of this study is to provide preliminary engineering analysis and design of the recommended improvements based on the “Alternative Analysis Summary Report (AASR)” prepared by LAN for Halls Bayou Tributary Unit No. P118-25-00/01. This feasibility analysis used topographic survey, geotechnical analysis, and H&H analysis to develop the project more thoroughly and ensure its compliance with HCFCD drainage criteria.

3.0 Existing Conditions

The project is located within the 100-Year FEMA floodplain with some portions located in the 500-Year floodplain. The drainage area is approximately 640 acres which consist of approximately 0.59 miles of channel P118-25-00 and 1 mile of channel P118-25-01. The project area is heavily influenced by overflows from P118-26-00 in the west and P100-00-00 (Greens Bayou) in the north, which drains south into P138-00-00 and eventually to P118-25-00/01. The existing layout and geometry of channel P118-25-00 and P118-25-01 are shown in [Exhibit 4 and 6](#). P118-25-01 drains into P118-25-00 and ultimately outfalls to P118-00-00. The project area experiences significant flooding.

The existing Level-of-Service was evaluated by LAN and found that a 250 to 500-year LOS is provided by the downstream end of P118-25-00 and at the upstream end and mid portion of P118-25-01. The LOS is between 35 and 100-years at the junction of P118-25-00 with P118-25-01 and along P118-25-01 north of Aldine Mail Route Road. A 100 to 200-year LOS is provided by P118-25-00 at the upstream end and south of Aldine Mail Route Road, and by P118-25-01 north of Texas Auto Parts on the straight section after meandering.

Existing storm runoff that drained into channels P118-25-00 and P118-25-01 will continue to be conveyed by the proposed improvements. Storm runoff on Aldine Mail Route Road is currently and will continue to be collected at two points: a junction box at the intersection with Sweeney Road, and into reinforced concrete boxes (RCB) crossing Aldine Mail Route Road at the intersection with Henry Road. Coordination with Harris County will need to take place regarding the replacement of the

existing RCBs currently crossing Aldine Mail Route Road at the intersection with Henry Road with a larger storm sewer system. Other existing swales and outfalls from properties will be picked captured by proposed backslope swales and urban backslope interceptor structures.

No critical infrastructure was found located within the drainage area.

4.0 Right-of-Way and Topographic Survey

A Category 6, Condition II Survey was performed by Miller Survey Group which consist of vertical and horizontal control, topographic survey, and tree survey. See [Exhibit 3](#).

The ROW survey was completed by LandTech for P118-25-00 and P118-25-01 and has been incorporated for use in the PER. Channel P118-25-01 is located within a 100-foot ROW from Corvette Court to Aldine Mail Road and a 50-foot easement from Aldine Mail Road to the confluence with channel P118-25-00. Channel P118-25-00 is located within a 50-foot easement from Hill Road to the channel's upstream end at Aldine Mail Route.

5.0 Environmental Assessments

Environmental reports were prepared corresponding to the project footprint from the Alternatives Analysis report as further outline below. The project footprint was modified near completion of the PER, and a final footprint was agreed upon February 10, 2022. Additional environmental due diligence reports will be completed during Final Design to ensure regulatory compliance in the new unstudied areas, which are relatively small and in close proximity to the original footprint.

5.1 Phase I Environmental Site Assessment

A Phase I Environmental Site Assessment (ESA-I) was conducted by Hollaway Environmental + Communications (Hollaway) and a report formalized July 2020. The report with approval memo by Regulatory Compliance Section (RCS) can be found in [Appendix A](#). Based on the ESA-I report, Hollaway found six potential Recognized Environmental Conditions (RECs) within the project area and two RECs adjacent to the project area.

Hollaway recommends conducting a Phase II ESA in the following areas to create a thorough record of the existing conditions:

- 1) Bronco Auto Salvage – 900 Aldine Mail Route Rd
- 2) North Houston Pole Line – 850 Aldine Mail Route Rd
- 3) Bobi Metal Inc – 810 Aldine Mail Route Rd
- 4) Indications of solid waste disposal – 14109 Sellers Rd
- 5) Suspicious filled area – 14351 Henry Rd
- 6) Samson Disposal – 14419 Henry Rd
- 7) Stressed Vegetation – 14028 Sellers Rd

Detailed observations of the RECs can be found in [Appendix A, Table 1](#). No Historical RECs (HRECs) or Controlled RECs (CRECs) were found on site.

5.2 Phase II Environmental Site Assessment

Based on the Phase I ESA conducted by Hollaway, Cypress Environmental Consulting anticipates 18 soil borings are needed to further investigate the 7 potential RECs in the locations mentioned above. The finalized Phase I ESA was provided to Cypress Environmental Consulting to determine the scope needed for a Phase II ESA to investigate the RECs identified in the Phase I ESA. Phase II ESA scope will be tailored to the final project footprint and conducted during final design.

5.3 Wetland Delineation

A wetland delineation was completed for the project site by Hollaway and summarized in a report dated September 2021. The report and approval memo by RCS can be found in [Appendix B](#). Based on the report, Hollaway identified thirteen aquatic features within the project limit. All the features are non-jurisdictional under the Clean Water Act based on the Navigable Water Protection Rule (NWPR) of 2020. An Approved Jurisdictional Determination (AJD) was provided by USACE on 09/13/2021, which can be found in [Appendix B](#). All aquatic features were determined to be non-jurisdictional. Additional wetland delineation and USACE request for AJD for the additional project footprint outside the original delineation will be completed in Final Design.

5.4 Threatened and Endangered Species Assessment

A Threatened and Endangered (T&E) species habitat assessment for the project site was conducted and summarized in a report dated April 2021. The report and RCS approval memo can be found in [Appendix C](#). Based on the report, no federally or state listed species were observed within the project limit. There is low potential for two state-listed species, swallow-tailed kite (*elanoides forficatus*) and white-tailed hawk (*buteo albicaudatus*), to be temporarily impacted by the construction activities.

It is Hollaway's professional judgement that the project site has moderate potential to support protected breeding, wintering, and transitory migratory birds. The construction documents will require the construction contractor to avoid activities that disturb bird habitat, including but not limited to clearing, grubbing, and impacts to structures where migratory birds and bald eagles might nest, until a nest habitat survey is conducted by RCS to verify active migratory bird nests and bald eagle nests are not present. FCD performs migratory bird surveys year-round for all clearing activities.

The contractor shall stop the construction and notify RCS if any T&E species are observed within the construction activities. Additional project limits not already reviewed will be completed in final design.

5.5 Cultural Resources Investigation Reports

The Cultural Resources Investigation Report is included in [Appendix D](#).

Concurrence from the Texas Historical Commission (THC) was received on 10/29/2021, with no additional investigation required. The concurrence can also be found in [Appendix D](#) along with

the RCS memo. However, should this project ultimately include any federal funding, additional consultation with THC/SHPO under Section 106 of the National Historic Preservation Act will be required.

Additional cultural resources investigation for the additional project footprint outside the original investigation will be completed in final design.

6.0 Geotechnical Report

A geotechnical report was provided by Terracon on April 8, 2022. The report is attached as [Appendix E](#). The scope of service for this project included 21 test borings to depths ranging from approximately 20 to 30 feet below existing natural ground. Terracon has completed 20 soil borings as of the writing of this report due to inaccessibility to a private property within the project area. These borings were used to provide findings as outlined in [Appendix E](#). Completed boring locations can be found in [Appendix E, Exhibit A-2](#).

Based on analysis of the completed soil borings, Terracon found fill soils at borings B-1, B-3, B-4, C-3, C-11, C-12, and C-13 from ground level to approximately 2 to 6 feet in depth. Soil observed within the excavation area were classified as lean clay, lean clay with sand and sandy lean clay underlain by fat clay, clayey sand, silty sand, poorly graded sand with silt, or silt with sand soils to the boring termination depths. The soils observed within the excavation depths are generally non-dispersive to intermediate dispersive based on testing. Soils classified as lean clay with sand and sandy lean clay that did not show dispersive potential can be used as select fill in accordance with Section 02314 of the 2020 HCFCD Standard Specifications.

Based on Crumb and Double Hydrometer tests, dispersive soils were observed in the borings. To reduce the potential of the dispersive soils eroding, backslope swales and drainage interceptor structures are proposed as per HCFCD Policy Criteria & Procedure Manual (PCPM). Terracon also recommended the geotechnical engineers should collect soil samples for laboratory testing and approval before utilizing fill soils.

Dry drilling techniques were performed at all the borings performed to evaluate groundwater conditions at depths from 10 to 30 feet. Generally, seepage that occurs in clay soils is minor and can likely be managed by sumps and pumps. However, groundwater was initially observed at 10 feet below existing grade at borings C-12 and C-13 and 13 feet below existing grade at boring C-8 and rose to about 3 to 4 feet after about one day. It is recommended additional piezometers be installed to the planned excavation depths in areas where significant rises in groundwater were observed. It is also recommended pump tests be performed to determine the in-site hydraulic conductivity of the soils at the bottom of the planned excavations.

Slope Stability Analyses were performed using the commercial slope stability software program, SLIDE. The test included short-term, long-term, and rapid drawdown conditions. Based on the test results, Terracon confirmed the side slope configuration being utilized in the channel and basin design of 4 Horizontal (H) to 1 Vertical (V) or flatter with a maximum depth of 9 ft is acceptable and meets

the minimum safety factor requirements. Side slopes area suggested to be protected with rip-rap, geofabrics, or vegetation with an aggressive root system at locations of concentrated high velocity water flow such as at channel bends and nearby inlet or outfall structures. Routine maintenance of the side slopes should be performed to reconstruct areas where sloughing and/or erosion have occurred.

7.0 Hydrology ad Hydraulic (H&H) Analysis

7.1 H&H Analysis

An Alternatives Analysis Study was originally conducted by Lockwood, Andrews & Newnam, Inc. (LAN) and was completed October 2018 to analyze and describe the existing flooding conditions within P118-25-00/01 and surrounding catchment area, and to propose alternative improvements for the flood risk mitigation. The project area is significantly influenced by overflow from P118-26-00 and Glen Oak Subdivision in the west and P100-00-00 in the north, which drains into P138-00-00 and then to the project area. The report by LAN is shown in [Appendix F](#). The hydraulic and hydrologic models were developed using pre-Atlas 14 for 2-yr, 10-yr, 100-yr, and 500-yr storm events.

The original precipitation frequency estimates used to design the channels in LAN's "Alternative Analysis Summary Report (AASR)" were based on the most current available analysis of rainfall rates at that time from TP-40 (U.S. Weather Bureau, 1961) and Hydro-35 (NOAA, 1977). In September 2018, National Oceanic and Atmospheric Administration (NOAA) released the NOAA Atlas 14 precipitation frequency estimates, and the rainfall rates have a notable increase for a 100-yr event compared to TP-40 and Hydro-35. While the increased rainfall rates provide a change to the original H&H results, the updated NOAA Atlas 14 100-year rainfall rates and resulting water surface elevations (WSEs) were approximated by the previous effective 500-year storm event as further explained in [Appendix F](#).

In the study found in [Appendix F](#), LAN utilized 2008 and 2018 LiDAR as existing conditions terrain and developed the combined 1D/2D Baseline Condition Model focus on four key hydraulic features: 1D cross section, 2D flow area, lateral structures and 2D connectors, and boundary conditions. Based on the model, ponding was estimated through project area for 2-yr, 10-yr, 100-yr, and 500-yr storm events. LAN provided eight combinations of improvement features (detention basins, channel improvements, and a channel extension) as potential flooding mitigation improvements. Based on coordination between LAN and HCFCFCD, alternative 3b was selected as it provides the best balance between cost and benefits while satisfying HCFCFCD drainage criteria in future conditions. Due to the multiple proposed system improvements in this area and the uncertain construction schedules, it is possible that the proposed improvements for P118-25-00/01 may negatively impact the WSEL for Halls Bayou. Therefore, an interim conveyance restrictor (using sheet piling) was added to the project improvements to prevent any adverse impacts. Adding an interim restrictor (sheet piling) at the project outfall at Hill Rd can prevent increasing WSEL throughout the watershed. If said sheet piling restrictor fails, there will

be downstream impacts to Halls Bayou. Detailed design methodology can be found in [Appendix F](#).

As part of the preliminary design efforts for the PER, a No Adverse Impact Study was conducted by HT&J, LLC based on drainage alternative 3b from the AASR, updated by and coordinated with RGME, and summarized in a report dated March 15, 2022. The report can be found in [Appendix G](#). The report analyzes the project improvements for alternative 3b, determines the feasibility of said improvements with supporting topographic data and preliminary design, and improves upon those improvements to provide a design that achieves all project criteria.

In the study found in [Appendix G](#), HT&J updated LAN's model by replacing the existing condition terrain with the surveyed existing surfaces overlaid to the 2018 LiDAR and re-calculated the combined 1D/2D baseline conditions. Based on the model, HT&J provided the ponding condition with more details in 2-yr, 10-yr, 100-yr, and 500-yr storm events ([Appendix G, Exhibits 4 to 7](#)). Based on the revised modeling results, HT&J recommended a detention basin with minimum 40 ac-ft volume with increased bottom width and increased depth of the weir structure at the detention basin outfall into channel P118-25-01. HT&J also recommended reducing the opening of the sheet piling upstream of the outfall at Hill Rd to achieve no adverse impact on Halls Bayou. Based on these updated improvements, HT&J demonstrated significant flood risk reduction benefits and no adverse impacts. Detailed recommendations for the project improvements are listed in Section 9.0 and detailed analysis and design methodology can be found in [Appendix F](#).

While criteria set by the Texas Water Development Board (TWDB) suggests modeling 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr, and 500-yr storm events, analysis for this project only consisted of 2-yr, 10-yr, 100-yr, and 500-yr based on the criteria set by HCFCD and deemed adequate for the analysis of the channels and improvements for this project.

H&H analysis will continue in final design to capture any additional changes to the project configuration and incorporate spatially varied Manning's n-values into the 2D areas of the model.

7.2 Oak Glen Place Subdivision

Neighborhood drainage improvements are proposed by Harris County Engineering Department (HCED) – Recovery and Resiliency Division (RRD) for the Oak Glen Place Subdivision, as shown in [Exhibits 9 and 10](#). Drainage from the proposed improvements will outfall into the P118-25-00/01 system. In existing conditions, the Oak Glen Place subdivision experiences structural flooding during extreme storm events. HCED-RRD is currently in the design phase for improving the Oak Glen subdivision drainage system to alleviate flooding experienced within the subdivision to a 100-yr level of service (LOS). The improvements consist of constructing an underground storm sewer system to supplement the existing roadside ditches that in existing conditions are deemed inadequate to convey and store the storm runoff, as well as a detention pond. The size of the detention pond to serve solely Oak Glen Place subdivision will be sized based on Harris County design criteria, along with coordination and approval from HCFCD. However, said detention pond is located within the footprint of the detention pond detailed in this PER for the P118-25-00/01

improvements. The detention pond for P118-25-00/01 will be sized to include the detention needed from the Oak Glen Place subdivision improvements based on HCFCFCD design criteria.

A detailed technical engineering memorandum to document the discharge hydrographs was prepared by Neel-Schaffer documenting the methodology used to generate the pre-Atlas 14 outflow hydrographs from the proposed storm sewer system of Oak Glen Place subdivision.

The hydrographs for the subdivision were obtained from the PCSWMM model for the Oak Glen Place subdivision for the pre-Atlas 14 rainfall 2-year, 10-year, 100-year, and 500-year storm event, and existing and ultimate condition hydrographs were developed. More information can be found at [Appendix H](#).

The pre-Atlas 14 rainfall hydrographs were included by HT&J for use in the P118-25-00/01 analysis to size the detention necessary for the P118-25 project and Oak Glen Place subdivision Drainage Improvement and confirm no adverse impacts.

7.3 Aldine Village Subdivision

Neighborhood drainage improvements are proposed by HCED-RRD for the Aldine Village Subdivision, as shown in [Exhibits 11](#) and [12](#). Drainage from the proposed improvements will outfall into the P118-25-00/01 system. In existing conditions, Aldine Village subdivision experiences structural flooding during extreme storm events and the eastern portion of the project ultimately outfalls to P118-25-01. HCED-RRD is currently in the design phase for improving the Aldine Village subdivision drainage system to alleviate this flooding. The improvements consist of installing an underground storm sewer system (24-inch reinforced concrete pipes (RCP) to 6-ft x 3-ft (RCB)) beneath Sellers Road and upsizing existing underground storm sewer system to 6-ft x 3-ft RCB along Corvette Court that will ultimately outfall to P118-25-01 by way of drainage channel. Coordination between HCED-RRD and HCFCFCD has taken place so the proposed detention pond detailed in this PER will be sized to include the detention needed from the Aldine Village subdivision improvements.

A detailed technical engineering memorandum to document the discharge hydrographs was prepared by LAN documenting the methodology used to generate the pre-Atlas 14 outflow hydrographs from the proposed storm sewer system of Aldine Village into HCFCFCD tributary.

The hydrology was developed using HEC-HMS, and then applied to the InfoWorks ICM to build the hydraulic model. Detailed description of the methodology can be found at [Appendix I](#).

The pre-Atlas 14 rainfall hydrographs were included by HT&J use in the P118-25-00/01 analysis to size the detention necessary for the P118-25 project and Aldine Village Subdivision Drainage Improvement and confirm no adverse impacts.

7.4 Future Land Use Changes

Future land use changes in the project drainage area require compliance with Harris County and Harris County Flood Control District regulations, including storm water detention, to mitigate

increased flows associated with development. The recommended drainage improvements for P118-25-00/01 are adequate for anticipated future development in the drainage area when developed in compliance with County regulations.

8.0 Utility Conflicts

There are private utilities, water lines, and sanitary sewer that may be impacted by the project. As part of the study, private utility maps and topographic information was reviewed, and a utility conflict matrix is provided in [Table 2](#). Details of necessary relocations will be investigated further in the final design.

8.1 Water

Sunbelt Fresh Water Supply District provides water to properties adjacent to the project. The surveyor located water valves on the back of the properties adjacent to the channel. The surveyor also found water meters for each mobile home within the mobile home property developments. Water meters that serve the mobile homes within the project improvement limit are anticipated to be removed with the houses if acquisition determines the removal of a mobile home is necessary. Landscape irrigation systems within the ROW acquisition limit will also be removed. Pressure release valves will be relocated outside of the ROW acquisition limit. Coordination with Sunbelt Fresh Water Supply District to abandon and remove or to relocate the water lines as necessary before the construction of the proposed improvements.

8.2 Sanitary Sewer

No public sanitary system owned by the city, county, or MUD were located within the project limit. Several properties adjacent to the project have their own On-site Sewage Facilities (OSSF) within their property limits. Sanitary cleanouts were located by the surveyor within the properties adjacent to the channels. As part of expanding the channel to the proposed limits, sanitary cleanouts and service lines that serve structures within the ROW acquisition limit will be removed. If building structures are not anticipated to be impacted by the proposed development, the cleanouts and service lines will need to be relocated. Coordination with the property owners to relocate or abandon the impacted private sanitary sewer systems will be necessary prior to the construction of the proposed improvement.

8.3 Electric – Conditions/Impacts

The project area is served by CenterPoint Energy Electric. Based on utility research, overhead power lines are located along the back of the properties adjacent to the channel ROW. Power poles on the north side of Hill Road will be impacted by the expansion of P118-25-00. Expansion of P118-25-01 will impact power poles on the west and east side of the channel. The channel extension of P118-25-01 will impact the power poles from the existing upstream end of P118-25-01 to Hollyvale Drive. Heavy equipment shall maintain 10 ft clearance from overhead distribution power lines and 15 ft from transmission power lines during construction. Coordination with CenterPoint Energy will be needed to relocate power poles before the construction of the proposed improvements.

8.4 Pipelines/Gas Lines – Conditions/Impacts

According to the topographic surveying in [Exhibit 3](#), CenterPoint Energy Gas, Sunoco Pipeline, British Petroleum (BP), Enterprise Products, and Explorer have pipelines located within and close to the project area. CenterPoint Energy's 10-inch pipeline and Sunoco Pipeline's 8-inch pipeline cross both channel P118-25-00 and channel P118-25-01. A 10-inch pipeline, formerly owned by BP, and Enterprise products' 10-inch pipeline were found crossing P118-25-01. Multiple pipeline owners were contacted to determine the current owner of the formerly owned BP pipeline, but none took ownership of the line. Field crews identified previous BP pipeline markers still in the area further from the project site indicating this line was ultimately abandoned when BP left Texas. The contractor should tap the line to confirm its status during construction. The expansion of the channels is anticipated to impact the crossing pipelines. Explorer's 10-inch pipeline is located along P118-25-01 south of Hollyvale Drive. Explorer's pipeline will not be impacted by the improvement since it is outside of the project limit.

CenterPoint Energy also has service lines along Hill Rd, Aldine Mail Route Rd, and back of properties south of Hollyvale Drive. The 2-inch service lines crossing channel P118-25-00 at Aldine Mail Route Rd. are anticipated to be affected by the proposed 9-ft x 6-ft culvert boxes. The rest of the service lines are outside the limits of the proposed channel improvements; thus, no conflicts are anticipated.

Coordination and detailed agreements with the utility owners will be necessary prior to construction to determine how pipelines need to be relocated or adjusted. Detailed breakdown of estimated cost to relocate the existing pipelines can be found in [Table 3](#). This estimate assumes the pipeline companies have prior rights and will need to be compensated. This will be further investigated in coordination with the pipeline companies during final design.

8.5 Telecommunications – Conditions/Impacts

Telecommunications are served by AT&T, Comcast, and Crown Castle in the project area. AT&T and Comcast lines that are located adjacent and parallel to the channel ROW are not anticipated to be impacted by the proposed improvements. Crown Castle lines are running along Hollyvale Drive and Hill Rd outside of the channel improvement limit. AT&T, Crown Castle, and Comcast's underground utilities and utility poles with overhead lines crossing the channel will be impacted by the channel widening and will require relocation of the utility poles and underground facilities.

9.0 Flood Mitigation Recommendations

The recommended drainage improvements for P118-25-00/01 are listed below:

- 1) Construction of a detention basin at north of Aldine Mail Route Road between residential area Oak Glen Place and P118-25-01, see [Exhibit 7](#). The basin is 9 feet deep and provides storage volume that satisfies the 40 ac-ft detention with requirement with free board. The basin outfalls to P118-25-01 through a 24-inch (RCP) with 12-inch restrictor and an inflow structure with 100-foot bottom and 5.3 feet in depth. A wet bottom detention basin with green features

- was considered, but due to the proximity to an airport the proposed detention pond is within the Federal Aviation Administration (FAA) exclusion zones.
- 2) Altering the existing channel to a wider and deeper cross section. The bottom of the channel will be widened to 25 feet with a 4:1 side slope to the top of bank. The channel depth will be increased by 1.4 feet, on average, for P118-25-00 and 2.1 feet, on average, for P118-25-01 to increase conveyance. See channel cross-sections in [Exhibit 5](#).
 - 3) Extending P118-25-00 by 2,770 feet north to Hollyvale Drive to help contain the overflow from P138-00-00. The channel extension is designed to have a 4:1 side slope, be 8 feet in depth, and contain a bottom width of 25 feet.
 - 4) Replace the single 9-foot x 4-foot RCB connecting P118-25-01 across Aldine Mail Route Rd with two 9-foot x 6-foot RCBs and one 8-foot x 6-foot RCB.
 - 5) Install a temporary restrictor (sheet piling) with 15-foot opening at upstream of Hill Rd to reduce the WSEL throughout the watershed downstream.
 - 6) The channel alignment was adjusted from the configuration in the Alternatives Analysis to reduce impacts to existing structures. The detention basin size and configuration was also adjusted to provide increased capacity to fully mitigate increased flows from the Oak Glen Place and Aldine Village projects by HCFCD-RRD.

See [Appendix F](#) for detail preliminary design.

10.0 Water Quality Features

A 20-foot buffer for maintenance access is proposed on both side of channels and around the detention basin. Maintenance access plans can be found at [Appendix J](#) sheets 29 -31. A floatables collection structure is proposed at the upstream end of the restrictor pipe in the detention basin. A 15 ft wide all-weather access road is proposed from Sellers Road to the detention basin outfall for access to the top of the floatables collection structure. See [Appendix J](#) for floatables collection screen detail on sheets 35-36. Detailed layout of the detention basin can be found at [Appendix J](#) page 21.

Tiered culverts were suggested by and discussed with HCFCD at Aldine Mail Route Road to improve storm water quality upstream. However, after further investigation by RGME and HT&J and changes to the size of the culvert crossings at Aldine Mail Route due to incorporating the Harris County RRD projects, there is insufficient cover to accommodate pipes more than 6 feet in height. Additionally, incorporating the Harris County RRD projects required increasing the size (widths) of the culvert crossing from two 9-ft x 6-ft RCBs to two 9-ft x 6-ft RCBs and one 8-ft x 6-ft RCB. This increase utilizes the usable channel width, eliminating alternatives for providing tiered culverts within the proposed channel section.

Additional water quality features, such as extended detention, are to be evaluated in final design.

11.0 Right-of-Way Acquisition

The existing channel ROW is proposed to be expanded to 155 feet to fit the proposed channel section with 10-ft backslope swales and 20-ft maintenance berms on each side. For budgetary purposes, if

the proposed ROW occupies at least 40% of the parcel, it is assumed that all of the parcel will need to be acquired. LAN identified 48 total parcels to be acquired including 2 properties where the whole property value was budgeted, as further illustrated in [Appendix F, Figure 4.2](#). The total acquired area was estimated at 35.2 acres with 42 structures within the area that will be impacted by the proposed improvements.

As a result of the topographic survey and a more detailed layout of the improvements, RGME also performed a ROW acquisition analysis to obtain a more accurate estimate of acquired acreage. Using the same assumption as LAN, RGME used the value for the whole property for budgetary purposes if the proposed ROW occupies 40% of the parcel. RGME identified 39 total parcels to be acquired in the project area, including 3 parcels where the whole property value was budgeted. Within the acquired parcels, approximately 53 structures will be impacted by the construction. The number of impacted structures may vary throughout the life of design due to many structures being mobile homes that may or may not remain in the same location. During investigation, RGME found a noticeable increase and decrease in structure amounts through aerial images at different points in time.

The proposed 155-foot-wide acquisition will be necessary throughout the entire project except at the southern tie-in between the proposed channel section and existing channel section just north of Hill Road. At this location, the channel tapers down from the proposed section, as shown in Exhibit 5, to the existing section just north of the Hill Road bridge. Due to this taper, the full acquisition of 155 feet is not necessary. However, maintenance will still require access to the channel from Hill Road. We recommend two access easements be obtained, one at 923 Hill Road and another at 1005 Hill Road, to allow for access to the proposed maintenance access road along the channel's western boundary. The total anticipated acquisition area is 32.41 acres. The ROW acquisition information can be seen in [Exhibit 8](#).

One parcel is necessary from the AISD Odom Weaver Elementary campus. Construction on this parcel is limited to the summer months when school is out of normal session. A fence separating the remaining school property from the proposed channel is needed. While fence is proposed around the entire project limits in [Appendix J](#), only the fence separating the school property from the proposed channel has been determined as necessary at this time. The need for the remainder of the fence will be determined during final design.

12.0 Preliminary Cost Estimate

The preliminary direct construction cost estimate for P118-25-00/01 is approximately \$7,734,632, the preliminary ROW acquisition cost estimate is about \$15,200,000, and the pipeline relocation estimate is about \$1,733,037. The overall cost estimate is approximately \$24,667,669, and with a 20% contingency (not applied to the preliminary ROW acquisition) is approximately \$26,561,202.76. Refer to [Table 1](#) for a detailed breakdown of the preliminary cost estimate.

Once the PER is accepted by Harris County Commissioners Court, the design of the improvements outlined in the PER will be able to begin. The design is anticipated to take a total of 313 calendar days, starting April 28, 2022 with the request for a Purchase Order and ending March 6, 2023. Construction

is anticipated to take a total of 502 calendar days, beginning March 27, 2023 and ending August 9, 2024. See [Appendix L](#) for project schedule through design and construction.

13.0 Permitting and Approval Requirements

Plan approval by the Harris County Engineering Department is required for work in the Harris County ROW. Plan approval by the Texas Water Development Board is required under the terms of the Flood Infrastructure Fund grant. The oil and gas pipeline easement may require a permit for crossing modifications if it is determined the easements are superior to the existing HCFCD channel easements. It is assumed the pipeline companies have prior rights and will need to be compensated, but this issue will be further resolved during final design.

14.0 Public Engagement

A virtual public meeting was held May 19, 2021 to make affected stakeholders in the project area aware of the Flood Risk Reduction Projects in Halls Bayou for Bond IDs C-25 and C-28. The project covered in this PER is Bond ID C-28 that includes channels P118-25-00 and P118-25-01. The presentation from that virtual public meeting can be found as [Appendix K](#).

EXHIBIT 1

VICINITY & LOCATION MAPS

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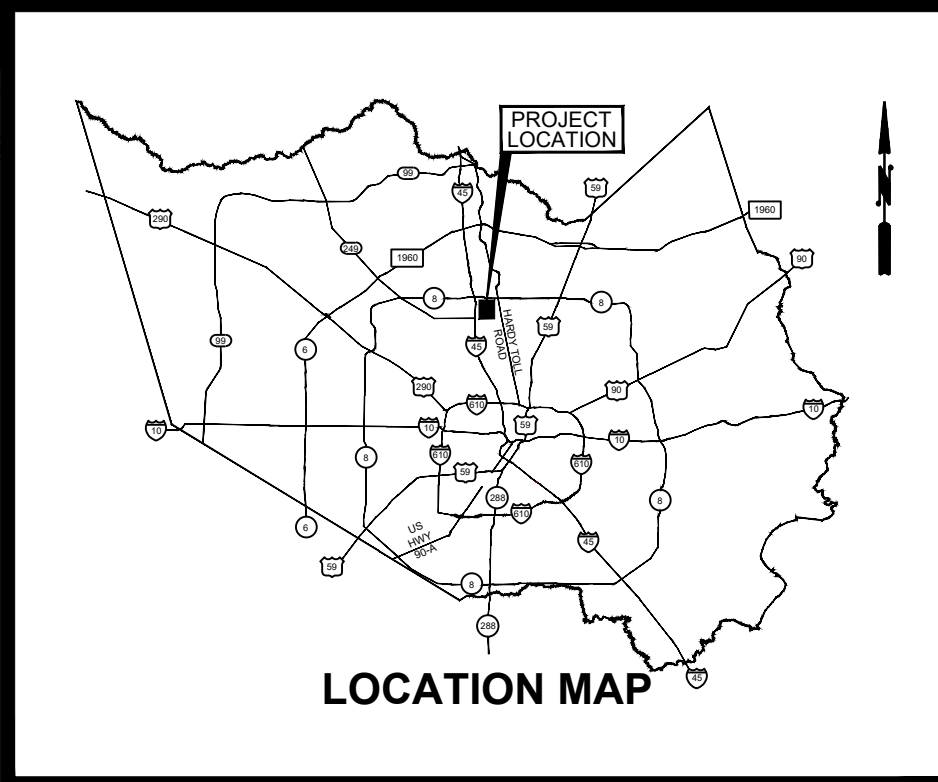
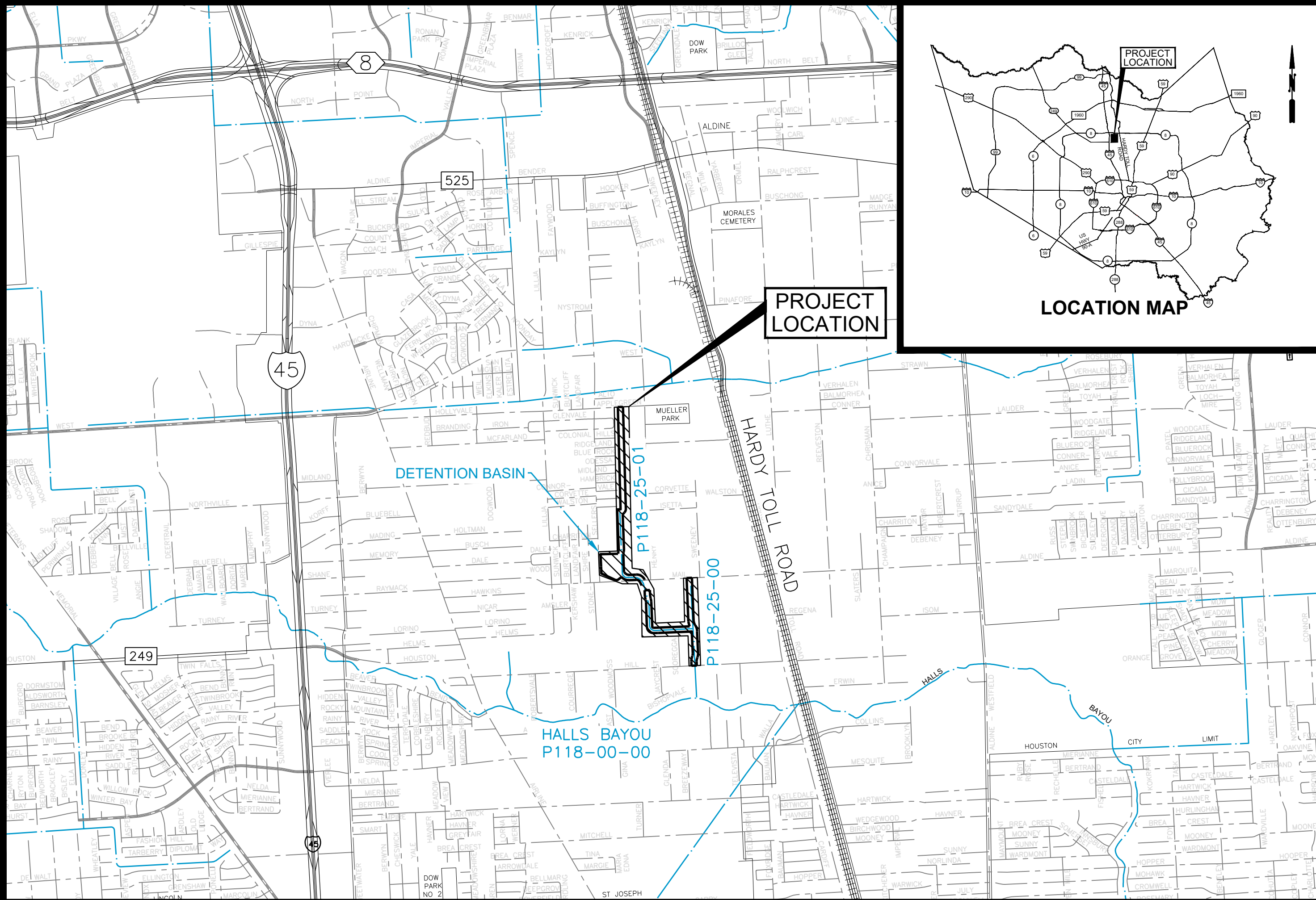
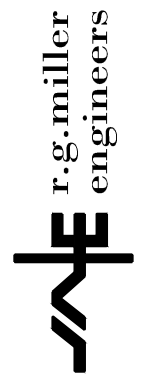


EXHIBIT 1 - VICINITY AND LOCATION MAP

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Suite 350
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(713) 461-9900



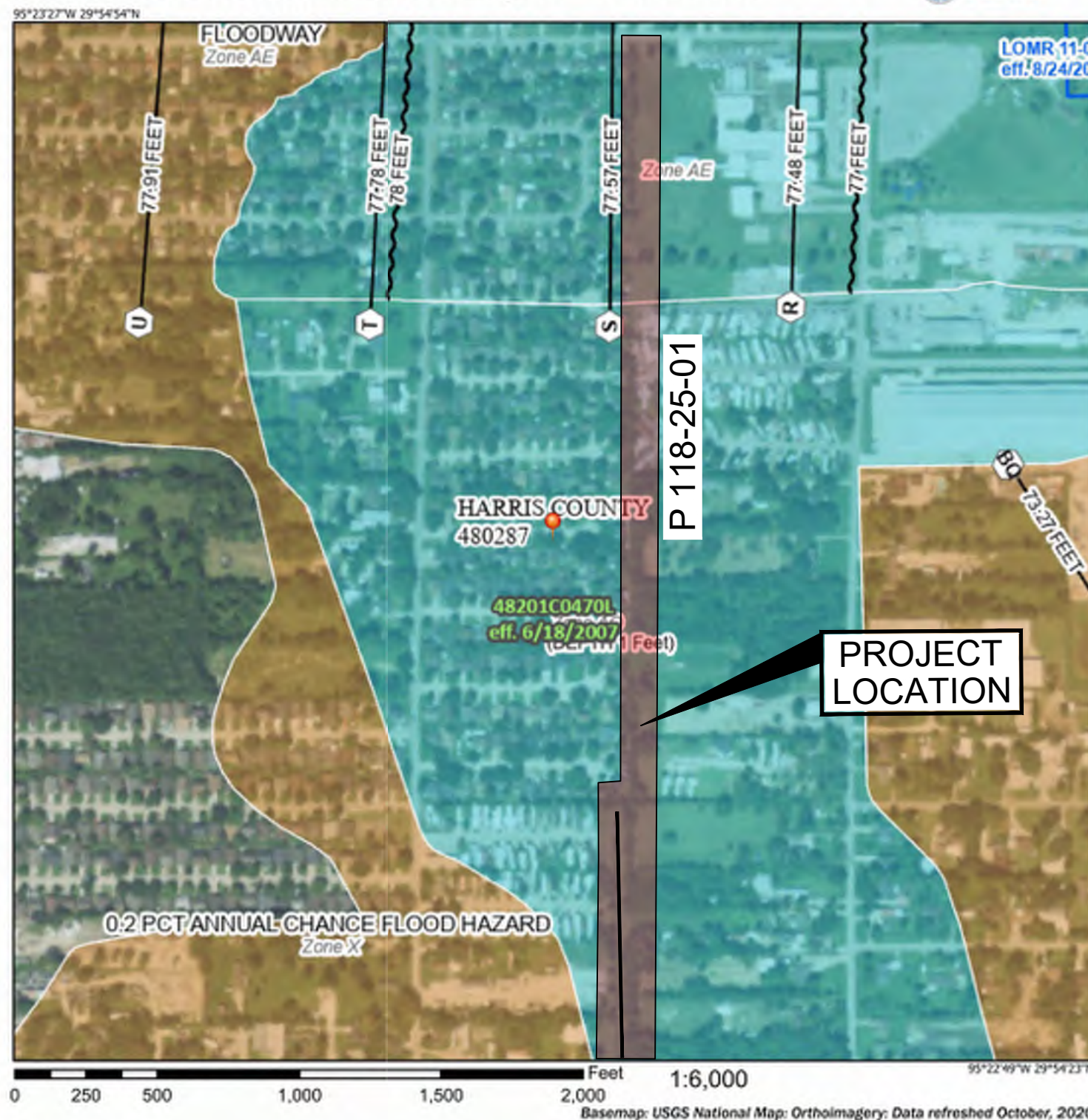
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TEXAS FIRM REGISTRATION NO. F-487

EXHIBIT 2

FEMA MAP

National Flood Hazard Layer FIRMette



Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

- SPECIAL FLOOD HAZARD AREAS**
 - Without Base Flood Elevation (BFE) Zone A, V, AP3
 - With BFE or Depth Zone AE, AO, AM, VE, AR
 - Regulatory Floodway
 - OTHER AREAS OF FLOOD HAZARD**
 - 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
 - Future Conditions 1% Annual Chance Flood Hazard Zone X
 - Area with Reduced Flood Risk due to Levee. See Notes. Zone X
 - Area with Flood Risk due to Levee Zone O
 - OTHER AREAS**
 - Area of Minimal Flood Hazard Zone X
 - Effective LOMRs
 - Area of Undetermined Flood Hazard Zone D
 - GENERAL STRUCTURES**
 - Channel, Culvert, or Storm Sewer
 - Levee, Dike, or Floodwall
 - OTHER FEATURES**
 - Cross Sections with 1% Annual Chance Water Surface Elevation
 - Coastal Transect
 - Base Flood Elevation Line (BFE)
 - Limit of Study
 - Jurisdiction Boundary
 - Coastal Transect Baseline
 - Profile Baseline
 - Hydrographic Feature
 - MAP PANELS**
 - Digital Data Available
 - No Digital Data Available
 - Unmapped
- The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

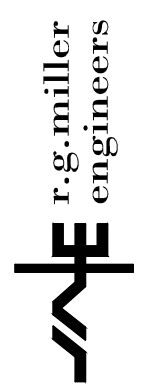
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards.

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 4/15/2021 at 7:03 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

EXHIBIT 2.1 - FEMA MAP

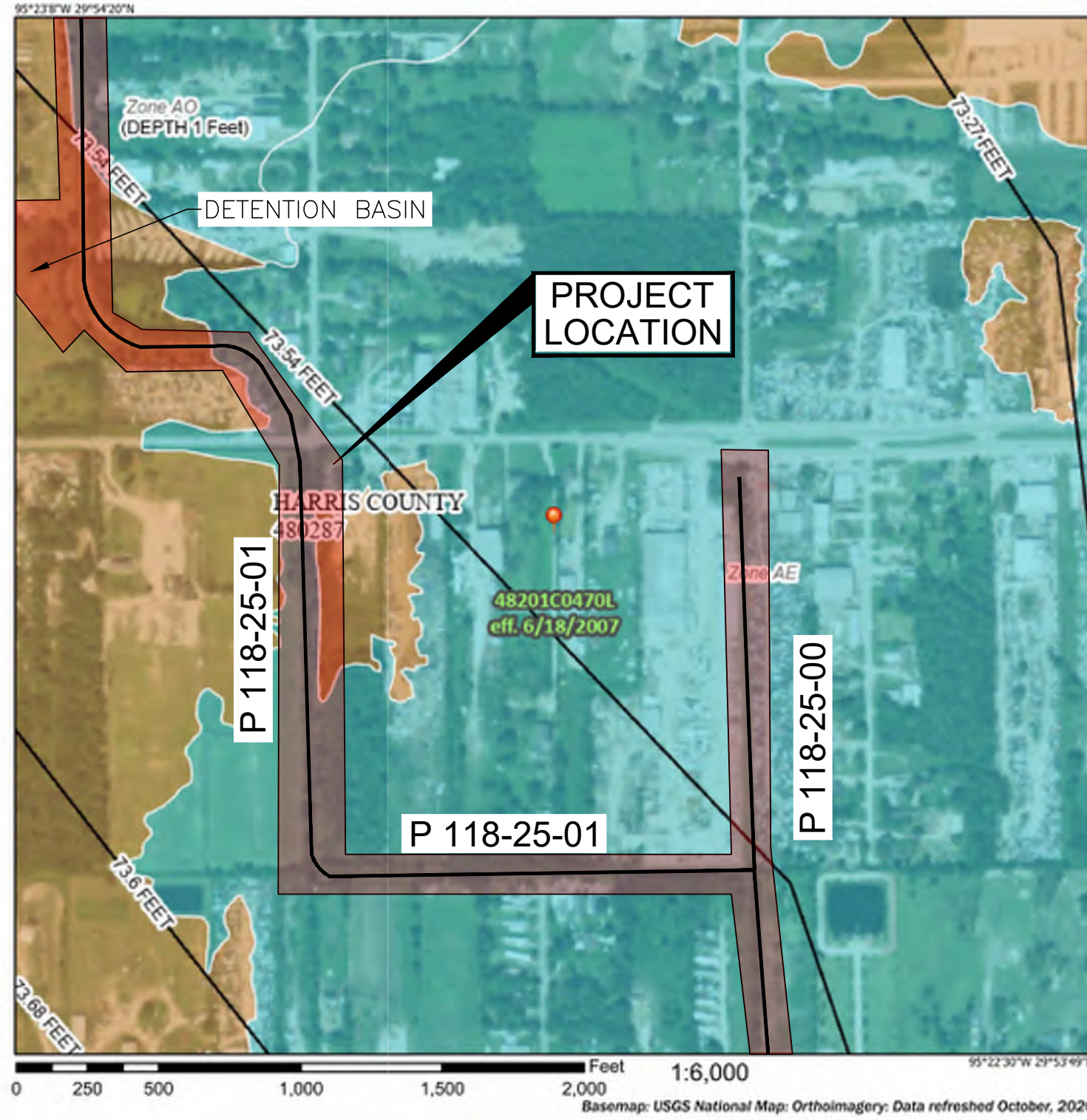
16340 Park Ten Place
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DATE: 3/15/2022

M:\0453\07 P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CAD\EXHIBITS\EXH-01 - KEY MAP.DWG | SAVED: Tuesday, March 15, 2022 3:40:28 PM | PLOTTED: Tuesday, March 15, 2022 3:41:59 PM

National Flood Hazard Layer FIRMette



Legend

- SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT
- SPECIAL FLOOD HAZARD AREAS**
- Without Base Flood Elevation (BFE) Zone A, V, A99
 - With BFE or Depth Zone AE, AO, AM, VE, AR
 - Regulatory Floodway
- OTHER AREAS OF FLOOD HAZARD**
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
 - Future Conditions 1% Annual Chance Flood Hazard Zone X
 - Area with Reduced Flood Risk due to Levee. See Notes. Zone X
 - Area with Flood Risk due to Levee Zone D
- OTHER AREAS**
- NO SCREEN Area of Minimal Flood Hazard Zone X
 - Effective LOMRs
 - Area of Undetermined Flood Hazard Zone D
- GENERAL STRUCTURES**
- Channel, Culvert, or Storm Sewer
 - Levee, Dike, or Floodwall
- OTHER FEATURES**
- Cross Sections with 1% Annual Chance Water Surface Elevation
 - Coastal Transect
 - Base Flood Elevation Line (BFE)
 - Limit of Study
 - Jurisdiction Boundary
 - Coastal Transect Baseline
 - Profile Baseline
 - Hydrographic Feature
- MAP PANELS**
- Digital Data Available
 - No Digital Data Available
 - Unmapped
- The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards.

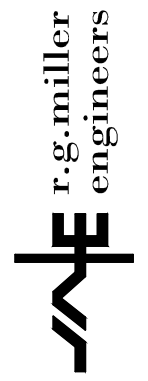
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This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

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EXHIBIT 2.2 - FEMA MAP

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TEXAS FIRM REGISTRATION NO. F-467

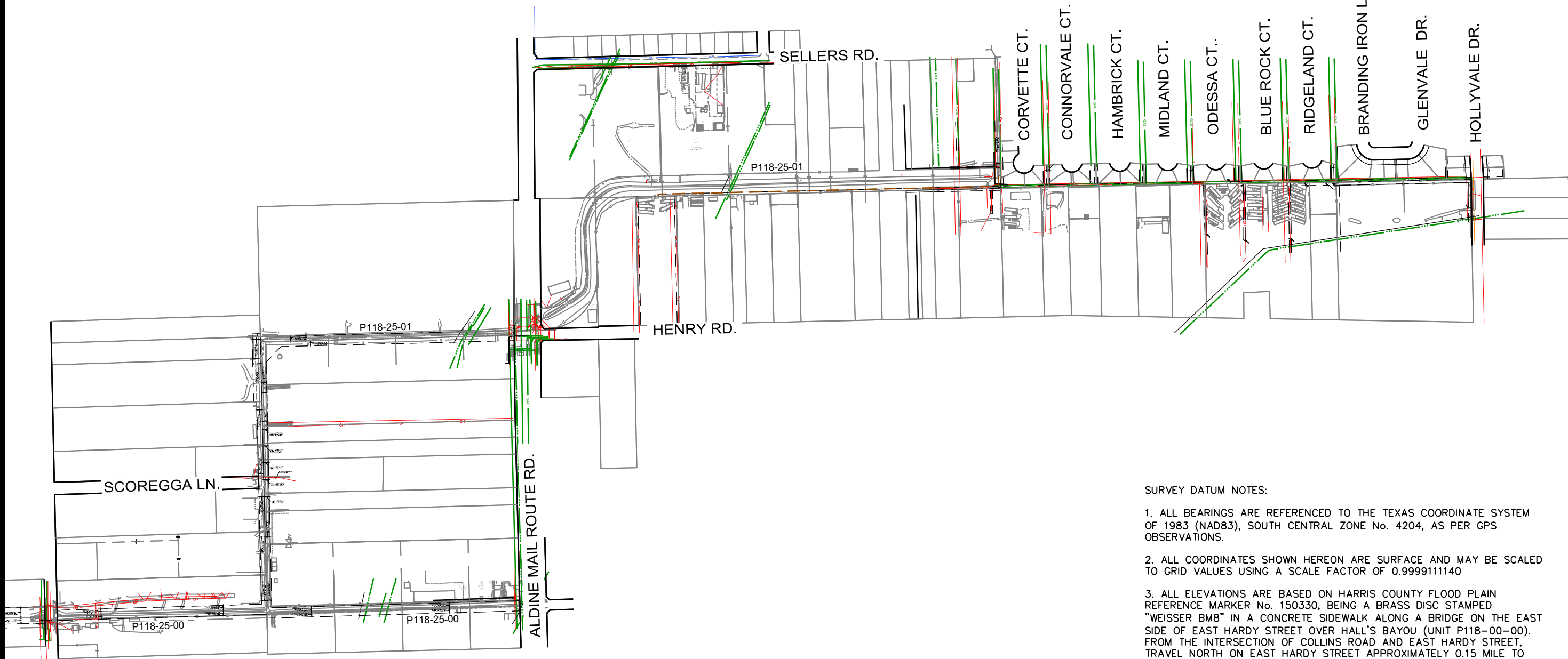


DATE: 3/15/2022

EXHIBIT 3

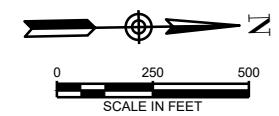
TOPOGRAPHIC SURVEY

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SURVEY DATUM NOTES:

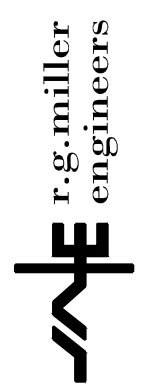
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2. ALL COORDINATES SHOWN HEREON ARE SURFACE AND MAY BE SCALED TO GRID VALUES USING A SCALE FACTOR OF 0.9999111140
3. ALL ELEVATIONS ARE BASED ON HARRIS COUNTY FLOOD PLAN REFERENCE MARKER No. 150330, BEING A BRASS DISC STAMPED "WEISSER BM8" IN A CONCRETE SIDEWALK ALONG A BRIDGE ON THE EAST SIDE OF EAST HARDY STREET OVER HALL'S BAYOU (UNIT P118-00-00). FROM THE INTERSECTION OF COLLINS ROAD AND EAST HARDY STREET, TRAVEL NORTH ON EAST HARDY STREET APPROXIMATELY 0.15 MILE TO CONCRETE BRIDGE. MONUMENT IS LOCATED ON DOWNSTREAM SIDE OF BRIDGE IN CENTERLINE SIDEWALK AT CENTERLINE STREAM. PUBLISHED ELEVATION = 77.39' NAVD88, 2001 ADJUSTMENT



LEGEND:

HCFCD ROW	---
LOT LINES	---
WATER LINE	---
GAS	---
TELEPHONE	---
ELECTRIC	---
UNKNOWN LINE	---
UNDERGROUND PIPELINE	---
UTILITY PIPELINE	---
SANITARY PIPELINE	---
OVERHEAD ELECTRIC LINE	---
BUILDING	---

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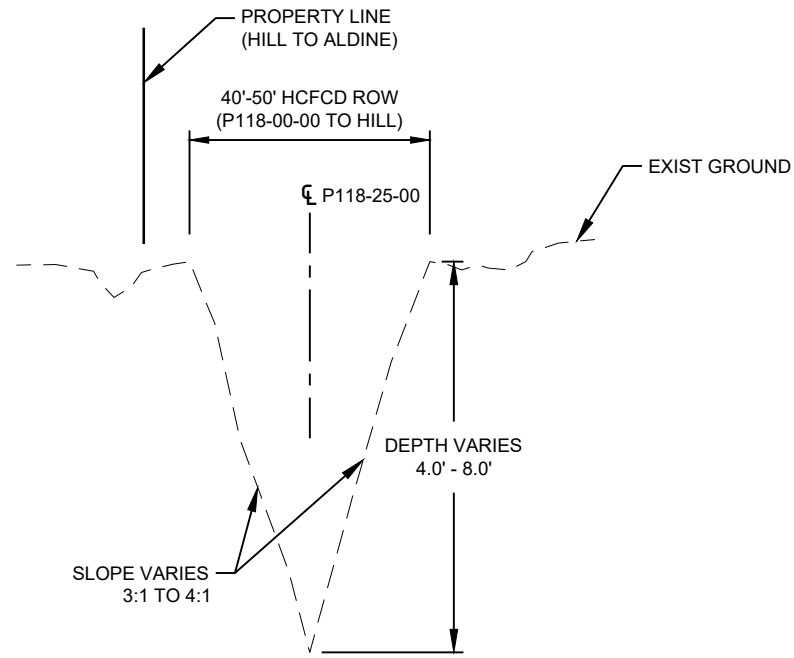


DATE: 3/4/2022

EXHIBIT 3 - TOPO SURVEY

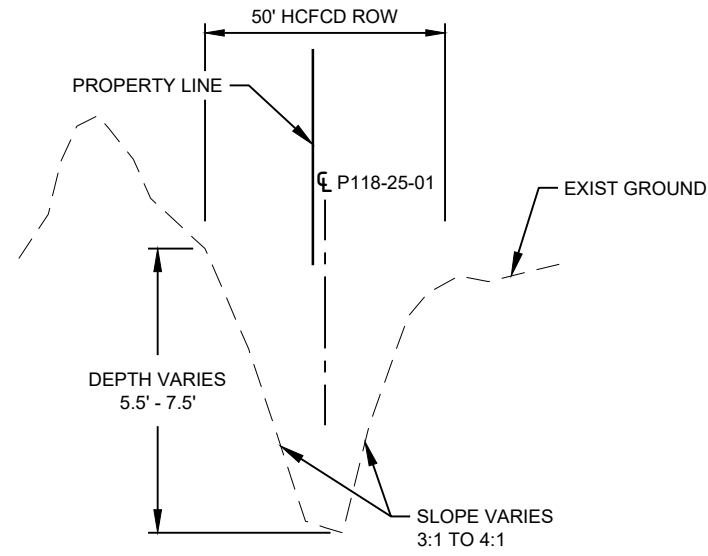
EXHIBIT 4

EXISTING CROSS-SECTIONS



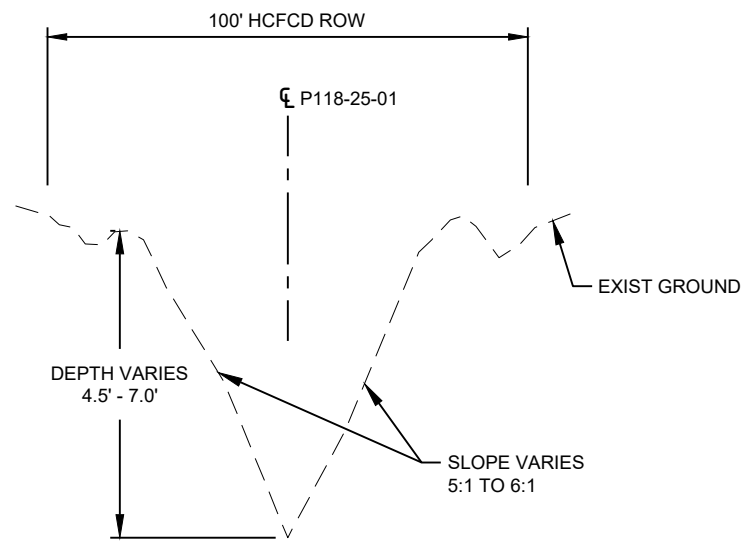
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 N.T.S.



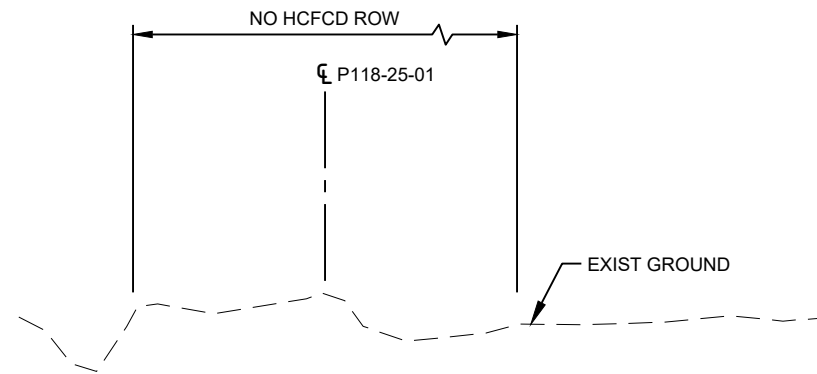
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**P118-25-01 EXISTING
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U/S OF ALDINE MAIL ROUTE RD. TO CORVETTE CT.
 N.T.S.



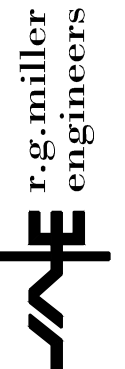
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 N.T.S.

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EXHIBIT 4 - EXISTING CHANNEL SECTIONS

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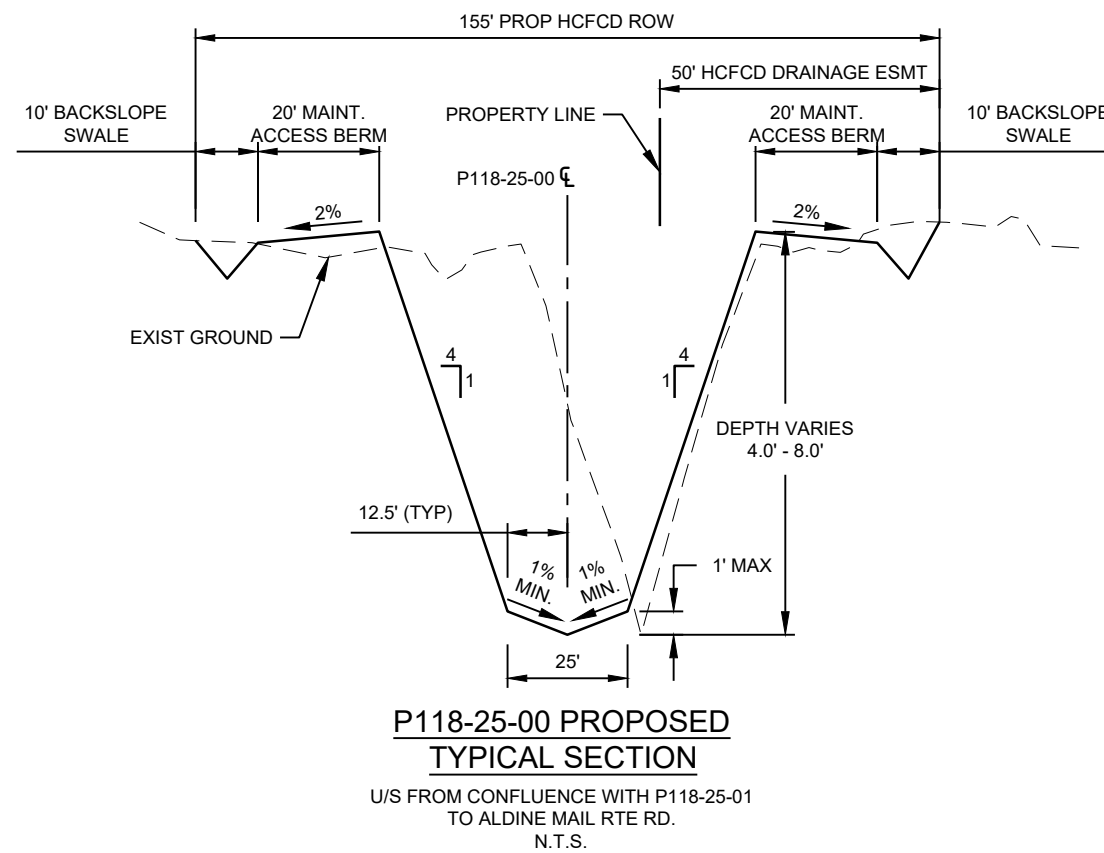
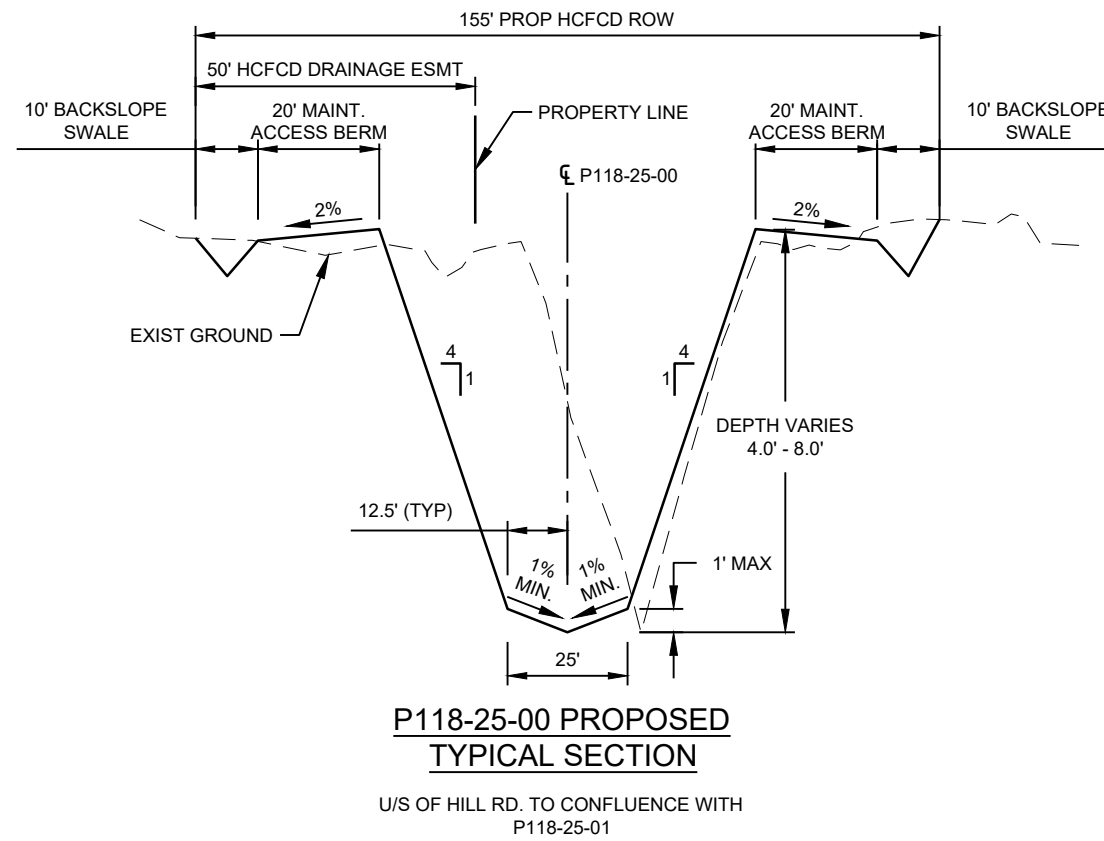


DATE: 3/3/2022

EXHIBIT 5

PROPOSED CROSS-SECTIONS

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REV	DESCRIPTION	DATE	APPR

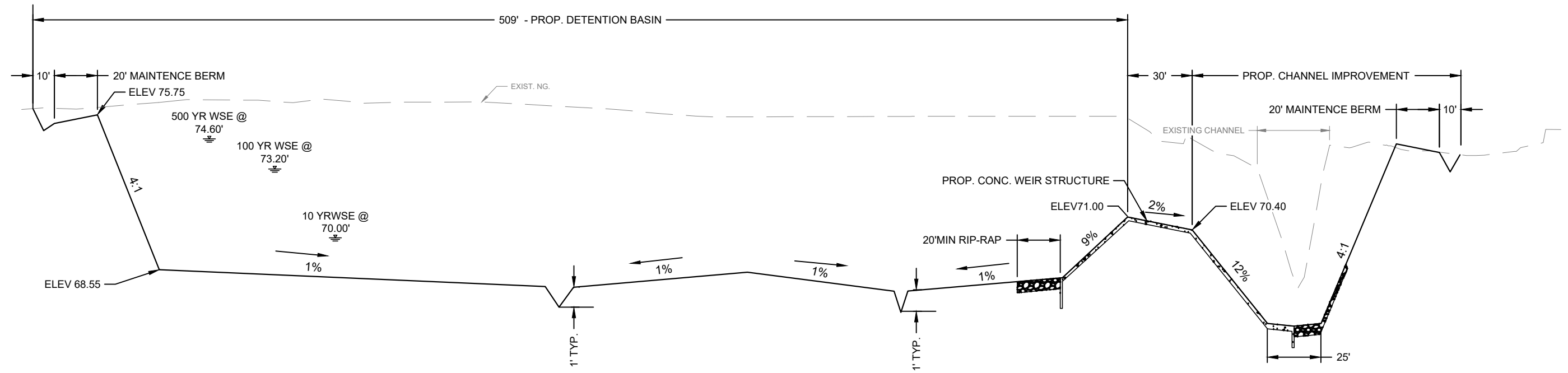
PREPARED: A.V.	CHECKED: M.J.	APPROVED:	
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<p style="font-size: small; margin: 0;">16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487</p>	<p style="font-size: small; margin: 0;">9900 Northwest Freeway Houston, Texas 77092</p>
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DATE: 3/15/2022	SHEET NUMBER
	07 OF 41

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

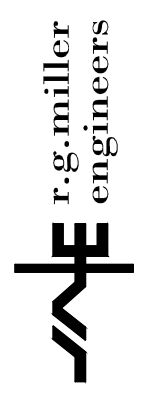
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HORIZONTAL 1"=40'
VERTICAL 1"=4'

EXHIBIT 5.2 - PROPOSED DETENTION CROSS SECTION

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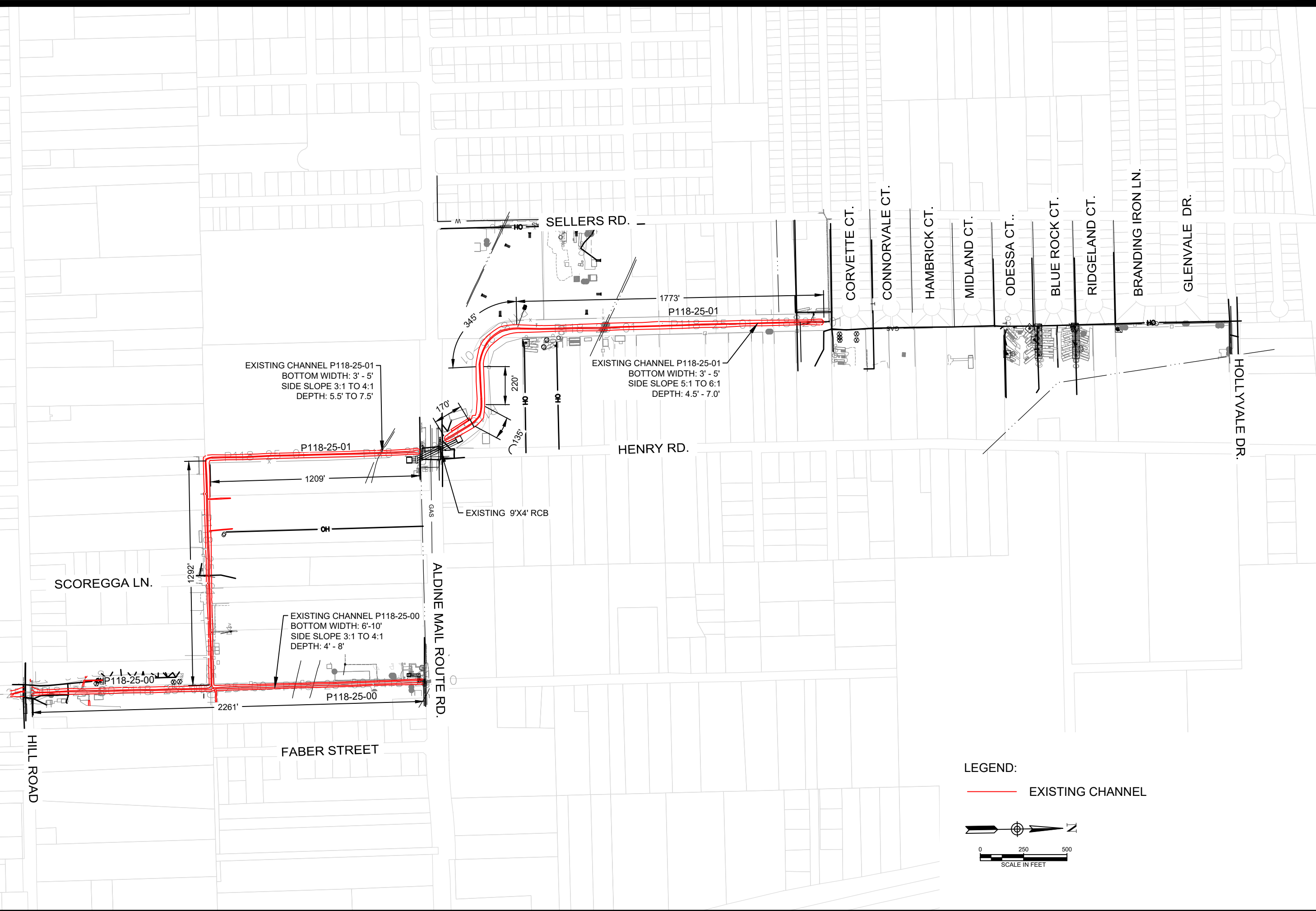



DATE: 3/3/2022

EXHIBIT 6

EXISTING STORM LAYOUT

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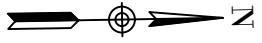
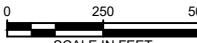
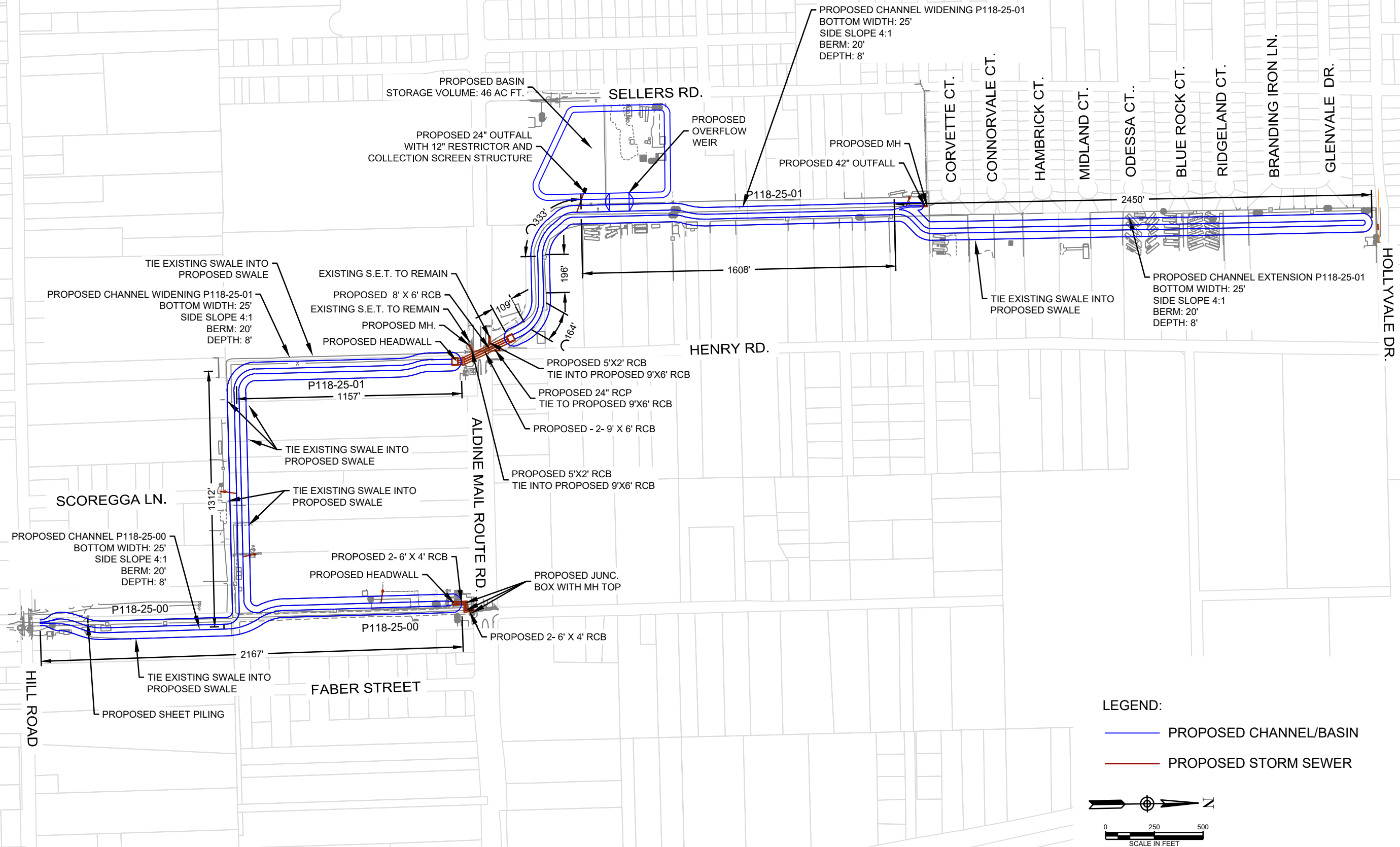


 SCALE IN FEET

EXHIBIT 7

PROPOSED STORM LAYOUT

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LEGEND:

- PROPOSED CHANNEL/BASIN
- PROPOSED STORM SEWER

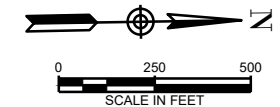
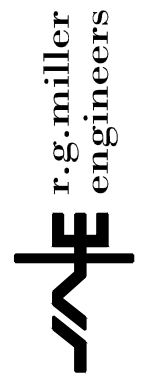


EXHIBIT 7 - PROPOSED CHANNEL- BASIN LAYOUT

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Houston, Texas 77084
(713) 461-9800








TEXAS FIRM REGISTRATION NO. F-487



DATE: 3/3/2022

EXHIBIT 8

ROW ACQUISITION EXHIBIT

- LEGEND:**
-  ACQUISITION AREA
 -  PARCEL REMAINDER LESS THAN 60% OF TOTAL PARCEL AREA
 -  ACCESS EASEMENT
 -  AFFECTED BUILDINGS
 -  PROP. HCFCO ROW
 -  EXIST. HCFCO LIMITS
 -  EXISTING PARCEL

TOTAL ACQUISITION AREA: 35 ACRE
 TOTAL PARTIAL ACQUISITION PARCEL : 35
 TOTAL FULL ACQUISITION PARCEL : 4
 TOTAL HOMES/BUILDING AFFECTED : 56

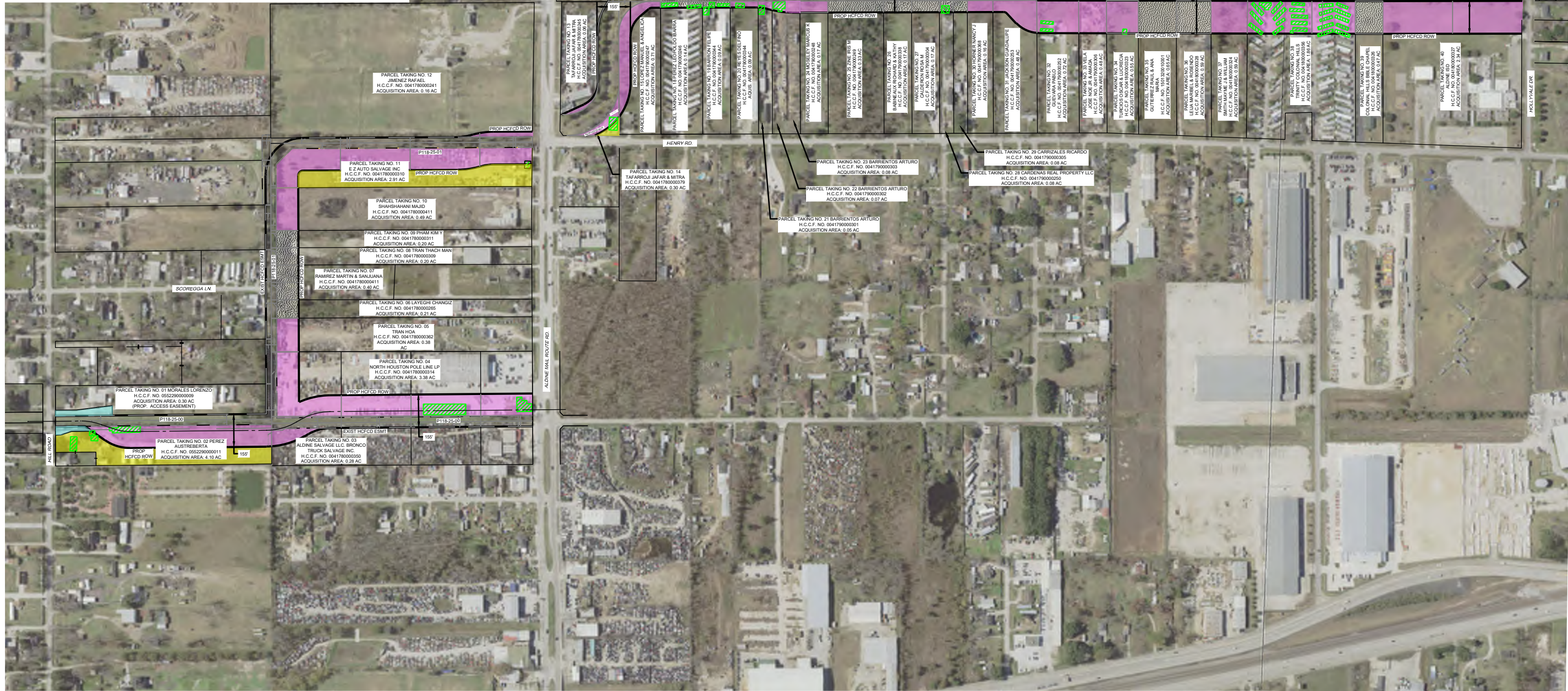
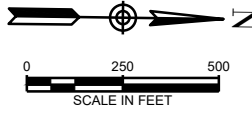


EXHIBIT 8 - ROW ACQUISITION

16340 Park Ten Place
 Suite 350
 Houston, Texas 77084
 (713) 461-9600
 TEXAS FIRM REGISTRATION NO. F-487

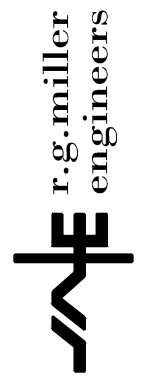
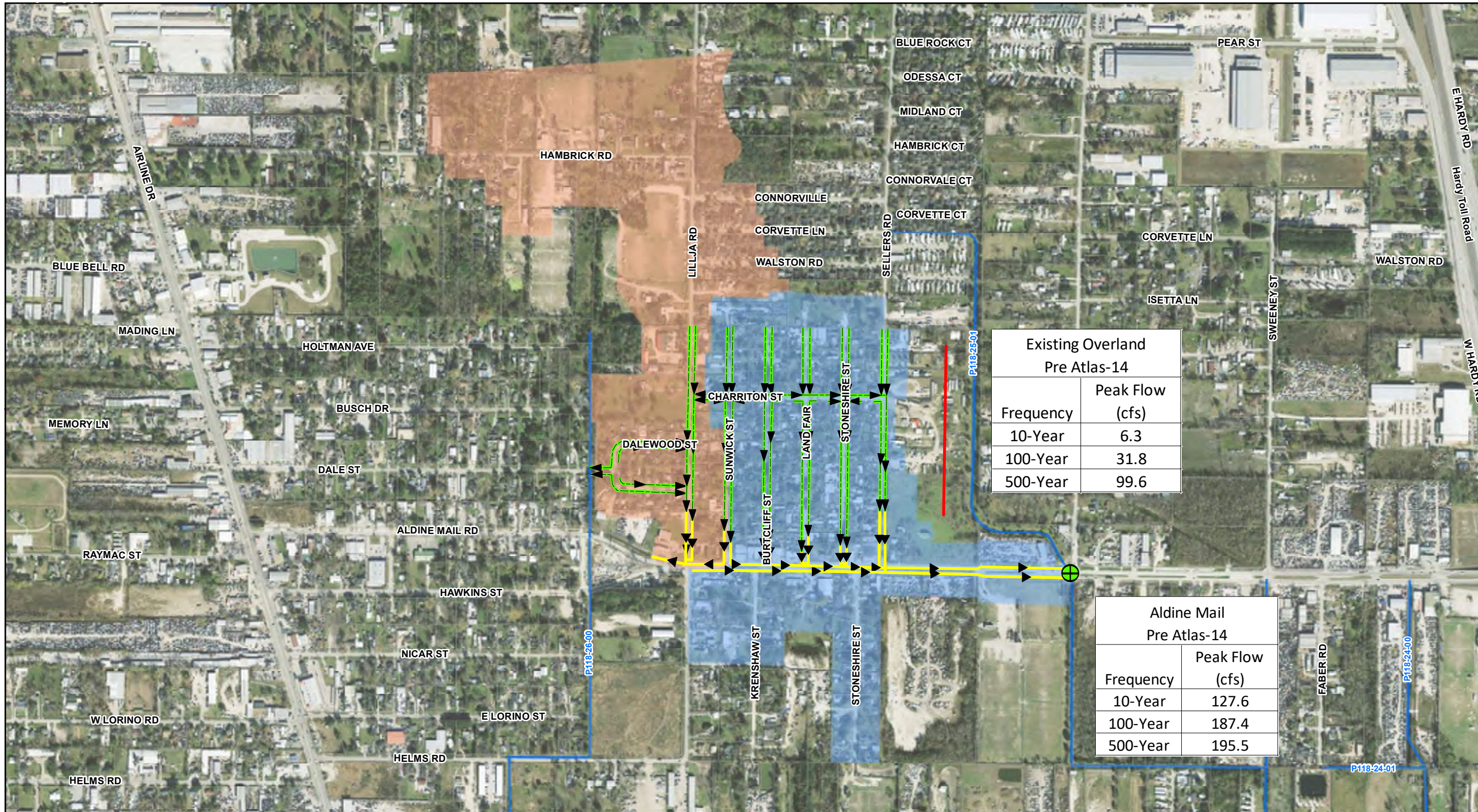


EXHIBIT 9

OAK GLEN PLACE SUBDIVISION

EXISTING DRAINAGE SYSTEM

LAYOUT



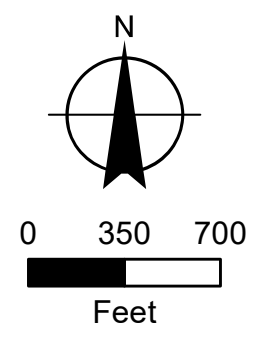
Legend

- Aldine Mail Outfall*
- Existing Overland Flow Outfall
- Existing Storm Sewer
- Roadside Ditches
- Drainage Area P118-25-01
- Drainage Area P118-26-00

* Discharge includes storm sewer and overland flow at the vicinity of the outfall.

Frequency	Peak Flow (cfs)
10-Year	6.3
100-Year	31.8
500-Year	99.6

Frequency	Peak Flow (cfs)
10-Year	127.6
100-Year	187.4
500-Year	195.5



Existing Drainage System Layout

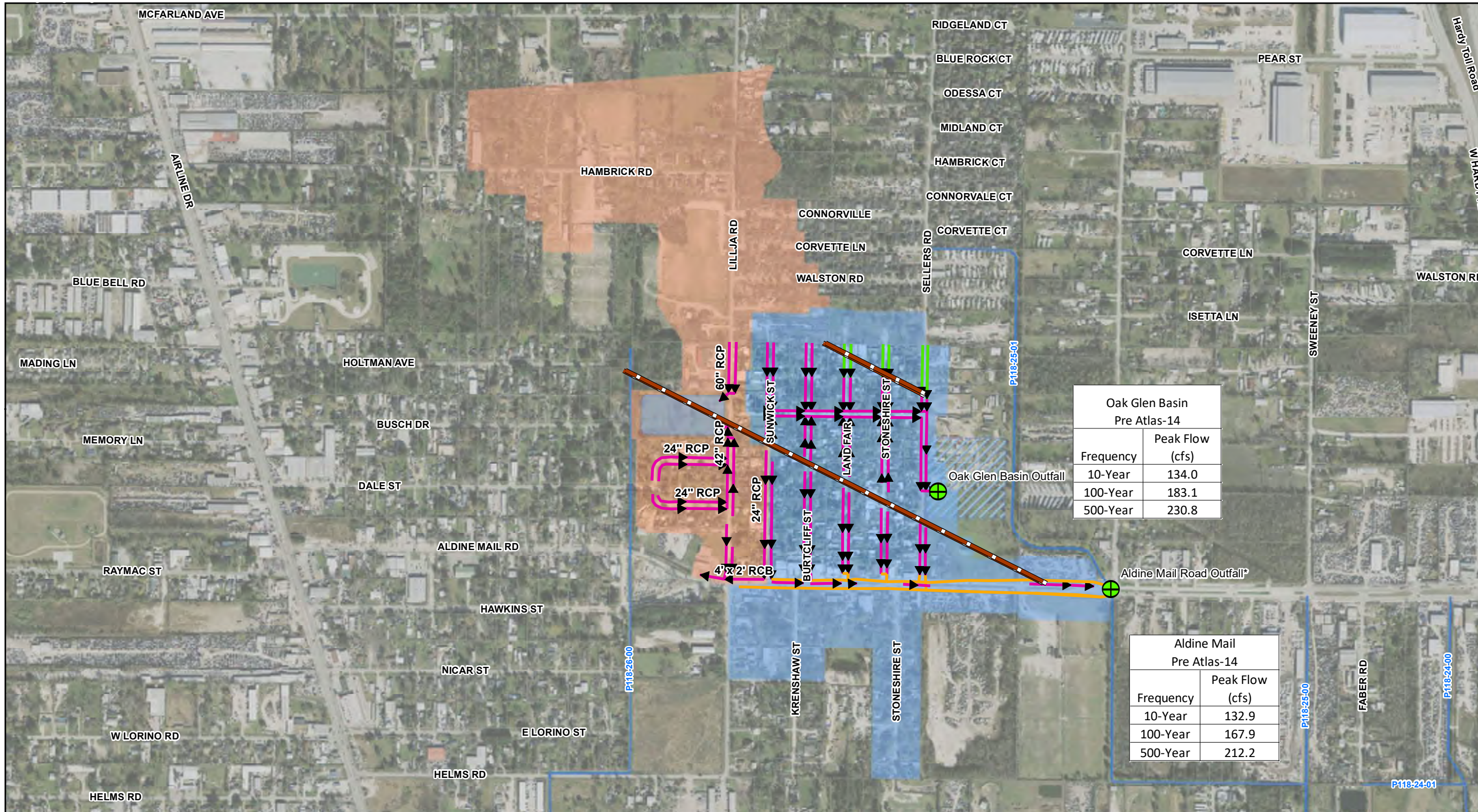


EXHIBIT 10

OAK GLEN PLACE SUBDIVISION

PROPOSED DRAINAGE SYSTEM

LAYOUT

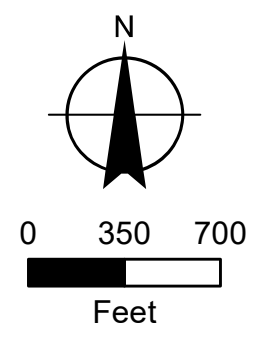


- Legend**
- Outfall
 - Gas Pipeline
 - Existing Storm Sewer
 - Proposed Storm Sewer
 - Proposed Roadside Ditch
 - Detention Pond West
 - Drainage Area P118-25-01
 - Drainage Area P118-26-00
 - Oak Glen Basin (HCFCD)

* Discharge includes storm sewer and overland flow at the vicinity of the outfall.

Oak Glen Basin Pre Atlas-14	
Frequency	Peak Flow (cfs)
10-Year	134.0
100-Year	183.1
500-Year	230.8

Aldine Mail Pre Atlas-14	
Frequency	Peak Flow (cfs)
10-Year	132.9
100-Year	167.9
500-Year	212.2



Proposed Drainage System Layout



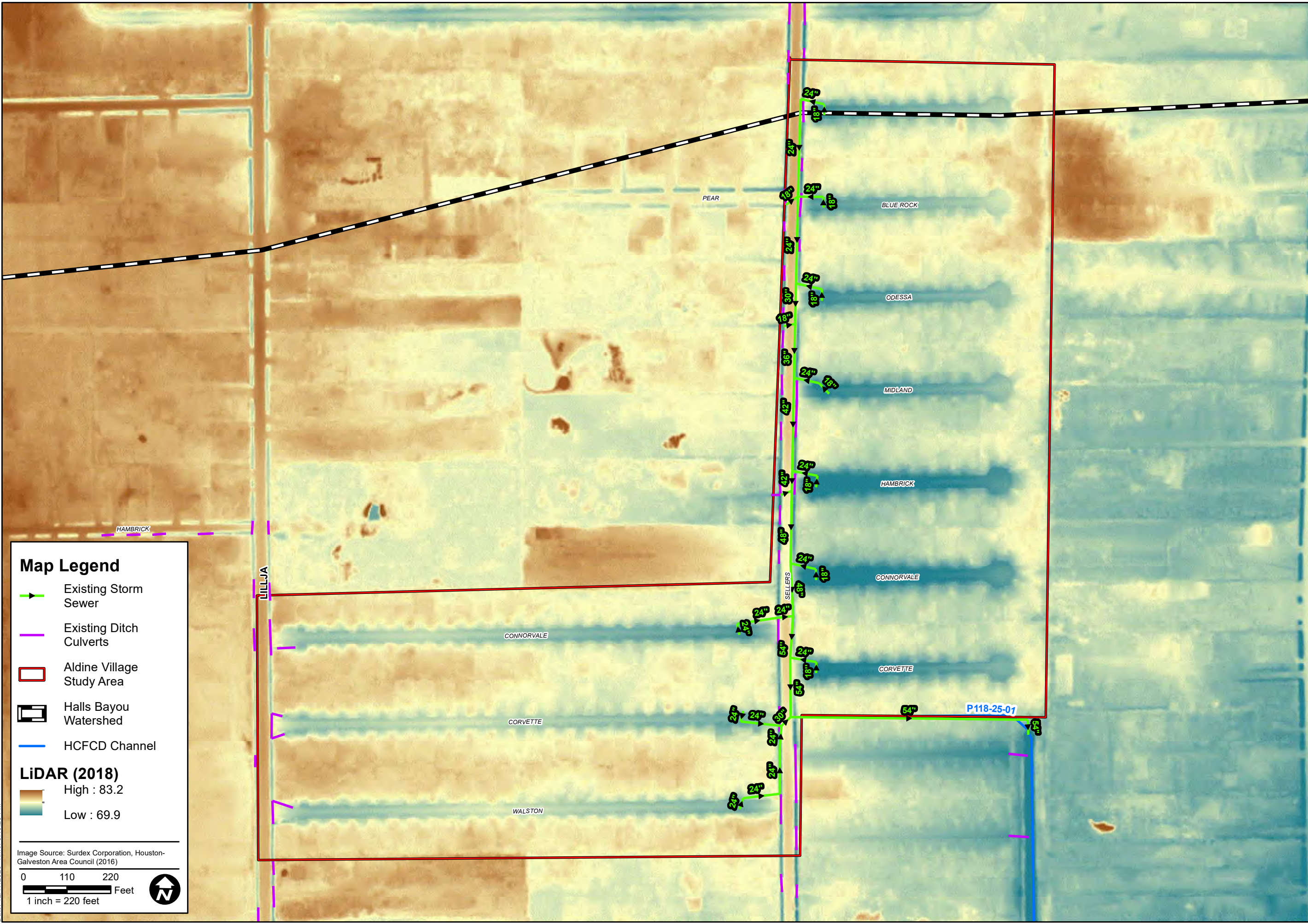
EXHIBIT 11

ALDINE VILLAGE SUBDIVISION

EXISTING DRAINAGE SYSTEM

LAYOUT

\\lacdc\shares\projects\1201120-12248-0004-0-Production-Working\4-9-GIS\ArcMap\Projects\Drainage Analysis Exhibits\06_Baseline_Infrastructure.mxd
 Date: 12/17/2020 Time: 3:40:25 PM



Map Legend

- Existing Storm Sewer
- Existing Ditch Culverts
- Aldine Village Study Area
- Halls Bayou Watershed
- HCFCDC Channel

LiDAR (2018)
 High : 83.2
 Low : 69.9

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 110 220 Feet
 1 inch = 220 feet

HARRIS COUNTY ENGINEERING DEPARTMENT (HCED)
 ALDINE VILLAGE SUBDIVISION DRAINAGE IMPROVEMENTS

EXISTING STORM INFRASTRUCTURE

PREPARED: JKB
 CHECKED: DMB
 APPROVED: DMB

IGN
 Lockwood, Andrews & Newnam, Inc.
 A ILLINOIS A DAILY COMPANY
 TBPE Firm No. 2614
 2825 Briarpark Drive • Houston, TX 77042-3720
 T 713.266.6900 • F 713.266.2089
 www.ign-inc.com • info@ign-inc.com



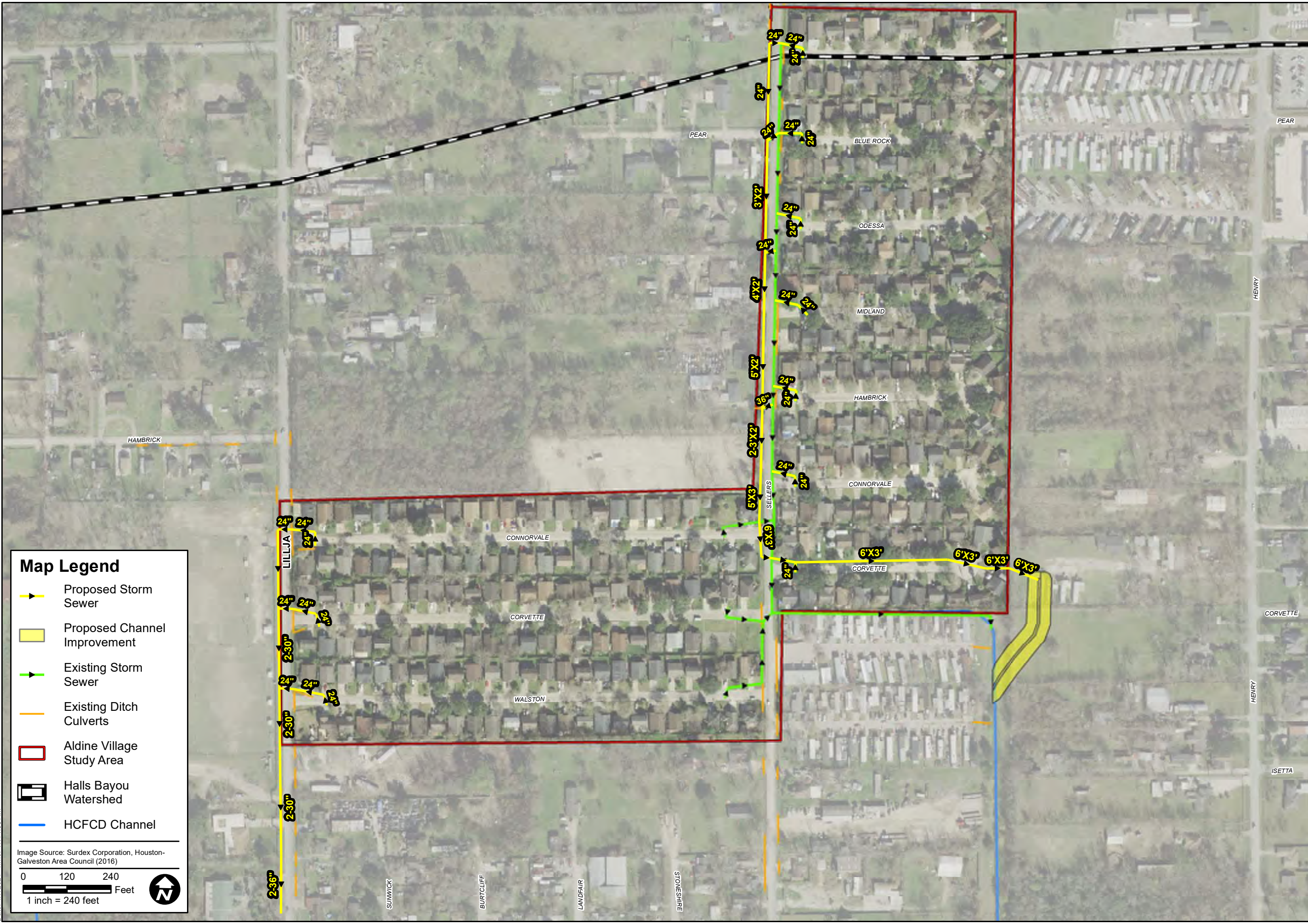
1001 Preston, 7th Floor
 Houston Texas, 77002

DATE: APR 2021
 SCALE: AS NOTED

EXHIBIT
 6

EXHIBIT 12

ALDINE VILLAGE SUBDIVISION PROPOSED DRAINAGE SYSTEM LAYOUT



Map Legend

- Proposed Storm Sewer
- Proposed Channel Improvement
- Existing Storm Sewer
- Existing Ditch Culverts
- Aldine Village Study Area
- Halls Bayou Watershed
- HCFCD Channel

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 120 240 Feet
 1 inch = 240 feet

HARRIS COUNTY ENGINEERING DEPARTMENT (HCED)
 ALDINE VILLAGE SUBDIVISION DRAINAGE IMPROVEMENTS

**RECOMMENDED ALTERNATIVE
 PROPOSED STORM INFRASTRUCTURE**

PREPARED:	JKB
CHECKED:	DMB
APPROVED:	DMB

IGN
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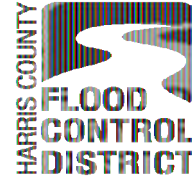
DATE: APR 2021
 SCALE: AS NOTED

**EXHIBIT
 11**

TABLE 1

PRELIMINARY COST ESTIMATE

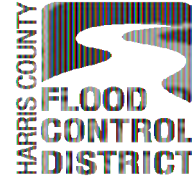
HARRIS COUNTY FLOOD CONTROL DISTRICT
Standardized Construction Cost Estimate
USING HCFCD STANDARD PAY ITEMS



Project ID Halls Bayou Tributary Unit No. P118-25-00/01
Submittal: Preliminary Cost Estimate
Date: 4/1/2022
Prepared By: R.G. MILLER ENGINEERS

Pay Item	Description	Long Desc	Incidental Spec	Units	Quantity	Unit Bid Price	Total Bid Price
1555-01	Traffic Control	TRAFFIC CONTROL	(02767)	LS	2	\$ 100,000.00	\$ 200,000.00
1562-01	Construction Fence	CONSTRUCTION FENCE		LF	20283	\$ 3.00	\$ 60,849.00
2120-02	Debris & Trash Removal	DEBRIS AND TRASH REMOVAL AND DISPOSAL IN A LANDFILL		CY	56	\$ 30.00	\$ 1,680.00
2120-03	Rem. & Dis. of Concrete Rubble	REMOVE & DISPOSE OF CONCRETE RUBBLE AND CONCRETE		CY	918	\$ 32.00	\$ 29,360.59
2120-04	Rem. & Dis. of All Pipe	REMOVE & DISPOSE OF ALL PIPE	(01565)	LF	941	\$ 12.00	\$ 11,292.00
2120-08	Rem. & Dis. of Metal Guard Fence	REMOVE & DISPOSE OF METAL GUARD FENCE	(01565)	LF	4255	\$ 5.00	\$ 21,275.00
2120-09	Rem. & Dis. of Tires <= 16"	REMOVE & DISPOSE OF TIRES <= 16"	(01565)	EA	13	\$ 23.00	\$ 299.00
2120-10	Rem. & Dis. of Tires > 16"	REMOVE & DISPOSE OF TIRES >16"	(01565)	EA	13	\$ 27.00	\$ 351.00
2120-19	Remove & Dispose of Storm Sewer Manhole	REMOVE & DISPOSE OF STORM SEWER MANHOLE	(01565)	EA	1	\$ 450.00	\$ 450.00
2120-21	Remove & Dispose of Sanitary Sewer Pipe	REMOVE & DISPOSE OF SANITARY SEWER PIPE	(01565)	LF	100	\$ 20.00	\$ 2,000.00
2120-23	Remove & Dispose of Inlet	REMOVE & DISPOSE OF INLET	(01565)	EA	10	\$ 400.00	\$ 4,000.00
2120-24	Remove & Dispose of Water Line	REMOVE & DISPOSE OF WATER LINE	(01565)	LF	200	\$ 10.00	\$ 2,000.00
2120-33	Dismount Rim, All Diameters	DISMOUNT RIM (IF ATTACHED TO TIRE), ALL DIAMETERS	(01565)	EA	26	\$ 30.00	\$ 780.00
2120-46	Rem. and Dis. of Asphalt Pvmt.	REMOVE & DISPOSE OF ASPHALT PAVEMENT & SUB GRADE	(01565)	SY	3534	\$ 11.00	\$ 38,872.78
2200-02	Site Preparation & Restoration	SITE PREPARATION & RESTORATION, INCLUDING FACILITY FOR ENGINEER	(01520) (01565) (01580) (02120)	EA	1	\$ 200,000.00	\$ 200,000.00
2220-06	Demolition, Septic Tank Removal	DEMOLITION, SEPTIC TANK REMOVAL	(02120)	EA	5	\$ 3,000.00	\$ 15,000.00
2233-01	Clearing and Grubbing	CLEARING & GRUBBING	(02120)	AC	42	\$ 6,000.00	\$ 250,162.40
2241-01	Care and Control of Water	CARE AND CONTROL OF WATER	(02269)(02120) (02462)(Plans)	LS	1	\$ 100,000.00	\$ 100,000.00
2269-01	Trench Shoring System, 5 to 20 feet	TRENCH SHORING SYSTEM,5 TO 20 FEET		LF	552	\$ 4.00	\$ 2,208.00
2315-02	Excavation & Off-site Disposal	EXCAVATION & OFF-SITE DISPOSAL	(02120) (02911)	CY	219169	\$ 15.00	\$ 3,287,535.00
2315-06	B/S Drainage System Swales	BACKSLOPE DRAINAGE SYSTEM SWALES		LF	19227	\$ 4.00	\$ 76,908.00
2361-02	Reinforced Silt Fence	REINFORCED SILT FENCE	(02120)	LF	12936	\$ 2.00	\$ 25,872.00
2364-02	Filter Dam - Type 2	FILTER DAM - TYPE 2	(02120) (02378) (02921)	LF	50	\$ 45.00	\$ 2,250.00
2365-01	Stabilized Construction Access	STABILIZED CONSTRUCTION ACCESS	(02120) (02378)	SY	896	\$ 22.00	\$ 19,712.00
2366-01	Inlet Protection Barrier	INLET PROTECTION BARRIER	(Plans)	EA	35	\$ 120.00	\$ 4,200.00
2368-02	Floatables Screen System	FLOATABLES SCREEN SYSTEM	(03310) (Plans)	EA	1	\$ 8,000.00	\$ 8,000.00
2376-03	Concrete Channel Lining, 6" NOMINAL THICKNESS	CONCRETE CHANNEL LINING, 6" NOMINAL THICKNESS	(02316) (03310)	SY	1385	\$ 80.00	\$ 110,835.56
2376-04	Concrete Channel Lining, 8" NOMINAL THICKNESS	CONCRETE CHANNEL LINING, 8" NOMINAL THICKNESS	(02316) (03310)	SY	921	\$ 120.00	\$ 110,560.00
2376-06	Concrete Interceptor Structure	CONCRETE INTERCEPTOR STRUCTURE	(02316) (03310)	SY	363	\$ 110.00	\$ 39,930.00
2378-01	Riprap, Gradation No. 1	RIPRAP, GRADATION NO. 1	(02315) (02316)	SY	6047	\$ 95.00	\$ 574,443.89
2462-15	Steel Sheet Piling 25-Foot to 35-Foot	STEEL SHEET PILING 25 FOOT LONG TO 35 FOOT LONG	(02316) (PLANS)	LF	95	\$ 100.00	\$ 9,500.00
2516-07	Cut and Plug Water Main	CUT AND PLUG WATER MAIN		EA	1	\$ 1,500.00	\$ 1,500.00
2611-05	42" RCP	42-INCH REINFORCED CONCRETE PIPE	(02316) (02321) (03310)	LF	40	\$ 165.00	\$ 6,600.00
2611-06	48" RCP	48-INCH REINFORCED CONCRETE PIPE	(02316) (02321) (03310)	LF	120	\$ 180.00	\$ 21,600.00
2611-15	12" RCP	12-INCH REINFORCED CONCRETE PIPE	(02316) (02321) (03310)	LF	128	\$ 40.00	\$ 5,120.00
2612-41	6' x 4' RCB	6' x 4' REINFORCED CONCRETE BOX	(02316) (02321) (03310)	LF	182	\$ 400.00	\$ 72,800.00
2612-63	8' x 6' RCB	8' x 6' REINFORCED CONCRETE BOX	(02316) (02321) (03310)	LF	286	\$ 600.00	\$ 171,600.00
2612-73	9' x 6' RCB	9' x 6' REINFORCED CONCRETE BOX	(02316) (02321) (03310)	LF	571	\$ 800.00	\$ 456,800.00
2630-30	Manhole for Concrete box	MANHOLE FOR CONCRETE BOX	(02120) (02316) (02321) (03310)	EA	4	\$ 1,500.00	\$ 6,000.00
2632-72	Headwalls and Wingwalls (Cast-in-Place)	HEADWALLS AND WINGWALLS (CAST-IN-PLACE)	(02120) (02316) (03310)	EA	4	\$ 17,200.00	\$ 68,800.00
2642-02	24" CMP	24-INCH CORRUGATED METAL PIPE	(02120) (02316) (02321)	LF	2104	\$ 65.00	\$ 136,760.00
2751-04	Concrete Pavement, 8"	CONCRETE PAVEMENT, 8" THICKNESS	(02752) (02753)	SY	943	\$ 100.00	\$ 94,333.33
2754-01	Concrete Driveway	CONCRETE DRIVEWAY	(02316) (02336) (02751)	SY	119	\$ 45.00	\$ 5,340.00
2771-02	Concrete Curb	CONCRETE CURB	(02752) (02753) (03310)	LF	110	\$ 6.00	\$ 660.00
2820-01	Rem. & Rep. 6' Chainlink Fence	REMOVE AND REPLACE 6' CHAINLINK FENCE		LF	6121	\$ 5.00	\$ 30,605.00

HARRIS COUNTY FLOOD CONTROL DISTRICT
Standardized Construction Cost Estimate
USING HCFCD STANDARD PAY ITEMS



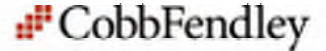
Project ID: Halls Bayou Tributary Unit No. P118-25-00/01
Submittal: Preliminary Cost Estimate
Date: 4/1/2022
Prepared By: R.G. MILLER ENGINEERS

Pay Item	Description	Long Desc	Incidental Spec	Units	Quantity	Unit Bid Price	Total Bid Price
2820-03	Rem. and Rep. 4 Str. B/Wire Fence	REMOVE AND REPLACE 4 STRAND BARBED WIRE FENCE		LF	1914	\$ 5.00	\$ 9,570.00
2820-09	8' Chain Link Fence	8' CHAIN LINK FENCE		LF	20730	\$ 15.00	\$ 310,950.00
2823-01	Rem. & Rep. Wood Fence	REMOVE AND REPLACE WOOD FENCE	(02120) (03310)	LF	315	\$ 10.00	\$ 3,150.00
2921-16	Anchored Sodding	ANCHORED SODDING		SY	4824	\$ 5.00	\$ 24,117.78
xxx	Pipeline Relocation			LS	1	\$ 1,733,036.64	\$ 1,733,036.64
xxx	Right of Way Acquisition			AC			
					35	\$ 434,285.71	\$ 15,200,000.00
xxx	Demolition of Metal Building	Demolition of Metal Building, Including Foundations and removing of mobile		EA	38	\$ 26,000.00	\$ 988,000.00
xxx	Demolition of Houses	Demolition of Houses, Including Foundation		EA	5	\$ 22,000.00	\$ 110,000.00
						Total Project Cost	\$ 24,667,668.96
						20% Contingency	\$ 1,893,533.79
						Total Project Cost + 20% Contingency	\$ 26,561,202.76

TABLE 2

UTILITY CONFLICT MATRIX

Utility Conflict Matrix
Halls Bayou Watershed P118-25-00-E001
Bond Project C-28/C-29



ID #	Current SUE Level	Drawing Sheet No.	Channel	Utility Owner	Utility Status/Type	Size	Material	Overhead/ Underground/ Aboveground	Nearest Street	Begin STA	Offset	End STA	Offset	Length (LF)	Orientation	Conflict Description	Conflict (Y/N)	Utility Investigation Level Needed	Level B Findings	Recommended Action of Conflict Resolution	Notes
1	Level D	9	P118-25-00	CenterPoint Electric	Electric	Unk	Cable	OH	Hill Rd.	0+72	LT/RT	N/A	N/A	72	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along the south side of Hill Rd.
2	Level D	9	P118-25-00	AT&T	Telecom	Unk	Cable	OH	Hill Rd.	0+72	LT/RT	N/A	N/A	72	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along the south side of Hill Rd on CNPE poles.
3	Level D	9	P118-25-00	Comcast	Telecom	0.500, 0.750	Cable	OH	Hill Rd.	0+72	LT/RT	N/A	N/A	72	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along the south side of Hill Rd on CNPE poles.
4	Level B	9	P118-25-00	Comcast	Telecom	0.540QR	Cable	UG	Hill Rd.	0+72	30' RT	1+30	30' RT	58	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	Depth: 3'	N/A	Cable comes down pole, continues UG across Hill Rd and serves property at NE corner
5	Level B	9	P118-25-00	AT&T	Telecom	Unk	Cable	UG	Hill Rd.	0+72	30' RT	1+27	30' RT	55	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	Depth: 3'	N/A	Cable comes down pole, continues UG across Hill Rd and serves property at NE corner
6	Level D	9	P118-25-00	CenterPoint Electric	Electric	Unk	Cable	OH	Hill Rd.	0+73	44' LT	5+70	110' LT	497	Longitudinal	Conflict with channel improvements.	Y	None	N/A	Relocate	Runs along west side of channel.
7	Level D	9	P118-25-00	CenterPoint Electric	Electric	Unk	Cable	OH	Hill Rd.	5+70	110' LT	9+61	112' LT	391	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along west side of channel.
8	Level D	9	P118-25-00	AT&T	Telecom	Unk	Cable	OH	Hill Rd.	0+73	44' LT	5+70	110' LT	497	Longitudinal	Conflict with channel improvements.	Y	None	N/A	Relocate	Runs along west side of channel on CNPE poles.
9	Level D	9	P118-25-00	AT&T	Telecom	Unk	Cable	OH	Hill Rd.	5+70	110' LT	9+61	112' LT	391	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along west side of channel on CNPE poles.
10	Level D	9	P118-25-00	Comcast	Telecom	0.625	Cable	OH	Hill Rd.	0+73	44' LT	5+70	110' LT	497	Longitudinal	Conflict with channel improvements.	Y	None	N/A	Relocate	Runs along west side of channel on CNPE poles.
11	Level D	9	P118-25-00	Comcast	Telecom	0.625	Cable	OH	Hill Rd.	5+70	110' LT	9+61	112' LT	391	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along west side of channel on CNPE poles.
12	Level B	9	P118-25-00	CenterPoint Gas	Gas	2"	Steel	UG/AG	Hill Rd.	0+79	LT/RT	N/A	N/A	57	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	No depth information	N/A	2" CNPG line runs UG and continues AG attached to south side of bridge.
13	Level D	9	P118-25-00	Crown Castle	Telecom	3-1.25" Z16CT	HDPE/Fiber	UG	Hill Rd.	0+85	LT/RT	N/A	N/A	72	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along south side of Hill Rd.
14	Level B	9	P118-25-00	AT&T	Telecom	Unk	Cable	UG	Hill Rd.	1+28	37' RT	1+25	46' RT	103	Longitudinal	Conflict with channel improvements.	Y	None	Depth: 2.9'	Relocate	Starts at pedestal and runs east on the north side of Hill Rd.
94	Level D	9	P118-25-00	CenterPoint Electric	Electric	Unk	Cable	OH	Hill Rd.	1+30	39' RT	3+36	13' RT	201	Longitudinal	Conflict with channel improvements.	Y	None	N/A	Relocate	Runs along east side of the channel in conflict with the proposed channel improvements. Service drop to property owner.
15	Level D	9	P118-25-00	CenterPoint Electric	Electric	Unk	Cable	OH	Hill Rd.	3+18	51' LT	3+36	13' RT	198	Crossing	Conflict with channel improvements.	Y	None	N/A	Relocate	Low OH CNP line crosses channel. Power pole on the east side of the channel in conflict with the proposed channel improvements. Service drop to property owner.
16	Level B	10	P118-25-00	Sunoco (Energy Transfer)	Pipeline	8"	Unk	UG/AG	Faber St.	16+55	78' RT	16+88	49' LT	75	Crossing	Conflict with channel improvements.	Y	None	Depth: 3'-4.2'	Relocate	Exposed in channel. CF to coordinate with Sunoco on relocation. Prior right will need to be determined for eligible reimbursement.
17	Level B	10	P118-25-00	CenterPoint Gas	Pipeline	10"	Steel	UG	Faber St.	17+58	78' RT	18+06	78' LT	75	Crossing	Conflict with channel improvements.	Y	None	Depth: 9.6'-12'	Relocate	10" CNPG line crossing west of Faber St. CF to coordinate relocation of pipeline. Prior rights will need to be determined for eligible reimbursement.
18	Level D	11	P118-25-00	Comcast	Telecom	0.540QR	Cable	UG	Aldine Mail Route Rd.	20+96	21' RT	24+14	19' RT	316	Longitudinal	Conflict with channel improvements.	Y	Level B	N/A	Relocate	Runs along west side of channel within project limits. QLB may be needed to confirm location
19	Level D	11	P118-25-00	Comcast	Telecom	48CT	Fiber	OH	Aldine Mail Route Rd.	24+03	7' RT	24+14	19' RT	75	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Drop to house at southwest corner of Aldine Mail Route Rd. and Halls Bayou
20	Level D	11	P118-25-00	CenterPoint Electric	Electric	Unk	Cable	OH	Aldine Mail Route Rd.	24+15	LT/RT	N/A	N/A	75	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along south side of Aldine Mail Route Rd.
21	Level D	11	P118-25-00	Comcast	Telecom	0.5	Cable	OH	Aldine Mail Route Rd.	24+15	LT/RT	N/A	N/A	75	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along south side of Aldine Mail Route Rd. on CNPE poles.
22	Level D	11	P118-25-00	CenterPoint Gas	Gas	2"	IP PE	UG	Aldine Mail Route Rd.	24+22	LT/RT	N/A	N/A	75	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along south side of Aldine Mail Route Rd.
23	Level B	11	P118-25-00	Enterprise	Pipeline	10"	Unk	UG	Aldine Mail Route Rd.	24+09	134' RT	25+37	72' LT	160	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	Depth: 6'	N/A	Crosses diagonally under existing 3-48" RCPs on Aldine Mail Route Rd. Line is outside of proposed improvements.
24	Level D	11	P118-25-00	CenterPoint Gas	Abandoned Gas Line	2"	Steel	UG	Aldine Mail Route Rd.	24+70	LT/RT	N/A	N/A	75	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Crosses existing 3-48" RCPs on Aldine Mail Route Rd. Can be removed if found to be in conflict.
25	Level D	13	P118-25-01	CenterPoint Electric	Electric	Unk	Cable	OH	Scoregga Ln.	8+24	LT/RT	N/A	N/A	150	Crossing	Conflict with channel improvements.	Y	None	N/A	Relocate	Pole and guy anchor in direct conflict with proposed channel improvements.
26	Level D	13	P118-25-01	CenterPoint Electric	Electric	Unk	Cable	OH	Scoregga Ln.	10+71	59' RT	N/A	N/A	N/A	Longitudinal	Conflict with channel improvements.	Y	None	N/A	Relocate	Pole and guy anchor in direct conflict with proposed channel improvements.
95	Level D	13	P118-25-01	AT&T	Telecom	Unk	Cable	OH	Scoregga Ln.	10+71	59' RT	N/A	N/A	N/A	Longitudinal	Conflict with channel improvements.	Y	None	N/A	Relocate	Runs on CNP pole in direct conflict with proposed channel improvements.
27	Level D	15	P118-25-01	Sunoco (Energy Transfer)	Pipeline	8"	Steel	UG/AG	Aldine Mail Route Rd.	22+81	42' RT	23+74	77' LT	125	Crossing	Conflict with channel improvements.	Y	Level B	Depth: 3'-3.5'	Relocate	Exposed in channel. CF to coordinate with Sunoco on relocation. Prior rights will need to be determined for eligible reimbursement.
28	Level B	15	P118-25-01	CenterPoint Gas	Pipeline	10"	Steel	UG	Aldine Mail Route Rd.	22+97	55' RT	23+81	77' LT	125	Crossing	No anticipated conflict	N	None	Depth: 7.8'-8.10'	N/A	Top of utility probes at elev. 62.58' to 62.47'. Proposed channel flowline approx. 65.00'. Assume pipeline can remain in place.
29	Level D	15	P118-25-01	CenterPoint Electric	Electric	Unk	Cable	OH	Aldine Mail Route Rd.	25+85	LT/RT	N/A	16' LT	90	Crossing	Conflict with channel improvements.	Y	None	N/A	Relocate	Runs along south side of Aldine Mail Route Rd. Power pole on the southwest corner in conflict with the proposed channel improvements.
30	Level D	15	P118-25-01	AT&T	Telecom	Unk	Cable	OH	Aldine Mail Route Rd.	25+85	LT/RT	N/A	16' LT	90	Crossing	Conflict with channel improvements.	Y	None	N/A	Relocate	Runs along south side of Aldine Mail Route Rd. on CNPE poles. CNPE pole in conflict. OH cables may also be a constructability conflict during construction of proposed boxes crossing Aldine Mail Route Rd. Contractor will need to maintain distance of 10ft. from overhead lines.
31	Level D	15	P118-25-01	Comcast	Telecom	0.5", 0.75"	Cable	OH	Aldine Mail Route Rd.	25+85	LT/RT	N/A	16' LT	90	Crossing	Conflict with channel improvements.	Y	None	N/A	Relocate	Runs along south side of Aldine Mail Route Rd. on CNPE poles. CNPE pole in conflict. OH cables may also be a constructability conflict during construction of proposed boxes crossing Aldine Mail Route Rd. Contractor will need to maintain distance of 10ft. from overhead lines.
32	Level B	15	P118-25-01	Comcast	Telecom	Unk	Cable	UG	Aldine Mail Route Rd.	25+84	LT/RT	N/A	72' RT	107	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	Depth: 4'8" - 5'2"	N/A	Crosses Aldine Mail Route Rd. on the east side of the existing 8'x4' box culvert.
33	Level B	15	P118-25-01	CenterPoint Gas	Gas	2"	Plastic	UG	Aldine Mail Route Rd.	25+86	LT/RT	N/A	N/A	90	Crossing	No anticipated conflict	N	None	Depth: 15'	N/A	Runs along south side of Aldine Mail Route Rd. Gas line assumed to have sufficient cover below proposed 2-9x6" RCB.
34	Level B	15	P118-25-01	Harris County	Traffic Signal	Unk	Cable	UG	Aldine Mail Route Rd.	25+94	9' RT	26+23	49' LT	65	Crossing	Conflict with proposed 2-9'x6" RCB	Y	None	Depth: 2'	Relocate	Runs along south side of Aldine Mail Route Rd. Traffic signal pole on the southwest corner is also in conflict with the proposed channel improvements.
35	Level B	15	P118-25-01	Harris County	Traffic Signal	Unk	Cable	UG	Aldine Mail Route Rd.	26+23	49' LT	26+69	18' LT	55	Crossing	Conflict with proposed 2-9'x6" RCB	Y	None	Depth: 7.5'	Relocate	Crosses Aldine Mail Route Rd. from signal pole on southwest corner. Lost signal near CL of Aldine Mail Route Rd.
36	Level B	15	P118-25-01	Harris County	Traffic Signal	Unk	Cable	UG	Aldine Mail Route Rd.	26+49	87' LT	26+30	4' LT	128	Crossing	Conflict with proposed 2-9'x6" RCB	Y	None	No depth info provided	Relocate	Crosses Aldine Mail Route Rd. running from handhole on southwest corner to cabinet on northwest corner.
37	Level D	15	P118-25-01	CenterPoint Gas	Abandoned Gas Line	2"	IP STL	UG	Aldine Mail Route Rd.	26+13	LT/RT	N/A	N/A	60	Crossing	Conflict with proposed 2-9'x6" RCB	Y	None	N/A	Remove	Can be removed if encountered.

Utility Conflict Matrix

Halls Bayou Watershed P118-25-00-E001

Bond Project C-28/C-29



ID #	Current SUE Level	Drawing Sheet No.	Channel	Utility Owner	Utility Status/Type	Size	Material	Overhead/ Underground/ Aboveground	Nearest Street	Begin STA	Offset	End STA	Offset	Length (LF)	Orientation	Conflict Description	Conflict (Y/N)	Utility Investigation Level Needed	Level B Findings	Recommended Action of Conflict Resolution	Notes
78	Level D	20	P118-25-01	CenterPoint Electric	Electric	Unk	Cable	OH	Ridgeland Ct.	68+91	LT/RT	N/A	N/A	100	Crossing	Conflict with channel improvements.	Y	None	N/A	Relocate	Crosses proposed new location channel. Multiple service drops and guy anchors in conflict.
79	Level D	20	P118-25-01	AT&T	Telecom	Unk	Cable	OH	Ridgeland Ct.	68+91	LT/RT	N/A	N/A	100	Crossing	Conflict with channel improvements.	Y	None	N/A	Relocate	Crosses proposed new location channel on CNPE poles. Multiple service drops and guy anchors in conflict.
80	Level D	20	P118-25-01	AT&T	Telecom	Unk	Cable	UG	Ridgeland Ct.	68+91	82' LT	70+56	82' LT	160	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along back property line.
81	Level D	20	P118-25-01	AT&T	Telecom	Unk	Cable	UG	Branding Iron Ln.	71+77	80' LT	72+77	80' LT	N/A	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along back property line.
82	Level D	20	P118-25-01	CenterPoint Electric	Electric	Unk	Cable	OH	Hollyvale Dr.	77+82	LT/RT	N/A	N/A	100	Crossing	Potential constructability conflict.	Potential	None	N/A	TBD	Runs along south side of Hollyvale Dr. No conflict anticipated. CF to coordinate any constructability concerns/overhead clearance for equipment during construction. Contractor will need to maintain distance of 10ft. from overhead lines.
83	Level D	20	P118-25-01	Comcast	Telecom	0.75	Cable	OH	Hollyvale Dr.	77+82	LT/RT	N/A	N/A	100	Crossing	Potential constructability conflict.	Potential	None	N/A	TBD	Runs along south side of Hollyvale Dr. on CNPE poles. No conflict anticipated. CF to coordinate any constructability concerns/overhead clearance for equipment during construction. Contractor will need to maintain distance of 10ft. from overhead lines.
84	Level D	20	P118-25-01	Crown Castle	Telecom	Unk	Fiber	UG	Hollyvale Dr.	77+91	LT/RT	N/A	N/A	100	Crossing	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	N/A	N/A	Runs along south side of Hollyvale Rd.
93	Level D	20	P118-25-01	J&S Water	Water	2"	PVC and Steel	UG	Ridgeland Ct/ Branding Iron Ln	71+34	LT/RT	N/A	N/A	155	Crossing	Conflict with channel improvements.	Y	None	Depth: 3'	Remove	OL B was not surveyed. Water meter box was located, but the meter has been removed. Field work confirmed that line has been abandoned.
85	Level B	20	P118-25-01	Explorer Pipeline Company	Pipeline	10"	Unk	UG	Glenvale Dr.	72+68	RT	78+00	RT	N/A	Longitudinal	No anticipated conflict. Outside limits of proposed channel improvements.	N	None	Depth: 3' -5'	N/A	10" Explorer pipeline is to the east of the channel and outside of project limits.
86	Level D	21	BASIN	CenterPoint Electric	Electric	Unk	Cable	OH	Sellers Rd.	35+69	705' LT	41+58	600' LT	588	Longitudinal	No anticipated conflict. Outside limits of proposed basin.	N	None	N/A	N/A	Runs along east ROW line of Sellers Rd.
87	Level D	21	BASIN	AT&T	Telecom	Unk	Cable	OH	Sellers Rd.	35+69	705' LT	41+58	600' LT	588	Longitudinal	Potential constructability conflict with proposed basin access.	Potential	Level B	TBD	TBD	Runs along east ROW line of Sellers Rd. on CNPE poles. CF recommends to determine cable height clearance prior to construction. CF to coordinate any constructability concerns/overhead clearance for equipment during construction. Contractor will need to maintain distance of 10ft. from overhead lines.
88	Level D	21	BASIN	Comcast	Telecom	Unk	Cable	OH	Sellers Rd.	35+69	705' LT	41+58	600' LT	588	Longitudinal	Potential constructability conflict with proposed basin access.	Potential	Level B	TBD	TBD	Runs along east ROW line of Sellers Rd. on CNPE poles. CF recommends to determine cable height clearance prior to construction. CF to coordinate any constructability concerns/overhead clearance for equipment during construction. Contractor will need to maintain distance of 10ft. from overhead lines.
89	Level D	21	BASIN	CenterPoint Gas	Gas	2"	Steel	UG	Sellers Rd.	35+06	268' LT	36+20	656' LT	588	Longitudinal	No anticipated conflict. Outside limits of proposed basin.	N	None	N/A	N/A	Runs along east ROW line of Sellers Rd.
90	Level D	21	BASIN	Sunbelt Fresh Water Supply District	Water	2"	Unk	UG	Sellers Rd.	35+70	751' LT	41+71	645' LT	588	Longitudinal	No anticipated conflict. Outside limits of proposed basin.	N	None	N/A	N/A	Runs along west ROW line of Sellers Rd.
91	Level B	21	BASIN	Sunoco (Energy Transfer)	Pipeline	8"	Steel	UG	Sellers Rd.	35+05	273' LT	36+19	655' LT	N/A	Longitudinal	No anticipated conflict. Outside limits of proposed basin.	N	None	Probe #6: Depth of Cover - 3.40'	N/A	Runs diagonally at southwest corner of proposed detention basin at Sellers east ROW line. Project footprint shows reduced basin limits. Line is outside of proposed basin.
92	Level B	21	BASIN	CenterPoint Gas	Pipeline	10"	Steel	UG	Sellers Rd.	35+06	268' LT	36+20	656' LT	N/A	Longitudinal	No anticipated conflict. Outside limits of proposed basin.	N	None	Probe #5: Depth of Cover - 5.07'	N/A	Runs diagonally at southwest corner of proposed detention basin at Sellers east ROW line. Project footprint shows reduced basin limits. Line is outside of proposed basin.

TABLE 3

COST ESTIMATE FOR PIPELINE RELOCATIONS

HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD) PROJECT Halls Bayou

Cost Estimate for Relocating Pipeline Facilities

Harris County, Texas

5/13/2021

Pipeline Owner	P118-25-00 (C-28)	P118-25-01 (C-29)	Total
Enterprise Products		\$ 332,332.63	\$ 332,332.63
SUNOCO - ETC	\$ 341,463.12	\$ 341,463.12	\$ 682,926.24
CenterPoint Gas	\$ 365,970.00		\$ 365,970.00
Unknown (Formerly BP)		\$ 351,807.77	\$ 351,807.77
Total Project Cost	\$ 707,433.12	\$ 1,025,603.52	\$ 1,733,036.64

Notes:

10" CNPG pipeline on C-29 is not anticipated to be in conflict with proposed channel bottom.

12" Unknown (Formerly BP) pipeline will need to be tapped to confirm status. If abandoned, it can be removed.

Mobil Vanderbilt shown on previous estimate was acquired by Sunoco.

HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD) PROJECT Halls Bayou

Cost Estimate for SUNOCO - ETC Pipeline Relocations

P118-25-00; Bond Project ID C-28

Harris County, Texas

Date: 5/13/2021

Description	Quantity	Unit	Unit Price (\$)	Total
8" Pipeline				
Materials				
8" Steel Pipe Pipe	403	Ft	\$ 27.20	\$ 10,961.60
8" Elbow	8	Ea	\$ 95.50	\$ 764.00
Anode for Cathodic Protection	2	Ea	\$ 17.50	\$ 35.00
Test Station	2	Ea	\$ 30.00	\$ 60.00
Contract Labor				
Horizontal Directional Drill - 8"	403	Ft	\$ 215.00	\$ 86,645.00
Pipe Removal	403	Ft	\$ 25.00	\$ 10,075.00
8" Pipeline Subtotal				\$ 108,540.60
MISC. CONSTRUCTION ITEMS				
Silt Fencing	1000	Ft	\$ 2.00	\$ 2,000.00
Construction Mats (4'x16')	500	Ft	\$ 150.00	\$ 75,000.00
Inspection - Construction	20	\$ / Day	\$ 850.00	\$ 17,000.00
Radiographic Services (X-Ray)	5	\$ / Day	\$ 1,800.00	\$ 9,000.00
Site Restoration / Obtaining Work Easements	2	\$ / Acre	\$ 2,500.00	\$ 5,000.00
Environmental	1	Ls	\$ 10,000.00	\$ 10,000.00
Permitting	1	Ls	\$ 10,000.00	\$ 10,000.00
Consulting & Engineering	1	Ls	\$ 40,612.00	\$ 40,612.00
Surveying (Staking)	5	Days	\$ 1,480.00	\$ 7,400.00
Materials & Labor Subtotal				\$ 108,540.60
Misc. Construction Items Subtotal				\$ 176,012.00
Overall Project Subtotal				\$ 284,552.60
Company Overhead (20%)				\$ 56,910.52
Total Project Cost				\$ 341,463.12

HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD) PROJECT Halls Bayou

Cost Estimate for CenterPoint Energy Gas Relocations

P118-25-00; Bond Project ID C-28

Harris County, Texas

Date: 5/13/2021

Description	Quantity	Unit	Unit Price (\$)	Total
10" Pipeline				
Materials				
10" Steel Pipe Pipe	400	Ft	\$ 34.74	\$ 13,896.00
10" Elbow	8	Ea	\$ 121.50	\$ 972.00
Anode for Cathodic Protection	2	Ea	\$ 17.50	\$ 35.00
Test Station	2	Ea	\$ 30.00	\$ 60.00
Contract Labor				
Horizontal Directional Drill - 10"	400	Ft	\$ 260.00	\$ 104,000.00
Pipe Removal	400	Ft	\$ 25.00	\$ 10,000.00
10" Pipeline Subtotal				\$ 128,963.00
MISC. CONSTRUCTION ITEMS				
Silt Fencing	1000	Ft	\$ 2.00	\$ 2,000.00
Construction Mats (4'x16')	500	Ft	\$ 150.00	\$ 75,000.00
Inspection - Construction	20	\$ / Day	\$ 850.00	\$ 17,000.00
Radiographic Services (X-Ray)	5	\$ / Day	\$ 1,800.00	\$ 9,000.00
Site Restoration / Obtaining Work Easements	2	\$ / Acre	\$ 2,500.00	\$ 5,000.00
Environmental	1	Ls	\$ 10,000.00	\$ 10,000.00
Permitting	1	Ls	\$ 10,000.00	\$ 10,000.00
Consulting & Engineering	1	Ls	\$ 40,612.00	\$ 40,612.00
Surveying (Staking)	5	Days	\$ 1,480.00	\$ 7,400.00
Materials & Labor Subtotal				\$ 128,963.00
Misc. Construction Items Subtotal				\$ 176,012.00
Overall Project Subtotal				\$ 304,975.00
Company Overhead (20%)				\$ 60,995.00
Total Project Cost				\$ 365,970.00

HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD) PROJECT Halls Bayou

Cost Estimate for SUNOCO - ETC Pipeline Relocations

P118-25-01; Bond Project ID C-29

Harris County, Texas

Date: 5/13/2021

Description	Quantity	Unit	Unit Price (\$)	Total
8" Pipeline				
Materials				
8" Steel Pipe Pipe	403	Ft	\$ 27.20	\$ 10,961.60
8" Elbow	8	Ea	\$ 95.50	\$ 764.00
Anode for Cathodic Protection	2	Ea	\$ 17.50	\$ 35.00
Test Station	2	Ea	\$ 30.00	\$ 60.00
Contract Labor				
Horizontal Directional Drill - 8"	403	Ft	\$ 215.00	\$ 86,645.00
Pipe Removal	403	Ft	\$ 25.00	\$ 10,075.00
8" Pipeline Subtotal				\$ 108,540.60
MISC. CONSTRUCTION ITEMS				
Silt Fencing	1000	Ft	\$ 2.00	\$ 2,000.00
Construction Mats (4'x16')	500	Ft	\$ 150.00	\$ 75,000.00
Inspection - Construction	20	\$ / Day	\$ 850.00	\$ 17,000.00
Radiographic Services (X-Ray)	5	\$ / Day	\$ 1,800.00	\$ 9,000.00
Site Restoration / Obtaining Work Easements	2	\$ / Acre	\$ 2,500.00	\$ 5,000.00
Environmental	1	Ls	\$ 10,000.00	\$ 10,000.00
Permitting	1	Ls	\$ 10,000.00	\$ 10,000.00
Consulting & Engineering	1	Ls	\$ 40,612.00	\$ 40,612.00
Surveying (Staking)	5	Days	\$ 1,480.00	\$ 7,400.00
Materials & Labor Subtotal				\$ 108,540.60
Misc. Construction Items Subtotal				\$ 176,012.00
Overall Project Subtotal				\$ 284,552.60
Company Overhead (20%)				\$ 56,910.52
Total Project Cost				\$ 341,463.12

HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD) PROJECT Halls Bayou

Cost Estimate for Unknown (Formerly BP) Pipeline Relocations

P118-25-01; Bond Project ID C-29

Harris County, Texas

Date: 5/13/2021

Description	Quantity	Unit	Unit Price (\$)	Total
12" Pipeline				
Materials				
12" Steel Pipe Pipe	313	Ft	\$ 42.28	\$ 13,233.64
12" Elbow	4	Ea	\$ 147.50	\$ 590.00
Anode for Cathodic Protection	1	Ea	\$ 17.50	\$ 17.50
Test Station	1	Ea	\$ 30.00	\$ 30.00
Contract Labor				
Horizontal Directional Drill - 12"	313	Ft	\$ 305.00	\$ 95,465.00
Pipe Removal	313	Ft	\$ 25.00	\$ 7,825.00
12" Pipeline Subtotal				\$ 117,161.14
MISC. CONSTRUCTION ITEMS				
Silt Fencing	1000	Ft	\$ 2.00	\$ 2,000.00
Construction Mats (4'x16')	500	Ft	\$ 150.00	\$ 75,000.00
Inspection - Construction	20	\$ / Day	\$ 850.00	\$ 17,000.00
Radiographic Services (X-Ray)	5	\$ / Day	\$ 1,800.00	\$ 9,000.00
Site Restoration / Obtaining Work Easements	2	\$ / Acre	\$ 2,500.00	\$ 5,000.00
Environmental	1	Ls	\$ 10,000.00	\$ 10,000.00
Permitting	1	Ls	\$ 10,000.00	\$ 10,000.00
Consulting & Engineering	1	Ls	\$ 40,612.00	\$ 40,612.00
Surveying (Staking)	5	Days	\$ 1,480.00	\$ 7,400.00
Materials & Labor Subtotal				\$ 117,161.14
Misc. Construction Items Subtotal				\$ 176,012.00
Overall Project Subtotal				\$ 293,173.14
Company Overhead (20%)				\$ 58,634.63
Total Project Cost				\$ 351,807.77

HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD) PROJECT Halls Bayou
Cost Estimate for Enterprise Products Pipeline Relocations
P118-25-01; Bond Project ID C-29
Harris County, Texas

Date: 5/13/2021

Description	Quantity	Unit	Unit Price (\$)	Total
10" Pipeline				
Materials				
10" Steel Pipe Pipe	314	Ft	\$ 34.74	\$ 10,908.36
10" Elbow	4	Ea	\$ 121.50	\$ 486.00
Anode for Cathodic Protection	1	Ea	\$ 17.50	\$ 17.50
Test Station	1	Ea	\$ 30.00	\$ 30.00
Contract Labor				
Horizontal Directional Drill - 10"	314	Ft	\$ 260.00	\$ 81,640.00
Pipe Removal	314	Ft	\$ 25.00	\$ 7,850.00
10" Pipeline Subtotal				\$ 100,931.86
MISC. CONSTRUCTION ITEMS				
Silt Fencing	1000	Ft	\$ 2.00	\$ 2,000.00
Construction Mats (4'x16')	500	Ft	\$ 150.00	\$ 75,000.00
Inspection - Construction	20	\$ / Day	\$ 850.00	\$ 17,000.00
Radiographic Services (X-Ray)	5	\$ / Day	\$ 1,800.00	\$ 9,000.00
Site Restoration / Obtaining Work Easements	2	\$ / Acre	\$ 2,500.00	\$ 5,000.00
Environmental	1	Ls	\$ 10,000.00	\$ 10,000.00
Permitting	1	Ls	\$ 10,000.00	\$ 10,000.00
Consulting & Engineering	1	Ls	\$ 40,612.00	\$ 40,612.00
Surveying (Staking)	5	Days	\$ 1,480.00	\$ 7,400.00
Materials & Labor Subtotal				\$ 100,931.86
Misc. Construction Items Subtotal				\$ 176,012.00
Overall Project Subtotal				\$ 276,943.86
Company Overhead (20%)				\$ 55,388.77
Total Project Cost				\$ 332,332.63

APPENDIX A

PHASE I ENVIRONMENTAL SITE ASSESSMENT REPORT

APPENDIX E

GEOTECHNICAL REPORT

APPENDIX F

ALTERNATIVE ANALYSIS

SUMMARY REPORT

Halls Bayou Tributary Unit No. P118-25-00/01

Alternatives Analysis Summary Report

Prepared for:

Harris County Flood Control District
HCFCDD Project ID P118-25-00-P001



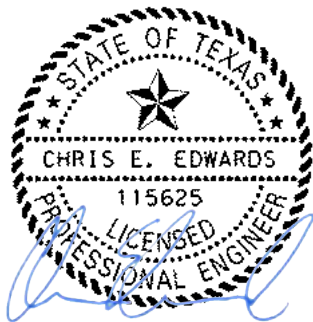
Prepared by:

Lockwood, Andrews & Newnam, Inc.



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

Engineer: Chris E. Edwards, P.E., CFM, ENV SP
PE Registration: 115625
Firm: Lockwood, Andrews & Newnam, Inc.
Date: 12/09/2019



1/6/2020



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

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LIST OF ACRONYMS

BFE	Base Flood Elevations
CE	Corrected Effective
DCC	Direct Construction Costs
DLU	Percent Land Urbanization
DS	Downstream
DSS	Data Storage System
FEE	Finished Floor Elevation
HCFC	Harris County Flood Control District
HEC	Hydrologic Engineering Center
H-GAC	Houston-Galveston Area Council
HMS	Hydrologic Modeling System
HVJ	HVJ Associates, Inc.
ID	Identifier
LAN	Lockwood, Andrews & Newnam, Inc.
LiDAR	Light Detection and Ranging
LOS	Level of Service
LS	Lateral Structure
R	Storage Coefficient
RAS	River Analysis System
ROW	Right-of-Way
RS	River Station
SID	Structure Inventory Database
SUE	Subsurface Utility Exploration/Engineering
Tc	Time of Concentration
US	Upstream
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WSEL	Water Surface Elevation



Executive Summary

The Harris County Flood Control District (HCFCD) authorized Lockwood, Andrews & Newnam, Inc. (LAN) in October 2018 to conduct an Alternatives Analysis Study on Tributary P118-25-00 and Sub-Tributary P118-25-01 (hereafter referred to as “P118-25-00/01”); 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 P118-25-00/01 catchment 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.

Hydrology & Hydraulic (H&H) models were developed for 10%, 2%, 1%, and 0.2% design storm events (Pre-Atlas 14 Update) based on HCFCD criteria using HEC-HMS and HEC-RAS software. Existing Level of Service (LOS) for the P118-25-00/01 drainage area is driven by overflows from adjacent tributaries P118-26-00 to the west and P138-00-00 to the north and by the Halls Bayou mainstem.

Existing and Proposed conditions models include a variety of combinations of boundary conditions including Normal Depth and Tailwater, as well as three (3) different overflow scenarios: #1 “Current”, #2 “Near Future”, and #3 “Future” overflow conditions resulting from the Overflow Analysis – refer to [Section 0](#). For this P118-25-00/01 Alternatives Analysis, Normal Depth downstream assumption with “Current” overflows were used for the formulation process and when developing the proposed conditions. However, upon arrival and sizing of the Recommended Alternative (RA), the RA was then analyzed in conjunction with Overflow Scenario #2 and #3 with associated performance metrics processed – refer to [Section 3.3.8](#).

Improvement features including detention, channel improvements, and a channel extension are identified as potential flooding mitigation solutions. These improvements were selected because they are at hydraulically influential locations, topographically functional, and relatively unobtrusive to residents. Eight combinations of the improvement features are considered as alternatives with varying cost and performance – refer to [Section 2.4](#).

Through coordination with HCFCD, LAN recommends Alternative 3b to advance to a PER Study. Alternative 3b includes a channel extension north to Hollyvale Drive and across the drainage boundary to help contain the overflow from P138-00-00, channel improvements upstream of Hill Road along P118-25-00 and P118-25-01 to increase conveyance, and the 33 acre-feet Oak Glen detention basin just north of Aldine Mail Route Road to mitigate impacts. Channel improvements are trapezoidal with a 25-foot bottom width, 4:1 side slopes, and a 0.08% longitudinal slope. Alternative 3b has a probable cost of approximately \$15.1 million, which includes construction and acquisition of 35.2 acres of land for improvements.

Under “Current” overflow conditions, Alternative 3b provides a 100-year LOS, removing the floodplain from approximately 606 structures, 2.9 miles of roadway, and 201 acres of land (assuming pre-Atlas 14 rainfall rates). Under “Future” overflow conditions, Alternative 3b provides a 500-year LOS (assuming pre-Atlas 14 rainfall rates). “Future” conditions assume that improvements on P118-26-00 have been completed eliminating overflow into P118-25-00/01 based on the Harris County Bond Program, and the drainage improvements outlined in the Greens Bayou Mid-Reach study have been completed reducing the overflow from P138-00-00 by 60%.



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 October 15, 2018. The purpose of this report is to provide a clear and concise summary of the hydrology and hydraulics (H&H) analysis for tributary P118-25-00 and sub-tributary P118-25-01 (“P118-25-00/01”). Refer to [Figure 1-1](#) for the workflow followed in this Alternatives Analysis Study.

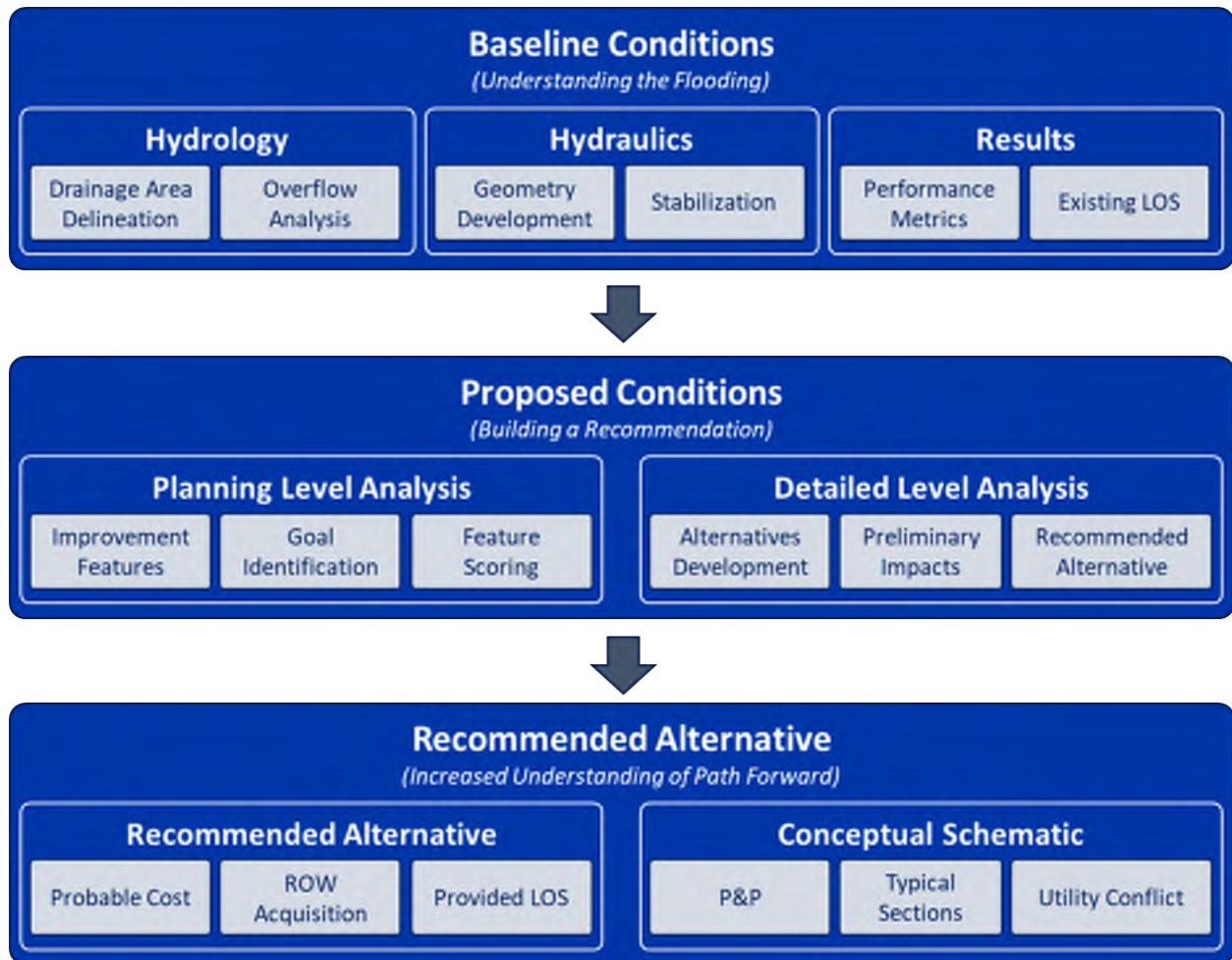


Figure 1-1: Alternatives Analysis Workflow

1.2 Background

Tributaries P118-25-00 and P118-25-01 were identified in the 2018 HCFCD Bond Program for Partnership Projects of Right-of-Way (ROW), design, and construction of channel conveyance improvements. This



Alternatives Analysis Study was the first step towards identifying what improvements should be made on the tributaries.

1.3 Study Area

HCFCFCD tributaries Unit Nos. P118-25-00 and P118-25-01 are located within Halls Bayou (HCFCFCD Unit No. P118-00-00) watershed in the northern portion of Harris County, Texas – refer to [Exhibit 1](#). The project limits encompass the length of the tributary, beginning at Corvette Court, north of Oak Glen Place, and ending at the confluence with Halls Bayou, approximately 900 feet south of Hills Road. The study area has a drainage area of approximately 1 square mile (640 acres) and consists of approximately 1.59 miles (8,391 feet) of open channel (P118-25-00: 0.59 miles [3,144 feet]; P118-25-01: 1.0 miles [5,247 feet]), including two road crossings for P118-25-01 at Aldine Mail Route Road (115 feet), and Hills Road (38 feet). P118-25-01 intersects P118-25-00 about 1,200 feet south of Aldine Mail Route Road. The land use consists primarily of mixed commercial and residential development.



2 Baseline Conditions Analysis

2.1 Data Collection

H&H models were developed by LAN as part of the HCFCD Halls Bayou Flood Risk Reduction Phasing Study (LAN, September 2018) utilizing Harris County Appraisal District (HCAD) 2004 parcel data, Houston-Galveston Area Council (H-GAC) 2017 aerial imagery, 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, Federal Emergency Management Agency (FEMA) Effective HEC-RAS and HEC-HMS models, and 2017 Structure Inventory Data from HCFCD. Refer to [Table 2-1](#) below for a summary of the data sources used in the analysis.

Table 2-1: Data Collection Summary

Data	Source	Purpose
2017 Parcel Data/Land Use	HCAD	Update land use for reference
2004-2017 Aerial Imagery	H-GAC	Manual digitization of land use for TC&R spreadsheet, Exhibit Development
2006 - 2011 Percent Impervious	USGS	Verify and update the land use parameters for TC&R spreadsheet
2008 and 2018 LIDAR (NUSA)	H-GAC	Update channel cross-sections geometry to reflect overland development, Exhibit development, used in RAS Mapper to plot results.
Channel Geometry	Baseline Corporation Professional Surveyors	Used in developing models to inform channel geometry, bridge location, and bridge geometry.
Halls Bayou Flood Risk Reduction Phasing Study Models	HCFCD	Starting models used
FEMA Effective Models	Harris County Flood Control District (HCFCD)	Reference models for Greens Bayou (P100-00-00) and Halls Bayou (P118-00-00)
2017 Structure Inventory	Harris County Flood Control District (HCFCD)	Estimate number of structures flooded to measure benefits.
Environmental Desktop Data	Harris County Flood Control District (HCFCD)	Used to evaluate potential environmental impact, and utility conflicts.
Greens Bayou Mid-Reach Analysis CLOMR Models	Harris County Flood Control District (HCFCD)	Used in quantifying the amount of overflow from Greens Bayou (P100-00-00) into P118-25-00/01 Drainage Area.
Site Visit Photos	LAN	Ground checking channel and potential detention locations.



2.1.1 Prior Studies

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

- FEMA Effective H&H models (FEMA, June 2014). After Tropical Storm Allison in 2001, FEMA and the HCFCD together developed a countywide study, Tropical Storm Allison Recovery Project (TSARP) to assess the flood risks associated with the major flooding sources and that became a Flood Insurance Study (FIS) and Effective Model. As part of the project, FEMA revised the H&H models and remapped the floodplains.
- Halls Bayou Watershed Flood Risk Reduction Phasing Study (LAN, September 2018). The H&H models from the Phasing Study served as the basis for this Baseline Conditions model development.

2.1.2 Site Conditions / Site Visit

On March 26th, 2019, LAN and HCFCD performed a site visit to photograph and document the drainage area. Major takeaways from the site visit included:

1. Sufficient outfall depth at the confluence of P118-25-00 with P118-00-00
2. Siltation in roadside ditches
3. Encroachments of ROW in P118-25-00
4. Dumping of trash along channel

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



Figure 2-1: Confluence of P118-25-00 and Halls Bayou



Figure 2-2: Misuse of Culverts on P118-25-01 South of Henry Rd



Figure 2-3: Illegal Waste Disposal on P118-25-01

2.2 Hydrology and Hydraulics Analysis

The methodology used to study the P118-25-00/01 project area involved H&H analysis and modeling in HEC-HMS and HEC-RAS, respectively. 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 P118-



25-00/01 standalone model. The Baseline Conditions model will establish an existing condition for conducting a flood risk assessment within the P118-25-00/01 watershed.

2.2.1 Hydrology

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

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

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

2.2.1.1 Drainage Area Delineation

The effective model sub-basin that covers P118-25-00/01 is named “P118C”. The effective HEC-HMS model was subdivided as part of the Halls Phasing Study, where the subdivided area was named “P118L1”. The drainage area was then further subdivided into seven (7) smaller areas, representing flow change locations, which are serving to provide appropriate boundary conditions for the dynamic HEC-RAS model. The delineation followed lot lines between properties, major roads, and ditches to break up the flow throughout the reach – refer to [Figure 2-4](#).



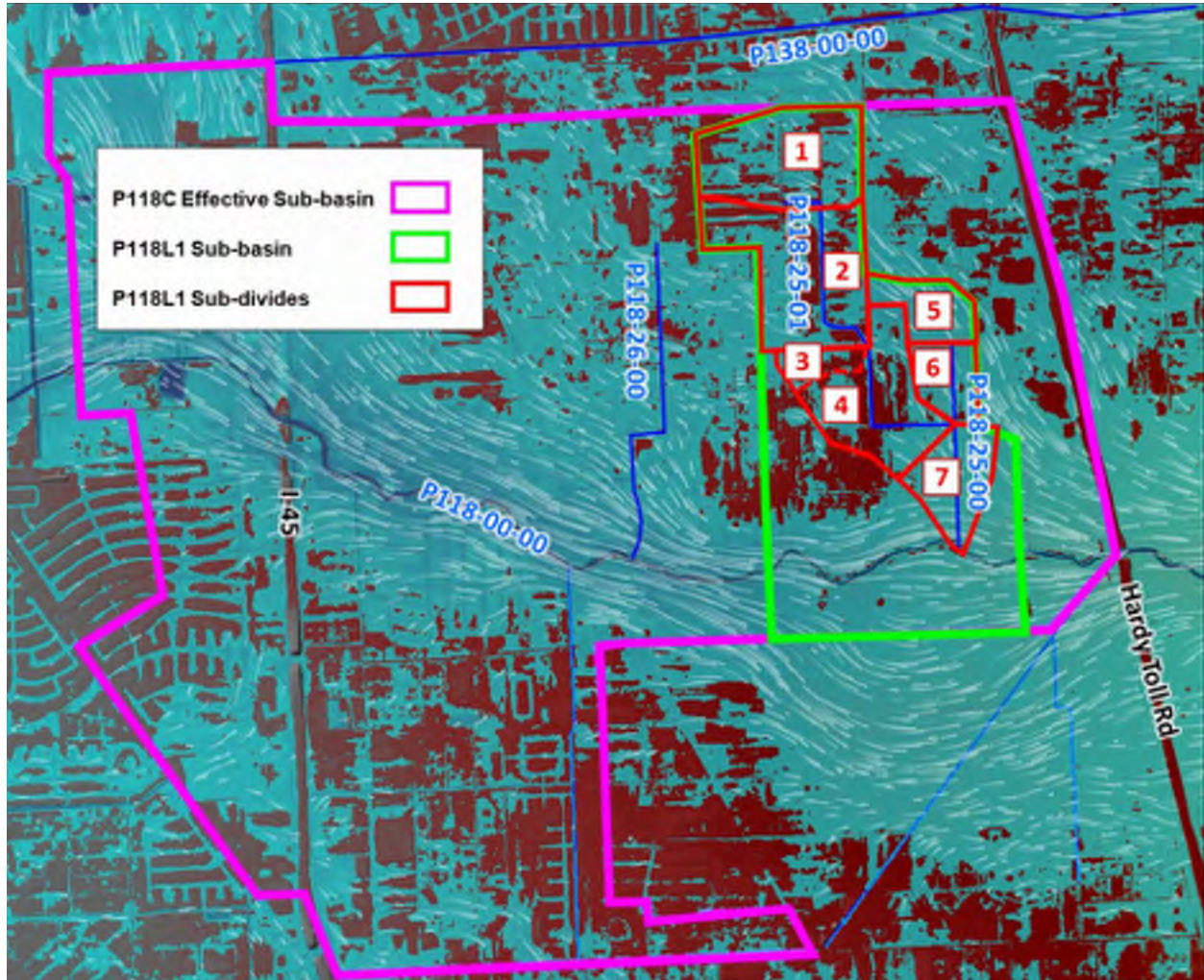


Figure 2-4: P118-25-00/01 Drainage Area “P118L1” with Subdivides

To re-evaluate the delineation of drainage area “P118L1” and drainage sub-divides, LAN developed a Rain-on-Mesh model, where precipitation is applied directly to the surface to determine overland flow paths. This procedure was conducted for a 2-year and 100-year storm event. [Figure 2-5](#) shows the result of a 100-year storm event with HEC-RAS’s particle tracking feature to show flow paths and the contributing area draining to the P118-25-00/01 channel. Flow change locations in the HEC-RAS model were connected to the HEC-HMS’s Data Storage System (DSS) output for sub-basin P118L1. Multipliers were set based on area-based ratios of subdivided drainage areas (HCFCD, March 2018).

Analysis by LAN indicated that the existing 635-acre (0.99 square miles) drainage area of P118L1 remains current. However, drainage areas #3 and #4 can be merged into one area, since their streams drain into the same channel segment – refer to [Exhibit 5](#).

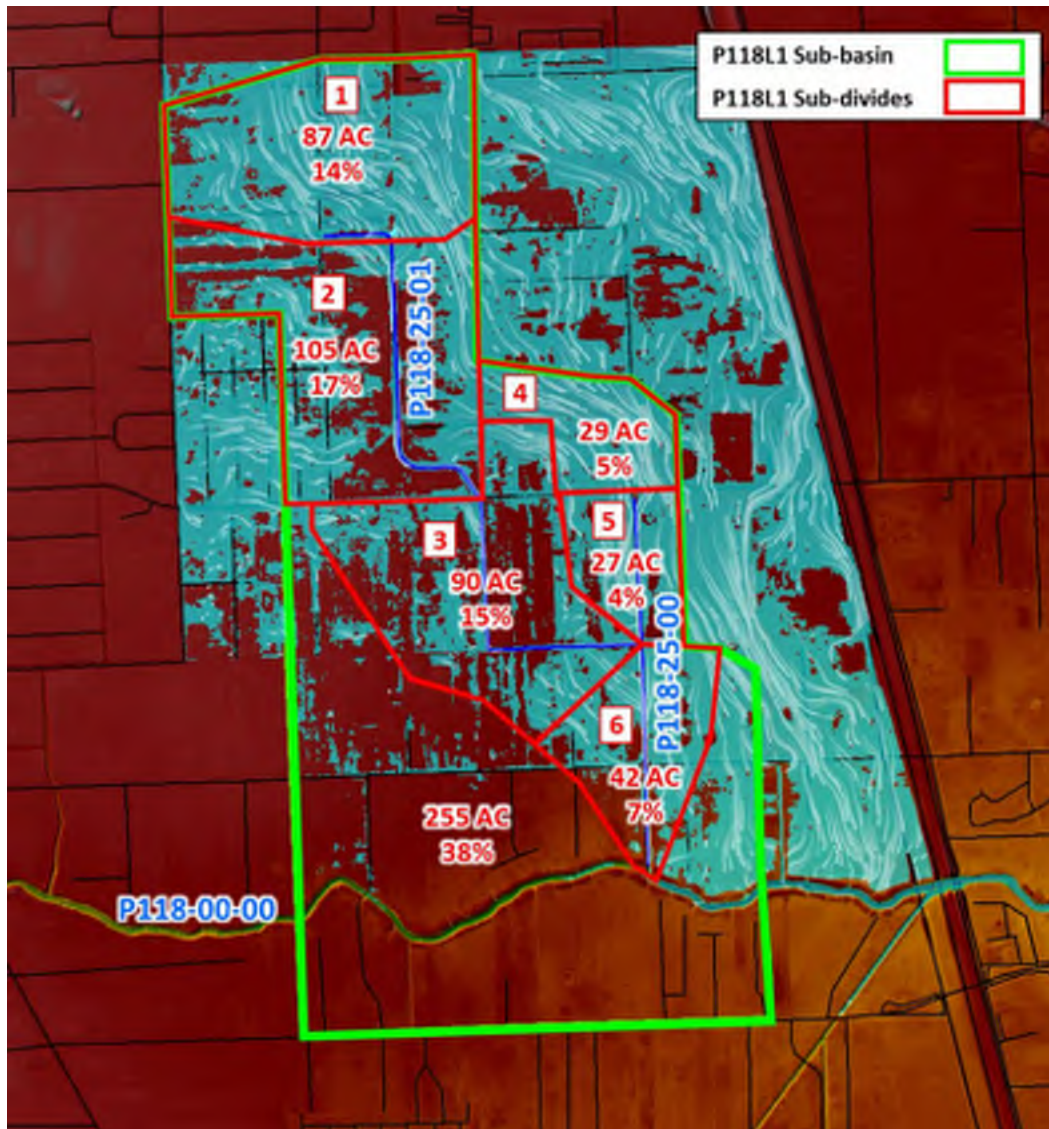


Figure 2-5: – Updated Drainage Subdivides – HEC-RAS Rain-on-Mesh Model (100-Year Rainfall Event)

2.2.1.2 Hydrograph Development

The hydrology model utilized to create the Baseline Conditions model came from the “Halls Bayou Watershed Flood Risk Reduction Phasing Study”, which was based on the FEMA effective HEC-HMS model and updated to reflect more current conditions. HEC-HMS version 3.4 (USACE 2009) was used throughout this analysis and was consistent with the Effective M3 hydrologic model development. Impervious percent values were updated based on 2014 aerial imagery. Time of Concentration (TC) & Storage Coefficient (R) parameters were developed using the HCFCD hydrologic methodology (HCFCD 2009). Channel slope and overland slope values were updated based on 2008 LIDAR data. Percent Land Urbanization (PLU) values were estimated by digitizing the land use categories based on 2014 aerial imagery. Subbasin P118L1 encompassed the P118-25-00/01 drainage area and had TC&R values of 0.61 hours and 6.10 hours, respectively.



The Baseline Conditions HEC-HMS model was used to generate hydrographs, which were then ratioed for each subbasin based on their percentage of total contributing drainage area. Refer to [Table 2-2](#) and [Section 2.2.2.5](#) “Inflow Boundary Conditions, p. 28”, for resulting ratio of peak flows and its application in the HEC-RAS Baseline Conditions model, respectively.

Note: It is assumed that 62% of drainage area P118L1 drains directly to tributary channels P118-25-00/01.

Table 2-2: Prorated Flows by Percent Area

Sub-Area	Drainage Area acres (sq. mi.)	Drainage Area (%)	500-YR Peak Flow (cfs)
1	87 (0.136)	14%	125
2	105 (0.164)	17%	152
3	90 (0.141)	15%	134
4	29 (0.045)	5%	45
5	27 (0.042)	4%	36
6	42 (0.066)	7%	63
Total	635 (0.992)	62%	

2.2.1.3 Overflow Analysis: A Brief Recap

The study area is heavily influenced by overflows from P118-26-00 in the west and P100-00-00 (Greens Bayou) in the north, which cascades south into P138-00-00 and then to the study area of P118-25-00/01 – refer to [Figure 2-6](#).

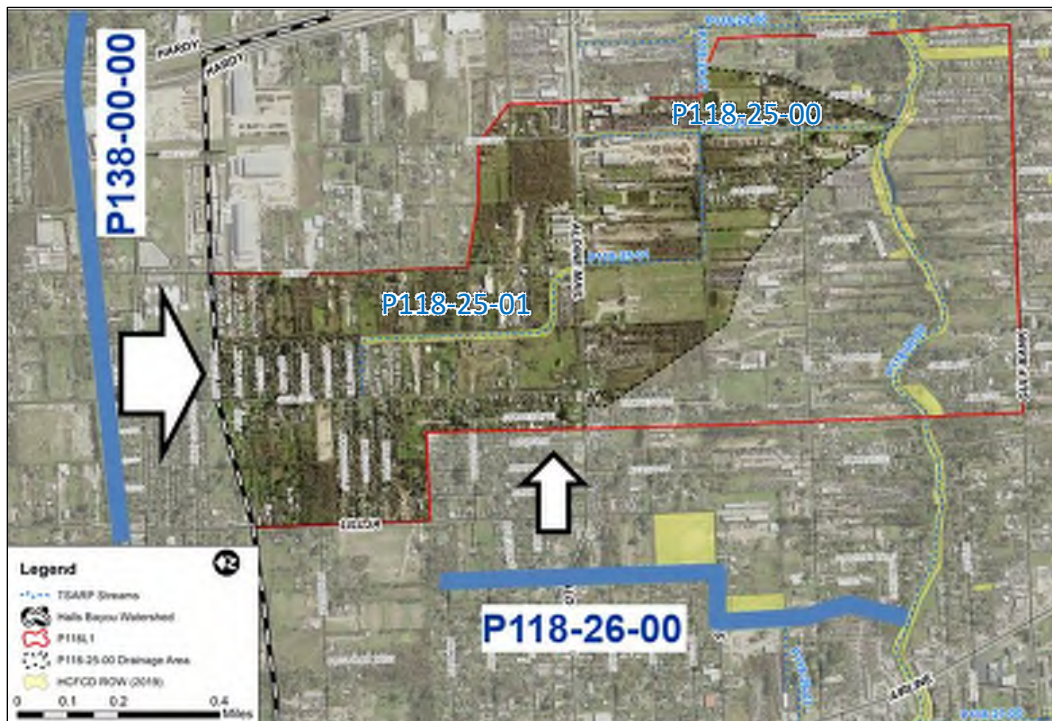


Figure 2-6: Study Area Boundary Conditions (view 90 deg left rotated)



Per HCFCF's request, LAN conducted an analysis towards understanding various overflow scenarios involving P118-25-00/01 Baseline Conditions. The initial Baseline Conditions analyses (completed 2/22/19) revealed the magnitude and extent of persisting and substantial overflows from P118-26-00 and especially from P138-00-00 entering the study catchment. As such, this analysis was conducted as a prerequisite prior to the full initiation of Detailed Alternatives formulation to understand key influences overflows have on developing effective flood risk mitigation alternatives.

With a few model retrofits, LAN utilized prior HCFCF studies (e.g. P118-26 PER model, Greens Bayou CLOMR model, and Greens Bayou Federal Study Model) to establish known overflow boundary conditions onto the P118-25-00 standalone model. The overflow scenarios are described as follows:

- **Overflow Scenario #1 ("Current" Conditions):**
Assumes that the existing overflows from P118-26-00 and P138-00-00 are in place.
- **Overflow Scenario #2 ("Near Future" Conditions):**
Assumes that the P118-26-00 bond project has been implemented and would eliminate overflow from that tributary.
- **Overflow Scenario #3 ("Future" Conditions):**
Assumes that the Mid-Reach Greens Bayou Project (Bond ID: C-20) has been completed and will reduce the amount of overflow coming from P138-00-00 by 60%.

The overflow data was utilized for P118-26-00 overflows from the PER Study Baseline Conditions "Standalone" Model, and for P138-00-00 overflows originally from the Greens Bayou Federal Study Model Without Project (WOP) Conditions as part of TSARP.

To facilitate the overflow analysis, HCFCF provided a Conditional Letter of Map Revision (CLOMR) model of Greens Bayou developed by Walter P. Moore (WPM) as part of the Greens Bayou Mid-Reach Study. LAN utilized this CLOMR model as a starting point to more accurately assess overflows entering P118-25-00/01 from P138-00-00.

However, additional updates to the CLOMR model were necessary as the CLOMR model did not include necessary cross-sections along the full length of P138-00-00 for establishing overflow sources. LAN imported cross-sections from the Halls Bayou Federal Study model, which was used originally to measure overflow from Greens Bayou. In addition, the cross-sections were adapted and updated based on 2018 LiDAR terrain.

Also, the Federal Study model utilizes a storage area approach ("OF2N_SA") to model overflows from Greens Bayou mainstem (P100-00-00) entering P138-00-00 from which LAN referenced into the CLOMR model. Refer to [Figure 2-7](#) for a comparison of the HEC-RAS geometry.



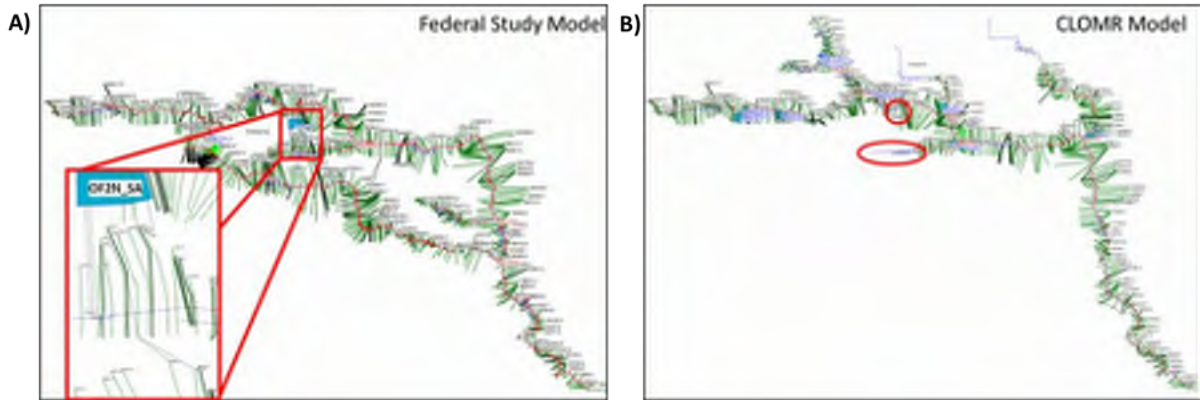


Figure 2-7 A) Federal Study HEC-RAS (Version 3.1.3) Geometry with Lateral Connections, B) CLOMR Study HEC-RAS (Version 4.1.0) Geometry Missing Lateral Connections and Cross-sections on the Upstream End of P138-00-00.

As shown in **Figure 2-8**, originally there was one lateral structure between Sellers Road and Henry Road that correlated to a single boundary condition line that ran across the whole edge of the 2D Area in the P118-25-00 model. LAN updated this to include three lateral structures that now correlate to three boundary condition lines in the P118-25-00 model. The lateral structures were added between (1) Lillja Road and Sellers Road (LS 17570), (2) Sellers Road and Henry Road (LS 16200), and (3) Henry Road and the Hardy Toll Road (LS 14800).

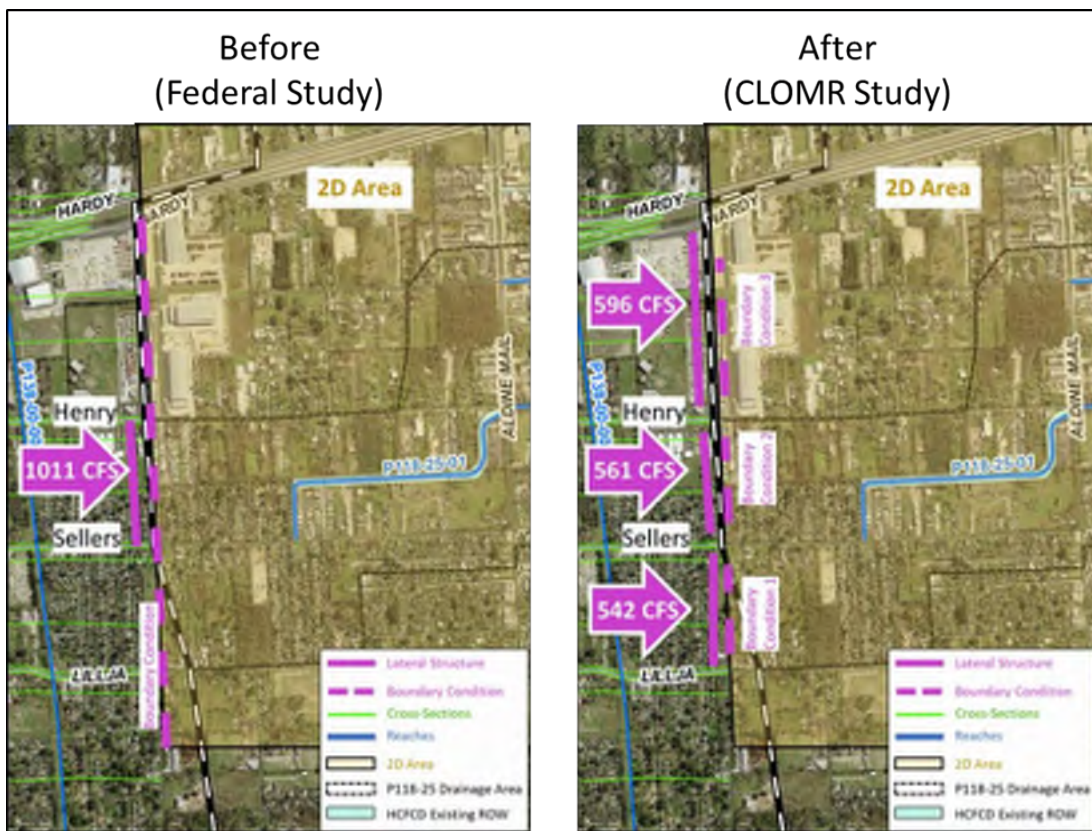


Figure 2-8: Comparison Lateral Structure Alignment and 500-Year Peak Flows



This process of updating the CLOMR Corrected Effective model to more accurately measure the overflow better defines the amount and location of the overflow coming from P138-00-00 into P118-00-00. Not only is the amount and location of overflow being measured more accurately, the way it is applied as three boundary conditions to the P118-25-00/01 model rather than one boundary condition is also more accurate. Refer to [Appendix A](#) for a comparison of the stage hydrographs before and after the update.

The flows and volumes were measured as they crossed the lateral structures into the P118-25-00/01 drainage area. Refer to [Table 2-3](#) for a comparison of the peak flow and volume overflow between prior and present overflow source models leaving P138-00-00. Refer to [Table 2-4](#) for the amount of overflow leaving P138-00-00 and effectively entering the study area P118-25-00/01.

Table 2-3: Baseline Conditions – Amount of Overflow Leaving P138-00-00

Model	Lateral Structure	Description	Peak Flow (cfs)				Volume (ac-ft)			
			10-Year	50-Year	100-Year	500-Year	10-Year	50-Year	100-Year	500-Year
Federal Study Model	LS 15500	Sellers to Henry	0	151	427	1012	0	107	361	995**
CLOMR CE*	LS 17570	Lillja to Sellers	51	198	289	542	35	166	265	560
CLOMR CE*	LS 16200	Sellers to Henry	7	234	313	561	3	153	255	561
CLOMR CE*	LS 14800	Henry to Hardy	0	143	284	596	0	69	177	525

* Corrected Effective
 ** Extrapolated based on log-log scale

Table 2-4: Baseline Conditions: Amount of Overflow Leaving P138-00-00 and Entering P118-25-00/01

Model	Lateral Structure	Description	Peak Flow (cfs)				Volume (ac-ft)			
			10-Year	50-Year	100-Year	500-Year	10-Year	50-Year	100-Year	500-Year
Federal Study Model	LS 15500	Sellers to Henry	0	151	427	1012	0	107	361	995**
CLOMR CE*	LS 17570	Lillja to Sellers	51	198	289	542	35	166	265	560
CLOMR CE*	LS 16200	Sellers to Henry	7	234	313	561	3	153	255	561
CLOMR CE*	LS 14800	Henry to Hardy	0	37	60	248	0	18	23	175

* Corrected Effective
 ** Extrapolated based on log-log scale

Because not all the overflow reaches the project’s drainage area, LAN considered the single overflow locations in isolation. Similar to the process of measuring flow over a lateral structure, profile lines (HEC-RAS feature) are another way of extracting linear data, but in post-process. Here, the profile line is running along the eastern boundary of the drainage area. [Figure 2-9](#) shows an example of the accumulated volume entering the project’s drainage area from Lateral Structure 3 (LS 14800) for the 500-year storm event.



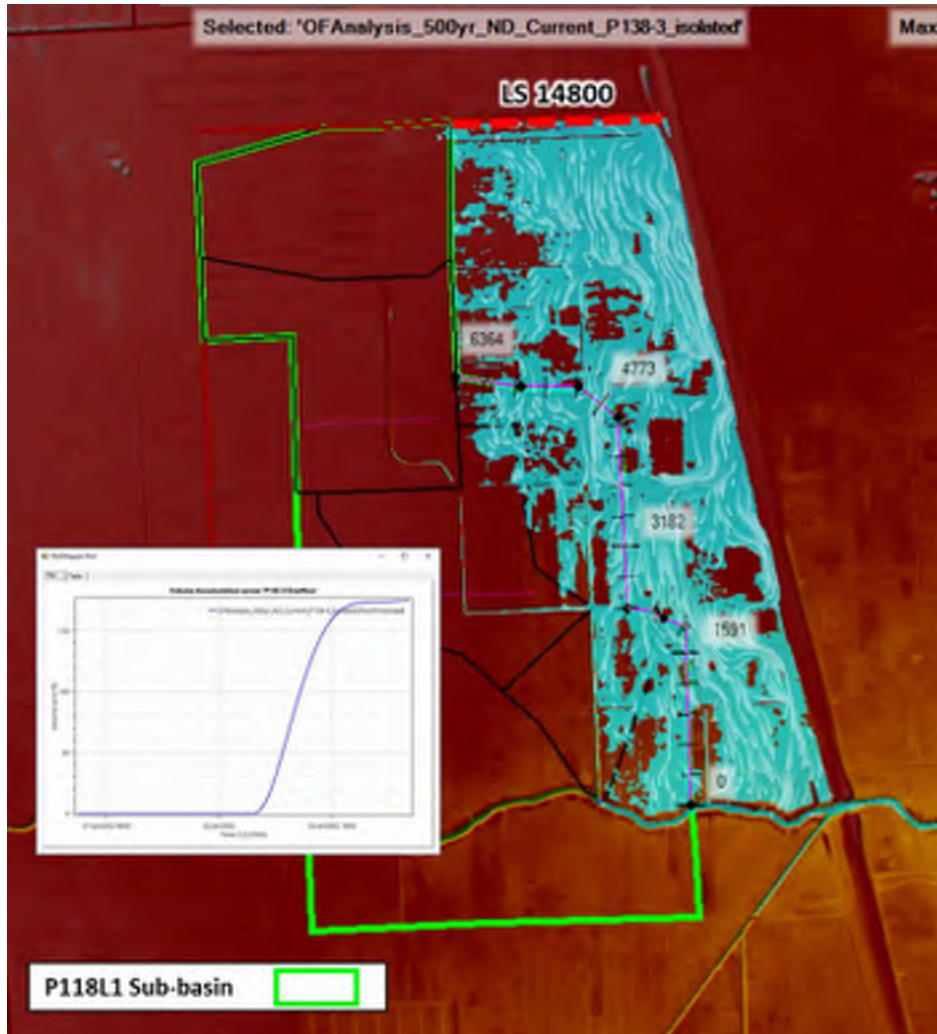


Figure 2-9: Overflow Determination (Accumulated Volume) in Post-Process with Profile Lines in HEC-RAS

Evaluations show that of the originally 525 acre-feet flow volume passing Lateral Structure 3 (LS 14800), only 175 acre-feet effectively enter the project's drainage area. The same procedure was utilized for evaluating the 10, 50, and 100-year storm events.

The results of the Overflow Analysis show an overall increase in overflow. This increase is because before this Overflow Analysis not all the volume of overflow was being measured. **Figure 2-10** shows the volume distribution of catchment area P118-25-00 before the update. In a 500-year flood event, Greens Bayou accounts for 61% of the total volume flow, and in a 100-year flood event, 46%. **Figure 2-11** shows the volume distribution of catchment area P118-25-00 after the update. In a 500-year flood event, Greens Bayou accounts for 67% of the total volume flow, and in a 100-year flood event, 56%. In general, overflows from P138-00-00 constitute a larger percentage of P118-25-00's overflow volume starting at the 100-year storm event.

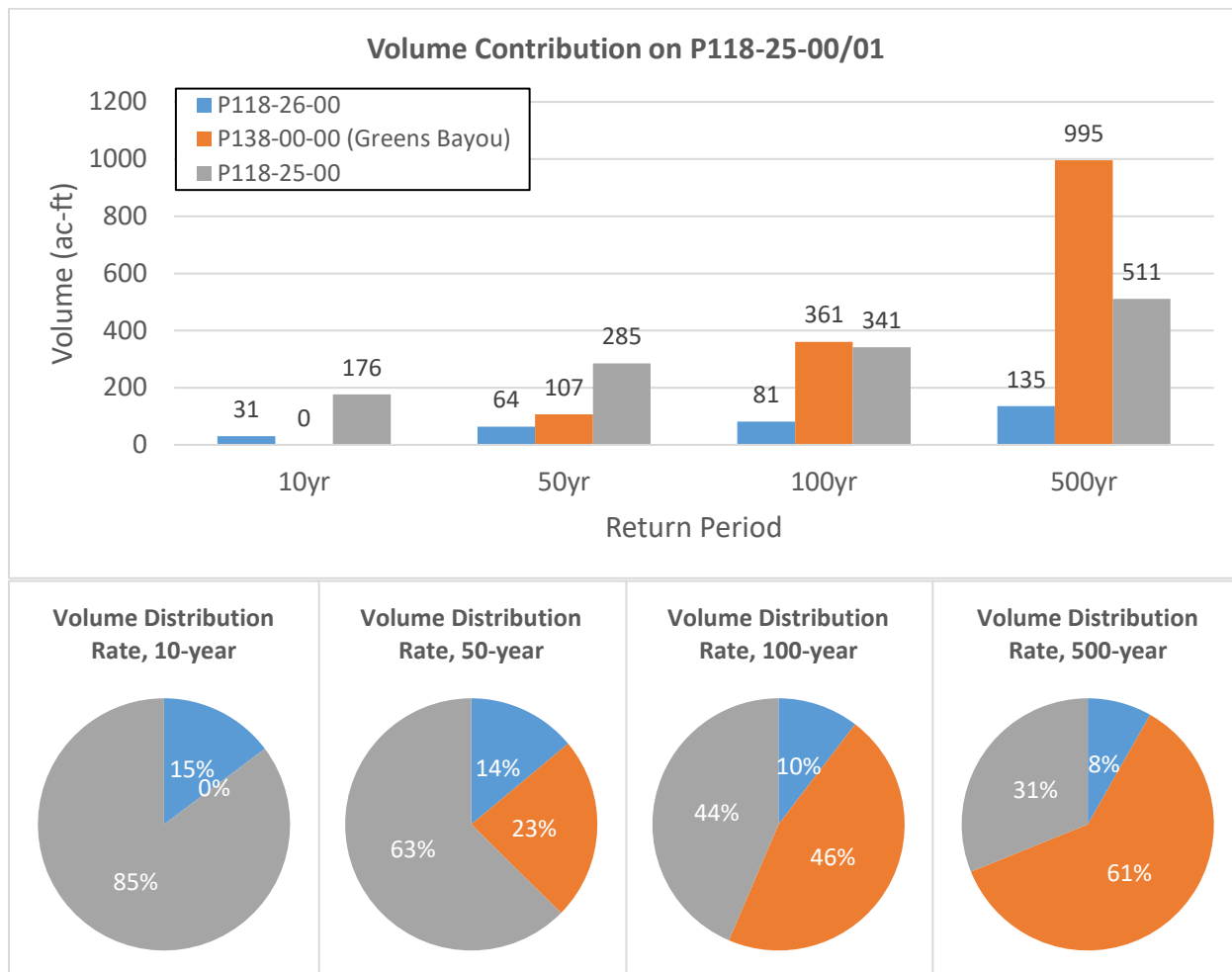


Figure 2-10: Volume Contribution on P118-25-00/01 before Overflow Analysis



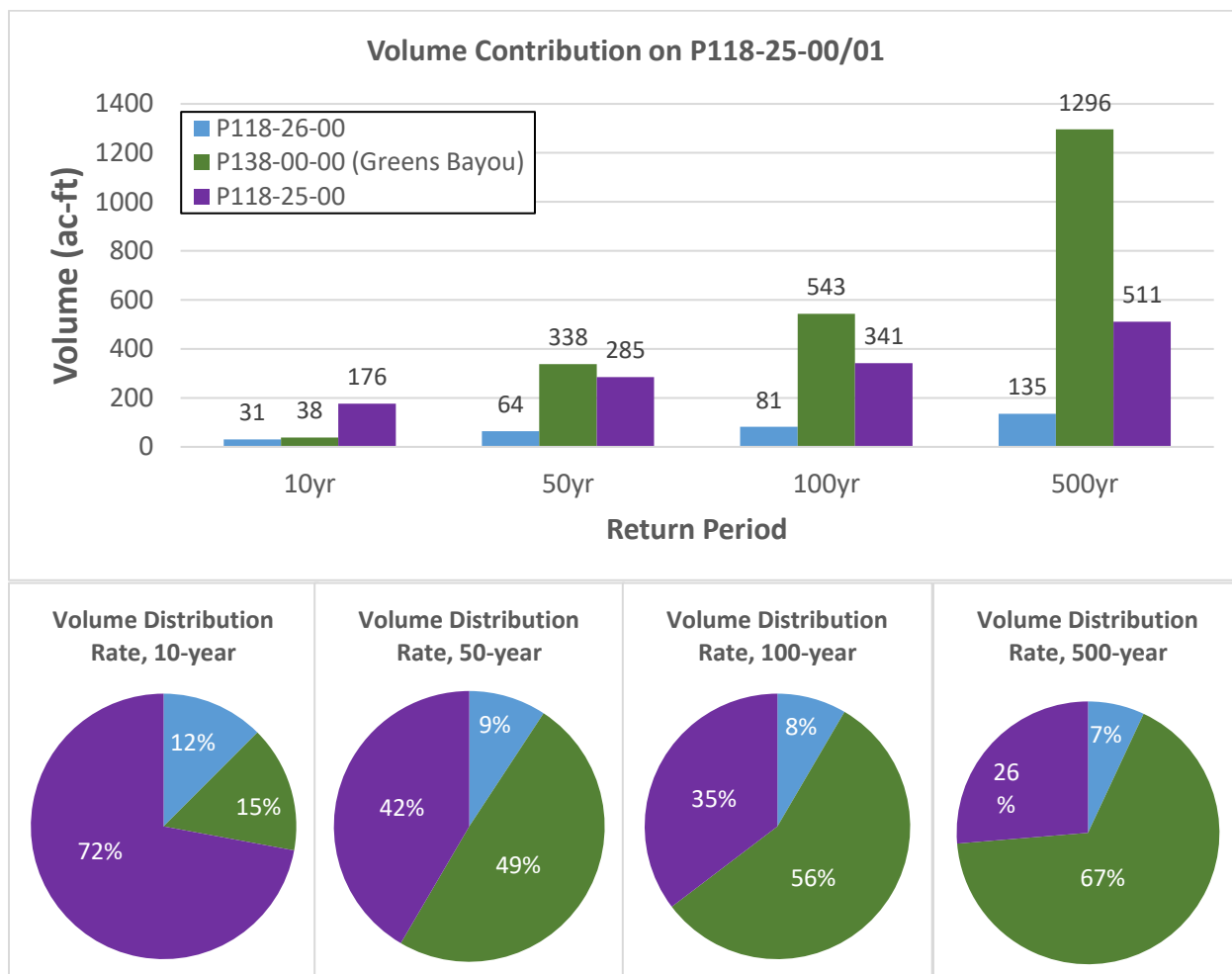


Figure 2-11: Volume Contribution on P118-25-00/01 after Overflow Analysis

2.2.2 Hydraulics

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

As a starting point for the Baseline Conditions model, LAN used a fully 1D unsteady standalone model of P118-25-00/01 that was developed as part of the Halls Phasing Study. LAN was scoped to re-evaluate and modify the hydrologic model from the Halls Phasing Study, modify the hydraulic 1D model to a combined 1D/2D model, bring in overflows from mainstem P100-00-00 (Greens Bayou) in the north, which cascades south into adjacent tributary P138-00-00 (a tributary to Greens Bayou) in the north and tributary P118-26-00 in the west, and stabilize the model for the 10-, 50-, 100-, and 500-year return periods, each considering two downstream boundary conditions scenarios; Scenario #1: Assuming that P118-25-00 is *not* influenced by Halls Bayou at river confluence (Normal Depth assumption), and Scenario #2: Assuming that P118-25-00 is influenced by Halls Bayou (Stage Hydrograph).



