Texas Water Development Board

VOLUME 2

2023 REGIONAL FLOOD PLAN
REGION 6
SAN JACINTO

January 2023

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

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Appendix 5-4G:
Greens Bayou CDBG-MIT

CivilTech
A WOOLPERT COMPANY

STATE OF TEXAS
JESSICA LYNN SPRAGUE
128625
LICENSED
PROFESSIONAL ENGINEER
11/14/22

MEMORANDUM

TO: Imelda Diaz, P.E.

CC: Barry Vanderwalt, P.E.

FROM: Mike McGovern, P.E.; Jessica Sprague, P.E.

DATE: November 14, 2022

RE: P100-00-00-E012 HEC-RAS Model Impact Results

CivilTech Engineering, Inc. has completed hydraulic modeling for the Greens Bayou Mid-Reach Preliminary Engineering Report (PER). As part of this modeling effort, a Without Project (WOP) model was developed to evaluate existing conditions and six (6) proposed alternatives. A detailed drainage report was developed as part of the project, titled *Greens Bayou Mid-Reach Channel Conveyance Improvements Drainage Study,* dated December 2021.

An evaluation was done to determine modeling impacts, defined as increases in water surface elevation under proposed conditions, for the WOP condition versus Proposed Alternative 3. The following outlines the location and magnitude of increases in water surface elevations within the current version of the HEC-RAS model for the 1% AEP (100-year) storm event.

Table 1 – Comparison of Water Surface Elevations for the 1% AEP Storm Event

River	Reach	River Station	WOP WSE (ft)	Prop Alt 3 WSE (ft)	Diff (ft)
P100-00-00	Greens Bayou	228843	126.30	126.32	0.02
P100-00-00	Greens Bayou	228719	124.63	124.64	0.01
P100-00-00	Greens Bayou	227095	124.56	124.57	0.01
P100-00-00	Greens Bayou	225535	123.65	123.66	0.01
P100-00-00	Greens Bayou	221345	122.47	122.48	0.01
P138-00-00	Tributary 24.97	143843	71.89	71.90	0.01
P138-00-00	Tributary 24.97	143652	71.78	71.79	0.01
P138-00-00	Tributary 24.97	142587	70.67	70.68	0.01
P138-00-00	Tributary 24.97	142511	70.56	70.57	0.01
P140-00-00	Hoods Bayou	146730	75.44	75.45	0.01
P145-00-00	North Fork Bayou	193493	105.42	105.43	0.01

These impacts are based on modeling anomalies and do not reflect true adverse impacts when compared to the without project conditions. Further modeling shall be completed to address the increases in water surface elevation once the project moves into the final design phase.

CDBG MIT Application Development Environmental Narrative Form

Date: 7/29/2020

Project Name: North Forest

Application #: Application 3

Reviewer: Courtney Blechle

1. Status of Environmental (Has Not Started, In Progress, Completed): Has not started.
2. Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met/addressed. CDBG- MIT funding would be used to upgrade the existing drainage system due to past structural flooding in the area. A high-level environmental review was performed for this application, further studies would be conducted before construction to ensure HUD CDBG environmental requirements have been met and in accordance with 24 CRF Part 58.
3. Will the proposed project have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No
    a. If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A
4. Is the proposed project site likely to require a historical resources/archaeological assessment? No
    a. If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A
5. Is the proposed project site listed on the National Register of Historic Places? No
    a. If yes, provide a brief narrative explaining how the historic site will be impacted: N/A
6. Is the proposed project site in a designated flood hazard area or a designated wetland? The proposed project site is located with the 1% and 0.2% annual chance flood hazard area. There is potential for wetlands located in drainage ditches, before construction begins a wetland delineation would be conducted to determine if wetlands exist in the area. Impacts to wetlands would be avoided and minimized as possible. Permitting efforts would be done in accordance with USACE protocols.
7. Is the applicant participating in the National Flood Insurance Program? Yes
8. Is the project in a designated Regulatory Floodway? No
    a. If yes, please explain. N/A
9. Is the proposed project site located in a known critical habitat for endangered species? No
    a. If yes, please explain. N/A
10. Is the proposed project site a known hazardous site? Yes
    a. If yes, please explain. One underground petroleum storage tank is located at the Valero at the corner of North Forest and Ella Blvd. Any work proposed in this area would be done as to avoid the underground storage tank.
11. Is the proposed project site located on federal lands or at a federal installation? No
    a. If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A
12. What level of environmental review is likely needed for the proposed project site (EA, CE, EIS)? CE

13. Provide a brief narrative to include any additional detail or information relevant to Environmental Review. Sources: Texas Parks and Wildlife National Diversity Database, U.S. Fish and Wildlife Service, National Wetland Inventory, Texas Historical Commission, and Texas Commission on Environmental Quality.

CDBG MIT Application Development Environmental Narrative Form

Date: 9/2/20207/28/2020

Project Name: Castlewood Sections 3 and 4

Application #: Application 3

Reviewer: Courtney Blechle/Kent Hickingbottom

1. Status of Environmental (Has Not Started, In Progress, Completed): In progress
2. Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met/addressed. CDBG- MIT funding would be used to upgrade the existing drainage system due to past structural flooding in the area. A high-level environmental review was performed for this application, further studies would be conducted before construction to ensure HUD CDBG environmental requirements have been met and in accordance with 24 CRF Part 58. In addition, a Phase II Environmental Site Assessment was completed by Terracon in August 2020.
3. Will the proposed project have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No
    a. If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A
4. Is the proposed project site likely to require a historical resources/archaeological assessment? No known historical resources or archaeological sites exist within the project site.
    a. If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A
5. Is the proposed project site listed on the National Register of Historic Places? No
    a. If yes, provide a brief narrative explaining how the historic site will be impacted: N/A
6. Is the proposed project site in a designated flood hazard area or a designated wetland? A portion of the proposed project site exists within the 0.2% chance of flood hazard area. There is potential for wetlands located in drainage ditches, before construction begins a wetland delineation would be conducted to determine if wetlands exist in the area. Impacts to wetlands would be avoided and minimized as possible. Permitting efforts would be done in accordance with USACE protocols.
7. Is the applicant participating in the National Flood Insurance Program? Yes
8. Is the project in a designated Regulatory Floodway? No
    a. If yes, please explain. N/A
9. Is the proposed project site located in a known critical habitat for endangered species? No known critical habitat exists within the proposed project site.
    a. If yes, please explain. N/A
10. Is the proposed project site a known hazardous site? No.
    a. If yes, please explain. No. The only potential hazard identified lies outside the site. It was determined that proposed work would not affect the site and no further investigation appears necessary at this time.
11. Is the proposed project site located on federal lands or at a federal installation? No

    a. If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A

12. What level of environmental review is likely needed for the proposed project site (EA, CE, EIS)? CE
13. Provide a brief narrative to include any additional detail or information relevant to Environmental Review. Sources: Texas Parks and Wildlife National Diversity Database, U.S. Fish and Wildlife Service, National Wetland Inventory, Texas Historical Commission, and Texas Commission on Environmental Quality.

CDBG MIT Application Development Environmental Narrative Form

Date: 7/28/2020

Project Name: Fountainview Sections 1 and 2

Application #: Application 3

Reviewer: Courtney Blechle/Kent Hickingbottom

1. Status of Environmental (Has Not Started, In Progress, Completed): In progress
2. Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met/addressed. CDBG- MIT funding would be used to upgrade the existing drainage system due to past structural flooding in the area. A high-level environmental review was performed for this application, further studies would be conducted before construction to ensure HUD CDBG environmental requirements have been met and in accordance with 24 CRF Part 58. In addition, a Phase I Environmental Site Assessment was completed in July 2020 by SWCA Environmental Consultants, along with a wetland delineation, threatened and endangered species review, and cultural resources constraints analysis.
3. Will the proposed project have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No
    a. If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A
4. Is the proposed project site likely to require a historical resources/archaeological assessment? No archaeological sites or other resources have been recorded within or adjacent to (within 300 feet of) the project area. The majority of the project area has been disturbed by construction and urbanization activity. No direct impacts to any existing historic structures are anticipated as a result of the proposed project construction activities.
    a. If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A
5. Is the proposed project site listed on the National Register of Historic Places? No
    a. If yes, provide a brief narrative explaining how the historic site will be impacted: N/A
6. Is the proposed project site in a designated flood hazard area or a designated wetland? Yes. SWCA performed a wetland delineation of the Fountainview Subdivision Project in June 2020. Collectively, the delineation identified four wetlands totaling 0.452 acre within the project area. Additionally, the delineation identified one intermittent stream, measuring 0.025 acres and 409.510 linear feet, as well as one perennial pond measuring 1.963 acres within the project area. Permitting efforts will need to be performed in accordance with USACE protocols.
7. Is the applicant participating in the National Flood Insurance Program? Yes
8. Is the project in a designated Regulatory Floodway? No
    a. If yes, please explain. N/A
9. Is the proposed project site located in a known critical habitat for endangered species? No
    a. If yes, please explain. N/A
10. Is the proposed project site a known hazardous site? No
    a. If yes, please explain. N/A

11. Is the proposed project site located on federal lands or at a federal installation? No
    a. If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A
12. What level of environmental review is likely needed for the proposed project site (EA, CE, EIS)? CE
13. Provide a brief narrative to include any additional detail or information relevant to Environmental Review. Sources: Texas Parks and Wildlife National Diversity Database, U.S. Fish and Wildlife Service, National Wetland Inventory, Texas Historical Commission, and Texas Commission on Environmental Quality.

CDBG MIT Application Development Environmental Narrative Form

Date: 7/29/2020

Project Name: Parkland Estates

Application #: Application 3

Reviewer: Courtney Blechle

1. Status of Environmental (Has Not Started, In Progress, Completed): Has not started.
2. Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met/addressed. CDBG- MIT funding would be used to upgrade the existing drainage system due to past structural flooding in the area. A high-level environmental review was performed for this application, further studies would be conducted before construction to ensure HUD CDBG environmental requirements have been met and in accordance with 24 CRF Part 58.
3. Will the proposed project have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No
    a. If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A
4. Is the proposed project site likely to require a historical resources/archaeological assessment? No
    a. If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A
5. Is the proposed project site listed on the National Register of Historic Places? No
    a. If yes, provide a brief narrative explaining how the historic site will be impacted: N/A
6. Is the proposed project site in a designated flood hazard area or a designated wetland? The proposed project site is located within the 0.2% annual chance flood hazard. There is potential for wetlands located in drainage ditches, before construction begins a wetland delineation would be conducted to determine if wetlands exist in the area. Impacts to wetlands would be avoided and minimized as possible. Permitting efforts would be done in accordance with USACE protocols.
7. Is the applicant participating in the National Flood Insurance Program? Yes
8. Is the project in a designated Regulatory Floodway? No
    a. If yes, please explain. N/A
9. Is the proposed project site located in a known critical habitat for endangered species? No
    a. If yes, please explain. N/A
10. Is the proposed project site a known hazardous site? No
    a. If yes, please explain. N/A
11. Is the proposed project site located on federal lands or at a federal installation? No
    a. If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A
12. What level of environmental review is likely needed for the proposed project site (EA, CE, EIS)?CE
13. Provide a brief narrative to include any additional detail or information relevant to Environmental Review. Sources: Texas Parks and Wildlife National Diversity Database, U.S. Fish and Wildlife Service,

National Wetland Inventory, Texas Historical Commission, and Texas Commission on Environmental Quality.

CDBG MIT Application Development Environmental Narrative Form

Date: 7/29/2020

Project Name: Humble Road Place and Parkland Estates

Application #: Application 3

Reviewer: Courtney Blechle

1. Status of Environmental (Has Not Started, In Progress, Completed): Has not started.
2. Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met/addressed. CDBG- MIT funding would be used to upgrade the existing drainage system due to past structural flooding in the area. A high-level environmental review was performed for this application, further studies would be conducted before construction to ensure HUD CDBG environmental requirements have been met and in accordance with 24 CRF Part 58.
3. Will the proposed project have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No
    a. If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A
4. Is the proposed project site likely to require a historical resources/archaeological assessment? No
    a. If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A
5. Is the proposed project site listed on the National Register of Historic Places? No
    a. If yes, provide a brief narrative explaining how the historic site will be impacted: N/A
6. Is the proposed project site in a designated flood hazard area or a designated wetland? Both the northern quarter and the southern third of the proposed project site overlap the 1% and 0.2% annual chance flood hazard area and the Regulated Floodway for Greens Bayou. There is potential for wetlands located in drainage ditches, before construction begins a wetland delineation would be conducted to determine if wetlands exist in the area. Impacts to wetlands would be avoided and minimized as possible. Permitting efforts would be done in accordance with USACE protocols.
7. Is the applicant participating in the National Flood Insurance Program? Yes
8. Is the project in a designated Regulatory Floodway? Yes
    a. If yes, please explain. The southern portion of the proposed project site is located within the floodway/riverine floodway.
9. Is the proposed project site located in a known critical habitat for endangered species?No
    a. If yes, please explain. N/A
10. Is the proposed project site a known hazardous site? No
    a. If yes, please explain. N/A
11. Is the proposed project site located on federal lands or at a federal installation?No
    a. If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A
12. What level of environmental review is likely needed for the proposed project site (EA, CE, EIS)?CE

13. Provide a brief narrative to include any additional detail or information relevant to Environmental Review. Sources: Texas Parks and Wildlife National Diversity Database, U.S. Fish and Wildlife Service, National Wetland Inventory, Texas Historical Commission, and Texas Commission on Environmental Quality.

Mitigation Application

General

Program *

Hurricane Harvey State Mitigation Competition – HUD MID

Applicant *

Harris County Community Services Department (CSD)

County *

Harris

Application Type *

New

FY End Date

2/28/2021

Council of Governments

Houston-Galveston Area Council (HGAC)

Each application must upload a MIT-Local Certifications form signed by an authorized signatory along with other required application documentation. Each applicant for CDBG-MIT funding must certify by signing that both the Application for Federal Assistance Standard Form 424 (SF-424) and the MIT-Local Certifications form provided on the GLO website and described in the application guide were followed in the preparation of any CDBG-MIT program application, and will continue to be followed in the event of funding.

The Application for Federal Assistance Standard Form 424 (SF-424) and the MIT-Local Certifications

Related Contacts

Contact *

Mrsny, Reid

Authorized Representative

Hidalgo, Lina

Grant Administrator

Hickingbottom, Kent

Standard Form 424

Application Title *

Greens Bayou Drainage Partnership Application

Applicant Delinquent on Federal Debt
◉ No ○ Yes

Construction Application
○ No ◉ Yes

Construction Pre-Application
◉ No ○ Yes

Program Not Selected by State for Review
◉ No ○ Yes

Mitigation Application

Addressed Risk - Select the risk identified in the Action Plan that will be addressed. (select all that apply)

- [x] **Hurricanes/Tropical Storms/Tropical Depressions**
- [ ] **Severe Coastal Flooding**
- [x] **Riverine Flooding**

"The Federal Register, 84 FR 45838 (August 30, 2019) defines mitigation as:
"Activities that increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, injury, damage to and loss of property, and suffering and hardship, by lessening the impact of future disasters."

Applicants must describe in narrative format how their proposed project meets the above definition and clearly identify the methodology used to determine how the described criteria are being met. Include information identifying how the proposed project addresses overall local mitigation needs.

Mitigation presents communities with unique opportunities to examine a wide range of issues including (1) housing quality and availability, (2) road and rail

Hazard, Risk Description - Describe how the risk(s) selected are impacting the proposed project area. Reference where adopted local mitigation efforts are planned or underway where appropriate.

Subdivisions and businesses throughout the Greens Bayou Watershed in Harris County experience flooding conditions during hurricanes, tropical storms and even intense rainfall events that overwhelm drainage systems and result in riverine, or out-of-bank, flooding of the local bayous, tributaries, and drainage channels. The risk of flooding is a daily threat to the residents that live in areas with aging and inadequate drainage systems. The project sites identified throughout this application are part of an organized county-wide effort to analyze infrastructure shortfalls, build community resilience, and mitigate future hazards through flood risk reduction projects and strict floodplain management practices. The sites described in this application benefit many residents in some of the most vulnerable and at-risk areas of the County.

The massive and long-term financial commitment is recognized locally, and so a portion of project site costs, most of the sites included in this application, were approved for funding in the 2018 Harris County Flood Control District Bond Program. While some funding was earmarked for these sites, and is currently being used to fund the engineering study and design, the bond funding is not adequate to construct the required improvements. As a result, Harris County and Harris County Flood Control District are in dire need of additional funding to help address these urgent concerns. Income and need were factors when selecting projects for inclusion in the Bond program and the improvements were designed to assist low- and moderate-income persons/communities. Earmarked funding can be found in the Harris County FY 2020 Mid-Year Review and Capital Improvements Program (CIP), adopted in September 2019, along with subdivisions and mapped sites. Additionally, measures needed to address subdivision drainage were included in the Harris County Hazard Mitigation Plan.

See the attached narrative for additional information.

Hazard Mitigation Actions - Describe how the proposed project will mitigate against the identified risks. Reference where adopted local mitigation efforts are being enhanced where appropriate.

The Greater Houston area has experienced multiple major flooding events in recent years including the Memorial Day Flood (2015), the Tax Day Flood (2016) and Hurricane Harvey (2017). These events have amounted to 84 deaths and over $125.5 billion in damages. Because of the devastation and the need to identify measures to mitigation the impacts of major storm events, Harris County studied over 100 previously flooded subdivisions and found drainage solutions to mitigate risk to life and safety during future storm events.

This Flood and Drainage Activity project improves drainage at neighborhood and regional levels by making improvements to five subdivisions within the Greens Bayou Watershed and provides 5.5 miles of channel improvements in Greens Bayou and detention at adjacent basins at Aldine Westfield and Hardy. The proposed improvements include adding or upgrading storm sewer systems, adding curb and gutter systems, and increasing storage capacity with new detention basins and enlarging channels. The increased capacity across multiple project sites ultimately places less burden on the watershed, or service area. The cumulative benefits of multiple project sites ultimately mitigate property, life, and economic loss in future flooding events.

Harris County and Harris County Flood Control District have adopted the most stringent floodplain regulations in the United States by incorporating robust infrastructure regulations that ensure development follows standards that minimize the likelihood of future flooding. Copies of the Harris County floodplain regulations, infrastructure regulations, and HCFCD Policies, Criteria, and Procedures Manual with proof of adoption by Commissioners Court can be found in the supporting documentation for this application.

Due to space limitations, details for this section can be found in the narrative attached in documents.

Local Adopted Plans - To meet the local plan requirement, applicants follow specific procedures identified in the CDBG-MIT Application Guide

Is the proposed project included in one or more locally adopted plans?

Yes

Provide the title of the adopted plan being referenced.

Harris County Multi-Hazard Mitigation Action Plan

Provide the page number(s) in the adopted plan(s) where the proposed project is identified.

11-1 through 11-38, 21-5

Provide the date (Month, Year) the plan(s) was/ were adopted:

5/19/2020

Added Resiliency Measures

Applicants must explain if prior capital improvement projects, short or long-range planning efforts, community engagement or educational outreach, the implementation of enhanced building codes or code enforcement, or other related work has been completed which enhances hazard mitigation and/or resiliency throughout the applicable community or service area of the applicant(s).

If no previous efforts have been made, this must be stated in the application. If a joint project is being submitted by multiple entities that crosses jurisdictional or service area boundaries, each jurisdiction or entity should provide examples of previous hazard mitigation or resiliency efforts that have been completed within their particular jurisdiction or service area. Source documents, such as signed memorandum, must be attached to the application which prove such efforts have been implemented.

Does the proposed project enhance mitigation efforts that are already completed or underway?

Yes

If Yes, then provide a brief description.

Public meetings were held for two of the five subdivision sites in this application during project development to gain public input and comments. The study reports and meeting information have been attached. Harris County and the Flood Control District have also taken measures through the most stringent floodplain regulations in the United States and by incorporating robust infrastructure regulations to ensure that development is built to standards that will minimize the likelihood of future flooding. Copies of the above documents and their adoption by Commissioners Court can be found in the supporting documentation for this application. Also, Harris County and the Flood Control District have included funding for the study and design of the projects in their capital program. A copy of the Capital Improvements Program (CIP) has also been attached.

Please see the attached narrative for additional information.

Select the type(s) of prior or current local efforts undertaken that, combined with the proposed project, will provide enhanced hazard mitigation:

- [ ] **Prior capital improvement project(s)**
- [x] **Current capital improvement project(s)**
- [x] **Short-range planning efforts**
- [x] **Long-range planning efforts**
- [x] **Community engagement**
- [x] **Educational outreach**
- [x] **Implementation of enhanced building codes**
- [x] **Code enforcement**

☐ **Other related work which enhances hazard mitigation and/or resiliency through the proposed project.**

Other Hazard Mitigation Work

Mitigation Application Project

Acknowledging that mitigation needs may span a variety of services and facilities, for purposes of Mitigation funding only, the definition of project is expanded to include a discrete and well-defined beneficiary population and subsequent geographic location consisting of all eligible activities required to complete and provide specific successful mitigation benefit to the identified population.

For purposes of Mitigation application and implementation, the Project provided represents the overall Mitigation need being met.

There may be more than one Activity included in a Project. For instance, a successful Mitigation Project may require a drainage facilities activity, a street improvements activity, and a water facilities activity.

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Subrecipient Application/Contract

Greens Bayou Drainage Partnership Application

Project Title

Greens Bayou Partnership Drainage Improvements

Project Summary

The Greens Bayou Watershed has experienced multiple major flooding events in recent years including the Memorial Day Flood (2015), the Tax Day Flood (2016) and Hurricane Harvey (2017). These events have amounted to 84 deaths and over $125.5 billion in damages. Because of the devastation and the need to identify measures to mitigation the impacts of major storm events, Harris County studied nearly 100 previously flooded subdivisions and found drainage solutions to mitigate risk to life and safety during future storm events.

This Flood and Drainage Activity improves drainage at a regional and neighborhood level by making improvements to flood control facilities within five subdivisions within the Greens Bayou Watershed and provides 5.5 miles of channel improvements in Greens Bayou and detention at adjacent basins at Aldine Westfield and Hardy. The proposed improvements include adding or upgrading storm sewer systems, adding curb and gutter systems, and increasing storage capacity with new detention basins and enlargement of channels. The increased capacity across multiple project sites ultimately places less burden on the watershed, or service area. The cumulative benefits of multiple project sites ultimately mitigate property, life, and economic loss in future flooding events.

Mitigation Application Project

All of the state's mitigation activities under this grant will meet a national objective for either (1) benefiting low- to moderate-income persons (LMI), or (2) urgent need mitigation (UNM). At least 50 percent of CDBG-MIT funds will be used to support activities that benefit LMI person, and all programs and projects will have an LMI priority. For CDBG-MIT activities, HUD approval will be required to rely on the national objective criteria for elimination of slum and blighting conditions, because this national objective generally is not appropriate in the context of mitigation activities.

As indicated in the State Mitigation Action Plan:

Does the proposed project principally benefit Low- and Moderate-Income Persons or Mitigation Urgent Need?

Low-and Moderate-Income Persons

Low- and Moderate-Income Persons

- [x] **LMI Area Benefit**
- [ ] **LMI Housing Activity**
- [ ] **LMI Limited Clientele**

Provide the proposed beneficiary data:

Total Beneficiaries

375945

LMI Beneficiaries

221350

% LMI Beneficiaries

58.88

Mitigation Application Project

Applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for grant administration, environmental, and engineering services if using CDBG-MIT funds to pay third-party vendors for those services. These rules and regula ons also apply to procurement of construction services. For better detail regarding procurement methods and requirements, refer to:
h ps://recovery.texas.gov/local-government/resources/procurement-contrac ng/index.html

Have you procured a third-party administrator to administer the proposed project?

No

Have you procured a third-party environmental service provider for the proposed project?

Yes

Company Name

Various (by site) - Procured with local funds and not requesting reimbursement.

Contact

Email

Phone

Have you procured a third-party engineer for the proposed project?

Yes

Company Name

Various (by site) - Procured with local funds and not requesting reimbursement.

Contact

Mitigation Application Project

Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met to date. Applicants should be advised that all HUD CDBG environmenal requirements must be met before reimbursement can be considered.

More information at https://www.hudexchange.info/resource/167/environmental-review-procedures-24-cfr-58 (https://www.hudexchange.info/resource/167/environmental-review-procedures-24-cfr-58)

This Flood and Drainage Activity improves drainage at a regional and neighborhood level by making improvements to flood control facilities and five subdivisions within the Greens Bayou Watershed. The proposed improvements include adding or upgrading storm sewer systems, adding curb and gutter systems, and increasing storage capacity with new detention basins and enlargement of channels. The increased capacity across multiple project sites ultimately places less burden on the watershed, or service area. The cumulative benefits of multiple project sites ultimately mitigate property, life, and economic loss in future flooding events.

Harris County is committed to meeting all HUD CDBG environmental requirements and performing environmental reviews in compliance with 24 CFR 58, and other federal guidelines. In preparation for this application and in meeting environmental requirements, Harris County has performed Phase I Environmental Site Assessments on some sites included in this application, and has performed high level reviews of all sites. The findings from those reviews are indicated below and further detail can be found in the documents section.

Will the proposed project site have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described?

More information at https://www.hudexchange.info/programs/environmental-review (https://www.hudexchange.info/programs/environmental-review)

No

Is the proposed project site likely to require a historical resources/archaeological assessment?

More information at https://www.hudexchange.info/environmental-review/historic-preservation (https://www.hudexchange.info/environmental-review/historic-preservation)

No

Is the proposed project site listed on the National Register of Historic Places?

More information at https://www.nps.gov/subjects/nationalregister/index.htm (https://www.nps.gov/subjects/nationalregister/index.htm)

No

Is the proposed project site in a designated ood hazard area or a designated wetland?

FEMA Firmette located here: https://msc.fema.gov/portal/search (https://msc.fema.gov/portal/search?)

Yes

Is the applicant participating in the National Flood Insurance Program?

More information at https://www.hudexchange.info/programs/environmental-review/flood-insurance (https://www.hudexchange.info/programs/environmental-review/flood-insurance)

Yes

Is the project in compliance with Executive Order 11990?

More information at https://www.hudexchange.info/environmental-review/wetlands-protection (https://www.hudexchange.info/environmental-review/wetlands-protection)

Yes

Is the project in a designated Regulatory Floodway?

More information at https://www.hudexchange.info/environmental-review/floodplain-management (https://www.hudexchange.info/environmental-review/floodplain-management)

Yes

Is the project considered functionally dependent or a floodplain restoration activity?

More information at https://www.govinfo.gov/content/pkg/CFR-2018-title24-vol1/xml/CFR-2018-title24-vol1-part55.xml#seqnum55.1 (https://www.govinfo.gov/content/pkg/CFR-2018-title24-vol1/xml/CFR-2018-title24-vol1-part55.xml#seqnum55.1)

Yes

Is the proposed project site located in a known critical habitat for endangered species?

More information at https://www.hudexchange.info/environmental-review/endangered-species (https://www.hudexchange.info/environmental-review/endangered-species)

No

Is the proposed project site a known hazardous site?

More information at https://www.hudexchange.info/environmental-review/site-contamination (https://www.hudexchange.info/environmental-review/site-contamination)

Unknown

Is the proposed project site located on federal lands or at a federal installation?

No

No

What level of environmental review is likely needed for the proposed project site?

More information at HUD Exchange (https://www.hudexchange.info/resource/785/summary-table-of-levels-of-environmental-review-and-documentation-required-in-err)

Categorical Exclusion

Provide any additional detail or information relevant to Environmental Review

For some sites, Phase I Environmental Site Assessments were completed. For others, desktop reviews were performed to evaluate the potential impacts. Findings from those reviews are summarized in the documents section of this application. Answers to the above questions could change upon further review. All State and Federal policies and guidelines will be followed in addressing any of the above noted issues.

Mitigation Application Project

Identify activities already achieved to further fair housing, and those activities to be undertaken if an award is made by CDBG-MIT and when that activity will be complete. Upload any backup documentation to support your efforts.

Name	Activity 1
Comment Planned	Publishing the contact information, at the local, state and federal levels, for repor ting a Fair Housing complaint—achieved March 1 2020
Name	Activity 2
Comment Planned	Designating a Fair Housing Month – will achieve April 1, 2021 and have achieved April 1, 2020
Name	Activity 3
Comment Planned	Develop an anti-NIMBYism plan – achieved Nov. 12, 2018
Name	Activity 4
Comment Planned	Developed an AFH/Fair Housing Plan and submitted to HUD – achieved Jan 31, 2019

Edit Mitigation Application Project

The Project Level Budget represents summary data compiled as each Activity and Site are defined. Applicants are expected to present a thorough budget at the site level that includes all elements required for an eligible and successful project. Construction or public facilities budgetary information must be provided by a professional engineer or architect licensed to practice in the state of Texas using the **MIT-Budget Justification of Retail Costs (formerly Table 2)** form available the GLO website at: https://recovery.texas.gov/files/resources/mitigation/mit-budget-justification-of-retail-costs.xlsx

Original sealed construction and public facilities budgetary information must be uploaded as supporting

Minimum Total Amount Requested

$0.00

Maximum Total Amount Requested

$1,000,000,000.00

Maximum # of Activities per Project

20 Activities

Total Estimated/Original Project Budget

$100,000,000.00

Budget Activities

Add Budget Activity (/blicm/?refentity=new_projectphase&refid=534e0b1b-f2fc-ea11-b5d9-00155d32209e&refrel=cdr_new_projectphase_new_budgetactivity_Project&pid=6f9cfc80-1770-ea11-a811-001dd8309f0e)

Program Budget Code	Flood control and drainage Improvements
Planned/Requested Amount	$100,000,000.00
Total Other Funds	$19,374,247.03
Activity Total	$119,374,247.03

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003163

Site Title *

Castlewood Addition Sections 3 and 4 Subdivision Drainage Improvements

Site Description

The Castlewood subdivision was developed in the 1960s and ‘70s. The two sections for this project site consist of 80+ acres of residential parcels served by a roadside ditch drainage system. The system of ditches drain into Harris County Flood Control district (HCFCD) channel P138-01-00, a tributary of Greens Bayou. Although current regulations allow ditches, this project site is considered non-conforming due to culvert sizing, inadequate extreme event sheet flow design, lack of detention, and poor lot grading. The subdivision experiences drainage issues during frequent rainfall events but becomes quickly inundated during high intensity or long duration rainfall events. The southern portion of the subdivision drains through a HCFCD channel which subsequently discharges into P138-01-00. The northern portions of the subdivision drain toward ditches along the south side of Lauder road which eventually drain into P138-01-00. The rest of the subdivision drains east, directly into P138-01-00.

Historical flooding information shows that the most damaging flood event was Hurricane Harvey (August 2017), which caused structural flooding in 195 of the 198 homes, up to 36 inches in depth. Other less intense historical flood events, including Hurricane Ike (September 2008), in June of 2006, and Tropical Storm Allison (June 2001) recorded a smaller number of water damaged homes. Most of the damages during these smaller flood events occurred in Section 3 of the Castlewood Addition, located in the western portion of the subdivision. Overall, this project site has suffered from structural flooding in 17 separate storm events. and 34 homes throughout the subdivision have been declared repetitive loss structures by FEMA.

Street Address

Connorvale Road and Russ Drive

Street Limits on Street

From Street

To Street

Zip Code

77039

City

Houston

County

Harris

State

TX

Latitude

29.91061

Longitude

-95.34506

Scope of Work

The proposed Castlewood flood and drainage activity will convert all roadside ditches and culverts to a curb and gutter roadway with underground storm sewer. Additional work to relocate utilities and provide sidewalks is included in the project as well. The new storm sewer will convey the 2-year, or 50% AEP, storm while the curb and gutter pavement will provide additional storage and conveyance for events up to a 100-year, or 1% AEP, rainfall event. Two major outfalls will be located on the eastern side of Woodgate and Connorvale. The Woodgate outfall will also have an extreme event swale. Other extreme event flow paths and approximately 40 acre-feet of detention is included in the project scope.

The proposed system will resolve internal drainage issues and is expected to reduce flooding by at least one foot which mitigates future flood risk for the 195 previously flooded structures. The addition of sidewalks increases the safety of pedestrians throughout the subdivision.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to:
https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

Yes

Estimated Number of Parcels

2

If yes, has acquisition been completed, in progress, or will need to be acquired?

In Progress

If yes, provide a brief narrative describing the acquisition activities required.

An easement is required for the new outfall.

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to 2 C

Districts and Elected Officials

Cong. Rep

Garcia, Sylvia

State Rep

Walle, Armando

State Senator

Alvarado, Carol

Cong. Rep District #

29

State Rep District #

140

State Senator Dist#

6

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$15,018,292.02

Total Other Funds

$1,057,189.00

Total Grant & Other Funds

$16,075,481.02

Amount Requested	$57,463.08
Site Budget Code	CDBG-MIT Environmental
Other Funds	
Site Budget Total	$57,463.08
Name	Castlewood Addition Sections 3 and 4 Subdivision Drainage Improvements - CDBG-MIT Environmental
Created On	9/22/2020 8:58 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$850,092.00
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$850,092.00
Name	Castlewood Addition Sections 3 and 4 Subdivision Drainage Improvements - CDBG-MIT Admin
Created On	9/22/2020 9:04 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$1,149,261.54
Site Budget Code	CDBG-MIT Engineering
Other Funds	$1,057,189.00
Site Budget Total	$2,206,450.54
Name	Castlewood Addition Sections 3 and 4 Subdivision Drainage Improvements - CDBG-MIT Engineering
Created On	9/22/2020 8:57 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$1,468,860.00
Site Budget Code	CDBG-MIT Acquisition
Other Funds	
Site Budget Total	$1,468,860.00
Name	Castlewood Addition Sections 3 and 4 Subdivision Drainage Improvements - CDBG-MIT Acquisition
Created On	9/22/2020 9:07 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$11,492,615.40
Site Budget Code	CDBG-MIT Construction
Other Funds	
Site Budget Total	$11,492,615.40
Name	Castlewood Addition Sections 3 and 4 Subdivision Drainage Improvements - CDBG-MIT Construction
Created On	9/22/2020 8:54 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Road replacement with new curb and gutter (LF) - 15312 Storm Sewer System (New) LF - 13427 New Outfall - 1
Numeric Resp Planned	28739

Name	Number of public improvements
Comment Planned	Road replacement with new curb and gutter (LF) 15312 New Storm Sewer System (LF) 13427 New outfall (Ea) 1
Numeric Resp Planned	3

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003164

Site Title *

Fountainview Sections 1 and 2 Subdivision Drainage Improvements

Site Description

Fountinview was constructed in the 1970's. The 40-acre residential development is comprised of single-family homes with concrete sidewalks and a curb and gutter storm sewer system. There are nine individual storm sewer systems within the neighborhood that outfall to the HCFCD channels P133-00-00 and P134-00-00, which border the project area on the west and east. Each system consists of two leads to a single trunk line located at the cul-de-sac of each street. The existing development is considered non-conforming in accordance with current regulations due to the storm sewer inability to convey the 2-year, or 50% AEP, storm event, non-existent detention facilities, and a lack of consideration for the extreme event ponding or sheet flow patterns.

The drainage issues in the neighborhood are immediately observed during smaller, more frequent, rainfall events primarily due to the flat street grading and low capacity inlets. During a 100-year, or a 1% AEP, storm event flow from P133-00-00 backs up into the two tributary channels, P133-03-00 and P133-04-00 exacerbating the ponding within the neighborhood. During Hurricane Harvey 19 homes experienced flood damages.

Street Address

McCracken Road and Indianola Drive

Street Limits on Street

From Street

To Street

Zip Code

77032

City

Houston

County

Harris

State

TX

Latitude

29.93567

Longitude

-95.30885

Scope of Work

The proposed Fountainview flood drainage activity replaces the existing storm sewer systems with new systems capable of conveying the 2-year, or 50% AEP, rainfall event without modifying the current storm sewer alignment or pavement grades. The evaluation and construction of extreme event overflow structures at each cul-de-sac is included in the project scope. In order to create no adverse impact downstream, a 10 acre-foot detention basin is proposed along the northern boundary of the project.

The proposed improvements conform with present-day infrastructure regulations and result in reduced inundation depths and durations for up to a 100-year, or 1% AEP, storm event. The reduction in water surface will mitigate future flood damages for at least 19 previously flooded homes.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to: https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

Yes

Estimated Number of Parcels

1

If yes, has acquisition been completed, in progress, or will need to be acquired?

In Progress

If yes, provide a brief narrative describing the acquisition activities required.

Acquisition is required for a detention basin. The pond area is outside of Harris County owned parcels and would require land acquisition. With the recommended upsized storm sewer, the two connections between the existing parallel storm systems and pond area would help reduce flood depth approximately 0.5’ to 1.0’ at the Sarti Street Cul-de-sac.

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to 2

Districts and Elected Officials

Cong. Rep

Garcia, Sylvia

State Rep

Thompson, Senfronia

State Senator

Whitmire, John

Cong. Rep District #

29

State Rep District #

141

State Senator Dist#

15

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$3,156,879.04

Total Other Funds

$463,271.00

Total Grant & Other Funds

$3,620,150.04

Amount Requested	$8,498.59
Site Budget Code	CDBG-MIT Environmental
Other Funds	
Site Budget Total	$8,498.59
Name	Fountainview Sections 1 and 2 Subdivision Drainage Improvements - CDBG-MIT Environmental
Created On	9/22/2020 9:12 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$169,971.74
Site Budget Code	CDBG-MIT Engineering
Other Funds	$463,271.00
Site Budget Total	$633,242.74
Name	Fountainview Sections 1 and 2 Subdivision Drainage Improvements - CDBG-MIT Engineering
Created On	9/22/2020 9:11 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$178,691.27
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$178,691.27
Name	Fountainview Sections 1 and 2 Subdivision Drainage Improvements - CDBG-MIT Admin
Created On	9/22/2020 9:13 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$1,100,000.00
Site Budget Code	CDBG-MIT Acquisition
Other Funds	
Site Budget Total	$1,100,000.00
Name	Fountainview Sections 1 and 2 Subdivision Drainage Improvements - CDBG-MIT Acquisition
Created On	9/22/2020 9:14 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$1,699,717.44
Site Budget Code	CDBG-MIT Construction
Other Funds	
Site Budget Total	$1,699,717.44
Name	Fountainview Sections 1 and 2 Subdivision Drainage Improvements - CDBG-MIT Construction
Created On	9/22/2020 9:09 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Storm Sewer Replacement (LF) - 1182 Detention Pond (Ac-Ft) - 10.2
Numeric Resp Planned	1182

Name	Number of public improvements
Comment Planned	Storm Sewer Replacement (LF) 1182 Detention Pond (ac ft) 10.2
Numeric Resp Planned	2

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003166

Site Title *

Humble Road Place and Parkland Estates Subdivisions Drainage Improvements

Site Description

The Humble Road Place and Parkland Estates subdivisions were developed prior to 1970 and the 200+ acre project site is served by roadside ditch systems that drain either north to HCFCD channel P133-00-00 or south to Greens Bayou. The extreme northern and southern portions of the area lie within the 100-year and 500-year floodplain but the vast majority of residents live in low risk areas. Although current regulations allow ditches, this area is considered non-conforming due to culver sizes, ditch geometry, inadequate sheet flow design, poor lot grading, and the lack of detention.

The subdivision experiences drainage issues during frequent rainfall events because the lack of capacity in the roadside ditch but becomes quickly inundated during high intensity or long duration rainfall events due to riverine flooding from P133-00-00 and P100-00-00. A primary issue for P133-00-00 is a constriction at the nearby railroad bridge. The railroad bridge forces all flow through its single bridge opening and causes a backwater of over 1.4' in the 100-year storm. The project area is inundated with overflow from Greens Bayou Tributary that then travels south through the subdivisions between the railroad and Old Humble Road until it drains into Greens Bayou approximately one mile south. This overflow into the subdivisions causes flooding and damage to the houses located in these developments.

54 homes within the Parkland Estates subdivision reported flooding during Hurricane Harvey. Only 16 of those 54 are located in the 500-year floodplain. 202 homes within the Humble Road Place subdivision reported flood damage during Hurricane Harvey. About half of the 202 flooded homes are actually in a special flood hazard area.

Street Address

Ravendale Road aand Laramie Street

Street Limits on Street

From Street

To Street

Zip Code

77396

City

Humble

County

Harris

State

TX

Latitude

29.92173

Longitude

-95.29215

Scope of Work

The improvements propose to mitigate P133-00-00 overflows into the Parkland Estates and Humble Road Place subdivisions and improve the capacity and conveyance of the internal drainage systems. The overflow from P133-00-00 will be reduced through the construction of a bypass channel under the existing railroad. The bypass channel will reduce the upstream water surface elevations during extreme events by providing additional flow capacity in the P133-00-00 channel. A mitigation basin in proposed downstream to account for any adverse impacts. The reduction in water surface elevations allows the proper function of the internal drainage system. The internal capacity is improved through the addition of storm sewer under the roadside ditch throughout the site. The system will be divided into a north (P133-00-00) and south (P100-00-00) system with adequate detention in each area to offset the increase in flow.

For additional information, please see the narrative listed in documents.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to: https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

Yes

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

Yes

Estimated Number of Parcels

4

If yes, has acquisition been completed, in progress, or will need to be acquired?

Still Needed

If yes, provide a brief narrative describing the acquisition activities required.

Acquisition required for detention.

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to 2 (

Districts and Elected Officials

Cong. Rep

Garcia, Sylvia

State Rep

—

State Senator

Alvarado, Carol

Cong. Rep District #

29

State Rep District #

141 142

State Senator Dist#

6

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$24,095,575.28

Total Other Funds

$1,394,549.98

Total Grant & Other Funds

$25,490,125.26

Amount Requested	$53,636.54
Site Budget Code	CDBG-MIT Environmental
Other Funds	
Site Budget Total	$53,636.54
Name	Humble Road Place and Parkland Estates Subdivisions Drainage Improvements - CDBG-MIT Engineering
Created On	9/22/2020 9:18 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$1,072,730.75
Site Budget Code	CDBG-MIT Engineering
Other Funds	$1,394,549.98
Site Budget Total	$2,467,280.73
Name	Humble Road Place and Parkland Estates Subdivisions Drainage Improvements - CDBG-MIT Engineering
Created On	9/22/2020 9:21 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$1,363,900.49
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$1,363,900.49
Name	Humble Road Place and Parkland Estates Subdivisions Drainage Improvements - CDBG-MIT Admin
Created On	9/22/2020 9:18 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$10,727,307.50
Site Budget Code	CDBG-MIT Construction
Other Funds	
Site Budget Total	$10,727,307.50
Name	Humble Road Place and Parkland Estates Subdivisions Drainage Improvements - CDBG-MIT Construction
Created On	9/22/2020 9:16 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$10,878,000.00
Site Budget Code	CDBG-MIT Acquisition
Other Funds	
Site Budget Total	$10,878,000.00
Name	Humble Road Place and Parkland Estates Subdivisions Drainage Improvements - CDBG-MIT Acquisition
Created On	9/22/2020 9:23 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Ditch Regrading - 31,800 Storm Sewer Improvements - 41,600
Numeric Resp Planned	73400

Name	Number of public improvements
Comment Planned	Channel Improvements (CY) - 1,110 Detention Improvements (CY) - 120,000 Ditch Regrading (LF) - Storm Sewer Improvements (L F)
Numeric Resp Planned	4

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003167

Site Title *

North Forest Subdivision Drainage Improvements

Site Description

The North Forest subdivision was built in the 1960's and 70's. The 110+ acre development is primarily dense residential lots served by a curb and gutter roadway and a storm sewer system that outfalls into HCFCD channel P145-03-03, a tributary of Greens Bayou. Based on the analysis, the existing system is partially non-conforming. The storm sewers were designed for up to a 10-year, or 10% AEP, storm event, but the project site has no detention and does not account for extreme event flow paths.

The primary drainage issue for North Forest is the extreme storm event. The storm sewer system along Ella Blvd, N Forest Boulevard and other streets within the North Forest subdivision become surcharged. The inadequate extreme event flow paths and relatively flat topography in the area result in excessive ponding within the subdivision with depths exceeding three (3) feet near the eastern and southeastern parts of the subdivision.

During Hurricane Harvey, 30 homes reported some amount of flood damage. The average depth of flooding in the homes was not readily available from existing data, but it is believed that it was generally about 1 to 2 feet with the southeastern part of the subdivision experiencing relatively more flooding with depths exceeding 3 feet. Within the subdivision, the average height of the finished floor is approximately 2 feet above the top of curb elevation of the street.

Street Address

Green Shade Drive and North forest Blvd

Street Limits on Street

From Street

To Street

Zip Code

77090

City

Houston

County

Harris

State

TX

Latitude

30.00340

Longitude

-95.43556

Scope of Work

The proposed North Forest flood drainage activity consists of splitting the existing storm sewer into two systems and constructing a detention basin to receive and store the flows from the subdivision. Extreme event overflow locations are included in the project scope as well. The existing outfall configuration will remain and continue to discharge into the P145-03-03 channel. The 110 acre-foot detention basin receives flow from the eastern part of the subdivision via proposed 60-inch RCP storm along Nort Forest Boulevard. The basin is spread over 12.32 acres with an average depth of eight (8) feet.

The aforementioned improvements conform with current regulations and mitigate the future damage to at least 30 previously flooded structures.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to:
https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

Yes

Estimated Number of Parcels

2

If yes, has acquisition been completed, in progress, or will need to be acquired?

In Progress

If yes, provide a brief narrative describing the acquisition activities required.

Acquisition is required for detention.

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to 2 (

Districts and Elected Officials

Cong. Rep

Jackson Lee, Sheila

State Rep

Thompson, Senfronia

State Senator

Whitmire, John

Cong. Rep District #

18

State Rep District #

141

State Senator Dist#

15

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$13,075,169.85

Total Other Funds

$1,113,404.40

Total Grant & Other Funds

$14,188,574.25

Amount Requested	$30,927.90
Site Budget Code	CDBG-MIT Environmental
Other Funds	
Site Budget Total	$30,927.90
Name	North Forest Subdivision Drainage Improvements - CDBG-MIT Environmental
Created On	9/22/2020 9:27 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$618,558.00
Site Budget Code	CDBG-MIT Engineering
Other Funds	$1,113,404.40
Site Budget Total	$1,731,962.40
Name	North Forest Subdivision Drainage Improvements - CDBG-MIT Engineering
Created On	9/22/2020 9:26 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$740,103.95
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$740,103.95
Name	North Forest Subdivision Drainage Improvements - CDBG-MIT Admin
Created On	9/22/2020 9:27 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$5,500,000.00
Site Budget Code	CDBG-MIT Acquisition
Other Funds	
Site Budget Total	$5,500,000.00
Name	North Forest Subdivision Drainage Improvements - CDBG-MIT Acquisition
Created On	9/22/2020 9:28 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Amount Requested	$6,185,580.00
Site Budget Code	CDBG-MIT Construction
Other Funds	
Site Budget Total	$6,185,580.00
Name	North Forest Subdivision Drainage Improvements - CDBG-MIT Construction
Created On	9/22/2020 9:25 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Storm Sewer Improvements (LF) - 6,000
Numeric Resp Planned	6000

Name	Number of public improvements
Comment Planned	Storm Sewer Improvements (LF) - 6,000 Detention (ac-ft) - 110
Numeric Resp Planned	2

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003328

Site Title *

Greens Bayou Mid-Reach Channel Improvements and Stormwater Detention Basins

Site Description

The site includes channel (P100-00-00) conveyance improvements from Imperial Valley Drive to JFK Boulevard and includes two storm water detention basins adjacent to the Bayou located just east of Hardy Toll Road.

Please see the attached narrative for more information about the site, the scope and benefits.

Street Address

15523 Aldine Westfield Rd.

Street Limits on Street

From Street

Imperial Valley Drive

To Street

John F. Kennedy Blvd.

Zip Code

77032

City

Houston

County

Harris

State

TX

Latitude

29.94091

Longitude

-95.35970

Scope of Work

This mitigation activity consists of improvements to approximately 5.5 miles of Greens Bayou (HCFCD Unit P100-00-00) from Imperial Valley Drive to JFK Boulevard and includes two stormwater detention basins adjacent to the Bayou located just east of Hardy Toll Road.

The channel improvements will be contained within the existing right of way and the existing depth of the channel will not be increased. All existing backslope interceptor structures, corrugated metal pipes, backslope swales, concrete lining, outfall structures, and riprap will be removed and replaced to accommodate Greens Bayou widening. A 15-foot wide all-weather access road of crushed limestone flexible base course 6" thickness will be required on both sides of Greens Bayou to allow for proper maintenance of the improved channel

Two basin to the north of Greens Bayou (Aldine Westfield Stormwater Detention Basin) and (Hardy Stormwater Detention Basin) will be built resulting in 1,000 ac-ft of capacity.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to: https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

No

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to

Districts and Elected Officials

Cong. Rep

Jackson Lee, Sheila

State Rep

Thompson, Senfronia

State Senator

Whitmire, John

Cong. Rep District #

18

State Rep District #

141

State Senator Dist#

15

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$44,654,083.81

Total Other Funds

$15,345,832.65

Total Grant & Other Funds

$59,999,916.46

Amount Requested	$44,654,083.81
Site Budget Code	CDBG-MIT Construction
Other Funds	$15,345,832.65
Site Budget Total	$59,999,916.46
Name	Aldine Westfield and Hardy Stormwater Detention Basins - CDBG-MIT Construction
Created On	9/30/2020 1:05 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11258-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	
Numeric Resp Planned	29000

Name	Number of public improvements
Comment Planned	(1) Channel Conveyance Improvements along Greens Bayou and (2) Stormwater Detention Basins
Numeric Resp Planned	3

Mitigation Application Project

The schedule requested here is the Project Level Schedule. Identify the time needed to complete every activity and ensure a full and eligible project. Activity Level schedules must be uploaded separately.

Project Phase	Start Date	Length (months)	End Date (calculated)	Phase Status
Procurement of Engineer/Architect Services Professional Services	1/16/2020	5	6/16/2020	Not Executing
Start-Up Documentation	1/16/2020	10	11/16/2020	Not Executing
Broad Environmental Review	6/11/2020	11	5/11/2021	Not Executing
Acquisition	10/7/2020	21	7/7/2022	Not Executing
Engineering Design	3/17/2021	12	3/17/2022	Not Executing
Bid Advertisement	2/9/2022	10	12/9/2022	Not Executing
Contract Award	4/1/2022	10	1/31/2023	Not Executing
Construction NTP	5/27/2022	14	7/27/2023	Not Executing
Construction	5/27/2022	32	1/26/2025	Not Executing
Submit As-Builts/COCC/FWCR	8/20/2023	19	3/20/2025	Not Executing
Contract Closeout	9/20/2023	19	4/20/2025	Not Executing
Construction Activity Completion	12/26/2024	1	1/26/2025	Not Executing

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BENEFIT-COST ANALYSIS
GREENS BAYOU WATERSHED
MITIGATION PROJECT

Prepared for:

Harris County

October 2020

Prepared by:

FREESE AND NICHOLS, INC.
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APPENDICES

EXECUTIVE SUMMARY

The benefit-cost analysis performed for Greens Bayou Watershed Covered Project included quantification of the following types of benefits:

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

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

Table ES-1 – Summary of Project Benefits

Expected Benefits	Annual Benefit	Present Value Benefit
Structures + Contents	$ 6,412,865	$ 88,502,328
Displacement, Residential	$ 2,823,961	$ 38,972,775
Displacement, Non-residential	$ -	$ -
Social (Mental Health & Productivity)	$ 7,739,150	$ 106,806,045
Environmental (Ecosystem services of converted land)	$ -	$ -
Total Expected Benefits (all categories)	**$ 16,975,977**	**$ 234,281,148**

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

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

Social benefits of the Greens Bayou Watershed Covered Project are shown in *Table ES-2*.

Table ES-2 – Summary of Social Benefits

Category	Number of Persons	Benefit per Person	Present Value Social Benefits
Number of Persons Directly Benefitted by Mitigation of Residential Structural Flooding	12,539	$ 2,443	$ 30,361,982
Number of Full-time Workers Directly Benefitted by Mitigation of Residential Structural Flooding	8,972	$ 8,736	$ 78,375,253
Total Social Benefit			**$ 109,007,234**

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

Table ES-3 – Impacts of Mitigation Project

Number of structures benefitted in any event *(estimated losses to structural damage are reduced)*	3,737
Number of structures removed from 10% AEP (10-year) floodplain	429
Number of structures removed from 1% AEP (100-year) floodplain	1,190
Number of acres removed from 10% AEP (10-year) floodplain	2,639
Number of acres removed from 1% AEP (100-year) floodplain	2,775
Number of structures removed from risk* in 10% AEP (10-year) event	153
Number of structures removed from risk* in 1% AEP (100-year) event	1375

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

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

Table ES-4 – Benefit-Cost Ratio

Present Value Total Benefits	**$234,281,148**
Present Value Total Cost	**$119,374,247**
Benefit-Cost Ratio	**2.13**

1.0 METHODOLOGY

1.1 BENEFIT-COST ANALYSIS REQUIREMENTS FOR CDBG-MIT PROJECTS

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

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

The analysis presented here meets these requirements as follows:

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

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

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

1.2 QUANTITATIVE BENEFIT CATEGORIES

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

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

1.3 INPUT DATA

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

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

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

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

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

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

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

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

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

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

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

1.4 CALCULATION OF EXPECTED ANNUAL BENEFITS

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

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

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

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

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

Equation 1

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

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

Equation 2

1.5 PRESENT VALUE ANALYSIS

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

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

Equation 3

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

Equation 4

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

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

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

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

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

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

2.0 QUANTITATIVE BENEFITS

2.1 BENEFITS BASED ON DEPTH OF FLOODING

A traditional BCA for flood mitigation projects assesses the difference in probable damages to a structure and its contents under existing (baseline) conditions and post-mitigation (proposed) conditions. Baseline and proposed impacts to a structure and its contents are assessed for multiple storm recurrence intervals based on the depth to which the structure is inundated in each scenario. Flooding depth for each structure is calculated as the difference in modeled water surface elevation (WSE) and finished floor elevation (FFE) as provided in the structure inventory. For structures with missing FFE data, FFE was estimated at 6 inches above ground elevation, using the same ground elevation data as was used in development of the structure inventory[8].

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

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

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

2.1.1 Building and Content Damages

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

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

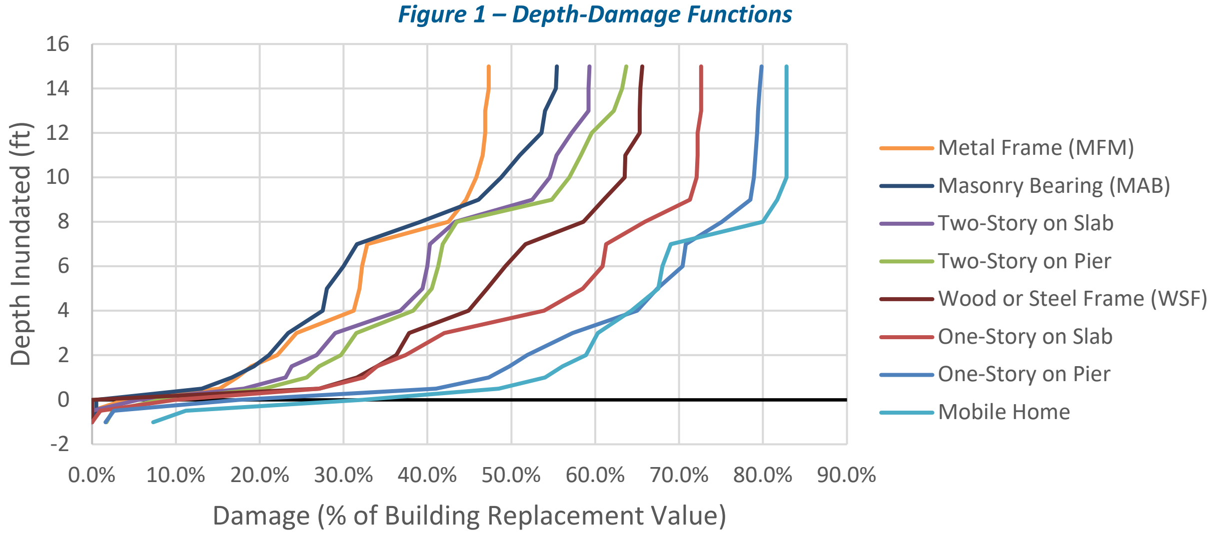
approach allowed for the use of local data to appropriately reflect structure values in the project service area.

$$Total\ BRV = Unit\ BRV\ (\$/sf) * Area\ (sf)$$ ***Equation 6***

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

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

Figure 1 – Depth-Damage Functions



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

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

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

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

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

2.1.2 Displacement Costs (Residential)

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

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

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

Table 2-1 – Residential Displacement Unit Costs

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

2.1.3 Displacement Costs (Non-Residential)

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

- One-time cost of relocating business equipment

- Monthly rental costs of new space

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

Table 2-2 – Non-residential Displacement Cost Factors

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

2.1.4 Loss of Income / Loss of Function

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

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

2.2 ANCILLARY BENEFITS

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

2.2.1 Avoided Social Costs

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

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

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

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

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

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

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

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

2.2.2 Environmental Benefits

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

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

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

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

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

2.3 SPECIAL CONSIDERATIONS

Certain mitigation activities occurring in areas that ultimately outfall to the main channel of the project service area are included in the Greens Bayou Watershed Covered Project. For these activities, benefits were calculated based on [insert HNTB methodology summary here] : , and social benefits were assumed to apply to the residents of all benefitted structures.

At this time in the project life cycle of the Greens Bayou Mid Reach mitigation activity, the exact number of remaining property acquisitions required to construct Hardy Basin have not been determined. Additionally, those buyouts are being funded through a separate funding source. Because of the lack of data, all structures in the potential buyout area for Hardy Basin have been excluded from the BCA. This exclusion is a conservative assumption; as a result, benefits may be understated.

3.0 QUALITATIVE BENEFITS

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

3.1 BENEFICIARIES VULNERABLE TO FLOOD RISK

This application has demonstrated that 58.9% of the beneficiaries of Greens Bayou Watershed Covered Project are low- to moderate-income persons. Additionally, many of the residents of the project service area may be considered particularly vulnerable to disasters. 39.1% of the households in the project service area are considered to be housing cost-burdened, and 18.4% are severely housing cost-burdened. These households spend 30+% and 50+% of their monthly income on housing-related costs, respectively. This cost burden may make it particularly hard for these households to recover from disaster, as they are less likely to have additional funds available for repairs, hotel stays, and lost wages during and after a flood. Additionally, 23.9% of the households in the project service area have no computer and/or no

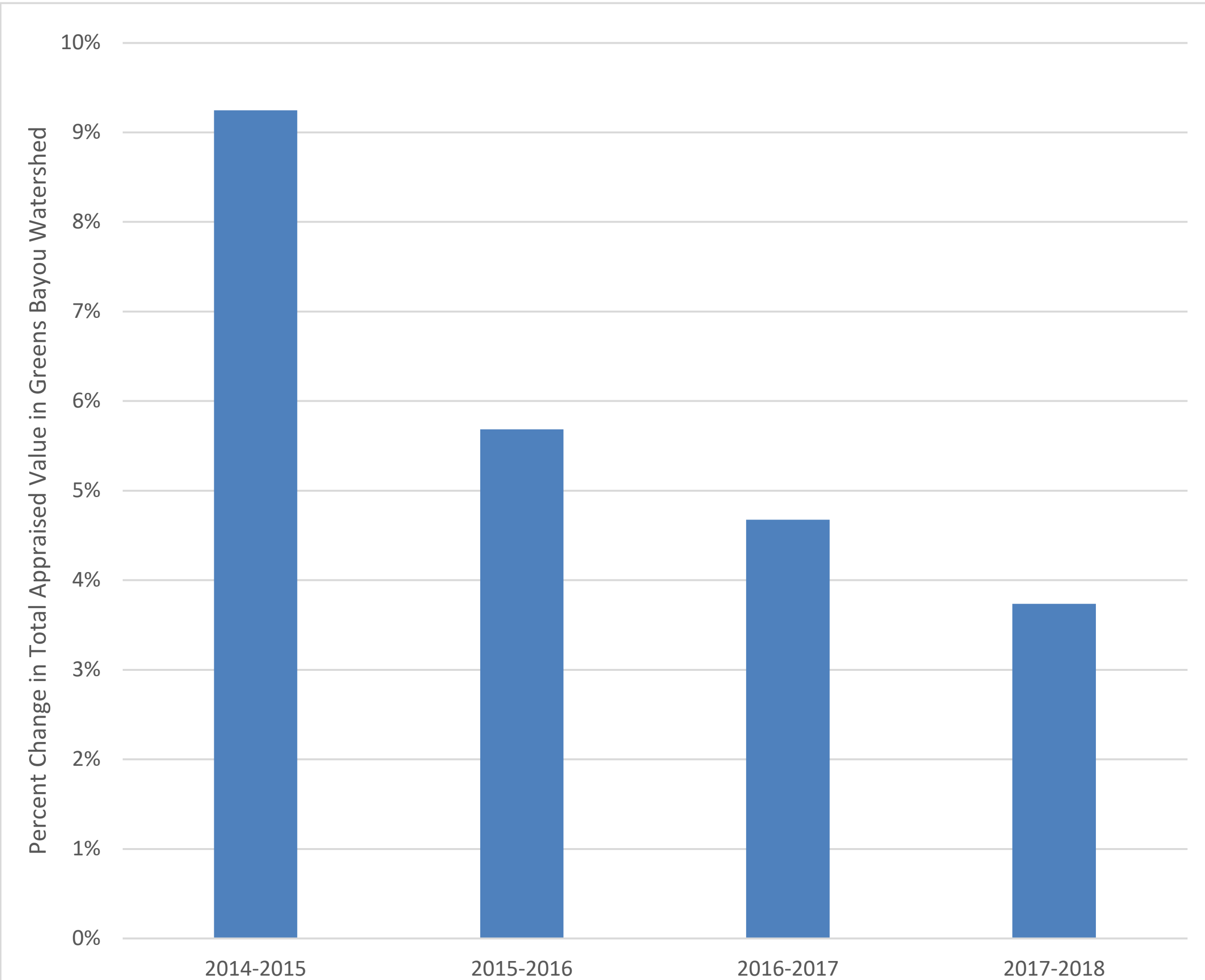
[15] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

internet subscription. Lack of reliable internet access may reduce residents' ability to benefit from early warning systems in case of flooding events, making them more vulnerable.

3.2 BENEFIT OF REDUCING FLOOD IMPACTS TO PROPERTY VALUES

A review of parcel appraisal values from the Harris County Appraisal District suggests that the annual rate of growth in property values, generally slowed from 2014 to 2018 in the Greens Bayou Watershed ().

Figure 2 - Year-to-Year Percent Change in Total Appraised Value of Property in Greens Bayou Watershed



These trends could be caused or influenced by floods in 2015, 2016, and 2017, but the degree to which local flooding impacted the value growth rates cannot be ascertained. General economic conditions in Harris County following Hurricane Harvey, as well as other external economic factors, could also contribute to changes in property values. Although the exact impact of local flooding on property values cannot be quantified, flood risk mitigation projects are likely to have a positive impact on the residents of flood-prone areas, as falling property values can have a negative effect on the financial flexibility of housing cost-burdened homeowners and even renters. Finally, the Greens Bayou Watershed Covered Project will remove 2,775 acres from the 100-year floodplain, providing a potential positive impact to property values.

3.3 TRANSPORTATION BENEFITS

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

In Harris County, over 50,000 workers 16 years and older use a bus or trolley bus as means of transportation to work. Of workers living within the watershed, 2.32% (4,616 workers) use a bus to commute to work. Data from the Metropolitan Transit Authority of Harris County (Metro) indicates that 45 bus routes through the watershed were closed for up to 9 days during and after Hurricane Harvey. No methods were found that could be used to quantify the productivity losses of workers impacted by road closures. Additionally, all Metro bus routes passing through the project service area also extend across multiple floodplains in Harris County. It was determined that even if a substantial section of a route is removed from the floodplain as a result of the Greens Bayou Watershed Covered Project, inundation elsewhere could still cause route closure. Because of this, assigning quantitative economic benefits to reduced flooding along bus routes that could be attributed only to this project was not considered to be a valid approach. However, the Greens Bayou Watershed Covered Project is important to reducing the overall flooding along major commuter routes, providing significant benefit to residents of the project service area as well as workers traveling to and through the area.

4.0 SUMMARY

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

APPENDIX A
BUILDING REPLACEMENT VALUES

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

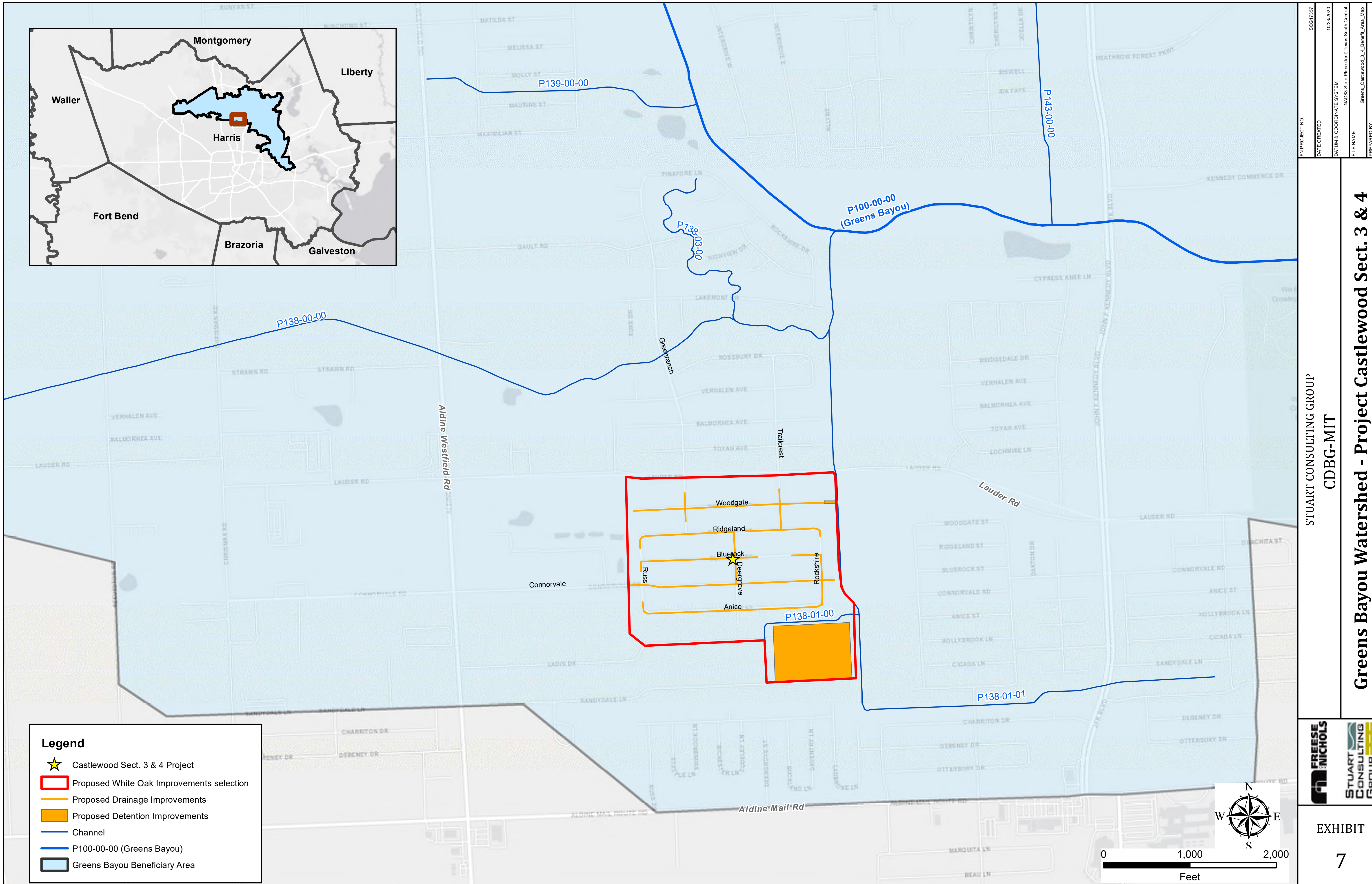
Income Ratio (r) Number of Stories	r < 0.5	0.5 <= r < 0.85	0.85 <= r < 1.25	1.25 <= r < 2.0	r >= 2.0
1	$97.28	$107.21	$145.17	$169.60	$206.28
2	$103.51	$110.89	$141.45	$166.65	$196.43
3	$103.51	$112.50	$147.76	$172.67	$202.32
split	$95.14	$102.70	$132.88	$155.34	$184.21

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

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

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

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



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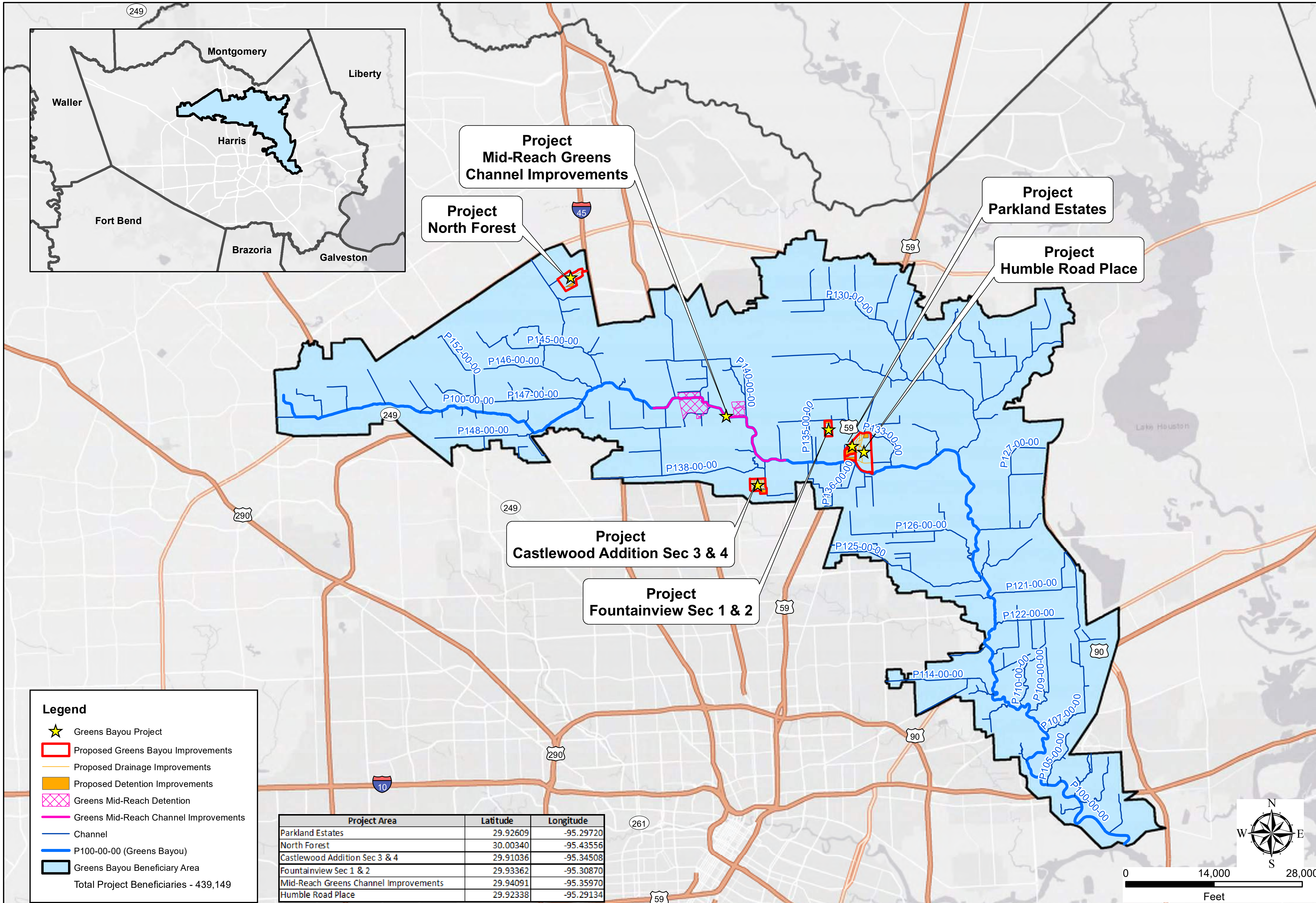

Project Area	Latitude	Longitude
Parkland Estates	29.92609	-95.29720
North Forest	30.00340	-95.43556
Castlewood Addition Sec 3 & 4	29.91036	-95.34508
Fountainview Sec 1 & 2	29.93362	-95.30870
Mid-Reach Greens Channel Improvements	29.94091	-95.35970
Humble Road Place	29.92338	-95.29134

FN PROJECT NO. SCG17357
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FILE NAME Greens_Bayou_Project_Area_Map
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Greens Bayou Watershed - Project Area Map

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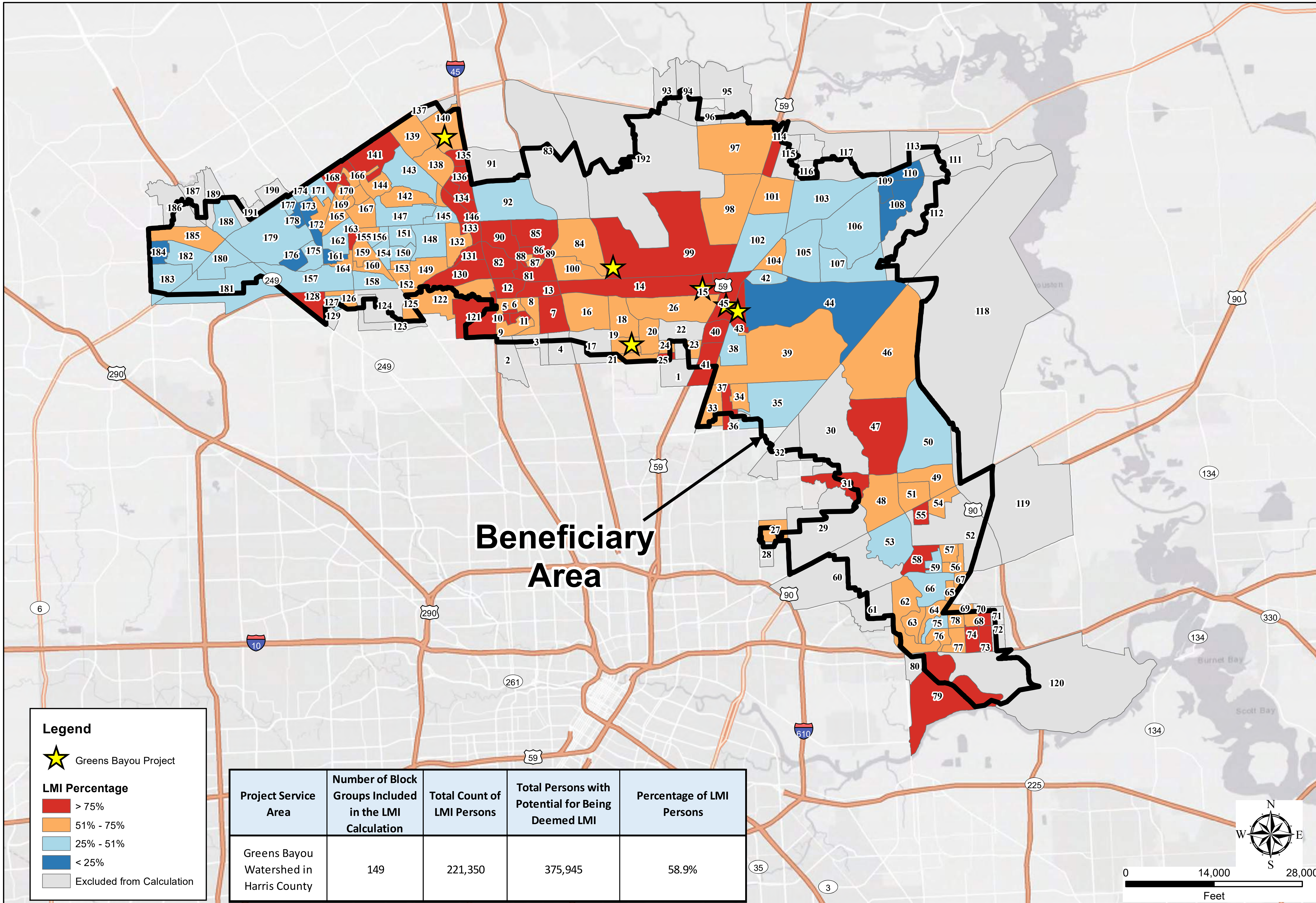

Project Service Area	Number of Block Groups Included in the LMI Calculation	Total Count of LMI Persons	Total Persons with Potential for Being Deemed LMI	Percentage of LMI Persons
Greens Bayou Watershed in Harris County	149	221,350	375,945	58.9%

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Greens Bayou Watershed Beneficiary Area Map

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Greens Bayou Watershed Beneficiary Area Table

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Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
1	482012222001	16	2,030	1%	No	53.6%
2	482012224012	5	1,895	0%	No	76.9%
3	482012224021	1,561	2,971	53%	No	53.9%
4	482012224023	448	2,706	17%	No	82.9%
5	482012225011	2,121	2,121	100%	Yes	95.4%
6	482012225012	2,015	2,015	100%	Yes	63.6%
7	482012225021	1,113	1,113	100%	Yes	82.5%
8	482012225022	2,610	2,610	100%	Yes	59.9%
9	482012225031	1,781	1,781	100%	Yes	73.6%
10	482012225032	2,713	2,713	100%	Yes	99.3%
11	482012225033	3,108	3,108	100%	Yes	82.6%
12	482012226001	2,914	2,914	100%	Yes	83.8%
13	482012226002	2,195	2,195	100%	Yes	94.6%
14	482012227001	3,602	3,602	100%	Yes	80.8%
15	482012227002	2,171	2,171	100%	Yes	88.7%
16	482012228001	1,320	1,320	100%	Yes	59.9%
17	482012228002	750	1,828	41%	No	70.6%
18	482012229001	982	982	100%	Yes	71.2%
19	482012229002	1,019	1,019	100%	Yes	57.5%
20	482012229003	3,309	3,309	100%	Yes	55.5%
21	482012229004	2,013	2,238	90%	Yes	60.1%
22	482012230011	506	3,228	16%	No	73.7%
23	482012230012	1,218	1,237	98%	Yes	70.9%
24	482012230021	1,181	1,721	69%	Yes	63.0%
25	482012230022	1,774	2,149	83%	Yes	92.4%
26	482012231001	2,336	2,336	100%	Yes	67.3%
27	482012309001	840	1,147	73%	Yes	68.9%
28	482012309002	128	956	13%	No	71.8%
29	482012311001	97	1,645	6%	No	94.0%
30	482012312001	1,294	3,126	41%	No	85.8%
31	482012312002	1,424	1,793	79%	Yes	76.2%
32	482012313001	110	1,750	6%	No	83.1%
33	482012318002	1,549	1,858	83%	Yes	65.7%
34	482012319001	2,341	2,341	100%	Yes	52.1%
35	482012319002	2,358	2,509	94%	Yes	32.6%
36	482012319003	598	1,470	41%	No	78.0%
37	482012319004	1,251	1,367	92%	Yes	100.0%
38	482012320001	1,746	1,746	100%	Yes	28.5%
39	482012320002	2,886	2,886	100%	Yes	65.3%
40	482012321001	716	716	100%	Yes	93.3%
41	482012321002	1,807	2,788	65%	Yes	81.9%
42	482012322001	1,953	1,953	100%	Yes	35.0%
43	482012322002	498	498	100%	Yes	93.7%
44	482012322003	12,548	12,548	100%	Yes	22.4%
45	482012322004	2,872	2,872	100%	Yes	85.9%
46	482012323011	4,574	4,574	100%	Yes	51.0%
47	482012323012	5,840	5,840	100%	Yes	86.5%
48	482012323013	1,463	1,463	100%	Yes	62.0%
49	482012323021	2,941	2,941	100%	Yes	52.6%
50	482012323022	7,705	7,705	100%	Yes	40.2%
51	482012323023	1,210	1,210	100%	Yes	67.0%
52	482012324011	2,868	4,984	58%	No	47.9%
53	482012324012	1,300	1,300	100%	Yes	49.5%
54	482012324013	1,065	1,065	100%	Yes	70.8%
55	482012324014	1,589	1,589	100%	Yes	88.3%
56	482012324021	1,876	1,876	100%	Yes	69.3%
57	482012324022	2,170	2,170	100%	Yes	59.4%
58	482012324031	2,735	2,735	100%	Yes	84.1%
59	482012324032	1,967	1,967	100%	Yes	45.5%
60	482012325001	1,877	4,300	44%	No	53.0%
61	482012327011	547	3,915	14%	No	78.6%
62	482012327023	2,404	2,479	97%	Yes	59.1%
63	482012328001	3,108	3,108	100%	Yes	62.6%
64	482012328002	2,583	2,583	100%	Yes	62.8%
65	482012329001	1,715	1,715	100%	Yes	52.1%
66	482012329002	3,354	3,354	100%	Yes	40.9%
67	482012329003	2,101	2,101	100%	Yes	64.8%
68	482012331011	1,112	1,112	100%	Yes	90.9%
69	482012331012	2,061	2,570	80%	Yes	68.5%
70	482012331013	254	744	34%	No	52.4%
71	482012331022	446	2,249	20%	No	79.4%
72	482012331023	976	3,478	28%	No	71.7%
73	482012331031	2,560	2,560	100%	Yes	83.8%
74	482012331032	2,814	2,814	100%	Yes	91.5%
75	482012332001	1,853	1,853	100%	Yes	39.8%
76	482012332002	1,600	1,600	100%	Yes	72.7%
77	482012332003	1,278	1,278	100%	Yes	55.6%
78	482012332004	1,649	1,649	100%	Yes	50.0%
79	482012333001	905	1,020	89%	Yes	77.9%
80	482012333003	305	2,037	15%	No	40.3%
81	482012401001	1,969	1,969	100%	Yes	91.6%
82	482012401002	1,747	1,747	100%	Yes	92.7%
83	482012404001	1,382	4,116	34%	No	33.3%
84	482012404002	3,994	3,994	100%	Yes	69.7%
85	482012405011	4,950	4,950	100%	Yes	90.6%
86	482012405012	1,185	1,185	100%	Yes	89.1%
87	482012405021	1,458	1,458	100%	Yes	74.0%
88	482012405022	2,150	2,150	100%	Yes	73.1%
89	482012405023	2,333	2,333	100%	Yes	100.0%
90	482012406001	2,792	2,792	100%	Yes	94.7%
91	482012407021	0	3,254	0%	No	55.6%
92	482012407022	12,312	12,312	100%	Yes	48.1%
93	482012409011	1,214	3,230	38%	No	32.3%
94	482012409012	4,177	8,629	48%	No	38.9%
95	482012409022	745	8,316	9%	No	34.6%
96	482012409024	26	2,396	1%	No	53.8%
97	482012415001	2,468	2,468	100%	Yes	63.6%
98	482012415002	1,437	1,437	100%	Yes	52.0%
99	482012415003	3,270	3,270	100%	Yes	77.8%
100	482012415004	1,273	1,273	100%	Yes	71.3%
101	482012501001	1,645	1,645	100%	Yes	51.0%
102	482012501002	3,024	3,024	100%	Yes	32.1%
103	482012501003	4,374	4,374	100%	Yes	48.7%
104	482012502001	2,323	2,323	100%	Yes	55.8%
105	482012502002	8,407	8,407	100%	Yes	41.4%
106	482012503011	2,871	2,871	100%	Yes	43.7%
107	482012503012	6,613	6,648	99%	Yes	33.6%
108	482012503021	7,298	7,298	100%	Yes	24.7%
109	482012503022	1,585	1,585	100%	Yes	15.8%
110	482012503023	2,822	2,822	100%	Yes	17.8%
111	482012504011	2,707	10,268	26%	No	19.4%
112	482012504021	7,189	13,373	54%	No	20.4%
113	482012505001	928	3,999	23%	No	32.6%
114	482012506001	2,739	2,739	100%	Yes	86.4%
115	482012506002	73	914	8%	No	60.0%
116	482012506004	298	968	31%	No	76.0%
117	482012506005	0	1,937	0%	No	72.2%
118	482012520001	3,949	13,872	28%	No	13.9%
119	482012522002	1,953	7,723	25%	No	55.5%
120	482012525001	265	876	30%	No	74.9%
121	482015337011	1,531	1,531	100%	Yes	100.0%
122	482015337013	1,579	1,804	88%	Yes	72.9%
123	482015338021	533	1,981	27%	No	73.7%
124	482015338022	2,311	3,874	60%	No	68.9%
125	482015338023	1,586	1,586	100%	Yes	64.3%
126	482015339011	3,538	3,538	100%	Yes	67.1%
127	482015339012	758	1,112	68%	Yes	34.1%
128	482015339021	1,563	1,563	100%	Yes	85.7%
129	482015339022	0	3,198	0%	No	84.3%
130	482015501001	2,902	2,902	100%	Yes	95.1%
131	482015501002	2,554	2,554	100%	Yes	92.3%
132	482015502001	2,276	2,276	100%	Yes	67.9%
133	482015502002	2,138	2,138	100%	Yes	95.7%
134	482015503011	2,661	2,661	100%	Yes	75.5%
135	482015503012	2,448	2,448	100%	Yes	78.8%
136	482015503013	2,719	2,719	100%	Yes	84.8%
137	482015503021	636	2,037	31%	No	45.0%
138	482015503022	3,361	3,361	100%	Yes	71.1%
139	482015503023	2,137	2,137	100%	Yes	68.3%
140	482015503024	3,847	4,723	81%	Yes	55.9%
141	482015504011	6,780	6,780	100%	Yes	75.6%
142	482015504012	3,865	3,865	100%	Yes	71.6%
143	482015504013	1,984	1,984	100%	Yes	31.1%
144	482015504014	2,187	2,187	100%	Yes	60.8%
145	482015504021	2,899	2,899	100%	Yes	44.9%
146	482015504022	2,456	2,456	100%	Yes	77.0%
147	482015504023	6,213	6,213	100%	Yes	26.2%
148	482015505001	3,370	3,370	100%	Yes	46.8%
149	482015505002	3,073	3,073	100%	Yes	71.4%
150	482015506011	2,037	2,037	100%	Yes	45.3%
151	482015506012	5,024	5,024	100%	Yes	41.7%
152	482015506021	1,911	1,911	100%	Yes	62.3%
153	482015506022	1,249	1,249	100%	Yes	63.6%
154	482015506031	1,222	1,222	100%	Yes	43.9%
155	482015506032	2,966	2,966	100%	Yes	60.9%
156	482015506033	2,218	2,218	100%	Yes	44.9%
157	482015507001	2,330	2,330	100%	Yes	36.3%
158	482015507002	1,562	1,562	100%	Yes	42.3%
159	482015508001	1,178	1,178	100%	Yes	58.9%
160	482015508002	2,491	2,491	100%	Yes	63.5%
161	482015509001	1,808	1,808	100%	Yes	23.9%
162	482015509002	3,962	3,962	100%	Yes	42.5%
163	482015509003	2,023	2,023	100%	Yes	79.4%
164	482015509004	1,986	1,986	100%	Yes	55.2%
165	482015510001	3,908	3,908	100%	Yes	65.1%
166	482015511001	2,062	2,062	100%	Yes	61.5%
167	482015511002	2,729	2,729	100%	Yes	56.9%
168	482015511003	2,729	2,729	100%	Yes	76.6%
169	482015511004	1,249	1,249	100%	Yes	52.2%
170	482015511005	2,125	2,125	100%	Yes	59.8%
171	482015512001	2,918	2,918	100%	Yes	46.2%
172	482015512002	1,132	1,132	100%	Yes	59.7%
173	482015512003	2,367	2,367	100%	Yes	21.6%
174	482015512004	1,301	1,301	100%	Yes	43.2%
175	482015513001	2,404	2,404	100%	Yes	43.9%
176	482015513002	2,030	2,030	100%	Yes	6.3%
177	482015514001	960	960	100%	Yes	25.6%
178	482015514002	1,595	1,595	100%	Yes	24.4%
179	482015514003	2,575	2,575	100%	Yes	48.9%
180	482015515001	3,000	3,000	100%	Yes	42.7%
181	482015515002	3,823	5,775	66%	Yes	38.6%
182	482015525001	5,416	5,416	100%	Yes	36.5%
183	482015525002	3,816	3,816	100%	Yes	37.2%
184	482015525003	2,246	2,246	100%	Yes	18.5%
185	482015526011	5,959	5,959	100%	Yes	52.8%
186	482015526021	1,269	4,923	26%	No	40.9%
187	482015527001	378	2,603	15%	No	38.2%
188	482015527002	2,823	2,823	100%	Yes	32.3%
189	482015527003	458	3,194	14%	No	49.9%
190	482015528002	39	561	7%	No	7.2%
191	482015528003	1,422	2,979	48%	No	33.1%
192	482019801001	0	154	0%	No	94.0%

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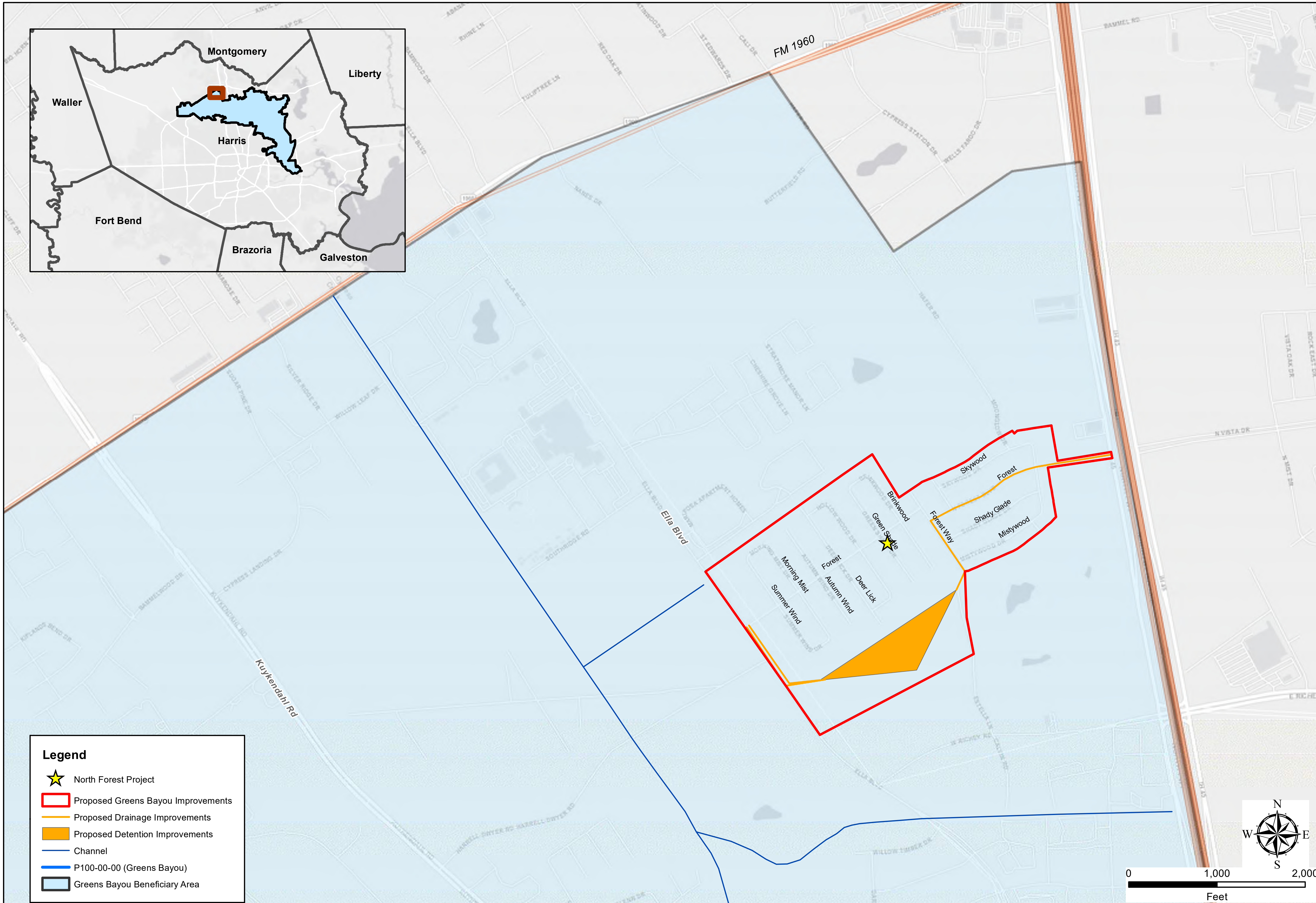

FN PROJECT NO.	SCG17357
DATE CREATED	10/21/2020
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Greens_North_Forest_Benefit_Area_Map
PREPARED BY	AMJ

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Greens Bayou Watershed - Project North Forest

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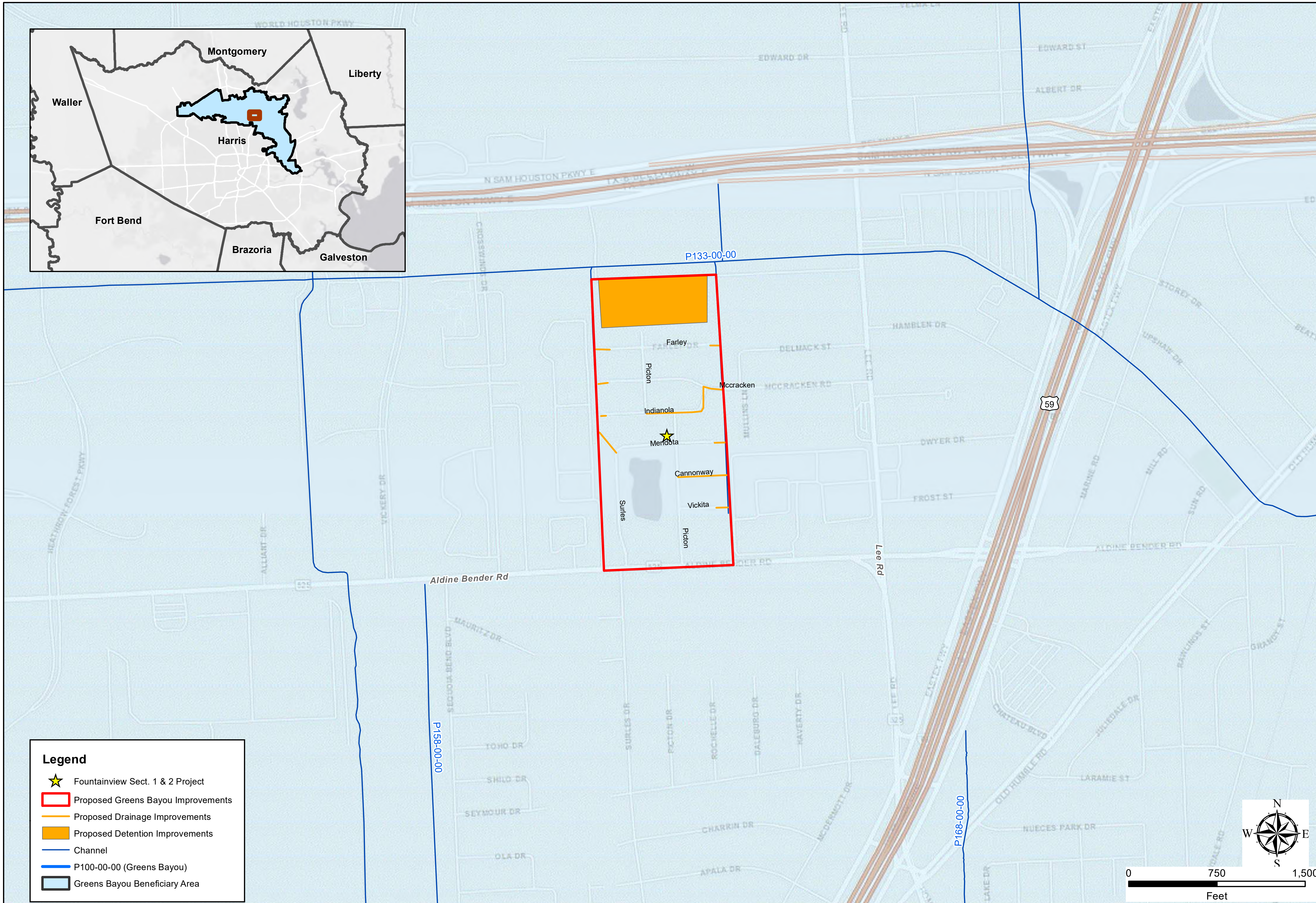

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FILE NAME Greens_Foutainview1_2_Benefit_Area_Map
PREPARED BY AMJ

STUART CONSULTING GROUP
CDBG-MIT

Greens Bayou Watershed - Project Fountainview Sect. 1 & 2

FREESE NICHOLS
STUART CONSULTING GROUP

EXHIBIT
4

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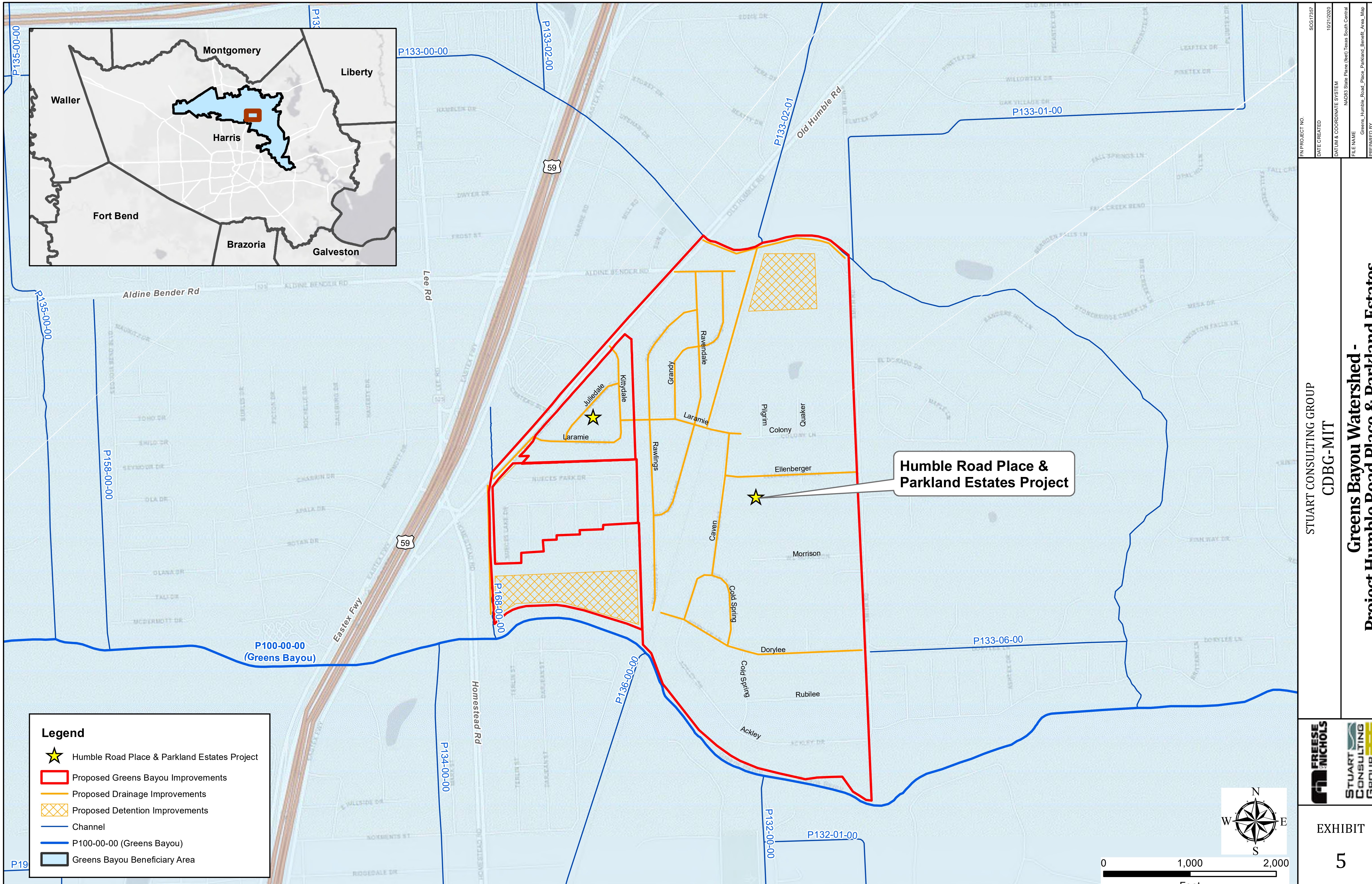

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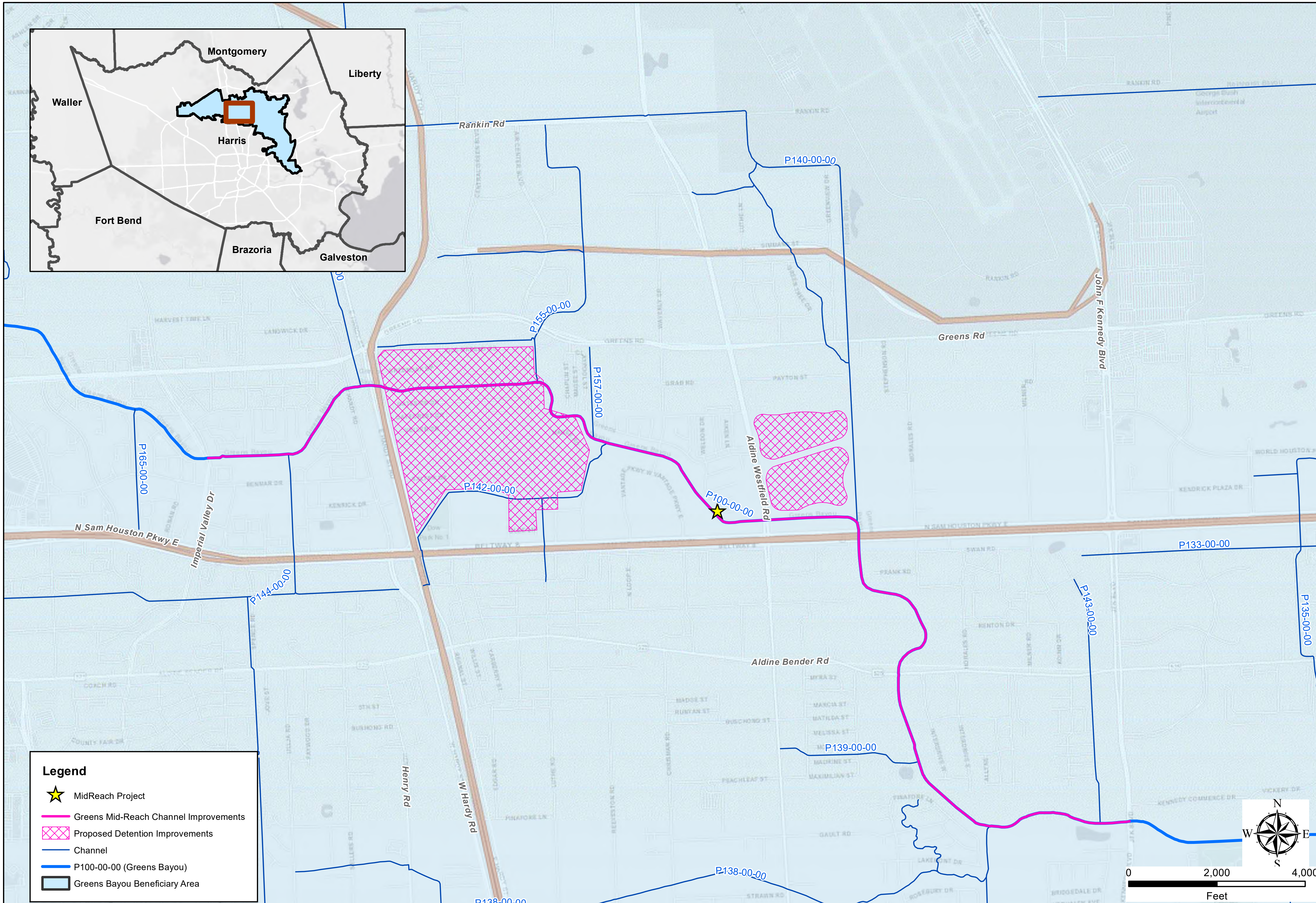

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DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Greens_Aldine_Westfield_Benefit_Area_Map
PREPARED BY AMJ

STUART CONSULTING GROUP

CDBG-MIT

Greens Bayou Watershed - Project Greens Mid-Reach Improvements

EXHIBIT

6

North Forest Subdivision Drainage Improvements

Harris County Precinct 1

Houston, Texas

Prepared for

by

Isani Consultants, LP
3143 Yellowstone Blvd
Houston, Texas 77054

STATE OF TEXAS
SATYA MURALI KRISHNA VEGI DAMODARA VARAHA NARASIMHA
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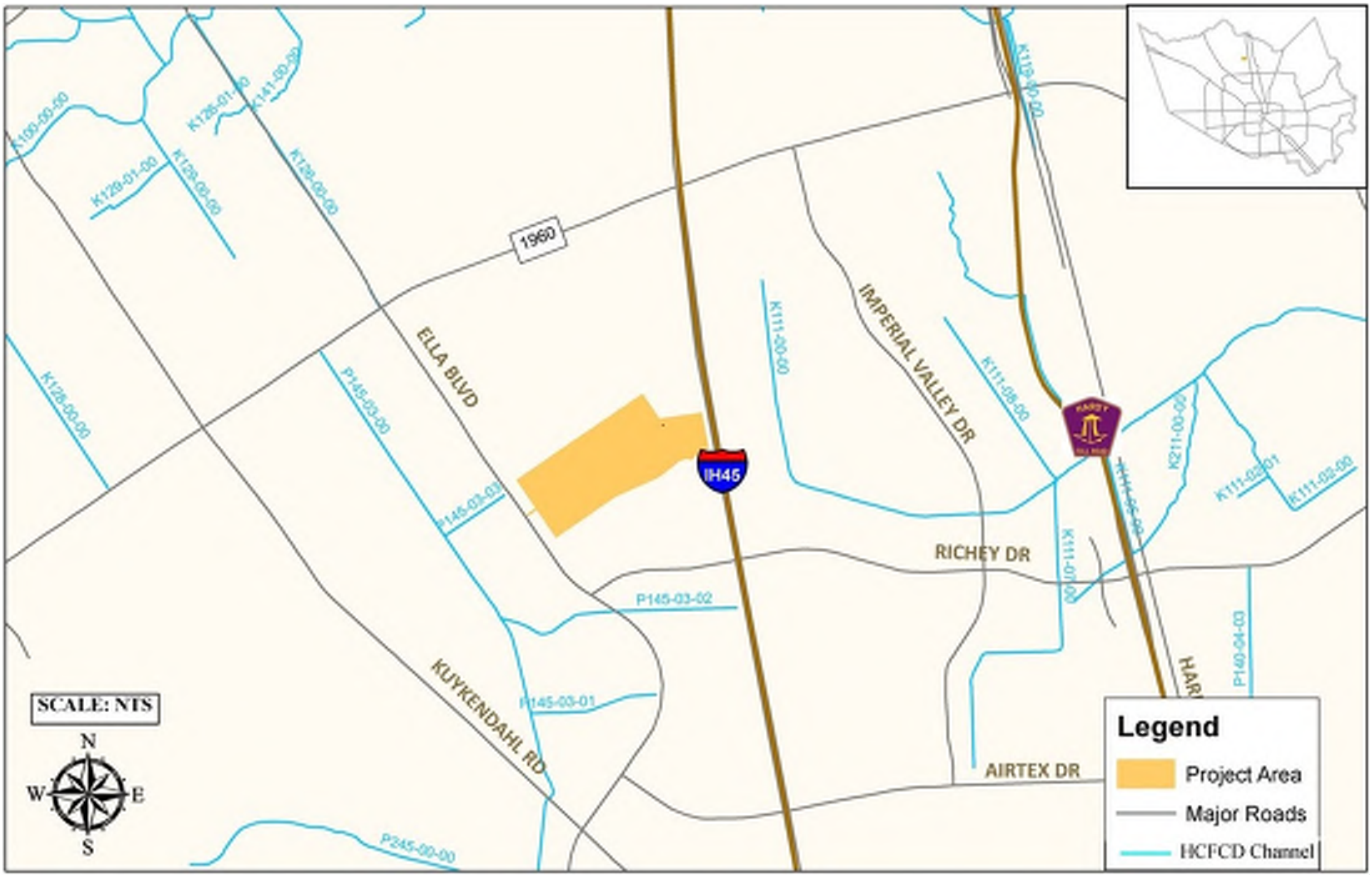


KEY MAP NOS. 332 S & T

HARRIS COUNTY
PRECINCT 1

TABLE OF CONTENTS

1.0 EXISTING CONDITIONS ANALYSIS:

a. Summary of Drainage Issues/Analysis of Problem

The North Forest subdivision is located within the Greens Bayou watershed. Only a small downstream portion of the study area was located within 500-year floodplain. However, about 30 homes within the subdivision experienced some form of flood damage during Hurricane Harvey in August 2017.

The drainage analysis was performed for a 500-year storm event or 0.2% Annual Exceedance Probability (AEP), as per directions provided by the County. However, it should be noted that rainfall amounts received during Hurricane Harvey was believed to be closer to a 1000-year event (0.1% AEP).

The drainage analysis within the subdivision focused on a scenario where the existing storm sewer system within the public ROW was in a surcharged state during an extreme storm event, and its ability to safely convey the storm water runoff to the receiving stream during an extreme storm event was compromised due to the high tailwater elevation at the outfall. The drainage analysis for the subdivision and the flow from the surrounding off-site areas was performed using a general approach with a Storm Water Management Model (XP-Storm 2018.2) program. The system capacity was analyzed using the 24-hour, 0.2% AEP rainfall depth of 18.9 inches for the Greens Bayou watershed, as specified in the HCFCD Policy Criteria & Procedure Manual (PCPM) October 2018 Version Section 3.6. This value is higher than the 24-hour, 1% AEP rainfall depth of 16.7 inches obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14-point precipitation value estimated at the subdivision as well as the peak 24-hour, 15.84 inches of rainfall recorded during Hurricane Harvey at the closest rain gage along Kuykendahl Road at Cypress Creek.

The analysis appears to support the conclusion that, during extreme storm events, the storm sewer system along Ella Blvd, N Forest Boulevard and other streets within the North Forest subdivision will backup and surcharge will spill out onto the streets. With inadequate flow paths to accommodate the extreme storm event runoff and relatively flat topography in the area, water will pond within the subdivision, with depths exceeding three (3) feet near the eastern and southeastern parts of the subdivision.

b. Drainage System – Conditions/Impacts

The existing storm sewer system outfalls into HCFCD Channel Unit No. P145-03-03 and finally to Cypress Creek Channel Unit No. P145-03-00, Tributary 1.95 to North Fork Greens Bayou. The existing trunk sewer consists of RCP segments ranging from 42” to 84” in diameter along with different types of inlets, manholes and junction boxes and finally out falling into the channel with a 90-inch RCP. The lateral storm sewers connecting to the trunk line comprises of RCPs ranging from 24” to 36” in diameter. Based on the analysis, the existing storm sewers draining to the trunk sewer appear to have been designed for up to a 10-year storm event (10% AEP). However, the receiving channel P145-03-03 has limitations to accommodate any excess flows. Exhibit 2 shows the existing storm sewer layout within the project limits, based off County record drawings.