2.2.2.1 1D Channel Geometry

In the Halls Phasing Study, channel cross-sections for the fully 1D unsteady standalone model of P118-25-00/01 were created based on terrain data from 2008 LiDAR and channel surveys. To convert that model to a combined 1D/2D model, LAN first trimmed cross-sections to make room for 2D areas that would model the overbanks. Cross-sections were trimmed to approximately 200 feet long for P118-25-00/01. The cross-sections were not trimmed to the bank stations for two reasons: (1) to provide room for channel widening as part of the Alternatives Analysis and (2) because RAS Mapper needs some cross-section overlap with the 2D area to form a smooth inundation extent. Ineffective flow areas in the channel overbanks were removed and 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. Manning's n values were set to 0.040 for grass-lined channels (HCFCD, October 2018). Interpolated cross-sections were added as needed to generate a smoother transition between cross-sections. **Figure 2-12** shows an example of the geometry and RAS Mapper view of the 1D cross-sections for the Baseline Conditions Model.

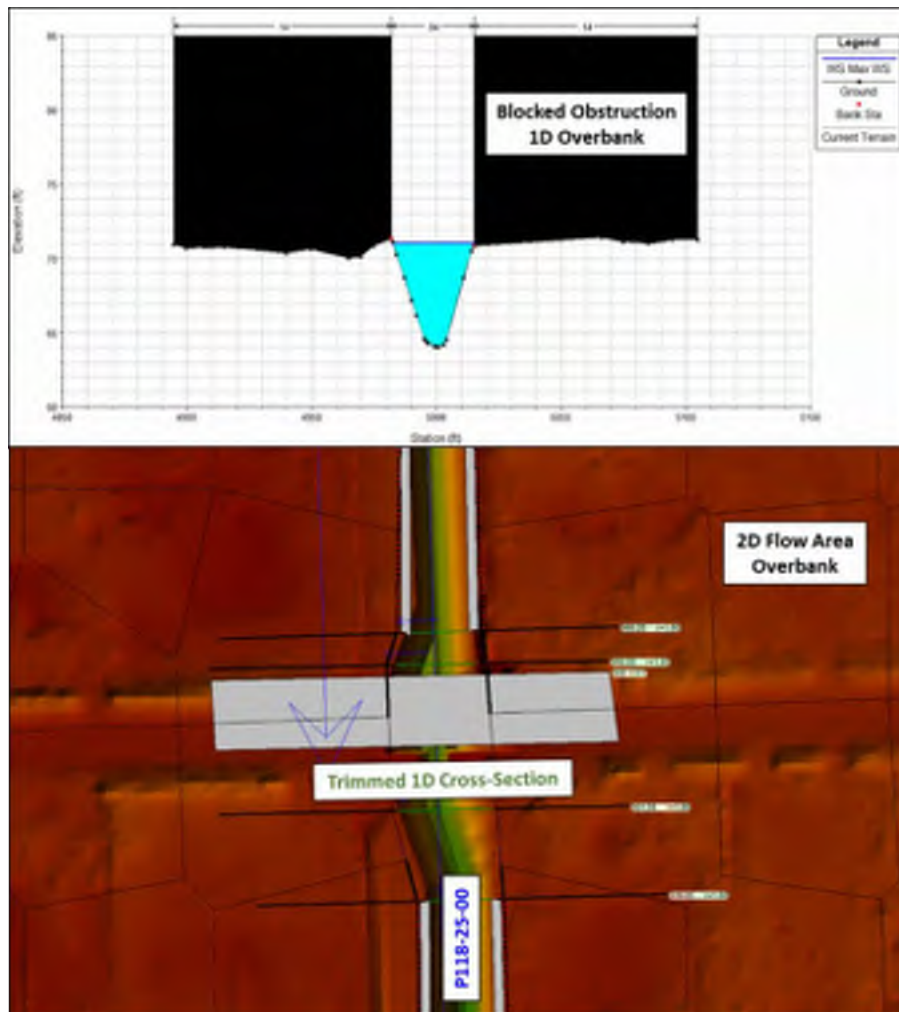


Figure 2-12: HEC-RAS Baseline Conditions Model Geometry –1D Cross-sections



2.2.2.2 2D Flow Areas

LAN created four initial 2D flow areas located within sub-basin P118L1/L2 for the Baseline Conditions model with a 100 square foot cell size – refer to **Figure 2-13: (1)** An Area 1 bound north by P118-25-00, south by sub-basins L118L1/L2, east by P118-25-00/01, and west by Lillja Road, **(2)** an Area 2 bound north by sub-basin L118L1/L2, south by P118-25-00 and Area 1 & 3, east by Hardy Toll Road, and west by P118-25-00, **(3)** An Area 3 bound north by Area 2, south by P118-25-00/01 and Area 4, east by Hardy Toll Road, and west by P118-25-00, and **(4)** an Area 4 bound north by Area 3, south by sub-basins L118L1/L2, east by Hardy Toll Road, and west by P118-25-01 and Area 1. As per HCFCD’s “2D Modeling Guidelines”, break lines were created for all major roadways contained within the new 2D mesh boundaries.

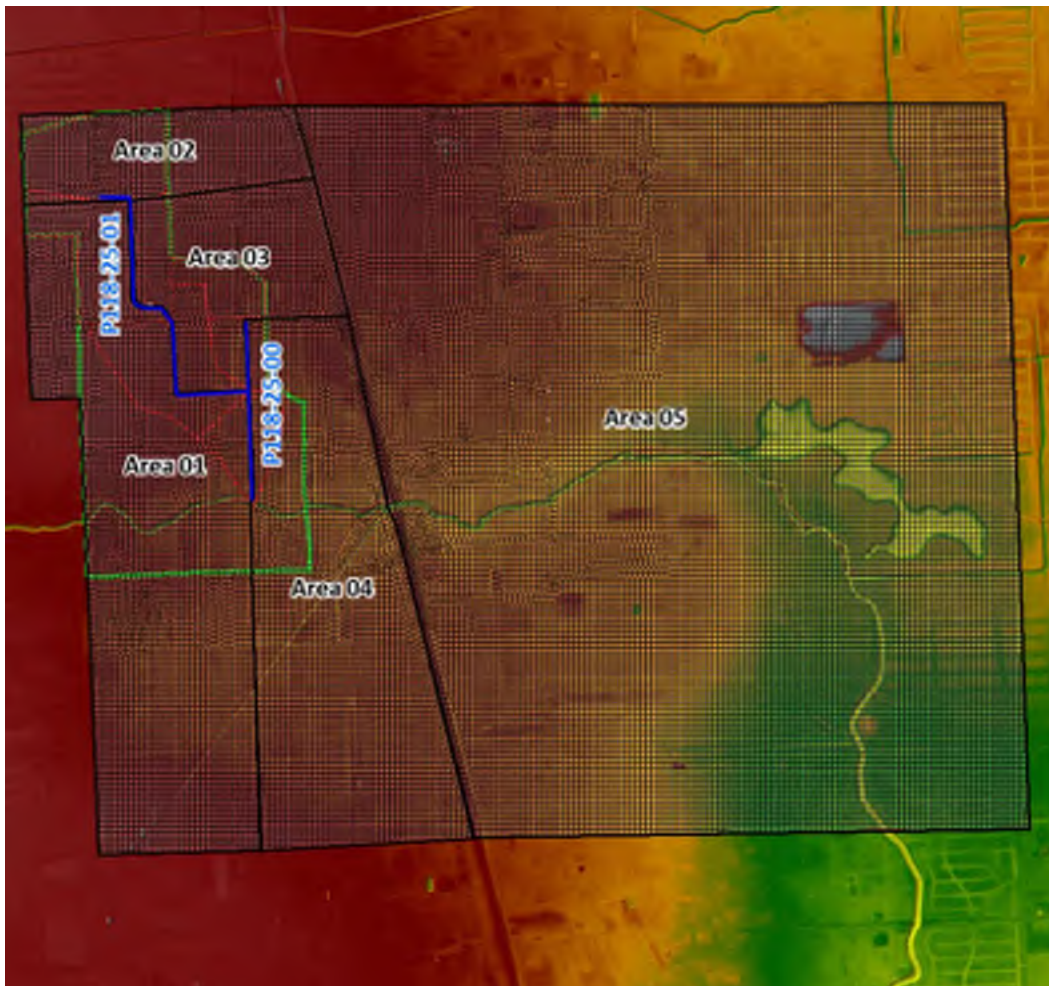


Figure 2-13: 2D Flow Areas

During analysis it was found that initial 2D flow area boundaries were not sufficiently extended, as the location of the 2D area boundary and boundary condition line can significantly affect the distribution of flow between 2D cells. LAN added a fifth 2D area extending past Hardy Toll Road to the east, covering Keith-Weiss, and added normal depth boundary conditions to the edges of the 2D area (Appendix C, HCFCD, July 2018). In this case, the extension led to a slight change of the WSEL of P118-25-01 at Aldine Mail Route Road – refer to **Figure 2-14**.



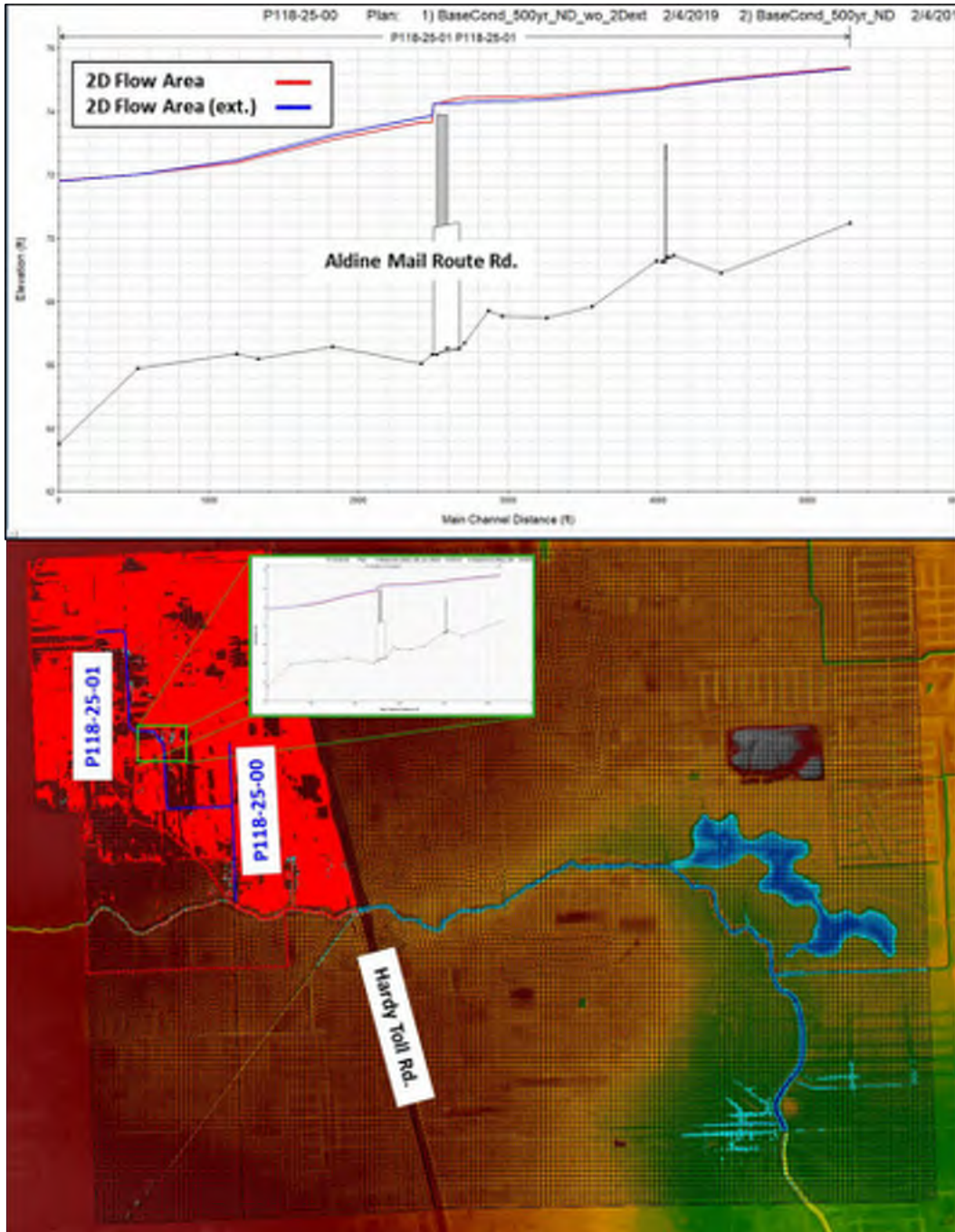


Figure 2-14: Initial 2D Flow Area (Red) vs. Extended 2D Flow Area (Blue)

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 placed lateral structures on left and right banks between inline structures along the entire length of the tributaries. Similarly, 2D connectors were placed along the shared edges of the four 2D areas, allowing water to pass from one 2D area to the next. 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). Refer to [Figure 2-15](#) for the final Baseline Conditions combined 1D/2D HEC-RAS geometry.

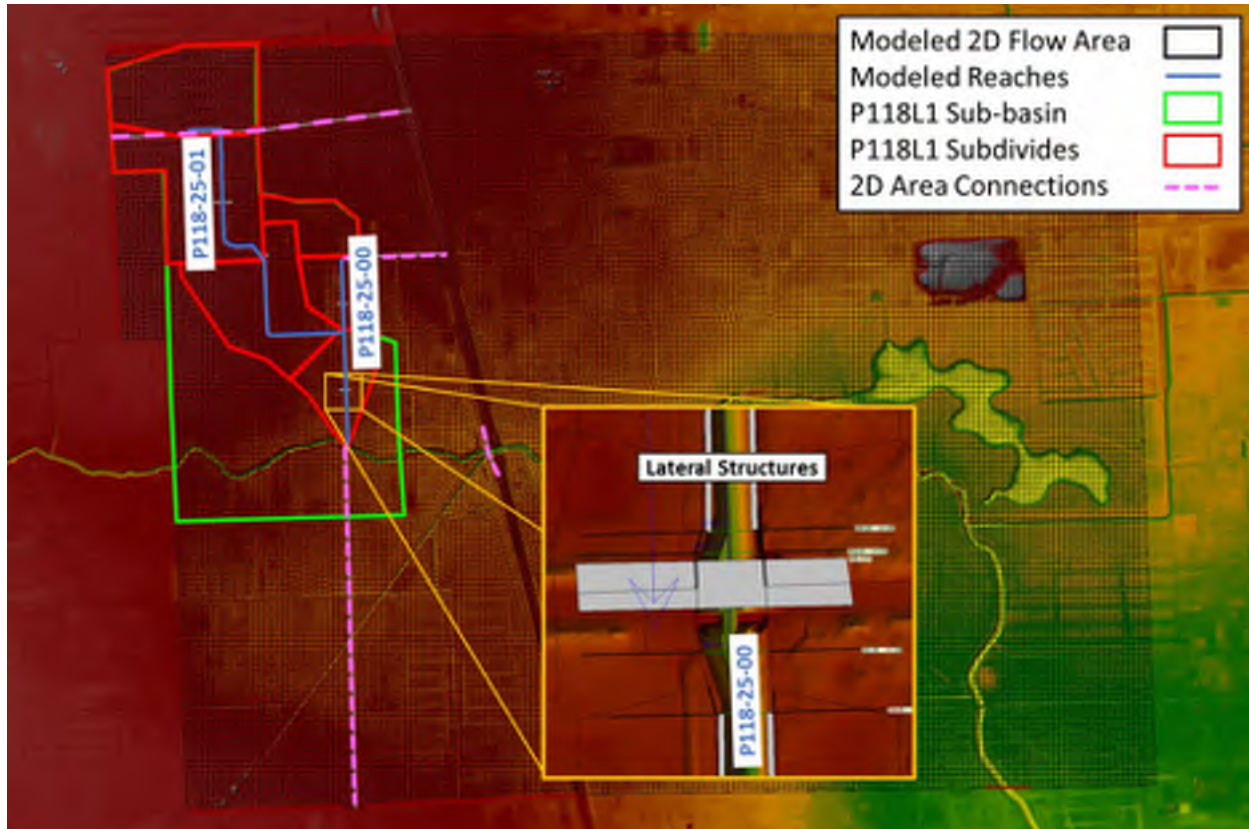


Figure 2-15: HEC-RAS Baseline Conditions Model Geometry – Lateral Structures & 2D Connections

2.2.2.4 Tailwater Conditions

Two tailwater boundary conditions scenarios were modeled: (1) assuming the WSEL of P118-25-00 is not influenced by tailwater conditions of Halls Bayou (Normal Depth assumption), and (2) assuming the WSEL of P118-25-00 is influenced by tailwater conditions of Halls Bayou using stage hydrographs computed from Halls Bayou Phasing Study at the P118-25-00 outfall.

For Scenario #1, LAN applied a channel slope representative of the average slope along P118-25-00/01. The normal depth scenario essentially assumes that Halls Bayou is empty, allowing P118-25-00/01 to gravity drain freely. Because Halls Bayou tributaries are highly influenced by tailwater conditions in the Halls Bayou Mainstem, Scenario #2's boundary condition is a stage hydrograph pulled from the cross-section just upstream of the confluence with P118-25-00 in the Halls Phasing Study Baseline Conditions model. [Figure 2-16](#) shows the significant influence Halls Bayou has on P118-25-00, with a maximum increase in WSEL of nearly 10 feet at the downstream end, and 1.5 feet on the upstream end for a 500-year storm event.

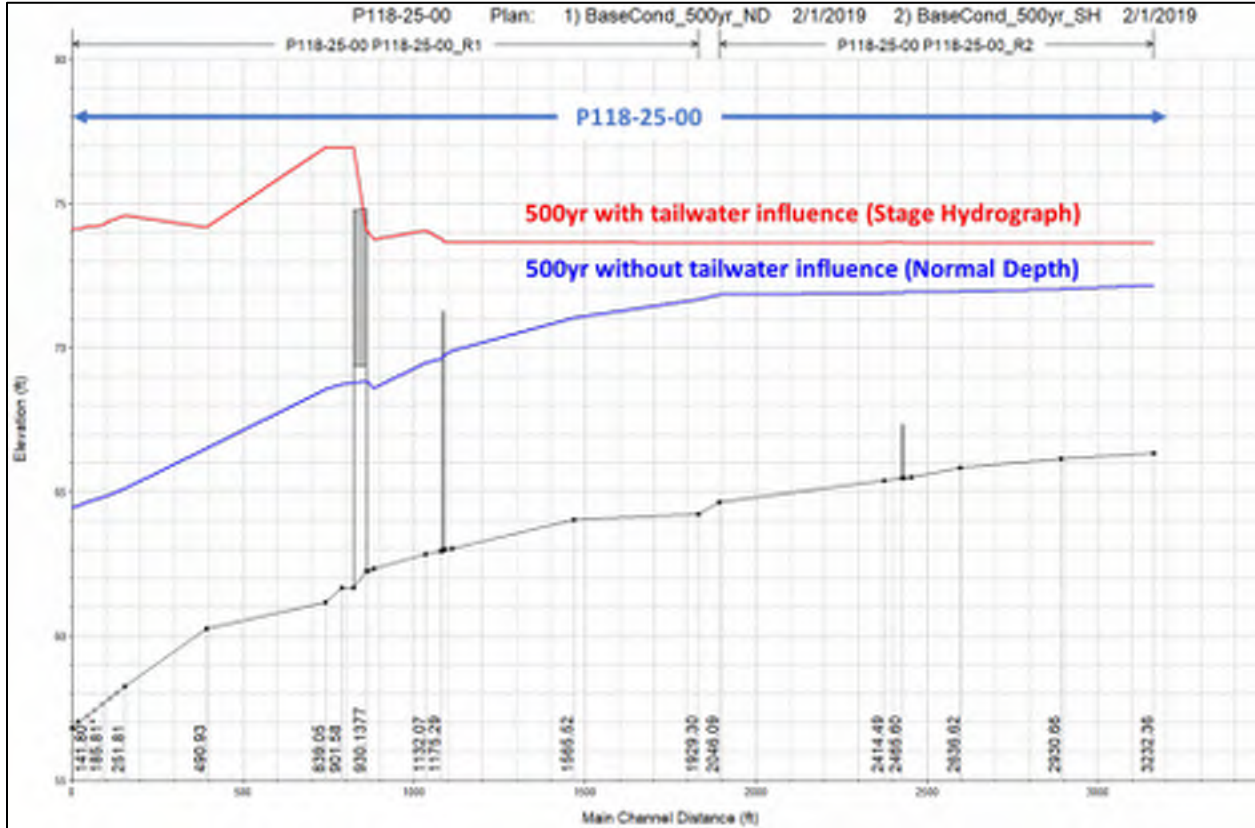


Figure 2-16: Halls Bayou Influence on WSEL of P118-25-00, 500-Year Storm Event

Scenario #2 is included to demonstrate the significant influence of Halls Bayou on the tributary, but the design was completed based on Scenario #1.

2.2.2.5 Inflow Boundary Conditions

Inflow hydrographs are applied via boundary conditions using DSS connections to the Baseline Conditions HEC-HMS model – refer to Section 2.2.1.2 “Hydrograph Development, p. 16”. Refer to Table 2-5 below for a summary of the HEC-RAS inflow connections.

Table 2-5: Baseline Conditions HEC-RAS Unsteady Flow Connections

#	Reach	River Station	HEC-RAS Boundary Condition	HEC-HMS Subbasin	Multiplier	500-YR Peak Flow (cfs)
1	P118-25-01	5341.48	Flow Hydrograph	P118L1	0.14 (14%)	125
2	P118-25-01	4477.47 to 2728.92	Uniform Lateral Inflow	P118L1	0.17 (17%)	152
3	P118-25-01	2475.84 to 1881.88	Uniform Lateral Inflow	P118L1	0.15 (15%)	134
4	P118-25-00_R2	3203.12	Flow Hydrograph	P118L1	0.05 (5%)	45
5	P118-25-00_R2	2930.66 to 2636.62	Uniform Lateral Inflow	P118L1	0.04 (4%)	36
6	P118-25-00_R1	1565.52 to 251.81	Uniform Lateral Inflow	P118L1	0.07 (7%)	63
	P118-25-00_R1	97.80	Normal Depth	P118L1		
	Total				0.62 (62%)	



2.2.2.6 Model Stabilization

Primary sources of instability were the bridge crossings, lateral structures, and 2D connections. To achieve stability, horizontal tabulation (HTAB) parameters were increased for the cross-sections and for the bridges to allow for greater resolution at bridge crossings, and weir coefficients were varied in the recommended 0.2 to 0.5 range for lateral structures and 2D connections (USACE, February 2016). Once the model was running to completion, oscillations in the resulting hydrographs indicated potential instabilities. Reducing the computational time step helped to reduce oscillation-based instabilities. LAN tested three different time steps (20-, 12-, 10-, and 5-second timesteps) to observe impacts on stage hydrographs. LAN found that a 5-second computational timestep offered the best reduction in stage hydrograph noise.

2.2.3 2018 LiDAR Update and Model 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 (**Figure 2-17**). The 2018 LiDAR also shows land improvements constructed over the past ten years.

To compare the effects of using the new data, the combined 1D/2D baseline conditions models for P118-25-00/01 were re-calculated using the 2018 LiDAR. Results were calculated for both the 100- and 500-year rainfall events. Overall, the results of the 2D models based on 2018 LiDAR are similar to previous models based on 2008 LiDAR. **Figure 2-18** shows the WSEL of P118-25-00 and **Figure 2-19** shows the terrain elevation of sub-basin P118L generated from the two datasets. The results show no significant discrepancies between the WSEL and terrains. The average deviation in WSEL is 0.29 feet and 0.27 feet for a 100-year and 500-year rainfall event, respectively. For the terrain, the average deviation is 0.1 feet. In P118-25-00, the hydrograph of the 2018 LiDAR shows an almost identical shape with a slightly lower peak to that of the 2008 LiDAR (**Figure 2-20**).

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.

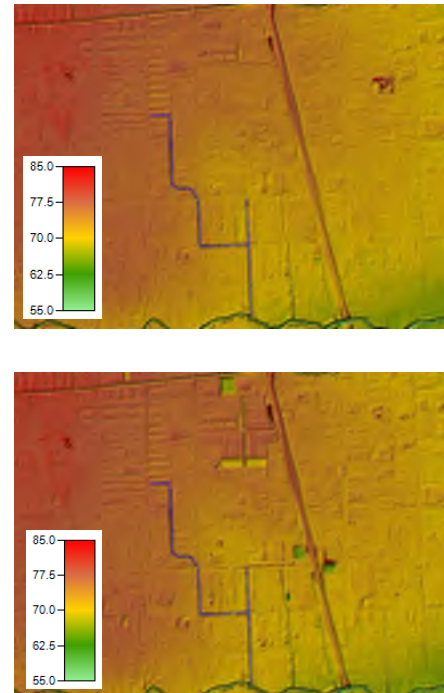


Figure 2-17 Examples of 2008 (top) and 2018 (bottom) LiDAR of P118-25-00/01

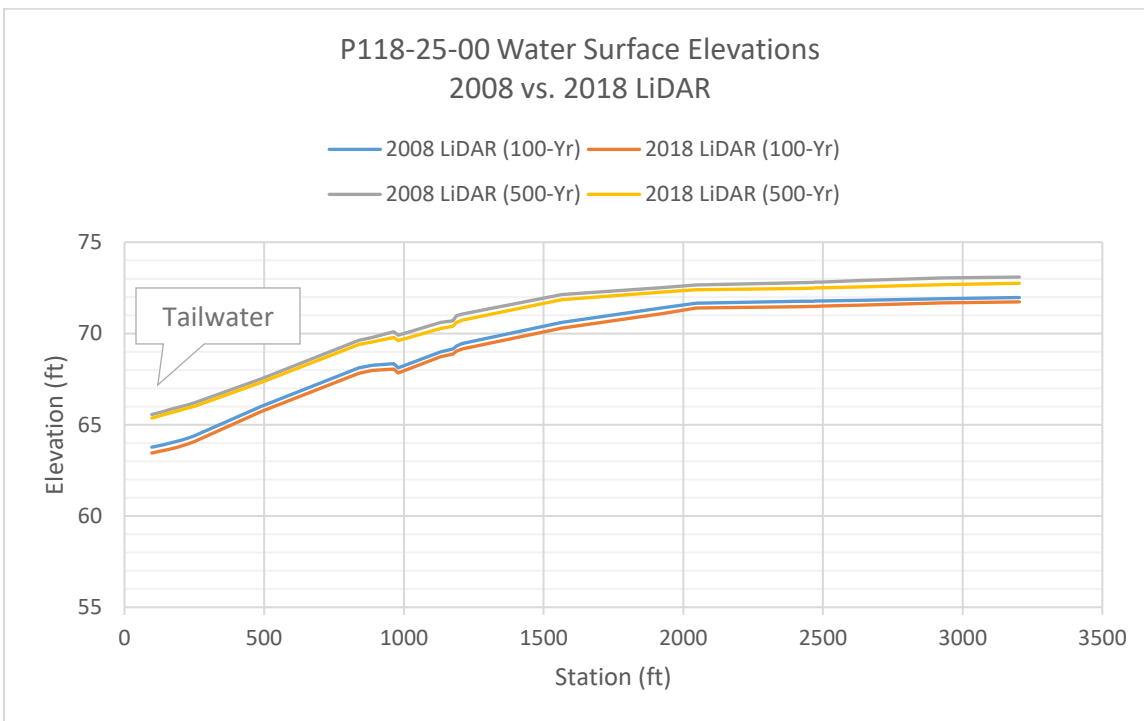


Figure 2-18: Water Surface Elevation Comparison of P118-25-00 using 2008 and 2018 LiDAR

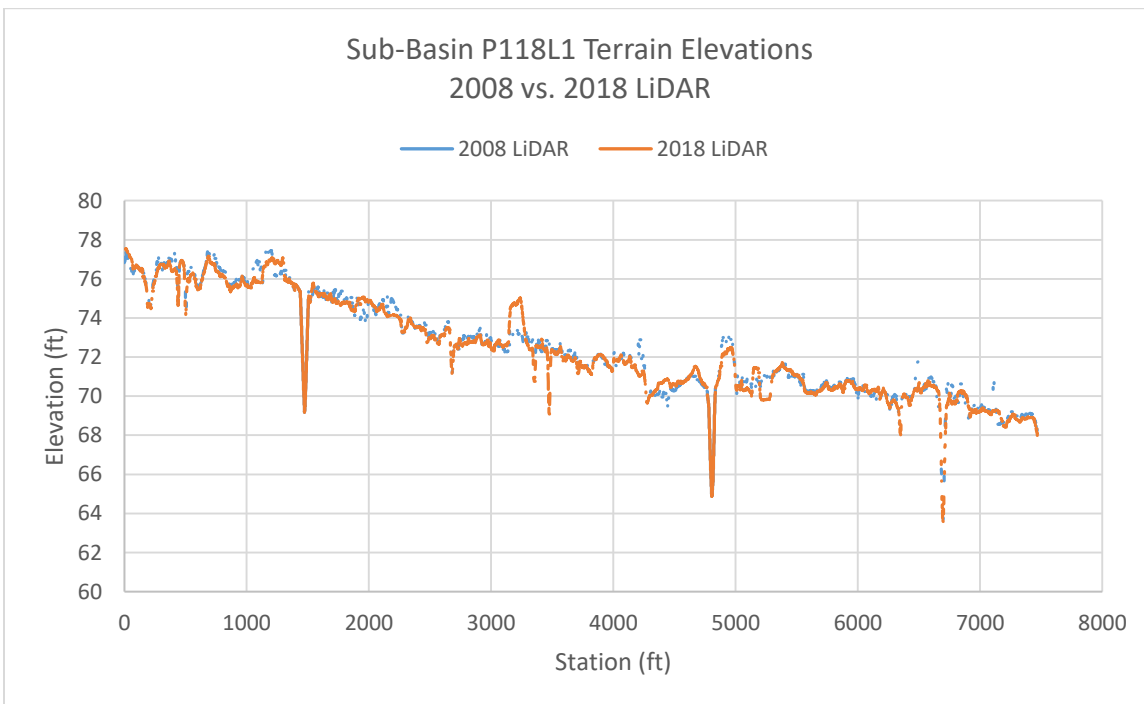


Figure 2-19: Terrain Elevation Comparison of Sub-Basin P118L using 2008 and 2018 LiDAR



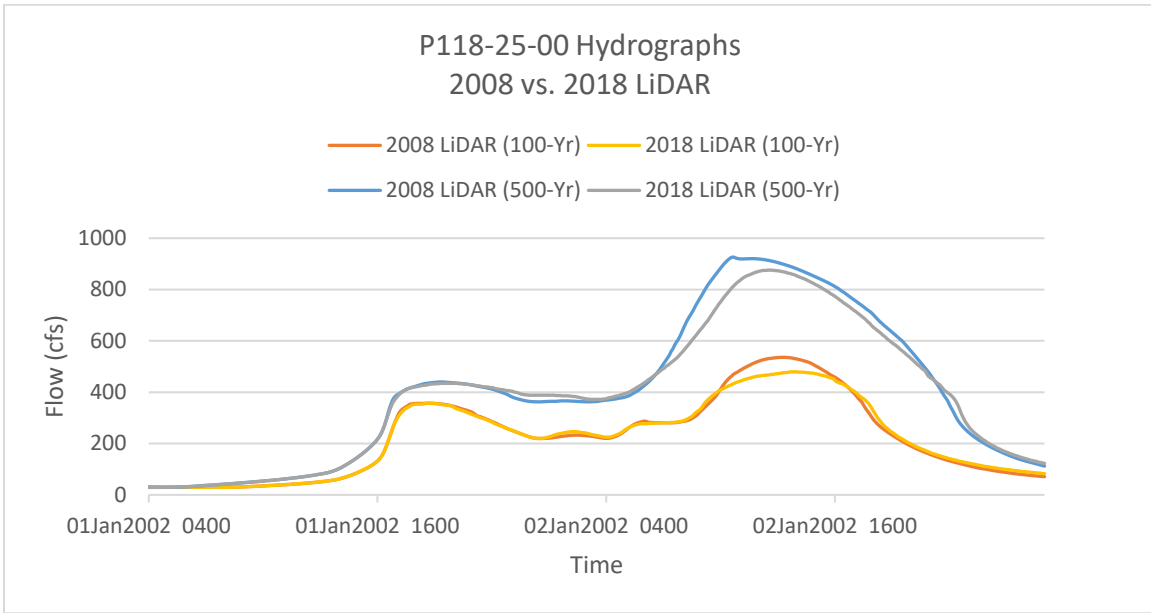


Figure 2-20: Hydrograph Comparison of P118-25-00 using 2008 and 2018 LiDAR

2.3 Baseline Conditions Results

The Baseline Conditions model demonstrated widespread ponding across the catchment. Maximum ponding extents and depths for all four storm events can be seen in Exhibits 7 through 10. Water surface profiles for all four storm events can be seen in Appendix B. A summary of Baseline Conditions WSELs at roadway crossings along P118-25-00/01 is shown in Table 2-6 below.

Table 2-6: Baseline Conditions WSELs at Roadway Crossings

Road	Culvert Size	High Chord (ft)	Low Chord (ft)	WSEL (ft)				Freeboard Bridge (ft)			
				500-Year	100-Year	50-Year	10-Year	500-Year	100-Year	50-Year	10-Year
Hill Road	-	74.8	69.4	70.0	68.4	67.1	66.2	4.8	6.4	7.8	8.6
Aldine Mail Route Road	Single 9'x4' RCB	73.9	70.3	74.4	73.9	70.5	70.5	-0.5	0.0	3.4	3.4

As shown in Figure 2-21, areas of ponding already occur at an early state in surrounding areas such as Oak Glen Place, Eversdale, and Aldine Gardens in a 100-year storm event. The water depths vary from 0.2 to 0.9 feet. The upstream portion of P118-25-01 is the primary location of flooded structures.



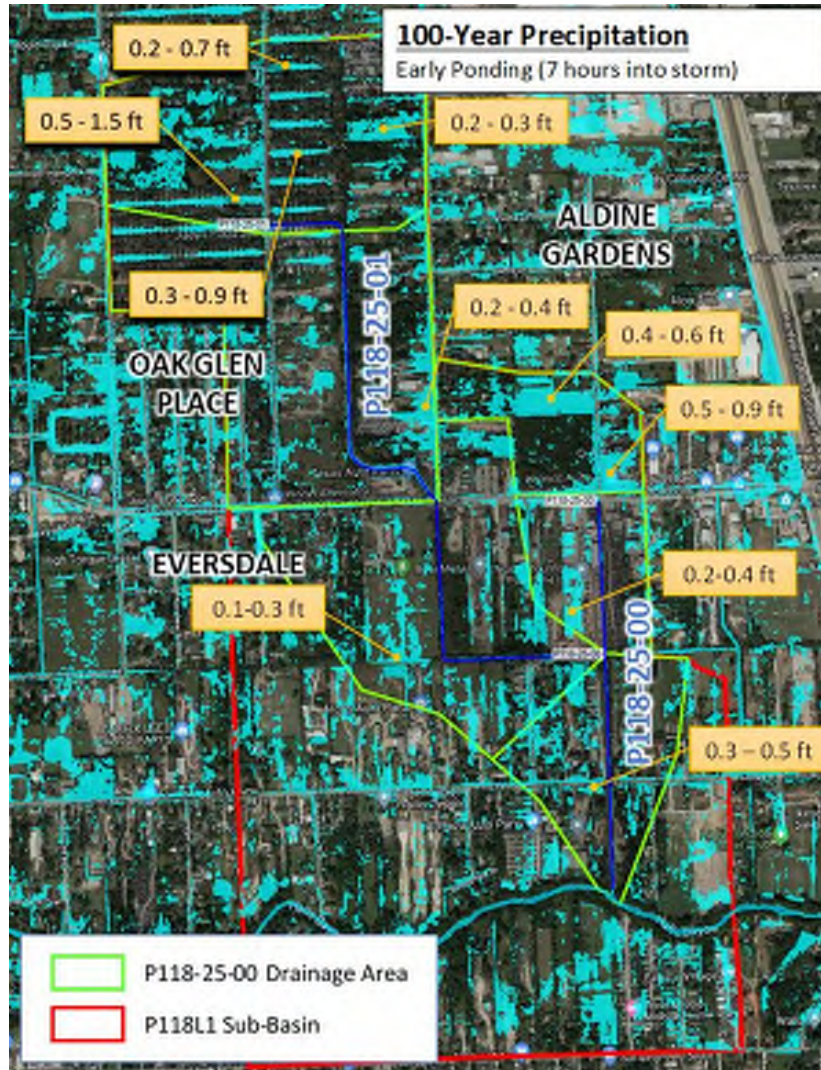


Figure 2-21: Baseline Conditions - Early Ponding Areas, 100-Year Storm Event

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 four design storms (10-, 50-, 100-, and 500-year) for the Normal Depth downstream boundary conditions (without tailwater influence from Halls Bayou) to GIS and intersected with the 2018 HCFCF 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 StarMaps roadway centerline shapefile. Refer to **Table 2-7** for a summary of the Baseline Conditions performance metrics for the 10-, 100-, and 500-year storm events.

Table 2-7: Baseline Conditions Performance Metrics

Metric	10-year Floodplain	50- year Floodplain	100- year Floodplain	500- year Floodplain
Structures in Floodplain	181	508	607	751
Flooded Structures (based on FFE)	8	163	203	329
Miles of Inundated Road	1.7	2.7	3.2	4.2
Acres of Inundated Land (Floodplain)	103	226	273	332

Figure 2-22 shows a histogram of the number of structures flooded based on the depth of inundation for the 500-year Normal Depth Baseline Conditions model. All performance metrics were calculated within the sub-basin P118L1 boundary. The analysis shows that 47% (154) of structures experience flooding at low inundation depths between 0.01 – 0.5 feet, followed by an increase of 39% (129) at additional 0.5 feet to an inundation depth of 1 foot, additional 13% (43) to an inundation depth of 1.5 feet, and 1% (3) of structures being inundated at depths between 2 – 2.5 feet. No additional structures are being flooded at inundation depths between 1.5 - 2 feet.

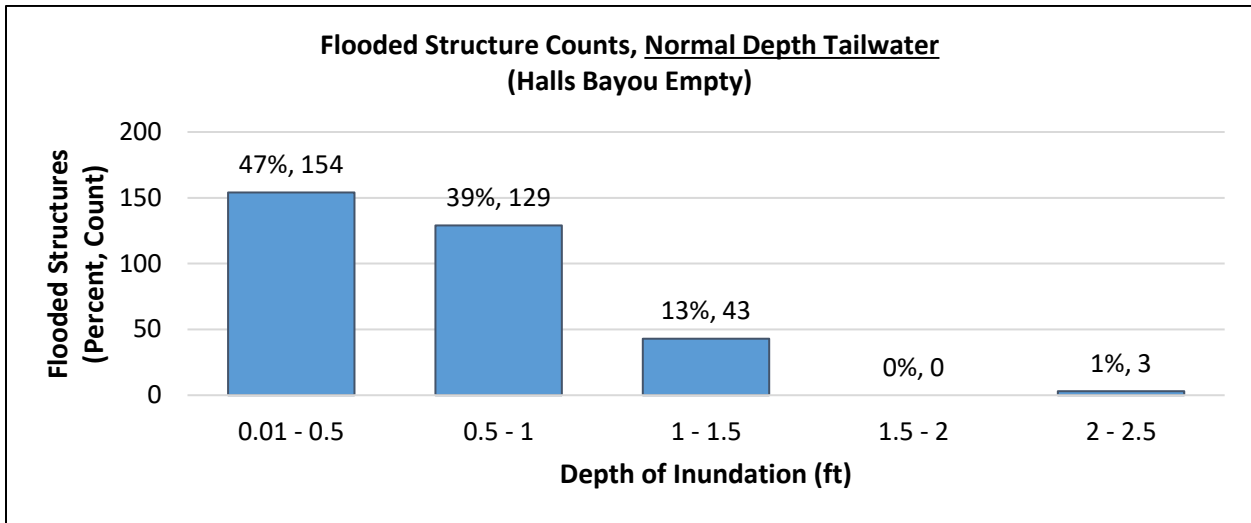


Figure 2-22: Histogram of Flooded Structures and Depth of Inundation for the 0.2 % (500-year) Return Period, Normal Depth Boundary Conditions

2.3.2 Existing Level-of-Service

Existing Level-of-Service was evaluated by comparing Service Elevation (minimum elevation of the right and left channel overbank; ROB and LOB, respectively) for each cross-section with modeled WSEL for a 10-, 50-, 100-, and 500-year return period, and set in a logarithmic relationship (Log 10) based on the return period. **Figure 2-23** demonstrates existing LOS for the Normal Depth tailwater boundary condition. A 250 to 500-Year LOS is provided by P118-25-00 at the downstream end and for P118-25-01 in the



upstream end and mid-portion. At the junction of P118-25-00 with P118-25-01, and along P118-25-01 north of Aldine Mail Route Road, the LOS is between 35-100 years. A 100-200-year LOS is provided by P118-25-00 at the upstream end, south of Aldine Mail Route Road, and by P118-25-01 north of Texas Auto Parts, on the straight section after meandering.

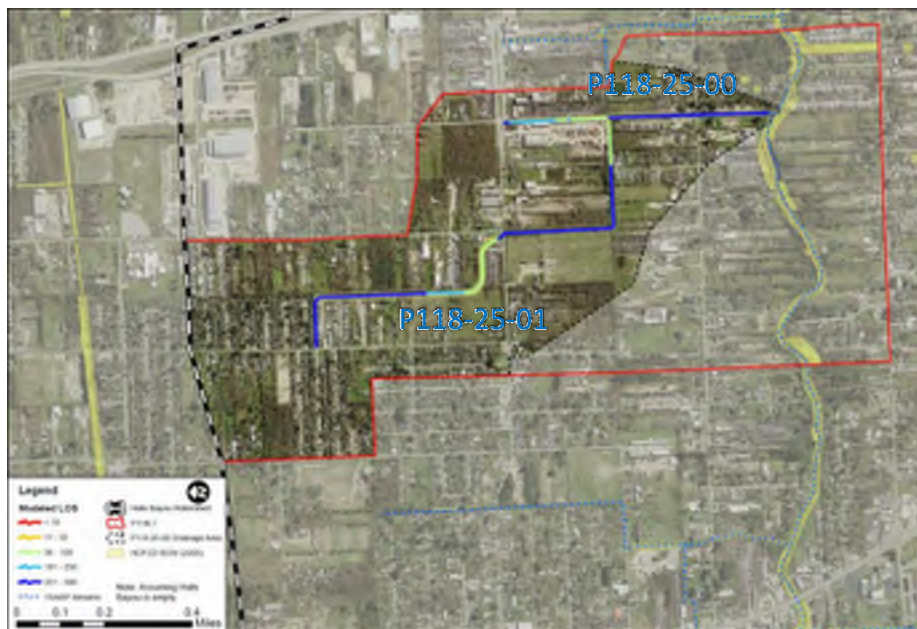


Figure 2-23: P118-25-00/01 Existing LOS (without Halls Bayou influence)

Figure 2-24 demonstrates existing LOS for the Stage Hydrograph tailwater boundary condition (tailwater influence of Halls Bayou on P118-25-00). While LOS conditions for P118-25-01 stay almost untouched, the significant influence of Halls Bayou on P118-25-00 results in a 10-Year LOS or less.

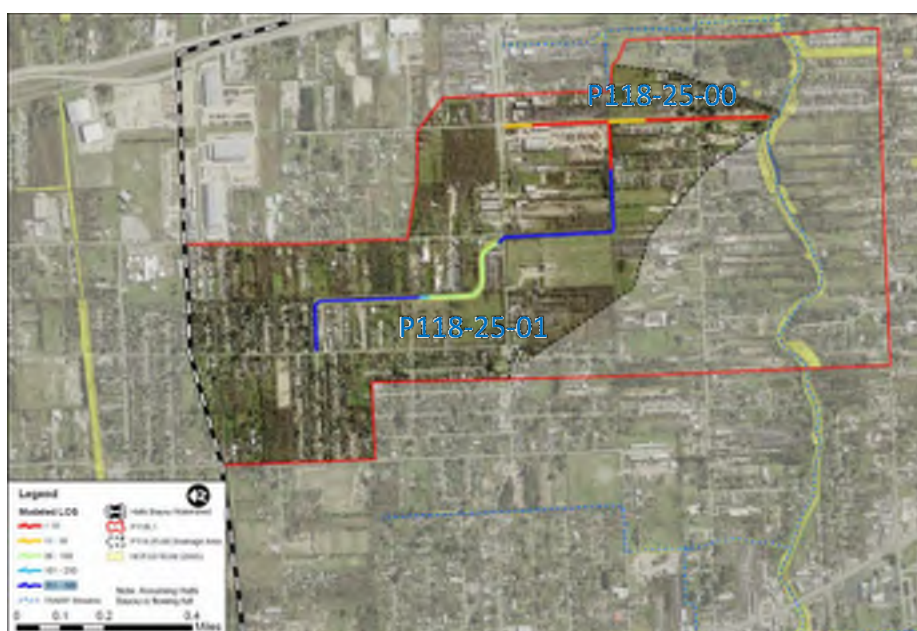


Figure 2-24: P118-25-00/01 Existing LOS (with Halls Bayou influence)



2.4 Community Engagement Meeting

A community engagement meeting, organized by Lopez Negrete Communications and HCFCD, was held on Monday, November 11th to discuss flood risks within the Halls Bayou Watershed and potential mitigation solutions. Refer to [Appendix K](#) for the summary report.

Community input from the meeting included the following:

- Support project/Concerned about timeline for completion
- Residents attribute trash and debris in ditches to area flooding
- Residents want help with street flooding

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 P118-25-00/01 service area and total flows are not considered as part of this analysis unless explicitly stated. The Baseline Conditions HEC-RAS model was used as a starting point for developing the various Proposed Conditions models. A summary of all alternatives is included in [Appendix C](#).

3.1 Alternatives Development

LAN started by identifying potential improvement features and estimated their effectiveness in the Planning Level Analysis. After the Planning Level Analysis was completed LAN began modeling the improvement features in HEC-RAS and combining them to form alternatives in the Detailed Alternatives Analysis – refer to [Section 3.2.10](#). **Note that dimensions of the single features described in this section varied from those in this section for the Alternatives, depending on the size of improvements made.**

3.2 Planning Level Drainage Improvement Features

LAN identified and scored eight (8) drainage improvement features along P118-25-00/01. They include six detention basins (Feature No. 1-5 and 8), one segment of channel improvement within existing ROW (Feature No. 6), and one segment of channel extension (Feature No. 7). [Figure 3-1](#) illustrates locations of considered features.





Figure 3-1: Proposed Improvement Features

Stormwater detention basins are laid out with a 30-foot maintenance berm along the perimeter. Since the detention ponds are located near residential areas, side slopes are designed with ratio of 4:1 to avoid potentially dangerous drop-offs. The depth of detention basins is determined by existing channel depth. A 20% volume loss during design is considered. Refer to **Table 3-1** for a summary of the basin’s characteristics.

Table 3-1: Summary of Planning Level Basins Characteristics

Basin Name	Side Slope	Depth	Maintenance Berm	Volume	Proposed ROW	Existing ROW	ROW acquisition	Structures in Footprint
	(h:v)	(ft)	(ft)	(ac-ft)	(ac)	(ac)	(ac)	(count)
Dynamo	4:1	4.68	30	18.36	5.66	0	5.66	0
Candela	4:1	3.53	30	9.72	4.06	0	4.06	1
Meadow	4:1	4.11	30	3.98	2.05	0	2.05	0
Wooded	4:1	7.43	30	20.69	4.43	0.46	3.97	7
Oak Glen	4:1	4.36	30	23.59	7.26	0.00	7.26	2
Inline Basin	4:1	5.41	30	56.31	15.18	1.02	14.16	0



3.2.1 Features Location Choice

The location and size of the drainage improvements were determined based on (1) most hydraulically influential locations (e.g. 90-degree bends), (2) topography of the watershed, (3) best availability of ROW, and (4) least infrastructural and environmental intervention. Refer to following [Sections 3.2.2](#) to [3.2.9](#) for features description.



3.2.2 Feature 1 – Detention Basin “Dynamo”

The Detention Basin “Dynamo” is in the middle part of P118-25-01, on an area of the Sports Club Houston Dynamo North (**Figure 3-2**). It is located on two hydraulically influential sites, (1) within the flood path of overflowing water from adjacent tributary P118-26-00, and (2) just upstream of a 90-degree bend of P118-25-01. Here, water will tend to flow fastest along the outside bend of the meander, and slowest on the inside bend. As a result, water will likely overflow the riverbanks at the bend, causing it to leave the channel and flow uncontrollably (in form of sheet flow) along topographic conditions further downstream. The Houston Dynamo North sports club owns five soccer fields, from which the two lower soccer fields would be occupied by this proposed basin.

The basin has a designed depth of 4.68 feet and provides a storage volume of 18.36 acre-feet. The basin’s storage volume is reduced to 80% of its original size to consider design loss during construction. HCFCF currently does not own any land within the proposed basin’s footprint. A total of 5.66 acres would be necessary to be acquired by HCFCF for ROW.

The basin aims to (1) reduce maximum peak discharge to the downstream channel of P118-25-01, thereby reducing stress on riverbanks, and (2) collect overflow coming from neighboring tributary P118-26-00. No structures are within the basin’s footprint.



Figure 3-2: Feature 1 “Dynamo Basin” – Layout and Location with Existing HCFCF ROW (red)

3.2.3 Feature 2 – Detention Basin “Candela”

Feature 2 – Detention Basin “Candela” is placed downstream of the 90-degree bend mentioned before in Feature 1, on soccer fields of the Candela Park – refer to [Figure 3-3](#). It targets to provide additional storage capacity to Feature 1 and reduce maximum peak discharge to the downstream channel P118-25-01, thereby preventing water from uncontrollably flowing downstream across the land in the southeast direction, where several structures are located.

The basin has a designed depth of 3.53 feet and provides a storage volume of 9.72 acre-feet. The basin’s storage volume is reduced to 80% of its original size to consider design loss during construction. HCFCD currently does not own any land within the proposed basin's footprint. A total of 4.06 acres would be necessary to be acquired by HCFCD for ROW. One structure is within the basin’s footprint.

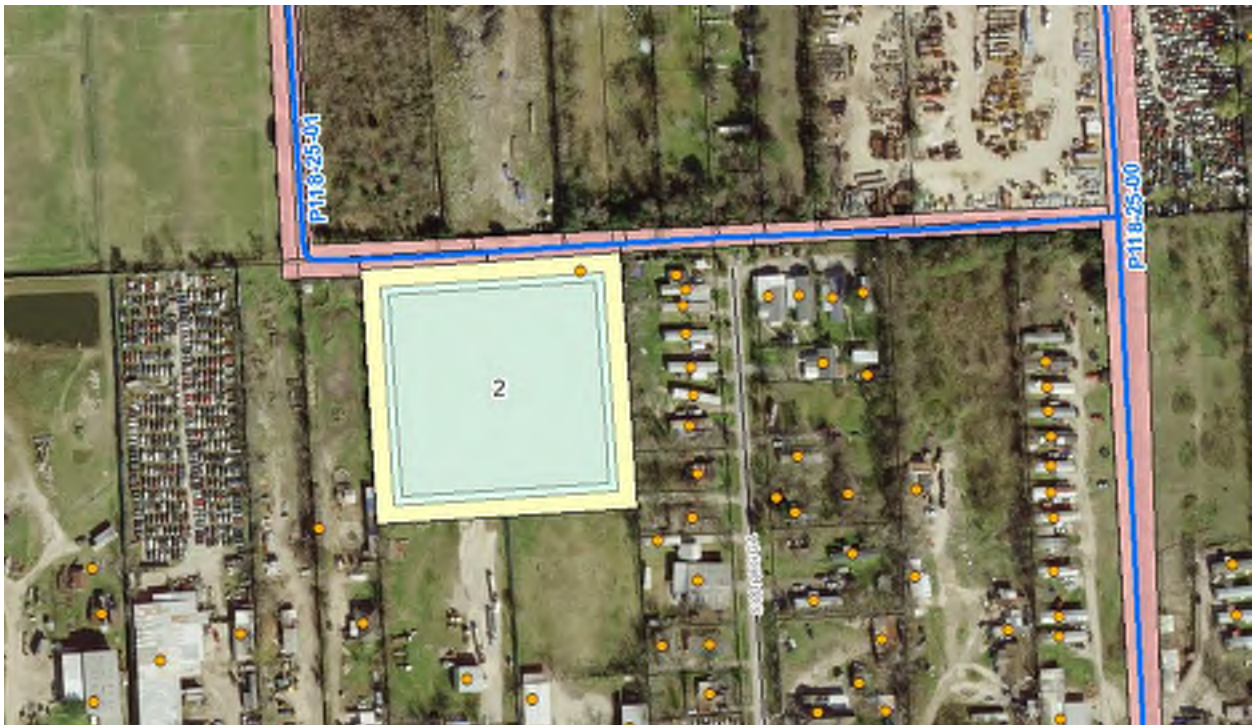


Figure 3-3: Feature 2 “Candela Basin” – Layout and Location with Existing HCFCD ROW (red)

3.2.4 Feature 3 – Detention Basin “Meadow”

The Meadow Basin is located further downstream, at the Junction of P118-25-00 with P118-25-01, where the channel experiences another 90-degree bend – refer to [Figure 3-4](#). The basin’s footprint is located on an unoccupied piece of land. No structures are located here. The basin attempts to mitigate the flooding impacts upstream of P118-25-00.

The basin has a designed depth of 4.11 feet and provides a storage volume of 3.98 acre-feet. HCFCF currently does not own any land within the proposed basin’s footprint. The basin’s storage volume is reduced to 80% of its original size to consider design losses during construction. A total of 2.05 acres would be necessary to be acquired by HCFCF for ROW.



Figure 3-4: Feature 3 “Meadow Basin” – Layout and Location with Existing HCFCF ROW (red)

3.2.5 Feature 4 – Detention Basin “Wooded”

The Detention Basin “Wooded” is on the downstream end of P118-25-00, at the confluence with the mainstem Halls Bayou (P118-00-00) – refer to [Figure 3-5](#). The site was chosen for its good integration with the Halls Bayou Vision Plan and because HCFCD already owns two pieces of land within basin’s footprint. The basin provides storage volume to help mitigate the Halls Bayou tailwater influence on P118-25-00. In total, seven structures are within basin’s footprint.

The basin has a designed depth of 7.43 feet and provides a storage volume of 20.69 acre-feet. The basin’s storage volume is reduced to 80% of its original size to consider design loss during construction. HCFCD currently owns 0.46 acres of land within the proposed basin's footprint. A remaining area of 3.97 acres would be required for complete ROW acquisition.



Figure 3-5: Feature 4 “Wooded Basin” – Layout and Location with Existing HCFCD ROW (red)

3.2.6 Feature 5 – Detention Basin “Oak Glen”

The Oak Glen basin is located north of Aldine Mail Route Road between residential area Oak Glen Place and P118-25-01 – refer to [Figure 3-6](#). It focuses on addressing the overflow from P118-26-00 as well as providing a probable outfall location and storage volume for future local drainage improvements. The Basin was set back 10 feet from Sunoco pipeline to avoid environmental and operational interferences. The basin has a hydraulic importance since it is the most upstream basin to control the downstream flow event. Two structures are within basin’s footprint.

The basin has a designed depth of 4.36 feet and provides a storage volume of 23.59 acre-feet. The basin’s storage volume is reduced to 80% of its original size to consider design loss during construction. HCFCD currently does not own any land within the proposed basin's footprint. A total of 7.26 acres would be necessary to be acquired by HCFCD for ROW.



Figure 3-6: Feature 5 “Oak Glen Basin” – Layout and Location with Existing HCFCD ROW (red)

3.2.7 Feature 6 – Channel Improvement within Existing ROW

The segment of Feature 6 is located north of Aldine Mail Route Road to the upstream end at Corvette Court – refer to [Figure 3-7](#). It attempts to maximize the capacity of the channel in P118-25-01 within existing ROW. The proposed channel improvement has a designed depth of 6 feet and 4:1 side slopes. After implementation, it is expected to increase the channel’s capacity from 7.84 acre-feet to 13.05 acre-feet, an increase of 5.21 acre-feet (66.5%).

Pipe-crossings: The channel is crossed by three pipelines, (1) BP Pipelines (North America), Inc. (contains CRD), (2) Enterprise Products Operating, LLC (contains natural gas), and (3) Sunoco Pipeline L.P. (contains highly volatile liquid). Refer also to [Section 2.1.2](#) “Site Conditions / Site Visit” for photographic documentation.



Figure 3-7: Feature 6 “Channel Improvements” - Layout and Location

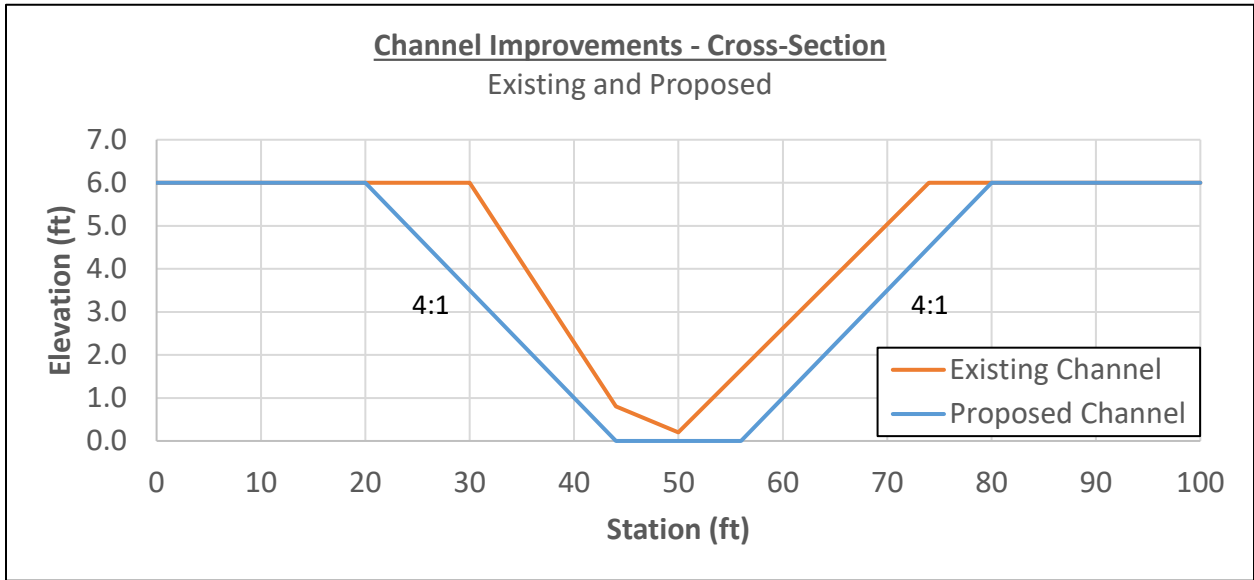


Figure 3-8: Feature 6 – Proposed Channel Geometry



3.2.8 Feature 7 – Channel Extension

Feature 7 is located at the upstream end of P118-25-01 – refer to [Figure 3-9](#). The proposed channel extension hooks upward at the end of the existing channel and runs parallel but offset in line to the north until Hollyvale Drive.

The idea of the channel extension is to (1) capture the northwestern P138-00-00 overflow between Lilja Road and Sellers Road (CLOMR Model, Lateral Structures 1+2) and convey the water downstream, and (2) preventing the water from sheet flowing to the southeast along terrain slope. The basic assumption for how the channel extension receives flow is that the runoff from roadside ditches could be discharged into the headwaters and the channel extension may provide an outfall location for future subsurface drainage systems of local drainage projects – refer to [Section 4](#).

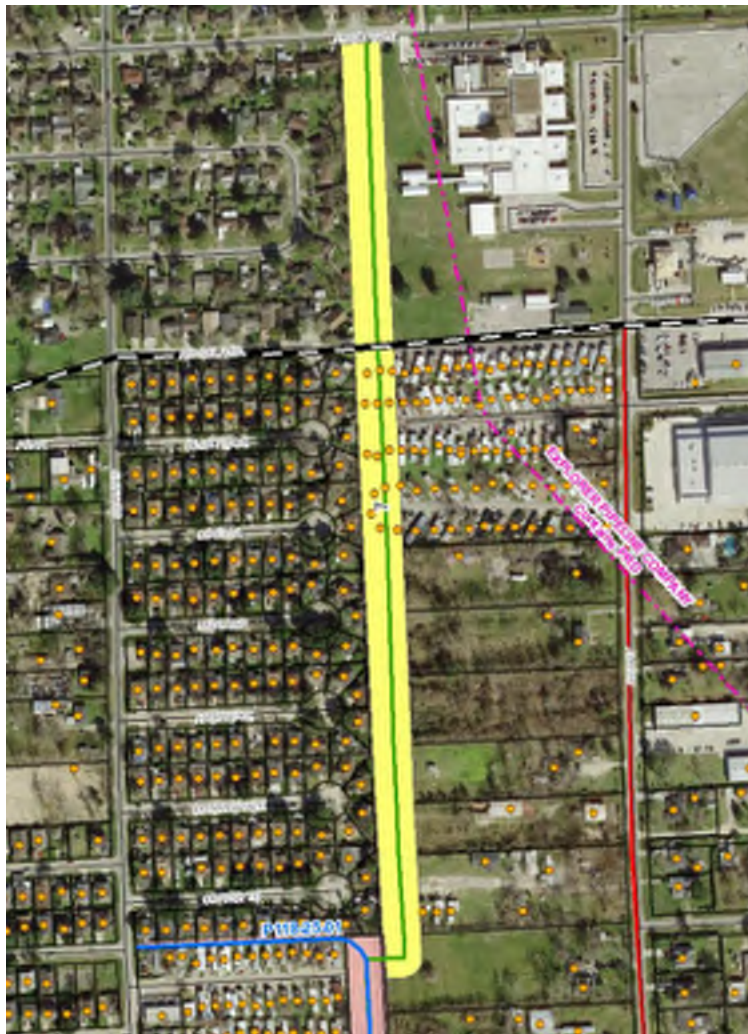


Figure 3-9: Feature 7 “Channel Extension” – Layout and Location

The channel extension is laid out with a depth of 4 feet and 4:1 side slopes. The proposed ROW width is 100 feet. To maximize channel capacity, the channel’s left and right berms are designed with 20-foot wide berms instead of 30 feet – refer to [Figure 3-10](#). According to HCFCD Design Manual, *Section 5.5.3* –



Minimum Berm Widths, the minimum berm width of 30 feet can be reduced to 20 feet if (1) Grass-lined channel top width is ≤ 60 feet or channel depth is ≤ 7 feet, and if (2) no trails, trees, or other multi-use features are planned. Both criteria are met in this case. Additionally, a backslope swale system is then not needed. With that in mind, the channel’s capacity can be maximized from 5.71 acre-feet to 10.47 acre-feet over a length of 2,590 feet, an increase of 83%.

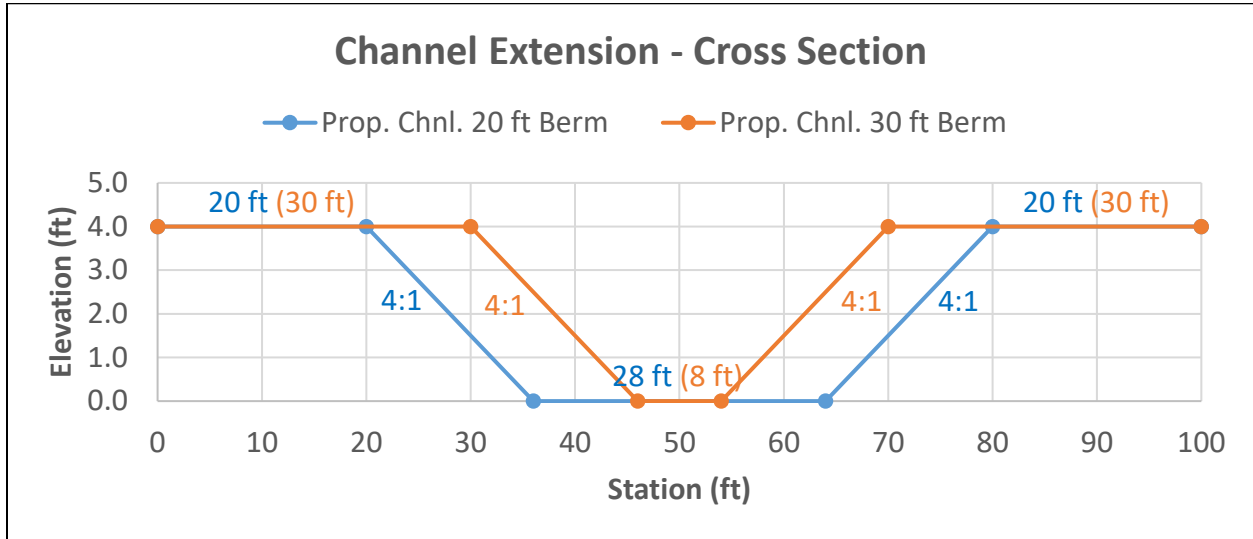


Figure 3-10: Feature 7 – Geometry Comparison with 20 feet and 30 feet Berm

The channel runs through 9 parcels, and a total of 14 structures are within the footprint area. HCFCF currently does not own any land within the proposed channel’s footprint. A total of 5.5 acres would be necessary to be acquired by HCFCF for ROW.



3.2.9 Feature 8 – Inline Detention Basin

The Inline Detention Basin is located at the 90-degree bend of P118-25-01 – refer to [Figure 3-11](#). It incorporates the Dynamo Basin (Feature 1) and the Candela Basin (Feature 2) and provides additional storage volume and flow control for stormwater runoff. The basin has a designed depth of 5.41 feet and provides the largest storage volume of 56.31 acre-feet compared to all other Features. The basin's storage volume is reduced to 80% of its original size to consider design loss during construction. HCFCF currently owns 1.02 acres of land (P118-25-01's ROW) within the proposed basin's footprint. A remaining area of 14.16 acres would be required for complete ROW acquisition. One structure is within the basin's footprint.



Figure 3-11: Feature 8 "Inline Basin" – Layout and Location with Existing HCFCF ROW

3.2.10 Planning Level Analysis Feature Scoring

To help narrow down the potential improvements, LAN developed a scoring system for the Planning Level features. Six attributes were considered and given weight. Greens Overflow (P138-00-00) [20%], Neighboring Tributary Overflow (P118-26-00) [15%], Vision Plan "Friendliness" [15%], Estimated Cost [20%], Structures in Service Area [15%], and Extent of Service Area [15%]. Weights of each attribute were value-based judgements from discussions between LAN and HCFCF.

Table 3-2: Feature Scoring Summary

#	Name	Cost	Structures in Service Area (count)	Estimated Service Area (ac)	Ability to mitigate Greens Bayou Overflow	Ability to mitigate P118-26-00 Overflow	Vision Plan "Friendliness"	Final Score
	Weight	20%	15%	15%	20%	15%	15%	
1	Dynamo	1.2	0.9 - (73)	3.3 - (83)	0	2.5	0	1.2
2	Candela	2.6	1.0 - (80)	1.8 - (46)	0	2.5	0	1.3
3	Meadow	3.8	0.7 - (52)	2.5 - (62)	1	0	1	1.6
4	Wooded	1	0.9 - (69)	2.5 - (62)	1	0	5	1.6
5	Oak Glen	0.9	4.0 - (316)	4.3 - (107)	1	5	0	2.4
6	Chnl.Imp.	4.5	4.6 - (365)	4.4 - (111)	3	5	0	3.6
7	Chnl.Ext.	0.7	5.0 - (422)	5.0 - (130)	5	0	0	2.6
8	Inline	0	2.0 - (163)	5.0 - (143)	1	4	0	1.9

Service areas for features and structures in service areas were determined on a parcel level based on the spatial location of the features. The service areas were estimated to allow for more insight into the feature's performance before modeling them in HEC-RAS. Highest weights were given to probable cost and ability to mitigate Greens Bayou overflows. The highest scoring features were the Channel Improvements in existing ROW (#6), the Channel Extension (#7), and the Oak Glen Basin (#5).

3.3 Detailed Level Alternatives

In consultation and coordination with HCFCD, LAN modeled the improvement features one at a time to build alternatives carried out to modeling. Alternatives were developed starting in the upstream because the upstream features were identified as the most beneficial in the planning level analysis. LAN developed and scored 7 Alternatives (Alternatives 1, 2, 3a, 3b, 4, 5a, and 5b) under "Current" Conditions and with the goal of achieving a 500-year LOS. The goal was to provide an upper bound perspective on mitigation needs. **Table 3-3** summarizes the modeled alternatives with their individual components.

Table 3-3: Summary of Modeled Alternatives

	Features Description (Feature #)
Alternative 1	Channel Extension (7) in P118-25-01
Alternative 2	Channel Extension (7) + Oak Glen Basin (5)
Alternative 3a	Channel Extension (7) + Oak Glen Basin (5) + Channel Improvements (6) in P118-25-01
Alternative 3b	Channel Extension (7) + Oak Glen Basin (5) + Channel Improvements (6) along P118-25-00 and P118-25-01
Alternative 4	Channel Extension (7) + Oak Glen Basin (5) + Channel Improvements (6) + Inline Basin (8)
Alternative 5a	Channel Extension (7) + Oak Glen Basin (5) + Channel Improvements (6) + Inline Basin (8) + Wooded Basin (4)
Alternative 5b	Channel Extension (7) + Oak Glen Basin (5) + Channel Improvements (6) + Inline Basin Large (8) + Wooded Basin (4)



In developing the alternatives, LAN assumed an improved drainage system in the surrounding neighborhoods. This allowed the alternatives to be modeled in a “worst-case scenario” in terms of volume of water in the channel. Greens Bayou overflows were assumed to flow directly into the channel extension rather than sheet flowing over the neighborhoods. Overflow from P118-26-00 was assumed to be discharged into the Oak Glen Basin and conveyed along Aldine Mail Route Road efficiently into the system. Alternatives and modeling methods will be discussed in more detail in the following sections.

Alternatives 1, 2, and 3a are not recommended as standalone alternatives because of impacts in 500-year storm events. Rather they were building blocks for developing effective alternatives.

3.3.1 Alternative 1

Alternative 1 consists solely of a channel extension in the P118-25-01 tributary, as highlighted in **Figure 3-12**. The extension is approximately 2,270 feet long and has a bottom width of 28 feet with 4:1 side slopes and a longitudinal slope of 0.08%. It presently has a projected cost of \$1.5 million and would provide a 10-year LOS under the region’s current overflow conditions. This Alternative provides the least amount of modifications and thus is the least expensive proposed alternative.

Overall, the channel extension did show improvements in smaller storm events, as it provides 10-year LOS. However, it does not show any significant effect on mitigating water level when tested under 500-year current overflow condition modeling. The benefits of the channel extension can be seen more clearly in combination with other features.

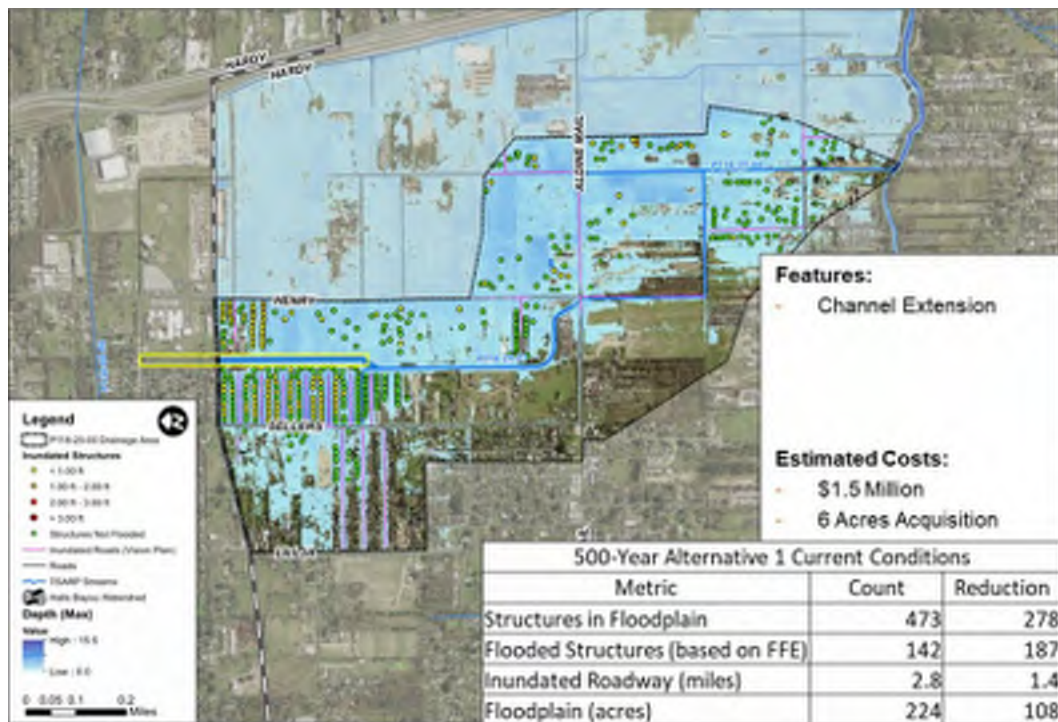


Figure 3-12: Alternative 1 - Channel Extension



3.3.2 Alternative 2

Alternative 2 features both a channel extension as well as the addition of the Oak Glen detention basin. It presently has a projected cost of \$3.3 million and would provide a 10-year LOS under the region’s current overflow conditions. The channel extension is identical to that of Alternative 1 (approximately 2,270 feet long with a bottom width of 28 feet, on the P118-25-01 tributary, with side slopes of 4:1 and a longitudinal slope of 0.08%).

The Oak Glen Basin is an offline basin with a depth of 6.35 feet and a storage volume of 26.2 acre-feet. The maintenance berm of the basin has a width of 30 feet while the basin’s side slopes are 4:1. Similar to the channel extension, the basin helped reduce the WSEL in the smaller storm events; however, it does not show any significant effect on mitigating water level when tested under 500-year current overflow condition modeling.

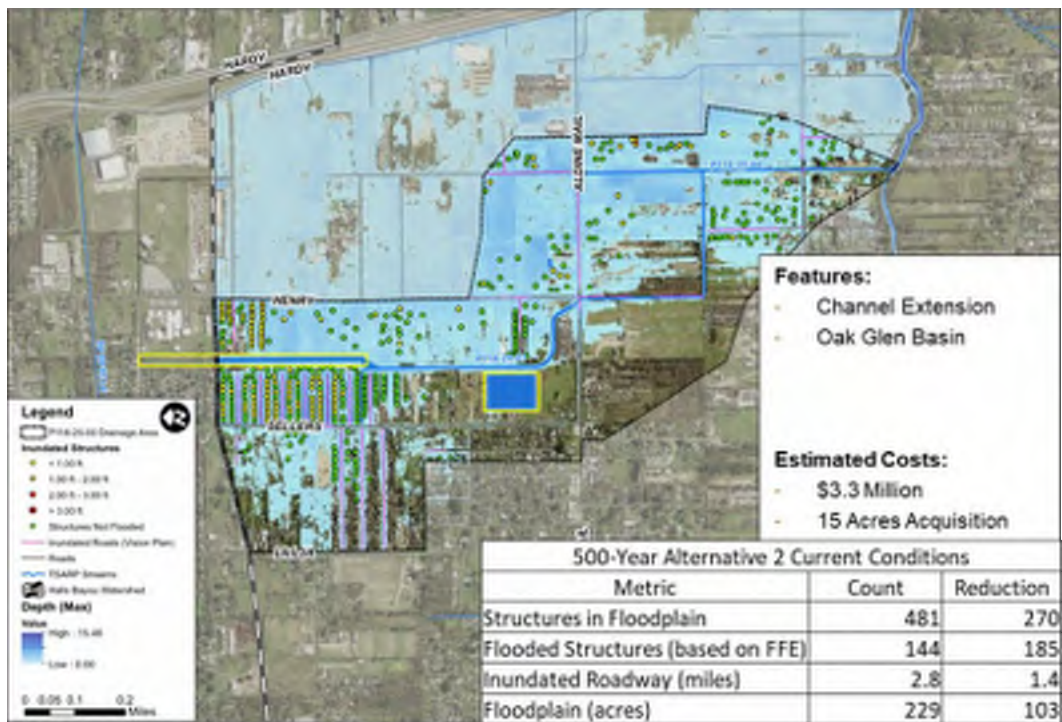


Figure 3-13: Alternative 2 - Channel Extension with Oak Glen Basin



3.3.3 Alternative 3a

Alternative 3a features channel improvements in the existing channel, in addition to the Oak Glen Detention Basin and channel extension from the previous alternatives. These modifications have a projected total cost of \$6.6 million and would provide a 10-year LOS under the region’s current overflow conditions.

Channel improvements occur over 2613 feet within existing HCFCD ROW, from upstream of Aldine Mail Route Road to the headwaters of P118-25-01. These channel improvements include widening the bottom of the existing channel to 12 feet, as well as increasing its average depth by approximately 1.3 feet. The channel and its extension both hold 4:1 side slopes and a 0.08% longitudinal slope.

The Oak Glen Basin improvements are the same as previously mentioned in Alternative 2. Overall, the channel improvements were able to reduce water elevation upstream of Aldine Mail Route Road by 0.3-0.5 feet when tested under 500-year current overflow condition modeling; however, it also increased water elevation downstream of that location by 0.15 feet.

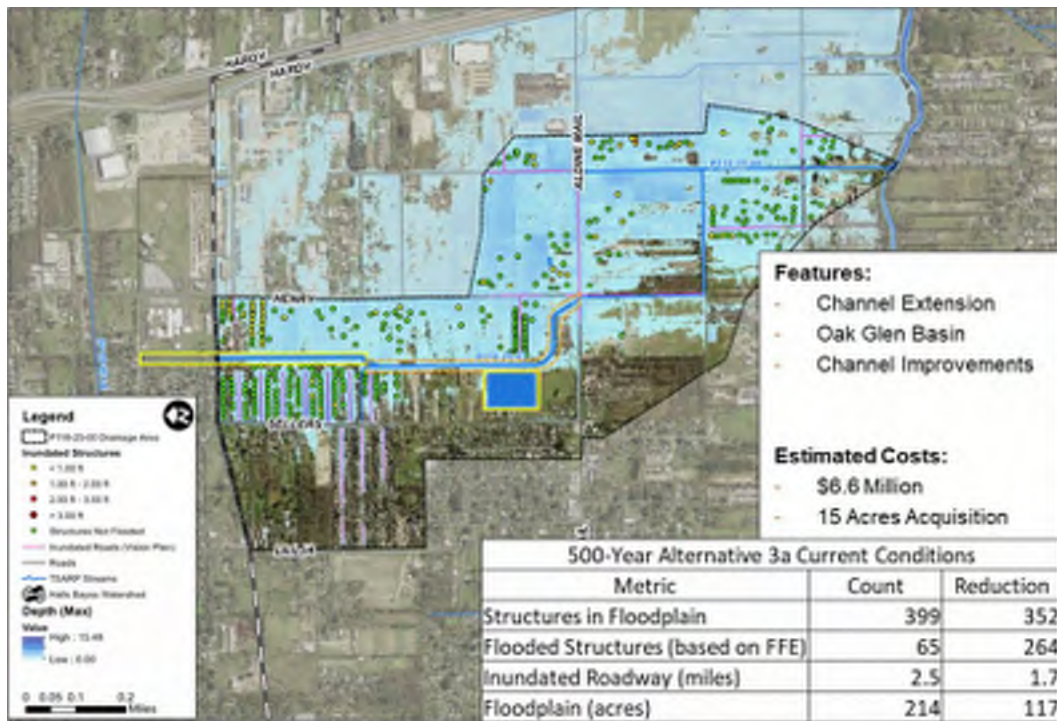


Figure 3-14: Alternative 3a - Channel Extension, Oak Glen Basin, and Channel Improvements (within existing ROW)



3.3.4 Alternative 3b

Alternative 3b features more channel improvements along P118-25-00 and P118-25-01, a deeper Oak Glen Basin, and bridge updates in addition to the improvements in Alternative 3a. These modifications have a projected total cost of \$15.1 million and would provide a 100-year LOS under the region’s current overflow conditions.

The new channel improvements include widening the bottom of the existing channel on P118-25-01 to 25 feet over a range of 6,897 feet (from the confluence of P118-25-00 and P118-25-01 to the headwaters of the channel extension), which is longer than that of previous alternatives. The length of the channel from upstream of Hill Road to the headwaters of P118-25-00 (2,252 feet) also has its bottom width widened to 25 feet. The average channel deepening on P118-25-00 and P118-25-00 is 1.4 ft and 2.1 ft, respectively. The channel extension is still 2,270 feet, but now has a bottom width of 25 feet (as opposed to 28 feet in previous alternatives). The channels have side slopes of 4:1 along with a 0.08% longitudinal slope.

In addition, the depth of the Oak Glen Detention Basin is now increased to 8.25 feet, resulting in a new total storage volume of approx. 33 acre-feet (+25.6%). Its specifications include a 30-foot maintenance berm and side slopes of 4:1. Lastly, bridge improvements include the replacement of a single 9’x4’ reinforced box culvert (RCB) with two 9’x6’ RCBs.

Overall, the channel improvements helped to lower general water elevation, but have led to higher water elevation downstream when tested under 500-year current overflow condition modeling. Impacts on WSEL are discussed in [Section 5](#) “Preliminary Impacts Analysis”.

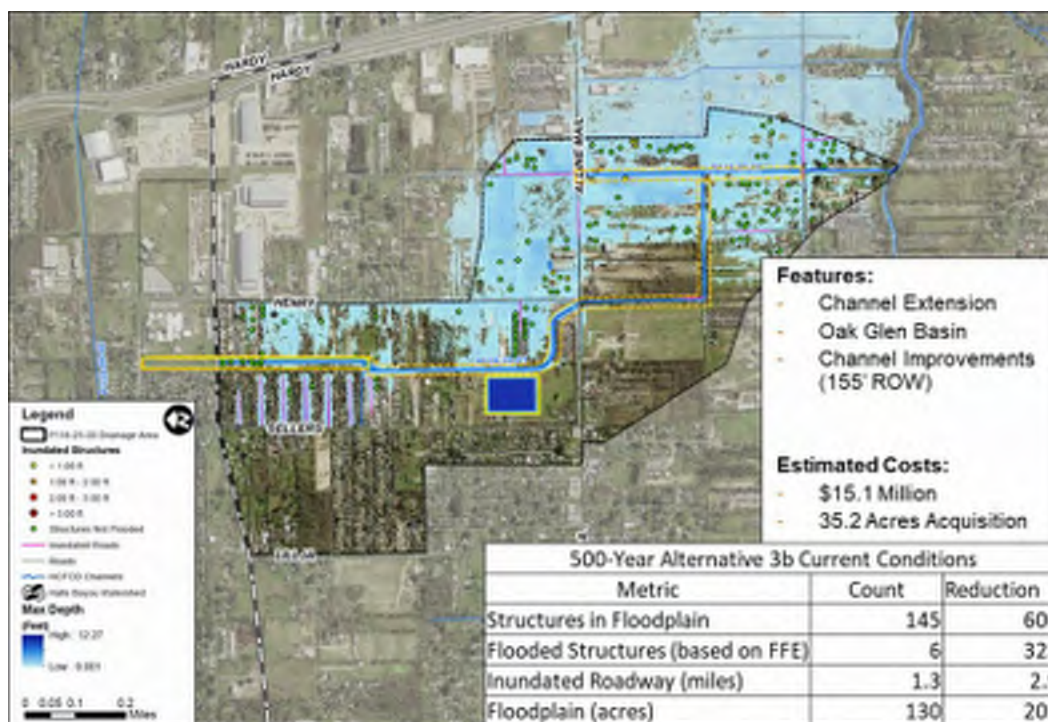


Figure 3-15: Alternative 3b - Channel Extension with Oak Glen Basin and Channel Improvements (Widening and Deepening) along P118-25-00/01



3.3.5 Alternative 4

Alternative 4 features channel extension, existing channel improvements, the same Oak Glen Detention Basin as that in Alternative 3b, as well as a new inline detention basin and more bridge updates. These modifications have a projected total cost of \$19.1 million and would provide a 100-year LOS under the region’s current overflow conditions.

As mentioned above, the channel will have its bottom width increased, but its depth will remain unchanged. This will occur over the same stretch as mentioned in Alternative 3b, which is highlighted in the exhibit below, which is specifically from the confluence of P118-25-00 and P118-25-01 to the headwaters of the channel extension, along with upstream of Hill Road to the headwater of P118-25-00. The bottom width will be increased to 25 feet. Furthermore, the channel will be relocated to accommodate the new inline detention basin. The channels still have side slopes of 4:1 along with a 0.08% longitudinal slope.

Oak Glen Basin’s specifications remain the same as they are in Alternative 3b. However, this improvement also includes a new inline detention basin at the channel’s 90-degree bend between Aldine Mail Route Road and Hill Road. This basin has a depth of 7.81 feet, providing a storage volume of 69.6 acre-feet.

Its other specifications include a 30-foot maintenance berm and 4:1 side slopes. Lastly, bridge improvements include the replacement of a single 9’x4’ RCB with five 7’x6’ RCBs. Overall, these changes have helped lower overall water levels, but the inline basin is too small to provide enough storage capacity for delayed water release and becomes overtopped when tested under 500-year current overflow condition modeling.

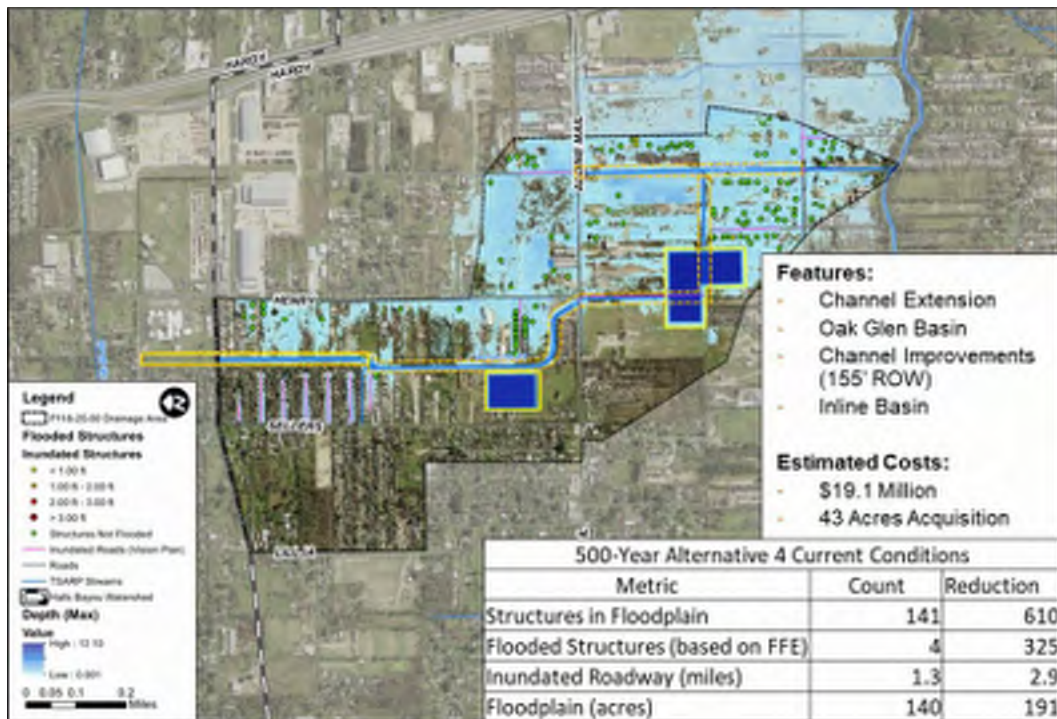


Figure 3-16: Alternative 4 - Channel Extension with Oak Glen Basin, Inline Basin, and Channel Improvements (Widening and Deepening) along P118-25-00/01



3.3.6 Alternative 5a

Alternative 5a is almost identical to Alternative 4, except that at the confluence of P118-25-00 with P118-00-00, a single offline basin (“Wooded Basin”) was added. These modifications have a projected total cost of \$20.8 million and would provide a 100-year LOS under the region’s current overflow conditions.

The new Wooded Basin has a depth of 11.69 feet. Its specifications include a 30-foot maintenance berm with 4:1 side slopes and 22.2 acre-feet storage capacity. Overall, the addition of the Wooded Basin at the tailwater of the channel helps to reduce water elevation locally by approximately 0.45 feet.

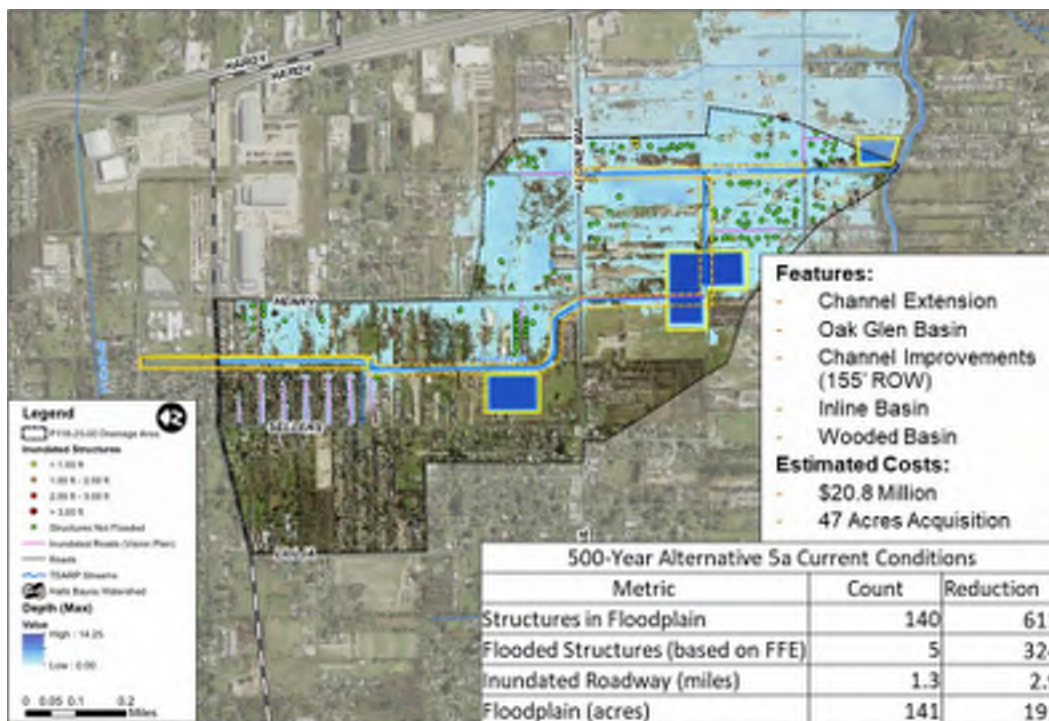


Figure 3-17: Alternative 5a - Channel Extension with Oak Glen Basin, Inline Basin, Wooded Basin, and Channel Improvements (Widening and Deepening) along P118-25-00/01



3.3.7 Alternative 5b

Alternative 5b features increased channel extension and existing channel improvements, channel relocation, a larger inline detention basin in addition to the Wooded Basin and Oak Glen Basin, as well as increased bridge improvements. These modifications have a projected total cost of \$35 million and provide a 500-year LOS under the region’s current overflow conditions.

As mentioned above, there are greater channel improvements in this alternative. Specifically, the bottom width of both the extension and existing channel will be widened to 35 feet. Channel depth will be increased by approximately 1.5 feet along the stretch of channel from downstream of Hill Road to the headwaters of P118-25-00 (~2,741 feet). Channel depth will also be increased by approximately 1.8 feet along the stretch of channel from the confluence of P118-25-00 and P118-25-01 to the headwaters of the extension (6,897 feet). The channel will be relocated to optimize flow through the new inline detention basin.

The specifications of the Wooded Basin remain the same as those in Alternative 5a. The Oak Glen Basin, however, has a new depth of 10.05 feet, increasing storage volume by 5.4 acre-feet to 38.3 acre-feet (+16.4%). The inline basin was further extended and increased the storage volume from 70 acre-feet to 223 acre-feet, and the depth was increased from 7.8 feet to 9.5 feet.

Lastly, bridge improvements include the replacement of a single 9’x4’ RCB with seven 7’x8’ RCBs, as well as the widening of the Hill Road bridge. Overall, these changes can retain a 500-year storm event.

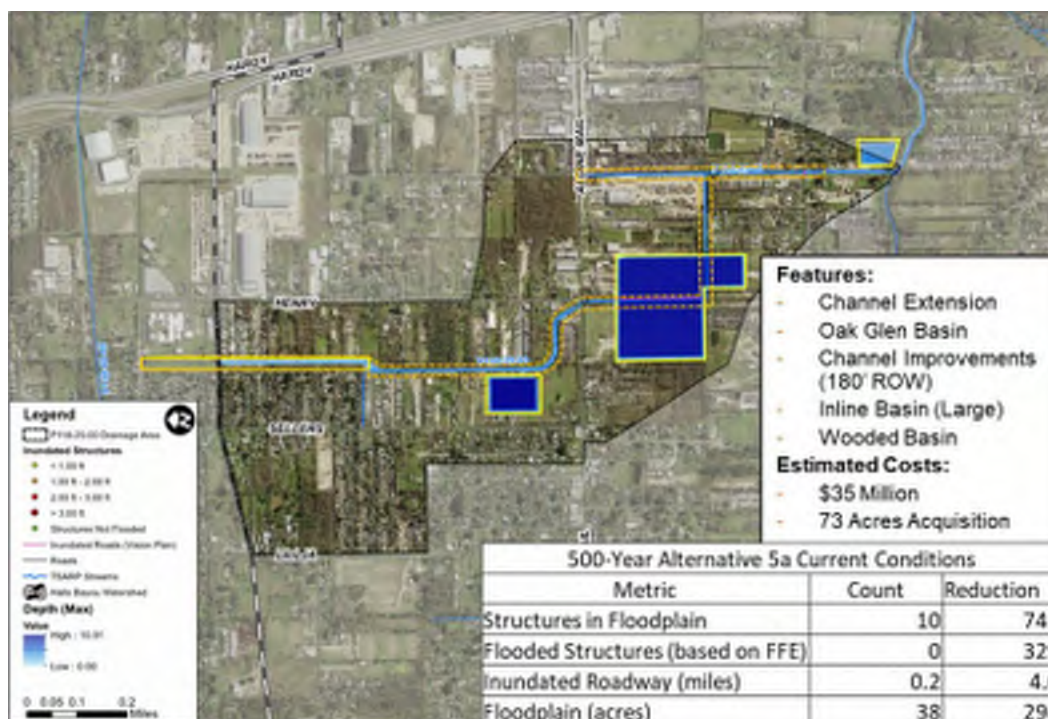


Figure 3-18: Alternative 5b - Channel Extension with Oak Glen Basin, Inline Basin, and more Channel Improvements (further Widening and Deepening) along P118-25-00/01



3.3.8 Detailed Alternatives Analysis Alternative Scoring

To “score” each of the alternatives, LAN considered six attributes and gave weight to each attribute: (1) Total Estimated Cost [20%], (2) Cost of ROW Acquisition [10%], (3) Number of Structures in Floodplain [15%], (4) Number of Flooded Structures [25%], (5) Miles of Inundated Roadway [15%], (6) Acres of Inundated Land [15%]. 70% of the weight was given to performance metrics and 30% to cost information. The alternatives' performances were compared to the Baseline Conditions. Refer to **Table 3-4** for results of the scoring process.

Table 3-4: Alternatives Scoring Matrix – “Current” Conditions

Alternative	Attributes						Final Scores
	Cost Information		Performance 500yr Normal Depth - "Current" Conditions				
	Total Estimated Cost	ROW Acquisition Cost	Structures in Floodplain	Flooded Structures	Miles of Inundated Roadway	Acres of Inundated Land	
	20%	10%	15%	25%	15%	15%	
Baseline	5.0	5.0	0.0	0.0	0.0	0.0	1.5
Alternative 1	5.0	5.0	0.2	1.4	1.3	0.0	2.1
Alternative 2	4.8	4.7	0.2	1.4	1.2	0.0	2.0
Alternative 3a	4.1	4.7	1.1	3.6	1.6	0.1	2.6
Alternative 3b	2.2	2.3	4.0	5.0	3.7	2.4	3.3
Alternative 4	1.2	1.2	3.9	5.0	3.5	2.0	3.0
Alternative 5a	0.8	0.9	3.9	5.0	3.5	2.0	2.9
Alternative 5b	0.0	0.0	5.0	5.0	5.0	4.5	3.4

As shown, Alternatives 3b and 5b ranked the highest with 3.3 and 3.4 points, respectively (on a scale of 0 to 5). To further compare the alternatives, LAN identified the LOS and the numbers of structures removed from the 500-year floodplain (compared to “Current” baseline conditions) for each alternative and the three overflow scenarios – refer to **Tables 3-5** and **3-6**.

As shown, there is a cut between Alternatives 3a and 3b. This cut is due to the channel deepening that was designed from Alternative 3b on. Alternative 5b met the goal of 500-year LOS, but with a cost of \$35 million, it is the most expensive.



Table 3-5: Alternatives Summary – Level of Service

Alternatives (Projected Costs)	Overflow Scenarios		
	“Current” Conditions	“Near Future” Conditions	“Future” Conditions
Baseline Cond.	< 10	< 10	10
Alternative 1 (~ \$1.6 Million)	10	10	10
Alternative 2 (~\$3.3 Million)	10	10	10
Alternative 3a (~\$7.7 Million)	10	10	50
Alternative 3b (~ \$15.7 Million)	100	100	500
Alternative 4 (~\$19.1 Million)	100	100	500
Alternative 5a (~ \$20 Million)	100	100	500
Alternative 5b (~ \$35 Million)	500	500	500

Table 3-6: Alternatives Summary – Flooded Structures Removed from 500-Year Floodplain

Alternatives (Projected Costs)	Overflow Scenarios		
	“Current” Conditions	“Near Future” Conditions	“Future” Conditions
Baseline	0	14	123
Alternative 1 (~ \$1.5 Million)	187	188	265
Alternative 2 (~\$3.3 Million)	185	185	265
Alternative 3a (~\$6.6 Million)	264	264	320
Alternative 3b (~ \$15.1 Million)	323	326	329
Alternative 4 (~\$19.1 Million)	325	326	329
Alternative 5a (~ \$20.8 Million)	324	326	329
Alternative 5b (~ \$35 Million)	329	329	329



4 Recommended Alternative

Through coordination with HCFCD, LAN recommends Alternative 3b to carry for advancement to a PER Study. It offers the best balance between costs and benefits compared to Alternatives 4, 5a, and 5b at probable costs of \$15.1 million. Although alternative 5b offers as the only solution a 500-year LOS for "Current" conditions, this design would be oversized for "Future" conditions, since it is expected that the project area will receive up to 60% less overflow from P138-00-00 once the Greens Bayou Mid-Reach Study is implemented. The costs include construction and acquisition of 35.2 acres of land for improvements. The Recommended Alternative provides a 100-year LOS for "Current" and "Near Future" overflow conditions, and a 500-year LOS for "Future" overflow conditions, where the floodplain is removed from all structures within the P118-25-00/01 service area.

The Recommended Alternative already incorporates mitigation volume for future local drainage improvements in its design. The HCFCD Bond Program currently identified Halls Bayou to have 6 Subdivision Drainage Improvement projects, two of which are in the P118-25-00/01 area (Aldine Village and Oak Glen Place Sector 2) – refer to [Figure 4-1](#). Subdivision drainage projects improve the internal drainage systems and related infrastructure that convey stormwater from neighborhoods to major drainage channels. **LAN assumed the completion of these subdivision drainage improvement projects as part of the proposed conditions.**

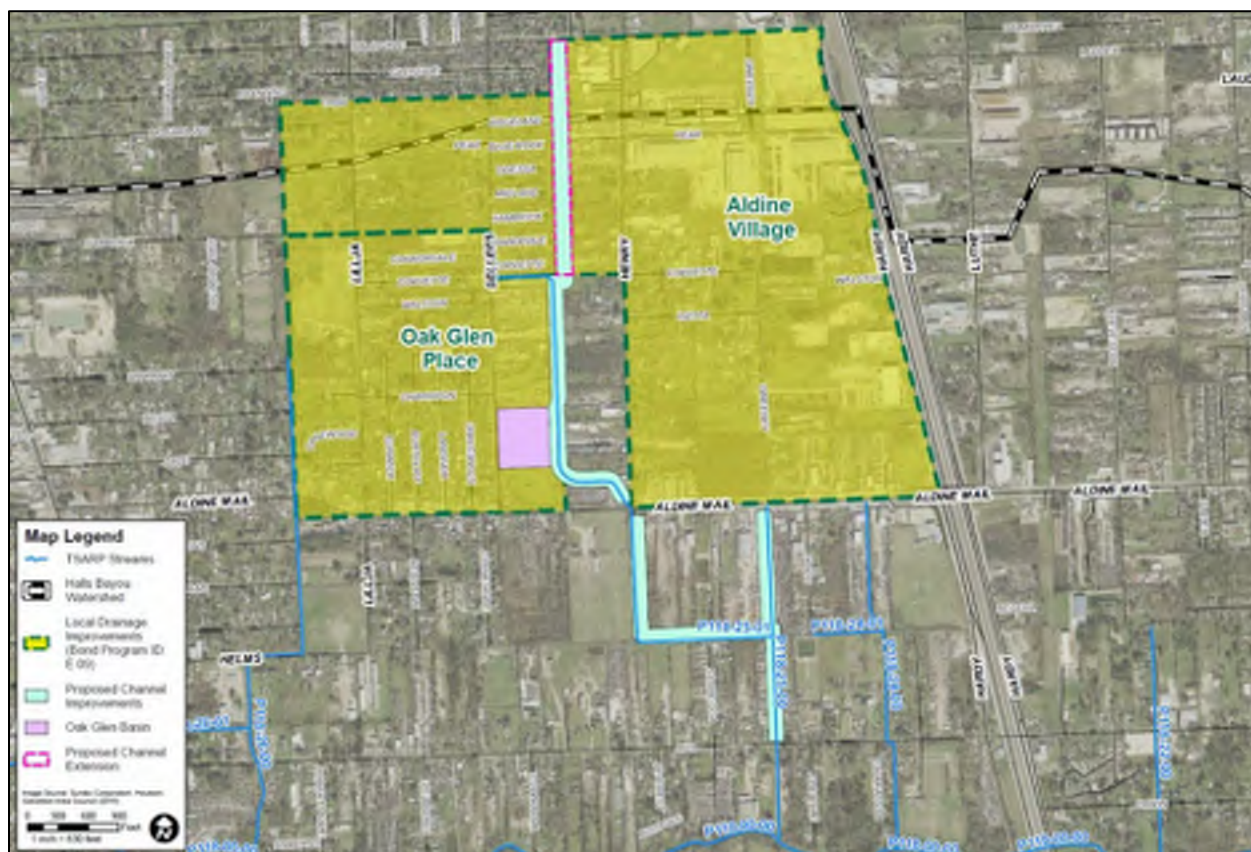


Figure 4-1: Local Drainage Improvements Service Areas (Bond Program ID: E-09); (edited by LAN)

4.1 Hydrology

No changes to the Baseline Conditions hydrology were required. All improvements done were not assumed to change the HEC-HMS model, rather they were represented in the HEC-RAS model as adjustments to the inflow boundary conditions. However, this analysis does consider three (3) different overflow scenarios, which resulted from the Overflow Analysis – refer to [Section 0](#).

- **Overflow Scenario #1 ("Current" Conditions)**
 - Unmitigated overflows from P118-26-00
 - Unmitigated overflows from P138-00-00 CLOMR Corrective Effective
- **Overflow Scenario #2 ("Near Feature" Conditions)**
 - Fully mitigated overflows from P118-26-00
 - Unmitigated overflows from P138-00-00 CLOMR Corrective Effective
- **Overflow Scenario #3 ("Future" Conditions)**
 - Fully mitigated overflows from P118-26-00
 - Unmitigated overflows from P138-00-00 CLOMR (60% less overflow)

4.2 Hydraulics

4.2.1 HEC-RAS Geometry

The development of the Recommended Alternative HEC-RAS model was borrowed from the Baseline Conditions model as a starting point. As with the Baseline Conditions model, inflow hydrographs are applied via boundary conditions using DSS connections to the Baseline Conditions HEC-HMS model. Channel modifications were cut into the cross-sectional geometry with HEC-RAS's built-in channel modification tools. The Oak Glen Basin was created in AutoCAD Civil 3D and graded to the existing surface of the terrain for a seamless transition. In HEC-RAS, the basin is represented with an internal refined 2D mesh with 25'x25' grid size over its underlying surface. Since it's a combined 1D/2D model, lateral structures are needed to allow flow between the 2D flow areas and 1D channel. A lateral structure is also used to model the side weir and outlet structure of the basin. Refer to [Exhibit 18](#) for the Recommended Alternative HEC-RAS geometry.

4.2.2 Inflow Boundary Conditions

The overflows leaving P138-00-00 between Lillja Road and Henry Road (LS 17570 and LS 16800, respectively – refer to [Section 0](#)) were directly applied to the headwaters of the proposed channel extension of P118-25-01 at River Station 6957.03 (assuming neighboring drainage projects will catch this overflow and drain into the channel extension). The amount of overflow leaving P138-00-00 between Henry Rd and Hardy Toll Rd (LS 14800) and partially enters P118-25-00 drainage area was measured in post process in HEC-RAS and applied at River Station 3203.12 in addition to the local runoff.



The P118-26-00 overflow was partially distributed with 50% directly into the Oak Glen basin, assuming the runoff from future local drainage improvements will be drained into the basin, and another 50% is distributed into a nearby portion of channel P118-25-00/01 along RS 2475.84 to 1881.88 as a Uniform Lateral Inflow boundary condition. Refer to [Table 4-1](#) for a summary of the Recommended Alternative unsteady flow boundary condition.

Note: Since HEC-RAS does not support the connection of two inflow boundary conditions to the same location, inflow boundary conditions #4 + #5 and #6 + #7 have been combined to one boundary condition each. This results in a double peak in hydrograph due to the different timing. The area-based multipliers (5% and 7%, respectively) were considered.

Table 4-1: Recommended Alternative HEC-RAS Unsteady Flow Boundary Conditions

#	Reach	River Station	HEC-RAS Boundary Condition	HEC-HMS Subbasin	Multiplier	500-YR Peak Flow (cfs)	Applied Overflows
River Boundary Conditions							
1	P118-25-01	6957.03	Flow Hydrograph	-	-	1090	P138-00-00 Overflows 1+2
2	P118-25-01	5341.48	Flow Hydrograph	P118L1	0.14 (14%)	125	
3	P118-25-01	4477.47 to 2728.92	Uniform Lateral Inflow	P118L1	0.17 (17%)	152	
4	P118-25-01	2475.84 to 1881.88	Uniform Lateral Inflow	P118L1	0.15 (15%)	134	
5	P118-25-01	2475.84 to 1881.88	Uniform Lateral Inflow	-	-	138	P118-26-00 Overflow (50%)
6	P118-25-00_R2	3203.12	Flow Hydrograph	P118L1	0.05 (5%)	45	
7	P118-25-00_R2	3203.12	Flow Hydrograph	-	-	247	P138-00-00 Overflow 3
8	P118-25-00_R2	2930.66 to 2636.62	Uniform Lateral Inflow	P118L1	0.04 (4%)	36	
9	P118-25-00_R1	1565.52 to 251.81	Uniform Lateral Inflow	P118L1	0.07 (7%)	63	
10	P118-25-00_R1	97.80	Normal Depth	P118L1			
Storage/2D Flow Areas Boundary Conditions							
11	Oak Glen Basin	-	Flow Hydrograph	-	-	138	P118-26-00 Overflow (50%)
Total					0.62 (62%)		

4.3 Results

As previously mentioned, the Recommended Alternative brings the entire P118-25-00/01 service area up to a 100-year LOS for “Current” and “Near Future” overflow conditions, and for “Future” overflow conditions to a 500-year LOS, assuming neighboring drainage improvement projects are in place.

Water surface profiles along P118-25-00/01 for all four (4) storm events can be found in [Appendix D](#). Comparison profiles between Baseline Conditions and the Recommended Alternative are attached in [Appendix E](#). A summary of WSELs at roadway crossings is shown in [Table 4-2](#) below.



Table 4-2: Recommended Alternative WSELs at Roadway Crossings

Road	Culvert Size	High Chord (ft)	Low Chord (ft)	WSEL (ft)				Freeboard at Bridge (ft)			
				500-Year	100-Year	50-Year	10-Year	500-Year	100-Year	50-Year	10-Year
Hill Road	-	74.8	69.4	70.7	69.1	68.2	66.2	4.0	5.8	6.6	8.6
Aldine Mail Route Road	Dual 9'x6' RCB	73.9	71.2	74.2	70.8	70.0	67.7	-0.4	3.1	3.9	6.2

As with Baseline Conditions, evaluated 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 10-, 100-, and 500-year storm events. The use of performance metrics allows for a quantitative evaluation of potential flood damage reduction benefits.

By providing a 100-year LOS under “Current” conditions, the 500-year floodplain is reduced from 332 acres to 130 acres, and structures remaining in the floodplain are reduced from 751 to 145. The number of flooded structures is reduced from 329 to 6 structures. From the originally 4.2 miles of inundated roadway, 1.3 miles remain inundated. Refer to **Table 4-3** for comparison of performance metrics under “Current” conditions.

Table 4-3: Performance Metrics – Baseline Conditions vs. Recommended Alternative

Performance Metric	Study Area	10-year Floodplain		50-year Floodplain		100-year Floodplain		500-year Floodplain	
		Basel.	Rec. Alt.	Basel.	Rec. Alt.	Basel.	Rec. Alt.	Basel.	Rec. Alt.
Structures	857	181	0	508	5	607	7	751	145
Flooded Structures (based on FFE)	-	8	0	163	0	203	0	329	6
Inundated Roadway (mile)	27.8	1.7	0.0	2.7	0.0	3.2	0.0	4.2	1.3
Floodplain (acre)	-	103	6	226	10	273	11	332	130

4.4 Right-of-Way Requirement

HCFCDD owns 12.8 acres of ROW in the study area. With the Recommended Alternative, an additional 35.2 acres would need to be acquired, and an expected 42 structures would lie within the proposed ROW limits – refer to **Figure 4-2** and **Exhibit 24**, respectively. The majority of probable affected structures are mobile homes, but 3 warehouses-metallic also lie within the proposed ROW. The number of structures also considers structures that are located within 25 feet around proposed ROW to account for potential damages on structures during construction.

LAN identified 46 parcels where partial ROW acquisition will be required and 2 parcels where full acquisition will be required along P118-25-00/01. LAN assumed that if the proposed ROW occupies 40% of a parcel, it is considered as full acquisition. Refer to **Appendix F** for a listing of affected parcels. A full acquisition would be required for the parcels in the footprint of the Oak Glen Basin and a portion of the



channel downstream of Aldine Mail Route Road. Both parcels are located on P118-25-01. The proposed channel extension crosses two sensitive parcels that are used by a school and church, respectively.

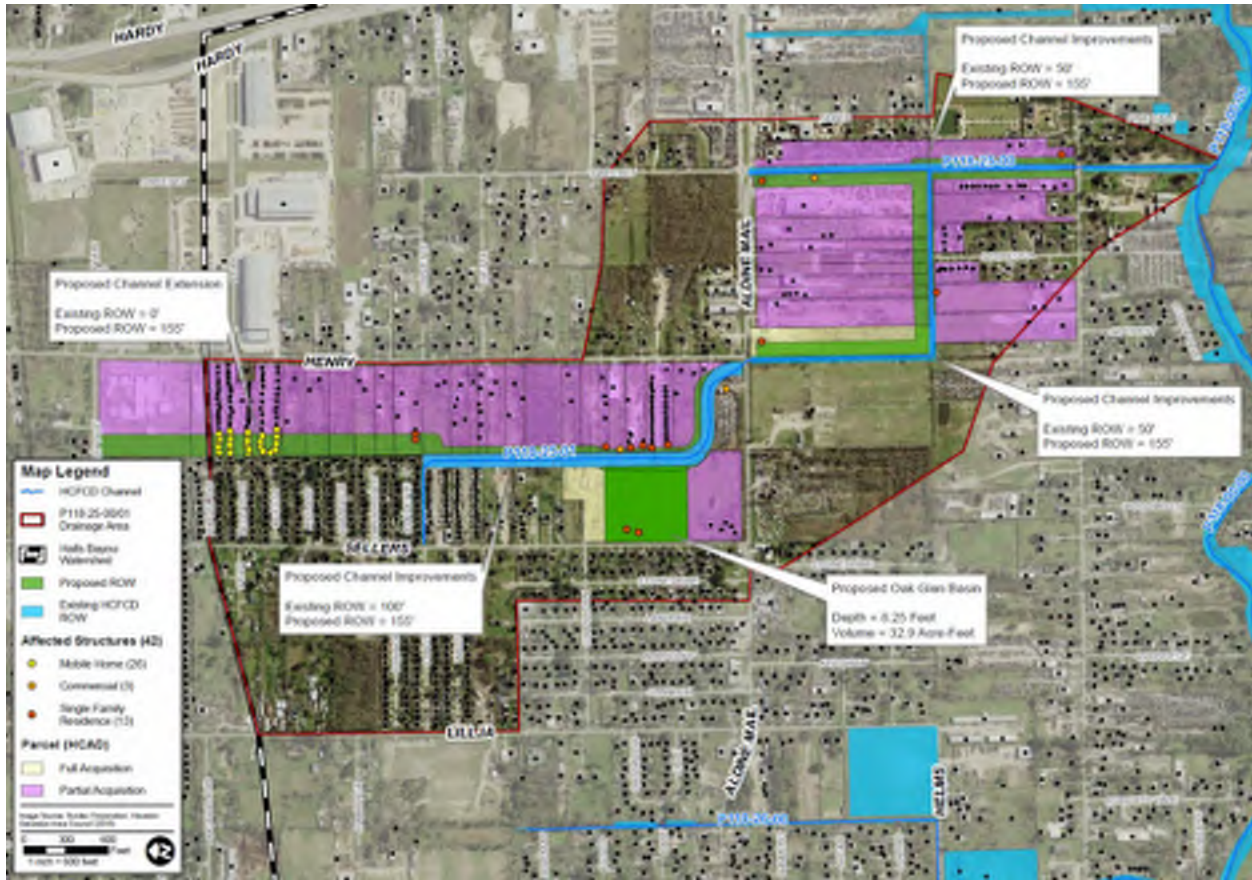


Figure 4-2: Proposed ROW – Alternative 3b (Recommended)

The proposed average 155-foot ROW width for the channel considers a 30-foot maintenance berm on each side and a 25-foot bottom width with 4:1 side slopes. Refer to Figure 4-3 for a cross-section representation of ROW requirements for the Recommended Alternative.

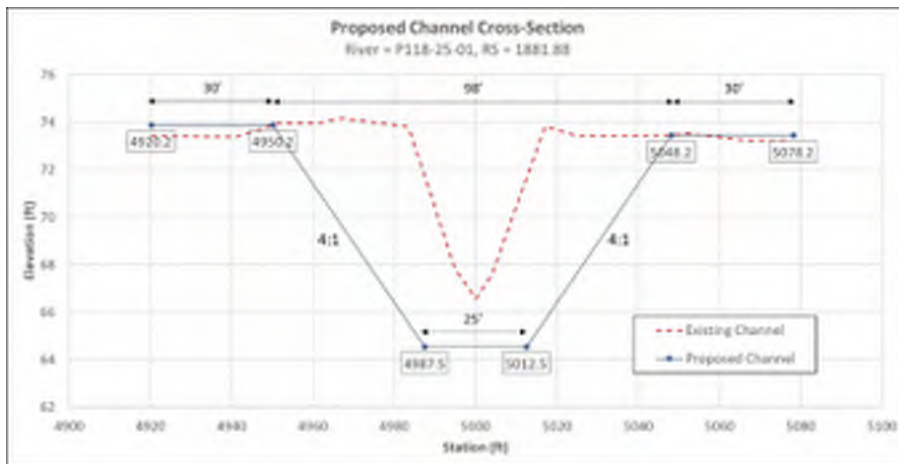


Figure 4-3: Recommended Alternative ROW Requirement.



4.5 Opinion of Probable Construction Cost

An opinion of probable construction cost for the Recommended Alternative can be found in **Table 4-4**. Detailed estimates of probable costs are also provided in **Appendix G**. Unit cost values utilized the latest TxDOT and HCFC average low bid tab and HCAD appraised land values. The costs consider clearing and grubbing, excavation and disposal, backslope drainage system swales, concrete interceptor structures, culverts, headwalls, site preparation, turf establishment, partial ROW acquisition, silt fencing, and pipeline relocation. A more detailed cost estimate for the pipeline relocations will be determined in the PER, and in the meantime, a place holder value of half a million dollars per relocation is used. LAN assumed 10% of direct construction costs for Planning, Engineering, and Design, 5% for Mobilization/Demobilization, 10% for Construction Management, and 20% for Contingency.

Table 4-4: Recommended Alternative Opinion of Probable Construction Cost

Item Description	Cost
Oak Glen Basin	\$1,845,102
Excavation	\$504,950
Features	\$245,320
ROW acquisition (9.9 acres)	\$1,094,832
Channel Extension	\$2,043,441
Excavation	\$310,500
Features	\$46,200
ROW acquisition (8.8 acres)	\$1,686,741
Channel Improvements (P118-25-00)	\$3,600,505
Excavation & Off-Site Disposal	\$225,360
Features	\$39,300
ROW acquisition (4.7 acres)	\$2,835,845
Pipeline Relocation (1x)	\$500,000
Channel Improvements (P118-25-01)	\$5,575,708
Excavation & Off-Site Disposal	\$668,340
Features	\$451,000
ROW acquisition (11.7 acres)	\$2,956,368
Pipeline Relocation (3x)	\$1,500,000
	<i>ROW Acquisition:</i> \$8,574,000
	<i>Direct Construction Cost (DCC):</i> \$4,491,000
	Subtotal: \$13,065,000
+ Planning, Engineering, and Design (10% of DCC):	\$449,100
+ Mobilization/Demobilization (5% of DCC):	\$224,550
+ Construction Management (10% of DCC):	\$449,100
+ Contingency (20% of DCC):	\$898,200
Total:	\$15,085,950



5 Preliminary Impacts Analysis

A preliminary assessment of potential impacts was performed on Halls Bayou as the result of the Recommended Alternative. The impacts model for Halls Bayou was developed based on the latest Halls Bayou model from the HCFCDD Halls Bayou Phasing Study. As P118-25-00/01 is an unstudied tributary of Halls Bayou, this analysis will only focus on the effect that the Recommended Alternative will potentially have on P118-00-00 WSEL pre- and post-project.

To conduct the preliminary impacts analysis, LAN utilized the P118-00-00 Halls Phasing HEC-RAS model and implemented the standalone model of P118-25-00/01 with its boundary conditions. Refer to [Figure 6-2](#) for HEC-RAS model geometry.

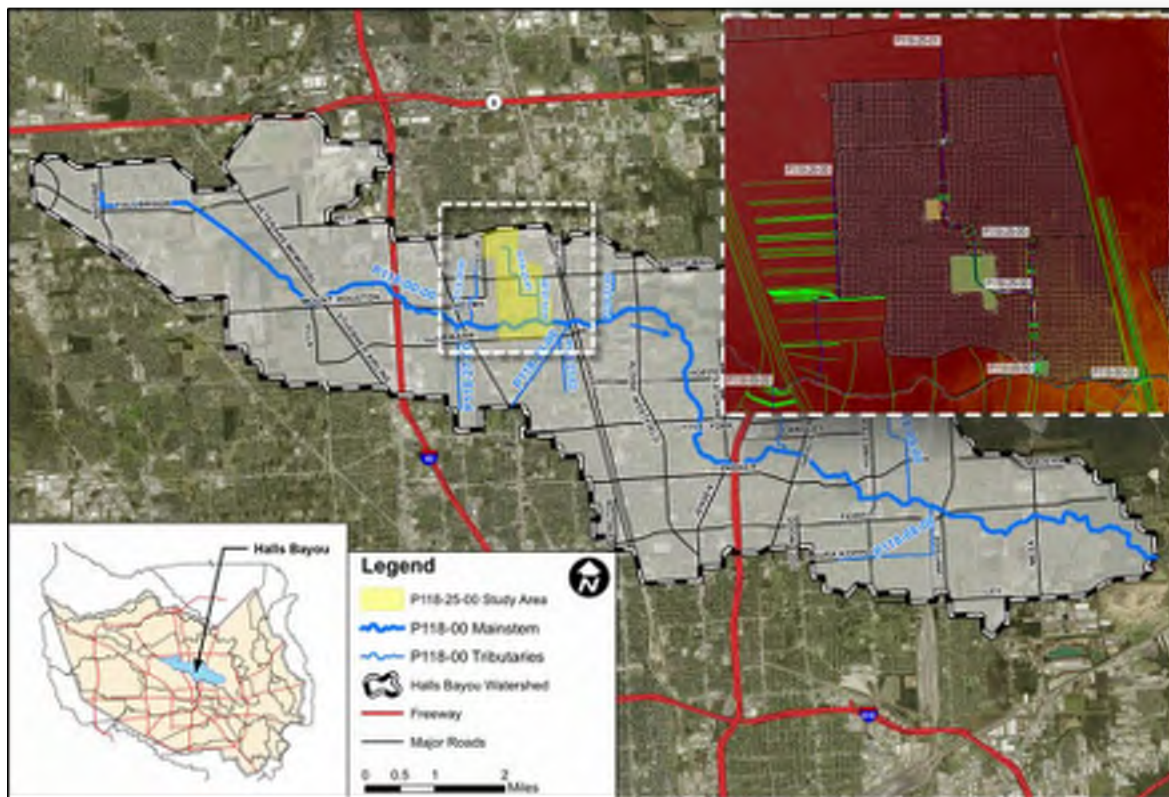


Figure 5-1: Impacts Analysis HEC-RAS Model Layout

The Recommended Alternative was modeled and resulted in decreases in WSEL upstream of the confluence of P118-25-00 and Halls Bayou. However, increases in WSEL were observed in all three storm events downstream of the confluence. LAN added a restrictor (sheet piling) U/S of Hill Road to help mitigate the impacts. Improvements are planned on Halls Bayou at the confluence with P118-25-00 as part of the Halls Bayou Vision Plan, which, when completed, will work in conjunction with the tributary improvements to reduce WSEL throughout the watershed. However, since Halls Bayou has not been improved yet, a restrictor is placed to reduce downstream impacts, until such time in the future that Halls Bayou is improved and able to receive the proposed flows without causing impacts downstream of the confluence of P118-25-00 with Halls Bayou.



Overall, the use of a restrictor with 19ft opening within P118-25-00 was effective in reducing WSELs downstream within Halls Bayou. Further refinement should be explored in the design phase of the project to eliminate all adverse impacts for all storm events. Refer to [Appendix L](#) for a list of WSEL comparisons.

LAN recommends considering this option in the PER and design phases of the project for the final Drainage Impacts Analysis to ensure no adverse impacts.



6 Additional Services

Sub-consultants were utilized for survey, geotechnical, and sub-surface utility exploration (SUE) efforts. Data collection for SUE and geotechnical analysis was performed only within existing HCFCO channel ROW unless otherwise stated. However, SUE Quality Level D (QL-D) records research, as-builts, and plan assessments extend to the entire project limits.

6.1 Survey

Baseline Corporation collected boundary and topographic survey in 2018 for the length of the P118-25-00/01 channel as part of the *Halls Bayou Watershed Flood Risk Reduction Phasing Study*. The surfaces were incorporated into the 2008 LiDAR terrain.

6.2 Geotechnical

Ulrich Engineers, Inc. (UEI) was contracted to provide geotechnical analysis in the P118-25-00/01 study area for the proposed channel extension, modifications of existing channels, and detention basins. However, HCFCO instructed UEI to focus investigations only on the existing channels and the proposed channel extension due to time constraints. A geotechnical design report was prepared to evaluate subsurface soil conditions and provide recommendations for use in the design of proposed improvements – refer to [Appendix I](#).

A total of 13 soil borings were drilled to depths ranging from 6 to 35 feet, of which three (3) borings were made in the proposed channel extension. Groundwater was encountered at depths ranging from 11 to 18 feet. Given the [1] existing soil parameters, [2] the visual performance of the existing channel slopes, [3] the results of EUI's slope stability analysis and [4] the HCFCO criteria for the minimum factor of safety, EUI recommends a cross-section for channels extending to 13-ft depths with 3(H):1(V) side slopes.

Refer to [Figure 6-1](#) for soil boring locations along P118-25-00/01.



Figure 6-1: Soil Boring Locations



6.3 Subsurface Utility Exploration (SUE)

Cobb, Fendley & Associates, Inc. was contracted to assist LAN with SUE to identify utilities located within the limits of the P118-25-00/01 project area. The designation of underground utility lines (QL-B) was limited to the HCFC and public ROW. However, records research, as-builts, and plan assessments (QL-D) extend to the entire project limits. Pipeline crossings were documented, and top of pipe elevations were surveyed for pipelines already exposed to the surface. Collected data was compiled into a CAD drawing and provided to LAN. All coordinate data were referenced to the Texas State Plane Coordinate System of 1983 (NAD83, 2011) and referenced vertically to NAVD88 (2001 ADJ).

Refer to **Table 6-1** for identified utility lines in conflict with the proposed channel improvements. The Sunoco Gas Pipeline (G2-8) crosses both channels. It is exposed to the surface at an elevation of 73.63 ft. Additionally, an abandoned Sunoco Gas Pipeline (G2-1-ABD) crosses the Channel Extension. For the other pipelines (CNP and BP) the elevation is unknown.

Table 6-1: Utility Summary

Location	Key	Utility	Elev. (ft)	Note
Channel Ext.	C1-1-D	COMCAST UNDERGROUND CTV	-	
	G1-1-D	CNP UNDERGROUND GAS	-	
	G2-1-ABD	SUNOCO UNDERGROUND GAS	-	Abandoned
		WATER METER	-	
P118-25-01	G2-8	SUNOCO UNDERGROUND GAS	73.63	
	G3-10	ENTERPRISE UNDERGROUND GAS	-	
	G4-10	BP UNDERGROUND GAS	-	
		SANITARY SEWER CLEAN OUT	76.25	
		H.C. STORM SEWER LINE 24" CMP	71.15	Oak Glen Basin
		H.C. STORM SEWER LINE 24" CMP	70.44	
		H.C. STORM SEWER LINE 54" CMP	-	
	SD2-1D	PRIVATE UNDERGROUND STORM SEWER LINE	-	
	T1-1	ATT UNDERGROUND TELEPHONE	74.30	Aldine Mail Rte Rd
P118-25-00	G2-8	SUNOCO UNDERGROUND GAS	73.63	
		TELEPHONE POLE W/ RISER	70.78	Hill Road

6.4 Environmental Considerations

A high-level desktop evaluation of environmental data was provided by HCFC through the Watershed Environmental Baseline Data Summary Tool (WEB-DST). The information identified wetlands, potential wetlands, endangered species, pipelines, hazardous material point sources, oil and gas wells, and landfills. Refer to **Figure 6-2** below for the spatial distribution of potential environmental concerns.



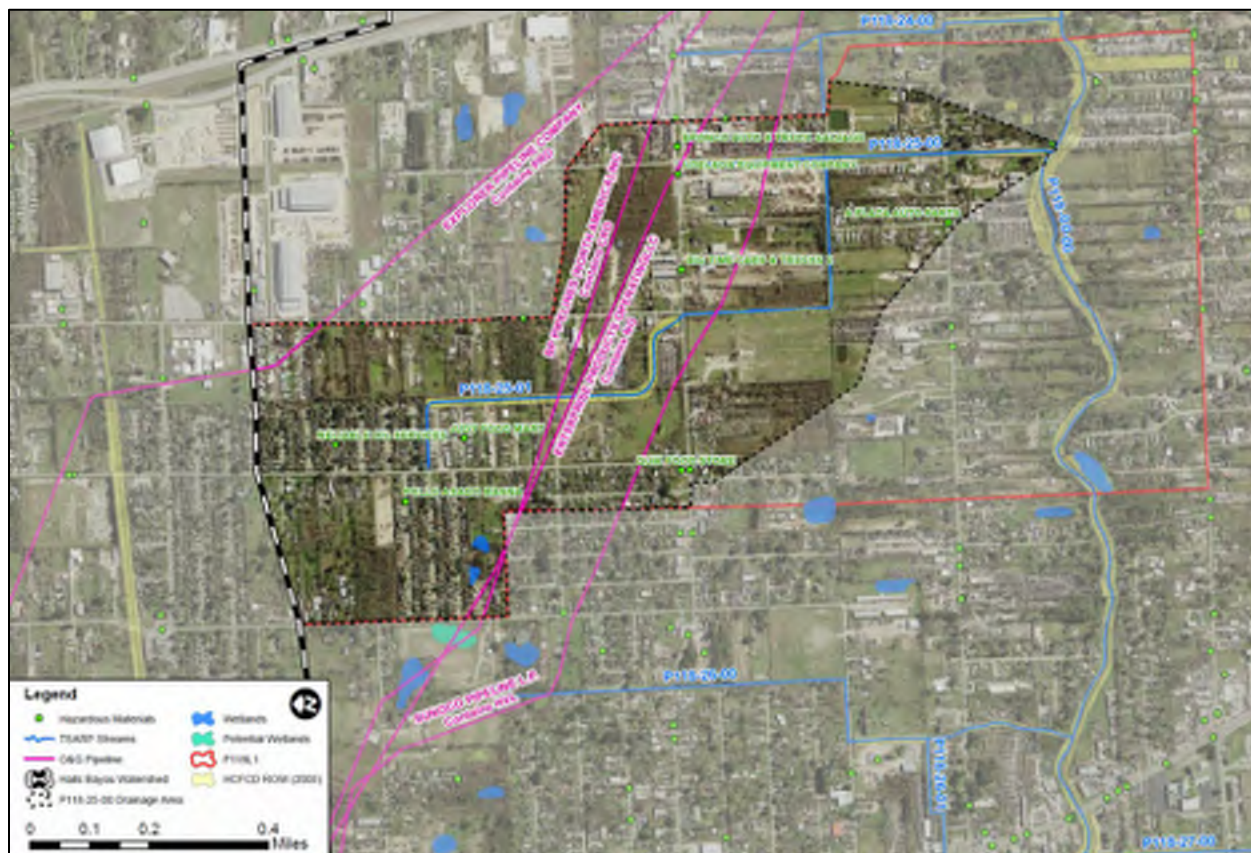


Figure 6-2: Desktop Environmental Summary for P118-25-00/01 Service Area

Several hazardous materials point sources exist inside the P118-25-00 service area, primarily in the form of auto parts and salvage yards.

Three oil and gas pipelines cross P118-25-01, (1) BP Pipelines (North America), Inc. (contains CRD), (2) Enterprise Products Operating, LLC (contains natural gas), and (3) Sunoco Pipeline L.P. (contains highly volatile liquid). Coordination with the owners will have to take place. No wetlands or potential wetlands were identified in the desktop analysis.

7 Conceptual Schematics (30% Design)

LAN was scoped to provide a 30% design set of drawings for the P118-25-00/01 Recommended Alternative. The design worked to answer questions of constructability and refined the layout of the Recommended Alternative. Refer to [Appendix J](#) for the 30% Design Drawings.

Locations of encroachment on HCFCD's existing ROW were identified along the upstream portion of P118-25-00. Early coordination with the landowners is recommended to not delay construction. LAN is prepared to assist HCFCD with coordination upon request.

Some preliminary changes in flow line alignment were made to reduce property acquisition and cost by the proposed ROW acquisition:

- For the upstream section of P118-25-00, the flow line was shifted eastwards, to (1) limit ROW acquisition to one parcel and (2) to avoid having an additional structure to be acquired.
- For the east-west span of P118-25-01 between Aldine Mail Route Road and Hill Road, the flow line was shifted north to avoid having at least seven structures to be acquired.

The road crossing at Aldine Mail Route Road is proposed to be replaced from a single 9'x4' reinforced box culvert (RCB) by two 9'x6' RCBs. All existing lateral connections are proposed to be tied into the channel. All dead-end streets (from Connorvale Court to Glenvale Drive) along the proposed channel extension upstream of P118-25-01 are proposed to have outfalls to be tied into the channel extension. **Final outfall design and location is to be coordinated with HC Engineers in their local drainage improvements projects – refer to [Section 4](#).**

Time to completion was estimated at approximately 2 years provided no major issues with land acquisition or pipeline relocation. This was based on the estimate of 6 months to finish design, 2 months out to bid, and 9 months for construction.



8 Summary and Conclusion

The Harris County Flood Control District (HCFCFD) authorized Lockwood, Andrews & Newnam, Inc. (LAN) in October 2018 to conduct an Alternatives Analysis Study on Tributary P118-25-00 and Sub-Tributary P118-25-01 (hereafter referred to as “P118-25-00/01”); located within the Halls Bayou (HCFCFD Unit No. P118-00-00) watershed.

The purpose of this study is to analyze and describe the existing flooding conditions within the P118-25-00/01 catchment 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 PER, which can efficiently be carried into detailed design.

The study area is heavily influenced by overflows from P118-26-00 in the west and P100-00-00 (Greens Bayou) in the north, which cascades south into P138-00-00 and then to the study area of P118-25-00/01. To assess and quantify the amount of overflow entering the study catchment, P118-26-00 PER and P100-00-00 (Greens Bayou) CLOMR/Federal Study models were utilized to conduct an Overflow Analysis – refer to [Section 0](#). The results were then used to establish boundary conditions onto the P118-25-00/01 standalone model.

H&H models were developed for the 10%, 2%, 1%, and 0.2% design storm events (pre-Atlas 14 update) based on HCFCFD criteria using the HEC-HMS and HEC-RAS software. Existing and Proposed conditions models include a variety of combinations of boundary conditions including Normal Depth and Tailwater, as well as three (3) different overflow scenarios derived from the Overflow Analysis: #1 “Current Overflows”, #2 “Near Future Overflows”, and #3 “Future Overflows”.

- Overflow Scenario #1 ("Current" Conditions):
Assumes that the existing overflows from P118-26-00 and P138-00-00 are in place.
- Overflow Scenario #2 ("Near Future" Conditions):
Assumes that the P118-26-00 bond project has been implemented and that project would eliminate overflow from that tributary.
- Overflow Scenario #3 ("Future" Conditions):
Assumes that the Mid-Reach Greens Bayou Project (Bond ID: C-20) has been completed and will reduce the amount of overflow coming from P138-00-00 by 60%.

For this P118-25-00/01 Alternatives Analysis, Normal Depth downstream assumption with “Current” overflows were used for the formulation process and when developing the proposed conditions. However, upon arrival and sizing of the RA, the RA was then analyzed in conjunction with overflow scenario #2 and #3 with associated performance metrics processed – refer to [Section 3.3.8](#).

Baseline Conditions results revealed the existing Level of Service for the P118-25-00/01 drainage area is mainly driven by P138-00-00 overflows for the 1% and 0.2% return period. It accounts for 56% and 65%, respectively, of the contributing runoff. The HEC-RAS results were used and processed in GIS to generate a set of performance metrics to measure proposed improvement alternatives. The model outcome for a 500-year design storm shows 595 structures in the floodplain, with 184 structures being flooded. The



majority of flooded homes are located in the headwaters of P118-25-01 at Colonia Hills and Oak Glen Place and flooding already occurs at an early state.

In total, eight (8) improvement features were identified as potential flooding mitigation solutions. They include detention basins, channel improvements (widening, deepening), and a channel extension. They were selected because they are at hydraulically influential locations, topographically integrable, and relatively unobtrusive to residents. Seven (7) alternatives were developed of the improvement features with varying costs and performances – refer to [Section 2.4](#).

In coordination with HCFCD, LAN recommends Alternative 3b to carry for advancement to a PER Study. It offers the best balance between costs and benefits compared to Alternatives 4, 5a, and 5b at probable costs of approximately \$15.1 million. Although alternative 5b offers as the only solution a 500-year LOS for "Current" conditions, this design would be oversized for "Future" conditions. The costs include construction and acquisition of 35.2 acres of land for improvements.

Alternative 3b incorporates three features, (1) a channel extension in the headwaters of P118-25-01 north of Hollyvale Drive to provide an outfall location for future subsurface drainage projects in the Oak Glen Place and Colonia Hill region addressing the P138-00-00 overflow, (2) channel deepening and widening upstream of Hill Road along P118-25-00 and P118-25-01 to increase overall channel capacity and conveyance, and (3) the 33 acre-feet Oak Glen detention basin just north of Aldine Mail Route Road to provide an outfall location for local drainage improvement projects addressing the P118-26-00 overflow (if not already done so in a previous HCFCD study) and to mitigate overall flooding impacts. Channel improvements are trapezoidal with a 25-foot bottom width, 4:1 side slopes, and a 0.08% longitudinal slope. The average channel deepening on P118-25-00 and P118-25-01 is 1.4 ft and 2.1 ft, respectively.

Under "Current" overflow conditions, Alternative 3b provides a 100-year LOS, removing approximately 461 structures from the floodplain, 2.0 miles of roadway, and 159 acres of land (assuming pre-Atlas 14 rainfall rates). Under "Future" overflow conditions, Alternative 3b provides a 500-year LOS, leaving six (6) non-flooded structures in the floodplain (assuming pre-Atlas 14 rainfall rates).

It is recommended to coordinate the proposed P118-25-00/01 project with Harris County Engineering on their local drainage improvement projects (refer to [Section 4.1](#)), as this is an opportunity to provide the local infrastructure that was envisioned for the channel extension and the proposed basin of Alternative 3b.

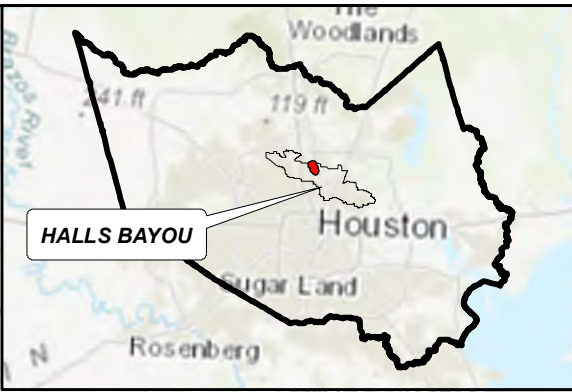
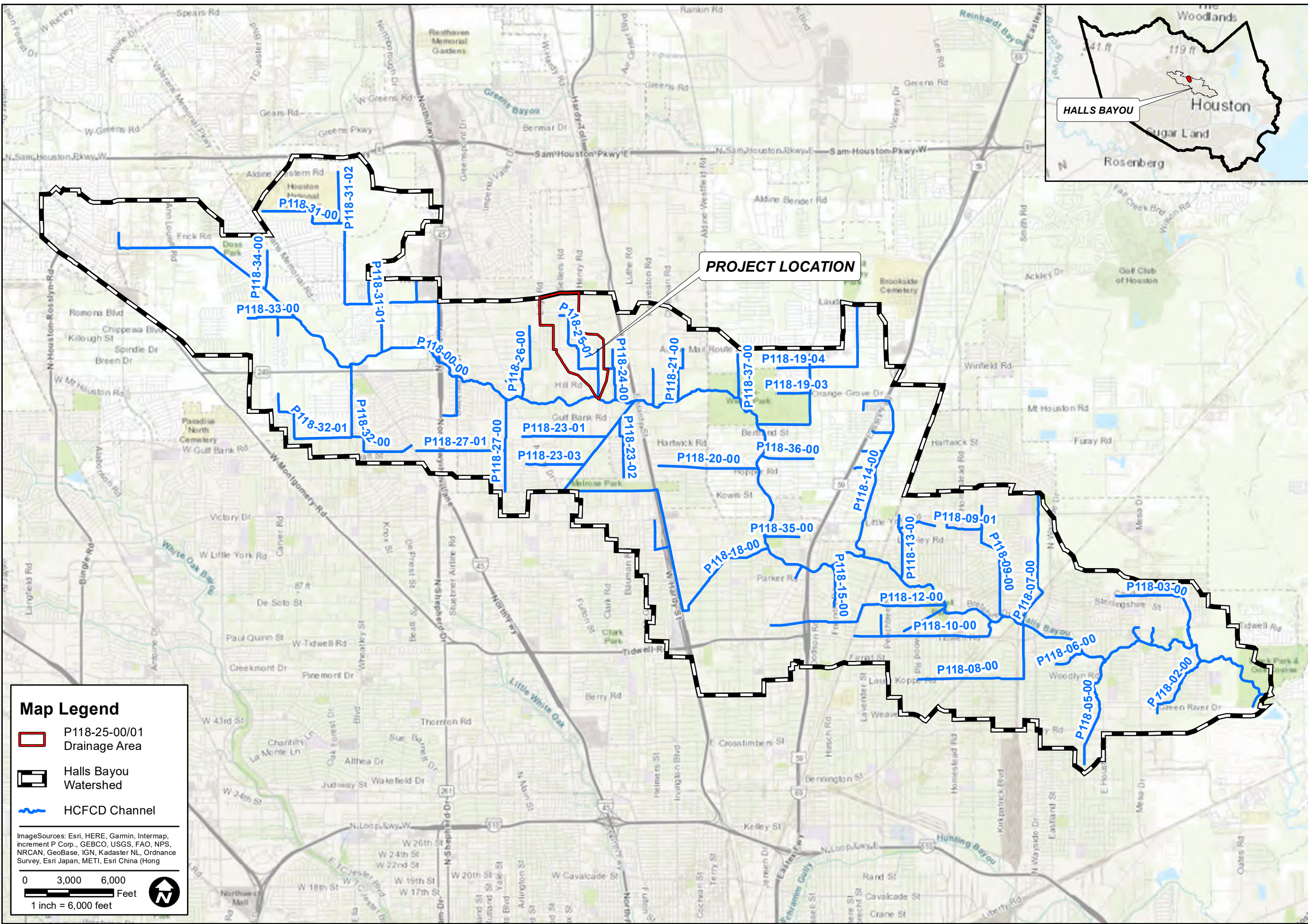


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- CLOMR model of Greens Bayou; developed by Walter P. Moore (WPM) (WPM 2018).



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Map Legend

-  P118-25-00/01 Drainage Area
-  Halls Bayou Watershed
-  HCFC Channel


ImageSources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong)


0 3,000 6,000
 Feet
 1 inch = 6,000 feet



**HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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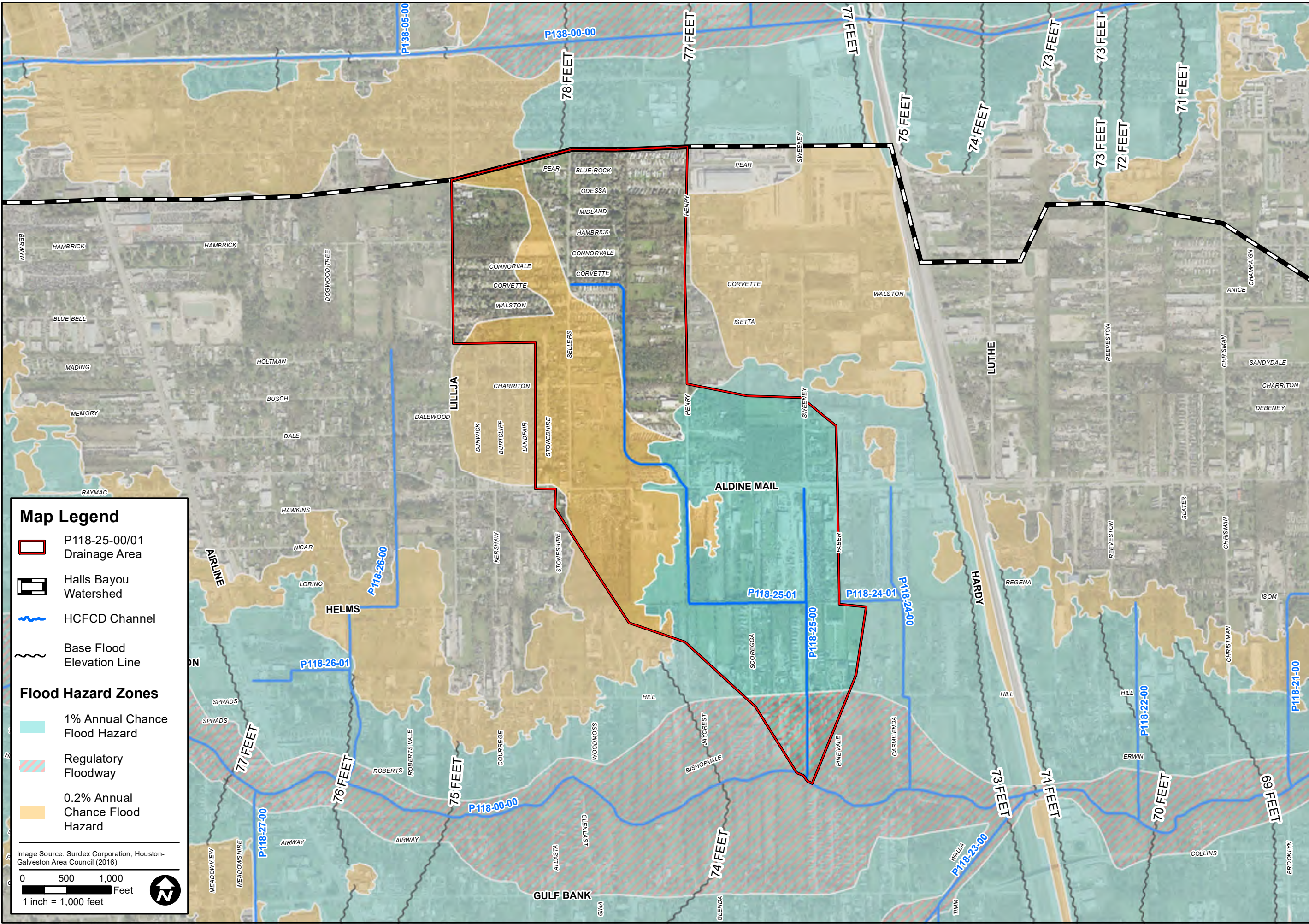

IGN
 TBPE Firm No. 2614
 2925 Briarpark Drive • Houston, TX 77042-3720
 T 713.266.6900 • F 713.266.2089
 www.ign-inc.com • info@ign-inc.com


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

DATE: AUG 2019
 SCALE: AS NOTED

EXHIBIT
 1

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Base Flood Elevation Line

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- 0.2% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 FEMA EFFECTIVE FLOODPLAIN**

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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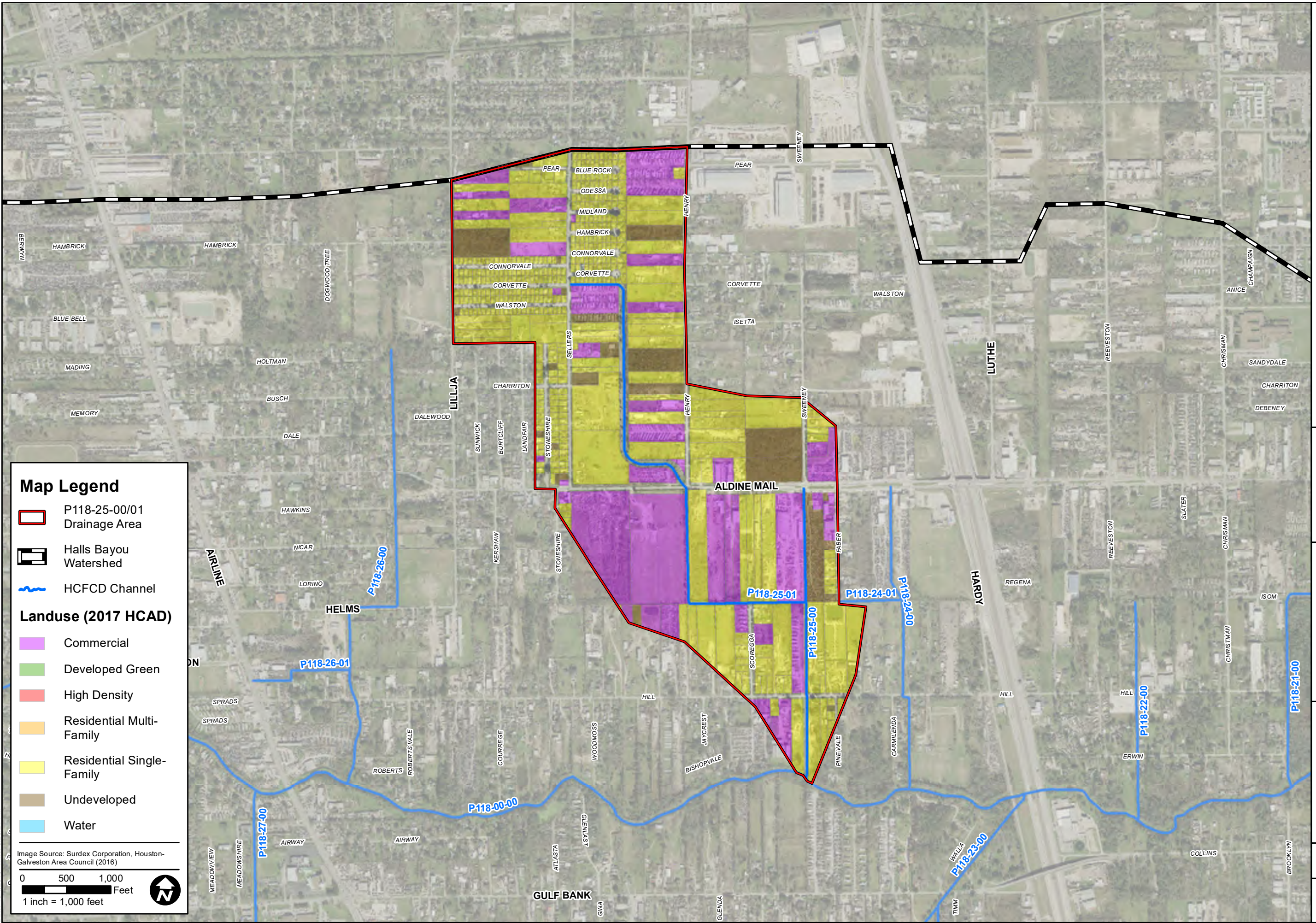
Lockwood, Andrews & Newnam, Inc.
 A U.S. A. S. COMPANY
 TBPE Firm No. 2614
 2925 Briarpark Drive • Houston, TX 77042-3720
 T 713.266.6900 • F 713.266.2089
 www.lan-inc.com • info@lan-inc.com

HARRIS COUNTY
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 9900 Northwest Freeway
 Houston, Texas 77092

DATE: AUG 2019
 SCALE: AS NOTED

EXHIBIT
 2

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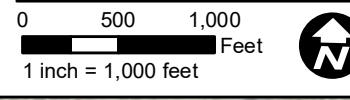
Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFC Channel

Landuse (2017 HCAD)

- Commercial
- Developed Green
- High Density
- Residential Multi-Family
- Residential Single-Family
- Undeveloped
- Water

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



**HCFC HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

LAND USE (2017 HCAD PARCELS)

PREPARED:	CWB
CHECKED:	LM
APPROVED:	CEE

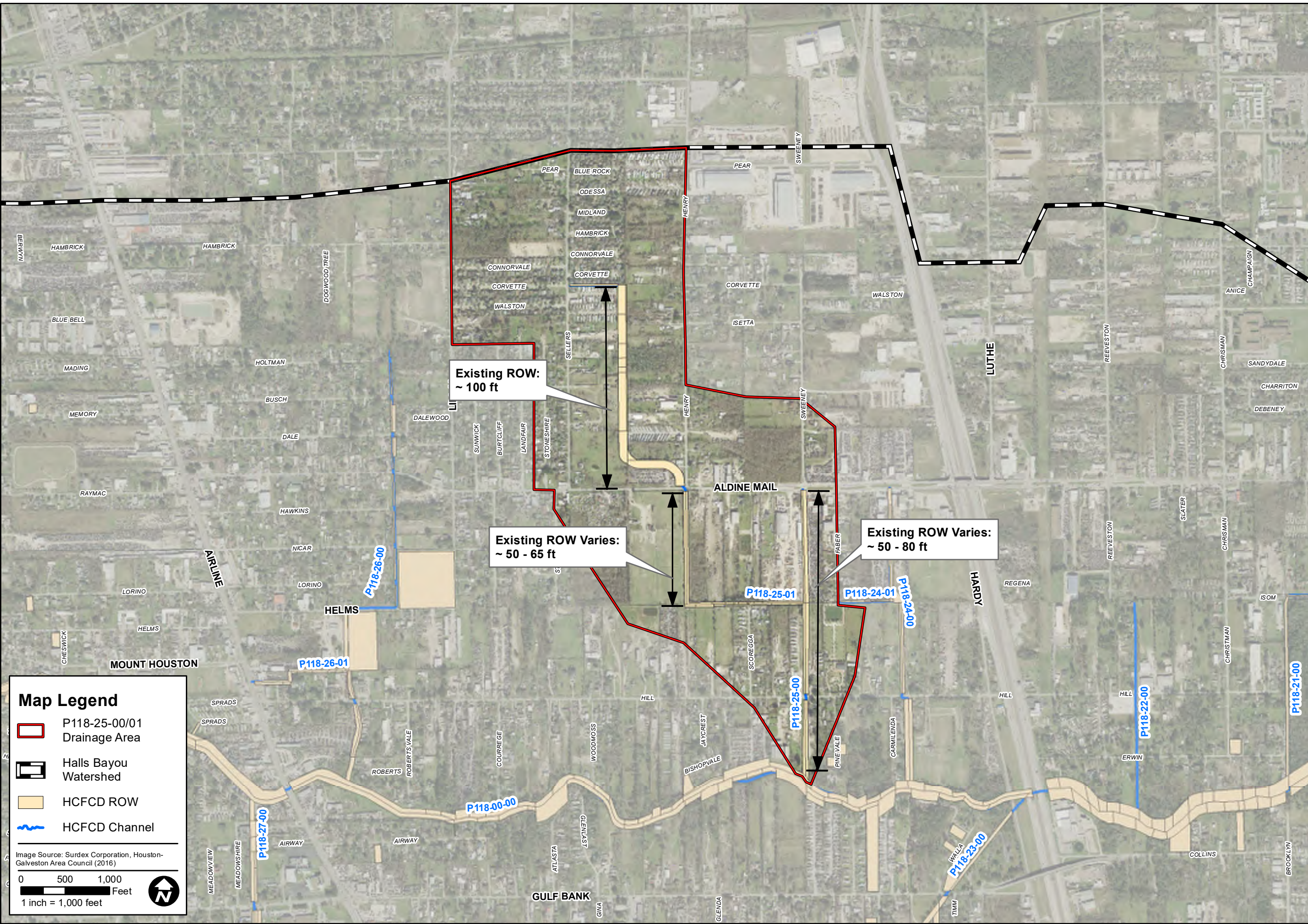
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 FLOOD CONTROL DISTRICT**
 9900 Northwest Freeway
 Houston, Texas 77092

DATE: AUG 2019
 SCALE: AS NOTED

EXHIBIT
 3

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Map Legend





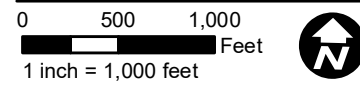


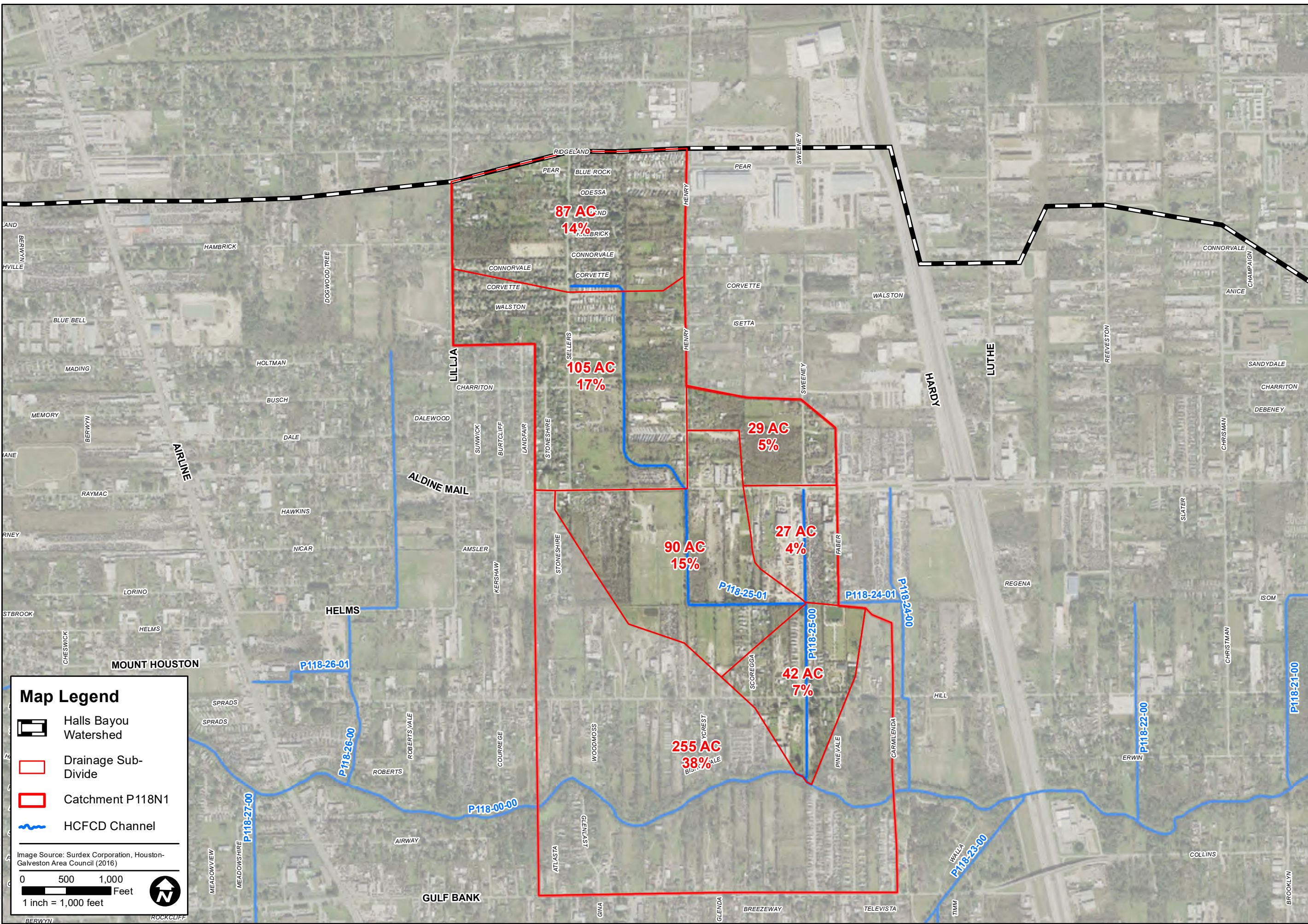
-  P118-25-00/01 Drainage Area
-  Halls Bayou Watershed
-  HCFCF ROW
-  HCFCF Channel

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



HCFCF HALLS BAYOU WATERSHED P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS		
EXISTING HCFCF ROW		
PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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 <p style="font-size: small; margin-top: 5px;"> HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092 </p>		
DATE: AUG 2019 SCALE: AS NOTED		
EXHIBIT 4		

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 Date: 10/4/2019 Time: 5:27:02 PM



Map Legend

- Halls Bayou Watershed
- Drainage Sub-Divide
- Catchment P118N1
- HCFCD Channel

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

DRAINAGE AREA DELINEATION SUBDIVIDES

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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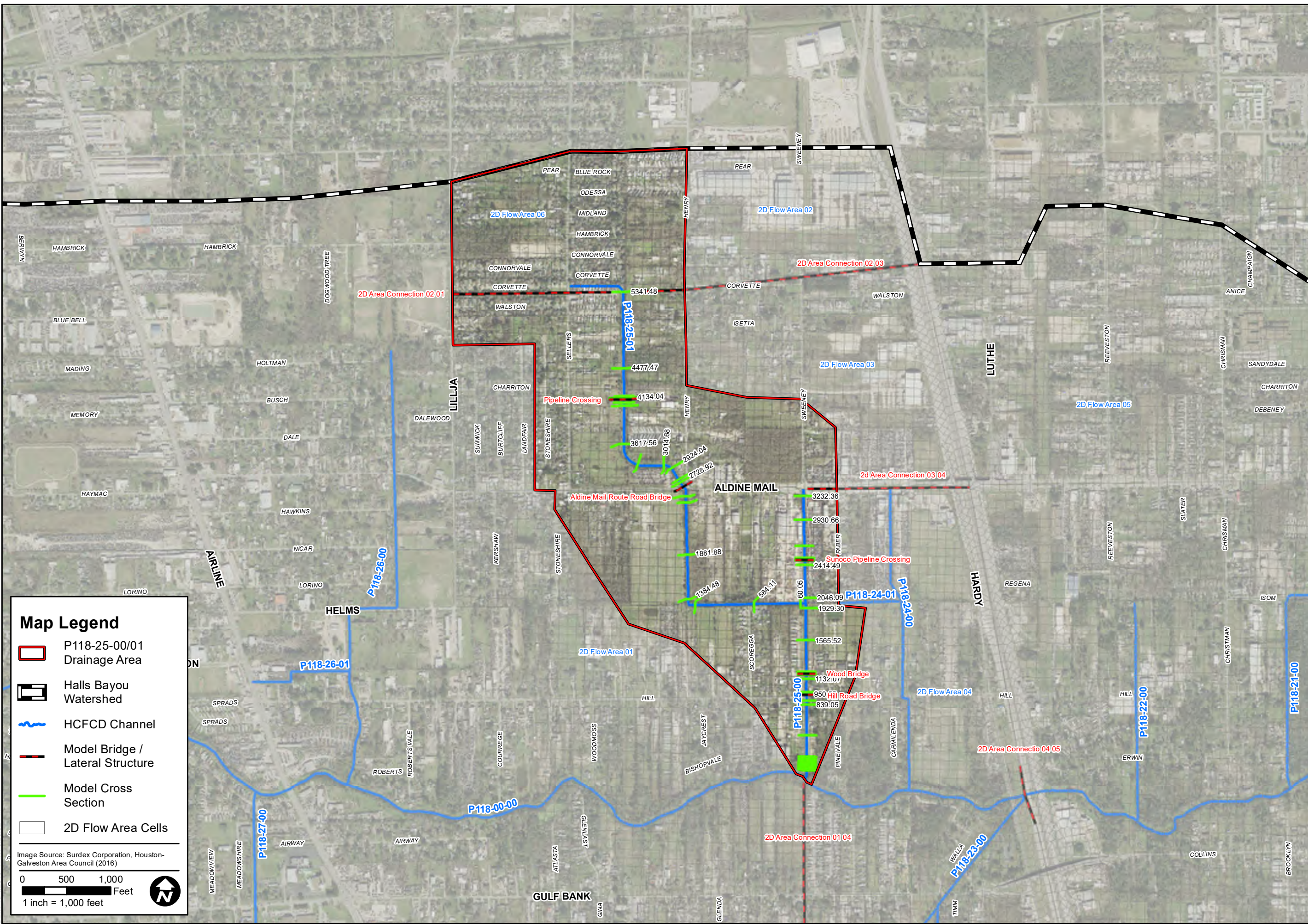
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EXHIBIT
 5

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- ~ HCFCD Channel
- Model Bridge / Lateral Structure
- Model Cross Section
- 2D Flow Area Cells

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 500 1,000
Feet

1 inch = 1,000 feet

HCFCD HALLS BAYOU WATERSHED
P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

HEC-RAS GEOMETRY
BASELINE CONDITIONS

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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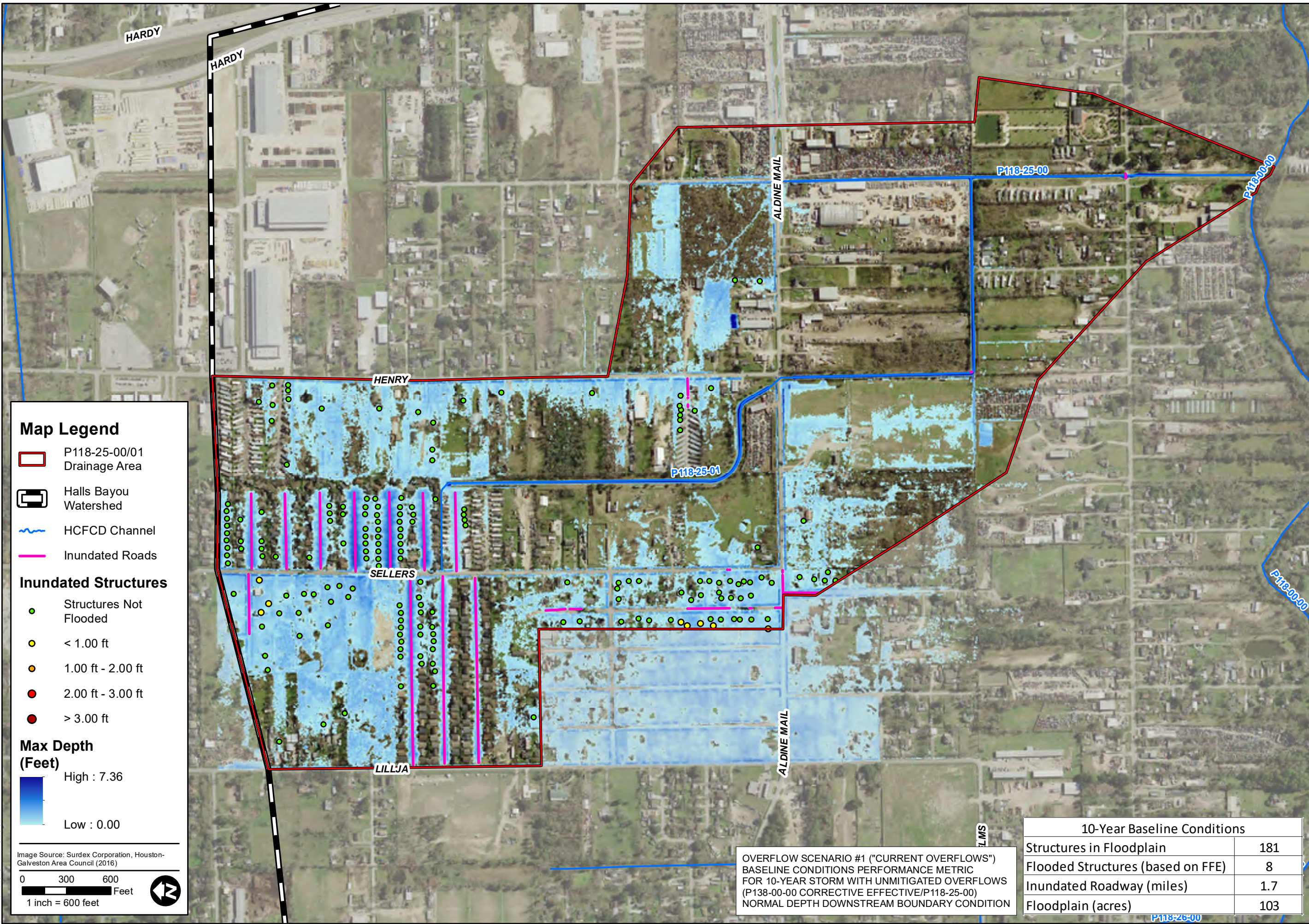
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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCO Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

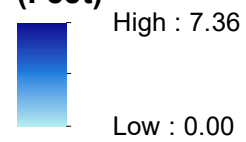
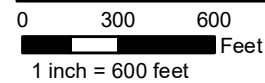


Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



OVERFLOW SCENARIO #1 ("CURRENT OVERFLOWS")
 BASELINE CONDITIONS PERFORMANCE METRIC
 FOR 10-YEAR STORM WITH UNMITIGATED OVERFLOWS
 (P138-00-00 CORRECTIVE EFFECTIVE/P118-25-00)
 NORMAL DEPTH DOWNSTREAM BOUNDARY CONDITION

10-Year Baseline Conditions	
Structures in Floodplain	181
Flooded Structures (based on FFE)	8
Inundated Roadway (miles)	1.7
Floodplain (acres)	103

HCFCO HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 PERFORMANCE METRICS
 BASELINE CONDITIONS - 10-YEAR STORM EVENT

PREPARED: CWB
 CHECKED: LM
 APPROVED: CEE

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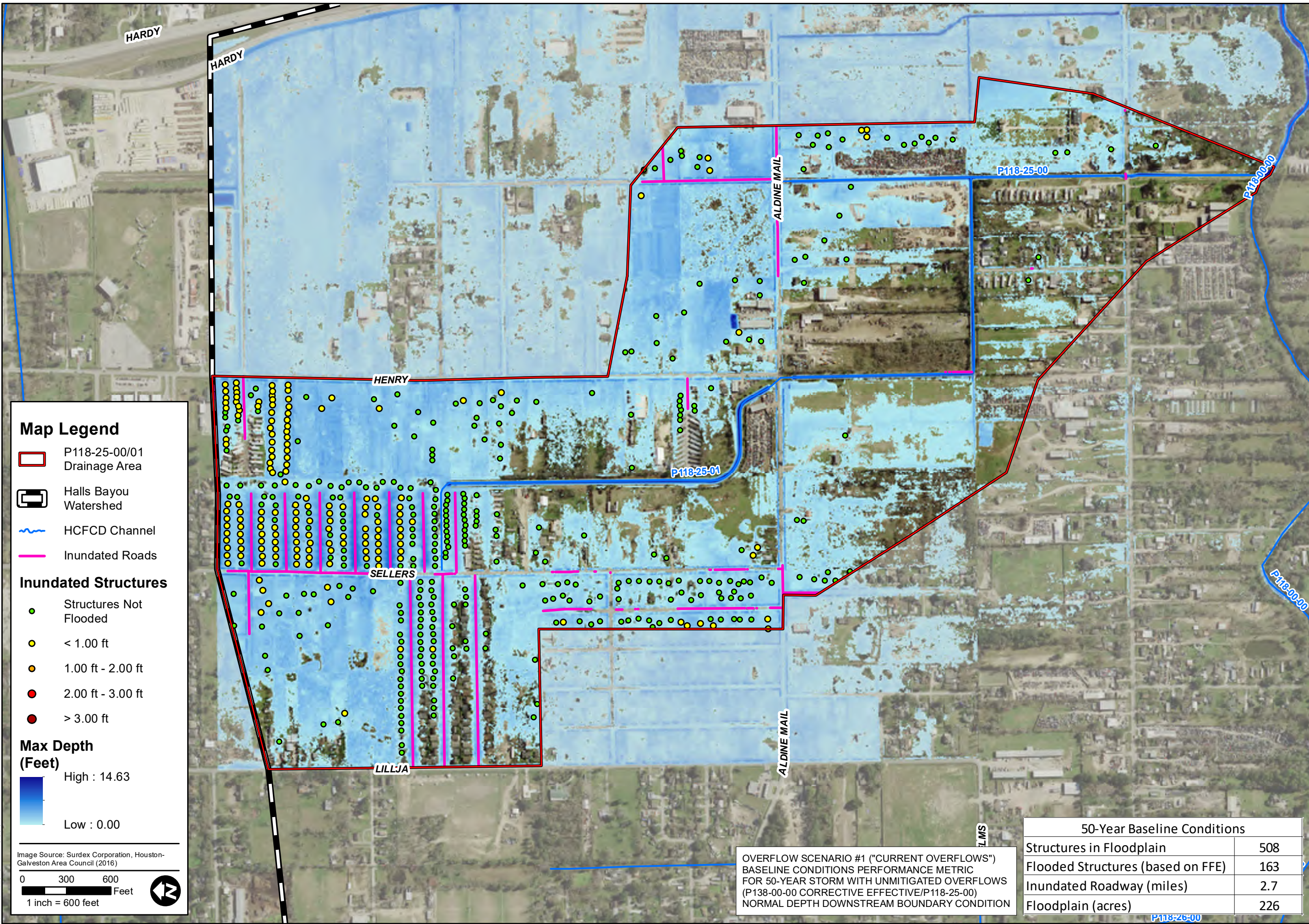
HARRIS COUNTY FLOOD CONTROL DISTRICT

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DATE: AUG 2019
 SCALE: AS NOTED

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 7

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 Date: 11/14/2019 Time: 3:30:54 PM



Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

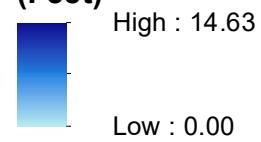
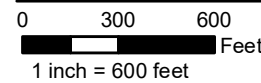


Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



OVERFLOW SCENARIO #1 ("CURRENT OVERFLOWS")
 BASELINE CONDITIONS PERFORMANCE METRIC
 FOR 50-YEAR STORM WITH UNMITIGATED OVERFLOWS
 (P138-00-00 CORRECTIVE EFFECTIVE/P118-25-00)
 NORMAL DEPTH DOWNSTREAM BOUNDARY CONDITION

50-Year Baseline Conditions	
Structures in Floodplain	508
Flooded Structures (based on FFE)	163
Inundated Roadway (miles)	2.7
Floodplain (acres)	226

HCFCF HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 PERFORMANCE METRICS
 BASELINE CONDITIONS - 50-YEAR STORM EVENT

PREPARED: CWB
 CHECKED: LM
 APPROVED: CEE

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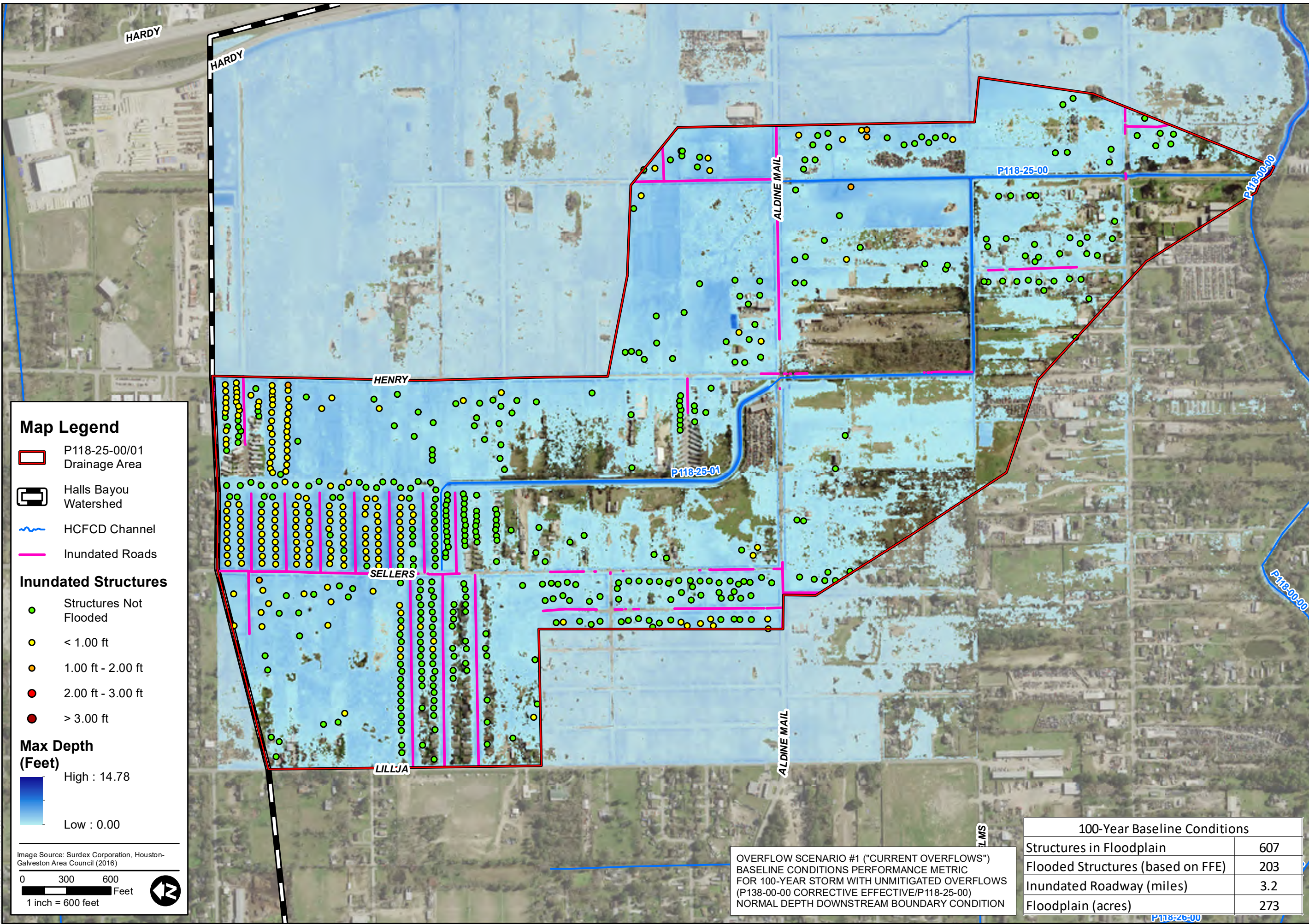


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DATE: AUG 2019
 SCALE: AS NOTED

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 8

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

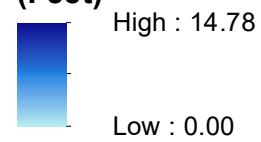
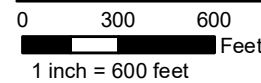


Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



OVERFLOW SCENARIO #1 ("CURRENT OVERFLOWS")
 BASELINE CONDITIONS PERFORMANCE METRIC
 FOR 100-YEAR STORM WITH UNMITIGATED OVERFLOWS
 (P138-00-00 CORRECTIVE EFFECTIVE/P118-25-00)
 NORMAL DEPTH DOWNSTREAM BOUNDARY CONDITION

100-Year Baseline Conditions	
Structures in Floodplain	607
Flooded Structures (based on FFE)	203
Inundated Roadway (miles)	3.2
Floodplain (acres)	273

HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 PERFORMANCE METRICS
 BASELINE CONDITIONS - 100-YEAR STORM EVENT

PREPARED: CWB
 CHECKED: LM
 APPROVED: CEE

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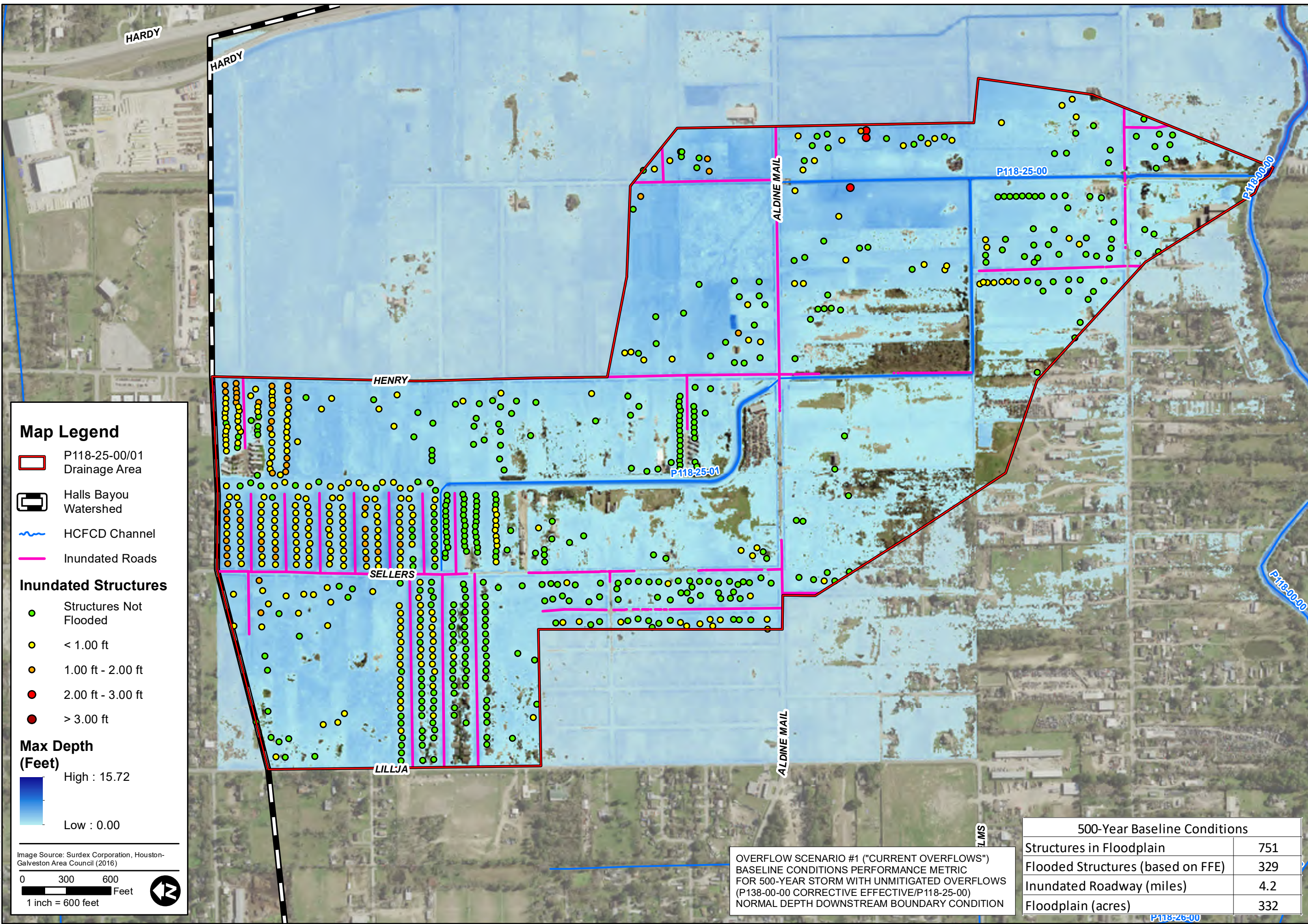
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9900 Northwest Freeway
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DATE: AUG 2019
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 9

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFC D Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

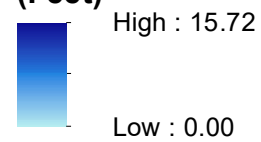
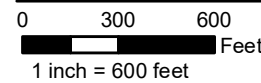


Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



OVERFLOW SCENARIO #1 ("CURRENT OVERFLOWS")
 BASELINE CONDITIONS PERFORMANCE METRIC
 FOR 500-YEAR STORM WITH UNMITIGATED OVERFLOWS
 (P138-00-00 CORRECTIVE EFFECTIVE/P118-25-00)
 NORMAL DEPTH DOWNSTREAM BOUNDARY CONDITION

500-Year Baseline Conditions	
Structures in Floodplain	751
Flooded Structures (based on FFE)	329
Inundated Roadway (miles)	4.2
Floodplain (acres)	332

HCFC D HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 PERFORMANCE METRICS
 BASELINE CONDITIONS - 500-YEAR STORM EVENT