The existing drainage system does not have sufficient storage capacity to accommodate excess flows during extreme storm events resulting in flooding of the subdivision, especially in the eastern and southeastern part of the subdivision and the upstream ends of several side streets. A depth grid map showing flooding within the subdivision for a 500-year storm event (0.2% AEP) is indicated in Exhibit 10. According to data obtained from the Harris County, about 30 properties within the subdivision flooded during Hurricane Harvey and the area generally floods during extreme storm events. Elevation information from LIDAR data (2008 LiDAR) and latest satellite imagery (2016 National Agriculture Imagery Program) indicated that the subdivision is slightly higher than the surrounding areas. However, according to feedback received from residents during the public meeting, there appears to be substantial off-site flows into the subdivision based on recent developments in some adjacent areas.

c. Water – Conditions/Impacts

The North Forest subdivision is served by an existing water distribution system that is owned and operated by the Harris County North Forest Municipal Utility District. According to record drawings obtained from the Harris County, existing 6”, 8” and 12” waterlines are present along the streets within the project limits. The main trunk line comprises of an 8” water line running along N Forest Blvd from the intersection with Ella Blvd up to the intersection with Forest Way Drive, a 12” water line along N Forest Blvd from Forest Way Drive up to Mistywood Drive and then an 8” water line again up to IH-45. This existing 8-inch diameter water line along N Forest Blvd connects to an existing 16-inch water line along Ella Blvd. Most of the waterline appears to be located within the street rights-of-way (see Exhibit 3 for overall existing water line layout).

The waterline alignments have the potential to conflict with any recommended storm sewer system modifications, as many of these lines are believed to be located adjacent to and/or cross the storm sewer. However, any potential conflicts may be overcome by adjustments to the profile of the waterline.

d. Sewer – Conditions/Impacts

The North Forest subdivision is served by an existing sanitary sewer collection system that is owned and operated by the Harris County North Forest Municipal Utility District. The size of the sanitary sewer lines within the subdivision range from 6” to 15” in diameter, according to record drawings obtained from the Harris County. The main trunk line comprises of sanitary sewer segments ranging from 10-inches to 15-inches along N Forest Blvd from the intersection with Ella Blvd up to the intersection with Forest Way Drive and then segments of 8 and 10 inches along N Forest Blvd up to IH-45. The laterals to this trunk sewer range from 6 to 8 inches diameter running through both the street rights-of-way and backlots. Most of the sanitary sewer lines are located along property backlots (see Exhibit 4 for overall existing sewer layout). The sanitary sewer system appears to present some potential for conflict with proposed storm sewer modifications that may be constructed. This will be evaluated in detail during the design phase.

e. Electric – Conditions/Impacts

Homes within the North Forest subdivision are served by underground electric cables that are believed to be located within the street rights-of-way. Power poles are located within street rights-of-way, with alignments that appear to be adjacent and parallel to other public infrastructure. Hence, any proposed work within the subdivision would entail close coordination due to the presence of multiple utilities.

f. Oil/Gas – Conditions/Impacts

There is an existing 6-inch Energy Transfer pipeline (NG) and two gas storage wells owned by Houston Pipeline (HPL) & Cathexis Oil & Gas, LLC. within the project limits. Aerial image captured from Railroad Commission of Texas is shown in Exhibit 5. Due to the presence of such facilities, Environmental Site Assessment studies may have to be performed during the design phase to evaluate environmental conditions and potential impacts.

g. Telecommunications – Conditions/Impacts

Based on field observations, it appears that telecommunication service is provided to homes along the property backlots. It is therefore anticipated that these telecommunication facilities would have very minimal potential for conflicts with proposed improvements on the existing storm system.

h. General Descriptions of Locations

The study area generally consists of single-family residential homes that were constructed in the late 1960's to early 1970's and is maintained by the North Forest Municipal Utility District. The project area is in Harris County Precinct 1, Greens Bayou Watershed, west of IH-45 (North Freeway).

The existing storm sewer system was originally designed for a 3-year storm event (33% AEP). About 30 properties in the subdivision got flooded during Hurricane Harvey as the existing drainage including both the underground storm sewers as well as overland flow paths exhibited limited capacity in storing flows during the extreme storm event.

The overall existing storm sewer system and outfall location for the subdivision is shown in Exhibit 2. No storm sewer profile data was available for the project area except for the outfall and storm sewers along Ella Blvd. Flowlines for the storm sewers were estimated based on an assumed uniform 0.08% slope for modeling purposes.

The existing drainage infrastructure primarily consists of underground storm sewers located within the street rights-of-way. Most of the streets within the subdivision route the runoff through inlets, storm sewers and overland flow along the streets. However, on Skywood Drive, Shady Glade Drive and Mistywood Drive, most of the drainage is routed via overland flows before being routed through inlets and storm laterals at the ends of each of these streets.

The properties that reported flood damages resulting from Hurricane Harvey were predominantly concentrated in the southeastern part of the subdivision and at the upstream ends of side streets that drain into the main trunk sewer. The largest number of structures reporting flood damage were located along Mistywood Drive and Forest Way Drive. Some of these structures have also recorded repetitive flood damages resulting from other storm events.

i. Other Issues

Based on Housing and Urban Development (HUD) census data, the study area is not considered to be classified as Low to Moderate Income (LMI), with the residents representing less than 50% of the LMI classification (see Exhibit 6). However, the area adjacent to and just west of the project limits has been identified as having residents that represent more than 50% of the LMI classification. Thus, it should be noted that project having limits within this area is eligible for LMI funding.

Close coordination will also be needed with Harris County Flood Control District (HCFCD) which owns and operates Channel Unit No. P145-03-03 which acts as the outfall location for the overall drainage system. Currently, impacts of the proposed improvements on trees and general landscaping within the subdivision appear minimal.

2.0 DESCRIPTION OF PROBLEM(S):

a. Damage Caused by Flooding

Data obtained from Harris County indicates that several homes within the subdivision experienced flood damage during Hurricane Harvey in August 2017. This could be attributed to several factors including insufficient inlet capacities, storm sewer system not being able to convey or detain extreme event flows and limitations on excess flows to receiving channel at outfall location.

b. Repetitive Loss Analysis (Structures Flooded Multiple Times)

Data obtained from Harris County also seemed to indicate that several properties within the subdivision have also reported flood damages from several past storm/flooding events. Two (2) properties have reported repetitive flood losses within this subdivision. Based on the location of these properties, it is believed that the flooding may have been caused by relatively flat topography of the area and inadequate inlets along the respective streets (along Shady Glade Drive and Mistywood Drive), thus causing water to back up overland and out of the streets into adjacent properties. It should be noted that the property along Mistywood Drive has since been bought out by HCFCD. In addition to the flooding recorded during Hurricane Harvey, flood damages were also reported for one (1) property within the subdivision due to the Tax Day flood event in April 2016.

c. Structures Flooded

During the Hurricane Harvey flood event of August 2017, thirty (30) homes reported some amount of flood damage resulting from flooding in the subdivision streets. The average depth of flooding in the homes was not readily available from existing data, but it is believed that it was generally about 1 to 2 feet with the southeastern part of the subdivision experiencing relatively more flooding with depths exceeding 3 feet. Within the subdivision, the average height of the finished floor is approximately 2 feet above the top of curb elevation of the street.

d. Issues with Access

No reported data was available that could provide information regarding access in or out of the subdivision during the flooding events. However, based on the existing pavement grades and Hydrologic and Hydraulic (H&H) analysis of the existing storm sewer system, it is believed that access was severely impacted during the flooding events. Feedback from residents during the Public Meeting also seemed to confirm this accessibility issue. The depth of flooding within the streets is believed to have exceeded 1.5 feet on an average, and more than three (3) feet at some locations.

e. Existing Drainage Infrastructure

The North Forest subdivision is located within the Greens Bayou watershed. As stated earlier, only a small downstream portion of the study area was found to be located within the 500-year floodplain. The floodplain map has been shown on Exhibit 8. Storm water runoff from the subdivision is served by the HCFCD Channel Unit No. P145-03-03 which then outfalls into Cypress Creek Channel (HCFCD Unit No. P145-03-00), Tributary 1.95 to North Fork Greens Bayou. The trunk sewer consists of RCP segments with sizes from 42” to 84” in diameter and finally out falling to the channel with a 90-inch RCP. The lateral storm sewers connecting to the trunk line comprises of RCPs with sizes from 24” to 36” in diameter. The existing storm sewers draining to the trunk sewer appear to have adequate capacity for up to a 10-year storm event (10% AEP).

The topography within the subdivision is generally flat, with elevation differences of approximately 2.5 feet, sloping from northeast to southwest. Historically, prior to development of the area, the storm water runoff from the area would drain in a west-southwest direction and contribute flows to the P145-03-00 channel. With the development of the subdivision and construction of the P145-03-03 channel, the storm water runoff is now intercepted but still generally flows in the southwest direction towards the P145-03-00 channel.

The overall drainage pattern within the subdivision comprises of collection of storm water runoff within the streets, from where it flows to curb inlets and subsequently into the underground storm sewers under the streets. The flows from the side streets is routed into the trunk sewer along N Forest Blvd which crosses Ella Blvd and finally outfalls into HCFCD Channel Unit No. P145-03-03.

During extreme storm events, the storm sewer system (designed for up to a 10-year storm event) is surcharged, thus limiting the capacity of the system to receive and store any further increase in runoff. Consequently, surcharged storm water spills out of the underground storm sewer system and start ponding in the neighborhood streets. The upstream ends of many of the side streets (Summer Wind Drive, Morning Mist Drive, Autumn Wind Drive, Deer Lick Drive, Hollow Wood Drive, Green Shade Drive, Brinkwood Drive and Forest Way Drive) as well as streets in the southeastern part of the subdivision (Shady Glade Drive and Mistywood Drive) have minimal drainage infrastructure to accommodate this runoff. During extreme storm events, the existing drainage infrastructure is overloaded with the volume of storm water runoff leading to excessive depth of ponding in the streets especially on streets with inadequate/insufficient storage capacities. Flat topography on such streets further aggravate the ponding which extend up to the finished floor elevations of some permanent structures in the vicinity.

f. Other Contributing Factors

An inlet capacity analyses was performed on the existing storm sewer system within the subdivision using the HouStorm program. Twenty (20) inlets within the subdivision were found to have insufficient capacity to carry the 2-year storm event (50% AEP) and seventeen (17) of these indicated ponding widths that exceeded the allowable width. Most of these inlets are located near the upstream ends of the side streets and incorporate a large concentration of overland flow along the streets. These inlets have been shown on Exhibit 9.

3.0 ANALYSIS AND PROPOSED SOLUTION:

a. Approach

Based on the field observations and review of the available data, it was inferred that the likely reasons for the flooding experienced within the subdivision were a combination of various factors such as inadequacy of the existing drainage system to store the storm water runoff arising from extreme storm events to the receiving channel, inadequate and undersized inlets and relatively flat topography of the area. Various design alternatives and their feasibilities were considered in order to mitigate the flooding issues that were encountered within the North Forest subdivision. This included upsizing the existing storm sewer system within the subdivision up to the outfall channel, upgrading existing inlets, providing additional inlets to take in the overland flow through the streets as well as providing additional surface detention to provide relief to the overloaded trunk sewer.

By performing a drainage analysis and preparing preliminary construction cost estimates for each alternative, it was determined that a combination of design options such as detention ponds, connected storm sewers as well as additional inlet capacities is the most effective approach to mitigate the extreme storm event runoff.

b. Methodology Used for Analysis

A general hydrologic and hydraulic model of the existing drainage system within the subdivision was prepared using a Storm Water Management Model (XP-Storm 2018.2) computer program. This program has the capability to transform rainfall into storm water runoff hydrographs and route the flows through the storm sewer system and also through a 2D grid surface superimposed on each drainage area, thus accounting for both overland flow paths and overall storage within the entire watershed.

It must be pointed out here that available record drawings were limited to storm sewer plan and profiles for the outfall and Ella Blvd and an overall layout of the existing storm sewers within the subdivision. Since the existing storm sewer profile within the subdivision area was unavailable, flowline elevations for the storm sewers were back calculated from the flow line at the outfall pipe, assuming a constant slope (0.08%) for the storm sewers. Rim elevations for the manholes and inlets were obtained from LIDAR data (2008). Percent imperviousness and time of concentration were then calculated for each sub-drainage area. These parameters for each sub- drainage area were determined based on topographic data, land use, and drainage area. Site runoff curves were then used to estimate peak flows from each sub-drainage area. From the HCFCD H&H Manual, the cumulative rainfall amounts were identified for a 24-hour, 0.2% AEP storm event that results in a total precipitation depth of 18.9 inches (total precipitation depth derived from HCFCD PCPM October 2018 Version Section 3.6). This value is higher than the 24-hour, 1% annual chance rainfall depth of 16.7 inches obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14-point precipitation value estimated at the subdivision and hence is a conservative estimate. Infiltration throughout the storm event is simulated using the Green and Ampt method, with the suction head, conductivity and initial deficit values obtained from those used in the Federal Emergency Management Agency (FEMA) effective hydrologic model of the Greens Bayou watershed. The hydrograph information thus obtained from HEC-HMS for each such catchment was then imported into the XP-Storm program. Runoff from individual sub-catchments were routed to appropriate storm sewer nodes representing general inlet locations.

To simulate approximate conditions that occurred during Hurricane Harvey, a tailwater elevation in the P145-03-03 channel at the outfall pipe location was set equivalent to that of the 1% annual chance flood elevation near the outfall. The P145-03-03 channel was not included in the drainage analysis.

An XP-Storm model showing analysis of existing conditions was built to establish baseline conditions with regards to flooding within the subdivision and for comparison with proposed design alternatives. Based on results from this model, it was concluded that increasing the capacity of the underground storm sewer system would not provide the required solution to alleviate flooding concerns without incorporating additional surface detention for the excess runoff from the neighborhood. Hence, the focus of the recommended solution was to provide enough detention to provide relief to the surcharged storm sewer system within the subdivision that will allow for controlled release of runoff towards the P145-03-03 channel. The XP-Storm model for existing conditions was thus modified to reflect a proposed condition incorporating a detention pond that accommodates such extreme storm event runoff.

c. Results of Analysis

The XP-Storm analysis of existing conditions appears to confirm the belief that the flooding within the subdivision during extreme storm events are primarily due to inadequate capacity of the existing underground storm sewer and overland drainage system to store and safely convey storm water runoff to the receiving channel. The analysis suggests that under existing conditions for an extreme storm event, the depth of flooding in the street at the southeastern part of the subdivision (Forest Way Drive and Mistywood Drive) is as much as three (3) feet. Flood depths along other streets within the subdivision are slightly less but still significant especially at the upstream ends of the side streets. See Exhibit 10 for a 2D flooding map of the project area under existing conditions for a 500-year storm event (0.2% AEP).

Based on recorded data for the number of flooded properties, the heaviest concentration of flooding occurrences has been for properties located along Mistywood Drive just to the east of the intersection with Forest Way Drive in the southeastern part of the subdivision. The XP-Storm analysis also seems to support these findings, with the overall ponding elevations ranging from two (2) to three (3) feet.

An analysis of the proposed conditions that incorporate the recommended design improvements seemed to suggest that the depth of flooding within the subdivision can be reduced by as much as 0.1 - 1.0 feet (with an average reduction of 0.5 feet). This reduction in the depth of flooding is believed to be adequate to restrict flooding within the ROW and ensure that existing structures/properties within the subdivision are protected from flooding risks due to future extreme storm events (see Exhibit 14 for depth grid map for the proposed condition).

d. Proposed Solutions/Recommended Approach to Improving Drainage

Three potential alternatives for improving drainage within the project limits were identified and analyzed. These alternatives are summarized below and also indicated on Exhibits 11 through 17:

1) Constructing two (2) detention ponds to store the excess extreme event runoff from the subdivision before discharging them into the P145-03-03 channel. Detention Pond 1 is to the southeast of the subdivision and accommodates flow from the eastern part of the subdivision via proposed 60-inch RCP storm sewer under N Forest Blvd and Forest Way Drive. The pond is spread over an area of 5.54 acres. The outlet pipe is a 66-inch RCP storm sewer that continues along Deer Lick Drive and connects to the existing trunk sewer (dual 66-inch pipes) at the intersection of Deer Lick Drive and N Forest Blvd. Detention Pond 2 is to the west of the subdivision, across Ella Blvd and alongside the P145-03-03 channel where the drainage finally outfalls. This accommodates runoff from the western part of the subdivision as well as the controlled release from Detention Pond 1 via the existing trunk sewer along N Forest Blvd. The pond occupies a total area of 14.45 acres. One significant factor to consider is that the site for the proposed Detention Pond 2 falls under the LMI Target Area (Above 50% of the population below median income). This may open the door for funding opportunities for the project. However, this alternative was found to be quite expensive, especially with regards to real estate acquisition. Preliminary cost estimates for this option was approximately $5.78 Million for construction and $13.56 Million towards real estate acquisition. Exhibit 11 indicates these proposed improvements while Exhibit 12 indicates the resulting depth grid maps.

2) Constructing a detention pond to store the excess extreme event runoff from the subdivision before discharging them into the P145-03-03 channel. This detention pond (110 Ac-Ft) is to the southeast of the subdivision and accommodates flow from the eastern part of the subdivision via proposed 60-inch RCP storm along N Forest Blvd from N Freeway Service Road to Forest Way Drive and along Forest Way Drive. The pond is spread over 12.32 acres. The average depth of the pond will be eight (8) feet and the pilot channel would have a minimum slope of 0.01%. The outlet pipes are dual 66-inch RCPs that continue towards and then along Ella Blvd and connect to the existing trunk sewer (dual 66-inch pipes) at the intersection of Ella Blvd and N Forest Blvd. Exhibit 13 indicates the proposed improvements while Exhibit 14 indicates the depth grid maps. Preliminary cost estimates for this alternative was approximately $6.19 Million for construction and $5.48 Million towards real estate acquisition.

3) Another alternative was analyzed keeping the storm pipe and detention pond configuration similar to Alternative 2 along with the removal of the 66-inch storm sewer along Forest Way Drive between N

Forest Blvd (E) and N Forest Blvd (W) that would divert runoff from the eastern part of the subdivision entirely into the detention pond than into the main trunk sewer. This alternative had the same pipe configuration for the outfall pipe as Alternative 2. Although the construction cost was marginally higher than Alternative 2 at approximately $6.20 Million, the extent of flooding on the streets was found to be greater than Alternative 2 with this approach.

After reviewing the results for all the three alternatives, it was concluded that Alternative 2 would provide the best solution for improving drainage within the subdivision and hence would be the recommended alternative. The other two alternatives were found to be either too expensive or less effective than the recommended alternative in reducing extreme event flooding within the subdivision. Construction of these recommended improvements require acquisition of two (2) parcels (see Exhibit 15) as well as a drainage easement from one private property for the 60-inch pipe out falling into the Detention Pond for ease of access and maintenance. The flooding map for the subdivision with these proposed improvements have been indicated in Exhibit 14. As shown in this exhibit, the flooding within the subdivision has been reduced and contained within the ROW with these improvements. A comparison of maximum water surface elevations under existing and the proposed conditions have been tabulated below:

Comparison of 0.2% Annual Chance Storm Hydraulic Analysis Results (ft)
Proposed Solution vs Existing Conditions

Location	EXISTING		PROPOSED		DIFF
	WSEL	DEPTH*	WSEL	DEPTH*	
Summer Wind Dr at Morning Mist Dr (N)	105.25	1.01	105.15	1.03	-0.10
Summer Wind Dr at Morning Mist Dr (S)	105.12	1.66	105.06	1.46	-0.20
North Arm of Autumn Wind Dr	105.53	1.99	105.11	1.41	-0.58
South Arm of Autumn Wind Dr	105.53	2.01	105.11	1.45	-0.56
North Arm of Hollow Wind Dr	105.90	1.71	105.50	1.37	-0.34
South Arm of Hollow Wind Dr	105.90	2.13	105.48	1.59	-0.54
North Arm of Brinkwood Dr	106.11	1.86	105.74	1.50	-0.36
South Arm of Brinkwood Dr	106.11	2.96	105.75	2.63	-0.33
Northwest Corner of Forest Way Dr	106.47	1.73	106.41	1.76	-0.06
Forest Way Dr at Shady Glade Dr	106.10	2.52	105.51	2.10	-0.42
Forest Way Dr at Mistywood Dr	105.99	2.96	105.39	2.32	-0.64
N Forest Blvd at Morning Shade Dr	107.14	2.78	106.94	2.64	-0.14
N Forest Blvd at Mistywood Dr	106.41	2.20	106.29	2.12	-0.08
Morning Shade Dr at Skywood Dr	106.42	2.18	106.29	2.18	-0.13
Skywood Dr at Hafer Rd	106.44	2.52	106.32	2.51	-0.12
N Forest Blvd at N Fwy Service Rd	106.44	2.87	106.35	2.75	-0.12
North Arm of Deer Lick Dr	105.76	1.41	105.22	0.82	-0.59
South Arm of Deer Lick Dr	105.76	2.59	105.22	1.81	-0.78
N Forest Blvd at Ella Blvd	105.22	0.10	105.21	0.09	-0.01

* Depth of ponding above street elevation

It should be noted that these results have been derived from record drawings. The model results and cost estimates need to be further refined with information obtained from topographic survey as well as utilities.

e. Project Cost

The total project cost for the recommended solution was estimated. This cost estimate includes construction, land acquisition and engineering design costs.

Project Cost Estimate for Recommended Solution

Item No.	Item Description	Quantity	Unit of Measurement	Unit Price	Total Price
1	Remove and Dispose of Existing 24" Storm Pipe All Types	560	LF	$15.00	$8,400.00
2	Remove and Dispose of Existing 42" Storm Pipe All Types	790	LF	$30.00	$23,700.00
3	Remove and Dispose of Existing 54" Storm Pipe All Types	1130	LF	$40.00	$45,200.00
4	Removing and disposing of Concrete pavements (all thickness, w/ or w/o Asphalt, including base & subgrade, w/ or w/o curb, all depths)	3800	SY	$7.00	$26,600.00
5	Concrete pavement (all thickness, including reinforcement, Asphaltic surfacing, base & subgrade)	3800	SY	$58.00	$220,400.00
6	Curb Inlets (All Types)	30	EA	$1,200.00	$36,000.00
7	60-inch RCP	3058	LF	$350.00	$1,070,300.00
8	66-inch RCP	2800	LF	$360.00	$1,008,000.00
9	Type 'C' Manhole for 48-inch Diameter and Larger Storm Sewers (up to 8' Depth)	15	EA	$6,000.00	$90,000.00
10	Storm Junction Box (Cast in place or Precast)	3	EA	$10,000.00	$30,000.00
11	Detention Pond (Dry)	110	AC-FT	$20,000.00	$2,200,000.00
12	Mobilization (5%)				$237,330.00
13	Contingencies (25%)				$1,186,650.00
	Total Construction Costs				**$6,186,180.00**
14	Land Acquisition	913,272	SF	$6.00	$5,479,632.00
15	Closing Documentation	5	EA	$3,000.00	$15,000.00
16	Appraisals	5	EA	$1,000.00	$5,000.00
	Total Acquisition Costs				**$5,499,632.00**
17	Engineering Study	1	LS	$122,000.00	$122,000.00
18	Design Survey	1	LS	$48,000.00	$48,000.00
19	Engineering Design	1	LS	$375,000.00	$375,000.00
	Total Engineering Costs				**$545,000.00**
	Total Project Cost				**$12,230,812.00**

4.0 PUBLIC COMMENT:

A community engagement meeting was held to coordinate the results of the study with the community and to solicit comments/input for the planned approach for improving drainage within the subdivision. The following provides details concerning the meeting:

Meeting Data: April 15, 2019

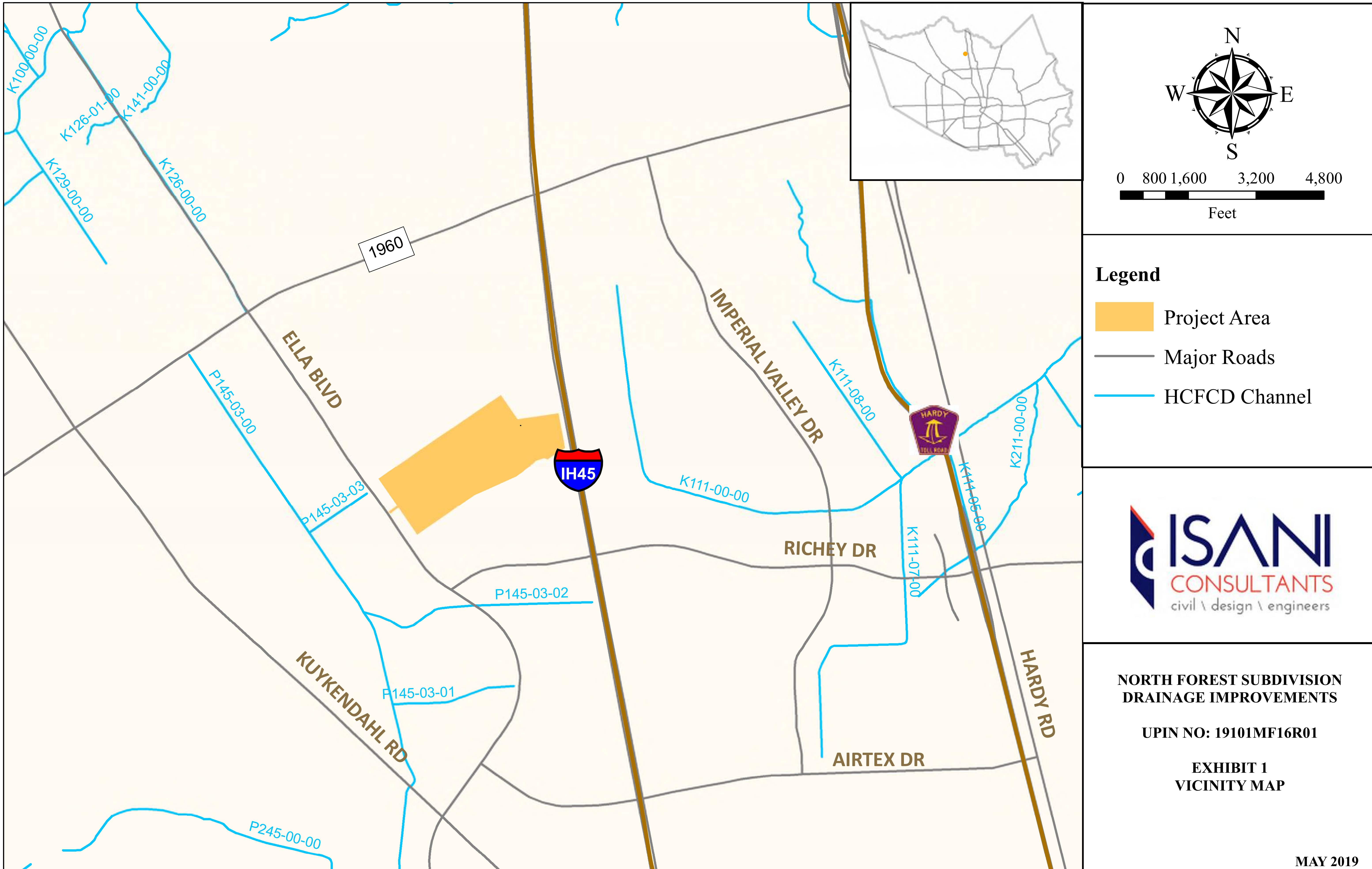
Meeting Start/End Time: 6:30 p.m. – 8:00 p.m.

Meeting Location: Westfield High School
16713 Ella Blvd
Houston, TX 77090

Opening remarks were provided by Marcus Baskin, P.E., providing an overview of the Bond program, information about the Harris County Engineering Department lifecycle, and the final deliverables that will be yielded as a result of the bond project. Project specific information was presented by Murali Vegi, P.E. with Isani Consultants, LP, and closing remarks were provided by the Harris County Engineering Department.

Different comments and concerns were received from the community which included frequent flooding issues for even smaller rain events, off-site flows from adjacent lots in the southeast and northeast areas, accessibility issues at the entry and exit points to the subdivision and waist high ponding depths at certain areas in the subdivision. These comments, and subsequent responses to them have been summarized and presented in Appendix A of this assessment document. Flooding photos provided by residents during the public meeting have also been attached to Appendix B for review and consideration.

EXHIBITS

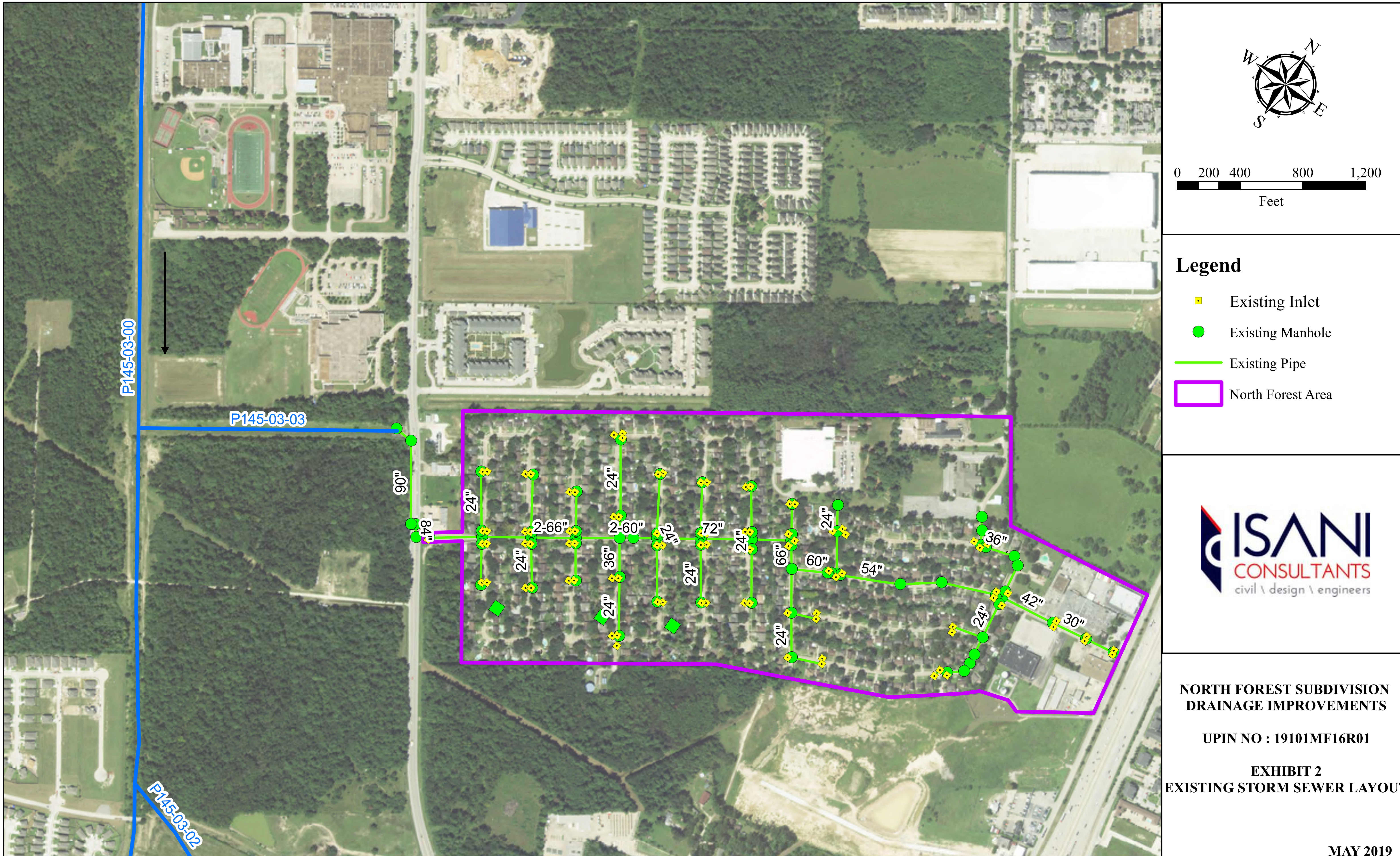


NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO: 19101MF16R01

EXHIBIT 1
VICINITY MAP

MAY 2019

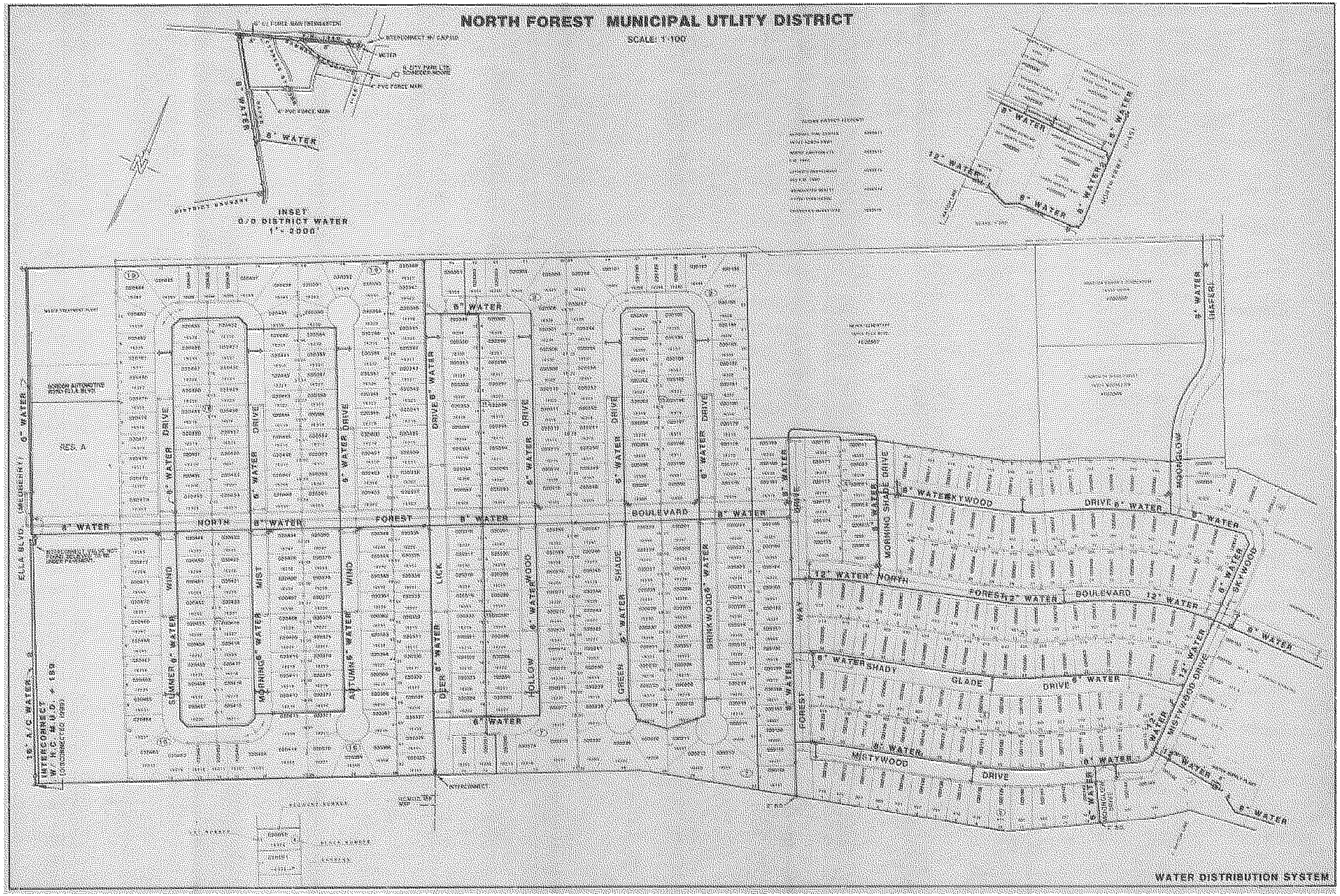


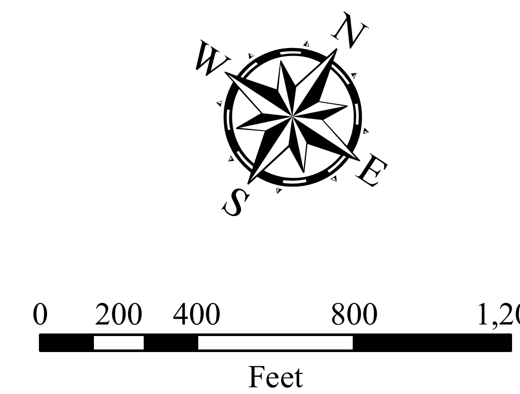
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO : 19101MF16R01

EXHIBIT 2
EXISTING STORM SEWER LAYOUT

MAY 2019





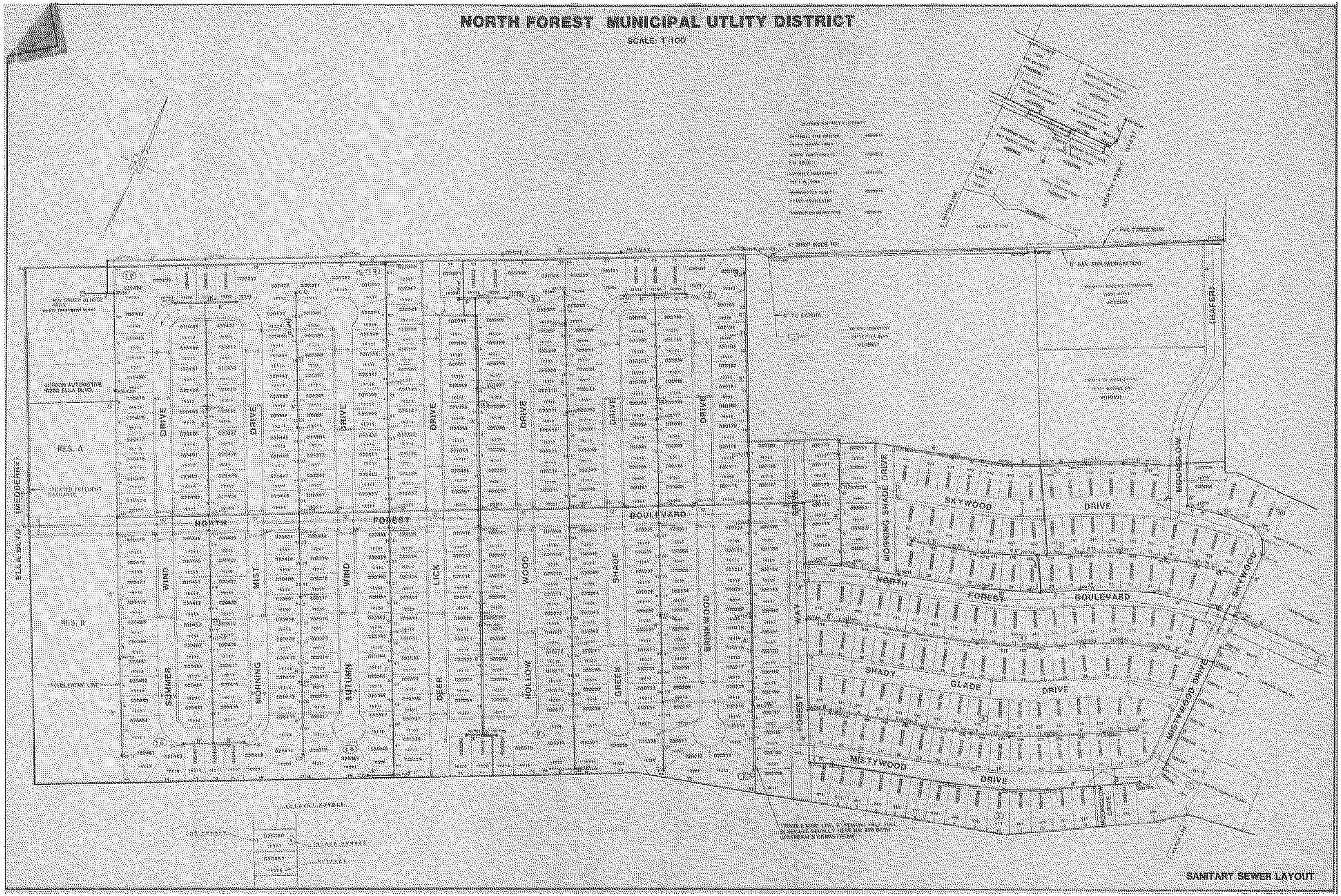
Source: Harris County Engineering Department Record Drawings

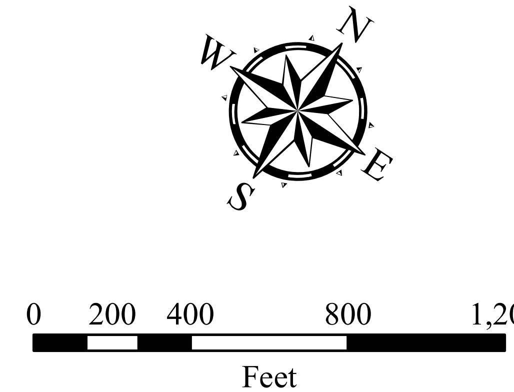
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO : 19101MF16R01

EXHIBIT 3
EXISTING WATER DISTRIBUTION LAYOUT

MAY 2019





Source: Harris County Engineering Department Record Drawings

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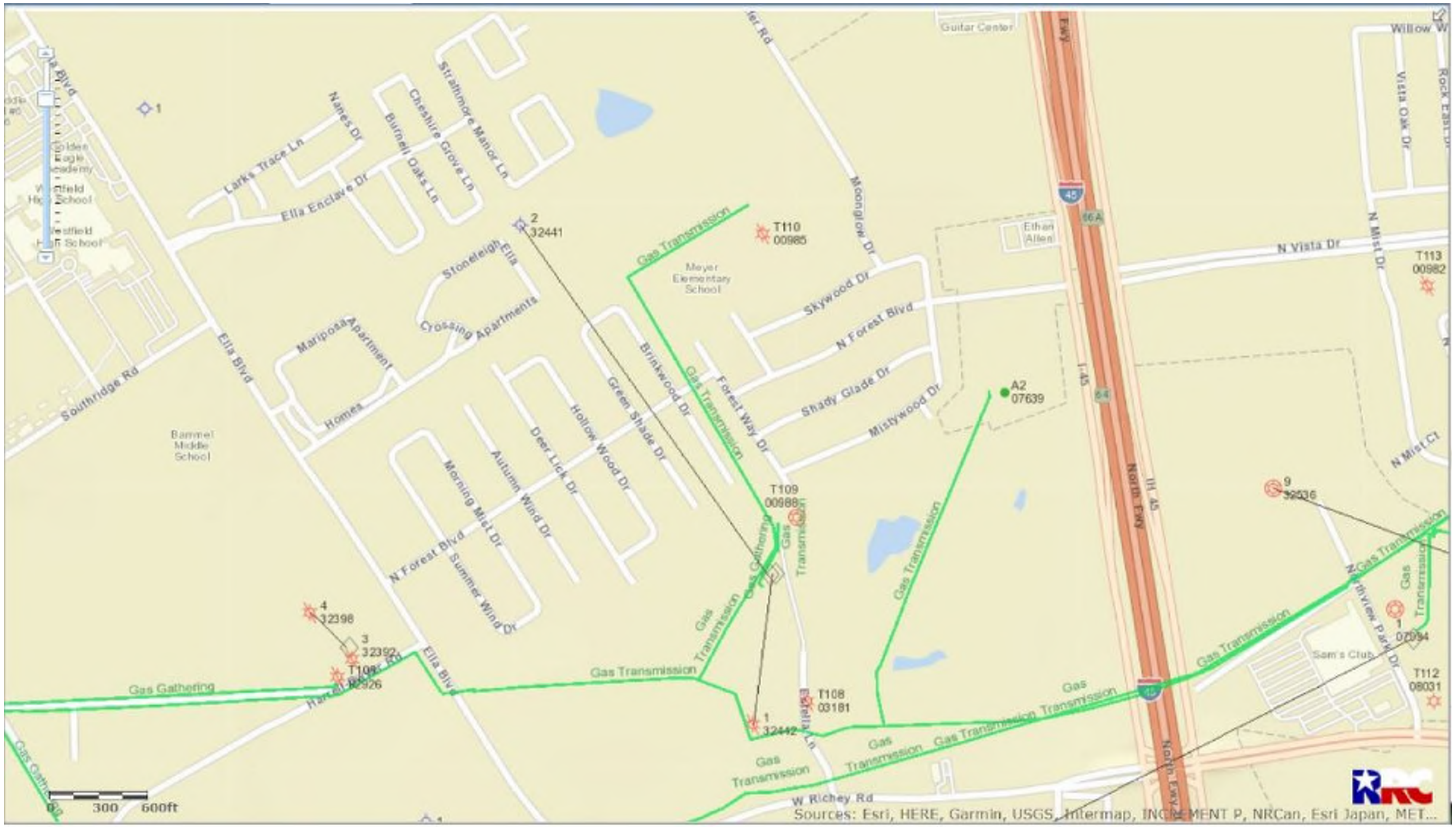
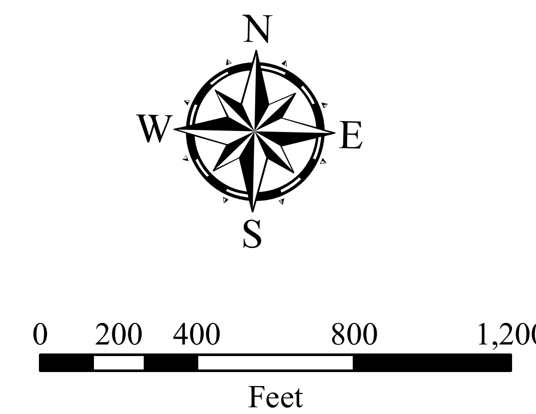
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO : 19101MF16R01

EXHIBIT 4
EXISTING SANITARY SEWER LAYOUT

MAY 2019





Legend

- EXISTING GAS LINES
- EXISTING GAS WELLS

NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

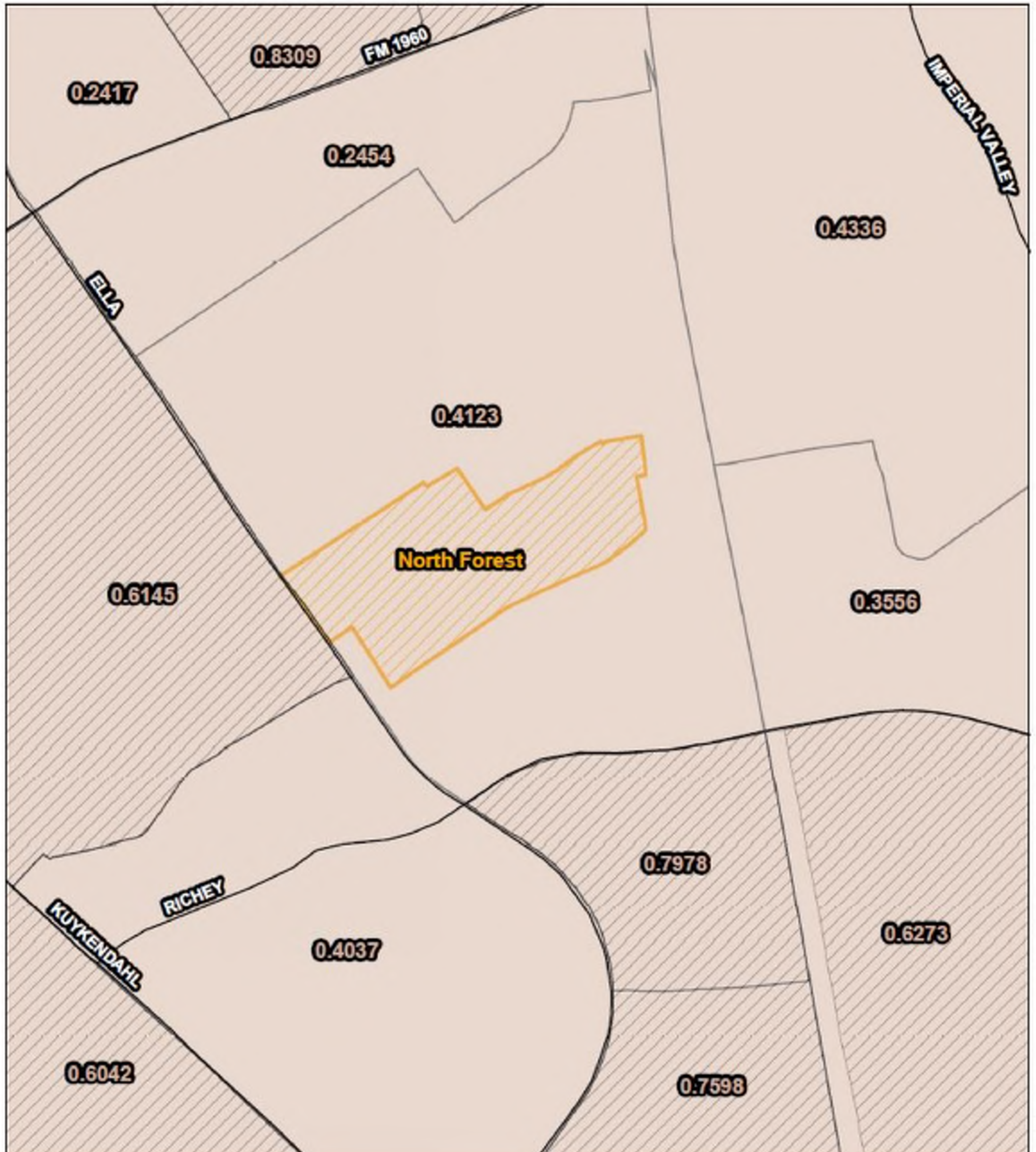
UPIN NO : 19101MF16R01

EXHIBIT 5
EXISTING GAS FACILITIES LAYOUT

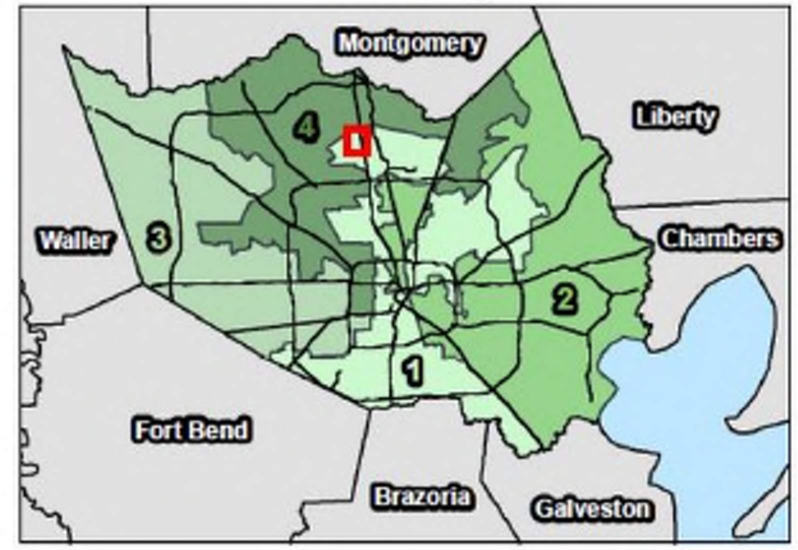
Source: Texas Railroad Commission GIS Map Viewer

MAY 2019

North Forest Subdivision LMI



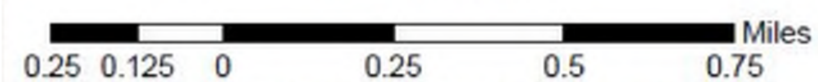
Reference Diagram



Legend

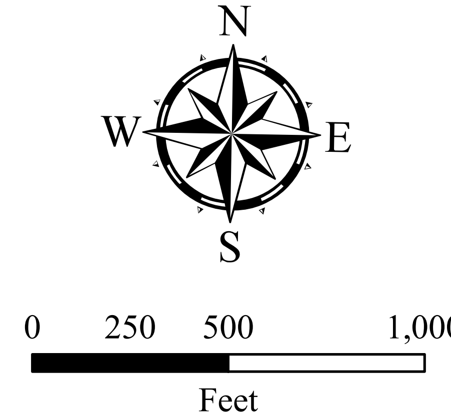
- Subdivision
- State LMI
- LMI Target Area

Scale: 1:20,000



DISCLAIMER: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative location of property boundaries and other geographic features. All data, specifically including the geographic data herein are provided "as is" without warranty of any kind,either expressed or implied. Use of the information is the sole responsibility of the user.

LMI Information Source: Harris County Engineering Department



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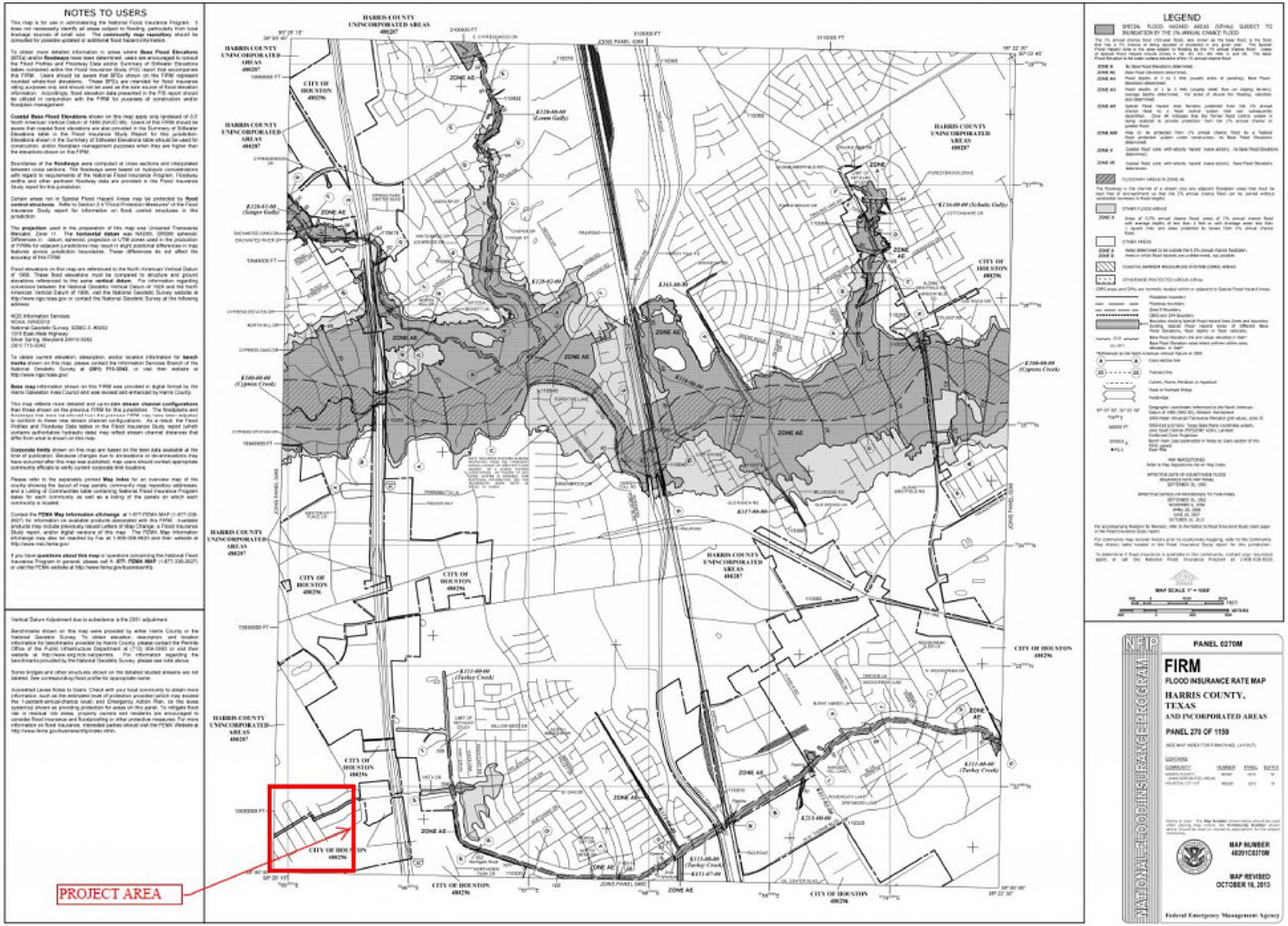
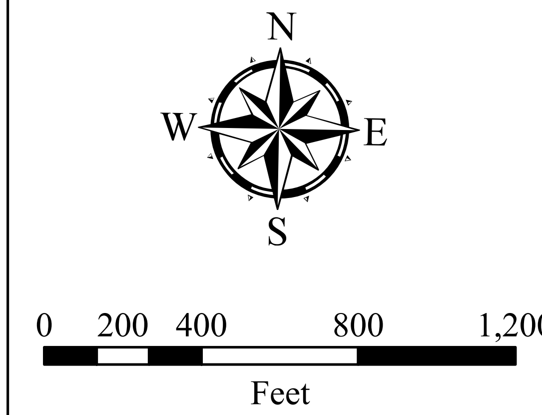
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO:19101MF16R01

EXHIBIT 6
LOW TO MODERATE INCOME (LMI) AREAS

MAY 2019





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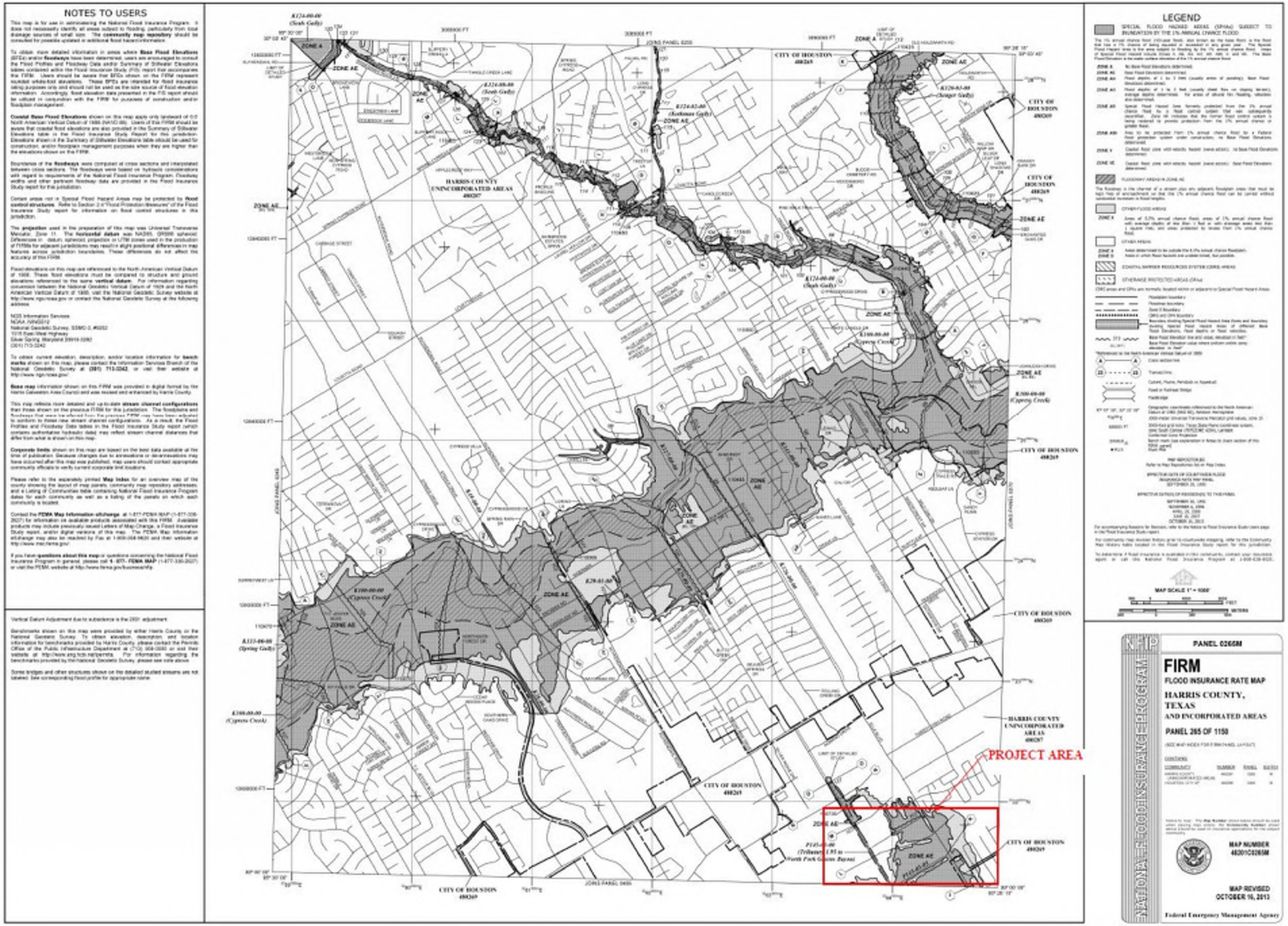
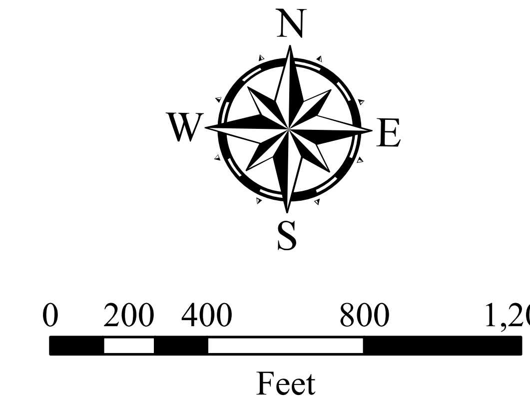
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO:19101MF16R01

EXHIBIT 7A
FEMA MAP

MAY 2019





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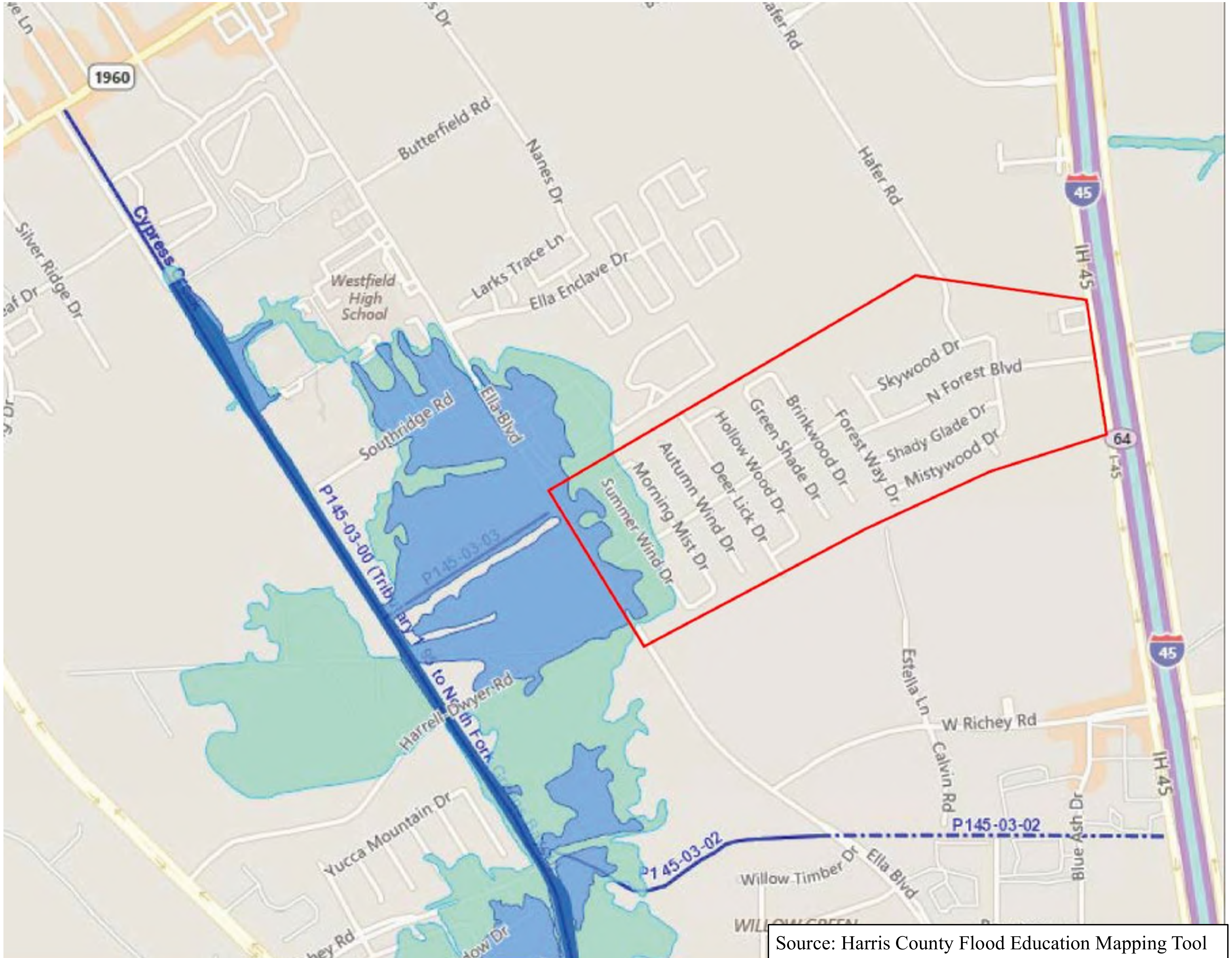
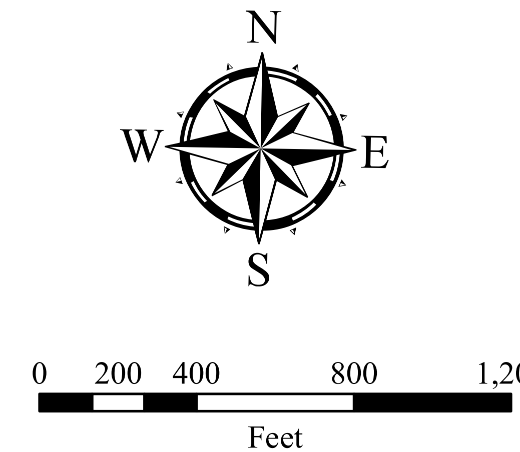
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO:19101MF16R01

EXHIBIT 7B
FEMA MAP

MAY 2019





Legend

- 100 yr Floodplain
- 500 yr Floodplain
- Project Limits

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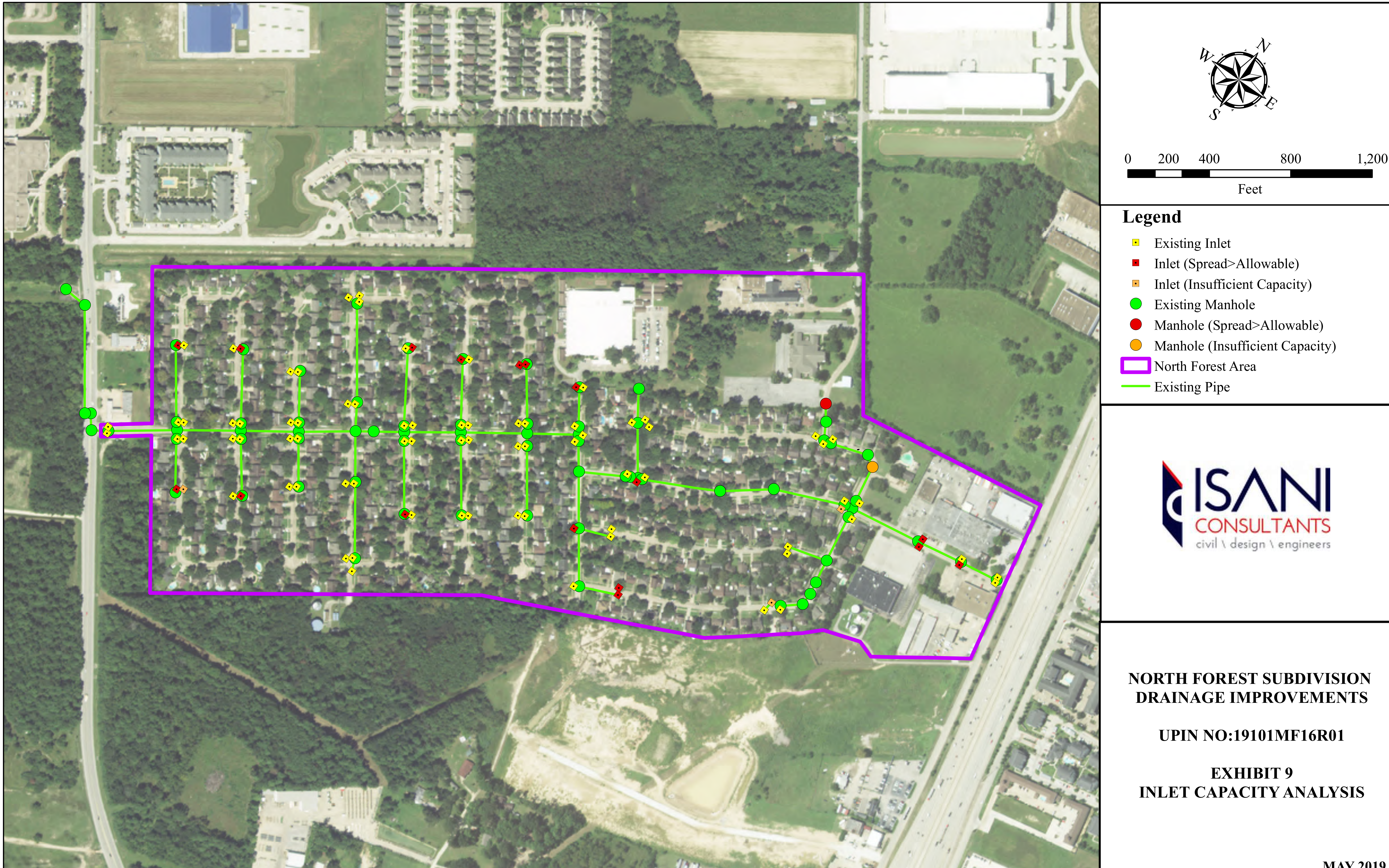
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO : 19101MF16R01

EXHIBIT 8
FLOODPLAIN MAP

MAY 2019



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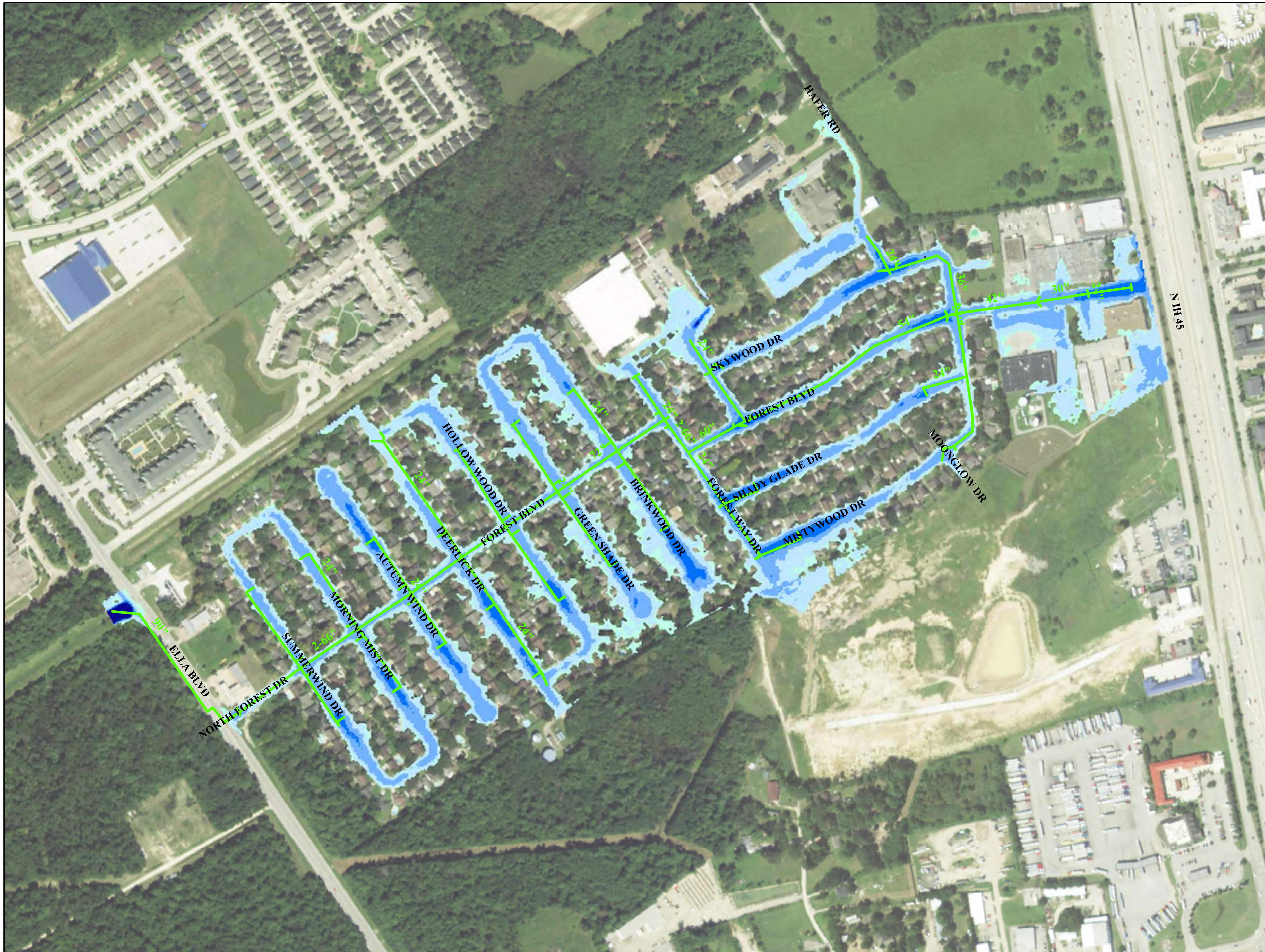
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO:19101MF16R01

EXHIBIT 9
INLET CAPACITY ANALYSIS

MAY 2019



Note : Depth Grid Maps are based on drainage analysis results from XPSTORM 2D models,Version 2018.2

N W E S

0 200 400 800 1,200

Feet

Legend

Existing Storm Sewer Pipe

Existing Conditions

Ponding Depth (Ft)

- 0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

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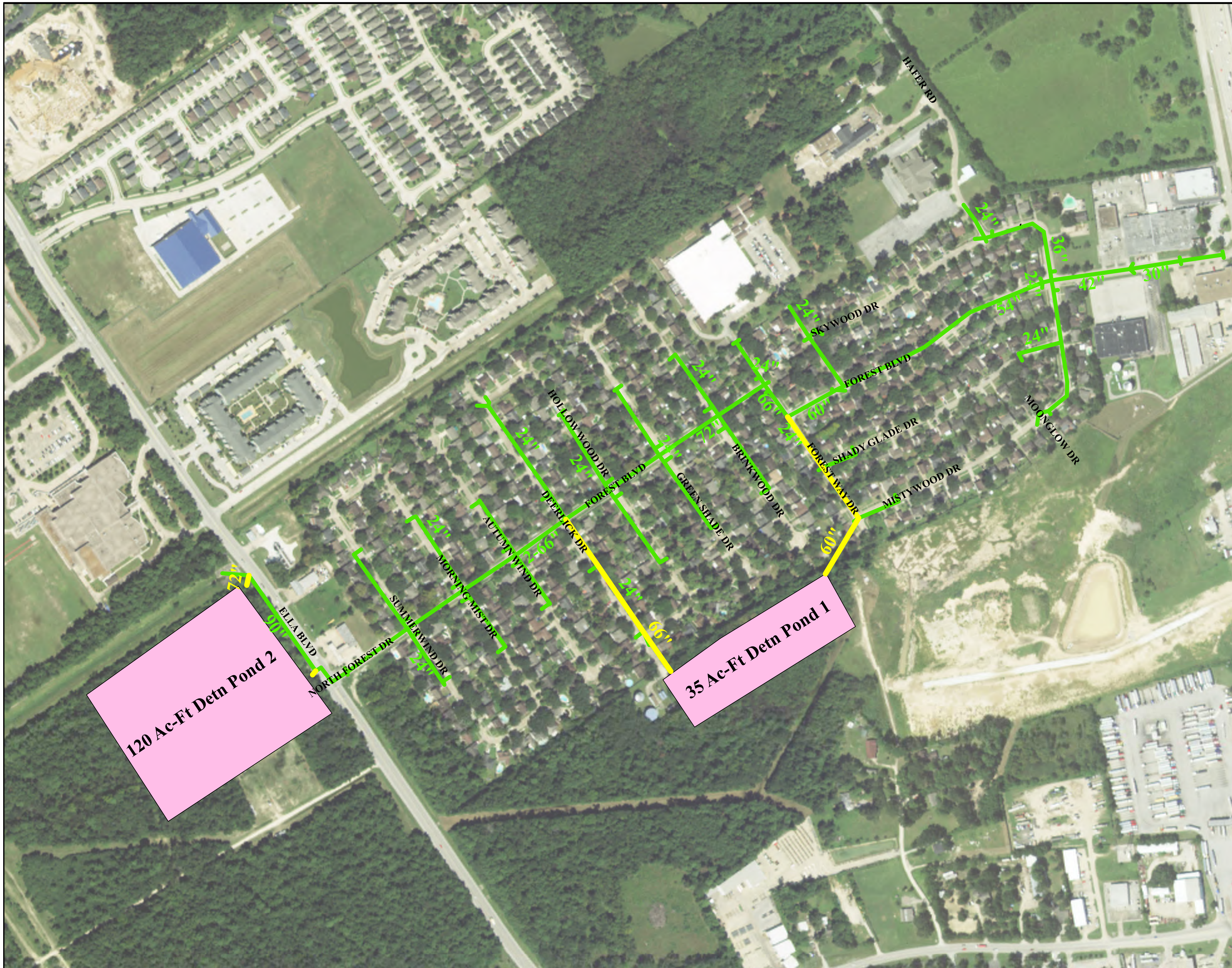
UPIN NO:19101MF16R01

EXHIBIT 10
2D DEPTH GRID MAP - EXISTING CONDITIONS

MAY 2019



N
W E
S

0 200 400 800 1,200

Feet

Legend

- Existing Storm Sewer Pipe
- Proposed Storm Sewer Pipe
- Proposed Detention Pond

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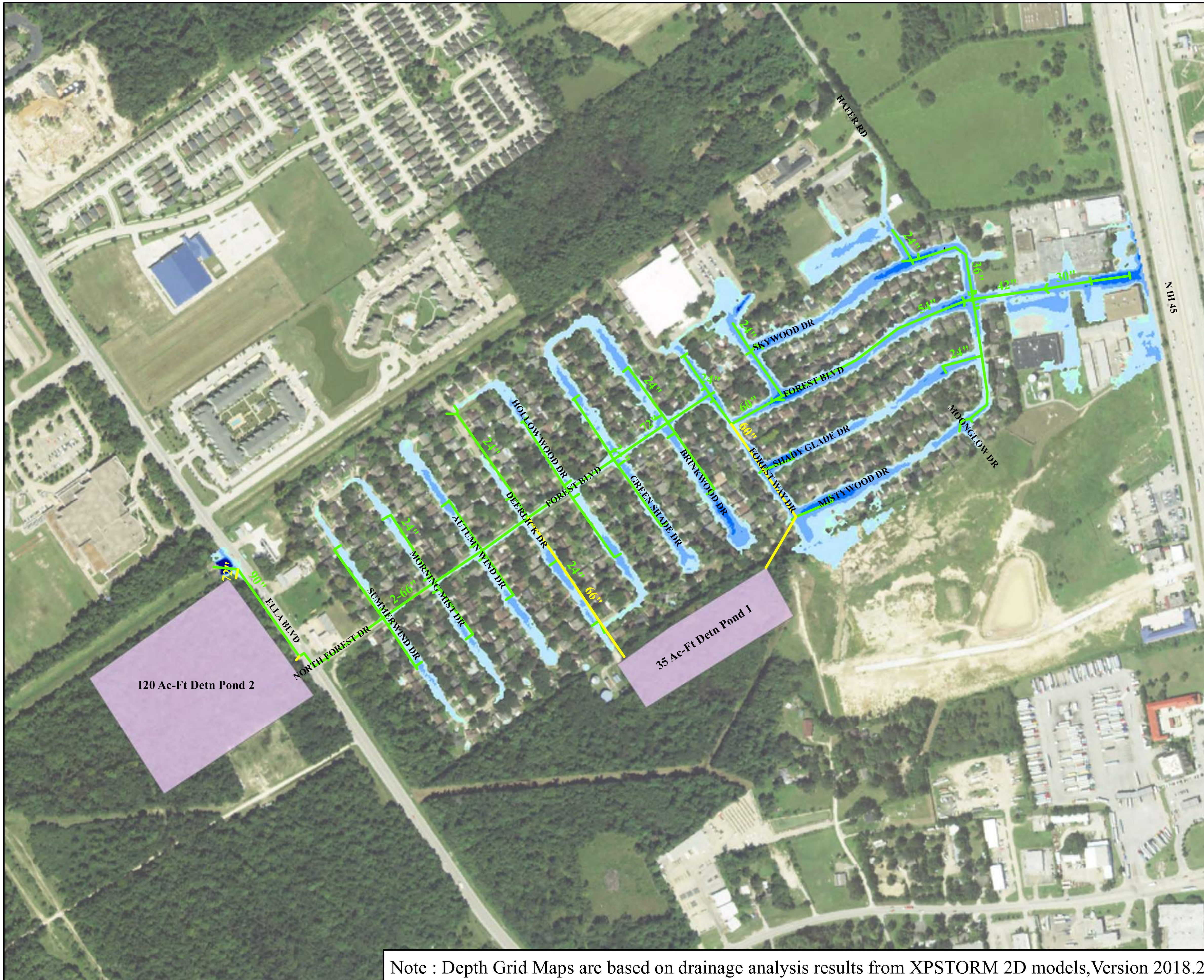
NORTH FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

UPIN NO:19101MF16R01

EXHIBIT 11
PROPOSED STORM SEWER LAYOUT - ALT 1

MAY 2019



Note : Depth Grid Maps are based on drainage analysis results from XPSTORM 2D models,Version 2018.2

N
W E
S

0 200 400 800 1,200

Feet

Legend

- Existing storm sewer
- Proposed storm sewer
- Proposed Detention Pond

Proposed Conditions (Alt 2)

Ponding Depth (Ft)

- 0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

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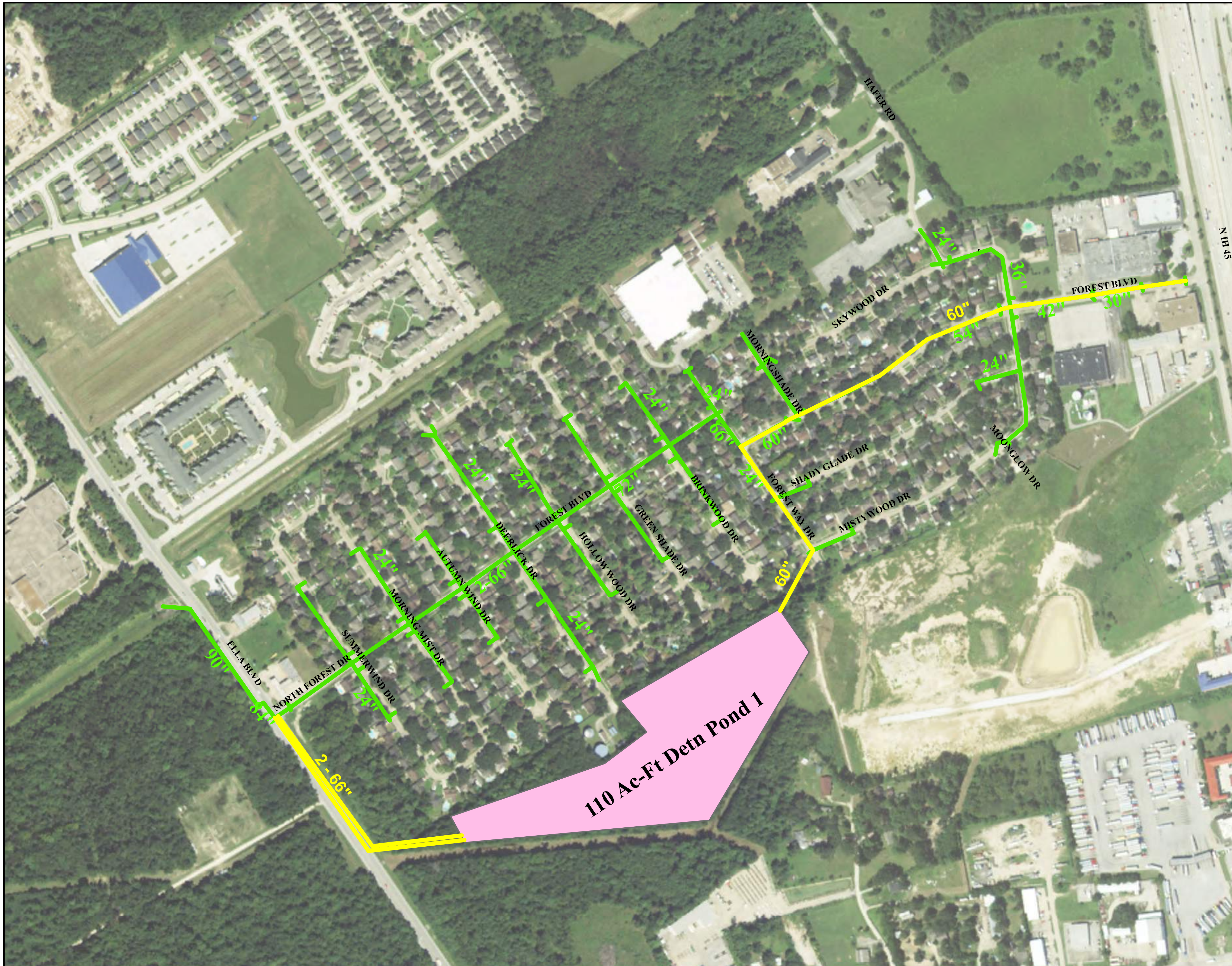
UPIN NO:19101MF16R01

EXHIBIT 12
2D DEPTH GRID MAP - PROPOSED CONDITIONS (ALT 1)

MAY 2019



N
W E
S

0 200 400 800 1,200

Feet

Legend

- Proposed storm sewer pipe
- Existing storm sewer pipe
- Proposed detention pond

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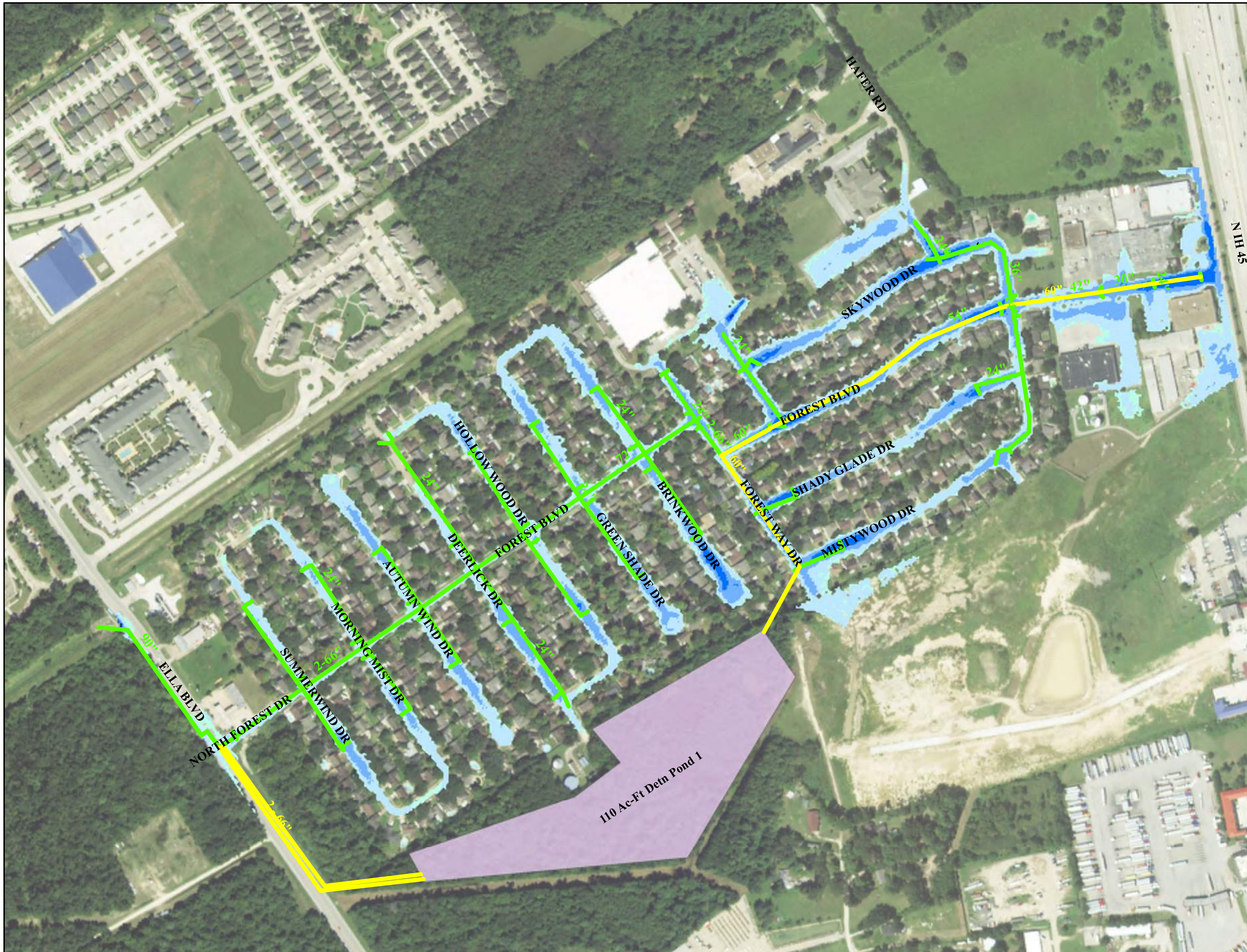
UPIN NO:19101MF16R01

EXHIBIT 13
PROPOSED STORM SEWER LAYOUT- ALT 2 RECOMMENDED SOLUTION

MAY 2019



N
W E
S

0 200 400 800 1,200

Feet

Legend

Existing Storm Sewer

Proposed Storm Sewer

Proposed Conditions (Alt 1)

Ponding Depth (Ft)

- 0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

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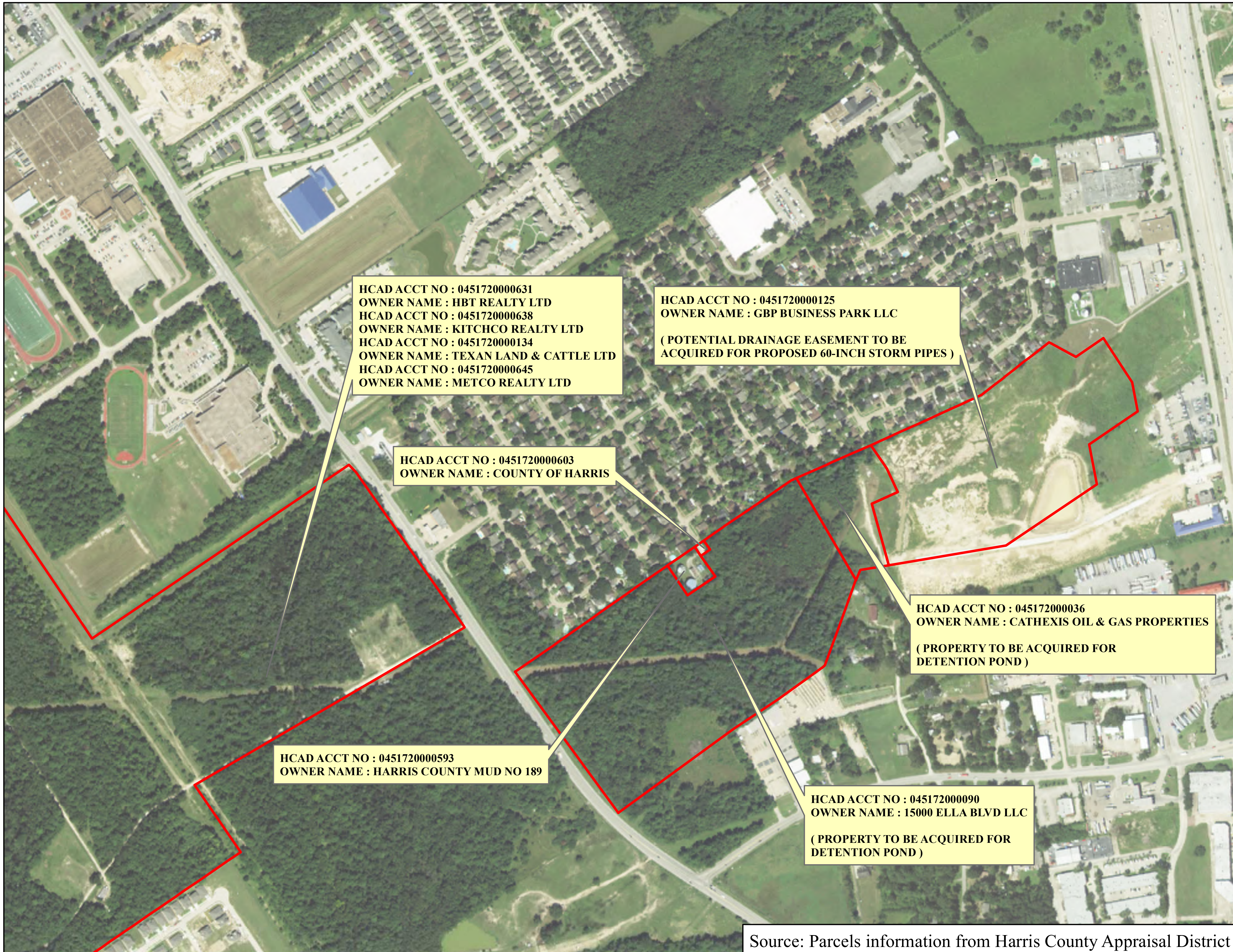
UPIN NO:19101MF16R01

EXHIBIT 14
2D DEPTH GRID MAP -
PROPOSED CONDITIONS (ALT 2)
RECOMMENDED SOLUTION

MAY 2019

Note: Depth Grid Maps are based on drainage analysis results from XPSTORM 2D models,Version 2018.2



N
W E
S

0 200 400 800 1,200
Feet

Legend

Parcels for Acquisition

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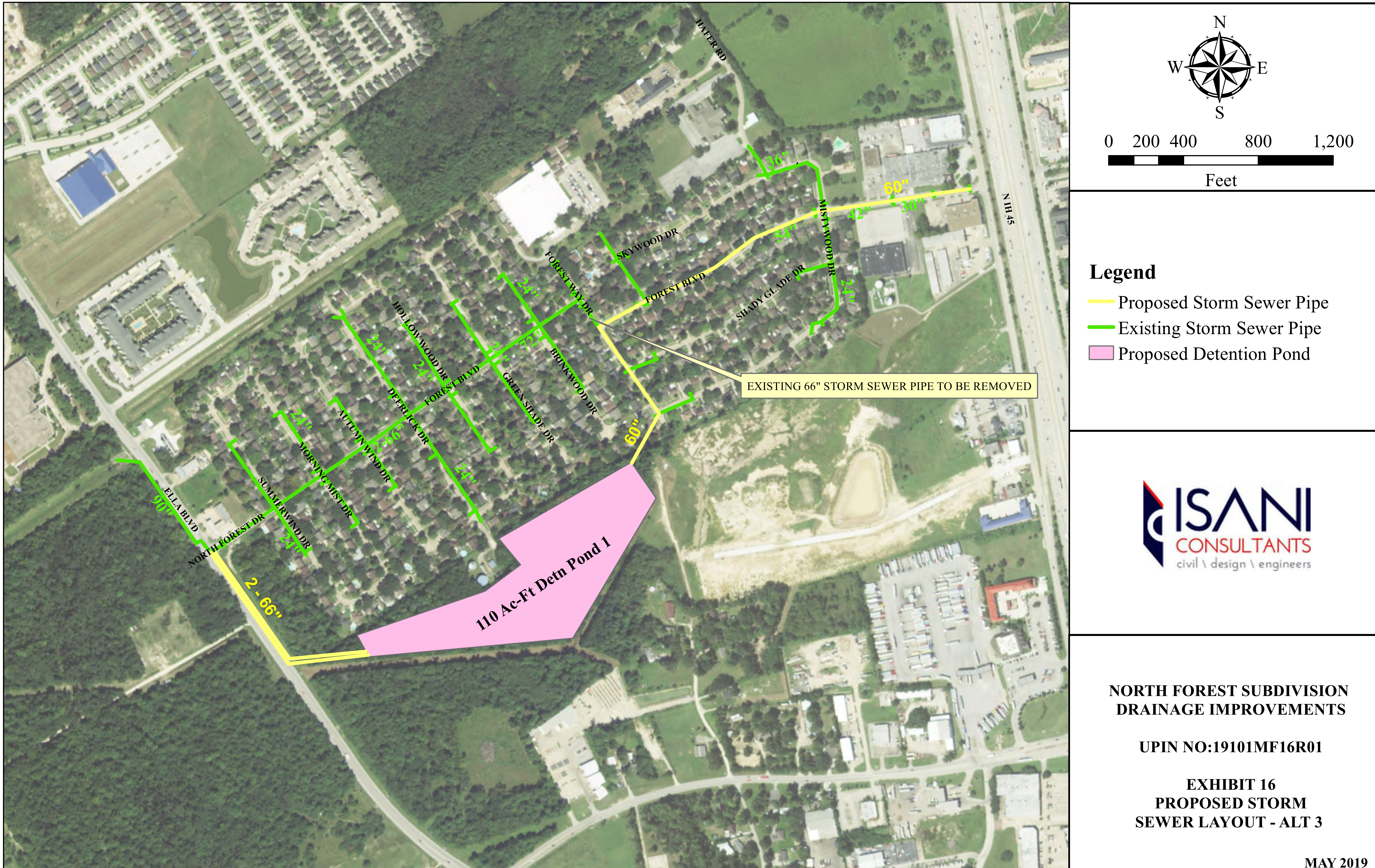
UPIN NO:19101MF16R01

EXHIBIT 15
HCAD MAP

MAY 2019



Legend

- Proposed Storm Sewer Pipe
- Existing Storm Sewer Pipe
- Proposed Detention Pond

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UPIN NO:19101MF16R01

EXHIBIT 16
PROPOSED STORM SEWER LAYOUT - ALT 3

MAY 2019

Note : Depth Grid Maps are based on drainage analysis results from XPSTORM 2D models,Version 2018.2

N
W E
S

0 200 400 800 1,200

Feet

Legend

- Existing Storm Sewer
- Proposed Storm Sewer
- Proposed Detention Pond

Proposed Conditions (Alt 3)

Ponding Depth (Ft)

- 0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

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UPIN NO:19101MF16R01

EXHIBIT 17
2D DEPTH GRID MAP - PROPOSED CONDITIONS (ALT 3)

MAY 2019

APPENDICES

APPENDIX A
PUBLIC COMMENTS/RESPONSES

PROJECT PROGRESS & COMMUNITY ENGAGEMENT 2018 | BOND PROGRAM

First Name	Last Name	Organization Name	Address	City	State	Zip Code	Phone	Input Type	Subject	Comment	Response
Robert	Watts		410 Skywood Dr.	Houston	Texas	77090	713-380-9832	Comment Form	Flood Control	1) Drainage from Meyer Elementary into the backyards on Skywood Dr.	1.) To minimize flooding in the backlots of properties along Skywood Drive, grading improvements might have to be made in the parking lot to drain runoff more efficiently.
										2) North Forest Blvd. (East) 3.5 of Runoff from I 45 Feeder South	2.) Proposed improvements along N Forest Blvd to minimize flooding at the east end of N Forest Blvd.
										3) Really deep at Skywood and Hafer Rd.	3.) Proposed improvements will assist in conveying flow better and minimize depth of flooding along Hafer Rd and Skywood Drive.
										4) Sinkholes are open in school playground	4.) Local grading improvements might have to be designed.
Dennis	Parle		334 Mistywood Dr.	Houston	Texas	77090	281-568-8821/ dparle@sbcglobal. net	Comment Form	Street Flooding	During moderately heavy rain is constant on Mistywood between the following addresses 339 and 347 Mistywood, directly across from 342 Mistywood	Engineer suspects this might have be due to off site runoff from the sand pits to the south of 339 Mistywood and 347 Mistywood Drive. A detailed review of this probable off site runoff from the sand pits might be needed during the detailed design phase.
David	Davila		16255 Hollow Wood Dr.	Houston	Texas	77090	832-253-3479/dstdavila@yahoo.com	Comment Form		Request a more detailed packet concerning projects and proposals	Acknowledged. Thank you for your comment. Communication with ongoing projects will look to continue throughout the Bond Program. -HCED

APPENDIX B
PHOTOS


FOREST
WAY
Development


Corner N. Forest &
Hollowood dr


Hollowood
NORTH FOREST


Hollowood


Hollowood dr.

Technical Report
Castlewood Addition Sections 3 and 4

Preliminary Engineering for Drainage Projects Geographically Eligible for CBDG-DR Funding

UPIN: 19102MF17301

This report has been prepared under the supervision of Texas Licensed Professional Engineer:

Project Manager

Ali Keyvani, Ph.D., P.E.___
Name

123443_________________
Texas P.E. No.

November 14, 2019__________
Date

11/14/2019

Any questions shall be submitted to:

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
281-304-0200
www.civiltecheng.com

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CONTENTS PAGE

TABLES

FIGURES

EXHIBITS

APPENDICES

1. General Project and Contact Information

1.1 Project Name

The drainage project is under the name of Castlewood Addition Sections 3 and 4 with UPIN: 19102MF17301.

1.2 Precinct

The project location resides within Precinct 2 of Harris County.

1.3 Project Location

The drainage project for Castlewood Addition Sections 3 and 4 is located just south of Lauder Road and east of Aldine-Westfield Road. The subdivision is part of the overall Castlewood Subdivision and drains into P138-01-00, a branch of Greens Bayou Tributary P138-00-00. A Project Location Map in relation to Harris County is shown on **Exhibit 1**.

1.4 Preparer Information

CivilTech Engineering, Inc. was contracted by Harris County on behalf of the Harris County Engineering Department for the completion of the Castlewood Addition Sections 3 and 4 Drainage Project.

2. Existing Conditions Analysis

2.1 Summary of Drainage Issues/Analysis of Problem

The historical flooding information within Castlewood Addition Sections 3 and 4 was provided by the Harris County Engineering Department. The data showed that the most damaging flood event to occur was Hurricane Harvey (August 2017) which caused structural flooding in almost every home within the subdivision, up to 36 inches in depth. Other, less intense, historical flood events showed a smaller number of water damaged homes reported, including Hurricane Ike (September 2008), in June of 2006, and Tropical Storm Allison (June 2001). Most of the damages during these smaller flood events occurred in Section 3 of the Castlewood Addition, located in the western portion of the subdivision.

Stream gage data collected from the Harris County Flood Warning System was used to analyze the historical flooding events. Stream elevation sensors 1640: Greens Bayou @ US 59, 1645: Greens Bayou @ Beltway 8, and 1695: P138-00-00 @ Aldine-Westfield Road were available within the vicinity of the project location. Extrapolation was performed on the FEMA Effective HEC-RAS model of Greens Bayou (P100-00-00) and P138-00-00 to find the equivalent water surface elevations in Greens Bayou at the outfall of P138-00-00. The results of the extrapolation are presented in **Table 1** showing the Water Surface Elevations (WSE) for various storm events.

Table 1: Statistical & Observed Gage Data

Gage ID	Bank Elevation	1% AEP WSE	0.2% AEP WSE	Hurricane Harvey WSE	2006 Event WSE
(-)	(ft)	(ft)	(ft)	(ft)	(ft)
1640/1645 – Greens Bayou @ P138-00-00	60.47	68.01	68.85	67.98	65.48
1695 – P138-00-00 @ Aldine-Westfield Rd.	67.30	68.39	68.73	69.07	69.60

The water surface elevations along P138-00-00 during both Hurricane Harvey and the 2006 event were greater than those in a statistical 0.2% Annual Exceedance Probability (AEP) event storm. The water surface elevation along Greens Bayou during Hurricane Harvey was equivalent to those in a statistical 100-year (1% AEP) event storm, while the 2006 event was closer to a 10-year (10% AEP) event storm.

The water surface elevation during Hurricane Harvey exceeded the top of bank elevation of Greens Bayou by more than 7 feet during its peak leading to out of bank flooding throughout the subdivision. The floodplain elevation map generated for the peak water surface elevation during Hurricane Harvey produced extents of flooding beyond the FEMA 500-year floodplain map. It was determined that the flooding within the subdivision during Hurricane Harvey was caused by the water surface elevation in Greens Bayou. The tailwater in Greens Bayou during Hurricane Harvey was shown to go out of bank for 3 days.

A floodplain elevation map was similarly developed for the peak water surface elevation during the 2006 event. The floodplain elevation map during this peak showed flooding of 6 to 18 inches in the eastern portion of the subdivision, consistent with the homes identified as having suffered flood damage by FEMA during the 2006 event. The source of this flooding was determined to be caused by the tailwater elevation in P138-00-00.

2.2 Drainage System – Conditions/Impacts

The existing drainage system within the subdivision consists of ditches and culverts, with several instances of overgrowth of greenery and other blockage. The subdivision currently has four outfalls. The two northern portions of the subdivision drain to Lauder Road then to P138-01-00, while the eastern drains directly into P138-01-00. The southern portion flows through a drainage ditch south of the subdivision to P138-01-00, which also receives additional runoff from areas west of the subdivision. According to the study by LAN on Lauder Detention basins, P138-01-00 has a level of service between a 25-year and 50-year event. 100-year flows are out of bank for existing conditions.

The direction of the extreme event, surface drainage for the subdivision, and neighboring areas was determined using ArcHydro and the Digital Elevation Model (DEM) obtained from TNRIS. The analysis of the extreme event drainage showed that the neighborhood received 70 acres of additional surface flow from the west, as well as substandard surface drainage within the subdivision itself. Deergrove Street, located in the middle of the subdivision, has a higher elevation than the rest of the neighborhood and therefore, prohibiting a path for surface flow to leave the subdivision. The current conditions require that surface flow must go through the crossing culverts, or pond in western portion of the subdivision until rising to the elevation of Deergrove Street in order to exit the subdivision to the east.

The project area is completely out of the FEMA regulatory 100-year floodplain (1% AEP), and only the eastern and northern portions of the subdivision are in the 500-year floodplain (0.2% AEP) floodplain as shown in FEMA Flood Insurance Rate Map (FIRM) for Harris County, Texas and Incorporated Areas, Map Number 48201C0490L, Map Revised June 18, 2007. The 500-year floodplain (0.2% AEP) flood elevations throughout the area impacting the subdivision range from 68 to 69 feet in elevation. The FEMA floodplains are shown on **Exhibit 2**.

The minimum home elevation is approximately 67 MSL. The analysis found that regional flooding from Greens Bayou and P138-00-00 will occur once the water surface elevation exceeds the identified elevation.

2.3 Water – Conditions/Impacts

The subdivision’s potable water system is composed of underground water lines throughout the subdivision. Sizes and locations of these water lines were identified from the waterline distribution map provided by Undine LLC. All water lines within the subdivision are 3” or 4” in diameter. A utility map of the location of each underground water utility in relation to the storm sewer system is shown on **Exhibit 3**. Depths of the existing waterlines were unavailable at the time of this analysis and potential conflicts cannot be confirmed. Coordination with Undine LLC is necessary before construction to avoid any potential conflicts. If a conflict cannot be avoided, additional utility adjustment cost will need to be added to the construction estimate.

2.4 Sewer – Conditions/Impacts

The subdivision's sanitary sewer system is composed of septic tanks throughout the subdivision.

2.5 Electric – Conditions/Impacts

The subdivision's electric facilities are operated by Centerpoint Energy. The current electrical service network consists of underground conduits. Contact was made with Centerpoint Energy to identify the locations of these underground facilities. An electrical facility map is shown on **Exhibit 4**. Depths of the existing electric conduits were unavailable at the time of this analysis and potential conflicts cannot be confirmed. Coordination with Centerpoint Energy is necessary before construction to avoid any potential conflicts. If a conflict cannot be avoided, additional utility adjustment cost will need to be added to the construction estimate.

2.6 Gas – Conditions/Impacts

The subdivision's gas system is operated by Centerpoint Energy. The current gas system consists of underground facilities. Contact was made with Centerpoint Energy to identify the locations of these underground facilities. A gas system map is shown on **Exhibit 5**. Depths of the existing gas lines were unavailable at the time of this analysis and potential conflicts cannot be confirmed. Coordination with Centerpoint Energy is necessary before construction to avoid any potential conflicts. If a conflict cannot be avoided, additional utility adjustment cost will need to be added to the construction estimate.

2.7 Telecommunications – Conditions/Impacts

No markings for telecommunication lines were present within the subdivision. Contact was made with Comcast and AT&T from DigSafe to identify any locations of telecommunication lines within the subdivision. All parties confirmed that no underground facilities were present within the subdivision.

2.8 General Description of Locations

Castlewood is a single-family subdivision located in northwest Harris County and is part of the Greens Bayou Watershed. Flood damage has consistently occurred in Section 3 of Castlewood which is the closest in proximity to P138-00-00, the main tributary to which the neighborhood drains to from P138-01-00. In general, Section 4 of Castlewood drains to the east and enters P138-01-00 which then drains directly into Greens Bayou.

Topography of the subdivision is designed for water to flow from west to east, draining to P138-01-00. LiDAR 2008 was used for the terrain data, and high and low points were determined. The highest points within the subdivision are along Greenranch St, with roadway elevations of approximately 68.5 feet. The lowest points within the subdivision are in the north-eastern area near Lauder Rd at Trailcrest, with ground elevations of approximately 65.6 feet. Topography of the subdivision is shown on **Exhibit 6**.

The western portion of the subdivision receives flow from an additional 69 acres of mixed-use land west of the project area. General concern with the current drainage system is the ability of the western portion of the system to convey the large amount of flow during extreme events which flows back into the system from P138-00-00 and Greens Bayou. A drainage map showing the drainage areas of the subdivision is shown on **Exhibit 7**.

2.9 Other Issues

The properties located at 2415 Ridgeland and 2602 Connorvale have been acquired by Harris County and have since been demolished. No plans for the vacant lots have been proposed by Harris County.

A detention pond of approximately 40 ac-ft is recommended south of the subdivision, between P138-01-00 and P138-01-01.

3. Description of Problems

3.1 Damage Caused by Flooding

The Harris County Engineering Department provided information regarding FEMA Flood Loss data within Castlewood Addition Sections 3 and 4. The damage reported in each subdivision shows structural flooding of homes throughout the subdivisions.

3.2 Repetitive Loss Analysis

Castlewood Addition Sections 3 and 4 have suffered from structural flooding in 17 separate storm events. From these storm events, 34 homes scattered throughout the subdivision have been declared repetitive loss structures by FEMA.

It was determined throughout the course of the analysis that the cause of flooding during Hurricane Harvey and the 2006 Event were a result of channel flooding in Greens Bayou and P138-00-00.

3.3 Structures Flooded

The largest flooding event to take place within the project area was Hurricane Harvey in August 2017. The flooding during Hurricane Harvey resulted in 195 flooded homes, which is almost all of the 198 total homes within Castlewood Addition Sections 3 and 4. The average flooding depth during Hurricane Harvey was reported at 36 inches in the northern portion to 4 inches in the southern portion.