PREPARED: CWB
 CHECKED: LM
 APPROVED: CEE

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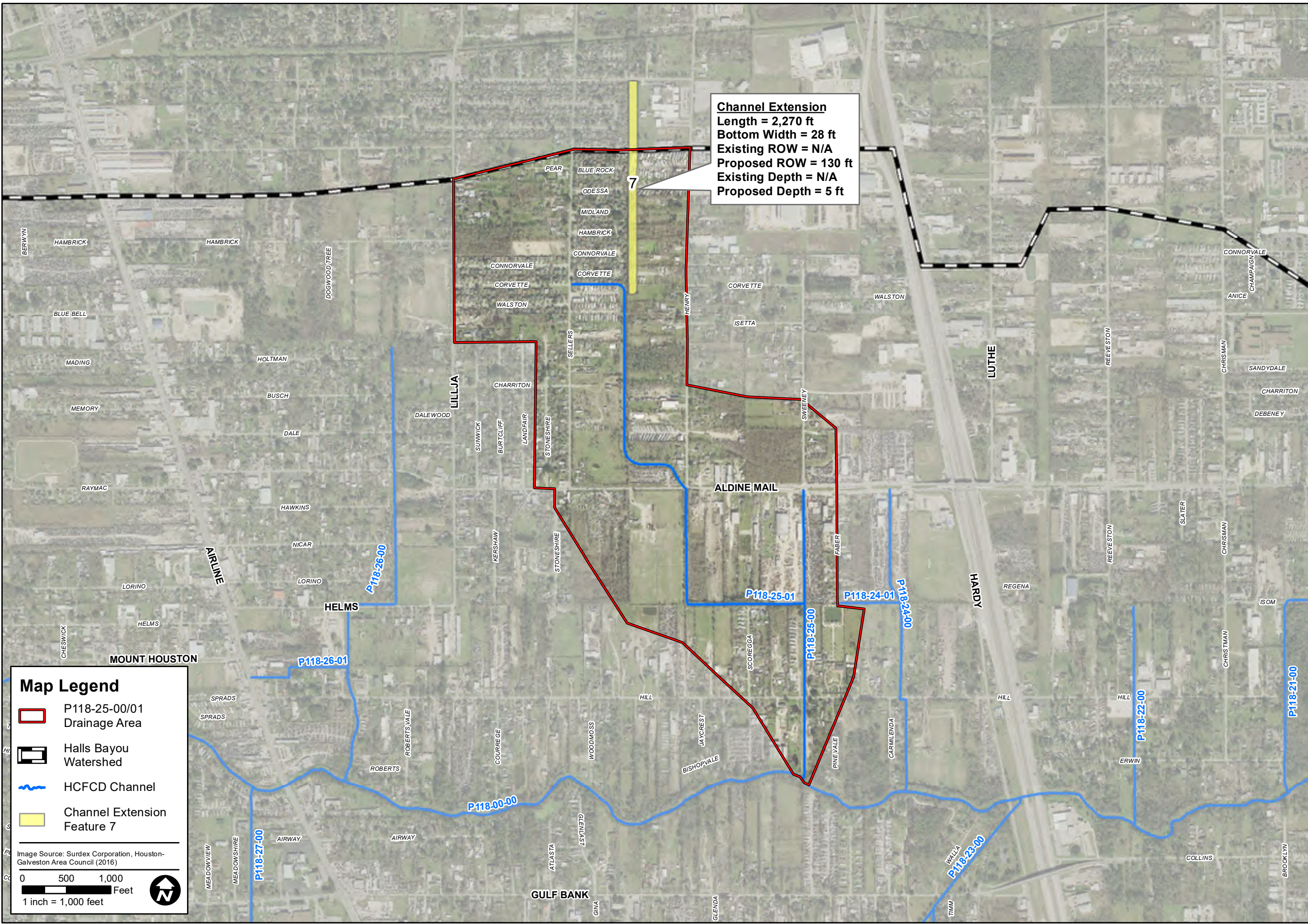


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DATE: AUG 2019
 SCALE: AS NOTED






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Channel Extension
 Length = 2,270 ft
 Bottom Width = 28 ft
 Existing ROW = N/A
 Proposed ROW = 130 ft
 Existing Depth = N/A
 Proposed Depth = 5 ft

Map Legend

-  P118-25-00/01 Drainage Area
 -  Halls Bayou Watershed
 -  HCFC Channel
 -  Channel Extension Feature 7
- Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)
- 0 500 1,000 Feet
 1 inch = 1,000 feet
- 

HCFC HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 DETAILED LEVEL ANALYSIS
 ALTERNATIVE 1 LAYOUT

PREPARED:	CWB
CHECKED:	LM
APPROVED:	CEE



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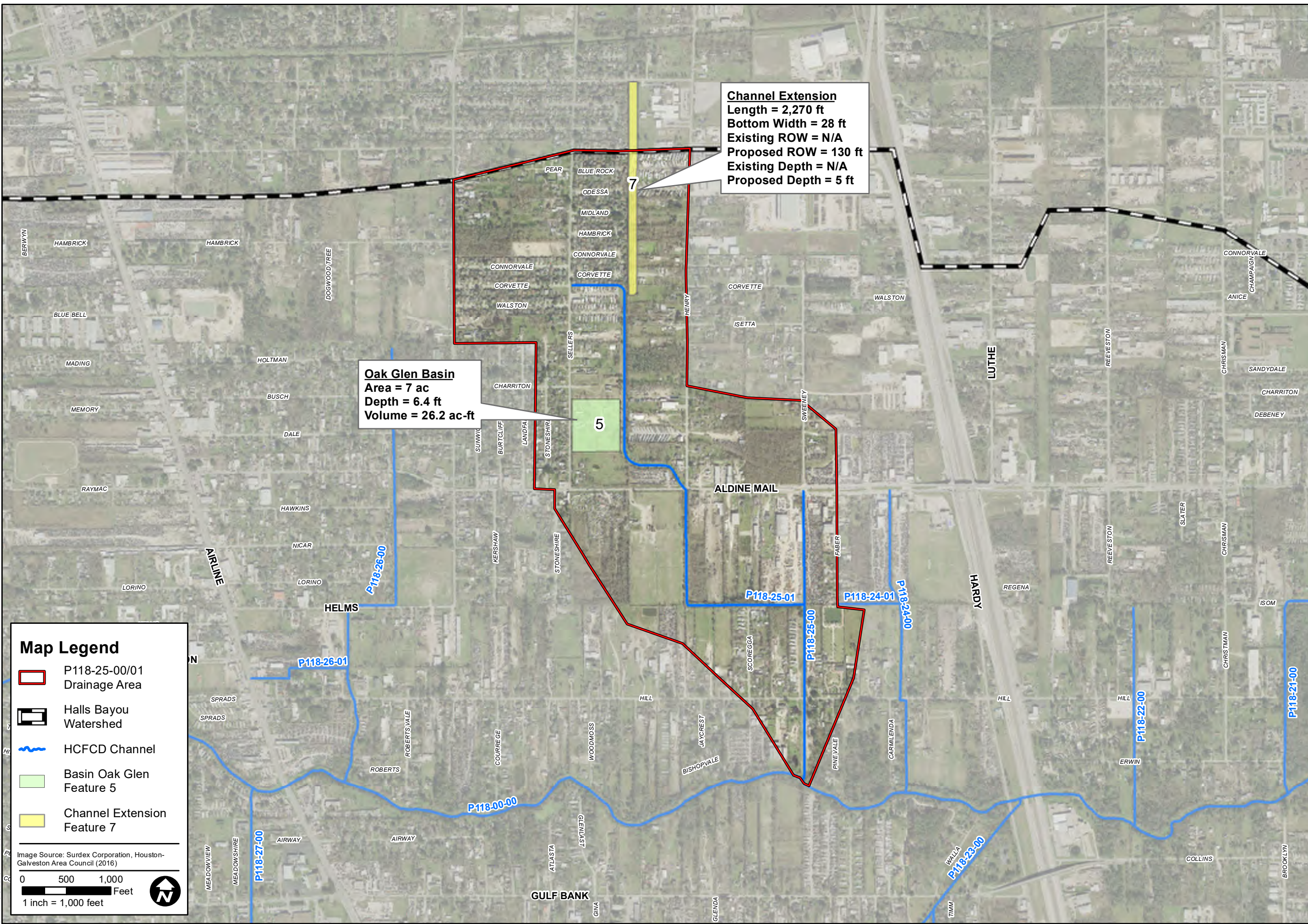


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 11

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Basin Oak Glen Feature 5
- Channel Extension Feature 7

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

**DETAILED LEVEL ANALYSIS
 ALTERNATIVE 2 LAYOUT**

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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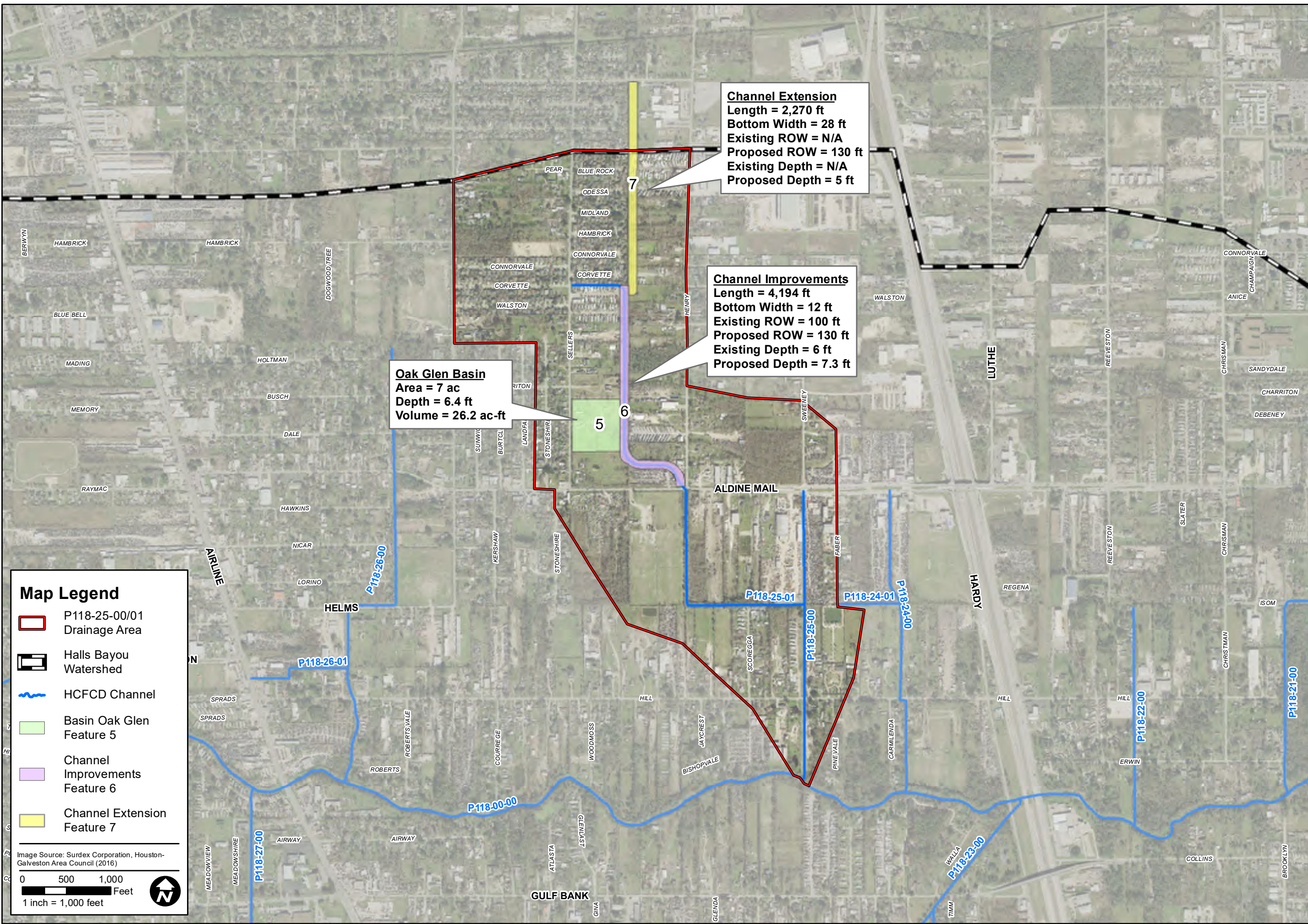
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9900 Northwest Freeway
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DATE: AUG 2019
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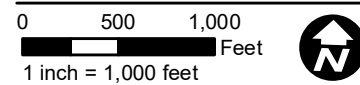
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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- ~ HCFCD Channel
- Basin Oak Glen Feature 5
- Channel Improvements Feature 6
- Channel Extension Feature 7

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



Oak Glen Basin
 Area = 7 ac
 Depth = 6.4 ft
 Volume = 26.2 ac-ft

Channel Extension
 Length = 2,270 ft
 Bottom Width = 28 ft
 Existing ROW = N/A
 Proposed ROW = 130 ft
 Existing Depth = N/A
 Proposed Depth = 5 ft

Channel Improvements
 Length = 4,194 ft
 Bottom Width = 12 ft
 Existing ROW = 100 ft
 Proposed ROW = 130 ft
 Existing Depth = 6 ft
 Proposed Depth = 7.3 ft

**HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

**DETAILED LEVEL ANALYSIS
 ALTERNATIVE 3a LAYOUT**

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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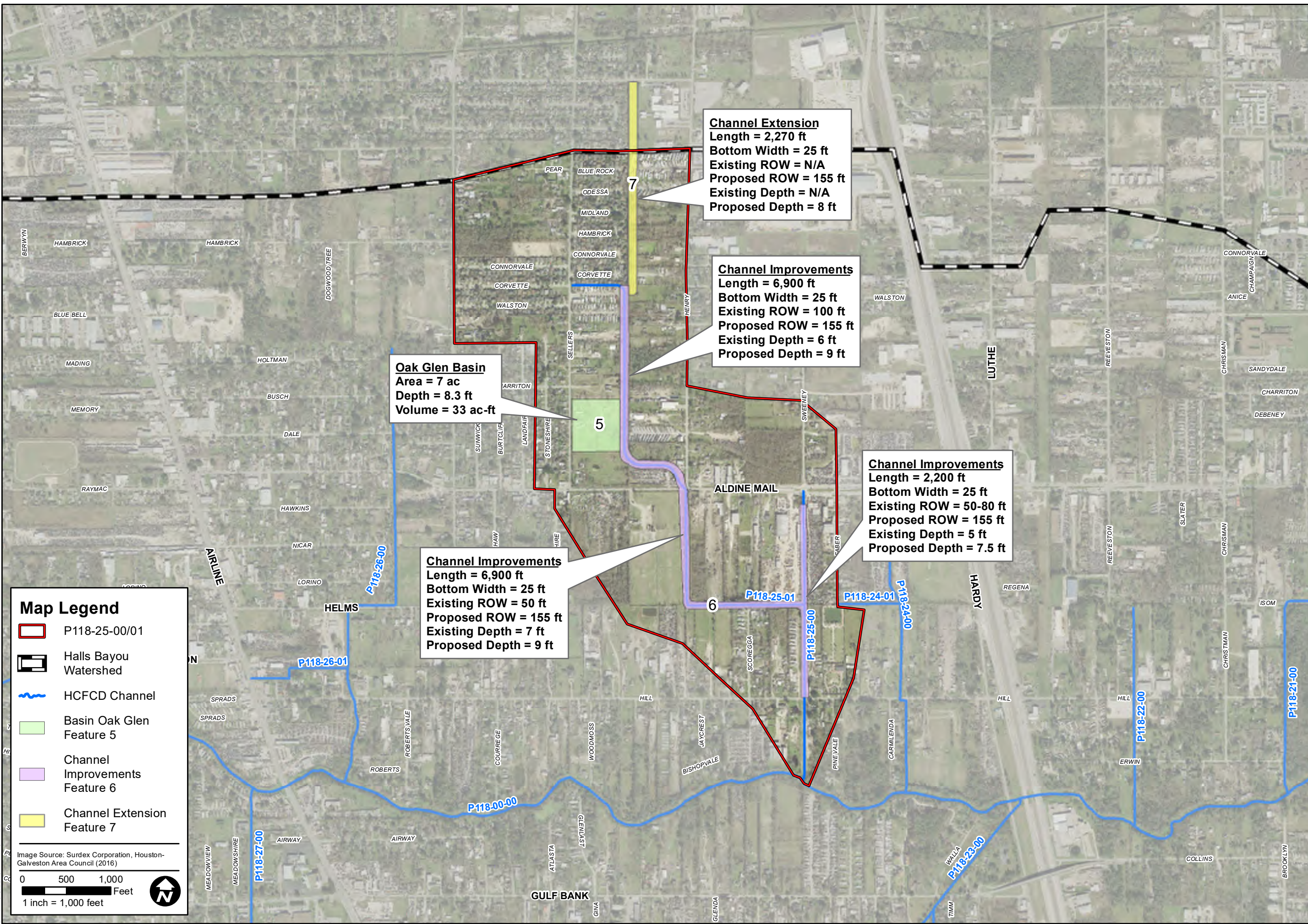
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DATE: AUG 2019
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Map Legend

- P118-25-00/01
- Halls Bayou Watershed
- HCFCD Channel
- Basin Oak Glen Feature 5
- Channel Improvements Feature 6
- Channel Extension Feature 7

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 500 1,000 Feet
 1 inch = 1,000 feet

Oak Glen Basin
 Area = 7 ac
 Depth = 8.3 ft
 Volume = 33 ac-ft

Channel Extension
 Length = 2,270 ft
 Bottom Width = 25 ft
 Existing ROW = N/A
 Proposed ROW = 155 ft
 Existing Depth = N/A
 Proposed Depth = 8 ft

Channel Improvements
 Length = 6,900 ft
 Bottom Width = 25 ft
 Existing ROW = 100 ft
 Proposed ROW = 155 ft
 Existing Depth = 6 ft
 Proposed Depth = 9 ft

Channel Improvements
 Length = 6,900 ft
 Bottom Width = 25 ft
 Existing ROW = 50 ft
 Proposed ROW = 155 ft
 Existing Depth = 7 ft
 Proposed Depth = 9 ft

Channel Improvements
 Length = 2,200 ft
 Bottom Width = 25 ft
 Existing ROW = 50-80 ft
 Proposed ROW = 155 ft
 Existing Depth = 5 ft
 Proposed Depth = 7.5 ft

HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 DETAILED LEVEL ANALYSIS
 RECOMMENDED ALTERNATIVE
 ALTERNATIVE 3b LAYOUT

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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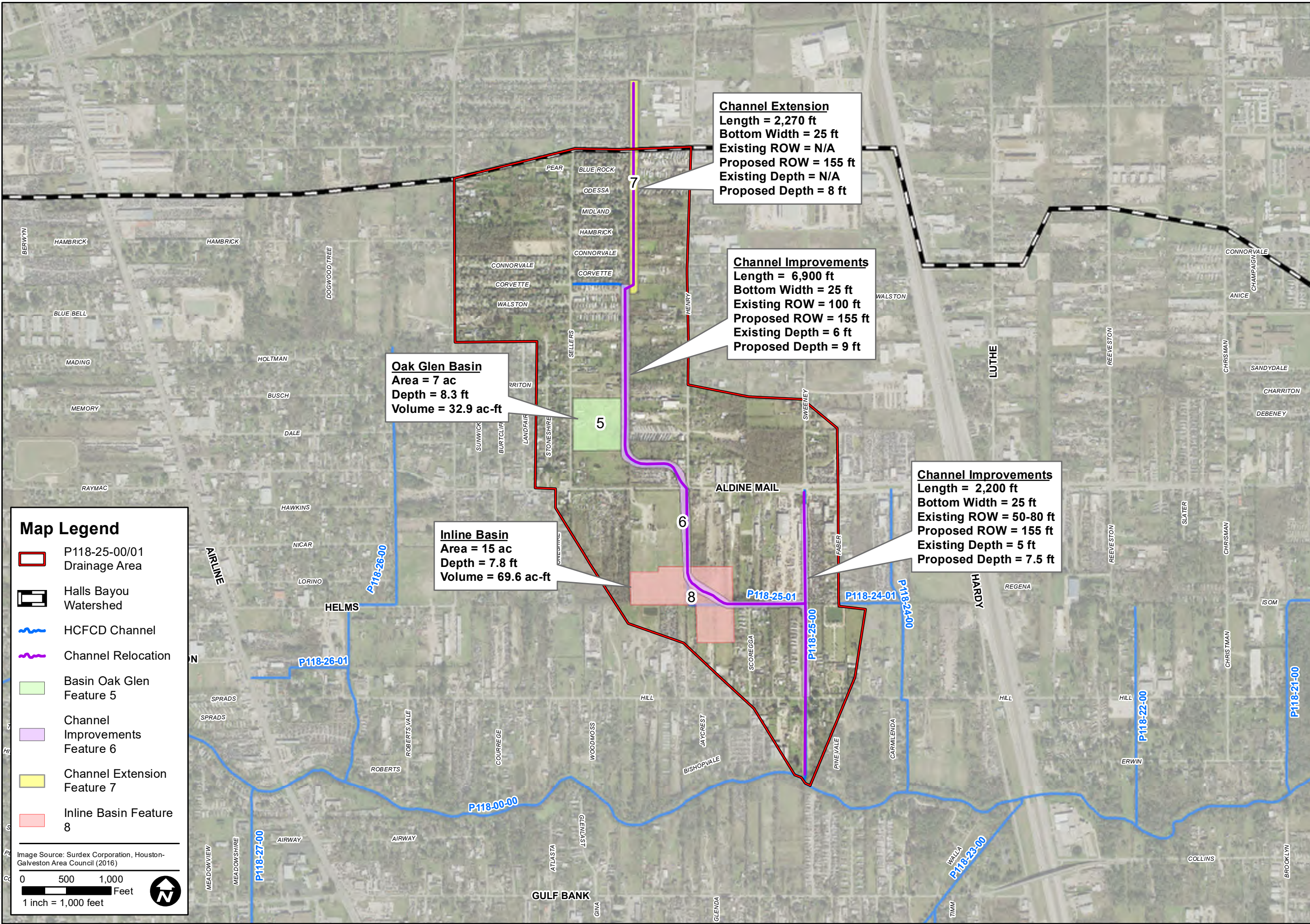
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EXHIBIT
 14

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- Channel Relocation
- Basin Oak Glen Feature 5
- Channel Improvements Feature 6
- Channel Extension Feature 7
- Inline Basin Feature 8

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 500 1,000 Feet
 1 inch = 1,000 feet

Oak Glen Basin
 Area = 7 ac
 Depth = 8.3 ft
 Volume = 32.9 ac-ft

Inline Basin
 Area = 15 ac
 Depth = 7.8 ft
 Volume = 69.6 ac-ft

Channel Extension
 Length = 2,270 ft
 Bottom Width = 25 ft
 Existing ROW = N/A
 Proposed ROW = 155 ft
 Existing Depth = N/A
 Proposed Depth = 8 ft

Channel Improvements
 Length = 6,900 ft
 Bottom Width = 25 ft
 Existing ROW = 100 ft
 Proposed ROW = 155 ft
 Existing Depth = 6 ft
 Proposed Depth = 9 ft

Channel Improvements
 Length = 2,200 ft
 Bottom Width = 25 ft
 Existing ROW = 50-80 ft
 Proposed ROW = 155 ft
 Existing Depth = 5 ft
 Proposed Depth = 7.5 ft

**HCFCF HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

**DETAILED LEVEL ANALYSIS
 ALTERNATIVE 4 LAYOUT**

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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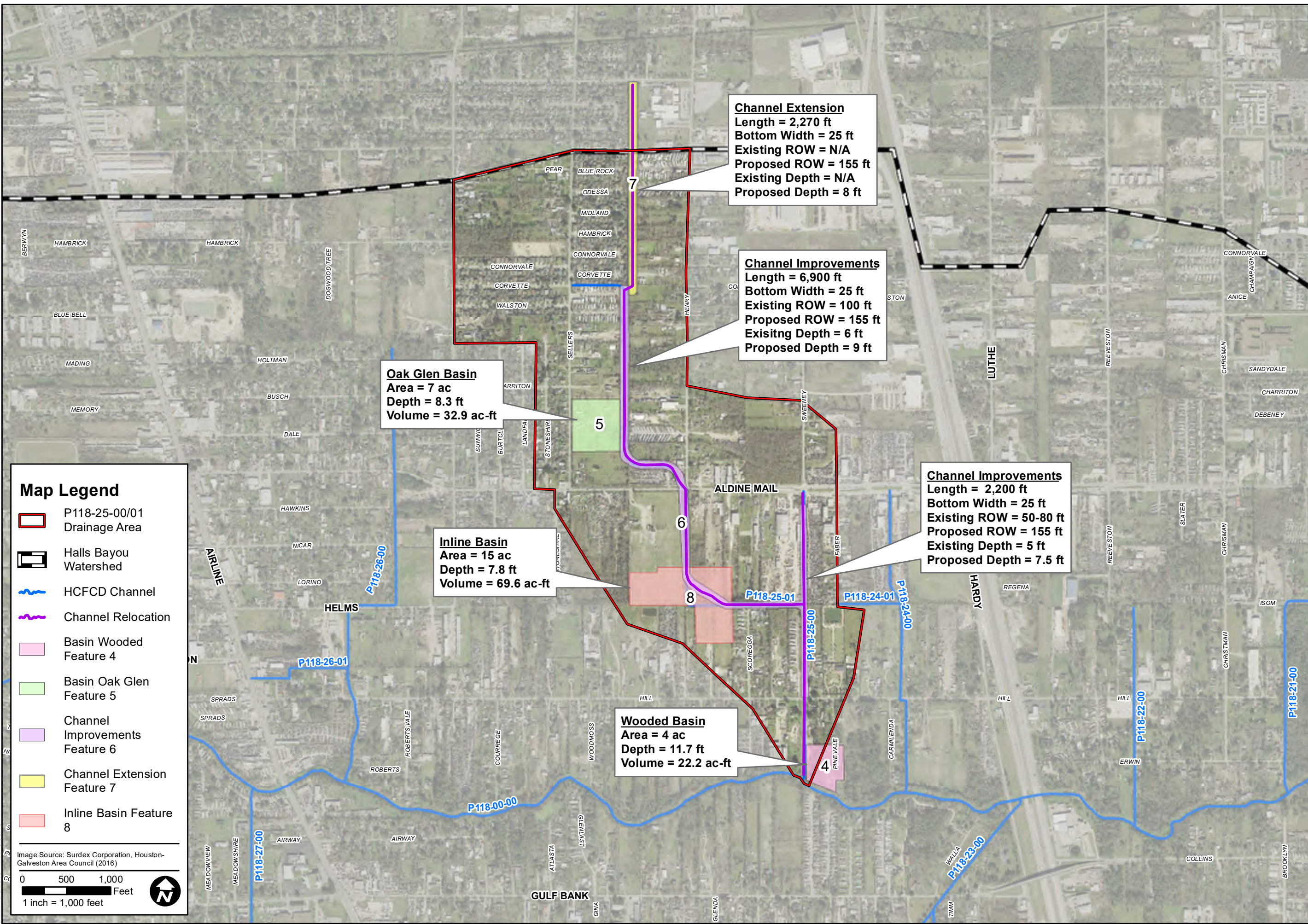
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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Channel Relocation
- Basin Wooded Feature 4
- Basin Oak Glen Feature 5
- Channel Improvements Feature 6
- Channel Extension Feature 7
- Inline Basin Feature 8

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

**DETAILED LEVEL ANALYSIS
 ALTERNATIVE 5a LAYOUT**

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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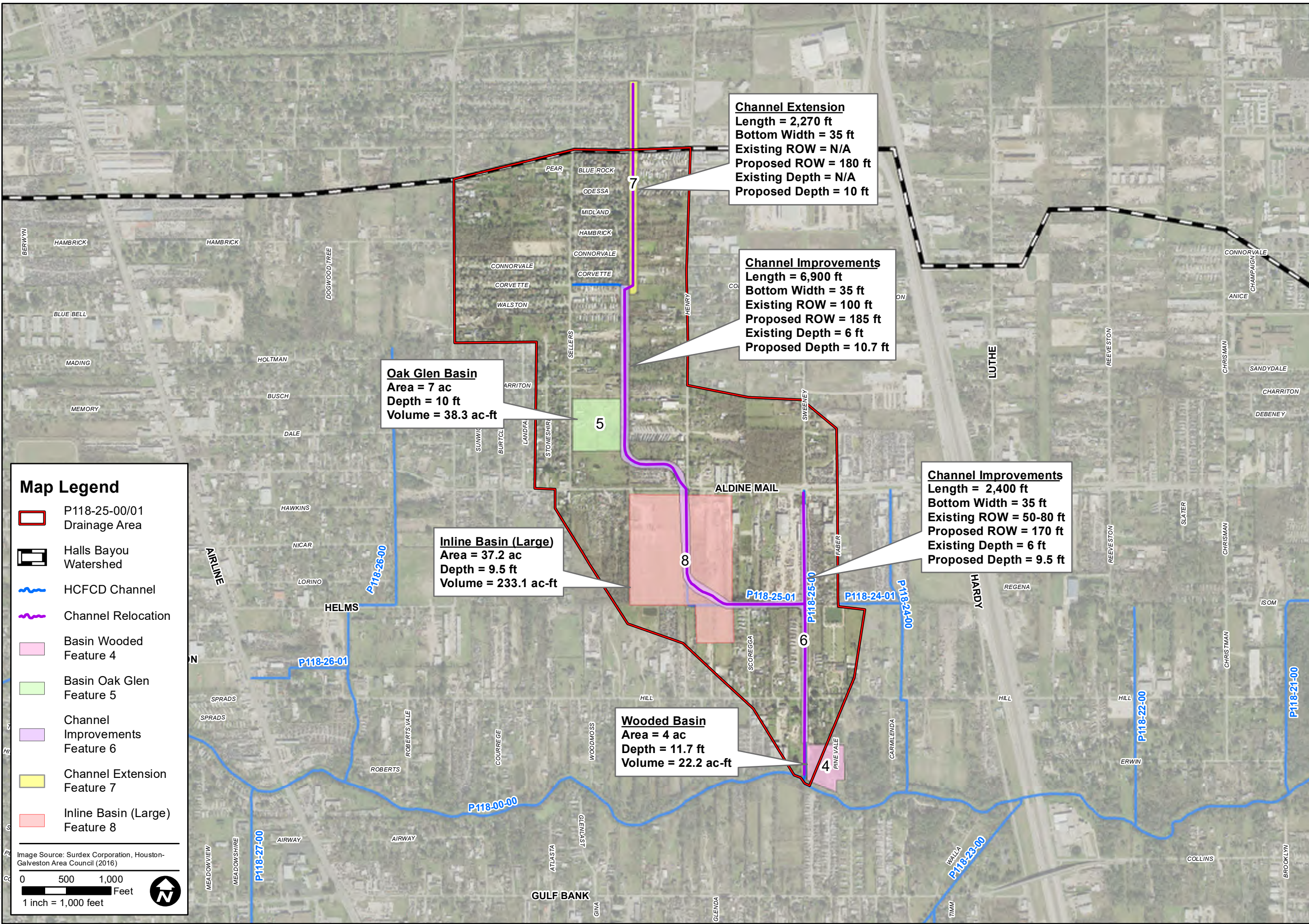
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9900 Northwest Freeway
 Houston, Texas 77092

DATE: AUG 2019
 SCALE: AS NOTED

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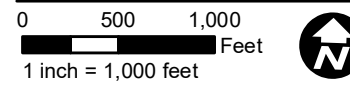
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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- Channel Relocation
- Basin Wooded Feature 4
- Basin Oak Glen Feature 5
- Channel Improvements Feature 6
- Channel Extension Feature 7
- In-line Basin (Large) Feature 8

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



Oak Glen Basin
 Area = 7 ac
 Depth = 10 ft
 Volume = 38.3 ac-ft

In-line Basin (Large)
 Area = 37.2 ac
 Depth = 9.5 ft
 Volume = 233.1 ac-ft

Wooded Basin
 Area = 4 ac
 Depth = 11.7 ft
 Volume = 22.2 ac-ft

Channel Extension
 Length = 2,270 ft
 Bottom Width = 35 ft
 Existing ROW = N/A
 Proposed ROW = 180 ft
 Existing Depth = N/A
 Proposed Depth = 10 ft

Channel Improvements
 Length = 6,900 ft
 Bottom Width = 35 ft
 Existing ROW = 100 ft
 Proposed ROW = 185 ft
 Existing Depth = 6 ft
 Proposed Depth = 10.7 ft

Channel Improvements
 Length = 2,400 ft
 Bottom Width = 35 ft
 Existing ROW = 50-80 ft
 Proposed ROW = 170 ft
 Existing Depth = 6 ft
 Proposed Depth = 9.5 ft

HCFCF HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 DETAILED LEVEL ANALYSIS
 ALTERNATIVE 5b LAYOUT

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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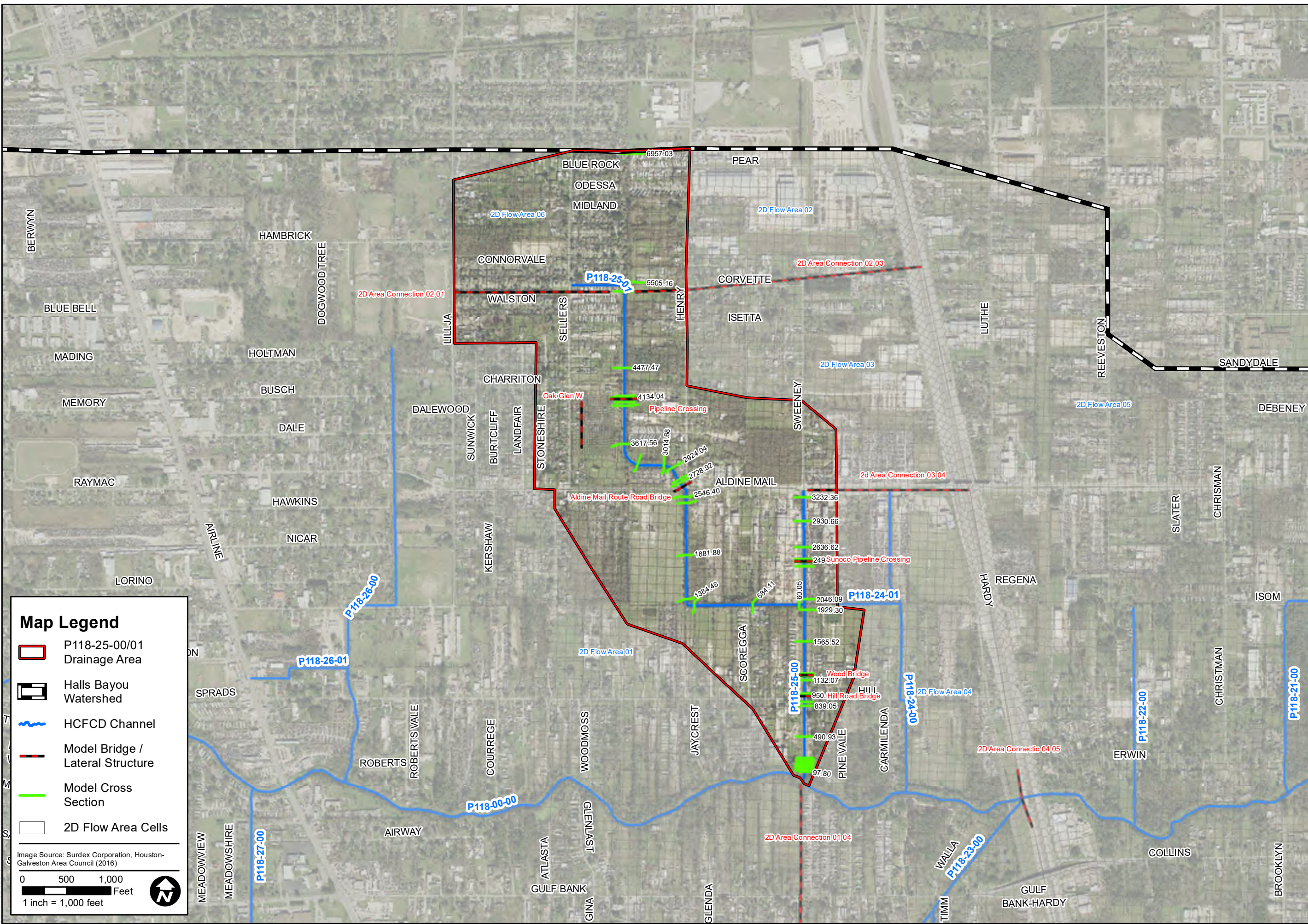
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 TBPE Firm No. 2614
 2925 Briarpark Drive • Houston, TX 77042-3720
 T 713.266.6900 • F 713.266.2089
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 17

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- ~ HCFCD Channel
- Model Bridge / Lateral Structure
- Model Cross Section
- 2D Flow Area Cells

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 500 1,000 Feet
 1 inch = 1,000 feet

HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

**HEC-RAS GEOMETRY
 RECOMMENDED ALTERNATIVE 3b**

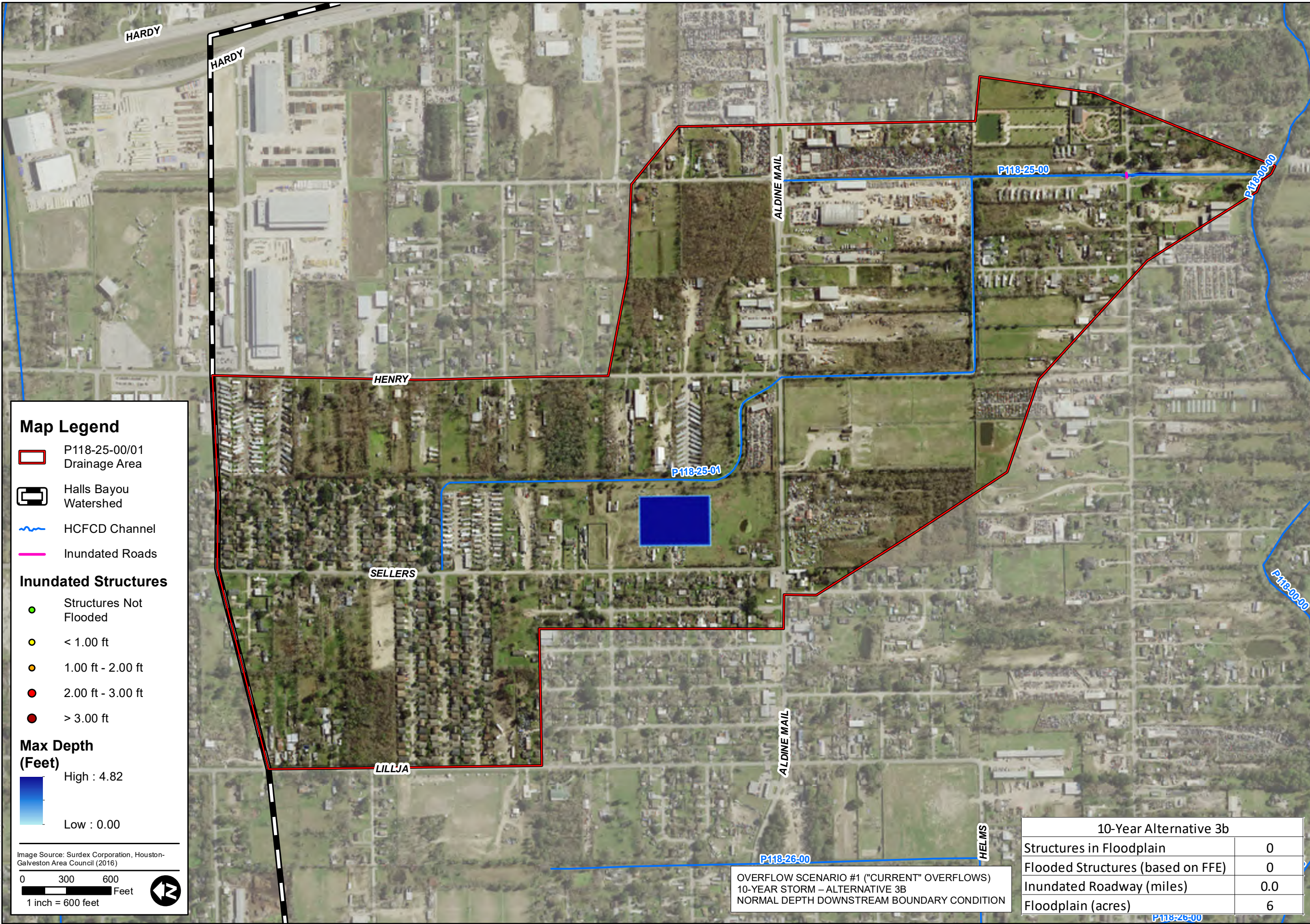
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 T 713.266.6900 • F 713.266.2089
 www.lan-inc.com • info@lan-inc.com

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

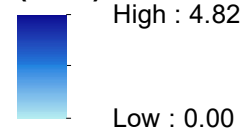
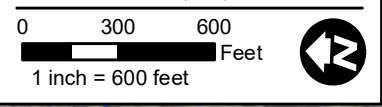


Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 PERFORMANCE METRICS
 RECOMMENDED ALTERNATIVE 3b
 10-YEAR STORM EVENT

PREPARED:	CWB
CHECKED:	LM
APPROVED:	CEE

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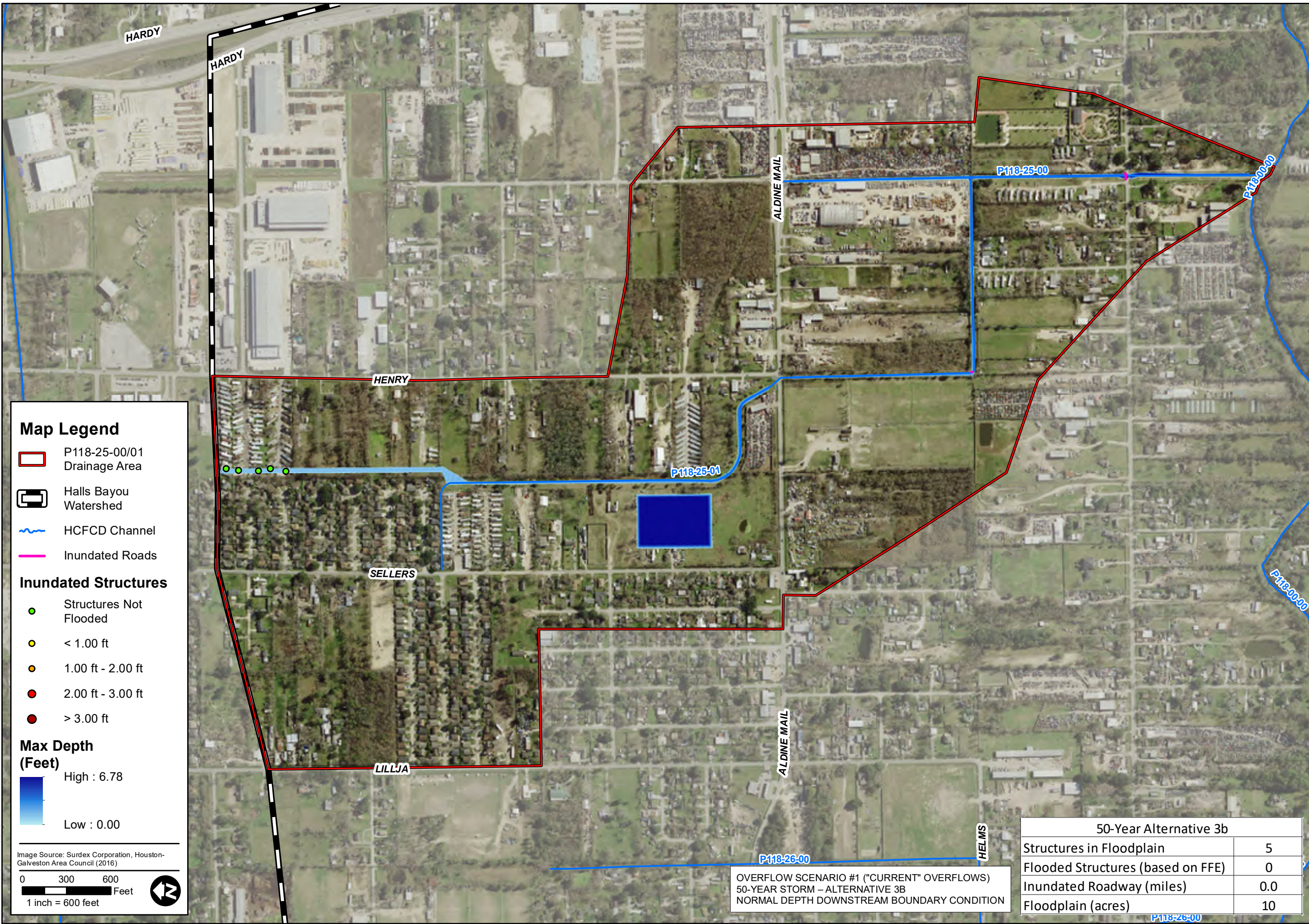
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 SCALE: AS NOTED

EXHIBIT
 19

10-Year Alternative 3b	
Structures in Floodplain	0
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.0
Floodplain (acres)	6

OVERFLOW SCENARIO #1 ("CURRENT" OVERFLOWS)
 10-YEAR STORM – ALTERNATIVE 3B
 NORMAL DEPTH DOWNSTREAM BOUNDARY CONDITION

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

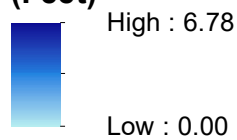
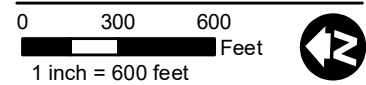


Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



HCFCF HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 PERFORMANCE METRICS
 RECOMMENDED ALTERNATIVE 3b
 50-YEAR STORM EVENT

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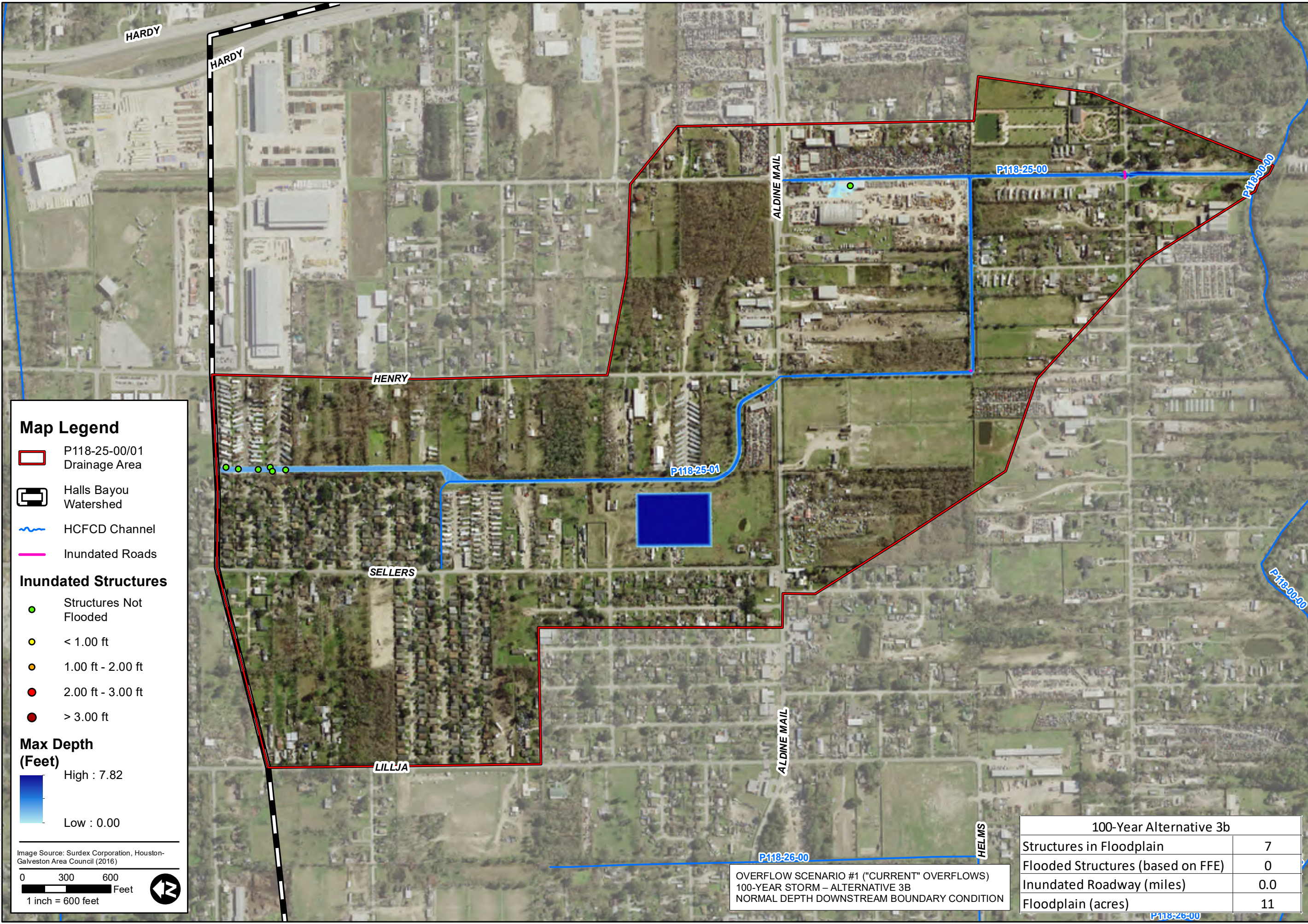
DATE: AUG 2019
 SCALE: AS NOTED

EXHIBIT
 20

50-Year Alternative 3b	
Structures in Floodplain	5
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.0
Floodplain (acres)	10

OVERFLOW SCENARIO #1 ("CURRENT" OVERFLOWS)
 50-YEAR STORM – ALTERNATIVE 3B
 NORMAL DEPTH DOWNSTREAM BOUNDARY CONDITION

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCO Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

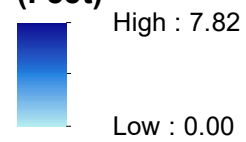
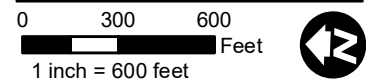


Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



HCFCO HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 PERFORMANCE METRICS
 RECOMMENDED ALTERNATIVE 3b
 100-YEAR STORM EVENT

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 CHECKED: LM
 APPROVED: CEE

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 2925 Briarpark Drive • Houston, TX 77042-3720
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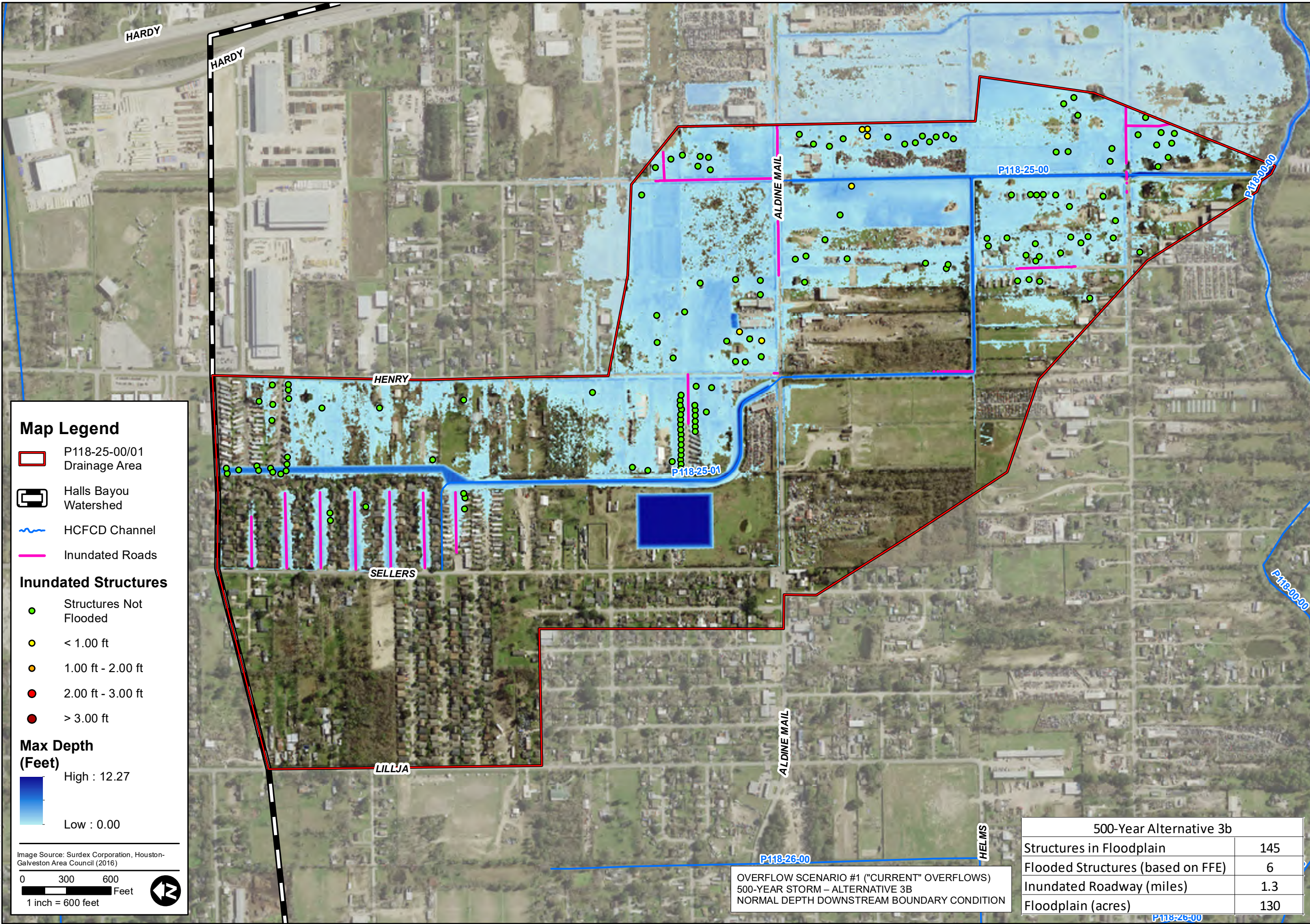
DATE: AUG 2019
 SCALE: AS NOTED

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 21

100-Year Alternative 3b	
Structures in Floodplain	7
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.0
Floodplain (acres)	11

OVERFLOW SCENARIO #1 ("CURRENT" OVERFLOWS)
 100-YEAR STORM – ALTERNATIVE 3B
 NORMAL DEPTH DOWNSTREAM BOUNDARY CONDITION

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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

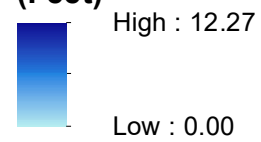
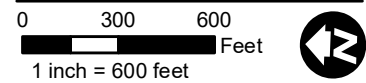


Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



500-Year Alternative 3b	
Structures in Floodplain	145
Flooded Structures (based on FFE)	6
Inundated Roadway (miles)	1.3
Floodplain (acres)	130

OVERFLOW SCENARIO #1 ("CURRENT" OVERFLOWS)
 500-YEAR STORM - ALTERNATIVE 3B
 NORMAL DEPTH DOWNSTREAM BOUNDARY CONDITION

HCFCF HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 PERFORMANCE METRICS
 RECOMMENDED ALTERNATIVE 3b
 500-YEAR STORM EVENT

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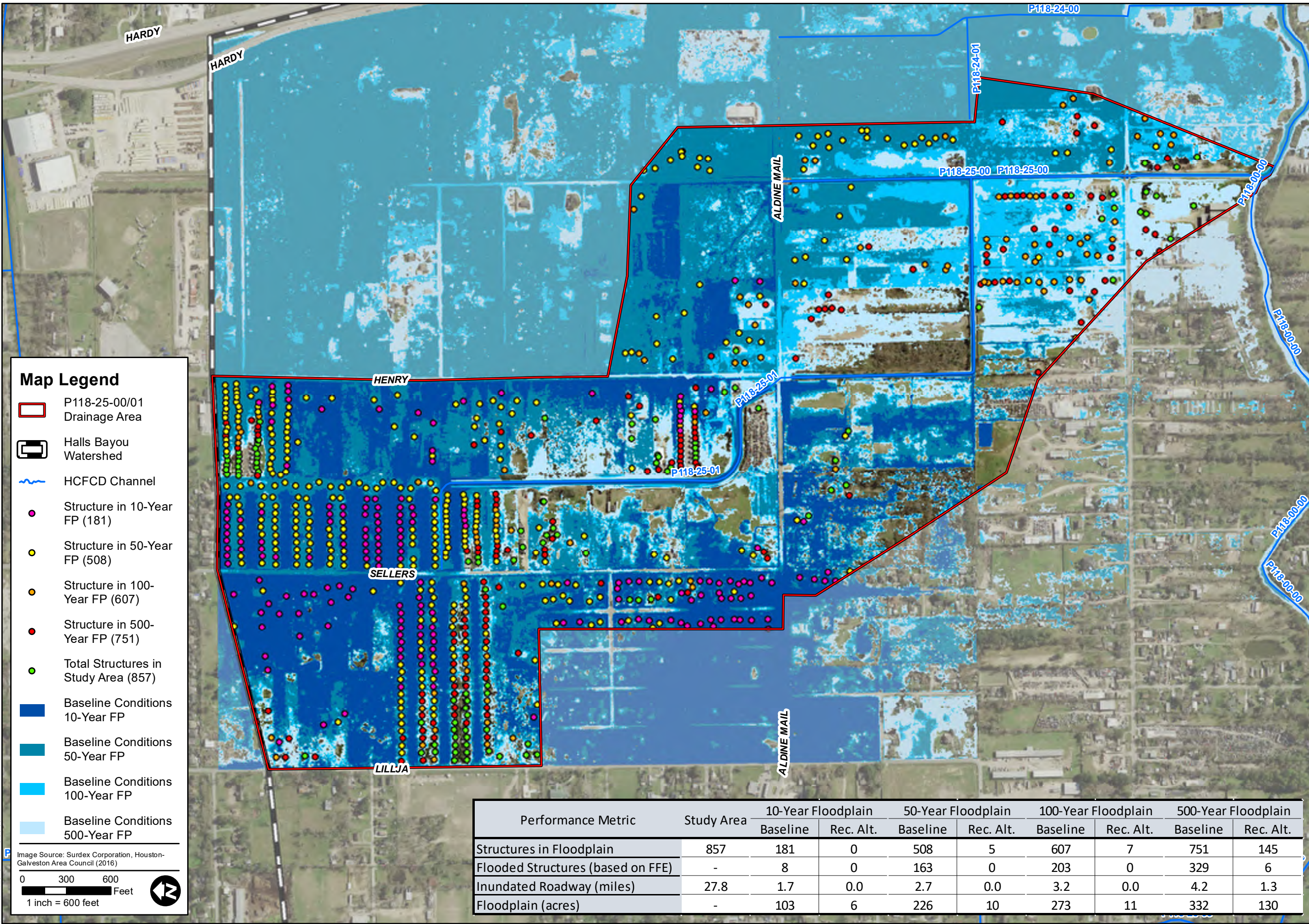


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EXHIBIT
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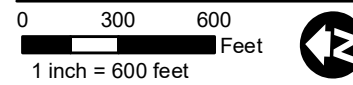
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Map Legend

- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structure in 10-Year FP (181)
- Structure in 50-Year FP (508)
- Structure in 100-Year FP (607)
- Structure in 500-Year FP (751)
- Total Structures in Study Area (857)
- Baseline Conditions 10-Year FP
- Baseline Conditions 50-Year FP
- Baseline Conditions 100-Year FP
- Baseline Conditions 500-Year FP

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)



Performance Metric	Study Area	10-Year Floodplain		50-Year Floodplain		100-Year Floodplain		500-Year Floodplain	
		Baseline	Rec. Alt.	Baseline	Rec. Alt.	Baseline	Rec. Alt.	Baseline	Rec. Alt.
Structures in Floodplain	857	181	0	508	5	607	7	751	145
Flooded Structures (based on FFE)	-	8	0	163	0	203	0	329	6
Inundated Roadway (miles)	27.8	1.7	0.0	2.7	0.0	3.2	0.0	4.2	1.3
Floodplain (acres)	-	103	6	226	10	273	11	332	130

HCFCD HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
**PERFORMANCE METRICS
 RECOMMENDED ALTERNATIVE**

PREPARED: CWB	CHECKED: LM	APPROVED: CEE
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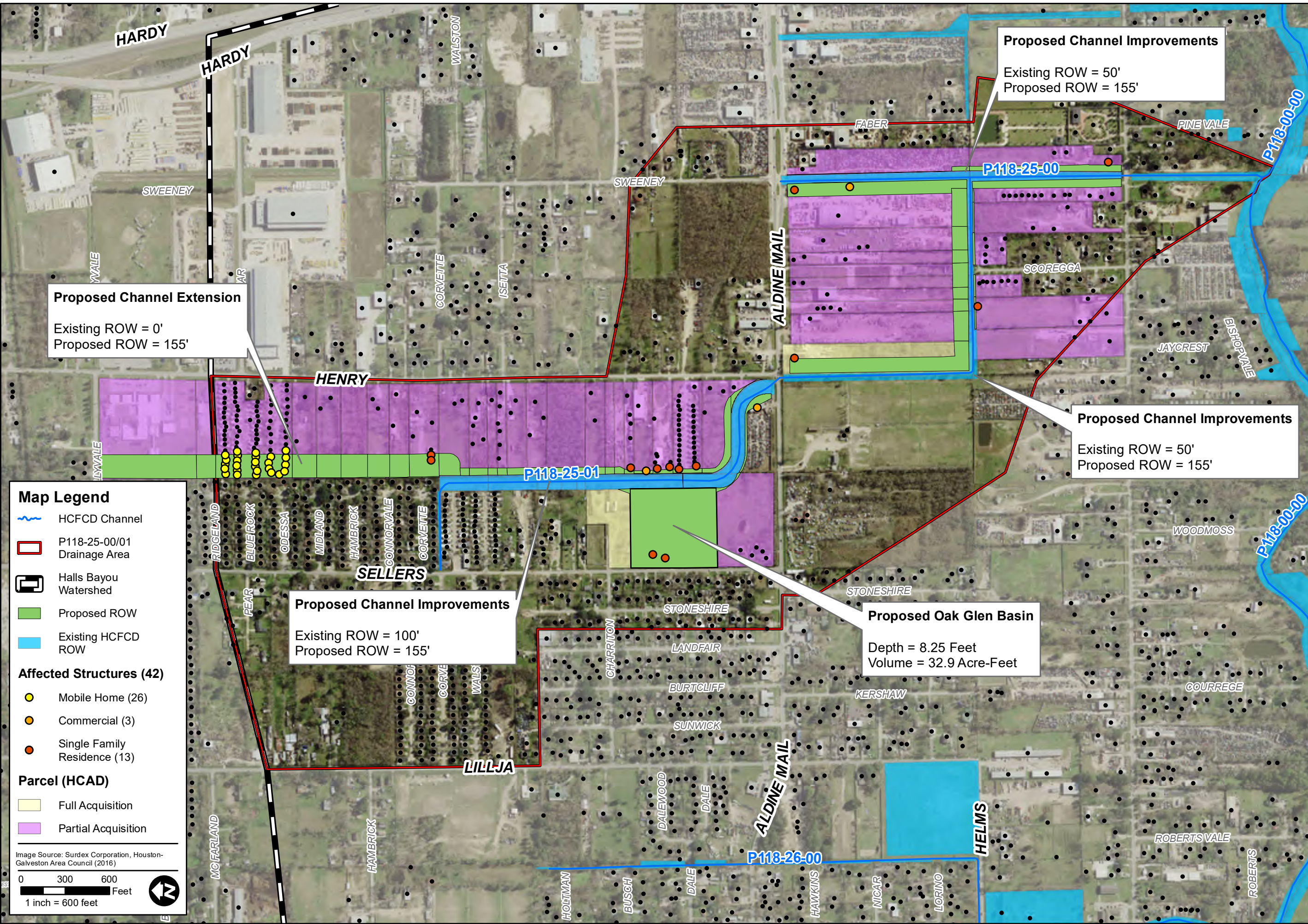
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 www.ign-inc.com • info@ign-inc.com

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EXHIBIT
 23

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Proposed Channel Extension
 Existing ROW = 0'
 Proposed ROW = 155'

Proposed Channel Improvements
 Existing ROW = 50'
 Proposed ROW = 155'

Proposed Channel Improvements
 Existing ROW = 50'
 Proposed ROW = 155'

Proposed Channel Improvements
 Existing ROW = 100'
 Proposed ROW = 155'

Proposed Oak Glen Basin
 Depth = 8.25 Feet
 Volume = 32.9 Acre-Feet

Map Legend

- HCFC Channel
- P118-25-00/01 Drainage Area
- Halls Bayou Watershed
- Proposed ROW
- Existing HCFC ROW

Affected Structures (42)

- Mobile Home (26)
- Commercial (3)
- Single Family Residence (13)

Parcel (HCAD)

- Full Acquisition
- Partial Acquisition

Image Source: Surdex Corporation, Houston-Galveston Area Council (2016)

0 300 600 Feet
 1 inch = 600 feet

HCFC HALLS BAYOU WATERSHED
 P118-25-00 & P118-25-01 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

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 A ILLINOIS SALLY 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

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EXHIBIT 24

PROPOSED ROW
 ALTERNATIVE 3b (RECOMMENDED)

APPENDIX G

NO ADVERSE IMPACT STUDY

**Halls Bayou Tributary Unit No. P118-25-00
Harris County**

No Adverse Impact Study

Prepared for:

RG Miller

F-14087



Prepared by:



HT&J, LLC

10351 Stella Link Road, Houston TX 77025

Ph: 832-767-0090 Fax: 832-767-0141

Engineering Registration No. F-14087

May 2022

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List of Exhibits

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- Exhibit 2 – FEMA Floodplain Map
- Exhibit 3 – HEC-RAS Geometry
- Exhibit 4 – 2-year Existing Conditions Inundation Map
- Exhibit 5 – 10-year Existing Conditions Inundation Map
- Exhibit 6 – 100-year Existing Conditions Inundation Map
- Exhibit 7 – 500-year Existing Conditions Inundation Map
- Exhibit 8 – 2-year Inundation Comparison Map
- Exhibit 9 – 10-year Inundation Comparison Map
- Exhibit 10 – 100-year Inundation Comparison Map
- Exhibit 11 – 500-year Inundation Comparison Map
- Exhibit 12 – Performance Metrics Boundary

List of Attachments

- Attachment 1 – Water Surface Elevation Profiles
- Attachment 2 – Maximum Water Surface Elevation Tabulation
- Attachment 3 – Model Review Comments

Executive Summary

This report involves the study on tributary P118-25-00 and sub-tributary P118-25-01. The purpose of this study is to update the proposed conditions developed by Lockwood, Andrews & Newnam, Inc. (LAN) and make recommendations to reduce flood risk in the surrounding area. The study and report called “Halls Bayou Tributary Unit No. P118-25-00/01 Alternative Analysis Summary Report” made by LAN in 2019 is referenced in this study. The hydrology and hydraulic models were developed by LAN for 10%, 1%, and 0.2% design storm events pre-Atlas 14 based on HCFCD criteria using HEC-HMS and HEC-RAS software. HT&J updated the provided HEC-RAS model based on the updated existing and proposed conditions terrain to assess the flood risk from the proposed improvements. HT&J also developed the 50% design storm events for the existing and proposed scenarios. The update was conducted for the provided P118-00-00 Halls Phasing HEC-RAS model with the implemented P118-25-00 and P118-25-01 model.

The recommended alternative that was proposed by LAN included a detention pond north of Aldine Mail Route Road. Additionally, channel improvements are included in this alternative upstream of Hill Road along P118-25-00 and P118-25-01 to increase conveyance. The channel improvement involves making the channel trapezoidal with a 25-foot bottom width, 4:1 side slope, and a depth of 8 feet, based on the proposed terrain. A channel extension is included between the northern extents of existing P118-25-01 and Hollyvale Drive. As for the dimensions, the proposed depth of the channel extension is 8 feet. The channel side slopes are set to be 4:1 with the bottom width of 25 feet. It is also recommended that the single 9 x 4 reinforced box culvert (RCB) along Aldine Mail Route Rd is replaced with two 9 x 6 RCBs and one 8 x 6 RCB.

HT&J updated the existing and proposed condition terrains based on the existing and proposed conditions surfaces, respectively. Modifications that were made to the proposed scenario include modifying the detention pond’s storage volume and the side weir to allow more flow into the detention pond. Additionally, the temporary restrictor was modified to improve the water surface elevation values downstream. Results of these modifications show that there is no impact downstream of the P118-25-00 system for all four storm events. In addition, the proposed improvements reduce ponding within the surroundings of P118-25-00 and P118-25-01 for all four storm events.

As a result of the analysis, 40 acre-feet of detention is recommended. In addition, it is recommended that the side weir be expanded to have a bottom width of 100 feet and a depth of 5.3 feet with a weir flow elevation of 70.4. It is also recommended that the temporary restrictor or sheet piling, be reduced to have an opening of 15 feet. No changes to the pond’s 12-inch outfall pipe are required. Table 1 presents the water surface elevation comparison table from P118-25-00 to Halls Bayou. The analysis shows that the proposed improvements will not cause any adverse impact to the receiving reach, Halls Bayou.

Table 1 – Water Surface Elevation Comparison

Storm Event	Existing Water Surface Elevation	Proposed Water Surface Elevation
2-year	69.7	69.4
10-year	71.1	70.8
100-year	72.4	71.9
500-year	73.6	72.6

As for the performance metrics, there is a decrease in ponding throughout the study area for the 2-, 10-, 100-, and 500-year events. The detention pond along the P118-25-01 channel and the channel modifications throughout the system benefit the surrounding drainage basin by decreasing the ponding depth. The performance metrics of the proposed conditions are evaluated based on structural flooding and the miles of road and total area removed from the existing floodplain. Table 2 presents the performance metrics across all four storm events.

Table 2 - Performance Metrics

Metric	2-Year Proposed Conditions		10-Year Proposed Conditions	
	Existing	Proposed	Existing	Proposed
Structures in Floodplain	72	64	360	281
Structures with recorded FFE in Floodplain	27	27	106	81
Flooded Structures (based on FFE)	0	0	4	2
Inundated Roadway (miles)	1.8	1.7	3.1	3
Floodplain (acres)	57.9	56.3	194	178

Metric	100-Year Proposed Conditions		500-Year Proposed Conditions	
	Existing	Proposed	Existing	Proposed
Structures in Floodplain	1446	1092	1738	1490
Structures with recorded FFE in Floodplain	378	277	440	400
Flooded Structures (based on FFE)	82	40	185	117
Inundated Roadway (miles)	7.6	6.4	9.6	8.6
Floodplain (acres)	653	529	769	694

1. Introduction

1.1 Purpose

The purpose of this report is to update the revised existing conditions and proposed conditions for tributary P118-25-00 and sub-tributary P118-25-01. The base of the proposed conditions in this analysis is the recommended alternative (3B) developed by Lockwood, Andrews & Newnam, Inc. (LAN). The study and report called “Halls Bayou Tributary Unit No. P118-25-00/01 Alternative Analysis Summary Report” made by LAN in 2019 is referenced in this study. HT&J updated and modified the proposed conditions to reduce flood risk in the surrounding area under the 2-Year, 10-Year, 100-Year, and 500-Year scenarios. HEC-RAS version 5.0.7 was used in this analysis.

1.2 Background

The previous study on P118-25-00 & P118-25-01 completed by LAN was part of the Harris County Flood Control District (HCFCD) Halls Bayou Flood Risk Reduction Phasing Study. HT&J updated the appropriate information to help reduce flood risk in the study area. In the past, this area has experienced significant flooding and the future improvements will help reduce the flood risk. The hydraulic models for tributary P118-25-00 and sub-tributary P118-25-01 were built by (LAN). The provided impacts analysis model made for Halls Bayou was revised in this study with the updated surface terrain for both existing and proposed conditions.

1.3 Study Area

The P118-25-00 and P118-25-01 tributaries that belong to HCFCD are located within the Halls Bayou Watershed (P118-00-00). This is located south of Beltway 8, west of Hardy Toll Road, and east of I-45. P118-25-00 is approximately 0.59 miles in length of open channel and P118-25-01 is approximately 1 mile in length. The land use around P118-25-00 and P118-25-01 consists primarily of mixed commercial and residential development. The topography of the surrounding area is characterized as being relatively flat. The study area lies within the 100-Year FEMA floodplain with some portions belonging in the 500-Year floodplain.

Exhibit 1 presents the vicinity map of the study area

Exhibit 2 presents the FEMA Floodplain Map

2. Existing Conditions Analysis

The existing conditions in this study stay consistent with the preliminary study made by LAN. The hydraulic models were developed by LAN as part of the HCFCD Halls Bayou Flood Risk Reduction Phasing Study. The existing surveyed terrain was overlaid to the 2018 LiDAR. The existing conditions model allows for a flood risk assessment to be conducted within the P118-25-00 watershed.

2.1 Hydrology

The hydrology portion of this study was developed by LAN and was modified by HT&J. According to the alternatives analysis summary report prepared by LAN, the meteorological model was developed to include the 10-year, 50-year, 100-year, and 500-year design storm based on Harris County Hydrologic Region 2 (HCFCD, December 2009). HT&J developed the 2-year design storm events for the existing scenarios. These precipitation frequency estimates are associated with TP-40 (U.S. Weather Bureau, 1961) and Hydro-35 (NOAA, 1977) and were effective during the initial scoping of this project. The rainfall data is from pre-Atlas14 conditions.

Based on the adjacent drainage improvements to Aldine Village and Oak Glen Place subdivisions, the flow data was modified to reflect the existing flow into P118-25-00. Two of the unsteady flow boundary conditions that are impacted by the subdivisions were modified respectively using the provided flow data and the calculated flow data from the remaining area. Figure 1 shows the breakdown of the contributing drainage areas and the modified boundary conditions.

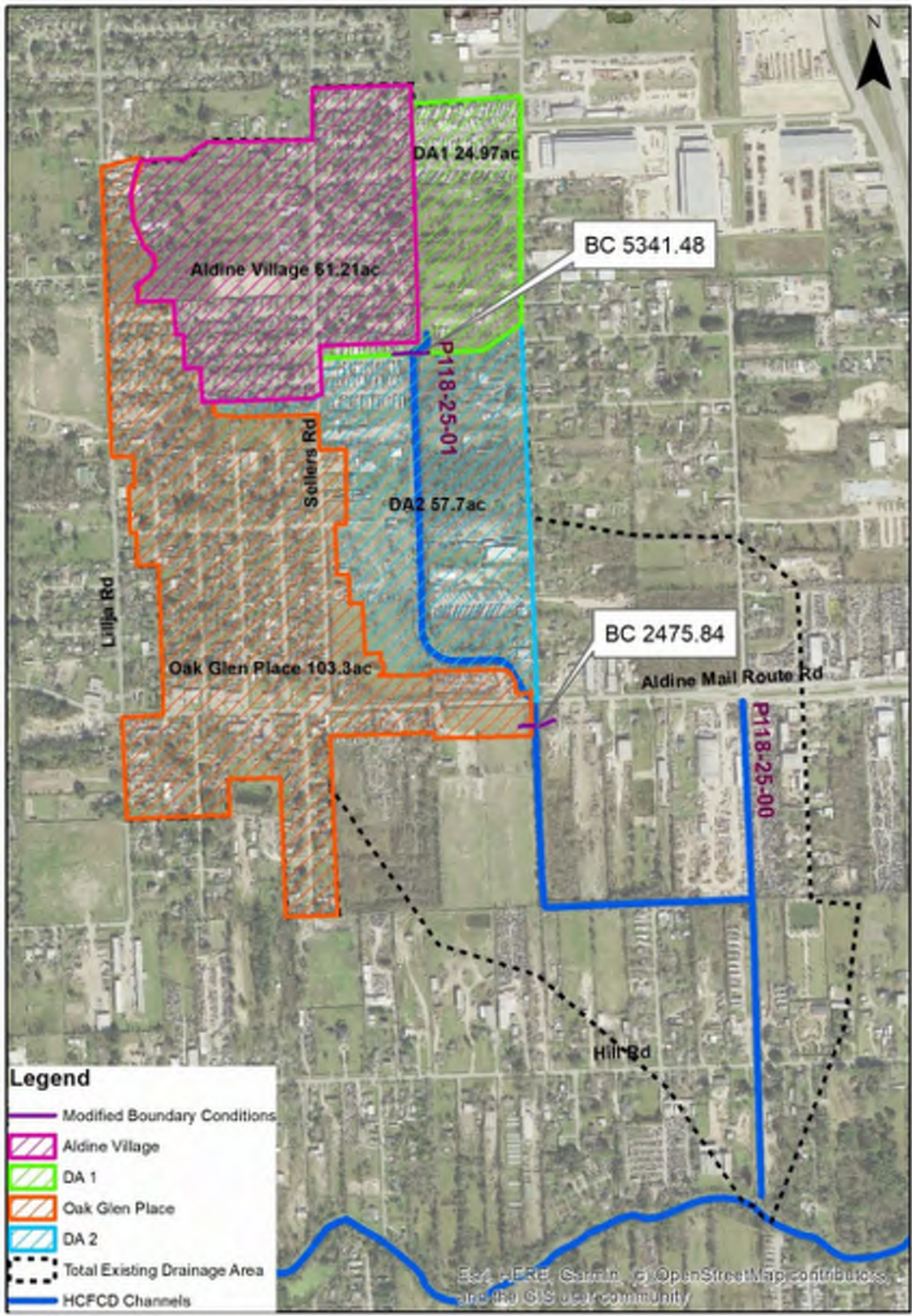


Figure 1 – Existing Drainage Areas with Aldine Village and Oak Glen Place

In incorporating the flow data for a hydrological boundary condition, the fraction of area that does not pertain to either subdivision was dissected from the unmodified flow data and included with the provided flow data for the subdivision. In Figure 1, the area with a green hatch pattern and the area with the pink hatch pattern belong to a single boundary flow condition. The area east of the P118-25-01 channel, labeled DA1, makes up roughly 29% of the sub-basin and hydrograph data corresponding to the boundary condition 5341.48. This ratio was applied to the unmodified data that was developed for the overall sub-basin for the boundary condition. The resulting hydrograph data points were added to the provided hydrograph data for Aldine Village. The resulting hydrograph was applied to the 5341.48 boundary condition in the model. The same method was done for the blue and orange hatch areas, which belong to a single boundary flow condition. The area east of the Oak Glen Place Subdivision, labeled DA2, makes up roughly 55% of the sub-basin and hydrograph data corresponding to the boundary condition 2474.84. This ratio was applied to the unmodified data that was developed for the overall sub-basin for the boundary condition. The resulting hydrograph data points were added to the provided hydrograph data for the Oak Glen Place. The resulting hydrograph was applied to the 2474.84 boundary condition in the model.

2.1.1. Overflow Analysis

Based on the alternatives analysis summary report prepared by LAN, the study area is influenced by overflows from P118-26-00 in the west and P100-00-00 (Greens Bayou) in the north, which moves south into P138-00-00 and then to the study area of P118-25-00 and P118-25-01. The overflow scenario used in the model assumes that the existing overflows from P118-26-00 and P138-00-00 are in place.

2.2 Hydraulics

The development of the combined 1D/2D existing condition model by LAN focused on five key hydraulic features. This includes the 1D cross-sections, 2D flow areas, lateral structures, 2D connectors, and boundary conditions. The model was developed following the “HEC-RAS 2D Modeling User’s Manual”. According to the previous study, LAN used a fully 1D unsteady standalone model of P118-25-00 and P118-25-01 that was developed as part of the Halls Phasing Study. This model was then revised to modify the hydraulic 1D model to a combined 1D/2D model, bring in overflows from mainstem P100-00-00 (Greens Bayou) in the north, which flows south into adjacent tributary P138-00-00 in the north and tributary P118-26-00 in the west, and stabilize the model for the 10-, 50-, 100-, and 500-year storm events.

Under the revision done by HT&J, the standalone P118-25-00 and P118-25-01 model was implemented in the P118-00-00 Halls Phasing HEC-RAS model to evaluate the existing connection that the P118-25-00 system has on Halls Bayou. The flow and geometry data that did not pertain to the P118-25-00 system was not modified or altered. HEC-RAS version 5.0.7 was used in this analysis. Figure 2 below show the existing conditions HEC-RAS conditions geometry.

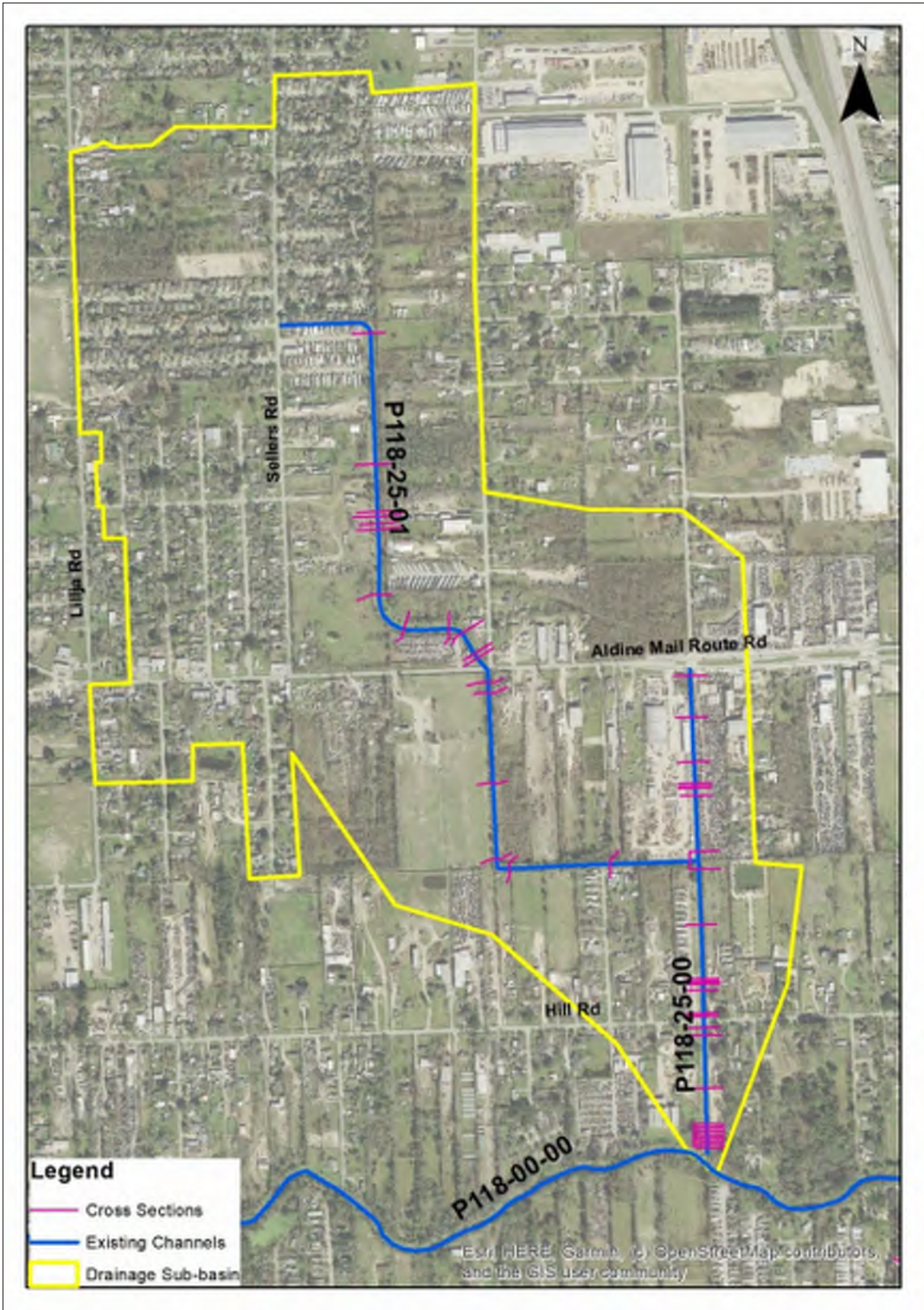


Figure 2 - Existing Conditions HEC-RAS Geometry

2.2.1. 1D Channel Geometry

The channel cross-sections were revised to reflect the updated terrain for each plan. The cross-sections were trimmed to make room for 2D areas that would model the overbanks. 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. Manning's n values were set to 0.04 for grass-lined channels and 0.1 for the overbank areas.

2.2.2 2D Flow Areas

Five 2D flow areas were created within the sub-basin in the previous study. Break lines were created for all major roadways contained within the new 2D mesh boundaries. No adjustments were made for the existing conditions 2D flow areas in this study. The overall Halls Bayou model uses homogeneous n-values and has been calibrated to historical storm events. The analysis results after adjusting the n-values in this study are not expected to change. Figure 3 presents the 2D areas.



Figure 3 - Extent of Existing Conditions 2D Areas

2.2.3 Lateral Structures - 1D/2D Model Interaction

In the previous study, lateral structures were created to connect the 1D river/reach to the 2D flow area. Lateral structures were placed along the left and right banks between inline structures along the entire length of the tributaries. 2D connections were placed along the shared edges of the 2D areas to allow water to pass from one 2D area to the next. The lateral structures were adjusted in this study to reflect the updated terrain along the banks of the channels.

2.2.4 2018 LiDAR Update

The existing conditions terrain was replaced with the surveyed existing surfaces overlaid to 2018 LiDAR. The combined 1D/2D baseline conditions were re-calculated using the updated terrain. The elevation difference between the previously used existing conditions terrain and the updated one varies across the system. For example, in a few cross sections, the updated channel flow line is approximately a foot lower than that of the previously used terrain. Additionally, other cross sections show the updated channel flow line at a higher elevation compared to the previously used terrain by a range of 4 to 8 inches.

2.3 Existing Conditions Results

Based on the existing conditions model, there is widespread ponding across the study area for the 2-, 10-, 100-, and 500-year storm events. The maximum depth raster sets were exported from HEC-RAS to GIS and the results were reviewed compared to the existing ground elevations. Please refer to exhibits 4 through 6 for the existing conditions ponding results. Attachment 2 presents the maximum water surface elevations along the P118-25-00 and P118-25-01 channels for the 2-, 10, 100-, and 500-year storm events.

2.3.1 2-Year Storm Event

Based on the existing conditions model, ponding exists across the northwestern section of the drainage sub-basin under the 2-year storm event. The ponding depths range from 0.1 inches to 24 inches.

Exhibit 4 presents the existing conditions 2-year ponding results.

2.3.2 10-Year Storm Event

For the 10-year storm event, there is widespread ponding across the drainage sub-basin. The P118-25-01 channel overflows at some locations along the channel. The ponding depths range from 0.2 inches to 36 inches. As for P118-25-00, the channel overflows at various locations. The ponding depths range from 2 to 24 inches. The 10-year results match closely with the results found in the original LAN models.

Exhibit 5 presents the existing conditions 10-year ponding results.

2.3.3 100-Year Storm Event

For the 100-year storm event, there is widespread ponding across the drainage sub-basin. The P118-25-01 channel overflows at some locations along the channel. The ponding depths range from 2 inches to 42 inches. As for P118-25-00, the channel overflows at various locations. The ponding depths range from 2 to 30 inches. The 100-year results match closely with the results found in the original LAN models.

Exhibit 6 presents the existing conditions 100-year ponding results.

2.3.4 500-Year Storm Event

For the 500-year storm event, there is widespread ponding across the drainage sub-basin. The P118-25-01 channel overflows at some locations along the channel. The ponding depths range from 2 inches to 46 inches. As for P118-25-00, the channel overflows at various locations. The ponding depths range from 20 to 44 inches. The 500-year results match closely with the results found in the original LAN models.

Exhibit 7 presents the existing conditions 500-year ponding results.

3. Proposed Conditions Analysis

The proposed conditions that were used in this study are based on the recommended alternative that LAN created in their study out of the seven alternatives presented for the drainage improvement project. The provided proposed surface was overlaid to 2018 LiDAR to create the updated terrain used in this model. The scenario presented by LAN includes a channel extension, channel improvements, and a detention basin. These items were evaluated and presented in detail in the feasibility study. The detention basin is located north of Aldine Mail Route Road between residential area Oak Glen Place and P118-25-01. This detention basin addresses the overflow from Oak Glen Place subdivision and acts as a side-weir pond to the P118-25-01 channel. The basin consists of a side weir and outfall pipe. In the modification made by HT&J, the detention pond was optimized to accommodate the Oak Glen Place subdivision and Aldine Village subdivision projects and provide no-adverse impacts downstream of the projects. It is also recommended by LAN that the single 9 x 4 reinforced box culvert (RCB) crossing Aldine Mail Route Rd. is replaced with two 9 x 6 RCBs. In the modifications made by HT&J, the proposed culverts are optimized to allow for better conveyance and provide no-adverse impact by adding a single 8 x 6 RCB to the two 9 x 6 RCBs.

The channel improvements along P118-25-01 were optimized to help maximize the capacity of the P118-25-00 system. The improvement begins north of Aldine Mail Route Road to the upstream end of the channel in P118-25-01 within existing ROW. Based on the proposed terrain, the designed depth is approximately 8 feet and the side slopes are 4:1. The bottom width is designed to be 25 feet over a range of 6,897 feet from the confluence of P118-25-00 and P118-25-01 to the headwaters of the channel extension. The bottom width of the channel is also widened to 25 feet from upstream of Hill Road to the headwaters of P118-25-00. The channel extension is located at the upstream end of P118-25-01. The channel extension bends to the east upward at the end of the

existing channel and runs parallel to the north up until reaching Hollyvale Drive. If proper drainage and conveyance is employed in the future, this extension helps to capture the northwestern P138-00-00 overflow between Lillja Road and Sellers Road and convey the water downstream. This prevents stormwater from sheet-flowing to the southeast. This channel extension is proposed to receive runoff from roadside ditches and will provide an outfall location for future subsurface drainage systems of drainage projects. As for the dimensions, the proposed depth of the channel extension is set to be 8 feet, according to the proposed terrain. The channel side slopes are set to be 4:1 with the width of the channel being 100 feet, of which the bottom width is 25 feet.

A cross-section representation of the recommended alternative and the existing cross-section is shown in the figure below.

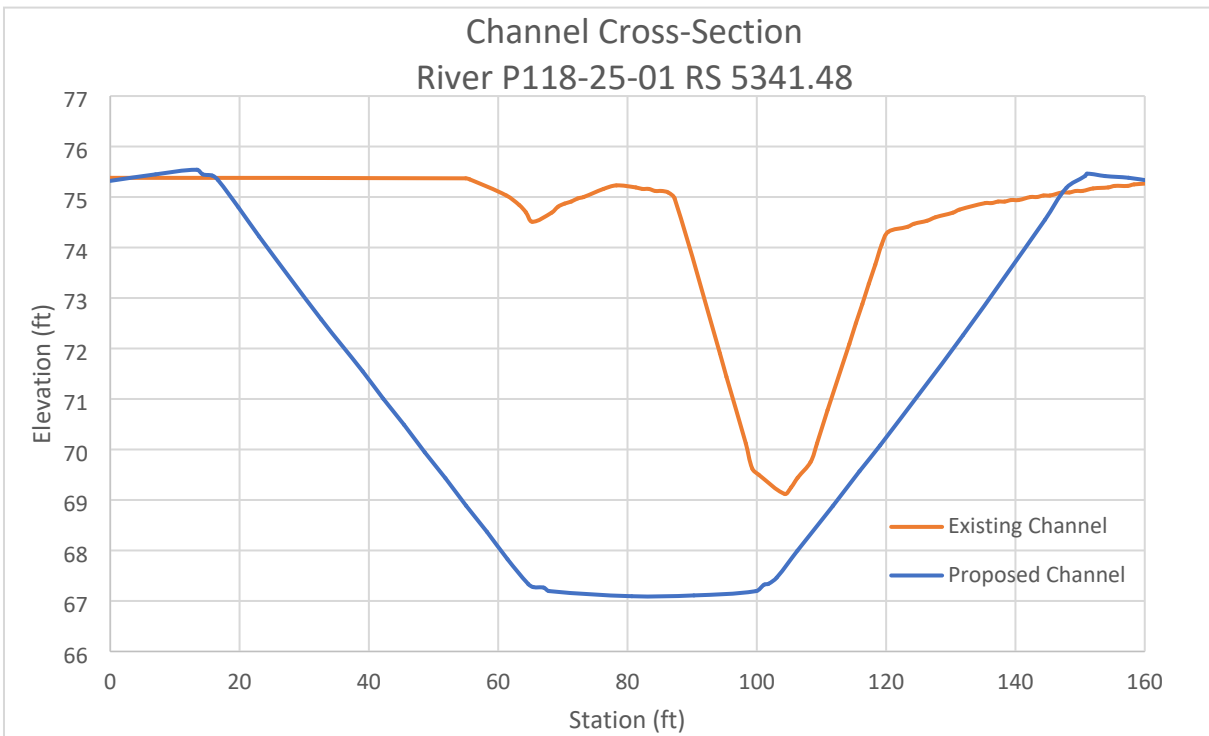


Figure 4 - Proposed & Existing Channel Cross Section

3.1 Hydrology

The proposed conditions include the unmitigated overflow from the Aldine Village and Oak Glen Place subdivision projects. Two of the unsteady flow, internal boundary conditions that are impacted by the subdivisions were modified respectively using the provided flow data and the calculated flow data from the remaining area. Figure 5 shows the breakdown of the contributing drainage areas. The Aldine Village subdivision drainage area remains the same and the Oak Glen Place drainage area decreases due to the proposed routing adjustment where a northwestern portion of the area drains to P118-26-00.

In incorporating the flow data for a hydrological boundary condition, the fraction of area that does not pertain to either subdivision was dissected from the unmodified flow data and included with the provided flow data for the subdivision. In Figure 5, the area with a green hatch pattern and the

area with the pink hatch pattern belong to a single boundary flow condition. The area east of the P118-25-01 channel, labeled DA1, makes up roughly 29% of the sub-basin and hydrograph data corresponding to the boundary condition 5341.48. This ratio was applied to the unmodified data that was developed for the overall sub-basin for the boundary condition. The resulting hydrograph data points were added to the provided hydrograph data for Aldine Village. The resulting hydrograph was applied to the 5341.48 boundary condition in the model. The same method was done for the blue and orange hatch areas, which belong to a single boundary flow condition. The area east of the Oak Glen Place Subdivision, labeled DA2, makes up roughly 55% of the sub-basin and hydrograph data corresponding to the boundary condition 2474.84. This ratio was applied to the unmodified data that was developed for the overall sub-basin for the boundary condition. The resulting hydrograph data points were added to the provided hydrograph data for the Oak Glen Place. The resulting hydrograph was applied to the 2474.84 boundary condition in the model. The proposed conditions overland flow from Oak Glen Place subdivision was routed to the proposed pond while the discharge from the Aldine Mail Route Road outfall was used for the boundary condition 2474.84 in the model.

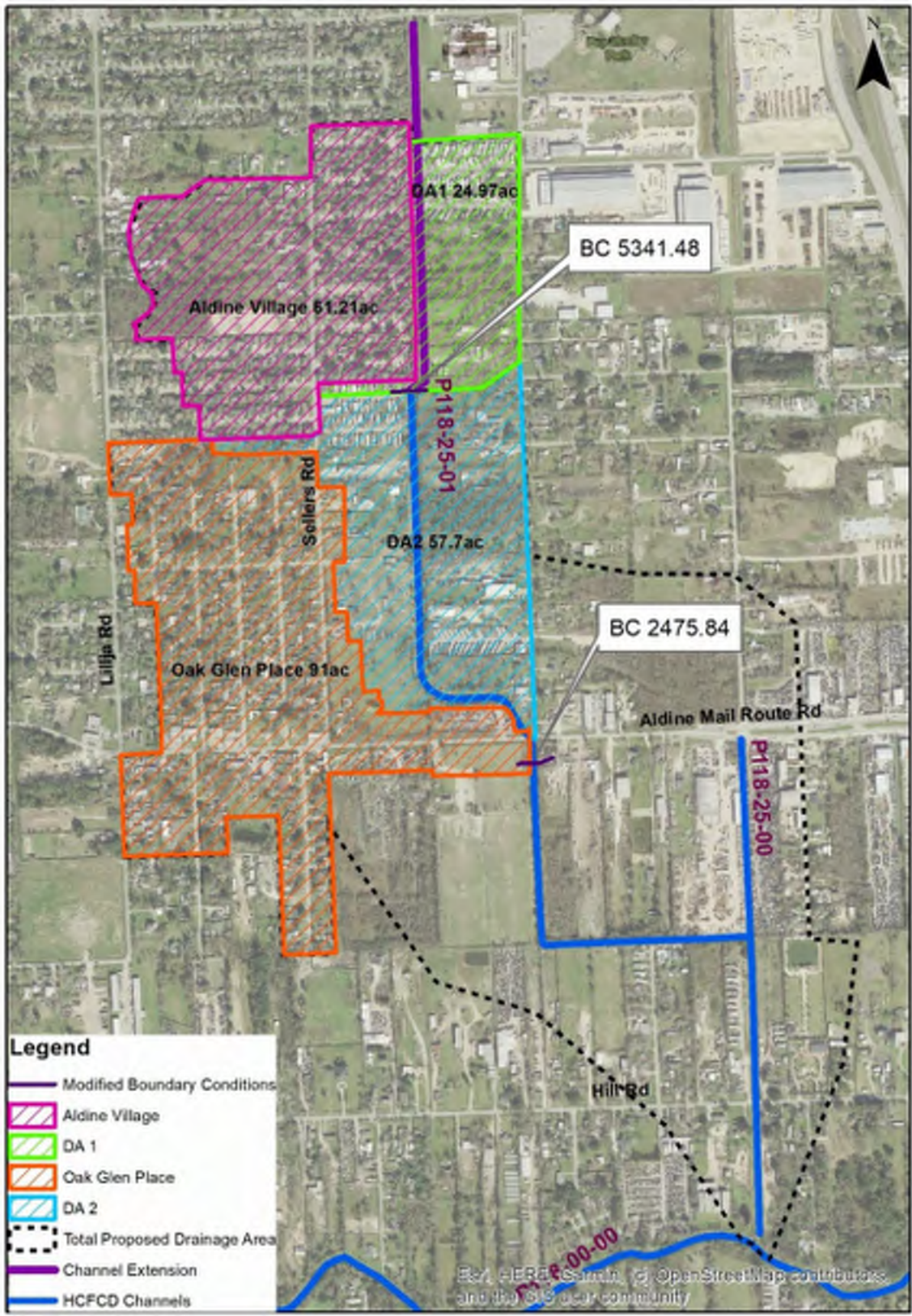


Figure 5 - Proposed Drainage Areas with Aldine Village and Oak Glen Place

3.2 Hydraulics

The proposed conditions model incorporates the recommended improvements provided by LAN. The channel modifications, channel extensions, and the detention pond are included in the proposed scenario. Under the revision done by HT&J, the channel modifications were reshaped by cutting the cross sections based on the updated proposed conditions terrain. The 2D flow areas were extended in this study to cover the terrain at towards the channel's extension more appropriately. The volume of the detention pond was expanded and optimized to accommodate the Oak Glen Place subdivision and Aldine Village subdivision projects. In the updated version of the model, the total storage provided is 46 acre-feet, as shown in table 3. The total provided volume is meant for use under maximum capacity conditions with no freeboard. Under the 500-year event, the calculated volume of 40 ac-ft provides freeboard and no adverse impact downstream, as shown in the section 3.3.5. This pond was modeled as a storage area with connections set up to connect the storage area with the 2D flow area. A side weir and outlet structure are implemented in a lateral structure along channel side of the detention pond. The side weir along the proposed detention pond was modified and optimized to allow more flow into the detention pond. It is recommended that the detention pond side weir be expanded to have a bottom width of 100 feet and a depth of 5.3 feet with the weir flow line elevation at 70.4. No changes to the 12-inch outfall pipe are made in this study.

The proposed temporary restrictor along P118-25-00 was modified to minimize the water surface elevation downstream of the restrictor. A temporary restrictor is necessary until the improvements at the P118-25-00 and Halls Bayou confluence, which are part of the Halls Bayou Vision Plan, are completed. The size of the proposed restrictor was optimized to help mitigate impacts downstream. As a result, it is recommended that the temporary restrictor or sheet piling, be reduced from having an opening of 19 feet to 15 feet. Figure 6 presents the restrictor geometry. Table 3 presents the stage-storage relationship provided by RG Miller. Figure 6 shows the cross-section of the Oak Glen Basin adjacent to P118-25-01. Refer to figure 8 or exhibit 3 for the HEC-RAS geometry under the proposed conditions.

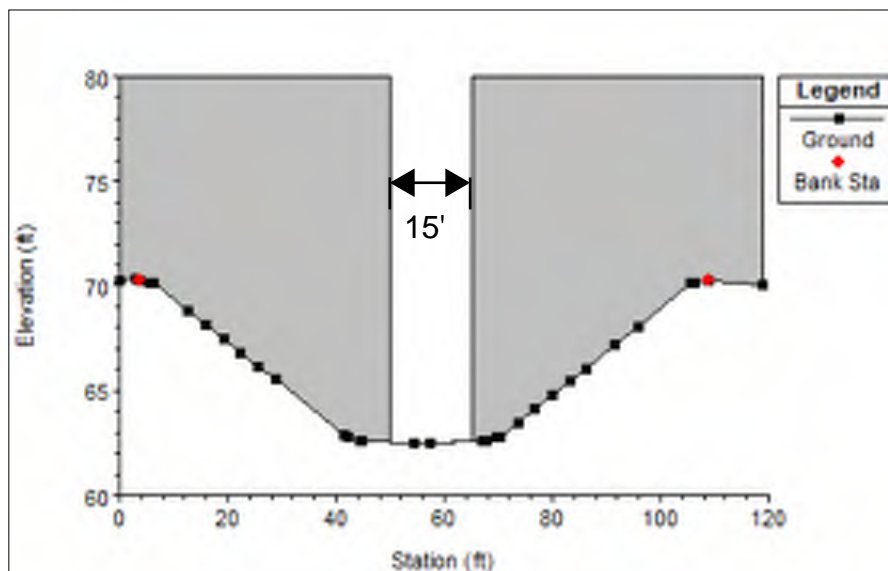


Figure 6 - Restrictor Geometry

Table 3 - Stage/Storage Relationship of Detention Pond

Stage (ft)	Storage (ac-ft)
66.5	0
67.5	0.2
68.5	3.2
69.5	8.4
70.5	14.2
71.5	20.2
72.5	26.3
73.5	32.6
74.5	39.2
75.5	45.9

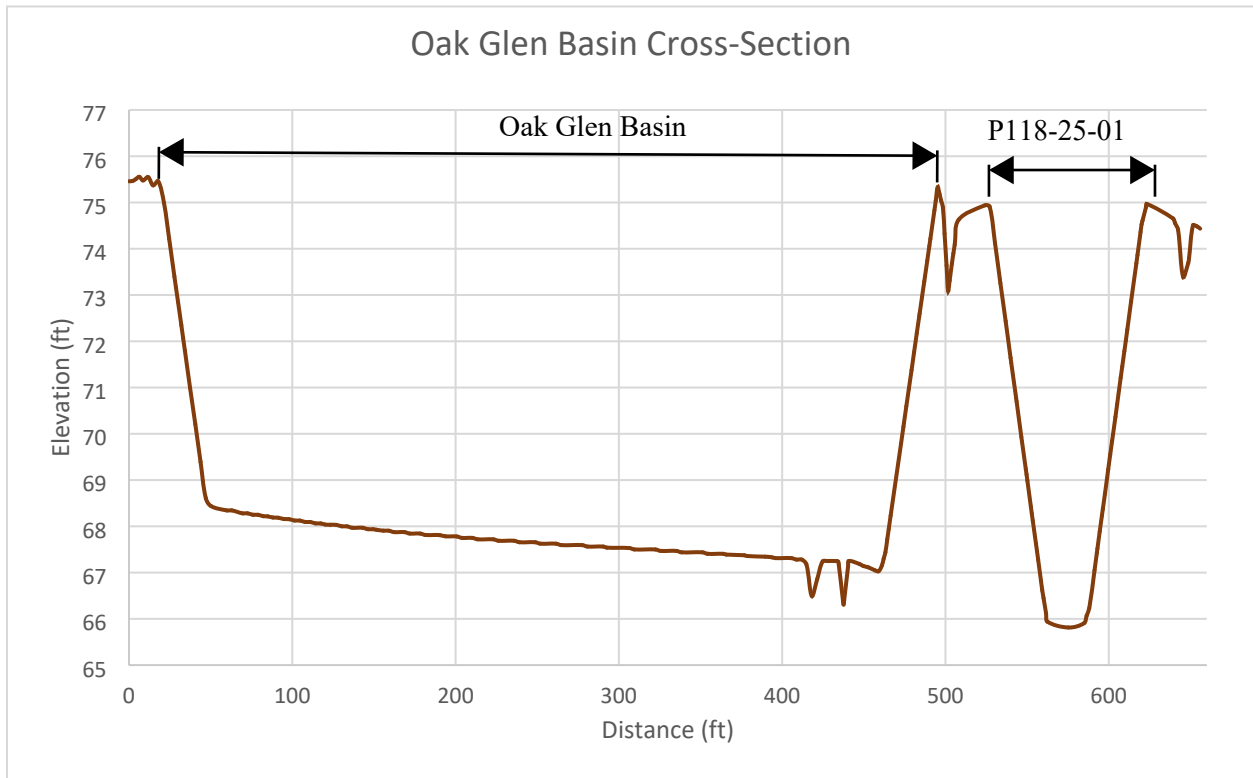


Figure 7 - Oak Glen Basin Cross-Section

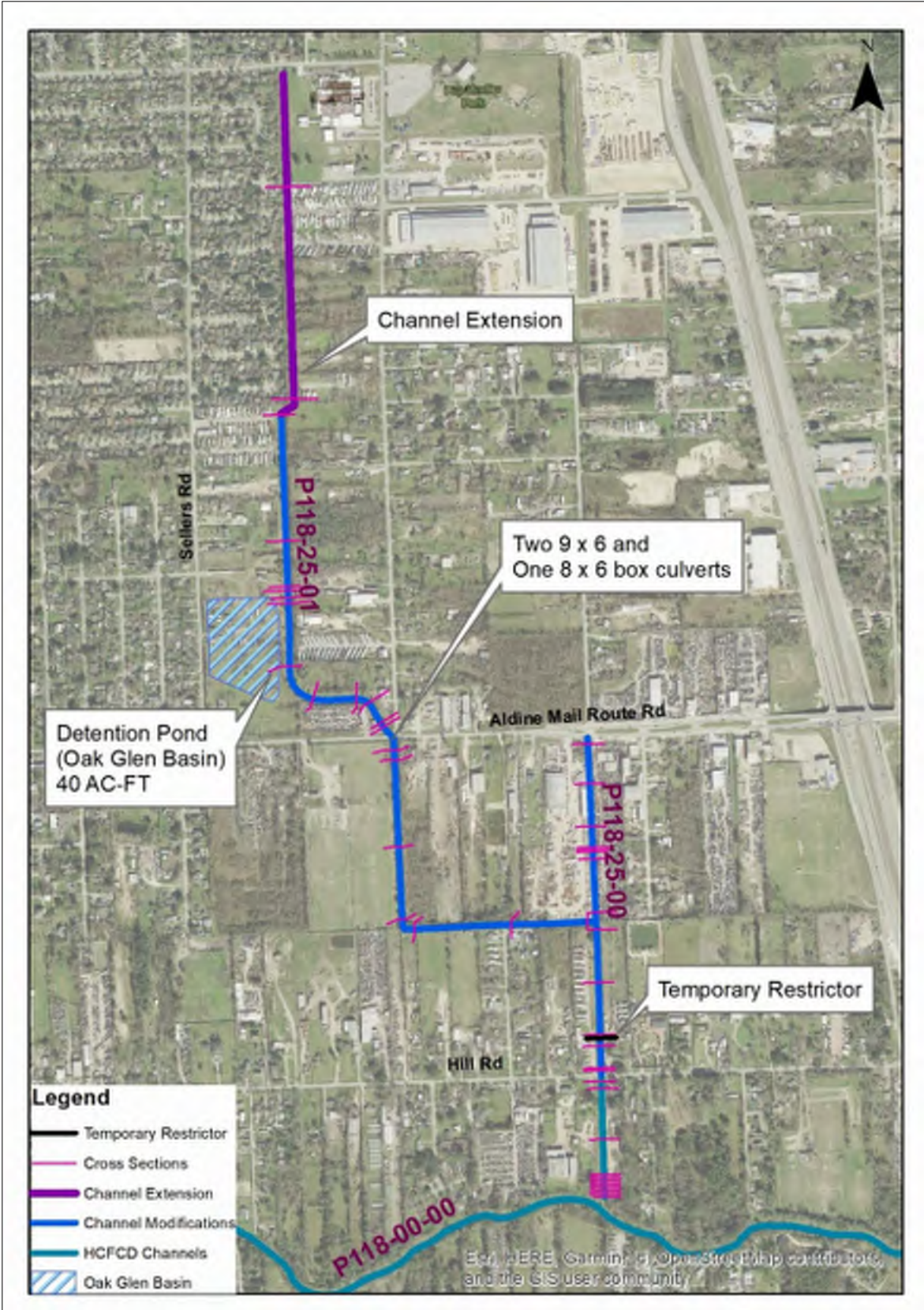


Figure 8 - Proposed Conditions HEC-RAS Geometry

The 2D flow areas were extended in this study to cover the terrain more appropriately. The overall Halls Bayou model uses homogeneous n-values and has been calibrated to historical storm events. The analysis results after adjusting the n-values in this study are not expected to change. Figure 9 below presents the extents of the 2D areas.

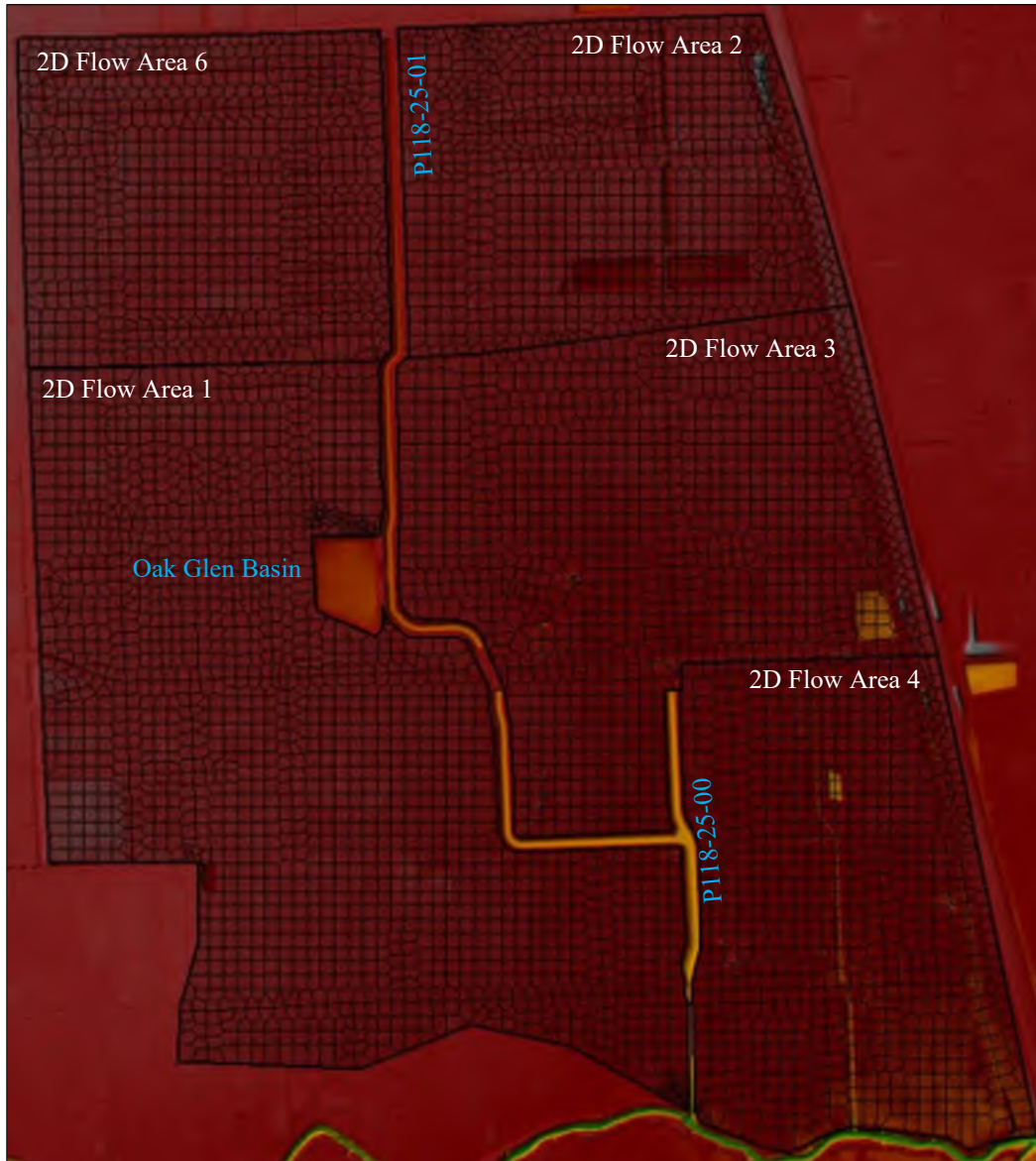


Figure 9 - Adjusted 2D Areas

3.2.1 Inflow Boundary Conditions

The inflow boundary conditions and overflows conditions are consistent with those from the previous study. The study area is influenced by overflows from P118-26-00 in the west and P100-00-00 (Greens Bayou) in the north, which moves south into P138-00-00 and then to the study area of P118-25-00 and P118-25-01. The overflow scenario used in the model assumes that the existing overflows from P138-00-00 are in place. According to the alternatives analysis summary report prepared by LAN, the amount of overflow leaving P138-00-00 between Henry Rd and Hardy Toll Rd and partially enters P118-25-00 drainage area was measured in post process in HEC-RAS and applied at River Station 3203.12, in addition to the local runoff.

3.3 Results

With the proposed improvements, there are no impacts downstream of the site into Halls Bayou. In addition, there is a decrease in ponding throughout the study area for the 2-, 10-, 100-, and 500-year events. The detention pond along the P118-25-01 channel and the channel modifications throughout the system benefit the surrounding drainage basin by decreasing the ponding depth. The performance metrics of the proposed conditions are evaluated based on structural flooding and the miles of road and total area removed from the existing floodplain. Exhibit 12 presents the performance metrics boundary. Table 4 presents the performance metrics across all four storm events. Attachment 2 presents the maximum water surface elevations along the P118-25-00 and P118-25-01 channels for the 2-, 10, 100-, and 500-year storm events.

Table 4 - Performance Metrics

Metric	2-Year Proposed Conditions		10-Year Proposed Conditions	
	Existing	Proposed	Existing	Proposed
Structures in Floodplain	72	64	360	281
Structures with recorded FFE in Floodplain	27	27	106	81
Flooded Structures (based on FFE)	0	0	4	2
Inundated Roadway (miles)	1.8	1.7	3.1	3
Floodplain (acres)	57.9	56.3	194	178

Metric	100-Year Proposed Conditions		500-Year Proposed Conditions	
	Existing	Proposed	Existing	Proposed
Structures in Floodplain	1446	1092	1738	1490
Structures with recorded FFE in Floodplain	378	277	440	400
Flooded Structures (based on FFE)	82	40	185	117
Inundated Roadway (miles)	7.6	6.4	9.6	8.6
Floodplain (acres)	653	529	769	694

3.3.1 2-Year Storm Event

Throughout the system, ponding is decreased by approximately 1 to 12 inches for the 2-year storm events. The channel improvements and extension of P118-25-01 help lower and even remove ponding from properties within the drainage basin. Outside of both the P118-25-00 and P118-25-01 channels, ponding occurs to the same extent to that of the existing scenario.

Exhibit 8 presents the inundation comparison map of this section.

3.3.2. 10-Year Storm Event

Throughout the system, ponding is decreased by approximately 0.5 to 5 inches for the 10-year storm events. The channel improvements and extension of P118-25-01 help lower and even remove ponding from properties within the drainage basin. Outside of both the P118-25-00 and P118-25-01 channels, ponding occurs to the same extent to that of the existing scenario.

Exhibit 9 presents the inundation comparison map of this section.

3.3.3. 100-Year Storm Event

Under the 100-year storm event, ponding is decreased by approximately 1 to 12 inches throughout the system. The channel improvements and extension of P118-25-01 help lower and even remove ponding from properties. Outside of both the P118-25-00 and P118-25-01 channels, ponding occurs to the same extent to that of the existing scenario.

Exhibit 10 presents the inundation comparison map of this section.

3.3.4. 500-Year Storm Event

Under the 500-year storm event, ponding is decreased by approximately 2 to 9.6 inches throughout the system. The channel improvements and extension of P118-25-01 help lower and even remove ponding from properties. Outside of both the P118-25-00 and P118-25-01 channels, ponding occurs to the same extent to that of the existing scenario.

Exhibit 11 presents the inundation comparison map of this section.

3.3.5 Detention Summary

After analyzing the recommended alternative, it was determined that the proposed improvements to the P118-25-00 system and adjacent projects have no adverse impact downstream to P118-25-00, P118-25-01, downstream into Halls Bayou, or the surrounding watershed in the 2-, 10-, 100-, and 500-year storm events (pre-Atlas 14). The calculated detention volume in the proposed detention basin is 40 acre-feet. Table 5 provides the detention summary. The 100-year stage hydrograph of the detention pond is shown in figure 10. Table 6 presents the detention pond's drain time calculations based on the 100-year event. This is based on section 6.3.12 of the HCFCDC PCPM.

Table 5 - Detention Summary

Project Name: Drainage Analysis for P118-25-00/01		Date: 3-15-2022			
Detention Basin Service Area		662 acres			
Offsite Drainage Area		-			
Storm Event		50% (2-yr)	10% (10-yr)	1% (100-yr)	0.2% (500-yr)
Flow	Direct Inflow from projects	96.8	134.0	183.1	230.8
	Maximum Existing Outflow at cross section after proposed restrictor (pre-development peak flow at XS 1175.29)	199.3	240.8	477.6	438
	Maximum Outflow Provided (XS 1175.29)	197.9	284.3	471.2	493.5
Elevations	Lowest Natural or Finished Ground Elevation Estimate	75.5			
	Maximum Allowable Water Surface	74.7			
	Based on	9.6 in of freeboard from top of berm (El. 75.5ft)			
	Design Water Surface Elevation	-	-	-	74.7
	Water Surface Elevation Calculated	70.5	71.6	73.03	74.7
Storage	Minimum Storage Required (ac-ft)	14.7	20.6	29.6	40.3
	Detention Storage Provided (ac-ft)	14.7	20.6	29.6	40.3
	Storage Rate Provided (ac-ft/ac)	-	-	-	-
Outflow Structure	Restrictor Size, if applicable (in)	12			
	Outflow Pipe Size (in)	24			
	Outflow Velocity into Channel (fps)	4.5	5.1	4.4	5.3
	Weir Description, if applicable (type, size, elevation, etc.)	Side Weir at elevation 70.4			
	Drain Time – 1% only (hours)	35			
	Emergency Overflow (type, size, elevation, etc.)	Proposed side weir will also function as an emergency overflow			

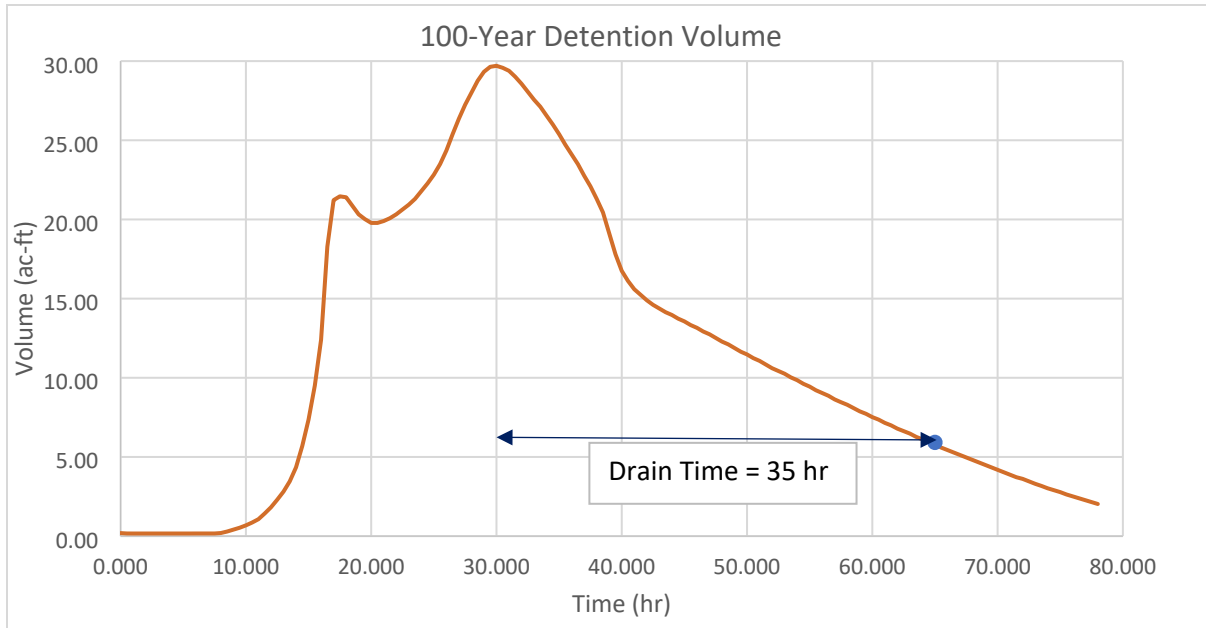


Figure 10 – Detention Pond 100-Year Stage Hydrograph

Table 6 - Detention Pond Drain Time Calculations

Calculations for 100-Year Event Drain Time	
Time of Peak	1/2/2002 10:00
Peak Volume (ac-ft)	29.6
80% of Peak Volume (ac-ft)	23.68
Allowable Remaining Storage (peak volume - 80% of peak volume)	5.92
Allowable Stage (ft)	69.02
Time 80% of peak volume has drained	1/3/2002 21:00
Drain Time (hr)	35

3.3.6 Response to comments regarding the model

To address specific comments regarding the models, attachment 3 presents HT&J’s model review response to comments received in March 2022. For the comment on the existing conditions 100-year event hydrograph fluctuations along P118-25-01 from cross section 1881.88 through 584.11, HT&J reviewed the matter and concluded that there are minor fluctuations in the hydrographs but they do not impact the overall results. In response to the WSEL error that occurs in the start of the existing conditions 10-year event run, it appears that it occurs during the first time-interval and has no bearings on the results. In response to the increase in WSEL along Halls Bayou beginning at station 32000 and continuing to station 20858 for the 100-year event, HT&J believes that this is a result of some computational issues, and cannot reasonably address the impact based on the changes that are made 6 miles upstream. In response to the increase in WSEL along Halls Bayou beginning at station 56000 and continuing downstream for the 10-year event, HT&J believes that this is a result of some computational issues, and cannot reasonably address the impact based on the changes that are made upstream. Additionally, the 10-year WSEL in the area is contained

within the channel banks. In response to the increase in WSEL along Halls Bayou beginning at station 35000 and continuing downstream for the 2-year event, HT&J believes that this is a result of some computational issues, and cannot reasonably address the impact based on the changes that are made upstream.

4. No-Impact Analysis

The downstream impact was compared for the existing and proposed conditions at the final cross section of the P118-25-00 system (cross section 97.8 in the HEC-RAS model) and at the confluence of the P118-25-00 system and Halls Bayou. The 2-, 10-, 100-, and 500-year storm events were analyzed for this purpose. It was determined that the proposed improvements to the P118-25-00 system and adjacent projects have no adverse impact downstream to P118-25-00, P118-25-01, downstream into Halls Bayou, or the surrounding watershed in the 2-, 10-, 100-, and 500-year storm events (pre-Atlas 14). Under all four events, the observed water surface elevation from the post-project scenario is lower than that of the existing scenario throughout P118-25-00 and P118-00-00.

Attachment 1 presents the water surface elevations of the 2-, 10-, 100-, and 500-year storm events along the P118-00-00 P118-R3-2 section, which intersects P118-25-00. Table 7 and 8 show the existing and proposed conditions water surface elevations at cross section 97.8 of the P118-25-00 system and at cross section 66733.6 of P118-00-00, P118-R3-2.

Attachment 2 presents the tabulation for the maximum water surface elevations downstream of the site along Halls Bayou before the confluence with Greens Bayou.

Table 7 - Peak Flow Comparison at XS 97.8

Storm Event	Existing Water Surface Elevation	Proposed Water Surface Elevation
2-year	69.7	69.4
10-year	71.1	70.8
100-year	72.4	71.9
500-year	73.6	72.6

Table 8 - Peak Flow Comparison at XS 66733.6

Storm Event	Existing Water Surface Elevation	Proposed Water Surface Elevation
2-year	69.3	69.2
10-year	70.9	70.7
100-year	72.3	71.8
500-year	73.6	72.5

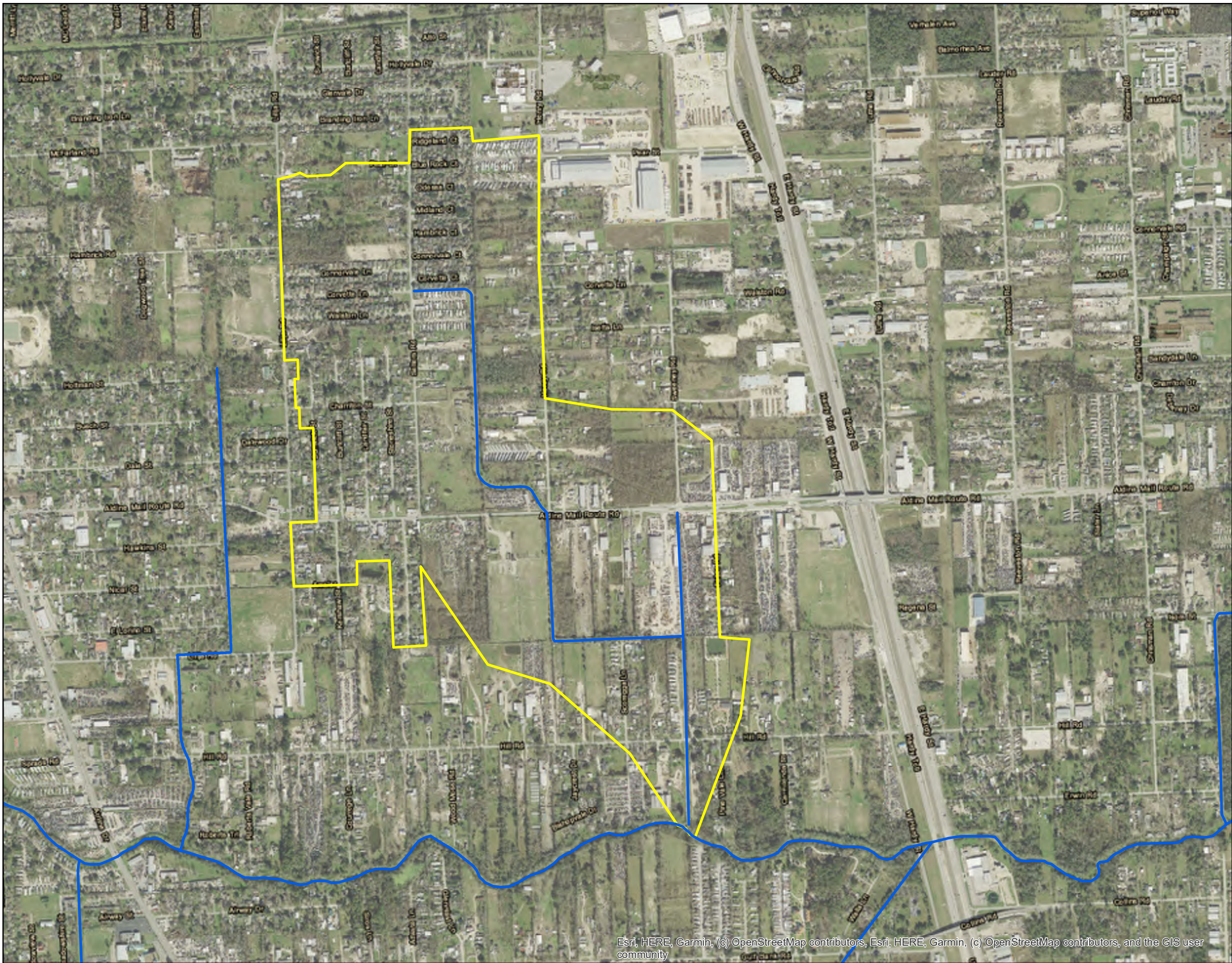
5. Recommendations

HT&J agrees with the recommended channel expansion to P118-25-01 and the channel modifications to both P118-25-01 and P118-25-00. Additionally, no changes to the pond's proposed 12-inch outfall pipe are required. It is recommended that the proposed detention pond be expanded to accommodate 40 acre-feet as shown in the detention summary table. Additionally, the detention pond side weir needs to be expanded to have a bottom width of 100 feet and a depth of 5.3 feet. This is for water quality purposes. At Aldine Mail Route Rd, it is recommended that the single 9 x 4 box be replaced with two 9 x 6 box culverts and one 8 x 6 box culvert. It is also recommended that the temporary restrictor or sheet piling, be reduced to have an opening of 15 feet.

6. Conclusions

Based on the analysis, the proposed improvements will provide a flood risk reduction for the area and will not cause any adverse impacts downstream.

EXHIBITS





N



0 500 1,000 2,000 Feet

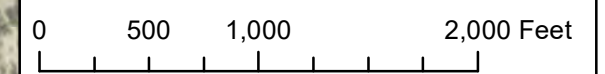
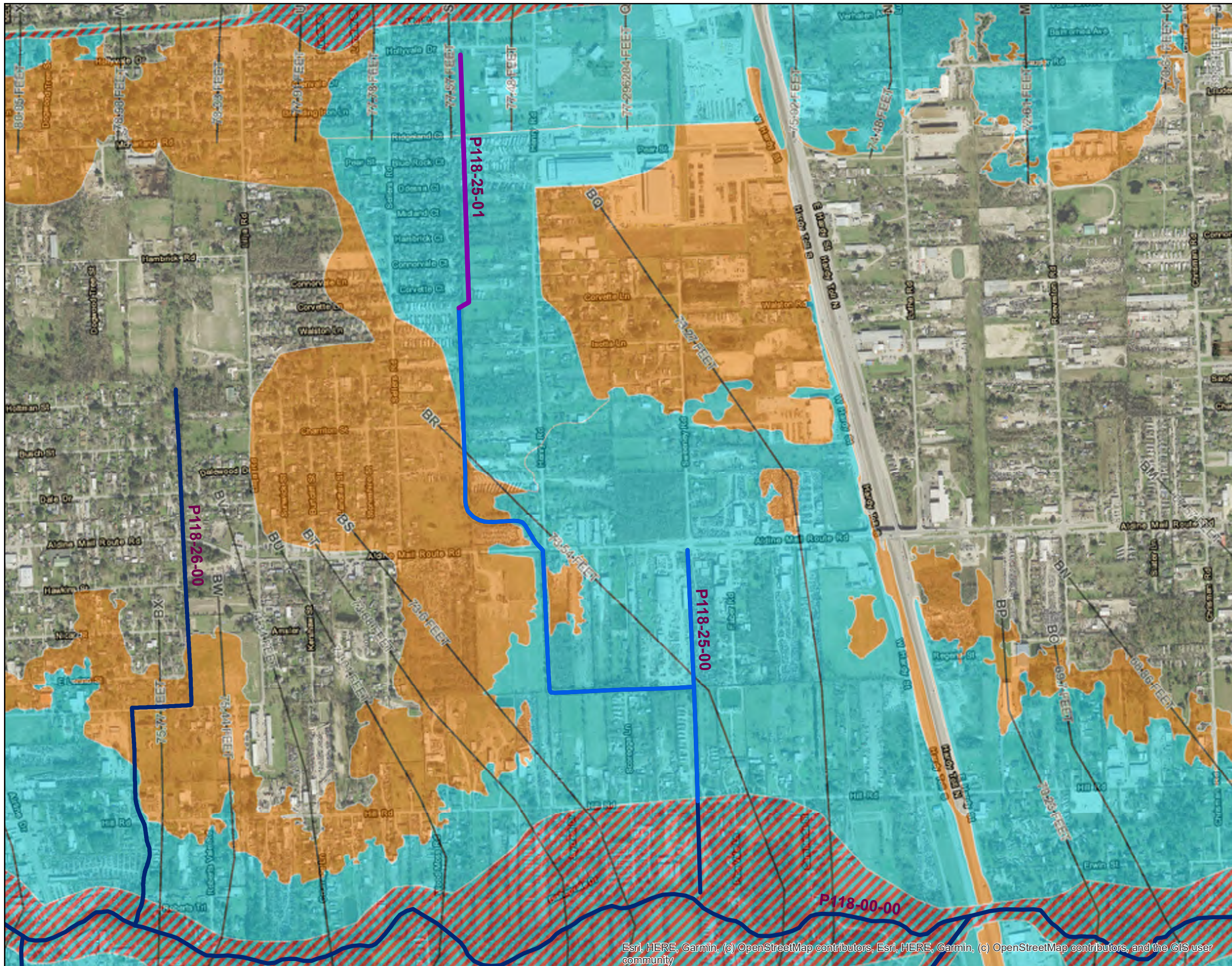
Legend

-  HCFCD Channels
-  Drainage Areas

Vicinity Map

Exhibit 1





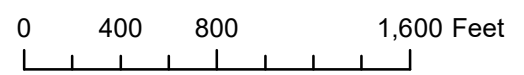
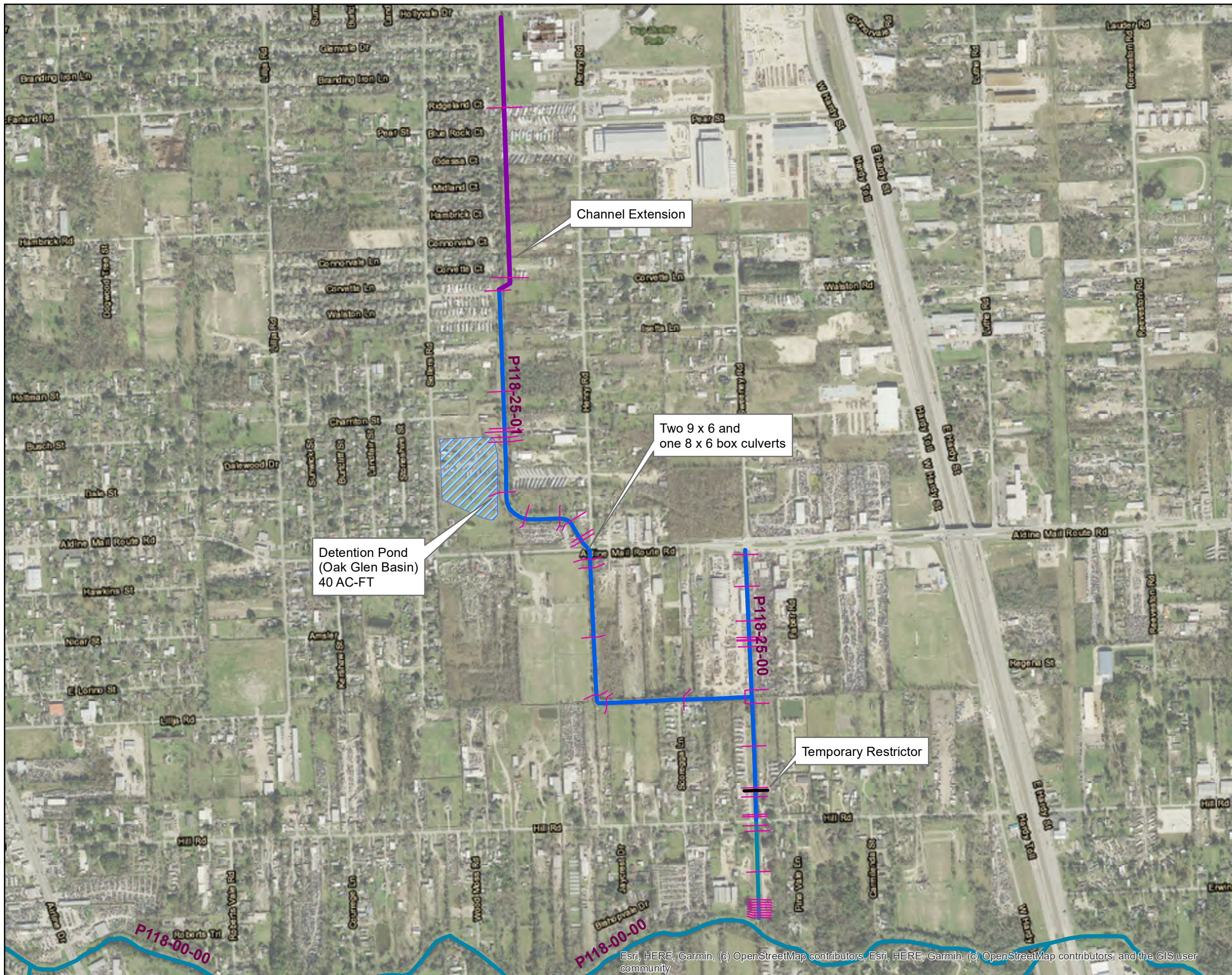
Legend

- Channel Extension
- Channel Modifications
- HCFC Channels
- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- Special Floodway
- Area of Undetermined Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Future Conditions 1% Annual Chance Flood Hazard
- Area with Reduced Risk Due to Levee

FEMA Floodplain Map

Exhibit 2



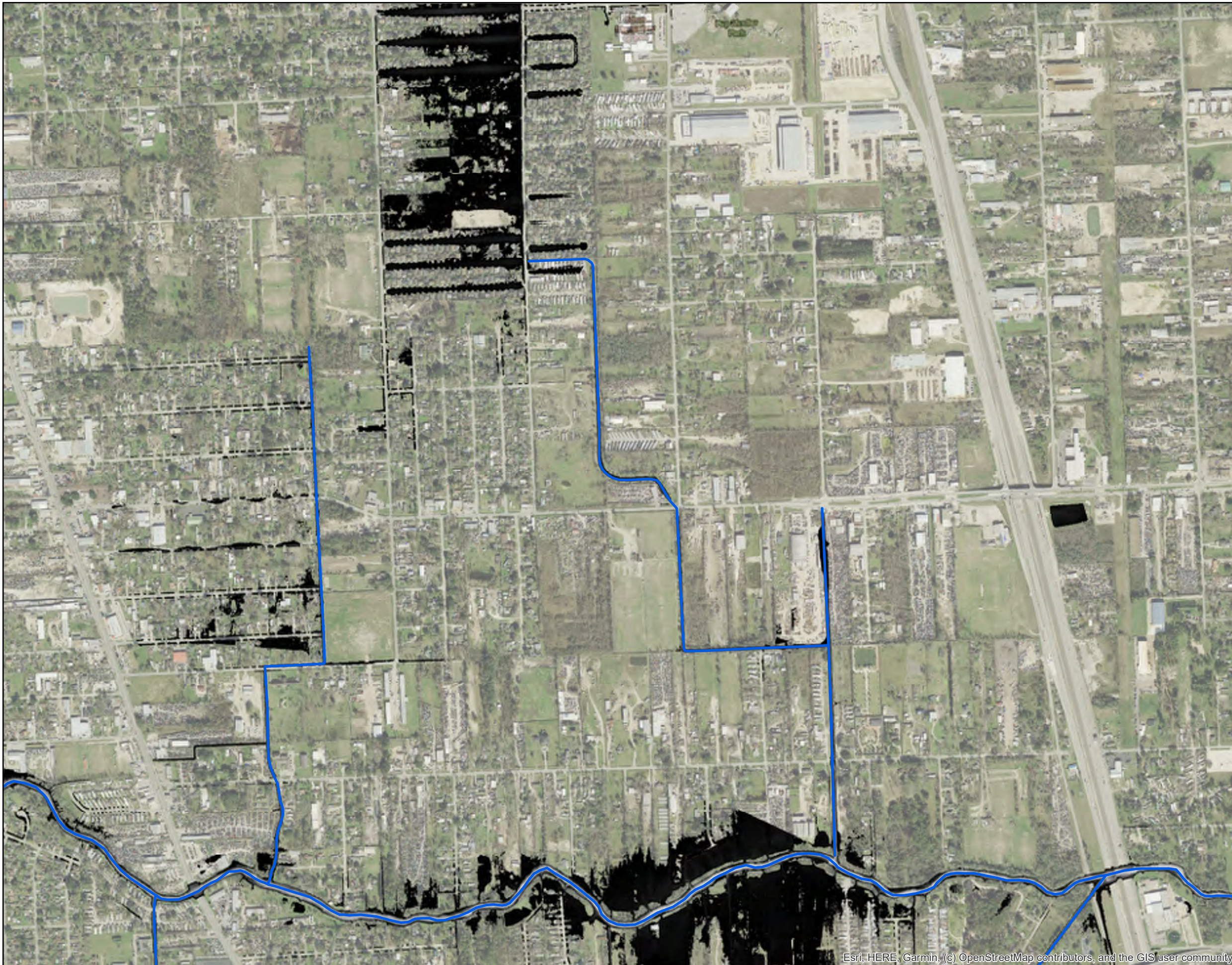


Legend

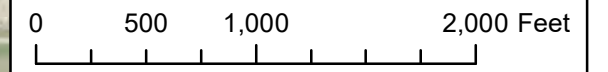
- Temporary Restrictor
- Cross Sections
- Channel Extension
- Channel Modifications
- HCFC Channels
- Oak Glen Basin

HEC-RAS Geometry
Exhibit 3



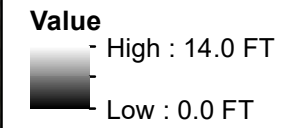


N



Legend

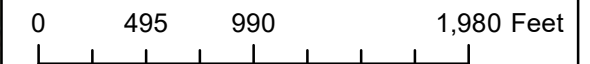
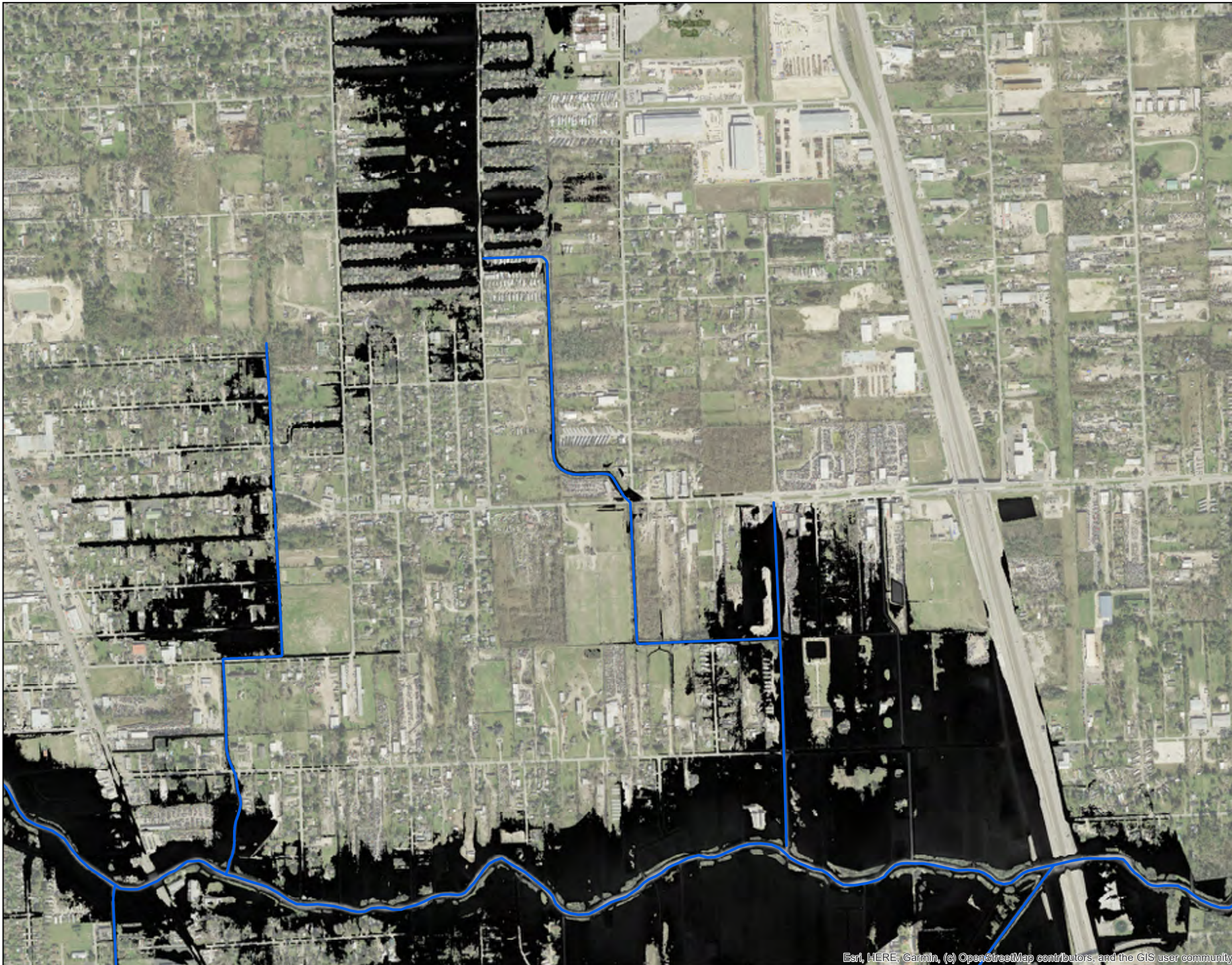
Existing Conditions Scenario



2-Year Existing Conditions
Inundation Map

Exhibit 4

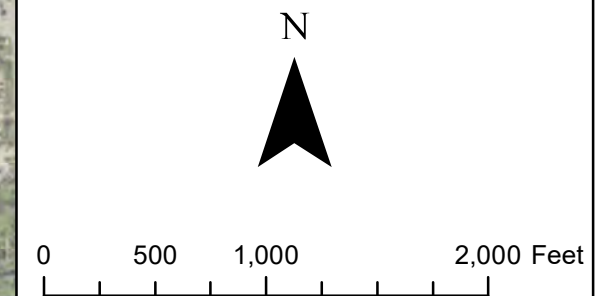
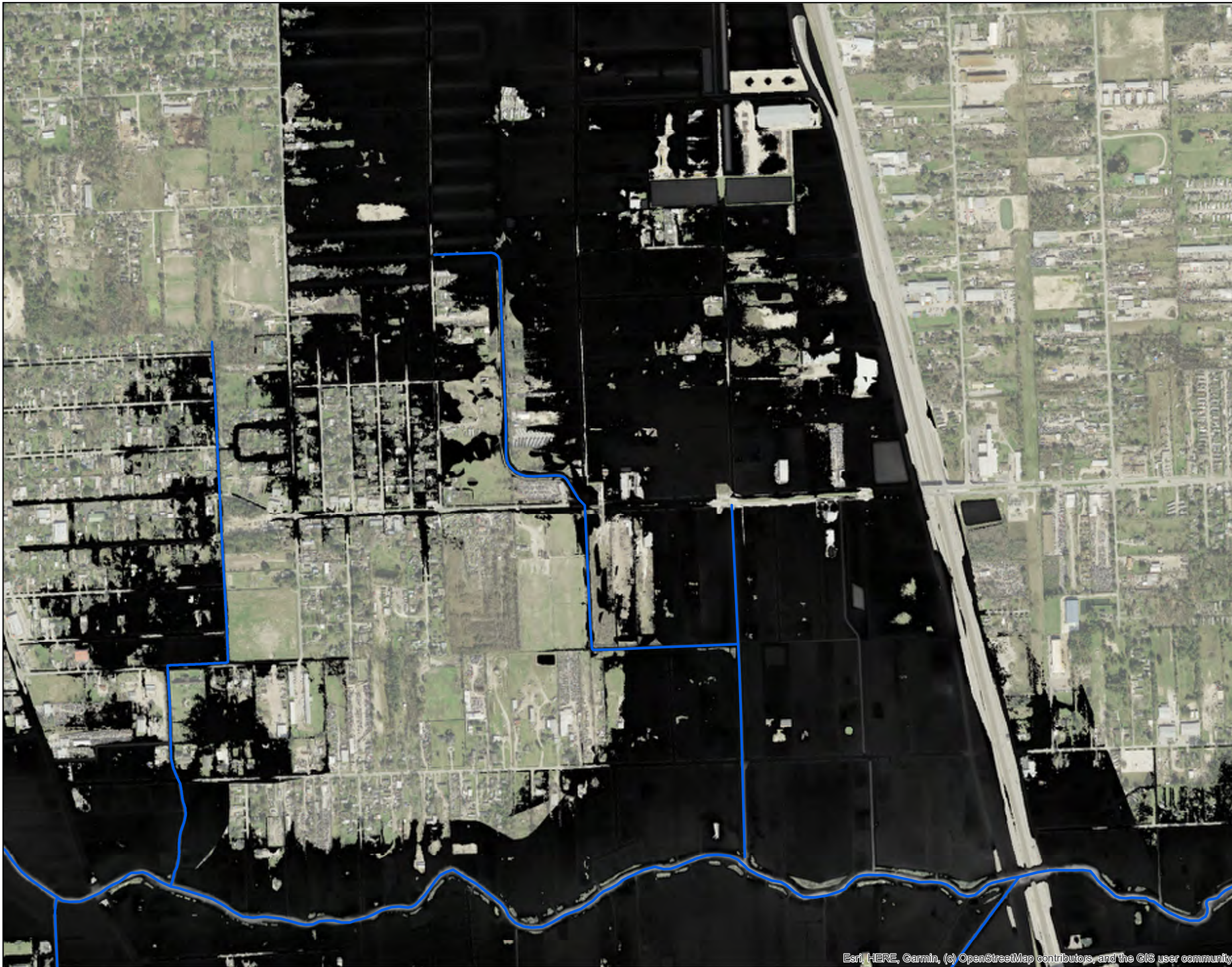




Legend
Existing Conditions
Value
High : 14.5 FT
Low : 0.0 FT

10-Year Existing Conditions
Inundation Map
Exhibit 5

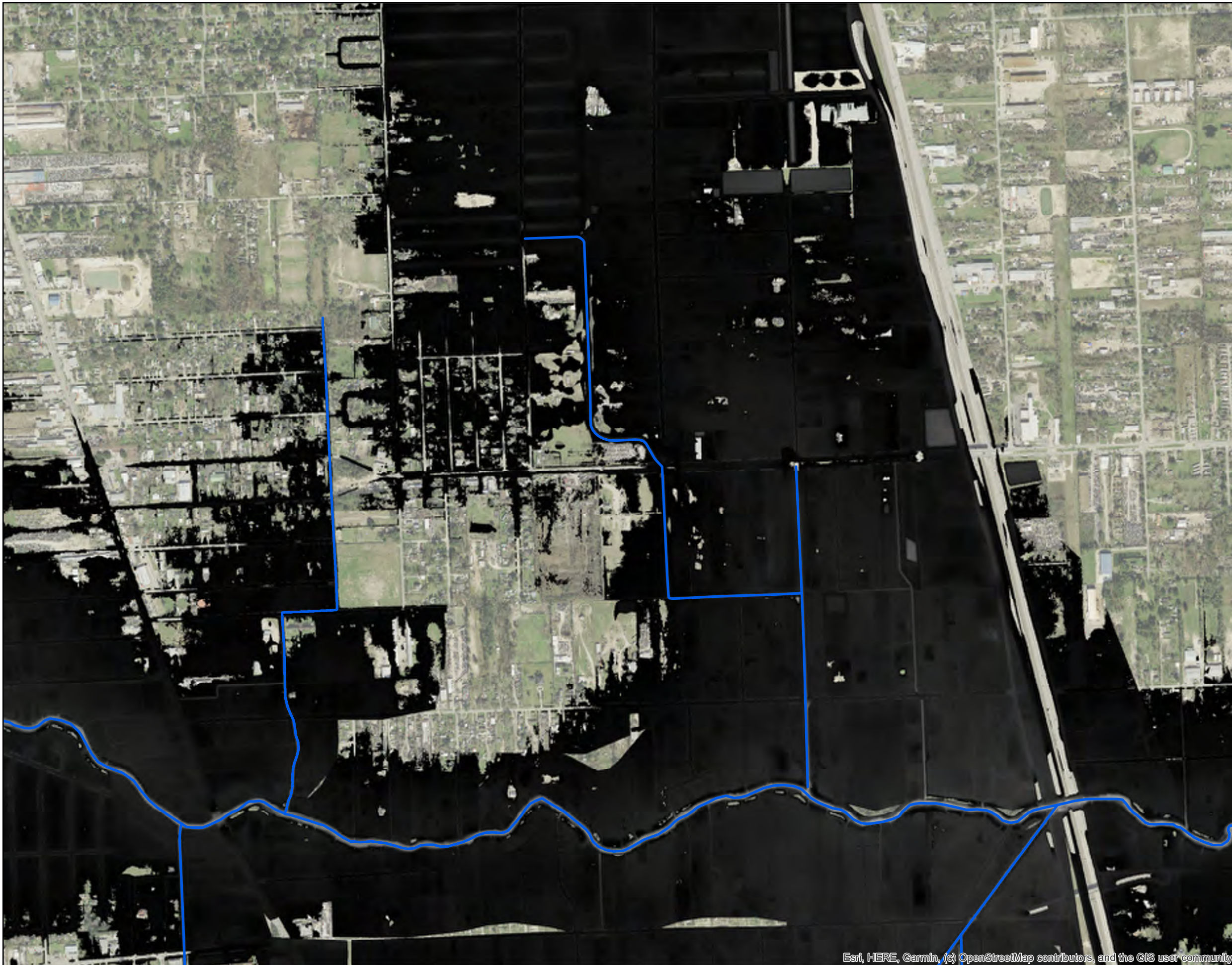




Legend
Existing Conditions Scenario
Value
- High : 15.8 FT
- Low : 0.0 FT

100-Year Existing Conditions
Inundation Map
Exhibit 6





N



0 500 1,000 2,000 Feet

Legend

Existing Conditions Scenario

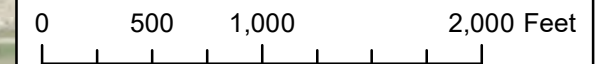
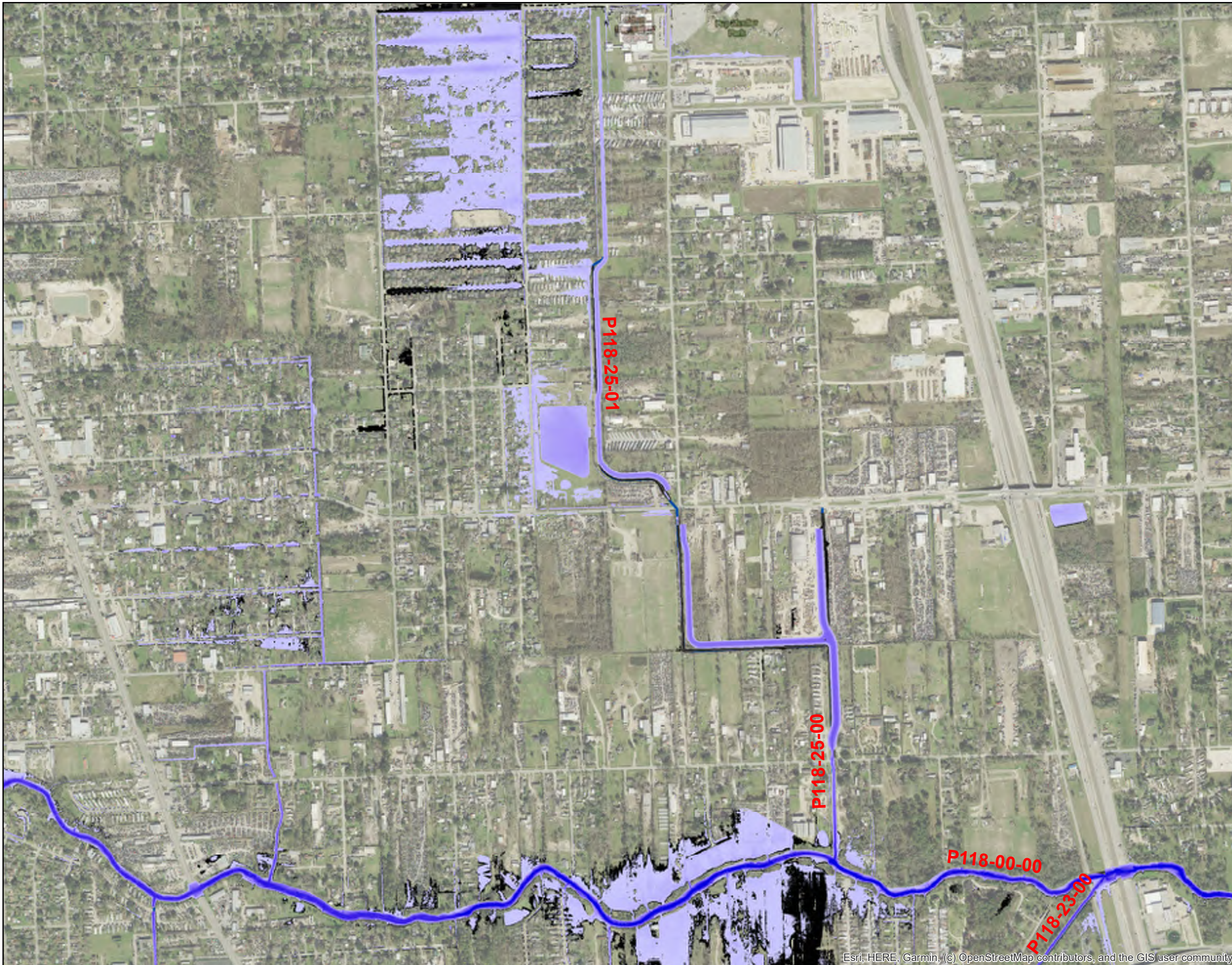
Value





High : 17.8 FT
Low : 0.0 FT

500-Year Existing Conditions
Inundation Map

Exhibit 7

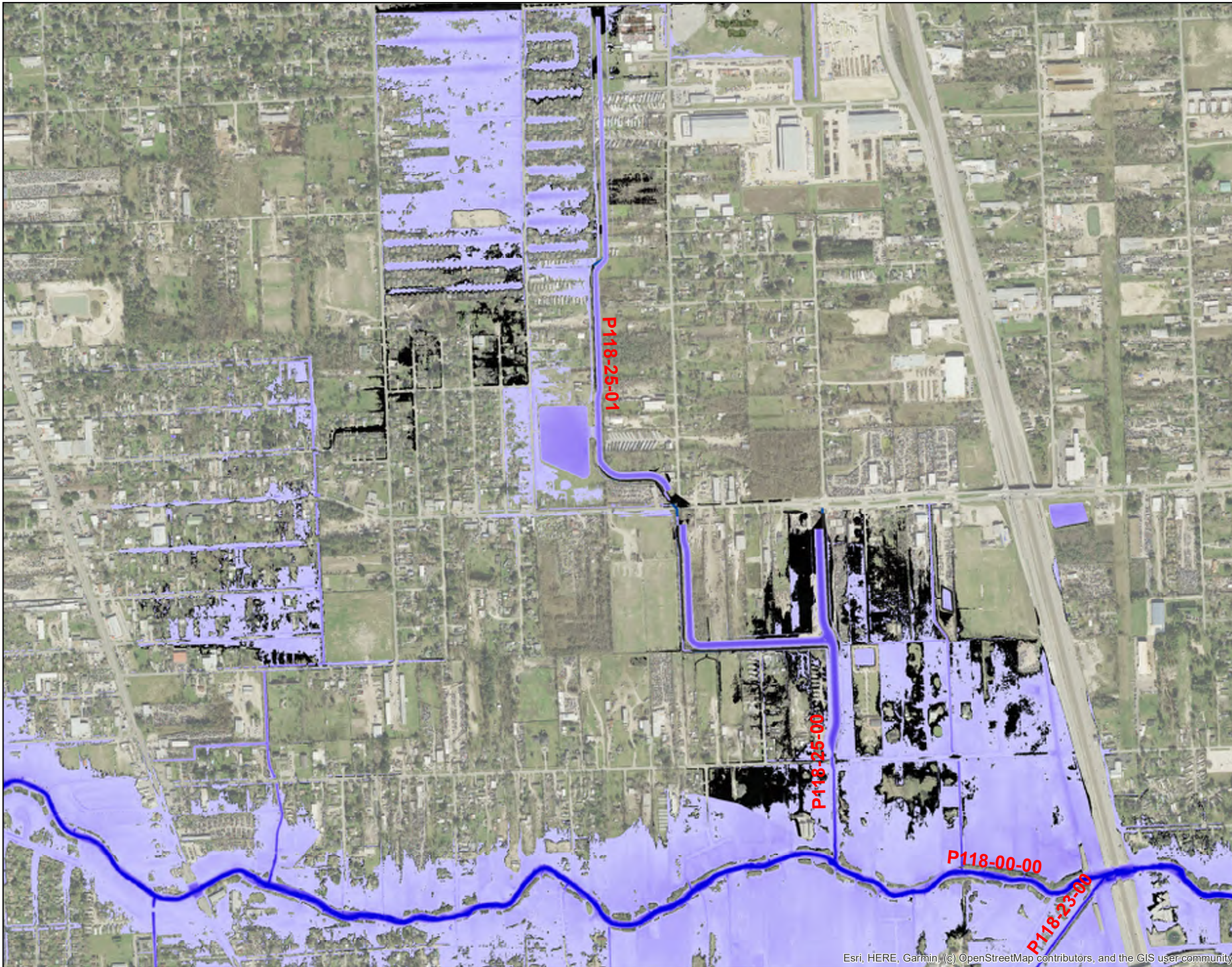




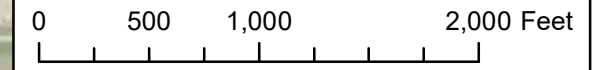
- Legend**
- Proposed Conditions Scenario**
- Value**
-  High : 13.5 FT
 -  Low : 0.0 FT
- Existing Conditions Scenario**
- Value**
-  High : 14.0 FT
 -  Low : 0.0 FT

2-Year Inundation Comparison Maps
Exhibit 8





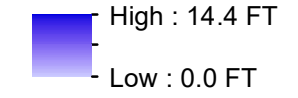
N



Legend

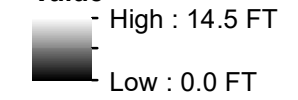
Proposed Conditions Scenario

Value



Existing Conditions Scenario

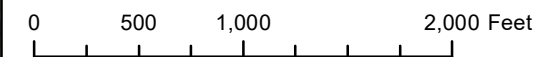
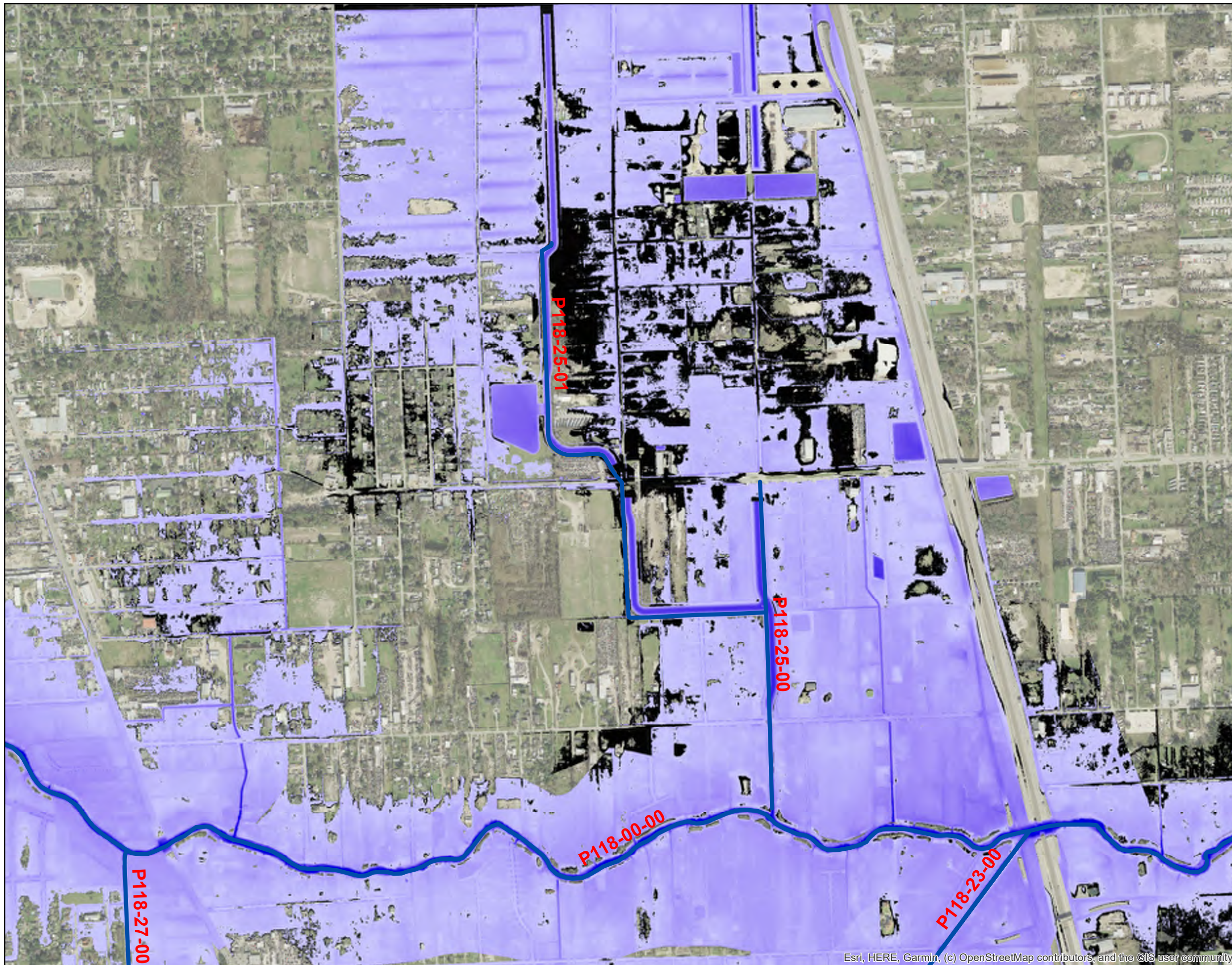
Value



10-Year Inundation Comparison Maps

Exhibit 9

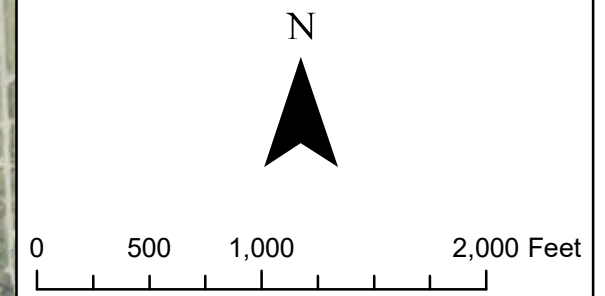
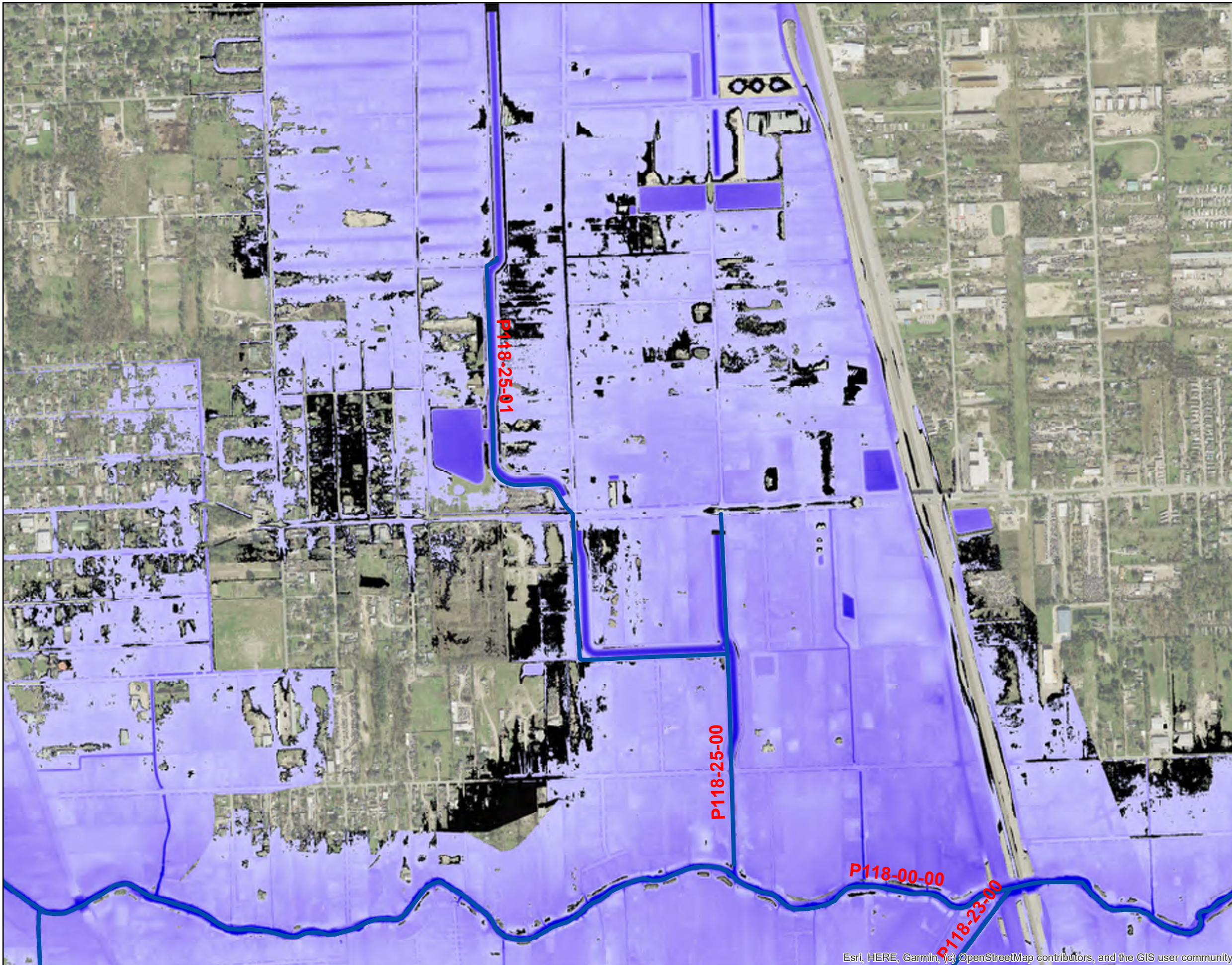




- Legend**
- Proposed Conditions Scenario**
 Value
 High : 15.7 FT
 Low : 0.0 FT
- Existing Conditions Scenario**
 Value
 High : 15.8 FT
 Low : 0.0 FT

100-Year Inundation Comparison Map
 Exhibit 10





Legend

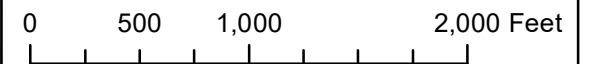
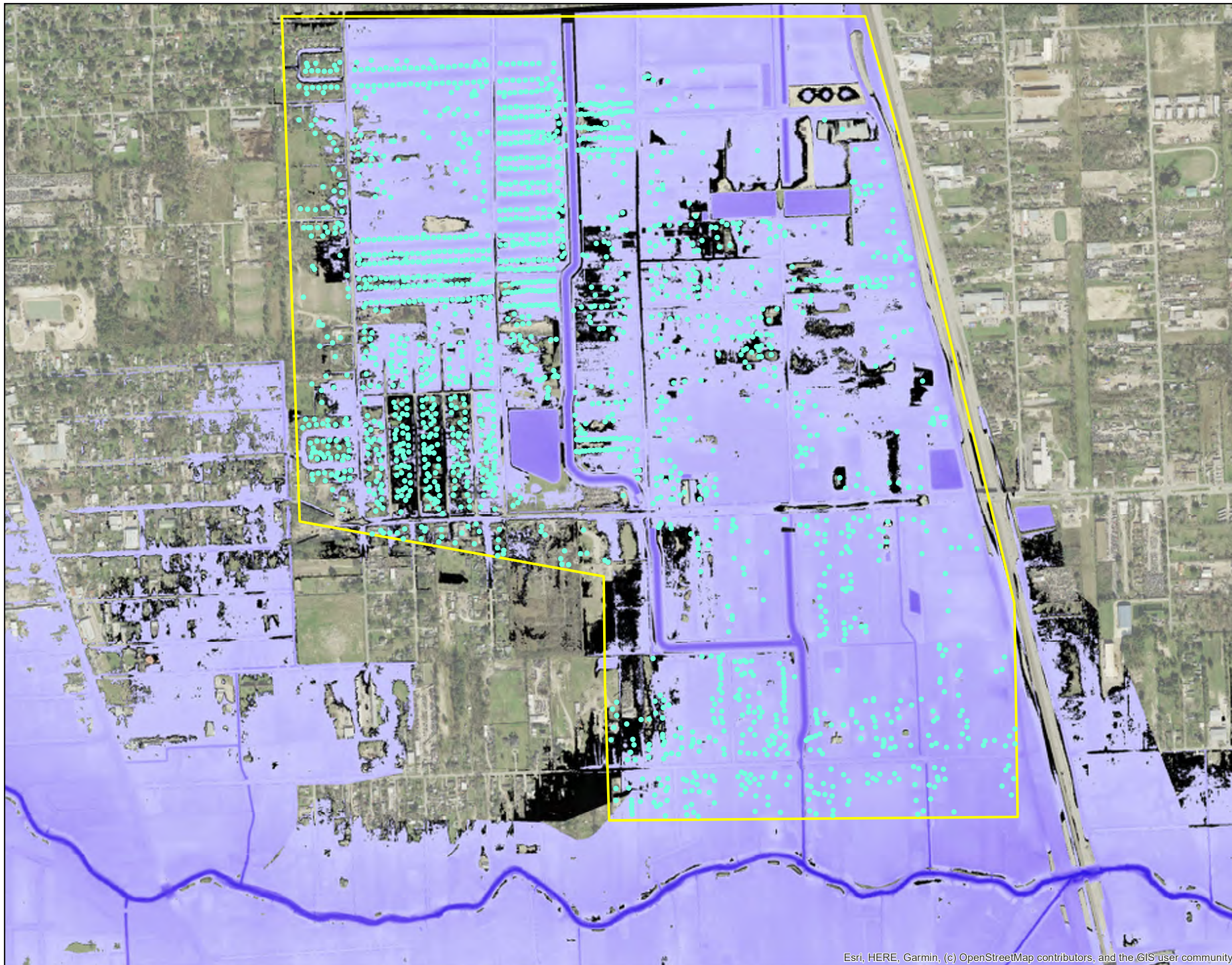
Proposed Conditions Scenario
 Value
 High : 17.4 FT
 Low : 0.0 FT

Existing Conditions Scenario
 Value
 High : 17.8 FT
 Low : 0.0 FT

500-Year Inundation
 Comparison Map with Structures

Exhibit 11

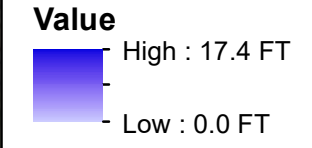




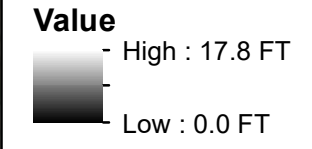
Legend

- Structures
- Performance Metrics Boundary

Proposed Conditions Scenario



Existing Conditions Scenario



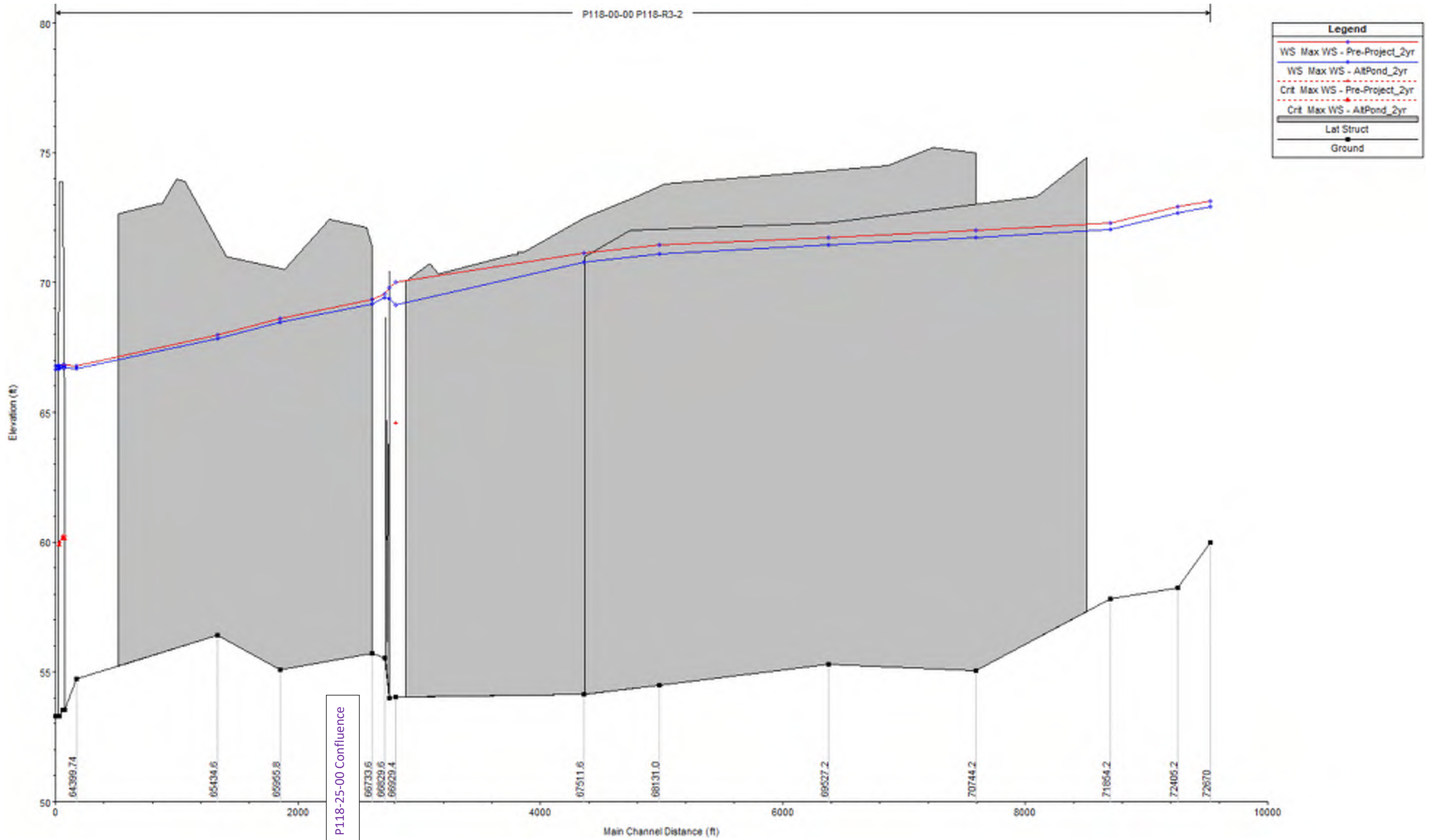
500-Year Inundation
Comparison Map with Structures

Exhibit 12

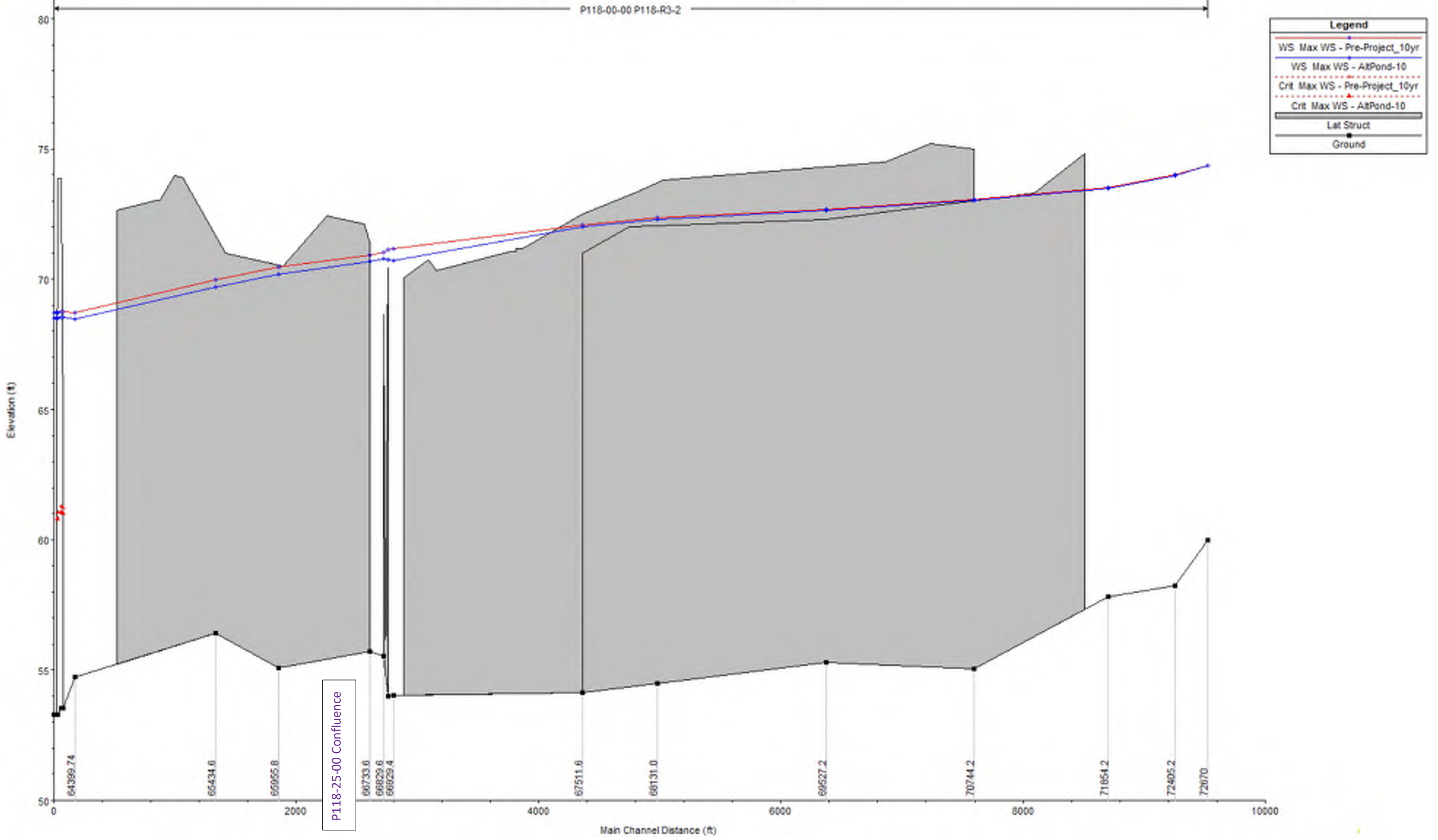


*ATTACHMENT 1 – WATER SURFACE ELEVATION
PROFILE*

2-Year Profile

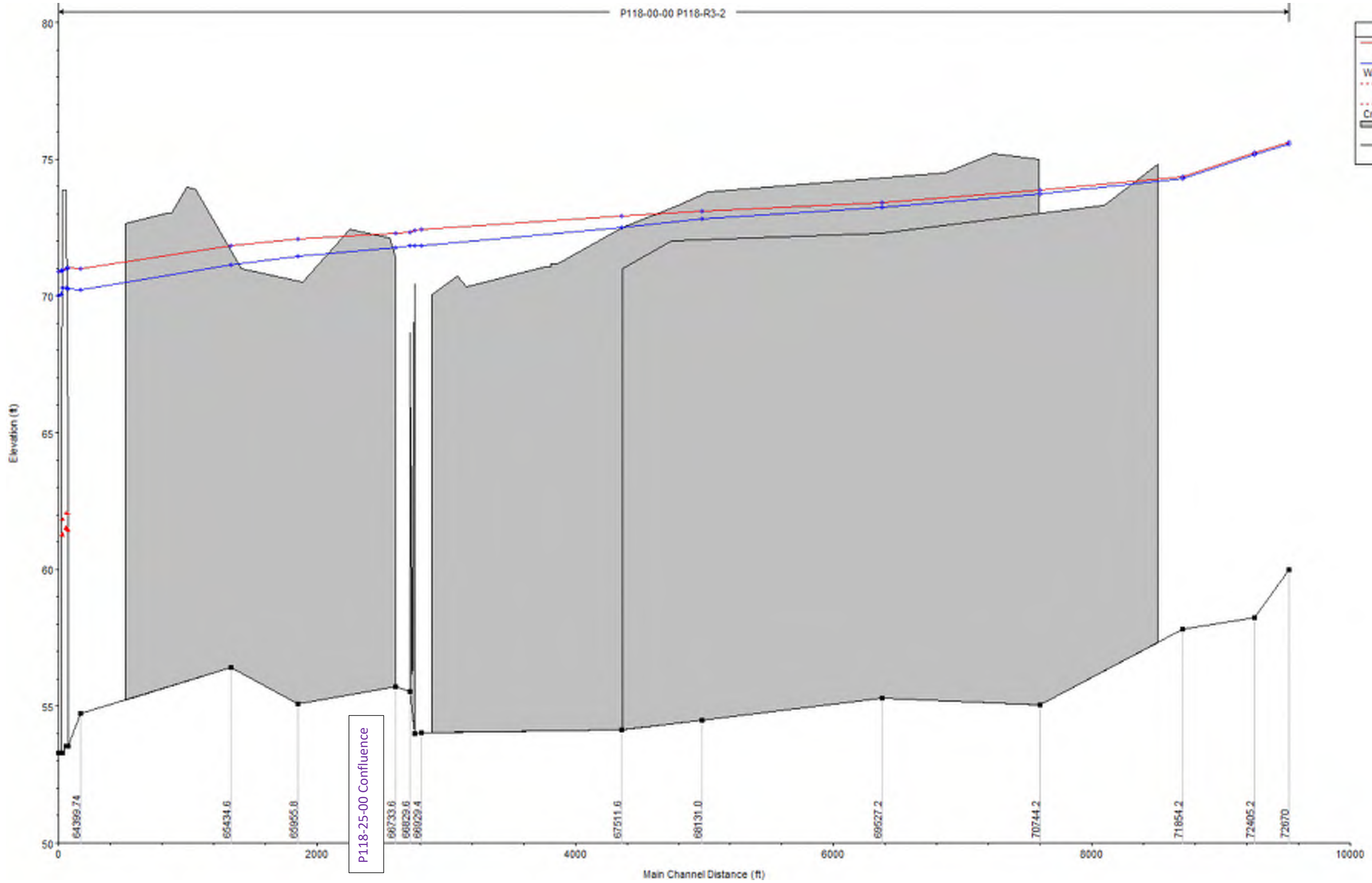


10-Year Profile



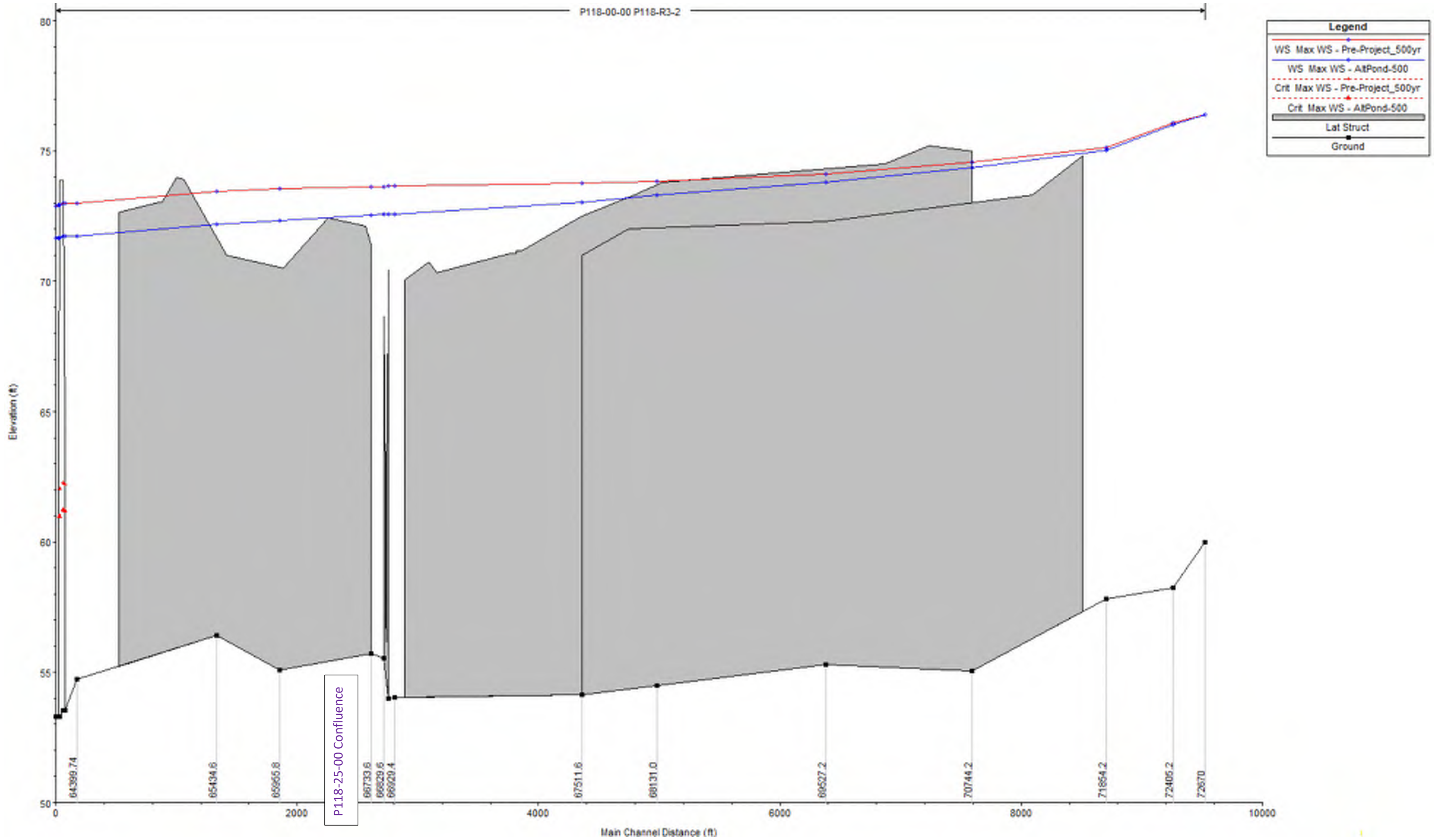
100-Year Profile

P118-00-00 P118-R3-2



Legend	
WS Max WS - 100_ex	Red line with triangle markers
WS Max WS - AltPond-100	Blue line with diamond markers
Crit Max WS - 100_ex	Red dotted line with triangle markers
Crit Max WS - AltPond-100	Blue dotted line with diamond markers
Lat Struct	Gray shaded area
Ground	Black line with square markers

500-Year Profile



*ATTACHMENT 2 – WATER SURFACE ELEVATION
TABULATION*

ATTACHMENT 3 – MODEL REVIEW COMMENTS



10351 Stella Link Road, Houston, Texas 77025
Phone: 832-767-0090, Fax: 832-767-0141
Email: nrp@ht-j.com

March 15, 2022

RE: Response to Comments
Halls Bayou Tributary Unit No. P118-25-00 No Impact Study HEC RAS Model

1. Lateral Structures 6950 and 6951 currently have XS 6957.03 as their upstream cross section connection. The lateral structures extend upstream to XS 7694 – they should be connected here, not at 6957.03. Both LSs downstream connection is XS 5505.16 – the length of both LS should be modified to end at XS 5505.16.