3.4 Issues with Access

No reports were provided or available regarding issues with access to the subdivision.

3.5 Existing Drainage Infrastructure

The subdivision drains into branch P138-01-00 of tributary P138-00-00 which lies within the southern portion of the Greens Bayou Watershed. The Castlewood Addition Sections 3 and 4 currently drain through a series of ditches and culverts to three outfalls on P138-01-00 that eventually lead to Greens Bayou. The southern portion of the subdivision drains through a Houston County Flood Control District owned channel which subsequently discharges into P138-01-00. The northern portions of the subdivision drain into ditches on Lauder road which eventually lead to an outfall into P138-01-00. The rest of the subdivision drains east, directly into P138-01-00. All existing ditches, culverts, and drainage areas are shown on **Exhibit 8**.

The analysis of the extreme event drainage showed that the western portion neighborhood does receive flow from an additional 69 acres of mixed-use land west of the project area. Deergrove Street has a higher elevation than the rest of the neighborhood and prevents the sheet flow path from leaving the subdivision. The current conditions require that surface flow must pond west of Deergrove Street until rising to the elevation of Deergrove Street in order to exit the subdivision along Connorvale Road or Anise Street. An extreme event drainage map is shown on **Exhibit 9**.

3.6 Other Contributing Factors

Another issue regarding flooding is the speed and height to which the water surface elevations in Greens Bayou and P138-00-00 rises. The rate at which the water surface in Greens Bayou rises during the extreme events prevents a significant volume of runoff from being able to leave the project area and causes a significant amount of backwater to enter the area, inundating the homes in the subdivision.

4. Analysis and Proposed Solution

4.1 Approach

To analyze the causes of flooding within the subdivision, the stream gages at Beltway 8, US 59 and Aldine-Westfield Road were used to determine the equivalent water surface elevations at the meeting point of Greens Bayou and P138-00-00. Figure 1 shows the gage elevations for Hurricane Harvey and the 2006 Event, as well as the top of bank elevation, indicating when out of bank flooding will begin to occur.

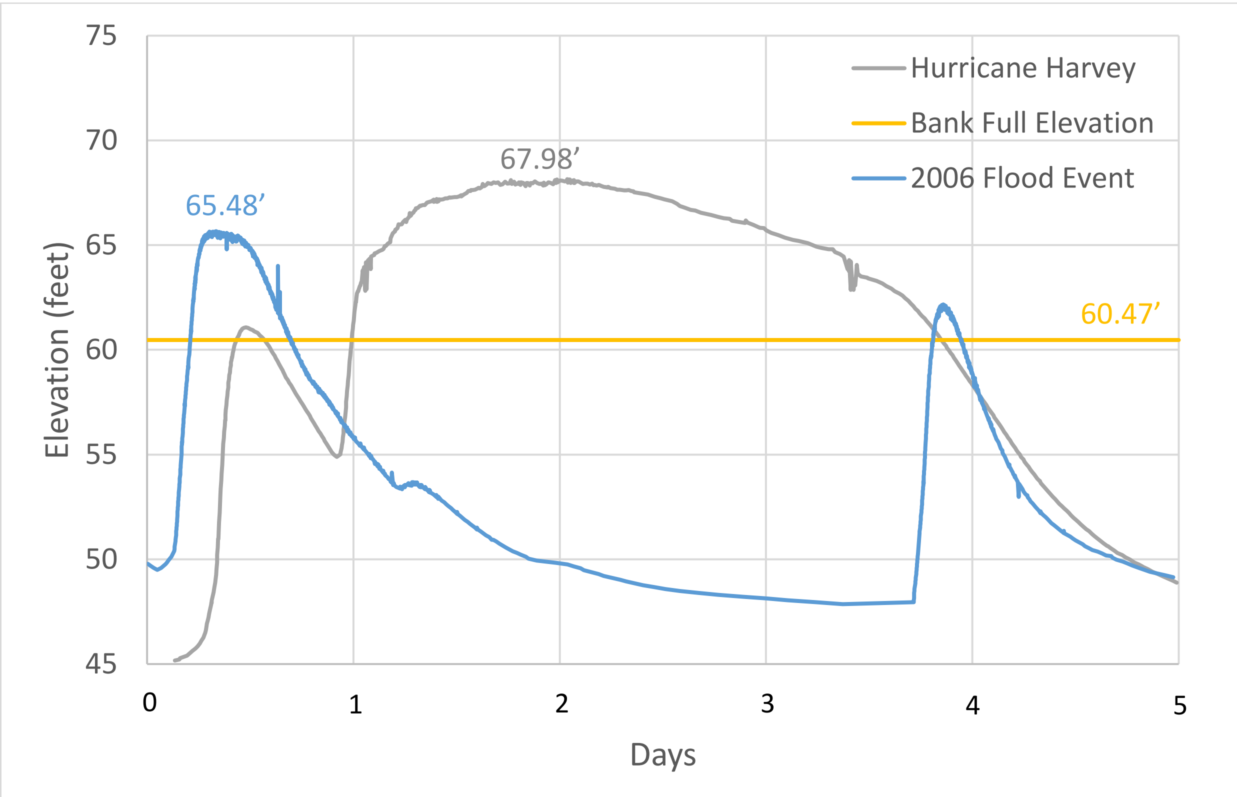

Figure 1: Tailwater Rating Curve for Greens Bayou at P138-00-00

The maximum water surface elevations were overlaid onto DEM surface to find the depth of ponding during each storm historical storm event. The maximum ponding depths during each event were compared to the reported flood damage to determine whether each event was a result of localized flooding or regional flooding. The ponding depth map for Hurricane Harvey (August 2017) and the ponding depth map for the 2006 Event (June 2006) are shown on **Exhibit 10** and **Exhibit 11**, respectively.

4.2 Methodology Used for Analysis

The drainage areas were developed to reflect the flow of runoff during the 2-year (50% AEP) event storm and were created based on the as-built construction drawings for the subdivision and surrounding areas. Extreme event flows directions and drainage areas were developed using

ArcHydro. The extreme event flows are based on the surface flow once the storm sewer has reached its capacity.

Hydrographs were developed for each drainage area within HEC-HMS by calibrating the peak flow of the hydrograph to the peak flow obtained from the Rational method for each respective drainage area. Precipitation data was based on the frequency duration values obtained from NOAA Atlas 14 for the Castlewood area.

4.2.1 Land Use

Land use tables were developed by visual inspection of the subdivision and offsite areas. Parcels were created in ArcGIS and assigned a runoff coefficient, C, based on the corresponding land use category from the Regulations of Harris County, Texas for the Approval and Acceptance of Infrastructure. For drainage areas containing multiple forms of land use, a composite C-value was calculated using the following equation:

$$C = \frac{\sum_{i=1}^{n} A_i C_i}{\sum_{i=1}^{n} A_i}$$

where,

C = Composite C-value

n = total number of land use categories within drainage area

A_i = area associated with ith land use (acres)

C_i = individual C-value associated with each land use

4.2.2 Time of Concentration

Time of concentration, T_C, for the drainage areas was computed based on the City of Houston Stormwater Design Requirements equation for time of concentration:

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

where,

T_C = time of concentration (minutes)

A = area of drainage area (acres)

4.2.3 Rainfall Intensity

The rainfall intensity parameters (b, d, and e) were used in the rainfall intensity calculations for each frequency of storm based on the NOAA Atlas 14 values. The expression for rainfall intensity was used:

$$i = \frac{b}{(d + T_C)^e}$$

where,

i = rainfall intensity (in/hr)

b, d, e = rainfall coefficients

T_C= time of concentration (minutes)

"e, b and d" values were derived from the "Atlas 14 IDF Curves" document developed for Harris County Flood Control District in May 2019 by HDR. Region 2 "e,b and d" values were used for this study.

4.2.4 Peak Flows

Peak flows were calculated for each drainage area using the rational method. This method was chosen given the relatively small size of the study area and contributing offsite area (<100 acres). Peak flows were calculated for both the 2-year (50% AEP) design frequency and 100-year (1% AEP) extreme event. Flows were calculated using the following formula:

$$Q = CiA$$

where,

Q = peak flow (cfs)

C = composite C-value

i = rainfall intensity (in/hr)

A = area of drainage area (acres)

4.2.5 Runoff Hydrographs

Runoff hydrographs were developed or each drainage area using HEC-HMS (version 3.5). HMS was used to calibrate the peak flows calculated for each drainage area to the values and parameters within HMS based on the storage coefficient from the Clark Unit Hydrograph Method. Precipitation data for the 2-year (50% AEP), 10-year (10% AEP), and 100-year (1% AEP) storms were imported into HMS using the Atlas 14 frequency and duration values. A 24-hour storm was simulated for each drainage area. All methods and assumption were consistent with those found in the FEMA Effective Model of the Greens Bayou watershed. Drainage basin P138B from the FEMA Effective Model was used as a reference for the values used in the calibration of each drainage area.

The following methods and parameters were used for each drainage area:

Canopy Method: Simple Canopy

Initial Storage (X): 0

Max Storage (IN): 0.1

Surface Method: None

Loss Method: Green and Ampt

Initial Content: 0.46

Saturated Content: 0.024

Suction (IN): 3.5

Conductivity (IN/HR): 0.024

*Impervious % Values based on individual drainage area

Transform Method: Clark Unit Hydrograph

*Time of Concentration and Storage Coefficient (Hrs) based on individual drainage area

Baseflow Method: None

The landuse table, peak flow derivation, HEC-HMS parameter calibrations, and the 2-year (50% AEP) hydrographs developed by the HEC-HMS model have been provided in **Appendix C**.

4.2.6 Hydraulic Model of Existing Condition

After developing the flow hydrographs of all drainage areas including the offsite drainage areas, an Existing model was developed using an XP-SWMM 1D/2D model to determine the capacity of the system. Flow hydrographs calculated by the HEC-HMS model were input into the XP-SWMM nodes as “User Inflows”. The 2008 LiDAR obtained from Houston-Galveston Area Council (HGAC) was used to create the 2D surface. The culverts in the streets were burned into the LiDAR elevations and modeled in XP-SWMM as continuous roadside ditches. Only the culverts crossing the roadway at the major intersections were modeled.

Two grid systems were used at the XP-SWMM model. The cell size for the main grid of the model was 10 foot by 10 foot and the cell sizes for the outside grid was 30 foot by 30 foot in order to reduce the computational time and efforts. Landuse shapefiles were developed based on Google Earth images to better describe the project area land uses. Roadways, building footprints and grass landuses were identified with their respective Manning Roughness coefficients to simulate the flows over these areas.

In the existing model, the 2-year (50% AEP) and 100-year (1% AEP) flow hydrographs were entered at the surface. Then, the water flows over the surface to find the roadside ditches with the low elevations. Cross culverts were modeled as 1D components with 2D connections at the upstream and downstream invert elevations. Tributary P138-01-00 is the major outfall of the system. Detailed results of the XP-SWMM model for existing conditions are presented in **Appendix D**.

4.3 Results of Analysis

The results of the Existing system showed that the system was not operating according to the criteria. The existing WSEs elevations at several strategic points are shown below in **Table 2** for the 2-year (50% AEP) and 100-year (1% AEP) storm events. The strategic points have been identified on **Exhibits 12 and 13** which depict the Existing model results of ponding depth elevations in the subdivision for the 2-year (50% AEP) and 100-year (1% AEP) storm events respectively. It must be noted that these depths are according to the available ditch elevations in the LiDAR. Since our 2D grid sizes are 10 foot by 10 foot, it cannot fully capture the ditch details. Final modeling would require detailed survey of all roadside ditches and adding them as a 1D component to the model.

As it can be seen in the **Table 2** and **Exhibits 12 and 13**, the road pavement has a very high elevation that water does not cross it even in an extreme event. That will cause the water to flow into the adjacent yards and therefore, increase the ponding depths.

Table 2: 50% AEP and 100% AEP Nodal Results – Existing Conditions

XP-SWMM Node	Strategic Point	Location	Existing Invert Elevation	Existing Top of Pavement	Existing WSE 50% AEP	Existing WSE 1% AEP
			(ft)	(ft)	(ft)	(ft)
Node100	A	Woodgate @ Green Ranch	65.01	68.66	66.67	67.09
Node104	B	Woodgate @ Trailcrest	63.39	68.29	66.07	66.86
Node79	C	Ridgeland @ Green Ranch	64.83	69.86	66.68	67.08
Node95	D	Ridgeland @ Trailcrest	64.49	69.46	66.29	66.87
Node85	E	Bluerock @ Deergrove	64.96	68.92	66.51	67.00
Node76	F	Bluerock @ Rockshire	64.62	67.59	66.42	66.86
Node94	G	Connorvale @ Russ	65.92	69.81	66.95	67.23
Node89	H	Connorvale @ Deergrove	64.54	68.80	66.39	67.00
Node72	I	Connorvale @ Rockshire	64.44	68.19	65.29	66.13
Node69	J	Anice @ Deergrove	64.04	68.05	66.40	66.99

4.4 Proposed Solutions / Recommended Approach to Improving Drainage

Two recommended alternatives were initially considered for improvements to drainage in the subdivision. The first recommendation was to regrade the existing roadside ditches, and clean or replace existing culverts in order to return them to functioning capacity. This recommendation also included the addition of a 6 foot by 5 foot RCB along Connorvale in order to reduce the impact of sheetflow from the west. The second recommendation was to convert the entire subdivision to curb and gutter streets with storm sewer and was ultimately recommended by the precinct. This recommendation was modeled and is described below.

The proposed storm sewer systems were sized for the design storm event (50% AEP) in HouStorm. The HouStorm model included the proposed inlets and had a starting tailwater at the top of pipe at the outfalls. Details of the HouStorm model results are provided in **Appendix D.** The proposed system will convert all roadside ditches and culverts to storm sewer. A 6 foot by 5 foot box along Connorvale will collect offsite flows and convey them to P138-01-00. Two major outfalls will be located on the eastern side of Woodgate and Connorvale. The Woodgate outfall will also have an extreme event swale. The other streets will be connected to these outfalls with storm sewer sized between 24 and 48 inches. **Exhibit 14** shows the detailed proposed storm sewer for the subdivision.

After finalizing the sizes of the storm sewer conduits, the dynamic model was created for the proposed system using XP-SWMM. The SWMM model simulates the flow hydrographs added on the surface which enter the inlets and flow through the storm sewer conduits to the outfall. The surface component of the SWMM model was a two-dimensional grid that modeled the Roadway Right-Of-Way. The roadway and roadside ditches elevations were approximately revised in the proposed model to reflect the new proposed surface**. Exhibit 15** shows a schematic comparison of the existing and proposed roadway profiles. Detailed results of the XP-SWMM model for Existing Conditions are presented in **Appendix D.**

The Proposed WSEs elevations at several strategic points are shown below in **Table 3** for 2-year (50% AEP) and 100-year (1% AEP) storm events. The strategic points have been identified on **Exhibits 16 and 17** which demonstrate the Proposed model results of ponding depth elevations in the subdivision for the 2-year (50% AEP) and 100-year (1% AEP) storm events, respectively.

Table 3: 50% AEP and 100% AEP Nodal Results – Proposed Conditions

XP-SWMM Node	Strategic Point	Location	Proposed Invert Elevation	Proposed Top of Pavement	Proposed WSE 50%AEP	Proposed WSE 1%AEP
()			(ft)	(ft)	(ft)	(ft)
WG-MH2.2	A	Woodgate @ Green Ranch	62.10	68.22	66.50	67.05
WG-MH5	B	Woodgate @ Trailcrest	60.30	67.24	66.24	66.83
RL-MH3.2	C	Ridgeland @ Green Ranch	60.35	67.76	61.67	64.85
RL-MH7	D	Ridgeland @ Trailcrest	61.00	67.34	66.23	66.82
BR-MH4	E	Bluerock @ Deergrove	58.80	68.44	60.34	63.52
BR-MH7	F	Bluerock @ Rockshire	65.50	67.34	61.09	61.96
Node238	G	Connorvale @ Russ	60.5	68.01	61.00	62.38
CV-MH4	H	Connorvale @ Deergrove	58.10	68.18	59.75	62.31
CV-MH7	I	Connorvale @ Rockshire	56.26	67.67	59.13	61.63
AN-MH3.2	J	Anice @ Deergrove	60.41	67.86	62.08	63.41

The proposed system has additional flows into P138-01-00 and need to be mitigated within a detention basin. The location of the detention basin should be determined in future. The size has been estimated to be around 35 ac-ft to 40 ac-ft. Detailed modeling will be required after locating the detention pond. The proposed system will fix internal drainage issues. Flooding is expected to be reduced by at least one foot. Greens Bayou out of bank flooding will be solved after improvements are made to Greens Bayou.

4.5 Project Cost

The proposed extreme event swale was determined to be the most cost-effective solution available for the subdivision. Prices and contingencies were estimated based on the FEMA cost curves and typical cost estimates provided by the Harris County Engineering Department. The construction costs for the proposed storm sewer system is estimated at a grand total of just over $14 million. A detailed copy of the construction cost estimate is presented in **Appendix E**.

4.6 Public Comment

The public meeting for the drainage improvement projects for Castlewood Addition Sections 3 and 4 was held on September 10, 2019 at East Aldine Management District. The results of the study were communicated with the attending residents. After the presentation, the Q&A session was held to receive the comments and concerns from residents of the subdivision. The comments in **Table 4** were received by Harris County Engineering Department.

Table 4: Public Comments and Responses

Name	Comment/Question	Response
Norma Montes	Will there be a sewer system installed in the near future?	Storm sewer system is the recommended alternative for improving drainage. The precinct is considering the option to install the sanitary sewers for the subdivision at the same time of installation of storm sewer system. Project timing and coordination is going under an evaluation for proper efficiency and benefit.
Ventura Ramirez	Clean and dig out the ditches so rain water can flow to the basins from Aldine Westfield to US 59 on Lauder Rd	Ditch maintenance is critical to ensure the proper performance of the drainage system. However, a storm sewer system is our recommended alternative for improving drainage in the subdivision.
Michael Guerra	Been talking about haven't did it.	Project timing and coordination is going under an evaluation for proper efficiency and benefit.
Maggie and John Wanza	Connorvale Rd is the only outlet for drainage for the whole neighborhood. There needs to be another outlet for water. The ditch in front of my house never drains completely. There are Snakes and mosquitos around my house because of this. They dug the ditch so deep we cant keep it cut. The culverts are filled with grass and debris. Our driveway was replaced with asphalt when they dug the deep ditch. Now that asphalt has sunk and my driveway is a mess. Water is draining down Connorvale Rd from Aldine Westfield into our neighborhood and that needs to stop. We have septic systems and no rules for houses requiring so much property for these systems. So this creates excess water in the sewer drain system.	Connorvale Rd has been identified as the primary outfall in the existing conditions. Storm sewer system is our recommended alternative for improving drainage. There will be three outfalls to the bayou in the recommendation. Furthermore, there is a recommended box sized to collect the runoff from west subdivision (Aldine Westfield) and take it to the bayou.

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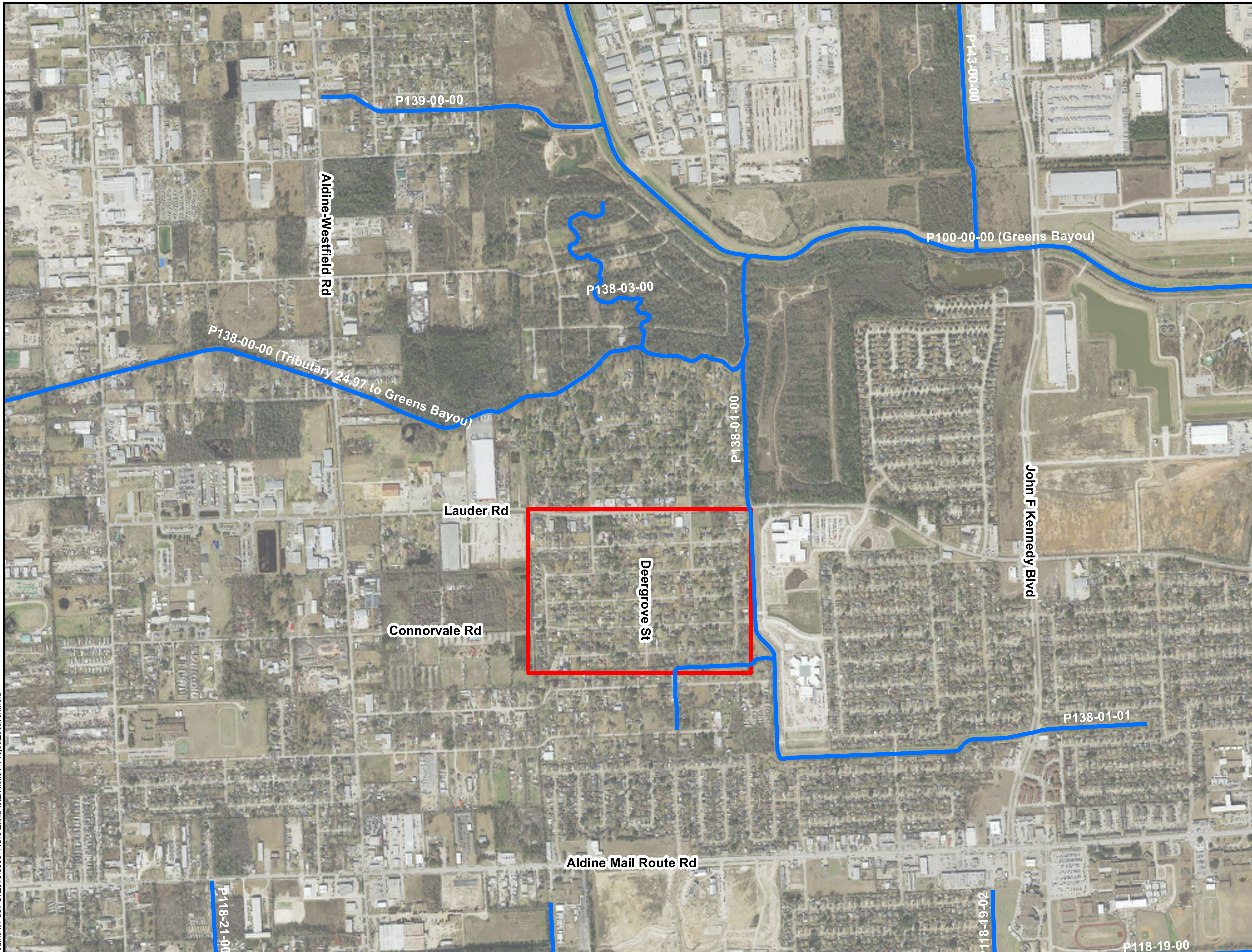

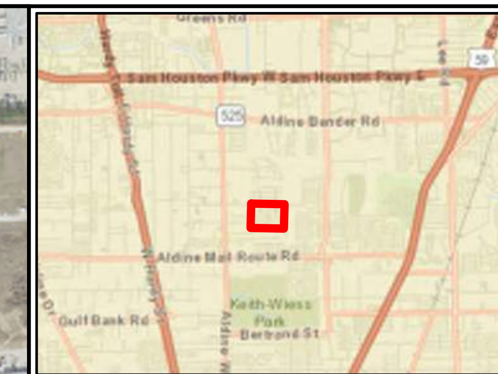

Legend

Project Location

Harris County Streams

0 500 1,000

1 inch = 1,000 feet

Source: HGAC 2018

N

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Cypress, Texas 77429
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Fax: 291-204-0210

Castlewood Addition, Sections 3 and 4

Project Location Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 1

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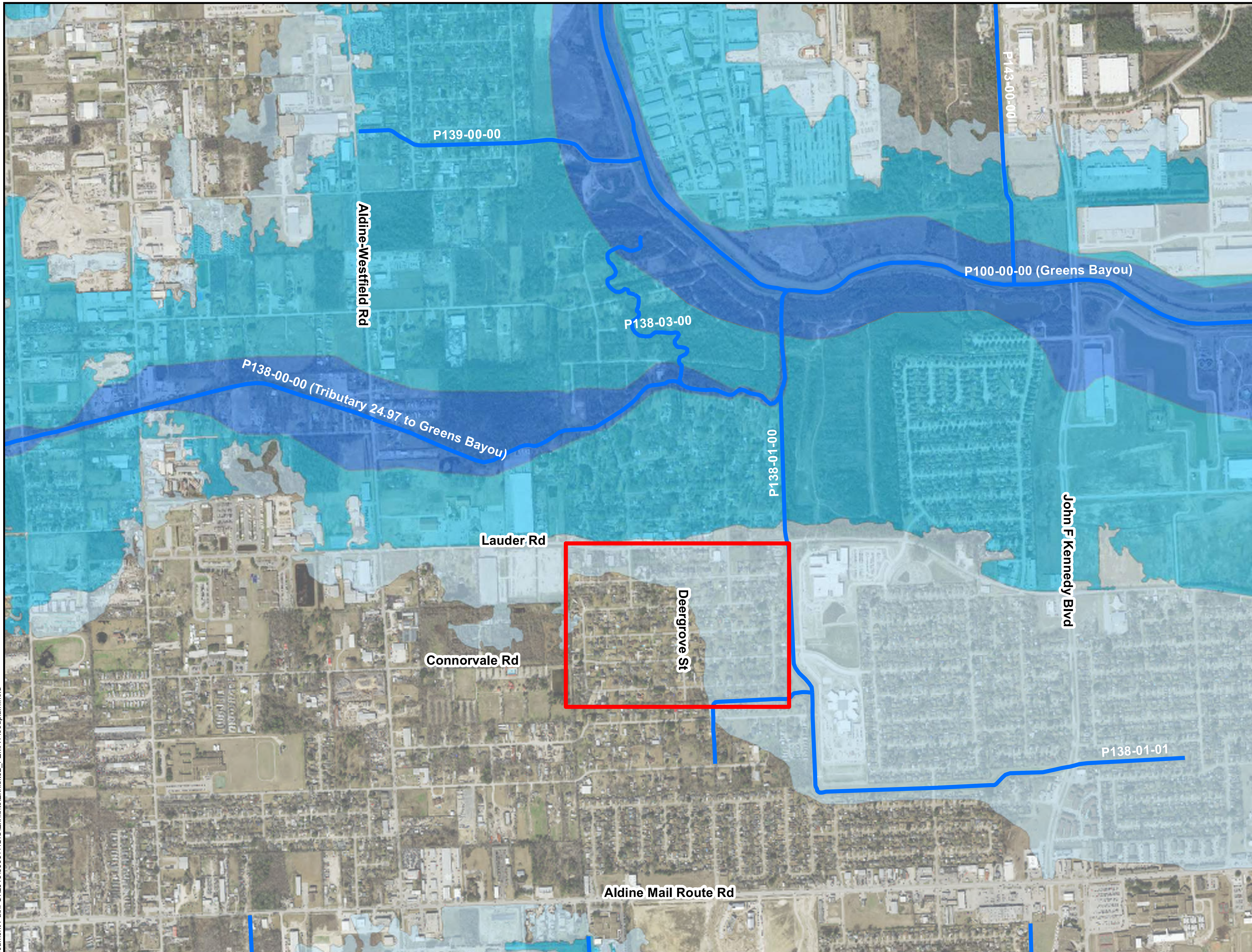

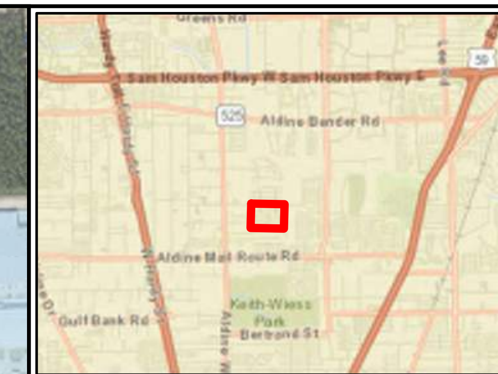

Legend

- Project Location
- Harris County Streams

FEMA Floodplains

- Floodway
- 1% AEP
- 0.2% AEP

0 500 1,000

1 inch = 1,000 feet

Source: HGAC 2018

N

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Castlewood Addition, Sections 3 and 4

FEMA Floodplain Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 2

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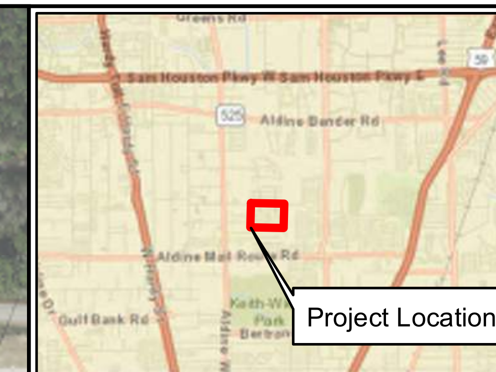

Legend

Water Lines

0 150 300

1 inch = 300 feet

Source: HGAC 2018

N

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Castlewood Addition, Sections 3 and 4

Water Line Location Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 3

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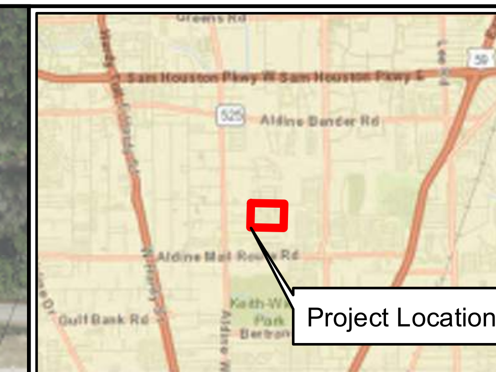

Legend

Electric Lines

0 150 300

1 inch = 300 feet
Source: HGAC 2018

N

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Castlewood Addition, Sections 3 and 4

Centerpoint Energy Electric Line Location Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 4

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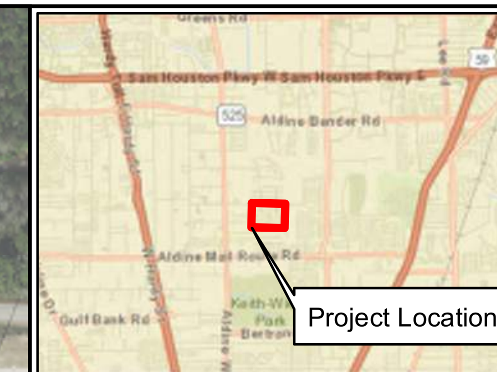

Legend

Gas Lines

0 150 300

1 inch = 300 feet

Source: HGAC 2018

N

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Castlewood Addition, Sections 3 and 4

Centerpoint Energy Gas Line Location Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 5

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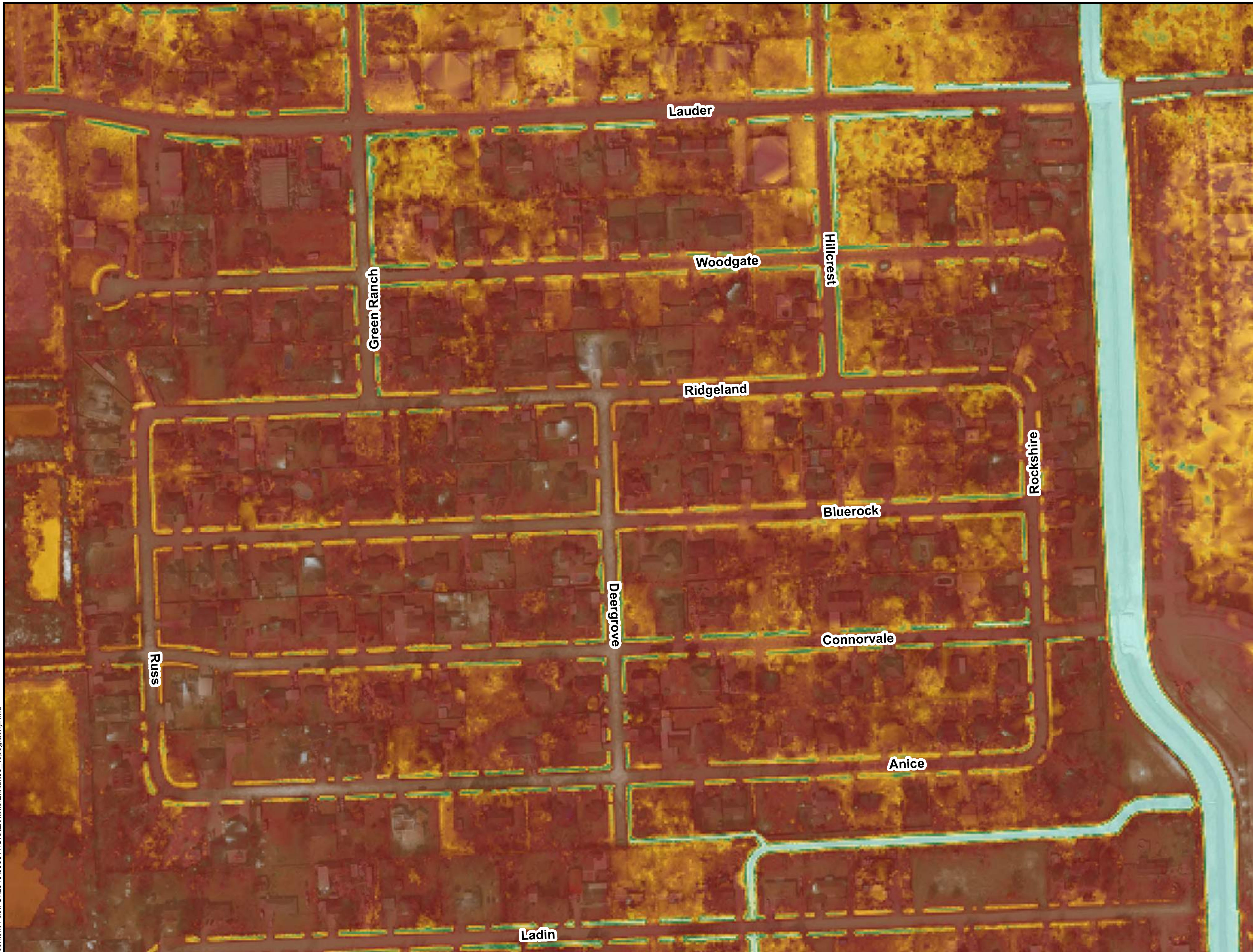

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Topography

Value

High : 70.05

Low : 53.04

0 150 300

1 inch = 221 feet

Source: HGAC 2018

N

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Castlewood Addition, Sections 3 and 4

Topography

SEPTEMBER 2019	Job No: 390011	EXHIBIT 6

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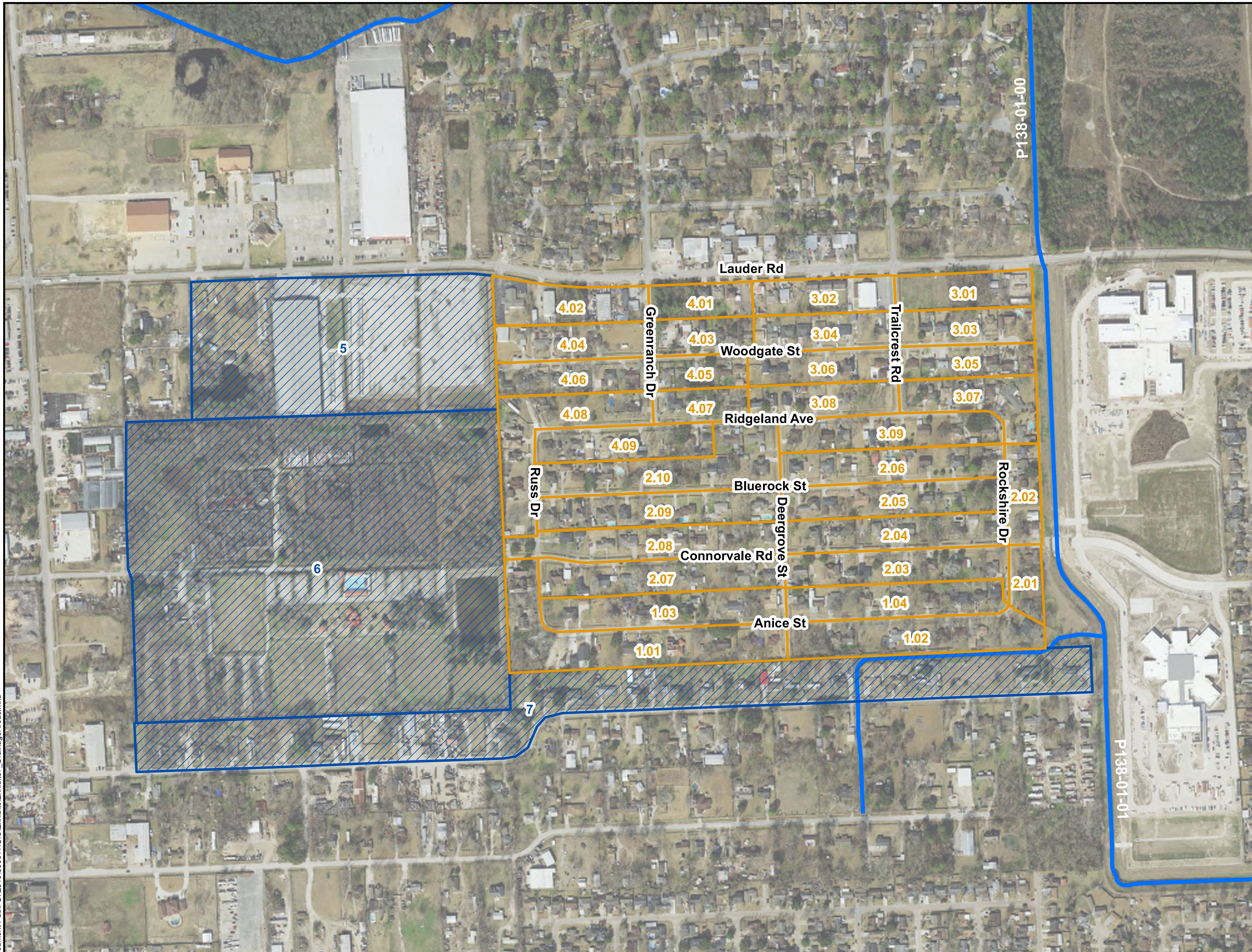

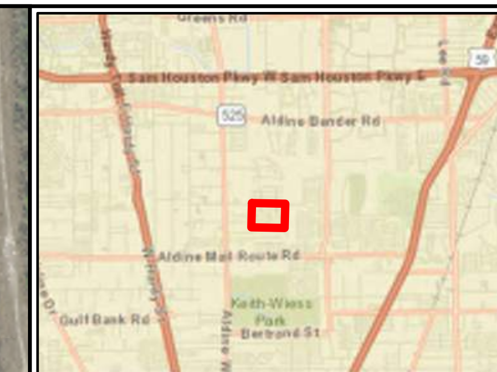

Legend

- Harris County Streams
- Onsite Drainage Areas
- Offsite Drainage Areas

0 250 500

1 inch = 417 feet
Source: HGAC 2018

N

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Castlewood Addition, Sections 3 and 4

Drainage Area Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 7

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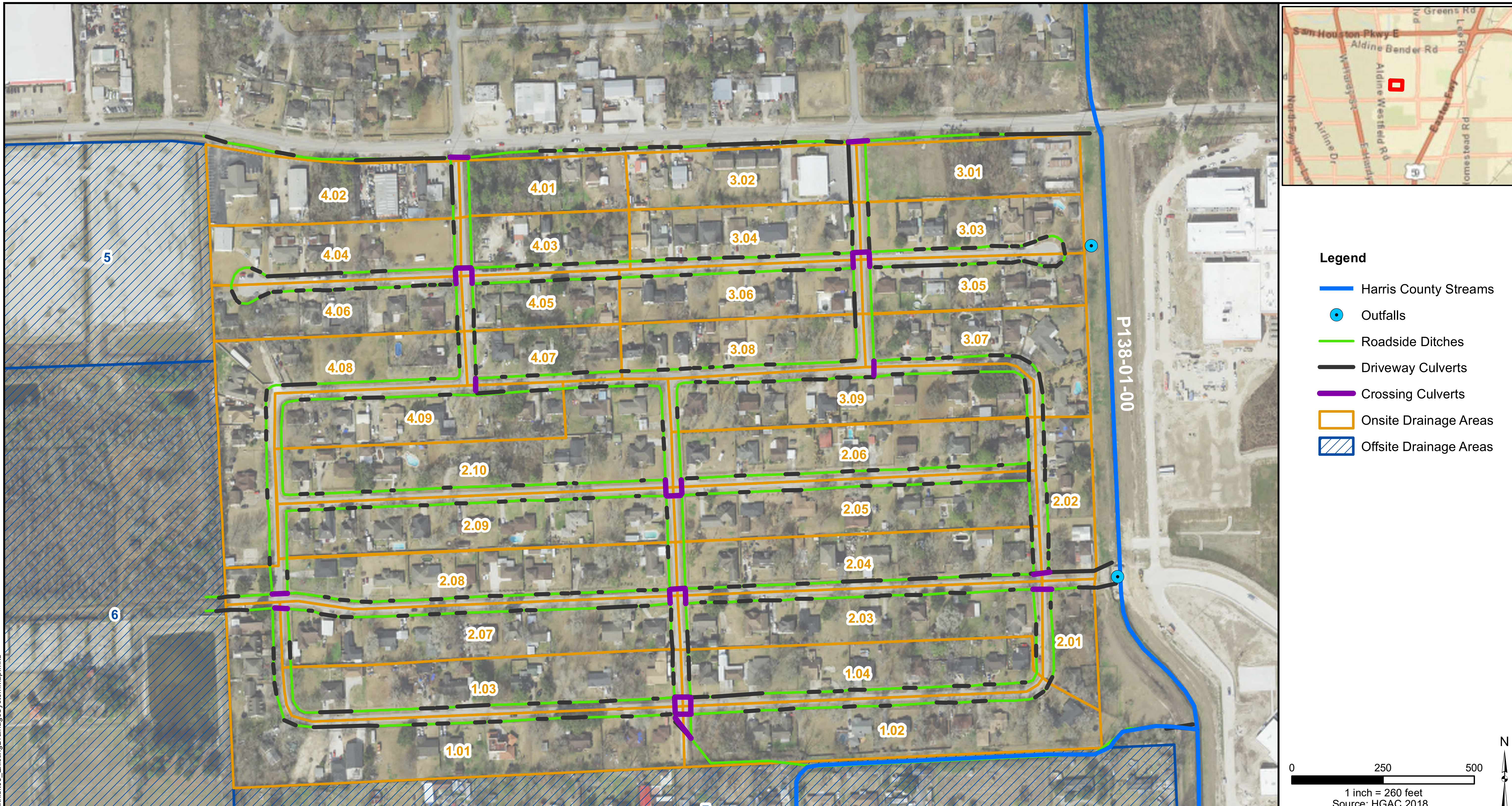

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Castlewood Sections 3 and 4

Existing Drainage System Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 8

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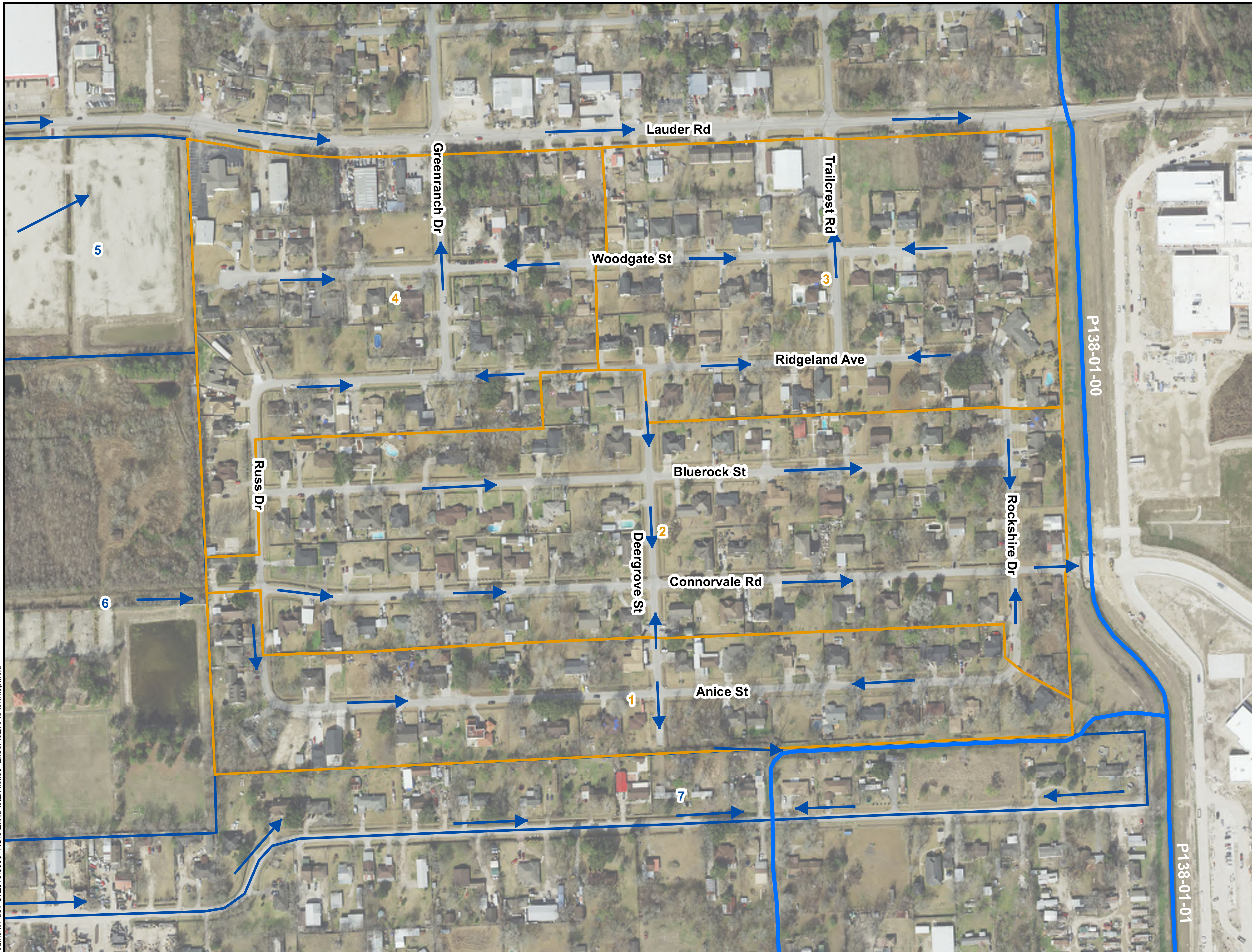

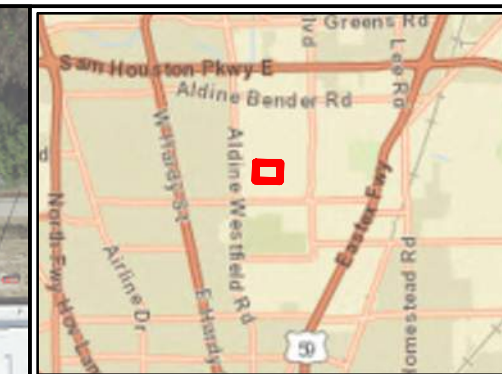

Legend

- Harris County Streams
- Extreme Event Path
- Onsite Drainage Areas
- Offsite Drainage Areas

0 125 250
1 inch = 260 feet
Source: HGAC 2018

N

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Castlewood Sections 3 and 4

Existing Extreme Event Overland Flow Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 9

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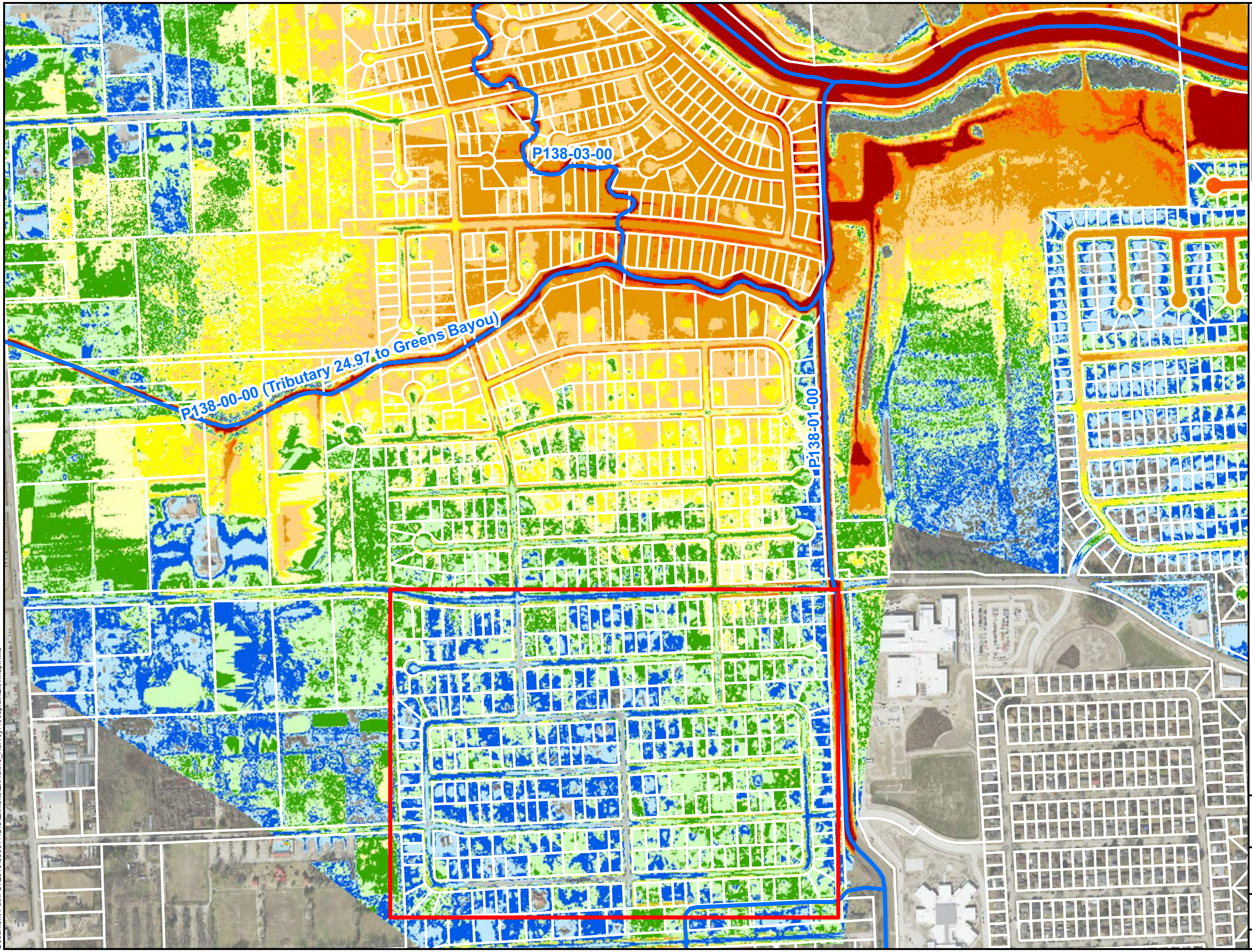

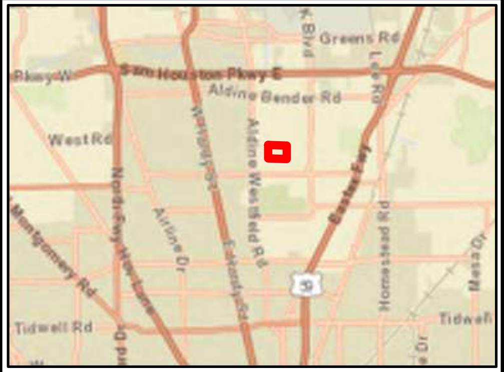

Legend

- Project Location
- Harris County Streams

Harvey Ponding Depths

- 0 - 0.5 (ft)
- 0.5 - 1 (ft)
- 1 - 1.5 (ft)
- 1.5 - 2 (ft)
- 2 - 2.5 (ft)
- 2.5 - 3 (ft)
- 3 - 4 (ft)
- 4 - 6 (ft)
- 6 - 8 (ft)
- > 8 (ft)

N

0 150 300

1 inch = 512 feet
Source: HGAC 2018

CivilTech Engineering, Inc.
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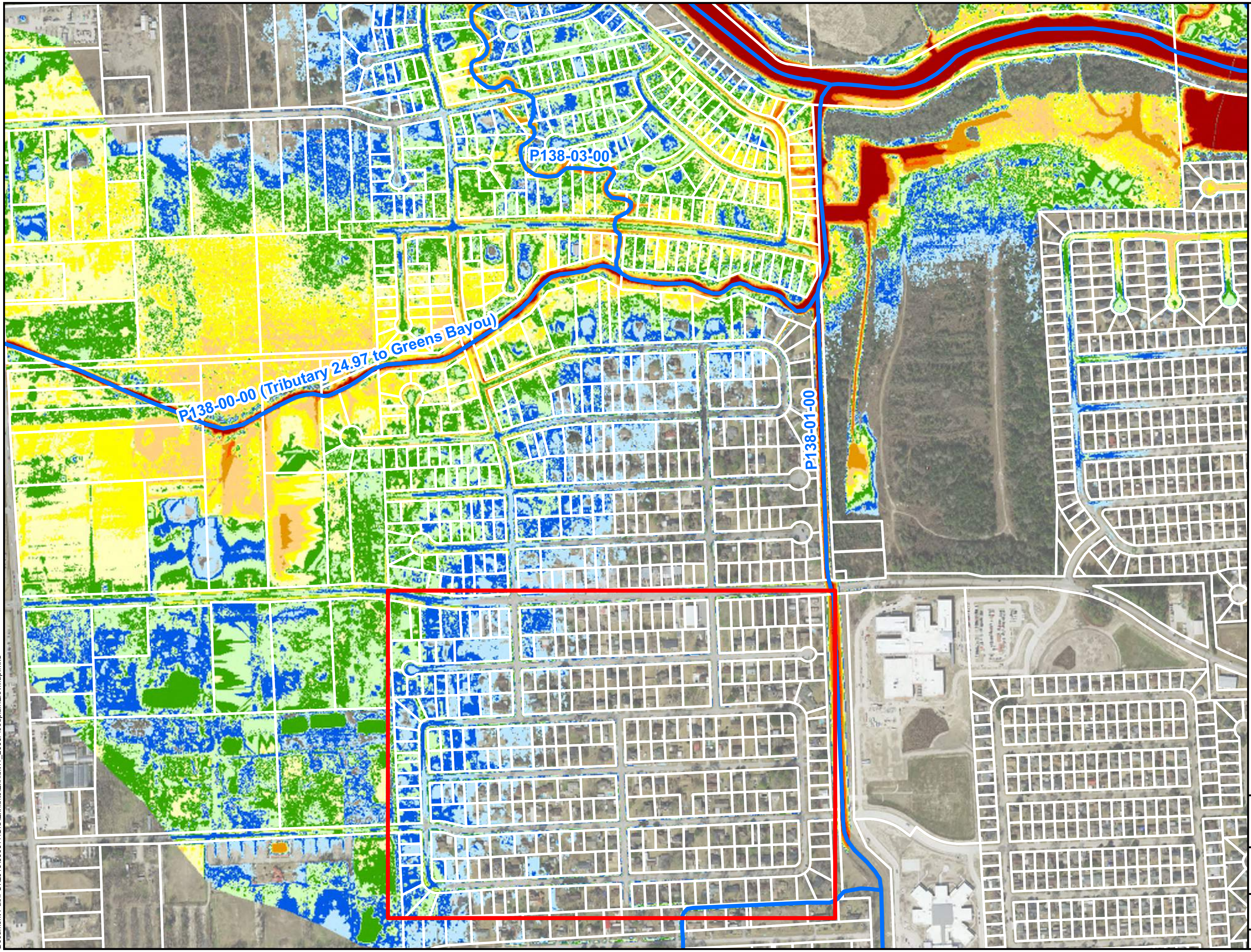
Cypress, Texas 77429
Tel: 281-304-0200
Fax: 291-204-0210