[This has been addressed in the model.](#)

2. LS 5341 downstream connection should be XS 4047.70.

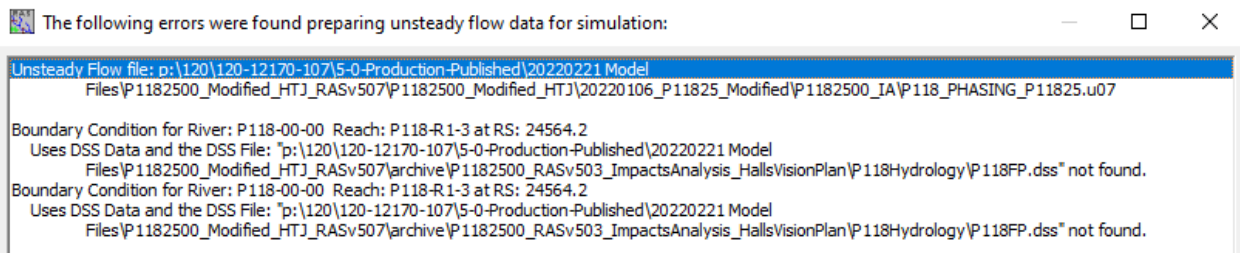
[This has been addressed in the model.](#)

3. LS 3203 upstream connection should be XS 2124.83.

[This has been addressed in the model.](#)

4. For 2-year existing run, it seems the wrong flow file is referenced for the two flows applied at XS 24564.2. See image below

[The 2-year existing scenario has been rerun to verify and establish this data connection.](#)



5. For 100-year existing, XS 1881.88 through 584.11 on P118-25-01 hydrographs are shaky. Same for LS 2541.

[In reviewing the hydrographs, we found that the recession and ascending limbs are relatively smooth. XS 1245.83, for example, has a minor fluctuation in the second peak but it does not impact the overall results. The peaks of the other hydrographs do not look impacted by any of the fluctuations. This system is at equilibrium and has a run error of 0.5%.](#)

6. For 10-year existing, WSEL error during run. See image below

```
Performing Unsteady Flow Simulation HEC-RAS 5.0.7 March 2019
Maximum iterations of 40
RS (or Cell) WSEL ERROR
01JAN2002 04:00:10 P118-21-00 P118-21-00 2135.78 66.86 0.22
Writing Results to DSS
The maximum xsec wsel error was 0.218
P118-21-00 P118-21-00 2135.78 at 01JAN2002 04:00:10
Finished Unsteady Flow Simulation
Reading Data for Post Process
Running Post Processor HEC-RAS 5.0.7 March 2019
Finished Post Processing
```

Since the error occurs in the first ten seconds of the simulated run, it does not have an impact on the results for this run. It appears that it occurs during the first time-interval, and has no bearings on the results.

7. Impact on 100-year storm event. Proposed conditions show increase in WSEL along Halls Bayou beginning around RS 32000 and continuing to RS 20858. Max impact is 0.15'

This occurs approximately 6 miles downstream of the P118-25-00 and Halls Bayou confluence. We believe this is a result of some computational issues, and cannot reasonably address the changes we can make 6 miles upstream.

8. Impact on 10-year storm event beginning around RS 56000 on Halls mainstem and continuing all the way downstream. Max impact is 0.4'

See response to Comment 7. In addition, the 10-year WSEL in the area is contained within the bank.

9. Impacts on 2-year storm event beginning around RS 35000 on Halls mainstem and continuing downstream. Max impact is 0.02'

See response to Comment 8.

APPENDIX H

DRAINAGE IMPROVEMENT FOR

OAK GLEN PLACE SUBDIVISION

MEMO

March 3, 2022

Mr. Michael Liga, P.E.
 Harris County Flood Control District
 9900 Northwest Freeway
 Houston, TX 77092

Re: *Drainage Improvements for Oak Glen Place Subdivision; HCFCF Pre-Atlas 14 Memorandum*

Dear Mr. Liga,

The purpose of this memo is to document the discharge hydrographs provided to HCFCF from the Oak Glen Place Subdivision into HCFCF Unit P118-25-01 north of Aldine Mail Route Road. The hydrographs were provided to HCFCF to be incorporated into the analysis of HCFCF Unit P118-25-01 channel improvements. This will ensure that the proposed improvements and detention for HCFCF Unit P118-25-01 will account for increased discharge created from proposed drainage improvements within the Oak Glen Place Subdivision.

The original analysis for the Oak Glen Place Subdivision was performed utilizing a 1D/2D PCSWMM model with Atlas 14 rainfall. HCFCF's study for HCFCF Unit P118-25-01 was started prior to Atlas 14 and was therefore modeled with pre-Atlas 14 rainfall. To tie the two studies together, The Oak Glen Place Subdivision hydrologic and hydraulic analysis was reanalyzed utilizing the pre-Atlas 14 rainfall.

The hydrographs were obtained from the PCSWMM model for the Oak Glen Place Subdivision for the Pre Atlas-14 rainfall 2-year, 10-year, 100-year and 500-year storm events. Existing condition and ultimate condition hydrographs were developed. Exhibits and hydrographs from the PCSWMM model discharge into HCFCF P118-25-01 were provided on September 24, 2021 and on October 4, 2021 and are attached to this memorandum. The following table summarizes the peak flows into HCFCF Unit P118-25-01 from all routes including storm sewers and overland flow paths.

Frequency	Peak Flow (cfs)	
	Existing	Proposed
2-Year	98.4	179.7
10-Year	133.4	249.3
100-Year	218.5	338.0
500-Year	294.9	407.1

Sincerely,

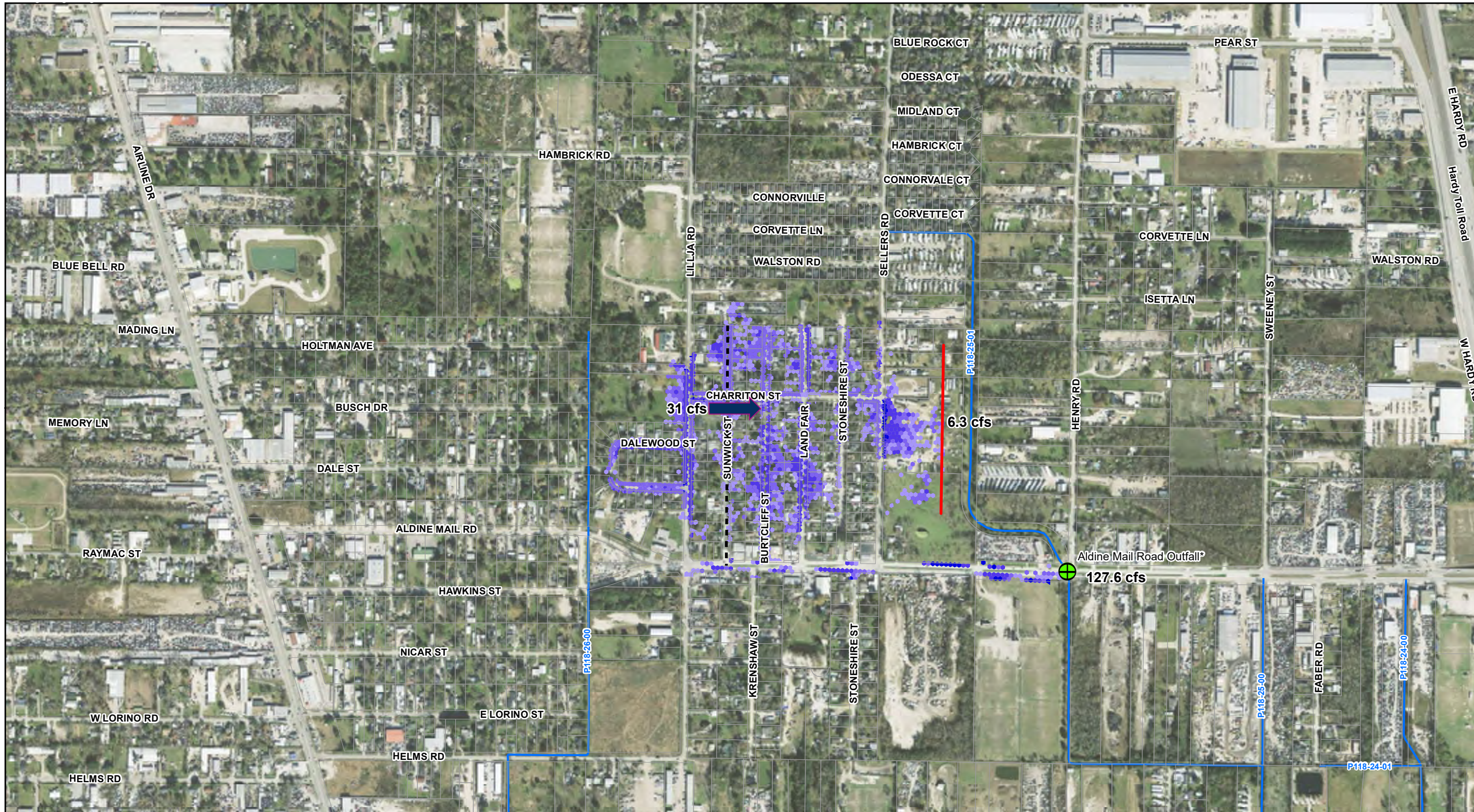
NEEL-SCHAFFER, INC.

Connor McColloch, PE
 Senior Project Manager



March 3, 2022





Legend

- Aldine Mail Outfall*
- Diversion
- Existing Overland Flow Outfall

MAXDEPTH

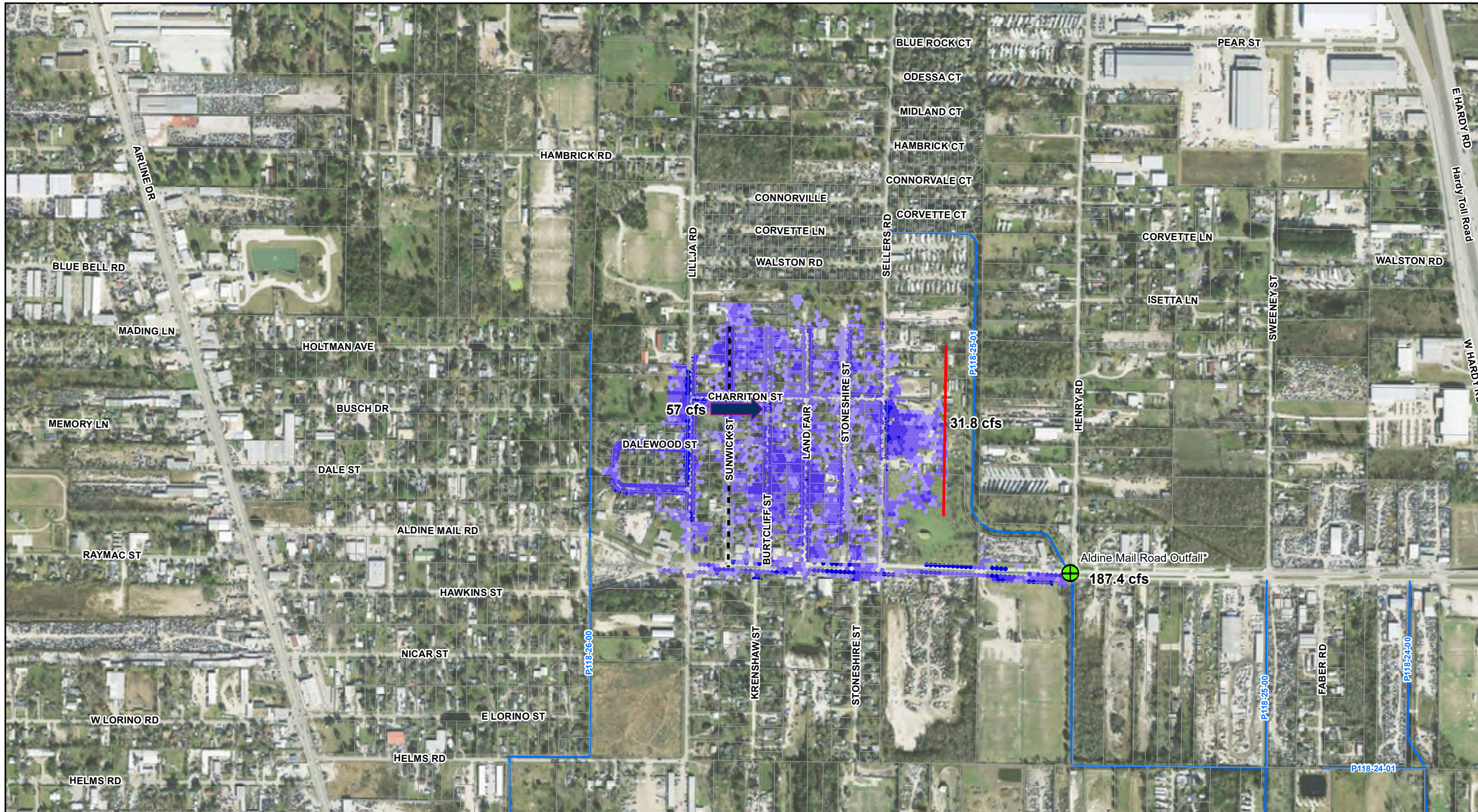
- <0.1'
- 0.1' - 0.25'
- 0.25' - 0.5'
- 0.5' - 1'
- >1'

* Discharge includes storm sewer and overland flow at the vicinity of the outfall.

0 350 700
Feet

**10-Year
Flow Diversion**





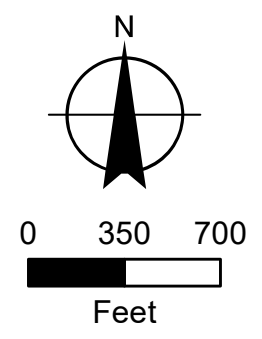
Legend

- Aldine Mail Outfall*
- Diversion
- Existing Overland Flow Outfall

MAXDEPTH

- <0.1'
- 0.1' - 0.25'
- 0.25' - 0.5'
- 0.5' - 1'
- >1'

* Discharge includes storm sewer and overland flow at the vicinity of the outfall.

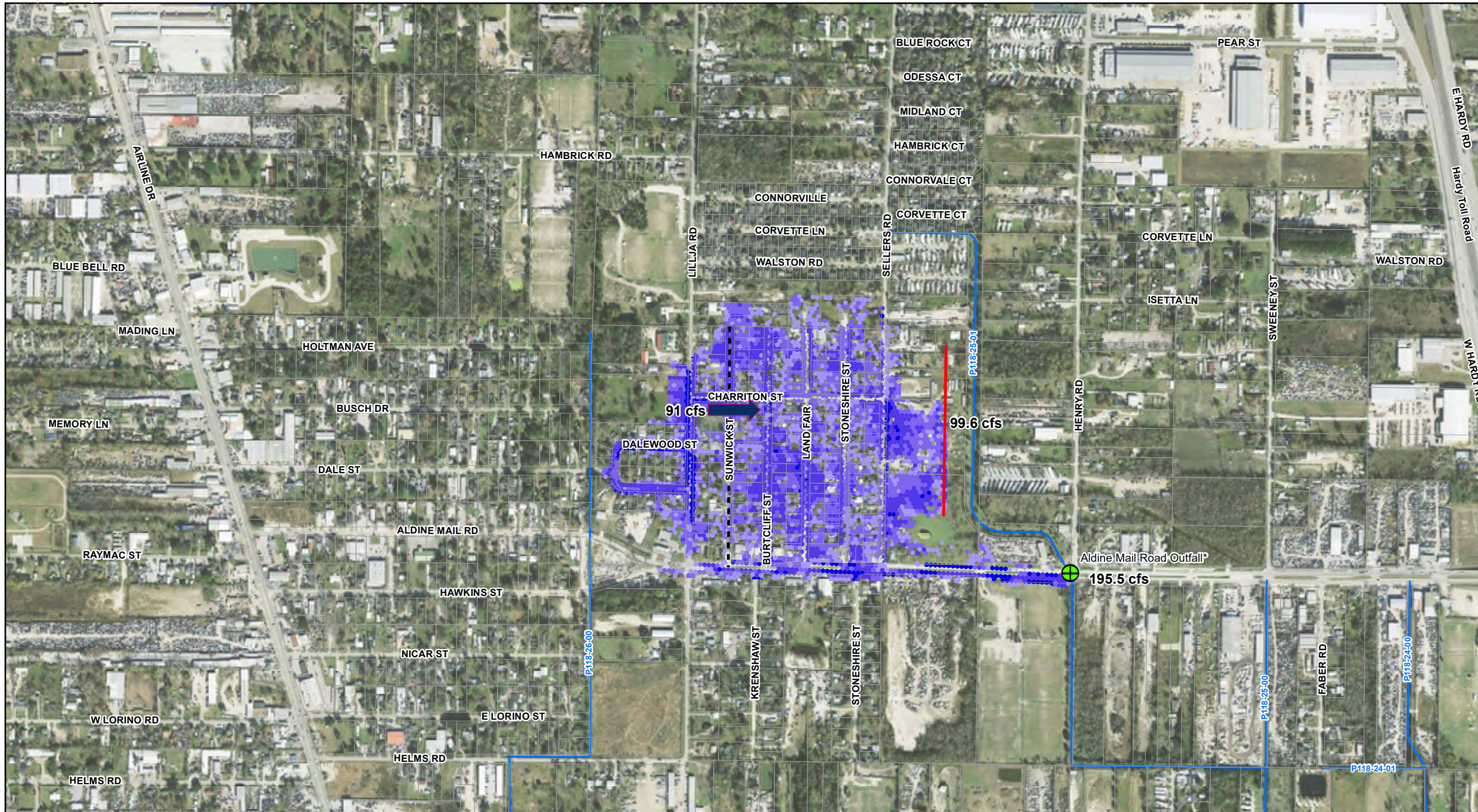


**100-Year
Flow Diversion**



www.hcfd.org/2018bondprogram





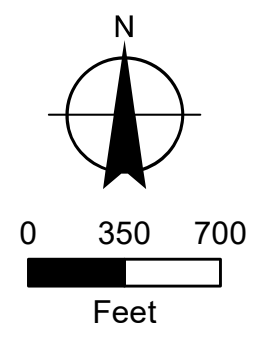
Legend

- Aldine Mail Outfall*
- Diversion
- Existing Overland Flow Outfall

MAXDEPTH

- <0.1'
- 0.1' - 0.25'
- 0.25' - 0.5'
- 0.5' - 1'
- >1'

* Discharge includes storm sewer and overland flow at the vicinity of the outfall.

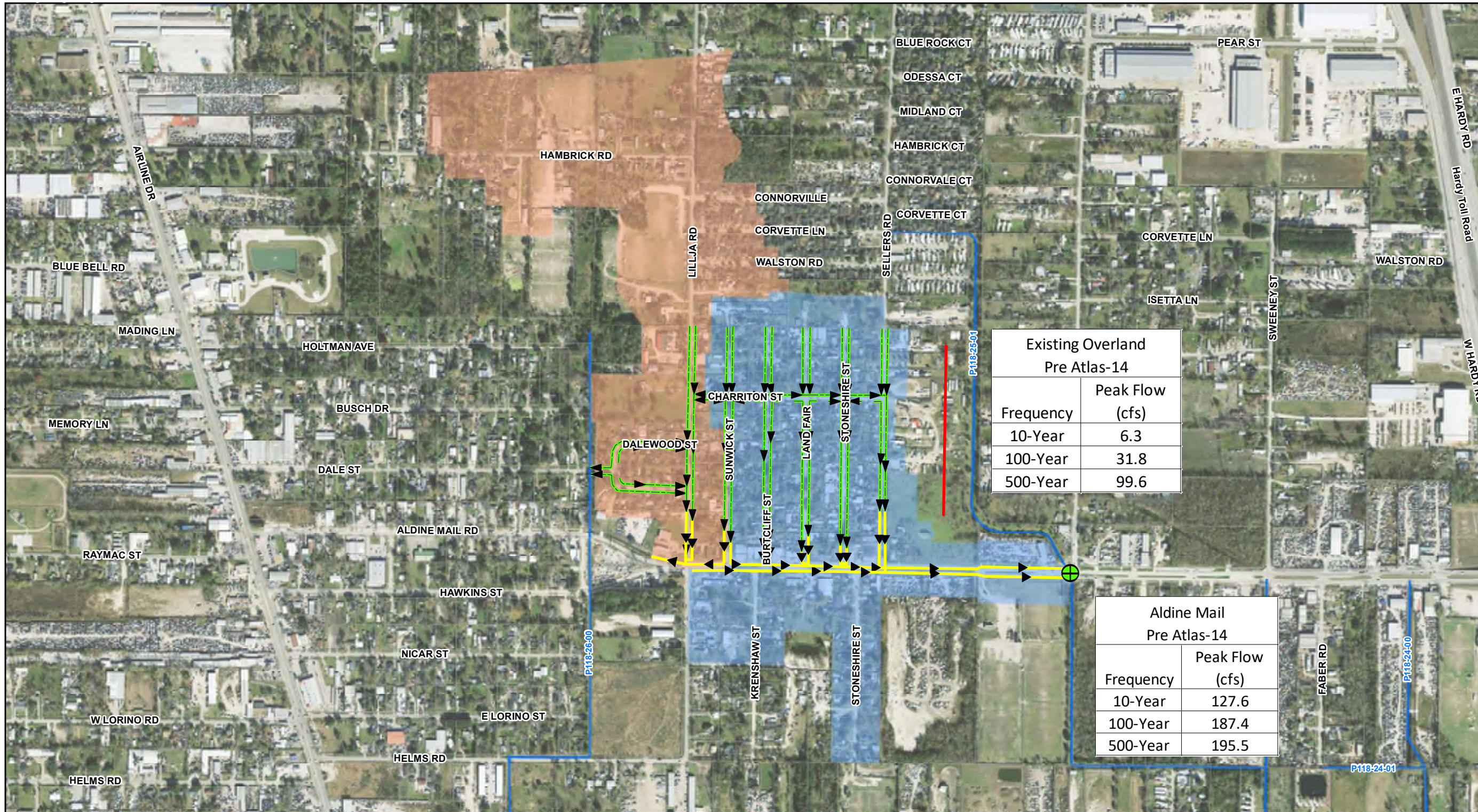


**500-Year
Flow Diversion**



www.hcfd.org/2018bondprogram



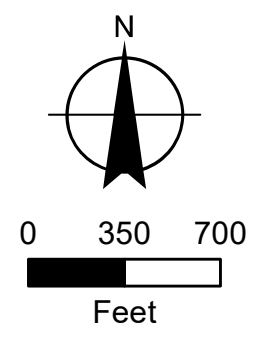


- Legend**
- Aldine Mail Outfall*
 - Existing Overland Flow Outfall
 - Existing Storm Sewer
 - Roadside Ditches
 - Drainage Area P118-25-01
 - Drainage Area P118-26-00

* Discharge includes storm sewer and overland flow at the vicinity of the outfall.

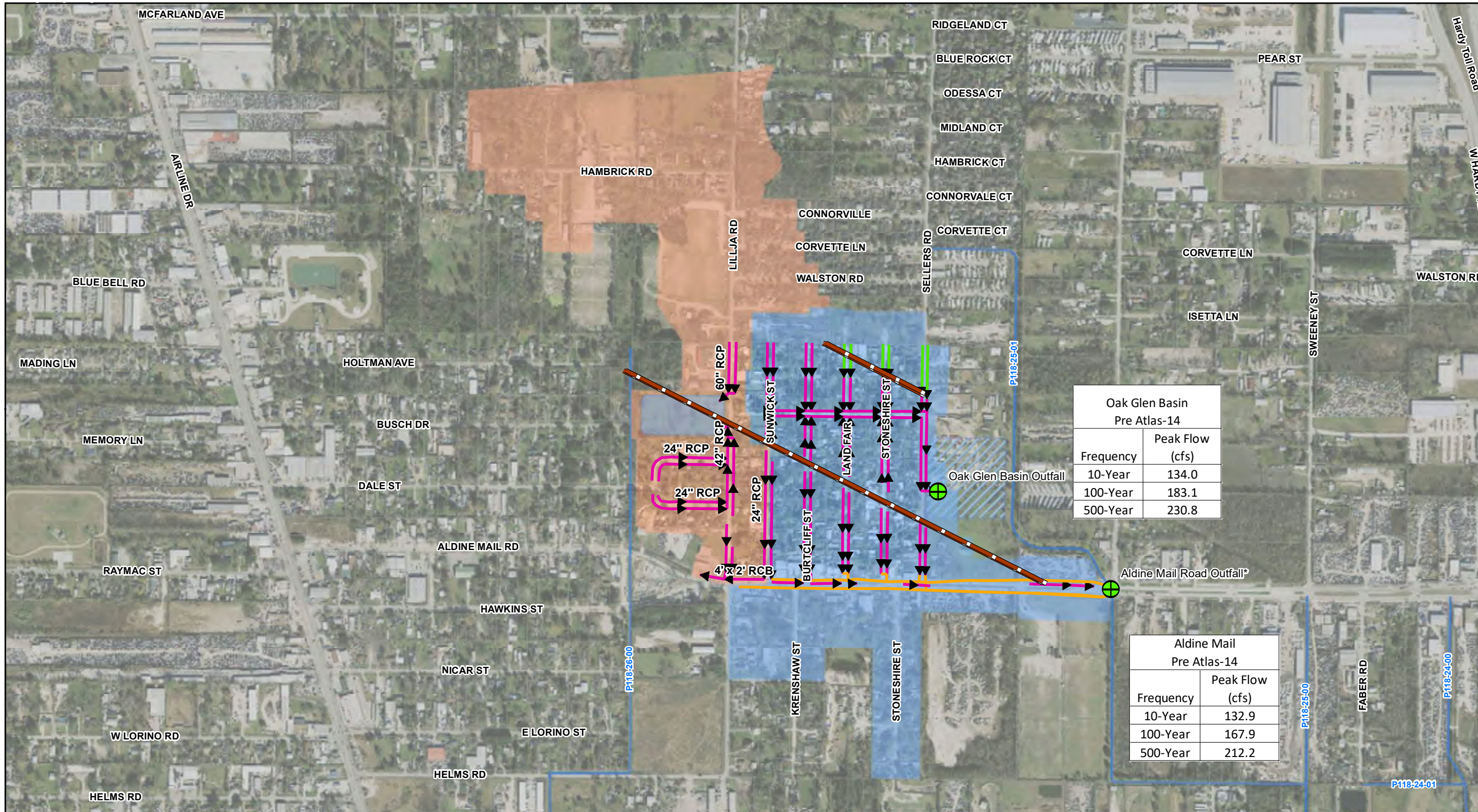
Existing Overland Pre Atlas-14	
Frequency	Peak Flow (cfs)
10-Year	6.3
100-Year	31.8
500-Year	99.6

Aldine Mail Pre Atlas-14	
Frequency	Peak Flow (cfs)
10-Year	127.6
100-Year	187.4
500-Year	195.5



Existing Drainage System Layout





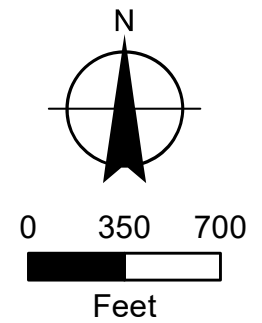
Legend

- Outfall
- Gas Pipeline
- Existing Storm Sewer
- Proposed Storm Sewer
- Proposed Roadside Ditch
- Detention Pond West
- Drainage Area P118-25-01
- Drainage Area P118-26-00
- Oak Glen Basin (HCFCD)

* Discharge includes storm sewer and overland flow at the vicinity of the outfall.

Frequency	Peak Flow (cfs)
10-Year	134.0
100-Year	183.1
500-Year	230.8

Frequency	Peak Flow (cfs)
10-Year	132.9
100-Year	167.9
500-Year	212.2



Proposed Drainage System Layout



APPENDIX I

DRAINAGE IMPROVEMENT FOR

ALDINE VILLAGE SUBDIVISION

MEMO

March 1, 2022

Harris County Engineering Department
Recovery and Resiliency Division
1001 Preston, 7th Floor
Houston, Texas 77002

ATTN: Mr. Cameron McCraw, P.E. – Freese and Nichols, Inc.

Re: Pre-Atlas 14 Hydrograph Development Methodology
Aldine Village Subdivision Drainage Improvements
Project No. 2101040013

Dear Mr. McCraw:

The purpose of this memorandum is to outline the methodology used to generate the pre-Atlas 14 outflow hydrographs from the storm sewer system of Aldine Village into HCFCD tributary Unit No. P118-25-01. This memo includes descriptions of hydrology development in HEC-HMS, how the rainfall was applied to the InfoWorks ICM hydraulic model, and the method for extracting the flow rates leaving the Aldine Village storm sewer system.

Background

Storm water detention for the Aldine Village Subdivision Drainage Improvements will be provided by the Harris County Flood Control District (HCFCD) as part of improvements to P118-25-00/01. An impact analysis of P118-25-00/01 is being performed by HCFCD's consultant, HTJ, to properly size the detention basin needed for both projects and ensure there is no downstream impact. The drainage impact analysis for Aldine Village used Atlas 14 rainfall values. The analysis for P118-25-00/01 is using pre-Atlas 14 rainfall. Therefore, HCFCD requested that LAN re-analyze Aldine Village using pre-Atlas 14 rainfall and provide the outfall hydrographs to HTJ for use in the P118-25-00/01 analysis.

Pre-Atlas 14 Precipitation

Pre-Atlas 14 precipitation estimates were collected from the HEC-HMS models completed in the Halls Bayou Tributary Unit No. P118-25-00/01 Alternatives Analysis. The annual exceedance probabilities (AEP) evaluated include the 50% (2-year), 10% (10-year), 1.0% (100-year), and 0.2% (500-year) design storms. **Table 1** outlines the precipitation estimates for the frequency storms.

Table 1: HEC-HMS Pre-Atlas 14 Precipitation Frequency Storms

PRECIPITATION FREQUENCY ESTIMATES				
Duration	2-Year (50% AEP)	10-Year (1.0% AEP)	100-Year (1.0% AEP)	500-Year (0.2% AEP)
5-min:	0.7	0.9	1.2	1.5
15-min:	1.1	1.5	2.1	2.7
60-min:	2.0	2.9	4.3	5.5
2-hr:	2.3	3.6	5.7	7.5
3-hr:	2.6	4.1	6.7	9.0
6-hr:	3.1	5.1	8.9	12.2
12-hr:	3.7	6.2	10.8	14.7
24-hr:	4.4	7.6	13.2	17.7

Pre-Atlas 14 Intensity

The results from the HEC-HMS model provided precipitation data (inches) for 5-minute intervals over a 24-hour rainfall event. To make this information usable in InfoWorks ICM, the precipitation data (inches) was converted to intensity (inches/hour). The intensities for the pre-Atlas 14 2-, 10-, 100-, and 500-year rainfall events were then imported into InfoWorks ICM to be used as a rainfall event for the 1D/2D hydraulic modeling of the Aldine Village Subdivision. **Figure 1** shows the 24-hour rainfall intensity for the evaluated pre-Atlas 14 storm frequencies.

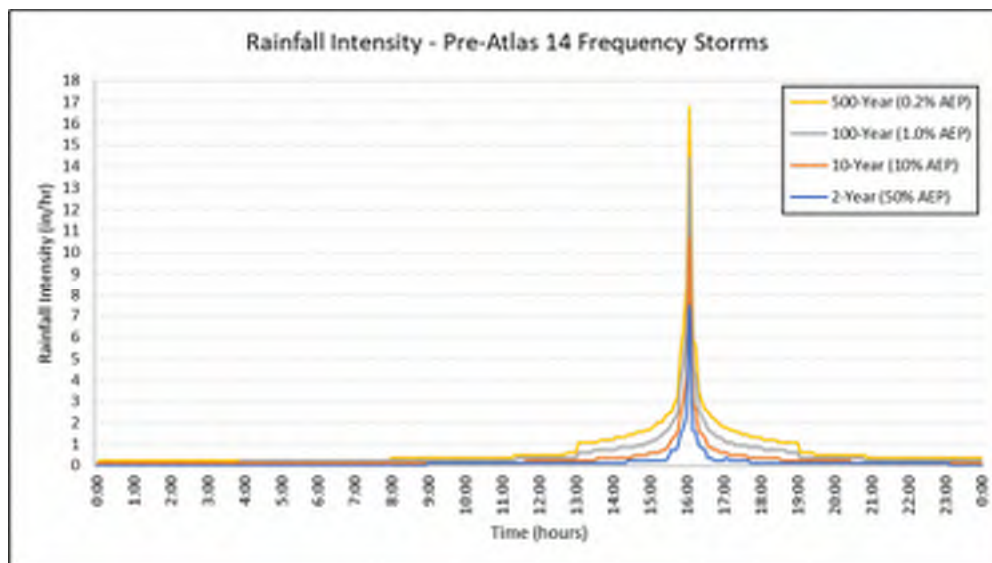


Figure 1: InfoWorks ICM Pre-Atlas 14 Rainfall Intensities

Rainfall Application

The rainfall intensities were then applied directly to the 2D ground surface/mesh within InfoWorks ICM. The ground surface is made up of triangular mesh elements generated from the Houston-Galveston Area Council (HGAC) LiDAR elevation data collected in 2018. Additionally, the storm infrastructure was

imported into InfoWorks ICM to allow for a fully integrated 1D/2D model. In general, pre-Atlas 14 rainfall is applied to the 2D ground surface, drains via overland flow into the 1D storm sewer system or culvert connections, and is routed and discharged to the downstream receiving systems (in this case P118-25-01).

Downstream Tailwater Conditions

Tailwater conditions for P118-25-01 at the Aldine Village system outfall were defined as normal depth conditions for all evaluated frequency storms. Normal depth conditions were chosen for three reasons: 1) to ensure tailwater conditions in P118-25-01 are not limiting the outflow of the local Aldine Village storm sewer system during extreme events, 2) to produce higher flow rates out of the storm sewer system compared to a drowned outfall, and 3) to be consistent with surrounding improvement projects that discharge to P118-25-01. Normal depth conditions, and the associated higher flow rates, allow for a more conservative approach to evaluating the design of downstream detention facilities for mitigation.

Pre-Atlas 14 Hydrograph Development:

To ensure all contributing runoff volume is captured post-rainfall event, the InfoWorks ICM simulations were extended to 48-hours. Existing and proposed outflow hydrographs were developed for the pre-Atlas 14 2-, 10-, 100-, and 500-year frequency storms at the Aldine Village storm sewer system outfall into tributary channel P118-25-01. For existing conditions, flow was evaluated at the existing 54” reinforced concrete pipe (RCP) outfall into P118-25-01. For proposed conditions, total flow was evaluated as the sum of flow at the existing 54” RCP outfall and the proposed 6’x3’ reinforced concrete box (RCB). The 6’x3’ RCB outfall has a separate outfall location to the east of Corvette Court into a proposed temporary channel extension of P118-25-01. While overland sheet flow occurs within the study area, flow leaving Aldine Village must be conveyed through the storm sewer system along Corvette Court to reach the outfall into P118-25-01. **Table 2** shows the existing and proposed peak flows leaving the Aldine Village storm sewer system and the magnitude of the increase.

Table 2: Pre-Atlas 14 Peak Flow into Tributary P118-25-01

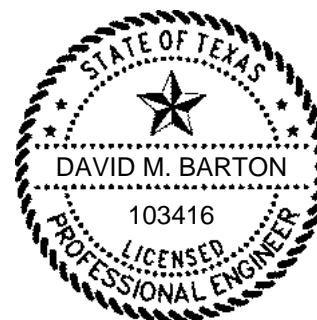
	Peak Flow (cfs)			
	2-Year	10-Year	100-Year	500-Year
Existing	107.6	117.5	129.2	137.1
Proposed	160.8	191.2	210.1	215.9
<i>Delta</i>	<i>+53.2</i>	<i>+73.7</i>	<i>+80.8</i>	<i>+78.8</i>

The existing and proposed outflow hydrographs and respective time-series data can be found in **Attachment A**.

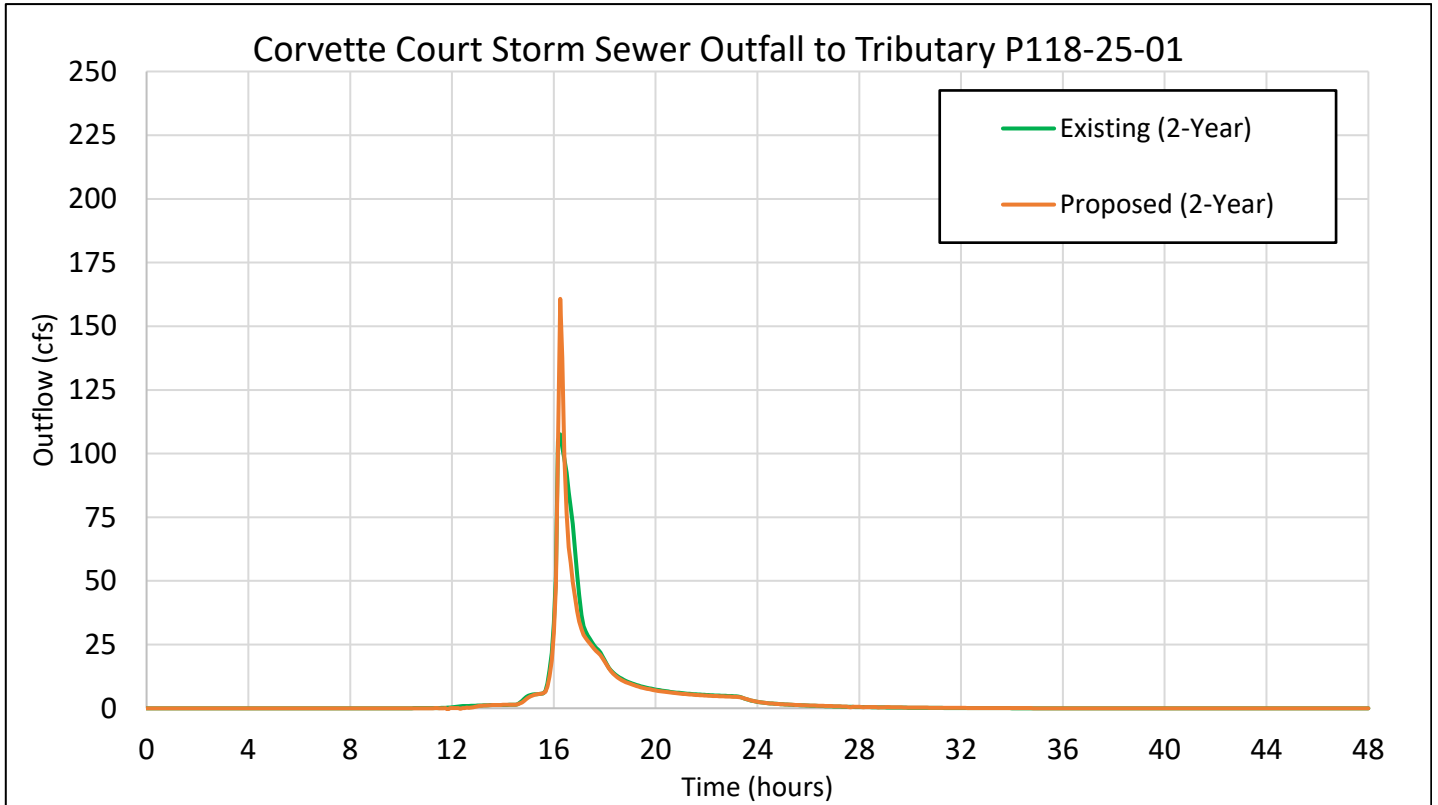
Sincerely,



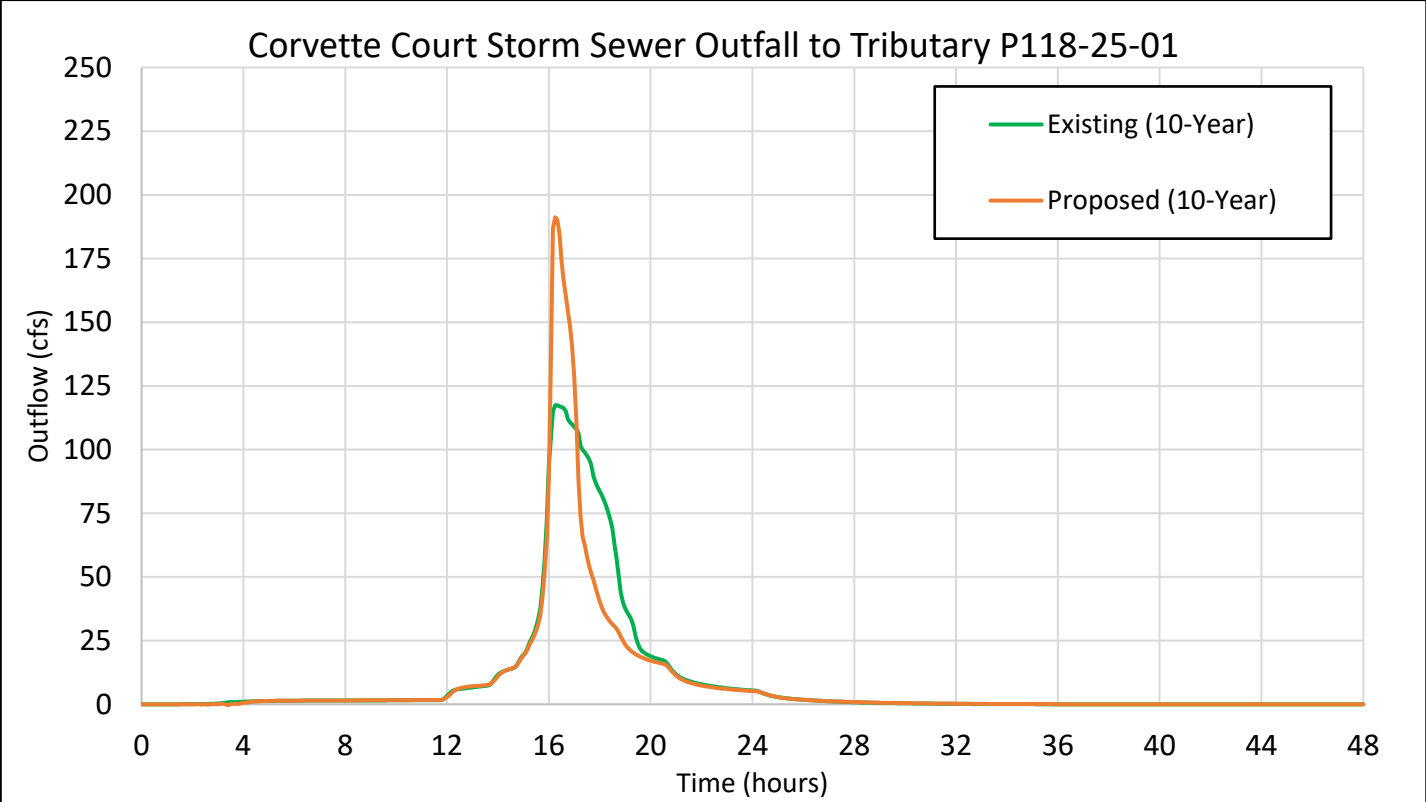
David M. Barton, P.E., C.F.M.
Project Manager – Lockwood, Andrews and Newnam, Inc.



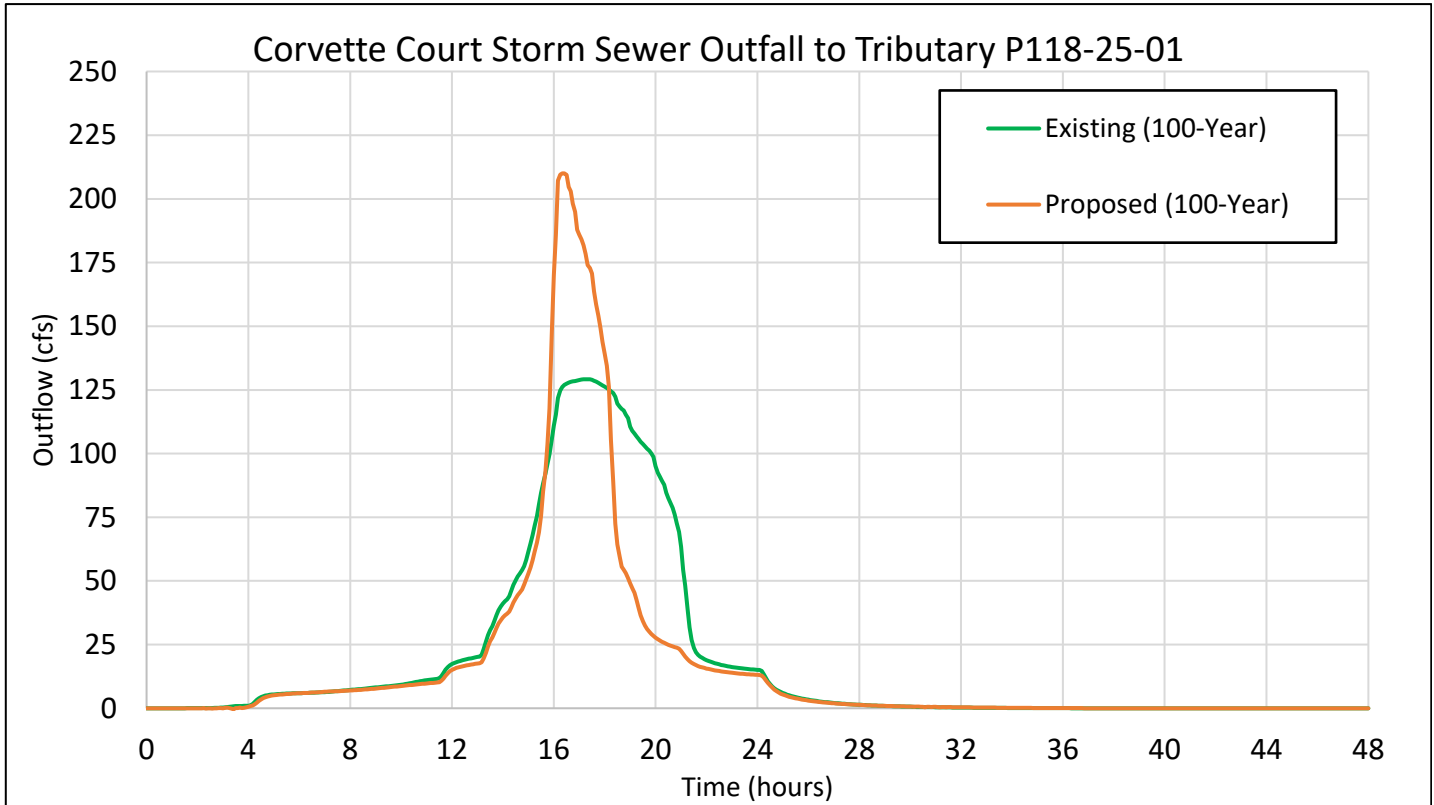
2-Year Hydrographs



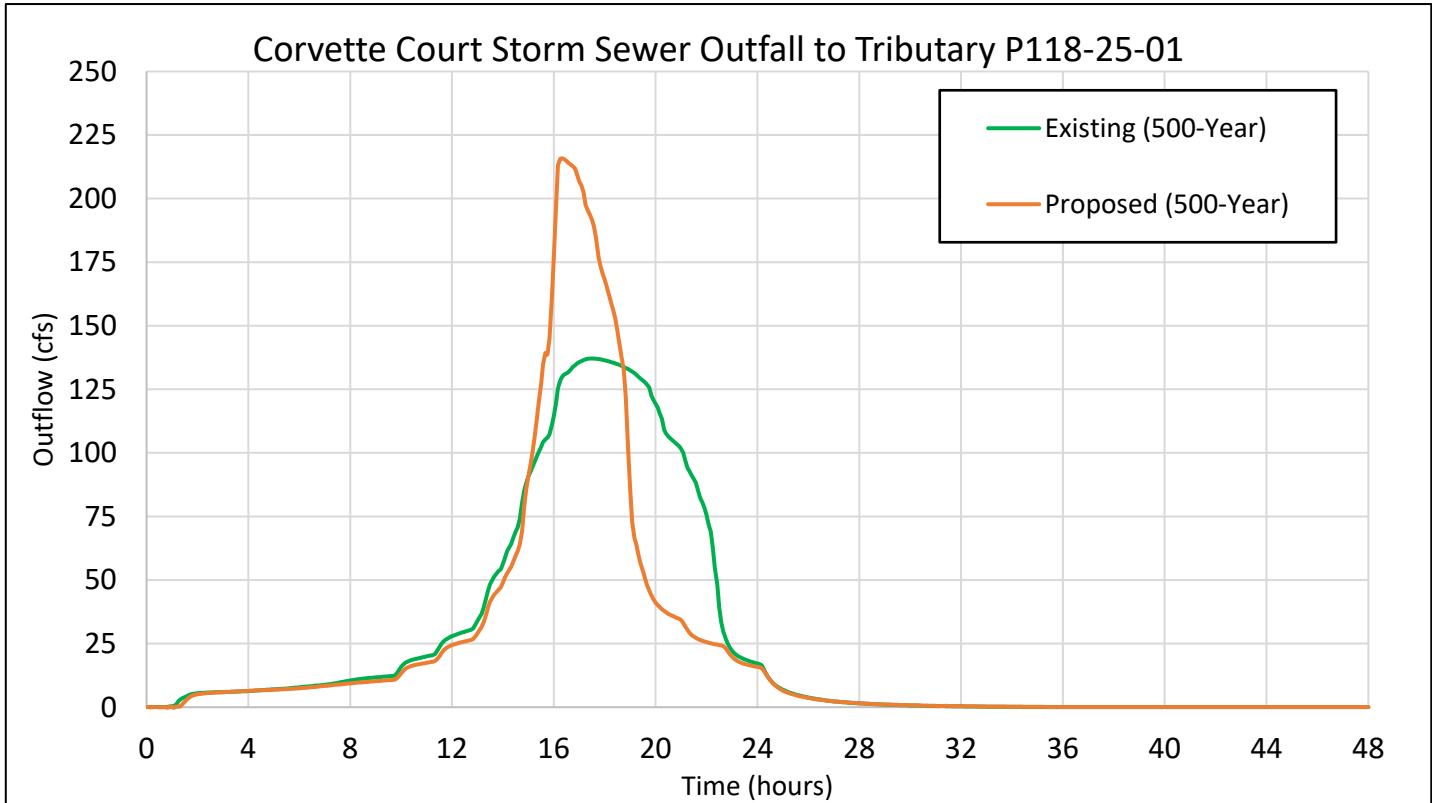
10-Year Hydrographs



100-Year Hydrographs



500-Year Hydrographs



Aldine Village Subdivision Storm Sewer Outfall to HCFCO Tributary Unit No. P118-25-01

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.083	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.167	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.250	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.333	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.417	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.583	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.667	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.750	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
50	0.833	0.0	0.0	0.0	0.2	0.0	0.0	0.0	-0.2
55	0.917	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.3
60	1.000	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1
65	1.083	0.0	0.0	0.0	0.6	0.0	0.0	0.0	-0.3
70	1.167	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.2
75	1.250	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.2
80	1.333	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.3
85	1.417	0.0	0.0	0.0	3.6	0.0	0.0	0.0	1.2
90	1.500	0.0	0.0	0.0	4.0	0.0	0.0	0.0	2.2
95	1.583	0.0	0.0	0.0	4.4	0.0	0.0	0.0	3.1
100	1.667	0.0	0.0	0.0	4.8	0.0	0.0	0.0	3.8
105	1.750	0.0	0.0	0.0	5.1	0.0	0.0	0.0	4.3
110	1.833	0.0	0.0	0.0	5.3	0.0	0.0	0.0	4.7
115	1.917	0.0	0.1	0.1	5.4	0.0	0.0	0.0	4.9
120	2.000	0.0	0.1	0.1	5.5	0.0	0.0	0.0	5.1
125	2.083	0.0	0.1	0.1	5.6	0.0	0.0	0.0	5.2
130	2.167	0.0	0.1	0.1	5.6	0.0	0.0	0.0	5.3
135	2.250	0.0	0.1	0.1	5.7	0.0	0.1	0.1	5.4
140	2.333	0.0	0.1	0.1	5.7	0.0	-0.2	-0.2	5.5
145	2.417	0.0	0.1	0.1	5.8	0.0	0.0	0.0	5.5
150	2.500	0.0	0.1	0.1	5.8	0.0	0.0	0.0	5.6
155	2.583	0.0	0.1	0.1	5.8	0.0	-0.1	-0.1	5.6
160	2.667	0.0	0.1	0.1	5.9	0.0	0.0	0.0	5.7
165	2.750	0.0	0.2	0.2	5.9	0.0	0.0	0.0	5.8
170	2.833	0.0	0.2	0.2	5.9	0.0	0.1	0.1	5.8
175	2.917	0.0	0.2	0.2	5.9	0.0	0.0	0.0	5.9
180	3.000	0.0	0.3	0.3	5.9	0.0	0.0	0.0	5.9
185	3.083	0.0	0.4	0.4	6.0	0.0	0.1	0.1	6.0
190	3.167	0.0	0.5	0.5	6.0	0.0	0.3	0.3	6.0
195	3.250	0.0	0.6	0.6	6.0	0.0	0.1	0.1	6.0
200	3.333	0.0	0.7	0.7	6.1	0.0	-0.1	-0.1	6.1
205	3.417	0.0	0.8	0.8	6.1	0.0	-0.5	-0.5	6.1
210	3.500	0.0	0.8	0.8	6.1	0.0	0.0	0.0	6.2
215	3.583	0.0	0.9	0.9	6.2	0.0	0.1	0.1	6.2

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
220	3.667	0.0	0.9	0.9	6.2	0.0	0.2	0.2	6.2
225	3.750	0.0	0.9	0.9	6.2	0.0	0.1	0.1	6.3
230	3.833	0.0	0.9	0.9	6.3	0.0	0.2	0.2	6.3
235	3.917	0.0	1.0	1.0	6.3	0.0	0.4	0.4	6.3
240	4.000	0.0	1.0	1.0	6.3	0.0	0.5	0.5	6.4
245	4.083	0.0	1.0	1.2	6.4	0.0	0.7	0.8	6.5
250	4.167	0.0	1.1	1.7	6.4	0.0	0.6	1.1	6.5
255	4.250	0.0	1.1	2.5	6.5	0.0	0.9	1.6	6.6
260	4.333	0.0	1.2	3.3	6.6	0.0	1.0	2.2	6.6
265	4.417	0.0	1.2	3.9	6.6	0.0	1.1	2.9	6.6
270	4.500	0.0	1.2	4.4	6.7	0.0	1.1	3.5	6.7
275	4.583	0.0	1.2	4.7	6.7	0.0	1.2	4.0	6.7
280	4.667	0.0	1.3	5.0	6.8	0.0	1.2	4.3	6.7
285	4.750	0.0	1.3	5.1	6.9	0.0	1.3	4.6	6.7
290	4.833	0.0	1.3	5.3	6.9	0.0	1.3	4.8	6.8
295	4.917	0.0	1.3	5.4	7.0	0.0	1.3	5.0	6.8
300	5.000	0.0	1.3	5.5	7.0	0.0	1.3	5.1	6.9
305	5.083	0.0	1.3	5.5	7.1	0.0	1.3	5.2	6.9
310	5.167	0.0	1.3	5.6	7.1	0.0	1.3	5.3	6.9
315	5.250	0.0	1.3	5.6	7.2	0.0	1.4	5.4	7.0
320	5.333	0.0	1.3	5.7	7.2	0.0	1.4	5.4	7.0
325	5.417	0.0	1.3	5.7	7.3	0.0	1.4	5.5	7.1
330	5.500	0.0	1.3	5.8	7.3	0.0	1.4	5.6	7.1
335	5.583	0.0	1.4	5.8	7.4	0.0	1.4	5.6	7.2
340	5.667	0.0	1.4	5.8	7.5	0.0	1.4	5.7	7.2
345	5.750	0.0	1.4	5.9	7.6	0.0	1.4	5.8	7.3
350	5.833	0.0	1.4	5.9	7.7	0.0	1.4	5.8	7.3
355	5.917	0.0	1.4	5.9	7.7	0.0	1.4	5.9	7.4
360	6.000	0.0	1.4	5.9	7.8	0.0	1.4	5.9	7.4
365	6.083	0.0	1.4	5.9	7.9	0.0	1.4	5.9	7.5
370	6.167	0.0	1.4	6.0	8.0	0.0	1.4	6.0	7.6
375	6.250	0.0	1.4	6.0	8.1	0.0	1.4	6.0	7.7
380	6.333	0.0	1.4	6.0	8.1	0.0	1.4	6.1	7.7
385	6.417	0.0	1.4	6.1	8.2	0.0	1.5	6.1	7.8
390	6.500	0.0	1.4	6.1	8.3	0.0	1.5	6.2	7.9
395	6.583	0.0	1.4	6.2	8.4	0.0	1.5	6.2	8.0
400	6.667	0.0	1.5	6.2	8.5	0.0	1.5	6.3	8.0
405	6.750	0.0	1.5	6.2	8.6	0.0	1.5	6.3	8.1
410	6.833	0.0	1.5	6.3	8.6	0.0	1.5	6.3	8.2
415	6.917	0.0	1.5	6.3	8.7	0.0	1.5	6.4	8.3
420	7.000	0.0	1.5	6.3	8.8	0.0	1.5	6.5	8.4
425	7.083	0.0	1.5	6.4	8.9	0.0	1.5	6.5	8.4
430	7.167	0.0	1.5	6.5	9.0	0.0	1.5	6.6	8.5
435	7.250	0.0	1.5	6.6	9.1	0.0	1.5	6.6	8.6
440	7.333	0.0	1.5	6.6	9.3	0.0	1.5	6.7	8.7

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
445	7.417	0.0	1.5	6.7	9.4	0.0	1.5	6.7	8.8
450	7.500	0.0	1.5	6.7	9.5	0.0	1.5	6.7	8.9
455	7.583	0.0	1.5	6.8	9.7	0.0	1.5	6.7	9.0
460	7.667	0.0	1.5	6.9	9.9	0.0	1.5	6.8	9.0
465	7.750	0.0	1.5	7.0	10.0	0.0	1.5	6.8	9.1
470	7.833	0.0	1.5	7.1	10.2	0.0	1.5	6.9	9.2
475	7.917	0.0	1.5	7.1	10.3	0.0	1.5	6.9	9.3
480	8.000	0.0	1.5	7.2	10.5	0.0	1.5	7.0	9.4
485	8.083	0.0	1.5	7.3	10.6	0.0	1.5	7.0	9.4
490	8.167	0.0	1.5	7.4	10.8	0.0	1.5	7.1	9.5
495	8.250	0.0	1.5	7.4	10.9	0.0	1.5	7.1	9.6
500	8.333	0.0	1.5	7.5	11.0	0.0	1.5	7.2	9.7
505	8.417	0.0	1.5	7.6	11.1	0.0	1.5	7.3	9.7
510	8.500	0.0	1.5	7.7	11.2	0.0	1.5	7.3	9.8
515	8.583	0.0	1.5	7.7	11.3	0.0	1.5	7.4	9.9
520	8.667	0.0	1.5	7.8	11.4	0.0	1.5	7.4	10.0
525	8.750	0.0	1.5	7.9	11.5	0.0	1.5	7.5	10.0
530	8.833	0.0	1.5	8.0	11.6	0.0	1.5	7.6	10.1
535	8.917	0.0	1.5	8.1	11.6	0.0	1.5	7.7	10.2
540	9.000	0.0	1.5	8.2	11.7	0.0	1.6	7.7	10.2
545	9.083	0.0	1.5	8.3	11.8	0.0	1.6	7.8	10.3
550	9.167	0.0	1.5	8.3	11.9	0.0	1.6	7.9	10.4
555	9.250	0.0	1.5	8.4	11.9	0.0	1.6	8.0	10.4
560	9.333	0.0	1.5	8.5	12.0	0.0	1.6	8.1	10.5
565	9.417	0.0	1.5	8.6	12.1	0.0	1.6	8.2	10.5
570	9.500	0.0	1.5	8.7	12.1	0.0	1.6	8.2	10.6
575	9.583	0.0	1.5	8.8	12.2	0.0	1.6	8.3	10.6
580	9.667	0.0	1.5	8.9	12.3	0.0	1.6	8.4	10.7
585	9.750	0.0	1.5	8.9	12.5	0.0	1.6	8.5	10.8
590	9.833	0.0	1.5	9.0	13.3	0.0	1.6	8.6	11.4
595	9.917	0.0	1.5	9.1	14.5	0.0	1.6	8.7	12.2
600	10.000	0.0	1.5	9.2	15.8	0.0	1.6	8.7	13.3
605	10.083	0.0	1.5	9.4	16.8	0.0	1.6	8.8	14.3
610	10.167	0.0	1.5	9.5	17.5	0.0	1.6	8.9	15.0
615	10.250	0.0	1.5	9.6	17.9	0.0	1.6	9.0	15.6
620	10.333	0.0	1.5	9.8	18.2	0.0	1.6	9.1	15.9
625	10.417	0.0	1.5	10.0	18.5	0.0	1.6	9.2	16.2
630	10.500	0.0	1.5	10.1	18.8	0.0	1.6	9.3	16.5
635	10.583	0.0	1.5	10.3	19.0	0.0	1.6	9.3	16.7
640	10.667	0.0	1.6	10.5	19.2	0.0	1.6	9.4	16.8
645	10.750	0.0	1.6	10.6	19.4	0.0	1.6	9.5	17.0
650	10.833	0.1	1.6	10.8	19.6	0.0	1.6	9.6	17.2
655	10.917	0.1	1.6	10.9	19.8	0.0	1.7	9.7	17.3
660	11.000	0.1	1.6	11.0	20.0	0.0	1.7	9.8	17.5
665	11.083	0.1	1.6	11.1	20.1	0.0	1.7	9.8	17.6

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
670	11.167	0.1	1.6	11.2	20.3	0.0	1.7	9.9	17.7
675	11.250	0.1	1.6	11.4	20.5	0.0	1.7	10.0	17.9
680	11.333	0.1	1.6	11.4	20.9	0.0	1.7	10.0	18.1
685	11.417	0.1	1.6	11.5	22.1	0.0	1.7	10.1	18.9
690	11.500	0.1	1.6	11.8	23.6	0.0	1.7	10.3	20.0
695	11.583	0.1	1.6	12.6	24.9	0.0	1.7	10.8	21.2
700	11.667	0.2	1.6	13.8	25.9	0.0	1.7	11.7	22.3
705	11.750	0.2	1.6	15.1	26.5	0.0	1.7	12.7	23.0
710	11.833	0.2	1.9	16.2	27.1	-0.5	1.9	13.7	23.6
715	11.917	0.3	2.5	16.9	27.5	0.1	2.2	14.5	24.0
720	12.000	0.4	3.3	17.4	27.9	0.0	2.8	15.1	24.4
725	12.083	0.5	4.1	17.7	28.2	0.1	3.5	15.5	24.7
730	12.167	0.6	4.9	18.1	28.6	0.1	4.3	15.8	24.9
735	12.250	0.7	5.4	18.3	28.9	0.1	5.0	16.1	25.2
740	12.333	0.8	5.7	18.6	29.2	-0.3	5.6	16.3	25.4
745	12.417	0.8	5.9	18.8	29.4	0.1	6.0	16.5	25.6
750	12.500	0.9	6.0	19.0	29.7	0.1	6.3	16.7	25.9
755	12.583	0.9	6.1	19.2	29.9	0.3	6.5	16.8	26.1
760	12.667	0.9	6.2	19.4	30.2	0.1	6.6	17.0	26.2
765	12.750	0.9	6.3	19.6	30.4	0.3	6.8	17.1	26.4
770	12.833	1.0	6.4	19.8	31.0	0.4	6.9	17.3	26.8
775	12.917	1.0	6.5	20.0	32.4	0.6	7.0	17.4	27.7
780	13.000	1.0	6.6	20.1	34.0	0.8	7.1	17.6	29.1
785	13.083	1.1	6.7	20.3	35.4	0.9	7.1	17.7	30.3
790	13.167	1.1	6.8	21.0	36.8	1.0	7.2	18.1	31.6
795	13.250	1.2	6.9	23.3	39.2	1.1	7.3	19.6	33.4
800	13.333	1.2	7.0	26.2	42.6	1.1	7.4	21.8	36.2
805	13.417	1.2	7.1	28.7	45.9	1.2	7.4	24.3	39.2
810	13.500	1.2	7.2	30.6	48.4	1.2	7.5	26.3	41.5
815	13.583	1.3	7.3	32.3	50.1	1.2	7.6	27.8	43.2
820	13.667	1.3	7.5	34.4	51.5	1.3	7.7	29.6	44.3
825	13.750	1.3	8.2	36.6	52.6	1.3	8.2	31.5	45.3
830	13.833	1.3	9.4	38.5	53.5	1.3	9.0	33.3	46.1
835	13.917	1.3	10.6	40.0	54.3	1.3	10.0	34.6	47.2
840	14.000	1.3	11.6	41.1	56.3	1.3	11.0	35.6	49.0
845	14.083	1.3	12.3	42.0	58.6	1.3	11.9	36.4	51.0
850	14.167	1.3	12.7	42.9	61.5	1.4	12.5	37.2	52.7
855	14.250	1.3	13.1	44.1	62.8	1.4	13.0	38.0	54.0
860	14.333	1.3	13.4	46.2	64.3	1.4	13.4	39.6	55.3
865	14.417	1.3	13.6	48.5	66.7	1.4	13.7	41.5	57.3
870	14.500	1.4	13.8	50.3	69.0	1.4	14.0	43.1	59.6
875	14.583	1.6	14.1	51.7	70.8	1.5	14.2	44.4	61.4
880	14.667	2.2	14.5	52.8	74.0	1.8	14.5	45.5	64.0
885	14.750	2.9	15.6	54.2	80.4	2.3	15.4	46.6	69.2
890	14.833	3.7	17.1	55.8	85.1	2.9	16.6	48.5	78.5

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
895	14.917	4.4	18.4	58.2	88.0	3.6	18.0	50.7	85.6
900	15.000	4.9	19.4	61.3	90.6	4.2	19.1	52.8	90.5
905	15.083	5.2	20.4	64.7	92.5	4.7	20.2	55.2	95.4
910	15.167	5.4	22.2	68.0	94.6	5.0	21.6	58.1	100.3
915	15.250	5.5	24.3	71.7	96.6	5.3	23.4	61.5	106.3
920	15.333	5.6	26.2	75.4	98.7	5.5	25.1	65.1	113.6
925	15.417	5.6	27.9	80.1	100.5	5.6	26.8	69.2	120.7
930	15.500	5.7	30.3	84.5	102.3	5.7	28.8	75.5	126.7
935	15.583	5.8	33.3	88.2	104.3	5.9	31.2	85.1	134.9
940	15.667	6.7	37.8	91.9	105.3	6.5	35.0	92.7	139.3
945	15.750	9.7	45.8	95.9	106.0	8.5	41.9	103.5	138.6
950	15.833	14.8	55.9	99.7	107.3	12.4	51.2	117.7	144.9
955	15.917	21.7	72.1	105.6	110.7	18.7	64.6	147.1	160.3
960	16.000	33.4	94.3	111.0	114.5	29.4	88.6	170.0	177.0
965	16.083	51.8	104.2	115.3	119.2	47.8	134.5	185.8	195.5
970	16.167	104.7	115.1	121.8	125.4	102.1	187.0	207.2	213.1
975	16.250	107.6	117.4	124.7	128.5	160.8	191.2	209.5	215.7
980	16.333	102.4	117.5	126.1	130.0	137.6	190.2	210.1	215.9
985	16.417	97.9	117.1	126.9	130.8	99.0	185.1	210.0	215.4
990	16.500	92.5	116.7	127.4	131.2	76.4	173.5	209.4	214.7
995	16.583	84.9	116.2	127.8	131.9	63.3	166.1	204.7	213.9
1000	16.667	78.7	115.2	128.1	132.8	57.0	160.6	203.0	213.3
1005	16.750	72.4	112.0	128.4	133.7	49.6	154.6	198.2	212.7
1010	16.833	61.8	110.7	128.5	134.5	43.5	148.2	195.0	211.8
1015	16.917	52.5	109.8	128.7	135.2	38.1	140.2	187.9	209.3
1020	17.000	44.5	108.9	128.9	135.7	34.1	128.9	185.9	206.8
1025	17.083	36.6	107.9	129.1	136.1	31.0	110.1	184.1	205.1
1030	17.167	32.2	106.4	129.2	136.5	28.9	87.3	181.7	202.4
1035	17.250	30.2	101.3	129.2	136.8	27.6	73.7	178.4	197.5
1040	17.333	28.6	100.0	129.2	137.0	26.5	65.7	174.1	195.5
1045	17.417	27.2	98.8	129.1	137.1	25.4	62.2	172.9	193.6
1050	17.500	25.9	97.6	128.9	137.1	24.4	57.9	170.7	191.7
1055	17.583	24.7	96.3	128.6	137.1	23.4	54.5	163.7	188.9
1060	17.667	23.7	94.2	128.2	137.0	22.5	51.6	158.6	184.4
1065	17.750	22.9	89.7	127.8	136.9	21.7	49.0	154.1	177.4
1070	17.833	21.8	87.3	127.2	136.7	20.9	46.1	149.4	173.6
1075	17.917	20.3	85.3	126.7	136.6	19.7	43.1	143.8	170.7
1080	18.000	18.8	83.6	126.3	136.4	18.3	40.3	139.0	168.0
1085	18.083	17.2	82.1	125.7	136.2	16.9	38.0	134.6	165.2
1090	18.167	15.9	80.2	125.2	136.0	15.7	36.2	126.1	162.2
1095	18.250	14.8	78.1	124.5	135.7	14.5	34.7	105.3	159.3
1100	18.333	14.0	75.2	123.7	135.5	13.6	33.4	88.8	156.2
1105	18.417	13.2	72.5	122.3	135.2	12.8	32.3	72.4	152.8
1110	18.500	12.6	69.1	119.6	134.9	12.1	31.4	64.3	148.0
1115	18.583	12.1	62.3	118.4	134.5	11.6	30.6	59.6	142.4

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
1120	18.667	11.6	56.9	117.5	134.2	11.1	29.6	55.6	137.3
1125	18.750	11.2	50.3	116.9	133.8	10.6	28.2	54.3	132.8
1130	18.833	10.8	43.7	115.3	133.4	10.3	26.5	53.0	121.8
1135	18.917	10.4	39.9	113.9	133.0	9.9	24.9	51.1	101.7
1140	19.000	10.0	37.7	110.5	132.5	9.6	23.5	49.0	85.8
1145	19.083	9.7	36.0	109.0	132.0	9.3	22.4	47.2	72.8
1150	19.167	9.4	34.6	107.9	131.4	9.0	21.5	45.3	66.4
1155	19.250	9.2	33.1	106.8	130.7	8.7	20.8	42.5	63.6
1160	19.333	8.9	30.4	105.7	129.9	8.5	20.1	39.4	59.6
1165	19.417	8.7	26.7	104.7	129.2	8.3	19.6	36.4	56.3
1170	19.500	8.5	23.7	103.7	128.5	8.1	19.1	34.1	53.6
1175	19.583	8.2	21.9	102.8	127.7	7.9	18.7	32.5	50.7
1180	19.667	8.0	20.9	102.0	126.8	7.7	18.3	31.1	48.0
1185	19.750	7.9	20.2	101.1	125.6	7.5	18.0	30.0	45.8
1190	19.833	7.7	19.7	100.0	122.5	7.3	17.7	29.2	43.9
1195	19.917	7.5	19.2	98.7	120.8	7.2	17.4	28.4	42.4
1200	20.000	7.4	18.9	95.1	119.4	7.0	17.1	27.7	41.2
1205	20.083	7.2	18.5	92.5	117.7	6.9	16.9	27.1	40.2
1210	20.167	7.1	18.2	91.0	115.3	6.7	16.7	26.6	39.3
1215	20.250	6.9	17.9	89.4	113.5	6.6	16.5	26.1	38.5
1220	20.333	6.8	17.7	87.7	109.0	6.5	16.3	25.7	37.9
1225	20.417	6.7	17.4	84.6	107.5	6.4	16.1	25.3	37.3
1230	20.500	6.6	17.2	82.5	106.5	6.3	15.9	24.9	36.8
1235	20.583	6.5	16.8	80.8	105.7	6.2	15.6	24.6	36.3
1240	20.667	6.4	15.7	78.7	104.9	6.1	14.9	24.3	35.8
1245	20.750	6.3	14.5	76.1	104.2	6.0	14.0	24.0	35.5
1250	20.833	6.2	13.4	72.7	103.5	5.9	13.0	23.8	35.1
1255	20.917	6.1	12.5	69.3	102.7	5.8	12.0	23.4	34.8
1260	21.000	6.0	11.7	63.5	101.6	5.7	11.3	22.5	34.3
1265	21.083	5.9	11.1	54.3	100.2	5.6	10.6	21.4	33.2
1270	21.167	5.8	10.6	48.1	97.1	5.6	10.0	20.3	31.8
1275	21.250	5.7	10.1	39.3	94.1	5.5	9.6	19.3	30.4
1280	21.333	5.7	9.8	31.8	92.7	5.4	9.2	18.5	29.3
1285	21.417	5.6	9.4	26.8	91.2	5.4	8.9	17.9	28.4
1290	21.500	5.5	9.2	23.7	89.6	5.3	8.6	17.4	27.7
1295	21.583	5.5	8.9	22.0	88.1	5.2	8.3	16.9	27.2
1300	21.667	5.4	8.7	21.0	85.3	5.2	8.1	16.6	26.8
1305	21.750	5.4	8.4	20.3	82.4	5.1	7.9	16.3	26.4
1310	21.833	5.3	8.2	19.7	80.5	5.1	7.7	16.1	26.1
1315	21.917	5.3	8.0	19.3	78.4	5.0	7.5	15.8	25.8
1320	22.000	5.2	7.9	18.9	75.7	5.0	7.4	15.6	25.6
1325	22.083	5.2	7.7	18.5	72.1	4.9	7.2	15.4	25.3
1330	22.167	5.1	7.5	18.2	68.9	4.9	7.1	15.2	25.1
1335	22.250	5.1	7.4	17.9	62.5	4.8	6.9	15.1	24.9
1340	22.333	5.0	7.2	17.7	54.5	4.8	6.8	14.9	24.8

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
1345	22.417	5.0	7.1	17.4	48.6	4.8	6.7	14.7	24.6
1350	22.500	5.0	7.0	17.2	39.1	4.7	6.6	14.6	24.4
1355	22.583	4.9	6.8	17.0	33.3	4.7	6.5	14.5	24.3
1360	22.667	4.9	6.7	16.8	29.7	4.7	6.4	14.4	24.0
1365	22.750	4.9	6.6	16.7	27.1	4.6	6.3	14.2	23.1
1370	22.833	4.8	6.5	16.5	25.1	4.6	6.2	14.1	22.0
1375	22.917	4.8	6.4	16.3	23.5	4.6	6.1	14.0	20.9
1380	23.000	4.8	6.3	16.2	22.2	4.5	6.0	13.9	19.9
1385	23.083	4.7	6.2	16.1	21.3	4.5	5.9	13.8	19.1
1390	23.167	4.7	6.1	15.9	20.6	4.5	5.8	13.7	18.5
1395	23.250	4.6	6.0	15.8	20.0	4.4	5.7	13.7	18.0
1400	23.333	4.4	6.0	15.7	19.6	4.3	5.7	13.6	17.6
1405	23.417	4.1	5.9	15.6	19.1	4.1	5.6	13.5	17.3
1410	23.500	3.8	5.8	15.5	18.8	3.8	5.5	13.4	17.0
1415	23.583	3.5	5.7	15.5	18.4	3.6	5.5	13.4	16.8
1420	23.667	3.3	5.7	15.4	18.1	3.3	5.4	13.3	16.5
1425	23.750	3.0	5.6	15.3	17.9	3.1	5.3	13.3	16.3
1430	23.833	2.8	5.5	15.2	17.6	2.9	5.3	13.2	16.2
1435	23.917	2.7	5.5	15.1	17.4	2.7	5.2	13.2	16.0
1440	24.000	2.5	5.4	15.1	17.2	2.6	5.2	13.1	15.8
1445	24.083	2.4	5.4	15.0	17.0	2.4	5.1	13.1	15.7
1450	24.167	2.3	5.3	14.6	16.4	2.3	5.1	12.8	15.3
1455	24.250	2.2	5.0	13.3	15.0	2.2	4.9	12.0	14.3
1460	24.333	2.1	4.7	11.9	13.4	2.1	4.6	11.0	13.1
1465	24.417	2.0	4.3	10.5	12.0	2.0	4.4	9.9	11.8
1470	24.500	1.9	4.0	9.4	10.8	1.9	4.1	8.9	10.7
1475	24.583	1.9	3.8	8.5	9.7	1.8	3.8	8.1	9.7
1480	24.667	1.8	3.5	7.8	9.0	1.8	3.6	7.3	8.9
1485	24.750	1.7	3.3	7.3	8.3	1.7	3.4	6.7	8.1
1490	24.833	1.7	3.1	6.8	7.8	1.7	3.2	6.2	7.5
1495	24.917	1.6	2.9	6.4	7.3	1.6	3.0	5.7	7.0
1500	25.000	1.6	2.8	6.0	6.9	1.6	2.8	5.4	6.5
1505	25.083	1.5	2.7	5.7	6.5	1.5	2.7	5.1	6.1
1510	25.167	1.5	2.6	5.4	6.1	1.5	2.5	4.8	5.8
1515	25.250	1.4	2.4	5.1	5.8	1.4	2.4	4.5	5.5
1520	25.333	1.4	2.3	4.8	5.5	1.4	2.3	4.3	5.2
1525	25.417	1.3	2.3	4.6	5.2	1.4	2.2	4.1	5.0
1530	25.500	1.3	2.2	4.4	5.0	1.3	2.1	3.9	4.7
1535	25.583	1.2	2.1	4.2	4.8	1.3	2.1	3.8	4.5
1540	25.667	1.2	2.0	4.0	4.6	1.2	2.0	3.6	4.3
1545	25.750	1.2	1.9	3.8	4.4	1.2	1.9	3.4	4.1
1550	25.833	1.1	1.9	3.7	4.2	1.2	1.9	3.3	4.0
1555	25.917	1.1	1.8	3.5	4.0	1.1	1.8	3.2	3.8
1560	26.000	1.1	1.8	3.4	3.8	1.1	1.8	3.0	3.6
1565	26.083	1.0	1.7	3.2	3.6	1.1	1.7	2.9	3.5

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
1570	26.167	1.0	1.6	3.1	3.5	1.1	1.7	2.8	3.3
1575	26.250	1.0	1.6	3.0	3.3	1.0	1.6	2.7	3.2
1580	26.333	0.9	1.5	2.9	3.2	1.0	1.6	2.6	3.1
1585	26.417	0.9	1.5	2.7	3.1	1.0	1.5	2.5	3.0
1590	26.500	0.9	1.4	2.6	2.9	1.0	1.5	2.4	2.9
1595	26.583	0.8	1.4	2.5	2.8	0.9	1.4	2.3	2.8
1600	26.667	0.8	1.4	2.4	2.7	0.9	1.4	2.3	2.7
1605	26.750	0.8	1.3	2.3	2.6	0.9	1.3	2.2	2.6
1610	26.833	0.8	1.3	2.3	2.5	0.9	1.3	2.1	2.5
1615	26.917	0.7	1.2	2.2	2.4	0.8	1.3	2.0	2.4
1620	27.000	0.7	1.2	2.1	2.3	0.8	1.2	2.0	2.3
1625	27.083	0.7	1.1	2.0	2.2	0.8	1.2	1.9	2.2
1630	27.167	0.7	1.1	1.9	2.1	0.8	1.2	1.8	2.1
1635	27.250	0.6	1.1	1.9	2.1	0.7	1.1	1.8	2.1
1640	27.333	0.6	1.0	1.8	2.0	0.7	1.1	1.7	2.0
1645	27.417	0.6	1.0	1.7	1.9	0.7	1.1	1.7	1.9
1650	27.500	0.6	1.0	1.7	1.9	0.7	1.0	1.6	1.9
1655	27.583	0.6	0.9	1.6	1.8	0.4	1.0	1.6	1.8
1660	27.667	0.5	0.9	1.6	1.7	0.4	1.0	1.5	1.8
1665	27.750	0.5	0.9	1.5	1.7	0.6	1.0	1.5	1.7
1670	27.833	0.5	0.8	1.5	1.6	0.6	0.9	1.4	1.7
1675	27.917	0.5	0.8	1.4	1.6	0.6	0.9	1.4	1.6
1680	28.000	0.5	0.8	1.4	1.5	0.6	0.9	1.3	1.5
1685	28.083	0.5	0.8	1.3	1.5	0.5	0.9	1.3	1.5
1690	28.167	0.5	0.7	1.3	1.4	0.4	0.8	1.3	1.5
1695	28.250	0.5	0.7	1.2	1.4	0.5	0.8	1.2	1.4
1700	28.333	0.4	0.7	1.2	1.3	0.5	0.8	1.2	1.4
1705	28.417	0.4	0.7	1.2	1.3	0.5	0.8	1.1	1.3
1710	28.500	0.4	0.7	1.1	1.2	0.5	0.8	1.1	1.3
1715	28.583	0.4	0.6	1.1	1.2	0.5	0.7	1.1	1.2
1720	28.667	0.4	0.6	1.1	1.2	0.4	0.7	1.0	1.2
1725	28.750	0.4	0.6	1.0	1.1	0.3	0.7	1.0	1.2
1730	28.833	0.4	0.5	1.0	1.1	0.4	0.7	1.0	1.1
1735	28.917	0.4	0.5	0.9	1.0	0.4	0.7	1.0	1.1
1740	29.000	0.3	0.5	0.9	1.0	0.4	0.6	0.9	1.1
1745	29.083	0.3	0.5	0.9	1.0	0.4	0.6	0.9	1.0
1750	29.167	0.3	0.5	0.9	0.9	0.4	0.4	0.9	1.0
1755	29.250	0.3	0.5	0.8	0.9	0.4	0.6	0.9	1.0
1760	29.333	0.3	0.5	0.8	0.9	0.4	0.6	0.8	1.0
1765	29.417	0.3	0.5	0.8	0.9	0.4	0.5	0.8	0.9
1770	29.500	0.3	0.5	0.8	0.8	0.3	0.6	0.8	0.9
1775	29.583	0.3	0.4	0.7	0.8	0.3	0.5	0.8	0.9
1780	29.667	0.3	0.4	0.7	0.8	0.3	0.5	0.8	0.9
1785	29.750	0.2	0.4	0.7	0.8	0.3	0.4	0.7	0.8
1790	29.833	0.2	0.4	0.7	0.7	0.3	0.4	0.7	0.8

Timestep		Existing Flow (cfs)				Proposed Flow (cfs)			
Minute	Hour	2-Year	10-Year	100-Year	500-Year	2-Year	10-Year	100-Year	500-Year
1795	29.917	0.2	0.4	0.6	0.7	0.3	0.5	0.7	0.8
1800	30.000	0.2	0.4	0.6	0.7	0.3	0.4	0.7	0.8
1805	30.083	0.2	0.4	0.6	0.7	0.3	0.5	0.6	0.8
1810	30.167	0.2	0.4	0.5	0.6	0.3	0.5	0.6	0.7
1815	30.250	0.2	0.3	0.5	0.6	0.3	0.4	0.7	0.7
1820	30.333	0.2	0.3	0.5	0.6	0.3	0.3	0.7	0.7
1825	30.417	0.2	0.3	0.5	0.6	0.3	0.4	0.6	0.7
1830	30.500	0.2	0.3	0.5	0.5	0.2	0.4	0.6	0.6
1835	30.583	0.2	0.3	0.5	0.5	0.2	0.4	0.4	0.6
1840	30.667	0.2	0.3	0.5	0.5	0.2	0.4	0.5	0.6
1845	30.750	0.2	0.3	0.5	0.5	0.2	0.3	0.5	0.5
1850	30.833	0.2	0.3	0.5	0.5	0.2	0.3	0.5	0.6
1855	30.917	0.1	0.3	0.4	0.5	0.2	0.3	0.6	0.6
1860	31.000	0.1	0.2	0.4	0.5	0.2	0.3	0.5	0.5
1865	31.083	0.1	0.2	0.4	0.4	0.2	0.3	0.5	0.4
1870	31.167	0.1	0.2	0.4	0.4	0.2	0.3	0.3	0.5
1875	31.250	0.1	0.2	0.4	0.4	0.2	0.3	0.4	0.5
1880	31.333	0.1	0.2	0.4	0.4	0.2	0.3	0.4	0.4
1885	31.417	0.1	0.2	0.4	0.4	0.2	0.3	0.4	0.5
1890	31.500	0.1	0.2	0.4	0.4	0.2	0.3	0.5	0.5
1895	31.583	0.1	0.2	0.3	0.4	0.2	0.3	0.4	0.4
1900	31.667	0.1	0.2	0.3	0.4	0.2	0.3	0.4	0.3
1905	31.750	0.1	0.2	0.3	0.3	0.2	0.2	0.4	0.4
1910	31.833	0.1	0.2	0.3	0.3	0.1	0.2	0.4	0.4
1915	31.917	0.1	0.2	0.3	0.3	0.1	0.2	0.4	0.4
1920	32.000	0.1	0.2	0.3	0.3	0.1	0.2	0.4	0.4
1925	32.083	0.1	0.2	0.3	0.3	0.1	0.2	0.4	0.4
1930	32.167	0.1	0.1	0.3	0.3	0.1	0.2	0.4	0.4
1935	32.250	0.1	0.1	0.3	0.3	0.1	0.2	0.3	0.3
1940	32.333	0.1	0.1	0.2	0.3	0.1	0.2	0.3	0.3
1945	32.417	0.1	0.1	0.2	0.3	0.1	0.2	0.3	0.3
1950	32.500	0.1	0.1	0.2	0.3	0.1	0.2	0.3	0.3
1955	32.583	0.1	0.1	0.2	0.2	0.1	0.2	0.3	0.3
1960	32.667	0.1	0.1	0.2	0.2	0.1	0.2	0.3	0.3
1965	32.750	0.1	0.1	0.2	0.2	0.1	0.2	0.3	0.3
1970	32.833	0.1	0.1	0.2	0.2	0.1	0.2	0.3	0.3
1975	32.917	0.1	0.1	0.2	0.2	0.1	0.2	0.3	0.3
1980	33.000	0.1	0.1	0.2	0.2	0.1	0.2	0.3	0.3
1985	33.083	0.1	0.1	0.2	0.2	0.1	0.1	0.3	0.3
1990	33.167	0.0	0.1	0.2	0.2	0.1	0.1	0.2	0.3
1995	33.250	0.0	0.1	0.2	0.2	0.1	0.1	0.2	0.2
2000	33.333	0.0	0.1	0.2	0.2	0.1	0.1	0.2	0.2
2005	33.417	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.2
2010	33.500	0.0	0.1	0.1	0.2	0.0	0.1	0.2	0.2
2015	33.583	0.0	0.1	0.1	0.2	0.0	0.1	0.2	0.2

APPENDIX J

PRELIMINARY DESIGN PLAN SET

P118-25-00 AND TRIBUTARIES CONVEYANCE AND DETENTION IMPROVEMENTS

HCFC D PROJECT ID P118-25-00-E001



COUNTY JUDGE LINA HIDALGO

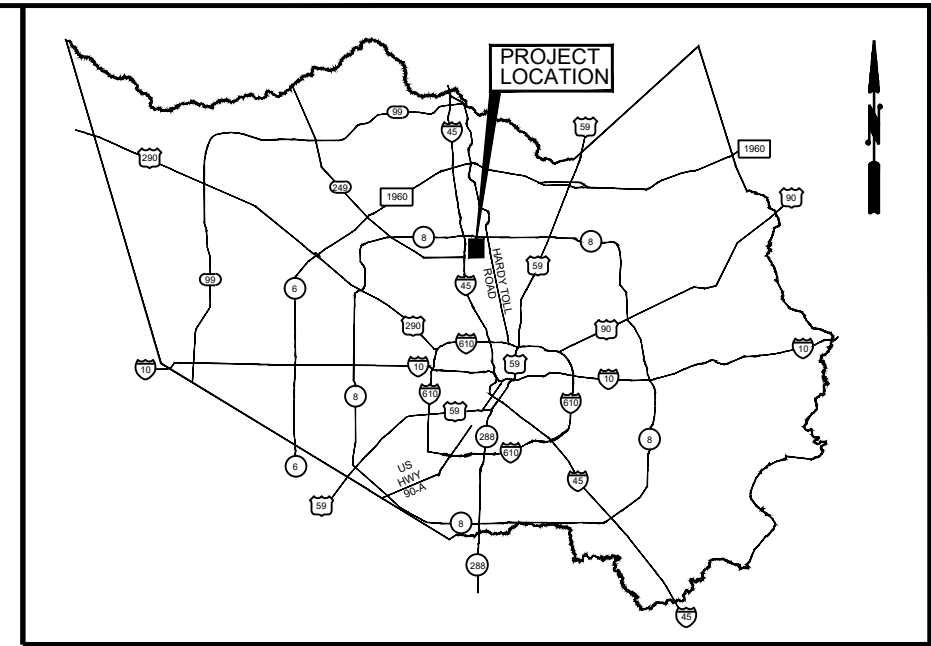
PCT . 1 RODNEY ELLIS

PCT . 3 TOM S. RAMSEY, P.E.

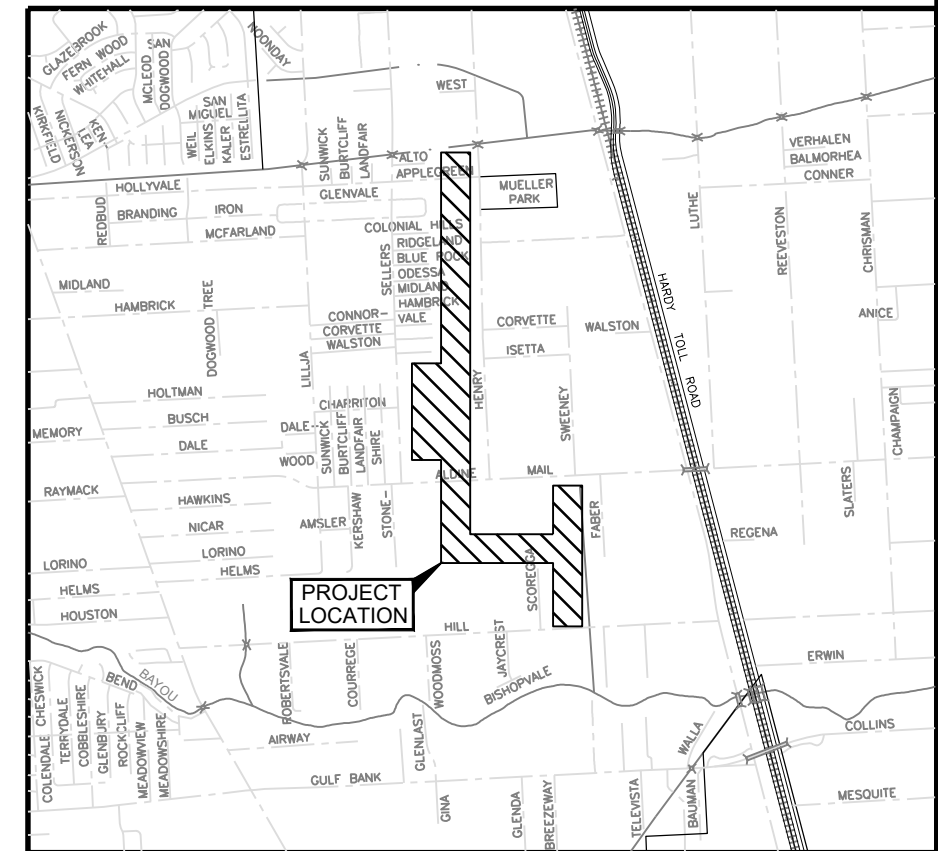
PCT . 2 ADRIAN GARCIA

PCT . 4 R. JACK CAGLE

EXECUTIVE DIRECTOR CHRISTINA PETERSEN, P.E. & PHD



LOCATION MAP





VICINITY MAP
KEY MAP 413 B, F, & K

3/4/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENT\SCADD\DWG001 - 4543.07 - FRONT END DRAWINGS.DWG

INDEX OF DRAWINGS		
SHEET NO.	SHEET TITLE	REV. NO.
FRONT END		
01	COVER	
02	INDEX SHEET	
03	LEGEND	
04	GENERAL NOTES	
05	OVERALL LAYOUT	
TYPICAL SECTIONS		
06	EXISTING TYPICAL SECTIONS	
07	PROPOSED P118-25-00 TYPICAL SECTIONS	
08	PROPOSED P118-25-01 TYPICAL SECTIONS	
P118-25-00 PLAN & PROFILE		
09	STA 0+00 TO 10+00	
10	STA 10+00 TO 20+00	
11	STA 20+00 TO 25+00	
P118-25-01 PLAN & PROFILE		
12	STA 0+00 TO 7+00	
13	STA 7+00 TO 15+00	
14	STA 15+00 TO 21+00	
15	STA 21+00 TO 30+00	
16	STA 30+00 TO 36+00	
17	STA 35+00 TO 45+00	
18	STA 45+00 TO 55+00	
19	STA 55+00 TO 65+00	
20	STA 65+00 TO 77+50	

INDEX OF DRAWINGS		
SHEET NO.	SHEET TITLE	REV. NO.
BASIN LAYOUT		
21	DETENTION BASIN LAYOUT	
22	DETAILED CROSS SECTION	
SWPPP		
23	P118-25-00	
24	P118-25-01 STA. 0+00 TO 23+00	
25	P118-25-01 STA. 23+00 TO 35+00	
26	P118-25-01 STA. 35+00 TO 57+00	
27	P118-25-01 STA. 57+00 TO 77+50	
28	BASIN SWPPP	
MAINTENANCE ACCESS		
29	MAINTENANCE ACCESS PLAN (1 OF 3)	
30	MAINTENANCE ACCESS PLAN (2 OF 3)	
31	MAINTENANCE ACCESS PLAN (3 OF 3)	
DETAILS		
32	HC - MODIFIED TYPE TYPE "A" INLET DETAILS	
33	HC - STORM WATER POLLUTION PREVENTION PLAN DETAILS	
34	HC - MONOLITHIC TYPE C INLET DETAILS	
35	HC - CHAIN LINK FENCING DETAIL	
36	HCFCF - HEADWALL STRUCTURE DETAILS	
37	HCFCF - FLOATABLE COLLECTION SCREEN DETAILS	
38	HCFCF - CONCRETE CHANNEL LINING DETAILS	
39	HCFCF - INT. STRUCTURE & CONC. PILOT CHANNEL DETAILS	
40	HCFCF - STORM SEWER & RIPRAP DETAILS	
41	HCFCF - STORM WATER POLLUTION PREVENTION PLAN DETAILS	

INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended
 for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022

DATE									
APPR									
DESCRIPTION									
REV									
PREPARED:	A.V.	CHECKED:	M.J.	APPROVED:					
 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 <small>TEXAS FIRM REGISTRATION NO. F-487</small>									
 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092									
DATE: 3/15/2022									
SHEET NUMBER									
02 OF 41									

3/4/2022 M:\04543.007\118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG01 - 4543.07 - FRONT END DRAWINGS.DWG

STANDARD LINETYPES

OBJECT	EXISTING	PROPOSED
CENTER LINE		
BASE LINE		
HCFCO ROW		
LOT LINES		
UTILITY EASEMENT		
OTHER BOUNDARY LINE		
TOPO MAJOR INDEX CONTOUR		
TOPO MINOR INDEX CONTOUR		
EDGE OF ASPHALT		
BARBED WIRE FENCE		
CHAIN LINK FENCE		
WOODEN FENCE		
LIMITS OF RIPRAP, WETLANDS, WASHOUT		
CHANNEL/BASIN TOP OF BANK		
CHANNEL/BASIN TOE OF SLOPE		
CURB (DOUBLE LINE)		
EDGE OF CONCRETE		
MISC. DRAINAGE STRUCTURES		
CULVERTS		
CHANNEL/SWALE FLOW LINE		
RAILROAD		
TOP OF BANK - LEFT CHANNEL		
TOP OF BANK - RIGHT CHANNEL		
NORTHEAST NATURAL GROUND		
SOUTH/WEST NATURAL GROUND		
WATER LINE		
GAS		
PROPANE		
STEAM		
TELEPHONE		
ELECTRIC		
FORCEMAIN		
UNKNOWN LINE		
STORM SEWER		
SANITARY SEWER		
QL"C"/QL"D" INFORMATION		

STANDARD SYMBOLS

OBJECT	SYMBOL / PATTERN
PROP/EXIST SLOPE SYMBOLS	
FLOW DIRECTION ARROW	
WATER SURFACE ELEVATION	
RIPRAP/BURIED RIPRAP	
RIPRAP/BURIED RIPRAP	
BACKSLOPE INTERCEPTOR STRUCTURE	

PLAN LEGEND

BUILDING	
TREES	
EXISTING / PROPOSED MANHOLE	

ABBREVIATIONS

APPROX	APPROXIMATELY	PP	POWER POLE
BL	BASE LINE	PPP	POLYPROPYLENE PIPE
B/S	BACKSLOPE	PROP.	PROPOSED
CL	CENTER LINE	PVC	POLYVINYL CHLORIDE
CMP	CORRUGATED METAL PIPE	PVMT	PAVEMENT
COH	CITY OF HOUSTON	RCB	REINFORCED CONCRETE BOX
CONC	CONCRETE	RCP	REINFORCED CONCRETE PIPE
CPEE	CENTERPOINT ENERGY ELECTRIC	ROW	RIGHT OF WAY
CPEG	CENTERPOINT ENERGY GAS	R	RADIUS
DWY	DRIVEWAY	RT	RIGHT
E	EAST	S	SOUTH
EL	ELEVATION	SAN	SANITARY
ESMT.	EASEMENT	SAN.SWR.	SANITARY SEWER
EXIST.	EXISTING	SBC	SOUTHWESTERN BELL COMMUNICATIONS
F.H.	FIRE HYDRANT	S.S.	SIDE SLOPE
FL.	FLOW LINE	S.S.E.	SANITARY SEWER EASEMENT
GIP	GALVANIZED IRON PIPE	STM	STORM
GPS	GLOBAL POSITIONING SYSTEM	STM.SWR.	STORM SEWER
HCFCO	HARRIS COUNTY FLOOD CONTROL DISTRICT	STM.S.E.	STORM SEWER EASEMENT
HGL	HYDRAULIC GRADIENT LINE	STA.	STATION
INT	INTERCEPTOR STRUCTURE	TC	TOP OF CURB
IR	IRON ROD	TOB	TOP OF BANK
LF	LINEAR FEET	TYP.	TYPICAL
LP	LOW POINT	U.E.	UTILITY EASEMENT
LT	LEFT	UP	UTILITY POLE
MAX	MAXIMUM	W	WEST
M.H.	MANHOLE	W.L.E.	WATER LINE EASEMENT
MIN	MINIMUM	W.S.E.	WATER SURFACE ELEVATION
N	NORTH	WTR	WATER
N/A	NOT APPLICABLE	WV	WATER VALVE
NAVD	NORTH AMERICAN VERTICAL DATUM	WWTP	WASTEWATER TREATMENT PLANT
N.G.	NATURAL GROUND	ST.	STREET LIGHT
OHWM	ORDINARY HIGH WATER MARK		
P.I.	POINT OF INTERSECTION		
PM	PIPELINE MARKER		

PROFILE LEGEND

	STORM SEWER PIPE
	WATER LINE
	SANITARY LINE
	MANHOLE
	HEADWALL

DATE	APPR	REV	DESCRIPTION

PREPARED: A.V.	CHECKED: M.J.	APPROVED:
<p style="font-size: small;">HCFCO UNIT NO. P118-25-00/01</p> <p style="font-size: small;">HALLS BAYOU WATERSHED</p> <p style="font-size: small;">LEGEND</p>		

16340 Park Ten Place
Suite 350
Houston, Texas 77084
(713) 461-9900
TEXAS FIRM REGISTRATION NO. F-487

9900 Northwest Freeway
Houston, Texas 77092

DATE: 3/15/2022	SHEET NUMBER
	03 OF 41

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

HCFCD GENERAL NOTES:

- FENCES AND/OR OTHER ENCROACHMENTS IN THE HCFCD RIGHT-OF-WAY ARE NOT TO BE REMOVED UNLESS OTHERWISE STATED ON THE PLANS. IN CASES WHERE FENCE REMOVAL IS INDICATED ON THE PLANS, THE FENCE SHALL BE REMOVED AND PLACED NEATLY ON THE ADJACENT PROPERTY AT THE START OF CONSTRUCTION. WHERE THERE IS NOT A SEPARATE ITEM LISTED ON THE UNIT PRICE SCHEDULE, THE ENCROACHMENT REMOVAL IS INCIDENTAL TO SITE PREPARATION AND RESTORATION.
- DO NOT ENTER PRIVATE PROPERTY WITHOUT PROPER WRITTEN AUTHORIZATION FROM THE OWNER. PROVIDE COPY OF WRITTEN PERMISSION TO HCFCD.
- STRIP VEGETATION AND TOPSOIL AND STOCKPILE FOR REUSE ONSITE. MATERIAL FOUND UNACCEPTABLE BY THE ENGINEER WILL BE REMOVED AND PAID AS EXCAVATION AND OFFSITE DISPOSAL. NO SEPARATE MEASUREMENT AND PAYMENT WILL BE MADE FOR STRIPPING, STOCKPILING AND PLACING ON-SITE TOPSOIL. THE COST FOR THIS WORK WILL BE INCIDENTAL TO RELATED PAY ITEMS UNDER SPECIFICATION SECTION NUMBER 02315 LISTED ON THE UNIT PRICE SCHEDULE.
- RIPRAP AND GRANULAR FILL MATERIAL REMOVED DURING EXCAVATION, MEETING SPECIFICATION SECTION NUMBER 02378, SHALL BE REUSED AS DIRECTED BY THE ENGINEER. REUSED MATERIAL WILL BE MEASURED AND PAID FOR AS EXCAVATION AND ON-SITE FILL UNDER SPECIFICATION NUMBER 02315. NO SEPARATE MEASUREMENT OR PAYMENT WILL BE MADE FOR PROCESSING, HANDLING, STOCKPILING, AND PLACING MATERIAL FOUND TO BE ACCEPTABLE FOR REUSE. UPON APPROVAL OF THE ENGINEER, DISPOSAL OF NONCONFORMING RIPRAP AND GRANULAR FILL MATERIAL WILL BE MEASURED AND PAID FOR AS REMOVE AND DISPOSE OF CONCRETE RUBBLE UNDER SPECIFICATION SECTION NUMBER 02120, MATERIAL DISPOSAL.
- THE LOCATION AND GRADE OF THE BACKSLOPE INTERCEPTOR STRUCTURES AND SWALES MAY BE ADJUSTED IN THE FIELD BY THE ENGINEER AT THE TIME OF CONSTRUCTION. UNLESS OTHERWISE INSTRUCTED BY THE ENGINEER, THE BACKSLOPE INTERCEPTOR STRUCTURE SHALL BE SET AT A MAXIMUM DEPTH OF 2.5 FEET AND THE MINIMUM GRADE FOR BACKSLOPE SWALES SHALL BE 0.2%.
- ADJUST AND/OR EXTEND YARD DRAINS TO OUTFALL AT TOE OF CHANNEL PER STANDARD OUTFALL DETAILS. PAYMENT WILL BE INCIDENTAL TO SITE PREPARATION AND RESTORATION.
- COMPLETED SECTIONS OF THE CHANNEL WILL BE TURNED OVER FOR VEGETATION ESTABLISHMENT IN MAXIMUM 1500 LINEAR FOOT SEGMENTS. CONTRACTOR MAY NOT DISTURB GREATER THAN 1500 LF OF CHANNEL AT A TIME.
- CLEAR AND REMOVE ALL SILT FROM CULVERTS, PIPES AND UNDER BRIDGES TO THE PROPOSED DESIGN GRADES TO PROVIDE POSITIVE FLOW.
- LENGTHS AND DIAMETERS REPRESENTED ON PLANS ARE APPROXIMATE. CONTRACTOR WILL BE RESPONSIBLE FOR FIELD VERIFICATION PRIOR TO ORDERING MATERIALS.
- ACTIVITIES THAT DISTURB BIRD HABITAT, INCLUDING BUT NOT LIMITED TO CLEARING, GRUBBING, AND IMPACTS TO STRUCTURES WHERE MIGRATORY BIRDS AND BALD EAGLES MIGHT NEST, REQUIRE A NEST HABITAT SURVEY. DO NOT PROCEED UNTIL HARRIS COUNTY FLOOD CONTROL DISTRICT HAS CONDUCTED A NEST HABITAT SURVEY TO VERIFY ACTIVE MIGRATORY BIRD NESTS AND BALD EAGLE NESTS ARE NOT PRESENT. THE HARRIS COUNTY FLOOD CONTROL DISTRICT MUST PROVIDE WRITTEN AUTHORIZATION TO PROCEED.
- WHEN BANK EROSION REPAIRS CALL FOR THE PLACEMENT OF 3"x5" GRANULAR FILL IN THE CHANNEL BOTTOM TO ESTABLISH A BASE FOR REBUILDING THE SLOPE. THE 3"x5" GRANULAR FILL SHALL BE LIMITED TO AN ELEVATION 6-INCHES ABOVE THE NORMAL WATER SURFACE ELEVATION LEVEL.
- THE CONTRACT CONTAINS UNIT ITEMS FOR THE ESTABLISHMENT OF BEST MANAGEMENT PRACTICES FOR STORM WATER QUALITY PURPOSES. WHEN NOT CALLED FOR IN THE PROJECT PLANS, COORDINATE THE NEED AND LOCATION OF THESE UNIT ITEMS WITH THE DISTRICT REPRESENTATIVE ON SITE PRIOR TO PLACEMENT. THESE UNIT ITEMS INCLUDE, BUT ARE NOT LIMITED TO, REINFORCED SILT FENCE FOR MATERIAL STOCKPILES, ANCHORED SODDING FOR DISTURBED EARTHEN AREAS OR AROUND CONCRETE AND CONCRETE INTERCEPTOR, AND STABILIZED CONSTRUCTION ACCESS FOR PROJECT SITE INGRESS/EGRESS.
- WHEN INCLUDED IN THE SCOPE OF WORK, THE PURPOSE OF DEEP PLOWING THE SLOPE OR BERM OF A CHANNEL IS TO BREAK UP THE DESICCATED SOILS AND TO ELIMINATE ANY VOIDS, OR RILLING CLOSE TO THE SURFACE OF THE SLOPE OR BERM. THE CONTRACTOR WILL DEEP PLOW THE SLOPE OR BERM TO A MINIMUM DEPTH OF 2 FEET IN AREAS CONTAINING VOIDS AND/OR RILLING. IN AREAS OF VOIDS ONLY, THE SURFACE FROM WHICH THE 2 FEET DEPTH IS MEASURED WILL BE THE LEVEL OF THE SURROUNDING UNDISTURBED SOIL. IN AREAS OF RILLING, THE RILLS WILL FIRST BE KNOCKED DOWN AND LEVELED OFF. THE 2 FEET DEPTH WILL THEN BE MEASURED FROM THIS NEW SURFACE. THE CONTRACTOR WILL DETERMINE THE MEANS AND METHODS FOR DEEP PLOWING.)
- TREES AND PLANTS LOCATED WITHIN A DESIGNATED TREE PROTECTION ZONE (TPZ) SHALL BE PRESERVED. REFER TO SPECIFICATION SECTION 01566 - TREE AND PLANT PROTECTION, FOR DETAILED INFORMATION ON TREE AND PLANT PRESERVATION PRACTICES AND PROCEDURES INCLUDING, BUT NOT LIMITED TO, ROOT PRUNING, VEGETATION TRIMMING, FENCING AND OTHER PRESERVATION OPERATIONS.
- IF APPLICABLE, CONTRACTOR SHALL AVOID ANY WETLAND AREAS BEYOND THE LIMITS OF EXCAVATION AND CLEARING. AS THE FIRST WORK ITEM CONTRACTOR WILL BE RESPONSIBLE FOR INSTALLING FENCING OR OTHER MATERIAL TO IDENTIFY AND PROTECT THE IDENTIFIED WETLAND AREAS, UNLESS WETLANDS HAVE BEEN IDENTIFIED AND FENCED BY HCFCD PRIOR TO CONSTRUCTION AND CONTRACTOR HAS WRITTEN EVIDENCE OF SUCH.

UTILITY NOTES

CENTERPOINT ENERGY RESOURCES CORP. (GAS)

CAUTION: UNDERGROUND GAS FACILITIES

THE CONTRACTOR SHALL CONTACT THE UTILITY COORDINATING COMMITTEE AT 1-800-545-6005 OR 811 A MINIMUM OF 48 HOURS PRIOR TO CONSTRUCTION TO HAVE MAIN AND SERVICE LINES FIELD LOCATED.

- WHEN CENTERPOINT ENERGY PIPE LINE MARKINGS ARE NOT VISIBLE, CALL (713) 207-5463 OR (713- 945-8037 (7:00 A.M. TO 4:30 P.M.)) FOR STATUS OF LINE LOCATION REQUEST BEFORE EXCAVATION BEGINS.
- WHEN EXCAVATING WITHIN EIGHTEEN INCHES (18") OF THE INDICATED LOCATION OF CENTERPOINT ENERGY FACILITIES, ALL EXCAVATION MUST BE ACCOMPLISHED USING NON-MECHANIZED EXCAVATION PROCEDURES.
- WHEN CENTERPOINT ENERGY FACILITIES ARE EXPOSED, SUFFICIENT SUPPORT MUST BE PROVIDED TO THE FACILITIES TO PREVENT EXCESSIVE STRESS ON THE PIPING.
- FOR EMERGENCIES REGARDING GAS LINES CALL (713) 659-2111 OR (713) 207-4200.

THE CONTRACTOR IS FULLY RESPONSIBLE FOR ANY DAMAGES CAUSED BY HIS FAILURE TO EXACTLY LOCATE AND PRESERVE THESE UNDERGROUND FACILITIES.

CENTERPOINT ENERGY HOUSTON ELECTRIC LLC

WARNING: OVERHEAD ELECTRICAL FACILITIES

OVERHEAD LINES MAY EXIST ON THE PROPERTY. THE LOCATION OF OVERHEAD LINES HAS NOT BEEN SHOWN ON THESE DRAWINGS AS THE LINES ARE CLEARLY VISIBLE, BUT YOU SHOULD LOCATE THEM PRIOR TO BEGINNING ANY CONSTRUCTION. TEXAS LAW, SECTION 752, HEALTH & SAFETY CODE FORBIDS ACTIVITIES THAT OCCUR IN CLOSE PROXIMITY TO HIGH VOLTAGE LINES, SPECIFICALLY:

- ANY ACTIVITY WHERE PERSON OR THINGS MAY COME WITHIN SIX(6) FEET OF LIVE OVERHEAD HIGH VOLTAGE LINES; AND
- OPERATING A CRANE, DERRICK, POWER SHOVEL, DRILLING RIG, PILE DRIVER, HOISTING EQUIPMENT, OR SIMILAR APPARATUS WITHIN 10 FEET OF LIVE OVERHEAD HIGH VOLTAGE LINES.

PARTIES RESPONSIBLE FOR THE WORK, INCLUDING CONTRACTORS ARE LEGALLY RESPONSIBLE FOR THE SAFETY OF CONSTRUCTION WORKERS UNDER THIS LAW. THIS LAW CARRIES BOTH CRIMINAL AND CIVIL LIABILITY. TO ARRANGE FOR LINES TO BE TURNED OFF OR REMOVED CALL CENTERPOINT ENERGY AT (713) 207-2222.

ACTIVITIES ON/OR ACROSS CENTERPOINT ENERGY FEE OR EASEMENT PROPERTY

NO APPROVAL TO USE, CROSS OR OCCUPY CENTERPOINT FEE OR EASEMENT PROPERTY IS GIVEN. IF YOU NEED TO USE CENTERPOINT PROPERTY, PLEASE CONTACT OUR SURVEYING & RIGHT OF WAY DIVISION AT (713) 207-6348 OR (713) 207-5769.

AT&T TEXAS/SWBT FACILITIES



- THE LOCATIONS OF AT&T TEXAS/SWBT FACILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION BEFORE COMMENCING WORK. HE AGREES TO BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE OCCASIONED BY THIS FAILURE TO EXACTLY LOCATE AND PRESERVE THESE UNDERGROUND UTILITIES.
- THE CONTRACTOR SHALL CALL 1-800-344-8377 (TEXAS 811) A MINIMUM OF 48 HOURS PRIOR TO CONSTRUCTION TO HAVE UNDERGROUND LINES FIELD LOCATED.
- WHEN EXCAVATING WITHIN EIGHTEEN INCHES (18") OF THE INDICATED LOCATION OF AT&T TEXAS/SWBT FACILITIES, ALL EXCAVATIONS MUST BE ACCOMPLISHED USING NON-MECHANIZED EXCAVATION PROCEDURES. WHEN BORING, THE CONTRACTOR SHALL EXPOSE THE AT&T TEXAS/SWBT FACILITIES.
- WHEN AT&T TEXAS/SWBT FACILITIES ARE EXPOSED, THE CONTRACTOR WILL PROVIDE SUPPORT TO PREVENT DAMAGE TO THE CONDUIT DUCTS OR CABLES. WHEN EXCAVATING NEAR TELEPHONE POLES THE CONTRACTOR SHALL BRACE THE POLE FOR SUPPORT.
- THE PRESENCE OR ABSENCE OF AT&T TEXAS/SWBT UNDERGROUND CONDUIT FACILITIES OR BURIED CABLE FACILITIES SHOWN ON THESE PLANS DOES NOT MEAN THAT THERE ARE NO DIRECT BURIED CABLES OR OTHER CABLES IN CONDUIT IN THE AREA.
- PLEASE CONTACT THE AT&T TEXAS DAMAGE PREVENTION MANAGER ROOSEVELT LEE JR. AT (713)567-4552 OR E-MAIL HIM AT RL7259@ATT.COM, IF CABLE LOCATE REQUEST(S) ARE NOT COMPLETED FOR OUR AT&T TEXAS/SWBT FACILITIES.

DIRECT BURIED CABLE PROCEDURE

DIRECT BURIED CABLE RECORDS ARE NOT AVAILABLE. TO DETERMINE THE LOCATION OF DIRECT BURIED CABLE PLANT DURING THE DESIGN PHASE OF YOUR PROJECT, FOLLOW THE PROCEDURE OUTLINED BELOW:

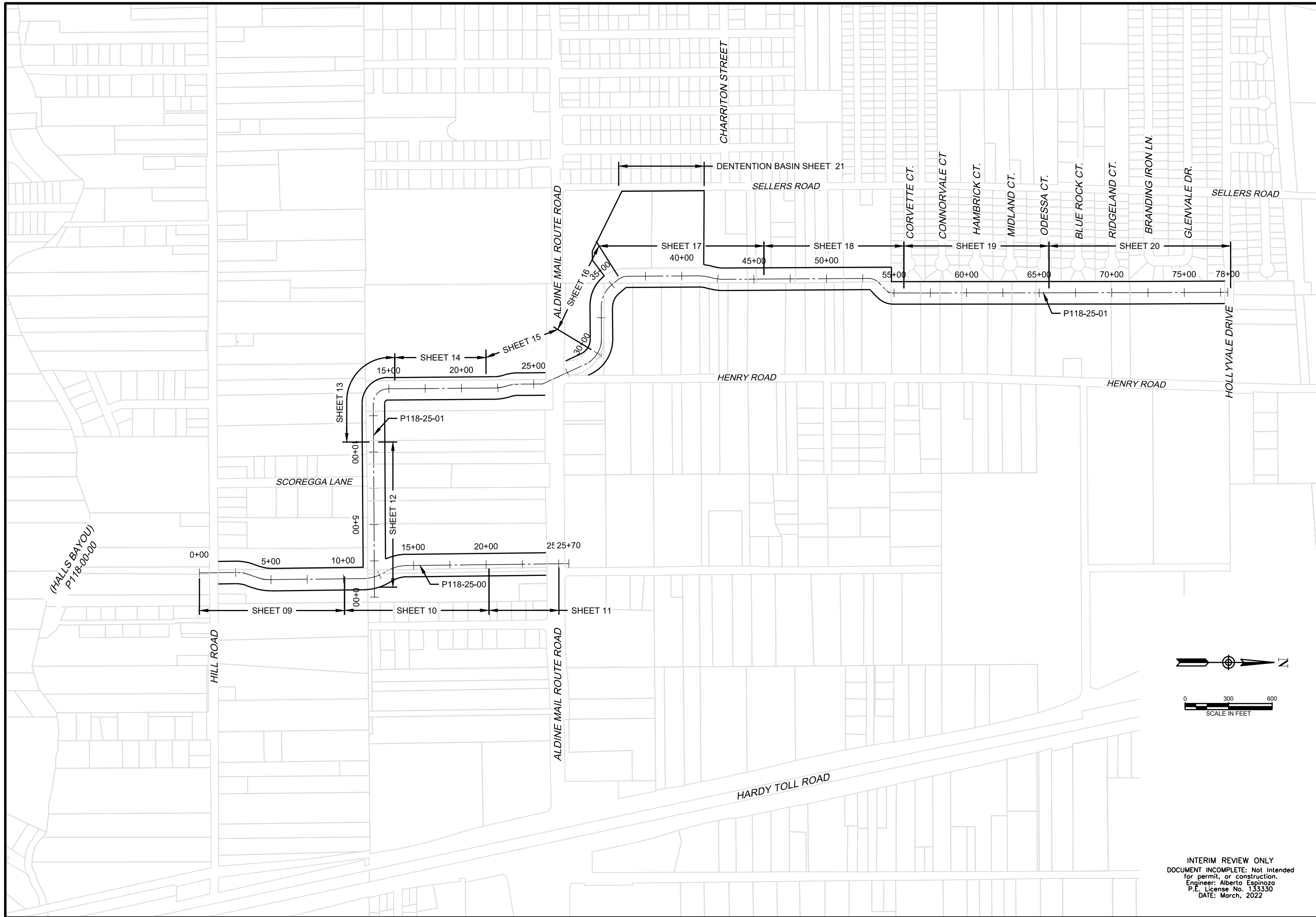
- CALL 1-800-344-8377 (TEXAS 811) AND ADVISE YOU NEED THE EXISTING AT&T TEXAS/SWBT FACILITIES LOCATED FOR THE DESIGN PHASE OF YOUR PROJECT PLEASE ALLOW AT LEAST 72 HOURS FOR THE CABLES TO GET MARKED BEFORE SENDING YOUR FIELD CREW FOR BASE LINE SURVEY FOR LOCATES OF. BE SPECIFIC ON THE PROJECT LOCATION.
- THE LOCATOR WILL FIELD LOCATE THE EXISTING AT&T TEXAS/SWBT FACILITIES WITH ORANGE PAINT AND/OR FLAGS.

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

DATE	APPR				
DESCRIPTION					
REV					
HCFCD UNIT NO. P118-25-00/01					
HALLS BAYOU WATERSHED					
GENERAL NOTES					
PREPARED: A.V.					
CHECKED: M.J.					
APPROVED:					
 <p>16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487</p>					
 <p>9900 Northwest Freeway Houston, Texas 77092</p>					
DATE: 3/15/2022					
SHEET NUMBER					
04 OF 41					

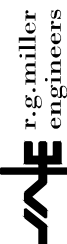

3/4/2022 M:\04543.007\118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG\01 - 4543.07 - FRONT END DRAWINGS.DWG

3/15/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\WG02-4543.07 - OVERALL.DWG

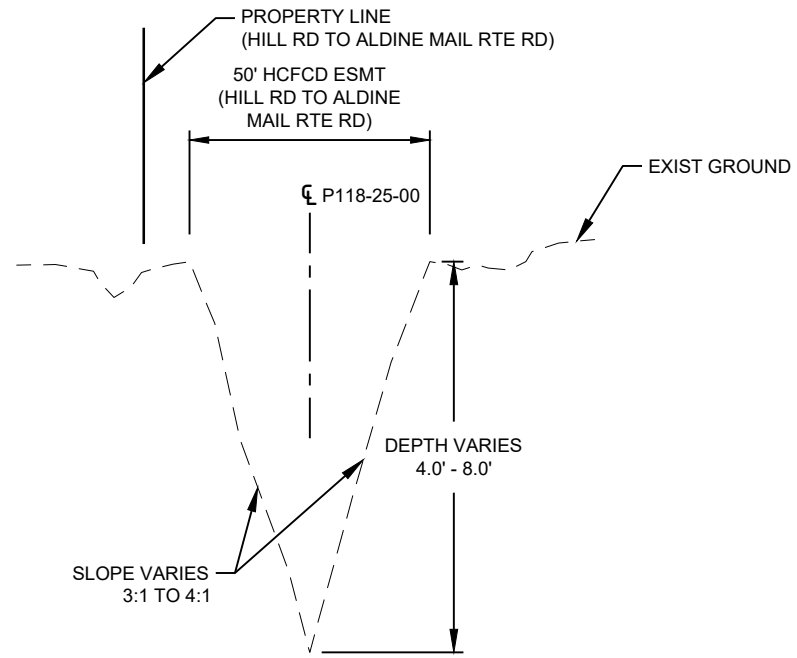


REV	DESCRIPTION	DATE	APPR

HCFC UNIT NO. P118-25-00/01	PREPARED: A.V.
HALLS BAYOU WATERSHED	CHECKED: M.J.
OVERALL LAYOUT	APPROVED:

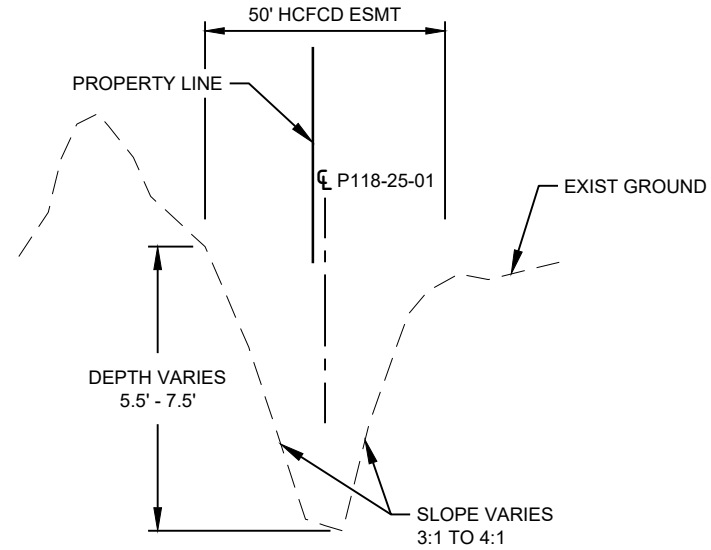
 r.g. miller engineers 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 <small>TEXAS FIRM REGISTRATION NO. F-487</small>
 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092

DATE: 3/15/2022
INTERIM REVIEW ONLY DOCUMENT INCOMPLETE: Not Intended for permit, or construction. Engineer: Alberto Espinoza P.E. License No. 133330 DATE: March, 2022
SHEET NUMBER 05 OF 41



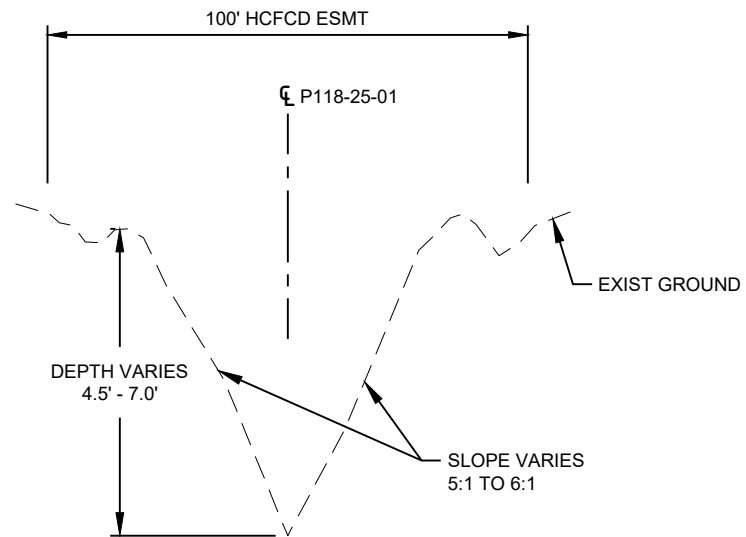
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TYPICAL SECTION**

HILL RD. TO ALDINE MAIL RTE RD.
N.T.S.



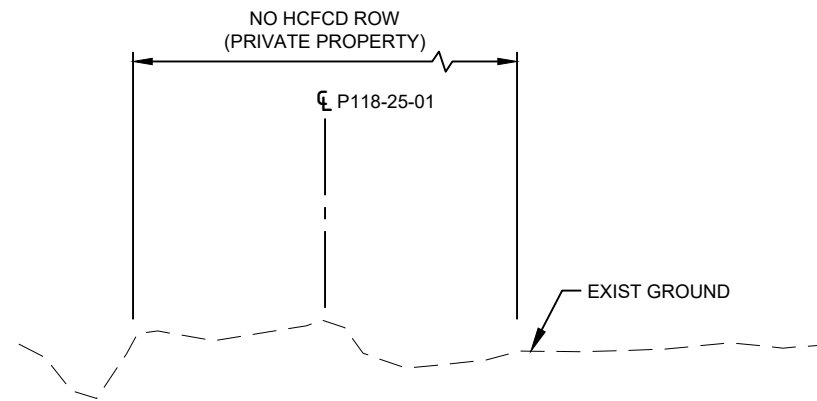
**P118-25-01 EXISTING
TYPICAL SECTION**

FROM CONFLUENCE OF P118-25-00 TO ALDINE MAIL RTE RD.
N.T.S.



**P118-25-01 EXISTING
TYPICAL SECTION**

U/S OF ALDINE MAIL RTE RD. TO CORVETTE CT.
N.T.S.

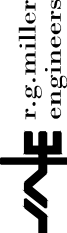


**P118-25-01 EXISTING
TYPICAL SECTION**

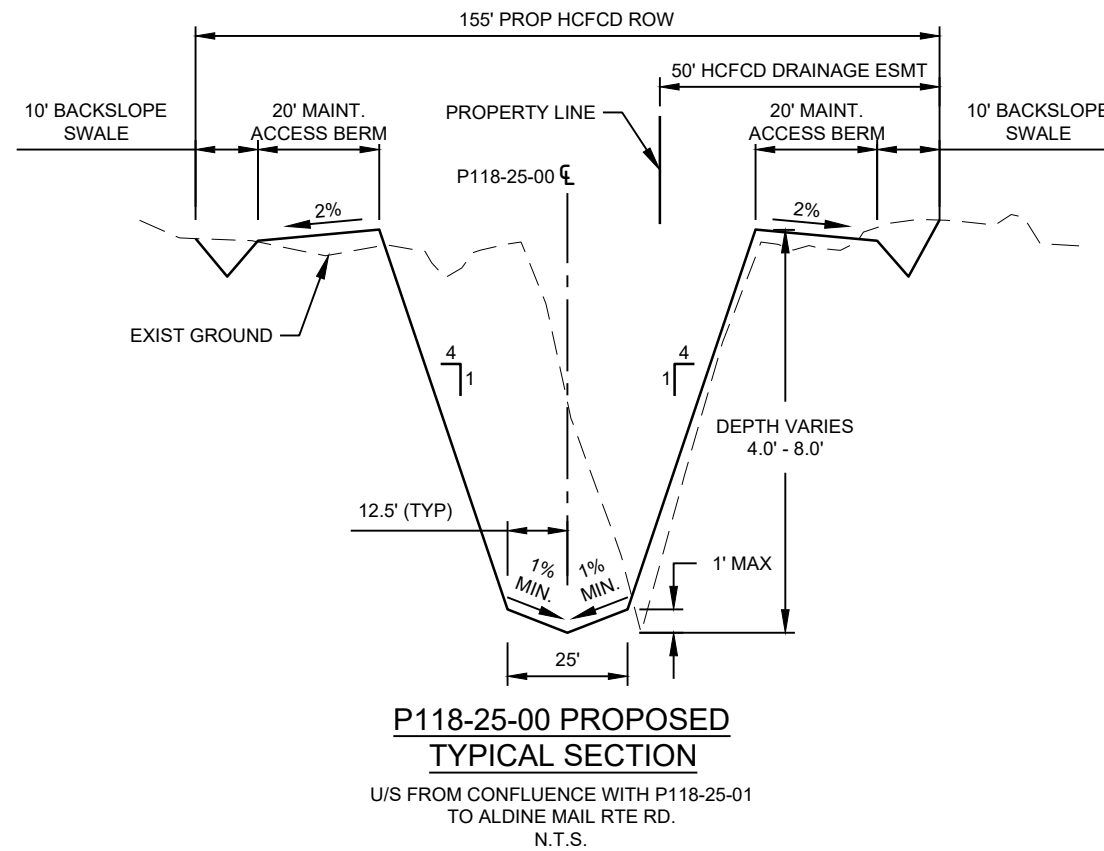
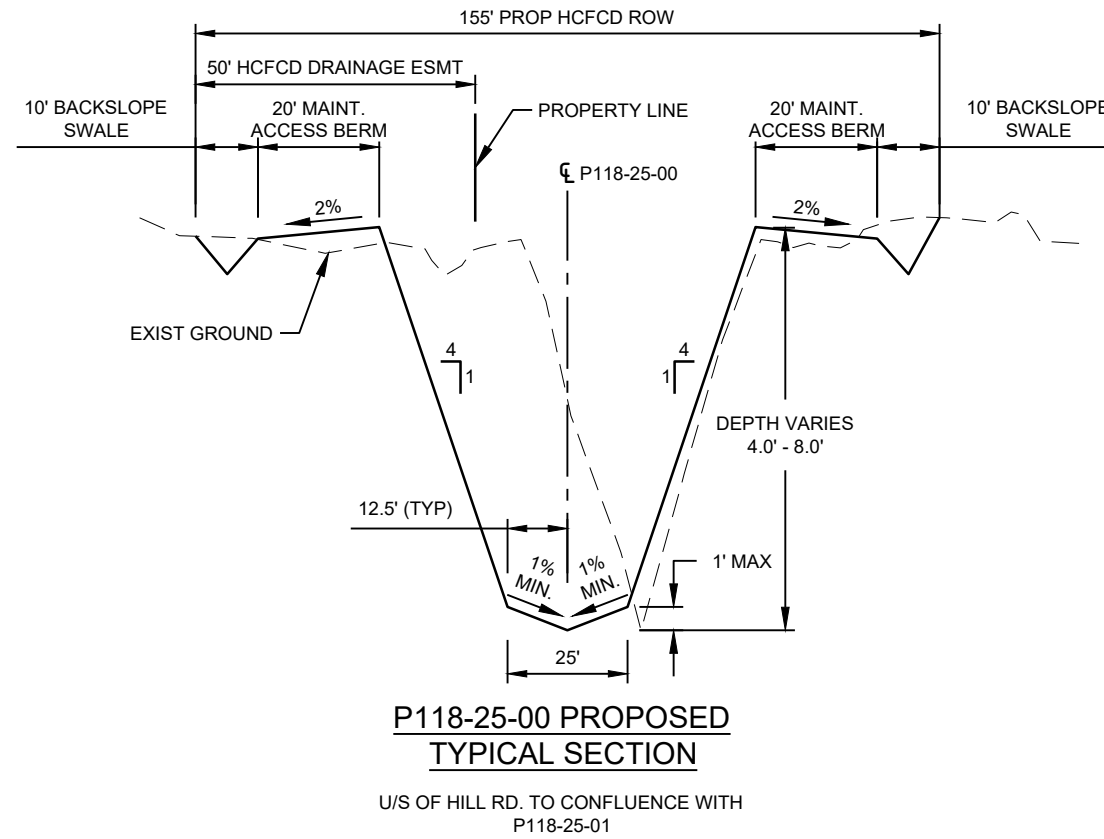
U/S OF CORVETTE CT. TO HOLLYVALE DR.
N.T.S.

3/15/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\WG04 -4543.07 - TYPICAL SECTIONS.DWG

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

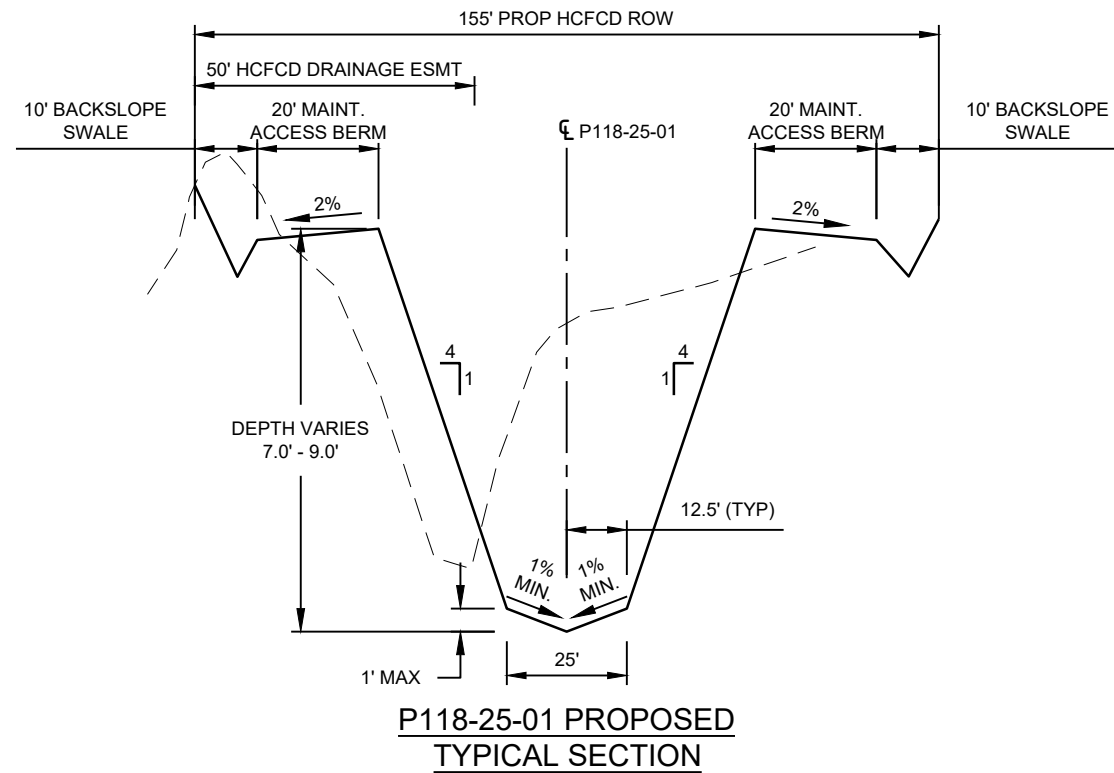
DATE	APPR	DESCRIPTION	REV	HCFCF UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED	EXISTING TYPICAL SECTIONS
PREPARED: A.V.		 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 <small>TEXAS FIRM REGISTRATION NO. F-487</small>				
CHECKED: M.J.						
APPROVED:						
 9900 Northwest Freeway Houston, Texas 77092						
DATE: 3/15/2022						
SHEET NUMBER						
06 OF 41						

3/15/2022 M:\04543.007 P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\WG04 -4543.07 - TYPICAL SECTIONS.DWG

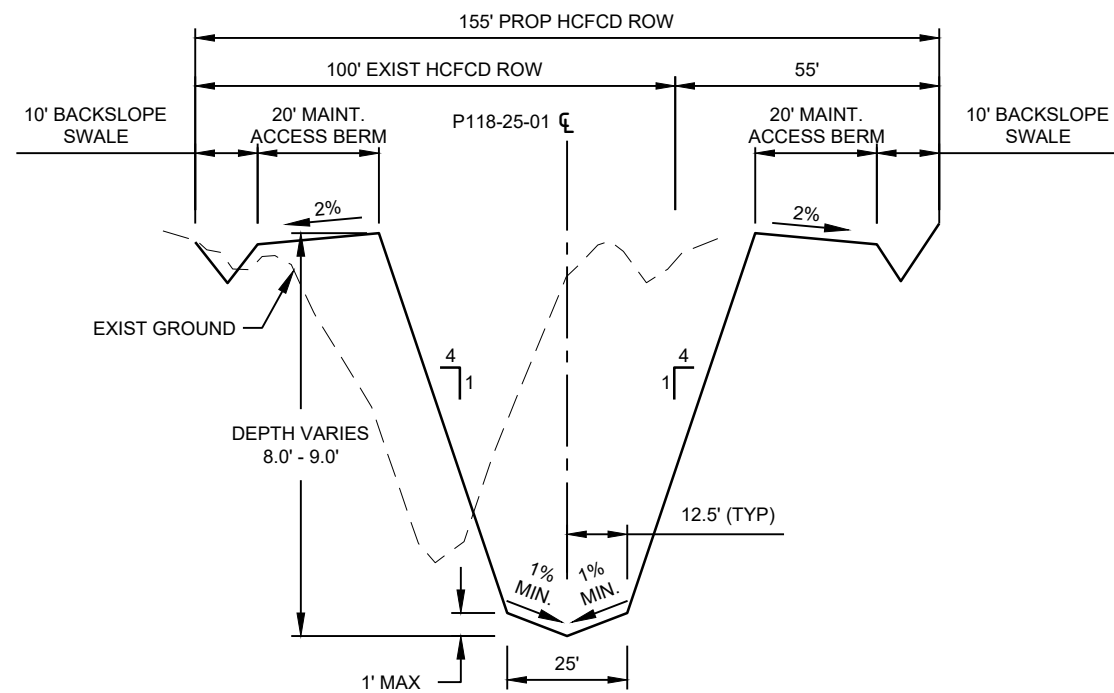


DATE		APPR			
DESCRIPTION		REV			
HCFCFCD UNIT NO. P118-25-00/01					
HALLS BAYOU WATERSHED					
PROPOSED P118-25-00 TYPICAL SECTIONS					
PREPARED: A.V.		CHECKED: M.J.		APPROVED:	
 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 <small>TEXAS FIRM REGISTRATION NO. F-487</small>					
 9900 Northwest Freeway Houston, Texas 77092					
DATE: 3/15/2022					
SHEET NUMBER					
07 OF 41					

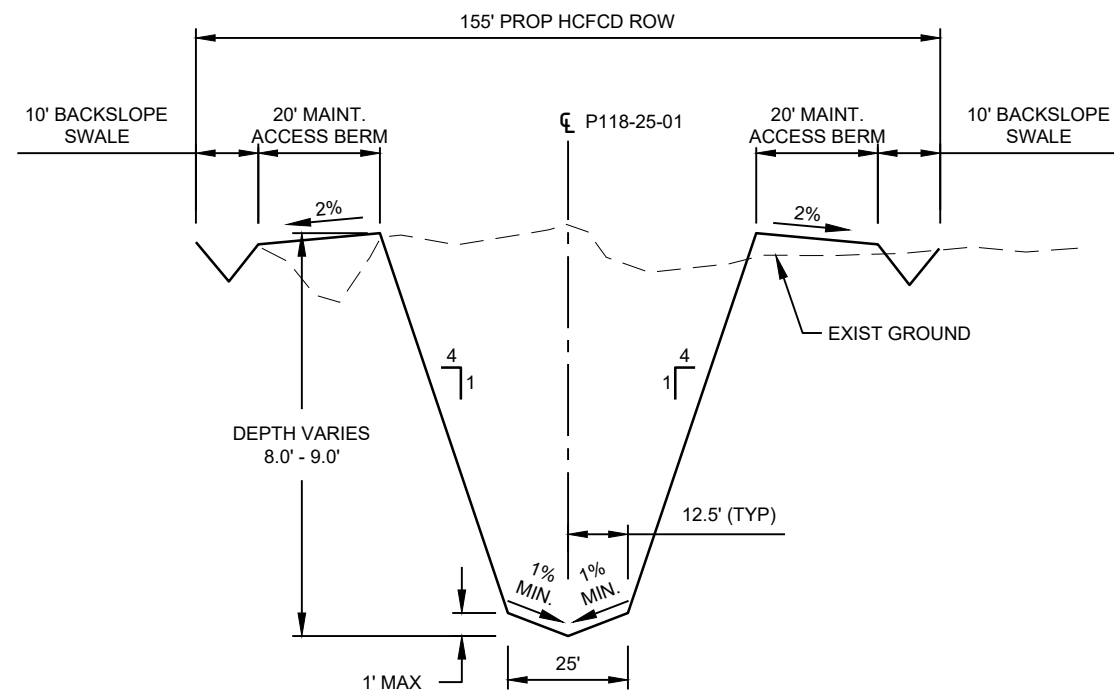
INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended
 for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022



FROM CONFLUENCE OF P118-25-00 TO ALDINE MAIL RTE RD.
N.T.S.



P118-25-01 PROPOSED TYPICAL SECTION
U/S OF ALDINE MAIL RTE RD. TO CORVETTE CT.
N.T.S.



P118-25-01 PROPOSED TYPICAL SECTION
U/S OF CORVETTE CT. TO HOLLYVALE DR.
N.T.S.

DATE	APPR
REV	DESCRIPTION

HCFC UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED	PROPOSED P118-25-01 TYPICAL SECTIONS
PREPARED: A.V.	CHECKED: M.J.	APPROVED:

r.g.miller engineers
 16340 Park Ten Place
 Suite 350
 Houston, Texas 77084
 (713) 461-9900
 TEXAS FIRM REGISTRATION NO. F-487



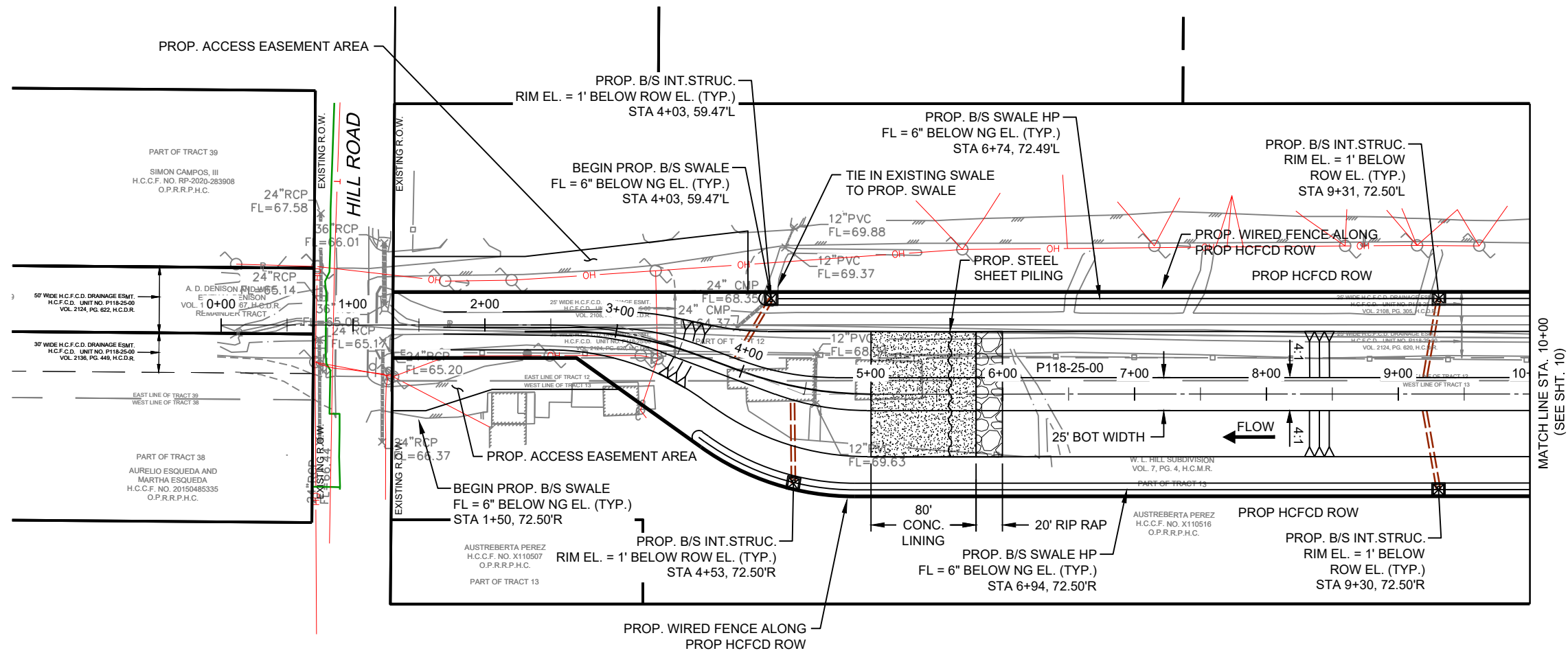
9900 Northwest Freeway
Houston, Texas 77092

DATE: 3/15/2022

SHEET NUMBER
08 OF 41

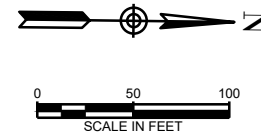
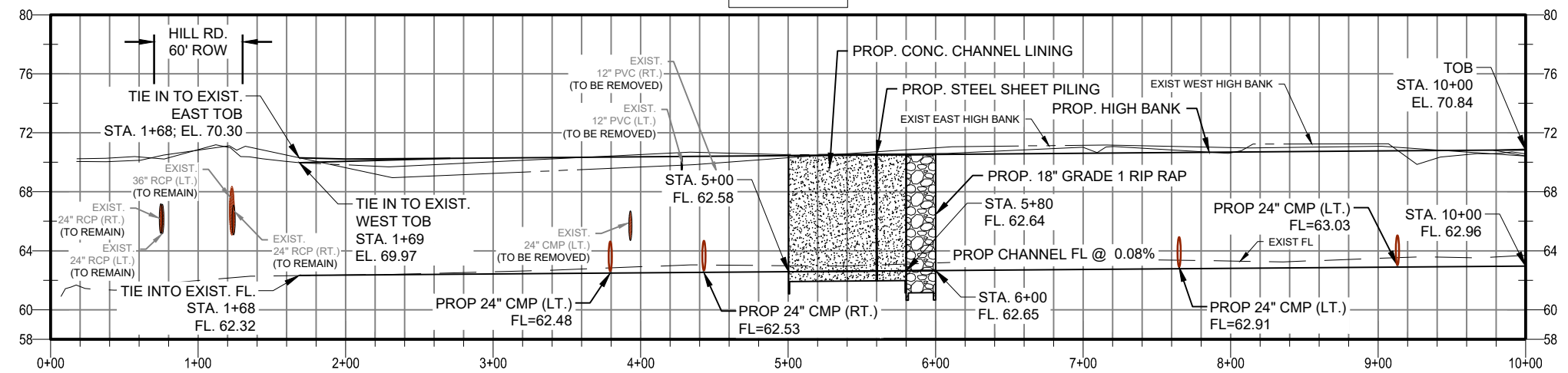
INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

6/29/2022 10:45:43.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS CAD DWG 07 - 4543.07 - CHANNEL LAYOUT.DWG



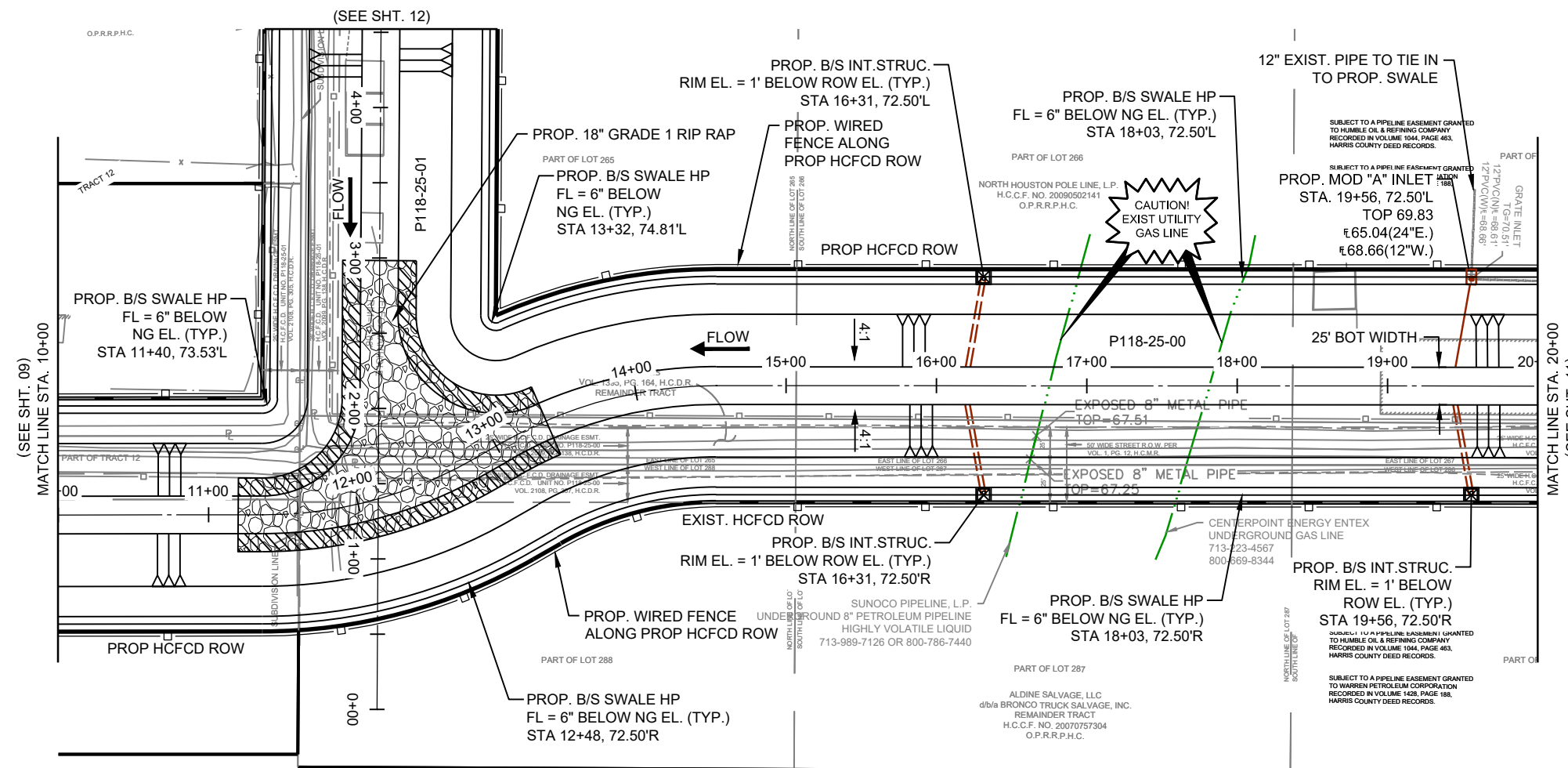
MATCH LINE STA. 10+00
(SEE SHT. 10)

P118-25-00



DATE	APPR				
DESCRIPTION	REV				
HCFCU UNIT NO. P118-25-00/01					
HALLS BAYOU WATERSHED					
P118-25-00 PLAN & PROFILE					
STA. 0+00 TO 10+00					
PREPARED: A.V.	CHECKED: M.J.				
APPROVED:					
DATE:	7/5/2022				
SHEET NUMBER	09 OF 41				

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: June, 2022



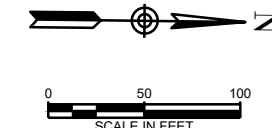
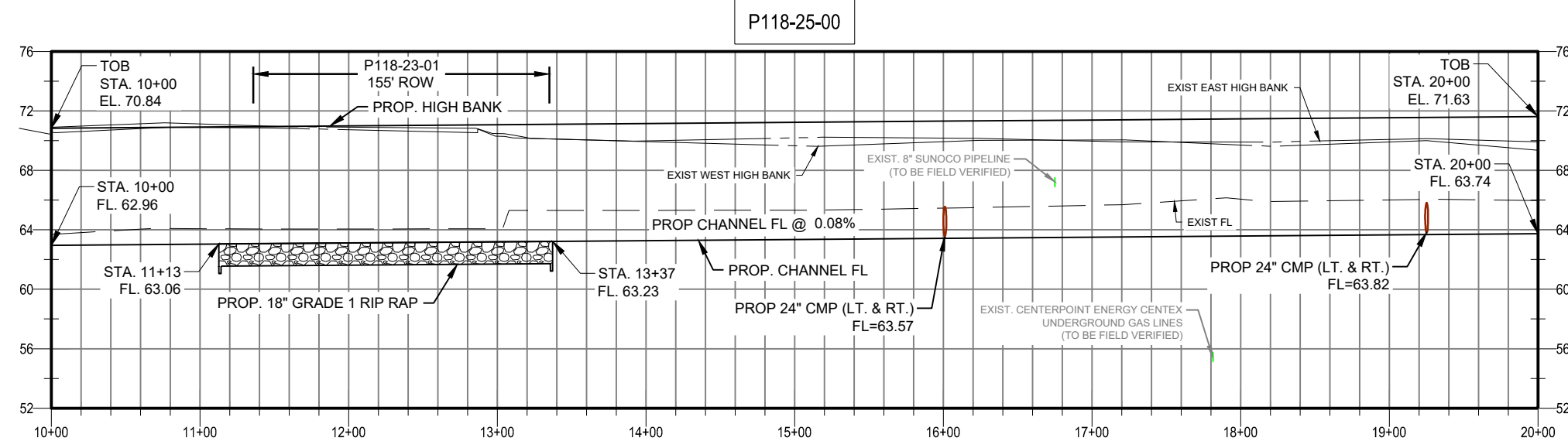
LEGEND



PROP. 18" GRADE 1 RIP RAP



PROP. 18" GRADE 1 RIP RAP TO BE COVERED WITH 6" TOP SOIL



DATE	APPR

REV	DESCRIPTION

HCFCD UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED
	P118-25-00 PLAN & PROFILE
	STA 10+00 TO 20+00

PREPARED: A.V.
 CHECKED: M.J.
 APPROVED:
r.g.miller engineers
 16340 Park Ten Place
 Suite 350
 Houston, Texas 77084
 (713) 461-9900
 TEXAS FIRM REGISTRATION NO. F-487

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

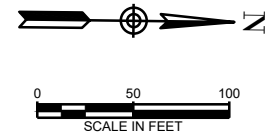
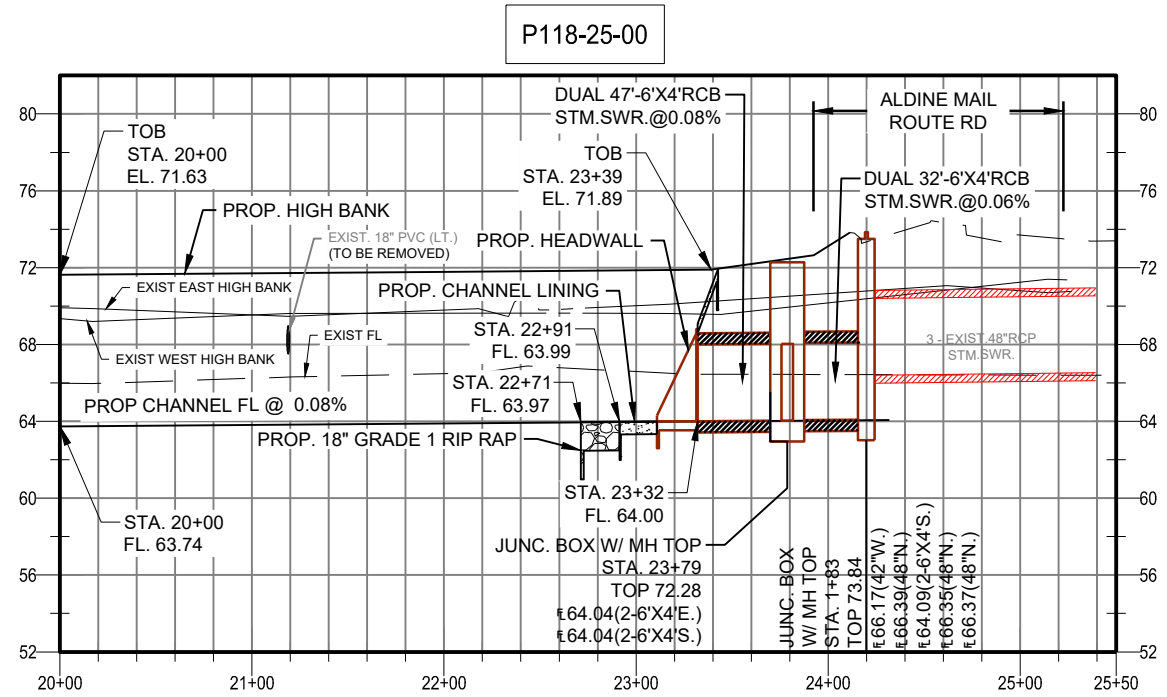
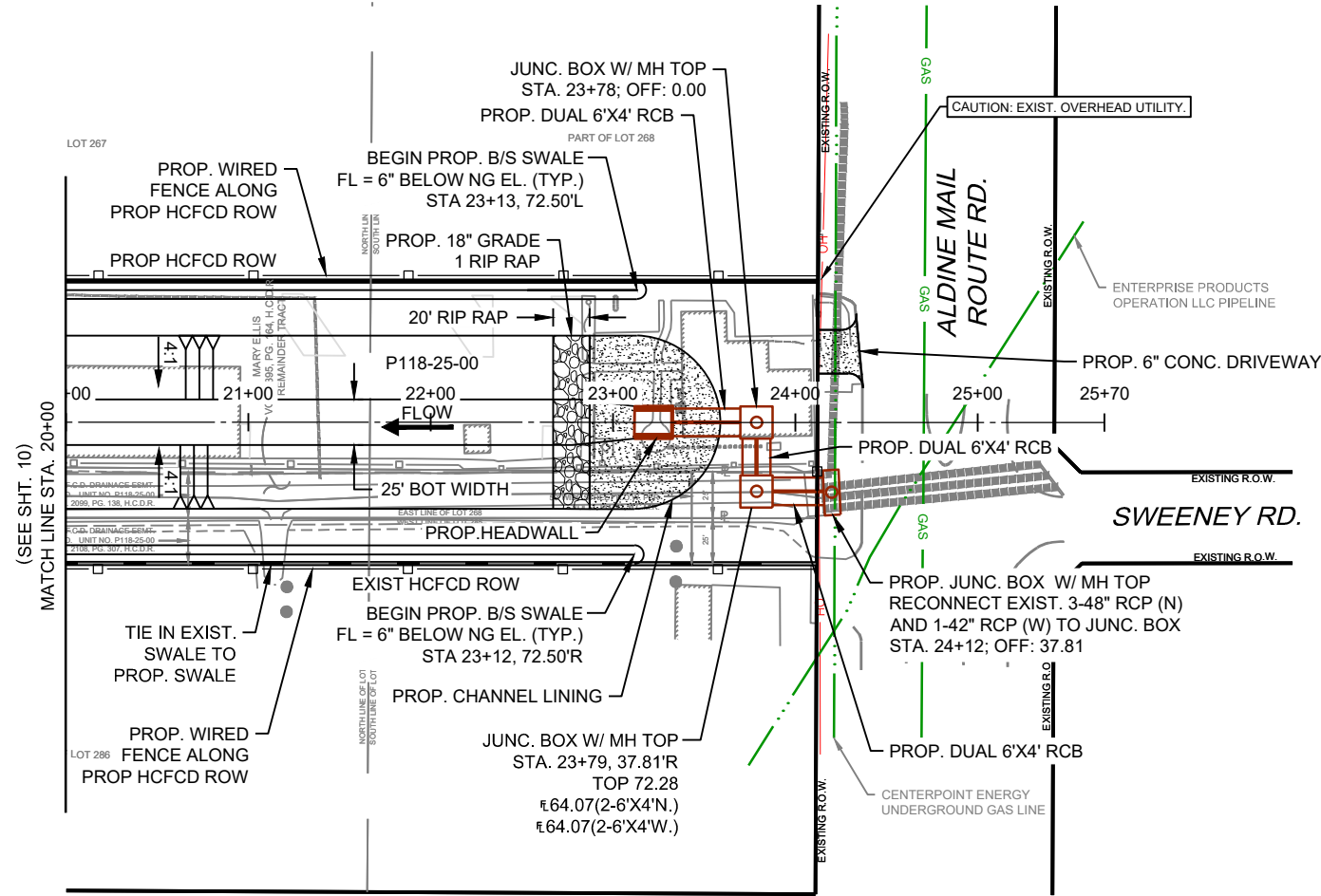
DATE: 3/15/2022

SHEET NUMBER
 10 OF 41

INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022

3/15/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG07 - 4543.07 - CHANNEL LAYOUT.DWG

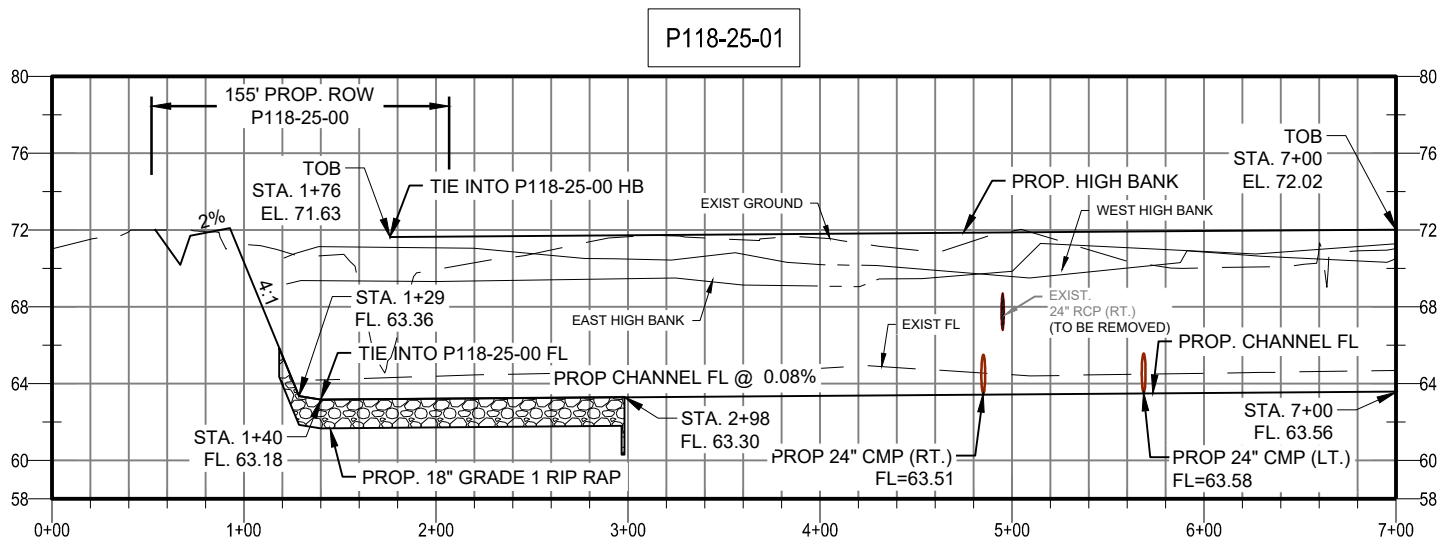
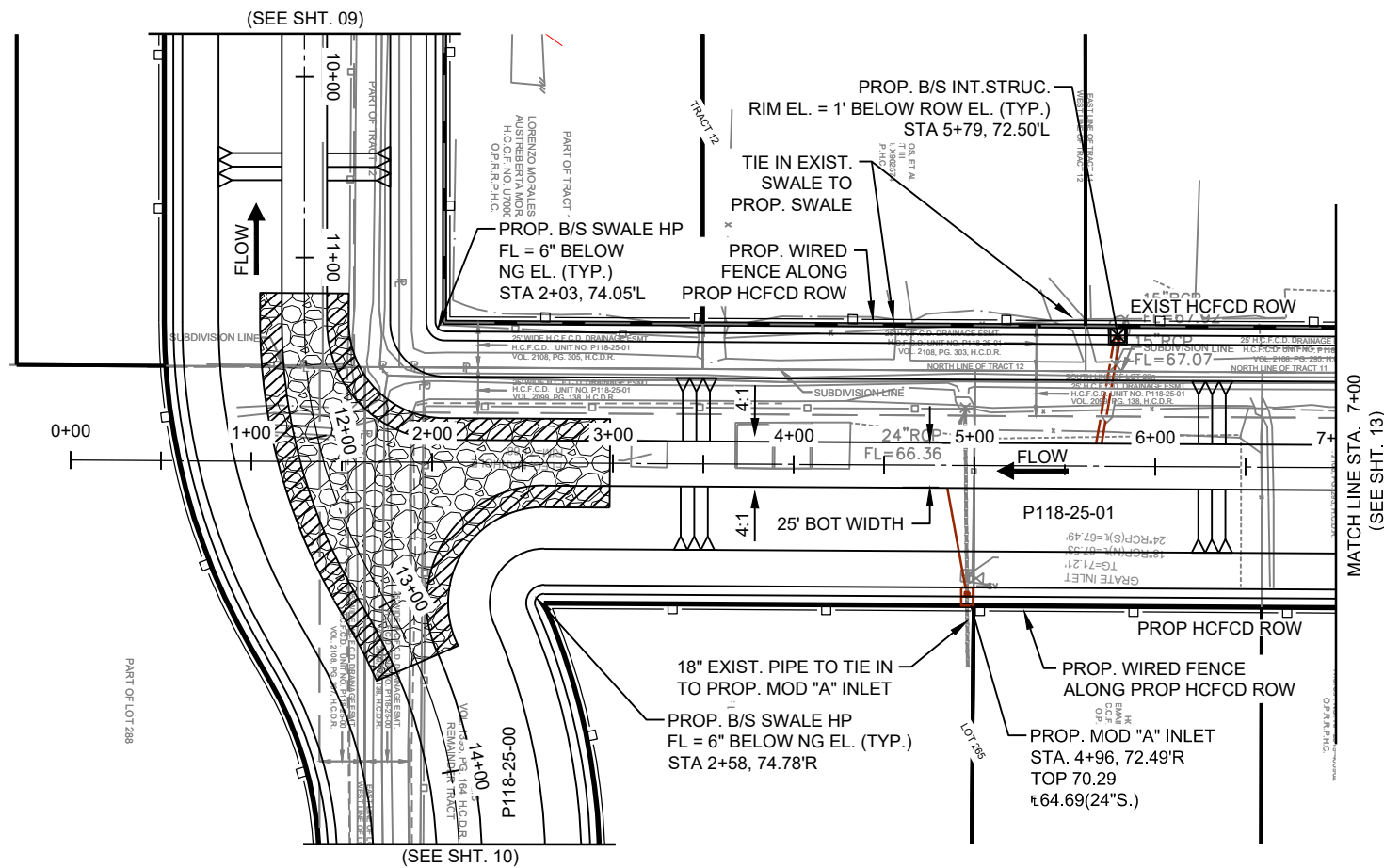
3/15/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG07 - 4543.07 - CHANNEL LAYOUT.DWG




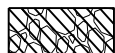
INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

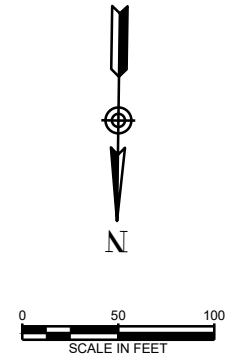
DATE	APPR				
DESCRIPTION					
REV					
HCFCD UNIT NO. P118-25-00/01					
HALLS BAYOU WATERSHED					
P118-25-00 PLAN & PROFILE STA 20+00 TO 25+00					
PREPARED: A.V.					
CHECKED: M.J.					
APPROVED:					
r.g.miller engineers 16940 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487					
HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092					
DATE: 3/15/2022					
SHEET NUMBER					
11 OF 41					

3/15/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG07 -4543.07 - CHANNEL LAYOUT.DWG



LEGEND

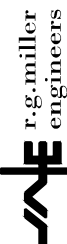

-  PROP. 18" GRADE 1 RIP RAP
-  PROP. 18" GRADE 1 RIP RAP TO BE COVERED WITH 6" TOP SOIL

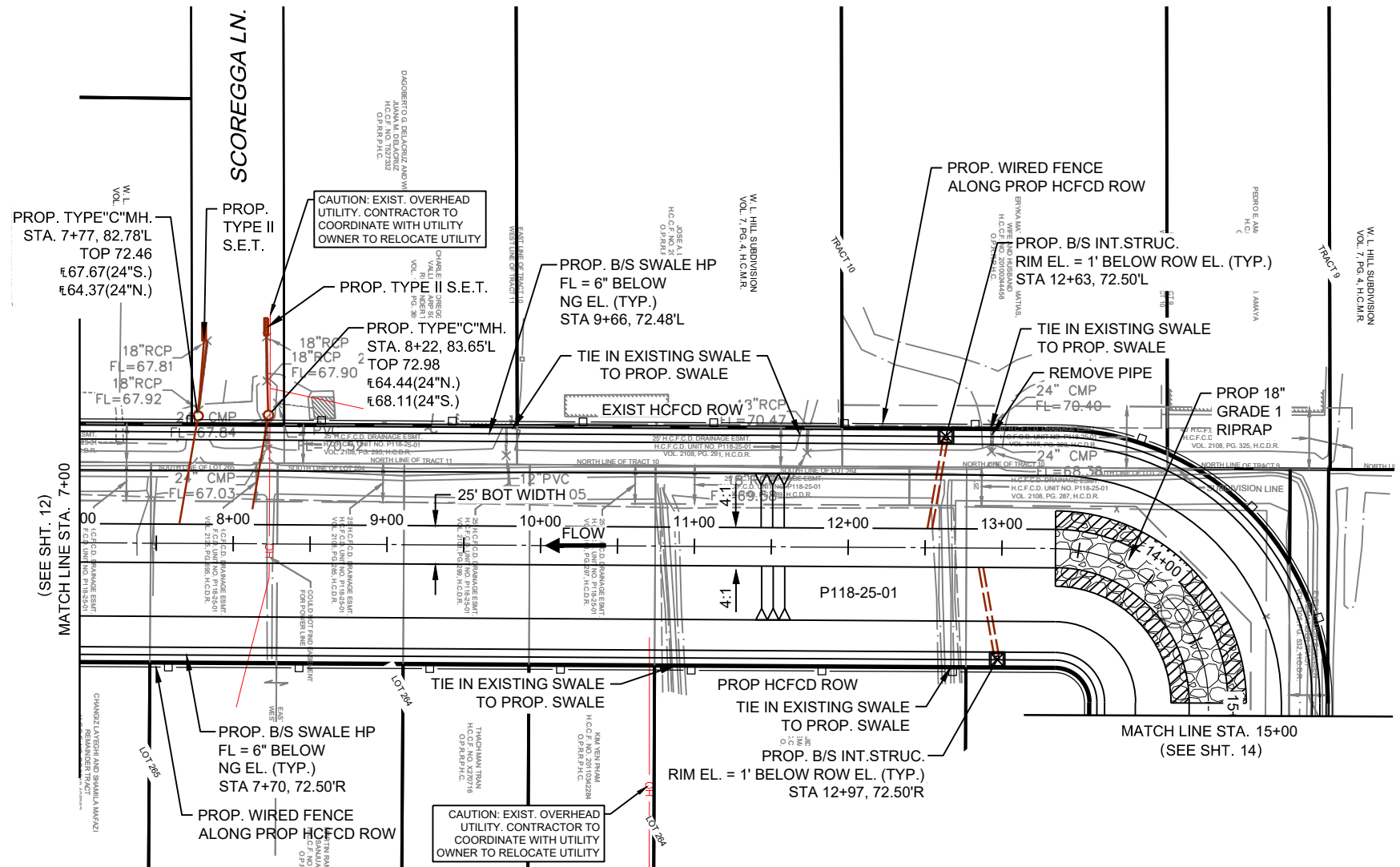


INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022



REV	DESCRIPTION	DATE	APPR

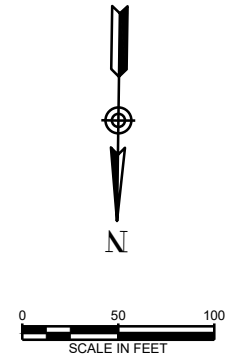
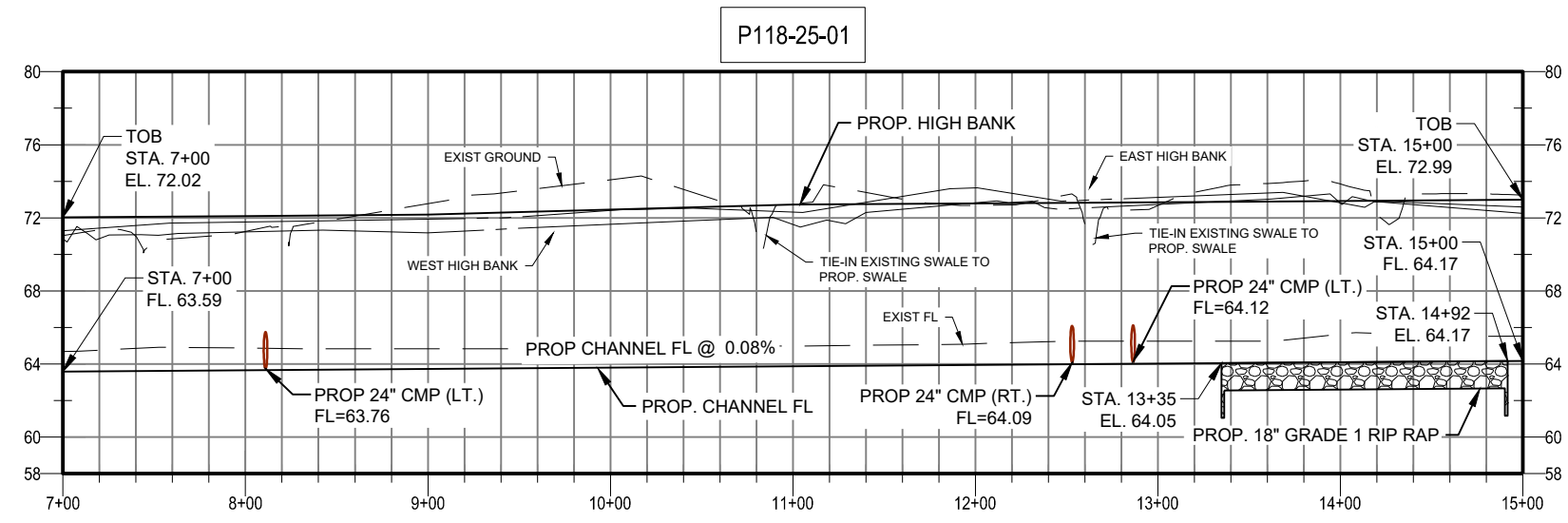
HCFCU UNIT NO. P118-25-00/01	PREPARED: A.V.
HALLS BAYOU WATERSHED	CHECKED: M.J.
P118-25-01 PLAN & PROFILE STA 0+00 TO 7+00	APPROVED:

 r.g.miller engineers 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487
 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092
DATE: 3/15/2022
SHEET NUMBER 12 OF 41



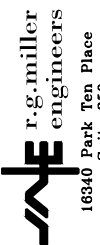

LEGEND

-  PROP. 18" GRADE 1 RIP RAP
-  PROP. 18" GRADE 1 RIP RAP TO BE COVERED WITH 6" TOP SOIL



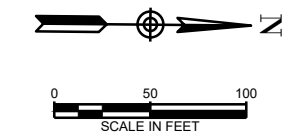
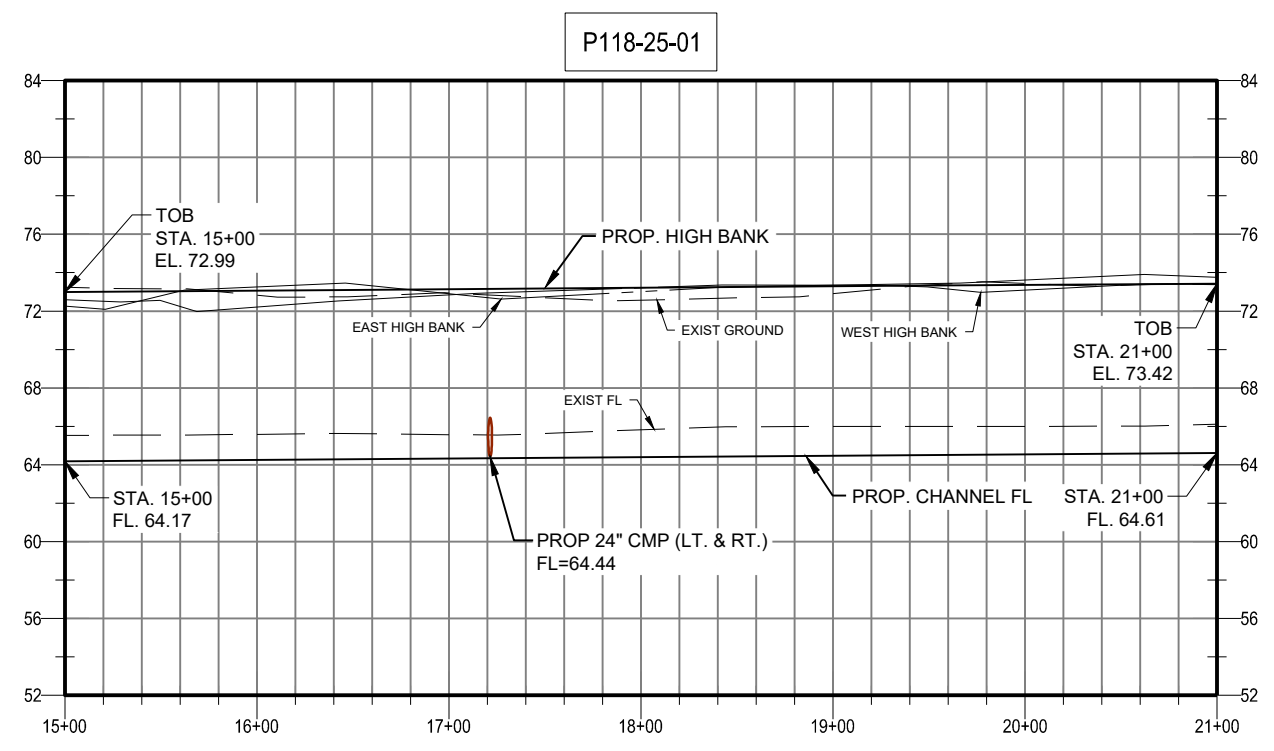
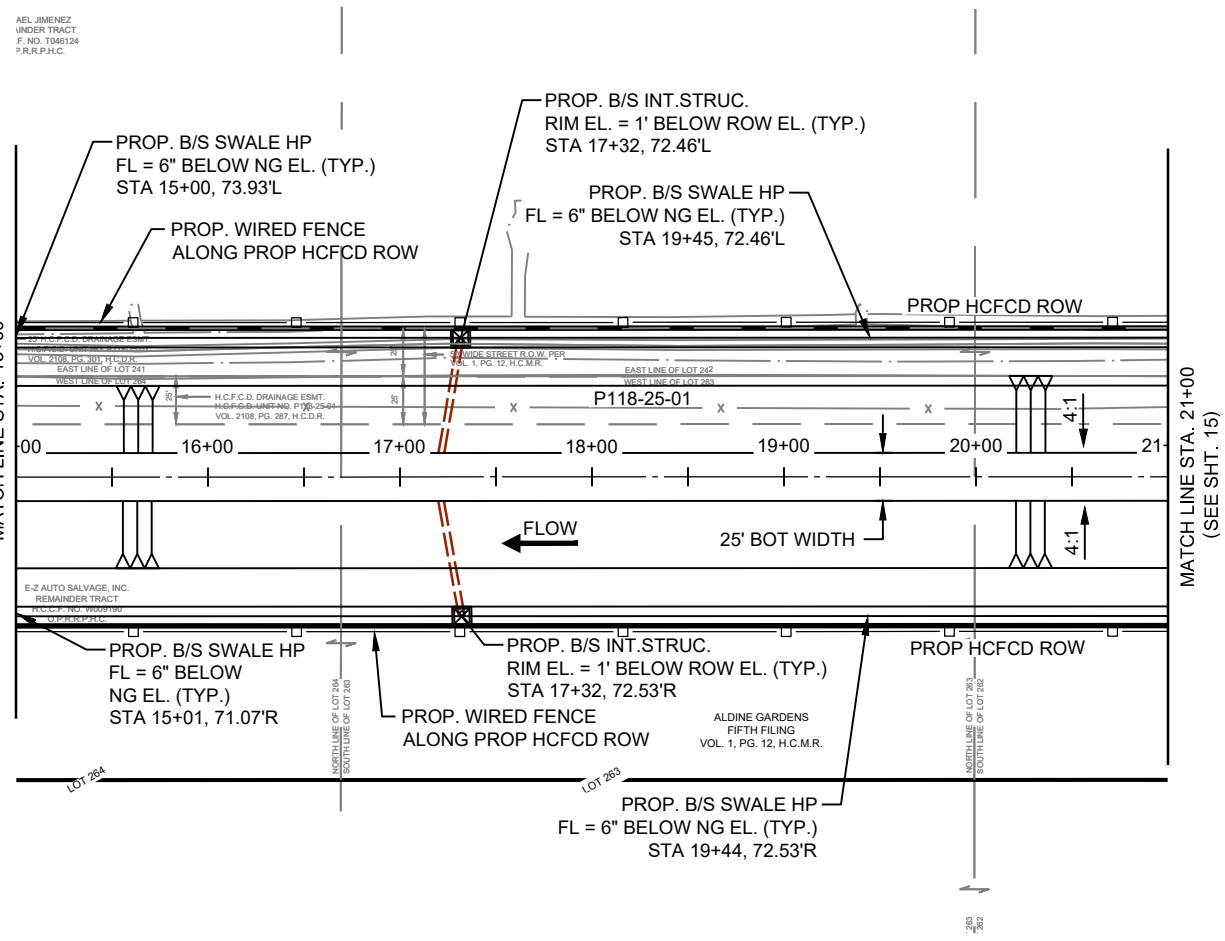
REV	DESCRIPTION	DATE	APPR

HCFC UNIT NO. P118-25-00/01	PREPARED: A.V.
HALLS BAYOU WATERSHED	CHECKED: M.J.
P118-25-01 PLAN & PROFILE STA. 7+00 TO 15+00	APPROVED:

 <p>r.g.miller engineers 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487</p>	 <p>HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092</p>

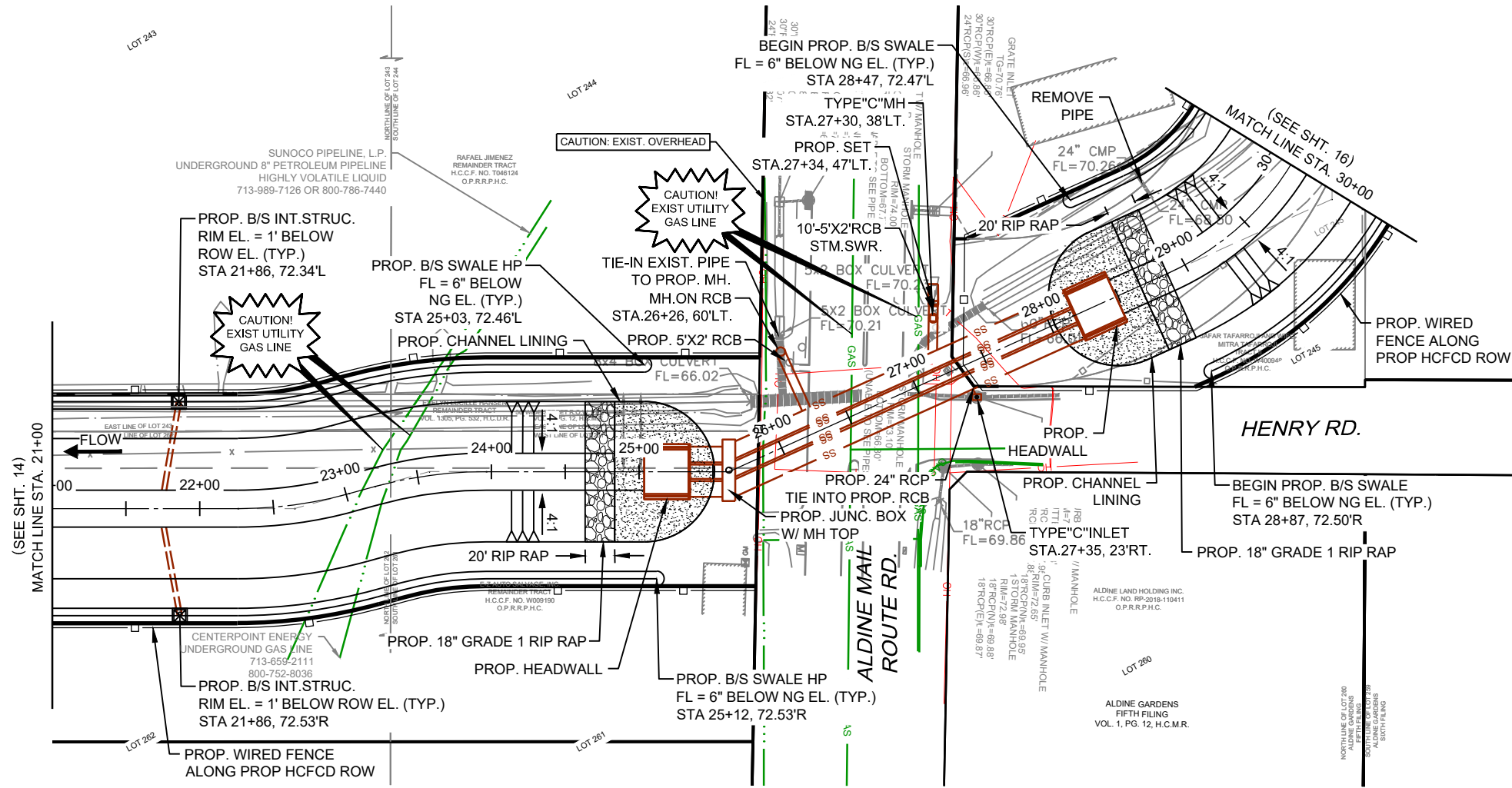
SHEET NUMBER
13 OF 41

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

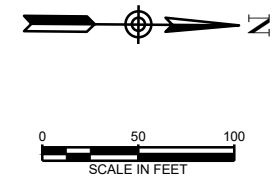
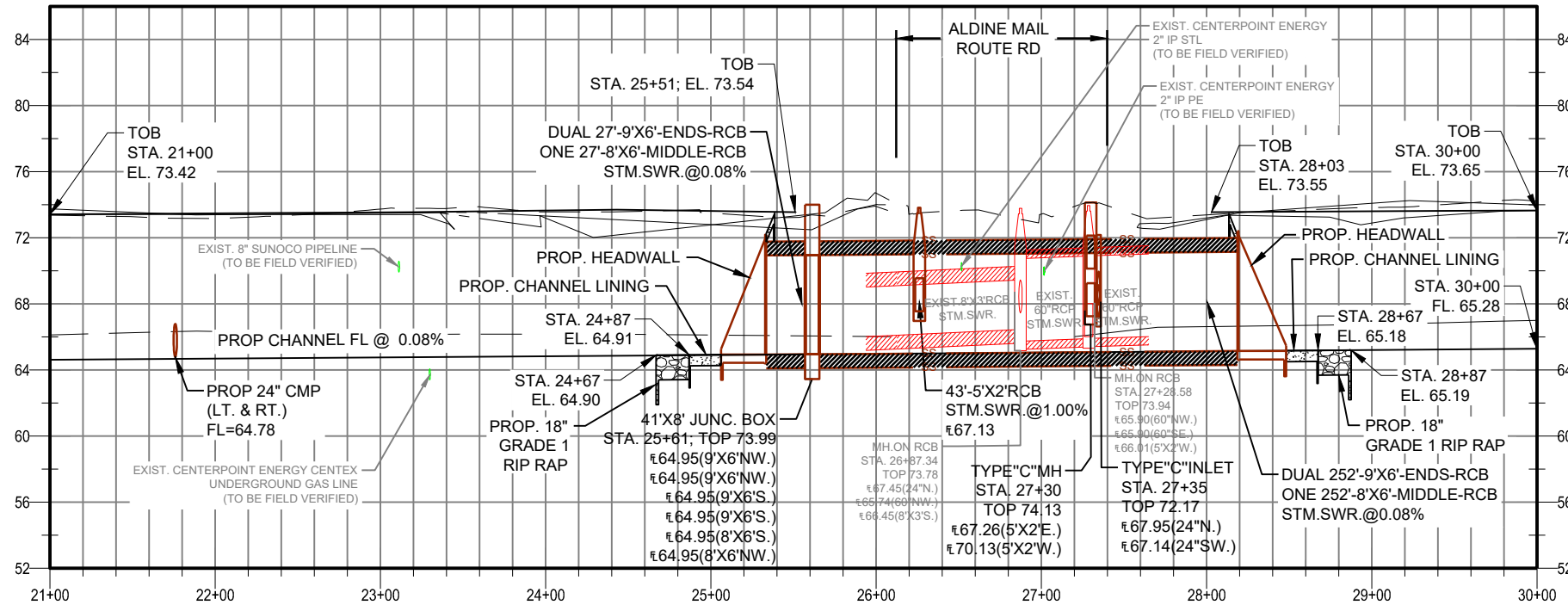


INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended
 for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022

DATE	APPR	
DESCRIPTION		
REV		
HCFCD UNIT NO. P118-25-00/01	PREPARED:	A.V.
HALLS BAYOU WATERSHED	CHECKED:	M.J.
P118-25-01 PLAN & PROFILE STA 15+00 TO 21+00	APPROVED:	
 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9600 TEXAS FRM REGISTRATION NO. F-487		
 9900 Northwest Freeway Houston, Texas 77092		
DATE:	3/15/2022	
SHEET NUMBER	14 OF 41	



P118-25-01



INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

DATE	APPR	DESCRIPTION	REV

HCFCU UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED
	P118-25-01 PLAN & PROFILE STA 21+00 TO 30+00

PREPARED: A.V.	CHECKED: M.J.	APPROVED:
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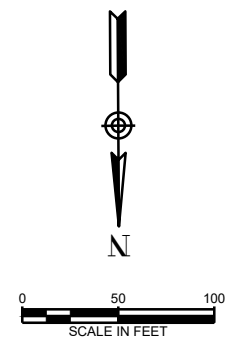
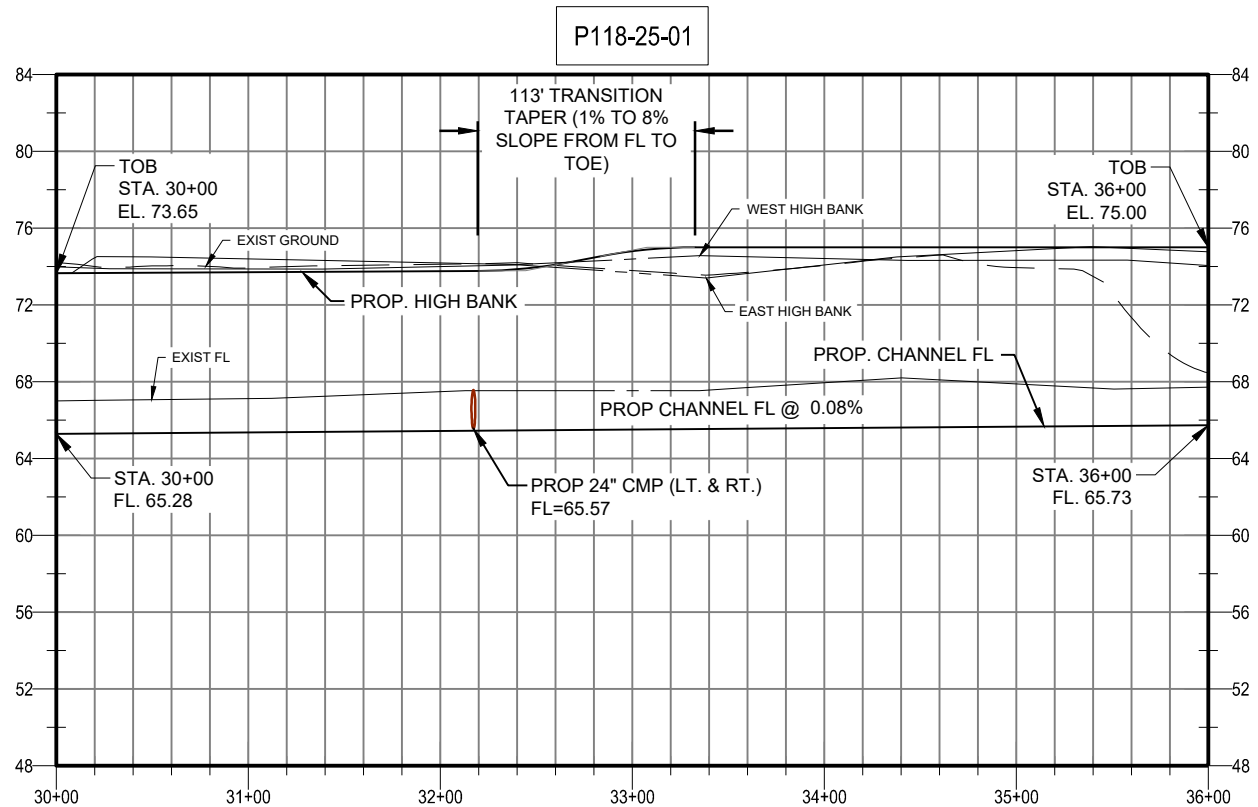
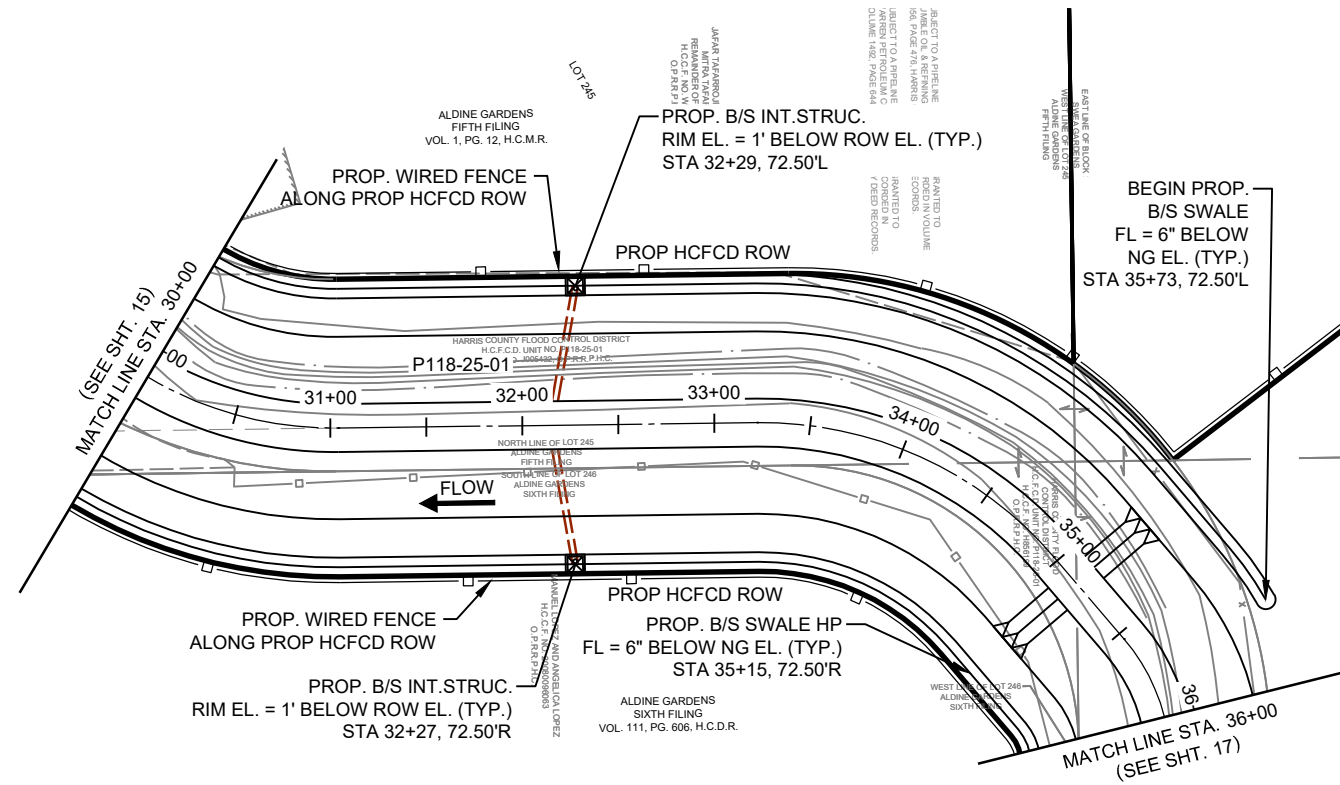
r.g.miller engineers
16340 Park Ten Place
Suite 350
Houston, Texas 77084
(713) 461-9000
TEXAS FIRM REGISTRATION NO. F-487

HARRIS COUNTY
FLOOD CONTROL DISTRICT

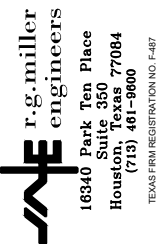
9900 Northwest Freeway
Houston, Texas 77092

DATE: 3/15/2022

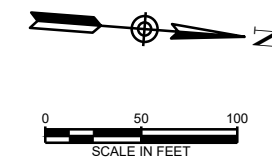
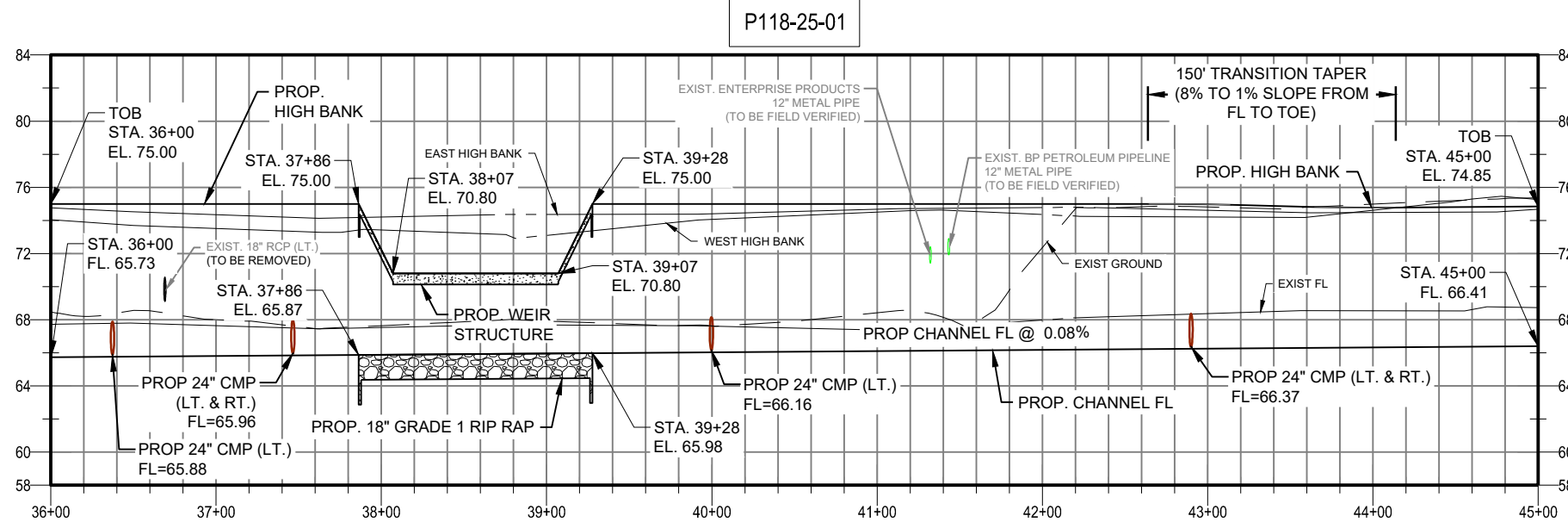
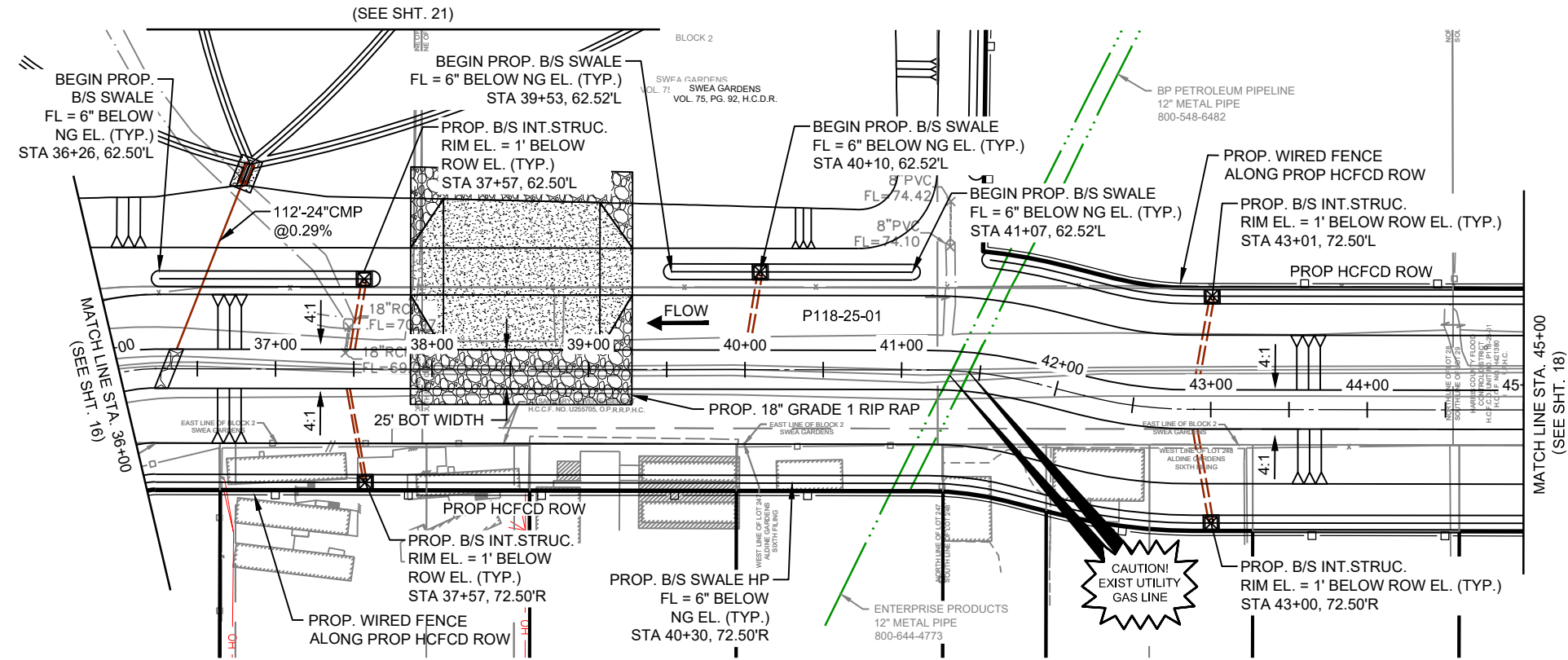
SHEET NUMBER
15 OF 41



INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended
 for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022

	DATE	APPR	
REV			DESCRIPTION
HCFCD UNIT NO. P118-25-00/01			
HALLS BAYOU WATERSHED			
P118-25-01 PLAN & PROFILE STA 30+00 TO 36+00			
PREPARED: A.V.			
CHECKED: M.J.			
APPROVED:			
			
			
DATE: 3/15/2022			
SHEET NUMBER 16 OF 41			

3/15/2022 M:\04543.007 P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG07 -4543.07 - CHANNEL LAYOUT.DWG

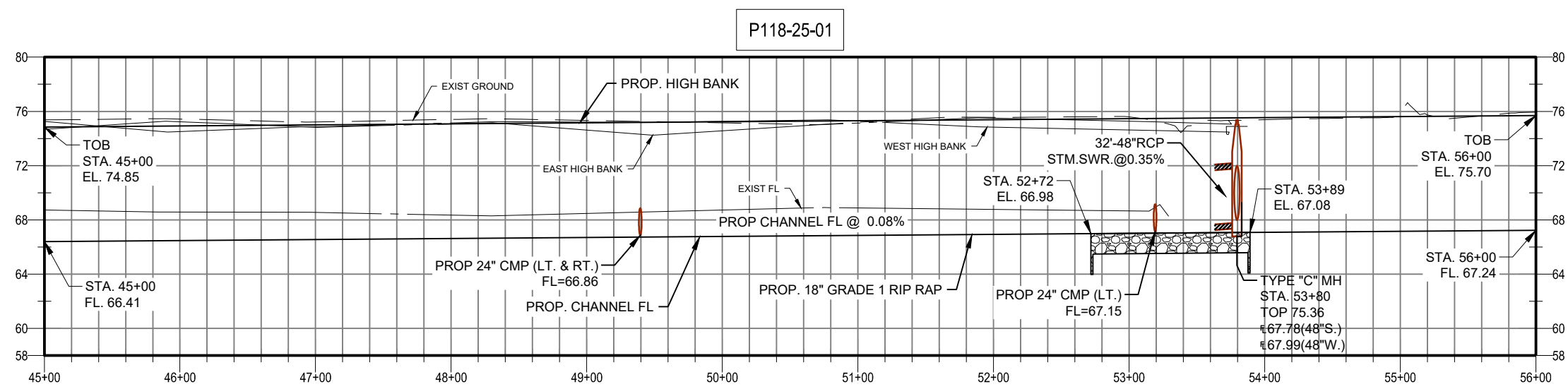
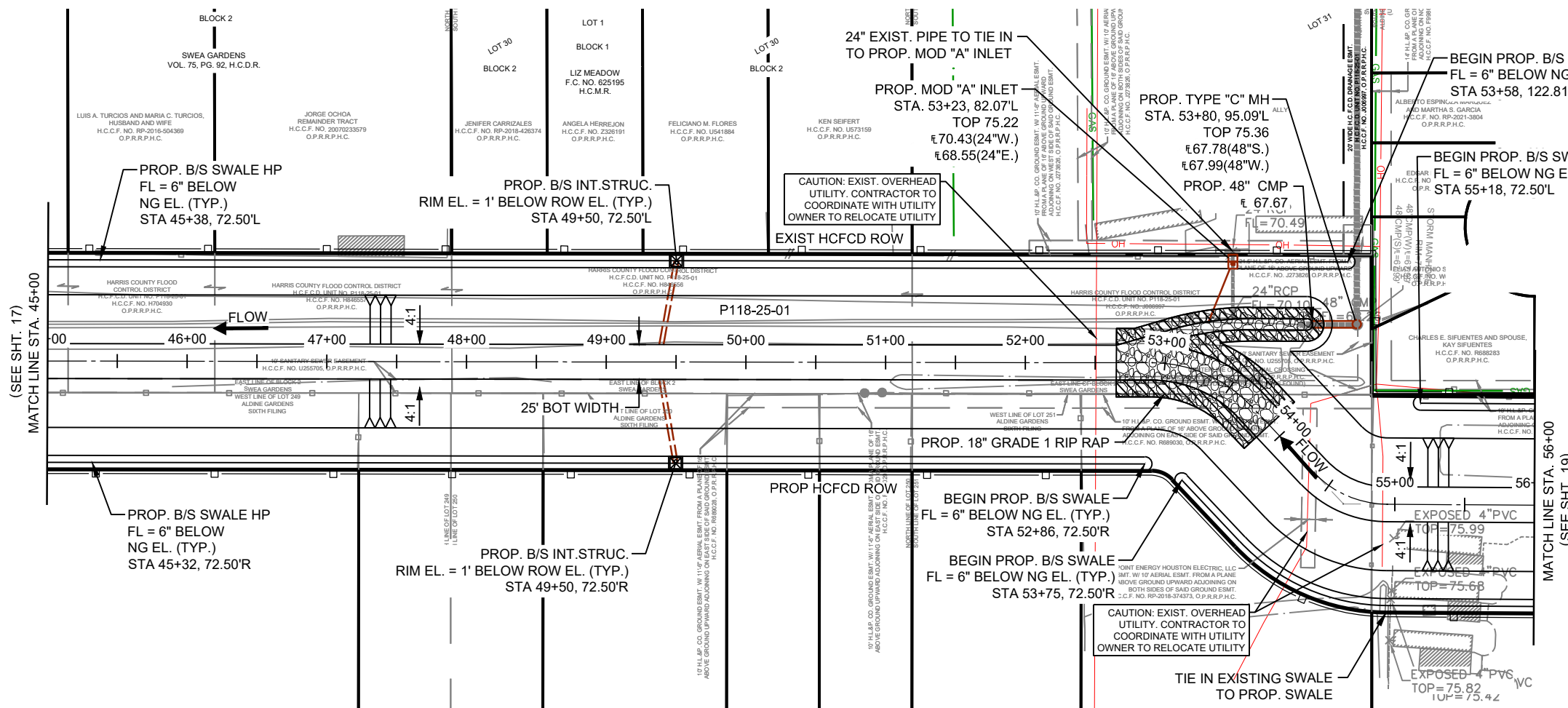


DATE	APPR
REV	DESCRIPTION

PREPARED: A.V.	HCFCD UNIT NO. P118-25-00/01
CHECKED: M.J.	HALLS BAYOU WATERSHED
APPROVED:	P118-25-01 PLAN & PROFILE STA 36+00 TO 45+00

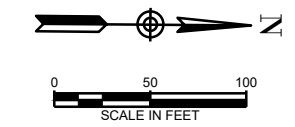
 r.g. miller engineers 16940 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487	 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092
	DATE: 3/15/2022 SHEET NUMBER 17 OF 41

INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended
 for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022



LEGEND

- PROP. 18" GRADE 1 RIP RAP
- PROP. 18" GRADE 1 RIP RAP TO BE COVERED WITH 6" TOP SOIL



DATE	APPR	DESCRIPTION

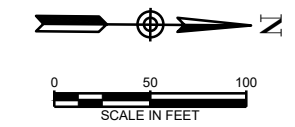
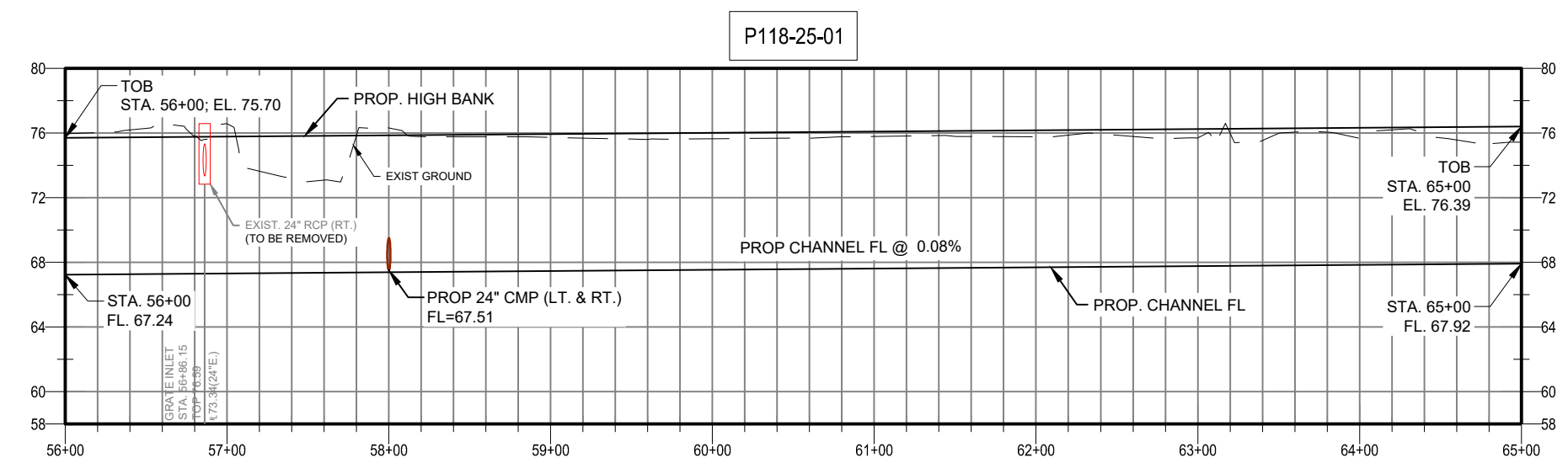
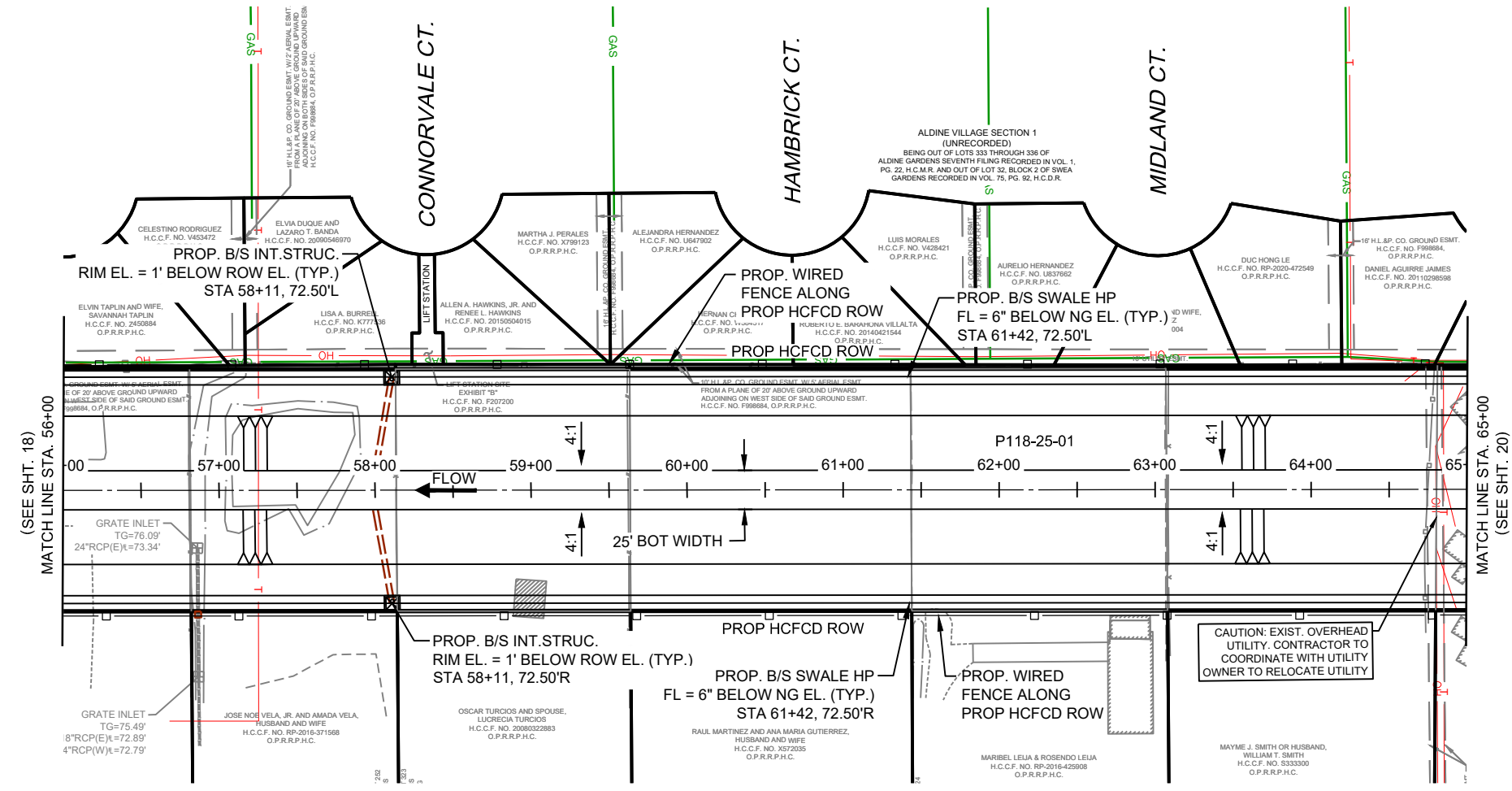
REV	DESCRIPTION

HCFCU UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED
PREPARED: A.V.	CHECKED: M.J.
APPROVED:	APPROVED:

 r.g. miller engineers 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487	 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092
--	---

DATE: 3/15/2022
INTERIM REVIEW ONLY DOCUMENT INCOMPLETE: Not Intended for permit, or construction. Engineer: Alberto Espinoza P.E. License No. 133330 DATE: March, 2022
SHEET NUMBER 18 OF 41

3/15/2022 M:\04543.007 P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG07 - 4543.07 - CHANNEL LAYOUT.DWG



REV	DESCRIPTION	DATE	APPR

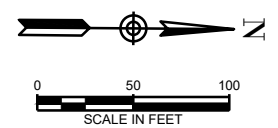
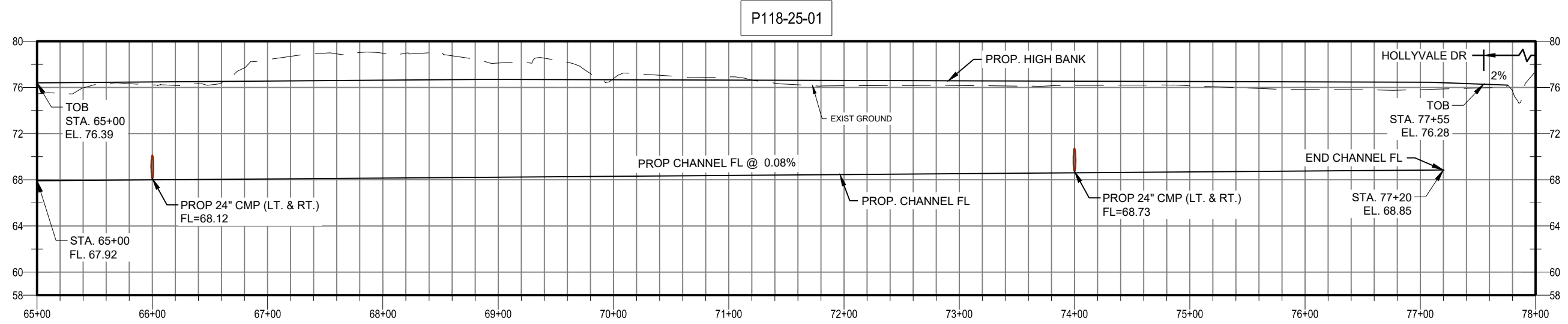
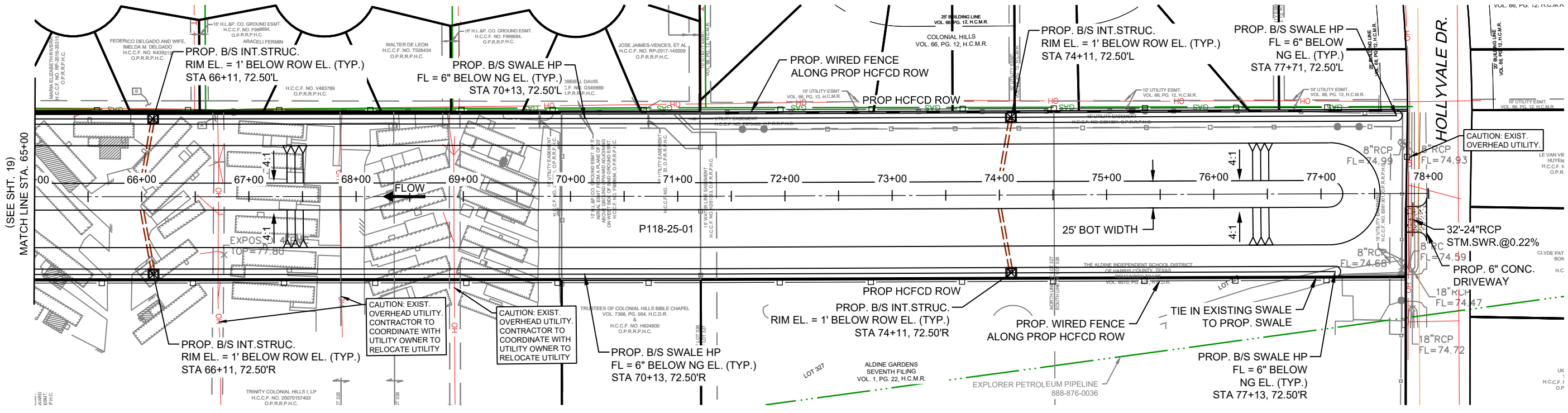
HCFCD UNIT NO. P118-25-00/01	PREPARED: A.V.
HALLS BAYOU WATERSHED	CHECKED: M.J.
P118-25-01 PLAN & PROFILE STA 55+00 TO 65+00	APPROVED:

 r.g.miller engineers 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487
 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092

DATE: 3/15/2022
SHEET NUMBER 19 OF 41

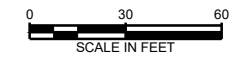
INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

3/15/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG07 - 4543.07 - CHANNEL LAYOUT.DWG

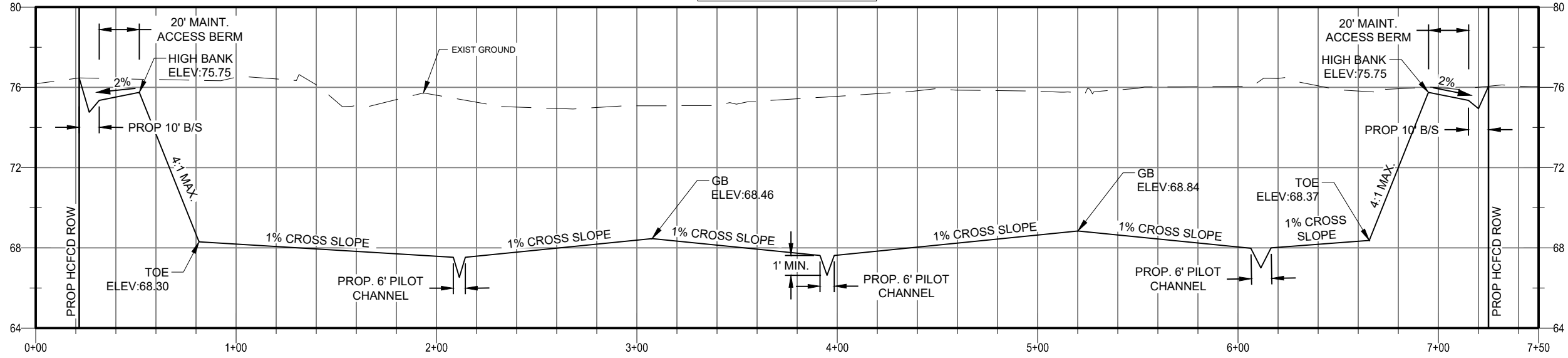


DATE	APPR		
DESCRIPTION			
REV			
HCFCU UNIT NO. P118-25-00/01			
HALLS BAYOU WATERSHED			
P118-25-01 PLAN & PROFILE			
STA 65+00 TO 77+50			
PREPARED: A.V.	CHECKED: M.J.	APPROVED:	
 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487			
 9900 Northwest Freeway Houston, Texas 77092			
DATE: 3/15/2022			
INTERIM REVIEW ONLY DOCUMENT INCOMPLETE: Not Intended for permit, or construction. Engineer: Alberto Espinoza P.E. License No. 133330 DATE: March, 2022			
SHEET NUMBER 20 OF 41			

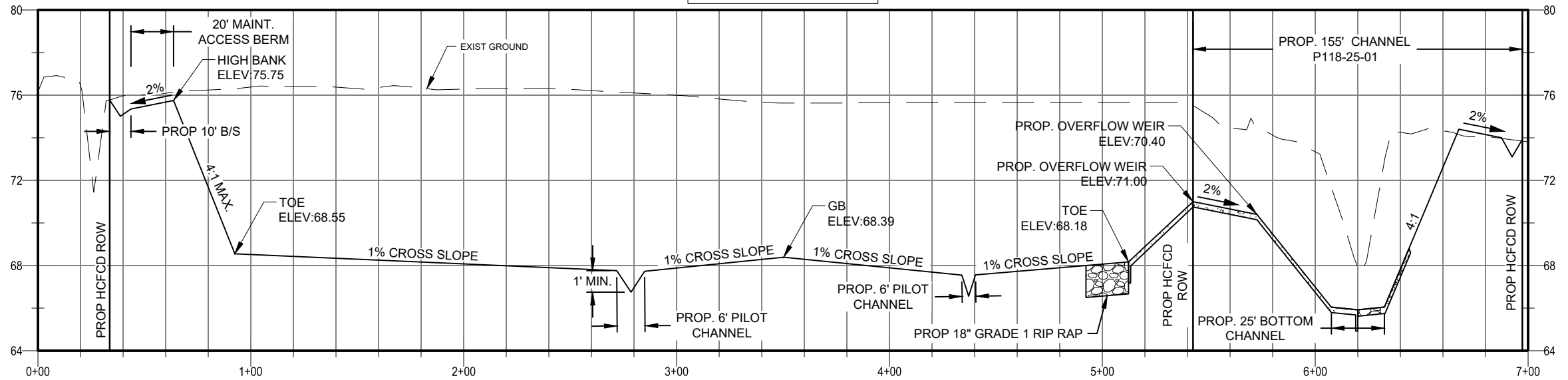
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SECTION A-A PROFILE



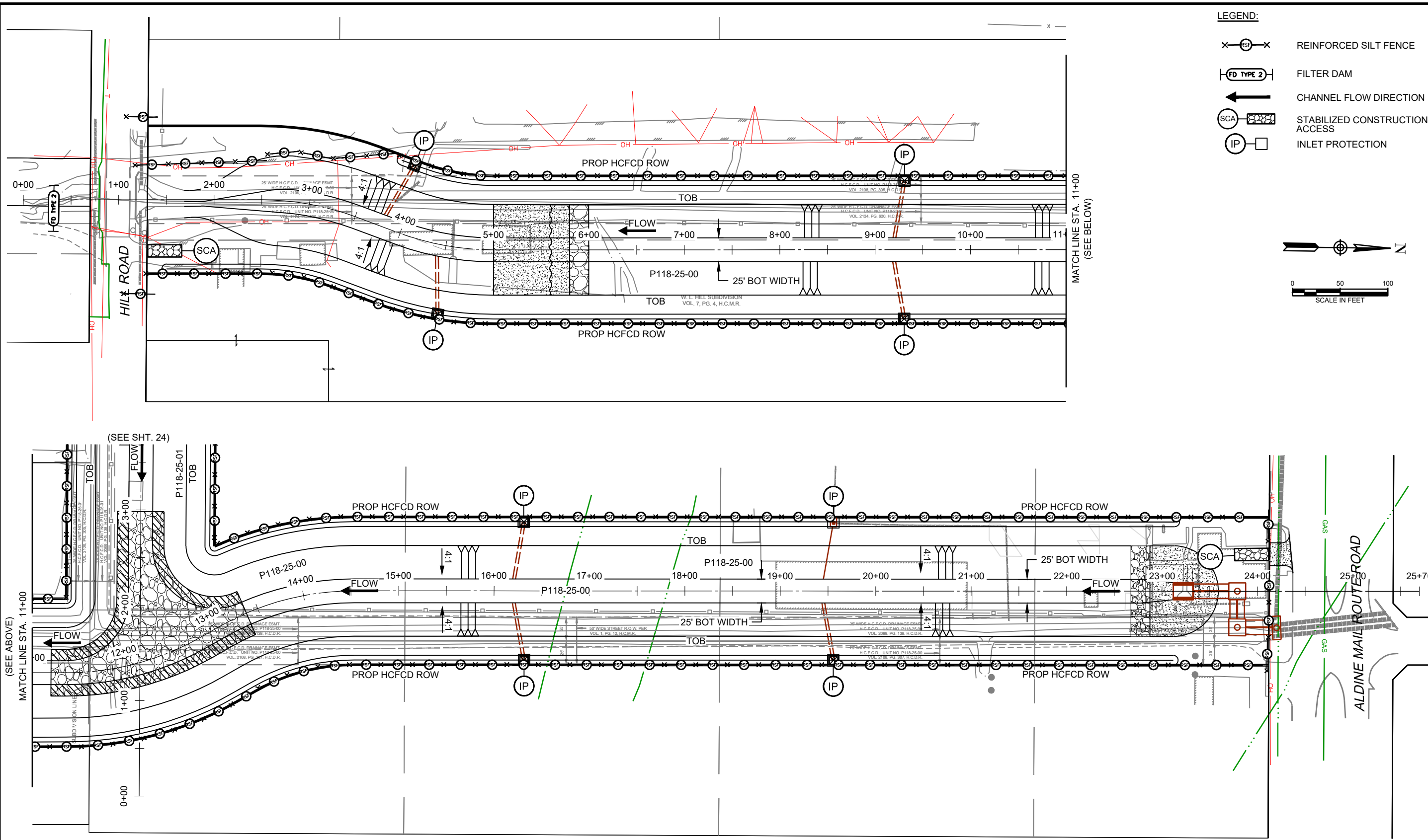
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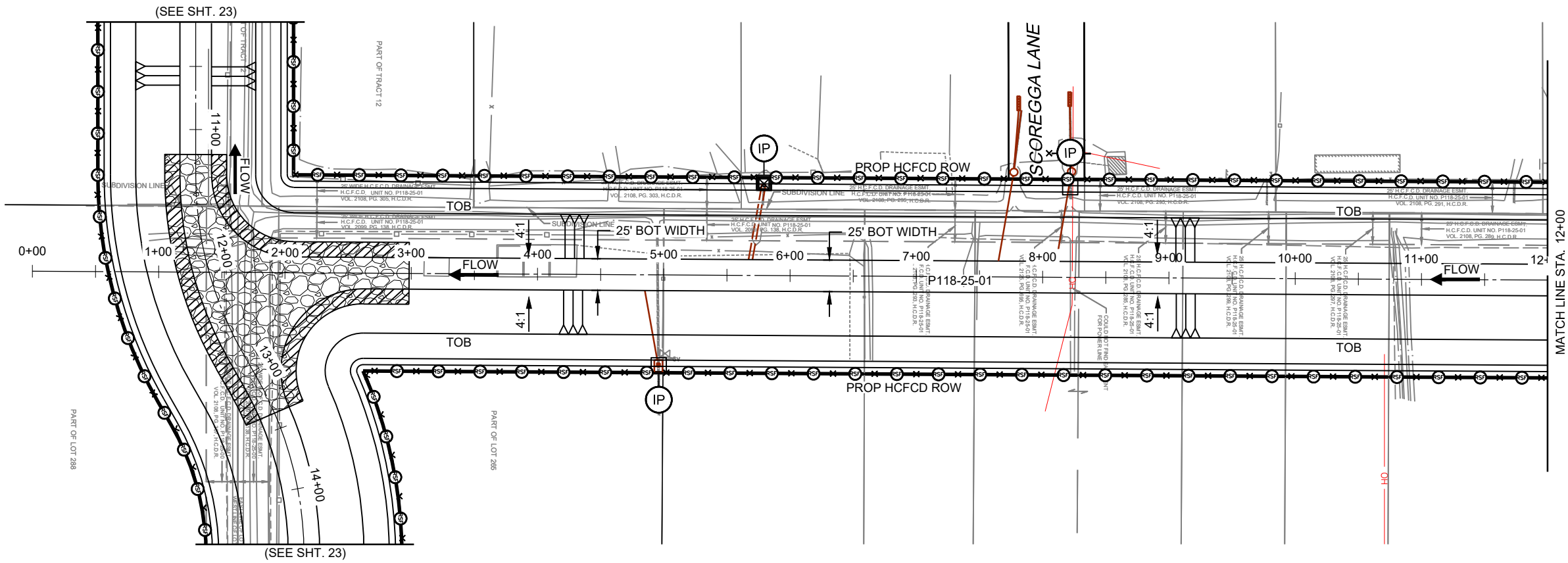
DATE	APPR		
DESCRIPTION			
REV			
HCFCFD UNIT NO. P118-25-00/01			
HALLS BAYOU WATERSHED			
DETAILED CROSS SECTION			
PREPARED: A.V.	CHECKED: M.J.	APPROVED:	
 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487			
 9900 Northwest Freeway Houston, Texas 77092			
DATE: 3/15/2022			
SHEET NUMBER	22 OF 41		

INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended
 for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022

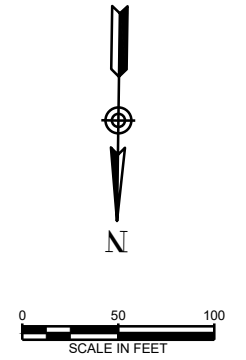
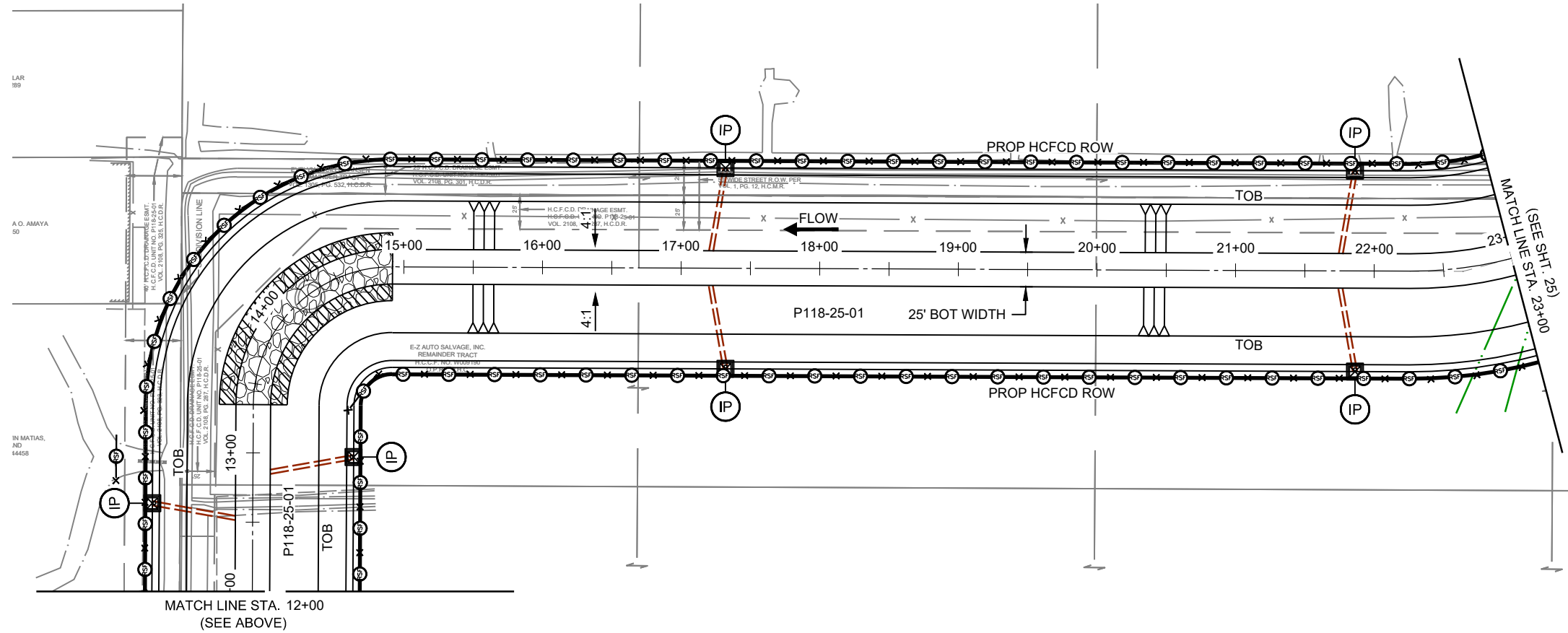
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3/1/2022 M:\04543.007\118-25-01 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG\10 - 4543.07 - SWPPP.DWG



- LEGEND:**
- REINFORCED SILT FENCE
 - FILTER DAM
 - CHANNEL FLOW DIRECTION
 - STABILIZED CONSTRUCTION ACCESS
 - INLET PROTECTION



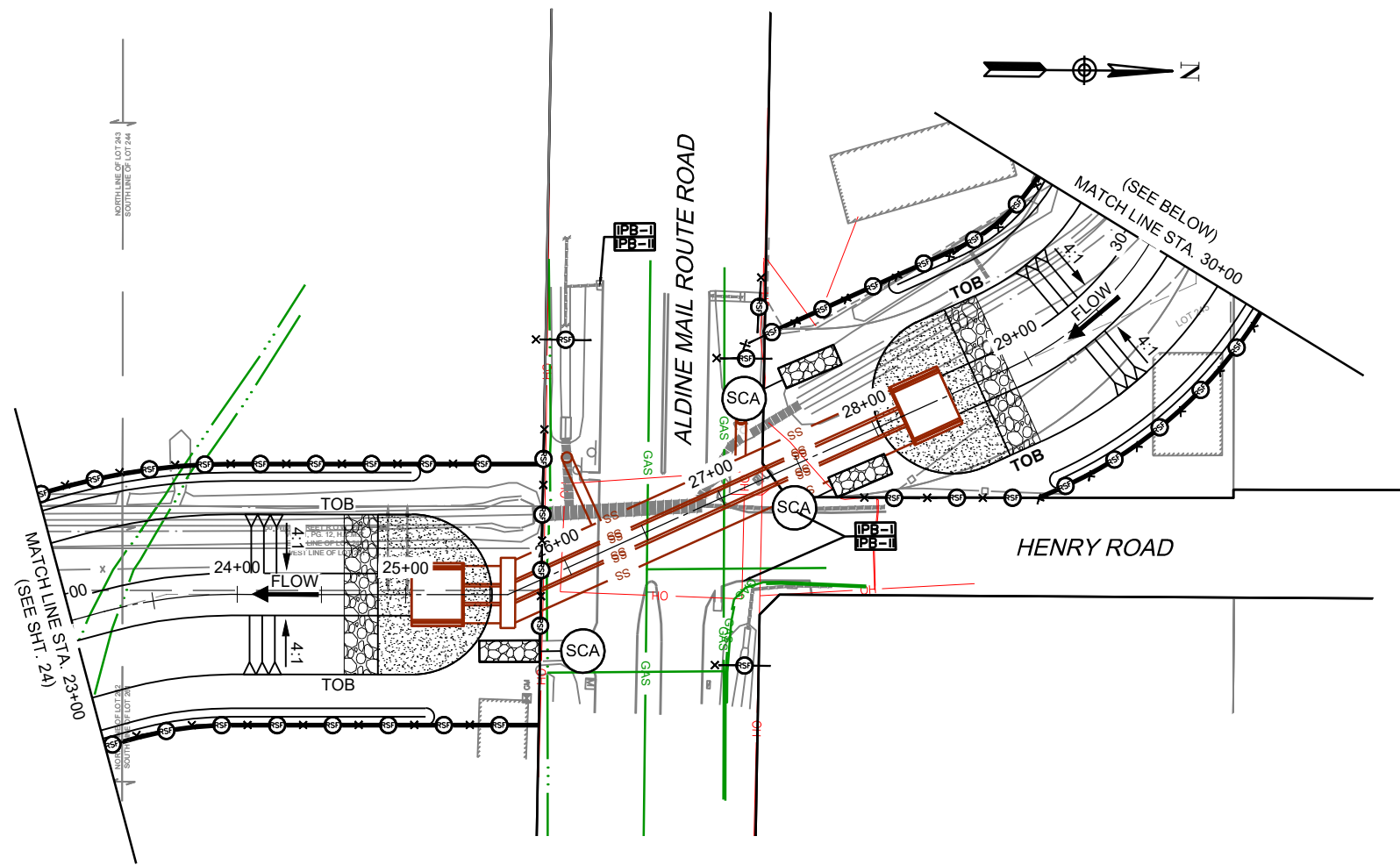
DATE	APPR	DESCRIPTION	REV

PREPARED: A.V.	HCFCD UNIT NO. P118-25-00/01
CHECKED: M.J.	HALLS BAYOU WATERSHED
APPROVED:	P118-25-01 STA. 0+00 TO 23+00 SWPPP

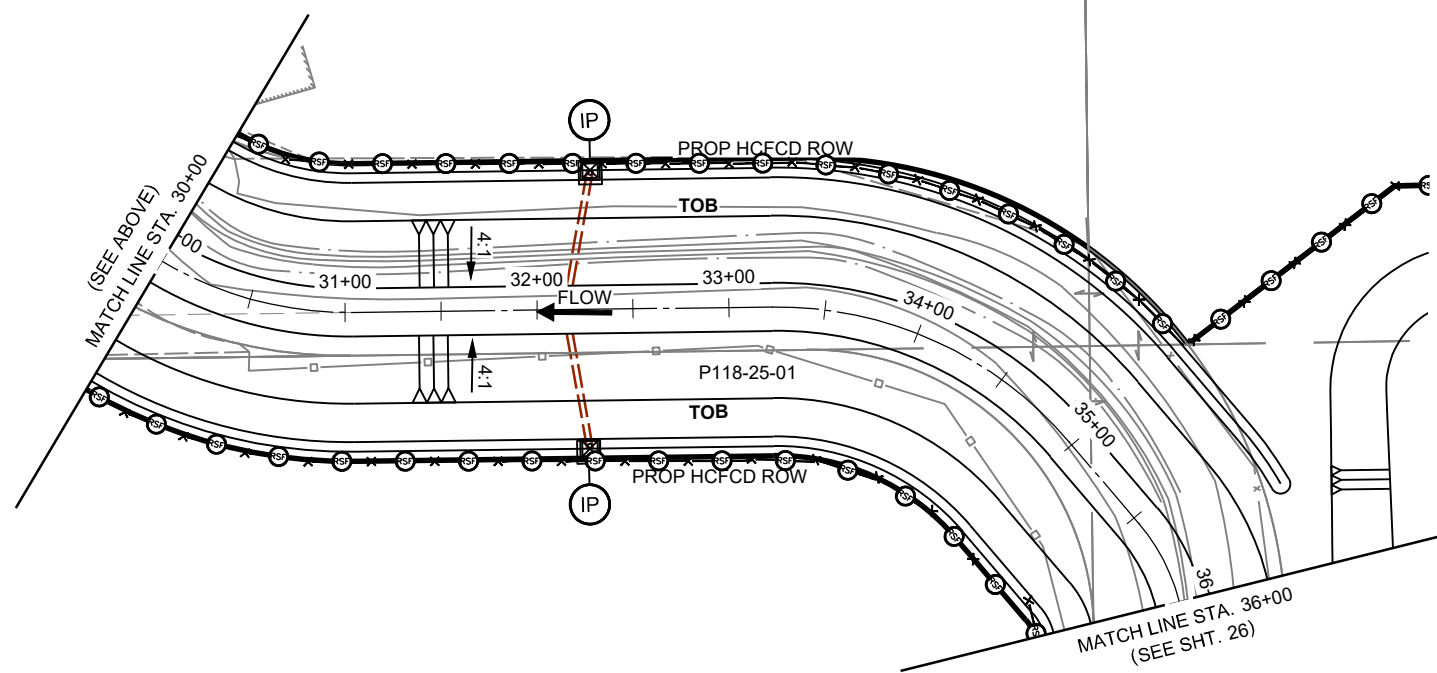
 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487	HARRIS COUNTY FLOOD CONTROL DISTRICT
	9900 Northwest Freeway Houston, Texas 77092

DATE: 3/15/2022
INTERIM REVIEW ONLY DOCUMENT INCOMPLETE: Not Intended for permit, or construction. Engineer: Alberto Espinoza P.E. License No. 133330 DATE: March, 2022
SHEET NUMBER 24 OF 41




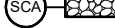



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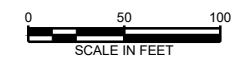


ALDINE MAIL ROUTE ROAD



LEGEND:



-  REINFORCED SILT FENCE
-  FILTER DAM
-  CHANNEL FLOW DIRECTION
-  STABILIZED CONSTRUCTION ACCESS
-  INLET PROTECTION
-  INLET PROTECTION BARRIER STAGE I
-  INLET PROTECTION BARRIER, STAGE II (GUTTER GATOR OR APPROVED EQUAL)



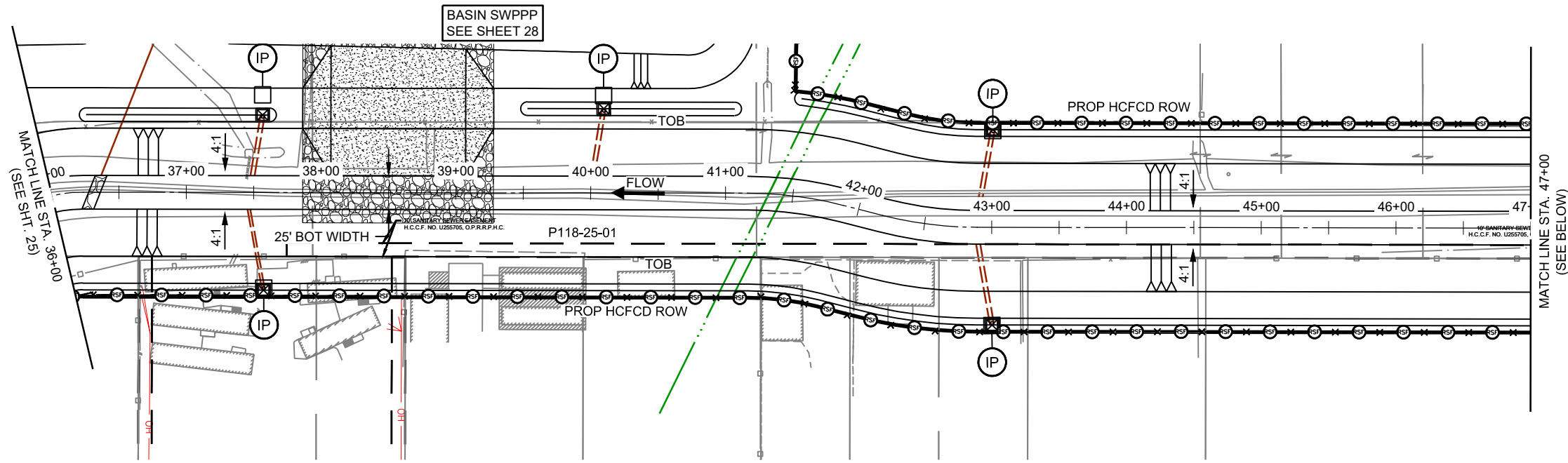
INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

REV	DESCRIPTION	DATE	APPR





PREPARED:	A.V.	HCFCD UNIT NO. P118-25-00/01
CHECKED:	M.J.	HALLS BAYOU WATERSHED
APPROVED:		P118-25-01 STA. 23+00 TO 35+00 SWPPP

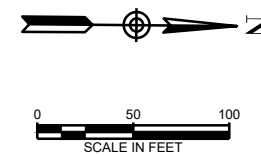
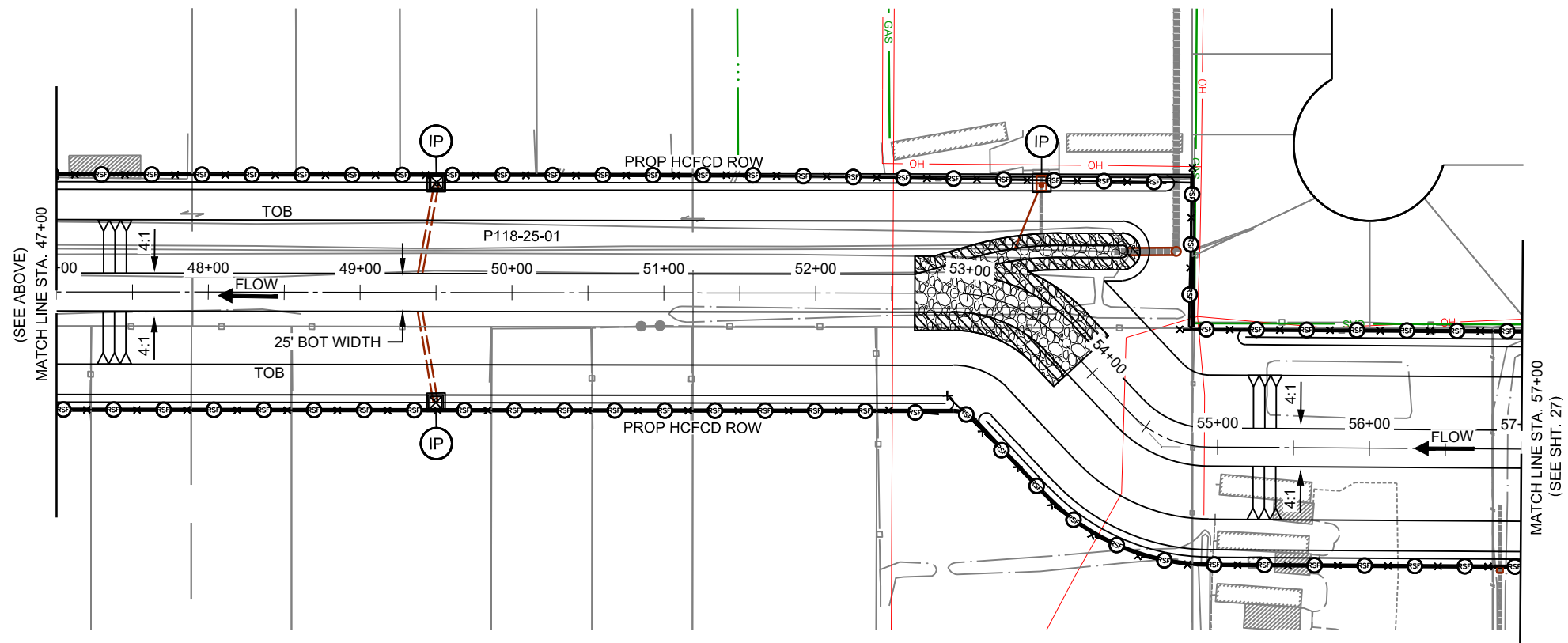
 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9600 TEXAS FIRM REGISTRATION NO. F-487	 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092
	DATE: 3/15/2022 SHEET NUMBER 25 OF 41

3/15/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CAD\DWG\10 - 4543.07 - SWPPP.DWG



LEGEND:

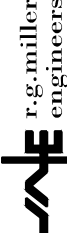

-  REINFORCED SILT FENCE
-  FILTER DAM
-  CHANNEL FLOW DIRECTION
-  INLET PROTECTION



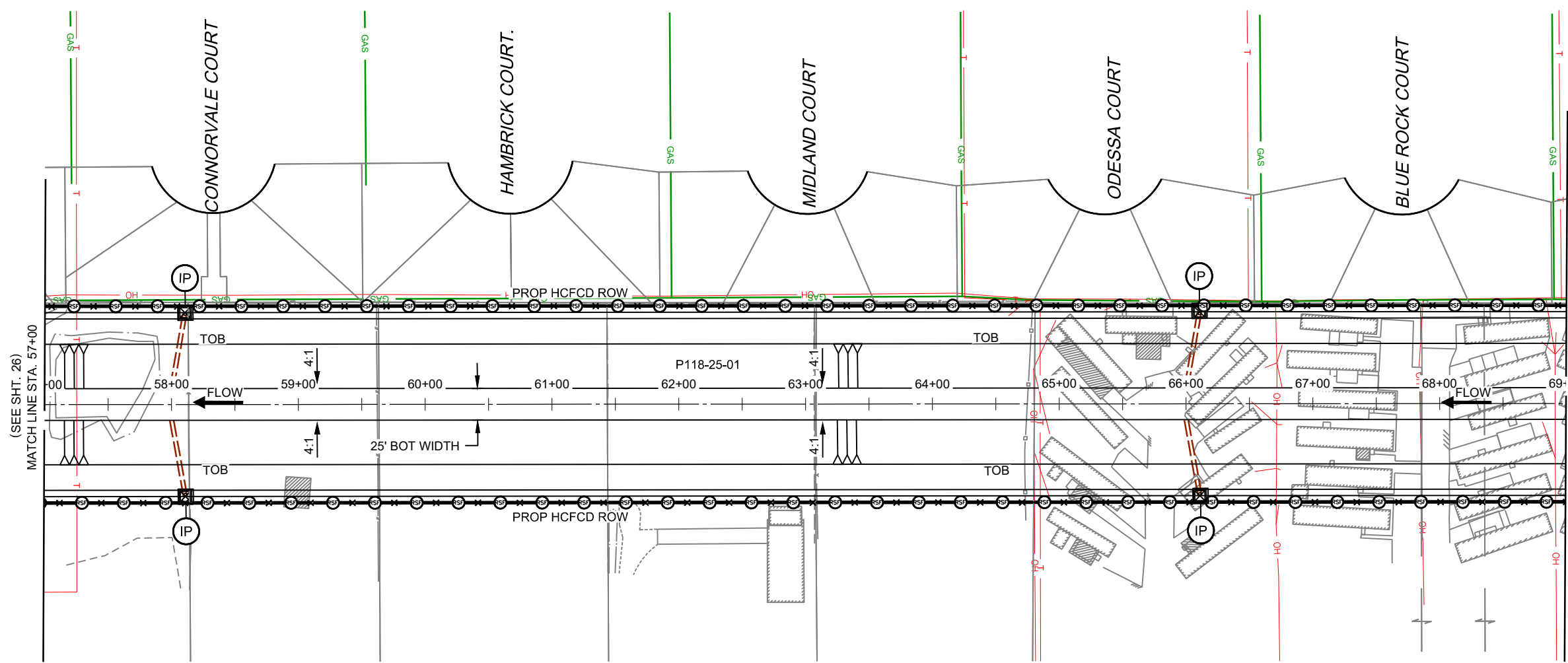
INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

REV	DESCRIPTION	DATE	APPR

PREPARED: A.V.	HCFCD UNIT NO. P118-25-00/01
CHECKED: M.J.	HALLS BAYOU WATERSHED
APPROVED:	SWPPP P118-25-01 STA. 35+00 TO 57+00

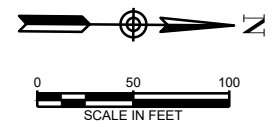
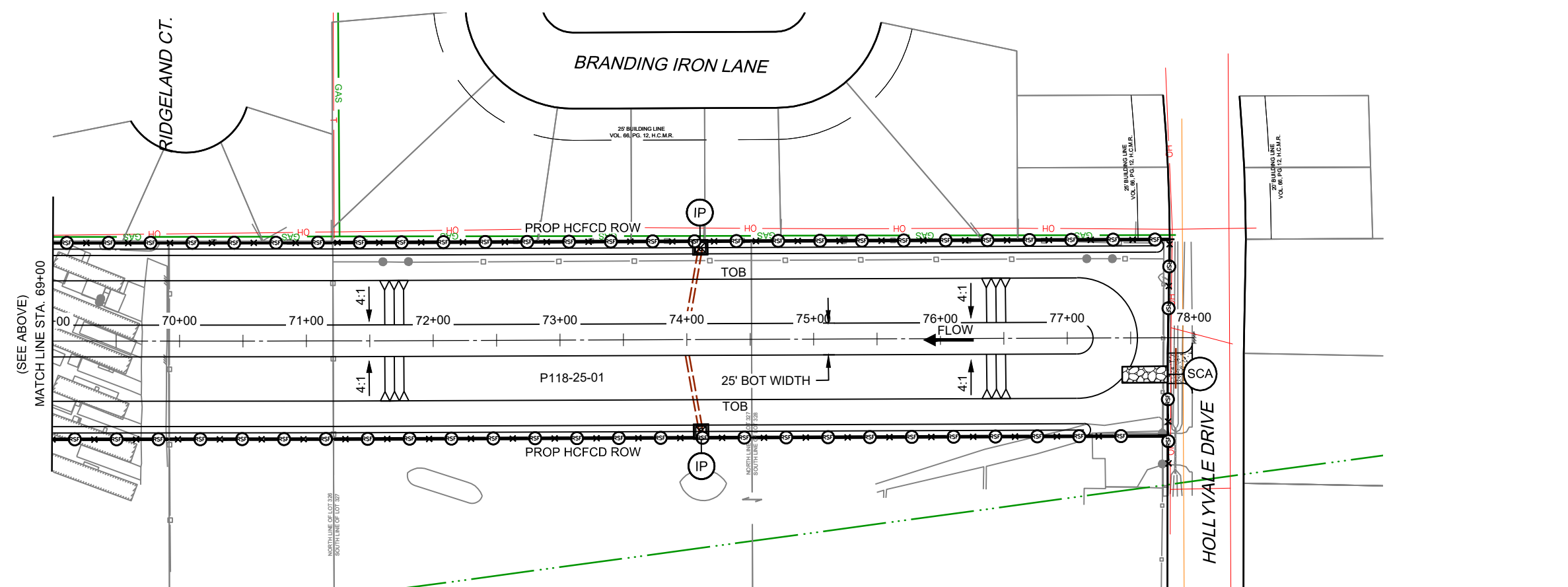
 r.g.miller engineers 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 <small>TEXAS FIRM REGISTRATION NO. F-487</small>	 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092

SHEET NUMBER
26 OF 41



LEGEND:

- REINFORCED SILT FENCE
- FILTER DAM
- CHANNEL FLOW DIRECTION
- STABILIZED CONSTRUCTION ACCESS
- INLET PROTECTION



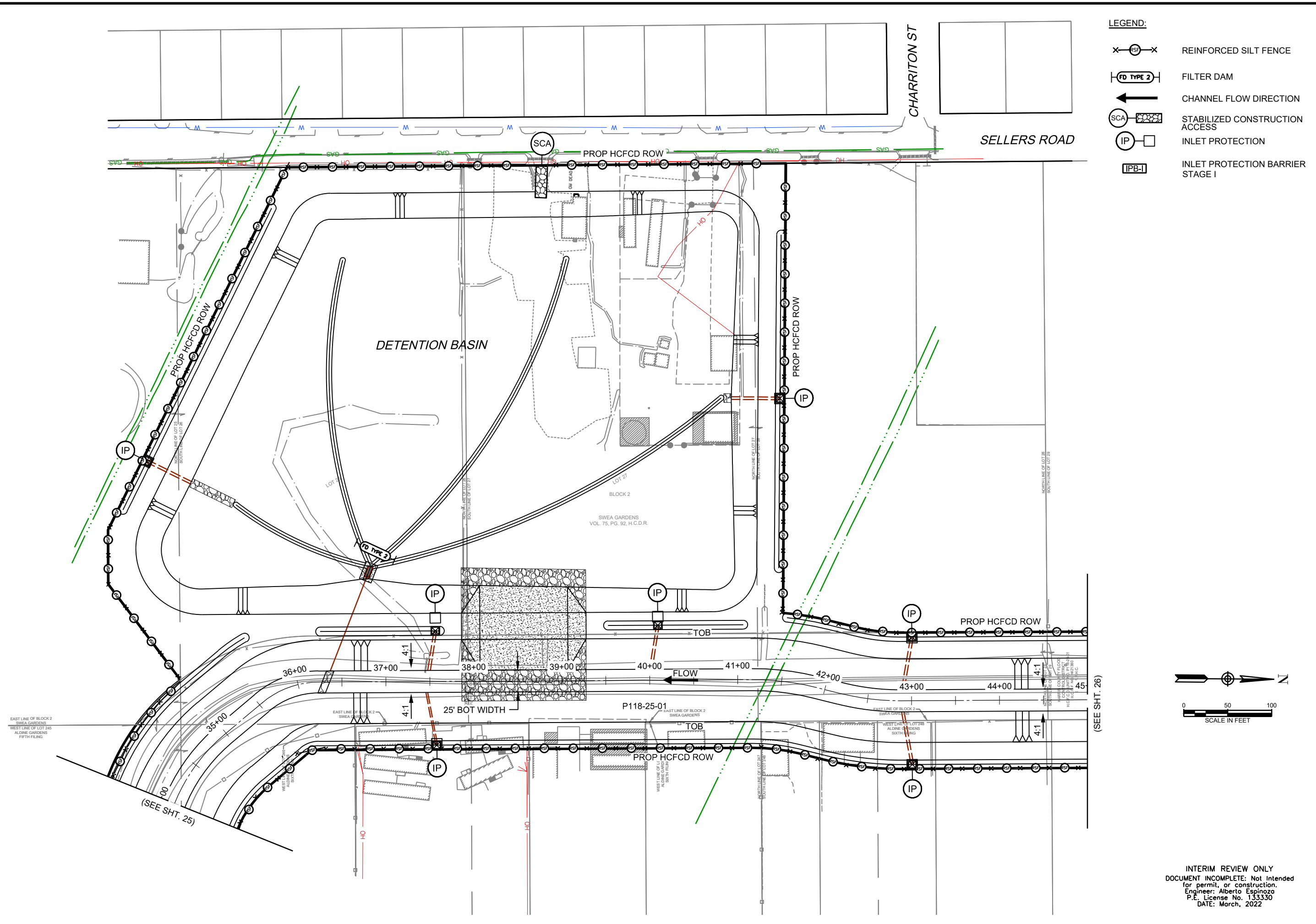
INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

DATE	APPR	DESCRIPTION	REV




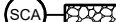


HCFCD UNIT NO. P118-25-00/01	PREPARED: A.V.
HALLS BAYOU WATERSHED	CHECKED: M.J.
P118-25-01 STA. 57+00 to 77+50	APPROVED:

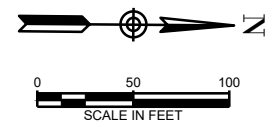
 16940 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487	DATE: 3/15/2022
	SHEET NUMBER 27 OF 41

3/1/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG\10 - 4543.07 - SWPPP.DWG



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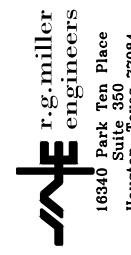

	REINFORCED SILT FENCE
	FILTER DAM
	CHANNEL FLOW DIRECTION
	STABILIZED CONSTRUCTION ACCESS
	INLET PROTECTION
	INLET PROTECTION BARRIER STAGE I



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DOCUMENT INCOMPLETE: Not Intended
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Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

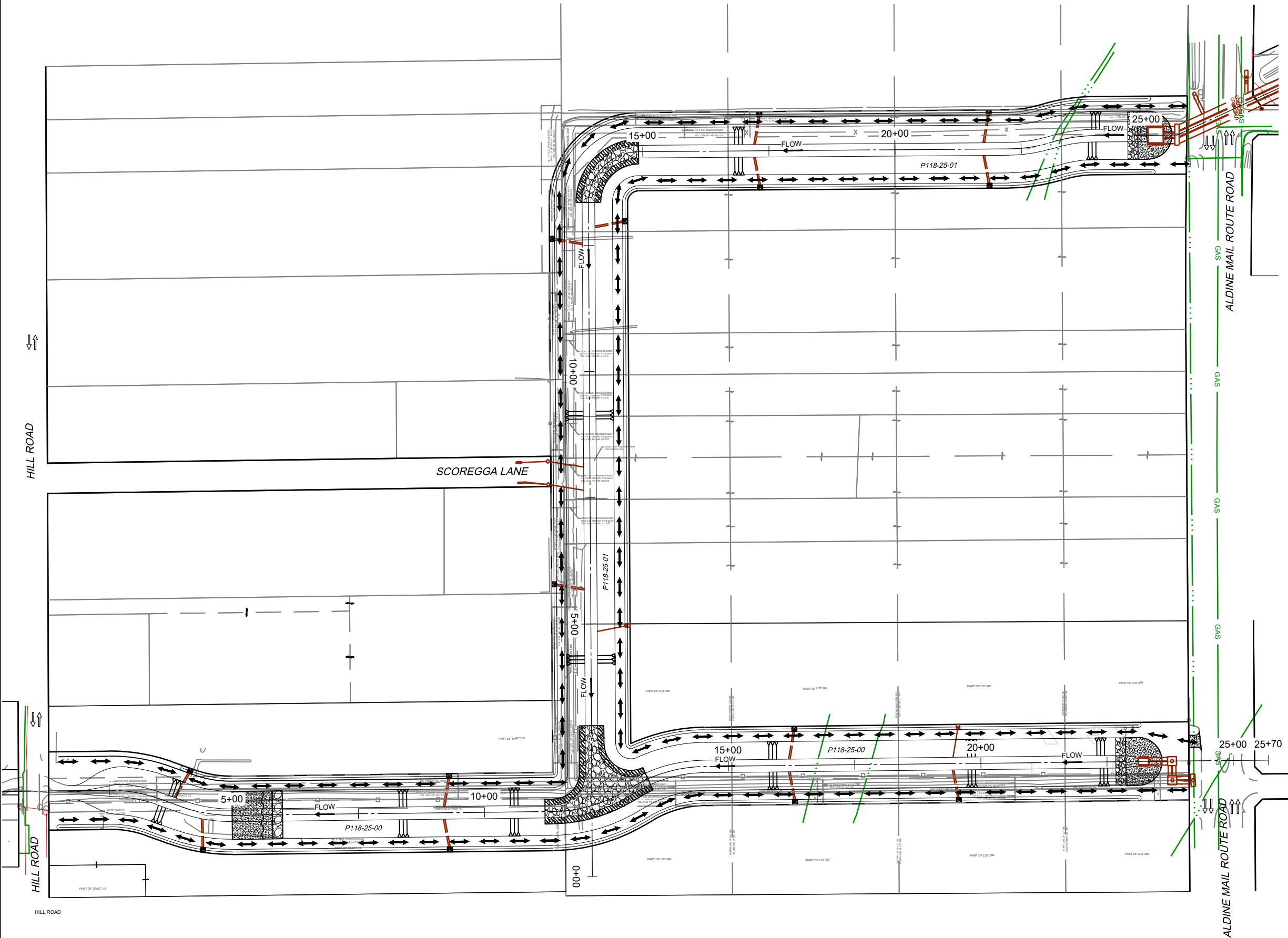
REV	DESCRIPTION	DATE	APPR

PREPARED: A.V.	HCFCF UNIT NO. P118-25-00/01	DATE
CHECKED: M.J.	HALLS BAYOU WATERSHED	
APPROVED:	SWPPP	
	BASIN SWPPP	

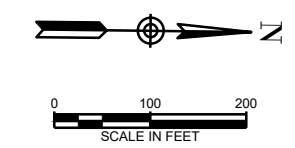
 <p>r.g.miller engineers 16940 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9000 TEXAS FIRM REGISTRATION NO. F-487</p>	 <p>HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092</p>
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DATE: 3/15/2022
SHEET NUMBER 28 OF 41

3/2/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CAD\DWG\09 - 4543.07 - MAINTENANCE ACCESS DWG



- LEGEND:
- ↔ BASIN/CHANNEL MAINTENANCE TRAVEL DIRECTION
 - ⇄ EXISTING ROADWAY TRAVEL DIRECTION
 - ← CHANNEL FLOW DIRECTION



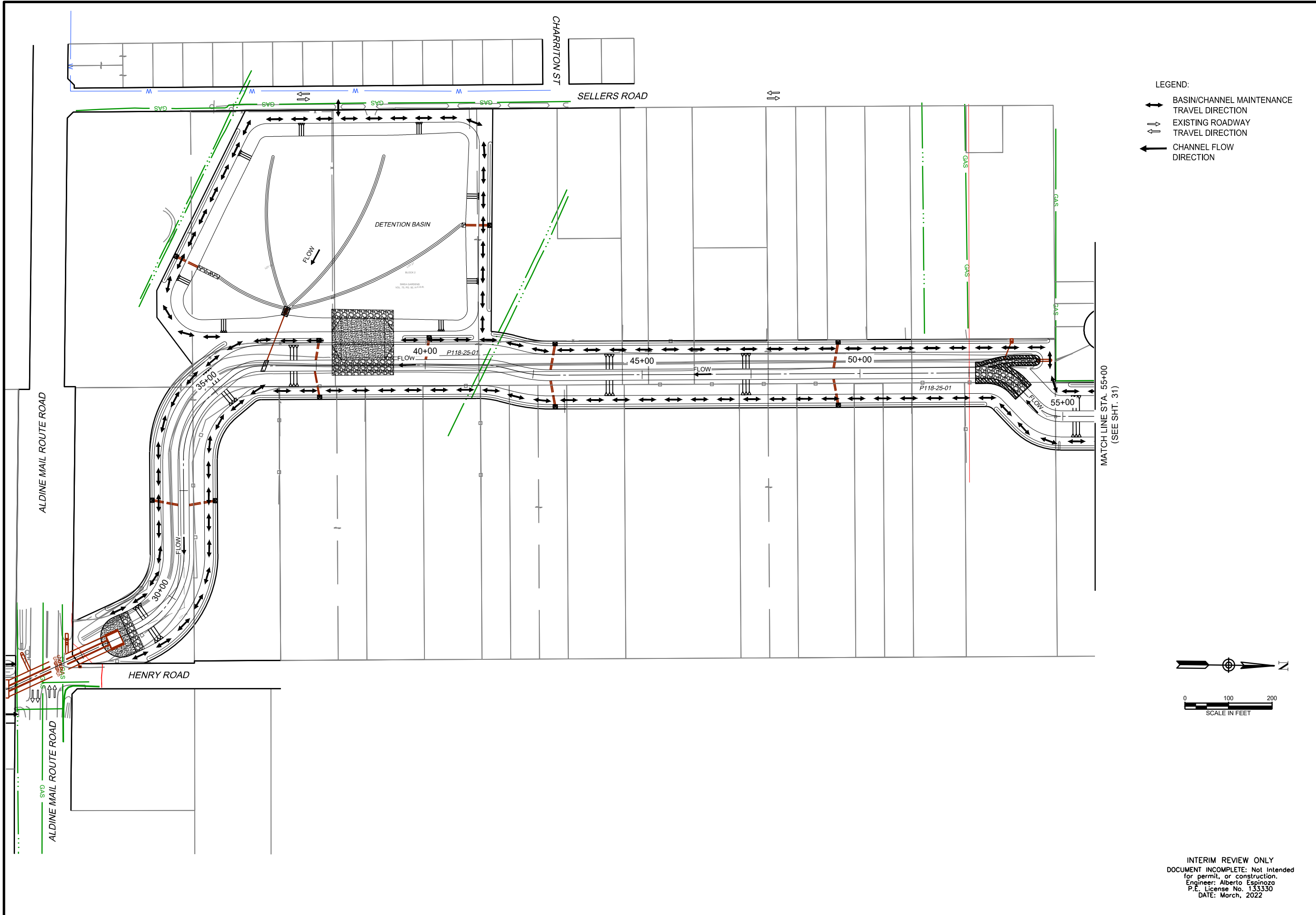
INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended
 for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022

REV	DESCRIPTION	DATE	APPR

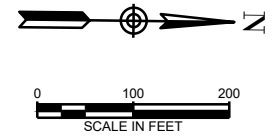
PREPARED: A.V.	HCFCU UNIT NO. P118-25-00/01
CHECKED: M.J.	HALLS BAYOU WATERSHED
APPROVED:	MAINTENANCE ACCESS PLAN (1 OF 3)

 16940 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487	DATE: 3/15/2022
	SHEET NUMBER 29 OF 41

3/2/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CAD\DWG\09 - 4543.07 - MAINTENANCE ACCESS.DWG



- LEGEND:
- ↔ BASIN/CHANNEL MAINTENANCE TRAVEL DIRECTION
 - ⇄ EXISTING ROADWAY TRAVEL DIRECTION
 - ← CHANNEL FLOW DIRECTION



REV	DESCRIPTION	DATE	APPR

HCFC UNIT NO. P118-25-00/01	PREPARED: A.V.
HALLS BAYOU WATERSHED	CHECKED: M.J.
MAINTENANCE ACCESS PLAN (2 OF 3)	APPROVED:

<p>r.g.miller engineers 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 TEXAS FIRM REGISTRATION NO. F-487</p>	<p>HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092</p>

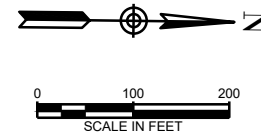
INTERIM REVIEW ONLY DOCUMENT INCOMPLETE: Not Intended for permit, or construction. Engineer: Alberto Espinoza P.E. License No. 133330 DATE: March, 2022
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SHEET NUMBER
30 OF 41

3/2/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG\09 - 4543.07 - MAINTENANCE ACCESS.DWG



- LEGEND:
- BASIN/CHANNEL MAINTENANCE TRAVEL DIRECTION
 - EXISTING ROADWAY TRAVEL DIRECTION
 - CHANNEL FLOW DIRECTION



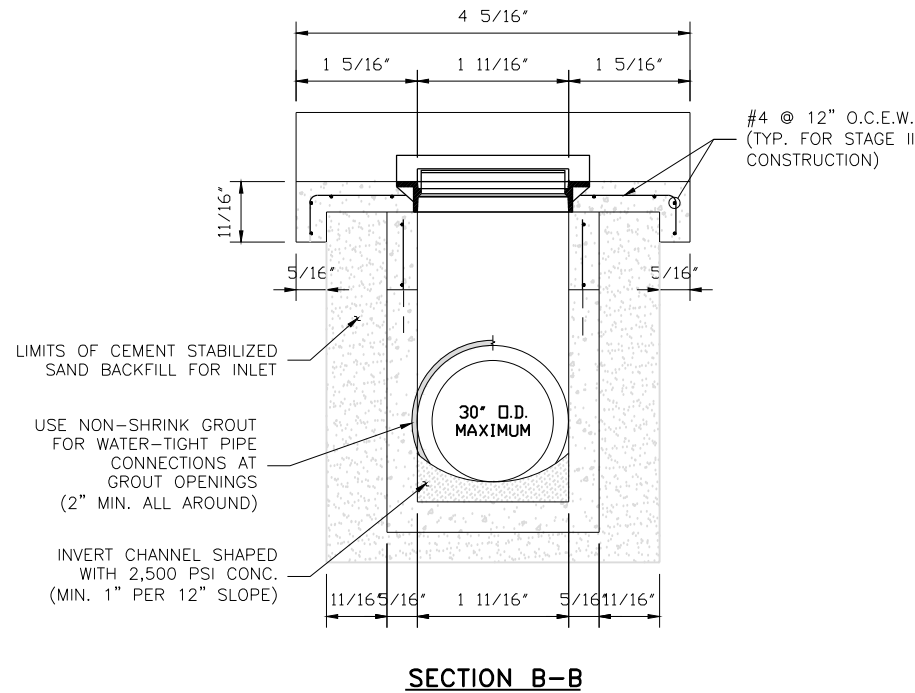
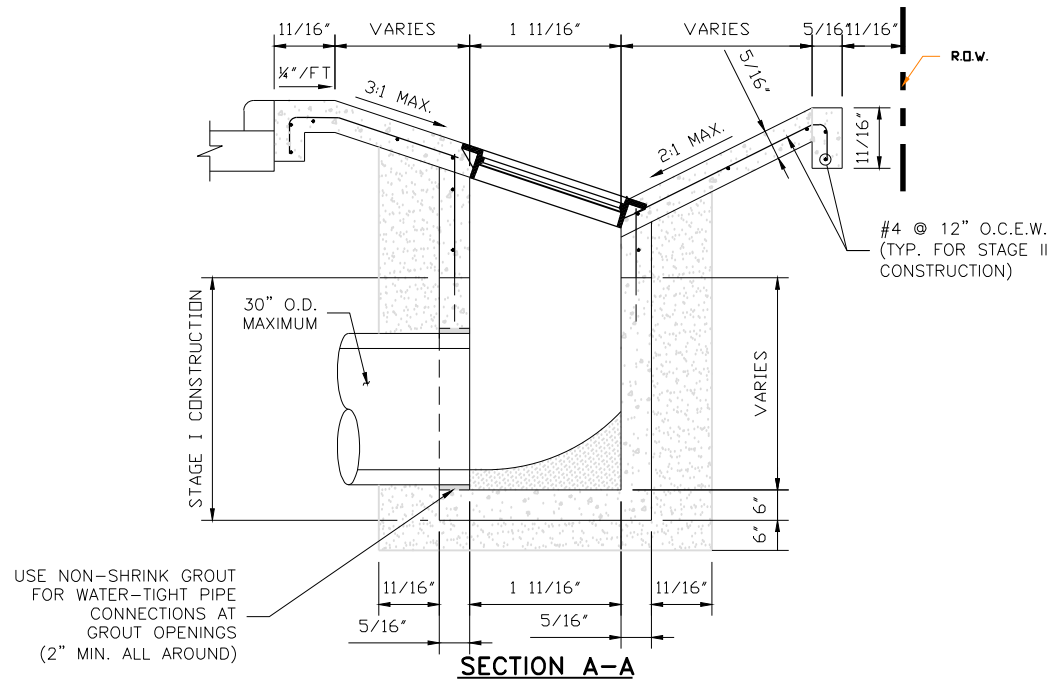
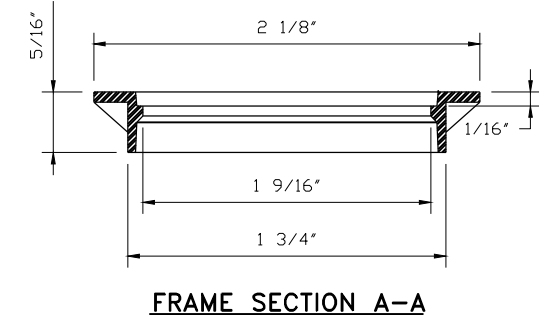
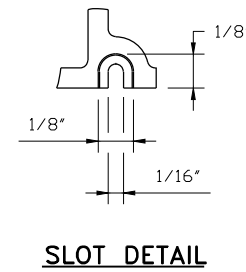
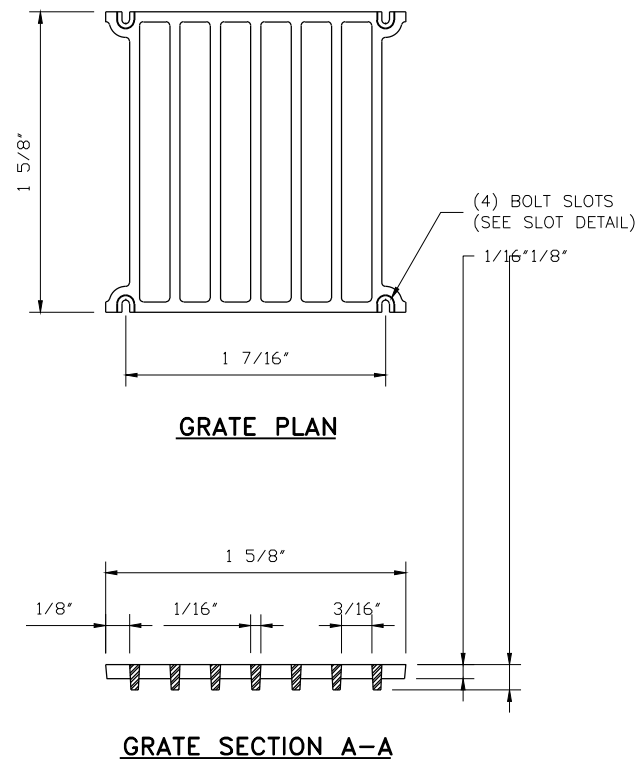
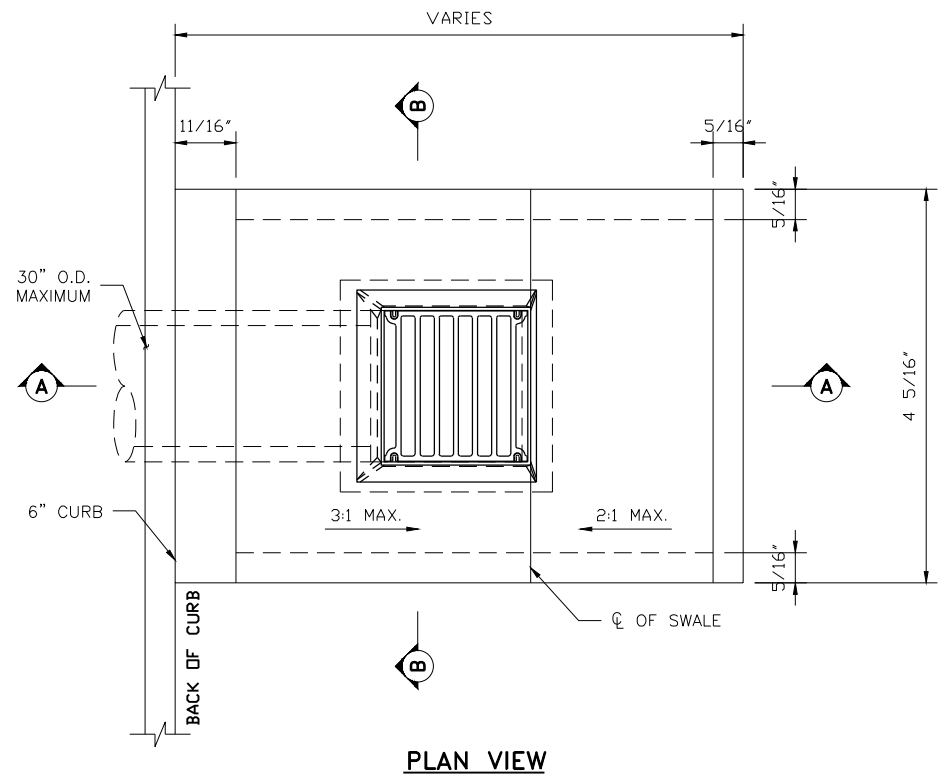
INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended
 for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022

REV	DESCRIPTION	DATE	APPR

PREPARED: A.V.	HCFC UNIT NO. P118-25-00/01
CHECKED: M.J.	HALLS BAYOU WATERSHED
APPROVED:	MAINTENANCE ACCESS PLAN (3 OF 3)

 r.g. miller engineers 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9900 <small>TEXAS FIRM REGISTRATION NO. F-487</small>
 HARRIS COUNTY FLOOD CONTROL DISTRICT 9900 Northwest Freeway Houston, Texas 77092

DATE: 3/15/2022
SHEET NUMBER
31 OF 41



GENERAL NOTES:

1. CONSTRUCTION AND MATERIALS SHALL MEET REQUIREMENTS OF ITEM 472 "INLETS".
2. CONCRETE: MINIMUM 4,000 PSI IN 28 DAYS
3. PRECAST STRUCTURE TO MEET ASTM C913.
4. FRAME AND GRATE SHALL BE EAST JORDAN IRON WORKS MODEL V-4882-3 FRAME AND V-4880-2 GRATE WITH (4) BOLT SLOT GRATE OR APPROVED EQUAL.
5. IF THE ENGINEER OF RECORD SPECIFIES A CAST-IN-PLACE INLET, HE/SHE SHALL INCORPORATE A DETAILED DRAWING INTO THE CONTRACT DOCUMENTS. HOWEVER, IF THE CONTRACTOR ELECTS TO CONSTRUCT A CAST-IN-PLACE INLET, THE CONTRACTOR WILL BE RESPONSIBLE FOR PROVIDING A DETAILED DRAWING, SIGNED AND SEALED BY A REGISTERED PROFESSIONAL ENGINEER LICENSED TO PRACTICE IN THE STATE OF TEXAS.
6. USE PRECAST UNITS FOR STAGE I CONSTRUCTION. CAST IN PLACE MAY BE REQUIRED DURING STAGE II CONSTRUCTION. SHOP DRAWINGS WILL BE REQUIRED FOR PRECAST CONSTRUCTION OF INLET.
7. KNOCK-OUTS ARE NOT PERMISSIBLE FOR PRECAST CONSTRUCTION OF INLET.
8. CONCRETE SLOPE PAVING SHALL CONFORM TO ITEM 491 "REINFORCED CONCRETE SLOPE PAVING", BUT IS INCIDENTAL TO THE INLET.
9. STAGE I OF THE INLET SHALL BE PRECAST. STAGE II SHALL BE CAST-IN-PLACE.
10. MINIMUM CLEARANCE FOR REINFORCING STEEL IN SLOPE PAVING SHALL BE TWO INCHES.

DATE	APPR	DESCRIPTION	REV

HCFCF UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED	HC - MODIFIED TYPE TYPE "A" INLET DETAILS
PREPARED: A.V.	CHECKED: M.J.	APPROVED:

r.g.miller
engineers

16340 Park Ten Place
Suite 350
Houston, Texas 77084
(713) 461-9000
TEXAS FIRM REGISTRATION NO. F-487

HARRIS COUNTY
FLOOD CONTROL DISTRICT

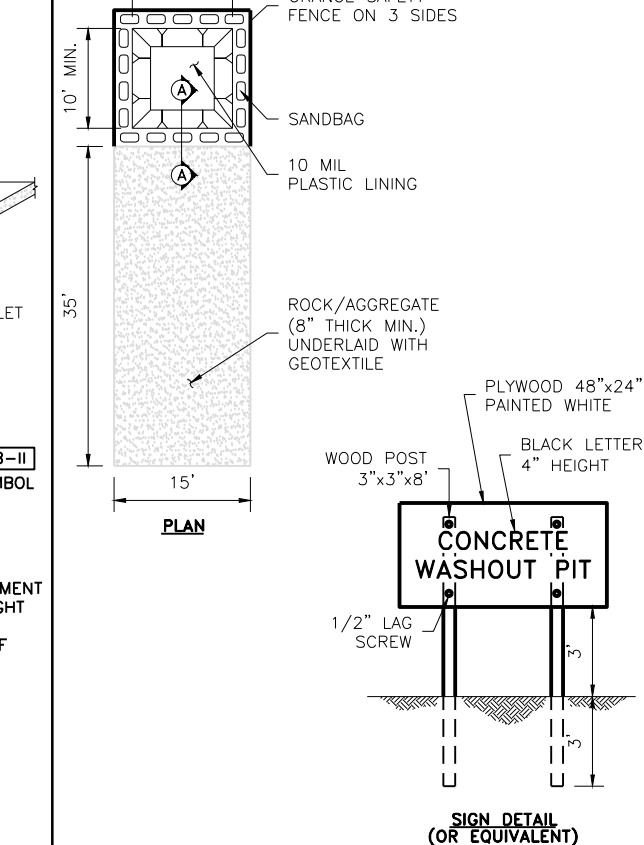
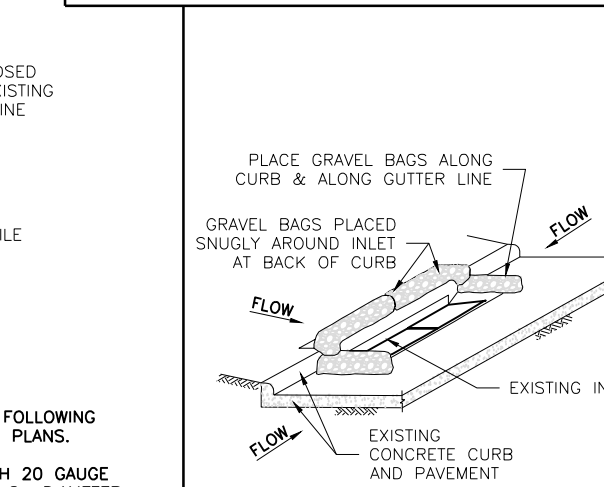
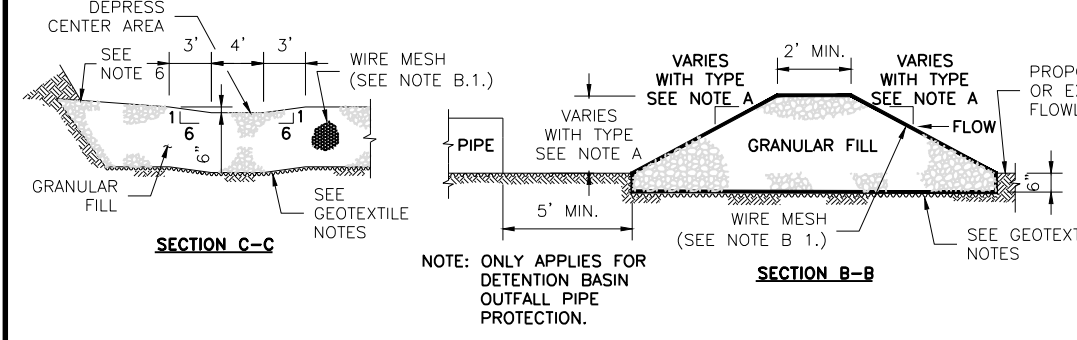
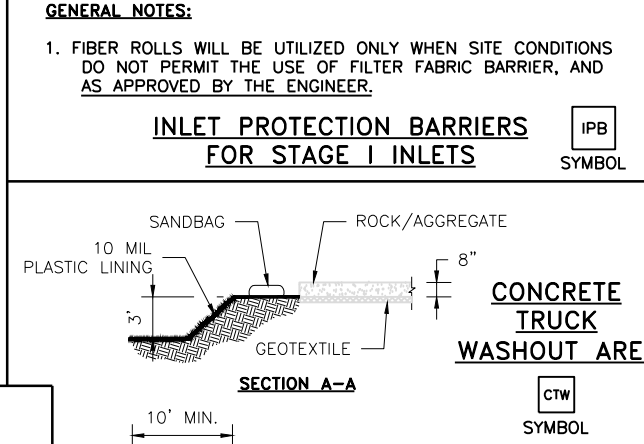
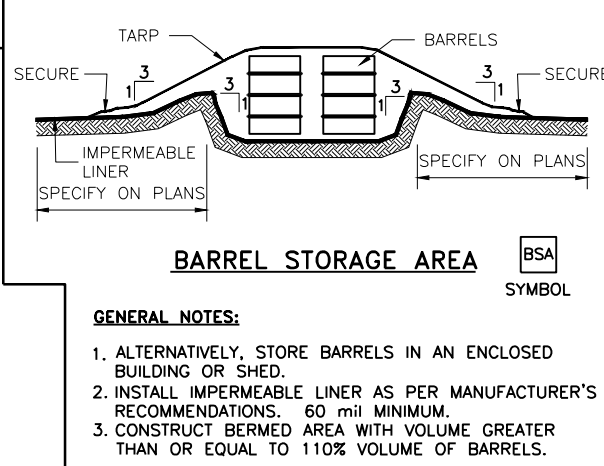
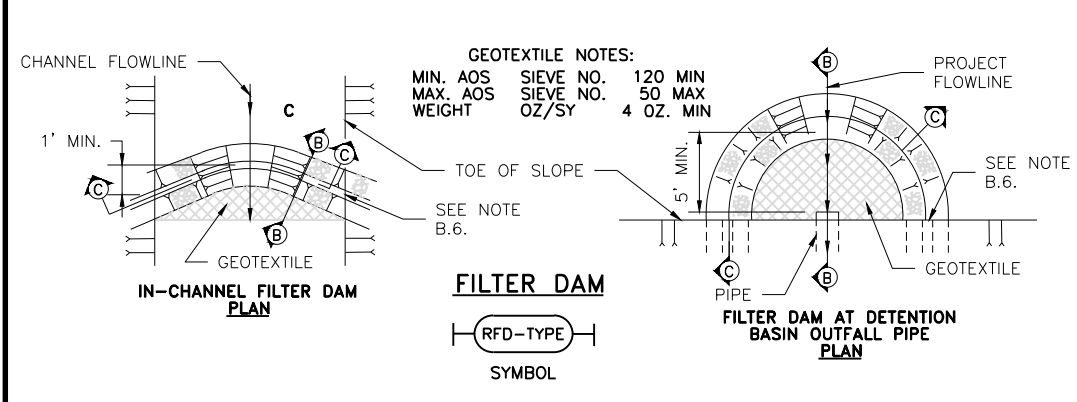
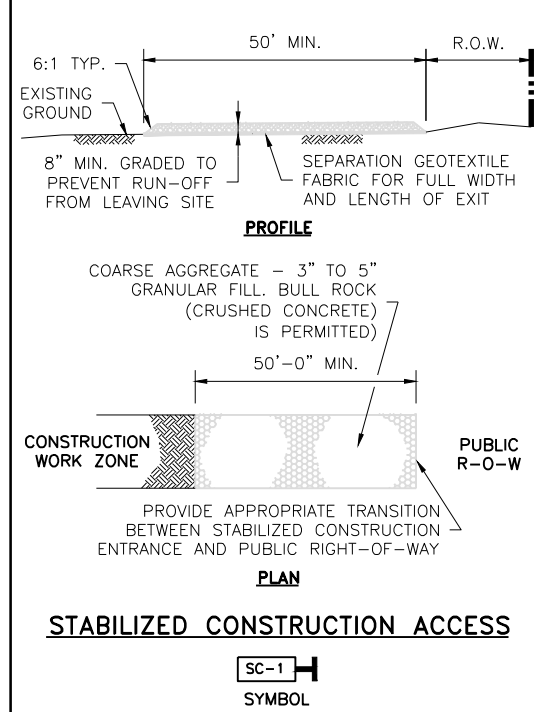
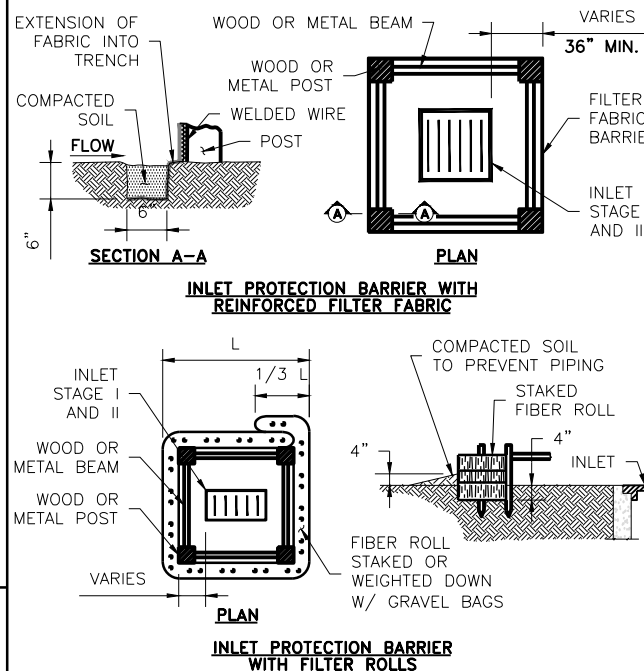
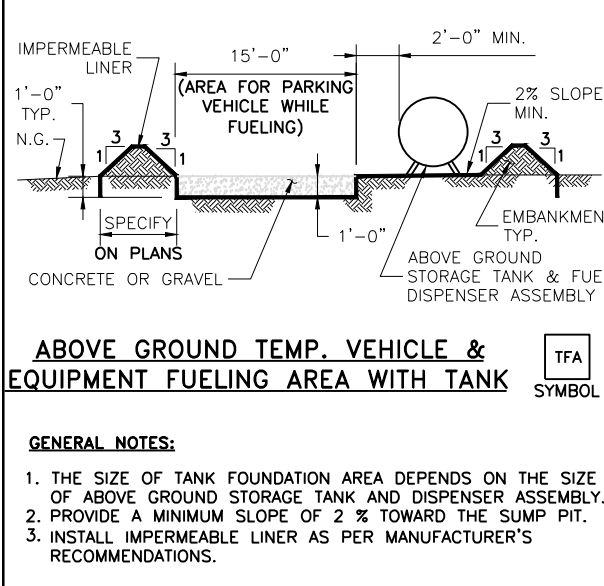
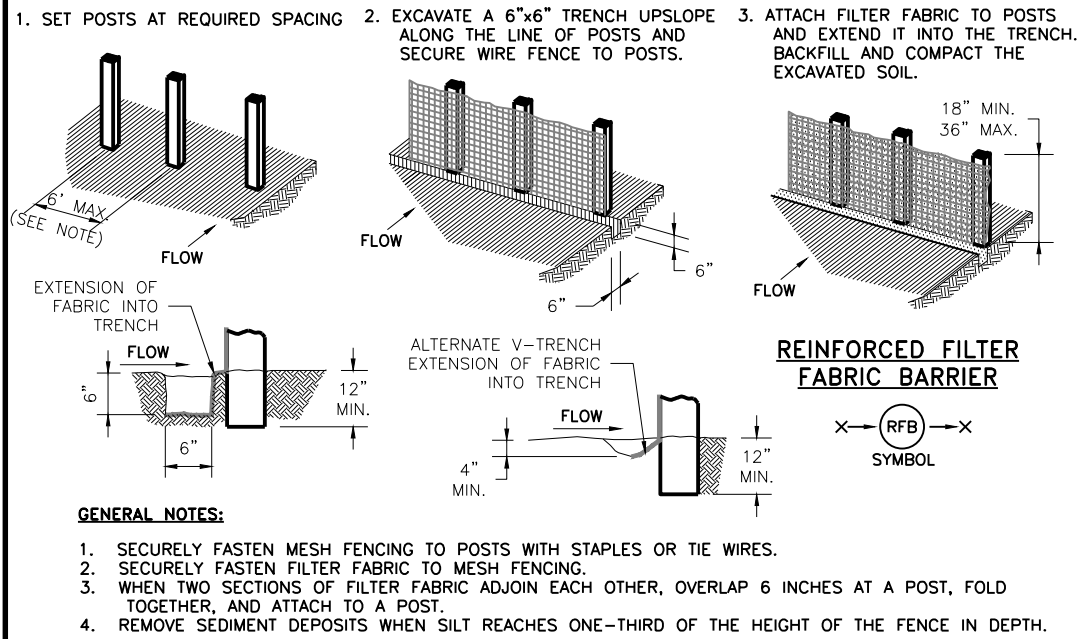
9900 Northwest Freeway
Houston, Texas 77092

DATE: 3/15/2022

SHEET NUMBER
32 OF 41

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended
for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

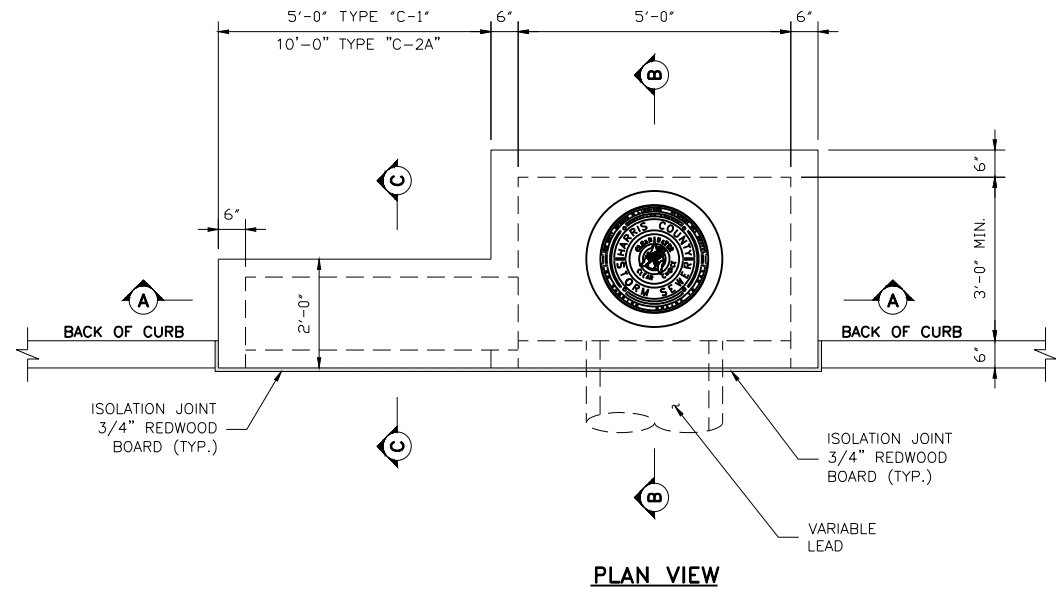
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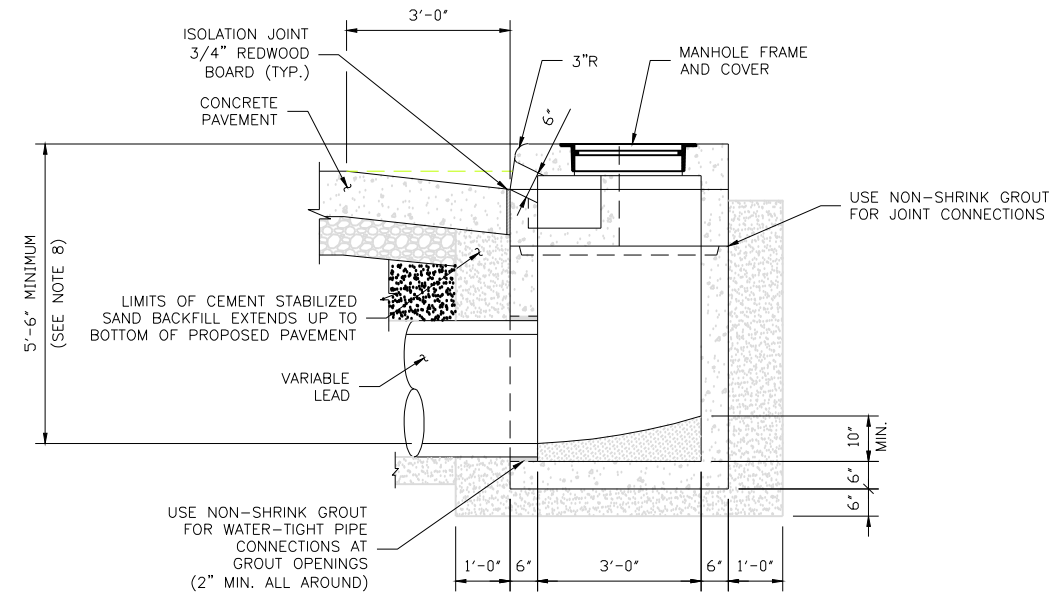
- GENERAL NOTES:**
- MINIMUM LENGTH IS AS SHOWN ON CONSTRUCTION DRAWINGS OR 50 FEET, WHICHEVER IS MORE.
 - CONSTRUCT AND MAINTAIN CONSTRUCTION EXIT WITH CONSTANT WIDTH ACROSS ITS LENGTH, INCLUDING ALL POINTS OF INGRESS OR EGRESS.
 - UNLESS SHOWN ON THE CONSTRUCTION DRAWINGS, STABILIZATION FOR OTHER AREAS WILL HAVE THE SAME AGGREGATE THICKNESS AND WIDTH REQUIREMENTS AS THE STABILIZED CONSTRUCTION EXIT.
 - WHEN SHOWN ON THE CONSTRUCTION DRAWINGS, WIDEN OR LENGTHEN STABILIZED AREA TO ACCOMMODATE A TRUCK WASHING AREA. PROVIDE OUTLET SEDIMENT TRAP FOR THE TRUCK WASHING AREA.
 - PROVIDE PERIODIC TOP DRESSING WITH ADDITIONAL COARSE AGGREGATE TO MAINTAIN THE REQUIRED DEPTH OR WHEN SURFACE BECOMES PACKED WITH MUD.
 - PERIODICALLY TURN AGGREGATE TO EXPOSE A CLEAN DRIVING SURFACE.
 - MINIMUM 14' WIDTH FOR ONE WAY TRAFFIC AND 20' WIDTH FOR TWO WAY TRAFFIC.
- GENERAL NOTES:**
- POST A SIGN READING "CONCRETE WASHOUT PIT" NEXT TO THE PIT.
 - VERBALLY INSTRUCT THE CONCRETE TRUCK DRIVERS WHERE THE PIT IS AND TO WASHOUT THEIR TRUCKS IN THE PIT AND NOWHERE ELSE.
 - UPON THE CONCRETE SETTING UP (CURING, DRYING OUT), THE CONCRETE WASTE SHALL BE REMOVED FROM THE PROJECT SITE AND DISPOSED OF PROPERLY BY THE CONTRACTOR. AFTER REMOVAL OF THE CONCRETE WASTE, THE WASHOUT PIT SHALL BE FILLED WITH CLEAN FILL MATERIAL AND COMPACTED TO IN-SITU CONDITIONS, OR AS DIRECTED BY THE PROJECT SPECIFICATIONS.
 - CONCRETE WASHOUT PITS SHALL NOT BE LOCATED DIRECTLY ADJACENT TO, NOR AT ANY TIME DRAIN INTO THE STORM SEWER SYSTEM OR ANY OTHER SWALE, DITCH, OR WATERWAY.
 - CONSTRUCT ENTRY ROAD AND BOTTOM OF WASHOUT AREA TO SUPPORT EXPECTED LOADINGS FROM TRUCKS EQUIPMENT.

DATE	APPR			
DESCRIPTION				
REV				
HCFCU UNIT NO. P118-25-00/01				
HALLS BAYOU WATERSHED				
HC - STORM WATER POLLUTION PREVENTION PLAN DETAILS				
PREPARED: A.V.	CHECKED: M.J.	APPROVED:		
16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9000 TEXAS FIRM REGISTRATION NO. F-87				
9900 Northwest Freeway Houston, Texas 77092				
DATE:	3/15/2022			
SHEET NUMBER	33 OF 41			

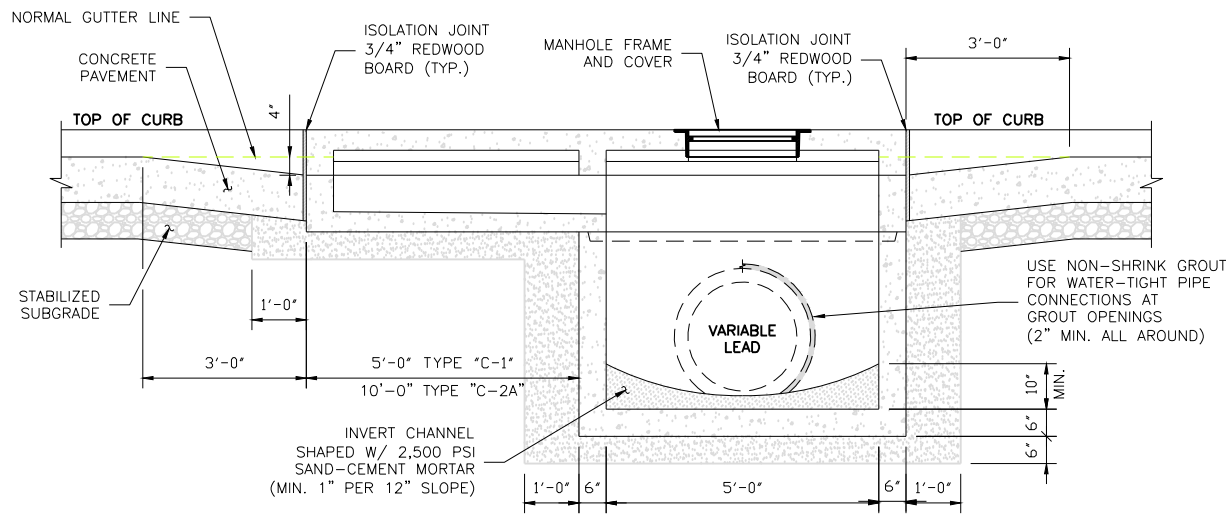
INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022



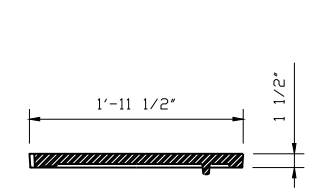
PLAN VIEW



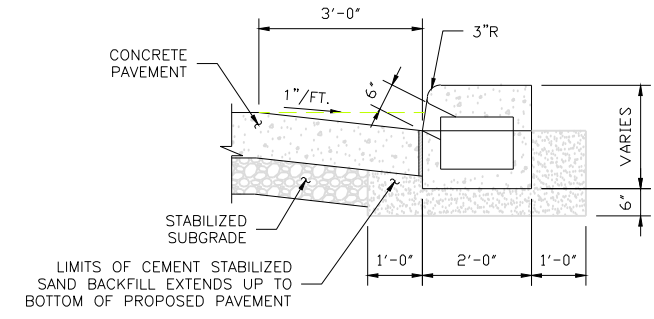
SECTION B-B



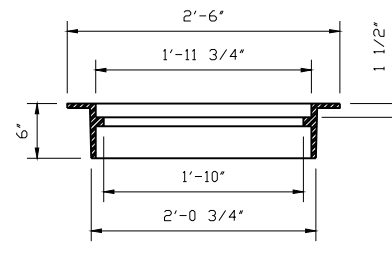
SECTION A-A INLET



COVER SECTION A-A



SECTION C-C



FRAME SECTION A-A

INLET NOTES:

- TYPE "C": INLET ONLY - NO EXTENSION
- TYPE "C-1": INLET WITH ONE EXTENSION (5'-0" LONG)
- TYPE "C-2": INLET WITH ONE EXTENSION (5'-0" LONG) ON EACH SIDE
- TYPE "C-2A": INLET WITH ONE DOUBLE EXTENSION (10'-0" LONG) ON ONE SIDE
- * FOR TYPE "C-2A" INLETS, PROVIDE A CENTER 6"x6" COLUMN IN THE CURB LINE BETWEEN ALL EXTENSIONS.

GENERAL NOTES:

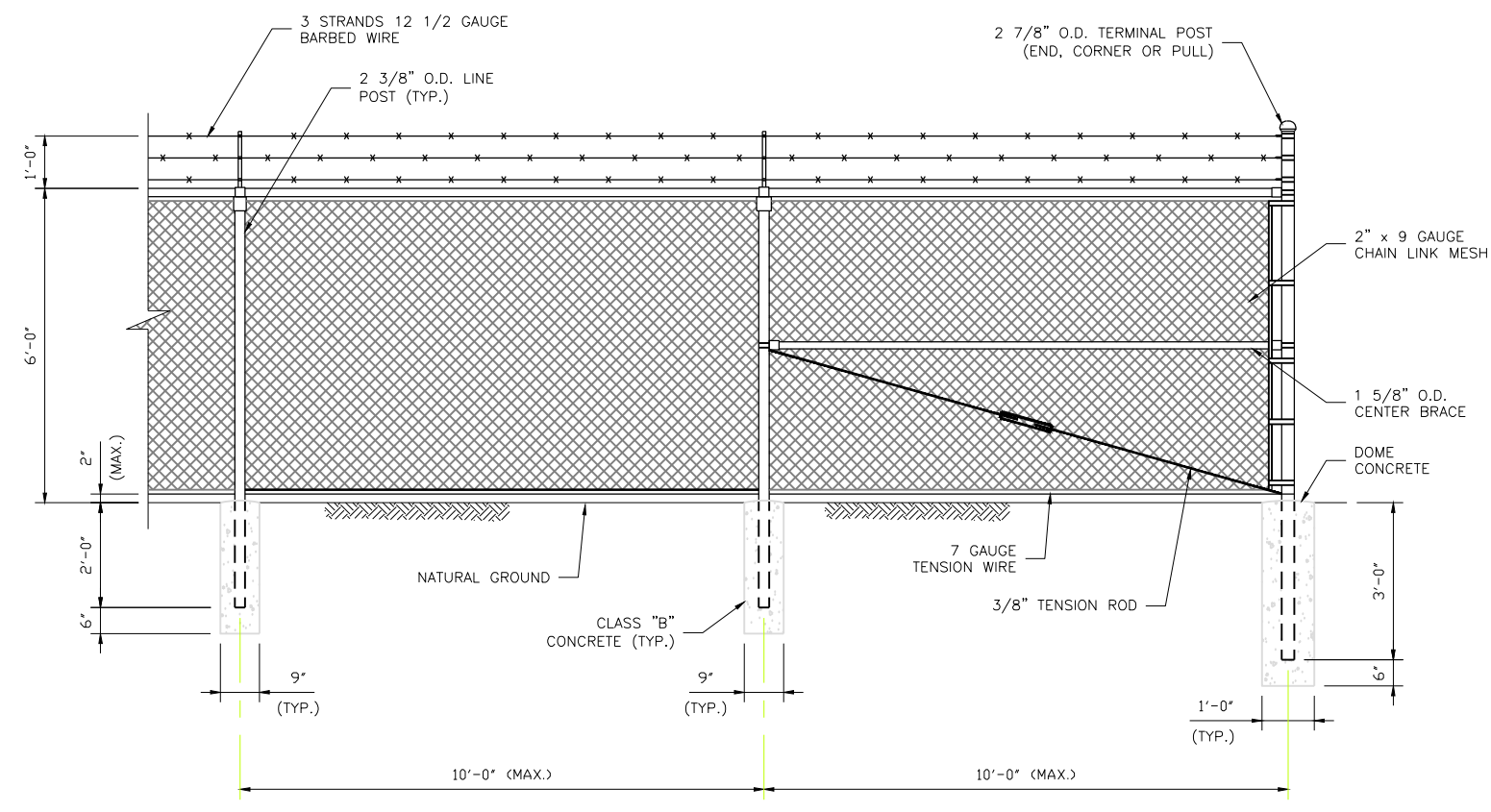
1. CONSTRUCTION AND MATERIALS SHALL MEET REQUIREMENTS OF ITEM 472 "INLETS".
2. CONCRETE FOR INLET: MINIMUM 4,000 PSI IN 28 DAYS
3. PRECAST STRUCTURE TO MEET ASTM C913.
4. FRAME AND COVER SHALL BE EAST JORDAN IRON WORKS MODEL V-1814 FRAME AND V-1418 COVER OR APPROVED EQUAL.
5. IF THE ENGINEER OF RECORD SPECIFIES A CAST-IN-PLACE INLET, HE/SHE SHALL INCORPORATE A DETAILED DRAWING INTO THE CONTRACT DOCUMENTS. HOWEVER, IF THE CONTRACTOR ELECTS TO CONSTRUCT A CAST-IN-PLACE INLET, THE CONTRACTOR WILL BE RESPONSIBLE FOR PROVIDING A DETAILED DRAWING, SIGNED AND SEALED BY A REGISTERED PROFESSIONAL ENGINEER LICENSED TO PRACTICE IN THE STATE OF TEXAS.
6. SHOP DRAWINGS WILL BE REQUIRED FOR THE PRECAST SECTION OF INLET.
7. KNOCK-OUTS ARE NOT PERMISSIBLE FOR THE PRECAST SECTION OF INLET.
8. 5'-6" MINIMUM OR AS SPECIFIED BY THE ENGINEER OF RECORD.

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Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

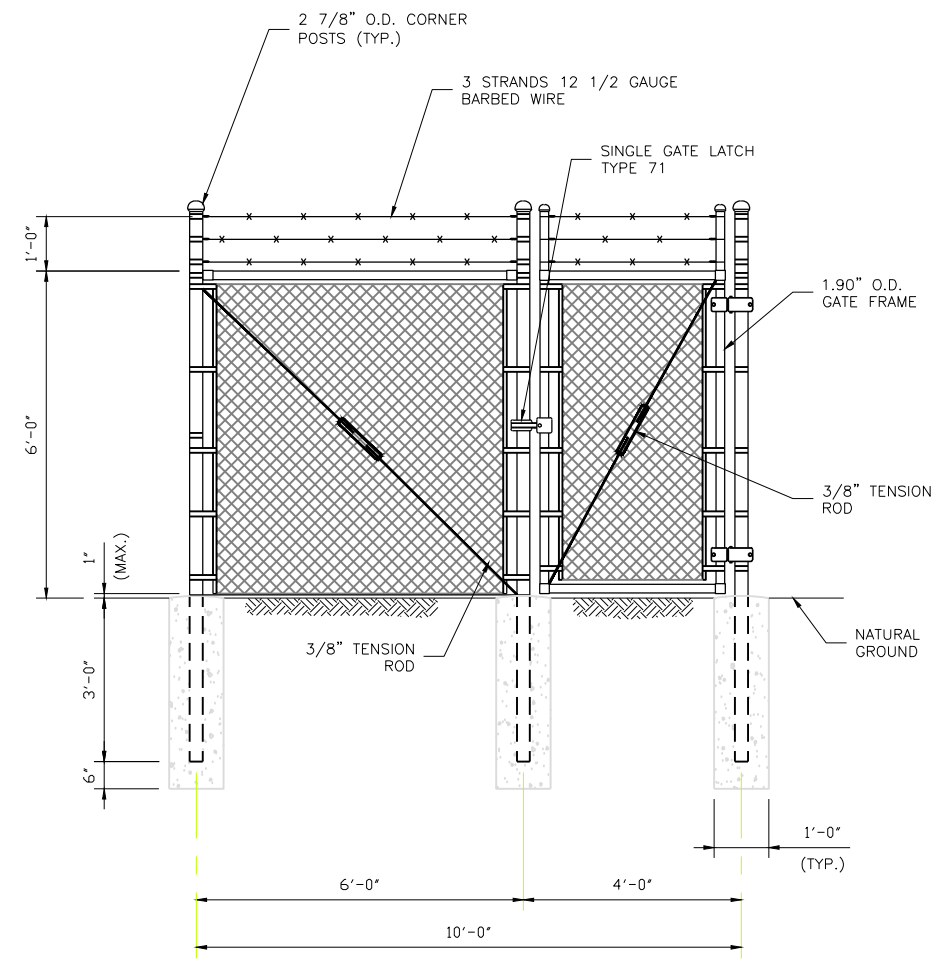
DATE	APPR				
DESCRIPTION					
REV					
HCFCU UNIT NO. P118-25-00/01					
HALLS BAYOU WATERSHED					
HC - MONOLITHIC TYPE C INLET DETAILS					
PREPARED: A.V.					
CHECKED: M.J.					
APPROVED:					
 16340 Park Ten Place Suite 350 Houston, Texas 77084 (713) 461-9600 TEXAS FIRM REGISTRATION NO. F-487					
 9900 Northwest Freeway Houston, Texas 77092					
DATE:	3/15/2022				
SHEET NUMBER	34 OF 41				

7/22/2021 1:04:43.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS/CADD/DWG13 - 4543.07 - HARRIS COUNTY DETAILS.DWG

7/22/2021 1:04:43.007 P:118-25-00 & P:118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS/CADD/DWG13 -4543.07 - HARRIS COUNTY DETAILS.DWG



ELEVATION WITH CORNER POST



SECURITY FENCE AND GATE FOR ELECTRICAL PANEL BOARD

REV	DESCRIPTION	DATE	APPR

HCFC UNIT NO. P118-25-00/01
HALLS BAYOU WATERSHED
HC - CHAIN LINK FENCING
DETAIL

PREPARED: A.V.
CHECKED: M.J.
APPROVED:

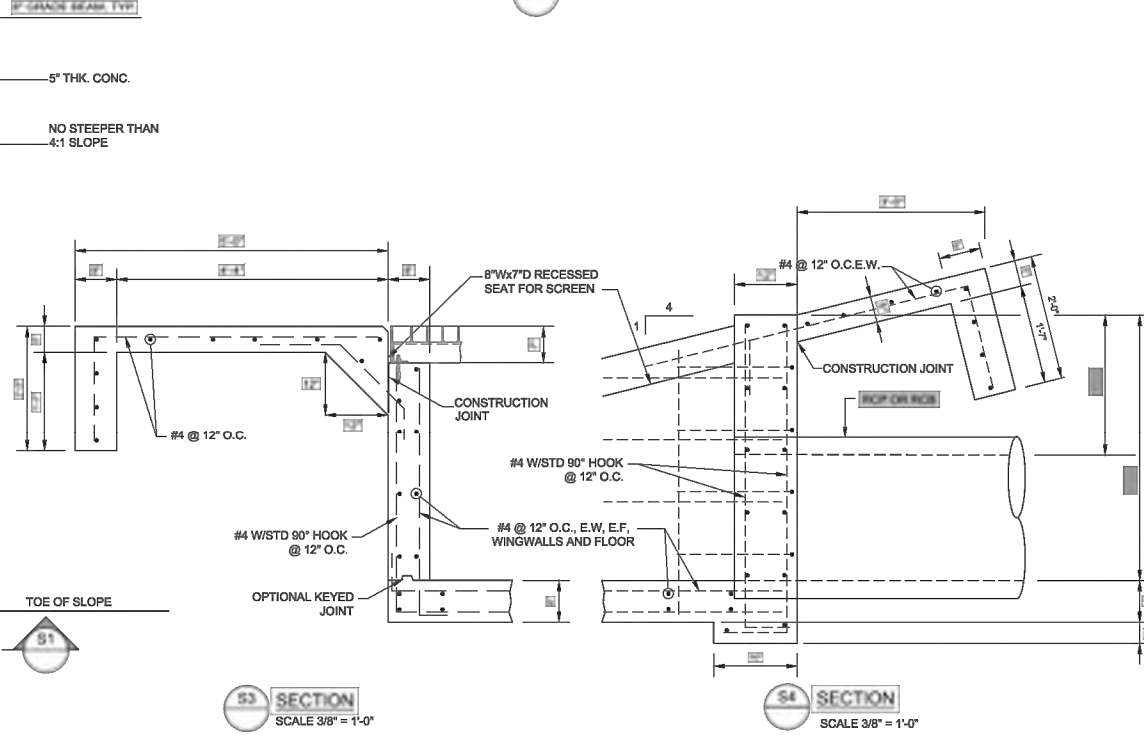
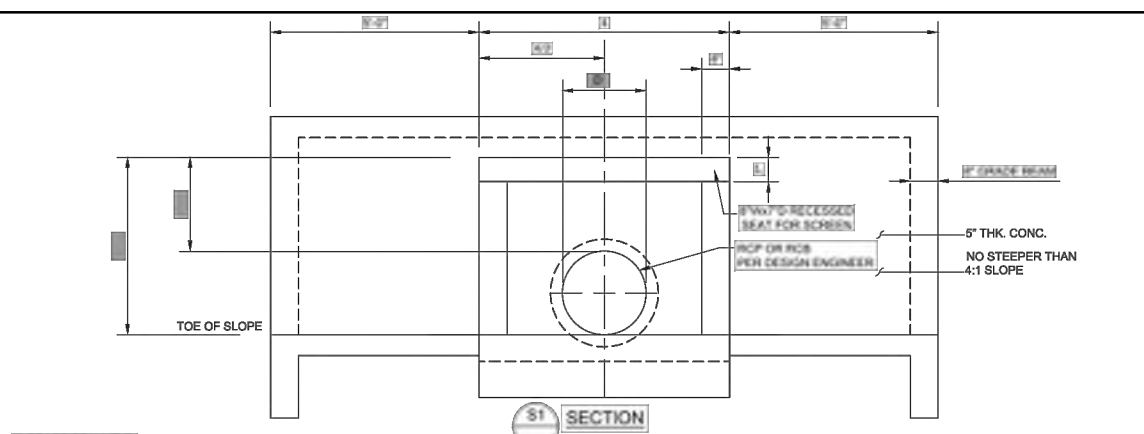
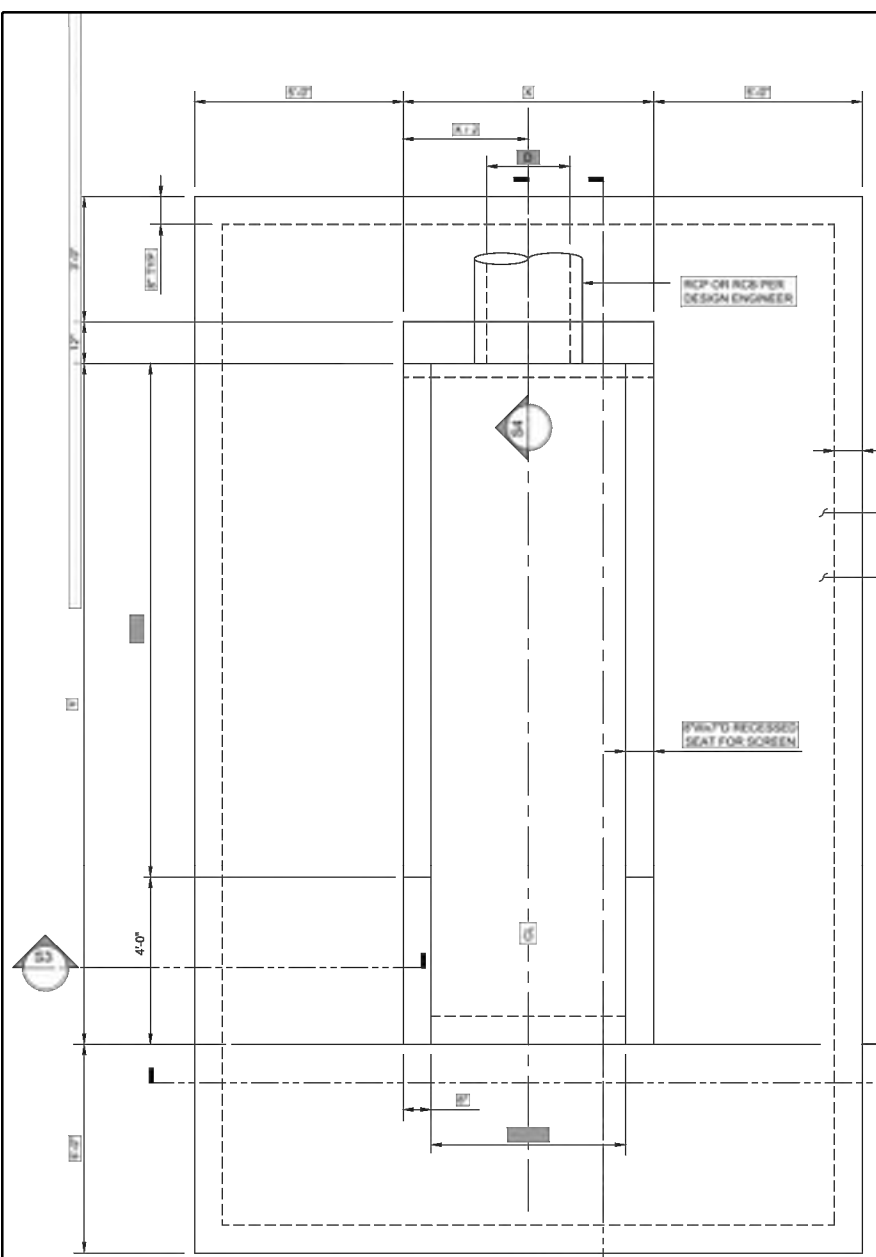
r.g.miller engineers
16340 Park Ten Place
Suite 350
Houston, Texas 77084
(713) 461-9600
TEXAS FIRM REGISTRATION NO. F-487

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

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

DATE: 3/15/2022
SHEET NUMBER
35 OF 41

3/10/2022 M:\04543.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG12 - 4543.07 - DETAILS.DWG



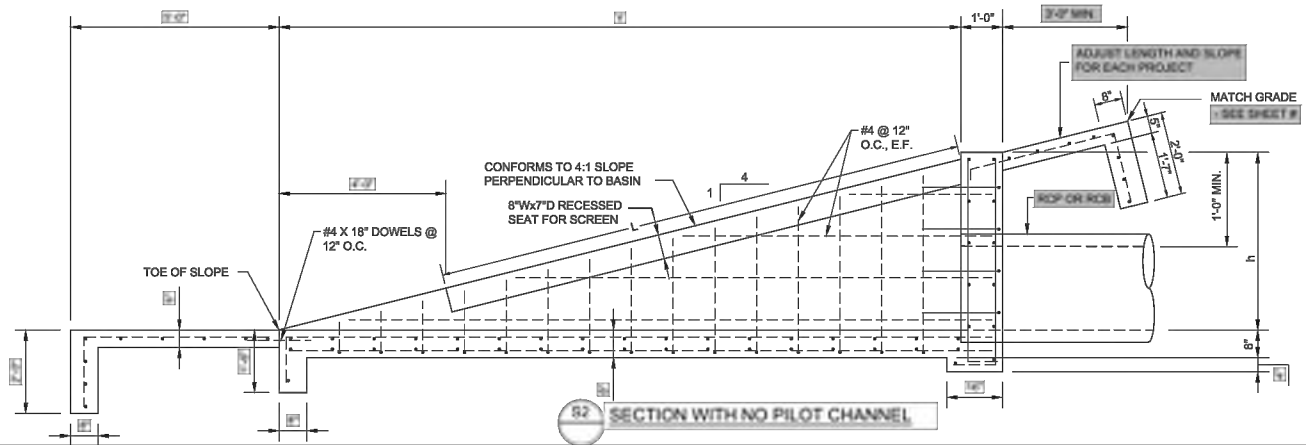
- NOTES:**
- FOLLOW REQUIREMENTS OF THE LATEST EDITION OF THE STANDARD SPECIFICATIONS BOOK OF THE HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFC), AS DISCUSSED BELOW.
 - STRUCTURAL EXCAVATION AND BACKFILL SHALL CONFORM TO REQUIREMENTS OF HCFC SPECIFICATION SECTION 02316. SUBGRADE PREPARATION AND SOIL STABILIZATION SHALL FOLLOW REQUIREMENTS OF APPLICABLE SPECIFICATIONS REFERENCED IN SECTION 02316.
 - CONSTRUCTION OF THE CONCRETE HEADWALL AND WINGWALLS SHALL CONFORM TO REQUIREMENTS OF HCFC SPECIFICATION SECTION 03310 (CAST-IN-PLACE CONCRETE, CLASSIFICATION: STRUCTURAL). THE REINFORCING STEEL SHALL CONFORM TO REQUIREMENTS OF ASTM A 615 OR ASTM A 775, GRADE 60. SUBMIT SHOP DRAWINGS OF PROPOSED REINFORCING STEEL, IF DIFFERENT FROM THAT SHOWN ON THE AGENCY STANDARD DRAWINGS.
 - CONSTRUCTION OF ACCESS CONCRETE PAVEMENT AROUND CULVERT CHANNEL SHALL ALSO CONFORM TO REQUIREMENTS OF HCFC SPECIFICATION SECTION 03310 (CAST-IN-PLACE CONCRETE, CLASSIFICATION: STRUCTURAL). THE REINFORCING STEEL SHALL CONFORM TO REQUIREMENTS OF ASTM A 615, GRADE 60.
 - PROVIDE REINFORCED CONCRETE PAVED SURFACE ON ALL SIDES OF CULVERT CHANNEL FOR USE BY MAINTENANCE PERSONNEL.
 - UTILIZE STRUCTURAL DETAILS SHOWN ON SHEET 2 FOR SCREEN HEADWALL AND WINGWALLS OF THE CULVERT CHANNEL.
 - FOR MULTIPLE SCREENS SIDE-BY-SIDE ALONG THE LENGTH OF THE SCREEN, SUBMIT SIGNED AND SEALED DESIGN DRAWINGS TO HCFC FOR APPROVAL PRIOR TO CONSTRUCTION.
 - SCREEN IS DESIGNED FOR A MAXIMUM TRACTOR WHEEL LOAD OF 3,000 LB. THEREFORE, THE DIMENSIONS SHOWN IN THE ABOVE TABLES SHALL NOT BE EXCEEDED WITHOUT REDESIGN OF THE SCREEN.
 - ALL STRUCTURAL STEEL OF THE SCREEN SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE AISC "STEEL CONSTRUCTION MANUAL", LATEST EDITION.
 - ALL STRUCTURAL STEEL PLATES AND ANGLES USED IN THE SCREEN SHALL CONFORM TO ASTM A36 (MIN. YIELD STRENGTH = 36 KSI).
 - UNLESS NOTED OTHERWISE, ALL BOLTS SHALL CONFORM TO ASTM A325. ALL ANCHOR BOLTS SHALL BE A307 HEX HEAD BOLTS WITH FLAT WASHERS. ALL BOLTS AND WASHERS SHALL BE HOT-DIP GALVANIZED.
 - ALL WELDED STEEL CONNECTIONS SHALL CONFORM TO AWS "STRUCTURAL WELDING CODE-STEEL", D1.1, LATEST EDITION. WELDING ELECTRODE TO BE E70-XX, LOW HYDROGEN. UNLESS NOTES OTHERWISE, USE 3/16" CONTINUOUS FILLET WELD.
 - ALL SCREEN MEMBERS AND SUPPORT STEEL ELEMENTS SHALL BE HOT-DIP GALVANIZED.
 - MAXIMUM SCREEN WIDTH FOR THIS DETAIL IS 8'-5".
- THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFC PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFC WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.
- P.E. SEAL AND SIGNATURE

TABLE 1
VARIABLE DIMENSIONS HEADWALL AND WINGWALLS (4:1 SLOPE)

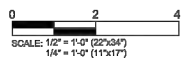
TD = DIA OF PIPE OR BOX SPAN (IN.)	VALUES FOR ONE PIPE OR BOX		
	X'	Y'	h'
24	6'-0"	12'-0"	3'-0"
30	6'-6"	14'-0"	3'-6"
36	7'-0"	16'-0"	4'-0"
42	7'-6"	18'-0"	4'-6"
48	8'-0"	21'-0"	5'-3"
54	8'-6"	23'-0"	5'-8"
36x18	7'-0"	12'-0"	3'-0"
36x24	7'-0"	12'-0"	3'-0"
36x36	7'-0"	16'-0"	4'-0"
48x24	8'-0"	12'-0"	3'-0"
48x36	8'-0"	16'-0"	4'-0"
48x48	8'-0"	21'-0"	5'-3"

TABLE 2
SCREEN SIZE

RCP OR RCB (IN.)	SCREEN SIZE	
	W = WIDTH	L = LENGTH
24	5'-11"	8'-2"
30	6'-5"	10'-2 1/2"
36	6'-11"	12'-3"
42	7'-5"	14'-4"
48	7'-11"	17'-5"
54	8'-5"	19'-6"
36x18	6'-11"	8'-2"
36x24	6'-11"	8'-2"
36x36	6'-11"	12'-3"
48x24	7'-11"	8'-2"
48x36	7'-11"	12'-3"
48x48	7'-11"	17'-5"



BAR SIZE #	MINIMUM LAP - SPLICE & DEVELOPMENT LENGTHS
4	1'-9"
5	2'-2"
6	2'-7"
7	3'-5"
8	4'-6"



DATE	APPR	DESCRIPTION	REV

PREPARED: A.V.	CHECKED: M.J.	APPROVED:
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HCFC UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED	HCFC - HEADWALL STRUCTURE DETAILS
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r.g.miller engineers
16340 Park Ten Place
Suite 350
Houston, Texas 77084
(713) 461-9900
TEXAS FIRM REGISTRATION NO. F-487

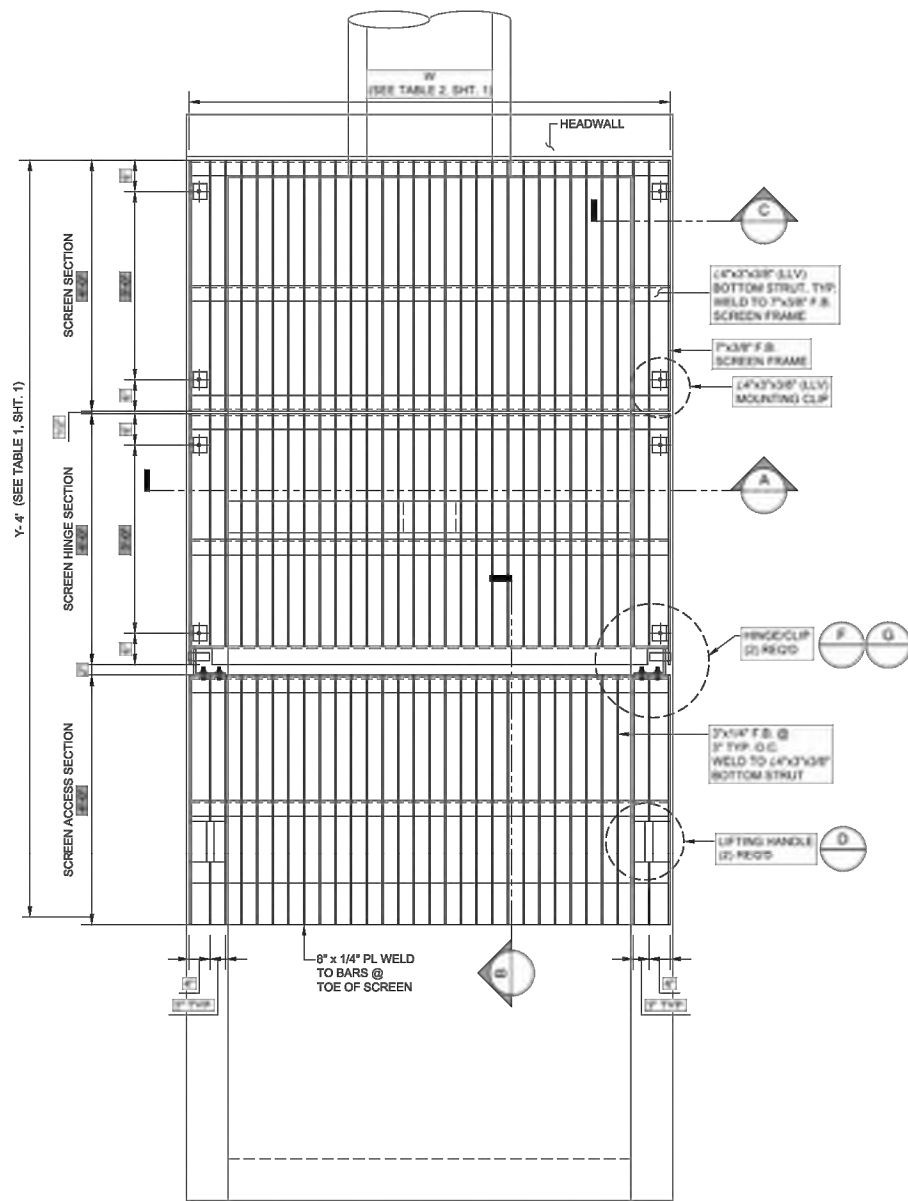
HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

DATE: 3/15/2022

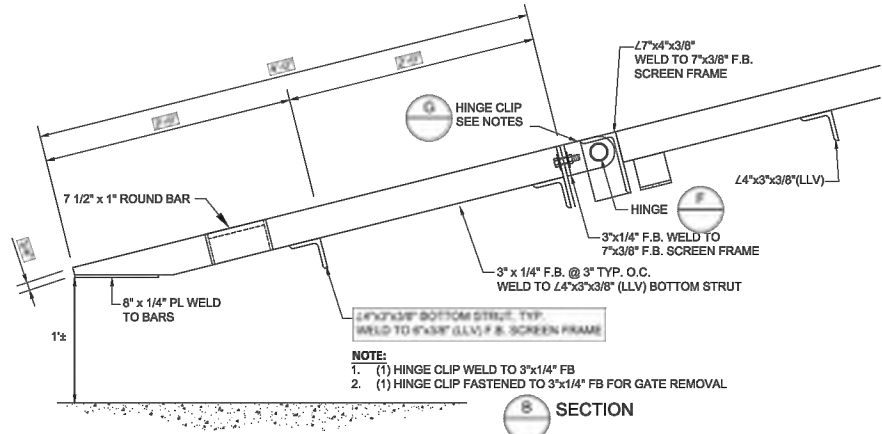
SHEET NUMBER
36 OF 41

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

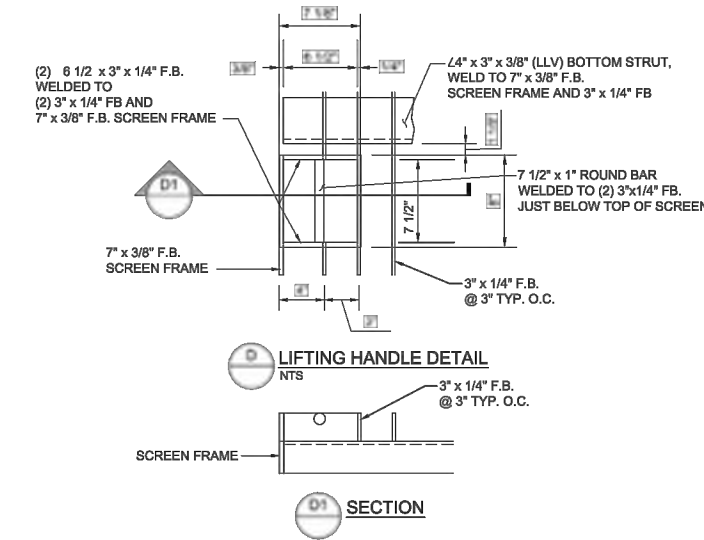
3/10/2022 M:\04543.007\P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG12 - 4543.07 - DETAILS.DWG



FLOATABLES SCREEN PLAN

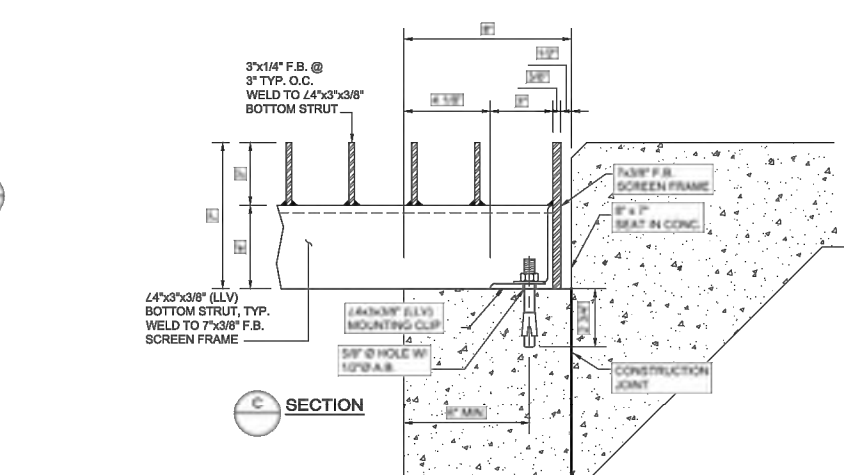


SECTION B

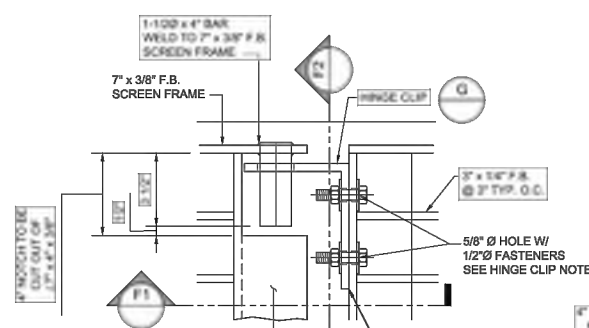


LIFTING HANDLE DETAIL

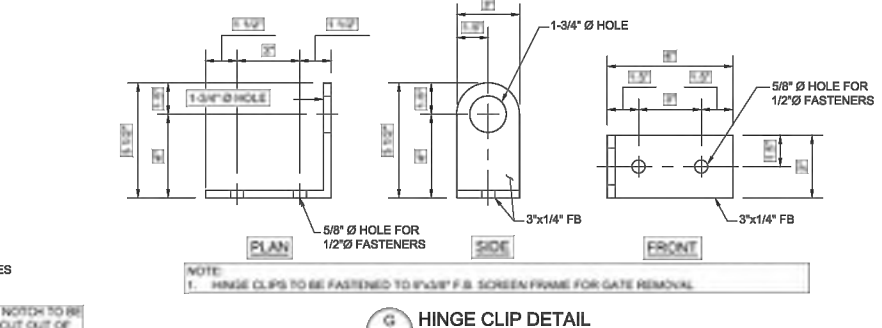
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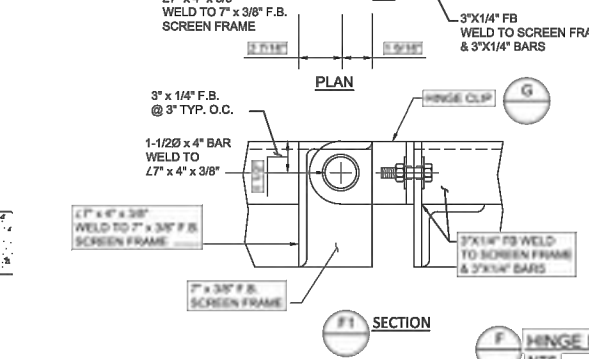
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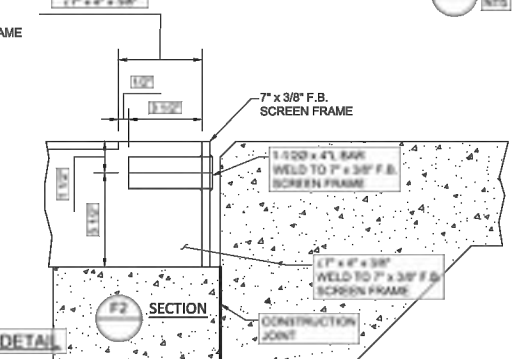
SECTION F1



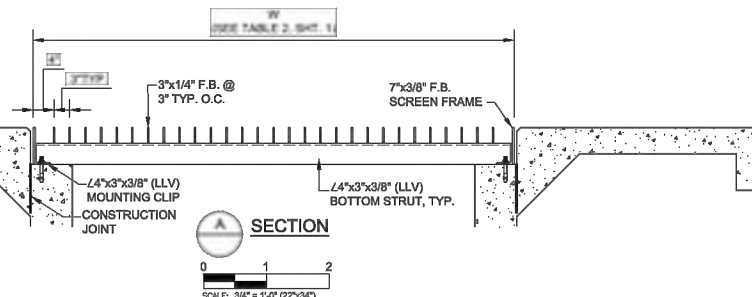
HINGE CLIP DETAIL



SECTION F2



SECTION F3



SECTION A

SCALE: 3/4" = 1'-0" (22:34)
3/8" = 1'-0" (11:17)

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFCDD PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCDD WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

DATE	APPROVED

REV	DESCRIPTION

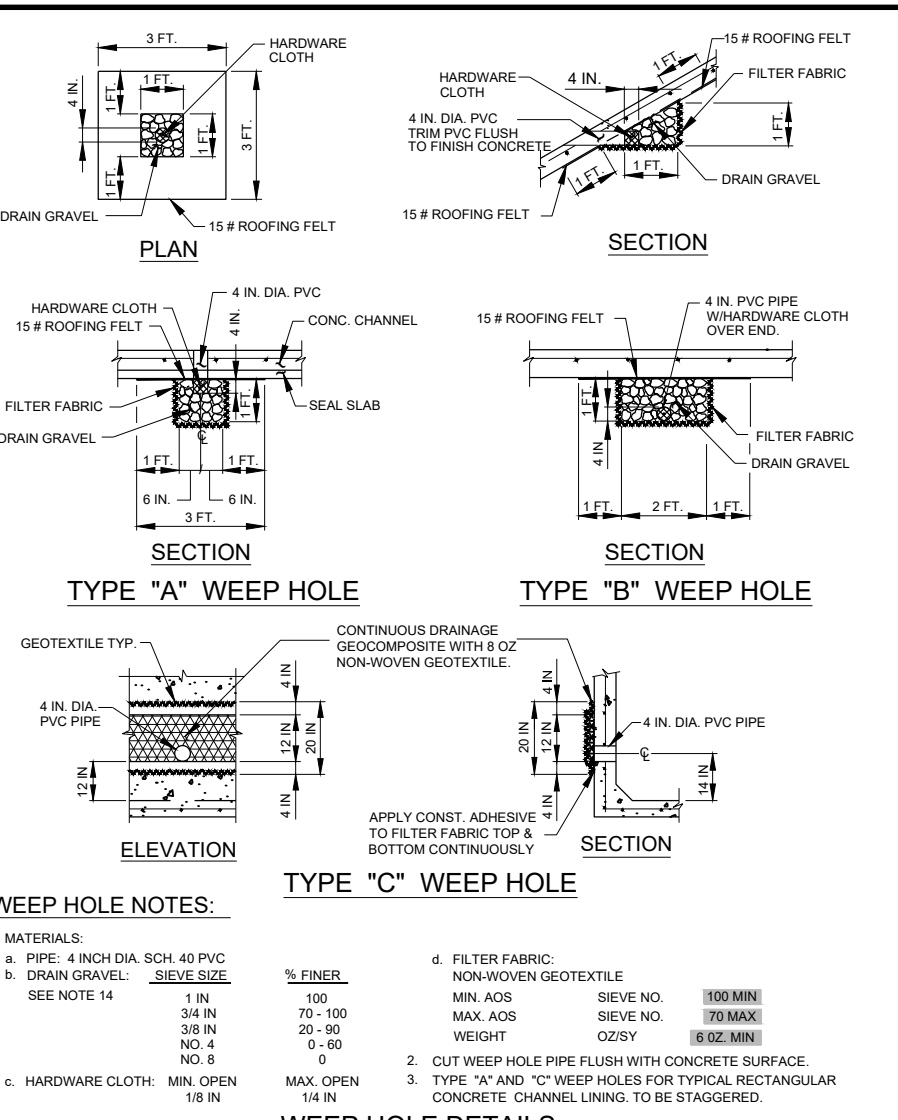
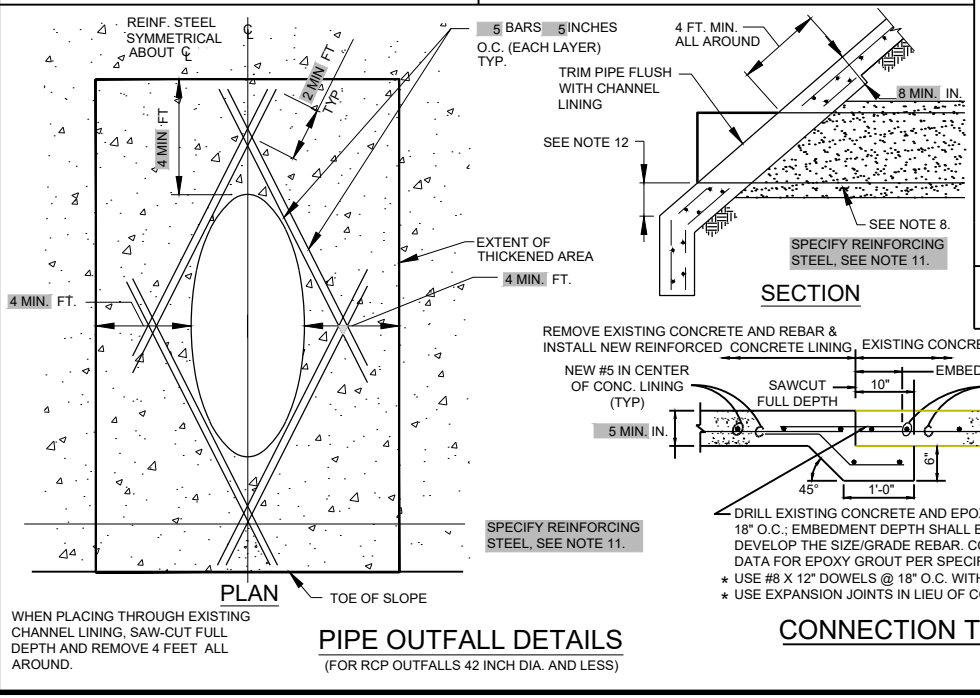
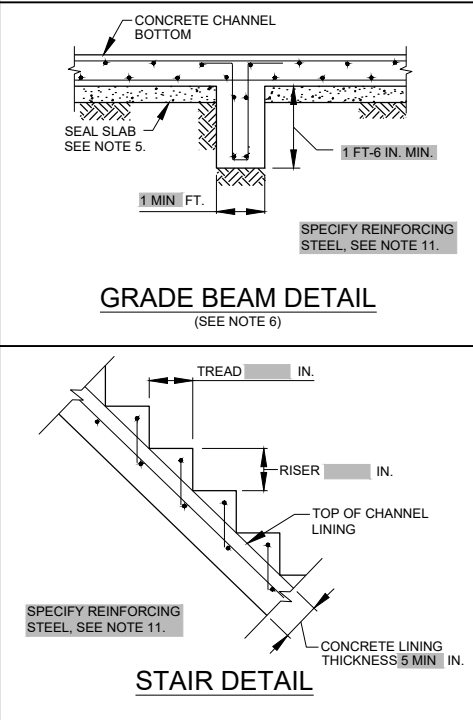
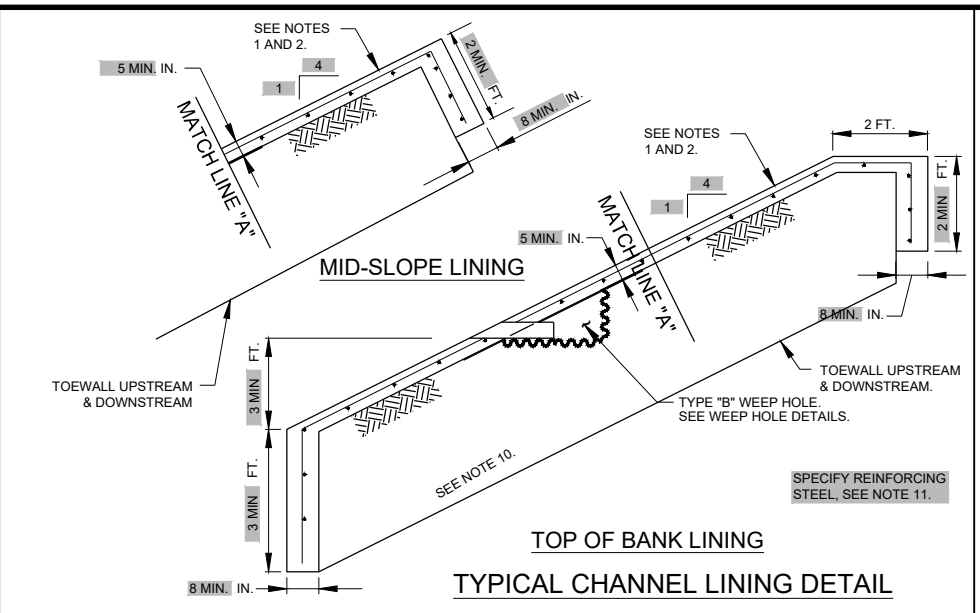
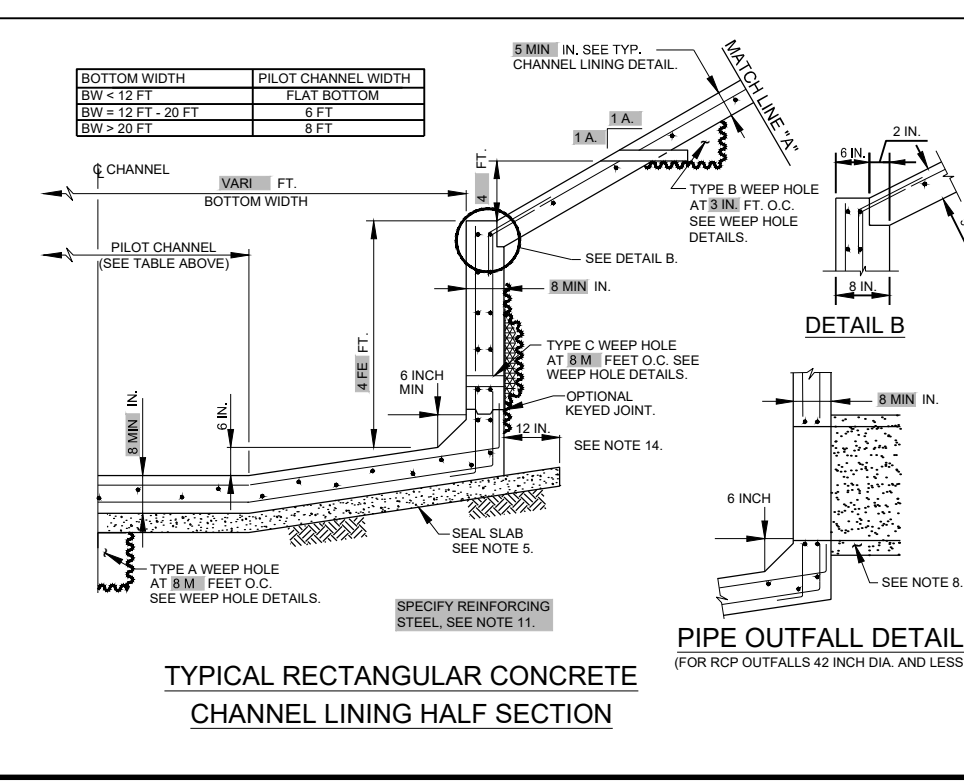
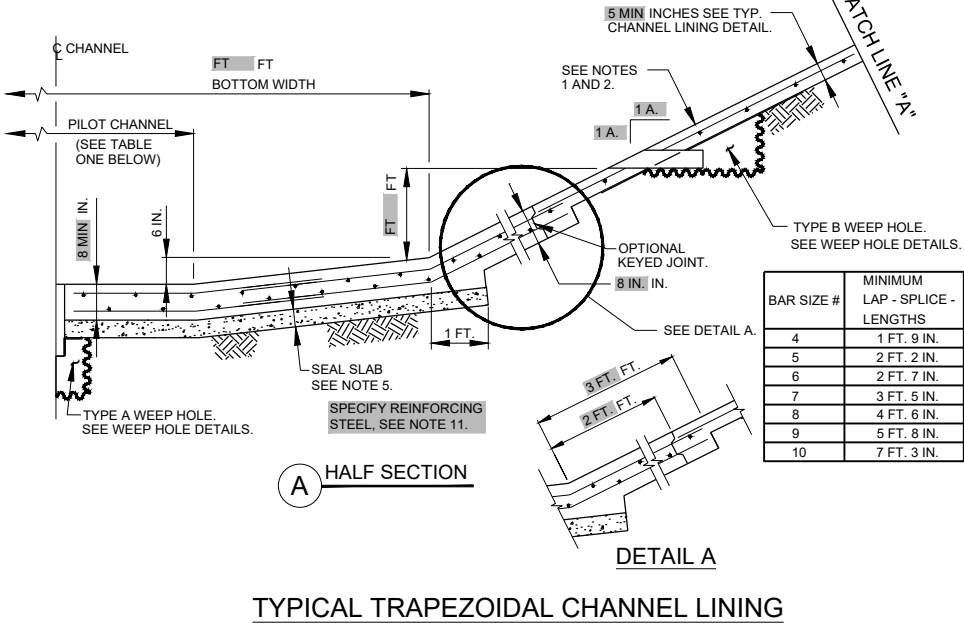
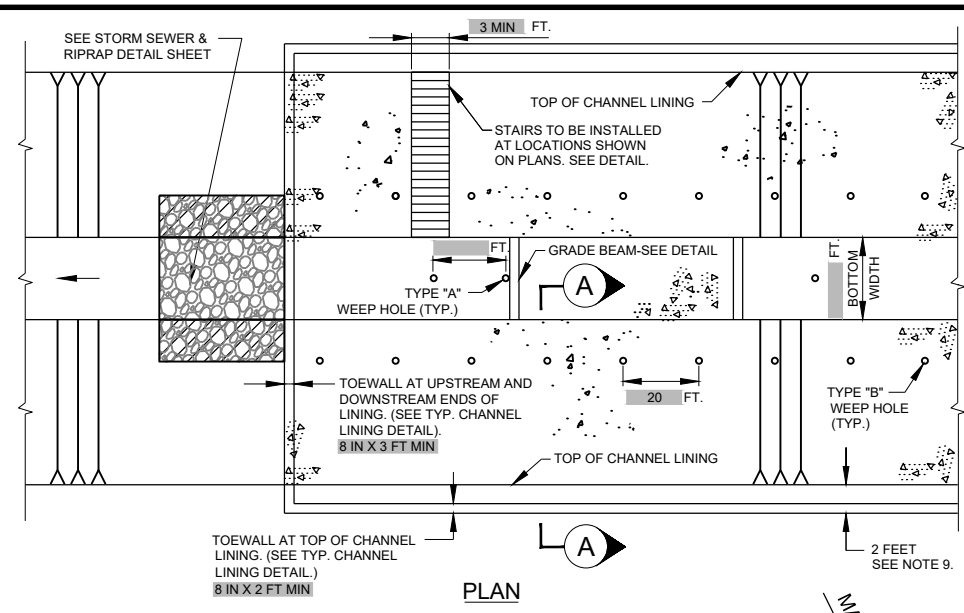
HCFCDD UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED	PREPARED: A.V.
		CHECKED: M.J.
	HCFCDD - FLOATABLE COLLECTION SCREEN DETAILS	APPROVED:

r.g.miller engineers
 16340 Park Ten Place
 Suite 350
 Houston, Texas 77084
 (713) 461-9900
 TEXAS FIRM REGISTRATION NO. F-487

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

DATE: 3/15/2022
SHEET NUMBER 37 OF 41

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022



- WEEP HOLE NOTES:**
- MATERIALS:
 - a. PIPE: 4 INCH DIA. SCH. 40 PVC
 - b. DRAIN GRAVEL:

SIEVE SIZE	% FINER
1 IN	100
3/4 IN	70 - 100
3/8 IN	20 - 90
NO. 4	0 - 60
NO. 8	0
 - c. HARDWARE CLOTH: MIN. OPEN 1/8 IN. MAX. OPEN 1/4 IN.
 - d. FILTER FABRIC: NON-WOVEN GEOTEXTILE. MIN. AOS 100, MAX. AOS 70, WEIGHT 6 OZ./SY.
 - APPLY CONST. ADHESIVE TO FILTER FABRIC TOP & BOTTOM CONTINUOUSLY.
- NOTES:**
- STRUCTURAL CONCRETE FOR CONCRETE CHANNEL LINING AND NONSTRUCTURAL CONCRETE FOR SEAL SLAB SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 03310-CONCRETE.
 - REINFORCING STEEL SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 03310-CONCRETE.
 - EXCAVATION AND BACKFILL FOR CONCRETE CHANNEL LINING SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02316-STRUCTURAL EXCAVATING AND BACKFILLING.
 - RIPRAP SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02378-RIPRAP AND GRANULAR FILL.
 - A NON-REINFORCED 4 INCH MINIMUM NONSTRUCTURAL CONCRETE SEAL SLAB IS REQUIRED BENEATH THE BOTTOM OF CONCRETE CHANNELS.
 - STRUCTURAL CONCRETE GRADE BEAMS SHALL BE INSTALLED TRANSVERSELY AT 20 FOOT MAX. CENTERS ON CONCRETE LINED CHANNELS WITH BOTTOM WIDTHS EQUAL TO OR GREATER THAN 20 FEET.
 - JOINTS:
 - A. PLACE CONSTRUCTION JOINT IN CONCRETE LOW-FLOW, TRAPEZOIDAL BOTTOM SECTIONS AND SLOPES AT 20 FOOT MIN. SPACING CONTINUOUSLY THROUGH CHANNEL LINING.
 - B. PLACE EXPANSION JOINT IN CONCRETE LOW-FLOW, TRAPEZOIDAL BOTTOM SECTIONS, AND SLOPES AT 60 FOOT MAX. SPACING CONTINUOUSLY THROUGH CHANNEL LINING.
 - C. CEMENT STABILIZED SAND SHALL BE PROVIDED AND PLACED IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02321 -CEMENT STABILIZED SAND.
 - D. DELETE 2 FT FLAT EDGE WHEN LINING IS BELOW TOP OF BANK. SEE MID-SLOPE LINING DETAIL.
 - UPSTREAM AND DOWNSTREAM TOE WALL 3 FOOT MIN. DEPTH AT BOTTOM OF SLOPE AND 8 INCHES THICK.
 - MINIMUM #4 BARS (GRADE 60) AT 12 INCHES ON CENTER EACH WAY.
 - VARIABLES BASED ON SIDE SLOPE. MINIMUM 1 FOOT VERTICAL AT TOE OF SLOPE.
 - FOR RCP OUTFALLS 48 INCHES DIA. AND LARGER, USE HEADWALL/WINGWALL DETAIL ON SHEET.
 - FOR STRUCTURAL BACKFILL MATERIAL PER SPECIFICATION SECTION 2316, USE CONCRETE COARSE AGGREGATE ASTM C33 SIZE NO. 48. LIMESTONE AND RECYCLED CONCRETE NOT ALLOWED.