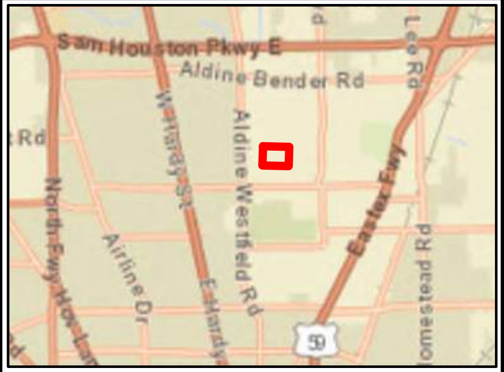
Castlewood Addition, Section 3 and 4

Hurricane Harvey Floodplain Elevation Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 10

Date Saved: 10/7/2019 11:23:52 AM





Legend

- Project Location
- Harris County Streams

2006 Event Ponding Depths

- 0 - 0.5 (ft)
- 0.5 - 1 (ft)
- 1 - 1.5 (ft)
- 1.5 - 2 (ft)
- 2 - 2.5 (ft)
- 2.5 - 3 (ft)
- 3 - 4 (ft)
- 4 - 6 (ft)
- 6 - 8 (ft)
- > 8 (ft)

0 250 500

1 inch = 500 feet

Source: HGAC 2018

N

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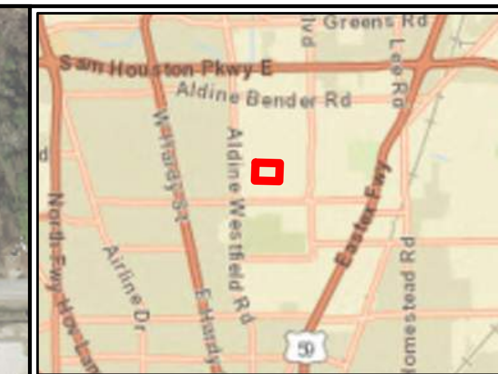
Castlewood Addition, Section 3 and 4

2006 Event Floodplain Elevation Map

SEPTEMBER 2019	Job No: 390011	EXHIBIT 11

Document Path: O:\2019\390011\GIS\Exhibits\Exhibit11_2006FloodplainElevMap.mxd

Date Saved: 10/7/2019 11:25:58 AM



Legend

★ Strategic Points

Ponding Depths (ft)

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

N

0 250 500

1 inch = 250 feet
Source: HGAC 2018

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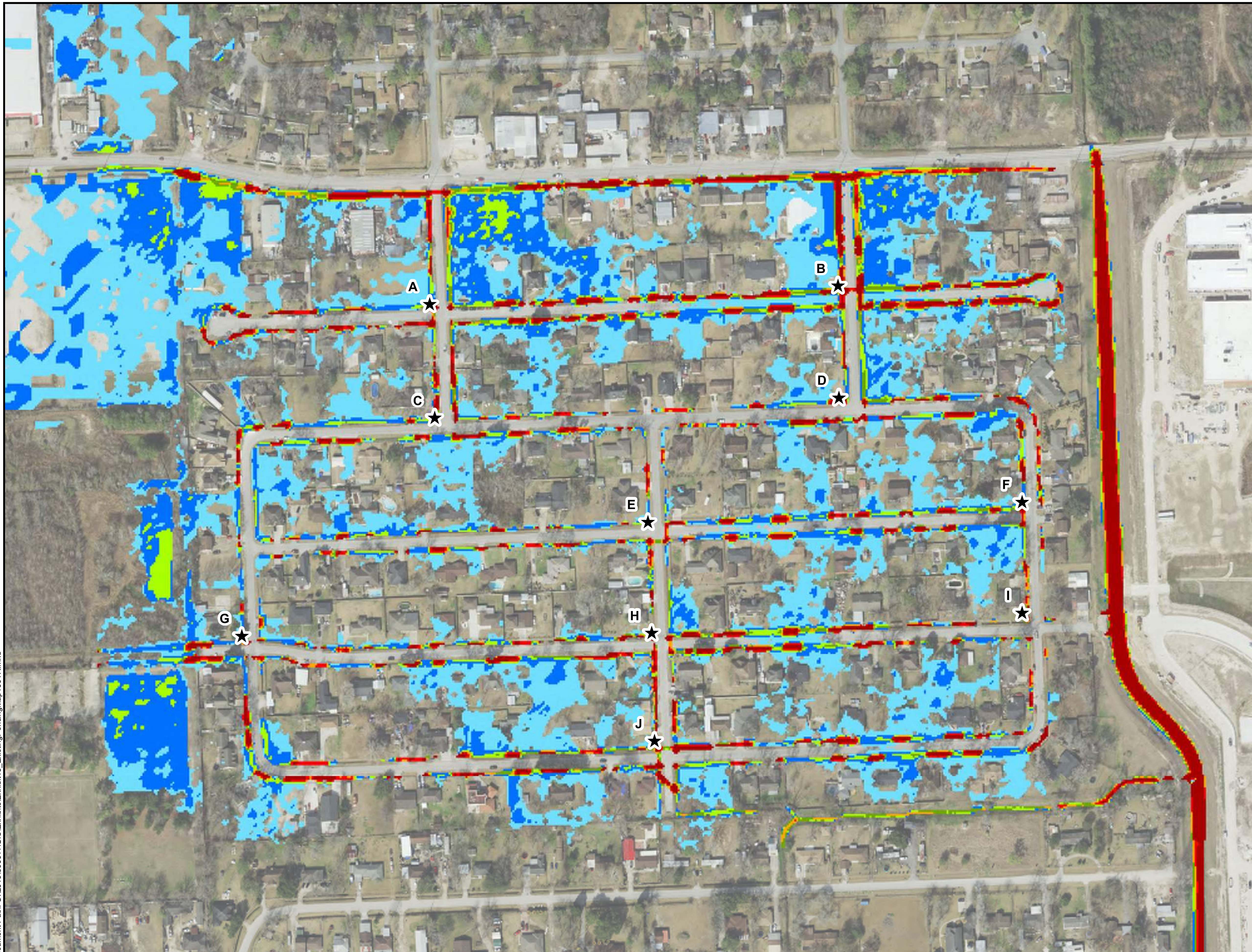
Castlewood Addition, Sections 3 and 4

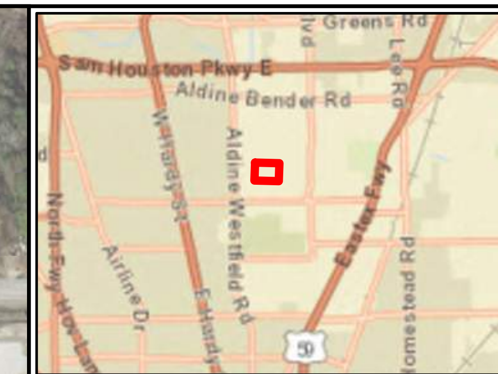
Existing Ponding Depth Map
2 YR

SEPTEMBER 2019	Job No: 390011	EXHIBIT 12

Document Path: O:\2019\390011\GIS\Exhibits\Exhibit12_ExistingPondingMap2YR.mxd

Date Saved: 10/7/2019 11:28:27 AM





Legend

★ Strategic Points

Ponding Depths (ft)

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

N

0 250 500

1 inch = 250 feet
Source: HGAC 2018

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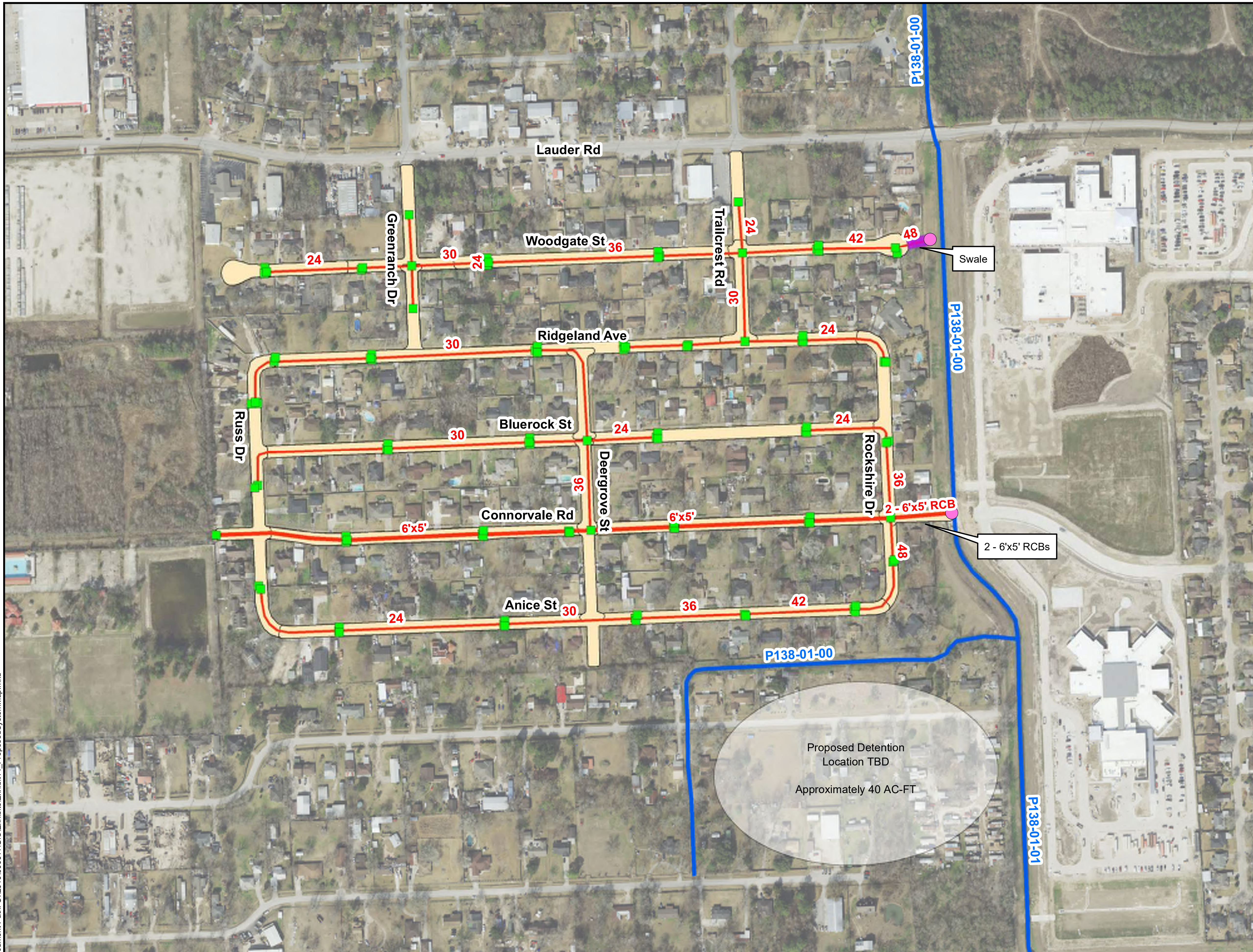
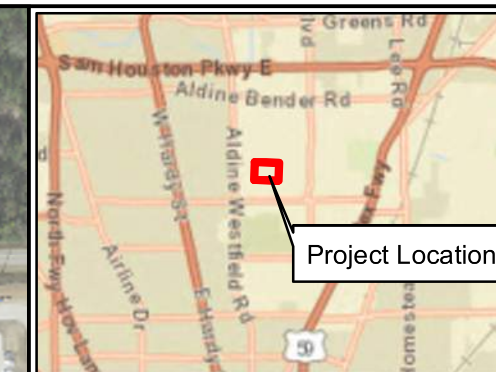
Castlewood Addition, Sections 3 and 4

Existing Ponding Depth Map
100 YR

SEPTEMBER 2019	Job No: 390011	EXHIBIT 13

Document Path: O:\2019\390011\GIS\Exhibits\Exhibit13_ExistingPondingMap100YR.mxd





Legend

- Proposed Storm Sewer System
- Proposed Inlets and Manholes
- Outfalls
- Proposed Extreme Event Swale
- Proposed Detention Pond Location (40 ac-ft)
- Proposed Roadway Replacement (Curb and Gutter)
- Harris County Streams

0 250 500

1 inch = 312 feet
Source: HGAC 2018

N

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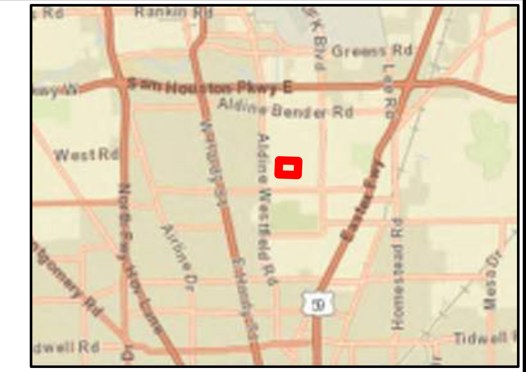
Castlewood Sections 3 and 4

Proposed System

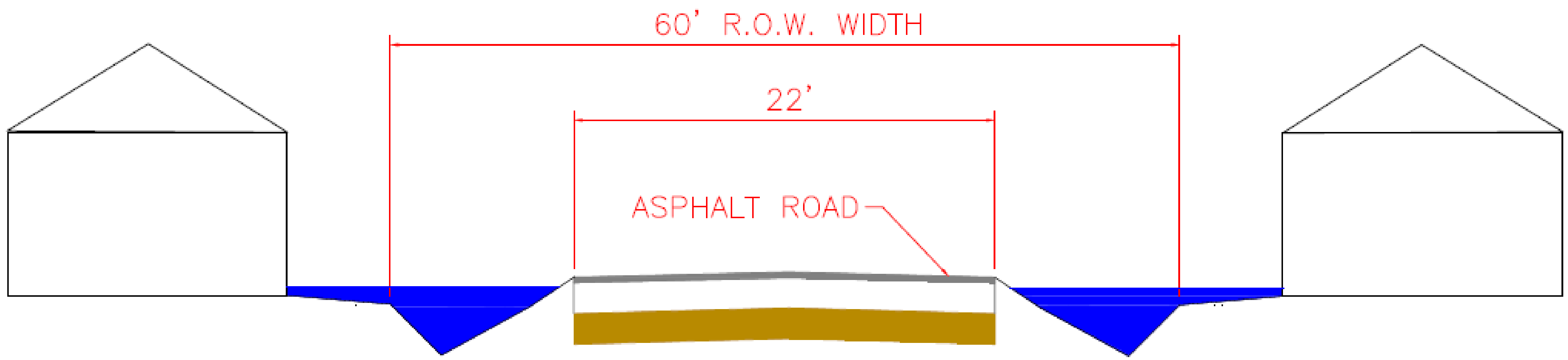
SEPTEMBER 2019	Job No: 390011	EXHIBIT 14

Date Saved: 10/7/2019 11:32:14 AM
Document Path: O:\2019\390011\GIS\Exhibits\Exhibit14_ProposedSystemMap.mxd

Date Saved: 10/7/2019 11:34:34 AM

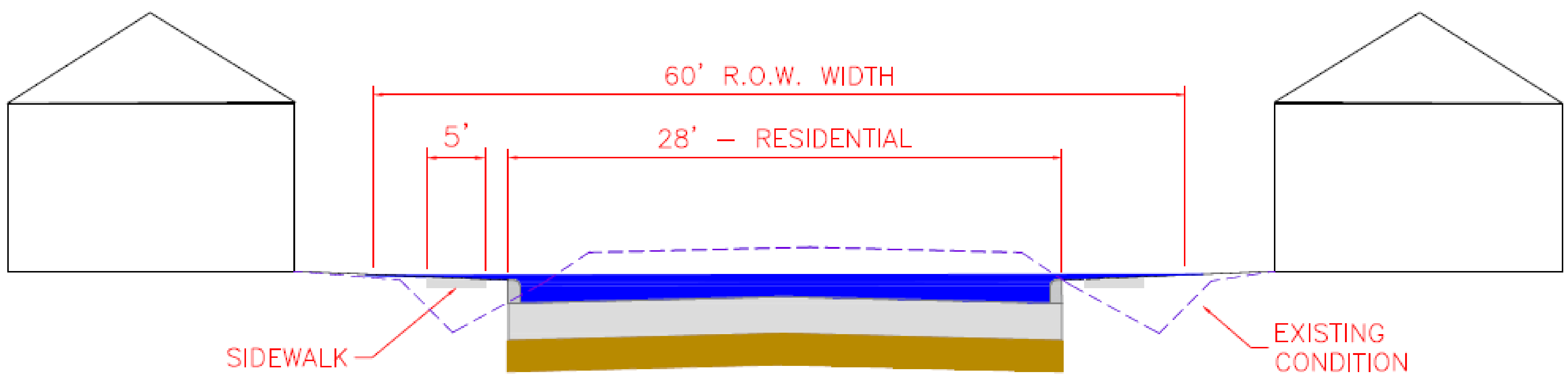


EXISTING

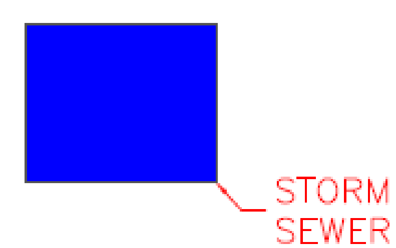


EXISTING ASPHALT

PROPOSE



PROPOSED CONCRETE



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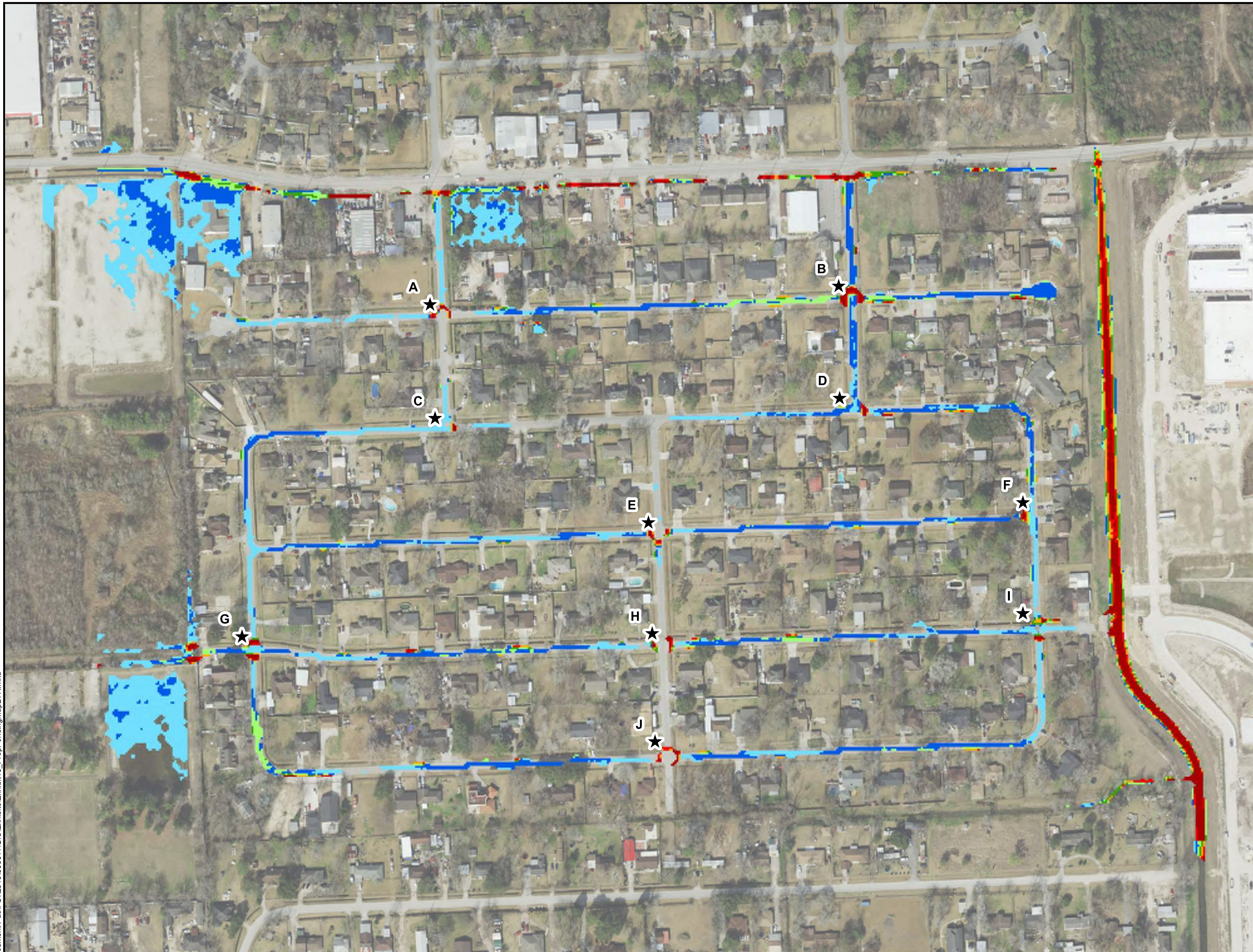
Castlewood Sections 3 and 4

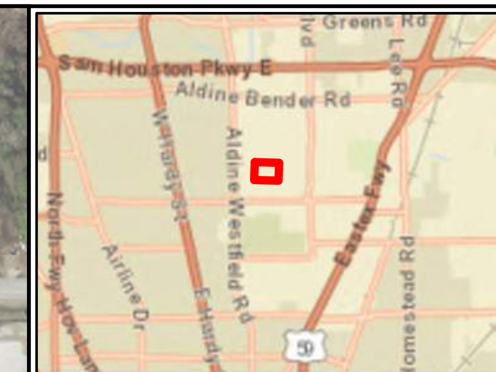
Existing Versus Proposed Roadway Schematic

SEPTEMBER 2019	No. 390011	EXHIBIT 15

Document Path: O:\2019\390011\GIS\Exhibits\Exhibit15_RoadwaySchematic.mxd

Date Saved: 10/7/2019 11:38:18 AM





Legend

★ Strategic Points

Ponding Depths (ft)

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

N

0 250 500

1 inch = 250 feet
Source: HGAC 2018

CivilTech Engineering, Inc.
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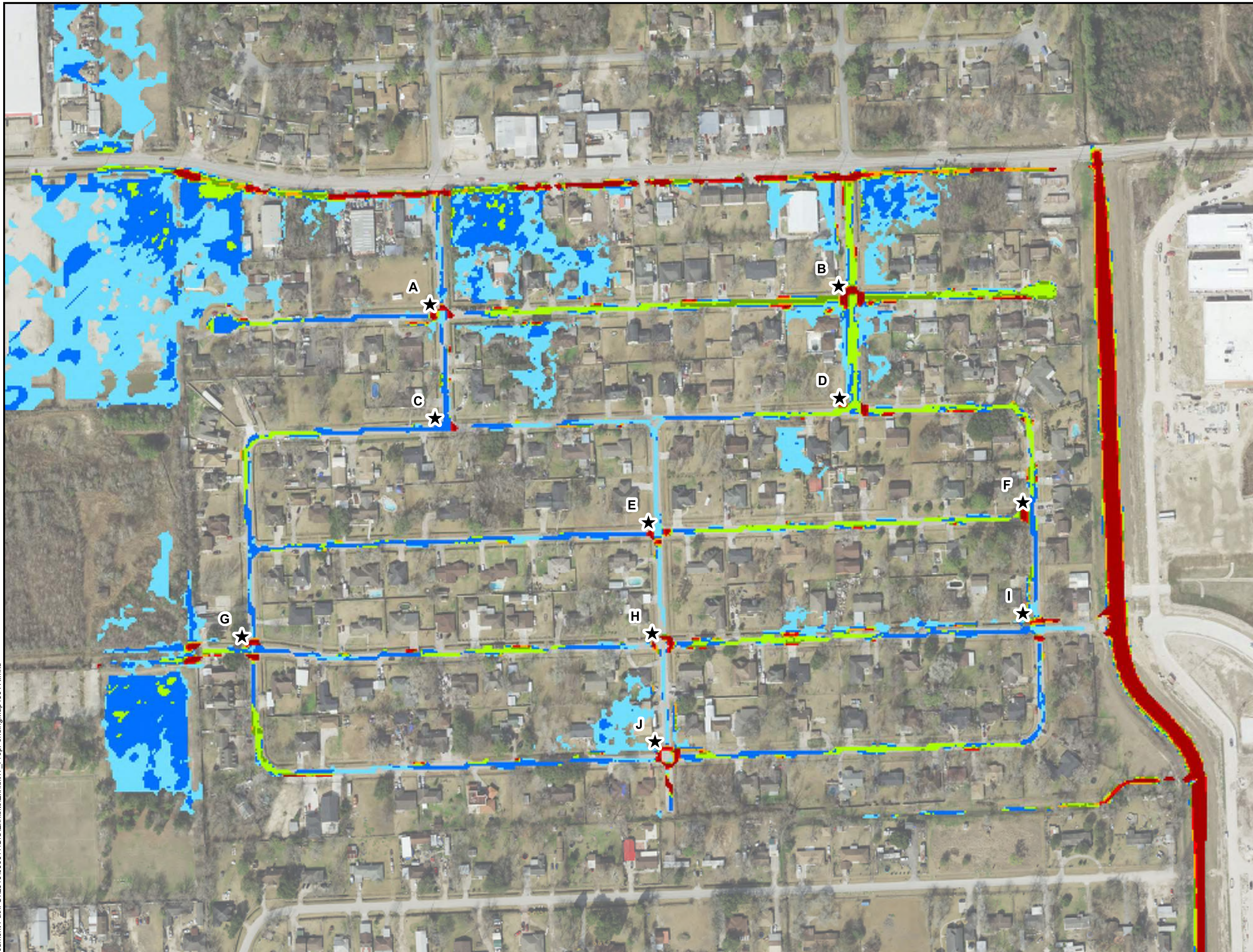
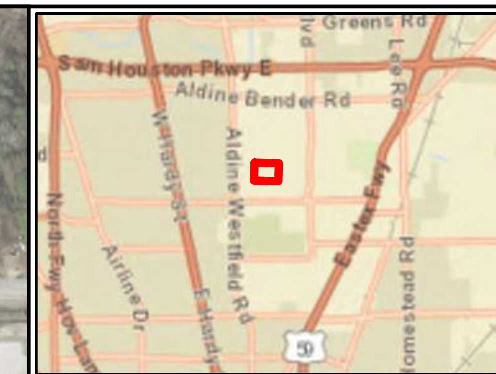
Castlewood Addition, Sections 3 and 4

Proposed Ponding Depth Map
2 YR

SEPTEMBER 2019	Job No: 390011	EXHIBIT 16

Document Path: O:\2019\390011\GIS\Exhibits\Exhibit16_PropPondingMap2YR.mxd





Legend

★ Strategic Points

Ponding Depths (ft)

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

N

0 250 500

1 inch = 250 feet
Source: HGAC 2018

CivilTech Engineering, Inc.

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Cypress, Texas 77429
Tel: 281-304-0200
Fax: 291-204-0210

Castlewood Addition, Sections 3 and 4

Proposed Ponding Depth Map
100 YR

SEPTEMBER 2019	Job No: 390011	EXHIBIT 17

Date Saved: 10/7/2019 11:39:54 AM

Document Path: O:\2019\390011\GIS\Exhibits\Exhibit17_PropPondingMap100YR.mxd

APPENDIX A

Date	Photograph ID	Location	Photograph	Comment
6-10-2019	20190610_093230	Connorvale Rd		Outfall to P138-01-00 located under Connorvale bridge
6-10-2019	IMG_3373	Connorvale Rd		Upstream side of Connorvale bridge

6-10-2019	IMG_3378	Connorvale Rd		P138-01 at Connorvale Rd
6-10-2019	20190610_094616	Lauder Rd		P138-01-00 crossing under Lauder Rd

6-10-2019	20190610_094318	Lauder at Trailcrest		Drainage ditch
6-10-2019	IMG_3412	Bluerock at Russ		Driveway culvert

6-10-2019	20190610_101956	Bluerock at Rockshire		Drainage ditch
6-10-2019	20190610_102036	Rockshire at Connorvale		Drainage ditch

6-10-2019	20190610_101325	Greenranch at Ridgeland		Drainage ditch
6-10-2019	IMG_3401	P138-00-00		Confluence of P138-00-00 and P138-01-00

6-10-2019	IMG_3408	P138-00-00		P138-00-00
6-10-2019	IMG_3405	P138-01-00		P138-01-00

APPENDIX B

Address	Flood Event																	
	8/27/2017	05/25/2015	07/31/2014	04/18/2009	09/13/2008	06/19/2006	11/17/2003	10/29/2002	06/09/2001	06/05/2001	03/12/1997	05/24/1997	03/04/1992	06/26/1989	05/18/1989	08/18/1983	05/20/1982	09/19/1979
(-)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)
13402 Rockshire Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13406 Rockshire Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13411 Russ Dr, Houston 77039	4	0*	0*	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
13414 Rockshire Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13415 Russ Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13421 Russ Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13423 Russ Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13502 Rockshire Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13503 Russ Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13507 Russ Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13510 Rockshire Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13514 Rockshire Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13518 Rockshire Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13519 Russ Dr, Houston 77039	4	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
13522 Rockshire Dr, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2402 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2402 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2403 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2404 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2406 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2407 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2410 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0*	0*	-
2410 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2410 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2411 Anice St, Houston 77039	4	0*	-	0*	0*	0*	-	-	-	-	-	-	-	-	-	-	-	-
2411 Bluerock St, Houston 77039	4	-	-	-	0*	0*	-	-	-	-	-	-	0*	0*	-	-	-	-
2414 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2415 Bluerock St, Houston 77039	4	-	-	-	0*	0*	-	-	-	-	-	-	-	-	-	-	-	-
2415 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2418 Bluerock St, Houston 77039	4	-	-	-	0*	-	-	-	-	0*	-	-	-	-	-	-	-	-
2422 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2422 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2423 Anice St, Houston 77039	4	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2423 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2426 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2430 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2431 Anice St, Houston 77039	4	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2431 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2434 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2502 Bluerock St, Houston 77039	4	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2502 Connorvale Rd, Houston 77039	4	-	-	-	0*	0*	-	-	-	-	-	-	-	-	-	-	-	-
2503 Bluerock St, Houston 77039	4	-	-	-	0*	0*	-	-	-	-	-	-	-	-	-	-	-	-
2506 Connorvale Rd, Houston 77039	4	-	-	-	0*	0*	-	-	-	-	-	-	-	-	-	-	-	-
2507 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2510 Bluerock St, Houston 77039	4	-	-	-	0*	-	-	-	0*	-	-	-	-	-	-	-	-	-
2510 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2511 Anice St, Houston 77039	4	-	-	-	0*	0*	-	-	-	0*	-	-	0*	0*	-	-	-	-
2511 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2602 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2603 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2603 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	0*	0*	-	-	-	-
2603 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2610 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2610 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2614 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2614 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2614 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2615 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2615 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2615 Connorvale Rd, Houston 77039	4	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2701 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Address	Flood Event																	
	8/27/2017	05/25/2015	07/31/2014	04/18/2009	09/13/2008	06/19/2006	11/17/2003	10/29/2002	06/09/2001	06/05/2001	03/12/1997	05/24/1997	03/04/1992	06/26/1989	05/18/1989	08/18/1983	05/20/1982	09/19/1979
(-)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)
2702 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2703 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2703 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2704 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2706 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2710 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2710 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2710 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2711 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2711 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2711 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2714 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2715 Bluerock St, Houston 77039	4	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2718 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2719 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2722 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2723 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2726 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2726 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2726 Connorvale Rd, Houston 77039	4	-	-	-	0*	-	-	-	-	0*	-	-	-	-	-	-	-	-
2727 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2727 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2803 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2806 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2806 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2806 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2807 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2807 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2810 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2814 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2814 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2814 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2815 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2815 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2815 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2819 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2822 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2822 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2823 Anice St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2823 Bluerock St, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2823 Connorvale Rd, Houston 77039	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2702 Lauder Rd, Houston 77039	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2703 Woodgate St, Houston 77039	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2706 Lauder Rd, Houston 77039	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2707 Woodgate St, Houston 77039	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2710 Lauder Rd, Houston 77039	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2719 Woodgate St, Houston 77039	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13526 Rockshire Dr, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13527 Russ Dr, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13531 Russ Dr, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13534 Rockshire Dr, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13535 Russ Dr, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2402 Ridgeland St, Houston 77039	36	-	-	-	0*	0*	-	-	-	-	-	-	-	-	-	-	-	-
2402 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2406 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2409 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2410 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2411 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2414 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2414 Woodgate St, Houston 77039	36	-	-	0*	0*	0*	-	0*	-	0*	-	-	-	-	-	-	-	-
2417 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Address	Flood Event																	
	8/27/2017	05/25/2015	07/31/2014	04/18/2009	09/13/2008	06/19/2006	11/17/2003	10/29/2002	06/09/2001	06/05/2001	03/12/1997	05/24/1997	03/04/1992	06/26/1989	05/18/1989	08/18/1983	05/20/1982	09/19/1979
(-)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)
2422 Woodgate St, Houston 77039	36	0*	-	0*	0*	0*	-	-	-	-	-	-	-	-	-	-	-	-
2425 Woodgate St, Houston 77039	36	-	-	0*	0*	0*	-	-	-	0*	-	-	0*	0*	-	-	-	0*
2426 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2430 Ridgeland St, Houston 77039	36	-	-	-	0*	0*	-	-	0*	-	-	-	0*	0*	0*	-	-	-
2430 Woodgate St, Houston 77039	36	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2434 Ridgeland St, Houston 77039	36	-	-	-	0*	0*	-	-	-	0*	-	-	-	-	-	-	-	-
2435 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2438 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2442 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2448 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2452 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2458 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2502 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2506 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2507 Ridgeland St, Houston 77039	36	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2510 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	0*	0*	-	-	-	-
2511 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2511 Woodgate St, Houston 77039	36	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2514 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2514 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2514 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2517 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2518 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2519 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2602 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2603 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2605 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2606 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2607 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2610 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2611 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2611 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2612 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2614 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2614 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2614 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2615 Ridgeland Dr, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2615 Woodgate St, Houston 77039	36	-	0*	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-
2618 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2619 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2623 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2701 Ridgeland Ave, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2702 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2703 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2706 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2707 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2710 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2710 Woodgate St, Houston 77039	36	-	-	-	0*	-	-	-	-	-	-	-	-	-	-	-	-	-
2714 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2715 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2718 Woodgate, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2722 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2726 Ridgeland Ave, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2802 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2806 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2806 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2807 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2807 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2811 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2811 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2814 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Address	Flood Event																	
	8/27/2017	05/25/2015	07/31/2014	04/18/2009	09/13/2008	06/19/2006	11/17/2003	10/29/2002	06/09/2001	06/05/2001	03/12/1997	05/24/1997	03/04/1992	06/26/1989	05/18/1989	08/18/1983	05/20/1982	09/19/1979
(-)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)
2814 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2819 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2819 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2821 Ridgeland Ave, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2822 Ridgeland St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2823 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2826 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2827 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2828 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2830 Woodgate St, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2836 Lauder Rd, Houston 77039	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2407 Woodgate St, Houston 77039	-	-	-	-	0*	0*	-	-	-	0*	-	-	-	-	-	-	-	-
2415 Ridgeland St, Houston 77039	-	-	-	-	-	-	0*	0*	0*	0*	0*	-	0*	0*	0*	-	-	-
2602 Connorvale Rd, Houston 77039	-	-	-	-	-	0*	0*	0*	-	0*	-	0*	0*	0*	-	-	-	-

Note: 0* = Flood Loss is reported on this date, but no depth was provided

APPENDIX C

Drainage Area ID	Area (ac)	Land Use Type														Computed Weighted Percent Impervious
		Undeveloped	Residential Rural Lot	Residential Large Lot (New)	Residential Large Lot (Old)	Residential Small Lot	Schools	Developed Green Areas	Light Industrial/ Commercial	High Density	Isolated Transportation	Water	Parcel w/ Detention	Paved Areas	Unpaved Areas	
		0%	5%	25%	25%	40%	40%	15%	65%	85%	80%	100%	0%	100%	15%	Total
1.01	5.99	--	--	--	--	4.78	--	--	--	--	--	--	--	0.34	0.87	40%
1.02	4.28	--	--	--	--	3.22	--	--	--	--	--	--	--	0.28	0.78	39%
1.03	3.80	--	--	--	--	2.84	--	--	--	--	--	--	--	0.36	0.60	42%
1.04	3.38	--	--	--	--	2.58	--	--	--	--	--	--	--	0.27	0.53	41%
2.01	1.07	--	--	--	--	0.81	--	--	--	--	--	--	--	0.12	0.14	44%
2.02	1.57	--	--	--	--	1.14	--	--	--	--	--	--	--	0.16	0.27	42%
2.03	3.47	--	--	--	--	2.58	--	--	--	--	--	--	--	0.32	0.57	41%
2.04	3.41	--	--	--	--	2.61	--	--	--	--	--	--	--	0.28	0.52	41%
2.05	3.46	--	--	--	--	2.61	--	--	--	--	--	--	--	0.32	0.53	42%
2.06	3.40	--	--	--	--	2.58	--	--	--	--	--	--	--	0.27	0.55	41%
2.07	3.82	--	--	--	--	2.98	--	--	--	--	--	--	--	0.32	0.53	42%
2.08	3.93	--	--	--	--	2.94	--	--	--	--	--	--	--	0.37	0.63	42%
2.09	3.72	--	--	--	--	2.82	--	--	--	--	--	--	--	0.29	0.61	41%
2.10	4.74	--	--	--	--	3.57	--	--	--	--	--	--	--	0.46	0.71	42%
3.01	2.24	1.44	--	--	--	--	--	--	0.68	--	--	--	--	0.04	0.07	22%
3.02	2.27	--	--	--	--	1.32	--	--	0.90	--	--	--	--	0.04	0.01	51%
3.03	2.23	--	--	--	--	1.71	--	--	--	--	--	--	--	0.22	0.31	42%
3.04	2.34	--	--	--	--	1.85	--	--	--	--	--	--	--	0.19	0.30	42%
3.05	2.05	--	--	--	--	1.57	--	--	--	--	--	--	--	0.19	0.29	42%
3.06	2.26	--	--	--	--	1.76	--	--	--	--	--	--	--	0.19	0.30	42%
3.07	2.65	--	--	--	--	2.05	--	--	--	--	--	--	--	0.17	0.43	40%
3.08	2.32	--	--	--	--	1.76	--	--	--	--	--	--	--	0.18	0.37	41%
3.09	3.41	--	--	--	--	2.58	--	--	--	--	--	--	--	0.35	0.48	43%
4.01	1.61	0.68	--	--	--	0.88	--	--	--	--	--	--	--	0.04	--	25%
4.02	2.78	0.42	--	--	--	--	--	--	2.13	--	--	--	--	0.06	0.18	53%
4.03	1.74	--	--	--	--	1.27	--	--	--	--	--	--	--	0.18	0.30	42%
4.04	2.52	--	--	--	--	2.08	--	--	--	--	--	--	--	0.21	0.23	43%
4.05	1.48	--	--	--	--	1.07	--	--	--	--	--	--	--	0.15	0.25	42%
4.06	2.36	--	--	--	--	1.82	--	--	--	--	--	--	--	0.21	0.33	42%
4.07	1.46	--	--	--	--	1.07	--	--	--	--	--	--	--	0.14	0.24	42%
4.08	4.02	--	--	--	--	3.27	--	--	--	--	--	--	--	0.29	0.46	42%
4.09	2.79	--	--	--	--	2.14	--	--	--	--	--	--	--	0.21	0.44	41%
5.00	18.89	4.91	--	--	--	--	--	--	13.76	--	--	--	--	--	--	47%
6.00	50.86	--	--	4.74	--	--	--	34.30	9.71	--	--	--	--	5.15	--	35%
7.00	83.64	--	--	--	--	67.95	--	--	3.20	--	--	--	--	3.59	8.90	41%

Drainage Analysis
Hydrological Analysis: Peak Flows

UPIN: 19102MF17301

Drainage Area ID	Area	C Value	Time of Concentration	I_2	Q_2	I_{100}	Q_{100}
(-)	(ac)	(-)	(min)	(in/hr)	(cfs)	(in/hr)	(cfs)
1.01	5.99	0.55	28.71	3.39	11.17	7.29	24.03
1.02	4.28	0.55	27.92	3.44	8.10	7.39	17.42
1.03	3.80	0.55	27.65	3.46	7.24	7.43	15.55
1.04	3.38	0.55	27.39	3.48	6.46	7.47	13.88
2.01	1.07	0.55	25.12	3.64	2.14	7.80	4.59
2.02	1.57	0.55	25.83	3.59	3.10	7.69	6.64
2.03	3.47	0.55	27.45	3.47	6.64	7.46	14.25
2.04	3.41	0.55	27.41	3.48	6.52	7.46	14.00
2.05	3.46	0.55	27.44	3.47	6.61	7.46	14.20
2.06	3.40	0.55	27.40	3.48	6.50	7.46	13.95
2.07	3.82	0.55	27.66	3.46	7.27	7.43	15.62
2.08	3.93	0.55	27.72	3.45	7.46	7.42	16.03
2.09	3.72	0.55	27.60	3.46	7.09	7.44	15.23
2.10	4.74	0.55	28.15	3.42	8.92	7.36	19.19
3.01	2.24	0.55	26.52	3.54	4.36	7.59	9.34
3.02	2.27	0.55	26.56	3.54	4.42	7.58	9.48
3.03	2.23	0.55	26.52	3.54	4.35	7.59	9.32
3.04	2.34	0.55	26.61	3.53	4.54	7.57	9.73
3.05	2.05	0.55	26.35	3.55	4.01	7.61	8.59
3.06	2.26	0.55	26.54	3.54	4.39	7.58	9.42
3.07	2.65	0.55	26.87	3.51	5.12	7.54	10.98
3.08	2.32	0.55	26.59	3.53	4.50	7.58	9.65
3.09	3.41	0.55	27.41	3.48	6.51	7.46	13.98
4.01	1.61	0.55	25.88	3.59	3.18	7.68	6.82
4.02	2.78	0.65	26.97	3.51	6.34	7.52	13.60
4.03	1.74	0.55	26.02	3.58	3.41	7.66	7.31
4.04	2.52	0.55	26.77	3.52	4.88	7.55	10.47
4.05	1.48	0.55	25.72	3.60	2.93	7.71	6.27
4.06	2.36	0.55	26.64	3.53	4.59	7.57	9.84
4.07	1.46	0.55	25.69	3.60	2.90	7.71	6.21
4.08	4.02	0.55	27.78	3.45	7.63	7.41	16.39
4.09	2.79	0.55	26.98	3.51	5.38	7.52	11.54
5.00	18.89	0.65	31.78	3.20	39.29	6.92	84.99
6.00	50.86	0.18	34.98	3.03	27.74	6.59	60.31
7.00	83.64	0.55	36.80	2.94	135.30	6.41	295.11

Drainage Analysis

Hydrological Analysis: HMS Parameters

UPIN: 19102MF17301

Subbasin		Green & Ampt Loss Method					Unit Clark Hydrograph Transform			
Drainage ID	Area	Initial Content	Saturated Content	Suction	Conductivity	Impervious	Time of Concentration	Uncalibrated R	R2	R100
(-)	(mi2)	(in)	(-)	(in)	(in/hr)	(%)	(hr)	(hr)	(hr)	(hr)
1.01	0.0094	0.024	0.46	3.5	0.024	39.78%	0.4784	0.96	0.50	0.54
1.02	0.0067	0.024	0.46	3.5	0.024	39.31%	0.4653	0.93	0.50	0.53
1.03	0.0059	0.024	0.46	3.5	0.024	41.74%	0.4609	0.92	0.50	0.53
1.04	0.0053	0.024	0.46	3.5	0.024	40.86%	0.4565	0.91	0.48	0.52
2.01	0.0017	0.024	0.46	3.5	0.024	43.51%	0.4187	0.84	0.49	0.47
2.02	0.0025	0.024	0.46	3.5	0.024	41.91%	0.4305	0.86	0.47	0.49
2.03	0.0054	0.024	0.46	3.5	0.024	41.45%	0.4575	0.92	0.50	0.52
2.04	0.0053	0.024	0.46	3.5	0.024	41.19%	0.4569	0.91	0.49	0.52
2.05	0.0054	0.024	0.46	3.5	0.024	41.65%	0.4574	0.91	0.49	0.52
2.06	0.0053	0.024	0.46	3.5	0.024	40.71%	0.4567	0.91	0.49	0.52
2.07	0.0060	0.024	0.46	3.5	0.024	41.56%	0.4611	0.92	0.49	0.53
2.08	0.0061	0.024	0.46	3.5	0.024	41.59%	0.4621	0.92	0.49	0.53
2.09	0.0058	0.024	0.46	3.5	0.024	40.55%	0.4601	0.92	0.49	0.53
2.10	0.0074	0.024	0.46	3.5	0.024	42.05%	0.4692	0.94	0.50	0.53
3.01	0.0035	0.024	0.46	3.5	0.024	22.19%	0.4421	0.88	0.47	0.51
3.02	0.0036	0.024	0.46	3.5	0.024	50.92%	0.4426	0.89	0.49	0.50
3.03	0.0035	0.024	0.46	3.5	0.024	42.39%	0.4420	0.88	0.49	0.50
3.04	0.0036	0.024	0.46	3.5	0.024	41.67%	0.4435	0.89	0.49	0.51
3.05	0.0032	0.024	0.46	3.5	0.024	42.10%	0.4391	0.88	0.48	0.50
3.06	0.0035	0.024	0.46	3.5	0.024	41.75%	0.4424	0.88	0.48	0.51
3.07	0.0041	0.024	0.46	3.5	0.024	39.69%	0.4479	0.90	0.49	0.51
3.08	0.0036	0.024	0.46	3.5	0.024	40.69%	0.4432	0.89	0.48	0.51
3.09	0.0053	0.024	0.46	3.5	0.024	42.65%	0.4568	0.91	0.49	0.52
4.01	0.0025	0.024	0.46	3.5	0.024	24.64%	0.4313	0.86	0.47	0.49
4.02	0.0043	0.024	0.46	3.5	0.024	52.75%	0.4496	0.90	0.34	0.33
4.03	0.0027	0.024	0.46	3.5	0.024	41.78%	0.4337	0.87	0.48	0.49
4.04	0.0039	0.024	0.46	3.5	0.024	42.66%	0.4461	0.89	0.48	0.50
4.05	0.0023	0.024	0.46	3.5	0.024	41.97%	0.4286	0.86	0.48	0.49
4.06	0.0037	0.024	0.46	3.5	0.024	41.98%	0.4439	0.89	0.48	0.51
4.07	0.0023	0.024	0.46	3.5	0.024	41.70%	0.4282	0.86	0.47	0.49
4.08	0.0063	0.024	0.46	3.5	0.024	41.50%	0.4629	0.93	0.50	0.53
4.09	0.0044	0.024	0.46	3.5	0.024	40.52%	0.4497	0.90	0.48	0.52
5.00	0.0295	0.024	0.46	3.5	0.024	47.35%	0.5296	1.06	0.39	0.39
6.00	0.0795	0.024	0.46	3.5	0.024	34.98%	0.5829	1.17	3.67	5.10
7.00	0.1307	0.024	0.46	3.5	0.024	40.87%	0.6134	1.23	0.68	0.75

Drainage Area 1.01 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0	0	0	0
2:45	0.01	0.01	0	0.1	0	0.1
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.2	0	0.2
9:00	0.02	0.01	0.01	0.2	0	0.2
9:15	0.02	0.01	0.01	0.2	0	0.2
9:30	0.02	0.01	0.01	0.2	0	0.2
9:45	0.02	0.01	0.01	0.2	0	0.2
10:00	0.02	0.01	0.01	0.2	0	0.2
10:15	0.02	0.01	0.01	0.2	0	0.2
10:30	0.02	0.01	0.01	0.2	0	0.2
10:45	0.02	0.01	0.01	0.2	0	0.2
11:00	0.02	0.01	0.01	0.2	0	0.2
11:15	0.02	0.01	0.01	0.2	0	0.2
11:30	0.02	0.01	0.01	0.2	0	0.2
11:45	0.02	0.01	0.01	0.2	0	0.2
12:00	0.03	0.01	0.01	0.3	0	0.3
12:15	0.03	0.01	0.01	0.3	0	0.3

12:30	0.03	0.01	0.02	0.3	0	0.3
12:45	0.03	0.01	0.02	0.3	0	0.3
13:00	0.03	0.01	0.02	0.4	0	0.4
13:15	0.03	0.01	0.02	0.4	0	0.4
13:30	0.04	0.01	0.02	0.5	0	0.5
13:45	0.04	0.01	0.03	0.5	0	0.5
14:00	0.04	0.01	0.03	0.6	0	0.6
14:15	0.05	0.01	0.03	0.6	0	0.6
14:30	0.05	0.01	0.04	0.7	0	0.7
14:45	0.07	0.01	0.06	0.9	0	0.9
15:00	0.08	0.01	0.07	1.1	0	1.1
15:15	0.06	0.01	0.05	1.2	0	1.2
15:30	0.08	0.01	0.07	1.3	0	1.3
15:45	0.21	0.01	0.2	1.7	0	1.7
16:00	0.44	0.01	0.43	3.3	0	3.3
16:15	1.1	0.01	1.09	7.3	0	7.3
16:30	0.25	0.01	0.24	11.2	0	11.2
16:45	0.09	0.01	0.08	10.6	0	10.6
17:00	0.07	0.01	0.06	7.5	0	7.5
17:15	0.08	0.01	0.07	5.2	0	5.2
17:30	0.07	0.01	0.06	3.8	0	3.8
17:45	0.05	0.01	0.04	2.8	0	2.8
18:00	0.05	0.01	0.04	2.2	0	2.2
18:15	0.04	0.01	0.03	1.7	0	1.7
18:30	0.04	0.01	0.03	1.3	0	1.3
18:45	0.04	0.01	0.03	1.1	0	1.1
19:00	0.03	0.01	0.03	0.9	0	0.9
19:15	0.03	0.01	0.02	0.8	0	0.8
19:30	0.03	0.01	0.02	0.7	0	0.7
19:45	0.03	0.01	0.02	0.6	0	0.6
20:00	0.03	0.01	0.02	0.6	0	0.6
20:15	0.03	0.01	0.02	0.5	0	0.5
20:30	0.03	0.01	0.02	0.5	0	0.5
20:45	0.02	0.01	0.02	0.5	0	0.5
21:00	0.02	0.01	0.01	0.4	0	0.4
21:15	0.02	0.01	0.01	0.4	0	0.4
21:30	0.02	0.01	0.01	0.4	0	0.4
21:45	0.02	0.01	0.01	0.4	0	0.4
22:00	0.02	0.01	0.01	0.3	0	0.3
22:15	0.02	0.01	0.01	0.3	0	0.3
22:30	0.02	0.01	0.01	0.3	0	0.3
22:45	0.02	0.01	0.01	0.3	0	0.3
23:00	0.02	0.01	0.01	0.3	0	0.3
23:15	0.02	0.01	0.01	0.3	0	0.3
23:30	0.02	0.01	0.01	0.2	0	0.2
23:45	0.02	0.01	0.01	0.2	0	0.2
0:00	0.02	0.01	0.01	0.2	0	0.2

Drainage Area 1.02 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0	0	0	0
2:45	0.01	0.01	0	0	0	0
3:00	0.01	0.01	0	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.2	0	0.2
11:45	0.02	0.01	0.01	0.2	0	0.2
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.01	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.3	0	0.3
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.4	0	0.4
14:00	0.04	0.01	0.03	0.4	0	0.4
14:15	0.05	0.01	0.03	0.5	0	0.5
14:30	0.05	0.01	0.04	0.5	0	0.5
14:45	0.07	0.01	0.06	0.6	0	0.6
15:00	0.08	0.01	0.07	0.8	0	0.8
15:15	0.06	0.01	0.05	0.9	0	0.9
15:30	0.08	0.01	0.07	0.9	0	0.9
15:45	0.21	0.01	0.2	1.3	0	1.3
16:00	0.44	0.01	0.43	2.4	0	2.4
16:15	1.1	0.01	1.09	5.3	0	5.3
16:30	0.25	0.01	0.24	8.1	0	8.1
16:45	0.09	0.01	0.08	7.6	0	7.6
17:00	0.07	0.01	0.06	5.3	0	5.3
17:15	0.08	0.01	0.07	3.7	0	3.7
17:30	0.07	0.01	0.06	2.7	0	2.7
17:45	0.05	0.01	0.04	2	0	2
18:00	0.05	0.01	0.04	1.5	0	1.5
18:15	0.04	0.01	0.03	1.2	0	1.2
18:30	0.04	0.01	0.03	0.9	0	0.9
18:45	0.04	0.01	0.03	0.8	0	0.8
19:00	0.03	0.01	0.03	0.6	0	0.6
19:15	0.03	0.01	0.02	0.5	0	0.5
19:30	0.03	0.01	0.02	0.5	0	0.5
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.4	0	0.4
20:15	0.03	0.01	0.02	0.4	0	0.4
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.01	0.3	0	0.3
21:15	0.02	0.01	0.01	0.3	0	0.3
21:30	0.02	0.01	0.01	0.3	0	0.3
21:45	0.02	0.01	0.01	0.3	0	0.3
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.2	0	0.2
23:30	0.02	0.01	0.01	0.2	0	0.2
23:45	0.02	0.01	0.01	0.2	0	0.2
0:00	0.02	0.01	0.01	0.2	0	0.2