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFC PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFC WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

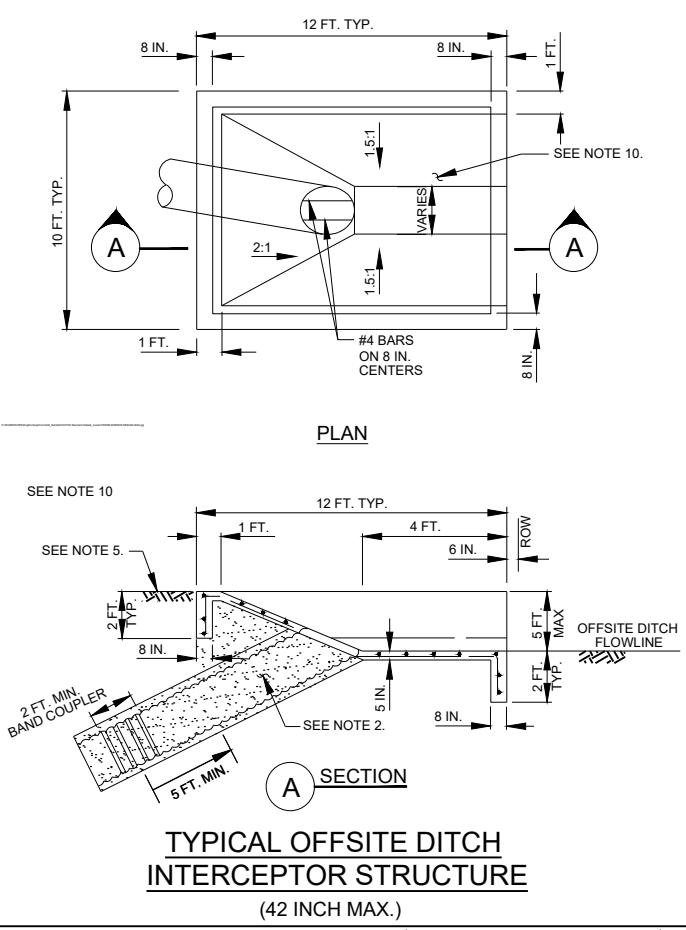
INTERIM REVIEW ONLY
 DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
 Engineer: Alberto Espinoza
 P.E. License No. 133330
 DATE: March, 2022

DATE	APPR
DESCRIPTION	
REV	
HCFC UNIT NO. P118-25-00/01	HALLS BAYOU WATERSHED
PREPARED: A.V.	CHECKED: M.J.
APPROVED:	APPROVED:
DATE: 3/15/2022	SHEET NUMBER
	38 OF 41

r.g.miller engineers
 16340 Park Ten Place
 Suite 350
 Houston, Texas 77084
 (713) 461-9900
 TEXAS FRM REGISTRATION NO. F-487

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

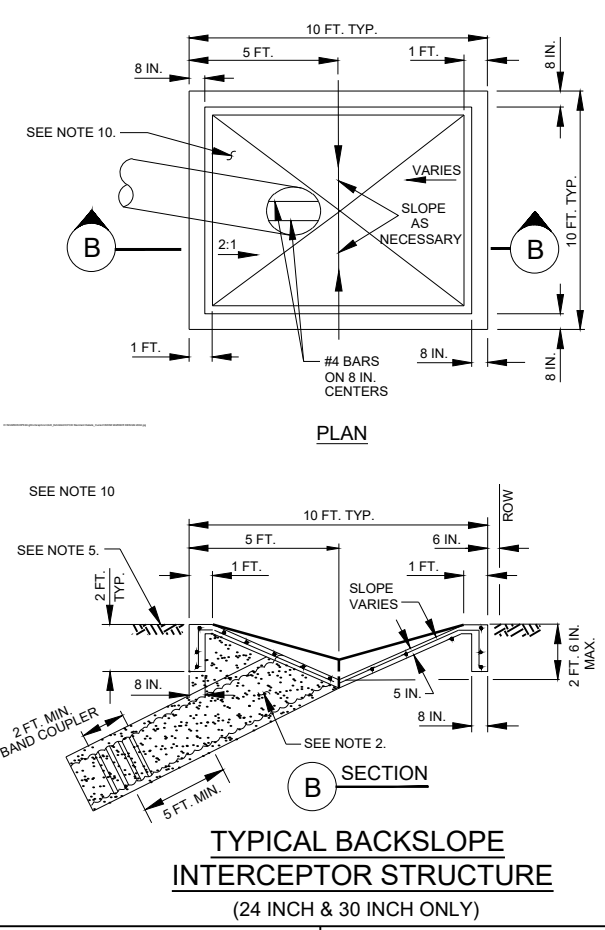
3/4/2022 M10:45:43.007 P118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS/SCADDWG12 - 4543.07 - DETAILS.DWG



PLAN

A SECTION

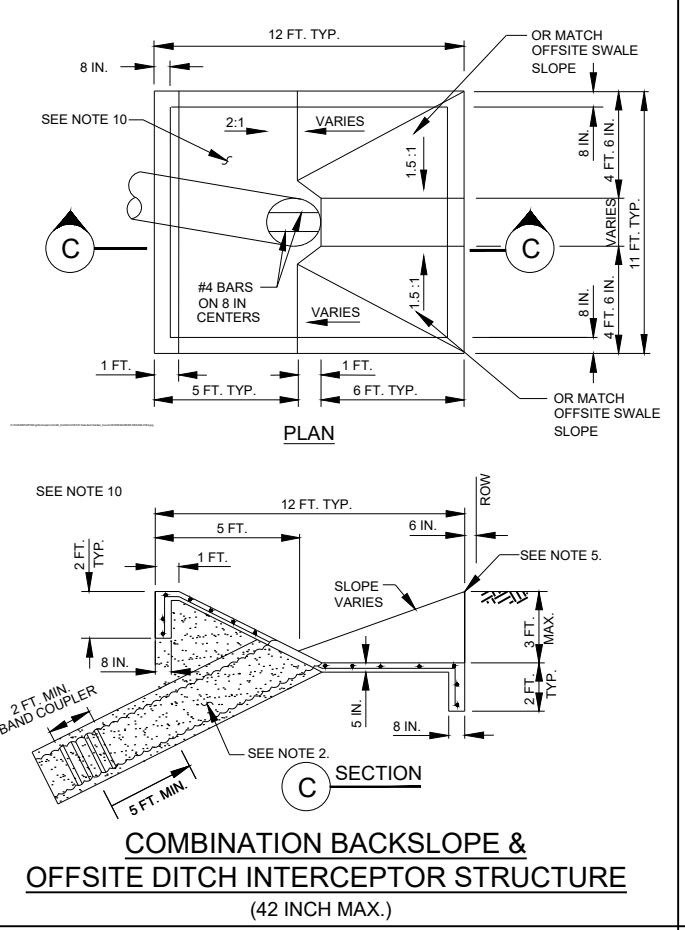
TYPICAL OFFSITE DITCH INTERCEPTOR STRUCTURE (42 INCH MAX.)



PLAN

B SECTION

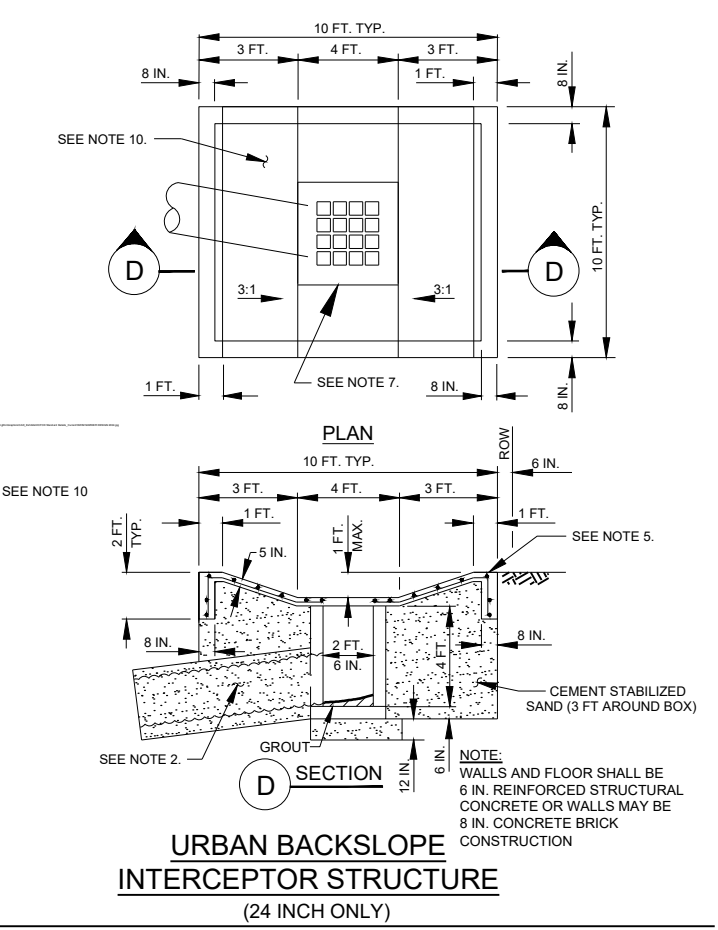
TYPICAL BACKSLOPE INTERCEPTOR STRUCTURE (24 INCH & 30 INCH ONLY)



PLAN

C SECTION

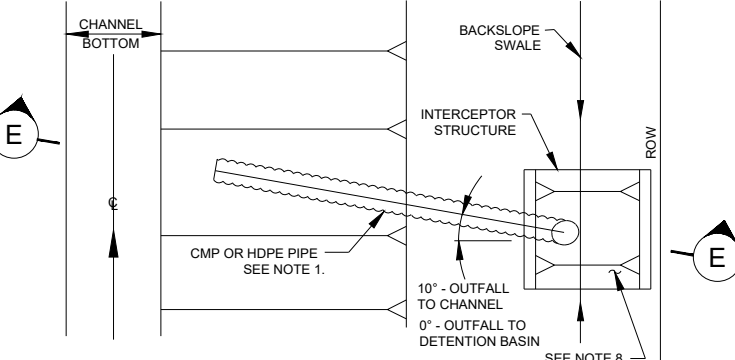
COMBINATION BACKSLOPE & OFFSITE DITCH INTERCEPTOR STRUCTURE (42 INCH MAX.)



PLAN

D SECTION

URBAN BACKSLOPE INTERCEPTOR STRUCTURE (24 INCH ONLY)



PLAN

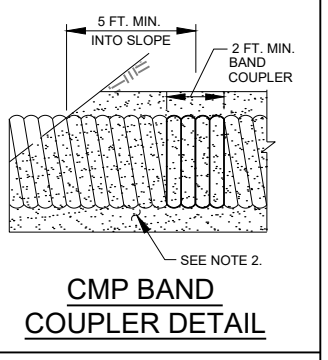
E SECTION

TYPICAL INTERCEPTOR OFFFALL STRUCTURE LAYOUT

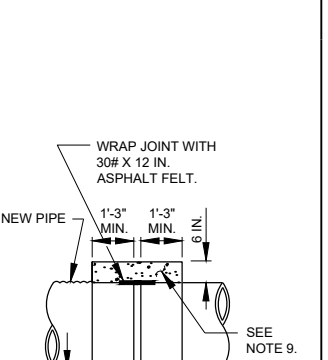
PIPE OFFFALL IN CHANNELS PIPE OFFFALL IN DETENTION BASINS

BOTTOM WIDTH	PIPE OUTLET INVERT
6 FEET ≤ BW ≤ 20 FT	1 FOOT ABOVE FLOWLINE *
20 FEET < BW ≤ 60 FT	AT TOE OF SLOPE *
BW > 60 FT	AT TOE OF SLOPE *

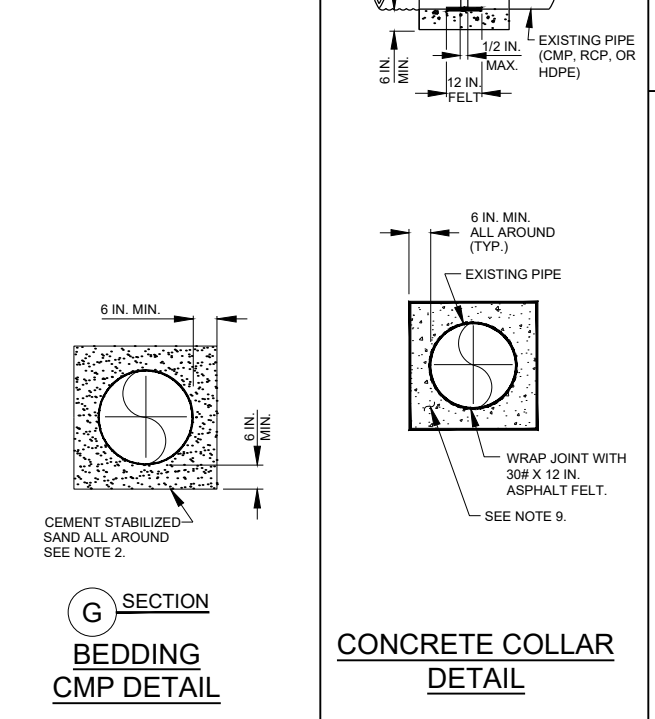
* OR 1 FOOT ABOVE NORMAL WATER LEVEL, WHICHEVER IS HIGHER



CMP BAND COUPLER DETAIL

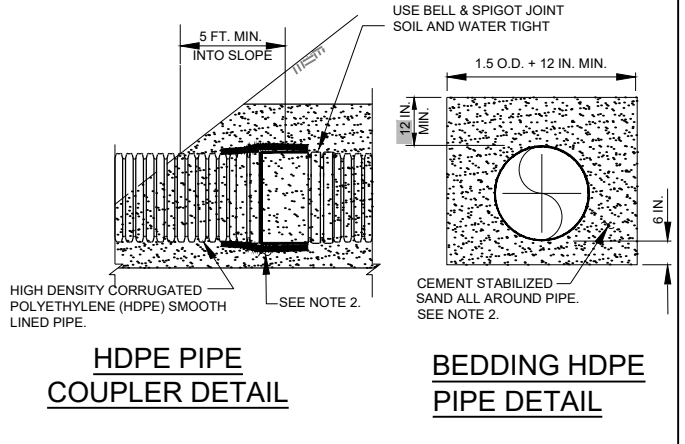


CONCRETE COLLAR DETAIL

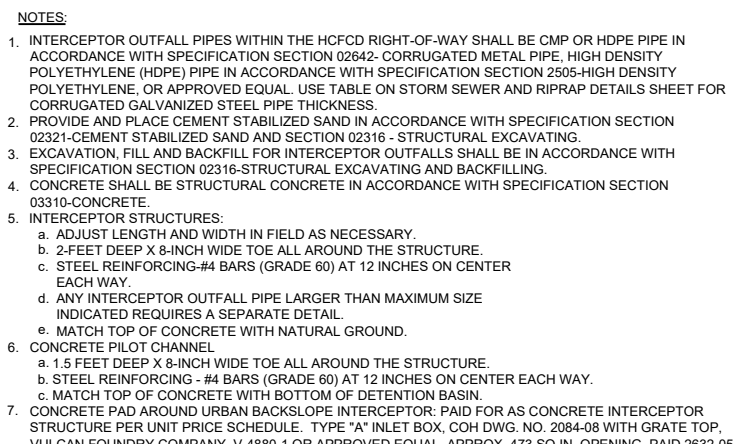


G SECTION

BEDDING CMP DETAIL

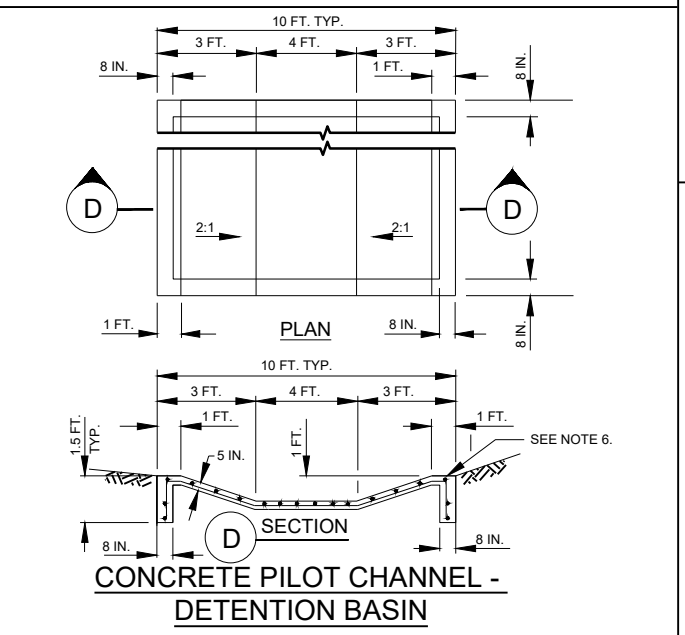


HDPE PIPE COUPLER DETAIL



BEDDING HDPE PIPE DETAIL

- NOTES:
- INTERCEPTOR OFFFALL PIPES WITHIN THE HCFC RIGHT-OF-WAY SHALL BE CMP OR HDPE PIPE IN ACCORDANCE WITH SPECIFICATION SECTION 02642. CORRUGATED METAL PIPE, HIGH DENSITY POLYETHYLENE (HDPE) PIPE IN ACCORDANCE WITH SPECIFICATION SECTION 2505-HIGH DENSITY POLYETHYLENE. OR APPROVED EQUAL. USE TABLE ON STORM SEWER AND RIPRAP DETAILS SHEET FOR CORRUGATED GALVANIZED STEEL PIPE THICKNESS.
 - PROVIDE AND PLACE CEMENT STABILIZED SAND IN ACCORDANCE WITH SPECIFICATION SECTION 02321-CEMENT STABILIZED SAND AND SECTION 02316 - STRUCTURAL EXCAVATING.
 - EXCAVATION, FILL AND BACKFILL FOR INTERCEPTOR OFFFALLS SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION 02316-STRUCTURAL EXCAVATING AND BACKFILLING.
 - CONCRETE SHALL BE STRUCTURAL CONCRETE IN ACCORDANCE WITH SPECIFICATION SECTION 03310-CONCRETE.
 - INTERCEPTOR STRUCTURES:
 - ADJUST LENGTH AND WIDTH IN FIELD AS NECESSARY.
 - 2- FEET DEEP X 8-INCH WIDE TOE ALL AROUND THE STRUCTURE.
 - STEEL REINFORCING-#4 BARS (GRADE 60) AT 12 INCHES ON CENTER EACH WAY.
 - ANY INTERCEPTOR OFFFALL PIPE LARGER THAN MAXIMUM SIZE INDICATED REQUIRES A SEPARATE DETAIL.
 - MATCH TOP OF CONCRETE WITH NATURAL GROUND.
 - CONCRETE PILOT CHANNEL:
 - 1.5 FEET DEEP X 8-INCH WIDE TOE ALL AROUND THE STRUCTURE.
 - STEEL REINFORCING - #4 BARS (GRADE 60) AT 12 INCHES ON CENTER EACH WAY.
 - MATCH TOP OF CONCRETE WITH BOTTOM OF DETENTION BASIN.
 - CONCRETE PAD AROUND URBAN BACKSLOPE INTERCEPTOR. PAID FOR AS CONCRETE INTERCEPTOR STRUCTURE PER UNIT PRICE SCHEDULE. TYPE "A" INLET BOX. COH DWG. NO. 2084-08 WITH GRATE TOP. VULCAN FOUNDRY COMPANY. V-4880-1 OR APPROVED EQUAL. APPROX. 473 SQ. IN. OPENING. PAID 2632-05
 - BACKSLOPE SWALE AND INTERCEPTOR STRUCTURE ELEVATIONS AND LOCATIONS SHOWN ON THE PLANS ARE APPROXIMATE. FINAL ELEVATIONS AND LOCATIONS SHALL BE FIELD VERIFIED BY THE ENGINEER PRIOR TO INSTALLATION.
 - STRUCTURAL CONCRETE WITH #4 BARS (GRADE 60) 12 INCH O.C. EACH WAY, 3 ROWS MIN. EACH WAY. - FOR COLLARS ONLY. WAIT A MINIMUM OF 24 HOURS AFTER PLACING CONCRETE TO BACKFILL.
 - EPOXY "CLEAN WATER CLEAR CHOICE" LOGO BUTTON ON INTERCEPTORS. LOCATION TO BE DETERMINED BY THE ENGINEER.



PLAN

D SECTION

CONCRETE PILOT CHANNEL - DETENTION BASIN

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFC PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFC WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

3/4/2022 M:\04543.007\PI-18-25-00 & PI-18-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\WG12 - 4543.07 - DETAILS.DWG

DATE	APPR	DESCRIPTION	REV	REV
HCFC UNIT NO. P118-25-00/01			PREPARED: A.V.	
HALLS BAYOU WATERSHED			CHECKED: M.J.	
HCFC - INT. STRUCTURE & CONC. PILOT CHANNEL DETAILS			APPROVED:	

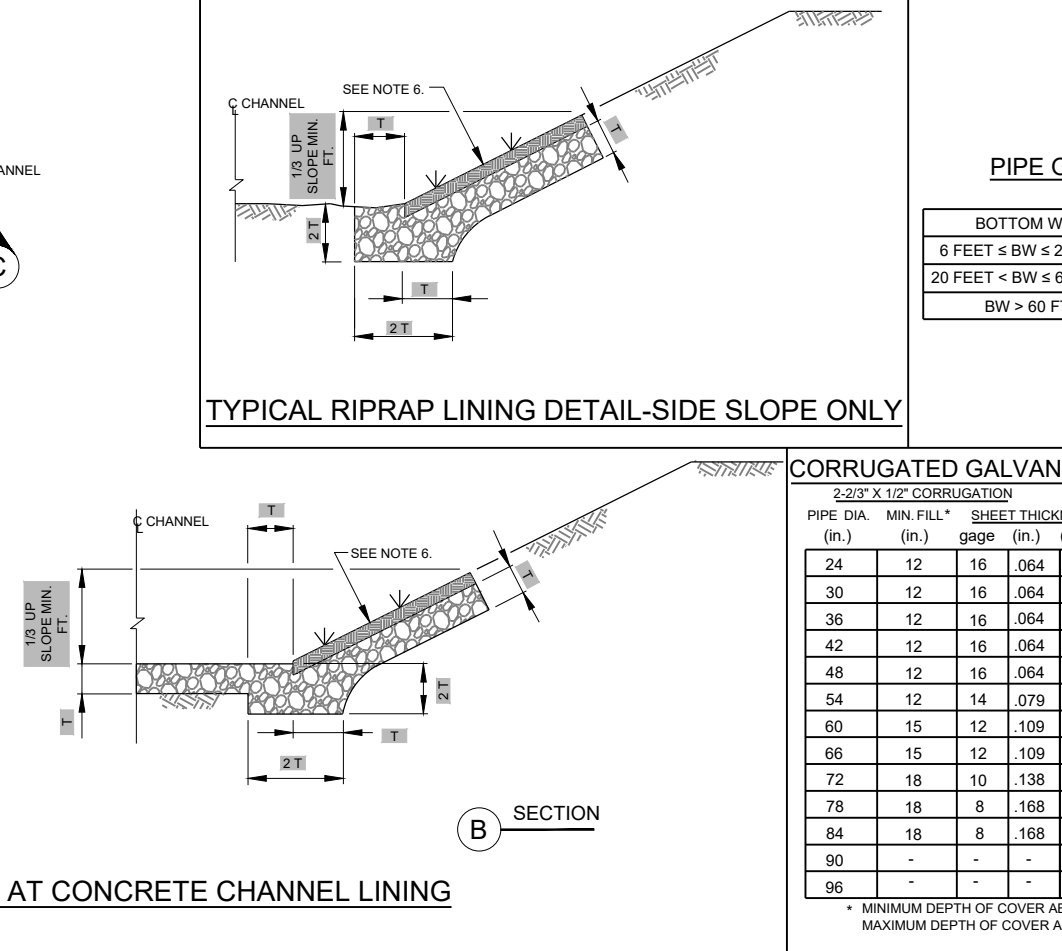
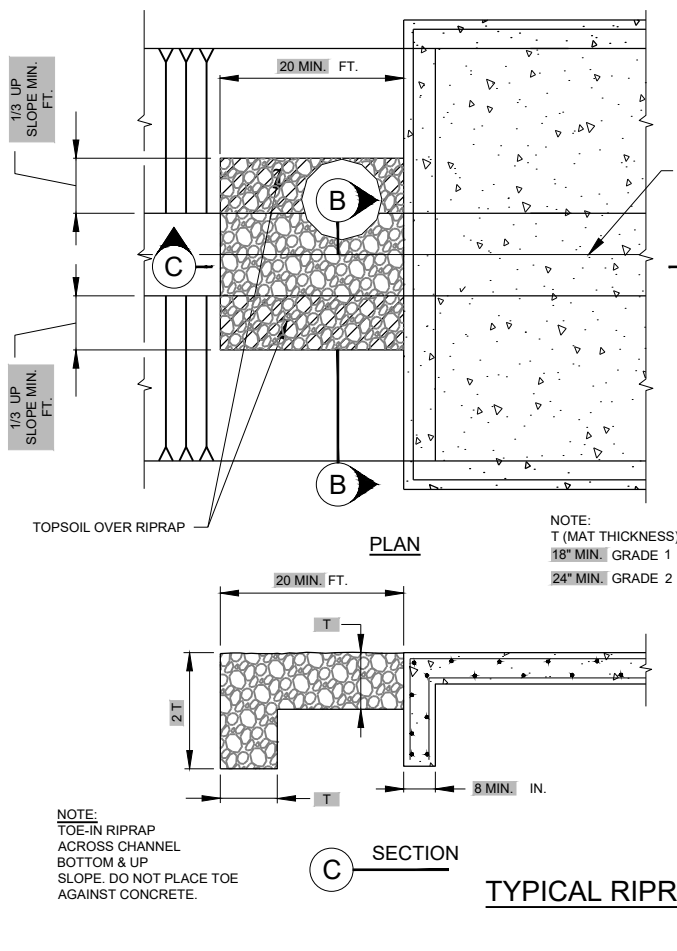
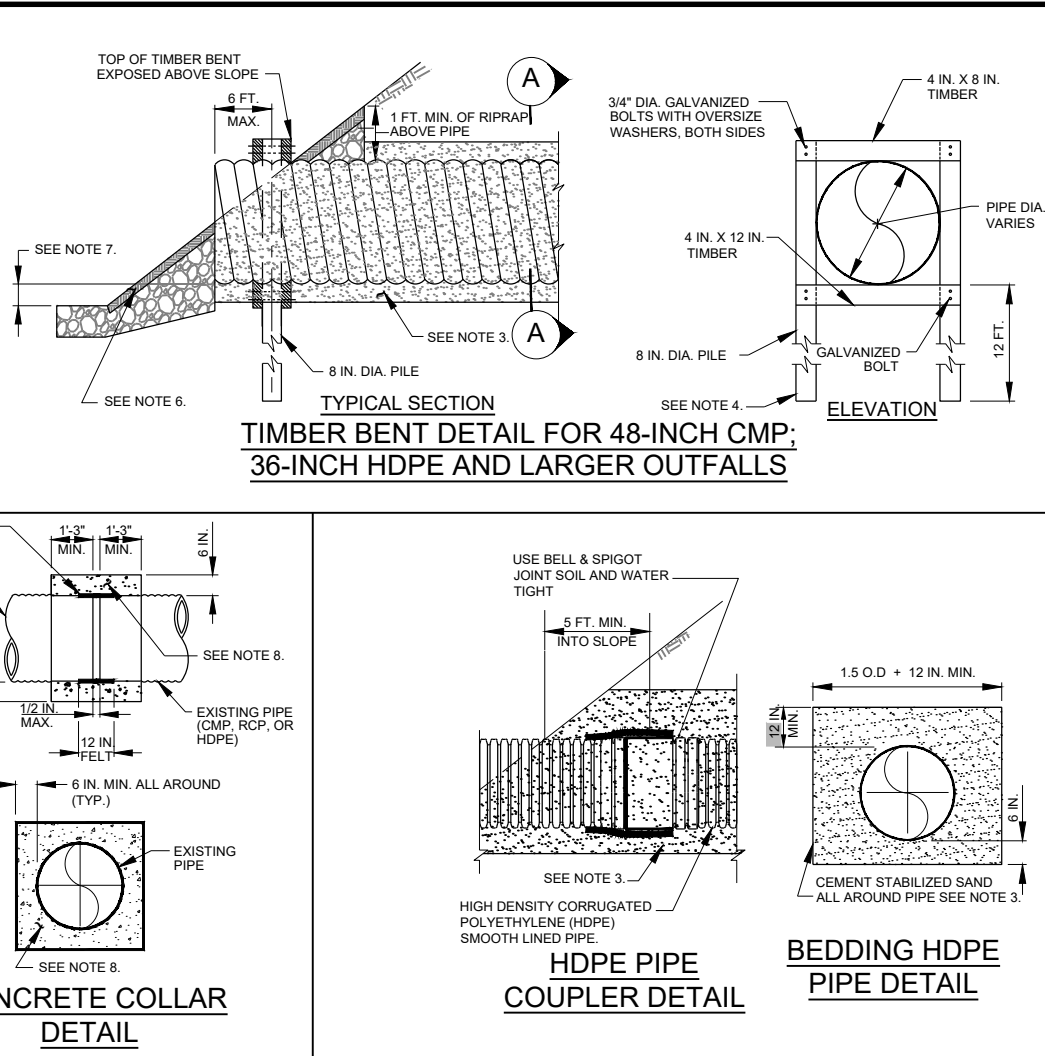
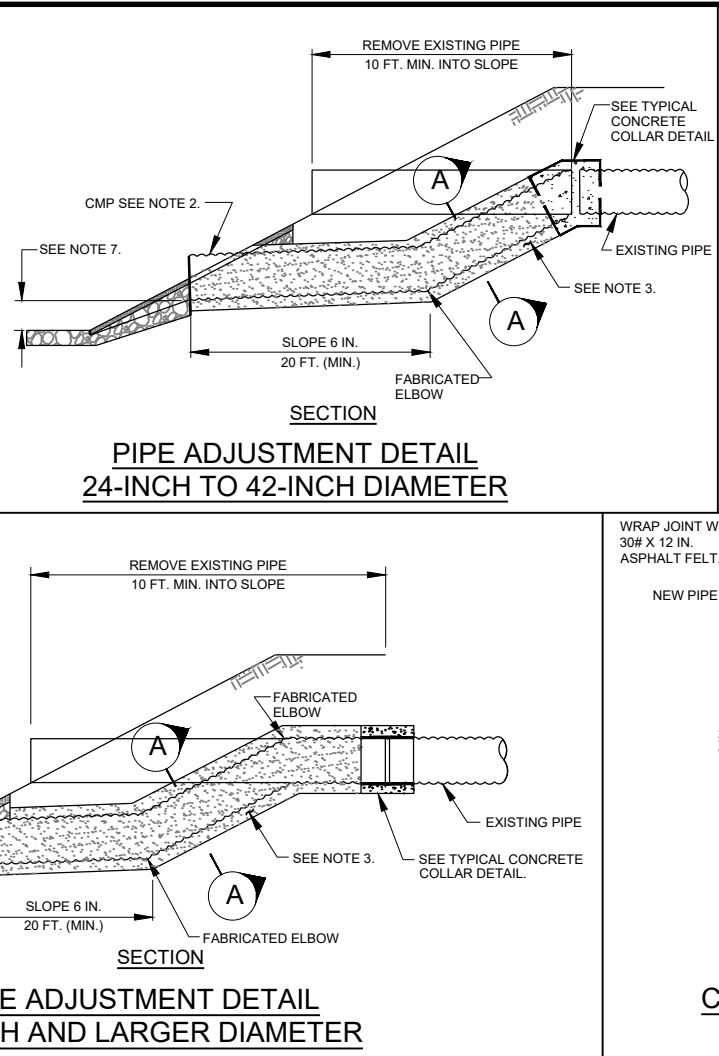
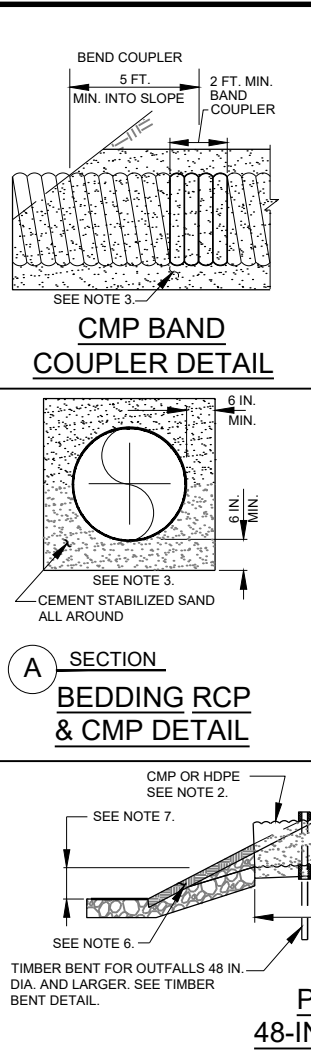
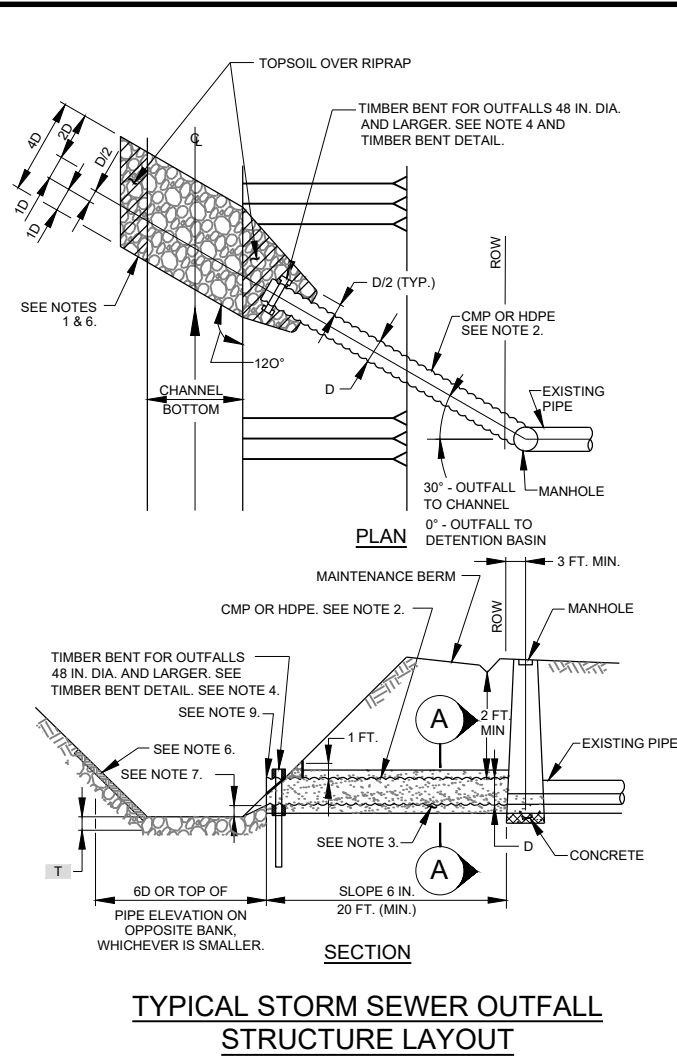
r.g.miller engineers

16340 Park Ten Place
Suite 350
Houston, Texas 77084
(713) 461-9900
TEXAS FPM REGISTRATION NO. F-487

HARRIS COUNTY FLOOD CONTROL DISTRICT

9900 Northwest Freeway
Houston, Texas 77092

DATE: 3/15/2022	SHEET NUMBER
	39 OF 41



PIPE OUTFALL IN CHANNELS

BOTTOM WIDTH	PIPE OUTLET INVERT
6 FEET ≤ BW ≤ 20 FT	1 FOOT ABOVE FLOWLINE *
20 FEET < BW ≤ 60 FT	AT TOE OF SLOPE *
BW > 60 FT	AT TOE OF SLOPE *

* OR 1 FOOT ABOVE NORMAL WATER LEVEL, WHICHEVER IS HIGHER

NOTES:

- INSTALL RIPRAP EROSION PROTECTION IN GRASS LINED CHANNELS AND DETENTION BASINS FOR ANY SIZE STORM SEWER PIPE AND TREATMENT PLANT OUTFALL, DIMENSIONED AS SHOWN IN "TYPICAL STORM SEWER OUTFALL STRUCTURE LAYOUT."
- STORM SEWER OUTFALL PIPES WITHIN THE HCFCO RIGHT-OF-WAY SHALL BE CMP OR HDPE IN ACCORDANCE WITH SPECIFICATION SECTION 02642-CORRUGATED METAL PIPE, HIGH DENSITY POLYETHYLENE PIPE (HDPE) IN ACCORDANCE WITH SPECIFICATION SECTION 02505-HIGH DENSITY POLYETHYLENE PIPE, OR APPROVED EQUAL. USE TABLE BELOW FOR CORRUGATED GALVANIZED STEEL PIPE.
- PROVIDE AND PLACE CEMENT STABILIZED SAND IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02321-CEMENT STABILIZED SAND.
- TIMBER BENTS SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION 02464-TIMBER BENTS.
- EXCAVATION, FILL, AND BACKFILL FOR STORM SEWER OUTFALLS SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION 02316- STRUCTURAL EXCAVATING AND BACKFILLING.
- RIPRAP SHALL BE PLACED IN ACCORDANCE WITH SPECIFICATION SECTION 02378-RIPRAP AND GRANULAR FILL. FILL RIPRAP VOIDS AND BURY RIPRAP A MINIMUM OF 6 INCHES WITH TOPSOIL ON SIDE SLOPE AS DIRECTED BY THE ENGINEER.
- IN DETENTION BASINS, SET FLOWLINE OF OUTFALL AT TOE OF THE SLOPE OR FLOWLINE OF PILOT CHANNEL. IN CHANNEL, USE ELEVATION INDICATED IN THE PIPE OUTFALL IN CHANNELS TABLE.
- STRUCTURAL CONCRETE #4 BARS (GRADE 40) 12 INCH O.C. EACH WAY - FOR COLLARS ONLY. WAIT A MINIMUM OF 24 HOURS AFTER PLACING CONCRETE TO BACKFILL.
- FOR RCP OUTFALL IN GRASS LINED CHANNELS AND DETENTION BASINS, USE HEADWALL/ WINGWALL/APRON DETAIL ON SHEET [REDACTED], FOR RCP OUTFALL IN CONCRETE LINED CHANNEL AND DETENTION BASINS, SEE HCFCO CONCRETE CHANNEL LINING DETAILS.

CORRUGATED GALVANIZED STEEL PIPE (TYPE I)

PIPE DIA. (in.)	2-2/3" X 1/2" CORRUGATION			3" X 1" & 5" X 1" CORRUGATION				
	MIN. FILL* (in.)	SHEET THICKNESS gage (in.)	SHEET THICKNESS (mm)	MIN. FILL* (in.)	SHEET THICKNESS gage (in.)	SHEET THICKNESS (mm)		
24	12	16	.064	1.63	-	-	-	-
30	12	16	.064	1.63	-	-	-	-
36	12	16	.064	1.63	-	-	-	-
42	12	16	.064	1.63	12	16	.064	1.63
48	12	16	.064	1.63	12	16	.064	1.63
54	12	14	.079	2.01	12	16	.064	1.63
60	15	12	.109	2.77	12	16	.064	1.63
66	15	12	.109	2.77	15	16	.064	1.63
72	18	10	.138	3.51	15	16	.064	1.63
78	18	8	.168	4.27	18	16	.064	1.63
84	18	8	.168	4.27	18	14	.079	2.01
90	-	-	-	-	18	14	.079	2.01
96	-	-	-	-	18	14	.079	2.01

* MINIMUM DEPTH OF COVER ABOVE TOP OF PIPE, MAXIMUM DEPTH OF COVER ABOVE TOP OF PIPE IS 20 FEET.

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INTERIM REVIEW ONLY
DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

DATE	APPR	DESCRIPTION	REV

HCFCO UNIT NO. P118-25-00/01
HALLS BAYOU WATERSHED
HCFCO - STORM SEWER & RIPRAP DETAILS

PREPARED: A.V.
CHECKED: M.J.
APPROVED:

r.g.miller engineers
16340 Park Ten Place
Suite 350
Houston, Texas 77084
(713) 461-9900
TEXAS FIRM REGISTRATION NO. F-487

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

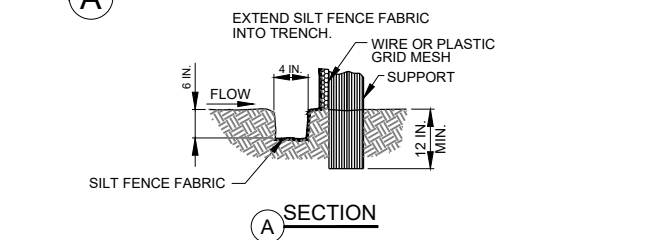
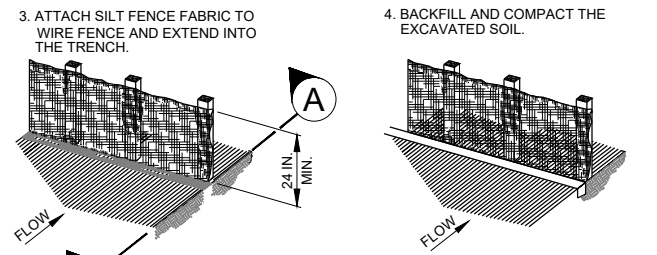
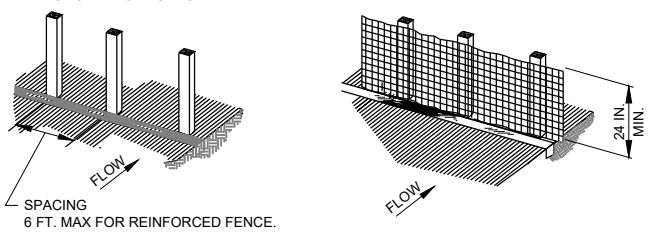
DATE: 3/15/2022

SHEET NUMBER
40 OF 41

3/14/2022 M:\04543.007\118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENT\SCAD\DWG12 - 4543.07 - DETAILS.DWG

3/4/2022 M:\04543.007\118-25-00 & P118-25-01 STORMWATER DETENTION BASIN & CHANNEL IMPROVEMENTS\CADD\DWG12 - 4543.07 - DETAILS.DWG

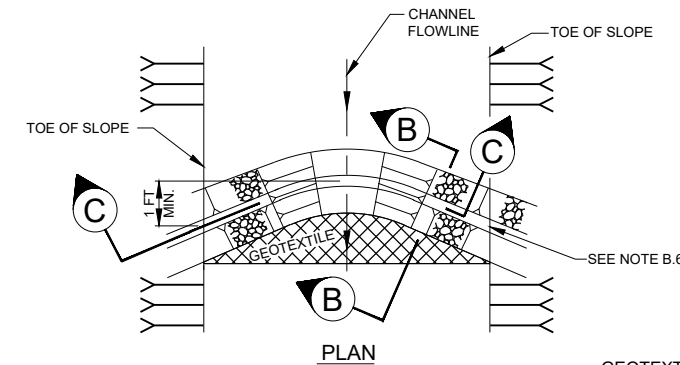
1. SET SUPPORTS AND EXCAVATE 4 IN. X 6 IN. TRENCH UPSLOPE ALONG LINE OF SUPPORTS.
2. SECURE WIRE FENCING TO SUPPORTS.



NOTE:
1. SEE SPECIFICATION SECTION NO. 02361-SILT FENCES.



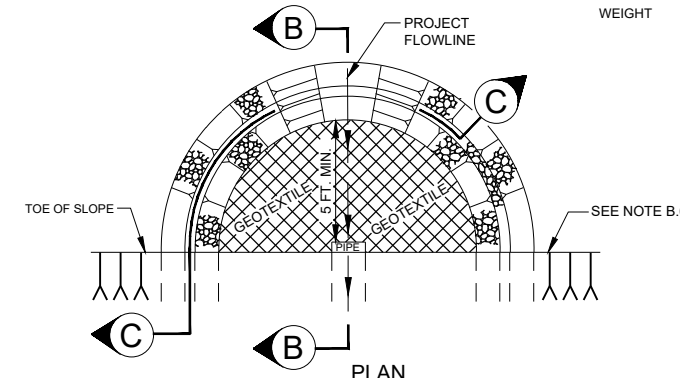
REINFORCED SILT FENCE



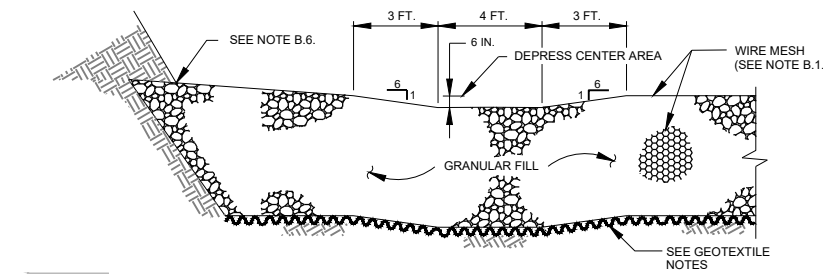
IN-CHANNEL FILTER DAM

GEOTEXTILE NOTES:

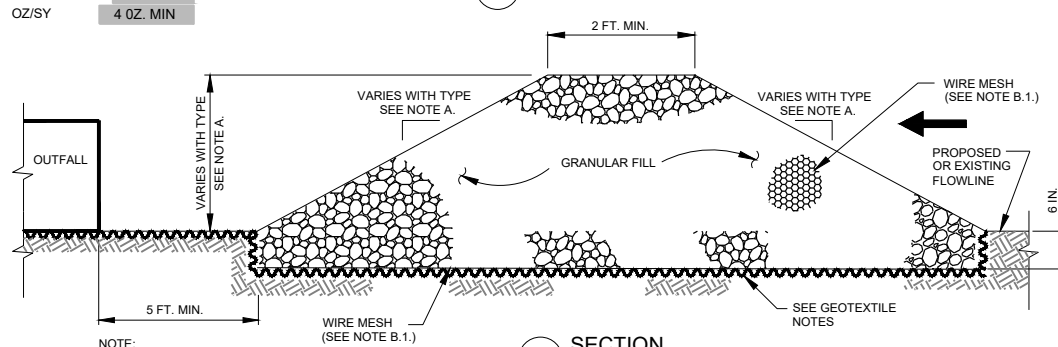
MIN. AOS	SIEVE NO.	120 MIN
MAX. AOS	SIEVE NO.	50 MAX
WEIGHT	OZ/SY	4 OZ. MIN



FILTER DAM AT DETENTION BASIN OUTFALL PIPE



C SECTION

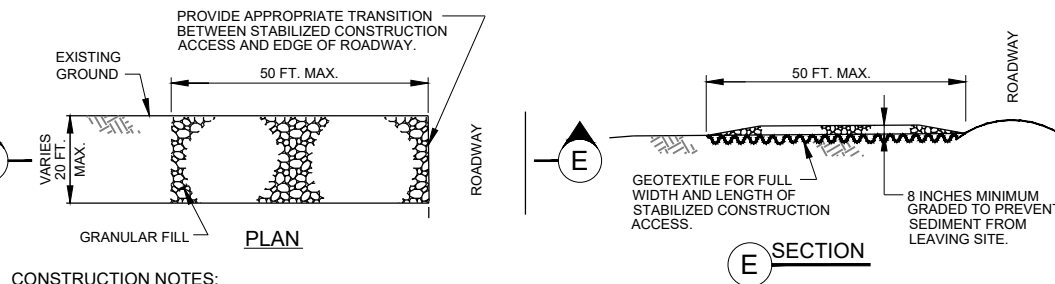


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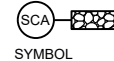
NOTE:
ONLY APPLIES FOR DETENTION BASIN OUTFALL PIPE PROTECTION



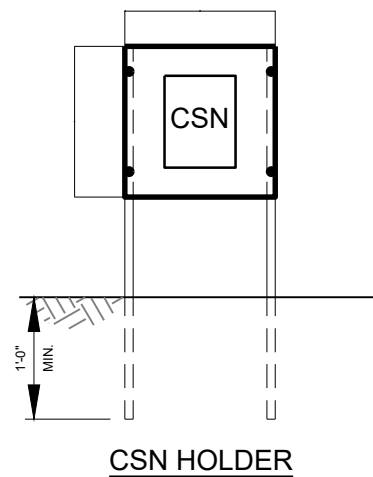
STABILIZED CONSTRUCTION ACCESS



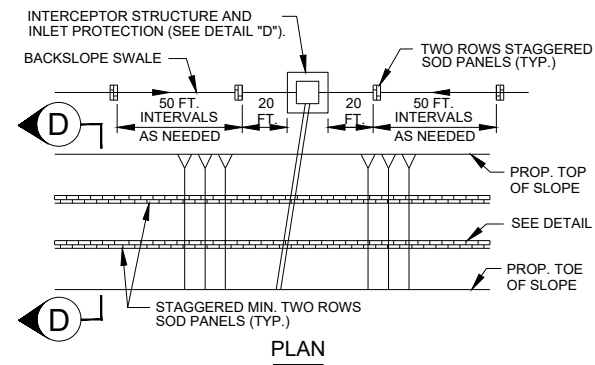
CONSTRUCTION NOTES:
1. SEE SPECIFICATION SECTION NO. 02365-STABILIZED CONSTRUCTION ACCESS.



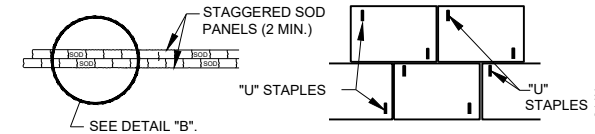
SWPPP / BMP SIGN AND CONSTRUCTION SITE NOTICE HOLDER DETAILS



NOTE:
CONSTRUCT IN ACCORDANCE WITH HCFC D SPECIFICATION SECTION 01580 - PROJECT SIGNS.

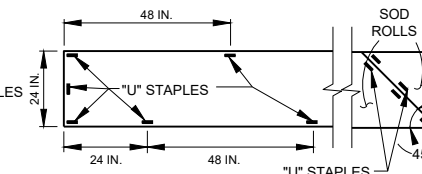


PLAN

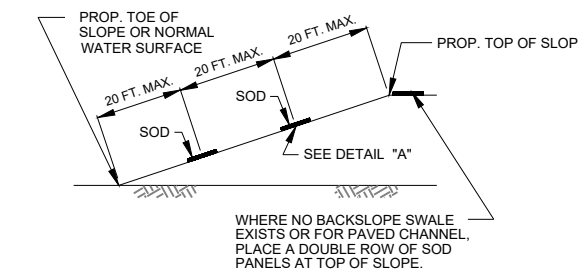


DETAIL "A"

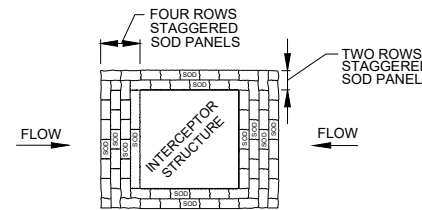
DETAIL "B"



DETAIL "C"



D SECTION



DETAIL "D" INTERCEPTOR STRUCTURE & INLET PROTECTION

SODDING

FILTER DAM NOTES:

- TYPES OF FILTER DAMS
 - TYPE 1 - NOT USED BY HCFC D
 - TYPE 2 (REINFORCED)
 - HEIGHT - 18-36 INCHES. MEASURE VERTICALLY FROM EXISTING GROUND TO TOP OF FILTER DAM.
 - TOP WIDTH - 2 FEET (MINIMUM).
 - SLOPES - 2:1 (MAXIMUM).
 - TYPE 3 - NOT USED BY HCFC D
 - TYPE 4 (GABION)
 - HEIGHT - 30 INCHES (MINIMUM). MEASURE VERTICALLY FROM EXISTING GROUND TO TOP OF FILTER DAM.
 - TOP WIDTH - 2 FEET (MINIMUM).
 - TYPE 5. AS SHOWN ON THE PLANS.
- CONSTRUCT FILTER DAMS ACCORDING TO THE FOLLOWING CRITERIA UNLESS SHOWN OTHERWISE ON THE PLANS.
 - TYPE 2 AND 3 FILTER DAMS: SECURE WITH 20 GAUGE GALVANIZED WOVEN WIRE MESH WITH 1 INCH DIAMETER HEXAGONAL OPENINGS.
 - GRANULAR FILL:
 - PLACE ON MESH TO HEIGHT AND SLOPES SHOWN ON PLANS OR AS SPECIFIED BY THE ENGINEER.
 - 3-5 INCHES FOR ROCK FILTER DAM TYPES 2, AND 4.
 REFER TO GRANULAR FILL IN SPECIFICATION SECTION NO. 02378-RIPRAP AND GRANULAR FILL.
 - WIRE MESH: FOLD AT UPSTREAM SIDE OVER GRANULAR FILL AND TIGHTLY SECURE TO ITSELF ON THE DOWNSTREAM SIDE USING WIRE TIES OR HOG RINGS.
 - IN STREAMS: SECURE OR STAKE MESH TO STREAM BED PRIOR TO AGGREGATE PLACEMENT.
 - SEE SPECIFICATION SECTION NO. 02364-FILTER DAMS.
 - EMBED ONE FOOT MINIMUM INTO SLOPE AND AT SLOPE RAISE ONE FOOT HIGHER THAN CENTER OF DEPRESSED AREA.

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFC D PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFC D WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

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DOCUMENT INCOMPLETE: Not Intended for permit, or construction.
Engineer: Alberto Espinoza
P.E. License No. 133330
DATE: March, 2022

DATE	APPR		
DESCRIPTION			
REV			
HCFC D UNIT NO. P118-25-00/01			
HALLS BAYOU WATERSHED			
HCFC D - STORM WATER POLLUTION PREVENTION PLAN DETAILS			
PREPARED: A.V.	CHECKED: M.J.	APPROVED:	
DATE: 3/15/2022			
SHEET NUMBER			
41 OF 41			

APPENDIX K

VIRTUAL PUBLIC MEETING

PRESENTATION

APPENDIX L

PROJECT SCHEDULE

Activity ID	Activity Name	At Completion Duration	Calendar	Start	Finish	Baseline Finish	Baseline Variance	Total Float	2022												2023												2024											
									D	J	F	M	A	M	J	J	A	S	O	N	D	D	J	F	M	A	M	J	J	A	S	O	N	D	D	J	F	M	A	M	J	J	A	S
Stormwater Detention Basin and Channel Improvements																																												
PROJECT ADMINISTRATION																																												
Project Milestones																																												
P118.PM-100#	Finish Milestone - OVERALL PROJECT	0	Cal Days = 365/Yr	8/9/2024	8/9/2024			0	◆ Finish																																			
3. PRELIMINARY ENGINEERING STAGE																																												
3.B001 Preliminary Engineering - Preliminary Engineering Report (PER)																																												
Preliminary Engineering Report (PER)																																												
1st Submittal																																												
P118.PER-305	RGME - Consultant & HCFCO performs additional H&H analysis & recommendations to incorp RRD flow & mitigation needs	217	Cal Days = 365/Yr	6/24/2021 A	1/26/2022	11/10/2021	-168	27	RGME - Consultant & HCFCO performs additional H&H analysis & recommendations to incorp RRD flow & mitigation needs																																			
P118.PER-307	RGME - Re-evaluate Basin Footprint & HHAnalysis to accomodate reduced ROW takes by RRD	25	Cal Days = 365/Yr	1/27/2022	2/20/2022			27	RGME - Re-evaluate Basin Footprint & HHAnalysis to accomodate reduced ROW takes by RRD																																			
P118.PER-310	RGME - Consultant Prepares & Submits "1st" FINAL Preliminary Engineering Report	14	Cal Days = 365/Yr	2/21/2022	3/6/2022	8/9/2021	-209	27	RGME - Consultant Prepares & Submits "1st" FINAL Preliminary Engineering Report																																			
P118.PER-450	RGME - Revise environmental reports for new project footprint	30	Cal Days = 365/Yr	2/21/2022	3/22/2022			27	RGME - Revise environmental reports for new project footprint																																			
P118.PER-320	RGME - PM Schedules & Conducts Review of "1st" FINAL PE Report at Consultant's Office	2	Cal Days = 365/Yr	3/7/2022	3/8/2022	9/6/2021	-183	27	RGME - PM Schedules & Conducts Review of "1st" FINAL PE Report at Consultant's Office																																			
2nd Submittal																																												
P118.PER-330	RGME - Consultant Prepares & Submits "2nd" FINAL PE Report	7	Cal Days = 365/Yr	3/9/2022	3/15/2022	9/20/2021	-176	27	RGME - Consultant Prepares & Submits "2nd" FINAL PE Report																																			
P118.PER-340	RGME - PM Reviews & Routes "2nd" FINAL Preliminary Engineering Report	7	Cal Days = 365/Yr	3/16/2022	3/22/2022	10/5/2021	-168	27	RGME - PM Reviews & Routes "2nd" FINAL Preliminary Engineering Report																																			
P118.PER-350	RGME - PM Compiles Review Comments to "2nd" FINAL Preliminary Engineering Report & Submits to Consultant	1	Cal Days = 365/Yr	3/23/2022	3/23/2022	10/7/2021	-167	27	RGME - PM Compiles Review Comments to "2nd" FINAL Preliminary Engineering Report & Submits to Consultant																																			
P118.PER-360	RGME - Consultant Written Response to Comments on "2nd Draft" FINAL PE Report & Issue "Completed" FINAL PER	7	Cal Days = 365/Yr	3/24/2022	3/30/2022	10/21/2021	-160	27	RGME - Consultant Written Response to Comments on "2nd Draft" FINAL PE Report & Issue "Completed" FINAL PER																																			
FINAL Preliminary Engineering Report																																												
P118.PER-370	RGME - PM Confirms all Comments are Addressed on the "Completed" FINAL Preliminary Engineering Report	1	Cal Days = 365/Yr	3/31/2022	3/31/2022	10/24/2021	-158	27	RGME - PM Confirms all Comments are Addressed on the "Completed" FINAL Preliminary Engineering Report																																			
P118.PER-410	RGME - PM Provides Draft CC Letter & FINAL PE Report "Package" to Contract Specialist for CC Acceptance	5	HCFCO Workdays	4/1/2022	4/7/2022	11/1/2021	-107	18	RGME - PM Provides Draft CC Letter & FINAL PE Report "Package" to Contract Specialist for CC Acceptance																																			
P118.PER-420	RGME - Contract Specialist Prepares & Routes CC Letter for CC to Accept FINAL Preliminary Engineering Report	5	HCFCO Workdays	4/8/2022	4/14/2022	11/8/2021	-107	18	RGME - Contract Specialist Prepares & Routes CC Letter for CC to Accept FINAL Preliminary Engineering Report																																			
Harris County CC accepts Prelim Eng Report																																												
P118.#PER-430	RGME - Harris County CC Agenda Deadline	0	CC Letter Deadline	4/27/2022	4/27/2022	11/10/2021	-9	2	RGME - Harris County CC Agenda Deadline																																			
P118.#PER-440	RGME - Harris County CC Accepts FINAL Preliminary Engineering Report	1	Cal Days = 365/Yr	4/27/2022	4/27/2022	11/10/2021	-168	20	RGME - Harris County CC Accepts FINAL Preliminary Engineering Report																																			
P118.#PER-440	RGME - Harris County CC Accepts FINAL Preliminary Engineering Report FINISH	0	Cal Days = 365/Yr	4/27/2022	4/27/2022	11/10/2021	-168	20	RGME - Harris County CC Accepts FINAL Preliminary Engineering Report FINISH																																			
4. ROW & UTILITY RELOCATION STAGE																																												
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P118.ROW-100	ROW & Acquisition Stage	964	Cal Days = 365/Yr	8/3/2020 A	3/24/2023	1/24/2023	-59	12	ROW & Acquisition Stage																																			
P118.#ROW-100	ROW & Acquisition Stage Complete	0	Cal Days = 365/Yr		3/24/2023	1/24/2023	-59	12	◆ ROW & Acquisition Stage Complete																																			
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P118.UTIL-100	Utility Relocation Stage	964	Cal Days = 365/Yr	8/3/2020 A	3/24/2023	1/24/2023	-59	12	Utility Relocation Stage																																			
P118.#UTIL-100	Utility Relocation - Utility Relocation Complete	0	Cal Days = 365/Yr		3/24/2023	1/24/2023	-59	12	◆ Utility Relocation - Utility Relocation Complete																																			
5. DESIGN STAGE																																												
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FINAL Design Submittal																																												
P118.Des-120	RGME - PM Requests Purchase Order	30	Cal Days = 365/Yr	4/28/2022	5/27/2022	12/10/2021	-168	20	RGME - PM Requests Purchase Order																																			
P118.Des-#120	RGME - Purchase Order Issued	0	Cal Days = 365/Yr		5/27/2022	12/10/2021	-168	20	◆ RGME - Purchase Order Issued																																			
P118.Des-100	RGME - Final Design NTP	1	Cal Days = 365/Yr	5/28/2022	5/28/2022	12/11/2021	-169	20	RGME - Final Design NTP																																			
P118.Des-105	RGME - Final Design	252	Cal Days = 365/Yr	5/29/2022	2/4/2023	8/19/2022	-169	20	RGME - Final Design																																			
P118.#Des-105	RGME - (MS) Consultant Submits FINAL Design Submittal	0	Cal Days = 365/Yr		2/4/2023*	1/24/2023	-11	20	◆ RGME - (MS) Consultant Submits FINAL Design Submittal																																			
P118.Des-107	RGME - Design Review & Approvals	30	Cal Days = 365/Yr	2/5/2023	3/6/2023	2/23/2023	-11	30	RGME - Design Review & Approvals																																			
6. CONSTRUCTION STAGE																																												
6.G001 Construction - Construction																																												
Contract Bidding																																												
P118.Bid-110	PM Submits "Initiate Bidding (Harris County Purchasing)" form in Kissflow	1	HCFCO Workdays	3/27/2023	3/27/2023	2/24/2023	-21	8	PM Submits "Initiate Bidding (Harris County Purchasing)" form in Kissflow																																			
P118.Bid-120	HCFCO & HC Purchasing Prepare Bid Documents	9	HCFCO Workdays	3/28/2023	4/10/2023	3/9/2023	-21	8	HCFCO & HC Purchasing Prepare Bid Documents																																			
P118.Bid-130	Executive Director Approves Advertising	1	HCFCO Workdays	4/11/2023	4/11/2023	3/10/2023	-21	8	Executive Director Approves Advertising																																			
P118.Bid-140	Noon Deadline for First Advertisement	1	1st Advertise Due	4/17/2023	4/17/2023	3/13/2023	-5	1	◆ Noon Deadline for First Advertisement																																			

Halls Bayou Tributary Unit No. P118-27-00 Alternatives Analysis Summary Report

Harris County Flood Control District



12/18/2020

12/18/2020



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

TIPE Firm No. 2614

Executive Summary

The Harris County Flood Control District (HCFCD) authorized Lockwood, Andrews & Newnam, Inc. (LAN) in March 2020 to conduct an Alternatives Analysis Study on Tributary P118-27-00 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 P118-27-00 catchment 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 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. Existing and Proposed conditions models include two downstream boundary conditions: Normal Depth and Tailwater. For this P118-27-00 Alternatives Analysis, Normal Depth downstream assumption was used for the formulation process and when developing the proposed conditions. However, the Tailwater condition (Stage Hydrograph) was analyzed to evaluate the impacts from the stage in Halls Bayou.

In total, six (6) improvement features were identified as potential flooding mitigation solutions. They include detention basins and channel improvements. They were selected based on their location at hydraulically influential locations, topographically integrable, and are relatively unobtrusive to residents. Three (3) alternatives were developed from the improvement features which were subsequently modeled and evaluated. The proposed improvements were based on the pre-Atlas 14 500-year storm event, which roughly approximates the updated Atlas 14 100-year storm event.

In coordination with HCFCD, LAN recommends Alternative 2 to carry for advancement to a PER Study. Compared to Alternative 1, Alternative 2 is less expensive (\$15.6 million vs. \$25.4 million), and also requires less ROW acquisition, eliminating the need to acquire the parking lot serving Sunny Flea Market. The costs include construction and acquisition of approximately 16 acres of ROW.

Alternative 1 consists of a concrete-lined trapezoidal channel along P118-27-00 with the Shevchenko and Gulf Bank basins in place to provide storage volume and to mitigate increased peak flows. The channel improvements will occur along 3,050 feet of P118-27-00 from the existing concrete-lined channel segment to the Pin Oak Mobile Home Community, having a bottom width of 6 feet with 2:1 side slopes. Alternative 2 achieves nearly the same benefit as Alternative 1 and does not require the Gulf Bank basin ROW acquisition that is required for Alternative 1, making Alternative 2 less expensive by approximately \$9.8 million while still showing substantial benefit. Alternative 3 was designed to provide a viable alternative that did not have as much ROW acquisition needs of the previous alternatives.

Alternative 3 consists of a grass-lined trapezoidal channel along P118-27-00, with the Karen and Dow basins in place to provide storage volume and to mitigate increased peak flows. Alternative 3 does not provide as much benefit as Alternative 2.

Alternative 2 incorporates two features, (1) concrete-lined channel improvements from the existing concrete-lined channel (River Station 3374) to Pin Oak Mobile Home Community (River Station 310), which is approximately 930 feet north of Gulf Bank Road, and (2) the 85 acre-feet Shevchenko Basin located in the footprint of Pin Oak Mobile Home Community. While the Shevchenko basin requires the acquisition and relocation of approximately 124 mobile homes, the entire community is deep within the effective 100-year floodplain of Halls Bayou, with depths exceeding four feet at multiple locations. Two homes in the Pin Oak Mobile Home Community have documented flooding claims, one being flooded during Hurricane Harvey. The neighboring residences directly west of the mobile home community show significant flooding claims, possibly indicating flooding in the mobile home community that was not

P118-27-00 Alternatives Analysis Summary Report

reported. Channel improvements are trapezoidal and concrete-lined with a 6 feet bottom width and 2:1 side slopes, and are designed to minimize ROW acquisition needs along the length of the channel. Four (4) pipelines were also identified crossing perpendicular to P118-27-00 south of Access Road 2 (running along the southern boundary of the Sunny Flea Market). These pipelines will need to be relocated prior to construction of the recommended alternative's proposed improvements.

Locally, Alternative 2 provides a 100-year (pre-Atlas 14 update) level-of-service (LOS), and reduces the number of structures in the floodplain from 154 to 0 (including structural buyouts), and removes all flooded structures based on finished floor elevation (FFE). Alternative 2 results in no adverse impacts to P118-27-00, Halls Bayou, and the surrounding region, up to and including the 500-year storm event (pre-Atlas 14 update).

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1 Introduction

1.1 Purpose

The efforts described in this report are submitted in fulfillment of the services described in the Scope of Services and Fee Proposal of the Professional Services Agreement between Lockwood, Andrews & Newnam, Inc. (LAN) and HCFCD. The overall purpose of this report is to provide a clear and concise summary of the hydrology and hydraulics (H&H) analysis for P118-27-00 – which will recommend a potential HCFCD construction project to improve drainage conditions along P118-27-00 and to mitigate flood risks in the contributing drainage area.

Refer to **Figure 1-1** for the workflow followed in the Alternatives Analysis Study.

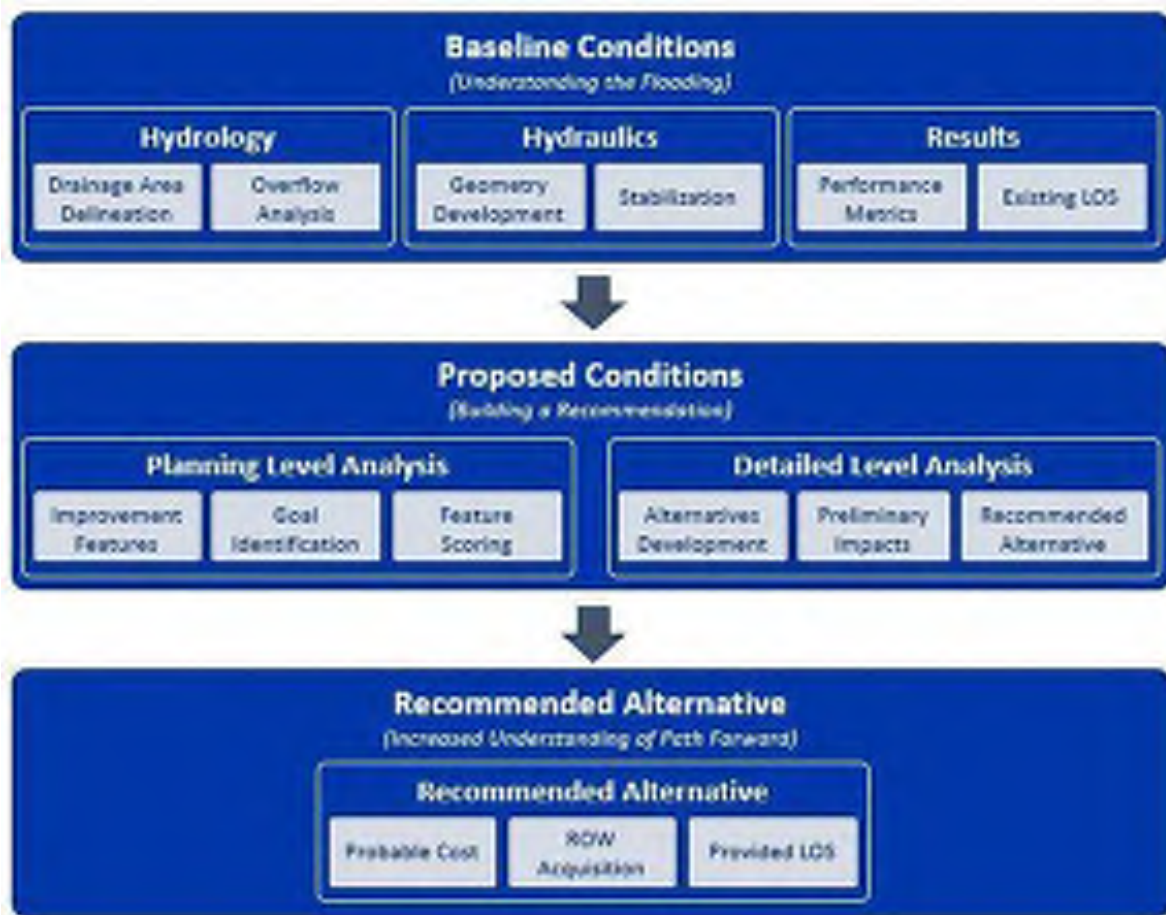


Figure 1-1: Alternatives Analysis Workflow

1.2 Background

Tributary P118-27-00 was identified in the 2018 HCFCD Bond Program for Partnership Projects of Right-of-Way (ROW), design, and construction of channel conveyance improvements. The baseline conditions analysis of the Alternatives Analysis Study is the first step towards identifying what improvements should be made on the tributary.

1.3 Study Area

P118-27-00 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 length of the tributary, beginning upstream at East Canino Road and ending at the confluence with Halls Bayou. The study area has a drainage area of approximately 0.85 square miles (546 acres) and consists of approximately 2.33 miles (12,310 feet) of open channel (P118-27-00: 1.19 miles [6,300 feet]; P118-27-01: 1.14 miles [6,010 feet]). The land use consists primarily of high density and residential development.

2 Baseline Conditions Analysis

2.1 Data Collection

H&H models were developed by LAN as part of the HCFCD Halls Bayou Flood Risk Reduction Phasing Study (LAN, September 2018) utilizing Harris County Appraisal District (HCAD) 2004 parcel data, Houston-Galveston Area Council (H-GAC) 2018 aerial imagery, H-GAC 2008 and 2018 Light Detection and Ranging (LiDAR), channel survey data from Baseline Corporation Professional Surveyors, Federal Emergency Management Agency (FEMA) Effective HEC-RAS and HEC-HMS models, and 2018 Structure Inventory Data from HCFCD. The FEMA Flood Insurance Rate Map (FIRM) for this project is shown in [Exhibit 2](#), HCAD parcel data in [Exhibit 3](#), and available HCFCD Right-of-Way (ROW) information in [Exhibit 4](#).

2.1.1 Prior Studies

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

- FEMA Effective H&H models (FEMA, June 2014). After Tropical Storm Allison in 2001, FEMA and the HCFCD together developed a countywide study, Tropical Storm Allison Recovery Project (TSARP) to assess the flood risks associated with the major flooding sources and that became a Flood Insurance Study (FIS) and Effective Model. As part of the project, FEMA revised the H&H models and remapped the floodplains.
- Halls Bayou flood loss data past storm events (FEMA, HCFCD). Heatmaps based on this data are included in [Appendix B](#). These exhibits depict flood losses from storms Harvey and Imelda, areas of repetitive flood loss, as well as FEMA loss claims in the area. Approximately 298 and 114 flood losses were documented from Harvey and Imelda, respectively, along with 73 repetitive flood losses and 352 FEMA loss claims total. A high concentration of losses were shown south of P118-27-00, as well as multiple instances of repetitive losses in the area.
- Halls Bayou Watershed Flood Risk Reduction Phasing Study (LAN, September 2018). The H&H models from the Phasing Study served as the basis for this Baseline Conditions model development.

2.1.2 Site Conditions / Site Visit

On May 13th, 2020, LAN performed a site visit to photograph and document the drainage area. Major takeaways from the site visit included:

- A 24" outfall pipe going into the upstream end of P118-27-00 at the headwall
- A temporary wood bridge along the pipeline easement upstream of Sunny Flea Market
- The concrete footbridge upstream of Shevchenko Road has been removed by HCFCD
- Culvert blockage by land and dirt build up under Access Road 2 upstream of Sunny Flea Market

Refer to [Figures 2-1](#) through [2-3](#) and [Appendix C](#) for photographic documentation.

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Figure 2-1: 24-inch culvert outfalling into the upstream end of P118-27-00



Figure 2-2: Temporary Pipeline Easement Wood Bridge



Figure 2-3: Culvert blockage under Access Road 1 upstream of Sunny Flea Market

Access Road 1 and Access Road 2 culvert geometries were updated in the model based on site visit photos. Shown in **Figure 2-4** below is a photo of the Access Road 2 culvert with its updated corresponding model geometry. The culverts have been blocked up to a certain depth due to land and dirt blockage seen during the site visit.

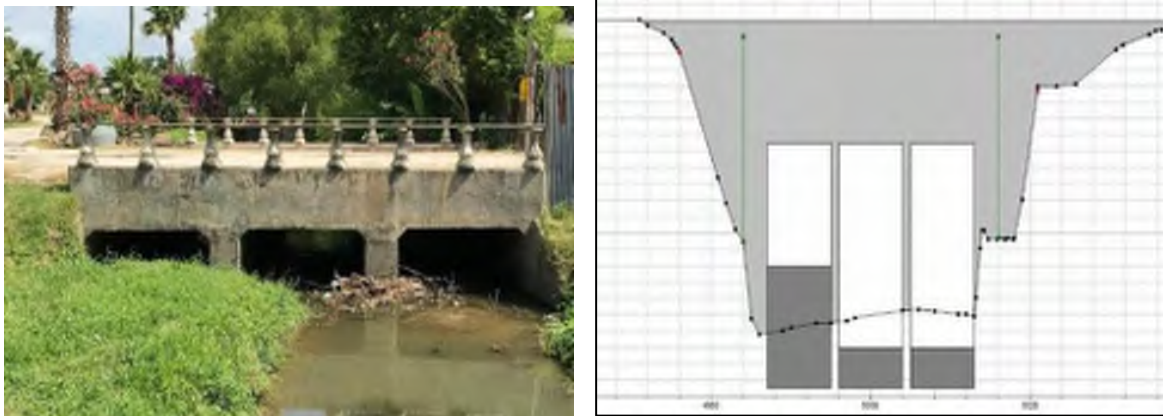


Figure 2-4: Access Road 2 Culvert Blockage

2.1.3 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 P118-27-00, several potential environmental impact sites were noted. There are two identified waste-water treatment facilities (WWTF) located along P118-27-00: Balaban

Apartment WWTF in the north, and Durke Manor WWTF toward the south end on the east bank. Canino Motorworks, located at the upstream end of P118-27-00, is also identified as a potential Priority 3 Hazardous Materials site. These facilities may influence potential ROW acquisition decisions at their locations.

Four (4) pipelines were also identified crossing perpendicular to P118-27-00 south of Access Road 2 (running along the southern boundary of the Sunny Flea Market). Sizes range from 8" to 20" in diameter and are owned by ExxonMobil (3) and Magellan (1). These pipelines are currently located below the existing P118-27-00 channel, though during the May 13th, 2020 site visit it appeared construction was underway throughout the pipeline corridor. These pipelines will need to be relocated prior to construction of the recommended alternative's proposed improvements, with a pipeline relocation cost of \$683,500. The pipeline relocation cost estimate was provided by CobbFendley and can be seen in [Appendix H](#).

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 conducted both a Preliminary Wetland and Threatened and Endangered Species Habitat Assessment, and a Phase I Environmental Site Assessment Report. These can be found in [Appendix I](#) & [Appendix J](#) respectively. There are no environmental concerns within the proposed improvements area for the recommended alternative.

2.2 Hydrology and Hydraulics Analysis

The methodology used to study the P118-27-00 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 P118-27-00 standalone model. The Baseline Conditions model will establish an existing condition for conducting a flood risk assessment within the P118-27-00 watershed.

2.2.1 Hydrology

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

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

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

2.2.1.1 Drainage Area Delineation

The effective model sub-basin that covers P118-27-00 is named "P118J". The drainage area was further subdivided into four (4) smaller areas, representing flow change locations, which are serving to provide appropriate boundary conditions for the dynamic HEC-RAS model.

P118-27-00 Alternatives Analysis Summary Report

To re-evaluate the delineation of drainage area “P118J” and drainage subdivides, LAN developed a Rain-on-Mesh model in HEC-RAS, where precipitation is applied directly to the surface to determine overland flow paths. This procedure was conducted for the 10-, 50-, 100-, and 500-year storm events. **Figure 2-5** shows the result of a 100-year storm event with HEC-RAS’s particle tracking feature to show flow paths and the contributing area draining to the P118-27-00 channel. Flow change locations in the HEC-RAS model were connected to the HEC-HMS’s Data Storage System (DSS) output for sub-basin P118J. Multipliers were set based on area-based ratios of subdivided drainage areas (HCFCD, March 2018).

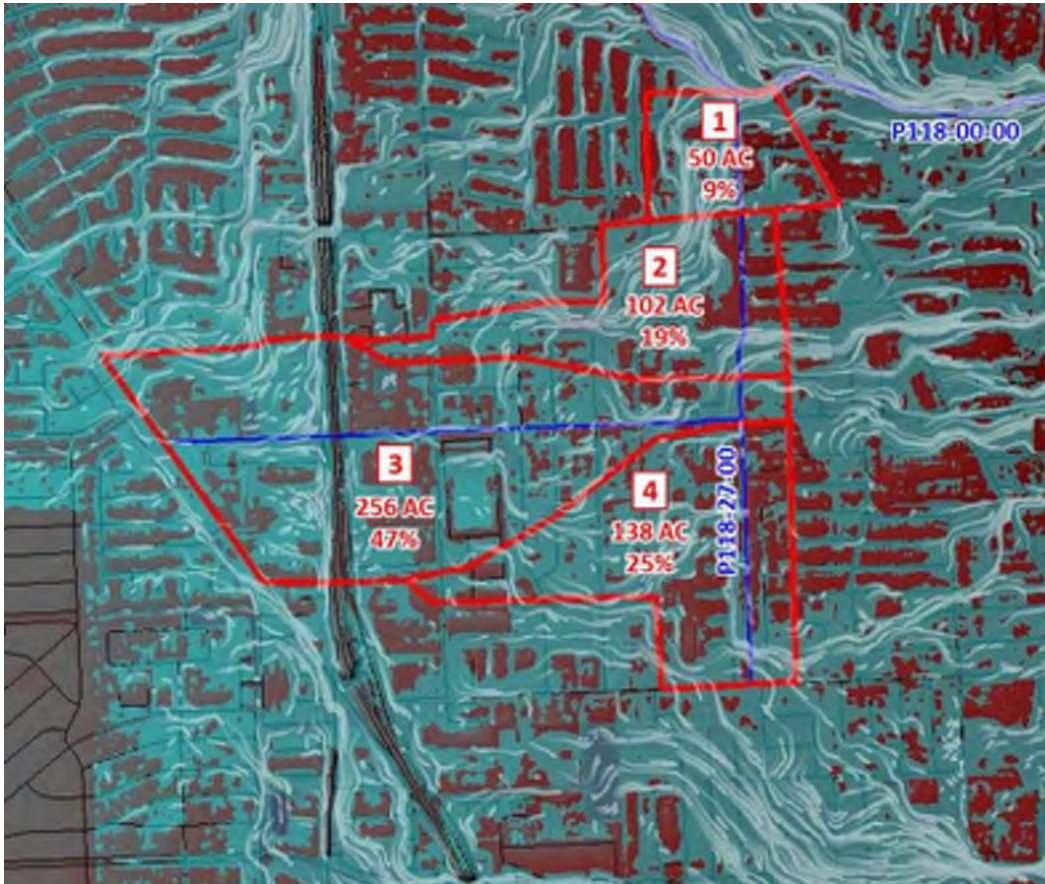


Figure 2-5: P118-27-00 Drainage Area “P118J” with Subdivides – HEC-RAS Rain-on-Mesh Model (100-Year Rainfall Event)

Analysis by LAN indicated that the existing 683-acre (1.07 square miles) drainage area of P118J required boundary adjustments. Consideration was given to the results from the Rain-on-Mesh model, as well as available storm sewer and roadside ditch information. Drainage area boundaries in the north, west and south corners were adjusted based on these factors. In total, approximately 136 acres (0.22 square miles) were removed from the subbasin. P118J now consists of approximately 546 acres. The P118J subbasin subdivides were minorly adjusted based on the removed area. Refer to **Exhibit 6** for the removed areas and **Exhibit 7** for the drainage area delineation subdivides.

2.2.2 Hydrograph Development

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

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throughout this analysis and was consistent with the Effective M3 hydrologic model development. Harris County Appraisal District (HCAD) 2004 parcel data, used in the development of the Halls Federal General Revaluation Report (GRR) and Halls Ahead Vision Studies, and 2019 aerial imagery were referenced to verify and update the land use parameters. Percent impervious and Percent Land Urbanization (DLU) were calculated by digitizing the land use categories from HCAD 2004 parcel data and verified based on 2019 aerial imagery. Subbasin area, watershed length and length to centroid were updated to reflect the modified P118J subbasin. Time of Concentration (TC) & Storage Coefficient (R) parameters were developed using the HCFCD hydrologic methodology (HCFCD 2009). Channel slope and overland slope values were updated based on 2008 LIDAR data. Subbasin P118J encompassed the P118-27-00 drainage area and had TC&R values of 1.39 hours and 4.19 hours, respectively.

The Baseline Conditions HEC-HMS model was used to generate hydrographs, which were then ratioed for each subbasin based on their percentage of total contributing drainage area. Refer to **Table 1** and Section 2.2.2.5 for resulting ratio of peak flows and its application in the HEC-RAS Baseline Conditions model.

Table 1: Prorated Flows by Percent Area

Sub-Area	Drainage Area Acres (sq. mi.)	Drainage Area (%)	500-year Peak Flow (cfs)
1	50 (0.08)	9%	91
2	102 (0.16)	19%	192
3	256 (0.40)	47%	474
4	138 (0.22)	25%	252
Total	546 (0.85)	100%	

2.2.3 Hydraulics

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

As a starting point for the Baseline Conditions model, LAN used a fully 1D unsteady standalone model of P118-27-00 that was developed as part of the Halls Bayou Phasing Study. LAN was scoped to convert this model from HEC-RAS Version 5.0.3 to Version 5.0.5, modify the hydraulic 1D model to a combined 1D/2D model, and stabilize the model for the 10-, 50-, 100-, and 500-year return period. In addition, two downstream boundary conditions were analyzed: Scenario #1: Assuming that P118-27-00 is *not* influenced by Halls Bayou at river confluence (Normal Depth assumption), and Scenario #2: Assuming that P118-27-00 is influenced by Halls Bayou (Stage Hydrograph).

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2.2.3.1 1D Channel Geometry

In the Halls Bayou Phasing Study, channel cross-sections for the fully 1D unsteady standalone model of P118-27-00 were created based on terrain data from 2008 LiDAR and channel surveys. Several steps were taken to convert that model to a combined 1D/2D model. Ineffective flow areas were added and modified as needed, and 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. Manning's n values were set to 0.040 and 0.013 for grass-lined and concrete-lined portions of the channel, respectively (HCFCD, July 2019). **Figure 2-6** shows an example of the geometry and RAS Mapper view of the 1D cross-sections for the Baseline Conditions Model.

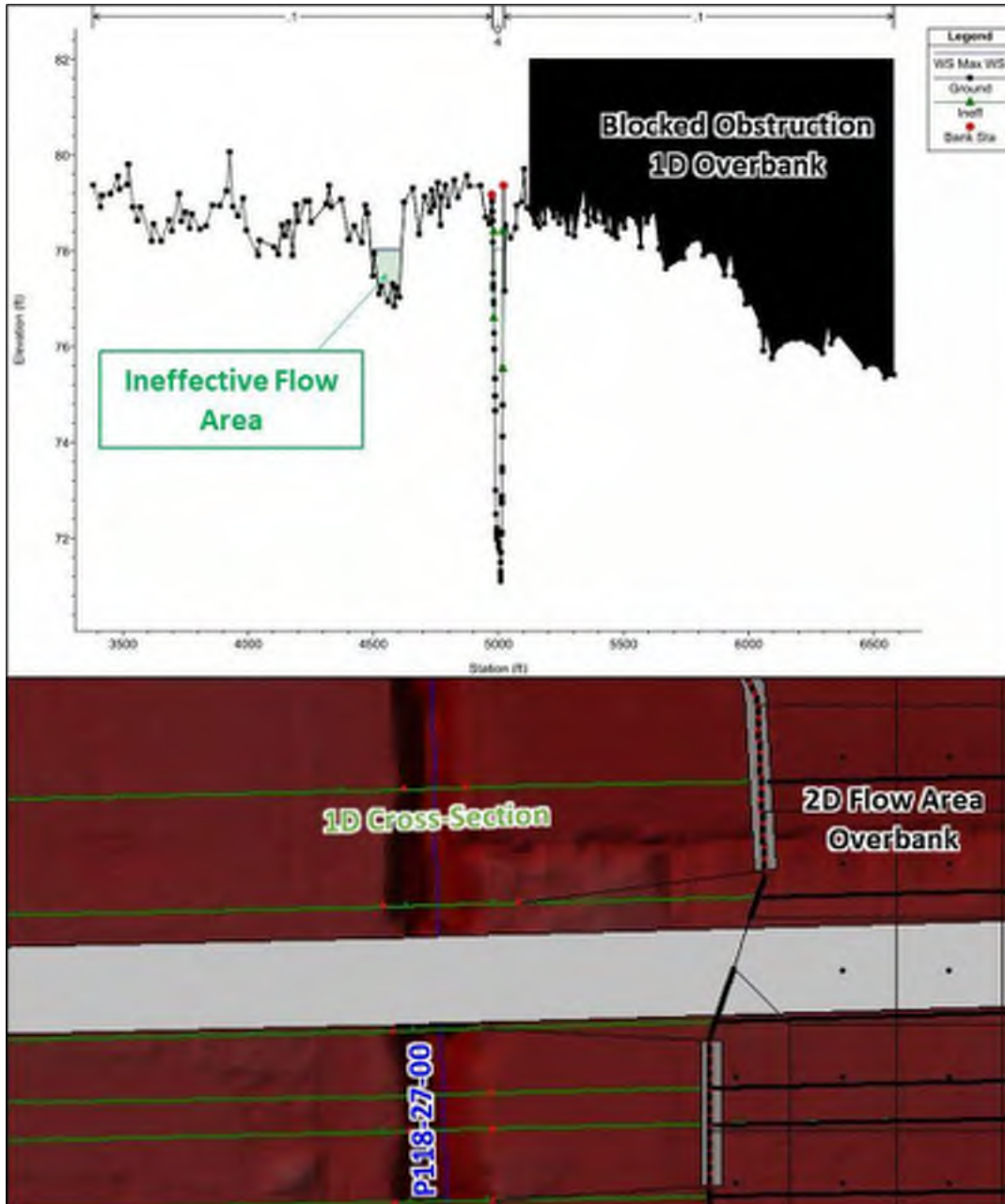


Figure 2-6: HEC-RAS Baseline Conditions Model Geometry – 1D Cross-Sections

2.2.3.2 2D Flow Areas

LAN created one initial 2D flow area located partially within subbasin P118J for the Baseline Conditions model with a 50 square foot cell size – refer to **Figure 2-7**. The 2D flow area extends outside of the P118-27-00 drainage area to capture overflow flowing out of the channel banks and cascading outside of the drainage area. East of P118-27-00, the 2D flow area is bound to the north by West Gulf Bank Road, to the south by East John Alber Road, to the west by P118-27-00, and extends approximately 1,650 feet east of P118-27-00. West of P118-27-00, the 2D flow area is bound to the south by Meadowlink Street, to the east by P118-27-00, and extends approximately 1,950 feet north of Meadowlink Street and approximately 970 feet west of P118-27-00. As per HCFCD’s “2D Modeling Guidelines”, break lines were created for all major roadways contained within the new 2D mesh boundaries.



Figure 2-7: 2D Flow Area

2.2.3.3 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 placed lateral structures on left and right banks between inline structures along the entire length of the tributaries. For the weir coefficients of the lateral structures and 2D connectors, Table 3-1 of the HEC-RAS 2D Manual recommended 0.2 to 0.5 for flow escaping the main river (USACE, February 2016). Refer to **Figure 2-8** and **Exhibit 8** for the final Baseline Conditions combined 1D/2D HEC-RAS geometry.

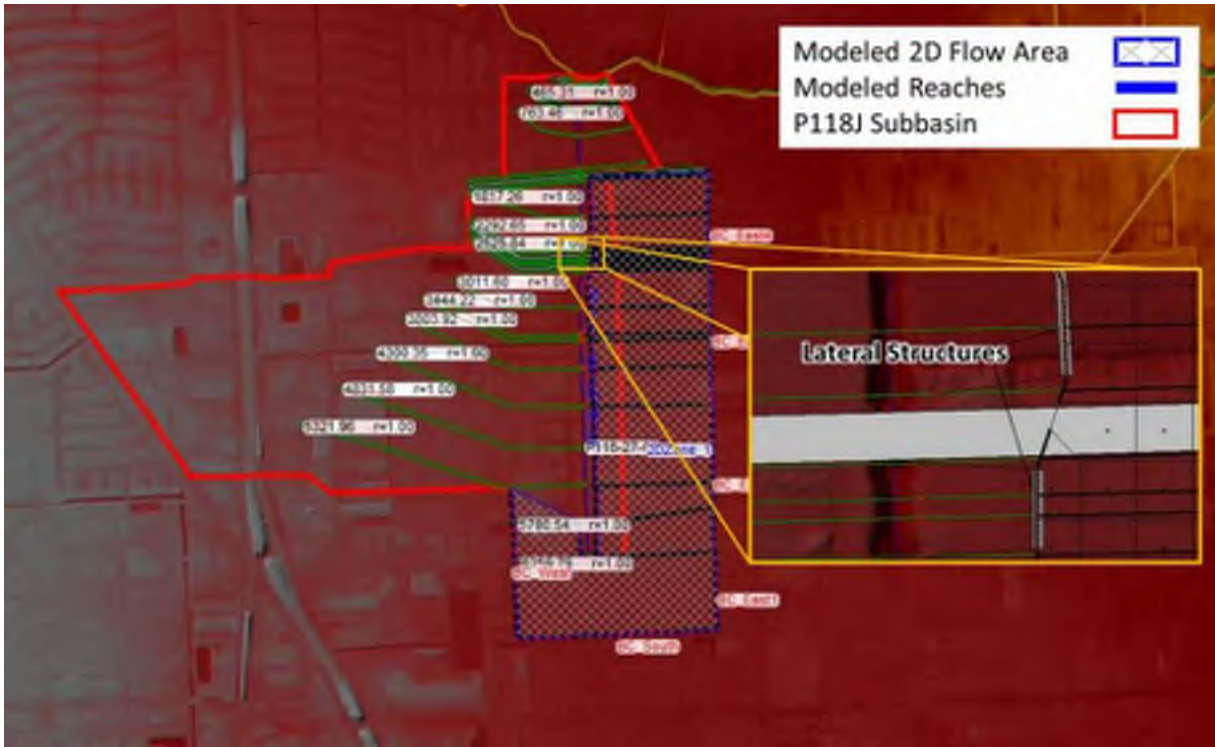


Figure 2-8: HEC-RAS Baseline Conditions Model Geometry – Lateral Structures

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2.2.3.4 Tailwater Conditions

Two tailwater boundary conditions scenarios were modeled: (1) assuming the WSEL of P118-27-00 is not influenced by tailwater conditions of Halls Bayou (Normal Depth assumption), and (2) assuming the WSEL of P118-27-00 is influenced by tailwater conditions of Halls Bayou using stage hydrographs computed from Halls Bayou Phasing Study at the P118-27-00 outfall.

For Scenario #1, LAN applied a normal depth channel slope representative of the average slope along P118-27-00. The normal depth scenario essentially assumes that Halls Bayou does not have backwater flowing into P118-27-00, allowing P118-27-00 to gravity drain freely. Because Halls Bayou tributaries are highly influenced by tailwater conditions in the Halls Bayou mainstem, Scenario #2 uses a stage hydrograph boundary condition pulled from the cross-section just upstream of the confluence with P118-27-00 in the Halls Phasing Study Baseline Conditions model. **Figure 2-9** shows the significant influence Halls Bayou has on P118-27-00, with a maximum increase in WSEL of nearly 12 feet at the downstream end for a 500-year storm event. Scenario #2 is included to demonstrate the significant influence of Halls Bayou on the tributary. Proposed improvements will be based on Scenario #1, ensuring that P118-27-00 can convey flow efficiently during local storm events without the influence of Halls Bayou tailwater.

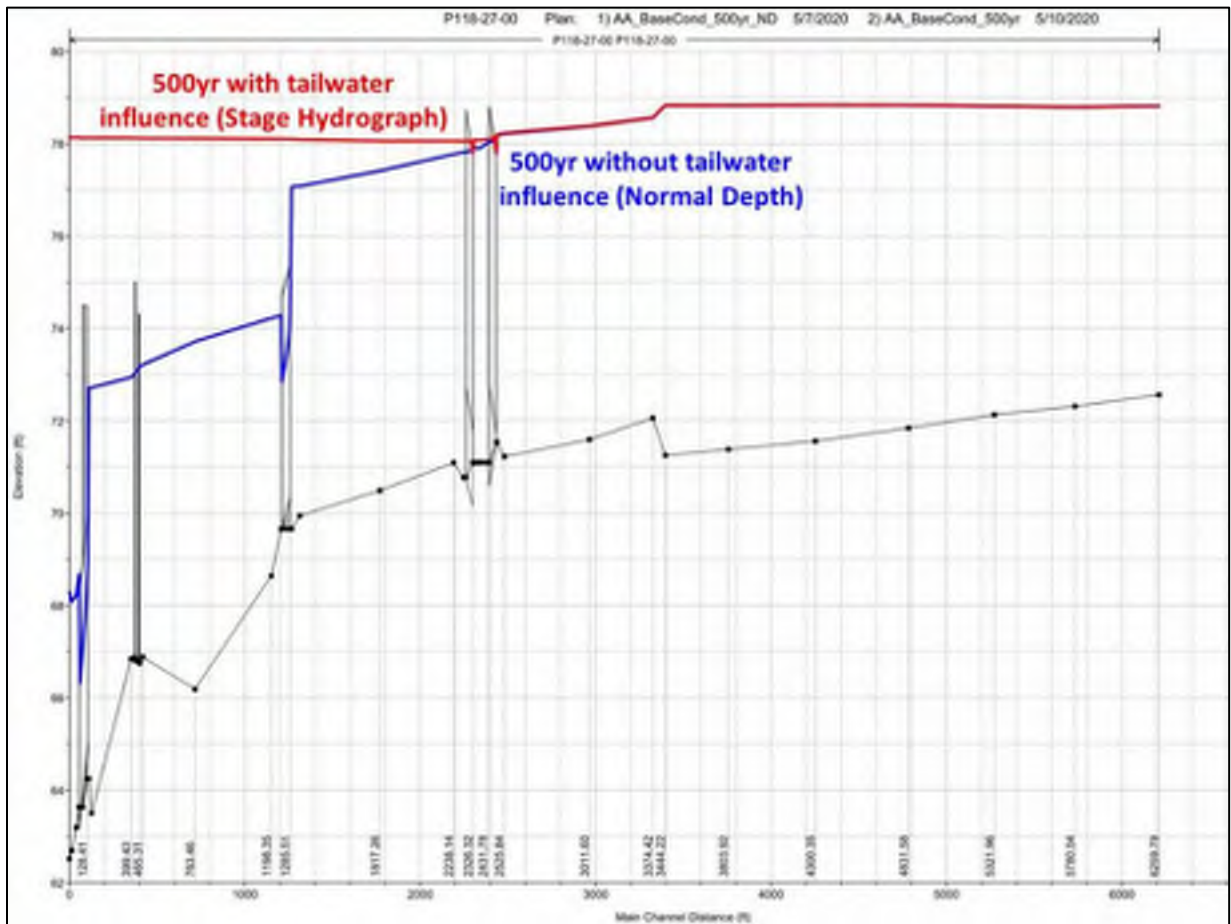


Figure 2-9: Halls Bayou Influence on WSEL of P118-27-00 – 500-Year Storm Event

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2.2.3.5 Inflow Boundary Conditions

Inflow hydrographs are applied via boundary conditions using DSS connections to the Baseline Conditions HEC-HMS model. **Table 2** provides a summary of the HEC-RAS inflow connections. Note: a baseflow of 5 cfs was added at river station (RS) 6259.79 to keep the cross-section from going dry for model stability.

Table 2: Baseline Conditions HEC-RAS Unsteady Flow Connections

#	Reach	River Station	HEC-RAS Boundary Condition	HEC-HMS Subbasin	Multiplier	500-year Peak Flow (cfs)
1	P118-27-00	6259.79	Flow Hydrograph	P118J	-	5
2	P118-27-00	5780.54	Uniform Lateral Inflow	P118J	0.25 (25%)	252
3	P118-27-00	3444.22	Lateral Inflow Hydrograph	P118J	0.47 (47%)	474
4	P118-27-00	3011.60	Uniform Lateral Inflow	P118J	0.19 (19%)	192
5	P118-27-00	1255.05	Uniform Lateral Inflow	P118J	0.09 (9%)	91
6	P118-27-00	47.31	Normal Depth	P118J	-	-

2.2.3.6 Model Stabilization

In general, there were few model stabilization challenges with the P118-27-00 hydraulic model. Some basic modeling techniques were performed to help stability, including adding a baseflow at the initial start of the model, updating HTab parameters, and maintaining adequate cross-section spacing.

2.2.4 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 (**Figure 2-10**). The 2018 LiDAR also shows land improvements constructed over the past ten years.

To compare the effects of using the new data, the raster calculator tool in GIS was used to calculate the elevation differences in the P118-27-00 project area. Elevation differences between the two datasets were found to be ranging from approximately 1-3 feet along the channel banks for the entire length of P118-27-00. After further evaluation, LAN concluded that there is a shift between the two LiDAR datasets. On the east side of P118-27-00 the 2018 LiDAR elevations are greater than that of the 2008 LiDAR, and on the west side of P118-27-00 the 2018 LiDAR elevations are less than that of the 2008 LiDAR by the same difference. The overall standard deviation between the two datasets falls within the margin of error. Areas along the channel banks outside of the margin of error fall within a standard deviation of 4-6 inches; this is due to the shift in the dataset. There are no significant differences between the two LiDAR datasets within the P118-27-00 project area.

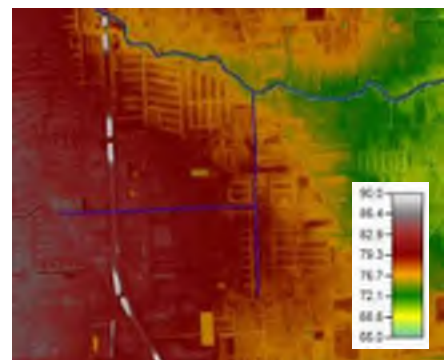
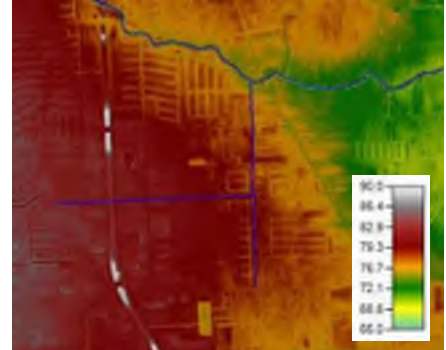


Figure 2-10: 2008 (Top) and 2018 (Bottom) LiDAR of the P118-27-00 Project Area

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 catchment. Maximum ponding extents and depths along with performance metrics for all four storm events can be seen in **Exhibits 9** through **16** for the normal depth and stage hydrograph condition. Water surface profiles for all four storm events can be seen in **Appendix A**.

2.3.1 Overflow Analysis

In larger storm events, a significant amount of stormwater from P118-27-00 overflows eastward out of the channel, ultimately sheet-flowing into P118-23-00. Stormwater also overflows to the south at the upstream end of P118-27-00 into several neighborhoods including Bellmar Estates, Durkee Manor, and Assumption Heights. **Exhibits 9** through **16** show the locations and magnitude of these overflow locations. Based on the hydraulic analysis, the undersized channel and culverts near Gulf Bank Road play a significant role in restricting the conveyance of stormwater toward Halls Bayou, resulting in these overflows. This effect can be seen in the hydraulic profiles in **Appendix A**, where high headlosses are observed around the Gulf Bank Road crossing. From this profile it should also be noted that the concrete-lined channel in the upstream reach of P118-27-00 results in a relatively flat WSE. This suggests that further improvements to this section of channel would not significantly reduce WSEs in the upstream reaches, until the constriction near Gulf Bank Road is first addressed.

2.3.2 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 four design storms (10-, 50-, 100-, and 500-year) for the Normal Depth downstream boundary conditions (without tailwater influence from Halls Bayou) to GIS and intersected with the 2018 HCFCDD 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 StarMaps roadway centerline shapefile. Refer to **Table 3** for a summary of the Baseline Conditions performance metrics for the 10-, 50-, 100-, and 500-year storm events.

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Table 3: Baseline Conditions Performance Metrics – Normal Depth Boundary Condition

Metric	10-year Floodplain	50-year Floodplain	100-year Floodplain	500-year Floodplain
Structures in Floodplain	4	84	154	303
Flooded Structures (based on FFE)	0	10	15	53
Miles of Inundated Road	1.5	3.2	3.7	4.7
Acres of Inundated Land (Floodplain)	33	88	114	168

All performance metrics were calculated within the boundaries of the subbasin P118J and the 2D flow area extending outside the drainage boundary. The 2D flow area was included in the performance metrics calculations due to significant overflows cascading eastward from P118-27-00 primarily into Bellmar Estates and Assumption Heights neighborhoods and south of East Canino Road. Although the flooding outside of the P118J drainage boundary does not account for rainfall, it shows the considerable amount of overflow coming out of P118-27-00. The analysis of the 500-year Floodplain shows that 95% of flooded structures experience flooding at inundation depths between 0.0 – 0.5 feet.

2.3.3 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 10-, 50-, 100-, and 500-year return period. **Figure 2-11** and **Exhibit 17** demonstrate existing LOS for the Normal Depth boundary condition. Approximately 0.94 miles (79%) of P118-27-00 has a LOS of less than 10 years. A 50-Year LOS is provided by P118-27-00 at the downstream end for approximately 0.25 miles (21%) of the tributary.

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Figure 2-11: P118-27-00 Existing LOS (without Halls Bayou Influence)

The culverts at the Gulf Bank Road crossing contribute to P118-27-00's poor LOS. In the 10-year storm event, there is nearly three feet of headloss at these culverts, indicating they are undersized. This results in high WSELs, particularly upstream of Gulf Bank Road, forcing water out of banks further upstream in the channel. Water surface profiles for all four storm events can be seen in [Appendix A](#). A summary of Baseline Conditions WSELs at roadway crossings along P118-27-00 is shown in [Table 4](#).

Table 4: Baseline Conditions WSELs at Roadway Crossings

Road	Type	High Chord (ft)	Low Chord (ft)	WSEL (ft)			
				10-yr	50-yr	100-yr	500-yr
Access Road 2	3-8'x6' RCB	79.2	N/A	77.37	77.89	78.03	78.33
Access Road 1	3-8'x6' RCB	79.2	N/A	77.15	77.56	77.67	77.88
W. Gulf Bank Road	2-60" RCP	77.9	N/A	76.16	76.67	76.79	77.02
N/A	Bridge	74.9	73.9	72.22	72.89	73.15	73.78
N/A	Bridge	76.6	75.0	72.13	72.82	73.08	73.72
Shevchenko	2-60" RCP	74.5	N/A	71.69	72.50	72.80	73.52

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 P118-27-00 service area and total flows are not considered as part of this analysis unless explicitly stated. All alternatives include planned improvements to the Gulf Bank Road crossing which are currently under design by Harris County. The Baseline Conditions HEC-RAS model was used as a starting point for developing the various Proposed Conditions models.

3.1 Alternatives Development

LAN started by identifying potential improvement features and estimated their effectiveness in the planning level analysis. After the planning level analysis was completed, LAN combined various features to form alternatives in the detailed alternatives analysis as described in Section 3.3.

3.2 Planning Level Drainage Improvement Features

LAN identified six drainage improvement features along P118-27-00 (see **Figure 3-1**). They include two channel improvement features (1, 2) and four detention basins (3-6). Once identified, features are to be combined to make up different parts of each alternative. The location and size of the drainage improvements were based on (1) most hydraulically influential locations, (2) topography of the watershed, (3) best availability of ROW, and (4) least infrastructural and environmental intervention.

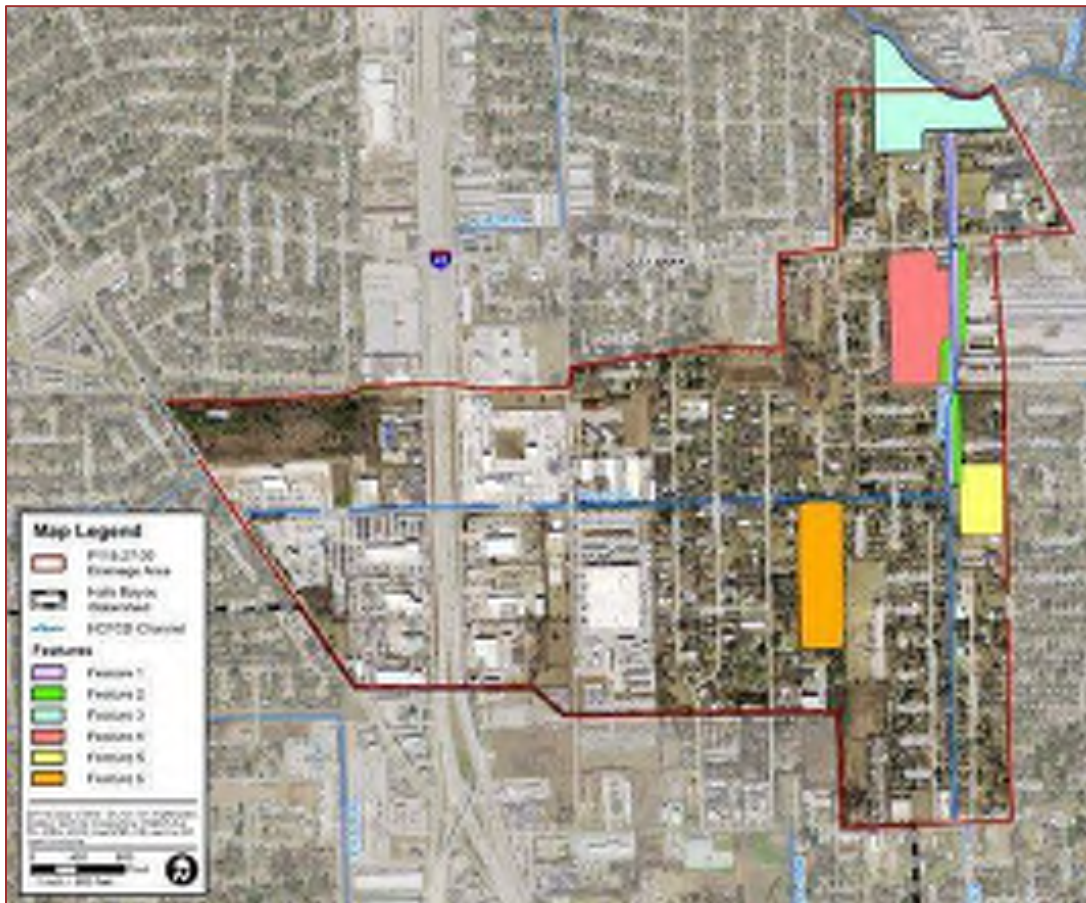


Figure 3-1: Combined Features Map

3.2.1 Feature 1 – Concrete-lined Channel Improvements

Feature 1 improvements will be implemented from the existing concrete-lined channel segment to Pin Oak Mobile Home Community (see **Figure 3-2**). It attempts to maximize the capacity of the P118-27-00 channel while minimizing the additional ROW required. The proposed channel improvement will be a concrete trapezoidal design with a bottom width of 6 feet and 2:1 side slopes. The channel slope is approximately 0.22%. Culverts and boxes were adjusted as necessary per alternative.



Figure 3-2: Feature 1 – Concrete-lined Channel Improvements

3.2.2 Feature 2 – Grass-lined Channel Improvements

Feature 2 improvements will be implemented from the existing concrete-lined channel segment to Gulf Bank Road. (see **Figure 3-3**). It attempts to maximize the capacity of the P118-27-00 channel with a grass-lined engineered channel design. The proposed channel improvement has a bottom width of 6 feet and 4:1 side slopes. The channel slope is approximately 0.07%. Culverts and boxes were adjusted as necessary per alternative.



Figure 3-3: Feature 2 – Grass-lined Channel Improvements

3.2.3 Feature 3 – Detention Basin “Shevchenko”

Shevchenko Detention Basin is located just south of Halls Bayou at the Pin Oak Mobile Home Community (see **Figure 3-4**). The basin has a designed depth of 11 feet and provides a storage volume of approximately 85 acre-feet with 1-foot of freeboard. A total of 13.6 acres would be necessary to be acquired by HCFCD for ROW, and there are currently 123 structures within the basin’s footprint. It should be noted that all of the 123 structures are within the effective 100-year floodplain of Halls Bayou, and 50 of them also reside in the effective floodway. Flood depths of over 4 feet are shown in this location. Two homes in the Pin Oak Mobile Home Community have documented flooding claims, one being flooded during Hurricane Harvey. The neighboring residences directly west of the mobile home community show significant flooding claims, possibly indicating flooding in the mobile home community that was not reported.

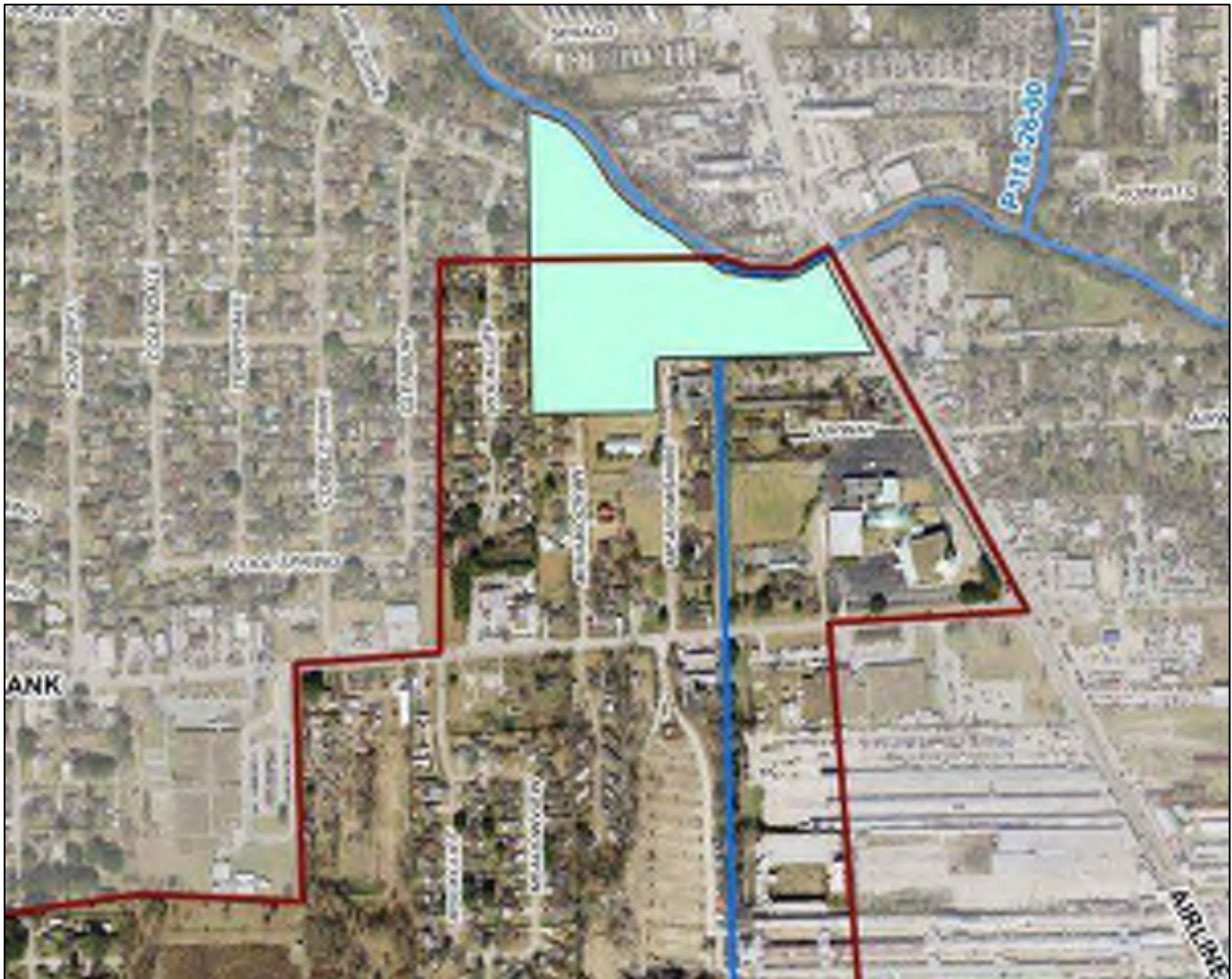


Figure 3-4: Feature 3 – Detention Basin “Shevchenko”

3.2.4 Feature 4 – Detention Basin “Gulf Bank”

Gulf Bank Detention Basin is located just south of Gulf Bank Road and west of Sunny Flea Market (see **Figure 3-5**). The basin has a designed depth of 8 feet and provides a storage volume of approximately 65 acre-feet with 1-foot of freeboard. A total of 13.2 acres would be necessary to be acquired by HCFCF for ROW, and there are currently 16 structures within the basin’s footprint and a parking lot that serves Sunny Flea Market.



Figure 3-5: Feature 4 – Detention Basin “Gulf Bank”

3.2.5 Feature 5 – Detention Basin “Karen”

Karen Detention Basin is located south of Sunny Flea Market, on the east side of P118-27-00 (see **Figure 3-6**). The basin has a designed depth of 7 feet and provides a storage volume of approximately 20 acre-feet with 1-foot of freeboard. A total of 5.5 acres would be necessary to be acquired by HCFCD for ROW, and there are currently 5 structures within the basin’s footprint.

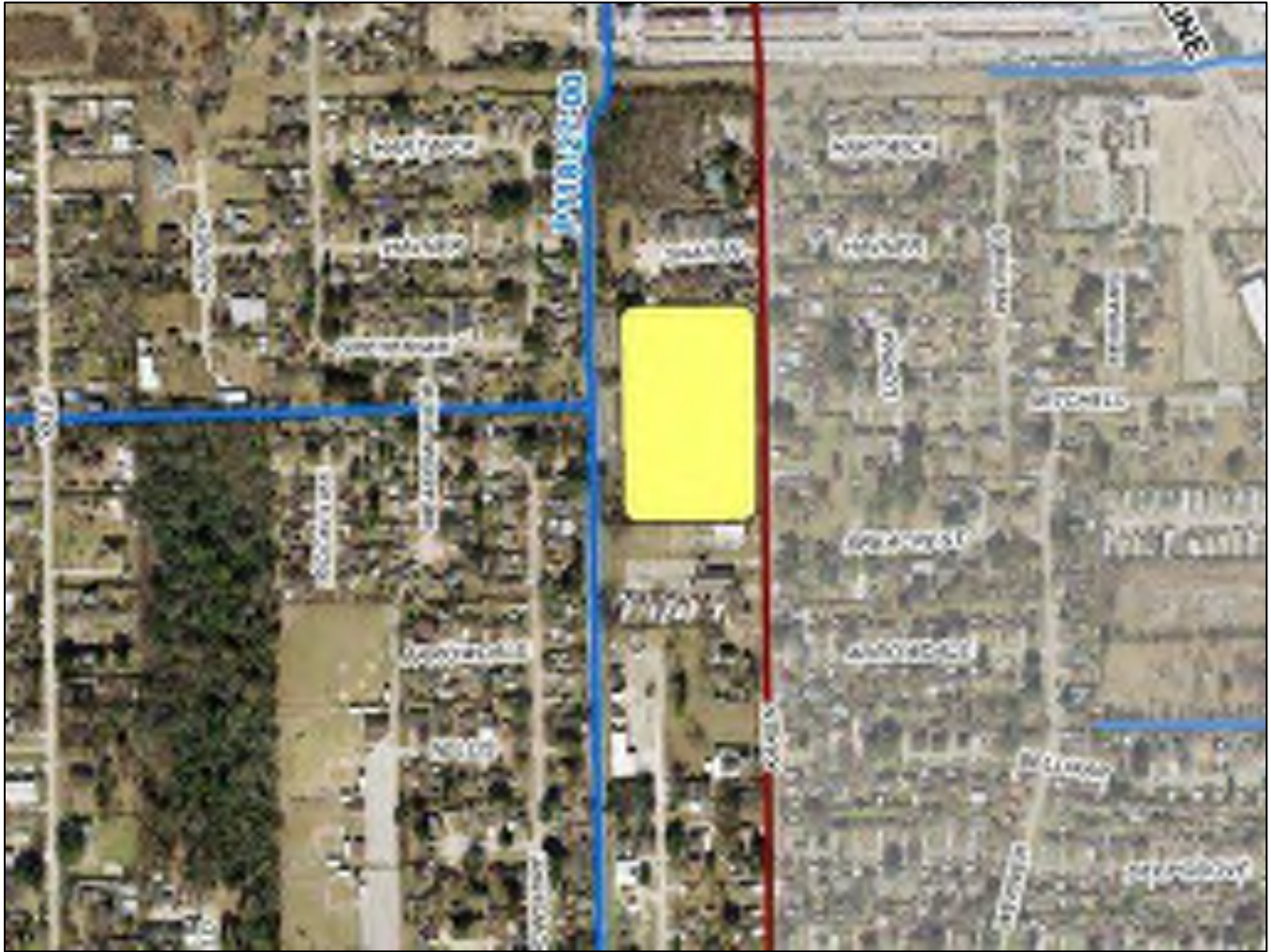


Figure 3-6: Feature 5 – Detention Basin “Karen”

3.2.6 Feature 6 – Detention Basin “Dow”

Dow Detention Basin is located just south of tributary P118-27-01 and east of Dow II Park (see [Figure 3-7](#)). The basin has a designed depth of 7 feet and provides a storage volume of approximately 40 acre-feet with 1-foot of freeboard. A total of 10.8 acres would be necessary to be acquired by HCFCF for ROW, and there aren't currently any structures within the basin's footprint.

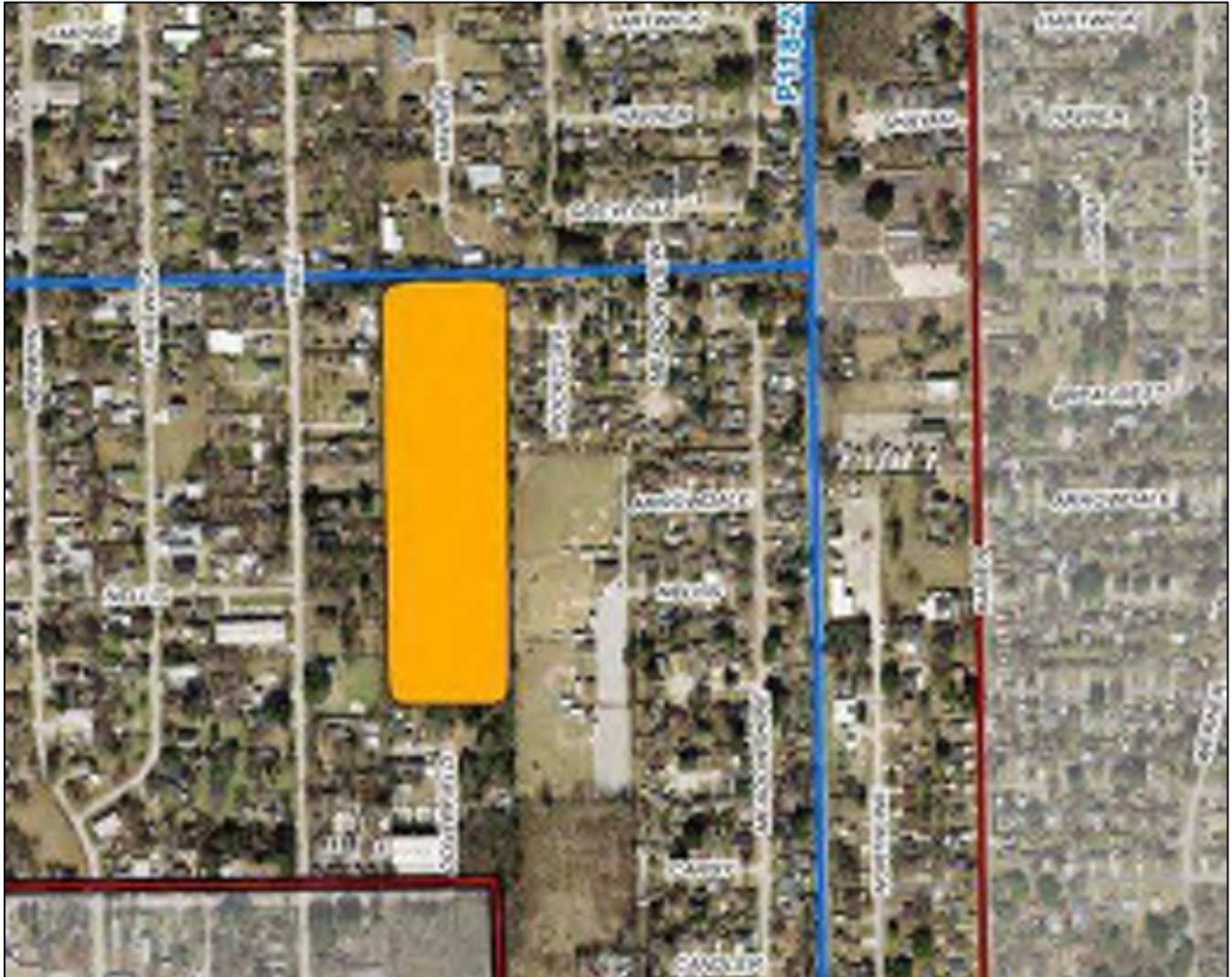


Figure 3-7: Feature 6 – Detention Basin “Dow”

3.3 Detailed Level Alternatives

LAN developed three (3) Alternatives under pre-Atlas 14 conditions. The three Alternative layouts can be seen in [Exhibits 18](#) through [20](#). [Table 5](#) below summarizes the modeled alternatives with their individual components.

Table 5: Summary of Modeled Alternatives

	Features
Alternative 1	Concrete-lined Channel, Shevchenko Basin, Gulf Bank Basin
Alternative 2	Concrete-lined Channel, Shevchenko Basin
Alternative 3	Grass-lined Channel, Karen Basin, Dow Basin

In developing the alternatives, LAN assumed an improved drainage system in the surrounding neighborhoods. This allowed the alternatives to be modeled in a “worst-case scenario” in terms of volume of water in the channel.

3.3.1 Alternative 1

Alternative 1 consists of a concrete-lined trapezoidal channel along P118-27-00 with the Shevchenko and Gulf Bank basins in place to provide storage volume and to mitigate increased peak flows. The channel improvements will occur along 3,050 feet of P118-27-00 from the existing concrete-lined channel segment to the Pin Oak Mobile Home Community, having a bottom width of 6 feet with 2:1 side slopes. An additional 20 to 30 feet of ROW will need to be acquired along the length of the proposed channel improvements. The channel slope is approximately 0.22%. The Shevchenko basin is 11 feet deep and has a 13.6-acre footprint, providing a storage volume of 85 acre-feet, including 1 foot of freeboard. The Gulf Bank basin is 8 feet deep and has a 13.2-acre footprint, providing a storage volume of 65 acre-feet, including 1 foot of freeboard. The specifications include a 30-foot maintenance berm and 4:1 side slopes for both detention basins. Also, in coordination with the Gulf Bank Road Extension, the existing dual 60-inch RCP culverts at Gulf Bank Road will be replaced with 2-10’x8’ RCBs. Detailed hydraulic calculations and floodplain maps with performance metrics are shown in [Appendix N](#) and [Appendix M](#), respectively. Water surface profiles along P118-27-00 for all four storm events can be found in [Appendix E](#). Comparison profiles between Baseline Conditions and the Alternative 3 are attached - see [Appendix F](#).

These modifications have a projected total cost of \$25.8 million, including utility pipeline relocation costs, and would provide a 100-year LOS under the region’s current normal depth downstream boundary conditions. ROW acquisition costs alone are approximately \$18.8 million for Alternative 1 primarily due to acquisition of the Pin Oak Mobile Home Community, which includes 125 structures, and a parking lot that serves Sunny Flea Market. The Alternative 1 layout is shown in [Exhibit 18](#) and below in [Figure 3-8](#). The detailed estimate of probable costs for Alternative 1 can be seen in [Appendix H](#).



Figure 3-8: Alternative 1 Layout

3.3.2 Alternative 2

Alternative 2 is identical to Alternative 1 except for the elimination of the Gulf Bank basin. Alternative 2 consists of a concrete-lined trapezoidal channel along P118-27-00 with the Shevchenko basin in place to provide storage volume and to mitigate increased peak flows. The channel improvements will occur along 3,050 feet of P118-27-00 from the existing concrete-lined channel segment to the Pin Oak Mobile Home Community, having a bottom width of 6 feet with 2:1 side slopes. An additional 20 to 30 feet of ROW will need to be acquired along the length of the proposed channel improvements. The channel slope is approximately 0.22%. The Shevchenko basin is 11 feet deep and has a 13.6-acre footprint, providing a storage volume of 85 acre-feet, including 1 foot of freeboard. The basin specifications include a 30-foot maintenance berm and 4:1 side slopes. Also, in coordination with the Gulf Bank Road Extension, the existing dual 60-inch RCP culverts at Gulf Bank Road will be replaced with 2-10'x8' RCBs. Detailed hydraulic calculations are shown in [Appendix N](#).

These modifications have a projected total cost of \$15.6 million, including utility pipeline relocation costs, and would also provide a 100-year LOS under the region's current normal depth downstream boundary conditions. ROW acquisition costs alone are approximately \$8.1 million for Alternative 2 primarily due to acquisition of the Pin Oak Mobile Home Community, which includes 125 structures. The Alternative 2 layout is shown in [Exhibit 19](#) and below in [Figure 3-9](#). The detailed estimate of probable costs for Alternative 2 can be seen in [Appendix H](#).



Figure 3-9: Alternative 2 Layout

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3.3.3 Alternative 3

Alternative 3 was designed to provide a viable alternative that did not have as much ROW acquisition needs of the previous alternatives. Alternative 3 consists of a grass-lined trapezoidal channel along P118-27-00, with the Karen and Dow basins in place to provide storage volume and to mitigate increased peak flows. The channel improvements will occur along 2,050 feet of P118-27-00 from the existing concrete-lined channel segment to Gulf Bank Road having a bottom width of 6 feet and 4:1 side slopes. An additional 80 feet of ROW will need to be acquired along the length of the proposed channel improvements. The channel slope is approximately 0.07%. The Karen basin is 8 feet deep and has a 5.5-acre footprint, providing a storage volume of 20 acre-feet, including 1 foot of freeboard. The Dow basin is 8 feet deep and has a 10.8-acre footprint, providing a storage volume of 40 acre-feet, including 1 foot of freeboard. The basin specifications include a 30-foot maintenance berm and 4:1 side slopes. Also, in coordination with the Gulf Bank Road Extension, the existing dual 60-inch RCP culverts at Gulf Bank Road will be replaced with 2-10'x8' RCBs. Detailed hydraulic calculations and floodplain maps with performance metrics are shown in [Appendix N](#) and [Appendix M](#), respectively. Water surface profiles along P118-27-00 for all four storm events can be found in [Appendix E](#). Comparison profiles between Baseline Conditions and the Alternative 3 are attached - see [Appendix F](#).

These modifications have a projected total cost of \$9.1 million, including utility pipeline relocation costs, and would provide a 50-year LOS under the region's current normal depth downstream boundary conditions. ROW acquisition costs are approximately \$4.8 million for Alternative 3. The Alternative 3 layout is shown in [Exhibit 20](#) and below in [Figure 3-10](#). The detailed estimate of probable costs for Alternative 3 can be seen in [Appendix H](#).



Figure 3-10: Alternative 3 Layout

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3.3.4 Detailed Alternatives Analysis Alternative Scoring

To score each of these alternatives, LAN considered six attributes and gave weight to each attribute: (1) Total Estimated Cost (including utility pipeline relocation) [20%], (2) Cost of ROW Acquisition [10%], (3) Number of Structures Removed from Floodplain [15%], (4) Number of Flooded Structures Removed [25%], (5) Miles of Inundated Roadway Removed [15%], (6) Acres of Inundated Land Removed [15%]. 70% of the weight was given to performance metrics and 30% to cost information. The scoring matrix was based on the Tailwater (Stage Hydrograph) boundary condition. The Stage Hydrograph boundary condition gives a more accurate depiction of what occurs in P118-27-00, particularly during extreme storm events. The Normal Depth boundary condition was used for design purposes when developing proposed improvements, while the Stage Hydrograph boundary condition was used to evaluate impacts and benefits that will be seen after construction. The alternatives' performances were compared to Baseline Conditions. Refer to **Table 6** for results of the scoring process.

Table 6: Alternative Scoring Matrix

Alternative	Attributes						Final Scores
	Cost Information		500yr Stage Hydrograph Condition				
	Total Estimated Cost	Cost of ROW Acquisition	Number of Structures in Floodplain Removed	Number of Flooded Structures Removed	Miles of Inundated Roadway Removed	Acres of Inundated Land Removed	
	20%	10%	15%	15%	15%	15%	
Baseline	5.0	5.0	0.0	0.0	0.0	0.0	1.5
Alternative 1	0.7	0.3	4.6	4.1	2.2	2.5	2.6
Alternative 2	2.4	3.0	4.6	4.0	2.0	2.4	3.1
Alternative 3	3.5	3.8	1.5	1.3	0.8	0.6	1.8

As shown, Alternative 2 ranked the highest with a score of 3.1 on the scale of 0 to 5. The estimated cost lowered Alternative 1's final score, and the metrics lowered Alternative 3's score. These rankings were linearly interpolated between zero and the max values shown below in **Table 7**:

Table 7: Attribute Scoring Matrix Values

Attribute	Weight	Max
Estimated Cost	20%	\$ 30,000,000.00
Cost or ROW Acquisition	10%	\$ 20,000,000.00
Number of Structures in Floodplain	15%	300
Number of Flooded Structures	25%	100
Miles of Inundated Roadway	15%	3
Acres of Inundated Land	15%	150

To put things into perspective on an absolute scale, the performance metrics and costs of each alternative are summarized in **Table 8** shown below. In Table 8, the number of structures in the floodplain and number of flooded structures for Alternatives 1 and 2 include the 125 structures in the Shevchenko basin footprint. These structures will be acquired and bought out.

Table 8: Performance Metrics and Costs

Alternative	Attributes					
	Cost Information		500yr Stage Hydrograph Condition			
	Total Estimated Cost	Cost of ROW Acquisition	Number of Structures in Floodplain	Number of Flooded Structures	Miles of Inundated Roadway	Acres of Inundated Land
Baseline	\$ -	\$ -	1114	609	12.0	443
Alternative 1	\$ 25,837,973.00	\$ 18,816,133.00	836	528	10.7	369
Alternative 2	\$ 15,644,128.00	\$ 8,096,853.00	841	529	10.8	370
Alternative 3	\$ 9,131,749.00	\$ 4,790,474.00	1024	583	11.5	426

4 Recommended Alternative

4.1 Results

As previously mentioned, the Recommended Alternative brings the P118-27-00 service area up to a 100-year LOS for the normal depth downstream boundary condition, which reflects the future conditions after implementation of the Halls Bayou improvement projects. The Recommended Alternative HEC-RAS geometry can be seen in [Exhibit 21](#). Water surface profiles along P118-27-00 for all four storm events can be found in [Appendix E](#). Comparison profiles between Baseline Conditions and the Recommended Alternative are attached - see [Appendix F](#).

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 10-, 50-, 100-, and 500-year storm events. The use of performance metrics allows for a quantitative evaluation of potential flood damage reduction benefits. Locally, Alternative 2 provides a 100-year level-of-service (LOS), and reduces the number of structures in the floodplain from 154 to 0 (including structural buyouts), and removes all flooded structures based on finished floor elevation (FFE). There are approximately 2,233 structures in the P118-27-00 project area and immediate surrounding area. Alternative 2 results in no adverse impacts to P118-27-00, Halls Bayou, and the surrounding region, up to and including the 500-year storm event.

By providing a 100-year LOS under the normal depth downstream boundary conditions, the 100-year floodplain is reduced from 114 acres to 22 acres. The structures in the floodplain are reduced from 154 to 0, and the number of flooded structures is down to 0 from the original 15 (including structural buyouts). The original 3.7 miles of inundated roadway is reduced to 0.4 miles. Refer to [Table 9](#) for the performance metrics for the normal depth boundary conditions and [Table 10](#) for the current Halls Bayou tailwater boundary conditions. In Tables 9 and 10 below, the 125 structures within the basin footprint of Alternative 2 are counted as structures removed from the floodplain. These structures will be acquired and bought out. In the 100-year storm event, the Recommended Alternative eliminates flooding and overflow from P118-27-00 in several neighborhoods just upstream of P118-27-00 including Bellmar Estates, Durkee Manor, and Assumption Heights. Ponding extents and depths along with performance metrics for all four storm events are included in [Exhibits 22](#) through [29](#) for the normal depth and stage hydrograph condition. Ponding depth comparisons between baseline conditions and the recommended alternative for the 10-, 50-, 100-, and 500-year storm events can be seen in [Exhibits 30](#) through [37](#). Detailed hydraulic calculations are shown in [Appendix N](#).

Table 9: Performance Metrics - Baseline versus Recommended Alternative 2 - Normal Depth Boundary Condition

Performance Metric	10-year Floodplain		50-year Floodplain		100-year Floodplain		500-year Floodplain	
	Basel.	Rec. Alt.	Basel.	Rec. Alt.	Basel.	Rec. Alt.	Basel.	Rec. Alt.
Structures in Floodplain	4	0	84	0	154	0	303	10
Flooded Structures (based on FFE)	0	0	10	0	15	0	53	1
Inundated Roadway (miles)	1.48	0.09	3.20	0.13	3.72	0.39	4.68	1.75
Floodplain (acre)	33	18	88	20	114	22	168	47

P118-27-00 Alternatives Analysis Summary Report

Table 10: Performance Metrics - Baseline versus Recommended Alternative 2 - Stage Hydrograph Tailwater Boundary Condition

Performance Metric	10-year Floodplain		50-year Floodplain		100-year Floodplain		500-year Floodplain	
	Basel.	Rec. Alt.	Basel.	Rec. Alt.	Basel.	Rec. Alt.	Basel.	Rec. Alt.
Structures in Floodplain	248	135	605	385	764	468	1114	717
Flooded Structures (based on FFE)	111	29	302	165	375	220	609	406
Inundated Roadway (miles)	4.11	2.57	8.74	5.66	9.93	7.13	11.99	10.83
Floodplain (acre)	126	99	271	201	323	238	443	370

4.2 Right-of-Way Requirement

HCFCDD owns 10.8 acres of ROW in the study area. With the Recommended Alternative 2, an additional 16 acres would need to be acquired, including 13 partial parcel acquisitions and 4 full parcel acquisitions. An expected 125 structures would lie within the proposed ROW limits – refer to **Exhibit 38**. The structures affected fall under the following categories: 123 mobile homes, all of which are located within the 100-year FEMA floodplain and 50 within the regulatory floodway, 1 single-family residential, and 1 commercial.

LAN identified 12 parcels where partial ROW acquisition will be required and 5 parcels where full acquisition will be required along P118-27-00. Full acquisition would be required for the parcels in the footprint of the Shevchenko Basin, and in one parcel along the proposed concrete-lined channel ROW. Refer to **Appendix G** for a listing of affected parcels.

The proposed 70 to 80-foot ROW width for the channel considers a 20-foot maintenance berm on the left side of the channel and a 15-foot maintenance berm on the right side. It has a 6-ft bottom width with 2:1 side slopes in accordance to HCFCDD standards. Refer to **Figure 4-1** for a cross-section representation for typical channel design standards.

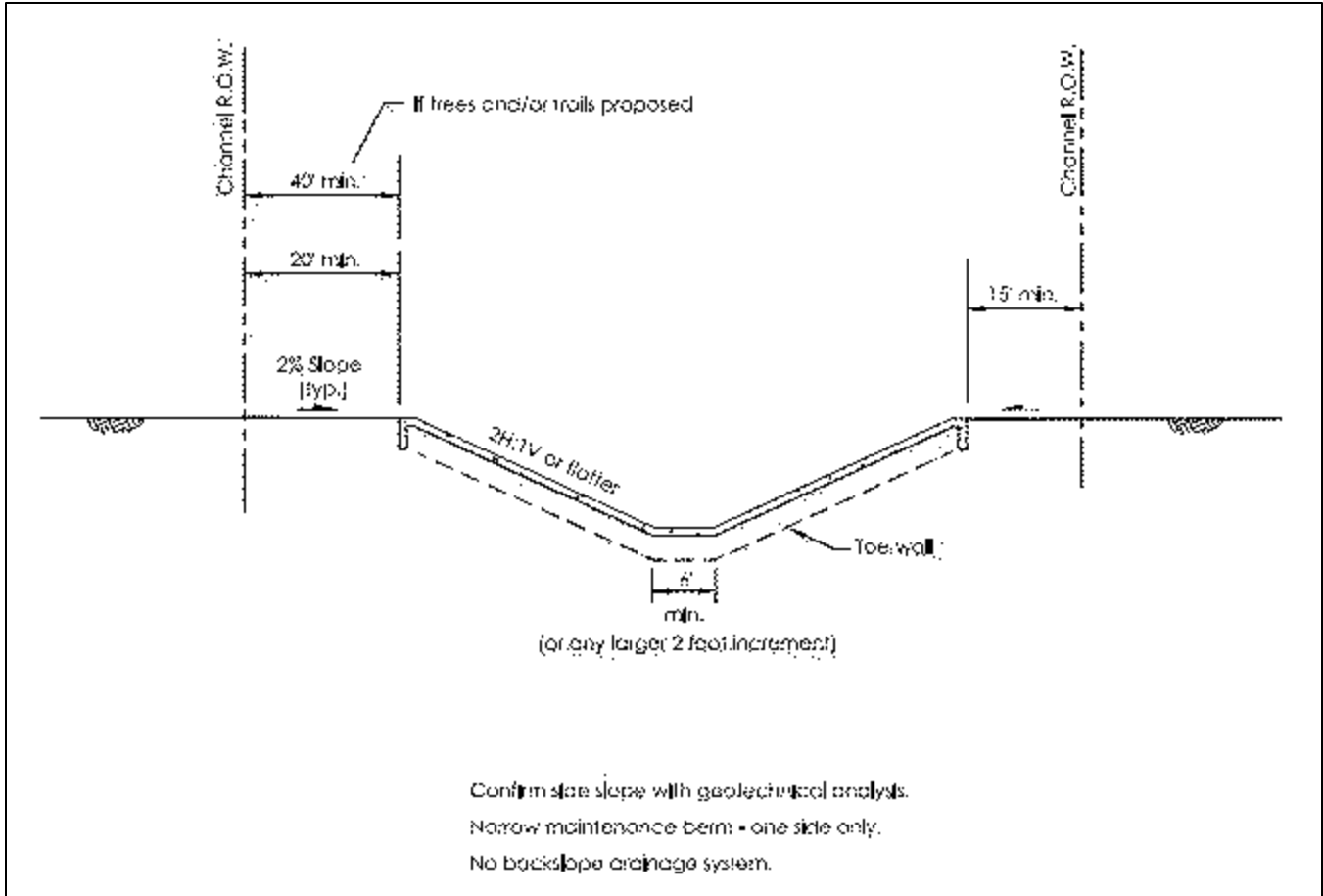


Figure 4-1: HCFCD Concrete-lined Trapezoidal Channel Design (HCFCD, 2019)

4.3 Opinion of Probable Construction Cost

An opinion of probable construction cost for the Recommended Alternative can be found in [Table 11](#). Detailed estimates of probable costs for each alternative are also provided in [Appendix H](#). Unit cost values utilized the latest TxDOT and HCFCD average low bid tab and HCAD appraised land values. The costs consider clearing, grubbing, excavation and disposal, backslope drainage system swales, concrete interceptor structures, culverts, headwalls and wingwalls, concrete channel lining, asphalt, concrete slope paving, removal & disposal, turf establishment, ROW acquisition, and pipeline relocation. LAN assumes 10% of direct construction costs for Planning, Engineering, and Design, 5% for Mobilization/Demobilization, 10% for Construction Management, and 20% for Contingency.

P118-27-00 Alternatives Analysis Summary Report

Table 11: Recommended Alternative Opinion of Probable Construction Cost

Item Description	Costs
Shevchenko Basin	\$10,483,548.00
Excavation & Off-site Disposal	\$2,419,995.00
Basin Features	\$449,100.00
ROW Acquisition	\$7,614,453.00
Channel Improvements	\$2,134,480.00
Excavation & Off-site Disposal	-
Channel Features	\$1,652,080.00
ROW Acquisition	\$482,400.00

ROW Acquisition: \$8,096,853.00

Pipeline Relocation: \$683,500.00

Direct Construction Cost (DCC): \$5,204,675.00

Subtotal: \$13,301,528.00

+ Planning, Engineering, and Design (10% of DCC): \$520,600.00

+ Mobilization/Demobilization (5% of DCC): \$260,300.00

+ Construction Management (10% of DCC): \$520,600.00

+ Contingency (20% of DCC): \$1,041,100.00

Total: \$15,644,128.00

5 Preliminary Impact Analysis

A preliminary assessment of potential impacts was performed on Halls Bayou as the 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 combined the P118-00-00 Halls Phasing HEC-RAS model and the standalone model of P118-27-00. Geometries were created for both Baseline and Alternative 2 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 0.2' upstream of the confluence of P118-27-00 and Halls Bayou for both the 100- and 500-year storm events. Downstream of the confluence of P118-27-00, WSELs show an average decrease of 0.04' and 0.02' in the 100- and 500-year storm events, respectively. At the confluence itself, a local increase in WSEL along Halls Bayou is observed in the 100- and 500-year storm events. However, this increase is attributed to differences in modeling methodology, as the P118-27-00 Baseline Condition at this location is modeled with cross sections, while the recommended alternative contains a 2D surface for the detention basin. The Baseline Condition is artificially forcing the flow to pass through the junction, where in reality the runoff would flow from the overbanks into Halls Bayou similar to the proposed alternative model. Lastly, there is one other location in the 100-year model where an increase is shown in WSEL significantly downstream of this project near 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 P118-27-00. Just upstream of this location, there are no WSEL impacts, and the hydrograph in the channel shows no flow impacts or significant changes in timing. Therefore, impacts at this location can be disregarded, or further refined during future project phases.

Overall, the Recommended Alternative 2 is effective in reducing WSELs both within P118-27-00 and along Halls Bayou. Further model refinement should be explored in the Preliminary Engineering phase of the project to eliminate all adverse impacts for all storm events. Refer to [Appendix L](#) for a WSEL comparison profile plot.

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.

6 Summary and Conclusion

The Harris County Flood Control District (HCFCD) authorized Lockwood, Andrews & Newnam, Inc. (LAN) to conduct an Alternatives Analysis Study on Tributary P118-27-00, 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 P118-27-00 drainage 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 10%, 2%, 1%, and 0.2% design storm events (pre-Atlas 14 update) based on HCFCD criteria using the HEC-HMS Version 3.4 and HEC-RAS Version 5.0.5 software. Two tailwater boundary conditions scenarios were modeled: (1) assuming the WSEL of P118-27-00 is not influenced by tailwater conditions of Halls Bayou (normal depth assumption), and (2) assuming the WSEL of P118-27-00 is influenced by tailwater conditions of Halls Bayou using stage hydrographs computed from Halls Bayou Phasing Study at the P118-27-00 outfall.

Baseline conditions results revealed the existing LOS for tributary P118-27-00 area is mainly driven by undersized culverts and a significant amount of flow coming from the west side of our project area and flowing into P118-27-00, causing overflows in each storm event. The HEC-RAS results were used and processed in GIS to generate a set of performance metrics to ultimately measure proposed improvement alternatives. The model outcome for a 500-year design storm (pre-Atlas 14 update) shows 1114 in the floodplain, with 609 structures being flooded. Most flooded homes are located in the Assumption Heights neighborhood.

In total, six improvement features were identified as potential flooding mitigation solutions. They include detention basins and channel improvements. They were selected because they are located at hydraulically influential locations, topographically integrable, and are relatively unobtrusive to residents. Three alternatives were developed from the improvement features which were subsequently modeled and evaluated.

In coordination with HCFCD, LAN recommends Alternative 2 to carry for advancement to a PER Study. It offers the best cost to benefit ratio, at \$15.6 million, compared to Alternative 1 (\$25.4 million). Compared to Alternative 1, Alternative 2 also requires less ROW acquisition, eliminating the need to acquire the parking lot serving Sunny Flea Market. The costs include construction and acquisition of 13 partial and 4 full tracts, approximately 16 acres, of ROW.

Alternative 2 incorporates two features, (1) concrete-lined channel improvements from the existing concrete-lined channel to Pin Oak Mobile Home Community and (2) the 85 acre-feet Shevchenko Basin located in the footprint of Pin Oak Mobile Home Community. Channel improvements are trapezoidal with a 6-foot bottom width, 2:1 side slopes, and a 0.22% longitudinal slope.

For the Normal Depth downstream boundary conditions, Alternative 2 provides a 100-year LOS, and reduces the number of structures in the floodplain from 154 to 0 (including structural buyouts), and removes all flooded structures based on FFE. For the Tailwater downstream boundary conditions, Alternative 2 reduces number of structures in the floodplain from 764 to 468 and the number of flooded structures from 375 to 220 (including structural buyouts).

It is recommended to coordinate the proposed P118-27-00 project with Harris County Engineering on their local drainage improvement projects and continue Alternative 2 in a Preliminary Engineering Report.

7 References

- Brown & Gay Engineers, Inc. (2013). "Halls Ahead Study Vision Plan Engineering Appendix," updated August 2013.
- Federal Emergency Management Agency. "Flood Insurance Study," revised June 9, 2014.
- Harris County Flood Control District. (2019). "Hydrology & Hydraulics Guidance Manual," updated June 2019.
- Harris County Flood Control District. (2019). "Policy Criteria & Procedure Manual for Approval and Acceptance of Infrastructure" updated October 2019.
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- Harris County Flood Control District. (2018). "Preliminary Guidelines for Unstudied Tributaries in Halls Bayou (DRAFT)" updated March 2018.
- Harris County Flood Control District. (2016). "Quality Assurance / Quality Control Memorandum" updated February 2016.
- United States Army Corps of Engineers (USACE). (2009). "HEC-HMS Hydrologic Modeling System Version 3.4 User's Manual," Institute for Water Resources, Hydrologic Engineering Center, Davis, CA. updated August 2009.
- United States Army Corps of Engineers (USACE). (2016). "HEC-RAS River Analysis System 2D Modeling User's Manual Version 5.0," Institute for Water Resources, Hydrologic Engineering Center, Davis, CA. updated February 2016.
- United States Army Corps of Engineers (USACE). (2016). "HEC-RAS River Analysis System Version 5.0 2D Modeling Users Manual," Institute for Water Resources, Hydrologic Engineering Center, Davis, CA. updated February 2016.

8 List of Exhibits

Exhibit 1 – Vicinity Map

Exhibit 2 – FEMA Effective Floodplain

Exhibit 3 – Land Use (2004 HCAD Parcels)

Exhibit 4 – Existing HCFCD ROW

Exhibit 5 – Drainage Area Revisions

Exhibit 6 – Drainage Area Delineation and Subdivides

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Exhibit 10 – 50-Year Baseline Conditions Performance Metrics (Normal Depth Tailwater)

Exhibit 11 – 100-Year Baseline Conditions Performance Metrics (Normal Depth Tailwater)

Exhibit 12 – 500-Year Baseline Conditions Performance Metrics (Normal Depth Tailwater)

Exhibit 13 – 10-Year Baseline Conditions Performance Metrics (Stage Hydrograph Tailwater)

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Exhibit 16 – 500-Year Baseline Conditions Performance Metrics (Stage Hydrograph Tailwater)

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Exhibit 18 – Alternative 1 Layout

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Exhibit 23 – 50-Year Recommended Alternative (Alt. 2) Performance Metrics (Normal Depth Tailwater)

Exhibit 24 – 100-Year Recommended Alternative (Alt. 2) Performance Metrics (Normal Depth Tailwater)

Exhibit 25 – 500-Year Recommended Alternative (Alt. 2) Performance Metrics (Normal Depth Tailwater)

Exhibit 26 – 10-Year Recommended Alternative (Alt. 2) Performance Metrics (Stage Hydrograph Tailwater)

Exhibit 27 – 50-Year Recommended Alternative (Alt. 2) Performance Metrics (Stage Hydrograph Tailwater)

P118-27-00 Alternatives Analysis Summary Report

Exhibit 28 – 100-Year Recommended Alternative (Alt. 2) Performance Metrics (Stage Hydrograph Tailwater)

Exhibit 29 – 500-Year Recommended Alternative (Alt. 2) Performance Metrics (Stage Hydrograph Tailwater)

Exhibit 30 – 10-Year Recommended Alternative (Alt. 2) vs. Baseline Conditions Comparison Performance Metrics (Normal Depth Tailwater)

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Exhibit 34 – 10-Year Recommended Alternative (Alt. 2) vs. Baseline Conditions Comparison Performance Metrics (Stage Hydrograph Tailwater)

Exhibit 35 – 50-Year Recommended Alternative (Alt. 2) vs. Baseline Conditions Comparison Performance Metrics (Stage Hydrograph Tailwater)

Exhibit 36 – 100-Year Recommended Alternative (Alt. 2) vs. Baseline Conditions Comparison Performance Metrics (Stage Hydrograph Tailwater)

Exhibit 37 – 500-Year Recommended Alternative (Alt. 2) vs. Baseline Conditions Comparison Performance Metrics (Stage Hydrograph Tailwater)

Exhibit 38 – Proposed ROW Alternative 2 (Recommended)

9 Appendices

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Appendix B – Historic Losses Heat Maps

Appendix C – Site Visit Photo Documentation

Appendix D – Summary Table of Alternatives

Appendix E – Water Surface Elevation Profiles

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Appendix G – Proposed ROW for Recommended Alternative

Appendix H – Detailed Opinion of Probable Cost and Pipeline Relocation Cost Estimate

Appendix I – Preliminary Wetland and Threatened and Endangered Species Habitat Assessment

Appendix J – Phase I Environmental Site Assessment Report

Appendix K – Attribute Scoring and Ranking Form and Harris County Flood Control District Project Scoring Form

Appendix L – Impact Analysis Baseline vs. Recommended Alternative Water Surface Profiles

Appendix M – Alternative 1 and Alternative 3 Metrics and Floodplain Maps

Appendix N – Detailed Hydraulic Calculations

Headquarters

2925 Briarpark Drive
Suite 400
Houston, TX 77042
713.266.6900

Info@lan-inc.com

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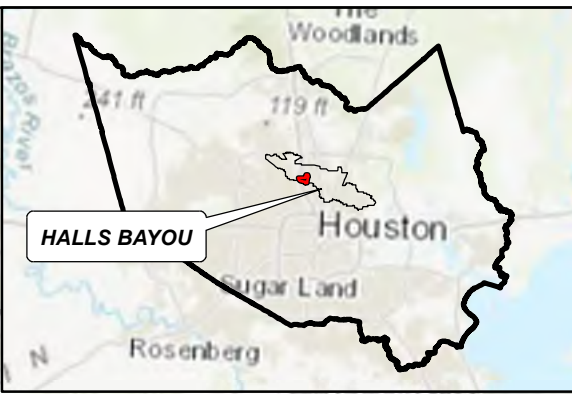
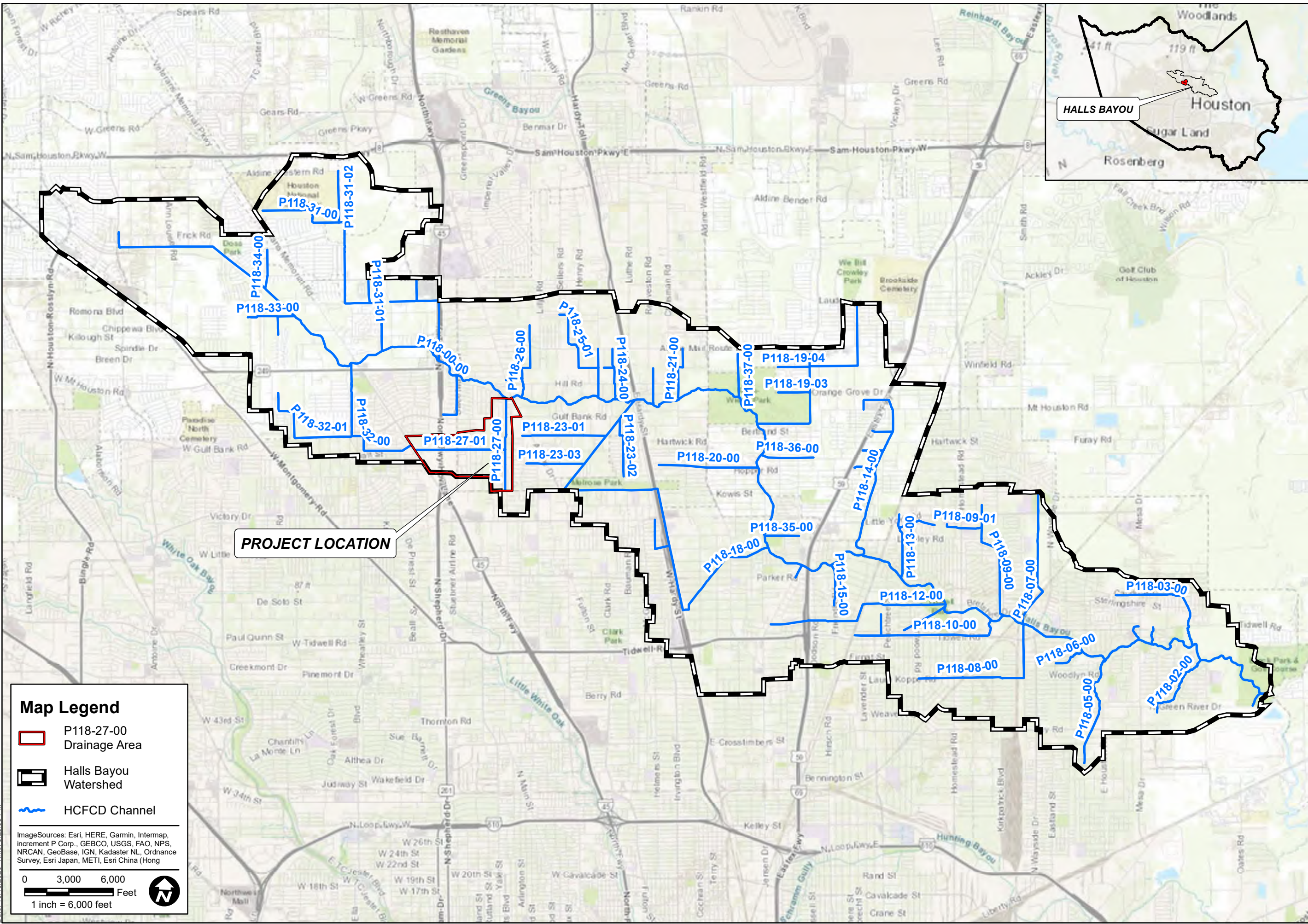
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EXHIBITS

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PROJECT LOCATION

Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- ~ HCFC Channel

ImageSources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong)

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 Feet
 1 inch = 6,000 feet

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 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

PREPARED: TMM
 CHECKED: BUI
 APPROVED: CEE

IGN
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 2925 Blairpark Drive • Houston, TX 77042-3720
 T 713.266.6900 • F 713.266.2089
 www.ign-hc.com • info@ign-hc.com

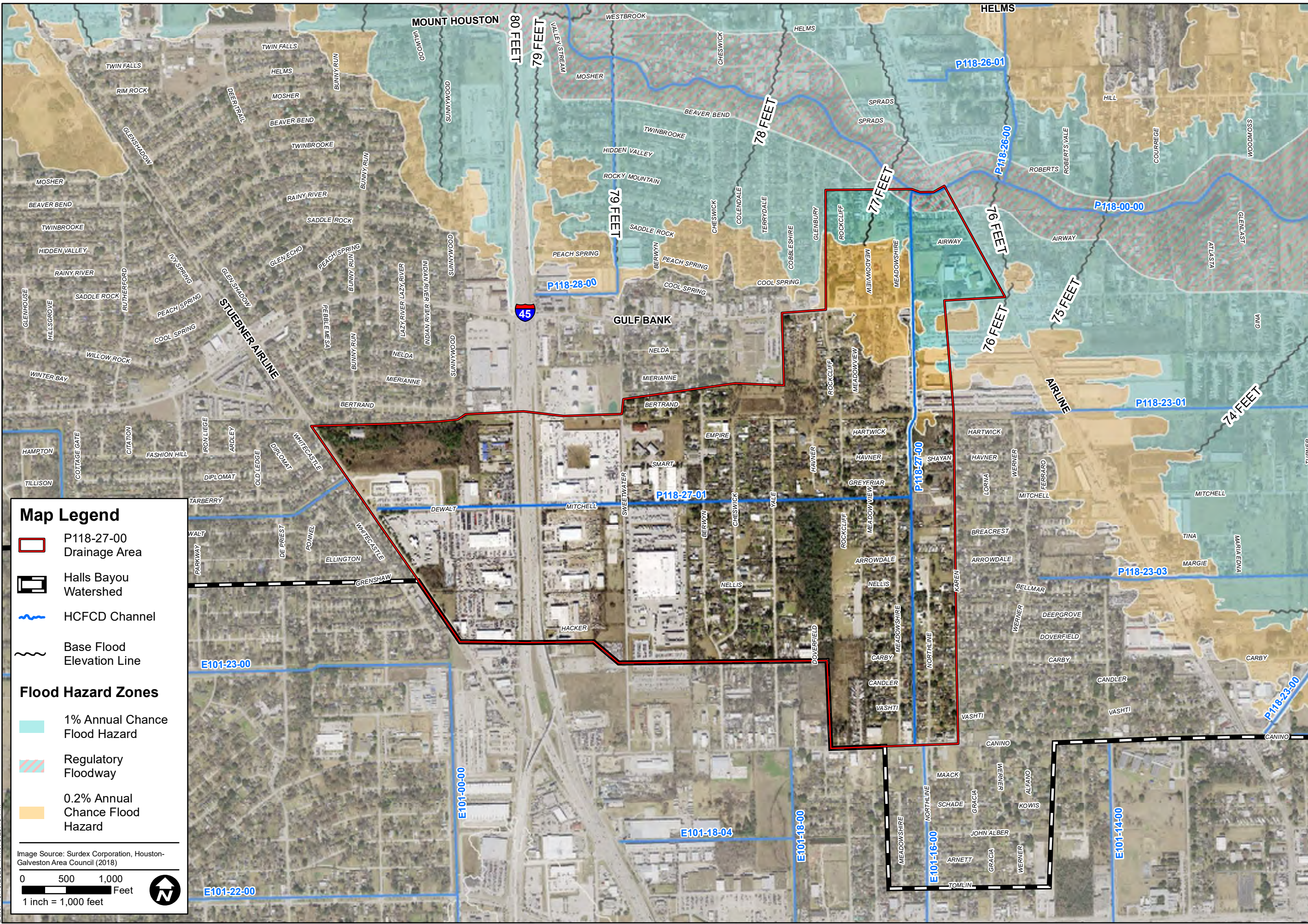
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 SCALE: AS NOTED





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VICINITY MAP

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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Base Flood Elevation Line

Flood Hazard Zones




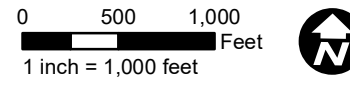
-  1% Annual Chance Flood Hazard
-  Regulatory Floodway
-  0.2% Annual Chance Flood Hazard

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



**HCFCD HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

P118-27-00

FEMA EFFECTIVE FLOODPLAIN

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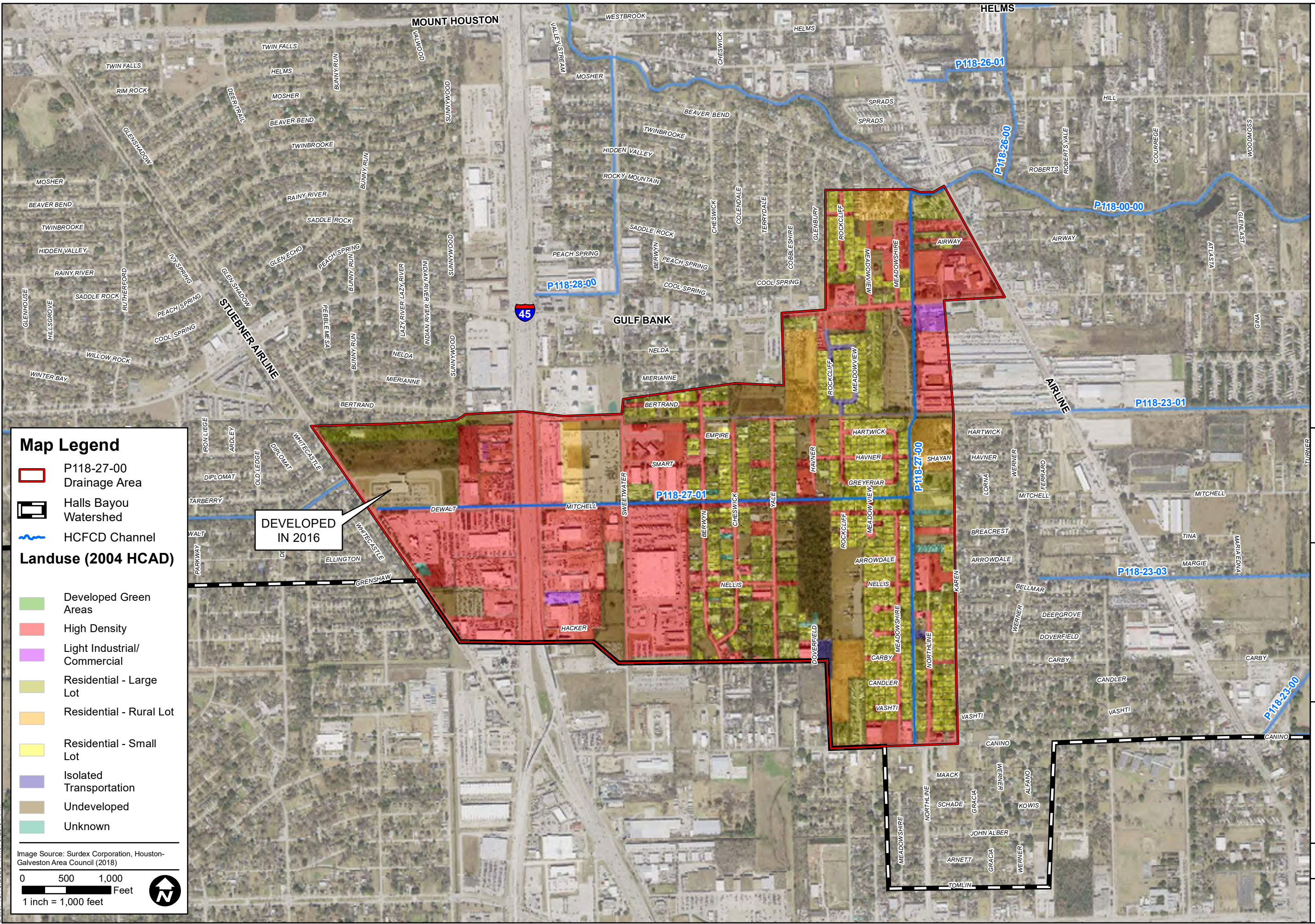
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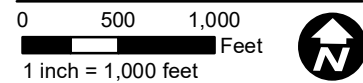
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFC D Channel
- Landuse (2004 HCAD)**
- Developed Green Areas
- High Density
- Light Industrial/ Commercial
- Residential - Large Lot
- Residential - Rural Lot
- Residential - Small Lot
- Isolated Transportation
- Undeveloped
- Unknown

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



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IN 2016

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

LAND USE (2004 HCAD PARCELS)

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 TBPE Firm No. 2614
 2825 Blairpark Drive • Houston, TX 77042-3720
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

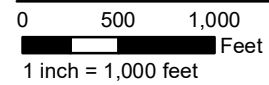
-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD ROW
-  HCFCD Channel

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



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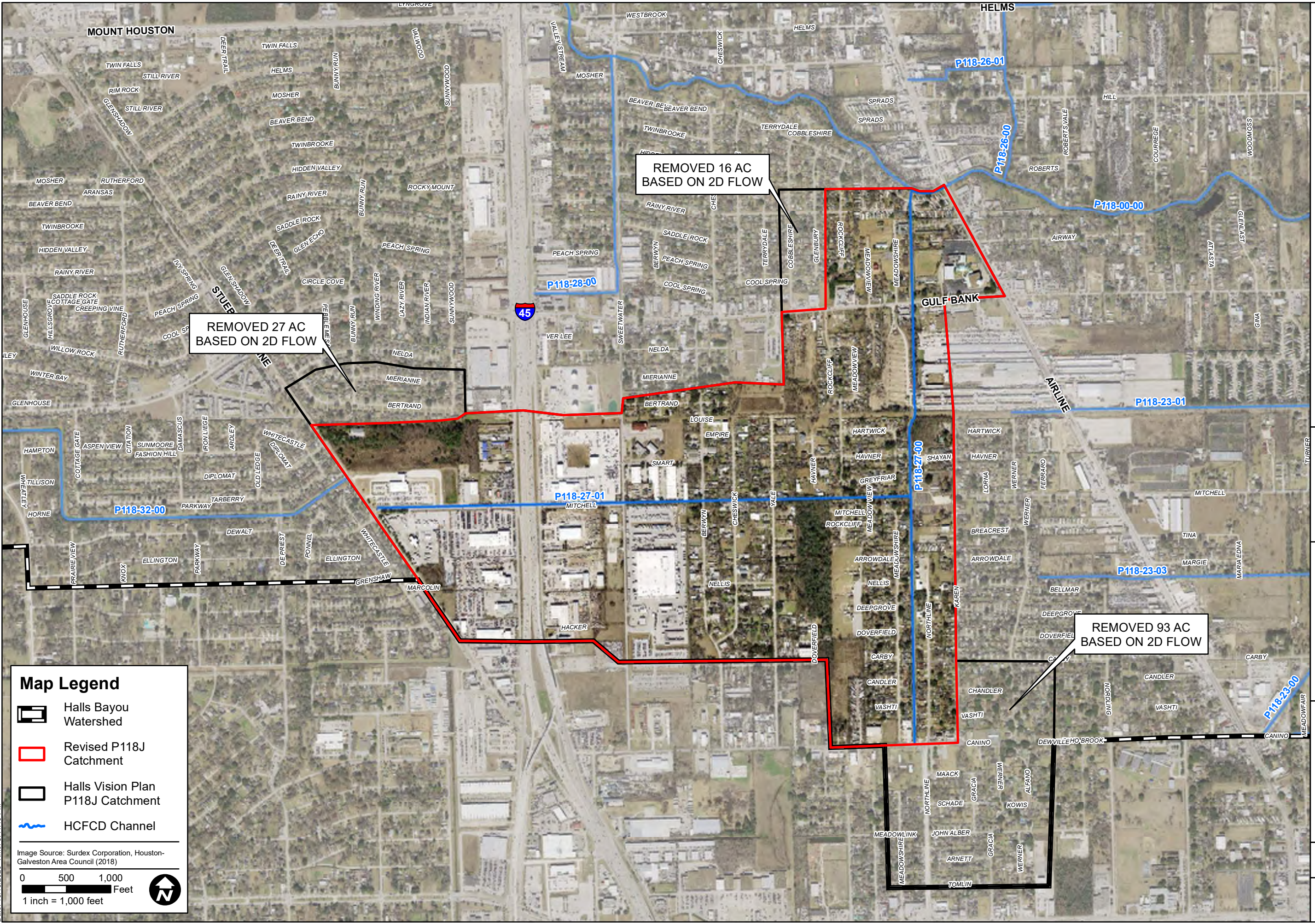
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EXISTING HCFCD ROW

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Map Legend

- Halls Bayou Watershed
- Revised P118J Catchment
- Halls Vision Plan P118J Catchment
- HCFCF Channel

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFCF HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

DRAINAGE AREA REVISIONS

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APPROVED:	CEE

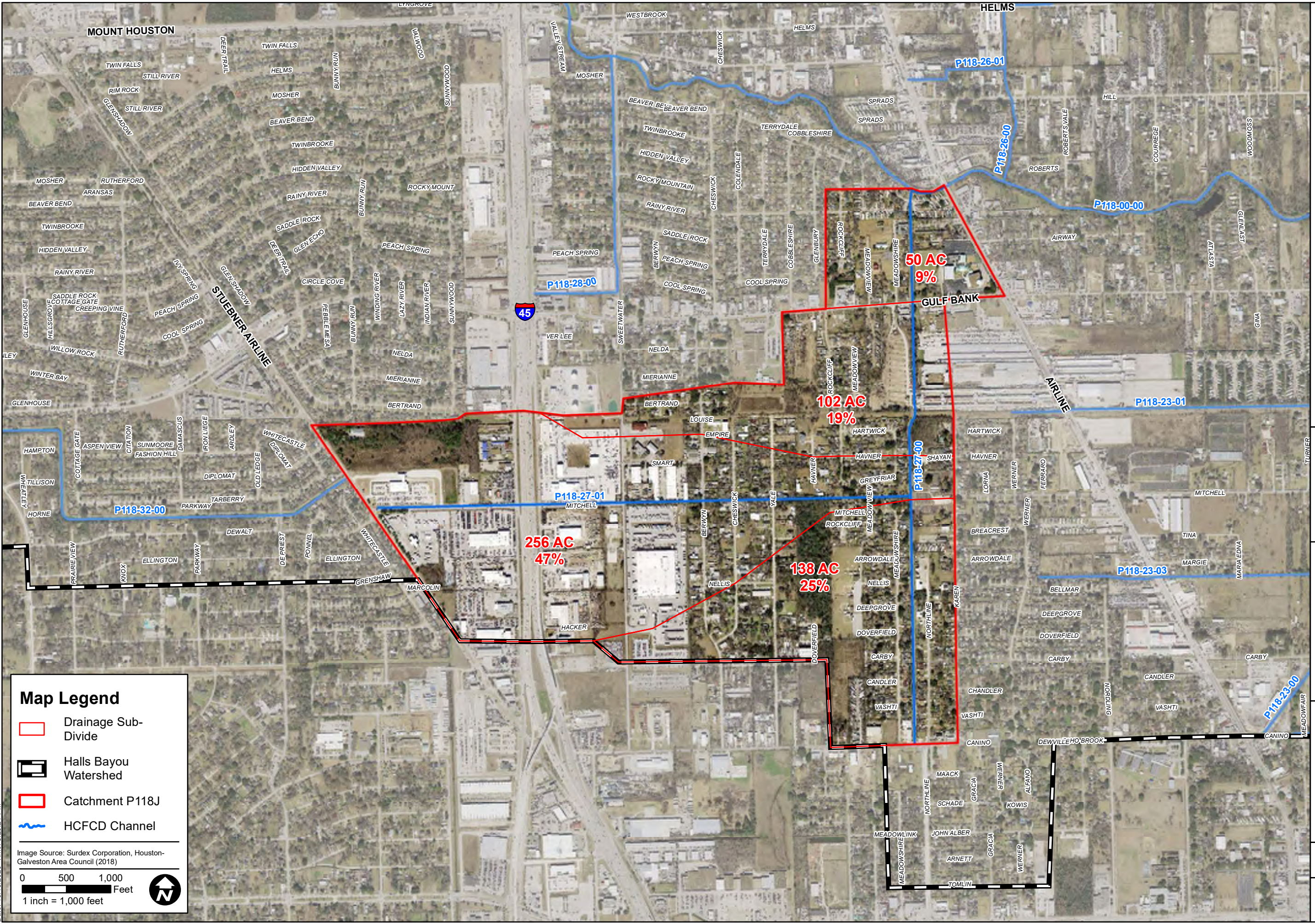
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Map Legend

- Drainage Sub-Divide
- Halls Bayou Watershed
- Catchment P118J
- ~ HCFCD Channel

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

DRAINAGE AREA DELINEATION SUBDIVIDES

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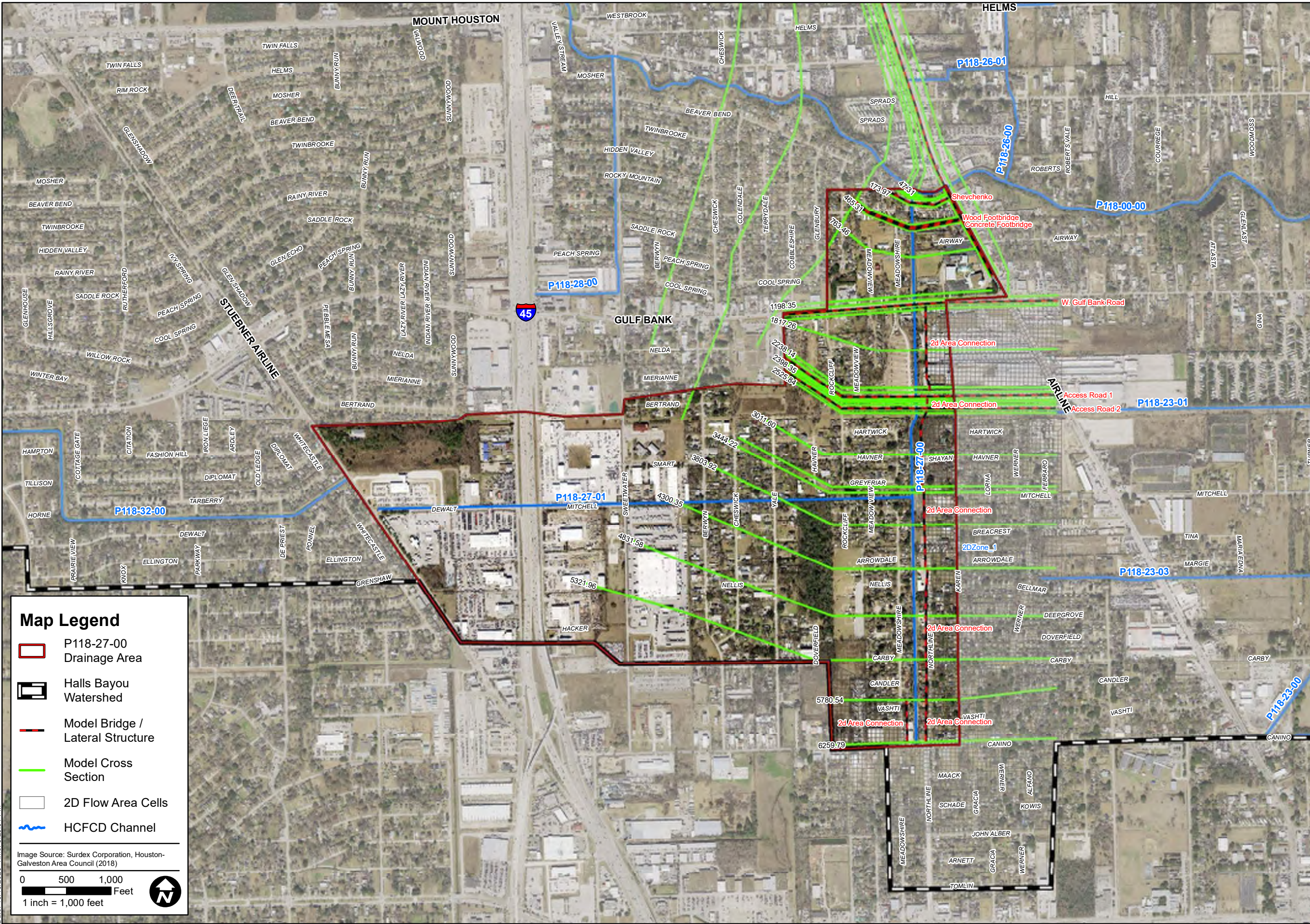
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- Model Bridge / Lateral Structure
- Model Cross Section
- 2D Flow Area Cells
- HCFCD Channel

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFC D HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

P118-27-00

**HEC-RAS GEOMETRY
 BASELINE CONDITIONS**

PREPARED:	TMM
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APPROVED:	CEE

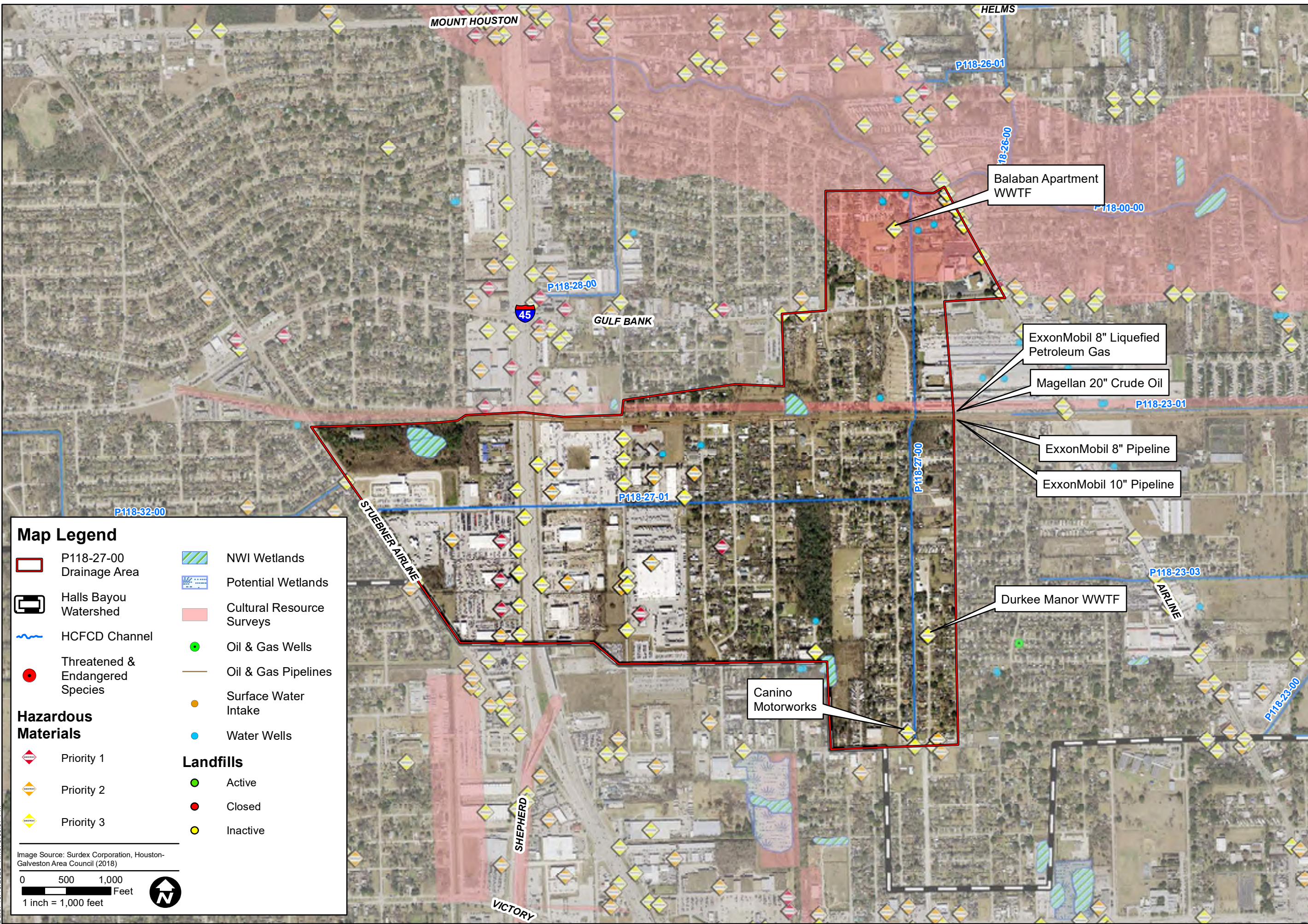
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Map Legend

	P118-27-00 Drainage Area		NWI Wetlands	
	Halls Bayou Watershed		Potential Wetlands	
	HCFC Channel		Cultural Resource Surveys	
	Threatened & Endangered Species		Oil & Gas Wells	
	Hazardous Materials		Oil & Gas Pipelines	
		Priority 1		Surface Water Intake
		Priority 2		Water Wells
	Priority 3		Active Landfills	
			Closed Landfills	
			Inactive Landfills	

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

HCFC HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 WATERSHED ENVIRONMENTAL BASELINE (WEB) MAP
 DATA SUMMARY TOOL (DST) DATA

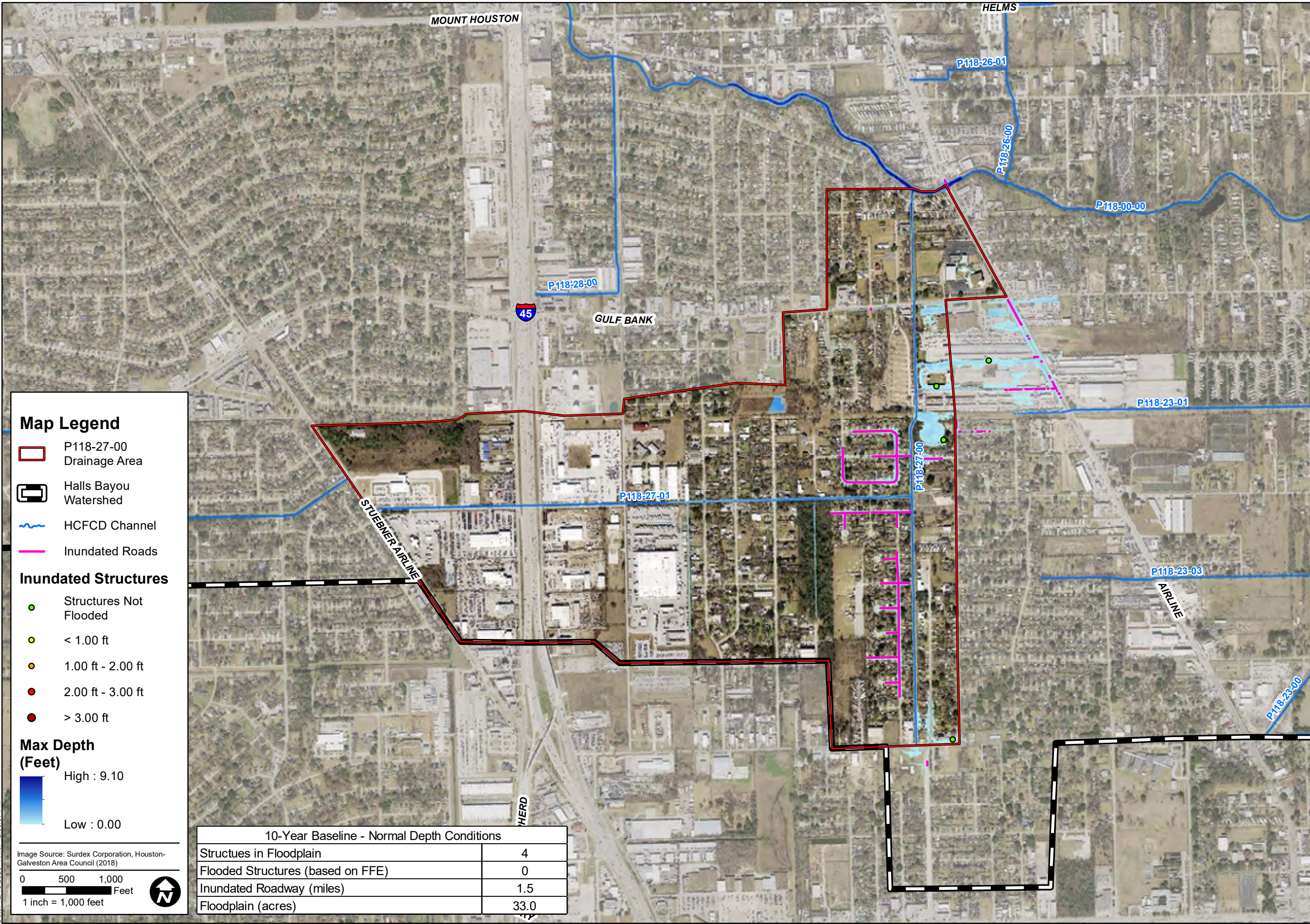
PREPARED:	BJI
CHECKED:	CEE
APPROVED:	CEE