Drainage Area 1.03 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.2	0	0.2
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.3	0	0.3
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.4	0	0.4
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.5	0	0.5
14:45	0.07	0.01	0.06	0.6	0	0.6
15:00	0.08	0.01	0.07	0.7	0	0.7
15:15	0.06	0.01	0.05	0.8	0	0.8
15:30	0.08	0.01	0.07	0.8	0	0.8
15:45	0.21	0.01	0.2	1.1	0	1.1
16:00	0.44	0.01	0.43	2.1	0	2.1
16:15	1.1	0.01	1.09	4.7	0	4.7
16:30	0.25	0.01	0.24	7.2	0	7.2
16:45	0.09	0.01	0.08	6.7	0	6.7
17:00	0.07	0.01	0.06	4.7	0	4.7
17:15	0.08	0.01	0.07	3.2	0	3.2
17:30	0.07	0.01	0.06	2.4	0	2.4
17:45	0.05	0.01	0.04	1.8	0	1.8
18:00	0.05	0.01	0.04	1.4	0	1.4
18:15	0.04	0.01	0.03	1.1	0	1.1
18:30	0.04	0.01	0.03	0.8	0	0.8
18:45	0.04	0.01	0.03	0.7	0	0.7
19:00	0.03	0.01	0.03	0.6	0	0.6
19:15	0.03	0.01	0.02	0.5	0	0.5
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.4	0	0.4
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.3	0	0.3
21:15	0.02	0.01	0.01	0.3	0	0.3
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.2	0	0.2
23:30	0.02	0.01	0.01	0.2	0	0.2
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 1.04 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.01	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.4	0	0.4
14:45	0.07	0.01	0.06	0.5	0	0.5
15:00	0.08	0.01	0.07	0.6	0	0.6
15:15	0.06	0.01	0.05	0.7	0	0.7
15:30	0.08	0.01	0.07	0.7	0	0.7
15:45	0.21	0.01	0.2	1	0	1
16:00	0.44	0.01	0.43	1.9	0	1.9
16:15	1.1	0.01	1.09	4.3	0	4.3
16:30	0.25	0.01	0.24	6.5	0	6.5
16:45	0.09	0.01	0.08	6	0	6
17:00	0.07	0.01	0.06	4.1	0	4.1
17:15	0.08	0.01	0.07	2.8	0	2.8
17:30	0.07	0.01	0.06	2	0	2
17:45	0.05	0.01	0.04	1.5	0	1.5
18:00	0.05	0.01	0.04	1.2	0	1.2
18:15	0.04	0.01	0.03	0.9	0	0.9
18:30	0.04	0.01	0.03	0.7	0	0.7
18:45	0.04	0.01	0.03	0.6	0	0.6
19:00	0.03	0.01	0.03	0.5	0	0.5
19:15	0.03	0.01	0.02	0.4	0	0.4
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.3	0	0.3
20:00	0.03	0.01	0.02	0.3	0	0.3
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.01 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0	0	0
5:00	0.01	0.01	0.01	0	0	0
5:15	0.01	0.01	0.01	0	0	0
5:30	0.01	0.01	0.01	0	0	0
5:45	0.01	0.01	0.01	0	0	0
6:00	0.01	0.01	0.01	0	0	0
6:15	0.01	0.01	0.01	0	0	0
6:30	0.01	0.01	0.01	0	0	0
6:45	0.01	0.01	0.01	0	0	0
7:00	0.01	0.01	0.01	0	0	0
7:15	0.01	0.01	0.01	0	0	0
7:30	0.02	0.01	0.01	0	0	0
7:45	0.02	0.01	0.01	0	0	0
8:00	0.02	0.01	0.01	0	0	0
8:15	0.02	0.01	0.01	0	0	0
8:30	0.02	0.01	0.01	0	0	0
8:45	0.02	0.01	0.01	0	0	0
9:00	0.02	0.01	0.01	0	0	0
9:15	0.02	0.01	0.01	0	0	0
9:30	0.02	0.01	0.01	0	0	0
9:45	0.02	0.01	0.01	0	0	0
10:00	0.02	0.01	0.01	0	0	0
10:15	0.02	0.01	0.01	0	0	0
10:30	0.02	0.01	0.01	0	0	0
10:45	0.02	0.01	0.01	0	0	0
11:00	0.02	0.01	0.01	0	0	0
11:15	0.02	0.01	0.01	0	0	0
11:30	0.02	0.01	0.01	0	0	0
11:45	0.02	0.01	0.01	0	0	0
12:00	0.03	0.01	0.01	0	0	0
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.1	0	0.1
13:30	0.04	0.01	0.03	0.1	0	0.1
13:45	0.04	0.01	0.03	0.1	0	0.1
14:00	0.04	0.01	0.03	0.1	0	0.1
14:15	0.05	0.01	0.04	0.1	0	0.1
14:30	0.05	0.01	0.04	0.1	0	0.1
14:45	0.07	0.01	0.06	0.2	0	0.2
15:00	0.08	0.01	0.07	0.2	0	0.2
15:15	0.06	0.01	0.05	0.2	0	0.2
15:30	0.08	0.01	0.07	0.2	0	0.2
15:45	0.21	0.01	0.2	0.3	0	0.3
16:00	0.44	0.01	0.43	0.6	0	0.6
16:15	1.1	0.01	1.09	1.4	0	1.4
16:30	0.25	0.01	0.25	2.1	0	2.1
16:45	0.09	0.01	0.08	1.8	0	1.8
17:00	0.07	0.01	0.06	1.3	0	1.3
17:15	0.08	0.01	0.07	0.9	0	0.9
17:30	0.07	0.01	0.06	0.6	0	0.6
17:45	0.05	0.01	0.04	0.5	0	0.5
18:00	0.05	0.01	0.04	0.4	0	0.4
18:15	0.04	0.01	0.04	0.3	0	0.3
18:30	0.04	0.01	0.03	0.2	0	0.2
18:45	0.04	0.01	0.03	0.2	0	0.2
19:00	0.03	0.01	0.03	0.2	0	0.2
19:15	0.03	0.01	0.02	0.1	0	0.1
19:30	0.03	0.01	0.02	0.1	0	0.1
19:45	0.03	0.01	0.02	0.1	0	0.1
20:00	0.03	0.01	0.02	0.1	0	0.1
20:15	0.03	0.01	0.02	0.1	0	0.1
20:30	0.03	0.01	0.02	0.1	0	0.1
20:45	0.02	0.01	0.02	0.1	0	0.1
21:00	0.02	0.01	0.02	0.1	0	0.1
21:15	0.02	0.01	0.01	0.1	0	0.1
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0	0	0
23:15	0.02	0.01	0.01	0	0	0
23:30	0.02	0.01	0.01	0	0	0
23:45	0.02	0.01	0.01	0	0	0
0:00	0.02	0.01	0.01	0	0	0

Drainage Area 2.02 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0	0	0
5:00	0.01	0.01	0.01	0	0	0
5:15	0.01	0.01	0.01	0	0	0
5:30	0.01	0.01	0.01	0	0	0
5:45	0.01	0.01	0.01	0	0	0
6:00	0.01	0.01	0.01	0	0	0
6:15	0.01	0.01	0.01	0	0	0
6:30	0.01	0.01	0.01	0	0	0
6:45	0.01	0.01	0.01	0	0	0
7:00	0.01	0.01	0.01	0	0	0
7:15	0.01	0.01	0.01	0	0	0
7:30	0.02	0.01	0.01	0	0	0
7:45	0.02	0.01	0.01	0	0	0
8:00	0.02	0.01	0.01	0	0	0
8:15	0.02	0.01	0.01	0	0	0
8:30	0.02	0.01	0.01	0	0	0
8:45	0.02	0.01	0.01	0	0	0
9:00	0.02	0.01	0.01	0	0	0
9:15	0.02	0.01	0.01	0	0	0
9:30	0.02	0.01	0.01	0	0	0
9:45	0.02	0.01	0.01	0	0	0
10:00	0.02	0.01	0.01	0	0	0
10:15	0.02	0.01	0.01	0	0	0
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.1	0	0.1
13:30	0.04	0.01	0.02	0.1	0	0.1
13:45	0.04	0.01	0.03	0.1	0	0.1
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.2	0	0.2
14:30	0.05	0.01	0.04	0.2	0	0.2
14:45	0.07	0.01	0.06	0.2	0	0.2
15:00	0.08	0.01	0.07	0.3	0	0.3
15:15	0.06	0.01	0.05	0.3	0	0.3
15:30	0.08	0.01	0.07	0.4	0	0.4
15:45	0.21	0.01	0.2	0.5	0	0.5
16:00	0.44	0.01	0.43	0.9	0	0.9
16:15	1.1	0.01	1.09	2.1	0	2.1
16:30	0.25	0.01	0.24	3.1	0	3.1
16:45	0.09	0.01	0.08	2.8	0	2.8
17:00	0.07	0.01	0.06	1.9	0	1.9
17:15	0.08	0.01	0.07	1.3	0	1.3
17:30	0.07	0.01	0.06	0.9	0	0.9
17:45	0.05	0.01	0.04	0.7	0	0.7
18:00	0.05	0.01	0.04	0.5	0	0.5
18:15	0.04	0.01	0.03	0.4	0	0.4
18:30	0.04	0.01	0.03	0.3	0	0.3
18:45	0.04	0.01	0.03	0.3	0	0.3
19:00	0.03	0.01	0.03	0.2	0	0.2
19:15	0.03	0.01	0.02	0.2	0	0.2
19:30	0.03	0.01	0.02	0.2	0	0.2
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.1	0	0.1
20:15	0.03	0.01	0.02	0.1	0	0.1
20:30	0.03	0.01	0.02	0.1	0	0.1
20:45	0.02	0.01	0.02	0.1	0	0.1
21:00	0.02	0.01	0.02	0.1	0	0.1
21:15	0.02	0.01	0.01	0.1	0	0.1
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.03 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.4	0	0.4
14:45	0.07	0.01	0.06	0.5	0	0.5
15:00	0.08	0.01	0.07	0.6	0	0.6
15:15	0.06	0.01	0.05	0.7	0	0.7
15:30	0.08	0.01	0.07	0.8	0	0.8
15:45	0.21	0.01	0.2	1	0	1
16:00	0.44	0.01	0.43	1.9	0	1.9
16:15	1.1	0.01	1.09	4.4	0	4.4
16:30	0.25	0.01	0.24	6.6	0	6.6
16:45	0.09	0.01	0.08	6.1	0	6.1
17:00	0.07	0.01	0.06	4.3	0	4.3
17:15	0.08	0.01	0.07	3	0	3
17:30	0.07	0.01	0.06	2.2	0	2.2
17:45	0.05	0.01	0.04	1.6	0	1.6
18:00	0.05	0.01	0.04	1.2	0	1.2
18:15	0.04	0.01	0.03	1	0	1
18:30	0.04	0.01	0.03	0.8	0	0.8
18:45	0.04	0.01	0.03	0.6	0	0.6
19:00	0.03	0.01	0.03	0.5	0	0.5
19:15	0.03	0.01	0.02	0.4	0	0.4
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.3	0	0.3
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.04 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.4	0	0.4
14:45	0.07	0.01	0.06	0.5	0	0.5
15:00	0.08	0.01	0.07	0.6	0	0.6
15:15	0.06	0.01	0.05	0.7	0	0.7
15:30	0.08	0.01	0.07	0.8	0	0.8
15:45	0.21	0.01	0.2	1	0	1
16:00	0.44	0.01	0.43	1.9	0	1.9
16:15	1.1	0.01	1.09	4.3	0	4.3
16:30	0.25	0.01	0.24	6.5	0	6.5
16:45	0.09	0.01	0.08	6	0	6
17:00	0.07	0.01	0.06	4.2	0	4.2
17:15	0.08	0.01	0.07	2.9	0	2.9
17:30	0.07	0.01	0.06	2.1	0	2.1
17:45	0.05	0.01	0.04	1.6	0	1.6
18:00	0.05	0.01	0.04	1.2	0	1.2
18:15	0.04	0.01	0.03	0.9	0	0.9
18:30	0.04	0.01	0.03	0.7	0	0.7
18:45	0.04	0.01	0.03	0.6	0	0.6
19:00	0.03	0.01	0.03	0.5	0	0.5
19:15	0.03	0.01	0.02	0.4	0	0.4
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.3	0	0.3
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.05 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.4	0	0.4
14:45	0.07	0.01	0.06	0.5	0	0.5
15:00	0.08	0.01	0.07	0.6	0	0.6
15:15	0.06	0.01	0.05	0.7	0	0.7
15:30	0.08	0.01	0.07	0.8	0	0.8
15:45	0.21	0.01	0.2	1	0	1
16:00	0.44	0.01	0.43	1.9	0	1.9
16:15	1.1	0.01	1.09	4.4	0	4.4
16:30	0.25	0.01	0.24	6.6	0	6.6
16:45	0.09	0.01	0.08	6.1	0	6.1
17:00	0.07	0.01	0.06	4.3	0	4.3
17:15	0.08	0.01	0.07	2.9	0	2.9
17:30	0.07	0.01	0.06	2.1	0	2.1
17:45	0.05	0.01	0.04	1.6	0	1.6
18:00	0.05	0.01	0.04	1.2	0	1.2
18:15	0.04	0.01	0.03	0.9	0	0.9
18:30	0.04	0.01	0.03	0.8	0	0.8
18:45	0.04	0.01	0.03	0.6	0	0.6
19:00	0.03	0.01	0.03	0.5	0	0.5
19:15	0.03	0.01	0.02	0.4	0	0.4
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.3	0	0.3
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.06 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.01	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.4	0	0.4
14:45	0.07	0.01	0.06	0.5	0	0.5
15:00	0.08	0.01	0.07	0.6	0	0.6
15:15	0.06	0.01	0.05	0.7	0	0.7
15:30	0.08	0.01	0.07	0.7	0	0.7
15:45	0.21	0.01	0.2	1	0	1
16:00	0.44	0.01	0.43	1.9	0	1.9
16:15	1.1	0.01	1.09	4.3	0	4.3
16:30	0.25	0.01	0.24	6.5	0	6.5
16:45	0.09	0.01	0.08	6	0	6
17:00	0.07	0.01	0.06	4.2	0	4.2
17:15	0.08	0.01	0.07	2.9	0	2.9
17:30	0.07	0.01	0.06	2.1	0	2.1
17:45	0.05	0.01	0.04	1.6	0	1.6
18:00	0.05	0.01	0.04	1.2	0	1.2
18:15	0.04	0.01	0.03	0.9	0	0.9
18:30	0.04	0.01	0.03	0.7	0	0.7
18:45	0.04	0.01	0.03	0.6	0	0.6
19:00	0.03	0.01	0.03	0.5	0	0.5
19:15	0.03	0.01	0.02	0.4	0	0.4
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.3	0	0.3
20:00	0.03	0.01	0.02	0.3	0	0.3
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.07 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.2	0	0.2
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.3	0	0.3
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.4	0	0.4
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.5	0	0.5
14:45	0.07	0.01	0.06	0.6	0	0.6
15:00	0.08	0.01	0.07	0.7	0	0.7
15:15	0.06	0.01	0.05	0.8	0	0.8
15:30	0.08	0.01	0.07	0.8	0	0.8
15:45	0.21	0.01	0.2	1.1	0	1.1
16:00	0.44	0.01	0.43	2.1	0	2.1
16:15	1.1	0.01	1.09	4.8	0	4.8
16:30	0.25	0.01	0.24	7.3	0	7.3
16:45	0.09	0.01	0.08	6.8	0	6.8
17:00	0.07	0.01	0.06	4.7	0	4.7
17:15	0.08	0.01	0.07	3.2	0	3.2
17:30	0.07	0.01	0.06	2.3	0	2.3
17:45	0.05	0.01	0.04	1.8	0	1.8
18:00	0.05	0.01	0.04	1.3	0	1.3
18:15	0.04	0.01	0.03	1	0	1
18:30	0.04	0.01	0.03	0.8	0	0.8
18:45	0.04	0.01	0.03	0.7	0	0.7
19:00	0.03	0.01	0.03	0.6	0	0.6
19:15	0.03	0.01	0.02	0.5	0	0.5
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.4	0	0.4
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.3	0	0.3
21:15	0.02	0.01	0.01	0.3	0	0.3
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.2	0	0.2
23:30	0.02	0.01	0.01	0.2	0	0.2
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.08 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.2	0	0.2
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.3	0	0.3
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.4	0	0.4
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.5	0	0.5
14:45	0.07	0.01	0.06	0.6	0	0.6
15:00	0.08	0.01	0.07	0.7	0	0.7
15:15	0.06	0.01	0.05	0.8	0	0.8
15:30	0.08	0.01	0.07	0.9	0	0.9
15:45	0.21	0.01	0.2	1.2	0	1.2
16:00	0.44	0.01	0.43	2.2	0	2.2
16:15	1.1	0.01	1.09	4.9	0	4.9
16:30	0.25	0.01	0.24	7.5	0	7.5
16:45	0.09	0.01	0.08	6.9	0	6.9
17:00	0.07	0.01	0.06	4.9	0	4.9
17:15	0.08	0.01	0.07	3.3	0	3.3
17:30	0.07	0.01	0.06	2.4	0	2.4
17:45	0.05	0.01	0.04	1.8	0	1.8
18:00	0.05	0.01	0.04	1.4	0	1.4
18:15	0.04	0.01	0.03	1.1	0	1.1
18:30	0.04	0.01	0.03	0.9	0	0.9
18:45	0.04	0.01	0.03	0.7	0	0.7
19:00	0.03	0.01	0.03	0.6	0	0.6
19:15	0.03	0.01	0.02	0.5	0	0.5
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.4	0	0.4
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.3	0	0.3
21:15	0.02	0.01	0.01	0.3	0	0.3
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.2	0	0.2
23:30	0.02	0.01	0.01	0.2	0	0.2
23:45	0.02	0.01	0.01	0.2	0	0.2
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.09 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.01	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.4	0	0.4
14:15	0.05	0.01	0.03	0.4	0	0.4
14:30	0.05	0.01	0.04	0.5	0	0.5
14:45	0.07	0.01	0.06	0.5	0	0.5
15:00	0.08	0.01	0.07	0.7	0	0.7
15:15	0.06	0.01	0.05	0.8	0	0.8
15:30	0.08	0.01	0.07	0.8	0	0.8
15:45	0.21	0.01	0.2	1.1	0	1.1
16:00	0.44	0.01	0.43	2.1	0	2.1
16:15	1.1	0.01	1.09	4.7	0	4.7
16:30	0.25	0.01	0.24	7.1	0	7.1
16:45	0.09	0.01	0.08	6.6	0	6.6
17:00	0.07	0.01	0.06	4.6	0	4.6
17:15	0.08	0.01	0.07	3.1	0	3.1
17:30	0.07	0.01	0.06	2.3	0	2.3
17:45	0.05	0.01	0.04	1.7	0	1.7
18:00	0.05	0.01	0.04	1.3	0	1.3
18:15	0.04	0.01	0.03	1	0	1
18:30	0.04	0.01	0.03	0.8	0	0.8
18:45	0.04	0.01	0.03	0.7	0	0.7
19:00	0.03	0.01	0.03	0.6	0	0.6
19:15	0.03	0.01	0.02	0.5	0	0.5
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.4	0	0.4
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.3	0	0.3
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.2	0	0.2
23:30	0.02	0.01	0.01	0.2	0	0.2
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 2.10 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0.1	0	0.1
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.2	0	0.2
10:45	0.02	0.01	0.01	0.2	0	0.2
11:00	0.02	0.01	0.01	0.2	0	0.2
11:15	0.02	0.01	0.01	0.2	0	0.2
11:30	0.02	0.01	0.01	0.2	0	0.2
11:45	0.02	0.01	0.01	0.2	0	0.2
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.3	0	0.3
12:45	0.03	0.01	0.02	0.3	0	0.3
13:00	0.03	0.01	0.02	0.3	0	0.3
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.4	0	0.4
13:45	0.04	0.01	0.03	0.4	0	0.4
14:00	0.04	0.01	0.03	0.5	0	0.5
14:15	0.05	0.01	0.04	0.5	0	0.5
14:30	0.05	0.01	0.04	0.6	0	0.6
14:45	0.07	0.01	0.06	0.7	0	0.7
15:00	0.08	0.01	0.07	0.8	0	0.8
15:15	0.06	0.01	0.05	1	0	1
15:30	0.08	0.01	0.07	1	0	1
15:45	0.21	0.01	0.2	1.4	0	1.4
16:00	0.44	0.01	0.43	2.6	0	2.6
16:15	1.1	0.01	1.09	5.8	0	5.8
16:30	0.25	0.01	0.24	8.9	0	8.9
16:45	0.09	0.01	0.08	8.4	0	8.4
17:00	0.07	0.01	0.06	5.9	0	5.9
17:15	0.08	0.01	0.07	4.1	0	4.1
17:30	0.07	0.01	0.06	3	0	3
17:45	0.05	0.01	0.04	2.2	0	2.2
18:00	0.05	0.01	0.04	1.7	0	1.7
18:15	0.04	0.01	0.03	1.3	0	1.3
18:30	0.04	0.01	0.03	1.1	0	1.1
18:45	0.04	0.01	0.03	0.9	0	0.9
19:00	0.03	0.01	0.03	0.7	0	0.7
19:15	0.03	0.01	0.02	0.6	0	0.6
19:30	0.03	0.01	0.02	0.5	0	0.5
19:45	0.03	0.01	0.02	0.5	0	0.5
20:00	0.03	0.01	0.02	0.5	0	0.5
20:15	0.03	0.01	0.02	0.4	0	0.4
20:30	0.03	0.01	0.02	0.4	0	0.4
20:45	0.02	0.01	0.02	0.4	0	0.4
21:00	0.02	0.01	0.02	0.3	0	0.3
21:15	0.02	0.01	0.01	0.3	0	0.3
21:30	0.02	0.01	0.01	0.3	0	0.3
21:45	0.02	0.01	0.01	0.3	0	0.3
22:00	0.02	0.01	0.01	0.3	0	0.3
22:15	0.02	0.01	0.01	0.3	0	0.3
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.2	0	0.2
23:30	0.02	0.01	0.01	0.2	0	0.2
23:45	0.02	0.01	0.01	0.2	0	0.2
0:00	0.02	0.01	0.01	0.2	0	0.2

Drainage Area 3.01 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0	0	0	0
2:45	0.01	0.01	0	0	0	0
3:00	0.01	0.01	0	0	0	0
3:15	0.01	0.01	0	0	0	0
3:30	0.01	0.01	0	0	0	0
3:45	0.01	0.01	0	0	0	0
4:00	0.01	0.01	0	0	0	0
4:15	0.01	0.01	0	0	0	0
4:30	0.01	0.01	0	0	0	0
4:45	0.01	0.01	0	0	0	0
5:00	0.01	0.01	0	0	0	0
5:15	0.01	0.01	0	0	0	0
5:30	0.01	0.01	0	0	0	0
5:45	0.01	0.01	0	0	0	0
6:00	0.01	0.01	0	0	0	0
6:15	0.01	0.01	0	0	0	0
6:30	0.01	0.01	0	0	0	0
6:45	0.01	0.01	0	0	0	0
7:00	0.01	0.01	0	0	0	0
7:15	0.01	0.01	0	0	0	0
7:30	0.02	0.01	0	0	0	0
7:45	0.02	0.01	0	0	0	0
8:00	0.02	0.01	0	0	0	0
8:15	0.02	0.01	0	0	0	0
8:30	0.02	0.01	0	0	0	0
8:45	0.02	0.01	0	0	0	0
9:00	0.02	0.01	0	0	0	0
9:15	0.02	0.01	0	0	0	0
9:30	0.02	0.01	0	0	0	0
9:45	0.02	0.01	0	0	0	0
10:00	0.02	0.01	0	0	0	0
10:15	0.02	0.02	0	0	0	0
10:30	0.02	0.02	0	0	0	0
10:45	0.02	0.02	0	0	0	0
11:00	0.02	0.02	0	0	0	0
11:15	0.02	0.02	0.01	0	0	0
11:30	0.02	0.02	0.01	0	0	0
11:45	0.02	0.02	0.01	0.1	0	0.1
12:00	0.03	0.02	0.01	0.1	0	0.1
12:15	0.03	0.02	0.01	0.1	0	0.1

12:30	0.03	0.02	0.01	0.1	0	0.1
12:45	0.03	0.02	0.01	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.1	0	0.1
13:30	0.04	0.01	0.02	0.1	0	0.1
13:45	0.04	0.01	0.02	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.03	0.2	0	0.2
14:30	0.05	0.01	0.04	0.2	0	0.2
14:45	0.07	0.01	0.05	0.3	0	0.3
15:00	0.08	0.01	0.06	0.4	0	0.4
15:15	0.06	0.01	0.05	0.4	0	0.4
15:30	0.08	0.01	0.07	0.5	0	0.5
15:45	0.21	0.01	0.19	0.7	0	0.7
16:00	0.44	0.01	0.43	1.3	0	1.3
16:15	1.1	0.01	1.09	2.9	0	2.9
16:30	0.25	0.01	0.24	4.4	0	4.4
16:45	0.09	0.01	0.08	3.9	0	3.9
17:00	0.07	0.01	0.06	2.7	0	2.7
17:15	0.08	0.01	0.07	1.8	0	1.8
17:30	0.07	0.01	0.06	1.3	0	1.3
17:45	0.05	0.01	0.04	1	0	1
18:00	0.05	0.01	0.04	0.7	0	0.7
18:15	0.04	0.01	0.03	0.6	0	0.6
18:30	0.04	0.01	0.03	0.4	0	0.4
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.02	0.3	0	0.3
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.2	0	0.2
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.01	0.2	0	0.2
20:45	0.02	0.01	0.01	0.1	0	0.1
21:00	0.02	0.01	0.01	0.1	0	0.1
21:15	0.02	0.01	0.01	0.1	0	0.1
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 3.02 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.02	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.03	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.3	0	0.3
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.3	0	0.3
15:00	0.08	0.01	0.07	0.4	0	0.4
15:15	0.06	0.01	0.05	0.5	0	0.5
15:30	0.08	0.01	0.07	0.5	0	0.5
15:45	0.21	0.01	0.2	0.7	0	0.7
16:00	0.44	0.01	0.43	1.3	0	1.3
16:15	1.1	0.01	1.09	3	0	3
16:30	0.25	0.01	0.25	4.4	0	4.4
16:45	0.09	0.01	0.08	4	0	4
17:00	0.07	0.01	0.06	2.8	0	2.8
17:15	0.08	0.01	0.08	1.9	0	1.9
17:30	0.07	0.01	0.06	1.4	0	1.4
17:45	0.05	0.01	0.05	1	0	1
18:00	0.05	0.01	0.04	0.8	0	0.8
18:15	0.04	0.01	0.04	0.6	0	0.6
18:30	0.04	0.01	0.03	0.5	0	0.5
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.4	0	0.4
19:15	0.03	0.01	0.03	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.02	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 3.03 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.2	0	0.2
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.3	0	0.3
15:00	0.08	0.01	0.07	0.4	0	0.4
15:15	0.06	0.01	0.05	0.5	0	0.5
15:30	0.08	0.01	0.07	0.5	0	0.5
15:45	0.21	0.01	0.2	0.7	0	0.7
16:00	0.44	0.01	0.43	1.3	0	1.3
16:15	1.1	0.01	1.09	2.9	0	2.9
16:30	0.25	0.01	0.24	4.3	0	4.3
16:45	0.09	0.01	0.08	3.9	0	3.9
17:00	0.07	0.01	0.06	2.7	0	2.7
17:15	0.08	0.01	0.07	1.9	0	1.9
17:30	0.07	0.01	0.06	1.4	0	1.4
17:45	0.05	0.01	0.04	1	0	1
18:00	0.05	0.01	0.04	0.8	0	0.8
18:15	0.04	0.01	0.03	0.6	0	0.6
18:30	0.04	0.01	0.03	0.5	0	0.5
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.3	0	0.3
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 3.04 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.3	0	0.3
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.3	0	0.3
15:00	0.08	0.01	0.07	0.4	0	0.4
15:15	0.06	0.01	0.05	0.5	0	0.5
15:30	0.08	0.01	0.07	0.5	0	0.5
15:45	0.21	0.01	0.2	0.7	0	0.7
16:00	0.44	0.01	0.43	1.3	0	1.3
16:15	1.1	0.01	1.09	3	0	3
16:30	0.25	0.01	0.24	4.5	0	4.5
16:45	0.09	0.01	0.08	4.1	0	4.1
17:00	0.07	0.01	0.06	2.8	0	2.8
17:15	0.08	0.01	0.07	2	0	2
17:30	0.07	0.01	0.06	1.4	0	1.4
17:45	0.05	0.01	0.04	1.1	0	1.1
18:00	0.05	0.01	0.04	0.8	0	0.8
18:15	0.04	0.01	0.03	0.6	0	0.6
18:30	0.04	0.01	0.03	0.5	0	0.5
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.4	0	0.4
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 3.05 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0	0	0
5:00	0.01	0.01	0.01	0	0	0
5:15	0.01	0.01	0.01	0	0	0
5:30	0.01	0.01	0.01	0	0	0
5:45	0.01	0.01	0.01	0	0	0
6:00	0.01	0.01	0.01	0	0	0
6:15	0.01	0.01	0.01	0	0	0
6:30	0.01	0.01	0.01	0	0	0
6:45	0.01	0.01	0.01	0	0	0
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.2	0	0.2
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.3	0	0.3
15:00	0.08	0.01	0.07	0.4	0	0.4
15:15	0.06	0.01	0.05	0.4	0	0.4
15:30	0.08	0.01	0.07	0.5	0	0.5
15:45	0.21	0.01	0.2	0.6	0	0.6
16:00	0.44	0.01	0.43	1.2	0	1.2
16:15	1.1	0.01	1.09	2.7	0	2.7
16:30	0.25	0.01	0.24	4	0	4
16:45	0.09	0.01	0.08	3.6	0	3.6
17:00	0.07	0.01	0.06	2.5	0	2.5
17:15	0.08	0.01	0.07	1.7	0	1.7
17:30	0.07	0.01	0.06	1.2	0	1.2
17:45	0.05	0.01	0.04	0.9	0	0.9
18:00	0.05	0.01	0.04	0.7	0	0.7
18:15	0.04	0.01	0.03	0.5	0	0.5
18:30	0.04	0.01	0.03	0.4	0	0.4
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.3	0	0.3
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.2	0	0.2
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.1	0	0.1
21:15	0.02	0.01	0.01	0.1	0	0.1
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 3.06 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.3	0	0.3
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.3	0	0.3
15:00	0.08	0.01	0.07	0.4	0	0.4
15:15	0.06	0.01	0.05	0.5	0	0.5
15:30	0.08	0.01	0.07	0.5	0	0.5
15:45	0.21	0.01	0.2	0.7	0	0.7
16:00	0.44	0.01	0.43	1.3	0	1.3
16:15	1.1	0.01	1.09	3	0	3
16:30	0.25	0.01	0.24	4.4	0	4.4
16:45	0.09	0.01	0.08	4	0	4
17:00	0.07	0.01	0.06	2.7	0	2.7
17:15	0.08	0.01	0.07	1.9	0	1.9
17:30	0.07	0.01	0.06	1.3	0	1.3
17:45	0.05	0.01	0.04	1	0	1
18:00	0.05	0.01	0.04	0.8	0	0.8
18:15	0.04	0.01	0.03	0.6	0	0.6
18:30	0.04	0.01	0.03	0.5	0	0.5
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.3	0	0.3
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 3.07 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0	0	0	0
2:45	0.01	0.01	0	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.01	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.03	0.3	0	0.3
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.4	0	0.4
15:00	0.08	0.01	0.07	0.5	0	0.5
15:15	0.06	0.01	0.05	0.5	0	0.5
15:30	0.08	0.01	0.07	0.6	0	0.6
15:45	0.21	0.01	0.2	0.8	0	0.8
16:00	0.44	0.01	0.43	1.5	0	1.5
16:15	1.1	0.01	1.09	3.4	0	3.4
16:30	0.25	0.01	0.24	5.1	0	5.1
16:45	0.09	0.01	0.08	4.6	0	4.6
17:00	0.07	0.01	0.06	3.2	0	3.2
17:15	0.08	0.01	0.07	2.2	0	2.2
17:30	0.07	0.01	0.06	1.6	0	1.6
17:45	0.05	0.01	0.04	1.2	0	1.2
18:00	0.05	0.01	0.04	0.9	0	0.9
18:15	0.04	0.01	0.03	0.7	0	0.7
18:30	0.04	0.01	0.03	0.6	0	0.6
18:45	0.04	0.01	0.03	0.5	0	0.5
19:00	0.03	0.01	0.03	0.4	0	0.4
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.3	0	0.3
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.01	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 3.08 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0	0	0
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.01	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.3	0	0.3
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.3	0	0.3
15:00	0.08	0.01	0.07	0.4	0	0.4
15:15	0.06	0.01	0.05	0.5	0	0.5
15:30	0.08	0.01	0.07	0.5	0	0.5
15:45	0.21	0.01	0.2	0.7	0	0.7
16:00	0.44	0.01	0.43	1.3	0	1.3
16:15	1.1	0.01	1.09	3	0	3
16:30	0.25	0.01	0.24	4.5	0	4.5
16:45	0.09	0.01	0.08	4.1	0	4.1
17:00	0.07	0.01	0.06	2.8	0	2.8
17:15	0.08	0.01	0.07	1.9	0	1.9
17:30	0.07	0.01	0.06	1.4	0	1.4
17:45	0.05	0.01	0.04	1	0	1
18:00	0.05	0.01	0.04	0.8	0	0.8
18:15	0.04	0.01	0.03	0.6	0	0.6
18:30	0.04	0.01	0.03	0.5	0	0.5
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.3	0	0.3
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 3.09 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.03	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.4	0	0.4
14:45	0.07	0.01	0.06	0.5	0	0.5
15:00	0.08	0.01	0.07	0.6	0	0.6
15:15	0.06	0.01	0.05	0.7	0	0.7
15:30	0.08	0.01	0.07	0.8	0	0.8
15:45	0.21	0.01	0.2	1	0	1
16:00	0.44	0.01	0.43	1.9	0	1.9
16:15	1.1	0.01	1.09	4.3	0	4.3
16:30	0.25	0.01	0.24	6.5	0	6.5
16:45	0.09	0.01	0.08	6	0	6
17:00	0.07	0.01	0.06	4.2	0	4.2
17:15	0.08	0.01	0.07	2.9	0	2.9
17:30	0.07	0.01	0.06	2.1	0	2.1
17:45	0.05	0.01	0.04	1.6	0	1.6
18:00	0.05	0.01	0.04	1.2	0	1.2
18:15	0.04	0.01	0.03	0.9	0	0.9
18:30	0.04	0.01	0.03	0.7	0	0.7
18:45	0.04	0.01	0.03	0.6	0	0.6
19:00	0.03	0.01	0.03	0.5	0	0.5
19:15	0.03	0.01	0.02	0.4	0	0.4
19:30	0.03	0.01	0.02	0.4	0	0.4
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.3	0	0.3
20:15	0.03	0.01	0.02	0.3	0	0.3
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 4.01 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0	0	0	0
2:45	0.01	0.01	0	0	0	0
3:00	0.01	0.01	0	0	0	0
3:15	0.01	0.01	0	0	0	0
3:30	0.01	0.01	0	0	0	0
3:45	0.01	0.01	0	0	0	0
4:00	0.01	0.01	0	0	0	0
4:15	0.01	0.01	0	0	0	0
4:30	0.01	0.01	0	0	0	0
4:45	0.01	0.01	0	0	0	0
5:00	0.01	0.01	0	0	0	0
5:15	0.01	0.01	0	0	0	0
5:30	0.01	0.01	0	0	0	0
5:45	0.01	0.01	0	0	0	0
6:00	0.01	0.01	0	0	0	0
6:15	0.01	0.01	0	0	0	0
6:30	0.01	0.01	0	0	0	0
6:45	0.01	0.01	0	0	0	0
7:00	0.01	0.01	0	0	0	0
7:15	0.01	0.01	0	0	0	0
7:30	0.02	0.01	0	0	0	0
7:45	0.02	0.01	0	0	0	0
8:00	0.02	0.01	0	0	0	0
8:15	0.02	0.01	0	0	0	0
8:30	0.02	0.01	0	0	0	0
8:45	0.02	0.01	0	0	0	0
9:00	0.02	0.01	0	0	0	0
9:15	0.02	0.01	0	0	0	0
9:30	0.02	0.01	0	0	0	0
9:45	0.02	0.01	0	0	0	0
10:00	0.02	0.01	0	0	0	0
10:15	0.02	0.01	0	0	0	0
10:30	0.02	0.02	0.01	0	0	0
10:45	0.02	0.02	0.01	0	0	0
11:00	0.02	0.02	0.01	0	0	0
11:15	0.02	0.02	0.01	0	0	0
11:30	0.02	0.02	0.01	0	0	0
11:45	0.02	0.02	0.01	0	0	0
12:00	0.03	0.02	0.01	0	0	0
12:15	0.03	0.02	0.01	0.1	0	0.1

12:30	0.03	0.01	0.01	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.1	0	0.1
13:30	0.04	0.01	0.02	0.1	0	0.1
13:45	0.04	0.01	0.02	0.1	0	0.1
14:00	0.04	0.01	0.03	0.1	0	0.1
14:15	0.05	0.01	0.03	0.2	0	0.2
14:30	0.05	0.01	0.04	0.2	0	0.2
14:45	0.07	0.01	0.05	0.2	0	0.2
15:00	0.08	0.01	0.06	0.3	0	0.3
15:15	0.06	0.01	0.05	0.3	0	0.3
15:30	0.08	0.01	0.07	0.3	0	0.3
15:45	0.21	0.01	0.19	0.5	0	0.5
16:00	0.44	0.01	0.43	0.9	0	0.9
16:15	1.1	0.01	1.09	2.2	0	2.2
16:30	0.25	0.01	0.24	3.2	0	3.2
16:45	0.09	0.01	0.08	2.8	0	2.8
17:00	0.07	0.01	0.06	1.9	0	1.9
17:15	0.08	0.01	0.07	1.3	0	1.3
17:30	0.07	0.01	0.06	0.9	0	0.9
17:45	0.05	0.01	0.04	0.7	0	0.7
18:00	0.05	0.01	0.04	0.5	0	0.5
18:15	0.04	0.01	0.03	0.4	0	0.4
18:30	0.04	0.01	0.03	0.3	0	0.3
18:45	0.04	0.01	0.03	0.3	0	0.3
19:00	0.03	0.01	0.02	0.2	0	0.2
19:15	0.03	0.01	0.02	0.2	0	0.2
19:30	0.03	0.01	0.02	0.2	0	0.2
19:45	0.03	0.01	0.02	0.1	0	0.1
20:00	0.03	0.01	0.02	0.1	0	0.1
20:15	0.03	0.01	0.02	0.1	0	0.1
20:30	0.03	0.01	0.01	0.1	0	0.1
20:45	0.02	0.01	0.01	0.1	0	0.1
21:00	0.02	0.01	0.01	0.1	0	0.1
21:15	0.02	0.01	0.01	0.1	0	0.1
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0	0	0
0:00	0.02	0.01	0.01	0	0	0

Drainage Area 4.02 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.02	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.03	0.3	0	0.3
13:45	0.04	0.01	0.03	0.3	0	0.3
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.04	0.3	0	0.3
14:30	0.05	0.01	0.04	0.4	0	0.4
14:45	0.07	0.01	0.06	0.5	0	0.5
15:00	0.08	0.01	0.07	0.6	0	0.6
15:15	0.06	0.01	0.05	0.6	0	0.6
15:30	0.08	0.01	0.07	0.7	0	0.7
15:45	0.21	0.01	0.2	0.9	0	0.9
16:00	0.44	0.01	0.43	1.9	0	1.9
16:15	1.1	0.01	1.09	4.4	0	4.4
16:30	0.25	0.01	0.25	6.3	0	6.3
16:45	0.09	0.01	0.08	5.2	0	5.2
17:00	0.07	0.01	0.06	3.1	0	3.1
17:15	0.08	0.01	0.08	1.8	0	1.8
17:30	0.07	0.01	0.06	1.3	0	1.3
17:45	0.05	0.01	0.05	1	0	1
18:00	0.05	0.01	0.04	0.7	0	0.7
18:15	0.04	0.01	0.04	0.5	0	0.5
18:30	0.04	0.01	0.03	0.5	0	0.5
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.4	0	0.4
19:15	0.03	0.01	0.03	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.3	0	0.3
20:00	0.03	0.01	0.02	0.3	0	0.3
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.02	0.2	0	0.2
21:30	0.02	0.01	0.02	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 4.03 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0	0	0
5:00	0.01	0.01	0.01	0	0	0
5:15	0.01	0.01	0.01	0	0	0
5:30	0.01	0.01	0.01	0	0	0
5:45	0.01	0.01	0.01	0	0	0
6:00	0.01	0.01	0.01	0	0	0
6:15	0.01	0.01	0.01	0	0	0
6:30	0.01	0.01	0.01	0	0	0
6:45	0.01	0.01	0.01	0	0	0
7:00	0.01	0.01	0.01	0	0	0
7:15	0.01	0.01	0.01	0	0	0
7:30	0.02	0.01	0.01	0	0	0
7:45	0.02	0.01	0.01	0	0	0
8:00	0.02	0.01	0.01	0	0	0
8:15	0.02	0.01	0.01	0	0	0
8:30	0.02	0.01	0.01	0	0	0
8:45	0.02	0.01	0.01	0	0	0
9:00	0.02	0.01	0.01	0	0	0
9:15	0.02	0.01	0.01	0	0	0
9:30	0.02	0.01	0.01	0	0	0
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.1	0	0.1
13:30	0.04	0.01	0.02	0.1	0	0.1
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.2	0	0.2
14:30	0.05	0.01	0.04	0.2	0	0.2
14:45	0.07	0.01	0.06	0.3	0	0.3
15:00	0.08	0.01	0.07	0.3	0	0.3
15:15	0.06	0.01	0.05	0.4	0	0.4
15:30	0.08	0.01	0.07	0.4	0	0.4
15:45	0.21	0.01	0.2	0.5	0	0.5
16:00	0.44	0.01	0.43	1	0	1
16:15	1.1	0.01	1.09	2.3	0	2.3
16:30	0.25	0.01	0.24	3.4	0	3.4
16:45	0.09	0.01	0.08	3	0	3
17:00	0.07	0.01	0.06	2.1	0	2.1
17:15	0.08	0.01	0.07	1.4	0	1.4
17:30	0.07	0.01	0.06	1	0	1
17:45	0.05	0.01	0.04	0.8	0	0.8
18:00	0.05	0.01	0.04	0.6	0	0.6
18:15	0.04	0.01	0.03	0.5	0	0.5
18:30	0.04	0.01	0.03	0.4	0	0.4
18:45	0.04	0.01	0.03	0.3	0	0.3
19:00	0.03	0.01	0.03	0.2	0	0.2
19:15	0.03	0.01	0.02	0.2	0	0.2
19:30	0.03	0.01	0.02	0.2	0	0.2
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.1	0	0.1
20:45	0.02	0.01	0.02	0.1	0	0.1
21:00	0.02	0.01	0.02	0.1	0	0.1
21:15	0.02	0.01	0.01	0.1	0	0.1
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 4.04 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.03	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.04	0.3	0	0.3
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.4	0	0.4
15:00	0.08	0.01	0.07	0.5	0	0.5
15:15	0.06	0.01	0.05	0.5	0	0.5
15:30	0.08	0.01	0.07	0.6	0	0.6
15:45	0.21	0.01	0.2	0.8	0	0.8
16:00	0.44	0.01	0.43	1.5	0	1.5
16:15	1.1	0.01	1.09	3.3	0	3.3
16:30	0.25	0.01	0.24	4.9	0	4.9
16:45	0.09	0.01	0.08	4.4	0	4.4
17:00	0.07	0.01	0.06	3.1	0	3.1
17:15	0.08	0.01	0.07	2.1	0	2.1
17:30	0.07	0.01	0.06	1.5	0	1.5
17:45	0.05	0.01	0.04	1.1	0	1.1
18:00	0.05	0.01	0.04	0.9	0	0.9
18:15	0.04	0.01	0.03	0.7	0	0.7
18:30	0.04	0.01	0.03	0.5	0	0.5
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.4	0	0.4
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.3	0	0.3
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 4.05 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0	0	0
5:00	0.01	0.01	0.01	0	0	0
5:15	0.01	0.01	0.01	0	0	0
5:30	0.01	0.01	0.01	0	0	0
5:45	0.01	0.01	0.01	0	0	0
6:00	0.01	0.01	0.01	0	0	0
6:15	0.01	0.01	0.01	0	0	0
6:30	0.01	0.01	0.01	0	0	0
6:45	0.01	0.01	0.01	0	0	0
7:00	0.01	0.01	0.01	0	0	0
7:15	0.01	0.01	0.01	0	0	0
7:30	0.02	0.01	0.01	0	0	0
7:45	0.02	0.01	0.01	0	0	0
8:00	0.02	0.01	0.01	0	0	0
8:15	0.02	0.01	0.01	0	0	0
8:30	0.02	0.01	0.01	0	0	0
8:45	0.02	0.01	0.01	0	0	0
9:00	0.02	0.01	0.01	0	0	0
9:15	0.02	0.01	0.01	0	0	0
9:30	0.02	0.01	0.01	0	0	0
9:45	0.02	0.01	0.01	0	0	0
10:00	0.02	0.01	0.01	0	0	0
10:15	0.02	0.01	0.01	0	0	0
10:30	0.02	0.01	0.01	0	0	0
10:45	0.02	0.01	0.01	0	0	0
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.1	0	0.1
13:30	0.04	0.01	0.02	0.1	0	0.1
13:45	0.04	0.01	0.03	0.1	0	0.1
14:00	0.04	0.01	0.03	0.1	0	0.1
14:15	0.05	0.01	0.04	0.2	0	0.2
14:30	0.05	0.01	0.04	0.2	0	0.2
14:45	0.07	0.01	0.06	0.2	0	0.2
15:00	0.08	0.01	0.07	0.3	0	0.3
15:15	0.06	0.01	0.05	0.3	0	0.3
15:30	0.08	0.01	0.07	0.3	0	0.3
15:45	0.21	0.01	0.2	0.5	0	0.5
16:00	0.44	0.01	0.43	0.9	0	0.9
16:15	1.1	0.01	1.09	2	0	2
16:30	0.25	0.01	0.24	2.9	0	2.9
16:45	0.09	0.01	0.08	2.6	0	2.6
17:00	0.07	0.01	0.06	1.8	0	1.8
17:15	0.08	0.01	0.07	1.2	0	1.2
17:30	0.07	0.01	0.06	0.9	0	0.9
17:45	0.05	0.01	0.04	0.7	0	0.7
18:00	0.05	0.01	0.04	0.5	0	0.5
18:15	0.04	0.01	0.03	0.4	0	0.4
18:30	0.04	0.01	0.03	0.3	0	0.3
18:45	0.04	0.01	0.03	0.3	0	0.3
19:00	0.03	0.01	0.03	0.2	0	0.2
19:15	0.03	0.01	0.02	0.2	0	0.2
19:30	0.03	0.01	0.02	0.2	0	0.2
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.1	0	0.1
20:15	0.03	0.01	0.02	0.1	0	0.1
20:30	0.03	0.01	0.02	0.1	0	0.1
20:45	0.02	0.01	0.02	0.1	0	0.1
21:00	0.02	0.01	0.02	0.1	0	0.1
21:15	0.02	0.01	0.01	0.1	0	0.1
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 4.06 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.2	0	0.2
14:15	0.05	0.01	0.04	0.3	0	0.3
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.3	0	0.3
15:00	0.08	0.01	0.07	0.4	0	0.4
15:15	0.06	0.01	0.05	0.5	0	0.5
15:30	0.08	0.01	0.07	0.5	0	0.5
15:45	0.21	0.01	0.2	0.7	0	0.7
16:00	0.44	0.01	0.43	1.4	0	1.4
16:15	1.1	0.01	1.09	3.1	0	3.1
16:30	0.25	0.01	0.24	4.6	0	4.6
16:45	0.09	0.01	0.08	4.2	0	4.2
17:00	0.07	0.01	0.06	2.9	0	2.9
17:15	0.08	0.01	0.07	2	0	2
17:30	0.07	0.01	0.06	1.4	0	1.4
17:45	0.05	0.01	0.04	1.1	0	1.1
18:00	0.05	0.01	0.04	0.8	0	0.8
18:15	0.04	0.01	0.03	0.6	0	0.6
18:30	0.04	0.01	0.03	0.5	0	0.5
18:45	0.04	0.01	0.03	0.4	0	0.4
19:00	0.03	0.01	0.03	0.3	0	0.3
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.2	0	0.2
20:00	0.03	0.01	0.02	0.2	0	0.2
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 4.07 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0	0	0
3:45	0.01	0.01	0.01	0	0	0
4:00	0.01	0.01	0.01	0	0	0
4:15	0.01	0.01	0.01	0	0	0
4:30	0.01	0.01	0.01	0	0	0
4:45	0.01	0.01	0.01	0	0	0
5:00	0.01	0.01	0.01	0	0	0
5:15	0.01	0.01	0.01	0	0	0
5:30	0.01	0.01	0.01	0	0	0
5:45	0.01	0.01	0.01	0	0	0
6:00	0.01	0.01	0.01	0	0	0
6:15	0.01	0.01	0.01	0	0	0
6:30	0.01	0.01	0.01	0	0	0
6:45	0.01	0.01	0.01	0	0	0
7:00	0.01	0.01	0.01	0	0	0
7:15	0.01	0.01	0.01	0	0	0
7:30	0.02	0.01	0.01	0	0	0
7:45	0.02	0.01	0.01	0	0	0
8:00	0.02	0.01	0.01	0	0	0
8:15	0.02	0.01	0.01	0	0	0
8:30	0.02	0.01	0.01	0	0	0
8:45	0.02	0.01	0.01	0	0	0
9:00	0.02	0.01	0.01	0	0	0
9:15	0.02	0.01	0.01	0	0	0
9:30	0.02	0.01	0.01	0	0	0
9:45	0.02	0.01	0.01	0	0	0
10:00	0.02	0.01	0.01	0	0	0
10:15	0.02	0.01	0.01	0	0	0
10:30	0.02	0.01	0.01	0	0	0
10:45	0.02	0.01	0.01	0	0	0
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.02	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.1	0	0.1
13:00	0.03	0.01	0.02	0.1	0	0.1
13:15	0.03	0.01	0.02	0.1	0	0.1
13:30	0.04	0.01	0.02	0.1	0	0.1
13:45	0.04	0.01	0.03	0.1	0	0.1
14:00	0.04	0.01	0.03	0.1	0	0.1
14:15	0.05	0.01	0.04	0.2	0	0.2
14:30	0.05	0.01	0.04	0.2	0	0.2
14:45	0.07	0.01	0.06	0.2	0	0.2
15:00	0.08	0.01	0.07	0.3	0	0.3
15:15	0.06	0.01	0.05	0.3	0	0.3
15:30	0.08	0.01	0.07	0.3	0	0.3
15:45	0.21	0.01	0.2	0.5	0	0.5
16:00	0.44	0.01	0.43	0.9	0	0.9
16:15	1.1	0.01	1.09	2	0	2
16:30	0.25	0.01	0.24	2.9	0	2.9
16:45	0.09	0.01	0.08	2.6	0	2.6
17:00	0.07	0.01	0.06	1.7	0	1.7
17:15	0.08	0.01	0.07	1.2	0	1.2
17:30	0.07	0.01	0.06	0.9	0	0.9
17:45	0.05	0.01	0.04	0.6	0	0.6
18:00	0.05	0.01	0.04	0.5	0	0.5
18:15	0.04	0.01	0.03	0.4	0	0.4
18:30	0.04	0.01	0.03	0.3	0	0.3
18:45	0.04	0.01	0.03	0.2	0	0.2
19:00	0.03	0.01	0.03	0.2	0	0.2
19:15	0.03	0.01	0.02	0.2	0	0.2
19:30	0.03	0.01	0.02	0.2	0	0.2
19:45	0.03	0.01	0.02	0.1	0	0.1
20:00	0.03	0.01	0.02	0.1	0	0.1
20:15	0.03	0.01	0.02	0.1	0	0.1
20:30	0.03	0.01	0.02	0.1	0	0.1
20:45	0.02	0.01	0.02	0.1	0	0.1
21:00	0.02	0.01	0.02	0.1	0	0.1
21:15	0.02	0.01	0.01	0.1	0	0.1
21:30	0.02	0.01	0.01	0.1	0	0.1
21:45	0.02	0.01	0.01	0.1	0	0.1
22:00	0.02	0.01	0.01	0.1	0	0.1
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 4.08 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0.1	0	0.1
3:15	0.01	0.01	0.01	0.1	0	0.1
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.2	0	0.2
12:00	0.03	0.01	0.01	0.2	0	0.2
12:15	0.03	0.01	0.02	0.2	0	0.2

12:30	0.03	0.01	0.02	0.2	0	0.2
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.3	0	0.3
13:15	0.03	0.01	0.02	0.3	0	0.3
13:30	0.04	0.01	0.02	0.3	0	0.3
13:45	0.04	0.01	0.03	0.4	0	0.4
14:00	0.04	0.01	0.03	0.4	0	0.4
14:15	0.05	0.01	0.04	0.4	0	0.4
14:30	0.05	0.01	0.04	0.5	0	0.5
14:45	0.07	0.01	0.06	0.6	0	0.6
15:00	0.08	0.01	0.07	0.7	0	0.7
15:15	0.06	0.01	0.05	0.8	0	0.8
15:30	0.08	0.01	0.07	0.9	0	0.9
15:45	0.21	0.01	0.2	1.2	0	1.2
16:00	0.44	0.01	0.43	2.2	0	2.2
16:15	1.1	0.01	1.09	5	0	5
16:30	0.25	0.01	0.24	7.6	0	7.6
16:45	0.09	0.01	0.08	7.1	0	7.1
17:00	0.07	0.01	0.06	5	0	5
17:15	0.08	0.01	0.07	3.4	0	3.4
17:30	0.07	0.01	0.06	2.5	0	2.5
17:45	0.05	0.01	0.04	1.9	0	1.9
18:00	0.05	0.01	0.04	1.4	0	1.4
18:15	0.04	0.01	0.03	1.1	0	1.1
18:30	0.04	0.01	0.03	0.9	0	0.9
18:45	0.04	0.01	0.03	0.7	0	0.7
19:00	0.03	0.01	0.03	0.6	0	0.6
19:15	0.03	0.01	0.02	0.5	0	0.5
19:30	0.03	0.01	0.02	0.5	0	0.5
19:45	0.03	0.01	0.02	0.4	0	0.4
20:00	0.03	0.01	0.02	0.4	0	0.4
20:15	0.03	0.01	0.02	0.4	0	0.4
20:30	0.03	0.01	0.02	0.3	0	0.3
20:45	0.02	0.01	0.02	0.3	0	0.3
21:00	0.02	0.01	0.02	0.3	0	0.3
21:15	0.02	0.01	0.01	0.3	0	0.3
21:30	0.02	0.01	0.01	0.3	0	0.3
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.2	0	0.2
22:30	0.02	0.01	0.01	0.2	0	0.2
22:45	0.02	0.01	0.01	0.2	0	0.2
23:00	0.02	0.01	0.01	0.2	0	0.2
23:15	0.02	0.01	0.01	0.2	0	0.2
23:30	0.02	0.01	0.01	0.2	0	0.2
23:45	0.02	0.01	0.01	0.2	0	0.2
0:00	0.02	0.01	0.01	0.2	0	0.2

Drainage Area 4.09 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0	0	0
2:45	0.01	0.01	0.01	0	0	0
3:00	0.01	0.01	0.01	0	0	0
3:15	0.01	0.01	0.01	0	0	0
3:30	0.01	0.01	0.01	0.1	0	0.1
3:45	0.01	0.01	0.01	0.1	0	0.1
4:00	0.01	0.01	0.01	0.1	0	0.1
4:15	0.01	0.01	0.01	0.1	0	0.1
4:30	0.01	0.01	0.01	0.1	0	0.1
4:45	0.01	0.01	0.01	0.1	0	0.1
5:00	0.01	0.01	0.01	0.1	0	0.1
5:15	0.01	0.01	0.01	0.1	0	0.1
5:30	0.01	0.01	0.01	0.1	0	0.1
5:45	0.01	0.01	0.01	0.1	0	0.1
6:00	0.01	0.01	0.01	0.1	0	0.1
6:15	0.01	0.01	0.01	0.1	0	0.1
6:30	0.01	0.01	0.01	0.1	0	0.1
6:45	0.01	0.01	0.01	0.1	0	0.1
7:00	0.01	0.01	0.01	0.1	0	0.1
7:15	0.01	0.01	0.01	0.1	0	0.1
7:30	0.02	0.01	0.01	0.1	0	0.1
7:45	0.02	0.01	0.01	0.1	0	0.1
8:00	0.02	0.01	0.01	0.1	0	0.1
8:15	0.02	0.01	0.01	0.1	0	0.1
8:30	0.02	0.01	0.01	0.1	0	0.1
8:45	0.02	0.01	0.01	0.1	0	0.1
9:00	0.02	0.01	0.01	0.1	0	0.1
9:15	0.02	0.01	0.01	0.1	0	0.1
9:30	0.02	0.01	0.01	0.1	0	0.1
9:45	0.02	0.01	0.01	0.1	0	0.1
10:00	0.02	0.01	0.01	0.1	0	0.1
10:15	0.02	0.01	0.01	0.1	0	0.1
10:30	0.02	0.01	0.01	0.1	0	0.1
10:45	0.02	0.01	0.01	0.1	0	0.1
11:00	0.02	0.01	0.01	0.1	0	0.1
11:15	0.02	0.01	0.01	0.1	0	0.1
11:30	0.02	0.01	0.01	0.1	0	0.1
11:45	0.02	0.01	0.01	0.1	0	0.1
12:00	0.03	0.01	0.01	0.1	0	0.1
12:15	0.03	0.01	0.01	0.1	0	0.1