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

DATE: APRIL 2020
 SCALE: AS NOTED
 EXHIBIT 8

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 Date: 12/15/2020 Time: 12:03:07 PM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

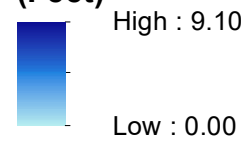
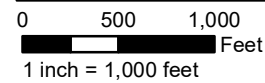


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



10-Year Baseline - Normal Depth Conditions	
Structures in Floodplain	4
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	1.5
Floodplain (acres)	33.0

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR BASELINE CONDITIONS
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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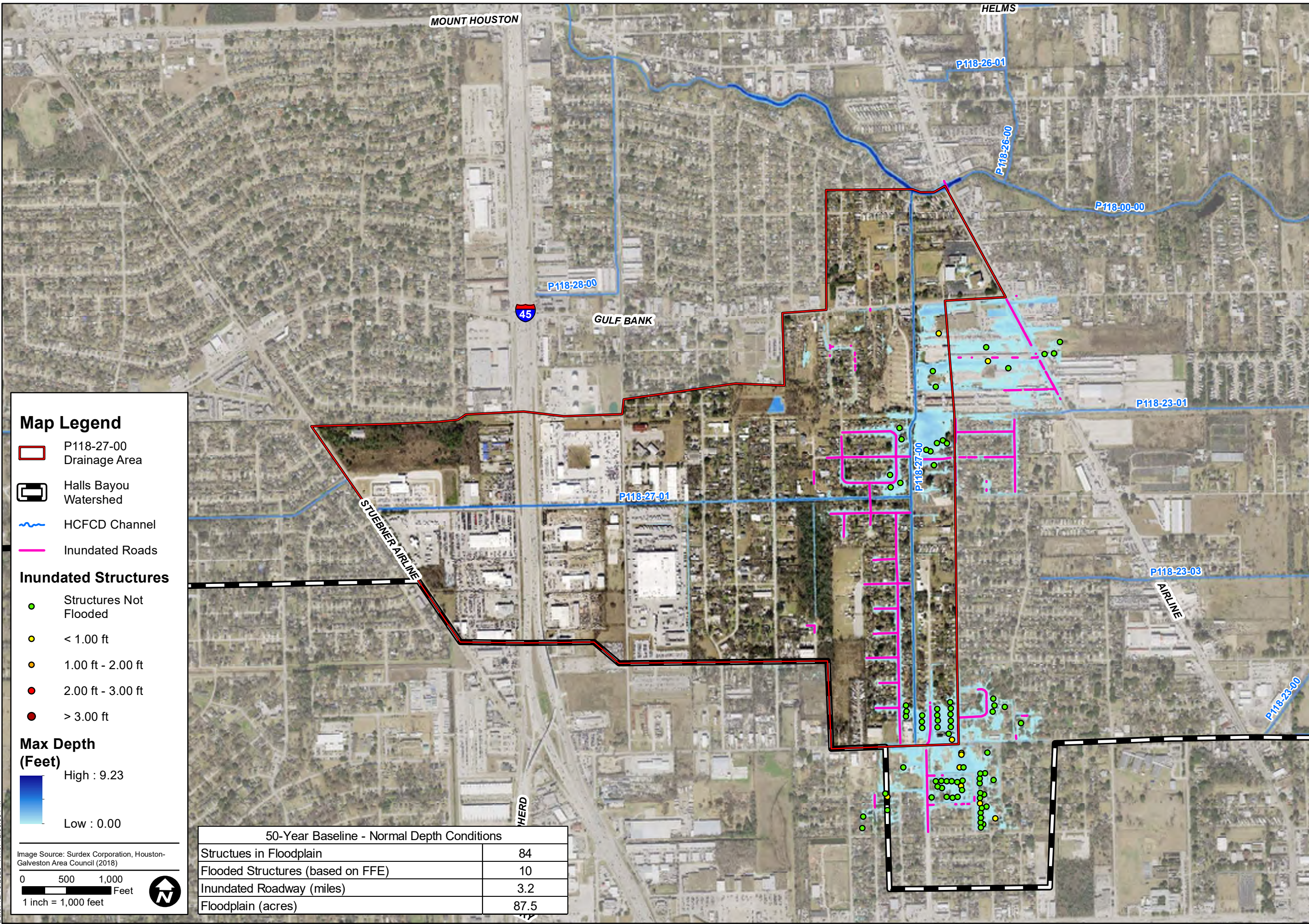


9900 Northwest Freeway
 Houston, Texas 77092

DATE: MAY 2020
 SCALE: AS NOTED

EXHIBIT
 9

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFC D Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

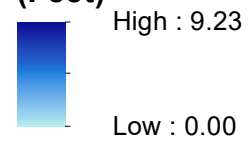
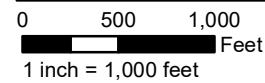


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



50-Year Baseline - Normal Depth Conditions	
Structues in Floodplain	84
Flooded Structures (based on FFE)	10
Inundated Roadway (miles)	3.2
Floodplain (acres)	87.5

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR BASELINE CONDITIONS
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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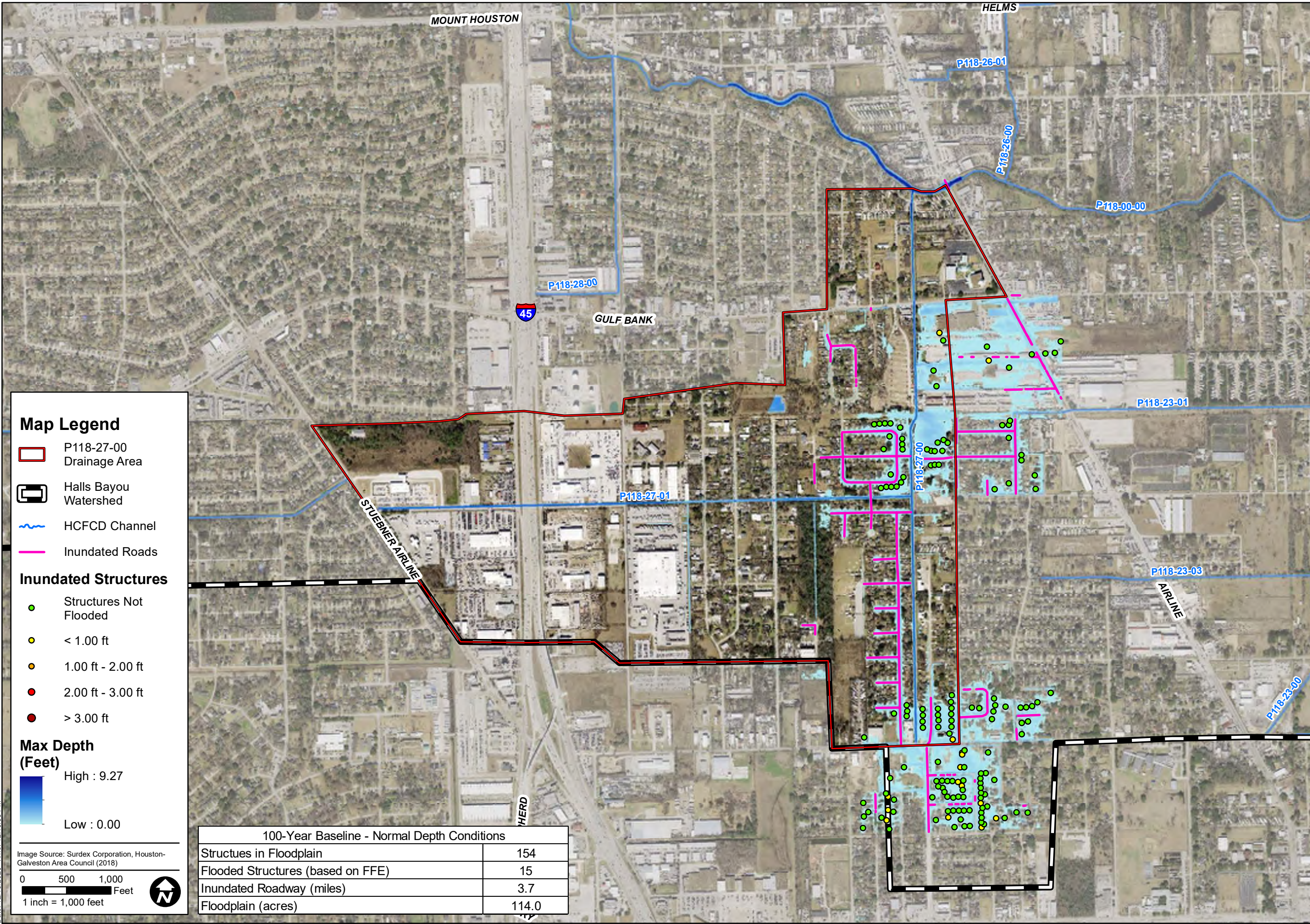


9900 Northwest Freeway
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 10






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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

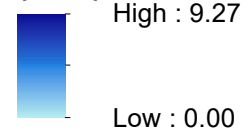
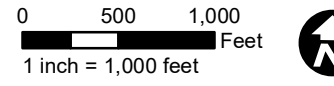


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



100-Year Baseline - Normal Depth Conditions	
Structues in Floodplain	154
Flooded Structures (based on FFE)	15
Inundated Roadway (miles)	3.7
Floodplain (acres)	114.0

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR BASELINE CONDITIONS
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

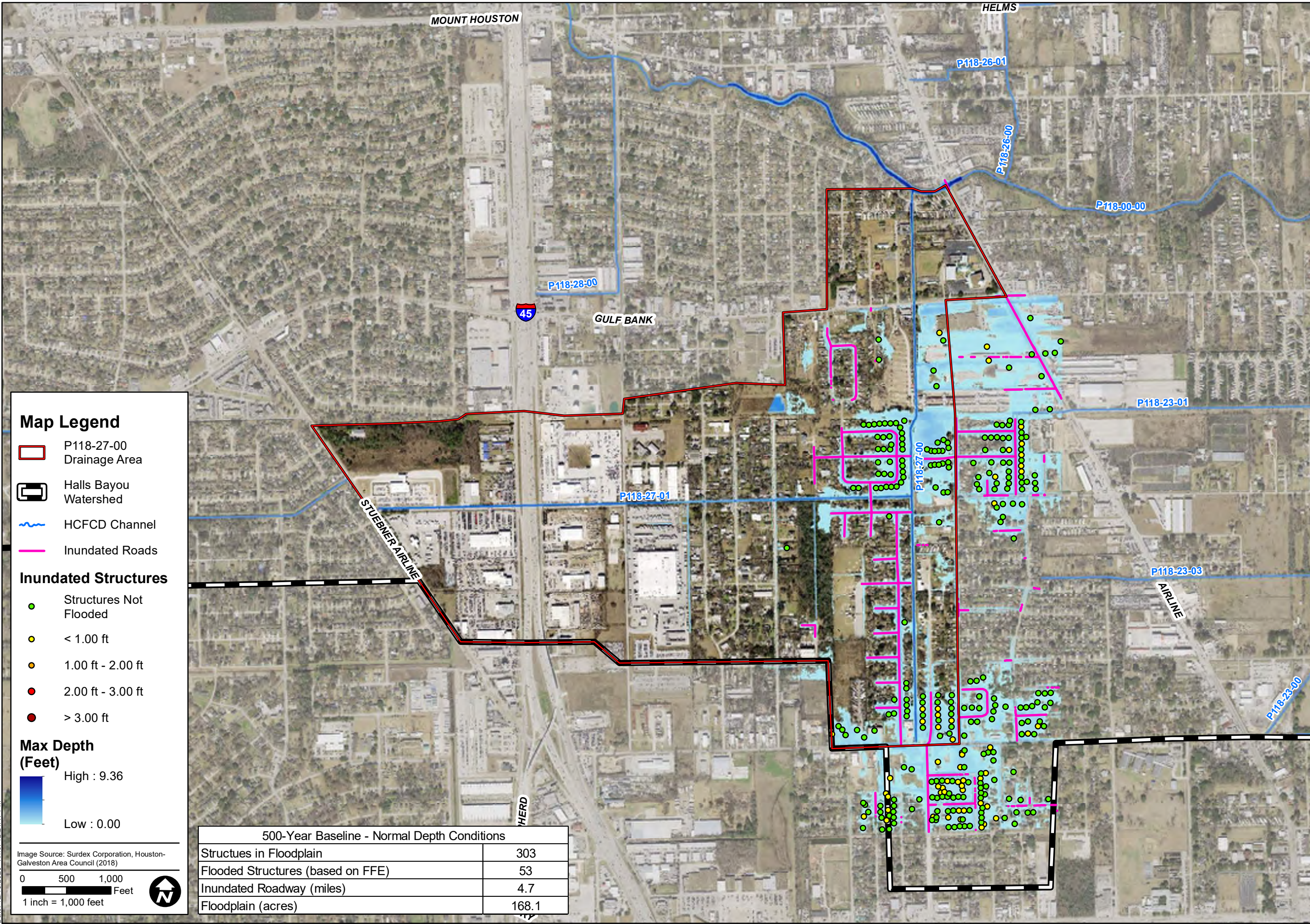
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DATE: MAY 2020
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 11






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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

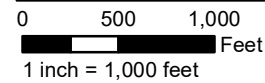
Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)



Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



500-Year Baseline - Normal Depth Conditions	
Structures in Floodplain	303
Flooded Structures (based on FFE)	53
Inundated Roadway (miles)	4.7
Floodplain (acres)	168.1

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

500-YEAR BASELINE CONDITIONS
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED: TMM

CHECKED: BJI

APPROVED: CEE

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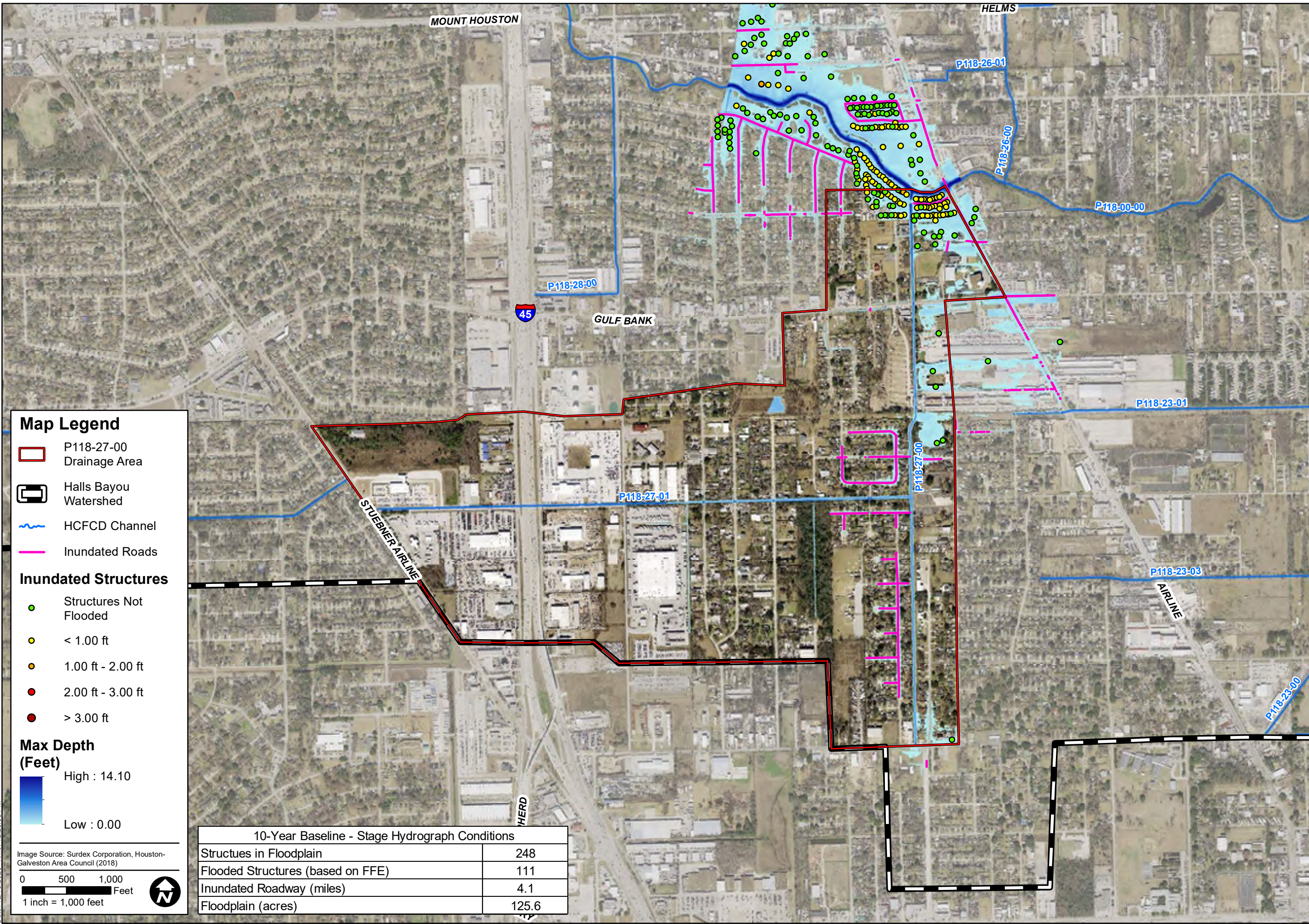


9900 Northwest Freeway
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DATE: MAY 2020
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 12






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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

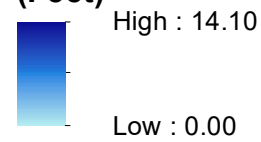
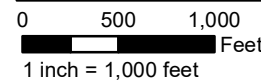


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



10-Year Baseline - Stage Hydrograph Conditions	
Structues in Floodplain	248
Flooded Structures (based on FFE)	111
Inundated Roadway (miles)	4.1
Floodplain (acres)	125.6

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR BASELINE CONDITIONS
 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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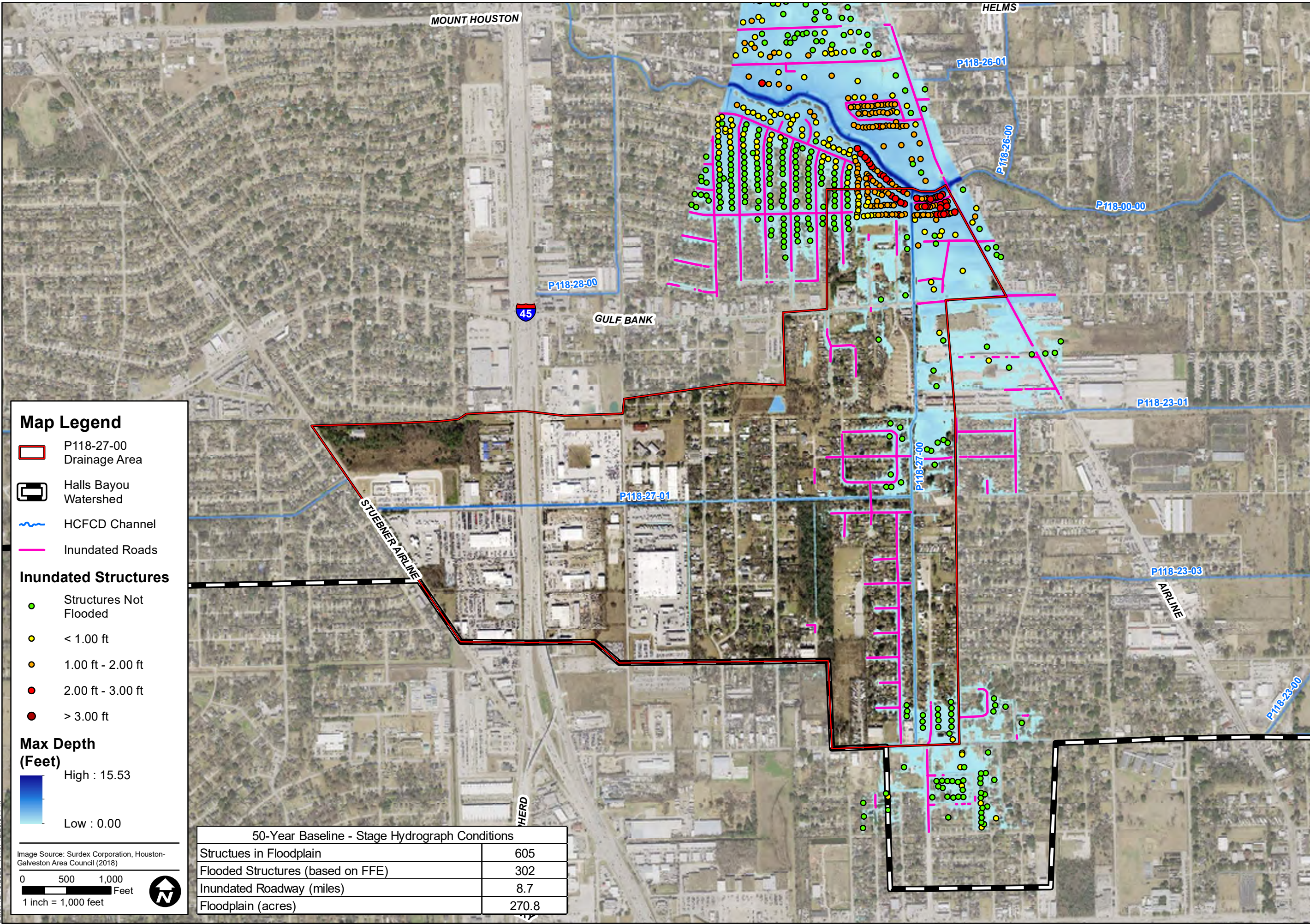


9900 Northwest Freeway
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DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT
 13

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

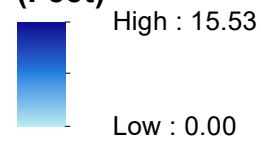
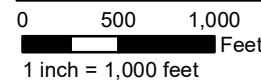


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



50-Year Baseline - Stage Hydrograph Conditions	
Structures in Floodplain	605
Flooded Structures (based on FFE)	302
Inundated Roadway (miles)	8.7
Floodplain (acres)	270.8

HCFCD HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR BASELINE CONDITIONS
 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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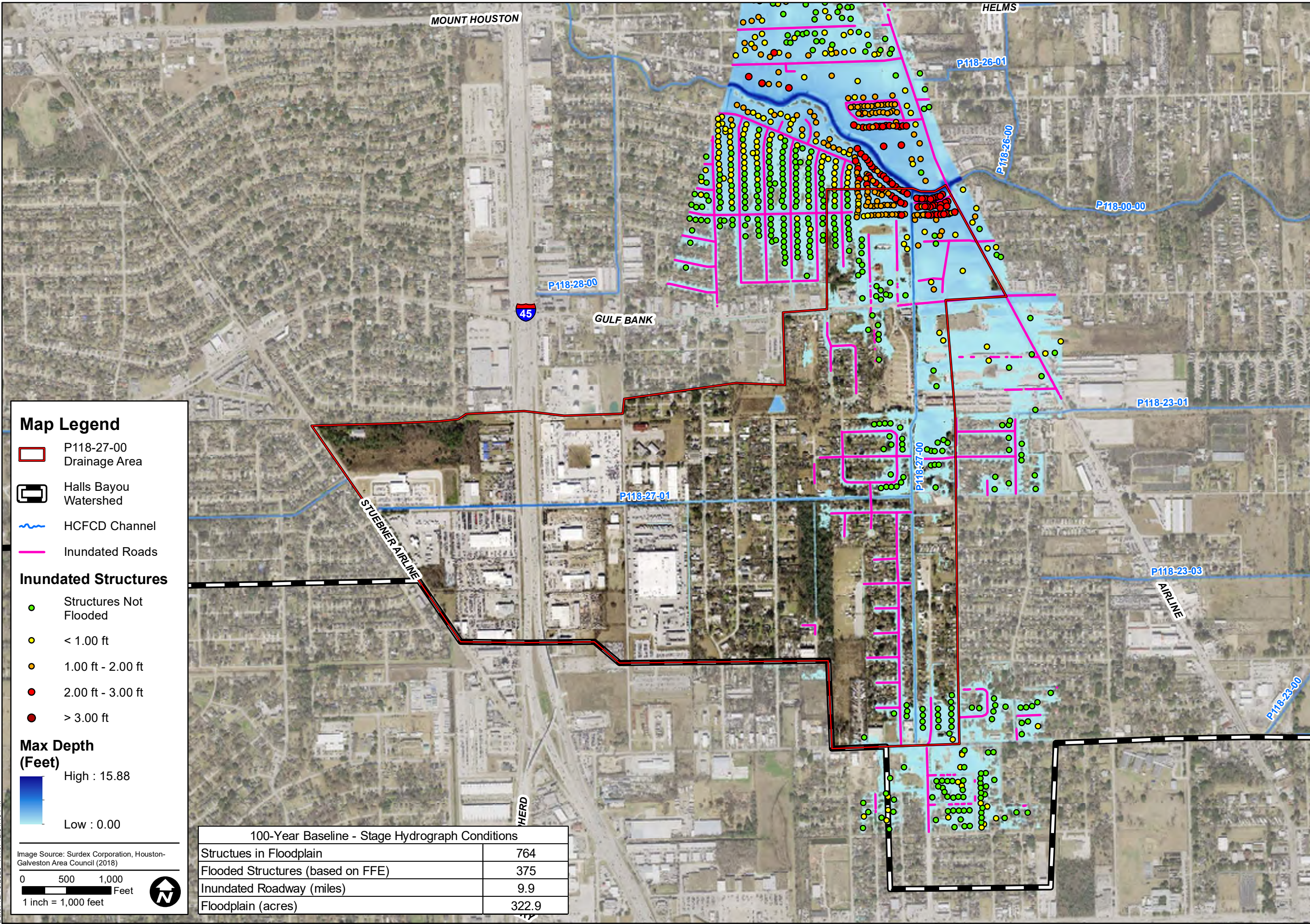


9900 Northwest Freeway
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DATE: OCT 2020
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 14






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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCF Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

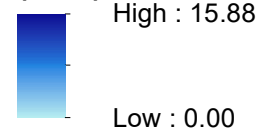
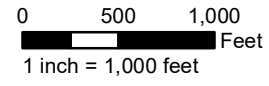


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



100-Year Baseline - Stage Hydrograph Conditions	
Structues in Floodplain	764
Flooded Structures (based on FFE)	375
Inundated Roadway (miles)	9.9
Floodplain (acres)	322.9

HCFCF HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR BASELINE CONDITIONS
 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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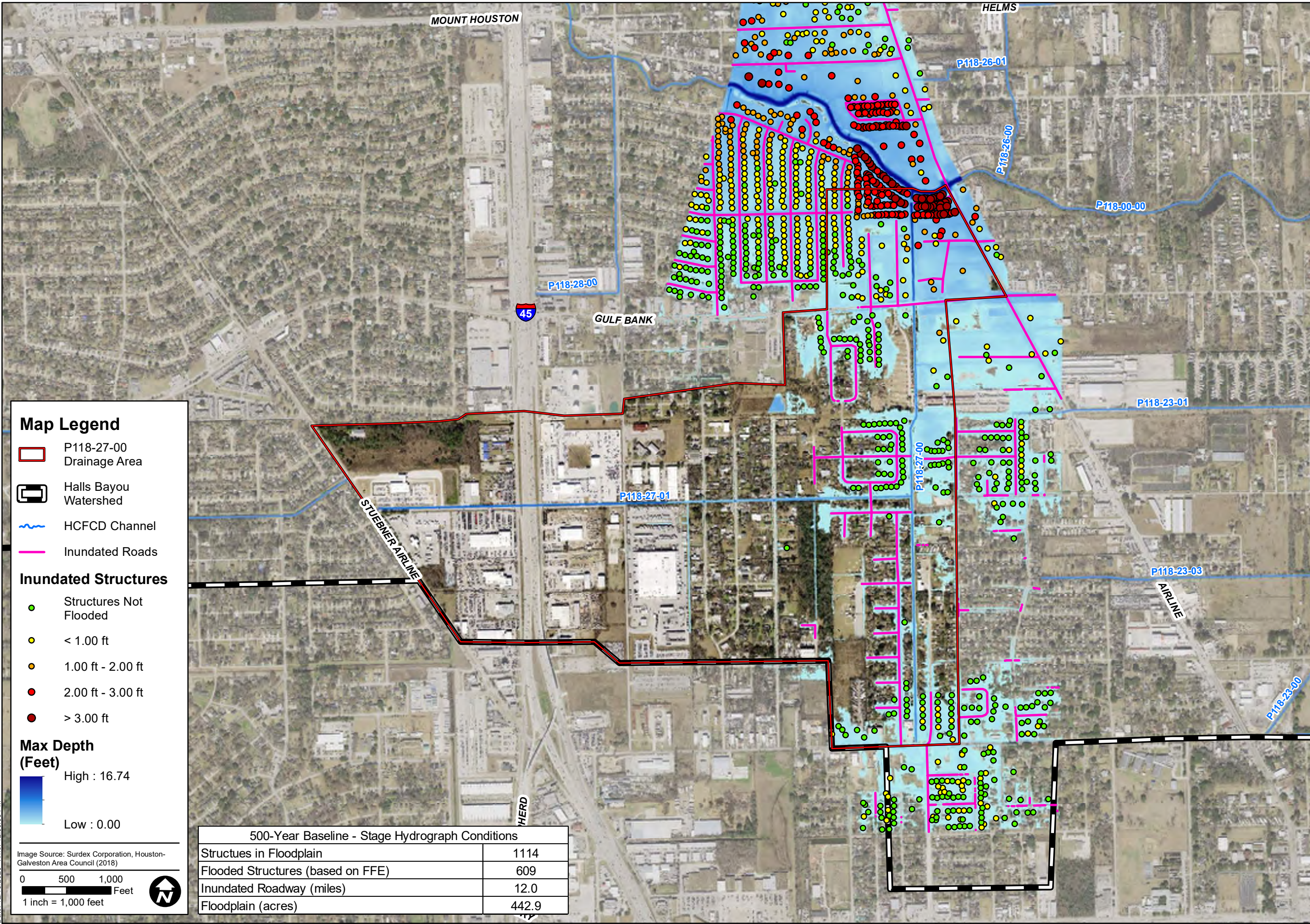


9900 Northwest Freeway
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DATE: OCT 2020
 SCALE: AS NOTED

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 15






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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

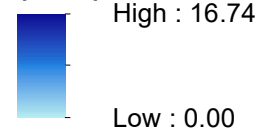
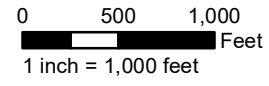


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



500-Year Baseline - Stage Hydrograph Conditions	
Structues in Floodplain	1114
Flooded Structures (based on FFE)	609
Inundated Roadway (miles)	12.0
Floodplain (acres)	442.9

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR BASELINE CONDITIONS
 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

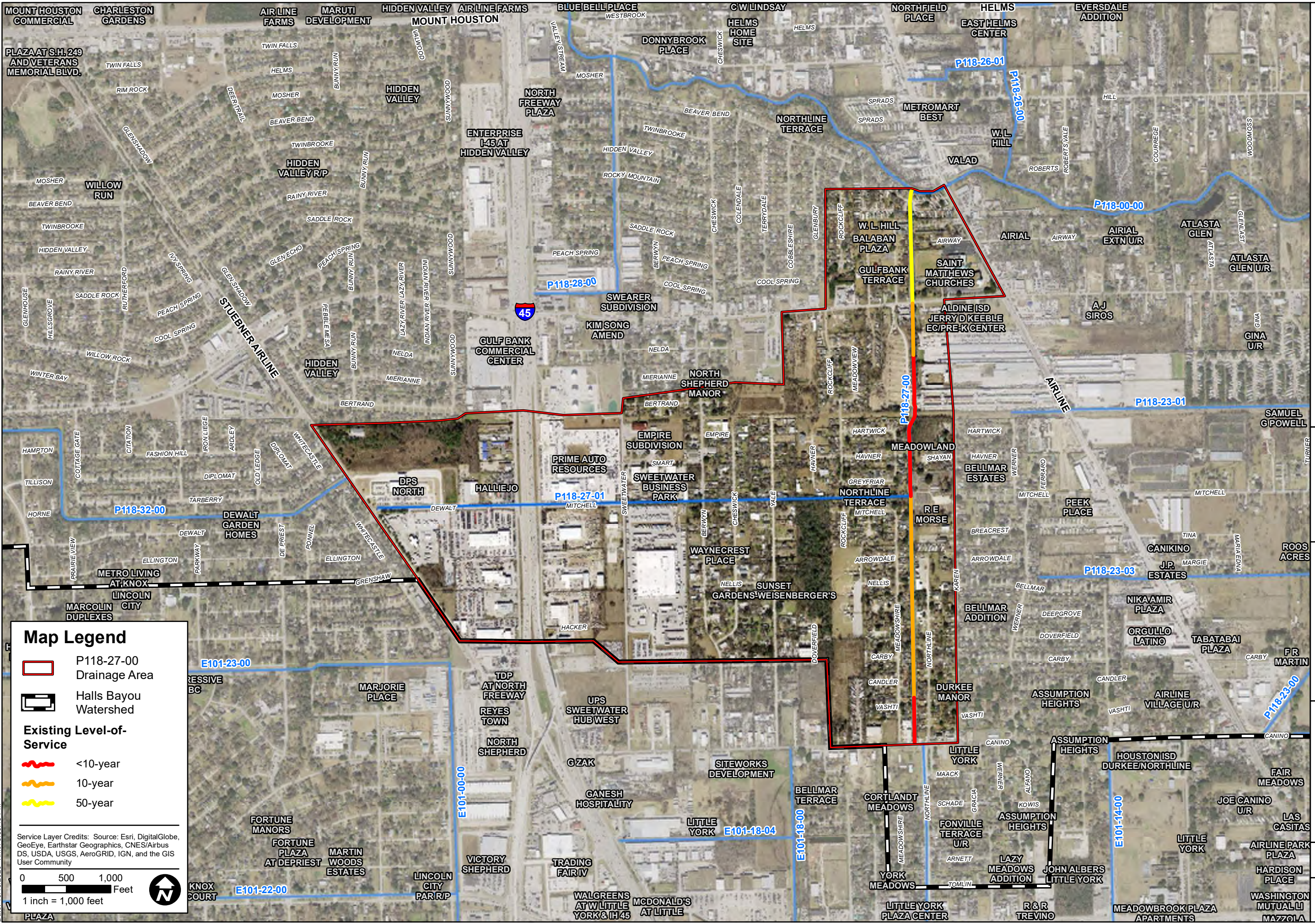
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HARRIS COUNTY FLOOD CONTROL DISTRICT
 9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT
 16

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed

Existing Level-of-Service

- <10-year
- 10-year
- 50-year

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

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFC D HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

P118-27-00

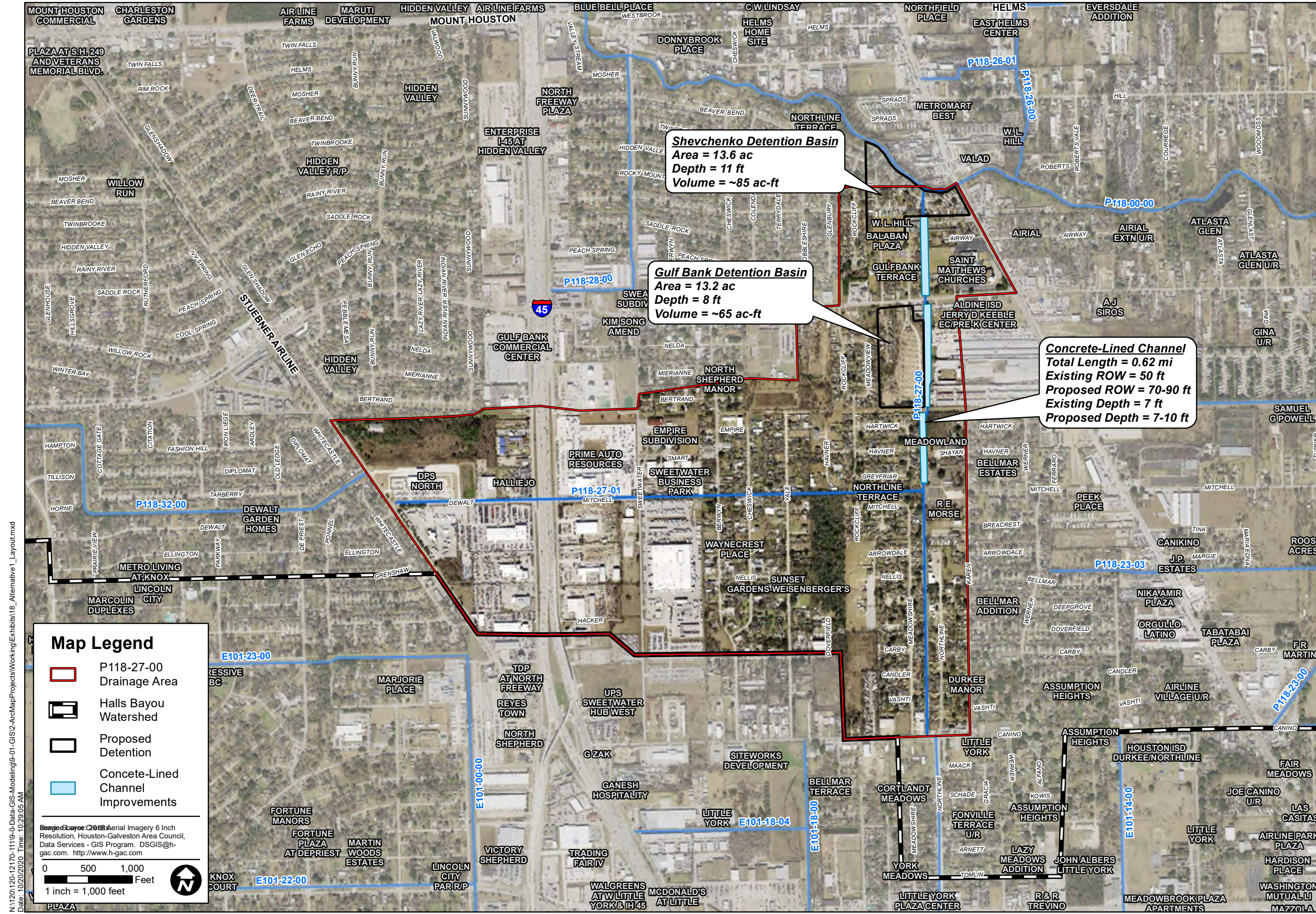
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CHECKED:	CEE
APPROVED:	CEE

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

DATE: MAY 2020
 SCALE: AS NOTED

EXHIBIT
 17



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HCFCD HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 P118-27-00

ALTERNATIVE 1 LAYOUT

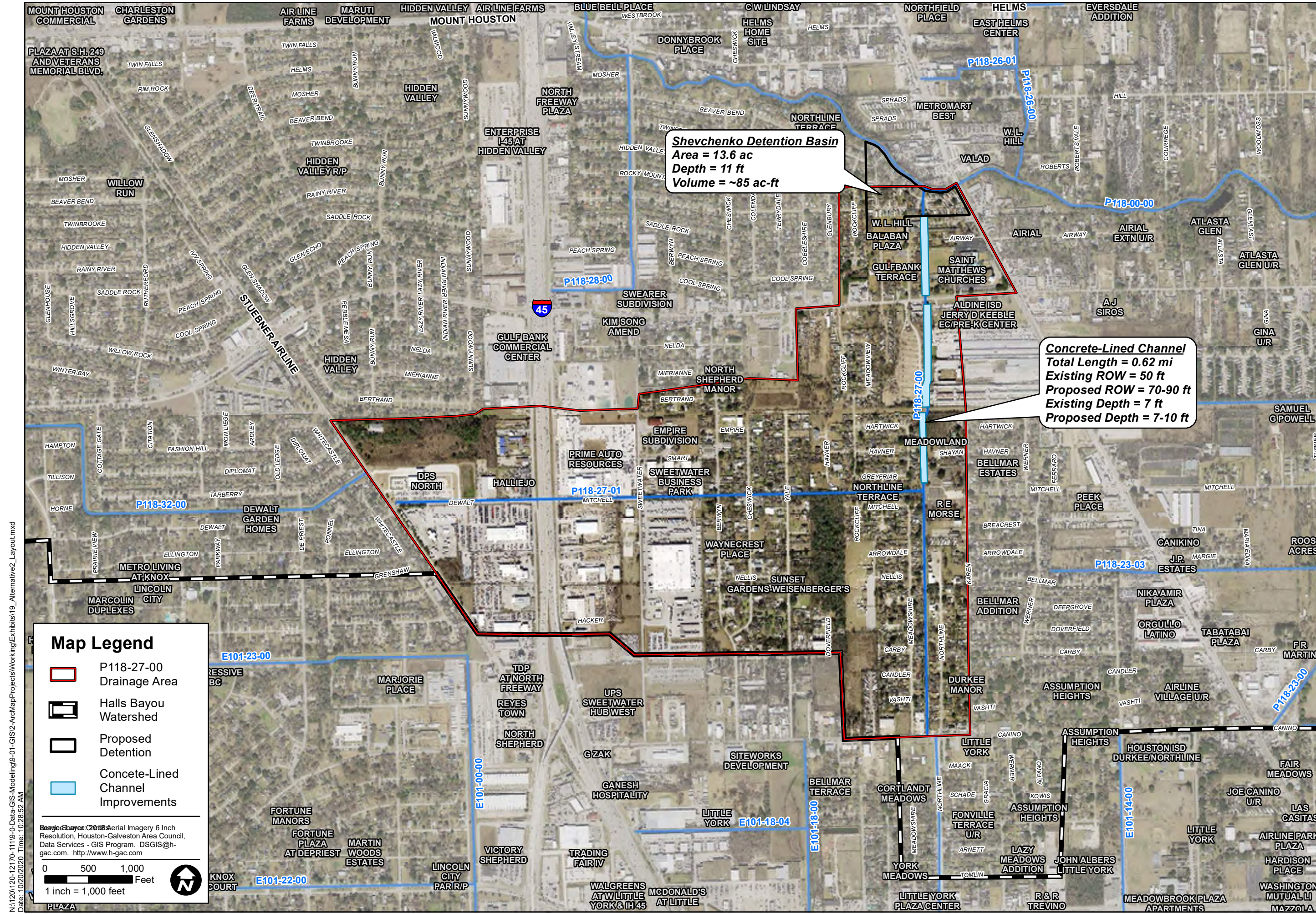
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APPROVED:	CEE

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 HARRIS COUNTY
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 9900 Northwest Freeway
 Houston, Texas 77092

DATE: AUG 2020
 SCALE: AS NOTED

EXHIBIT
 18



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- Proposed Detention
- Concrete-Lined Channel Improvements

Scale: 1 inch = 1,000 feet

North Arrow

Shevchenko Detention Basin
 Area = 13.6 ac
 Depth = 11 ft
 Volume = ~85 ac-ft

Concrete-Lined Channel
 Total Length = 0.62 mi
 Existing ROW = 50 ft
 Proposed ROW = 70-90 ft
 Existing Depth = 7 ft
 Proposed Depth = 7-10 ft

HCFCD HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 P118-27-00 ALTERNATIVE 2 LAYOUT
 (RECOMMENDED ALTERNATIVE)

PREPARED:	ENR
CHECKED:	CEE
APPROVED:	CEE

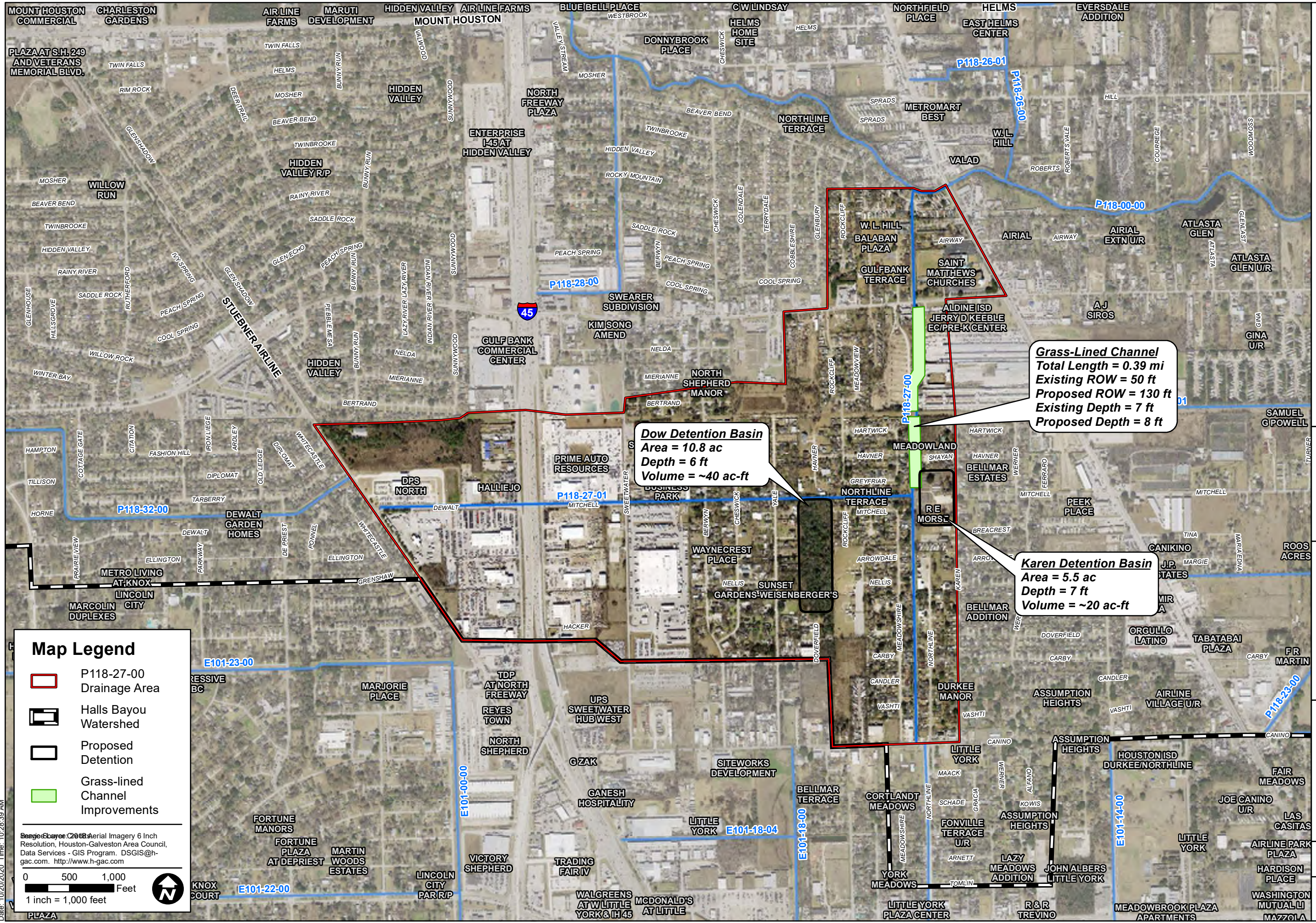
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 Houston, Texas 77092

DATE: AUG 2020
 SCALE: AS NOTED
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 19

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- Proposed Detention
- Grass-lined Channel Improvements

Scale: 1 inch = 1,000 feet

North Arrow

Source: Esri Aerial Imagery 6 Inch Resolution, Houston-Galveston Area Council, Data Services - GIS Program. DSGIS@h-gac.com. http://www.h-gac.com

Grass-Lined Channel
 Total Length = 0.39 mi
 Existing ROW = 50 ft
 Proposed ROW = 130 ft
 Existing Depth = 7 ft
 Proposed Depth = 8 ft

Dow Detention Basin
 Area = 10.8 ac
 Depth = 6 ft
 Volume = ~40 ac-ft

Karen Detention Basin
 Area = 5.5 ac
 Depth = 7 ft
 Volume = ~20 ac-ft

**HCFCD HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

ALTERNATIVE 3 LAYOUT

PREPARED:	ENR
CHECKED:	CEE
APPROVED:	CEE

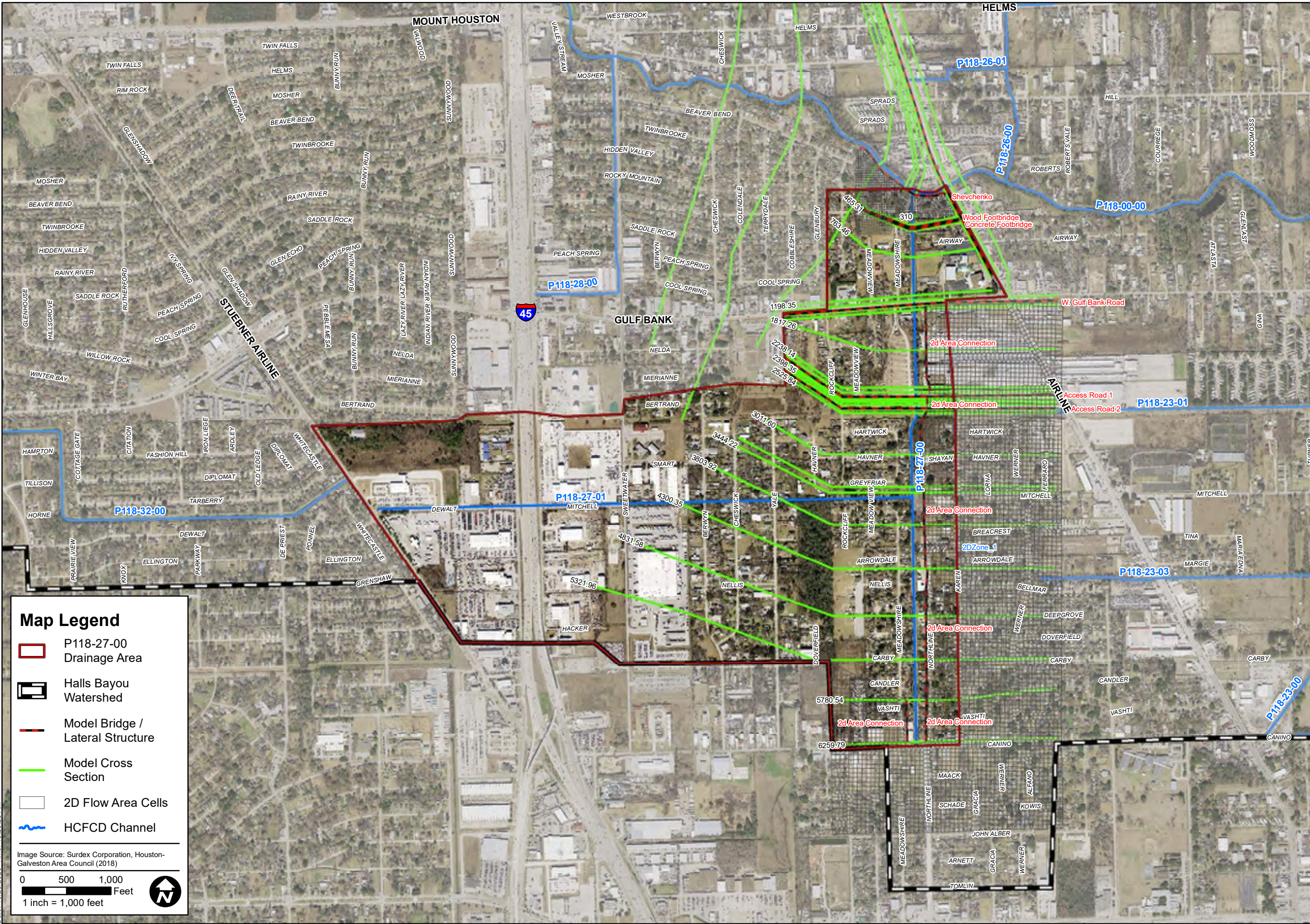
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 9900 Northwest Freeway
 Houston, Texas 77092

DATE: AUG 2020
 SCALE: AS NOTED

EXHIBIT
 20

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- Model Bridge / Lateral Structure
- Model Cross Section
- 2D Flow Area Cells
- HCFCD Channel

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

**HCFCD HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

P118-27-00

**HEC-RAS GEOMETRY
 RECOMMENDED ALTERNATIVE**

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

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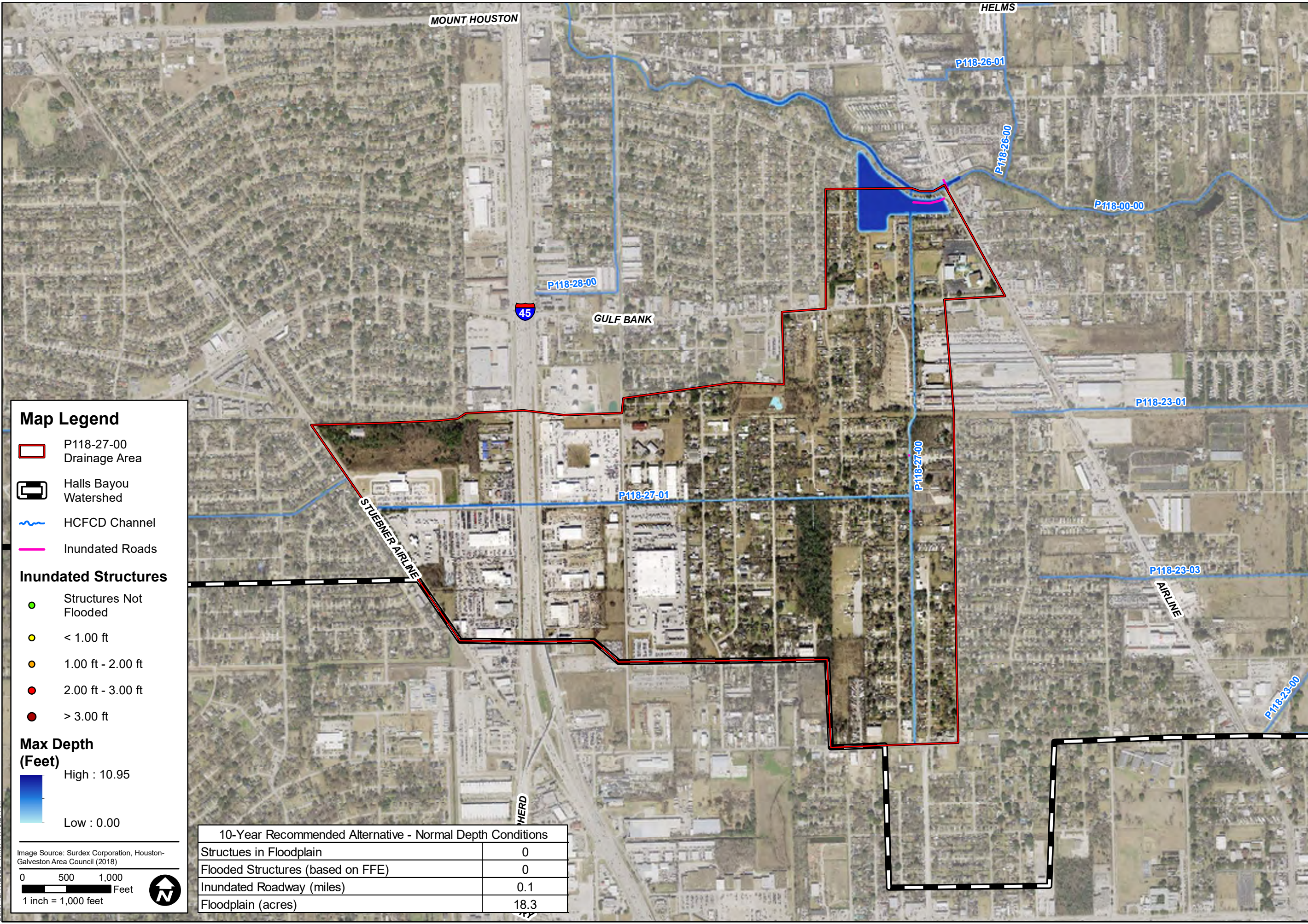
**HARRIS COUNTY
 FLOOD CONTROL DISTRICT**

9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT
 21

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 Date: 12/17/2020 Time: 11:15:21 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

High : 10.95

Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

10-Year Recommended Alternative - Normal Depth Conditions	
Structures in Floodplain	0
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.1
Floodplain (acres)	18.3

**HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

**10-YEAR RECOMMENDED ALTERNATIVE (ALT. 2)
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)**

PREPARED: TMM	CHECKED: BJI	APPROVED: CEE
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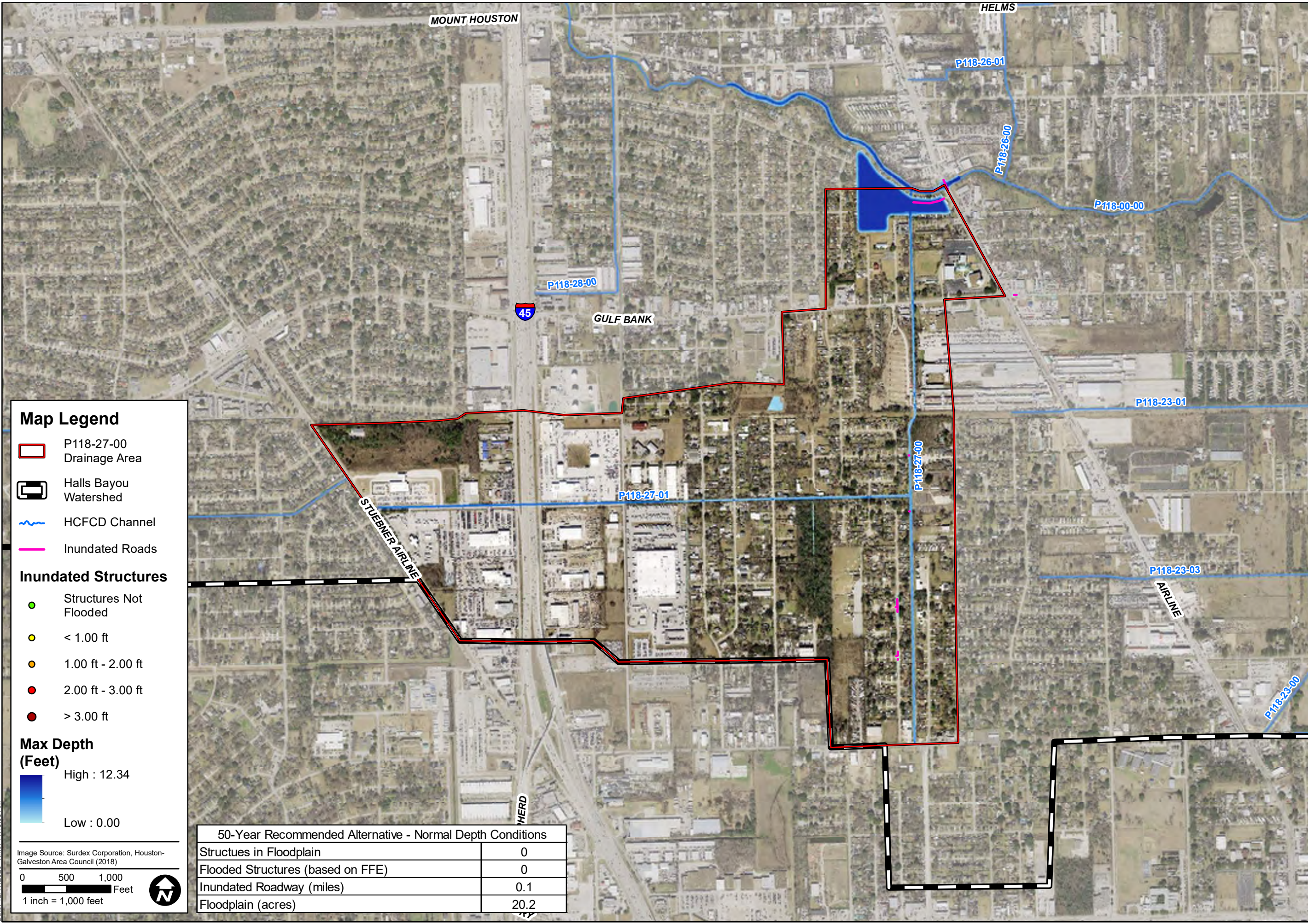
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

High : 12.34

Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

50-Year Recommended Alternative - Normal Depth Conditions	
Structures in Floodplain	0
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.1
Floodplain (acres)	20.2

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR RECOMMENDED ALTERNATIVE (ALT. 2)
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

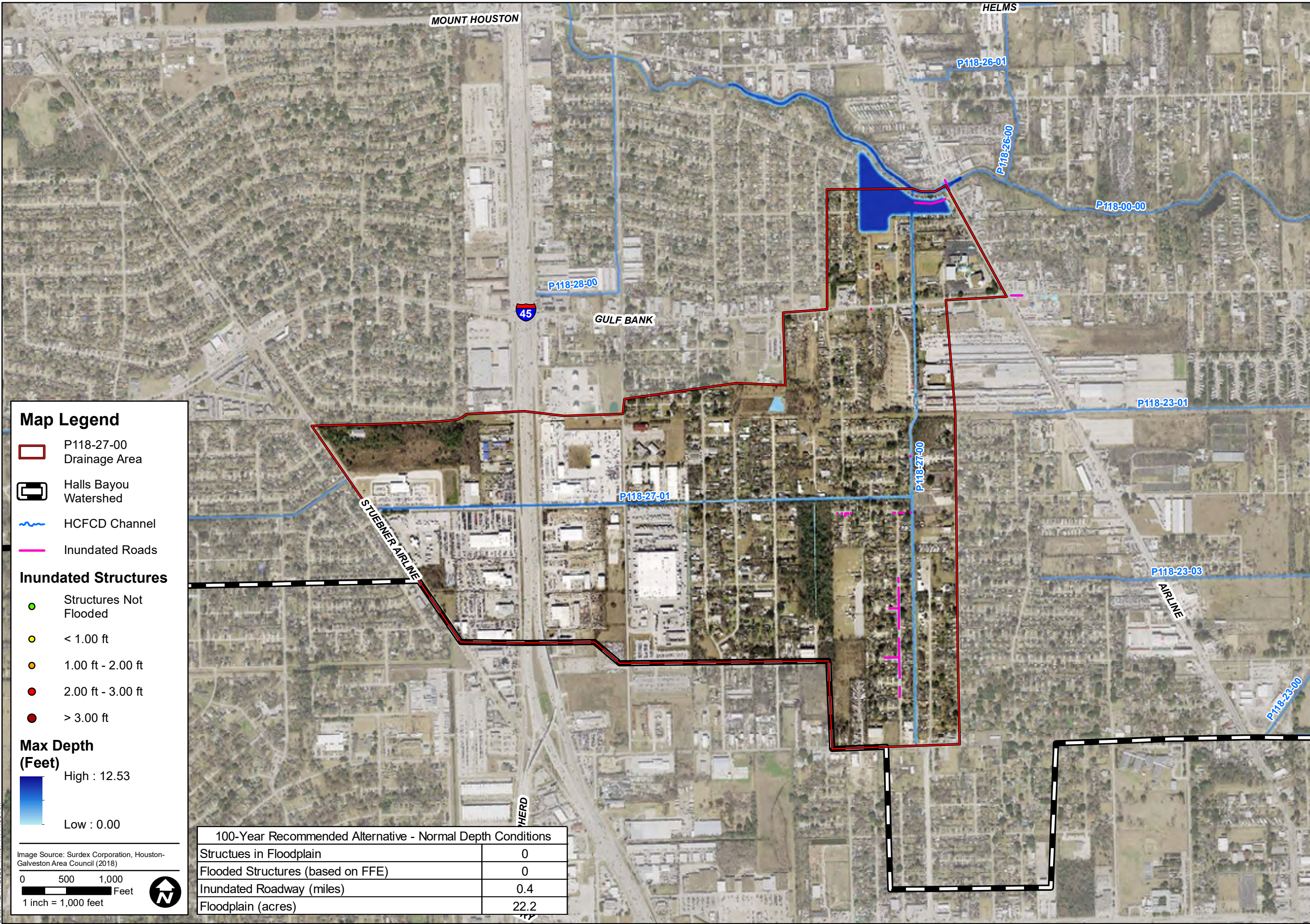
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 Date: 12/17/2020 Time: 11:14:56 AM



Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

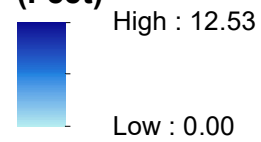
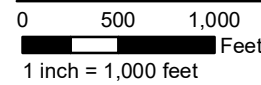


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



100-Year Recommended Alternative - Normal Depth Conditions	
Structures in Floodplain	0
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.4
Floodplain (acres)	22.2

HCFC D HALLS BAYOU WATERSHED
P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
100-YEAR RECOMMENDED ALTERNATIVE (ALT. 2)
PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE


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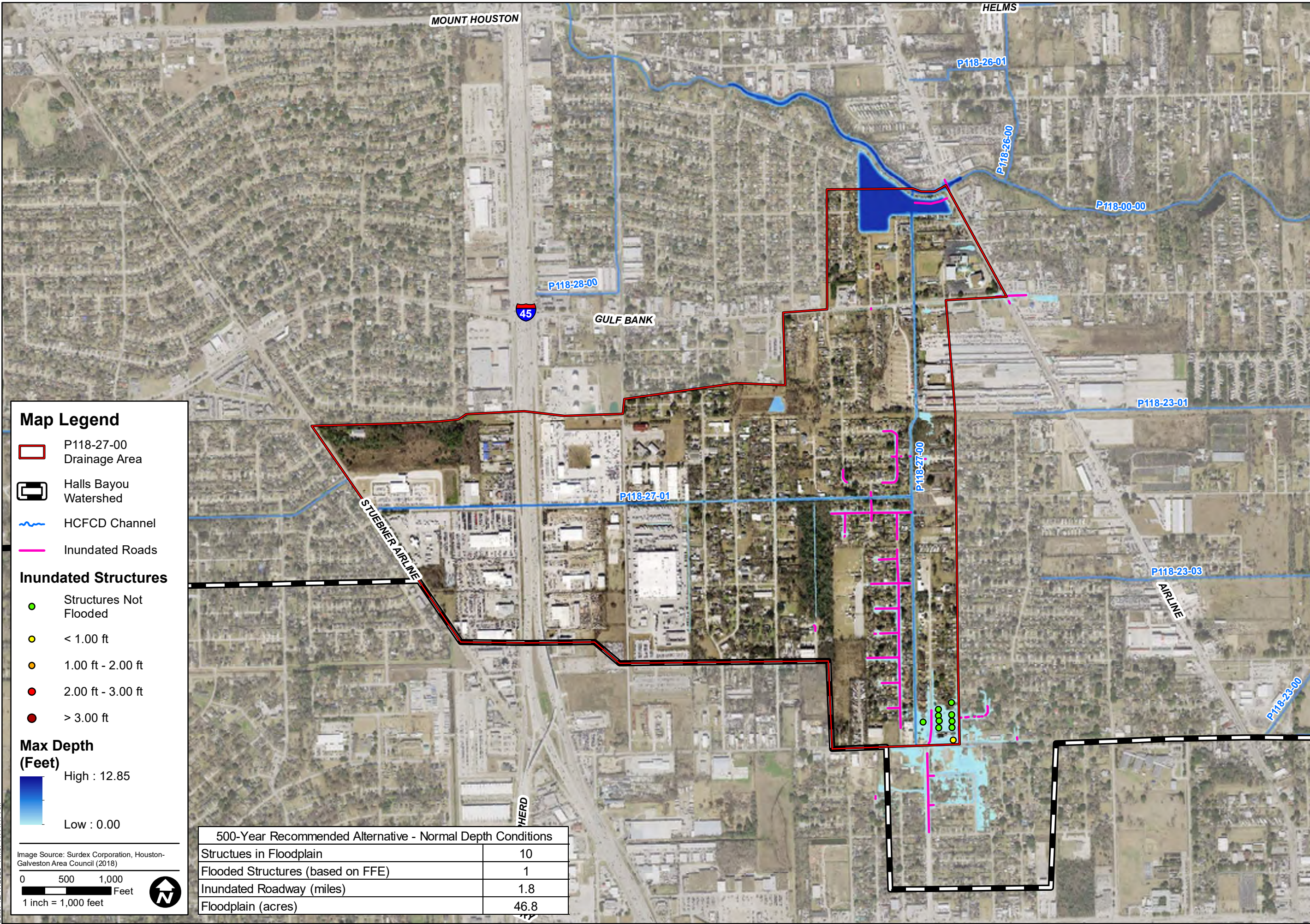

HARRIS COUNTY
FLOOD CONTROL DISTRICT

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DATE: OCT 2020
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 24

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 Date: 12/17/2020 Time: 11:14:47 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCFD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

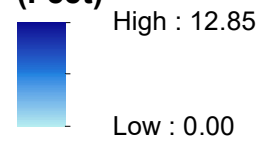
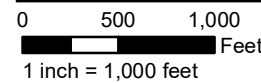


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



500-Year Recommended Alternative - Normal Depth Conditions	
Structues in Floodplain	10
Flooded Structures (based on FFE)	1
Inundated Roadway (miles)	1.8
Floodplain (acres)	46.8

HCFCFD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR RECOMMENDED ALTERNATIVE (ALT. 2)
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED: TMM

CHECKED: BJI

APPROVED: CEE

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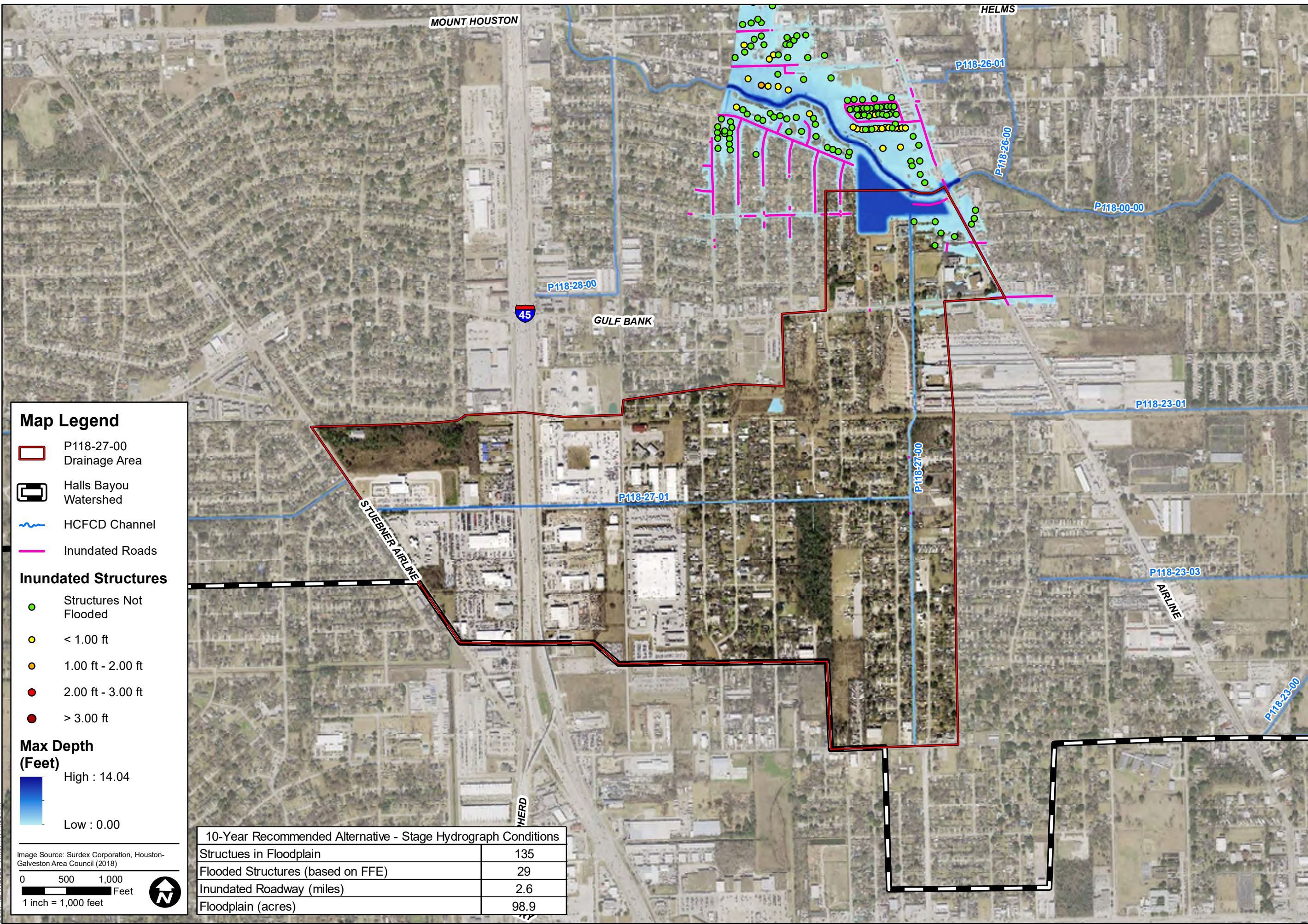


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 25






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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCDD Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

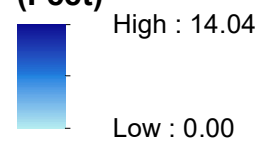
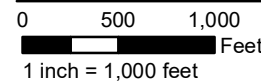


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



10-Year Recommended Alternative - Stage Hydrograph Conditions	
Structures in Floodplain	135
Flooded Structures (based on FFE)	29
Inundated Roadway (miles)	2.6
Floodplain (acres)	98.9

HCFCDD HALLS BAYOU WATERSHED
P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
10-YEAR RECOMMENDED ALTERNATIVE (ALT. 2)
PERFORMANCE METRICS
(STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE


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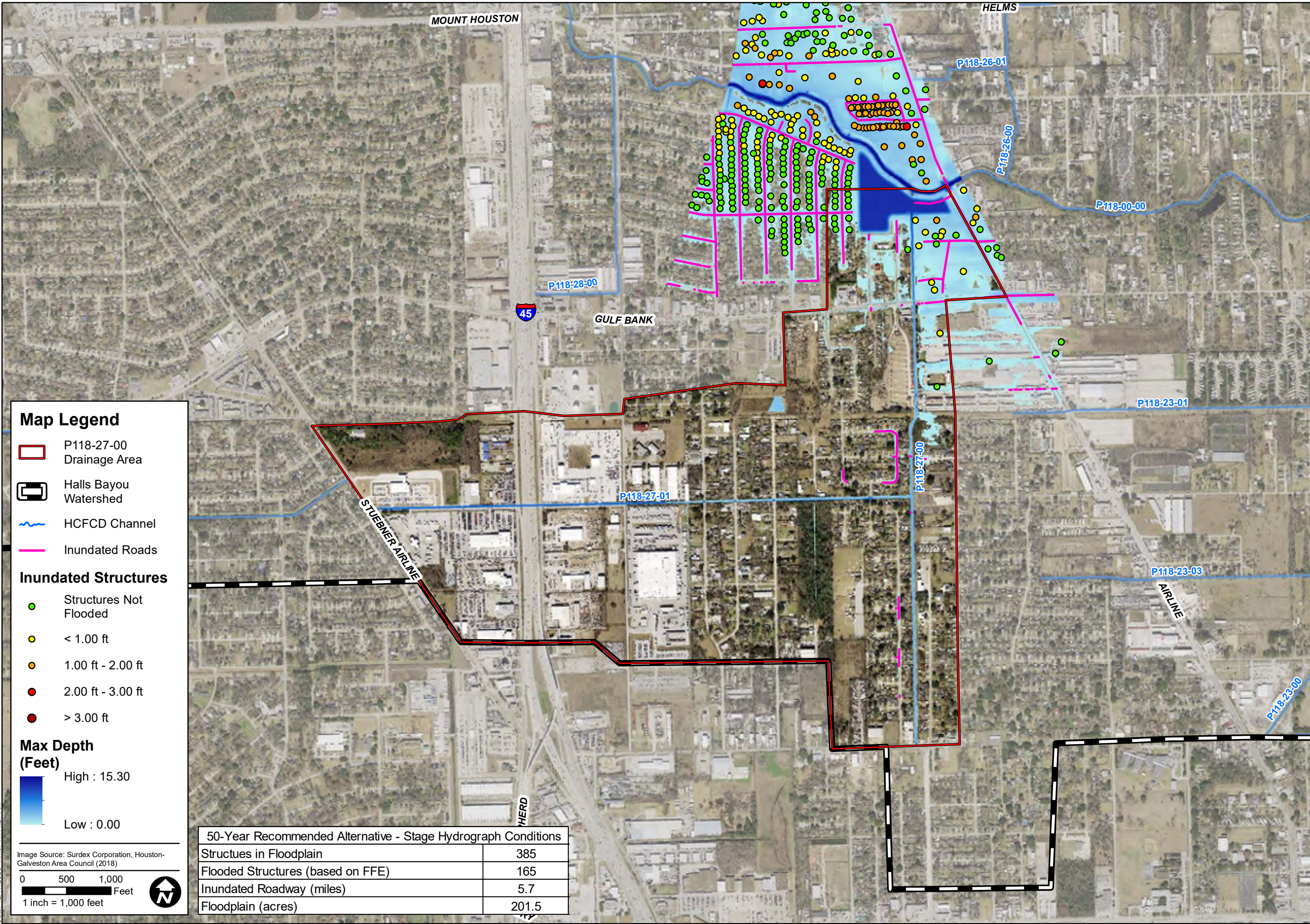


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26

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

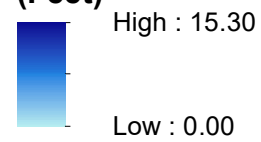
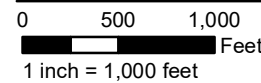


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



50-Year Recommended Alternative - Stage Hydrograph Conditions

Structues in Floodplain	385
Flooded Structures (based on FFE)	165
Inundated Roadway (miles)	5.7
Floodplain (acres)	201.5

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR RECOMMENDED ALTERNATIVE (ALT. 2)
 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM

CHECKED: BJI

APPROVED: CEE



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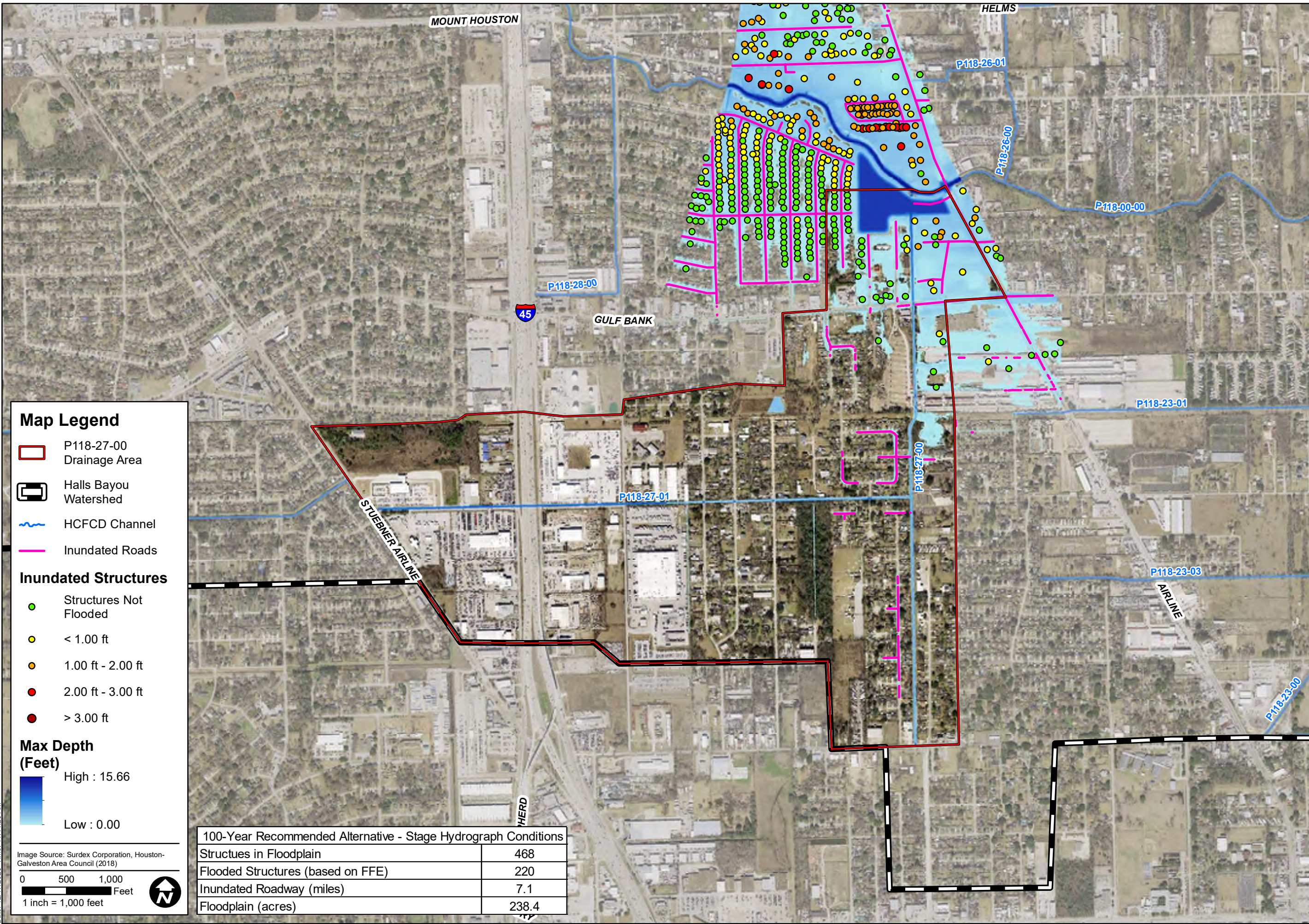


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 27






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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

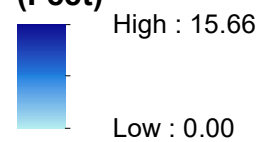
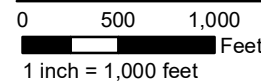


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



100-Year Recommended Alternative - Stage Hydrograph Conditions	
Structures in Floodplain	468
Flooded Structures (based on FFE)	220
Inundated Roadway (miles)	7.1
Floodplain (acres)	238.4

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR RECOMMENDED ALTERNATIVE (ALT. 2)
 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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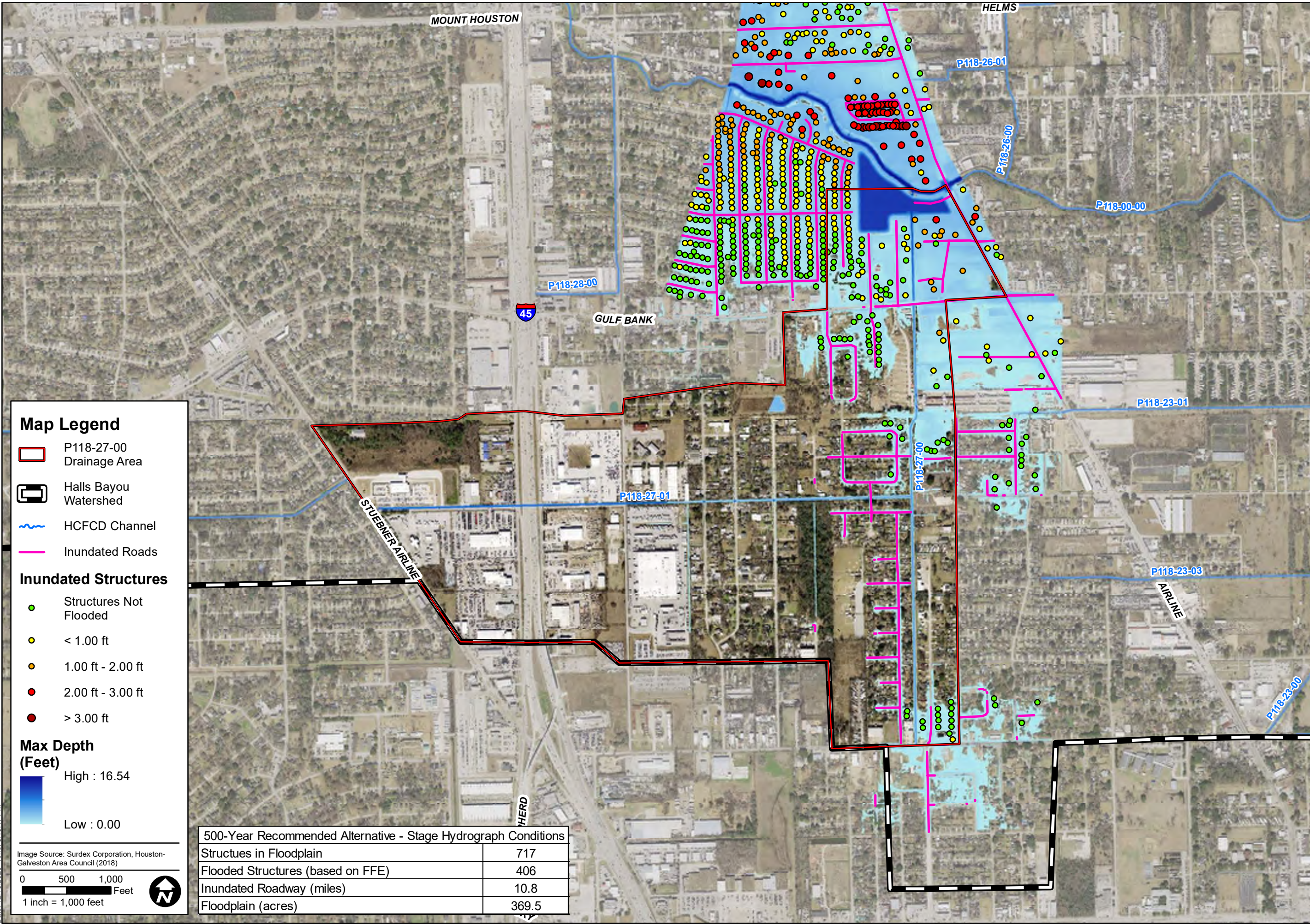
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 28






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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

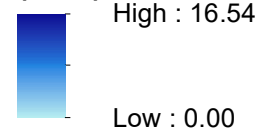
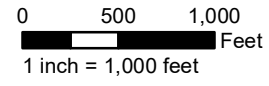


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



500-Year Recommended Alternative - Stage Hydrograph Conditions

Structures in Floodplain	717
Flooded Structures (based on FFE)	406
Inundated Roadway (miles)	10.8
Floodplain (acres)	369.5

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR RECOMMENDED ALTERNATIVE (ALT. 2)
 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

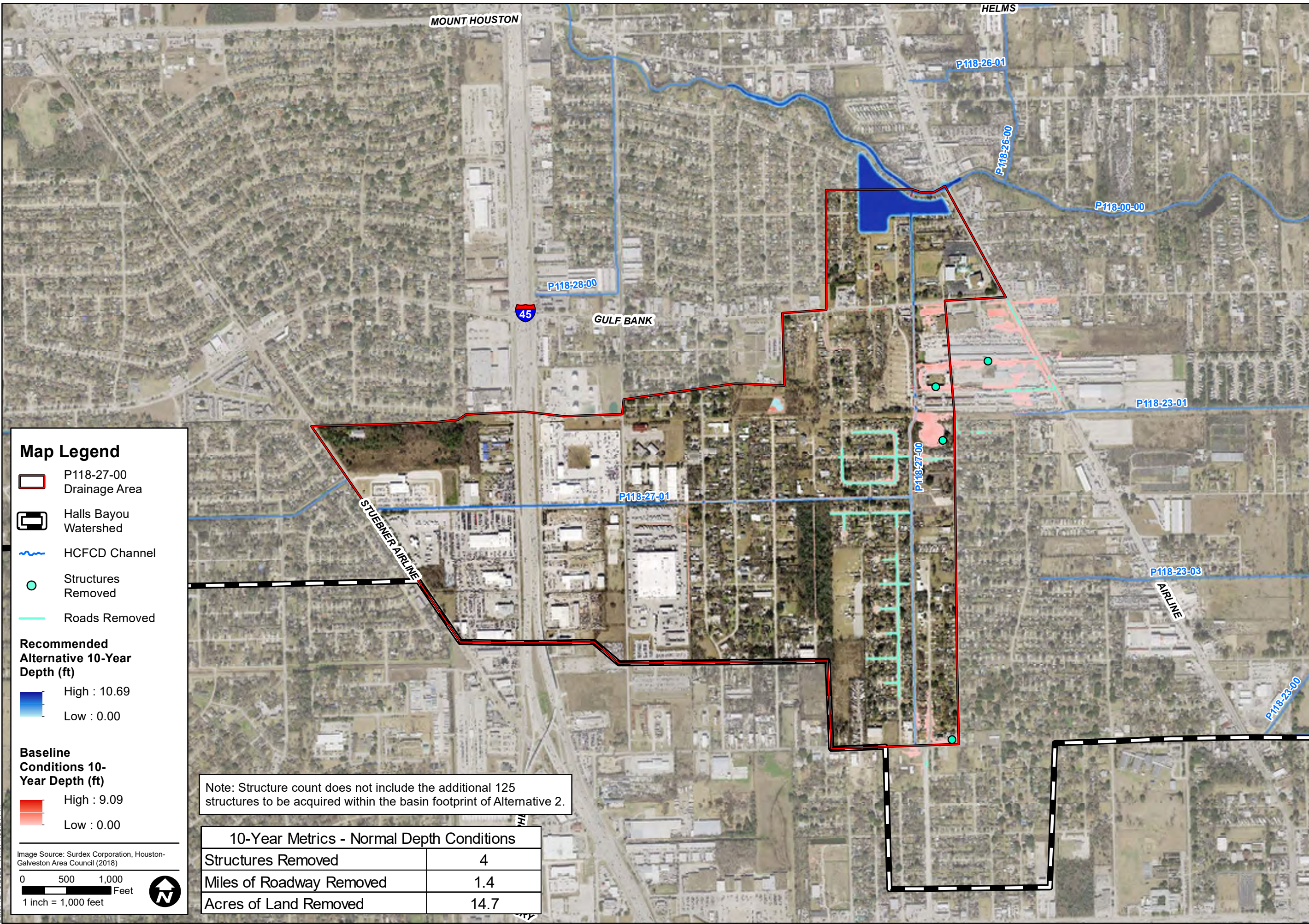
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

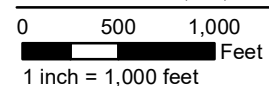
Recommended Alternative 10-Year Depth (ft)

- High : 10.69
- Low : 0.00

Baseline Conditions 10-Year Depth (ft)

- High : 9.09
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional 125 structures to be acquired within the basin footprint of Alternative 2.

10-Year Metrics - Normal Depth Conditions	
Structures Removed	4
Miles of Roadway Removed	1.4
Acres of Land Removed	14.7

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR RECOMMENDED ALTERNATIVE (ALT. 2) VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

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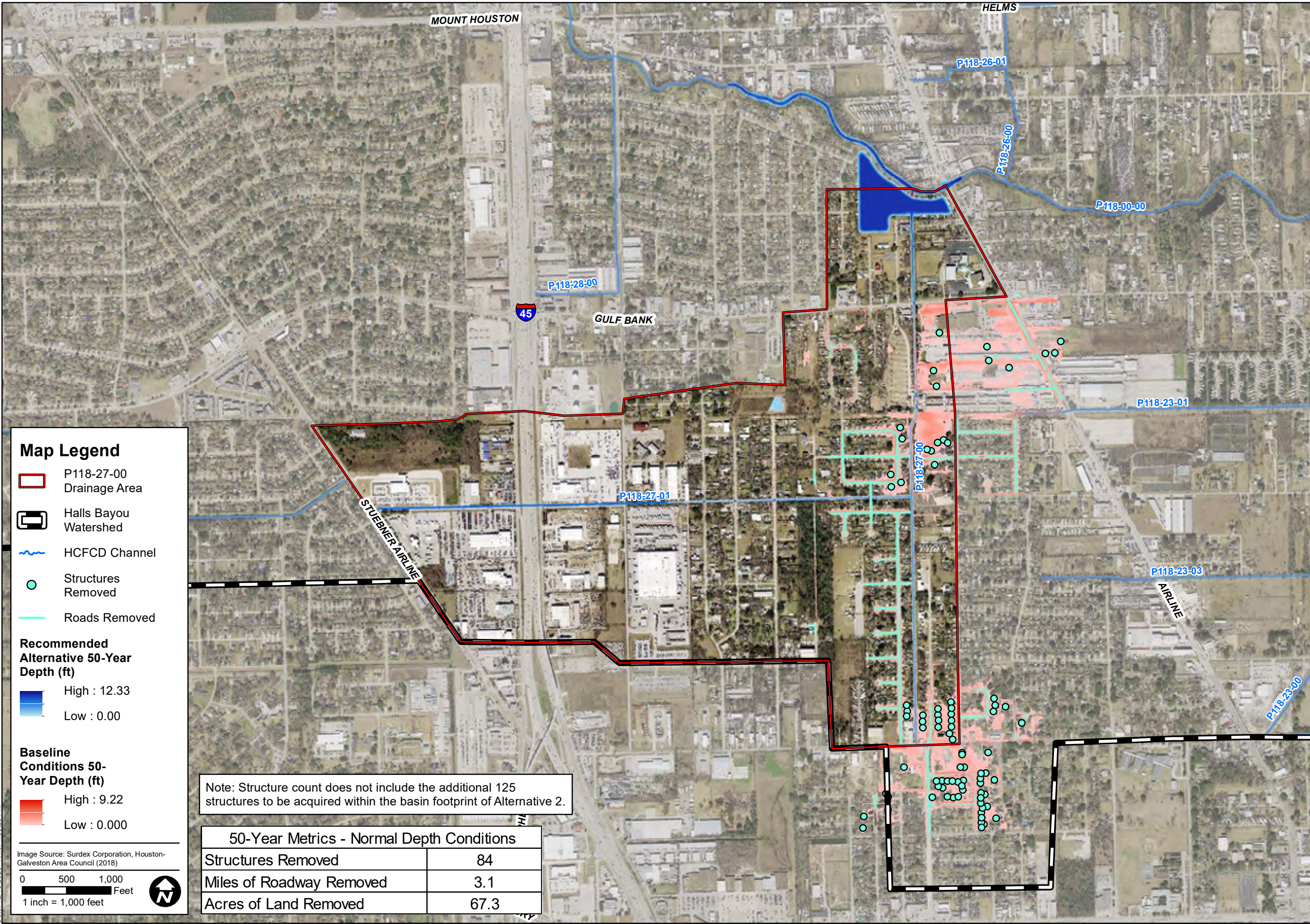


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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCO Channel
- Structures Removed
- Roads Removed

Recommended Alternative 50-Year Depth (ft)

- High : 12.33
- Low : 0.00

Baseline Conditions 50-Year Depth (ft)

- High : 9.22
- Low : 0.000

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet



Note: Structure count does not include the additional 125 structures to be acquired within the basin footprint of Alternative 2.

50-Year Metrics - Normal Depth Conditions	
Structures Removed	84
Miles of Roadway Removed	3.1
Acres of Land Removed	67.3

HCFCO HALLS BAYOU WATERSHED
 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 P118-27-00
 50-YEAR RECOMMENDED ALTERNATIVE (ALT. 2) VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

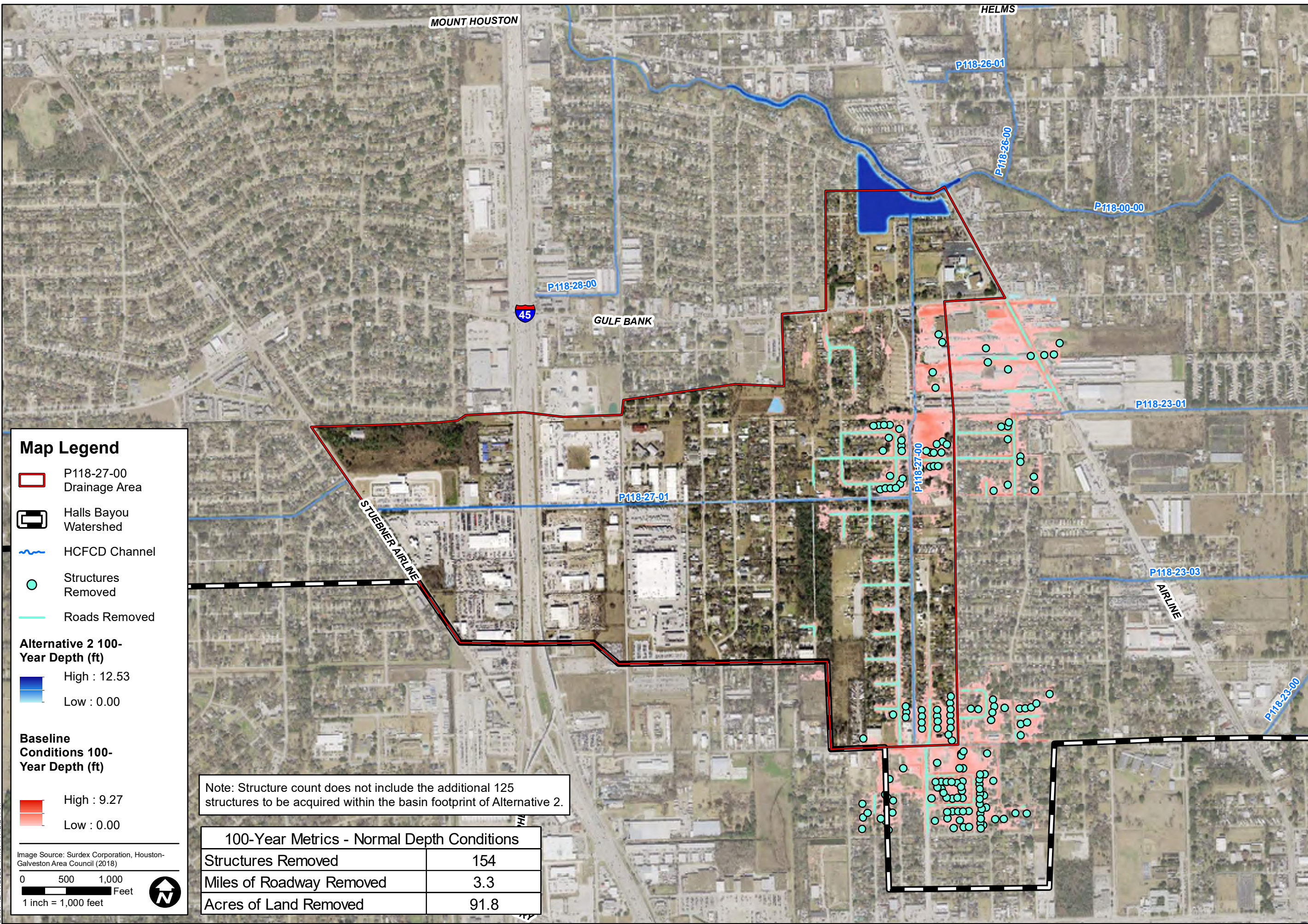
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DATE: OCT 2020
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCO Channel
- Structures Removed
- Roads Removed

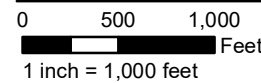
Alternative 2 100-Year Depth (ft)

- High : 12.53
- Low : 0.00

Baseline Conditions 100-Year Depth (ft)

- High : 9.27
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional 125 structures to be acquired within the basin footprint of Alternative 2.

100-Year Metrics - Normal Depth Conditions	
Structures Removed	154
Miles of Roadway Removed	3.3
Acres of Land Removed	91.8

HCFCO HALLS BAYOU WATERSHED
P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
100-YEAR RECOMMENDED ALTERNATIVE (ALT. 2) VS.
BASELINE CONDITIONS COMPARISON
PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

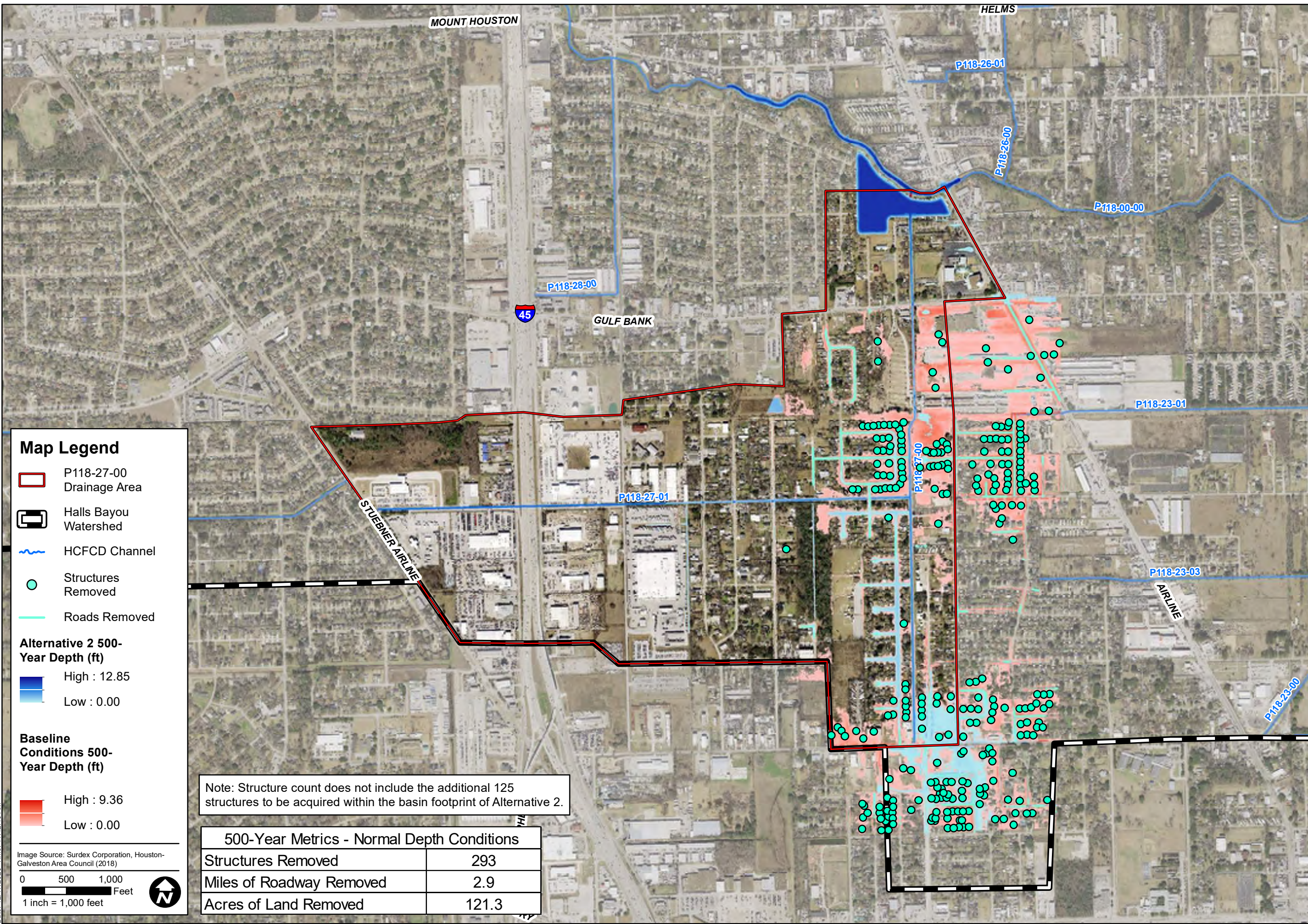
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 SCALE: AS NOTED

EXHIBIT
 32

N:\120\120-12170-1119-0-Data-GIS-Modeling\9-01-GIS2-ArcMapProjects\Working\Exhibits\33_MetricsComparison_500yrND.mxd
 Date: 12/17/2020 Time: 11:12:40 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

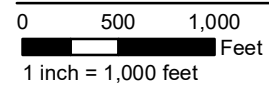
Alternative 2 500-Year Depth (ft)

- High : 12.85
- Low : 0.00

Baseline Conditions 500-Year Depth (ft)

- High : 9.36
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional 125 structures to be acquired within the basin footprint of Alternative 2.

500-Year Metrics - Normal Depth Conditions	
Structures Removed	293
Miles of Roadway Removed	2.9
Acres of Land Removed	121.3

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR RECOMMENDED ALTERNATIVE (ALT. 2) VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

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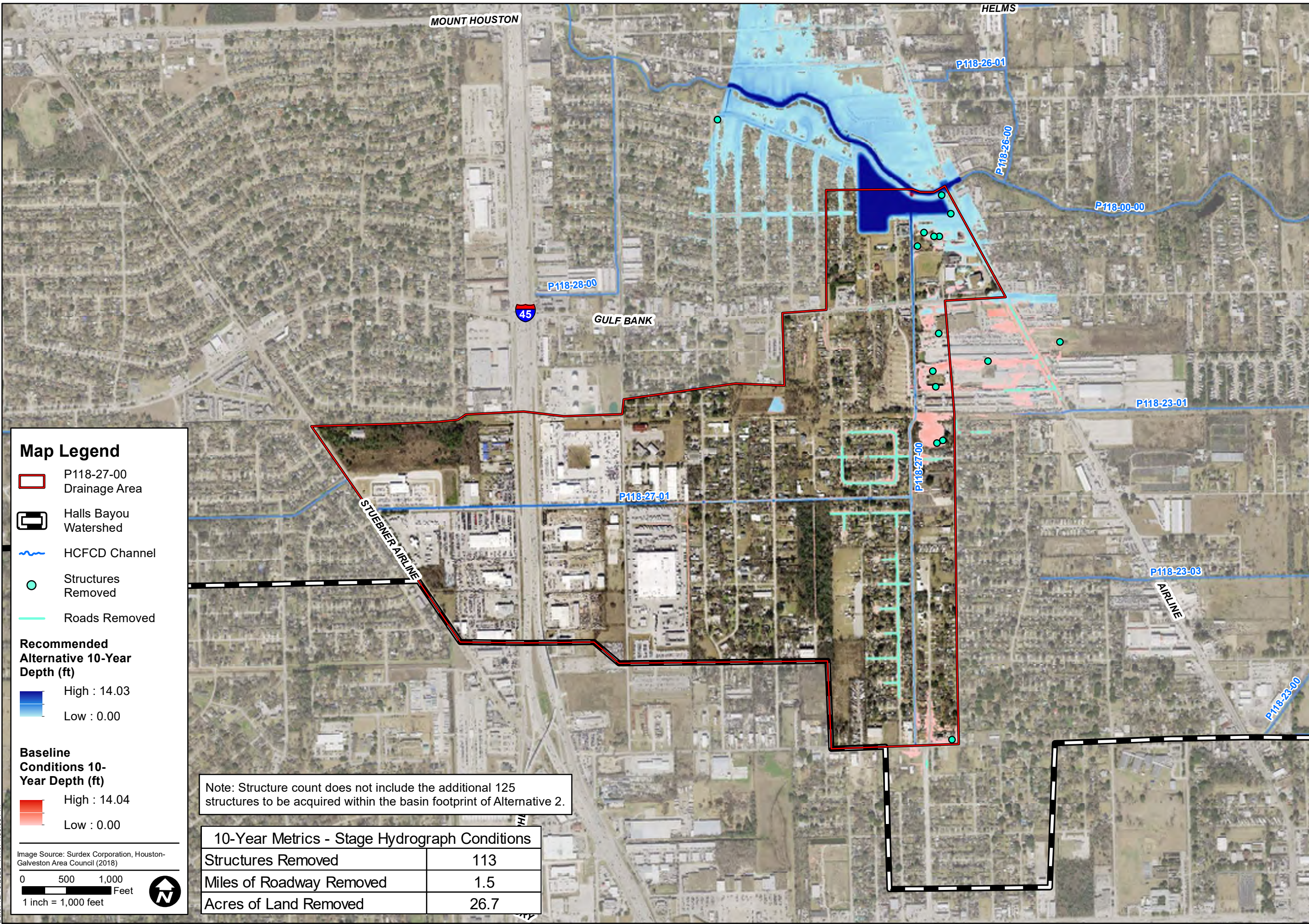


9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT
 33

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCO Channel
- Structures Removed
- Roads Removed

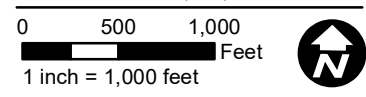
Recommended Alternative 10-Year Depth (ft)

- High : 14.03
- Low : 0.00

Baseline Conditions 10-Year Depth (ft)

- High : 14.04
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional 125 structures to be acquired within the basin footprint of Alternative 2.

10-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	113
Miles of Roadway Removed	1.5
Acres of Land Removed	26.7

HCFCO HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR RECOMMENDED ALTERNATIVE (ALT. 2) VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

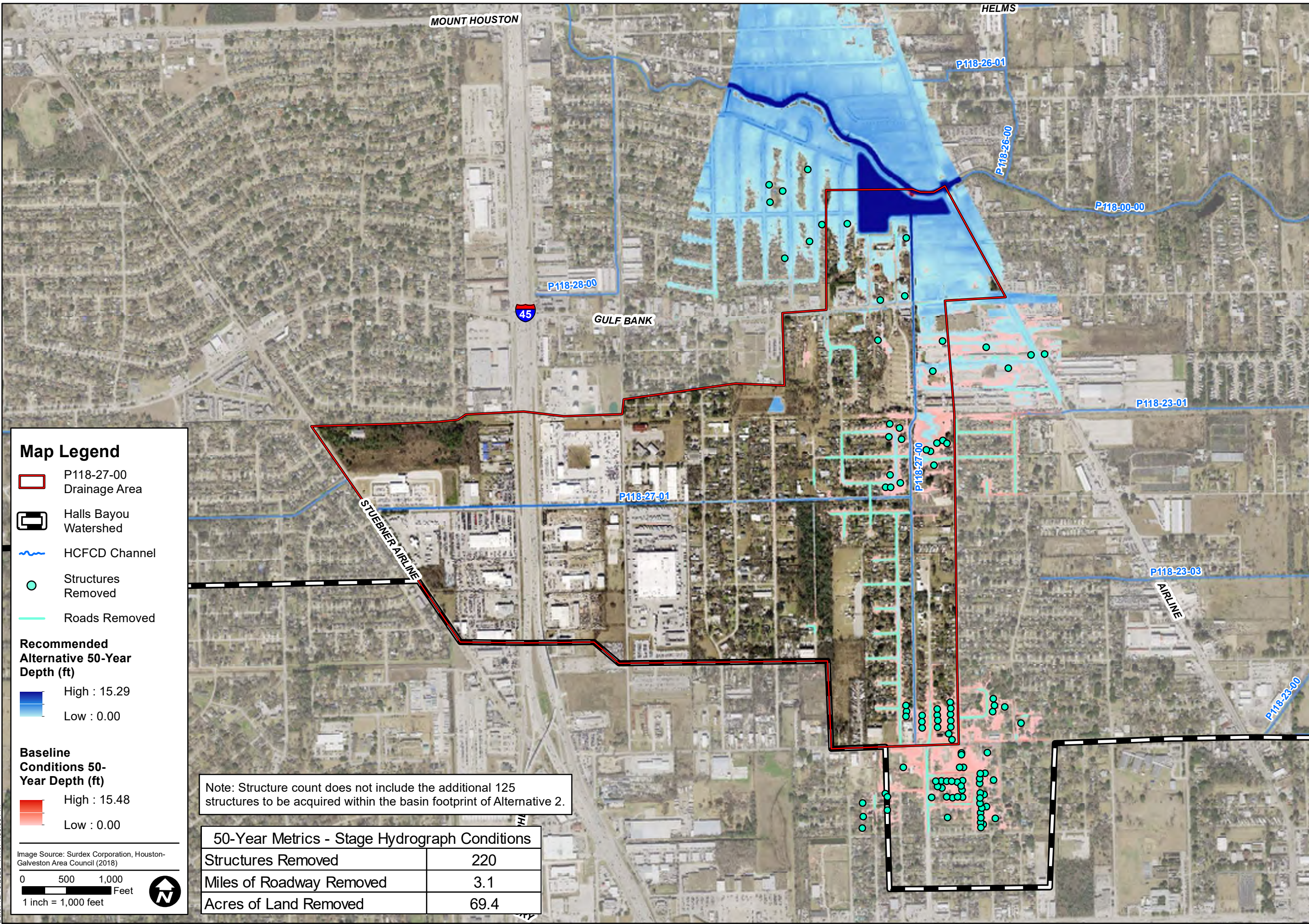
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DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT
 34



N:\120\120-12170-1119-0-Data-GIS-Modeling\9-01-GIS2-ArcMapProjects\Working\Exhibits\35_MetricsComparison_50yrSH.mxd
 Date: 12/15/2020 Time: 1:56:36 PM



Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Structures Removed
-  Roads Removed

Recommended Alternative 50-Year Depth (ft)

-  High : 15.29
-  Low : 0.00

Baseline Conditions 50-Year Depth (ft)



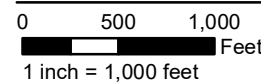
-  High : 15.48
-  Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional 125 structures to be acquired within the basin footprint of Alternative 2.

50-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	220
Miles of Roadway Removed	3.1
Acres of Land Removed	69.4

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR RECOMMENDED ALTERNATIVE (ALT. 2) VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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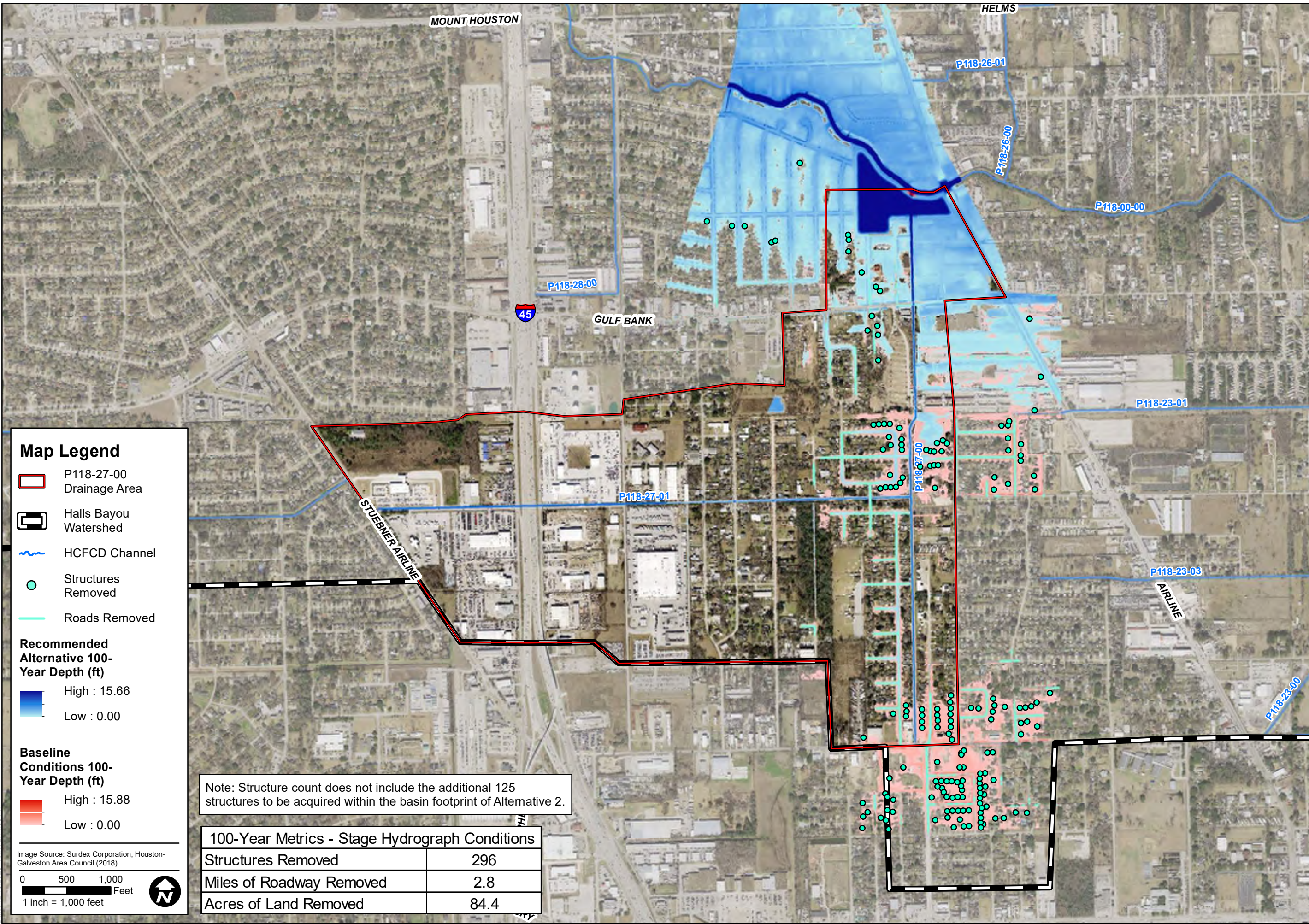


9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT
 35

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCO Channel
- Structures Removed
- Roads Removed

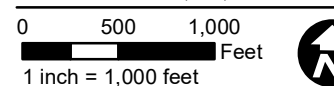
Recommended Alternative 100-Year Depth (ft)

- High : 15.66
- Low : 0.00

Baseline Conditions 100-Year Depth (ft)

- High : 15.88
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional 125 structures to be acquired within the basin footprint of Alternative 2.

100-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	296
Miles of Roadway Removed	2.8
Acres of Land Removed	84.4

HCFCO HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR RECOMMENDED ALTERNATIVE (ALT. 2) VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

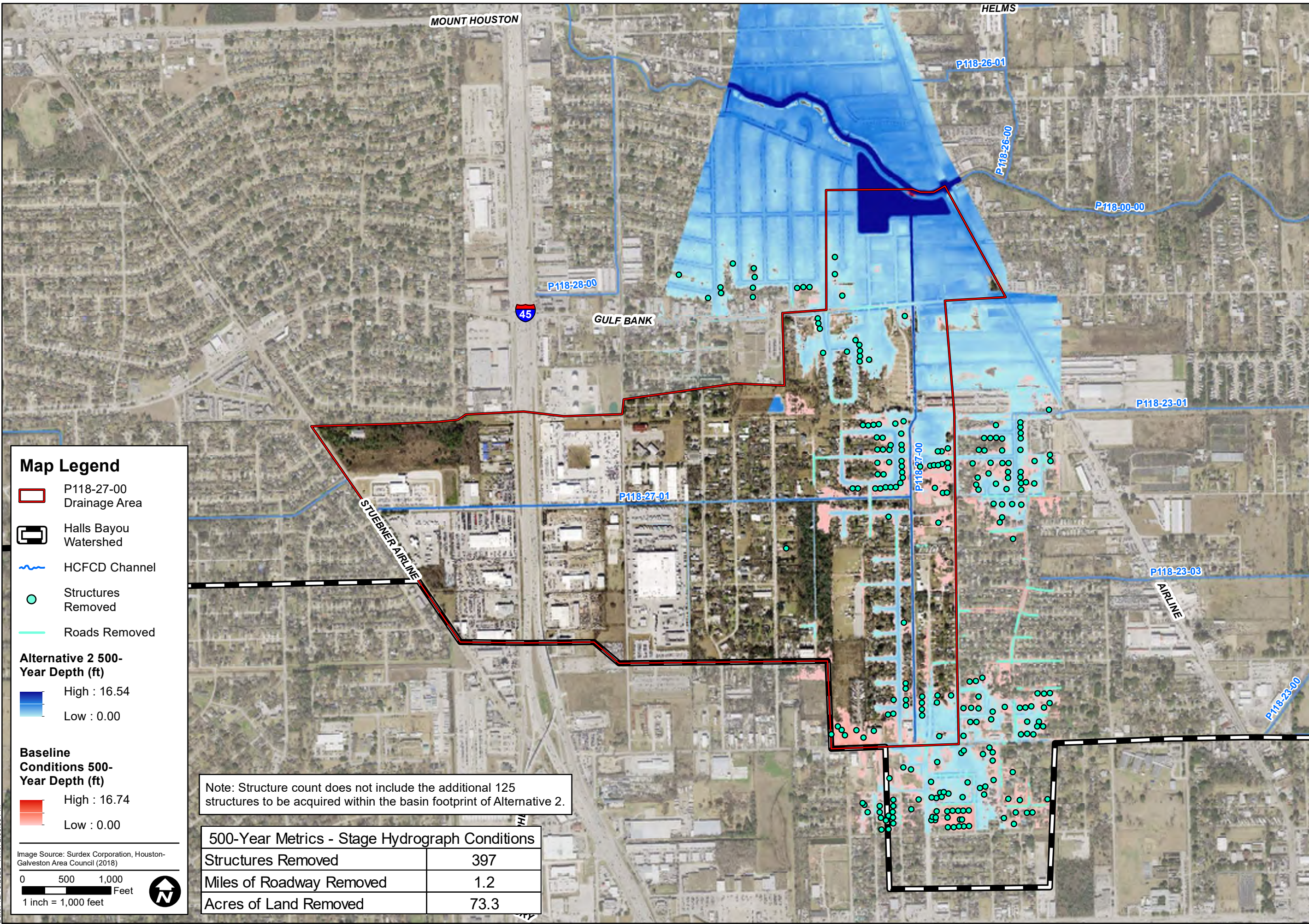
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DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT
 36

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- Structures Removed
- Roads Removed

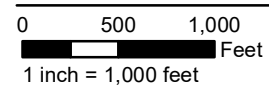
Alternative 2 500-Year Depth (ft)

- High : 16.54
- Low : 0.00

Baseline Conditions 500-Year Depth (ft)

- High : 16.74
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional 125 structures to be acquired within the basin footprint of Alternative 2.

500-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	397
Miles of Roadway Removed	1.2
Acres of Land Removed	73.3

HCFCF HALLS BAYOU WATERSHED
P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
500-YEAR RECOMMENDED ALTERNATIVE (ALT. 2) VS.
BASELINE CONDITIONS COMPARISON
PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

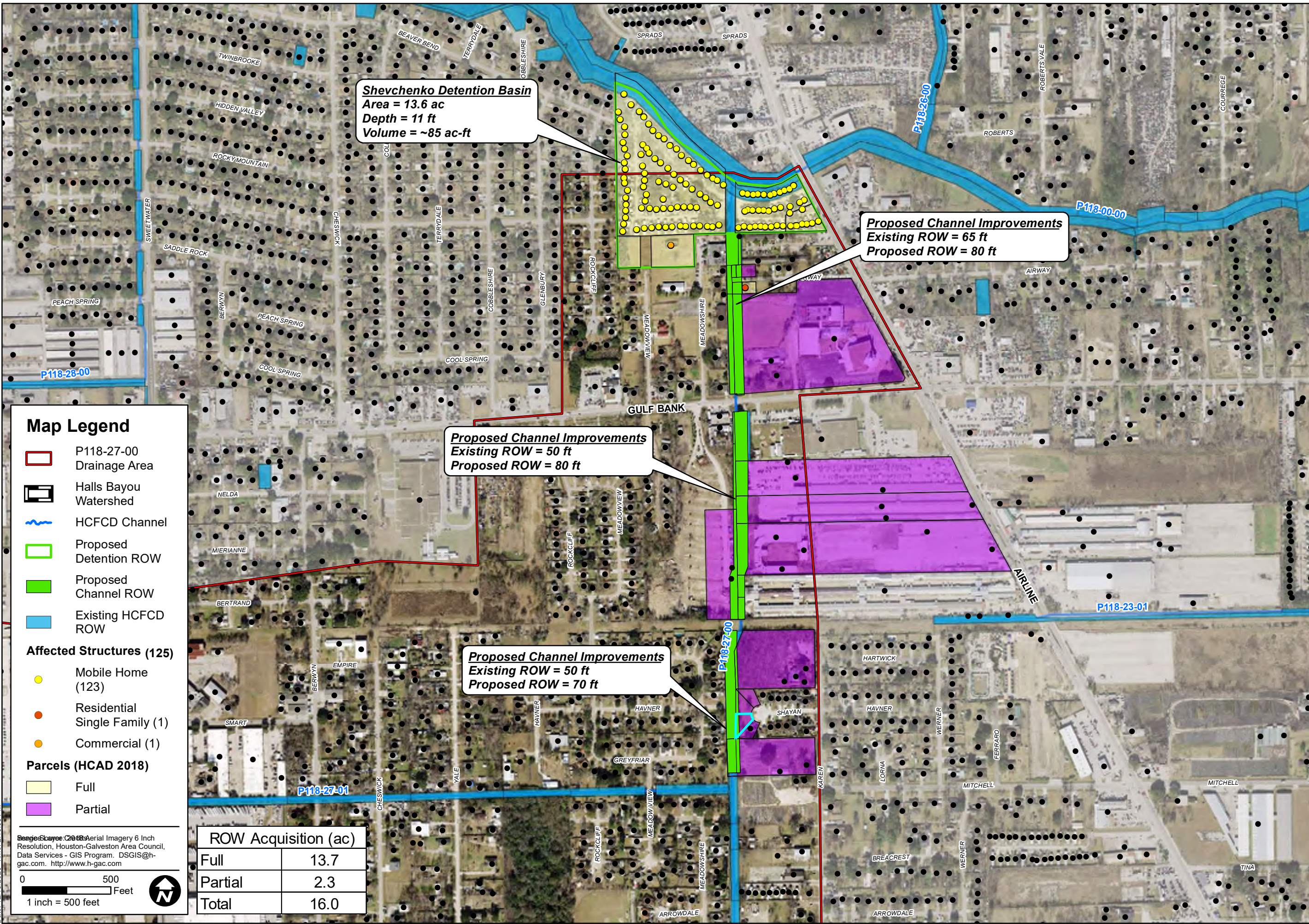
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DATE: OCT 2020
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 37

N:\120\120-12170-1119-0-Data-GIS-Modeling\9-01-GIS2-ArcMap\Projects\Working\Exhibits\38_RecAIL_ROW\Exhibit.mxd
 Date: 12/15/2020 Time: 2:10:03 PM



Shevchenko Detention Basin
 Area = 13.6 ac
 Depth = 11 ft
 Volume = ~85 ac-ft

Proposed Channel Improvements
 Existing ROW = 65 ft
 Proposed ROW = 80 ft

Proposed Channel Improvements
 Existing ROW = 50 ft
 Proposed ROW = 80 ft

Proposed Channel Improvements
 Existing ROW = 50 ft
 Proposed ROW = 70 ft

Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Proposed Detention ROW
- Proposed Channel ROW
- Existing HCFCD ROW
- Affected Structures (125)**
- Mobile Home (123)
- Residential Single Family (1)
- Commercial (1)
- Parcels (HCAD 2018)**
- Full
- Partial

Scale: 2000
 Resolution: Houston-Galveston Area Council, Data Services - GIS Program. DSGIS@h-gac.com. http://www.h-gac.com

0 500 Feet
 1 inch = 500 feet

ROW Acquisition (ac)	
Full	13.7
Partial	2.3
Total	16.0

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
**PROPOSED ROW
 ALTERNATIVE 2 (RECOMMENDED)**

PREPARED: BJI
 CHECKED: CEE
 APPROVED: CEE

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DATE: SEPT 2020
 SCALE: AS NOTED
**EXHIBIT
 38**

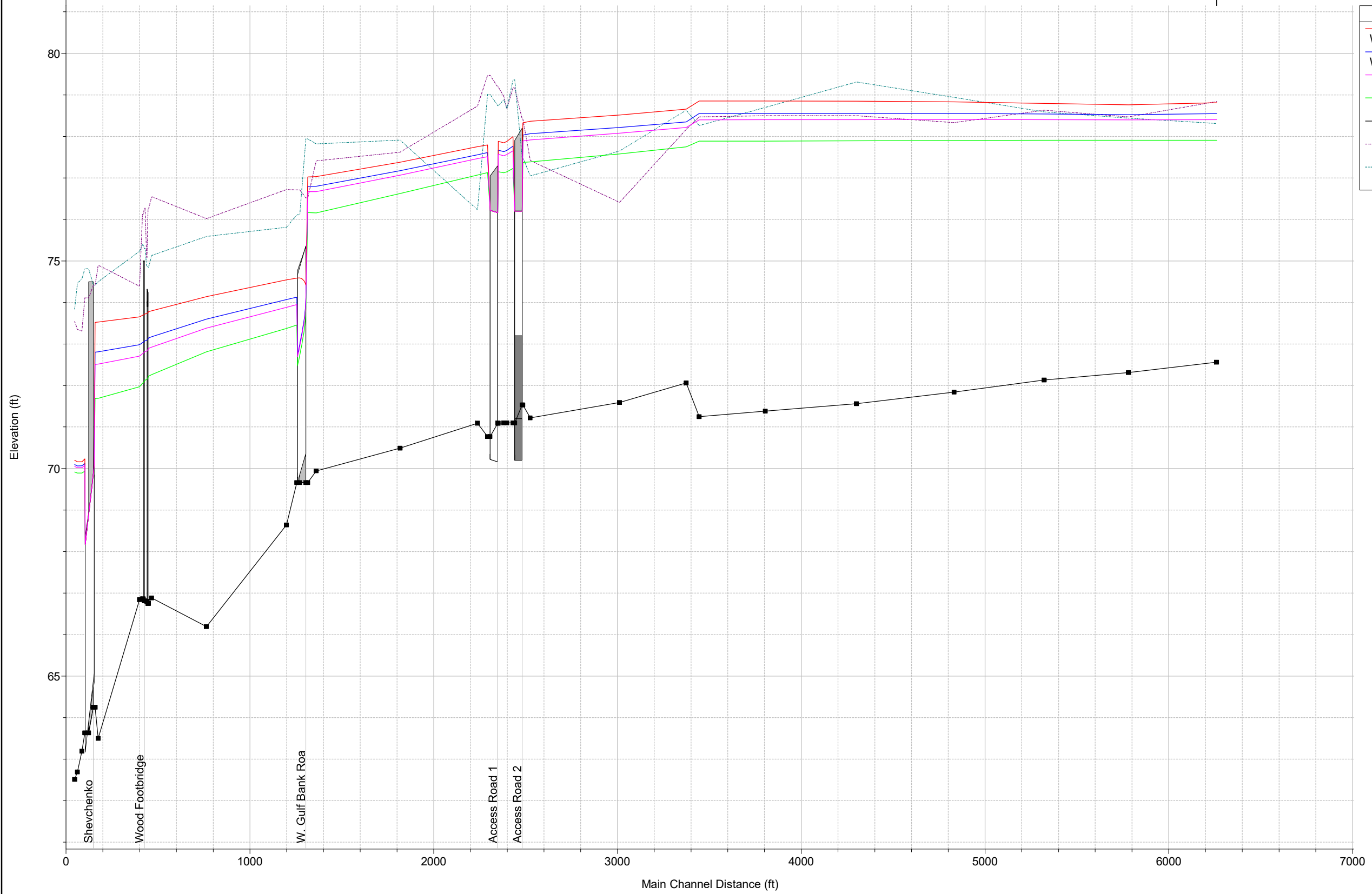
APPENDICES

Appendix A

Baseline Conditions Water Surface Profiles

P118-27-00 Plan: 1) Baseline_10_ND 12/1/2020 2) Baseline_100_ND 12/1/2020 3) Baseline_500_ND 12/1/2020 4) Baseline_50_ND 12/2/2020

P118-27-00 P118-27-00

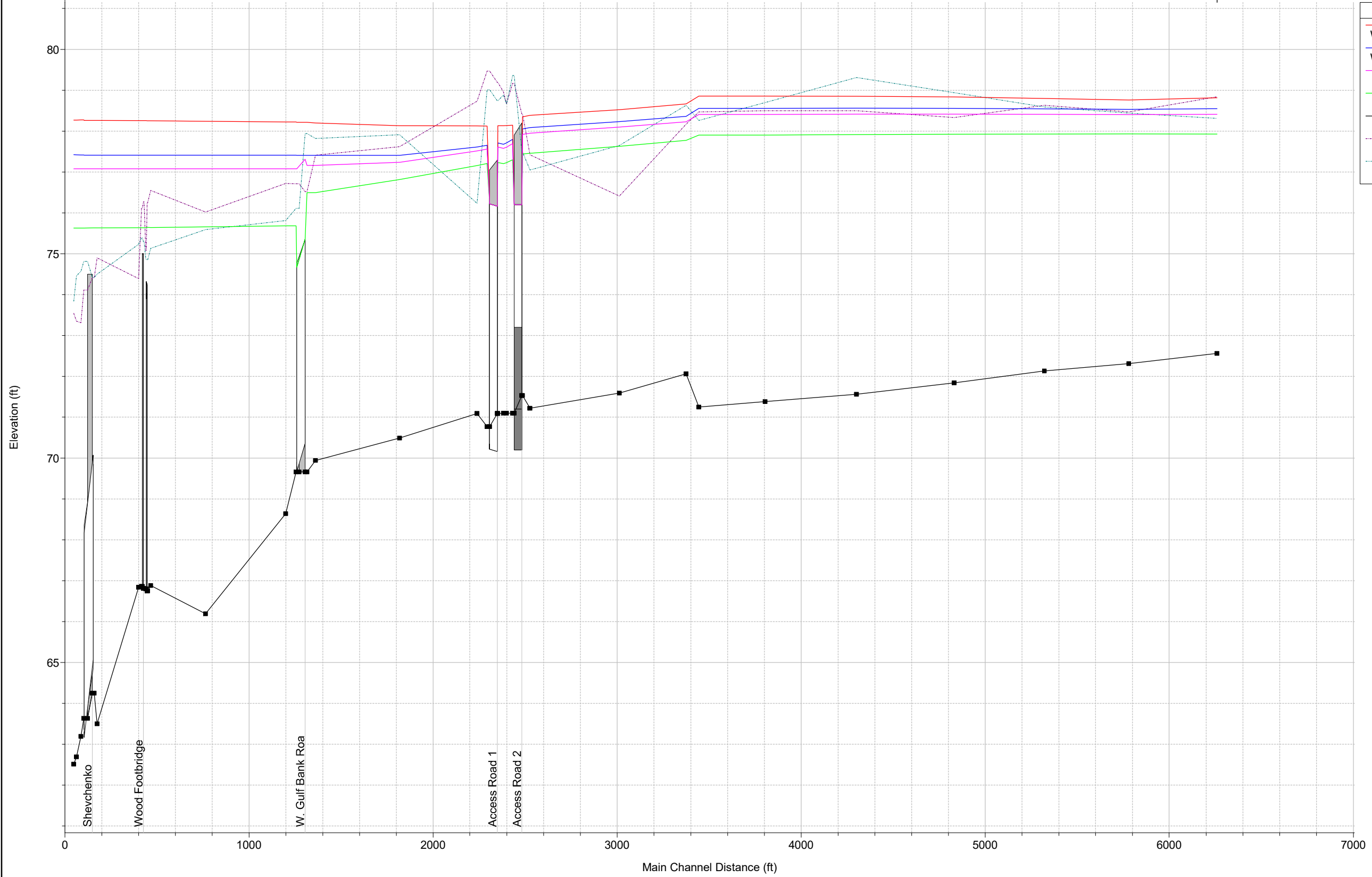


Legend	
—	WS Max WS - Baseline_500_ND
—	WS Max WS - Baseline_100_ND
—	WS Max WS - Baseline_50_ND
—	WS Max WS - Baseline_10_ND
■	Ground
- - -	LOB
- - -	ROB

1 in Horiz. = 565 ft 1 in Vert. = 2.5 ft

P118-27-00 Plan: 1) Baseline_100 12/1/2020 2) Baseline_500 12/14/2020 3) Baseline_10 12/1/2020 4) Baseline_50 12/1/2020

P118-27-00 P118-27-00

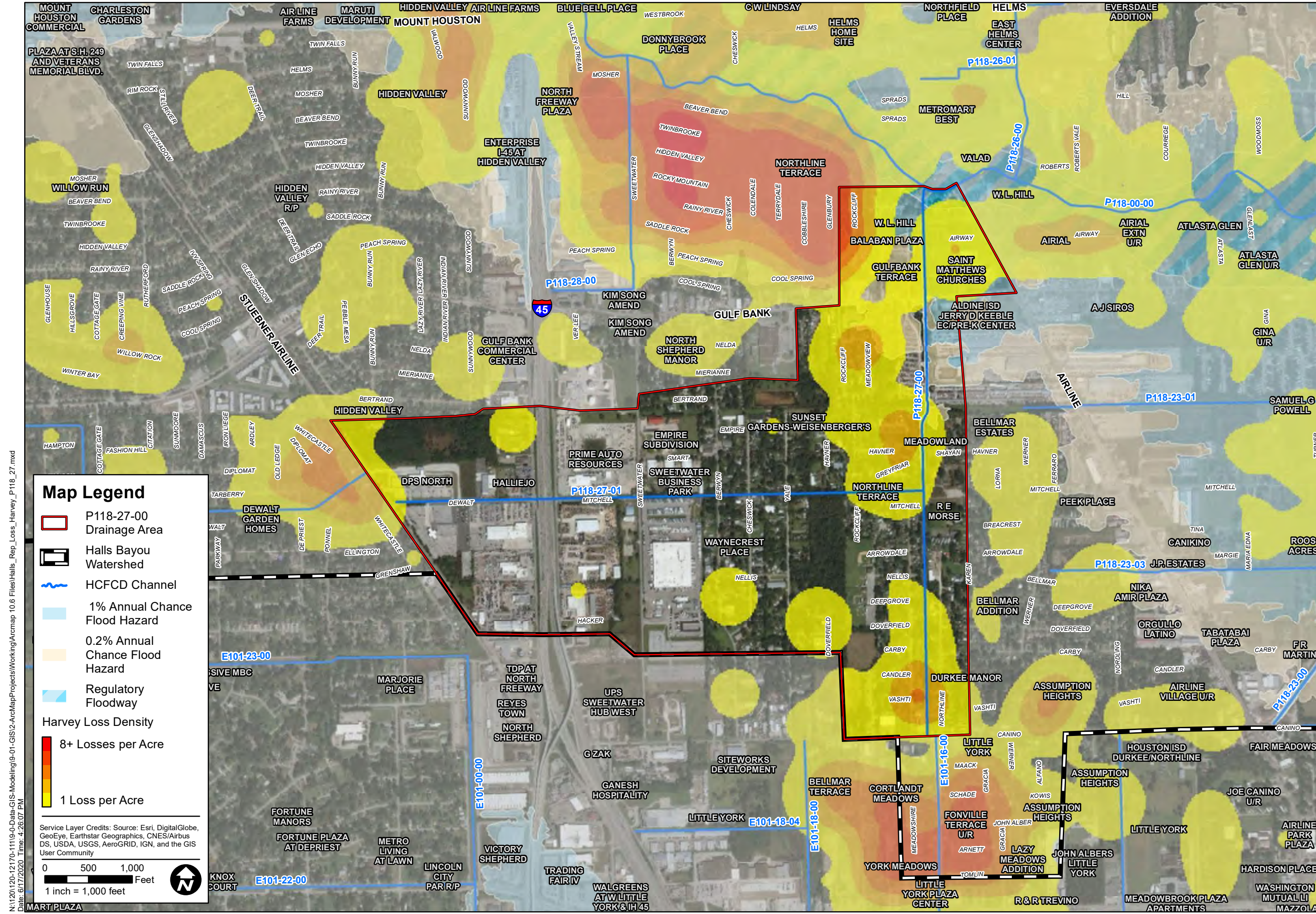


Legend	
WS Max WS - Baseline_500	(Red solid line)
WS Max WS - Baseline_100	(Blue solid line)
WS Max WS - Baseline_50	(Magenta solid line)
WS Max WS - Baseline_10	(Green solid line)
Ground	(Black line with square markers)
LOB	(Dashed purple line)
ROB	(Dashed cyan line)

1 in Horiz. = 555 ft 1 in Vert. = 2.5 ft

Appendix B

Historical Losses Heat Maps



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- ~ HCFCF Channel
- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Regulatory Floodway

Harvey Loss Density

8+ Losses per Acre

1 Loss per Acre

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

0 500 1,000 Feet

1 inch = 1,000 feet

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HCFCF HALLS BAYOU WATERSHED
P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

PREPARED: PSK

CHECKED: CEE

APPROVED: CEE

HARVEY LOSS DATA

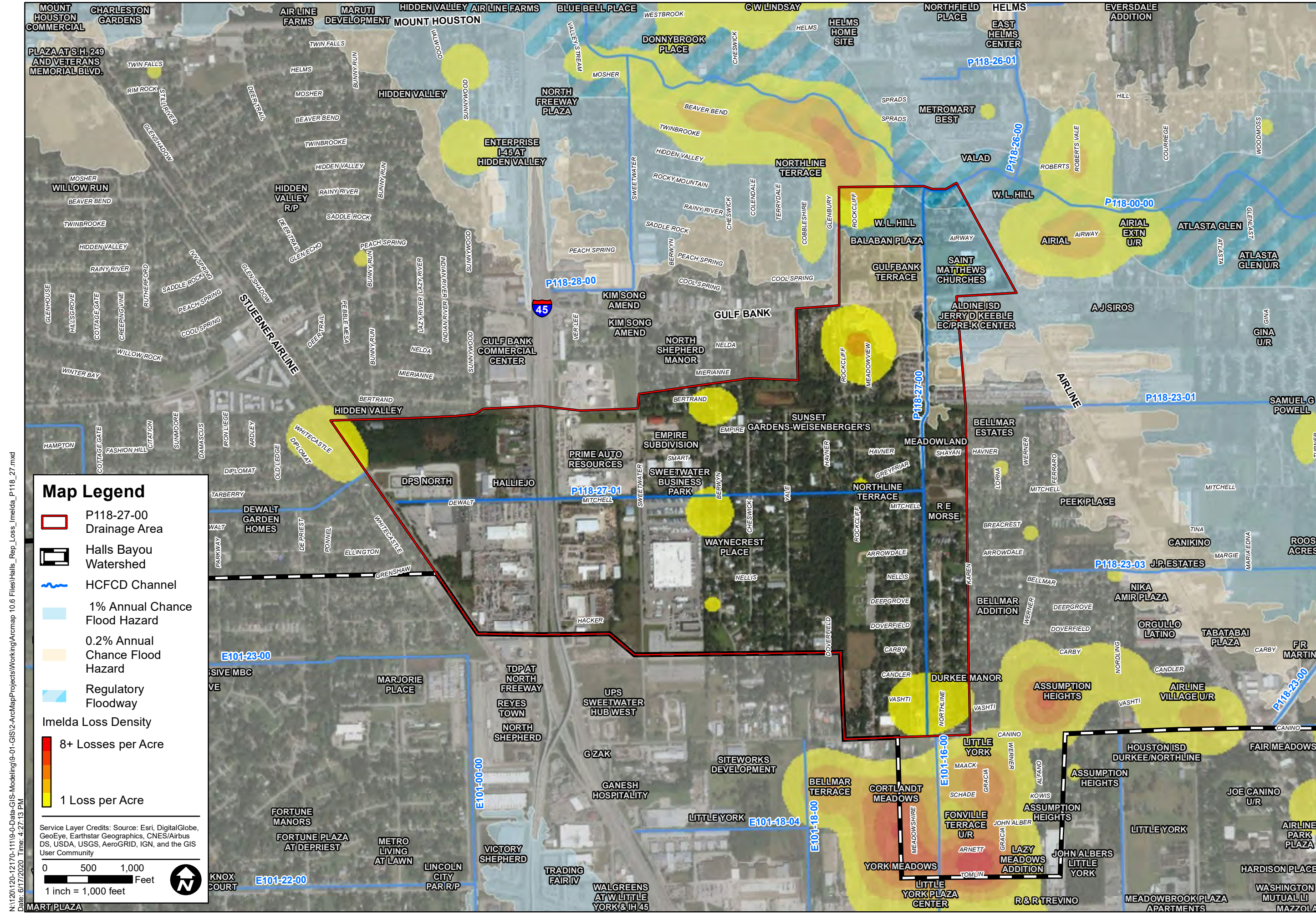
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9900 Northwest Freeway
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DATE: MAY 2020
 SCALE: AS NOTED



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Regulatory Floodway

Imelda Loss Density

8+ Losses per Acre

1 Loss per Acre

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

0 500 1,000

Feet

1 inch = 1,000 feet

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HCFCF HALLS BAYOU WATERSHED

P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS

PREPARED: PSK

CHECKED: CEE

APPROVED: CEE

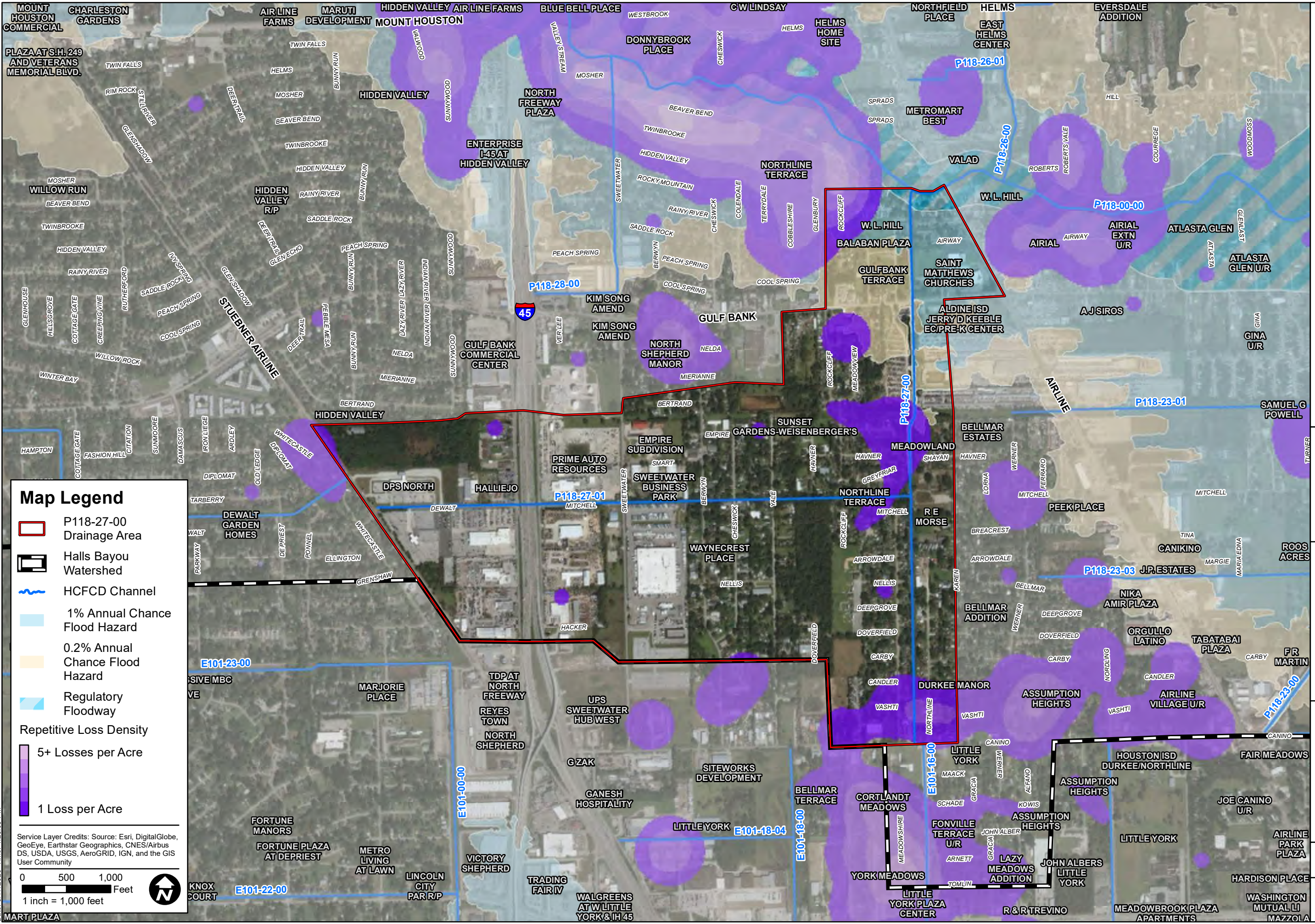
IMELDA LOSS DATA

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DATE: MAY 2020
SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD 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

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

0 500 1,000 Feet

1 inch = 1,000 feet

N
North Arrow

**HCFCO HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

PREPARED: PSK	CHECKED: CEE	APPROVED: CEE
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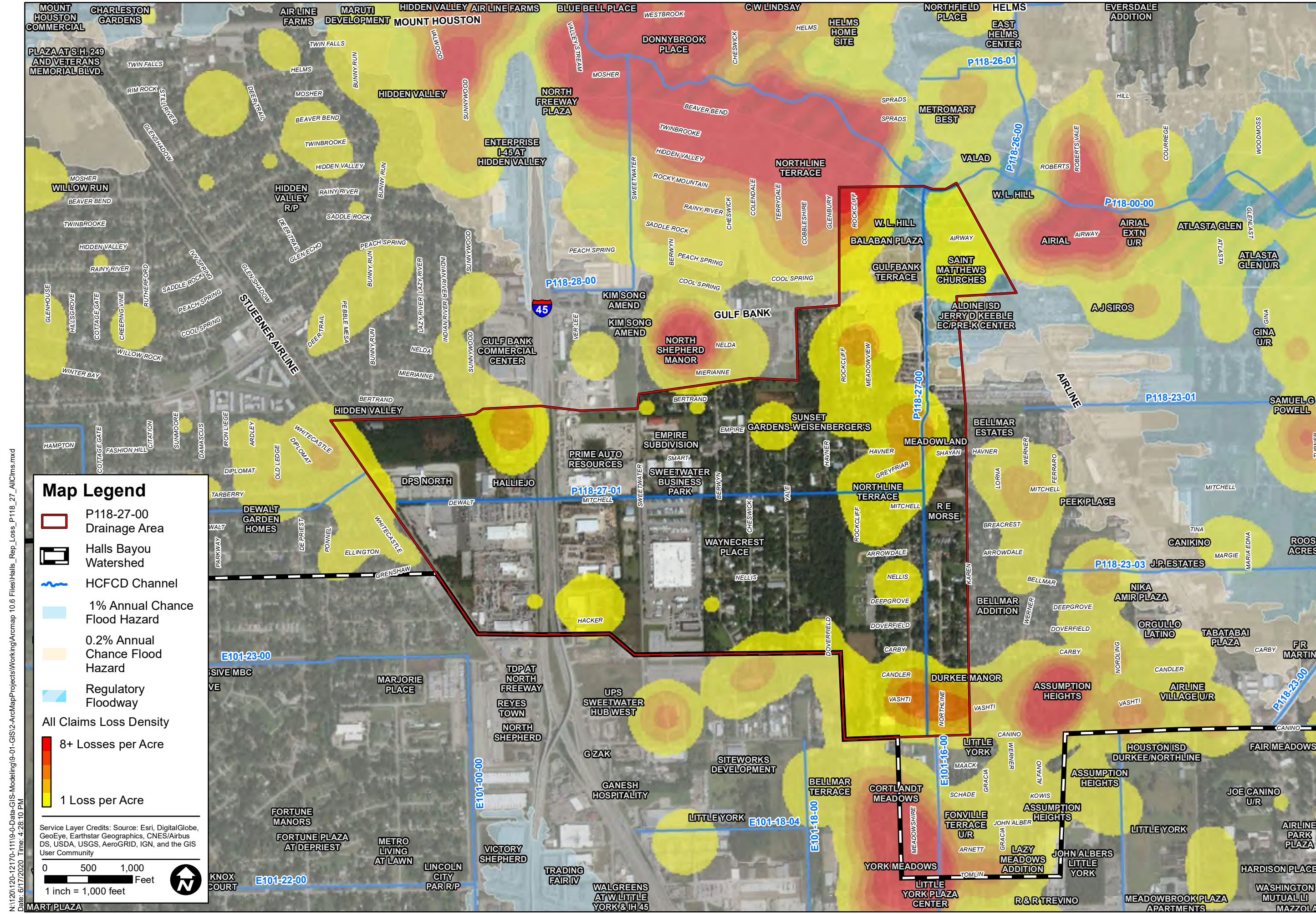
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N:\120\120-12170-1119-0-Data-GIS-Modeling\9-01-GIS2-ArcMapProjects\Working\Arcmap 10.6 Files\Halls_Rep_Loss_P118_27_AllClaims.mxd
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFC Channel
- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Regulatory Floodway

All Claims Loss Density

8+ Losses per Acre

1 Loss per Acre

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

0 500 1,000 Feet

1 inch = 1,000 feet

**HCFCD HALLS BAYOU WATERSHED
P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS**

PREPARED: PSK	CHECKED: CEE	APPROVED: CEE
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DATE: MAY 2020
SCALE: AS NOTED

ALL CLAIMS LOSS DATA

Appendix C

Site Visit Photo Documentation

Appendix D

Summary Table of Alternatives

Appendix D
Summary Table of Alternatives

P118-27-00 - Detailed Alternatives Analysis

Alternatives Description

Alternative 1: Concrete-lined Channel Improvements (1) + Shevchenko Basin (3) + Gulf Bank Basin (4)

Alternative 2: Concrete-lined Channel Improvements (1) + Shevchenko Basin (3)

Alternative 3: Grass-lined Channel Improvements (2) + Karen Basin (5) + Dow Basin (6)

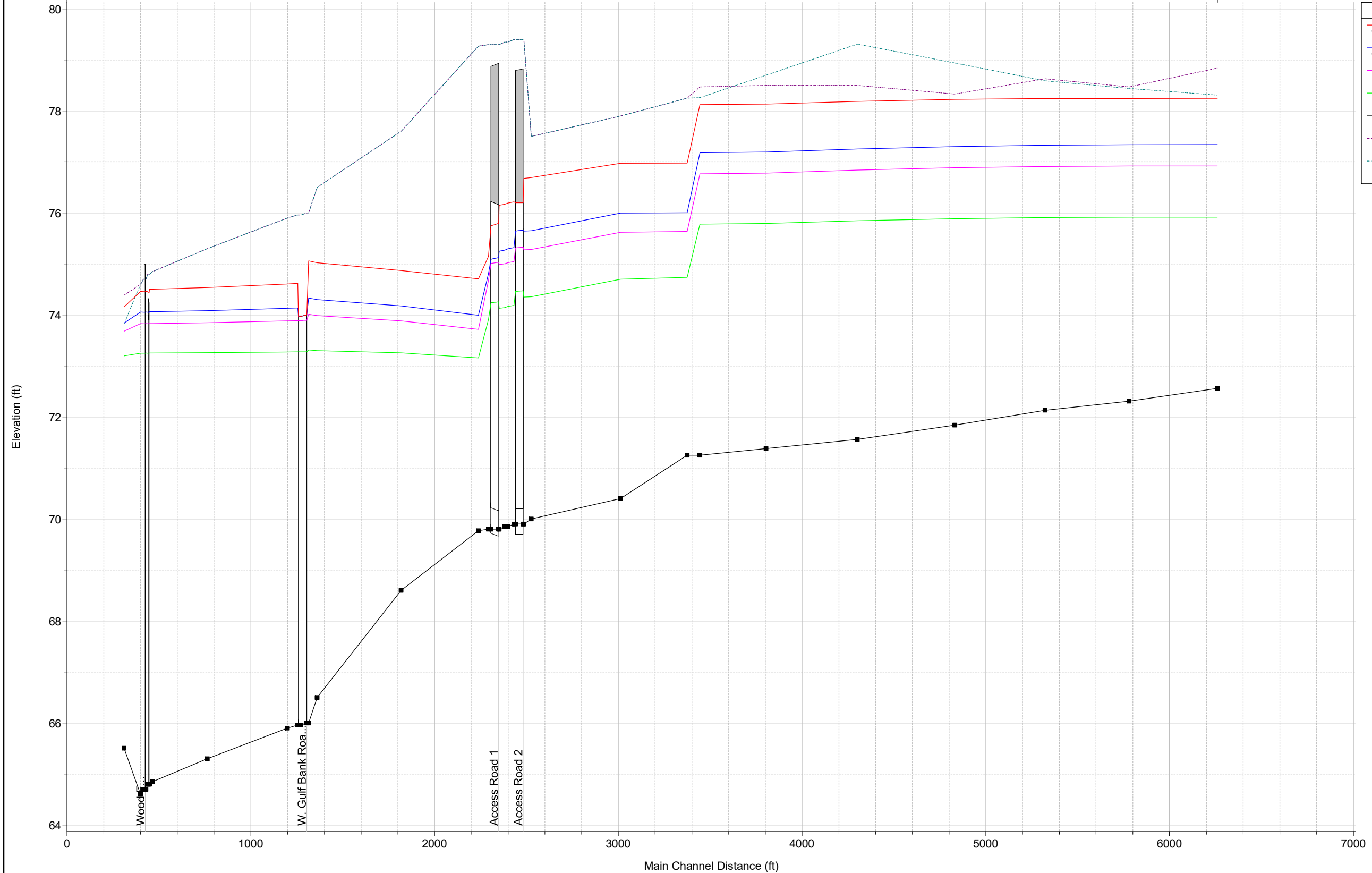
Alternatives	Channel Improvements			Detention Basin (Feature #)								Bridge/Culvert Updates
	Proposed Channel Bottom Width	Proposed Channel Depth (avg)	Location	Depth Shevchenko Basin (3)	Volume Shevchenko Basin (3)	Depth Gulf Bank Basin (4)	Volume Gulf Bank Basin (4)	Depth Karen Basin (5)	Volume Karen Basin (5)	Depth Dow Basin (6)	Volume Dow Basin (6)	Gulf Bank Rd
	(ft)	(ft)	P118-08-00	(ft)	(acre-feet)	(ft)	(acre-feet)	(ft)	(acre-feet)	(ft)	(acre-feet)	Dimension
Alternative 1	6	7-10	RS 3374 to RS 399	11	85	8	65					2 - 10' x 8' RCBs
Alternative 2	6	7-10	RS 3374 to RS 399	11	85							2 - 10' x 8' RCBs
Alternative 3	6	8	RS 3374 to RS 1360					7	20	6	40	2 - 10' x 8' RCBs

Appendix E

Water Surface Elevation Profiles

P118-27-00 Plan: 1) Alt1_10_ND 12/14/2020 2) Alt1_100_ND 12/14/2020 3) Alt1_500_ND 12/14/2020 4) Alt1_50_ND 12/14/2020

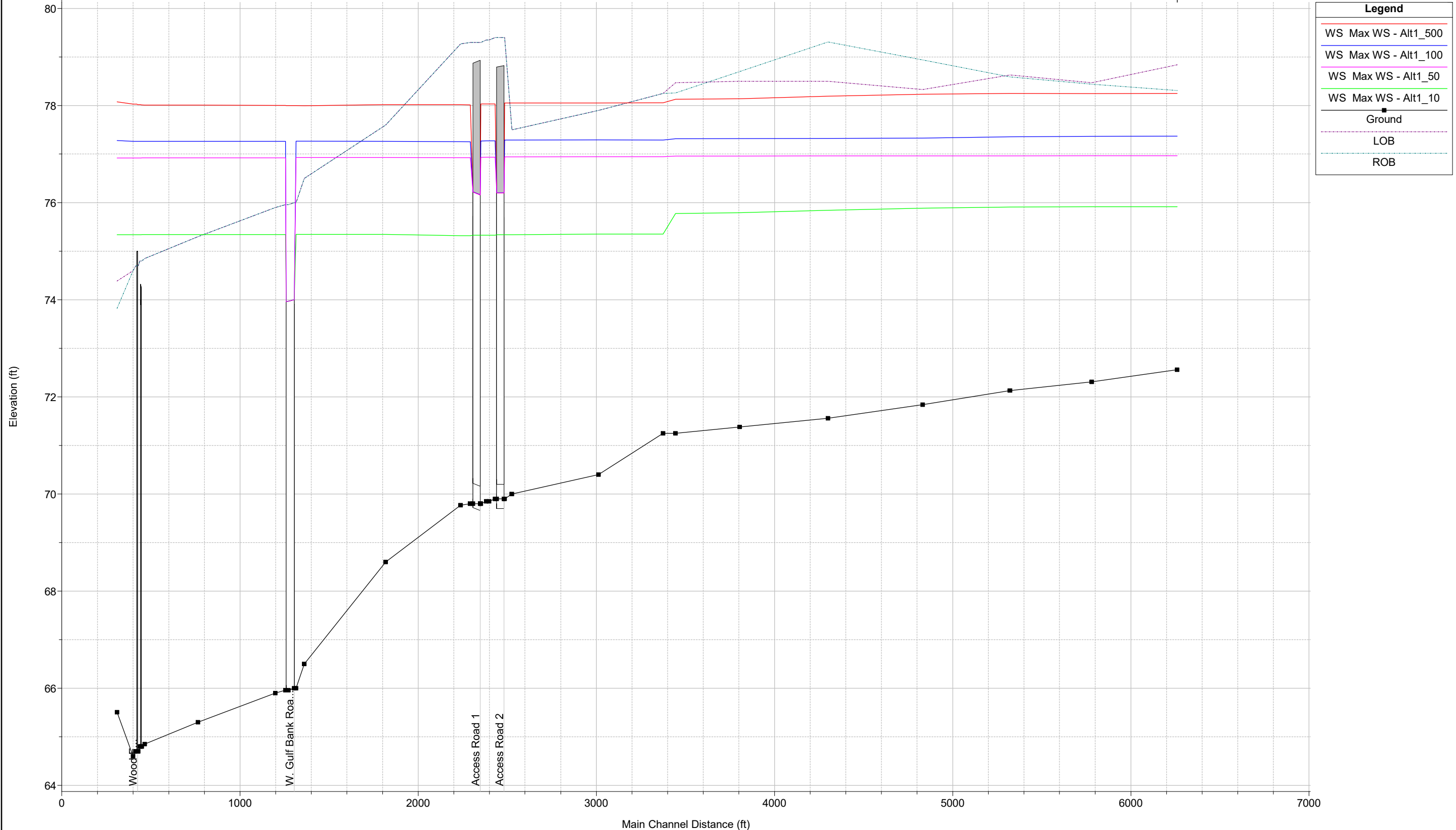
P118-27-00 P118-27-00



Legend	
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WS Max WS - Alt1_100_ND	(Blue line)
WS Max WS - Alt1_50_ND	(Magenta line)
WS Max WS - Alt1_10_ND	(Green line)
Ground	(Black line with square markers)
LOB	(Dashed purple line)
ROB	(Dashed cyan line)

1 in Horiz. = 555 ft 1 in Vert. = 2 ft

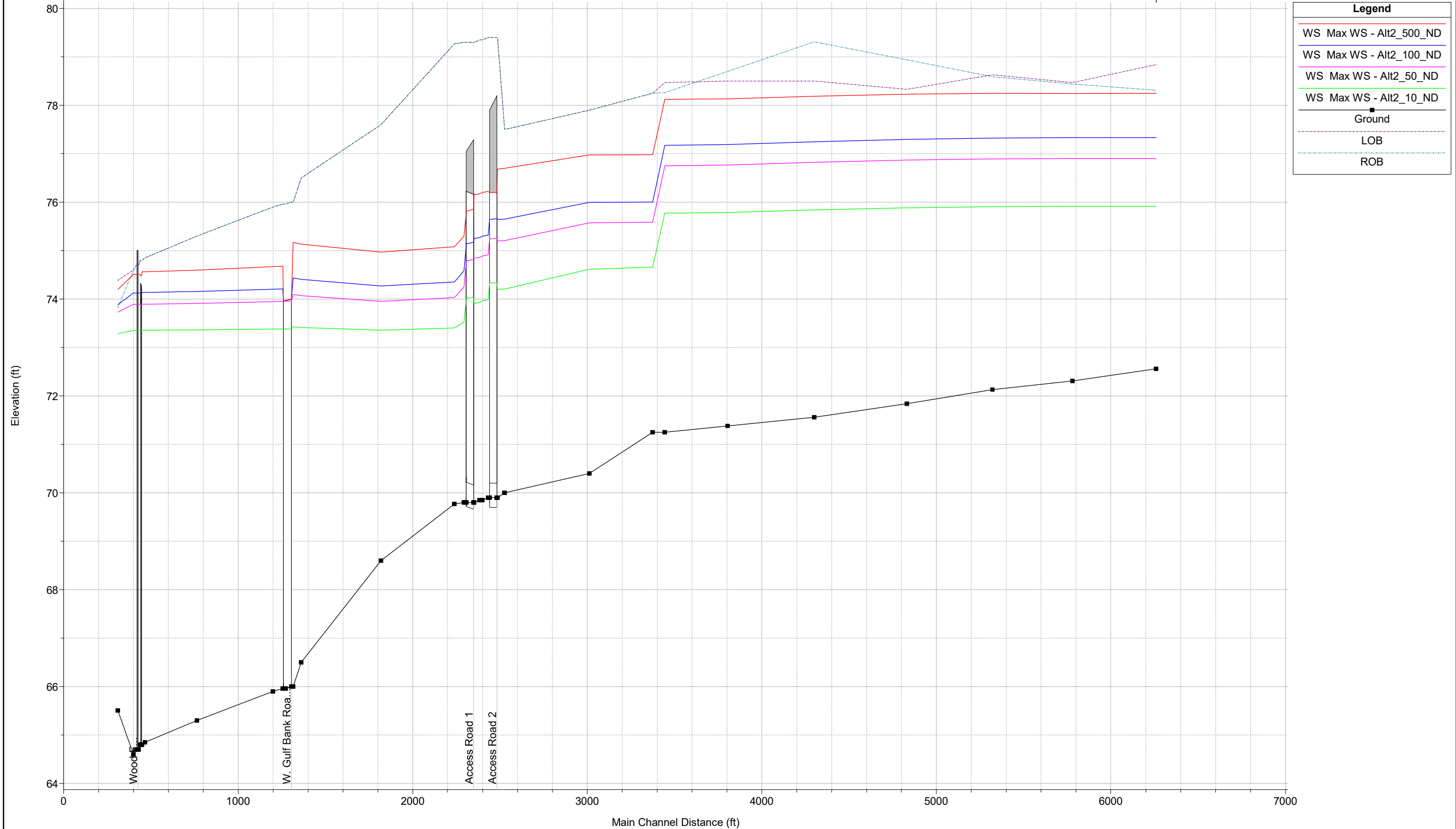
P118-27-00 P118-27-00



1 in Horiz. = 545 ft 1 in Vert. = 2 ft

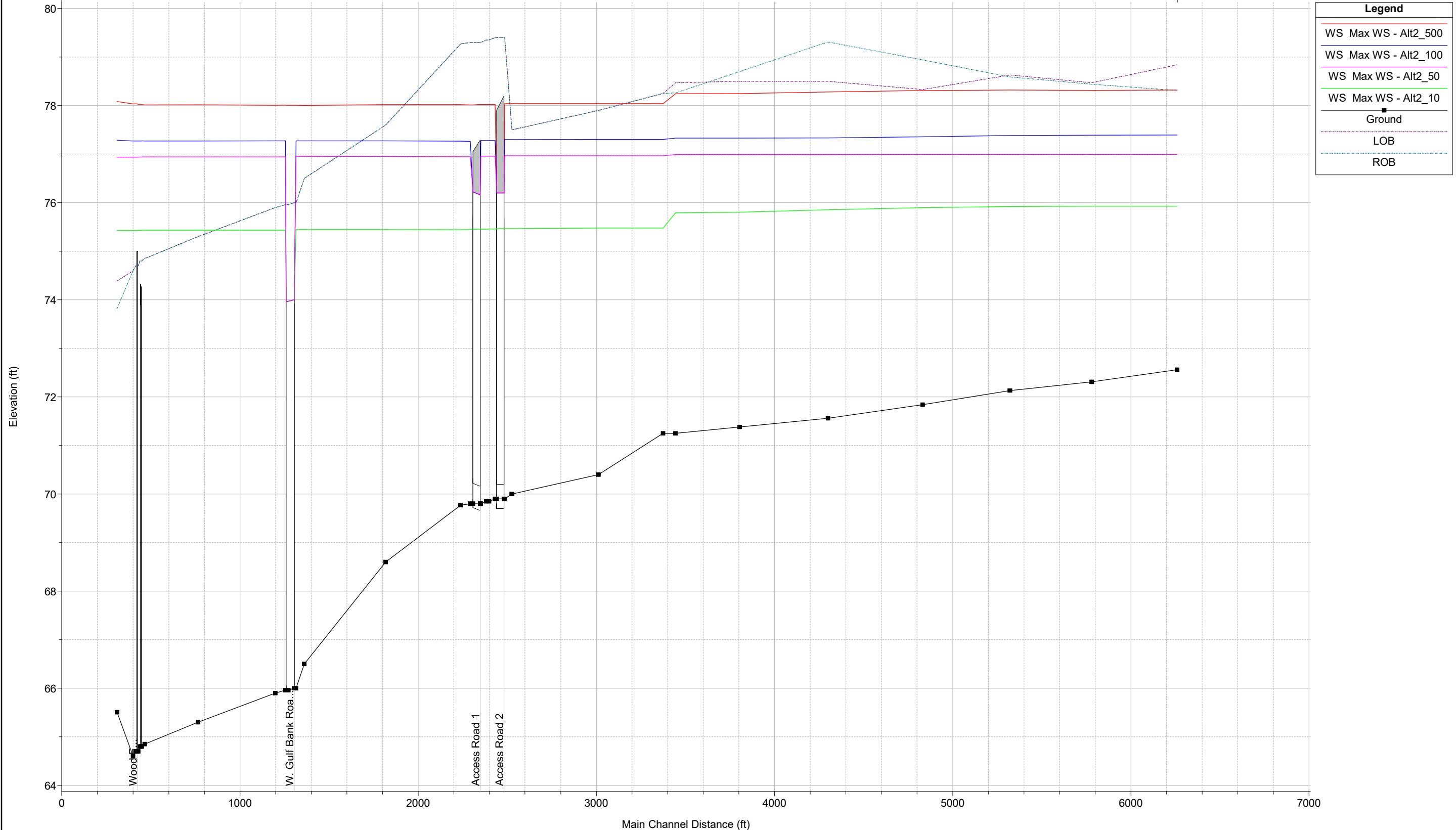
P118-27-00 Plan: 1) Alt2_10_ND 12/14/2020 2) Alt2_100_ND 12/14/2020 3) Alt2_500_ND 12/14/2020 4) Alt2_50_ND 12/14/2020

P118-27-00 P118-27-00

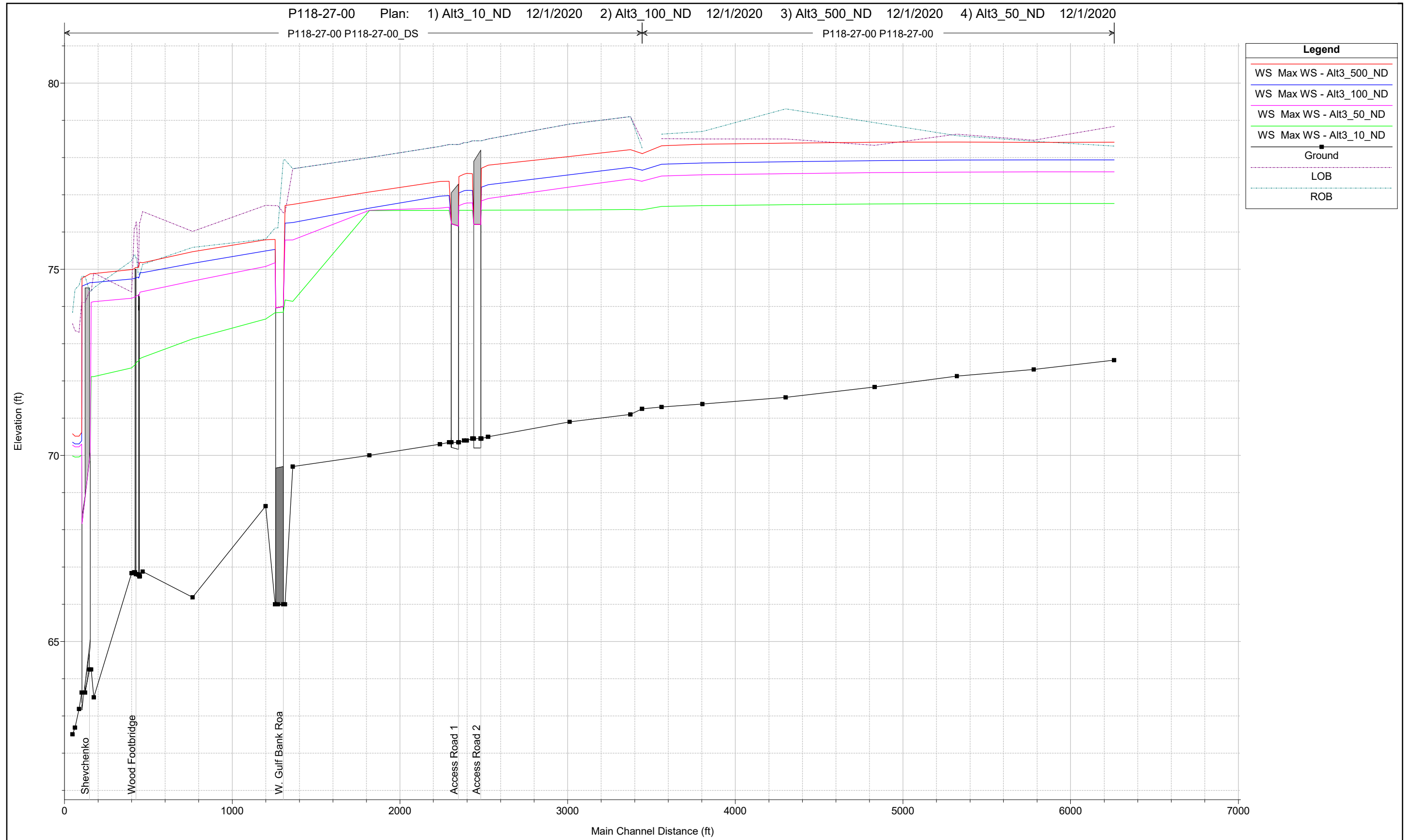


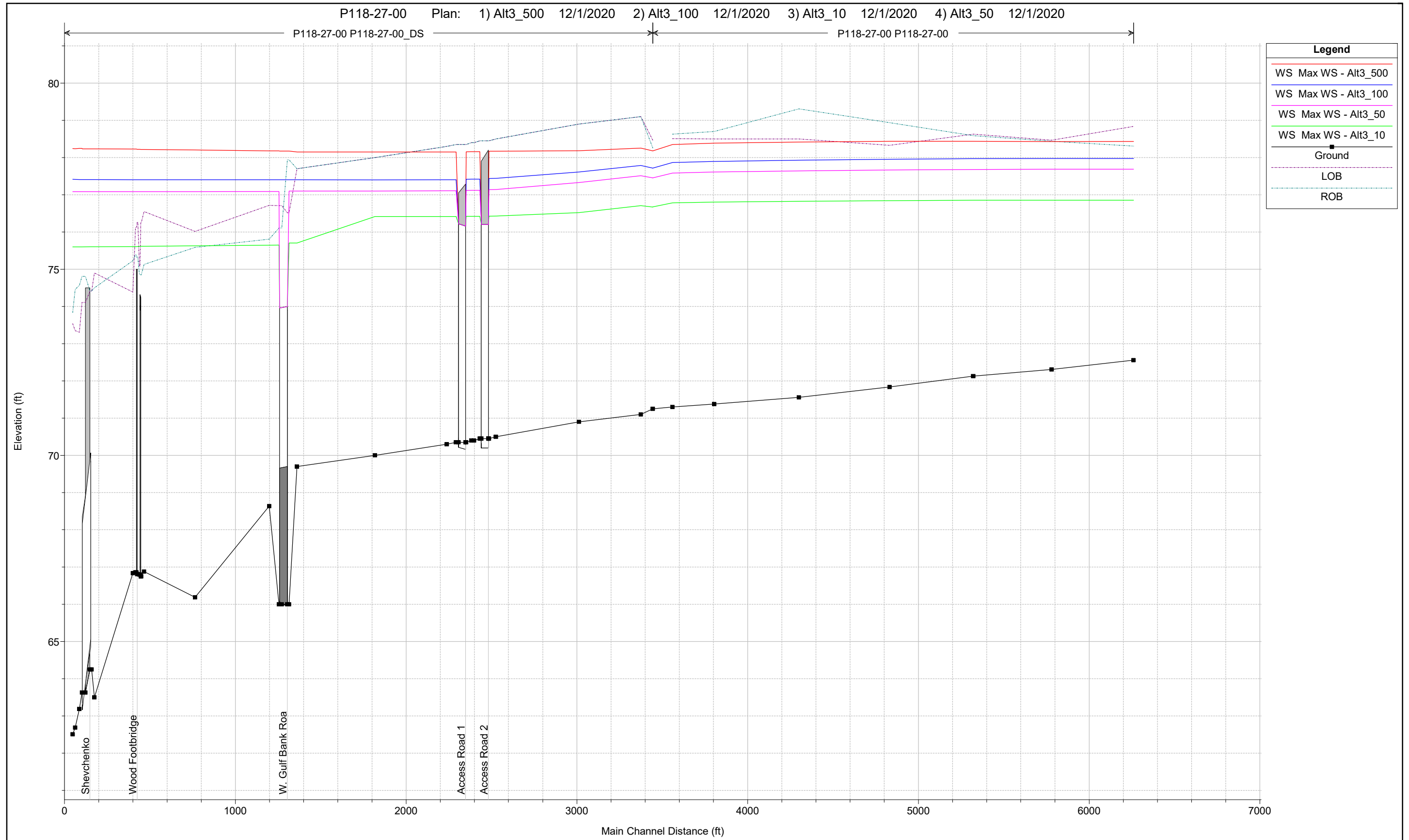
1 in Horiz. = 555 ft 1 in Vert. = 2 ft

P118-27-00 P118-27-00



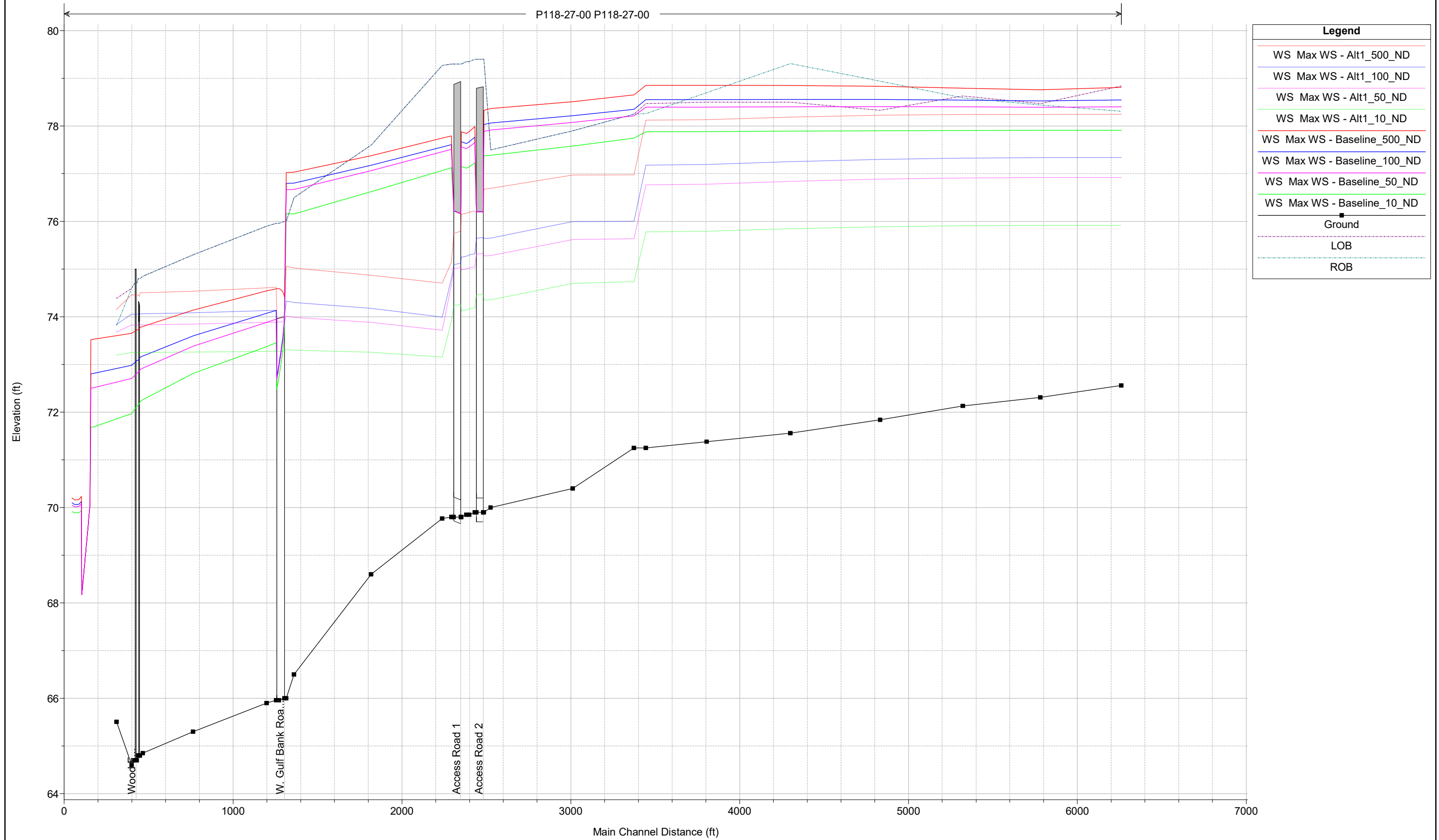
1 in Horiz. = 545 ft 1 in Vert. = 2 ft





Appendix F

Baseline Conditions vs. Alternatives Water Surface Profiles

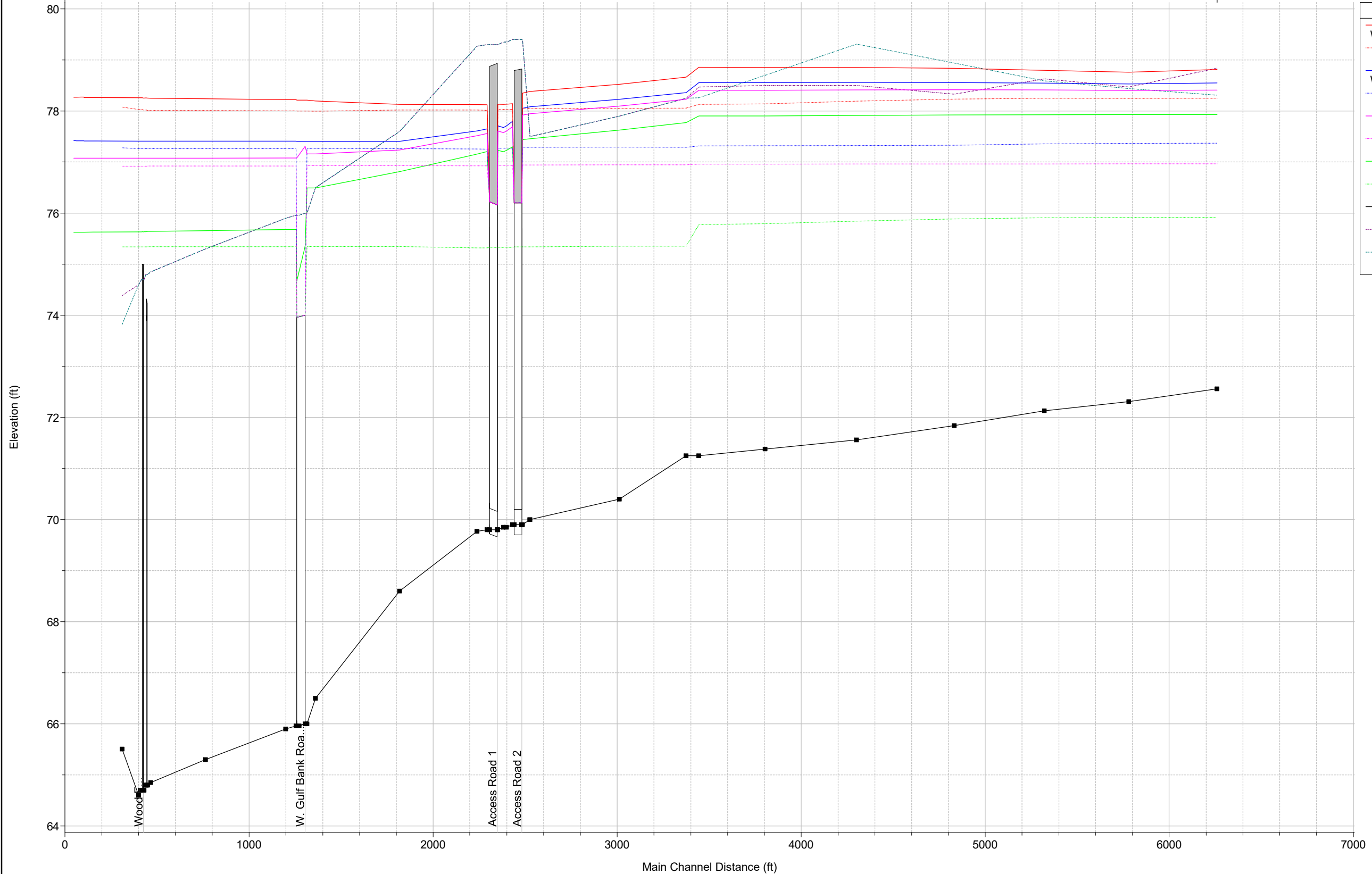


Legend

- WS Max WS - Alt1_500_ND
- WS Max WS - Alt1_100_ND
- WS Max WS - Alt1_50_ND
- WS Max WS - Alt1_10_ND
- WS Max WS - Baseline_500_ND
- WS Max WS - Baseline_100_ND
- WS Max WS - Baseline_50_ND
- WS Max WS - Baseline_10_ND
- Ground
- LOB
- ROB

1 in Horiz. = 565 ft 1 in Vert. = 2 ft

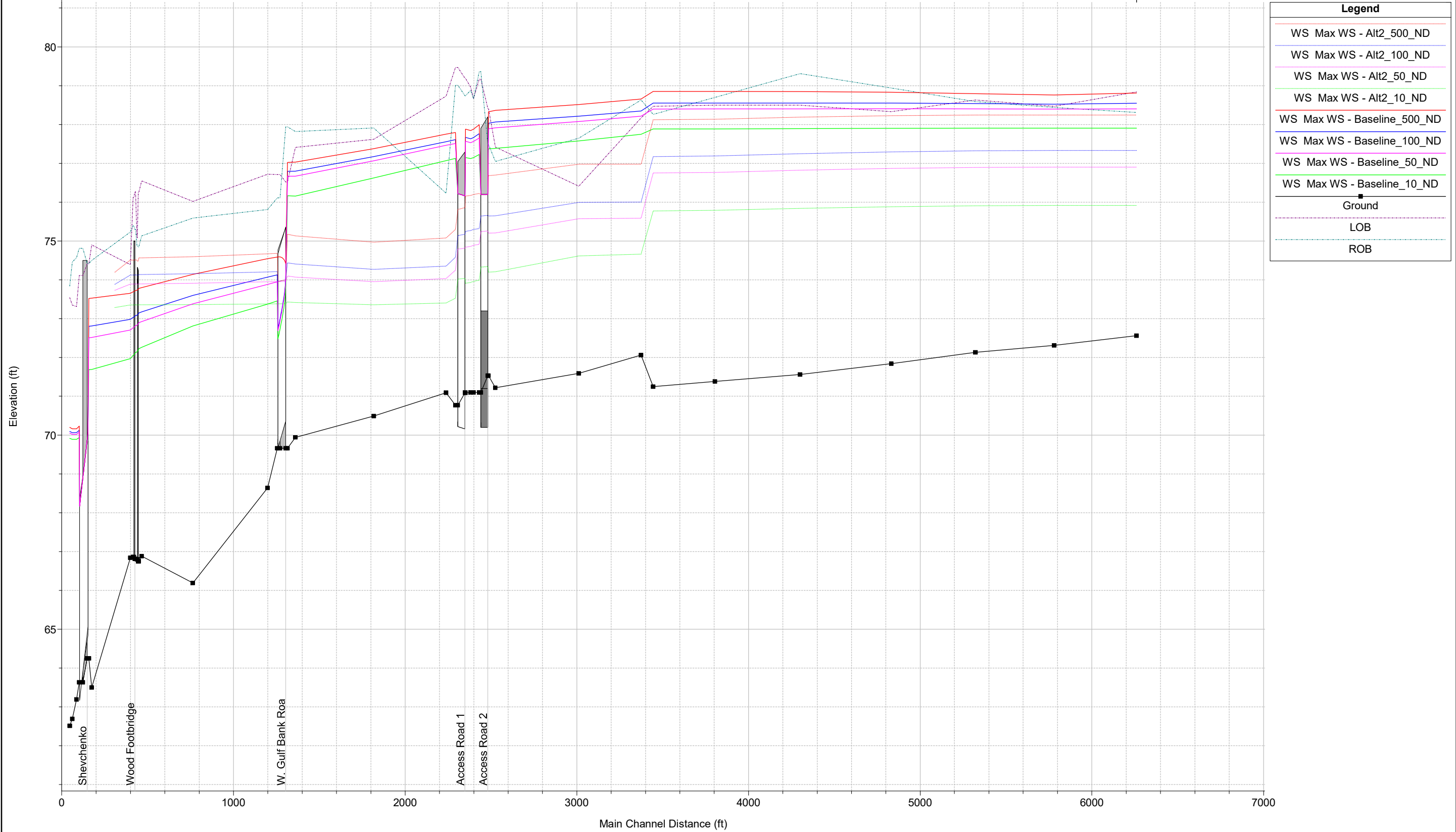
P118-27-00 P118-27-00



Legend	
WS Max WS - Baseline_500	(Red solid line)
WS Max WS - Alt1_500	(Red dashed line)
WS Max WS - Baseline_100	(Blue solid line)
WS Max WS - Alt1_100	(Blue dashed line)
WS Max WS - Baseline_50	(Magenta solid line)
WS Max WS - Alt1_50	(Magenta dashed line)
WS Max WS - Baseline_10	(Green solid line)
WS Max WS - Alt1_10	(Green dashed line)
Ground	(Black line with square markers)
LOB	(Black dotted line)
ROB	(Black dash-dot line)

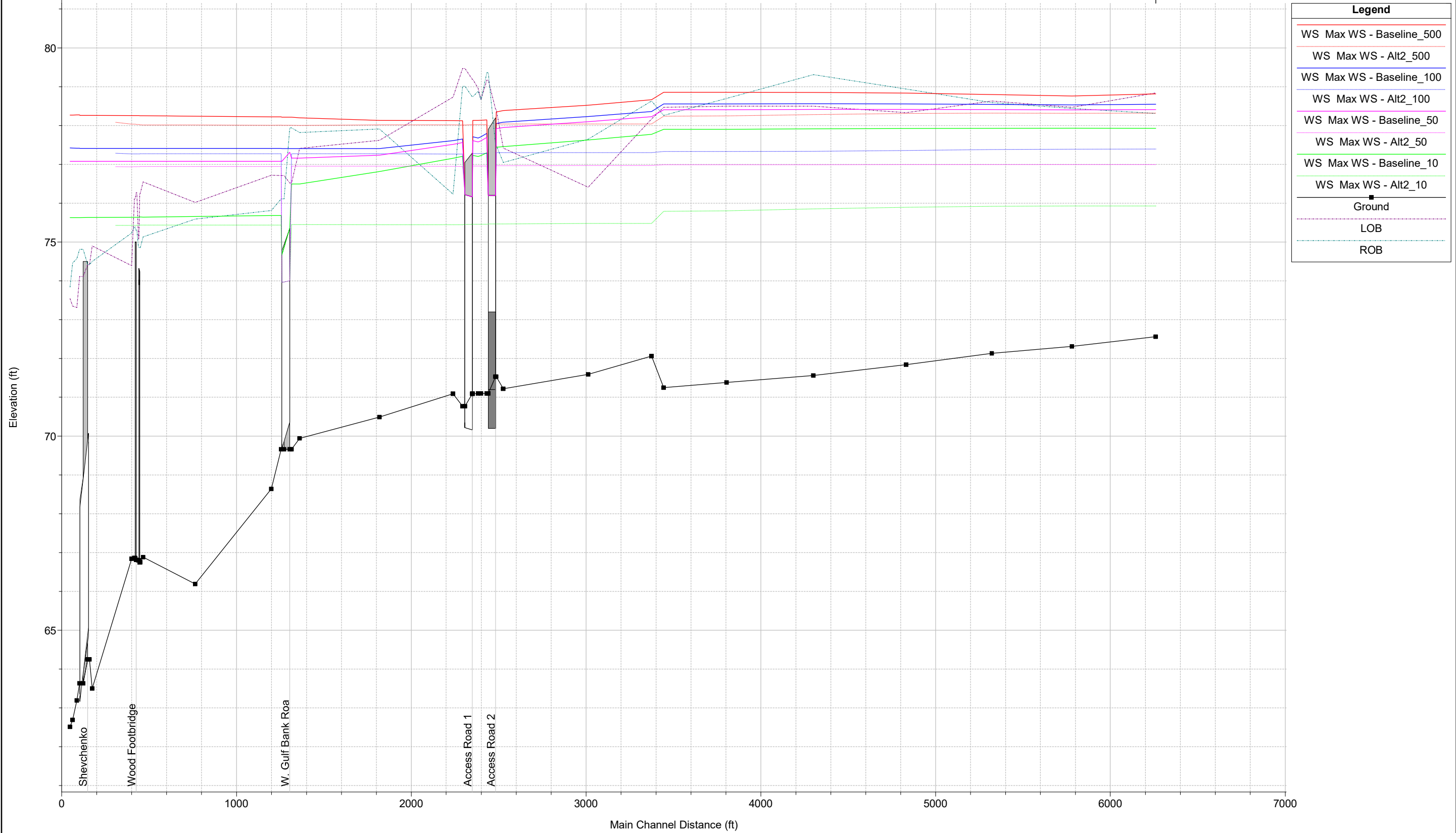
1 in Horiz. = 555 ft 1 in Vert. = 2 ft

P118-27-00 P118-27-00



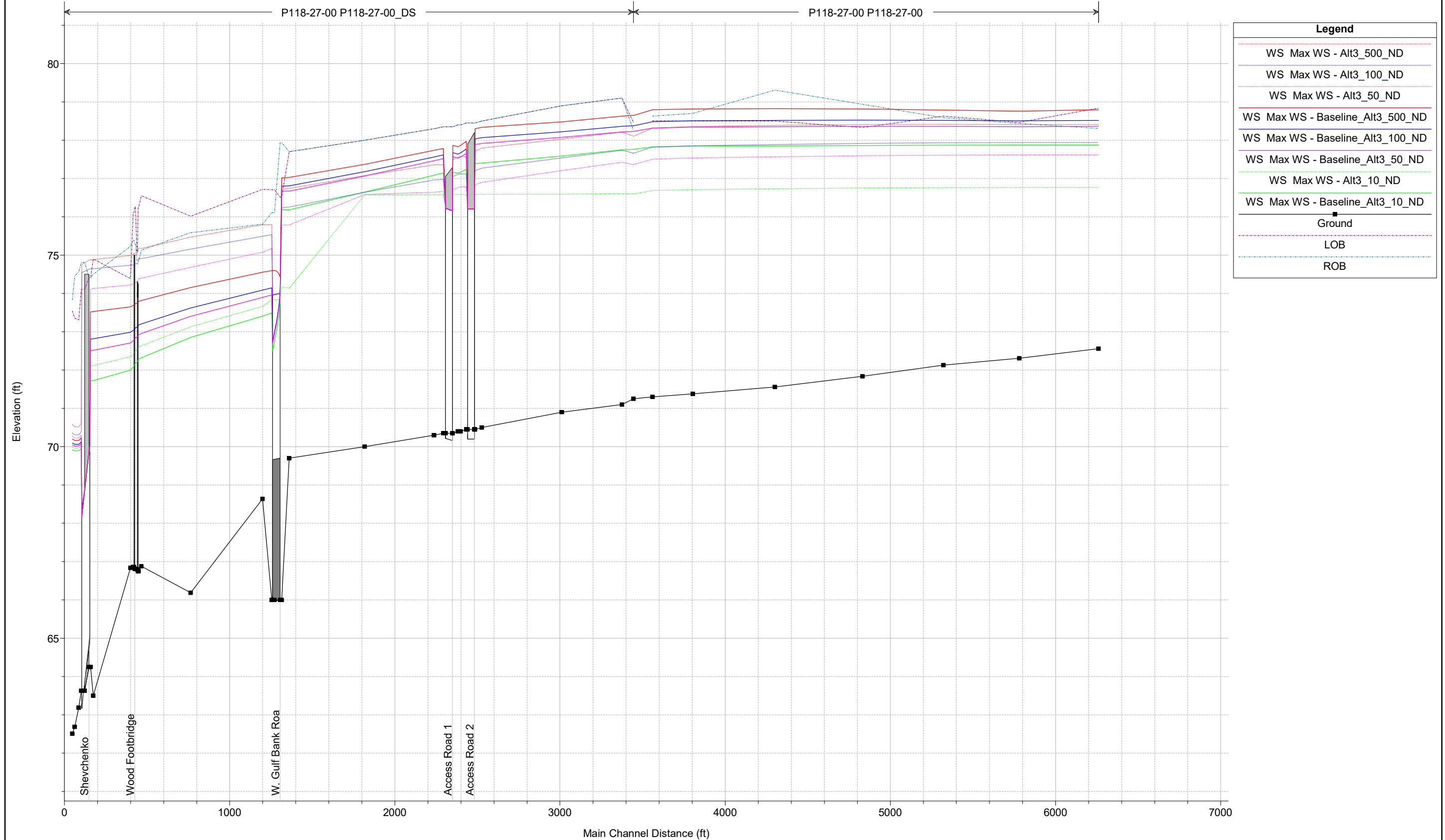
1 in Horiz. = 565 ft 1 in Vert. = 2.5 ft

P118-27-00 P118-27-00

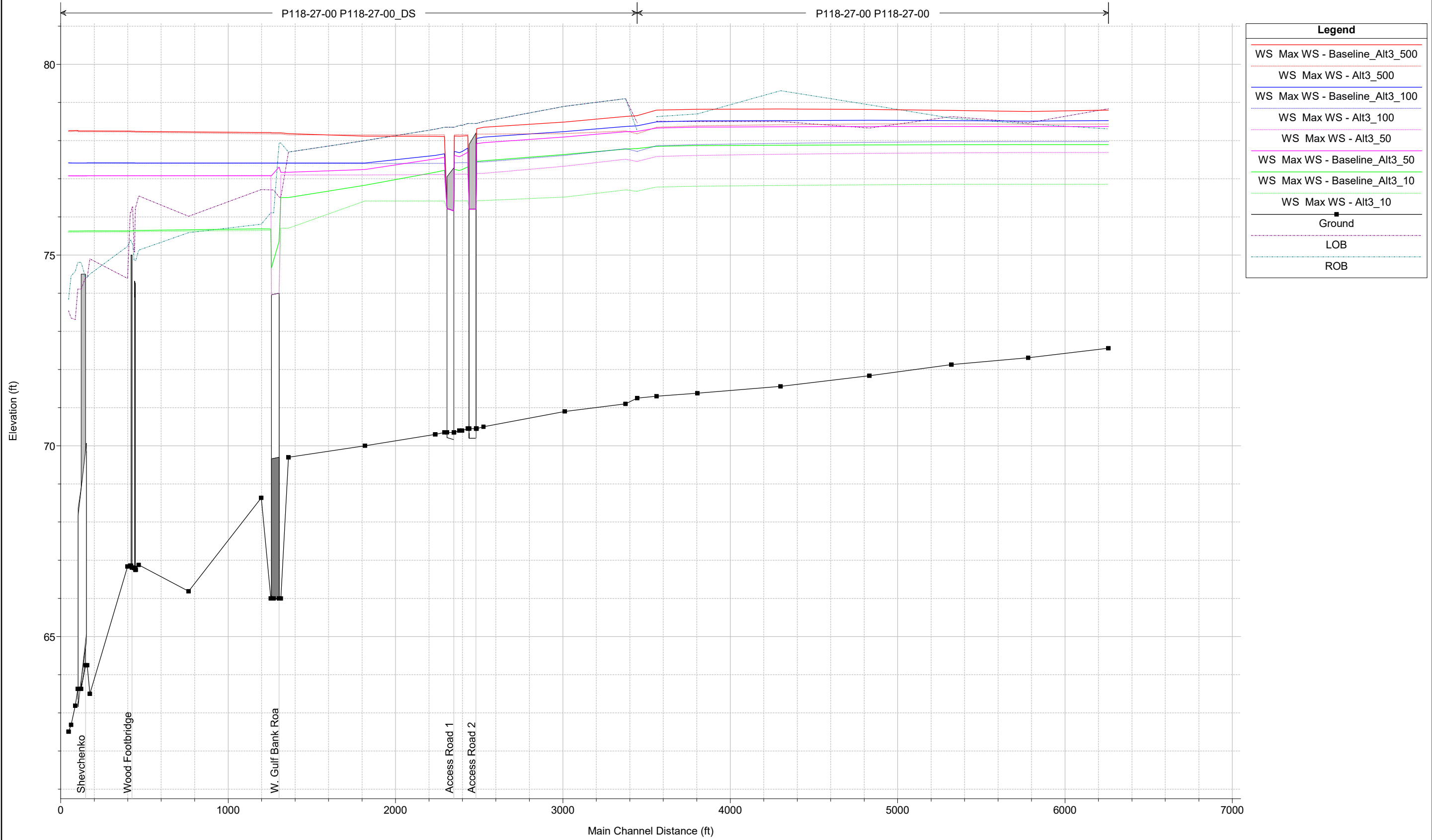


Legend	
WS Max WS - Baseline_500	(Red solid line)
WS Max WS - Alt2_500	(Blue solid line)
WS Max WS - Baseline_100	(Purple solid line)
WS Max WS - Alt2_100	(Green solid line)
WS Max WS - Baseline_50	(Magenta solid line)
WS Max WS - Alt2_50	(Cyan solid line)
WS Max WS - Baseline_10	(Orange solid line)
WS Max WS - Alt2_10	(Yellow solid line)
Ground	(Black line with square markers)
LOB	(Dashed line)
ROB	(Dotted line)

1 in Horiz. = 555 ft 1 in Vert. = 2.5 ft



1 in Horiz. = 580 ft 1 in Vert. = 2.5 ft



Legend	
WS Max WS - Baseline_Alt3_500	(Red solid line)
WS Max WS - Alt3_500	(Blue solid line)
WS Max WS - Baseline_Alt3_100	(Purple solid line)
WS Max WS - Alt3_100	(Magenta solid line)
WS Max WS - Baseline_Alt3_50	(Green solid line)
WS Max WS - Alt3_50	(Light green solid line)
Ground	(Black line with square markers)
LOB	(Dashed purple line)
ROB	(Dashed cyan line)

1 in Horiz. = 570 ft 1 in Vert. = 2.5 ft

Appendix G

Proposed ROW for Recommended Alternative

Shevchenko Basin - ROW acquisition costs

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

HCAD #	Parcel Area	Parcel Area within Basin	Parcel Area Used	Property Type	Valuations (as of January 2020)	Multiplier	Full Acquisition Cost	Partial Acquisition Cost	Full or Partial	Relocation	Total ROW Acquisition Cost	Notes
(-)	(ac)	(ac)	(%)	(-)	(\$)	(-)	(\$)	(\$)	-		-	-
0552280000057	11.56	11.56	100%	Commercial (MH)	\$ 1,160,416.00	3	\$ 3,481,248.00	\$ 3,481,248.00	Full	\$ 2,925,000.00	\$ 6,406,248.00	Relocation cost for appx 117 mobile homes x \$25k = \$2,925,000
0552280000056	0.57	0.57	100%	Commercial (MH)	\$ 220,025.00	3	\$ 660,075.00	\$ 660,075.00	Full	\$ 150,000.00	\$ 810,075.00	Relocation of 6 mobile homes estimated \$150,000
1058070000001	0.54	0.54	100%	Vacant Commercial	\$ 44,448.00	3	\$ 133,344.00	\$ 133,344.00	Full		\$ 133,344.00	This tract may function in conjunction with the apartment complexes to the east (same owner). If so, acquisition of this parcel may require relocation of unknown structure seen in aerial.
1058080000001	1.02	1.02	100%	Vacant Commercial	\$ 88,262.00	3	\$ 264,786.00	\$ 264,786.00	Full		\$ 264,786.00	
	13.69	13.69			\$ 1,513,151.00		\$ 4,539,453.00	\$ 4,539,453.00		\$ 3,075,000.00	\$ 7,614,453.00	

Concrete-lined Channel - ROW acquisition costs

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

HCAD #	Parcel Area	Parcel Area within ROW	Parcel Area Used	Property Type	Valuations (as of January 2020)	Multiplier	Full Acquisition Cost	Partial Acquisition Cost	Full or Partial	Relocation	Total ROW Acquisition Cost	Notes
(-)	(ac)	(ac)	(%)	(-)	(\$)	(-)	(\$)	(\$)	-		-	-
0552280000057	11.56	0.08	1%	Commercial (MH)	\$ 1,076,427.00	3	\$ 3,229,281.00	\$ 22,339.24	Partial		\$ 22,339.24	HCAD land value
0552280270039	0.18	0.00	2%	Vacant Lot	\$ 15,264.00	3	\$ 45,792.00	\$ 914.66	Partial		\$ 914.66	
0552280270015 & 0552280270018	0.12	0.00	3%	RSF	\$ 58,461.00	1.15	\$ 67,230.15	\$ 1,864.22	Full	\$ 120,769.85	\$ 188,000.00	Used 2019 value for vacant lot. Acquisition bisects house on - 0018
0552280810001	5.78	0.11	2%	Commercial (Vacant)	\$ 866,810.00	3	\$ 2,600,430.00	\$ 50,222.63	Partial		\$ 50,222.63	
0552280810002	4.87	0.08	2%	Commercial	\$ 898,447.00	3	\$ 2,695,341.00	\$ 46,074.60	Partial		\$ 46,074.60	HCAD land value
0552280820002	9.91	0.09	1%	Commercial	\$ 1,550,367.00	3	\$ 4,651,101.00	\$ 40,981.34	Partial		\$ 40,981.34	HCAD land value
0552280830005	2.54	0.18	7%	Commercial	\$ 196,608.00	3	\$ 589,824.00	\$ 40,873.19	Partial		\$ 40,873.19	
0580790000030	3.36	0.08	2%	Other Exempt (Religious)	\$ -	3	\$ -	\$ 3,539.73	Partial		\$ 3,539.73	used avg land value from nearby tracts
1262590010011	0.17	0.00	1%	Vacant Lot	\$ 29,068.00	3	\$ 87,204.00	\$ 1,258.82	Partial		\$ 1,258.82	
1262590010010	0.20	0.05	25%	Vacant Lot	\$ 32,193.00	3	\$ 96,579.00	\$ 24,280.23	Partial		\$ 24,280.23	ROW in this area doesn't
1262590010009	0.19	0.06	31%	Vacant Lot	\$ 31,792.00	3	\$ 95,376.00	\$ 29,278.21	Partial		\$ 29,278.21	line up with parcel
1262590010008	0.17	0.01	4%	RSF	\$ 28,982.00	3	\$ 86,946.00	\$ 3,123.73	Partial		\$ 3,123.73	boundaries
0580790000003 & 0580790000036	2.39	0.09	4%	RSF	\$ 59,195.00	3	\$ 177,585.00	\$ 6,497.71	Partial	\$ 25,000.00	\$ 31,497.71	business property move, used combined land value of both HCAD accounts
	59.38	2.10			\$ 8,691,183.00		\$ 25,965,396.15	\$ 1,726,671.00		\$ 145,769.85	\$ 482,384.00	

Total: \$ 8,096,837.00

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 URA guidelines. Estimates shown above are based on examples from other projects and past experience, but actual amounts will vary.

Appendix H

Detailed Opinion of Probable Cost and Pipeline Relocation Cost Estimate

Alternative 1 - Opinion of Probable Cost

P118-27-00 Alternatives Analysis Preliminary Cost Summary						
Improvement	HCFC Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Shevchenko Basin	2233-01	Clearing and Grubbing	AC	13.6	\$ 4,000.00	\$ 54,400.00
	2315-02	Excavation & Off-Site Disposal	CY	161,333	\$ 15.00	\$ 2,419,995.00
	2921-01	Turf Establishment	AC	13.6	\$ 3,000.00	\$ 40,800.00
	2315-06	Backslope Drainage System Swales	LF	3,600	\$ 2.00	\$ 7,200.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	\$ 85.00	\$ 85,000.00
	2376-06	Concrete Interceptor Structure	SY	60	\$ 120.00	\$ 7,200.00
	2632-70	Headwalls and Wingwalls	CY	90	\$ 950.00	\$ 85,500.00
	2378-01	Riprap, Gradation No. 1	SY	980	\$ 100.00	\$ 98,000.00
	2642-02	24" CMP	LF	400	\$ 90.00	\$ 36,000.00
	2612-32	5' x 5' RCB	LF	70	\$ 500.00	\$ 35,000.00
Subtotal:						\$ 2,869,095.00

P118-27-00 Alternatives Analysis Preliminary Cost Summary						
Improvement	HCFC Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Gulf Bank Basin	2233-01	Clearing and Grubbing	AC	13.2	\$ 4,000.00	\$ 52,800.00
	2315-02	Excavation & Off-Site Disposal	CY	125,840	\$ 10.00	\$ 1,258,400.00
	2921-01	Turf Establishment	AC	13.2	\$ 3,000.00	\$ 39,600.00
	2315-06	Backslope Drainage System Swales	LF	3,100	\$ 2.00	\$ 6,200.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	\$ 85.00	\$ 85,000.00
	2376-06	Concrete Interceptor Structure	SY	48	\$ 120.00	\$ 5,760.00
	2632-70	Headwalls and Wingwalls	CY	90	\$ 950.00	\$ 85,500.00
	2378-01	Riprap, Gradation No. 1	SY	450	\$ 100.00	\$ 45,000.00
	2642-02	24" CMP	LF	320	\$ 90.00	\$ 28,800.00
	2611-02	24" RCP	LF	50	\$ 180.00	\$ 9,000.00
Subtotal:						\$ 1,616,060.00

P118-27-00 Alternatives Analysis Preliminary Cost Summary						
Improvement	HCFC Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Existing Channel Improvements Concrete-lined	2612-63	8' x 6' RCB	LF	250	\$ 588.00	\$ 147,000.00
	2632-70	Headwalls and Wingwalls	CY	180	\$ 950.00	\$ 171,000.00
	2120-01	REMOVE & DISPOSE OF ROADWAY PAVEMENT AND SUBGRADE	SY	520	\$ 12.00	\$ 6,240.00
	2120-03	REMOVE & DISPOSE OF CONCRETE RUBBLE AND CONCRETE STRUCTURES	CY	90	\$ 50.00	\$ 4,500.00
	2120-04	REMOVE & DISPOSE OF ALL PIPE (01565)	LF	350	\$ 15.00	\$ 5,250.00
	2336-01	Lime Stab. Subgrade, 6"	SY	370	\$ 6.00	\$ 2,220.00
	2336-05	Hydrated Lime (7%)	TON	7	\$ 210.00	\$ 1,470.00
	2714-02	Hot Mix Asphaltic Base Course, 8"	SY	370	\$ 80.00	\$ 29,600.00
	2741-02	Asphalt, 2"	SY	370	\$ 40.00	\$ 14,800.00
	2376-04	Concrete Slope Paving	SY	12,700	\$ 100.00	\$ 1,270,000.00
		Pipeline Relocation	LS	1	\$ 683,500.00	\$ 683,500.00
	Subtotal:					

Planning, Engineering, and Design (10% of DCC):	\$	682,300.00
Mobilization/Demobilization (5% of DCC):	\$	341,200.00
Construction Management (10% of DCC):	\$	682,300.00
Contingency (20% of DCC):	\$	1,364,400.00
Shevchenko ROW Acquisition:	\$	7,614,453.00
Gulf Bank ROW Acquisition:	\$	10,719,280.00
Concrete-Lined Channel Improvements ROW Acquisition:	\$	482,400.00
Total:	\$	25,837,973.00

Alternative 2 - Opinion of Probable Cost

P118-27-00 Alternatives Analysis Preliminary Cost Summary						
Improvement	HCFC Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Shevchenko Basin	2233-01	Clearing and Grubbing	AC	13.6	\$ 4,000.00	\$ 54,400.00
	2315-02	Excavation & Off-Site Disposal	CY	161,333	\$ 15.00	\$ 2,419,995.00
	2921-01	Turf Establishment	AC	13.6	\$ 3,000.00	\$ 40,800.00
	2315-06	Backslope Drainage System Swales	LF	3,600	\$ 2.00	\$ 7,200.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	\$ 85.00	\$ 85,000.00
	2376-06	Concrete Interceptor Structure	SY	60	\$ 120.00	\$ 7,200.00
	2632-70	Headwalls and Wingwalls	CY	90	\$ 950.00	\$ 85,500.00
	2378-01	Riprap, Gradation No. 1	SY	980	\$ 100.00	\$ 98,000.00
	2642-02	24" CMP	LF	400	\$ 90.00	\$ 36,000.00
	2612-32	5' x 5' RCB	LF	70	\$ 500.00	\$ 35,000.00
Subtotal:						\$ 2,869,095.00

P118-27-00 Alternatives Analysis Preliminary Cost Summary						
Improvement	HCFC Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Existing Channel Improvements Concrete-lined	2612-63	8' x 6' RCB	LF	250	\$ 588.00	\$ 147,000.00
	2632-70	Headwalls and Wingwalls	CY	180	\$ 950.00	\$ 171,000.00
	2120-01	REMOVE & DISPOSE OF ROADWAY PAVEMENT AND SUBGRADE	SY	520	\$ 12.00	\$ 6,240.00
	2120-03	REMOVE & DISPOSE OF CONCRETE RUBBLE AND CONCRETE STRUCTURES	CY	90	\$ 50.00	\$ 4,500.00
	2120-04	REMOVE & DISPOSE OF ALL PIPE (01565)	LF	350	\$ 15.00	\$ 5,250.00
	2336-01	Lime Stab. Subgrade, 6"	SY	370	\$ 6.00	\$ 2,220.00
	2336-05	Hydrated Lime (7%)	TON	7	\$ 210.00	\$ 1,470.00
	2714-02	Hot Mix Asphaltic Base Course, 8"	SY	370	\$ 80.00	\$ 29,600.00
	2741-02	Asphalt, 2"	SY	370	\$ 40.00	\$ 14,800.00
	2376-04	Concrete Slope Paving	SY	12,700	\$ 100.00	\$ 1,270,000.00
		Pipeline Relocation	LS	1	\$ 683,500.00	\$ 683,500.00
	Subtotal:					

Planning, Engineering, and Design (10% of DCC):	\$ 520,600.00
Mobilization/Demobilization (5% of DCC):	\$ 260,300.00
Construction Management (10% of DCC):	\$ 520,600.00
Contingency (20% of DCC):	\$ 1,041,100.00
Shevchenko ROW Acquisition:	\$ 7,614,453.00
Concrete-Lined Channel Improvements ROW Acquisition:	\$ 482,400.00
Total:	\$ 15,644,128.00

Alternative 3 - Opinion of Probable Cost

P118-27-00 Alternatives Analysis Preliminary Cost Summary						
Improvement	HCFC Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Dow Basin	2233-01	Clearing and Grubbing	AC	10.8	\$ 4,000.00	\$ 43,200.00
	2315-02	Excavation & Off-Site Disposal	CY	80,667	\$ 10.00	\$ 806,670.00
	2921-01	Turf Establishment	AC	10.8	\$ 3,000.00	\$ 32,400.00
	2315-06	Backslope Drainage System Swales	LF	3,000	\$ 2.00	\$ 6,000.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	\$ 85.00	\$ 85,000.00
	2376-06	Concrete Interceptor Structure	SY	48	\$ 120.00	\$ 5,760.00
	2632-70	Headwalls and Wingwalls	CY	90	\$ 950.00	\$ 85,500.00
	2378-01	Riprap, Gradation No. 1	SY	200	\$ 100.00	\$ 20,000.00
	2642-02	24" CMP	LF	320	\$ 90.00	\$ 28,800.00
	2611-02	24" RCP	LF	40	\$ 180.00	\$ 7,200.00
						Subtotal:

P118-27-00 Alternatives Analysis Preliminary Cost Summary						
Improvement	HCFC Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount
Karen Basin	2233-01	Clearing and Grubbing	AC	5.5	\$ 4,000.00	\$ 22,000.00
	2315-02	Excavation & Off-Site Disposal	CY	41,947	\$ 10.00	\$ 419,470.00
	2921-01	Turf Establishment	AC	5.5	\$ 3,000.00	\$ 16,500.00
	2315-06	Backslope Drainage System Swales	LF	1,800	\$ 2.00	\$ 3,600.00
	2376-02	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	\$ 85.00	\$ 85,000.00
	2376-06	Concrete Interceptor Structure	SY	36	\$ 120.00	\$ 4,320.00
	2632-70	Headwalls and Wingwalls	CY	90	\$ 950.00	\$ 85,500.00
	2378-01	Riprap, Gradation No. 1	SY	200	\$ 100.00	\$ 20,000.00
	2642-02	24" CMP	LF	240	\$ 90.00	\$ 21,600.00
	2611-04	36" RCP	LF	30	\$ 250.00	\$ 7,500.00
						Subtotal:

P118-27-00 Alternatives Analysis Preliminary Cost Summary							
Improvement	HCFC Pay Item #	Pay Item Description	Unit	Quantity	Unit Price	Amount	
Existing Channel Improvements Grass-lined	2315-02	Excavation & Off-Site Disposal	CY	6,750	\$ 10.00	\$ 67,500.00	
	2612-63	8' x 6' RCB	LF	250	\$ 588.00	\$ 147,000.00	
	2632-70	Headwalls and Wingwalls	CY	180	\$ 950.00	\$ 171,000.00	
	2315-06	Backslope Drainage System Swales	LF	4,070	\$ 5.00	\$ 20,350.00	
	2376-06	Concrete Interceptor Structure	SY	65	\$ 150.00	\$ 9,750.00	
	2120-01	REMOVE & DISPOSE OF ROADWAY PAVEMENT AND SUBGRADE	SY	370	\$ 12.00	\$ 4,440.00	
	2120-03	REMOVE & DISPOSE OF CONCRETE RUBBLE AND CONCRETE STRUCTURES	CY	90	\$ 50.00	\$ 4,500.00	
	2120-04	REMOVE & DISPOSE OF ALL PIPE (01565)	LF	250	\$ 15.00	\$ 3,750.00	
	2336-01	Lime Stab. Subgrade, 6"	SY	370	\$ 6.00	\$ 2,220.00	
	2336-05	Hydrated Lime (7%)	TON	7	\$ 210.00	\$ 1,470.00	
	2714-02	Hot Mix Asphaltic Base Course, 8"	SY	370	\$ 80.00	\$ 29,600.00	
	2741-02	Asphalt, 2"	SY	370	\$ 40.00	\$ 14,800.00	
	2378-01	Riprap, Gradation No. 1	SY	60	\$ 100.00	\$ 6,000.00	
	2642-02	24" CMP	LF	255	\$ 85.00	\$ 21,675.00	
		Pipeline Relocation	LS	1	\$ 683,500.00	\$ 683,500.00	
						Subtotal:	\$ 1,187,555.00

Planning, Engineering, and Design (10% of DCC):	\$ 299,500.00
Mobilization/Demobilization (5% of DCC):	\$ 149,800.00
Construction Management (10% of DCC):	\$ 299,500.00
Contingency (20% of DCC):	\$ 598,900.00
Dow ROW Acquisition:	\$ 2,292,097.00
Karen ROW Acquisition:	\$ 1,107,377.00
Grass-Lined Channel Improvements ROW Acquisition:	\$ 1,391,000.00
Total:	\$ 9,131,749.00

HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD) PROJECT Halls Bayou
Cost Estimate for ExxonMobil Pipeline Relocations
Bond Project ID C-30
Harris County, Texas

Date: 11/17/2020

Description	Quantity	Unit	Unit Price (\$)	Total	Pipeline ID(s)
8" Pipeline					
Materials					
8" Steel Pipe Pipe	127	Ft	\$ 27.20	\$ 3,454.40	
8" Elbow	4	Ea	\$ 95.50	\$ 382.00	
Anode for Cathodic Protection	1	Ea	\$ 17.50	\$ 17.50	
Test Station	1	Ea	\$ 30.00	\$ 30.00	
Contract Labor					
Horizontal Directional Drill - 8"	127	Ft	\$ 215.00	\$ 27,305.00	
Pipe Removal	127	Ft	\$ 25.00	\$ 3,175.00	
8" Pipeline Subtotal				\$ 34,363.90	
8" Pipeline					
Materials					
8" Steel Pipe Pipe	127	Ft	\$ 27.20	\$ 3,454.40	
8" Elbow	4	Ea	\$ 95.50	\$ 382.00	
Anode for Cathodic Protection	1	Ea	\$ 17.50	\$ 17.50	
Test Station	1	Ea	\$ 30.00	\$ 30.00	
Contract Labor					
Horizontal Directional Drill - 8"	127	Ft	\$ 215.00	\$ 27,305.00	
Pipe Removal	127	Ft	\$ 25.00	\$ 3,175.00	
8" Pipeline Subtotal				\$ 34,363.90	
10" Pipeline					
Materials					
10" Steel Pipe Pipe	127	Ft	\$ 34.74	\$ 4,411.98	
10" Elbow	4	Ea	\$ 121.50	\$ 486.00	
Anode for Cathodic Protection	1	Ea	\$ 17.50	\$ 17.50	
Test Station	1	Ea	\$ 30.00	\$ 30.00	
Contract Labor					
Horizontal Directional Drill - 10"	127	Ft	\$ 260.00	\$ 33,020.00	
Pipe Removal	127	Ft	\$ 25.00	\$ 3,175.00	
10" Pipeline Subtotal				\$ 41,140.48	
MISC. CONSTRUCTION ITEMS					
Silt Fencing	1000	Ft	\$ 2.00	\$ 2,000.00	
Construction Mats (4'x16')	500	Ft	\$ 150.00	\$ 75,000.00	
Inspection - Construction	20	\$ / Day	\$ 850.00	\$ 17,000.00	
Radiographic Services (X-Ray)	5	\$ / Day	\$ 1,800.00	\$ 9,000.00	
Site Restoration / Obtaining Work Easements	2	\$ / Acre	\$ 2,500.00	\$ 5,000.00	
Environmental	1	Ls	\$ 10,000.00	\$ 10,000.00	
Permitting	1	Ls	\$ 10,000.00	\$ 10,000.00	
Consulting & Engineering	1	Ls	\$ 73,245.00	\$ 73,245.00	
Surveying (Staking)	5	Days	\$ 1,480.00	\$ 7,400.00	
Materials & Labor Subtotal				\$ 109,868.28	
Misc. Construction Items Subtotal				\$ 208,645.00	
Overall Project Subtotal				\$ 318,513.28	
Company Overhead (20%)				\$ 63,702.66	
Total Project Cost				\$ 382,215.94	

HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD) PROJECT Halls Bayou
Cost Estimate for Magellan Pipeline Relocations
Bond Project ID C-30
Harris County, Texas

Date: 11/17/2020

Description	Quantity	Unit	Unit Price (\$)	Total	Pipeline ID(s)
20" Pipeline					
Materials					
20" Steel Pipe Pipe	127	Ft	\$ 72.59	\$ 9,218.93	
20" Elbow	4	Ea	\$ 251.50	\$ 1,006.00	
Anode for Cathodic Protection	1	Ea	\$ 17.50	\$ 17.50	
Test Station	1	Ea	\$ 30.00	\$ 30.00	
Contract Labor					
Horizontal Directional Drill - 20"	127	Ft	\$ 485.00	\$ 61,595.00	
Pipe Removal	127		\$ 25.00	\$ 3,175.00	
20" Pipeline Subtotal				\$ 75,042.43	
MISC. CONSTRUCTION ITEMS					
Silt Fencing	1000	Ft	\$ 2.00	\$ 2,000.00	
Construction Mats (4'x16')	500	Ft	\$ 150.00	\$ 75,000.00	
Inspection - Construction	20	\$ / Day	\$ 850.00	\$ 17,000.00	
Radiographic Services (X-Ray)	5	\$ / Day	\$ 1,800.00	\$ 9,000.00	
Site Restoration / Obtaining Work Easements	2	\$ / Acre	\$ 2,500.00	\$ 5,000.00	
Environmental	1	Ls	\$ 10,000.00	\$ 10,000.00	
Permitting	1	Ls	\$ 10,000.00	\$ 10,000.00	
Consulting & Engineering	1	Ls	\$ 40,612.00	\$ 40,612.00	
Surveying (Staking)	5	Days	\$ 1,480.00	\$ 7,400.00	
Materials & Labor Subtotal				\$ 75,042.43	
Misc. Construction Items Subtotal				\$ 176,012.00	
Overall Project Subtotal				\$ 251,054.43	
Company Overhead (20%)				\$ 50,210.89	
Total Project Cost				\$ 301,265.32	

Appendix I

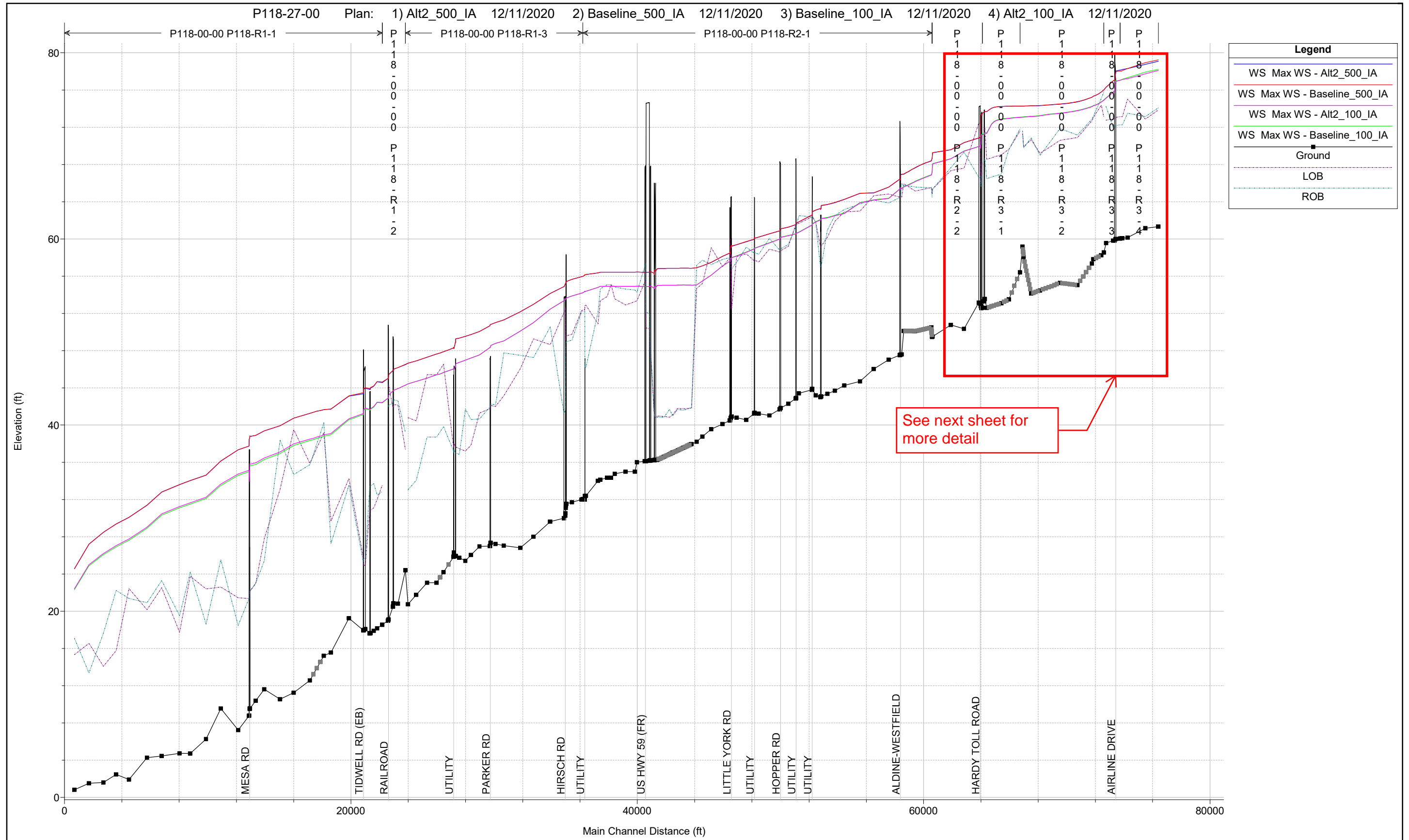
Preliminary Wetland and Threatened and Endangered Species Habitat Assessment

Appendix K

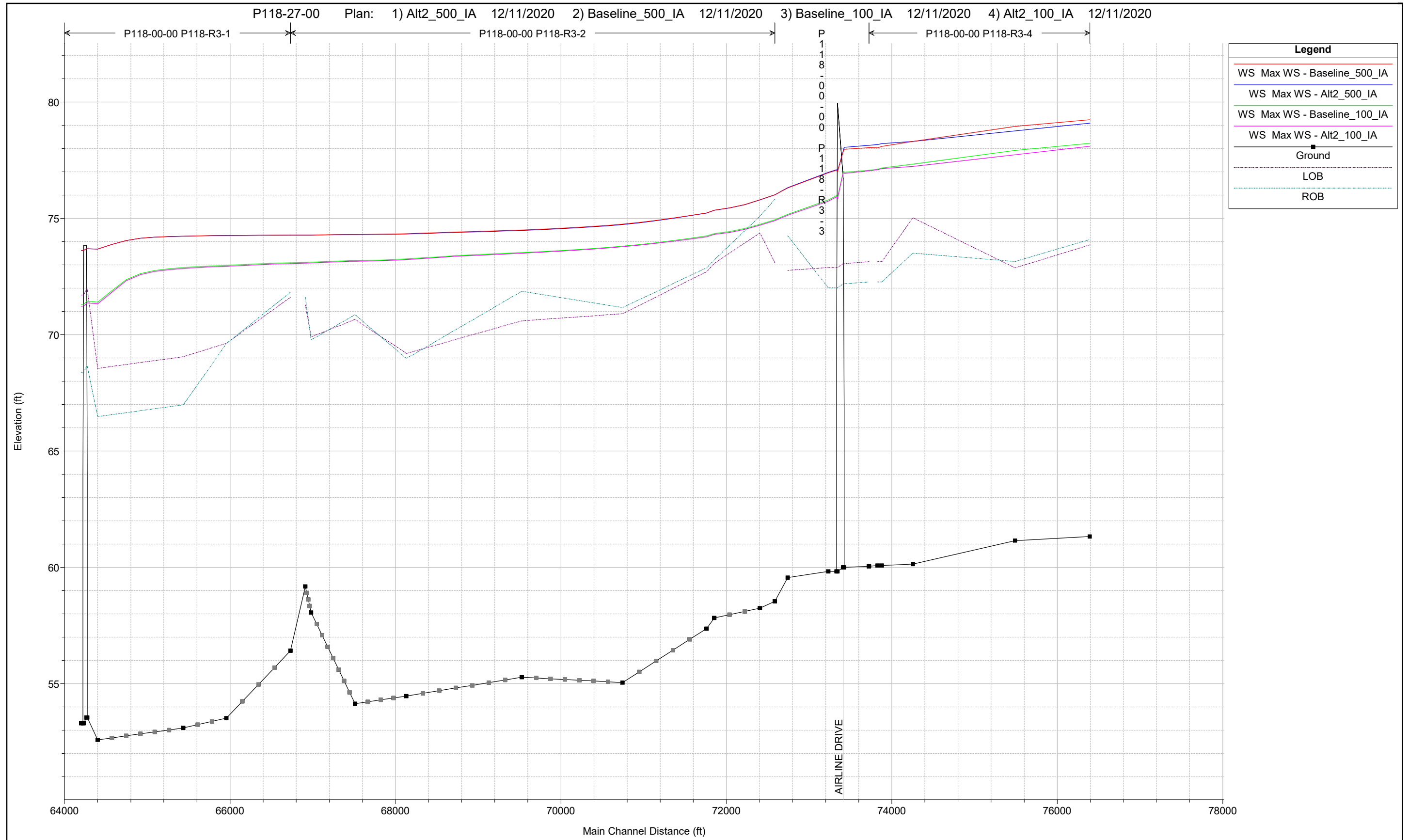
Attribute Scoring and Ranking Form and
Harris County Flood Control District Project Scoring Form

Appendix L

Impact Analysis Baseline vs. Recommended Alternative Water Surface Profiles



1 in Horiz. = 6500 ft 1 in Vert. = 10 ft

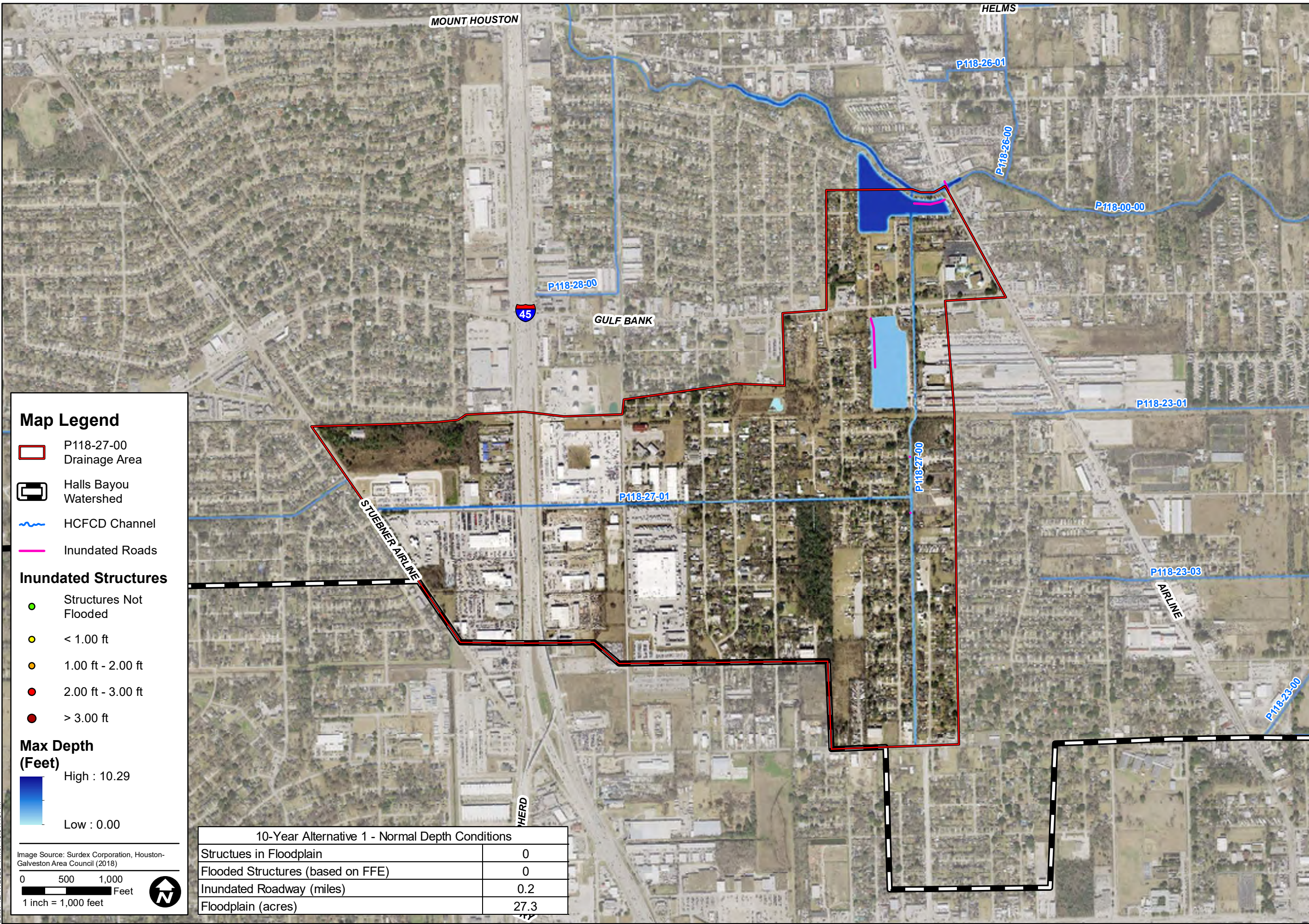


1 in Horiz. = 1125 ft 1 in Vert. = 4 ft

Appendix M

Alternative 1 and Alternative 3 Metrics and Floodplain Maps

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 Date: 12/17/2020 Time: 10:01:43 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

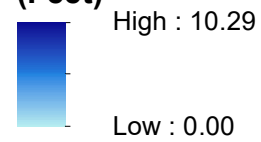
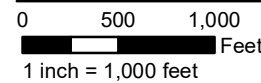


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



10-Year Alternative 1 - Normal Depth Conditions	
Structures in Floodplain	0
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.2
Floodplain (acres)	27.3

HCFCF HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR ALTERNATIVE 1 PERFORMANCE METRICS
 (NORMAL DEPTH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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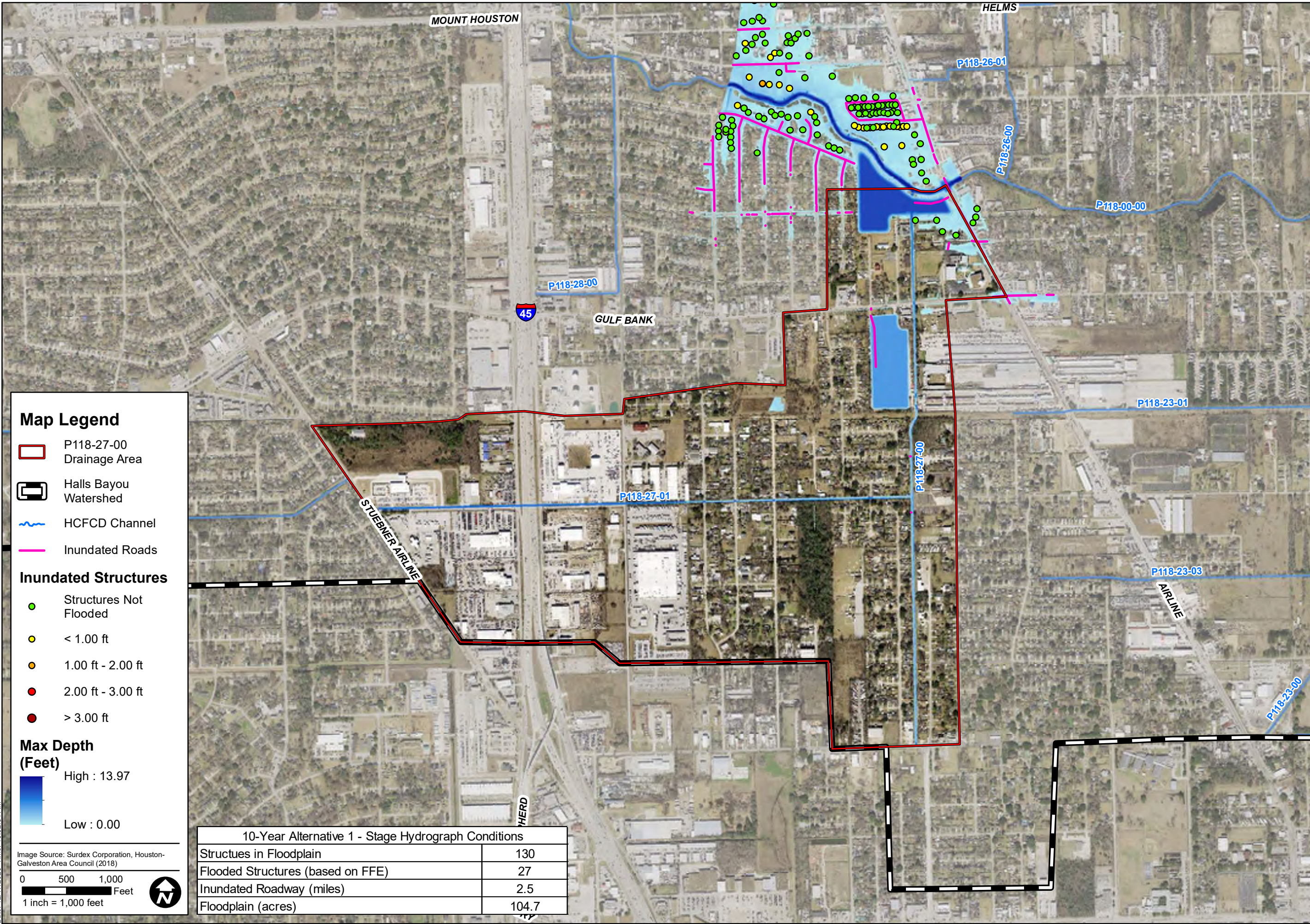


9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

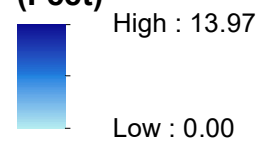
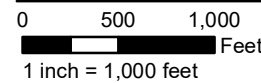


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



10-Year Alternative 1 - Stage Hydrograph Conditions	
Structures in Floodplain	130
Flooded Structures (based on FFE)	27
Inundated Roadway (miles)	2.5
Floodplain (acres)	104.7

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR ALTERNATIVE 1 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

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CHECKED:	BJI
APPROVED:	CEE

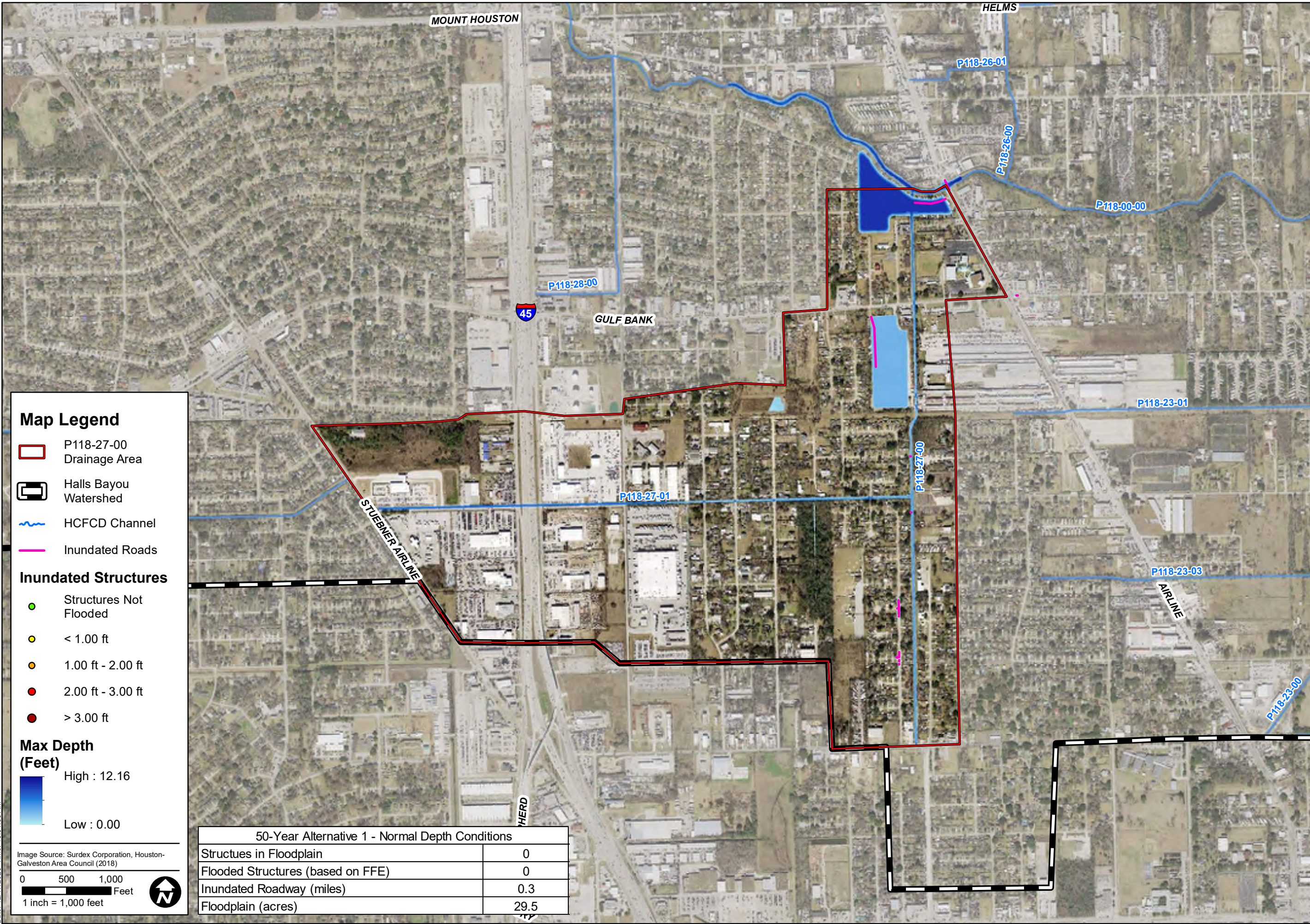
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HARRIS COUNTY FLOOD CONTROL DISTRICT
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DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

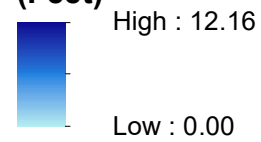
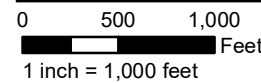


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



50-Year Alternative 1 - Normal Depth Conditions	
Structures in Floodplain	0
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.3
Floodplain (acres)	29.5

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR ALTERNATIVE 1 PERFORMANCE METRICS
 (NORMAL DEPTH TAILWATER)

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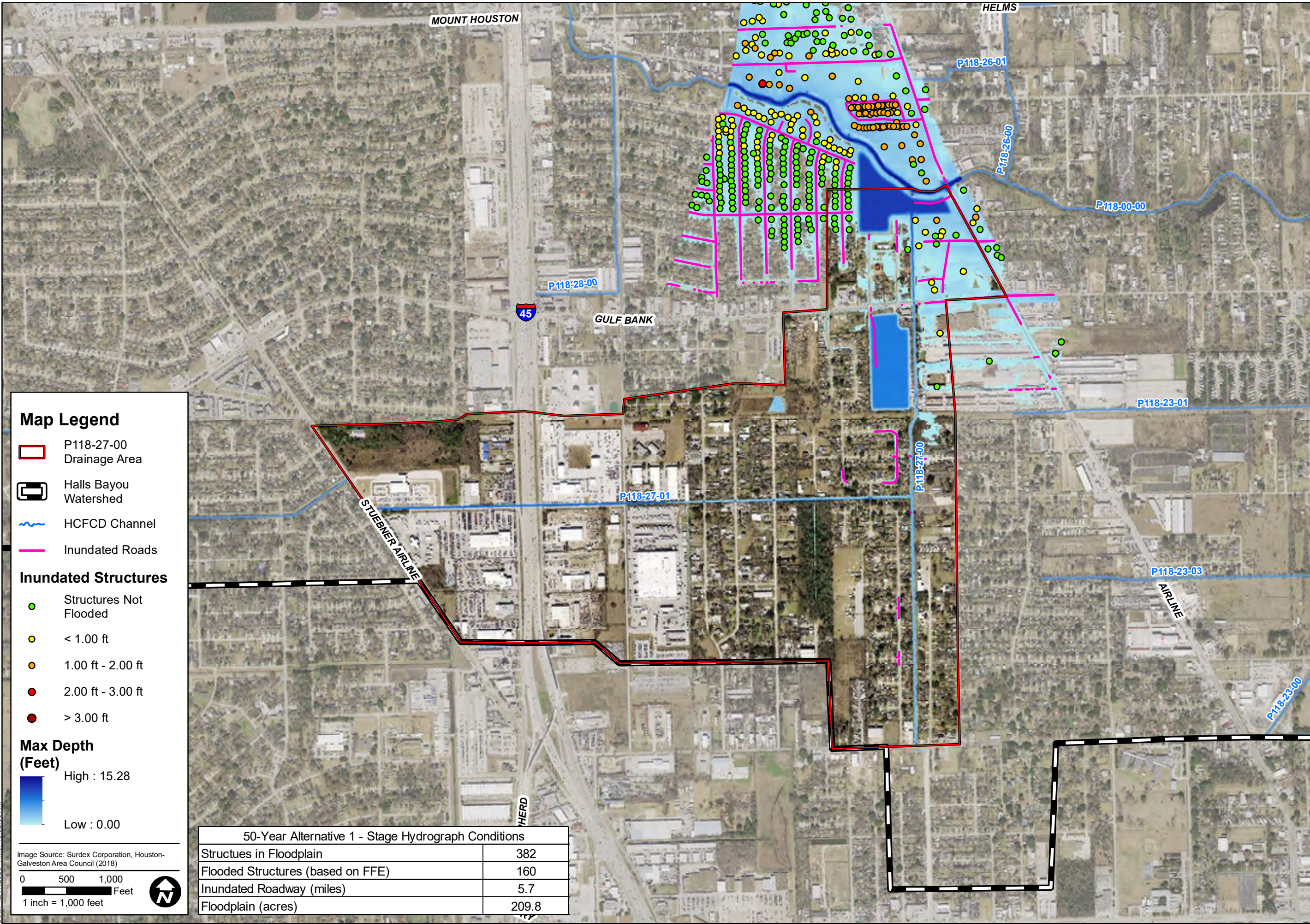


9900 Northwest Freeway
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DATE: OCT 2020
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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCO Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

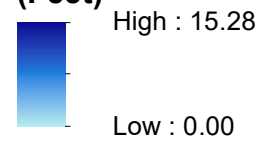
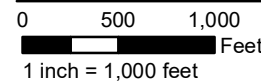


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



50-Year Alternative 1 - Stage Hydrograph Conditions	
Structures in Floodplain	382
Flooded Structures (based on FFE)	160
Inundated Roadway (miles)	5.7
Floodplain (acres)	209.8

HCFCO HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR ALTERNATIVE 1 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

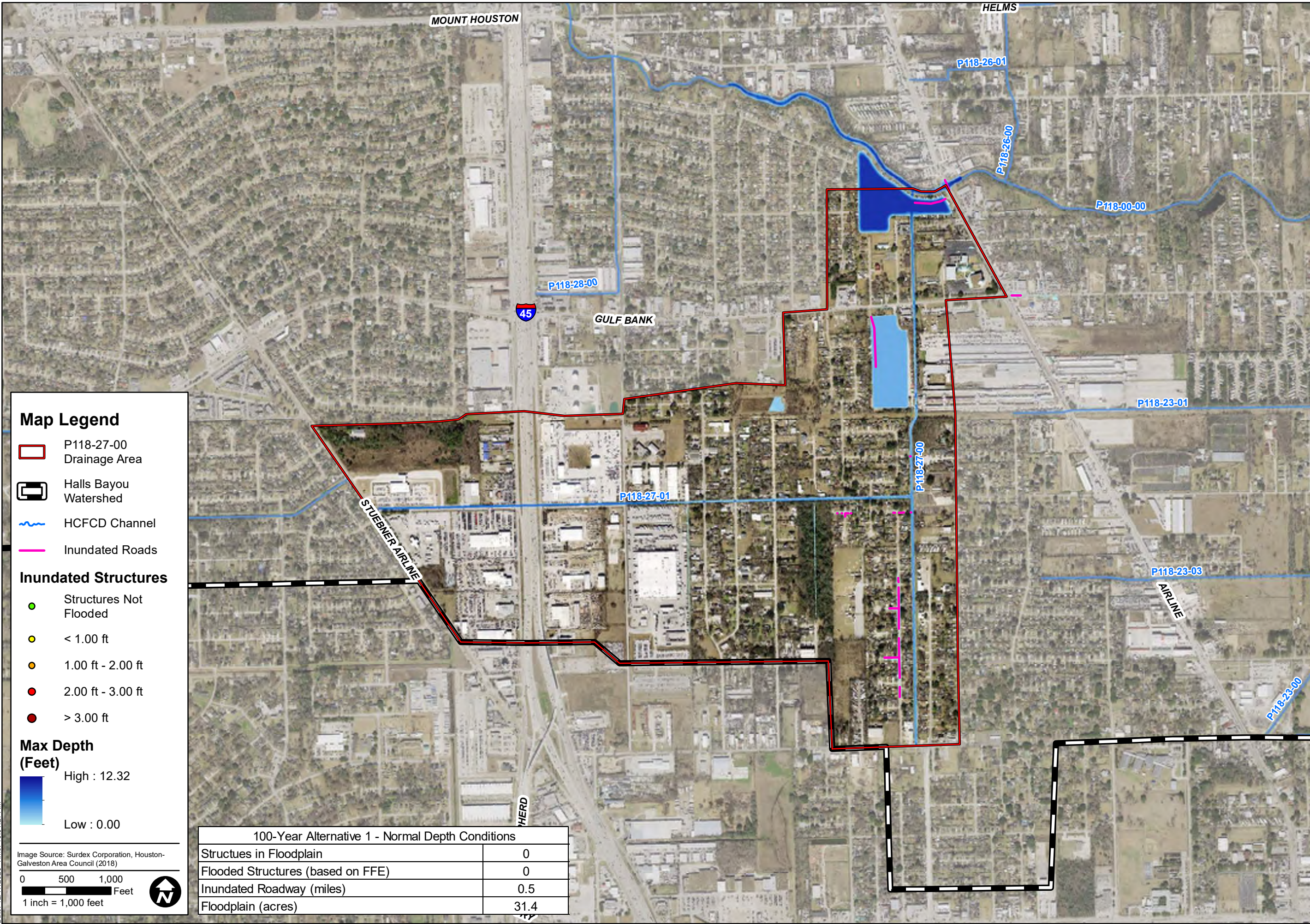
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DATE: OCT 2020
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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

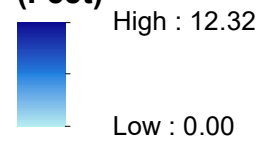
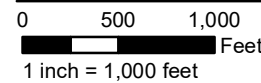


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



100-Year Alternative 1 - Normal Depth Conditions	
Structues in Floodplain	0
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.5
Floodplain (acres)	31.4

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR ALTERNATIVE 1 PERFORMANCE METRICS
 (NORMAL DEPTH TAILWATER)

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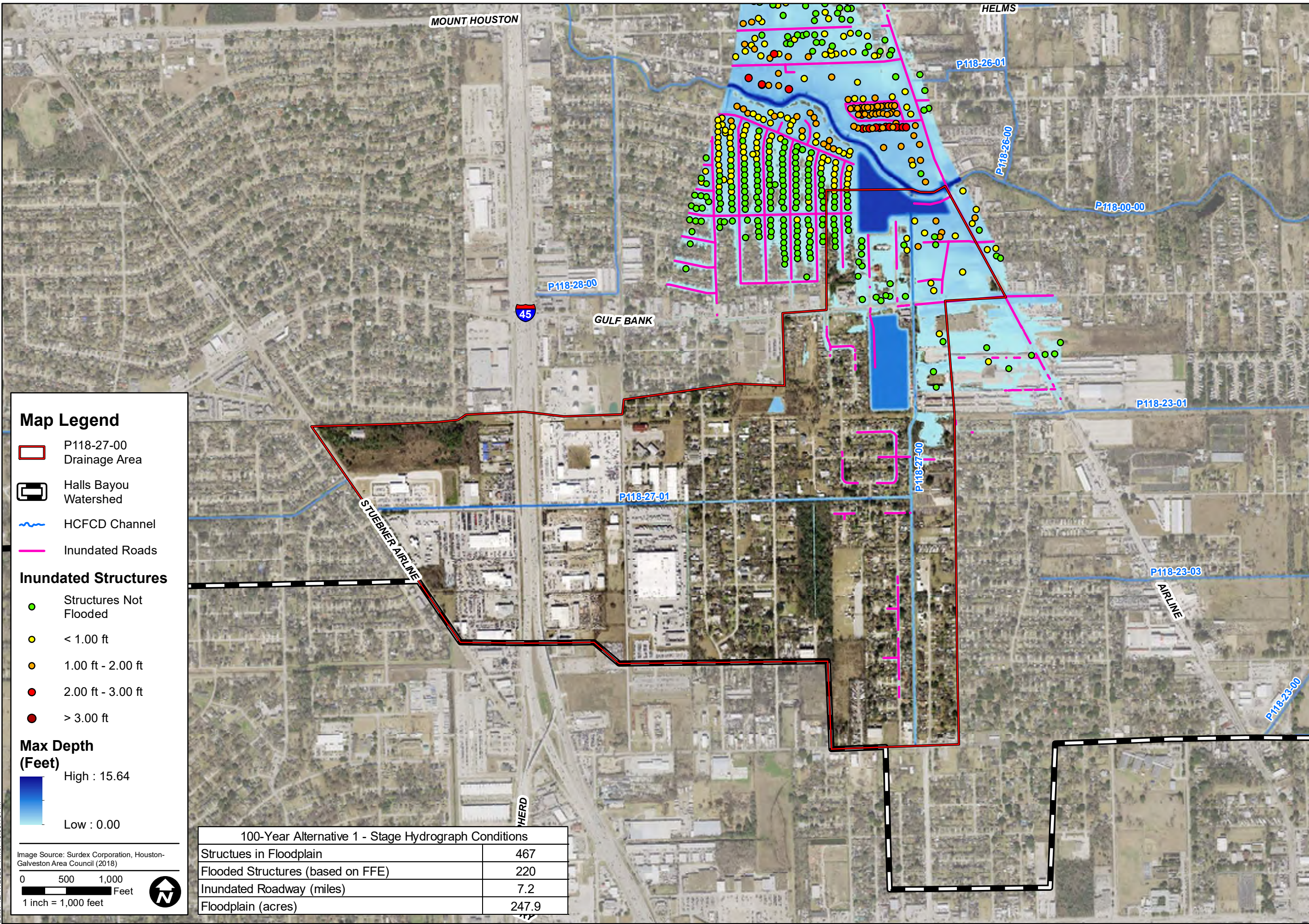


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DATE: OCT 2020
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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCO Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

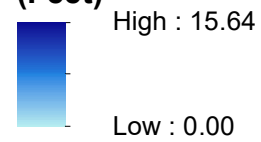
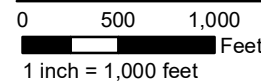


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



100-Year Alternative 1 - Stage Hydrograph Conditions	
Structures in Floodplain	467
Flooded Structures (based on FFE)	220
Inundated Roadway (miles)	7.2
Floodplain (acres)	247.9

HCFCO HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR ALTERNATIVE 1 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

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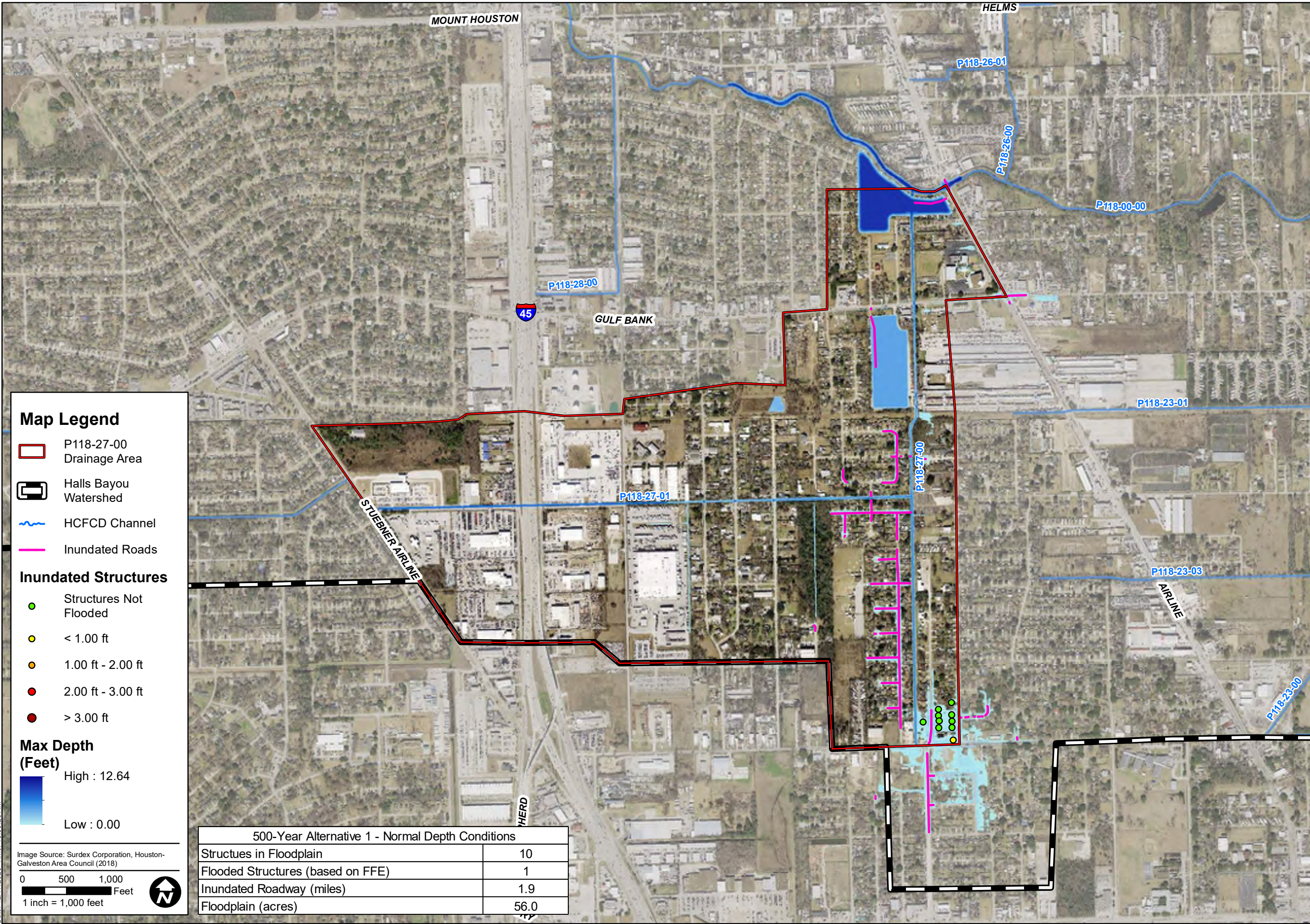


9900 Northwest Freeway
 Houston, Texas 77092





DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

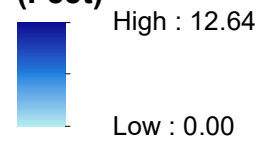
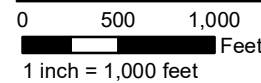


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



500-Year Alternative 1 - Normal Depth Conditions	
Structues in Floodplain	10
Flooded Structures (based on FFE)	1
Inundated Roadway (miles)	1.9
Floodplain (acres)	56.0

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR ALTERNATIVE 1 PERFORMANCE METRICS
 (NORMAL DEPTH TAILWATER)

PREPARED: TMM
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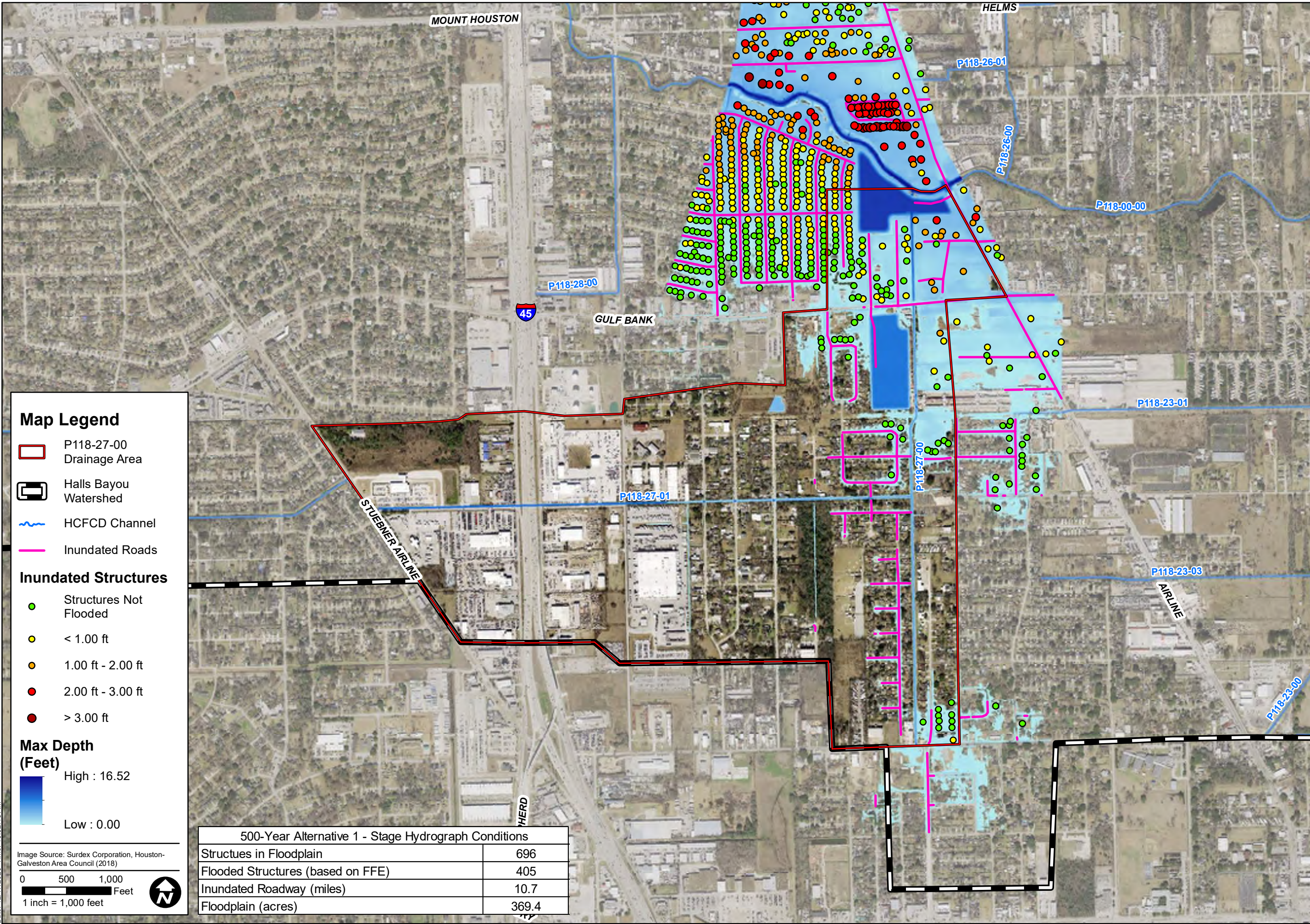


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DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCF Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

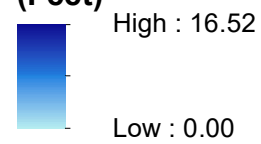
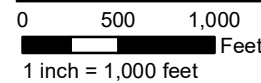


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



500-Year Alternative 1 - Stage Hydrograph Conditions	
Structures in Floodplain	696
Flooded Structures (based on FFE)	405
Inundated Roadway (miles)	10.7
Floodplain (acres)	369.4

HCFCF HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR ALTERNATIVE 1 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM

CHECKED: BJI

APPROVED: CEE

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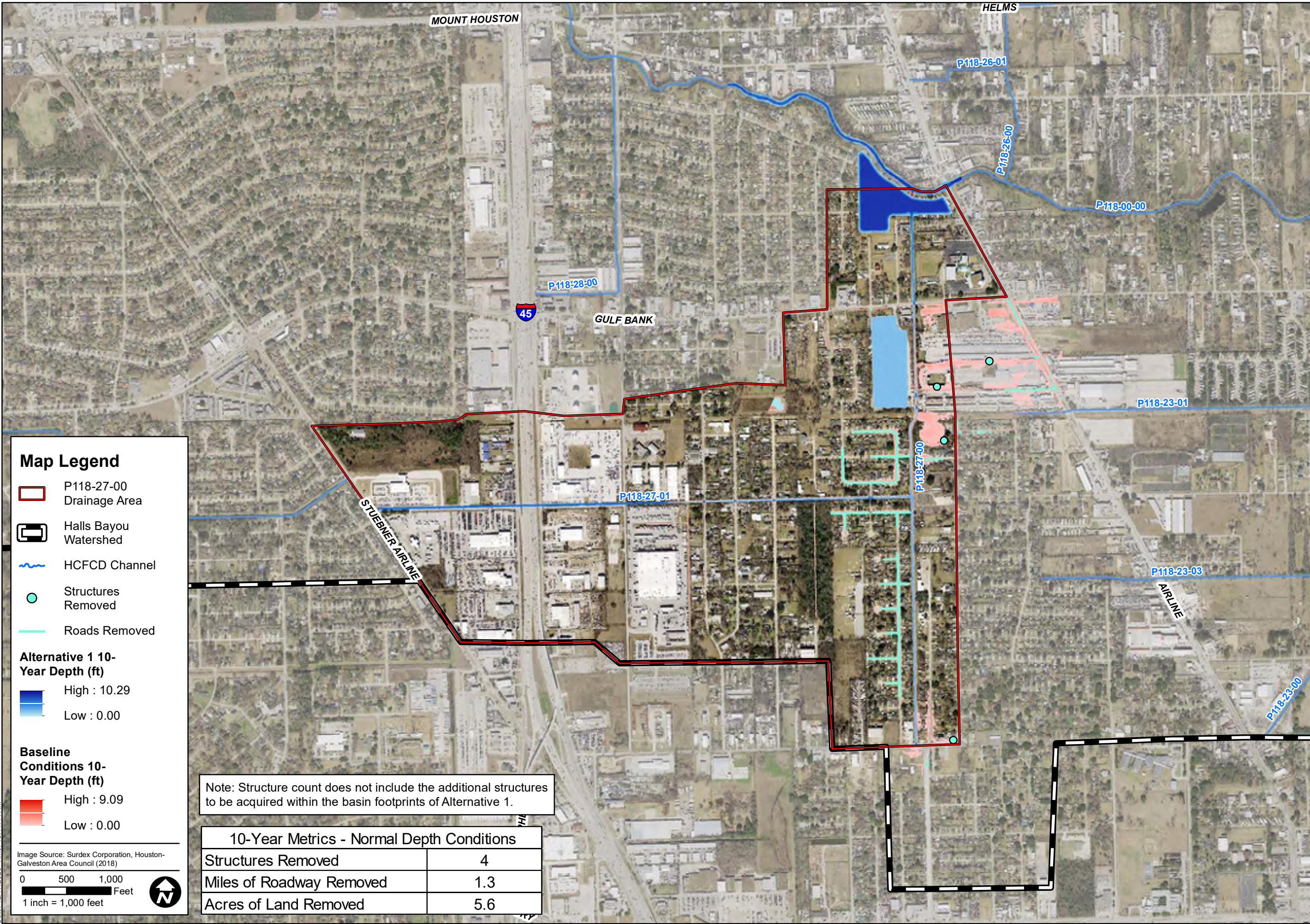


9900 Northwest Freeway
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DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

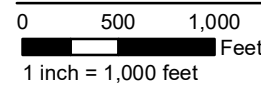
Alternative 1 10-Year Depth (ft)

- High : 10.29
- Low : 0.00

Baseline Conditions 10-Year Depth (ft)

- High : 9.09
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 1.

10-Year Metrics - Normal Depth Conditions	
Structures Removed	4
Miles of Roadway Removed	1.3
Acres of Land Removed	5.6

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR ALTERNATIVE 1 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

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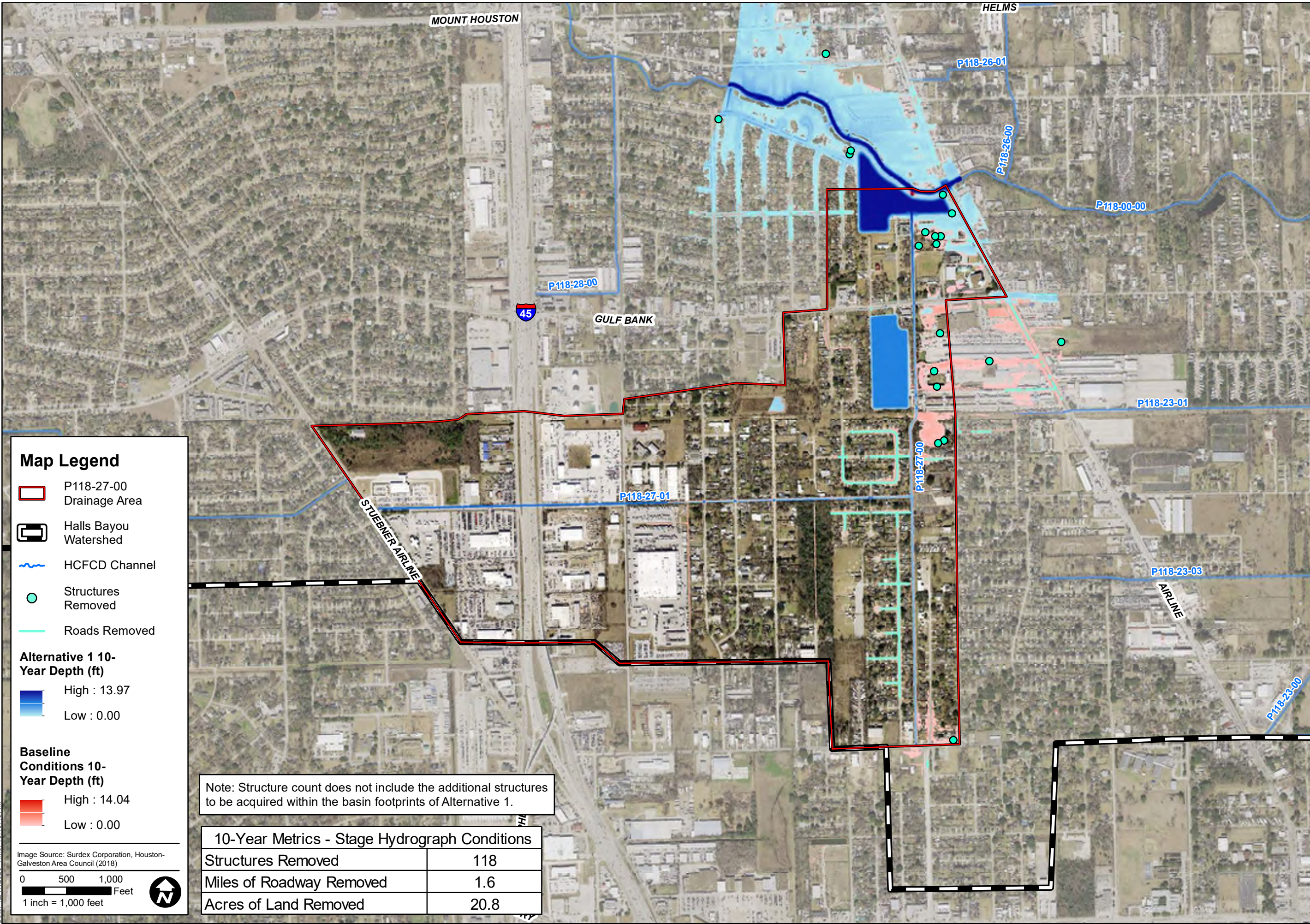


9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFC D Channel
- Structures Removed
- Roads Removed

Alternative 1 10-Year Depth (ft)

- High : 13.97
- Low : 0.00

Baseline Conditions 10-Year Depth (ft)

- High : 14.04
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 1.

10-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	118
Miles of Roadway Removed	1.6
Acres of Land Removed	20.8

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR ALTERNATIVE 1 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

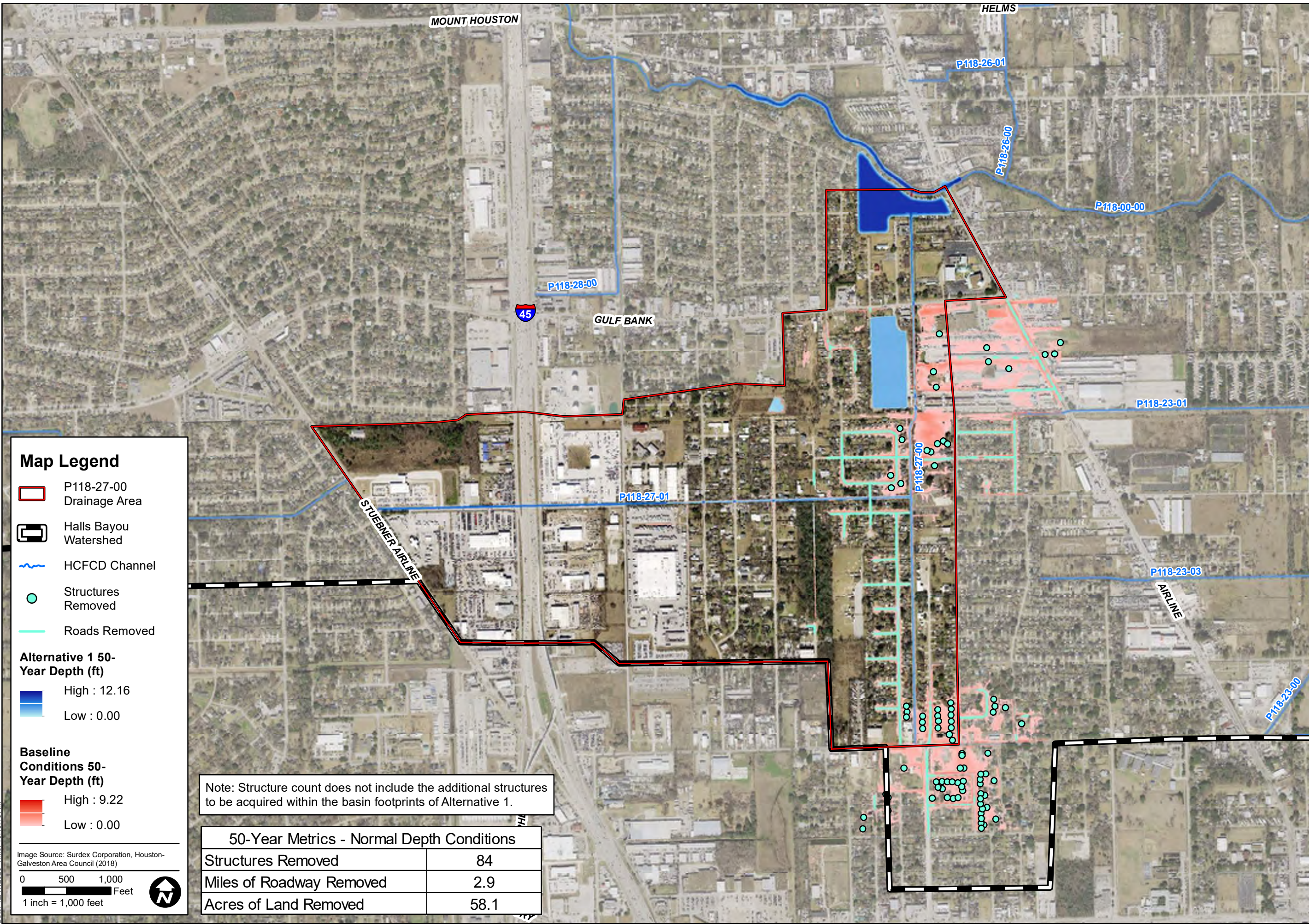
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HARRIS COUNTY FLOOD CONTROL DISTRICT
 9900 Northwest Freeway
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DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFC Channel
- Structures Removed
- Roads Removed

Alternative 1 50-Year Depth (ft)
 High : 12.16
 Low : 0.00

Baseline Conditions 50-Year Depth (ft)
 High : 9.22
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 1.

50-Year Metrics - Normal Depth Conditions	
Structures Removed	84
Miles of Roadway Removed	2.9
Acres of Land Removed	58.1

HCFC HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR ALTERNATIVE 1 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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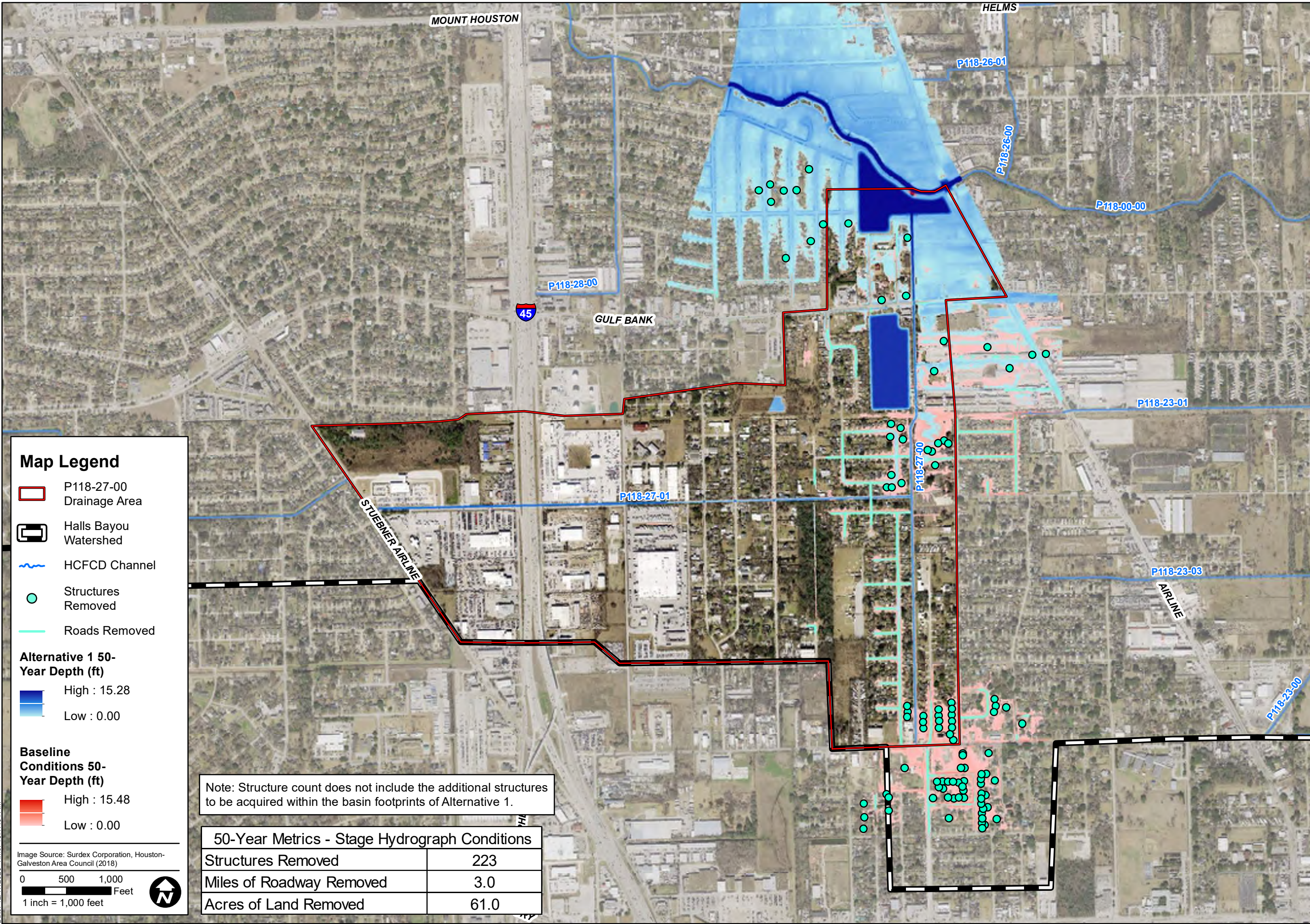


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DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT

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 Date: 12/17/2020 Time: 10:47:01 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

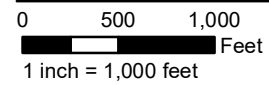
Alternative 1 50-Year Depth (ft)

- High : 15.28
- Low : 0.00

Baseline Conditions 50-Year Depth (ft)

- High : 15.48
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 1.

50-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	223
Miles of Roadway Removed	3.0
Acres of Land Removed	61.0

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR ALTERNATIVE 1 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

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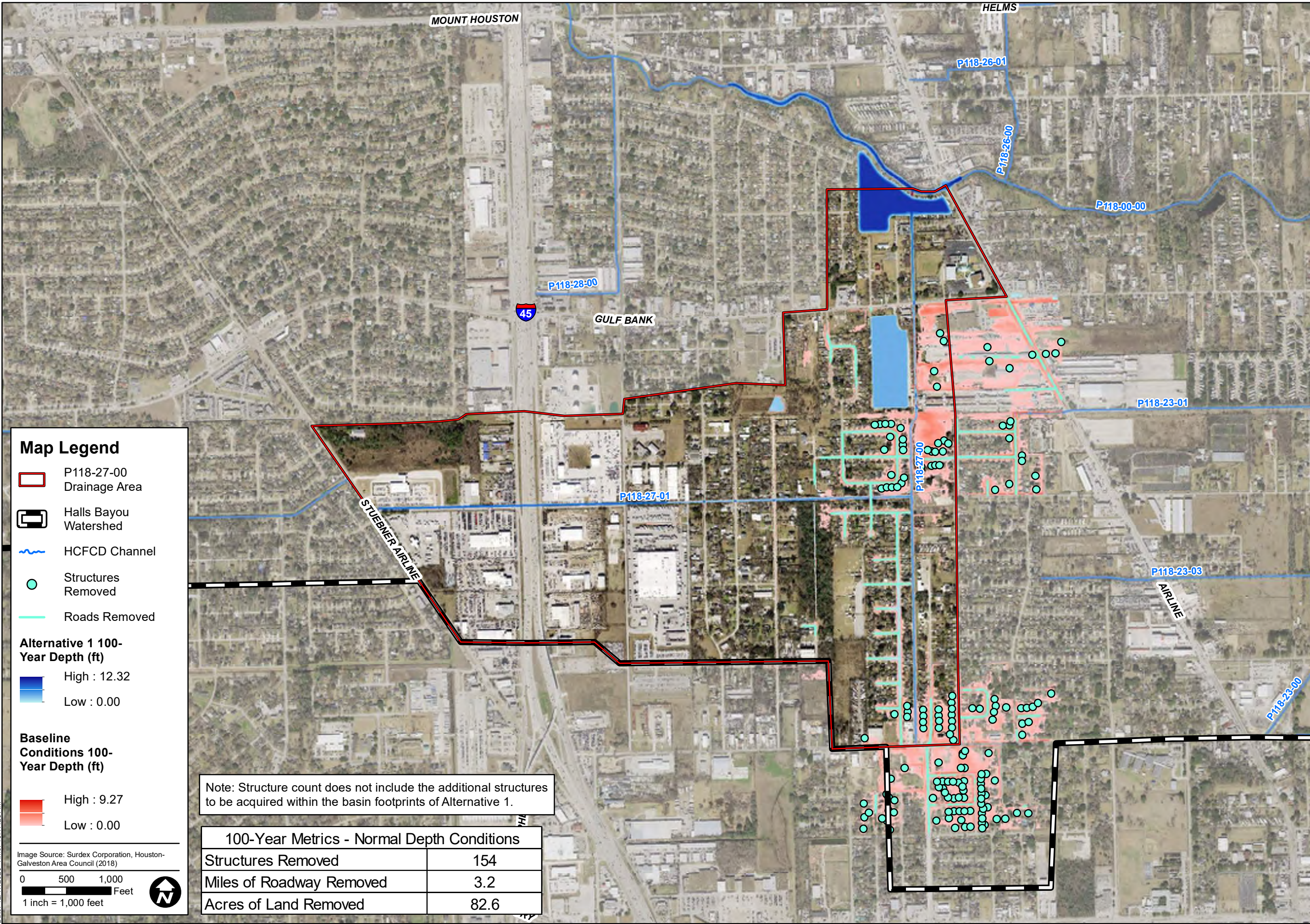


9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT

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 Date: 12/17/2020 Time: 10:47:28 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

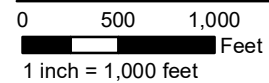
Alternative 1 100-Year Depth (ft)

- High : 12.32
- Low : 0.00

Baseline Conditions 100-Year Depth (ft)

- High : 9.27
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 1.

100-Year Metrics - Normal Depth Conditions	
Structures Removed	154
Miles of Roadway Removed	3.2
Acres of Land Removed	82.6

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR ALTERNATIVE 1 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

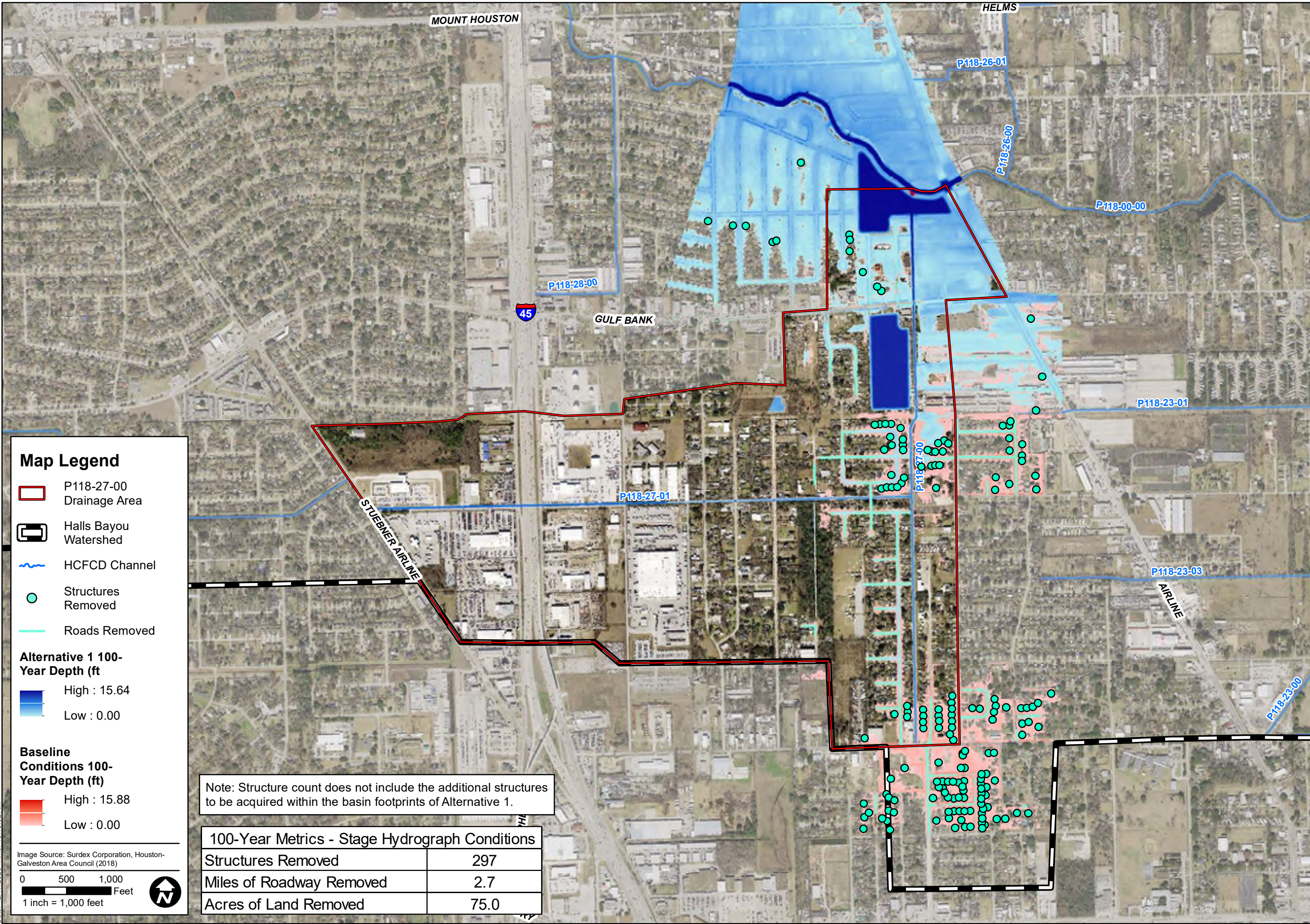
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HARRIS COUNTY FLOOD CONTROL DISTRICT
 9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT

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 Date: 12/17/2020 Time: 10:48:02 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

Alternative 1 100-Year Depth (ft)
 High : 15.64
 Low : 0.00

Baseline Conditions 100-Year Depth (ft)
 High : 15.88
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 1.

100-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	297
Miles of Roadway Removed	2.7
Acres of Land Removed	75.0

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR ALTERNATIVE 1 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

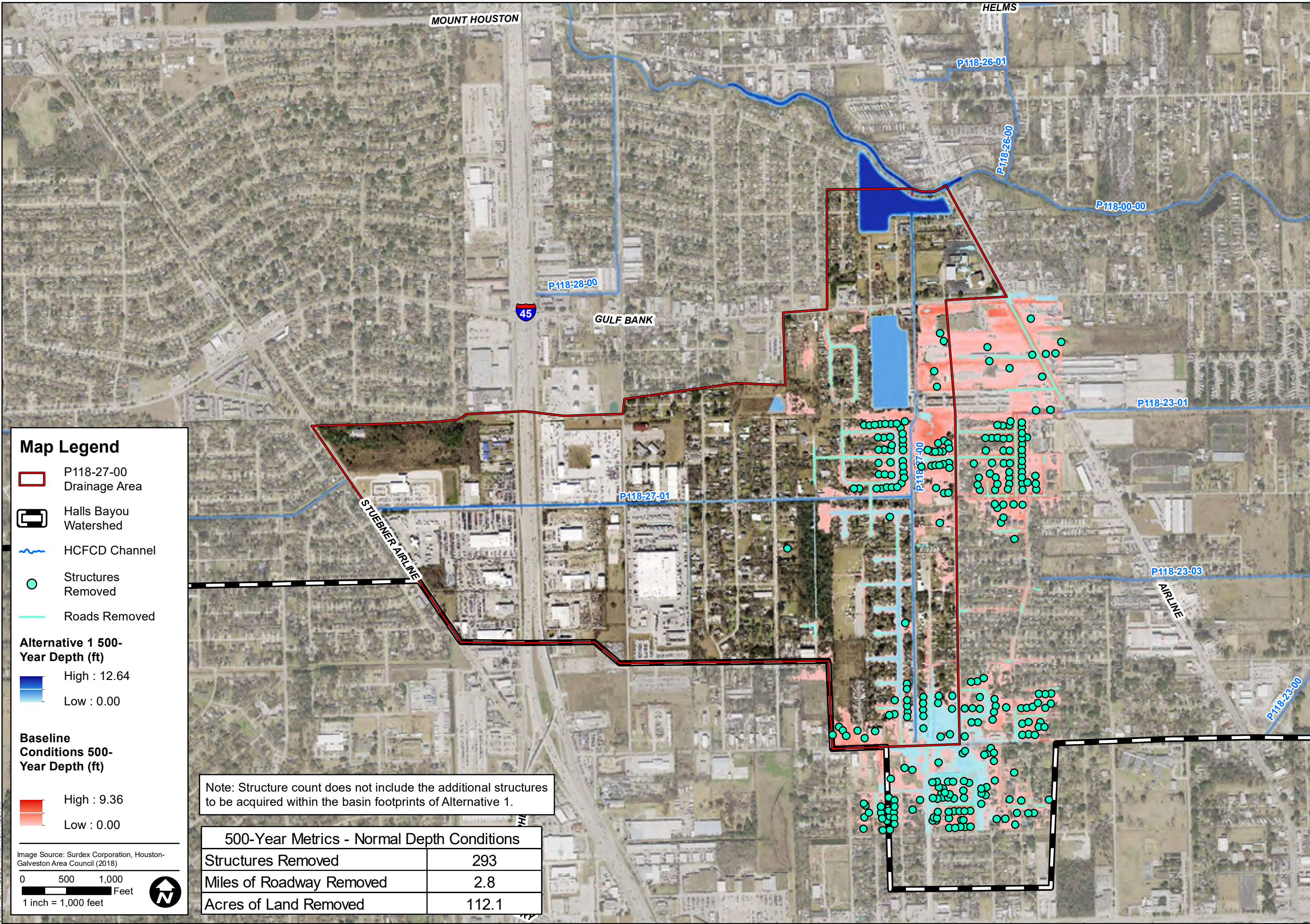
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DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT

N:\120\120-12170-1119-0-Data-GIS-Modeling\9-01-GIS2-ArcMapProjects\Working\Exhibits\Alt 1 Alt 3 Appendices\Alt1_MetricsComparison_50yrND.mxd
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

Alternative 1 500-Year Depth (ft)
 High : 12.64
 Low : 0.00

Baseline Conditions 500-Year Depth (ft)
 High : 9.36
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 1.

500-Year Metrics - Normal Depth Conditions	
Structures Removed	293
Miles of Roadway Removed	2.8
Acres of Land Removed	112.1

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR ALTERNATIVE 1 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

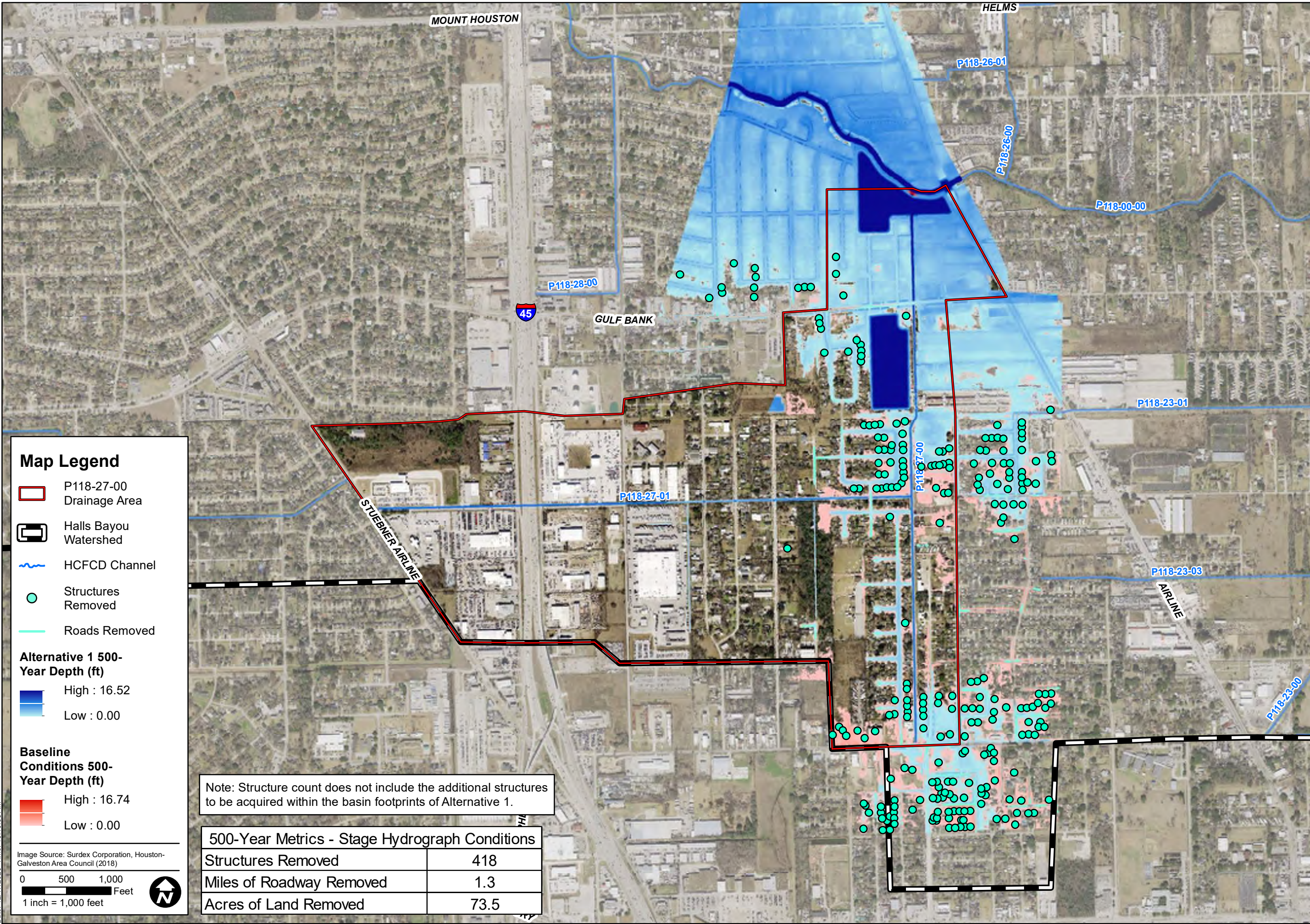
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DATE: OCT 2020
 SCALE: AS NOTED

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 Date: 12/17/2020 Time: 10:46:38 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

Alternative 1 500-Year Depth (ft)
 High : 16.52
 Low : 0.00

Baseline Conditions 500-Year Depth (ft)
 High : 16.74
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 1.

500-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	418
Miles of Roadway Removed	1.3
Acres of Land Removed	73.5

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR ALTERNATIVE 1 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

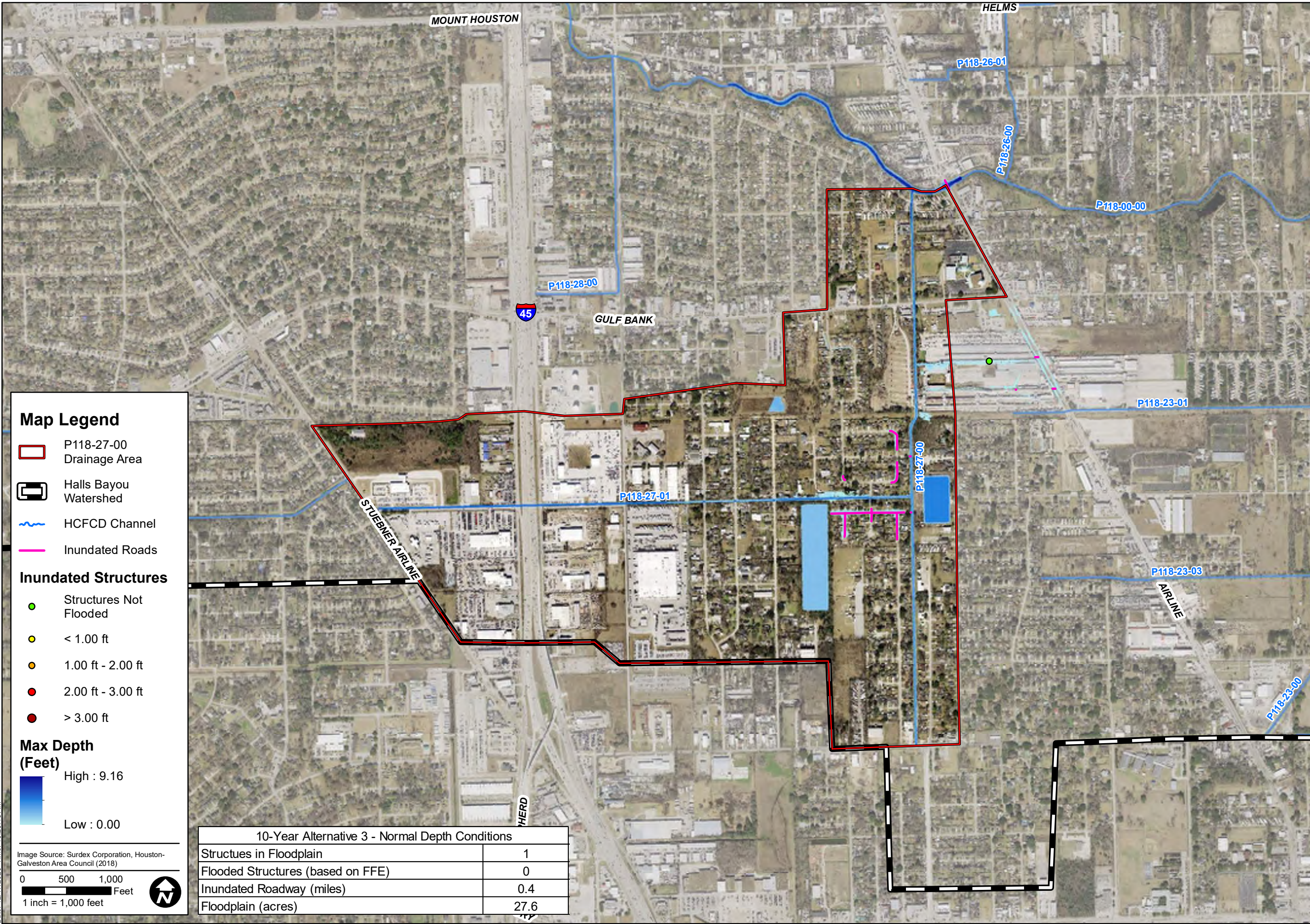
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

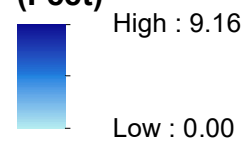
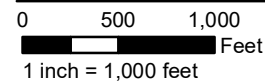


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



10-Year Alternative 3 - Normal Depth Conditions	
Structues in Floodplain	1
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	0.4
Floodplain (acres)	27.6

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR ALTERNATIVE 3 PERFORMANCE METRICS
 (NORMAL DEPTH TAILWATER)

PREPARED: TMM

CHECKED: BJU

APPROVED: CEE

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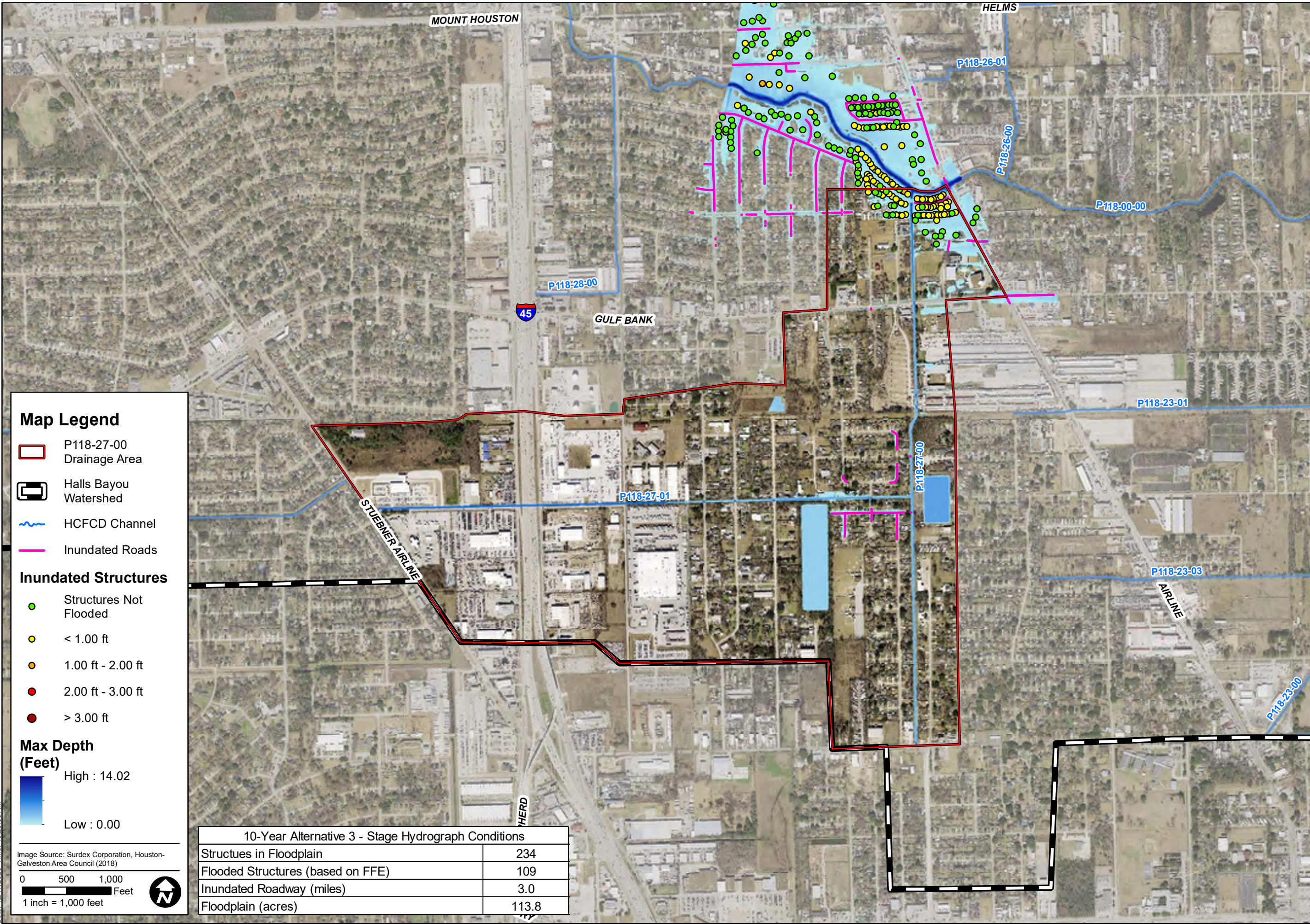


9900 Northwest Freeway
 Houston, Texas 77092





DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

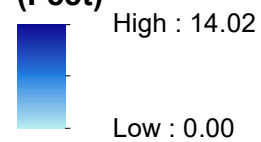
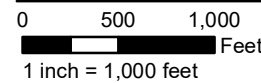


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



10-Year Alternative 3 - Stage Hydrograph Conditions	
Structues in Floodplain	234
Flooded Structures (based on FFE)	109
Inundated Roadway (miles)	3.0
Floodplain (acres)	113.8

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR ALTERNATIVE 3 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE



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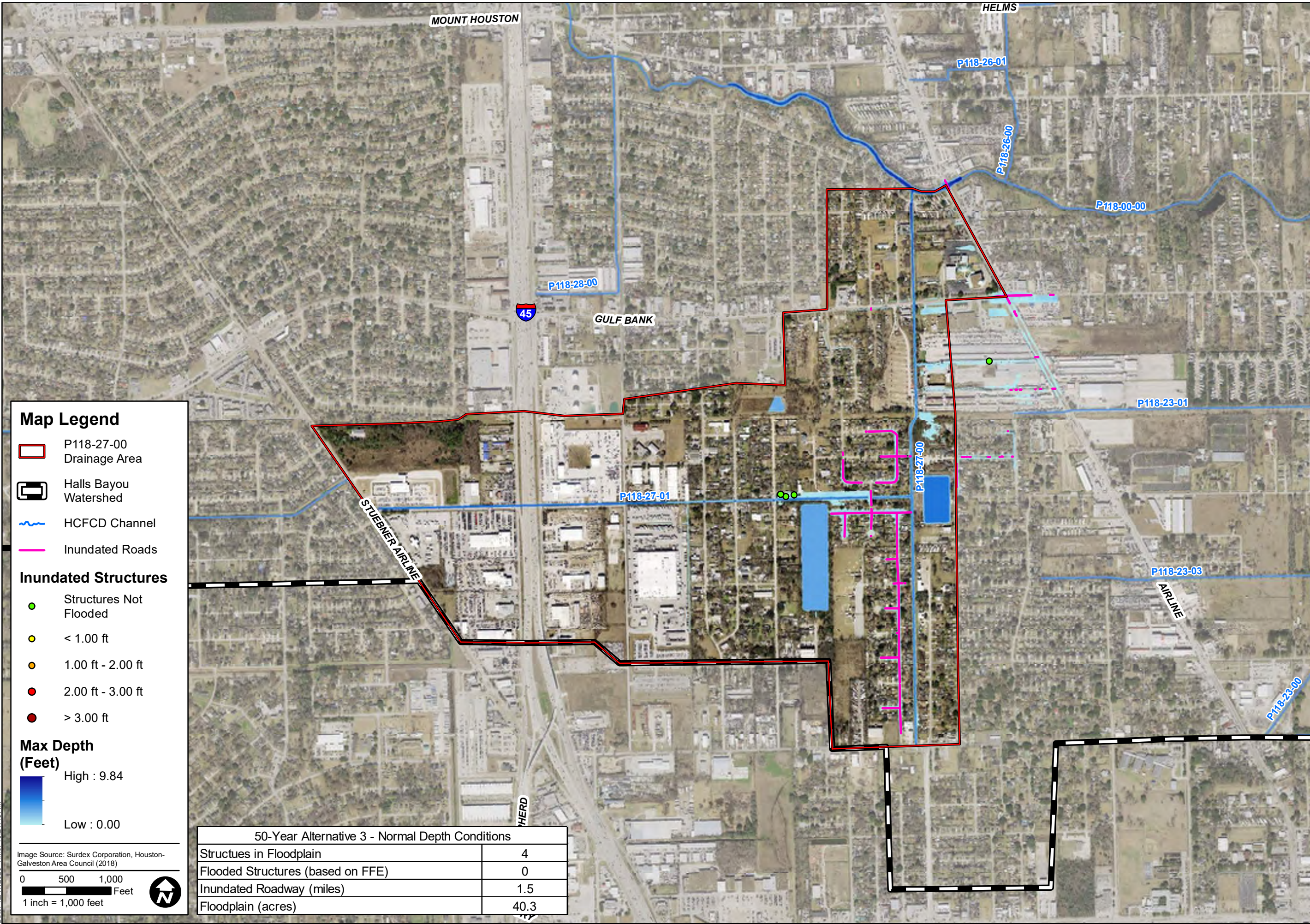


HARRIS COUNTY
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 9900 Northwest Freeway
 Houston, Texas 77092





DATE: OCT 2020
 SCALE: AS NOTED

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N:\120\120-12170-1119-0-Data-GIS-Modeling\9-01-GIS2-ArcMapProjects\Working\Exhibits\Alt 1 Alt 3 Appendices\Alt3_50yr.mxd
 Date: 12/17/2020 Time: 10:24:46 AM



Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

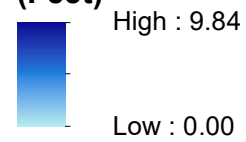
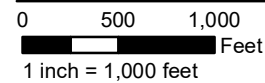


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



50-Year Alternative 3 - Normal Depth Conditions	
Structures in Floodplain	4
Flooded Structures (based on FFE)	0
Inundated Roadway (miles)	1.5
Floodplain (acres)	40.3

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR ALTERNATIVE 3 PERFORMANCE METRICS
 (NORMAL DEPTH TAILWATER)

PREPARED: TMM

CHECKED: BJI

APPROVED: CEE

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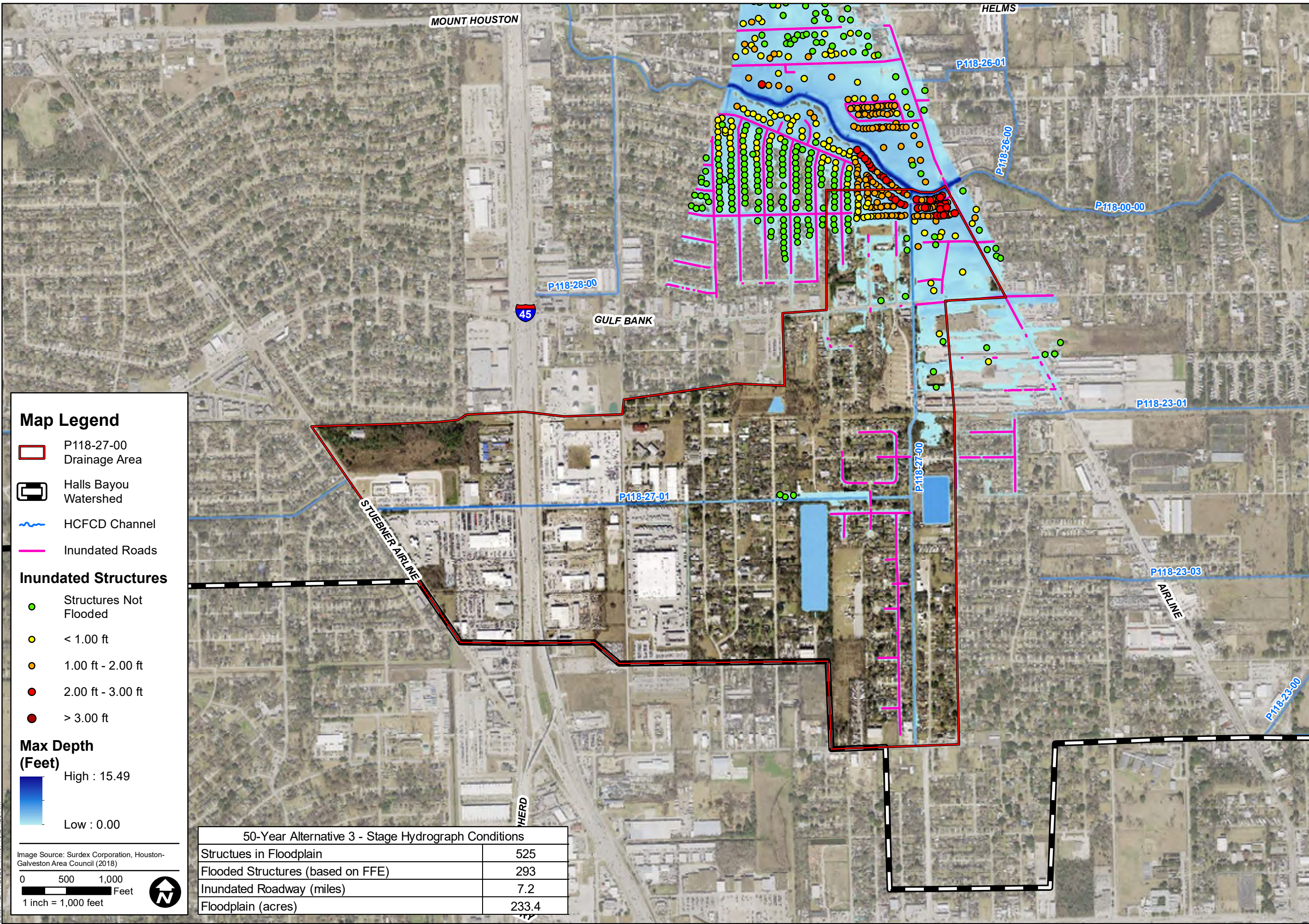


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DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFC D Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

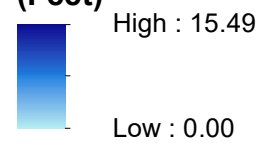
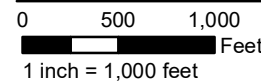


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



50-Year Alternative 3 - Stage Hydrograph Conditions	
Structues in Floodplain	525
Flooded Structures (based on FFE)	293
Inundated Roadway (miles)	7.2
Floodplain (acres)	233.4

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR ALTERNATIVE 3 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

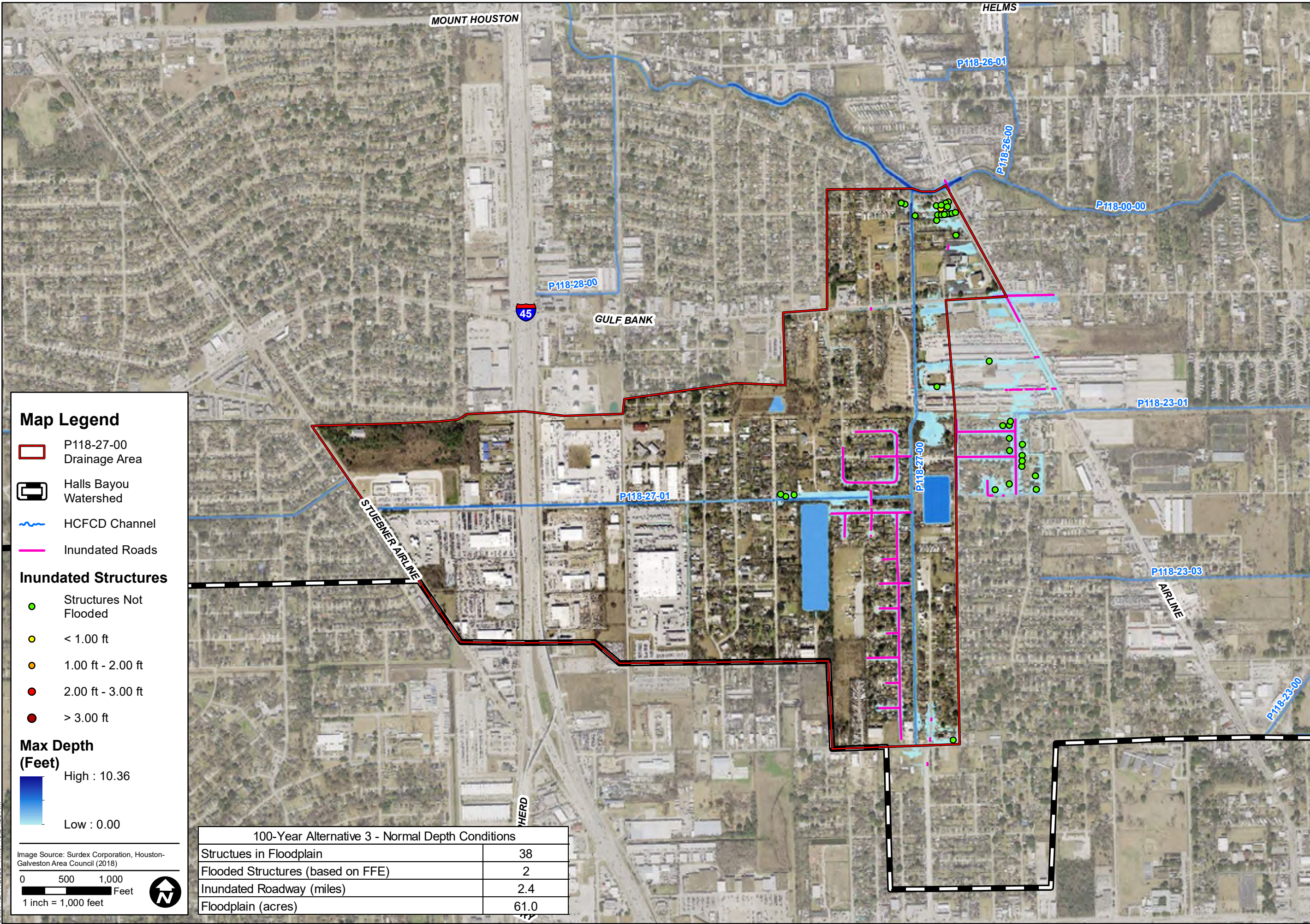
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HARRIS COUNTY FLOOD CONTROL DISTRICT
 9900 Northwest Freeway
 Houston, Texas 77092

DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFC D Channel
- Inundated Roads

Inundated Structures

- Structures Not Flooded
- < 1.00 ft
- 1.00 ft - 2.00 ft
- 2.00 ft - 3.00 ft
- > 3.00 ft

Max Depth (Feet)

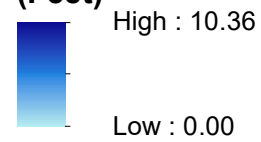
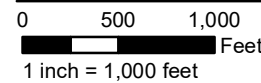


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



100-Year Alternative 3 - Normal Depth Conditions	
Structues in Floodplain	38
Flooded Structures (based on FFE)	2
Inundated Roadway (miles)	2.4
Floodplain (acres)	61.0

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR ALTERNATIVE 3 PERFORMANCE METRICS
 (NORMAL DEPTH TAILWATER)

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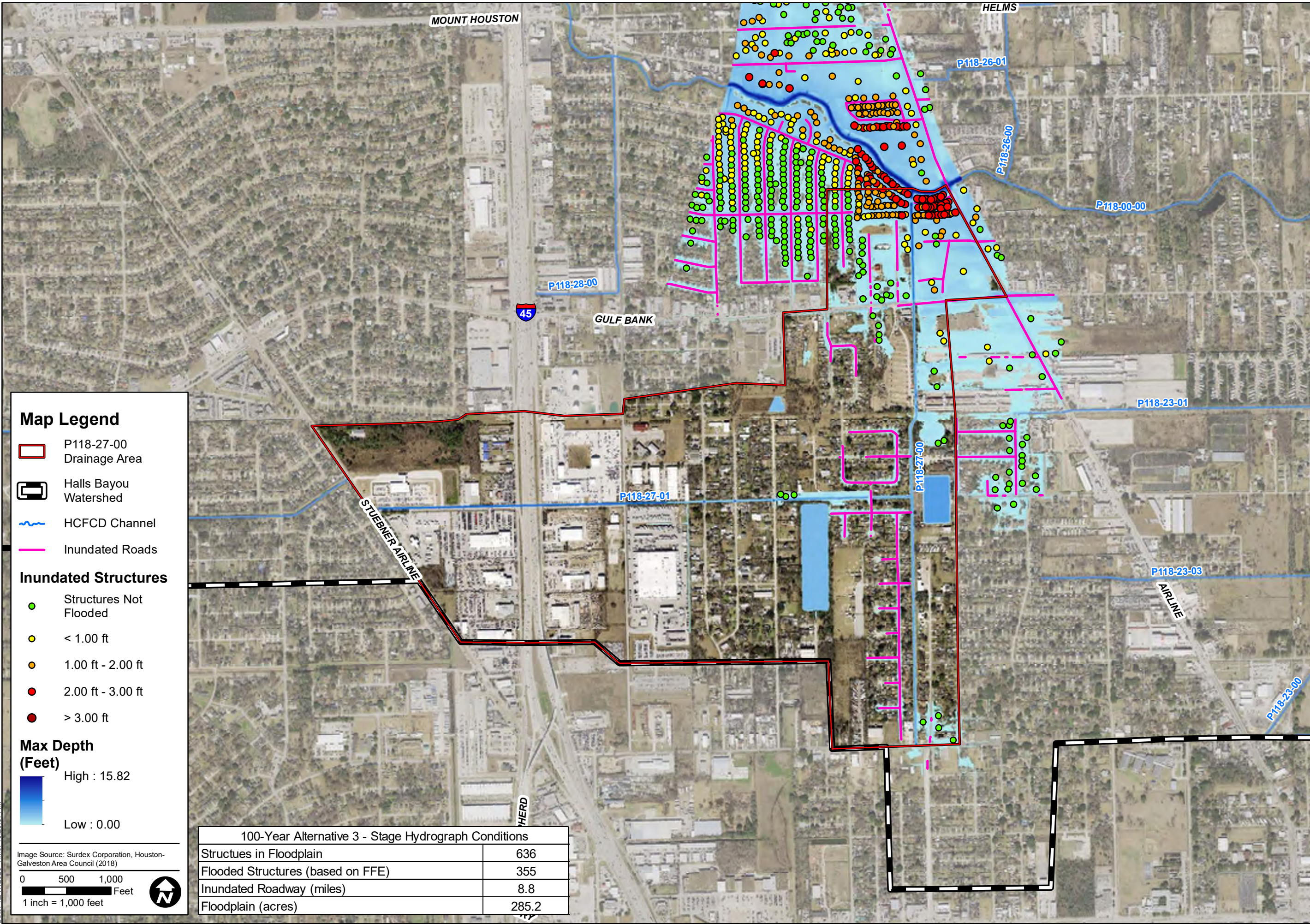


9900 Northwest Freeway
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DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

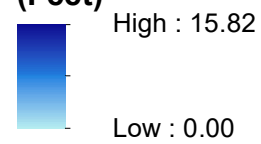
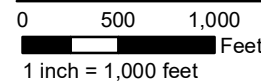


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



100-Year Alternative 3 - Stage Hydrograph Conditions	
Structures in Floodplain	636
Flooded Structures (based on FFE)	355
Inundated Roadway (miles)	8.8
Floodplain (acres)	285.2

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR ALTERNATIVE 3 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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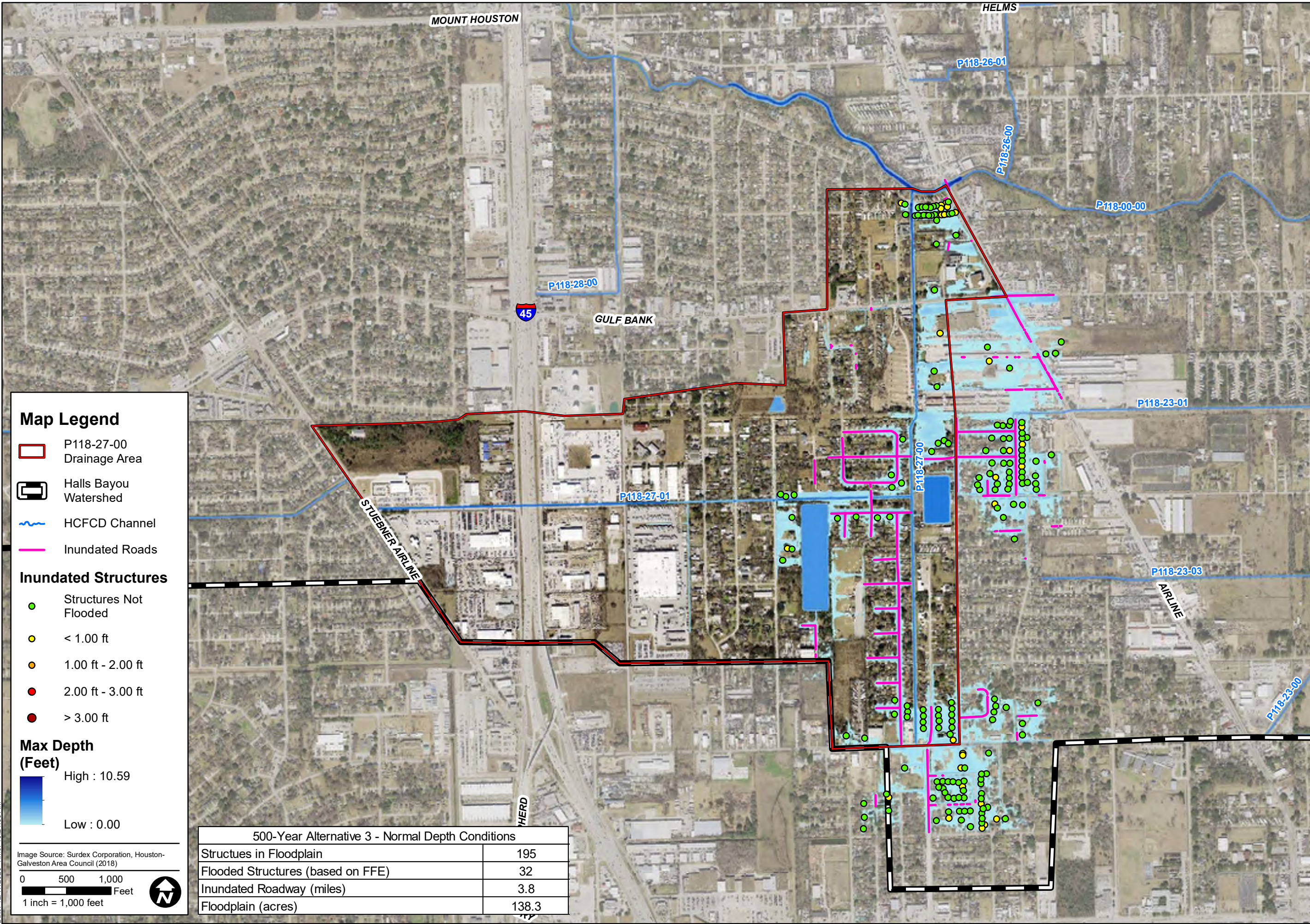


9900 Northwest Freeway
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DATE: OCT 2020
 SCALE: AS NOTED

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 Date: 12/17/2020 Time: 10:24:59 AM



Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

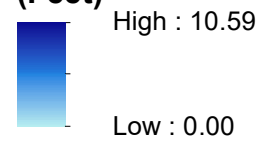
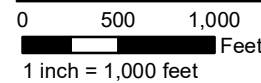


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



500-Year Alternative 3 - Normal Depth Conditions	
Structues in Floodplain	195
Flooded Structures (based on FFE)	32
Inundated Roadway (miles)	3.8
Floodplain (acres)	138.3

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR ALTERNATIVE 3 PERFORMANCE METRICS
 (NORMAL DEPTH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

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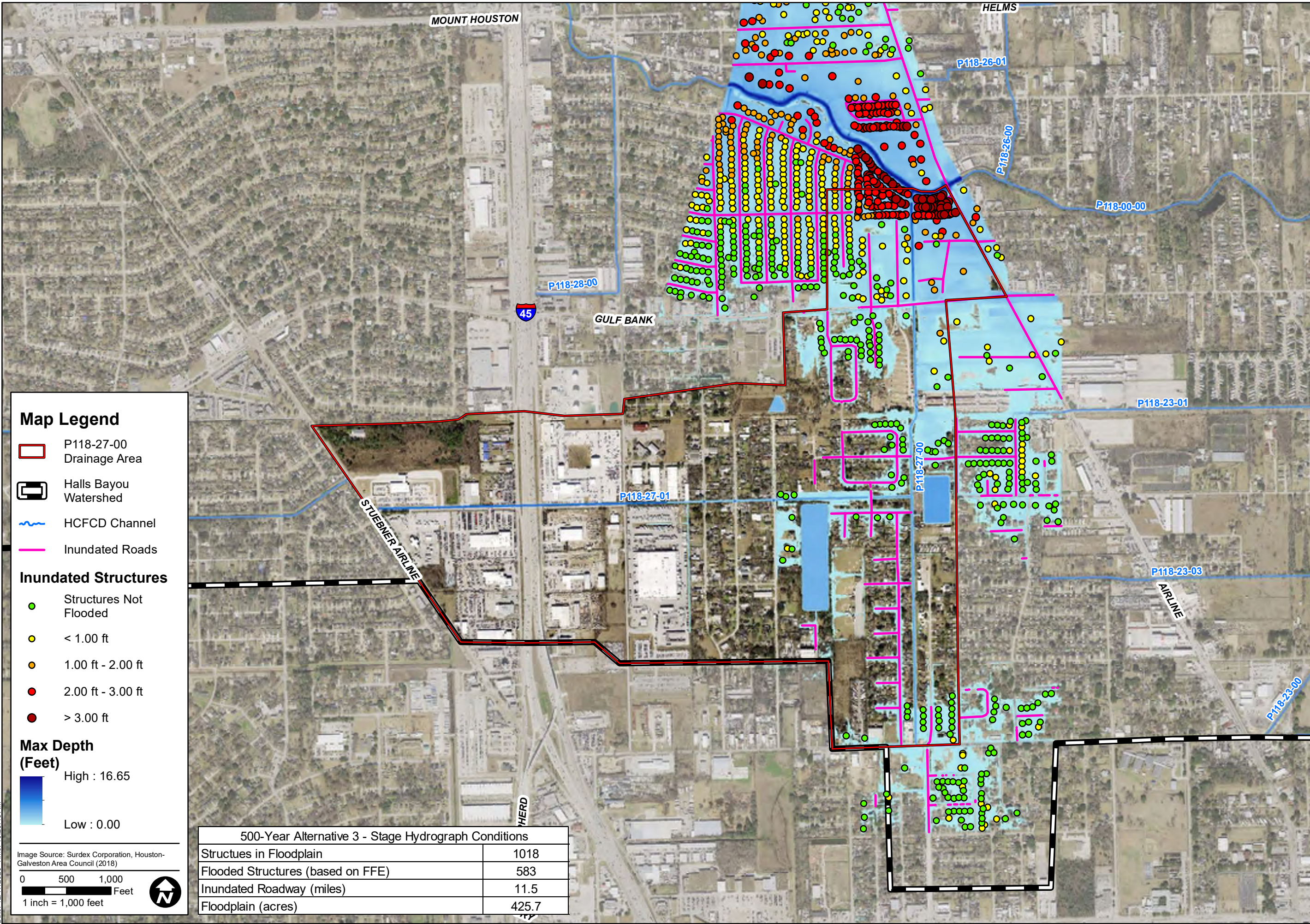


9900 Northwest Freeway
 Houston, Texas 77092





DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT






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 Date: 12/17/2020 Time: 10:25:46 AM



Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFC D Channel
-  Inundated Roads

Inundated Structures

-  Structures Not Flooded
-  < 1.00 ft
-  1.00 ft - 2.00 ft
-  2.00 ft - 3.00 ft
-  > 3.00 ft

Max Depth (Feet)

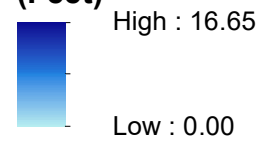
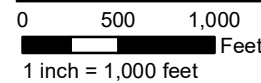


Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



500-Year Alternative 3 - Stage Hydrograph Conditions	
Structures in Floodplain	1018
Flooded Structures (based on FFE)	583
Inundated Roadway (miles)	11.5
Floodplain (acres)	425.7

HCFC D HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR ALTERNATIVE 3 PERFORMANCE METRICS
 (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJJ
 APPROVED: CEE

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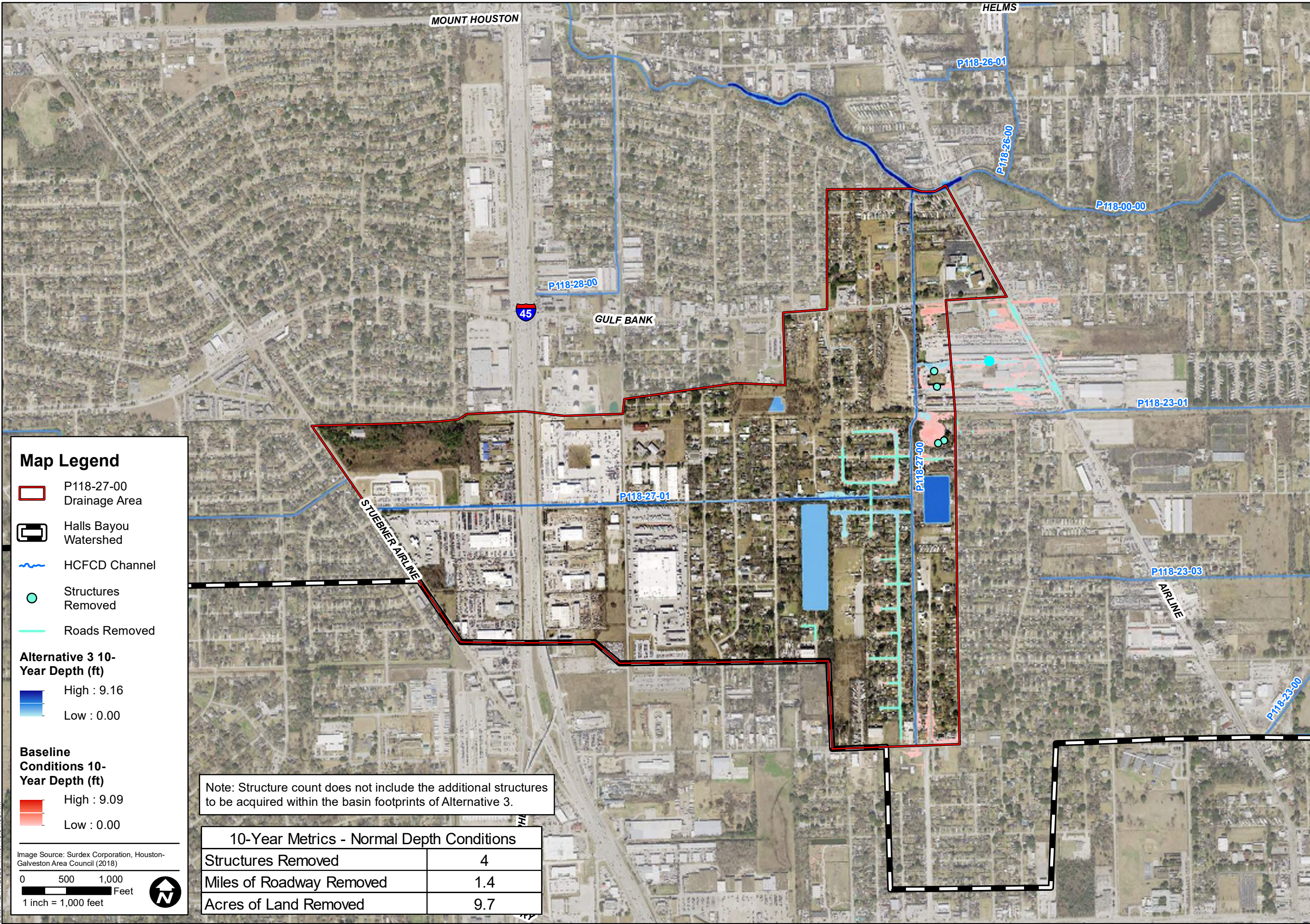


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DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT



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 Date: 12/17/2020 Time: 10:54:08 AM



Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Structures Removed
-  Roads Removed

Alternative 3 10-Year Depth (ft)

-  High : 9.16
-  Low : 0.00

Baseline Conditions 10-Year Depth (ft)



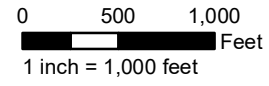
-  High : 9.09
-  Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 3.

10-Year Metrics - Normal Depth Conditions	
Structures Removed	4
Miles of Roadway Removed	1.4
Acres of Land Removed	9.7

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR ALTERNATIVE 3 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

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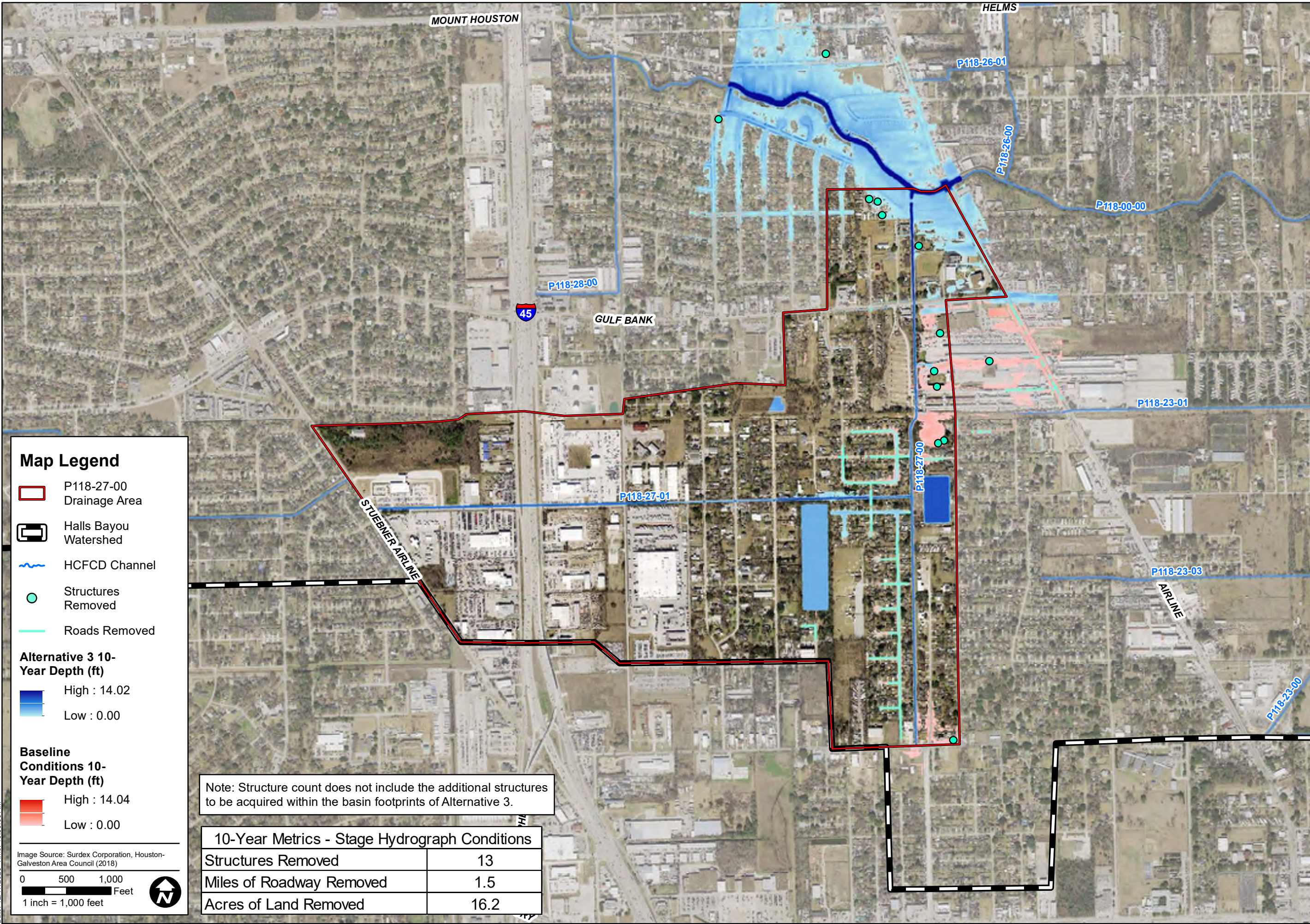
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DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

Alternative 3 10-Year Depth (ft)
 High : 14.02
 Low : 0.00

Baseline Conditions 10-Year Depth (ft)
 High : 14.04
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 3.

10-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	13
Miles of Roadway Removed	1.5
Acres of Land Removed	16.2

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 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 10-YEAR ALTERNATIVE 3 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

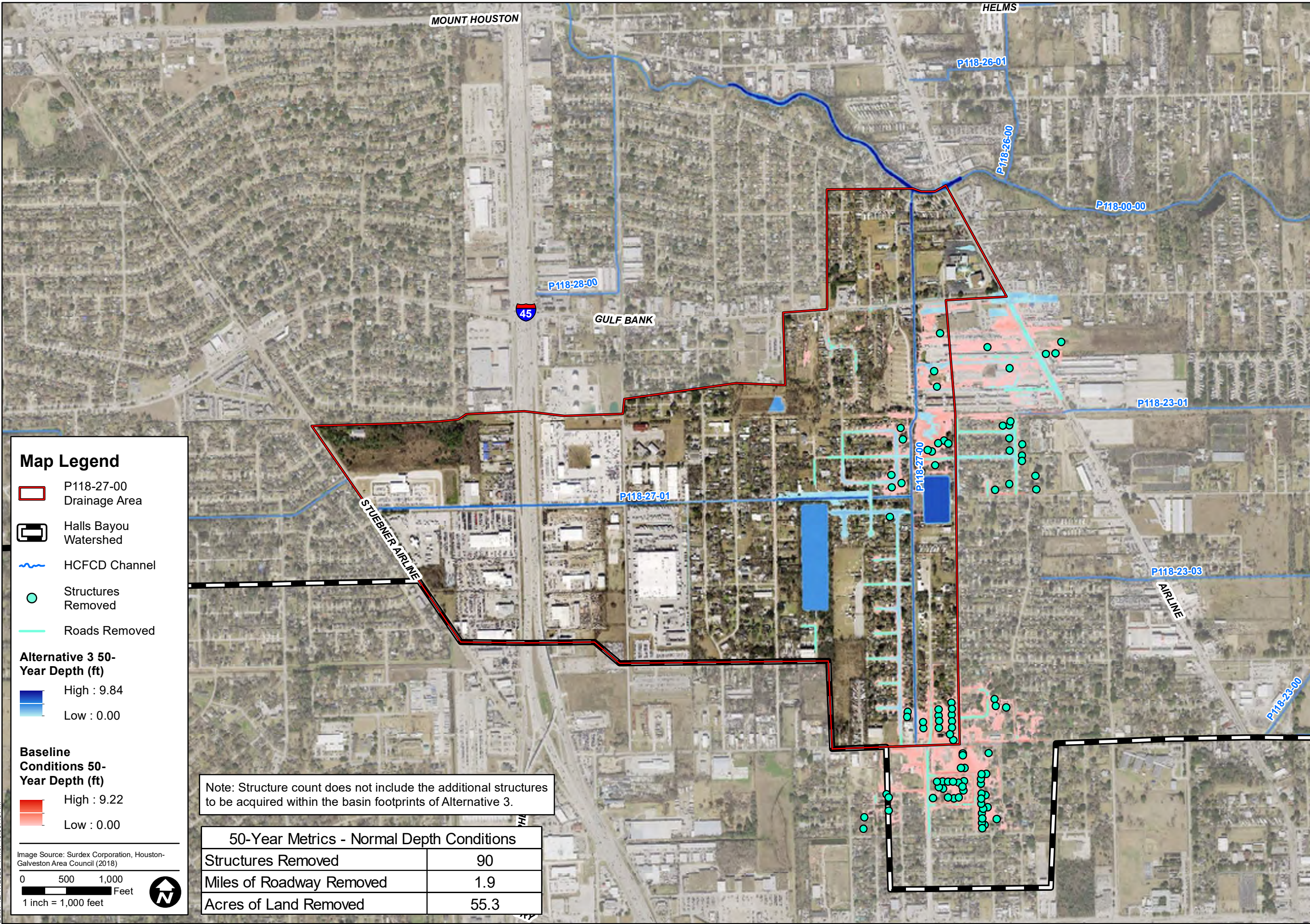
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DATE: OCT 2020
 SCALE: AS NOTED

EXHIBIT

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 Date: 12/17/2020 Time: 10:53:49 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

Alternative 3 50-Year Depth (ft)
 High : 9.84
 Low : 0.00

Baseline Conditions 50-Year Depth (ft)
 High : 9.22
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 3.

50-Year Metrics - Normal Depth Conditions	
Structures Removed	90
Miles of Roadway Removed	1.9
Acres of Land Removed	55.3

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR ALTERNATIVE 3 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

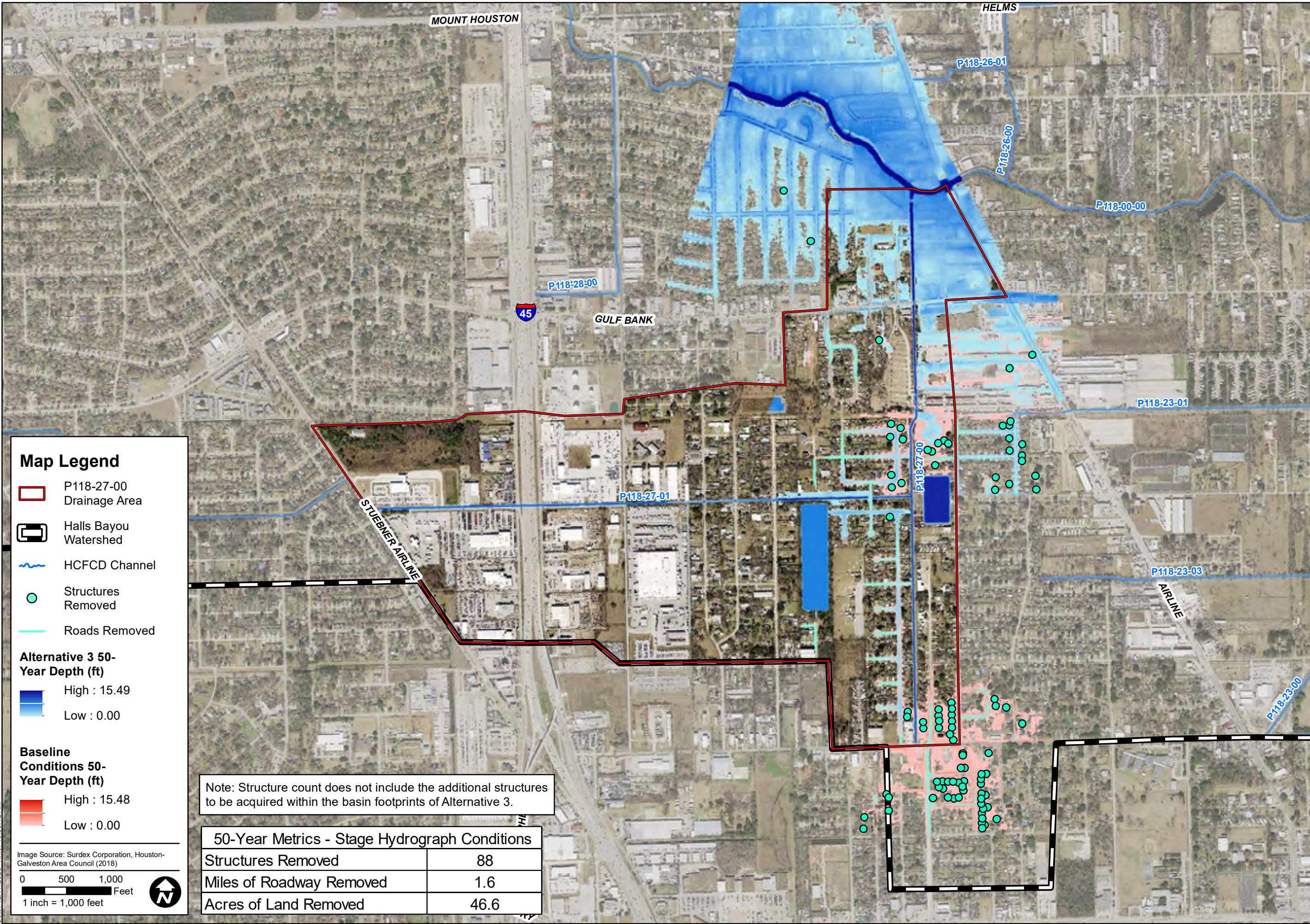
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DATE: OCT 2020
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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

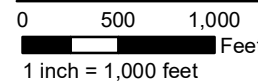
Alternative 3 50-Year Depth (ft)

- High : 15.49
- Low : 0.00

Baseline Conditions 50-Year Depth (ft)

- High : 15.48
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 3.

50-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	88
Miles of Roadway Removed	1.6
Acres of Land Removed	46.6

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 50-YEAR ALTERNATIVE 3 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJI
APPROVED:	CEE

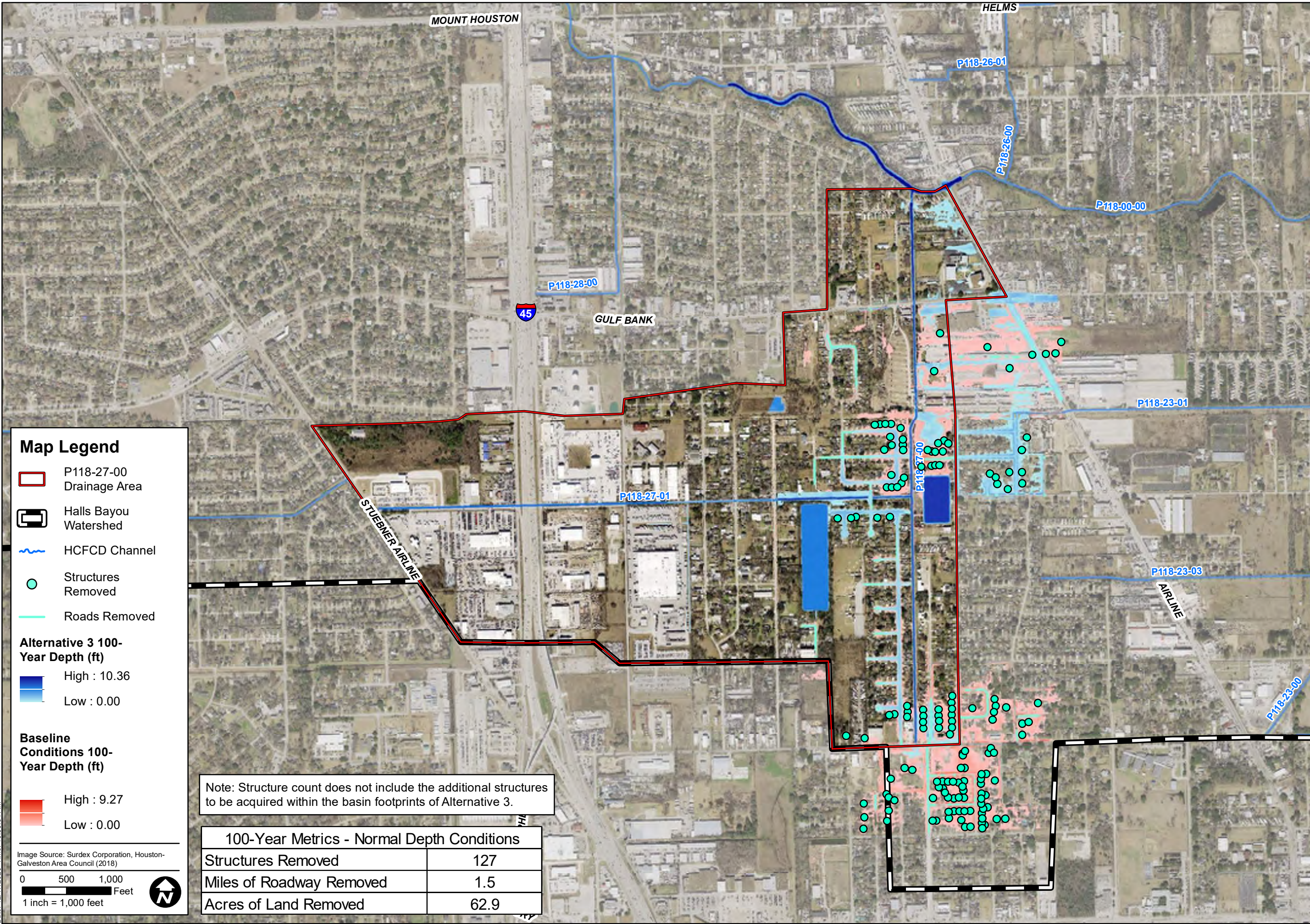
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 Date: 12/17/2020 Time: 10:55:31 AM



Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

Alternative 3 100-Year Depth (ft)
 High : 10.36
 Low : 0.00

Baseline Conditions 100-Year Depth (ft)
 High : 9.27
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet

Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 3.

100-Year Metrics - Normal Depth Conditions	
Structures Removed	127
Miles of Roadway Removed	1.5
Acres of Land Removed	62.9

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR ALTERNATIVE 3 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED: TMM
 CHECKED: BJI
 APPROVED: CEE

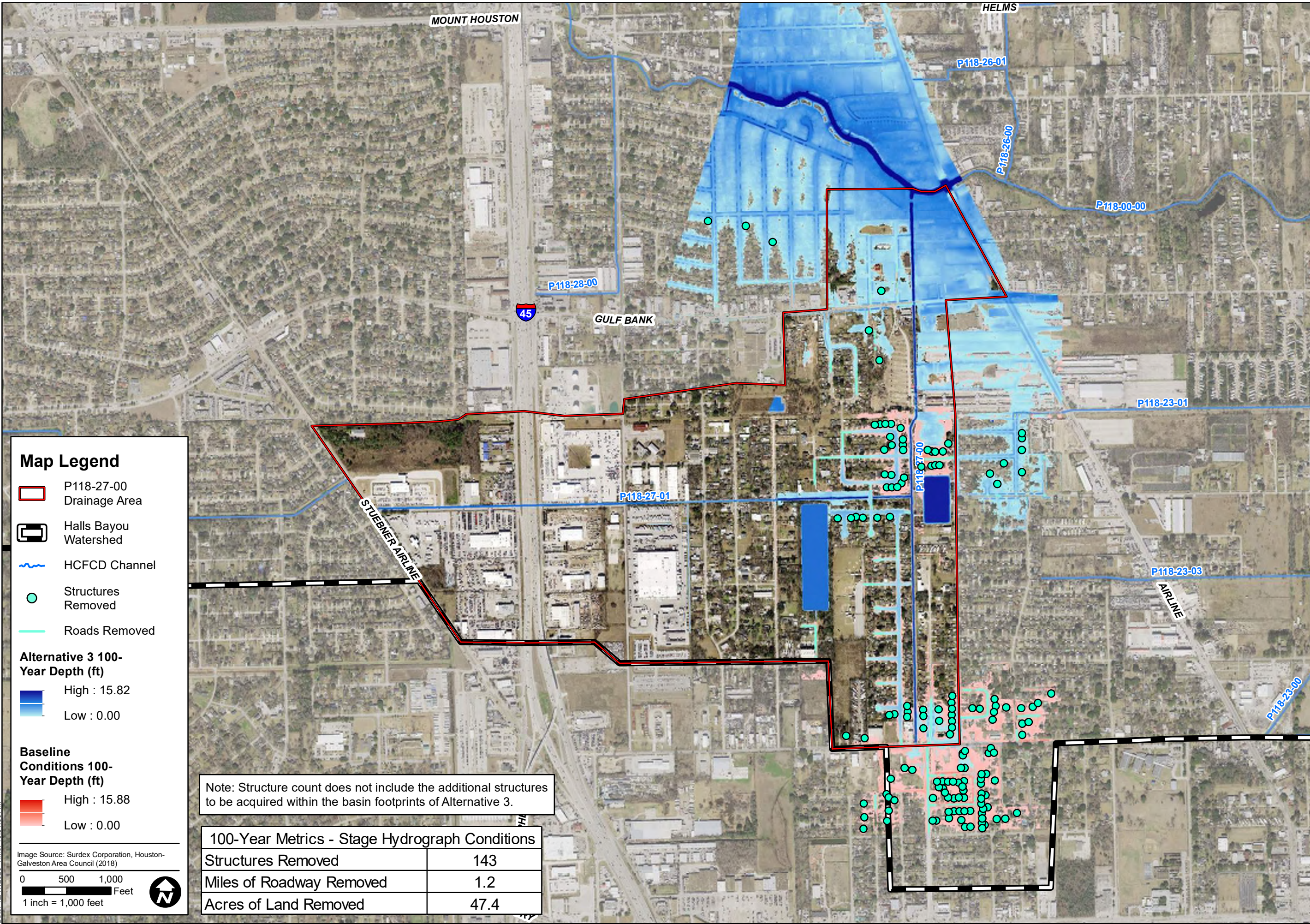
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DATE: OCT 2020
 SCALE: AS NOTED



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 Date: 12/17/2020 Time: 10:54:30 AM



Map Legend

-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Structures Removed
-  Roads Removed

Alternative 3 100-Year Depth (ft)
 High : 15.82
 Low : 0.00




Baseline Conditions 100-Year Depth (ft)
 High : 15.88
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 3.

100-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	143
Miles of Roadway Removed	1.2
Acres of Land Removed	47.4

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 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 100-YEAR ALTERNATIVE 3 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

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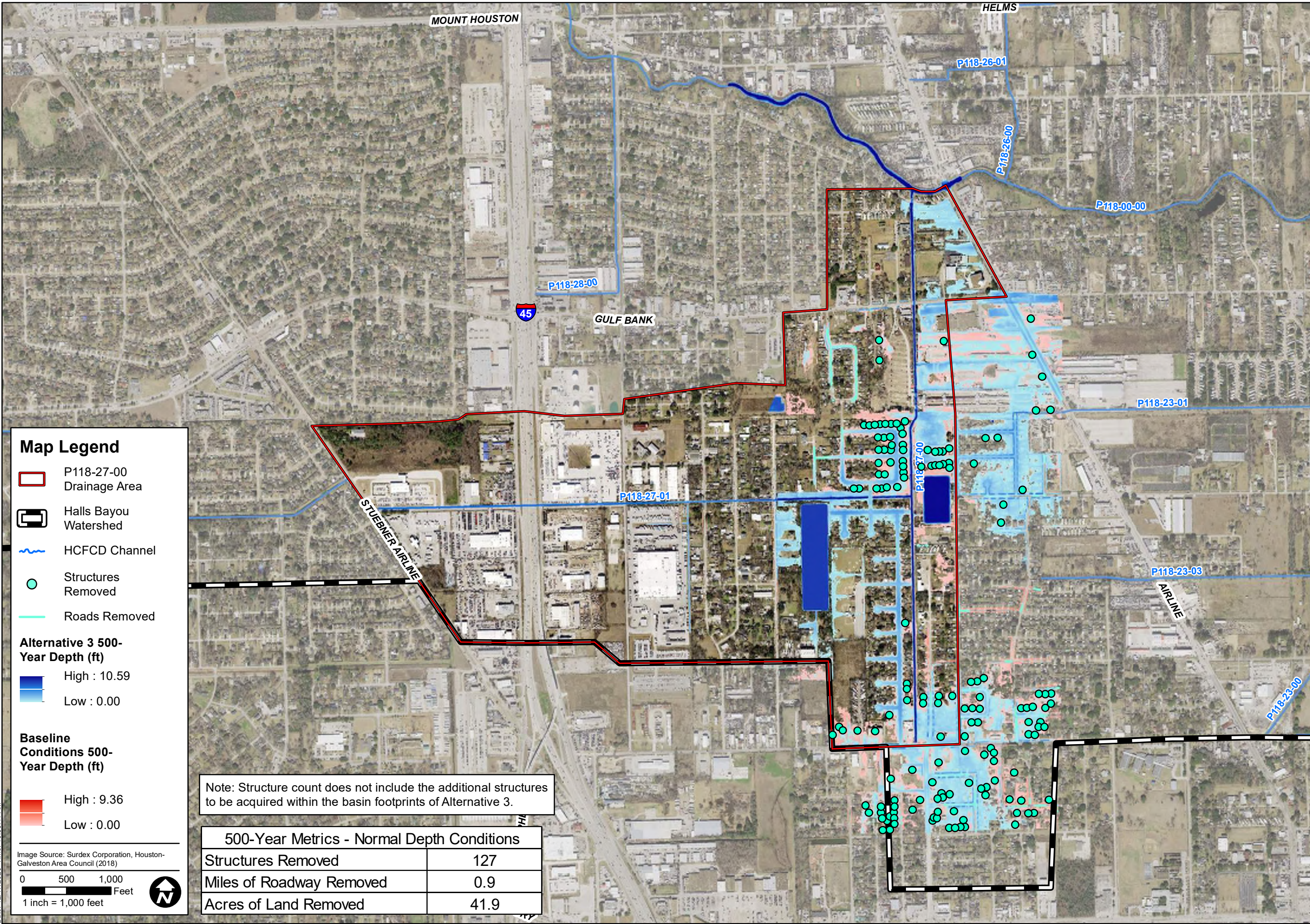
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DATE: OCT 2020
 SCALE: AS NOTED

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Map Legend

- P118-27-00 Drainage Area
- Halls Bayou Watershed
- HCFCD Channel
- Structures Removed
- Roads Removed

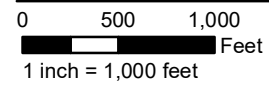
Alternative 3 500-Year Depth (ft)

- High : 10.59
- Low : 0.00

Baseline Conditions 500-Year Depth (ft)

- High : 9.36
- Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 3.

500-Year Metrics - Normal Depth Conditions	
Structures Removed	127
Miles of Roadway Removed	0.9
Acres of Land Removed	41.9

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR ALTERNATIVE 3 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (NORMAL DEPTH TAILWATER)

PREPARED:	TMM
CHECKED:	BJJ
APPROVED:	CEE

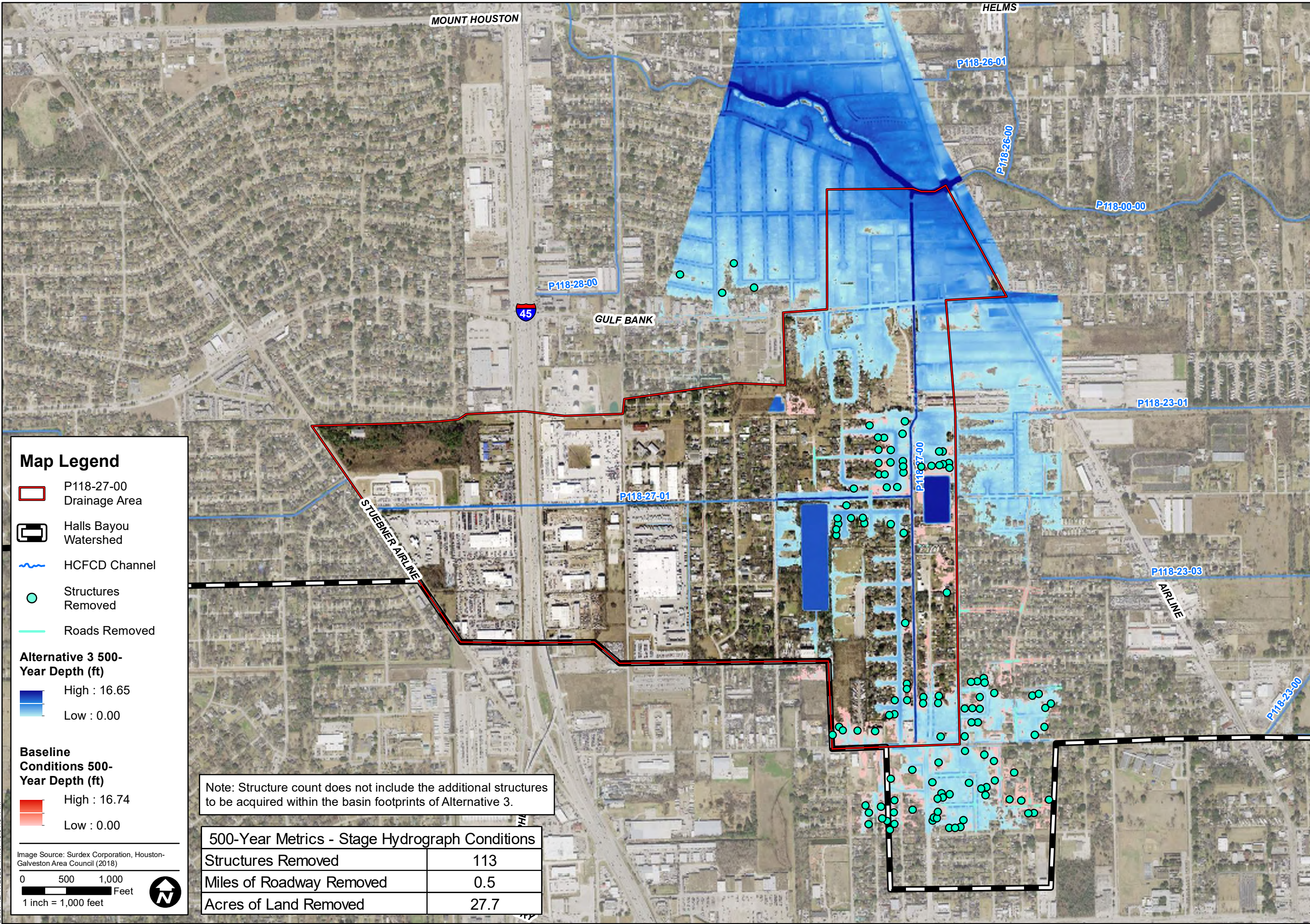
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 SCALE: AS NOTED

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 Date: 12/17/2020 Time: 10:54:51 AM



Map Legend


-  P118-27-00 Drainage Area
-  Halls Bayou Watershed
-  HCFCD Channel
-  Structures Removed
-  Roads Removed

Alternative 3 500-Year Depth (ft)
 High : 16.65
 Low : 0.00

Baseline Conditions 500-Year Depth (ft)
 High : 16.74
 Low : 0.00

Image Source: Surdex Corporation, Houston-Galveston Area Council (2018)

0 500 1,000 Feet
 1 inch = 1,000 feet



Note: Structure count does not include the additional structures to be acquired within the basin footprints of Alternative 3.

500-Year Metrics - Stage Hydrograph Conditions	
Structures Removed	113
Miles of Roadway Removed	0.5
Acres of Land Removed	27.7

HCFCD HALLS BAYOU WATERSHED
 P118-27-00 ALTERNATIVES ANALYSIS OF DRAINAGE IMPROVEMENTS
 500-YEAR ALTERNATIVE 3 VS.
 BASELINE CONDITIONS COMPARISON
 PERFORMANCE METRICS (STAGE HYDROGRAPH TAILWATER)

PREPARED: TMM
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Appendix N

Detailed Hydraulic Calculations