12:30	0.03	0.01	0.02	0.1	0	0.1
12:45	0.03	0.01	0.02	0.2	0	0.2
13:00	0.03	0.01	0.02	0.2	0	0.2
13:15	0.03	0.01	0.02	0.2	0	0.2
13:30	0.04	0.01	0.02	0.2	0	0.2
13:45	0.04	0.01	0.03	0.2	0	0.2
14:00	0.04	0.01	0.03	0.3	0	0.3
14:15	0.05	0.01	0.03	0.3	0	0.3
14:30	0.05	0.01	0.04	0.3	0	0.3
14:45	0.07	0.01	0.06	0.4	0	0.4
15:00	0.08	0.01	0.07	0.5	0	0.5
15:15	0.06	0.01	0.05	0.6	0	0.6
15:30	0.08	0.01	0.07	0.6	0	0.6
15:45	0.21	0.01	0.2	0.8	0	0.8
16:00	0.44	0.01	0.43	1.6	0	1.6
16:15	1.1	0.01	1.09	3.6	0	3.6
16:30	0.25	0.01	0.24	5.4	0	5.4
16:45	0.09	0.01	0.08	4.9	0	4.9
17:00	0.07	0.01	0.06	3.4	0	3.4
17:15	0.08	0.01	0.07	2.3	0	2.3
17:30	0.07	0.01	0.06	1.7	0	1.7
17:45	0.05	0.01	0.04	1.3	0	1.3
18:00	0.05	0.01	0.04	1	0	1
18:15	0.04	0.01	0.03	0.7	0	0.7
18:30	0.04	0.01	0.03	0.6	0	0.6
18:45	0.04	0.01	0.03	0.5	0	0.5
19:00	0.03	0.01	0.03	0.4	0	0.4
19:15	0.03	0.01	0.02	0.3	0	0.3
19:30	0.03	0.01	0.02	0.3	0	0.3
19:45	0.03	0.01	0.02	0.3	0	0.3
20:00	0.03	0.01	0.02	0.3	0	0.3
20:15	0.03	0.01	0.02	0.2	0	0.2
20:30	0.03	0.01	0.02	0.2	0	0.2
20:45	0.02	0.01	0.02	0.2	0	0.2
21:00	0.02	0.01	0.02	0.2	0	0.2
21:15	0.02	0.01	0.01	0.2	0	0.2
21:30	0.02	0.01	0.01	0.2	0	0.2
21:45	0.02	0.01	0.01	0.2	0	0.2
22:00	0.02	0.01	0.01	0.2	0	0.2
22:15	0.02	0.01	0.01	0.1	0	0.1
22:30	0.02	0.01	0.01	0.1	0	0.1
22:45	0.02	0.01	0.01	0.1	0	0.1
23:00	0.02	0.01	0.01	0.1	0	0.1
23:15	0.02	0.01	0.01	0.1	0	0.1
23:30	0.02	0.01	0.01	0.1	0	0.1
23:45	0.02	0.01	0.01	0.1	0	0.1
0:00	0.02	0.01	0.01	0.1	0	0.1

Drainage Area 5.00 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0.01	0.1	0	0.1
2:45	0.01	0.01	0.01	0.3	0	0.3
3:00	0.01	0.01	0.01	0.4	0	0.4
3:15	0.01	0.01	0.01	0.4	0	0.4
3:30	0.01	0.01	0.01	0.4	0	0.4
3:45	0.01	0.01	0.01	0.4	0	0.4
4:00	0.01	0.01	0.01	0.5	0	0.5
4:15	0.01	0.01	0.01	0.5	0	0.5
4:30	0.01	0.01	0.01	0.5	0	0.5
4:45	0.01	0.01	0.01	0.5	0	0.5
5:00	0.01	0.01	0.01	0.5	0	0.5
5:15	0.01	0.01	0.01	0.5	0	0.5
5:30	0.01	0.01	0.01	0.5	0	0.5
5:45	0.01	0.01	0.01	0.5	0	0.5
6:00	0.01	0.01	0.01	0.5	0	0.5
6:15	0.01	0.01	0.01	0.5	0	0.5
6:30	0.01	0.01	0.01	0.5	0	0.5
6:45	0.01	0.01	0.01	0.5	0	0.5
7:00	0.01	0.01	0.01	0.5	0	0.5
7:15	0.01	0.01	0.01	0.5	0	0.5
7:30	0.02	0.01	0.01	0.5	0	0.5
7:45	0.02	0.01	0.01	0.5	0	0.5
8:00	0.02	0.01	0.01	0.5	0	0.5
8:15	0.02	0.01	0.01	0.6	0	0.6
8:30	0.02	0.01	0.01	0.6	0	0.6
8:45	0.02	0.01	0.01	0.6	0	0.6
9:00	0.02	0.01	0.01	0.6	0	0.6
9:15	0.02	0.01	0.01	0.6	0	0.6
9:30	0.02	0.01	0.01	0.6	0	0.6
9:45	0.02	0.01	0.01	0.6	0	0.6
10:00	0.02	0.01	0.01	0.6	0	0.6
10:15	0.02	0.01	0.01	0.7	0	0.7
10:30	0.02	0.01	0.01	0.7	0	0.7
10:45	0.02	0.01	0.01	0.7	0	0.7
11:00	0.02	0.01	0.01	0.7	0	0.7
11:15	0.02	0.01	0.01	0.8	0	0.8
11:30	0.02	0.01	0.01	0.8	0	0.8
11:45	0.02	0.01	0.01	0.9	0	0.9
12:00	0.03	0.01	0.01	0.9	0	0.9
12:15	0.03	0.01	0.02	1	0	1

12:30	0.03	0.01	0.02	1.1	0	1.1
12:45	0.03	0.01	0.02	1.2	0	1.2
13:00	0.03	0.01	0.02	1.4	0	1.4
13:15	0.03	0.01	0.02	1.5	0	1.5
13:30	0.04	0.01	0.03	1.6	0	1.6
13:45	0.04	0.01	0.03	1.8	0	1.8
14:00	0.04	0.01	0.03	2	0	2
14:15	0.05	0.01	0.04	2.2	0	2.2
14:30	0.05	0.01	0.04	2.5	0	2.5
14:45	0.07	0.01	0.06	2.9	0	2.9
15:00	0.08	0.01	0.07	3.6	0	3.6
15:15	0.06	0.01	0.05	4.1	0	4.1
15:30	0.08	0.01	0.07	4.4	0	4.4
15:45	0.21	0.01	0.2	5.8	0	5.8
16:00	0.44	0.01	0.43	11	0	11
16:15	1.1	0.01	1.09	24.9	0	24.9
16:30	0.25	0.01	0.25	39.3	0	39.3
16:45	0.09	0.01	0.08	36.5	0	36.5
17:00	0.07	0.01	0.06	23.5	0	23.5
17:15	0.08	0.01	0.08	14.7	0	14.7
17:30	0.07	0.01	0.06	10.1	0	10.1
17:45	0.05	0.01	0.05	7.5	0	7.5
18:00	0.05	0.01	0.04	5.7	0	5.7
18:15	0.04	0.01	0.04	4.4	0	4.4
18:30	0.04	0.01	0.03	3.5	0	3.5
18:45	0.04	0.01	0.03	2.9	0	2.9
19:00	0.03	0.01	0.03	2.6	0	2.6
19:15	0.03	0.01	0.02	2.3	0	2.3
19:30	0.03	0.01	0.02	2.1	0	2.1
19:45	0.03	0.01	0.02	1.9	0	1.9
20:00	0.03	0.01	0.02	1.8	0	1.8
20:15	0.03	0.01	0.02	1.7	0	1.7
20:30	0.03	0.01	0.02	1.6	0	1.6
20:45	0.02	0.01	0.02	1.5	0	1.5
21:00	0.02	0.01	0.02	1.4	0	1.4
21:15	0.02	0.01	0.02	1.3	0	1.3
21:30	0.02	0.01	0.01	1.2	0	1.2
21:45	0.02	0.01	0.01	1.2	0	1.2
22:00	0.02	0.01	0.01	1.1	0	1.1
22:15	0.02	0.01	0.01	1.1	0	1.1
22:30	0.02	0.01	0.01	1	0	1
22:45	0.02	0.01	0.01	0.9	0	0.9
23:00	0.02	0.01	0.01	0.9	0	0.9
23:15	0.02	0.01	0.01	0.9	0	0.9
23:30	0.02	0.01	0.01	0.8	0	0.8
23:45	0.02	0.01	0.01	0.8	0	0.8
0:00	0.02	0.01	0.01	0.8	0	0.8

Drainage Area 6.00 (50% AEP)						
Time	Precip	Loss	Excess	Direct Flow	Base Flow	Total Flow
(Hr:Min)	(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)
0:00				0	0	0
0:15	0.01	0.01	0	0	0	0
0:30	0.01	0.01	0	0	0	0
0:45	0.01	0.01	0	0	0	0
1:00	0.01	0.01	0	0	0	0
1:15	0.01	0.01	0	0	0	0
1:30	0.01	0.01	0	0	0	0
1:45	0.01	0.01	0	0	0	0
2:00	0.01	0.01	0	0	0	0
2:15	0.01	0.01	0	0	0	0
2:30	0.01	0.01	0	0	0	0
2:45	0.01	0.01	0	0.1	0	0.1
3:00	0.01	0.01	0	0.1	0	0.1
3:15	0.01	0.01	0	0.2	0	0.2
3:30	0.01	0.01	0	0.2	0	0.2
3:45	0.01	0.01	0	0.3	0	0.3
4:00	0.01	0.01	0	0.3	0	0.3
4:15	0.01	0.01	0	0.4	0	0.4
4:30	0.01	0.01	0	0.4	0	0.4
4:45	0.01	0.01	0	0.4	0	0.4
5:00	0.01	0.01	0	0.5	0	0.5
5:15	0.01	0.01	0	0.5	0	0.5
5:30	0.01	0.01	0	0.5	0	0.5
5:45	0.01	0.01	0	0.6	0	0.6
6:00	0.01	0.01	0	0.6	0	0.6
6:15	0.01	0.01	0	0.6	0	0.6
6:30	0.01	0.01	0.01	0.7	0	0.7
6:45	0.01	0.01	0.01	0.7	0	0.7
7:00	0.01	0.01	0.01	0.7	0	0.7
7:15	0.01	0.01	0.01	0.7	0	0.7
7:30	0.02	0.01	0.01	0.7	0	0.7
7:45	0.02	0.01	0.01	0.8	0	0.8
8:00	0.02	0.01	0.01	0.8	0	0.8
8:15	0.02	0.01	0.01	0.8	0	0.8
8:30	0.02	0.01	0.01	0.8	0	0.8
8:45	0.02	0.01	0.01	0.9	0	0.9
9:00	0.02	0.01	0.01	0.9	0	0.9
9:15	0.02	0.01	0.01	0.9	0	0.9
9:30	0.02	0.01	0.01	0.9	0	0.9
9:45	0.02	0.01	0.01	0.9	0	0.9
10:00	0.02	0.01	0.01	1	0	1
10:15	0.02	0.01	0.01	1	0	1
10:30	0.02	0.01	0.01	1	0	1
10:45	0.02	0.01	0.01	1.1	0	1.1
11:00	0.02	0.01	0.01	1.1	0	1.1
11:15	0.02	0.01	0.01	1.1	0	1.1
11:30	0.02	0.01	0.01	1.2	0	1.2
11:45	0.02	0.01	0.01	1.2	0	1.2
12:00	0.03	0.01	0.01	1.3	0	1.3
12:15	0.03	0.01	0.01	1.3	0	1.3

12:30	0.03	0.01	0.02	1.4	0	1.4
12:45	0.03	0.01	0.02	1.6	0	1.6
13:00	0.03	0.01	0.02	1.7	0	1.7
13:15	0.03	0.01	0.02	1.8	0	1.8
13:30	0.04	0.01	0.02	2	0	2
13:45	0.04	0.01	0.03	2.2	0	2.2
14:00	0.04	0.01	0.03	2.4	0	2.4
14:15	0.05	0.01	0.03	2.6	0	2.6
14:30	0.05	0.01	0.04	2.9	0	2.9
14:45	0.07	0.01	0.06	3.3	0	3.3
15:00	0.08	0.01	0.07	3.8	0	3.8
15:15	0.06	0.01	0.05	4.3	0	4.3
15:30	0.08	0.01	0.07	4.8	0	4.8
15:45	0.21	0.01	0.19	5.7	0	5.7
16:00	0.44	0.01	0.43	8	0	8
16:15	1.1	0.01	1.09	13.9	0	13.9
16:30	0.25	0.01	0.24	22.4	0	22.4
16:45	0.09	0.01	0.08	27.3	0	27.3
17:00	0.07	0.01	0.06	27.7	0	27.7
17:15	0.08	0.01	0.07	26.9	0	26.9
17:30	0.07	0.01	0.06	26.1	0	26.1
17:45	0.05	0.01	0.04	25.2	0	25.2
18:00	0.05	0.01	0.04	24.2	0	24.2
18:15	0.04	0.01	0.03	23.1	0	23.1
18:30	0.04	0.01	0.03	22.1	0	22.1
18:45	0.04	0.01	0.03	21.1	0	21.1
19:00	0.03	0.01	0.03	20.1	0	20.1
19:15	0.03	0.01	0.02	19.1	0	19.1
19:30	0.03	0.01	0.02	18.2	0	18.2
19:45	0.03	0.01	0.02	17.3	0	17.3
20:00	0.03	0.01	0.02	16.4	0	16.4
20:15	0.03	0.01	0.02	15.6	0	15.6
20:30	0.03	0.01	0.02	14.8	0	14.8
20:45	0.02	0.01	0.02	14	0	14
21:00	0.02	0.01	0.01	13.3	0	13.3
21:15	0.02	0.01	0.01	12.6	0	12.6
21:30	0.02	0.01	0.01	12	0	12
21:45	0.02	0.01	0.01	11.4	0	11.4
22:00	0.02	0.01	0.01	10.8	0	10.8
22:15	0.02	0.01	0.01	10.2	0	10.2
22:30	0.02	0.01	0.01	9.7	0	9.7
22:45	0.02	0.01	0.01	9.2	0	9.2
23:00	0.02	0.01	0.01	8.7	0	8.7
23:15	0.02	0.01	0.01	8.3	0	8.3
23:30	0.02	0.01	0.01	7.9	0	7.9
23:45	0.02	0.01	0.01	7.5	0	7.5
0:00	0.02	0.01	0.01	7.1	0	7.1

APPENDIX D

Detailed Hydraulic Calculations Existing - Nodes - 2-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
1.03	2YR	67.04	67.05	Link Spill Crest to 2D	67.59
1.01	2YR	67.00	67.005	Link Spill Crest to 2D	67.104
1.04	2YR	66.95	66.96	Link Spill Crest to 2D	67.349
1.02	2YR	66.67	66.679	Link Spill Crest to 2D	66.679
2.1	2YR	67.26	67.271	Link Spill Crest to 2D	67.569
2.09	2YR	66.94	66.949	Link Spill Crest to 2D	67.417
2.06	2YR	66.64	66.654	Link Spill Crest to 2D	66.679
2.05	2YR	66.59	66.598	Link Spill Crest to 2D	66.803
2.02	2YR	66.41	66.417	Link Spill Crest to 2D	66.417
2.08	2YR	66.65	66.658	Link Spill Crest to 2D	67.038
2.07	2YR	67.10	67.106	Link Spill Crest to 2D	67.402
2.04	2YR	65.05	65.057	Link Spill Crest to 2D	65.18
2.03	2YR	66.82	66.828	Link Spill Crest to 2D	67.136
2.01	2YR	66.56	66.572	Link Spill Crest to 2D	66.572
4.02	2YR	66.23	66.775	Link Spill Crest to 2D	67.705
4.01	2YR	64.99	66.405	Link Spill Crest to 2D	66.64
3.02	2YR	65.85	66.2	Link Spill Crest to 2D	66.943
3.01	2YR	65.91	65.916	Link Spill Crest to 2D	66.199
4.08	2YR	66.73	66.743	Link Spill Crest to 2D	66.937
4.09	2YR	65.48	65.487	Link Spill Crest to 2D	66.677
4.07	2YR	66.79	66.795	Link Spill Crest to 2D	66.925
3.08	2YR	67.00	67.007	Link Spill Crest to 2D	67.14
3.07	2YR	66.47	66.481	Link Spill Crest to 2D	66.682
3.09	2YR	66.78	66.786	Link Spill Crest to 2D	67.112
4.04	2YR	66.68	66.689	Link Spill Crest to 2D	66.842
4.06	2YR	66.53	66.543	Link Spill Crest to 2D	66.668
4.03	2YR	67.20	67.209	Link Spill Crest to 2D	67.335
4.05	2YR	66.86	66.867	Link Spill Crest to 2D	66.966
3.04	2YR	66.52	66.531	Link Spill Crest to 2D	66.723
3.06	2YR	66.13	66.138	Link Spill Crest to 2D	66.138
3.03	2YR	66.02	66.029	Link Spill Crest to 2D	66.274
3.05	2YR	66.54	66.554	Link Spill Crest to 2D	66.71
Node61	2YR	64.55	68.636	Link Invert to 2D	66.385
Node62	2YR	64.47	68.178	Link Invert to 2D	66.392
Node63	2YR	64.10	68.438	Link Invert to 2D	66.402
Node64	2YR	63.81	67.739	Link Invert to 2D	66.402
Node68	2YR	63.53	68.466	Link Invert to 2D	66.402
Node69	2YR	64.04	68.05	Link Invert to 2D	66.402
Node71	2YR	64.74	67.475	Link Invert to 2D	65.29
Node72	2YR	64.44	68.192	Link Invert to 2D	65.29
Node73	2YR	63.67	68.135	Link Invert to 2D	63.67

Detailed Hydraulic Calculations Existing - Nodes - 2-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
Node74	2YR	57.32	68	Link Invert to 2D	58.646
Node75	2YR	64.79	68.333	Link Invert to 2D	66.425
Node76	2YR	64.62	67.593	Link Invert to 2D	66.424
Node77	2YR	61.92	68.867	Link Invert to 2D	63.075
Node78	2YR	57.93	68	Link Invert to 2D	58.607
Node79	2YR	64.83	69.857	Link Invert to 2D	66.676
Node80	2YR	64.66	70.04	Link Invert to 2D	66.676
Node83	2YR	64.76	68.419	Link Invert to 2D	66.514
Node84	2YR	64.78	69.036	Link Invert to 2D	66.514
Node85	2YR	64.96	68.919	Link Invert to 2D	66.514
Node86	2YR	64.96	70.045	Link Invert to 2D	66.514
Node89	2YR	64.54	68.804	Link Invert to 2D	66.388
Node90	2YR	63.55	69.373	Link Invert to 2D	66.386
Node91	2YR	64.86	69.274	Link Invert to 2D	67.054
Node92	2YR	65.16	70.036	Link Invert to 2D	67.054
Node93	2YR	66.15	70.126	Link Invert to 2D	66.947
Node94	2YR	65.92	69.81	Link Invert to 2D	66.948
Node95	2YR	64.49	69.464	Link Invert to 2D	66.286
Node96	2YR	64.79	68.572	Link Invert to 2D	66.285
Node99	2YR	64.99	68.8	Link Invert to 2D	66.668
Node100	2YR	65.01	68.662	Link Invert to 2D	66.668
Node101	2YR	64.32	69.569	Link Invert to 2D	66.668
Node102	2YR	64.41	68.671	Link Invert to 2D	66.668
Node103	2YR	63.78	67.714	Link Invert to 2D	66.069
Node104	2YR	63.39	68.292	Link Invert to 2D	66.069
Node105	2YR	63.80	67.93	Link Invert to 2D	66.067
Node106	2YR	63.48	69.462	Link Invert to 2D	66.069
Node109	2YR	64.31	67.99	Link Invert to 2D	66.382
Node110	2YR	63.24	70.003	Link Invert to 2D	66.383
Node111	2YR	63.18	67.782	Link Invert to 2D	66.048
Node112	2YR	62.28	66.1	Link Invert to 2D	66.047
Node113	2YR	62.00	67.228	Link Invert to 2D	64.177
Node114	2YR	61.00	68	Link Invert to 2D	61
Node115	2YR	64.29	67.849	Link Invert to 2D	66.695
Node116	2YR	63.62	66.808	Link Invert to 2D	66.682
Node117	2YR	60.06	63.059	Link Invert to 2D	60.059
Node118	2YR	54.56	68	Link Invert to 2D	58.897
7	2YR	59.13	59.137	Link Spill Crest to 2D	62.891
5	2YR	67.18	67.186	Link Spill Crest to 2D	67.98
6	2YR	66.76	66.77	Link Spill Crest to 2D	67.254

Detailed Hydraulic Calculations Existing - Nodes - 100-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
1.03	2YR	67.04	67.05	Link Spill Crest to 2D	67.756
1.01	2YR	67.00	67.005	Link Spill Crest to 2D	67.242
1.04	2YR	66.95	66.96	Link Spill Crest to 2D	67.533
1.02	2YR	66.67	66.679	Link Spill Crest to 2D	66.995
2.1	2YR	67.26	67.271	Link Spill Crest to 2D	67.768
2.09	2YR	66.94	66.949	Link Spill Crest to 2D	67.641
2.06	2YR	66.64	66.654	Link Spill Crest to 2D	66.889
2.05	2YR	66.59	66.598	Link Spill Crest to 2D	66.963
2.02	2YR	66.41	66.417	Link Spill Crest to 2D	66.417
2.08	2YR	66.65	66.658	Link Spill Crest to 2D	67.244
2.07	2YR	67.10	67.106	Link Spill Crest to 2D	67.591
2.04	2YR	65.05	65.057	Link Spill Crest to 2D	65.304
2.03	2YR	66.82	66.828	Link Spill Crest to 2D	67.278
2.01	2YR	66.56	66.572	Link Spill Crest to 2D	66.572
4.02	2YR	66.23	66.775	Link Spill Crest to 2D	68.067
4.01	2YR	64.99	66.405	Link Spill Crest to 2D	67.075
3.02	2YR	65.85	66.2	Link Spill Crest to 2D	67.271
3.01	2YR	65.91	65.916	Link Spill Crest to 2D	66.788
4.08	2YR	66.73	66.743	Link Spill Crest to 2D	67.191
4.09	2YR	65.48	65.487	Link Spill Crest to 2D	67.081
4.07	2YR	66.79	66.795	Link Spill Crest to 2D	67.094
3.08	2YR	67.00	67.007	Link Spill Crest to 2D	67.234
3.07	2YR	66.47	66.481	Link Spill Crest to 2D	66.886
3.09	2YR	66.78	66.786	Link Spill Crest to 2D	67.339
4.04	2YR	66.68	66.689	Link Spill Crest to 2D	67.1
4.06	2YR	66.53	66.543	Link Spill Crest to 2D	67.09
4.03	2YR	67.20	67.209	Link Spill Crest to 2D	67.449
4.05	2YR	66.86	66.867	Link Spill Crest to 2D	67.088
3.04	2YR	66.52	66.531	Link Spill Crest to 2D	66.878
3.06	2YR	66.13	66.138	Link Spill Crest to 2D	66.861
3.03	2YR	66.02	66.029	Link Spill Crest to 2D	66.859
3.05	2YR	66.54	66.554	Link Spill Crest to 2D	66.874
Node61	2YR	64.55	68.636	Link Invert to 2D	66.948
Node62	2YR	64.47	68.178	Link Invert to 2D	66.961
Node63	2YR	64.10	68.438	Link Invert to 2D	66.989
Node64	2YR	63.81	67.739	Link Invert to 2D	66.988
Node68	2YR	63.53	68.466	Link Invert to 2D	66.995
Node69	2YR	64.04	68.05	Link Invert to 2D	66.988
Node71	2YR	64.74	67.475	Link Invert to 2D	66.143
Node72	2YR	64.44	68.192	Link Invert to 2D	66.131
Node73	2YR	63.67	68.135	Link Invert to 2D	63.67

Detailed Hydraulic Calculations Existing - Nodes - 100-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
Node74	2YR	57.32	68	Link Invert to 2D	60.914
Node75	2YR	64.79	68.333	Link Invert to 2D	66.864
Node76	2YR	64.62	67.593	Link Invert to 2D	66.863
Node77	2YR	61.92	68.867	Link Invert to 2D	64.118
Node78	2YR	57.93	68	Link Invert to 2D	60.903
Node79	2YR	64.83	69.857	Link Invert to 2D	67.08
Node80	2YR	64.66	70.04	Link Invert to 2D	67.08
Node83	2YR	64.76	68.419	Link Invert to 2D	67.005
Node84	2YR	64.78	69.036	Link Invert to 2D	67.006
Node85	2YR	64.96	68.919	Link Invert to 2D	67.002
Node86	2YR	64.96	70.045	Link Invert to 2D	67.002
Node89	2YR	64.54	68.804	Link Invert to 2D	67.001
Node90	2YR	63.55	69.373	Link Invert to 2D	66.992
Node91	2YR	64.86	69.274	Link Invert to 2D	67.219
Node92	2YR	65.16	70.036	Link Invert to 2D	67.219
Node93	2YR	66.15	70.126	Link Invert to 2D	67.225
Node94	2YR	65.92	69.81	Link Invert to 2D	67.227
Node95	2YR	64.49	69.464	Link Invert to 2D	66.871
Node96	2YR	64.79	68.572	Link Invert to 2D	66.869
Node99	2YR	64.99	68.8	Link Invert to 2D	67.089
Node100	2YR	65.01	68.662	Link Invert to 2D	67.09
Node101	2YR	64.32	69.569	Link Invert to 2D	67.084
Node102	2YR	64.41	68.671	Link Invert to 2D	67.084
Node103	2YR	63.78	67.714	Link Invert to 2D	66.861
Node104	2YR	63.39	68.292	Link Invert to 2D	66.86
Node105	2YR	63.80	67.93	Link Invert to 2D	66.859
Node106	2YR	63.48	69.462	Link Invert to 2D	66.86
Node109	2YR	64.31	67.99	Link Invert to 2D	66.984
Node110	2YR	63.24	70.003	Link Invert to 2D	66.985
Node111	2YR	63.18	67.782	Link Invert to 2D	66.805
Node112	2YR	62.28	66.1	Link Invert to 2D	66.797
Node113	2YR	62.00	67.228	Link Invert to 2D	66.088
Node114	2YR	61.00	68	Link Invert to 2D	61
Node115	2YR	64.29	67.849	Link Invert to 2D	67.084
Node116	2YR	63.62	66.808	Link Invert to 2D	67.084
Node117	2YR	60.06	63.059	Link Invert to 2D	60.412
Node118	2YR	54.56	68	Link Invert to 2D	61.105
7	2YR	59.13	59.137	Link Spill Crest to 2D	64.243
5	2YR	67.18	67.186	Link Spill Crest to 2D	68.449
6	2YR	66.76	66.77	Link Spill Crest to 2D	67.564

Detailed Hydraulic Calculations Proposed - Nodes - 2-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
AN-01	2YR	63.00	66.831	Link Spill Crest to 2D	63.984
AN-02	2YR	62.50	67.738	Link Spill Crest to 2D	63.247
AN-03	2YR	62.50	67.245	Link Spill Crest to 2D	63.247
AN-04	2YR	61.75	67.014	Link Spill Crest to 2D	62.498
AN-05	2YR	61.75	67.246	Link Spill Crest to 2D	62.509
AN-06	2YR	61.50	67.635	Link Spill Crest to 2D	61.996
AN-07	2YR	61.50	65.86	Link Spill Crest to 2D	62.236
AN-08	2YR	61.40	65.881	Link Spill Crest to 2D	61.573
AN-09	2YR	61.30	66.815	Link Spill Crest to 2D	61.3
AN-10	2YR	61.30	66.306	Link Spill Crest to 2D	61.3
BR-01	2YR	62.30	66.469	Link Spill Crest to 2D	62.3
BR-02	2YR	61.80	66.681	Link Spill Crest to 2D	61.8
BR-03	2YR	61.80	66.191	Link Spill Crest to 2D	62.015
BR-04	2YR	61.75	67.18	Link Spill Crest to 2D	61.75
BR-05	2YR	61.75	66.496	Link Spill Crest to 2D	62.27
BR-06	2YR	61.20	66.569	Link Spill Crest to 2D	61.2
BR-07	2YR	61.20	66.182	Link Spill Crest to 2D	61.2
BR-08	2YR	61.40	65.886	Link Spill Crest to 2D	62.457
BR-09	2YR	61.40	66.737	Link Spill Crest to 2D	62.435
BR-10	2YR	61.50	66.437	Link Spill Crest to 2D	61.5
CV-01	2YR	62.75	66.979	Link Spill Crest to 2D	62.75
CV-02	2YR	62.75	66.727	Link Spill Crest to 2D	63.44
CV-03	2YR	61.75	66.776	Link Spill Crest to 2D	62.181
CV-04	2YR	61.75	66.963	Link Spill Crest to 2D	61.75
CV-05	2YR	61.75	67.295	Link Spill Crest to 2D	61.75
CV-06	2YR	61.25	66.424	Link Spill Crest to 2D	61.25
CV-07	2YR	61.25	66.57	Link Spill Crest to 2D	61.25
CV-08	2YR	61.00	66.56	Link Spill Crest to 2D	61
CV-09	2YR	61.00	65.702	Link Spill Crest to 2D	61.304
CV-10	2YR	61.60	67.017	Link Spill Crest to 2D	61.6
LA-01	2YR	62.25	67.333	Link Spill Crest to 2D	62.817
LA-02	2YR	62.00	65.904	Link Spill Crest to 2D	63.073
LA-03	2YR	61.80	66.775	Link Spill Crest to 2D	61.8
LA-04	2YR	61.50	66.269	Link Spill Crest to 2D	61.595
RL-01	2YR	61.80	66.585	Link Spill Crest to 2D	62.466
RL-02	2YR	61.50	67.211	Link Spill Crest to 2D	62.174
RL-03	2YR	61.80	65.88	Link Spill Crest to 2D	62.553
RL-04	2YR	61.50	67.293	Link Spill Crest to 2D	62.05
RL-05	2YR	61.50	66.268	Link Spill Crest to 2D	62.138
RL-06	2YR	61.50	67.383	Link Spill Crest to 2D	61.5
RL-07	2YR	61.50	67.088	Link Spill Crest to 2D	61.5

Detailed Hydraulic Calculations Proposed - Nodes - 2-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
RL-08	2YR	62.25	67.199	Link Spill Crest to 2D	66.24
RL-09	2YR	62.25	66.236	Link Spill Crest to 2D	66.236
RL-10	2YR	62.00	65.724	Link Spill Crest to 2D	66.256
RL-11	2YR	61.90	66.335	Link Spill Crest to 2D	66.227
RL-12	2YR	61.90	65.965	Link Spill Crest to 2D	66.226
RL-13	2YR	62.00	66.392	Link Spill Crest to 2D	66.229
WG-01	2YR	63.00	67.321	Link Spill Crest to 2D	66.98
WG-02	2YR	63.20	66.967	Link Spill Crest to 2D	66.967
WG-03	2YR	62.50	66.001	Link Spill Crest to 2D	66.489
WG-04	2YR	62.00	67.069	Link Spill Crest to 2D	66.591
WG-05	2YR	61.90	66.196	Link Spill Crest to 2D	66.422
WG-06	2YR	61.50	65.792	Link Spill Crest to 2D	66.241
WG-07	2YR	61.50	65.561	Link Spill Crest to 2D	66.244
WG-08	2YR	61.50	66.375	Link Spill Crest to 2D	66.24
WG-09	2YR	61.50	66.676	Link Spill Crest to 2D	66.24
WG-10	2YR	61.80	66.679	Link Spill Crest to 2D	66.241
RL-MH5	2YR	62.00	67.403	Link Spill Crest to 2D	66.238
RL-MH6	2YR	61.50	67.264	Link Spill Crest to 2D	66.255
RL-MH7	2YR	61.00	67.341	Link Spill Crest to 2D	66.234
RL-MH8	2YR	61.20	67.216	Link Spill Crest to 2D	66.227
RL-MH9	2YR	61.80	67.266	Link Spill Crest to 2D	66.229
WG-MH1	2YR	63.00	67.55	Link Spill Crest to 2D	66.959
WG-MH2	2YR	62.25	67.855	Link Spill Crest to 2D	66.484
WG-MH3	2YR	61.75	67.328	Link Spill Crest to 2D	66.419
WG-MH4	2YR	60.75	66.753	Link Spill Crest to 2D	66.246
WG-MH5	2YR	60.30	67.24	Link Spill Crest to 2D	66.239
WG-MH6	2YR	60.00	66.886	Link Spill Crest to 2D	66.24
WG-MH7	2YR	57.50	66.901	Link Spill Crest to 2D	66.241
LA-MH1	2YR	61.50	67.704	Link Spill Crest to 2D	62.816
LA-MH2	2YR	60.90	67.138	Link Spill Crest to 2D	62.806
LA-MH3	2YR	60.10	67.491	Link Spill Crest to 2D	61.315
LA-MH4	2YR	57.00	66.921	Link Spill Crest to 2D	58.724
LA-MH5	2YR	56.50	67	Link Spill Crest to 2D	57.989
OUTFALL	2YR	56.00	59.742	Link Invert to 2D	56
AN-MH1	2YR	62.95	67.328	Link Spill Crest to 2D	63.979
AN-MH2	2YR	62.40	68.524	Link Spill Crest to 2D	63.247
AN-MH3	2YR	61.10	68.204	Link Spill Crest to 2D	62.509
AN-MH4	2YR	60.20	67.338	Link Spill Crest to 2D	61.996
AN-MH5	2YR	59.50	66.957	Link Spill Crest to 2D	61.159
AN-MH6	2YR	58.95	67.166	Link Spill Crest to 2D	60.173
AN-MH7	2YR	57.50	67.403	Link Spill Crest to 2D	58.979

Detailed Hydraulic Calculations Proposed - Nodes - 2-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
CV-MH1	2YR	59.75	67.933	Link Spill Crest to 2D	60.453
CV-MH2	2YR	58.75	67.424	Link Spill Crest to 2D	59.919
CV-MH3	2YR	58.30	68.111	Link Spill Crest to 2D	59.764
CV-MH4	2YR	58.10	68.175	Link Spill Crest to 2D	59.749
CV-MH5	2YR	57.80	66.701	Link Spill Crest to 2D	59.447
CV-MH6	2YR	56.50	67.208	Link Spill Crest to 2D	59.2
CV-MH7	2YR	56.25	67.699	Link Spill Crest to 2D	59.13
BR-MH1	2YR	62.00	68.088	Link Spill Crest to 2D	62
BR-MH2	2YR	61.20	67.504	Link Spill Crest to 2D	61.632
BR-MH3	2YR	60.60	67.825	Link Spill Crest to 2D	61.38
BR-MH4	2YR	58.80	68.436	Link Spill Crest to 2D	60.338
BR-MH5	2YR	60.90	66.941	Link Spill Crest to 2D	60.9
BR-MH6	2YR	61.30	67.085	Link Spill Crest to 2D	62.435
BR-MH7	2YR	60.50	67.338	Link Spill Crest to 2D	61.086
RL-MH1	2YR	61.50	67.419	Link Spill Crest to 2D	62.466
RL-MH2	2YR	60.80	67.397	Link Spill Crest to 2D	62.174
RL-MH3	2YR	60.70	67.73	Link Spill Crest to 2D	62.05
RL-MH4	2YR	60.00	68.202	Link Spill Crest to 2D	61.17
OUTFALL_EAST	2YR	56.00	67	Link Invert to 2D	59.053
Node117	2YR	60.06	63.059	Link Invert to 2D	60.059
Node118	2YR	54.56	68	Link Invert to 2D	59.121
1.03	2YR	66.98	67.232	Link Spill Crest to 2D	67.232
1.01	2YR	66.36	66.612	Link Spill Crest to 2D	67.202
1.04	2YR	67.72	67.971	Link Spill Crest to 2D	67.971
1.02	2YR	65.43	65.684	Link Spill Crest to 2D	66.556
2.1	2YR	66.19	66.436	Link Spill Crest to 2D	66.905
2.09	2YR	65.23	65.478	Link Spill Crest to 2D	66.888
2.06	2YR	66.07	66.321	Link Spill Crest to 2D	66.425
2.05	2YR	66.25	66.495	Link Spill Crest to 2D	66.495
2.02	2YR	67.29	67.535	Link Spill Crest to 2D	67.535
2.08	2YR	66.84	67.089	Link Spill Crest to 2D	67.089
2.07	2YR	66.20	66.45	Link Spill Crest to 2D	66.887
2.04	2YR	65.79	66.039	Link Spill Crest to 2D	66.198
2.03	2YR	65.32	65.565	Link Spill Crest to 2D	66.108
2.01	2YR	66.67	66.918	Link Spill Crest to 2D	66.918
4.02	2YR	66.82	67.067	Link Spill Crest to 2D	67.067
4.01	2YR	64.52	64.766	Link Spill Crest to 2D	66.511
3.02	2YR	65.82	66.068	Link Spill Crest to 2D	66.203
3.01	2YR	63.75	63.996	Link Spill Crest to 2D	66.214
4.08	2YR	66.33	66.579	Link Spill Crest to 2D	66.743
4.09	2YR	66.11	66.358	Link Spill Crest to 2D	66.604

Detailed Hydraulic Calculations Proposed - Nodes - 2-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
4.07	2YR	67.50	67.748	Link Spill Crest to 2D	67.748
3.08	2YR	67.01	67.259	Link Spill Crest to 2D	67.259
3.07	2YR	66.94	67.193	Link Spill Crest to 2D	67.193
3.09	2YR	66.91	67.16	Link Spill Crest to 2D	67.16
4.04	2YR	66.72	66.97	Link Spill Crest to 2D	67.028
4.06	2YR	65.70	65.953	Link Spill Crest to 2D	66.489
4.03	2YR	66.28	66.527	Link Spill Crest to 2D	66.527
4.05	2YR	65.60	65.846	Link Spill Crest to 2D	66.421
3.04	2YR	65.26	65.506	Link Spill Crest to 2D	66.242
3.06	2YR	66.14	66.392	Link Spill Crest to 2D	66.392
3.03	2YR	66.37	66.619	Link Spill Crest to 2D	66.699
3.05	2YR	66.58	66.828	Link Spill Crest to 2D	66.828
7	2YR	58.91	59.164	Link Spill Crest to 2D	62.831
5	2YR	67.56	67.813	Link Spill Crest to 2D	67.971
6	2YR	67.72	67.971	Link Spill Crest to 2D	67.971
Node237	2YR	63.60	68.005	Link Spill Crest to 2D	0
Node238	2YR	60.50	68.014	Link Spill Crest to 2D	60.999
CV_Off6_1	2YR	61.00	67.626	Link Spill Crest to 2D	61
CV_Off6_2	2YR	61.00	66.75	Link Spill Crest to 2D	61.908
CV_05_2	2YR	58.40	67.417	Link Spill Crest to 2D	59.764
AN-08_1	2YR	59.60	66.576	Link Spill Crest to 2D	61.16
Outfall_Swale	2YR	50.00	67	Link Spill Crest to 2D	66.241
Node244	2YR	60.80	66.97	Link Spill Crest to 2D	66.211
Node245	2YR	61.00	64.919	Link Spill Crest to 2D	66.213
Node246	2YR	61.00	65.781	Link Spill Crest to 2D	66.203
GR1	2YR	62.60	68.094	Link Spill Crest to 2D	66.507
Node248	2YR	63.00	65.38	Link Spill Crest to 2D	66.511
Node249	2YR	63.00	67.076	Link Spill Crest to 2D	66.507
WG-MH2.2	2YR	62.10	68.215	Link Spill Crest to 2D	66.503
Node251	2YR	62.50	67.947	Link Spill Crest to 2D	66.481
Node252	2YR	63.00	65.853	Link Spill Crest to 2D	66.483
Node253	2YR	63.00	67.235	Link Spill Crest to 2D	66.481
RL-MH3.2	2YR	60.35	67.757	Link Spill Crest to 2D	61.666
AN-MH3.2	2YR	60.41	67.862	Link Spill Crest to 2D	62.079
AN-MH3.3	2YR	60.55	68.23	Link Spill Crest to 2D	62.144
Node259	2YR	62.50	66.97	Link Spill Crest to 2D	66.486
Node111	2YR	63.18	67.782	Link Invert to 2D	66.102
Node112	2YR	62.28	66.1	Link Invert to 2D	66.099
Node113	2YR	62.00	67.228	Link Invert to 2D	64.257
Node114	2YR	61.00	68	Link Invert to 2D	61
Node115	2YR	64.29	67.849	Link Invert to 2D	66.638

Detailed Hydraulic Calculations Proposed - Nodes - 2-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
Node116	2YR	63.62	66.808	Link Invert to 2D	66.638

Detailed Hydraulic Calculations Proposed - Nodes - 100-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
AN-01	2YR	63.00	66.831	Link Spill Crest to 2D	64.602
AN-02	2YR	62.50	67.738	Link Spill Crest to 2D	64.173
AN-03	2YR	62.50	67.245	Link Spill Crest to 2D	64.173
AN-04	2YR	61.75	67.014	Link Spill Crest to 2D	63.995
AN-05	2YR	61.75	67.246	Link Spill Crest to 2D	63.97
AN-06	2YR	61.50	67.635	Link Spill Crest to 2D	63.228
AN-07	2YR	61.50	65.86	Link Spill Crest to 2D	63.102
AN-08	2YR	61.40	65.881	Link Spill Crest to 2D	62.463
AN-09	2YR	61.30	66.815	Link Spill Crest to 2D	61.977
AN-10	2YR	61.30	66.306	Link Spill Crest to 2D	62.074
BR-01	2YR	62.30	66.469	Link Spill Crest to 2D	64.238
BR-02	2YR	61.80	66.681	Link Spill Crest to 2D	64.266
BR-03	2YR	61.80	66.191	Link Spill Crest to 2D	64.297
BR-04	2YR	61.75	67.18	Link Spill Crest to 2D	63.808
BR-05	2YR	61.75	66.496	Link Spill Crest to 2D	63.851
BR-06	2YR	61.20	66.569	Link Spill Crest to 2D	64.105
BR-07	2YR	61.20	66.182	Link Spill Crest to 2D	64.132
BR-08	2YR	61.40	65.886	Link Spill Crest to 2D	62.989
BR-09	2YR	61.40	66.737	Link Spill Crest to 2D	62.954
BR-10	2YR	61.50	66.437	Link Spill Crest to 2D	62.078
CV-01	2YR	62.75	66.979	Link Spill Crest to 2D	63.417
CV-02	2YR	62.75	66.727	Link Spill Crest to 2D	63.616
CV-03	2YR	61.75	66.776	Link Spill Crest to 2D	62.486
CV-04	2YR	61.75	66.963	Link Spill Crest to 2D	62.313
CV-05	2YR	61.75	67.295	Link Spill Crest to 2D	62.311
CV-06	2YR	61.25	66.424	Link Spill Crest to 2D	61.863
CV-07	2YR	61.25	66.57	Link Spill Crest to 2D	62.139
CV-08	2YR	61.00	66.56	Link Spill Crest to 2D	62.33
CV-09	2YR	61.00	65.702	Link Spill Crest to 2D	62.022
CV-10	2YR	61.60	67.017	Link Spill Crest to 2D	61.797
LA-01	2YR	62.25	67.333	Link Spill Crest to 2D	62.924
LA-02	2YR	62.00	65.904	Link Spill Crest to 2D	63.182
LA-03	2YR	61.80	66.775	Link Spill Crest to 2D	61.984
LA-04	2YR	61.50	66.269	Link Spill Crest to 2D	61.826
RL-01	2YR	61.80	66.585	Link Spill Crest to 2D	66.933
RL-02	2YR	61.50	67.211	Link Spill Crest to 2D	65.598
RL-03	2YR	61.80	65.88	Link Spill Crest to 2D	66.887
RL-04	2YR	61.50	67.293	Link Spill Crest to 2D	65.328
RL-05	2YR	61.50	66.268	Link Spill Crest to 2D	65.349
RL-06	2YR	61.50	67.383	Link Spill Crest to 2D	64.369
RL-07	2YR	61.50	67.088	Link Spill Crest to 2D	64.369

Detailed Hydraulic Calculations Proposed - Nodes - 100-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
RL-08	2YR	62.25	67.199	Link Spill Crest to 2D	66.813
RL-09	2YR	62.25	66.236	Link Spill Crest to 2D	66.813
RL-10	2YR	62.00	65.724	Link Spill Crest to 2D	66.824
RL-11	2YR	61.90	66.335	Link Spill Crest to 2D	66.802
RL-12	2YR	61.90	65.965	Link Spill Crest to 2D	66.798
RL-13	2YR	62.00	66.392	Link Spill Crest to 2D	66.729
WG-01	2YR	63.00	67.321	Link Spill Crest to 2D	67.017
WG-02	2YR	63.20	66.967	Link Spill Crest to 2D	67.015
WG-03	2YR	62.50	66.001	Link Spill Crest to 2D	67.043
WG-04	2YR	62.00	67.069	Link Spill Crest to 2D	66.961
WG-05	2YR	61.90	66.196	Link Spill Crest to 2D	66.964
WG-06	2YR	61.50	65.792	Link Spill Crest to 2D	66.849
WG-07	2YR	61.50	65.561	Link Spill Crest to 2D	66.851
WG-08	2YR	61.50	66.375	Link Spill Crest to 2D	66.837
WG-09	2YR	61.50	66.676	Link Spill Crest to 2D	66.835
WG-10	2YR	61.80	66.679	Link Spill Crest to 2D	66.841
RL-MH5	2YR	62.00	67.403	Link Spill Crest to 2D	66.813
RL-MH6	2YR	61.50	67.264	Link Spill Crest to 2D	66.821
RL-MH7	2YR	61.00	67.341	Link Spill Crest to 2D	66.816
RL-MH8	2YR	61.20	67.216	Link Spill Crest to 2D	66.8
RL-MH9	2YR	61.80	67.266	Link Spill Crest to 2D	66.733
WG-MH1	2YR	63.00	67.55	Link Spill Crest to 2D	67.016
WG-MH2	2YR	62.25	67.855	Link Spill Crest to 2D	67.068
WG-MH3	2YR	61.75	67.328	Link Spill Crest to 2D	66.961
WG-MH4	2YR	60.75	66.753	Link Spill Crest to 2D	66.849
WG-MH5	2YR	60.30	67.24	Link Spill Crest to 2D	66.83
WG-MH6	2YR	60.00	66.886	Link Spill Crest to 2D	66.834
WG-MH7	2YR	57.50	66.901	Link Spill Crest to 2D	66.848
LA-MH1	2YR	61.50	67.704	Link Spill Crest to 2D	62.923
LA-MH2	2YR	60.90	67.138	Link Spill Crest to 2D	62.923
LA-MH3	2YR	60.10	67.491	Link Spill Crest to 2D	61.45
LA-MH4	2YR	57.00	66.921	Link Spill Crest to 2D	59.763
LA-MH5	2YR	56.50	67	Link Spill Crest to 2D	58.863
OUTFALL	2YR	56.00	59.742	Link Invert to 2D	56
AN-MH1	2YR	62.95	67.328	Link Spill Crest to 2D	64.595
AN-MH2	2YR	62.40	68.524	Link Spill Crest to 2D	64.173
AN-MH3	2YR	61.10	68.204	Link Spill Crest to 2D	63.967
AN-MH4	2YR	60.20	67.338	Link Spill Crest to 2D	63.228
AN-MH5	2YR	59.50	66.957	Link Spill Crest to 2D	62.483
AN-MH6	2YR	58.95	67.166	Link Spill Crest to 2D	61.977
AN-MH7	2YR	57.50	67.403	Link Spill Crest to 2D	61.771

Detailed Hydraulic Calculations Proposed - Nodes - 100-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
CV-MH1	2YR	59.75	67.933	Link Spill Crest to 2D	62.367
CV-MH2	2YR	58.75	67.424	Link Spill Crest to 2D	62.335
CV-MH3	2YR	58.30	68.111	Link Spill Crest to 2D	62.311
CV-MH4	2YR	58.10	68.175	Link Spill Crest to 2D	62.307
CV-MH5	2YR	57.80	66.701	Link Spill Crest to 2D	62.138
CV-MH6	2YR	56.50	67.208	Link Spill Crest to 2D	61.9
CV-MH7	2YR	56.25	67.699	Link Spill Crest to 2D	61.629
BR-MH1	2YR	62.00	68.088	Link Spill Crest to 2D	64.237
BR-MH2	2YR	61.20	67.504	Link Spill Crest to 2D	64.262
BR-MH3	2YR	60.60	67.825	Link Spill Crest to 2D	63.808
BR-MH4	2YR	58.80	68.436	Link Spill Crest to 2D	63.52
BR-MH5	2YR	60.90	66.941	Link Spill Crest to 2D	64.102
BR-MH6	2YR	61.30	67.085	Link Spill Crest to 2D	62.954
BR-MH7	2YR	60.50	67.338	Link Spill Crest to 2D	61.964
RL-MH1	2YR	61.50	67.419	Link Spill Crest to 2D	66.863
RL-MH2	2YR	60.80	67.397	Link Spill Crest to 2D	65.598
RL-MH3	2YR	60.70	67.73	Link Spill Crest to 2D	65.328
RL-MH4	2YR	60.00	68.202	Link Spill Crest to 2D	64.369
OUTFALL_EAST	2YR	56.00	67	Link Invert to 2D	61.373
Node117	2YR	60.06	63.059	Link Invert to 2D	60.54
Node118	2YR	54.56	68	Link Invert to 2D	61.426
1.03	2YR	66.98	67.232	Link Spill Crest to 2D	67.333
1.01	2YR	66.36	66.612	Link Spill Crest to 2D	67.323
1.04	2YR	67.72	67.971	Link Spill Crest to 2D	67.971
1.02	2YR	65.43	65.684	Link Spill Crest to 2D	66.955
2.1	2YR	66.19	66.436	Link Spill Crest to 2D	67.136
2.09	2YR	65.23	65.478	Link Spill Crest to 2D	67.111
2.06	2YR	66.07	66.321	Link Spill Crest to 2D	66.681
2.05	2YR	66.25	66.495	Link Spill Crest to 2D	66.682
2.02	2YR	67.29	67.535	Link Spill Crest to 2D	67.535
2.08	2YR	66.84	67.089	Link Spill Crest to 2D	67.089
2.07	2YR	66.20	66.45	Link Spill Crest to 2D	67.071
2.04	2YR	65.79	66.039	Link Spill Crest to 2D	66.568
2.03	2YR	65.32	65.565	Link Spill Crest to 2D	66.527
2.01	2YR	66.67	66.918	Link Spill Crest to 2D	66.918
4.02	2YR	66.82	67.067	Link Spill Crest to 2D	67.067
4.01	2YR	64.52	64.766	Link Spill Crest to 2D	66.984
3.02	2YR	65.82	66.068	Link Spill Crest to 2D	66.796
3.01	2YR	63.75	63.996	Link Spill Crest to 2D	66.806
4.08	2YR	66.33	66.579	Link Spill Crest to 2D	67.006
4.09	2YR	66.11	66.358	Link Spill Crest to 2D	67.026

Detailed Hydraulic Calculations Proposed - Nodes - 100-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
4.07	2YR	67.50	67.748	Link Spill Crest to 2D	67.748
3.08	2YR	67.01	67.259	Link Spill Crest to 2D	67.259
3.07	2YR	66.94	67.193	Link Spill Crest to 2D	67.193
3.09	2YR	66.91	67.16	Link Spill Crest to 2D	67.16
4.04	2YR	66.72	66.97	Link Spill Crest to 2D	67.085
4.06	2YR	65.70	65.953	Link Spill Crest to 2D	67.043
4.03	2YR	66.28	66.527	Link Spill Crest to 2D	66.913
4.05	2YR	65.60	65.846	Link Spill Crest to 2D	66.964
3.04	2YR	65.26	65.506	Link Spill Crest to 2D	66.849
3.06	2YR	66.14	66.392	Link Spill Crest to 2D	66.853
3.03	2YR	66.37	66.619	Link Spill Crest to 2D	66.838
3.05	2YR	66.58	66.828	Link Spill Crest to 2D	66.835
7	2YR	58.91	59.164	Link Spill Crest to 2D	64.068
5	2YR	67.56	67.813	Link Spill Crest to 2D	68.422
6	2YR	67.72	67.971	Link Spill Crest to 2D	67.971
Node237	2YR	63.60	68.005	Link Spill Crest to 2D	0
Node238	2YR	60.50	68.014	Link Spill Crest to 2D	62.389
CV_Off6_1	2YR	61.00	67.626	Link Spill Crest to 2D	62.389
CV_Off6_2	2YR	61.00	66.75	Link Spill Crest to 2D	62.417
CV_05_2	2YR	58.40	67.417	Link Spill Crest to 2D	62.311
AN-08_1	2YR	59.60	66.576	Link Spill Crest to 2D	62.498
Outfall_Swale	2YR	50.00	67	Link Spill Crest to 2D	66.849
Node244	2YR	60.80	66.97	Link Spill Crest to 2D	66.803
Node245	2YR	61.00	64.919	Link Spill Crest to 2D	66.804
Node246	2YR	61.00	65.781	Link Spill Crest to 2D	66.796
GR1	2YR	62.60	68.094	Link Spill Crest to 2D	66.984
Node248	2YR	63.00	65.38	Link Spill Crest to 2D	66.984
Node249	2YR	63.00	67.076	Link Spill Crest to 2D	66.984
WG-MH2.2	2YR	62.10	68.215	Link Spill Crest to 2D	67.045
Node251	2YR	62.50	67.947	Link Spill Crest to 2D	66.982
Node252	2YR	63.00	65.853	Link Spill Crest to 2D	66.981
Node253	2YR	63.00	67.235	Link Spill Crest to 2D	66.982
RL-MH3.2	2YR	60.35	67.757	Link Spill Crest to 2D	64.849
AN-MH3.2	2YR	60.41	67.862	Link Spill Crest to 2D	63.408
AN-MH3.3	2YR	60.55	68.23	Link Spill Crest to 2D	63.527
Node259	2YR	62.50	66.97	Link Spill Crest to 2D	67.08
Node111	2YR	63.18	67.782	Link Invert to 2D	66.688
Node112	2YR	62.28	66.1	Link Invert to 2D	66.667
Node113	2YR	62.00	67.228	Link Invert to 2D	65.639
Node114	2YR	61.00	68	Link Invert to 2D	61
Node115	2YR	64.29	67.849	Link Invert to 2D	66.948

Detailed Hydraulic Calculations Proposed - Nodes - 100-Year					
Name	Scenario	Invert Elevation ft	Ground Elevation (Spill Crest) ft	Ponding Type	Max Water Elevation ft
Node116	2YR	63.62	66.808	Link Invert to 2D	66.949

APPENDIX E

HARRIS COUNTY

Project Scoping & Cost Estimating Development Tool

Castlewood Addition, Sections 3 and 4

PROJECT NAME

TWO

PRECINCT

Areas highlighted are to be completed by Consultant

PREPARER INFORMATION		PROJECT INFORMATION	
1. DATE SUBMITTED:	10/7/19	4. PROJECT TYPE:	Drainage
2. SUBMITTED BY:	Ali Keyvani	5. PROJECT TITLE:	Castlewood Addition Sections 3 and 4
3. NAME OF FIRM:	CivilTech Engineering, Inc.		

6. ESTIMATED FUNDING (Item 6 to be prepared by Harris County):		
A. CDBG-DR:		** Specify MUD or Other Funding Sources:*
B. OTHER FEDERAL:*		
C. STATE:		
D. COUNTY:		
E. MUD:*		
F. OTHER:*		
ESTIMATED TOTAL:	$ 0.00	

7. NO ACTION ASSESSMENT: Briefly describe the impact of taking no action to repair the damaged facilities.

Subdivision drainage within the roadside ditch network will not meet the Harris County Engineering Department requirements for the 50% AEP (design) storm event and flooding will occur.

DESCRIPTION OF THE NEED(S) ADDRESSED IN THIS DOCUMENT

Provide full and complete answers to each of the following. Descriptions should include the cause of the damage, current condition of the facility, and a detailed description of the project that coincides with the information contained in both Table 1 and 2. All activities must have documented proof of an impact by the floods and storms. CDBG-DR funds must be used for disaster-related expenses in the most impacted and distressed areas.

1. ***Describe the specific flood and storm-related condition that directly caused the damage(s).***

   Hurricane Harvey resulted in flooding of almost the entire subdivision. However, the existing roadside ditches are inadequate even in lesser storm events.

2. ***Describe the system that was damaged and how it was damaged.***

   The system of roadside ditches and culverts have been silted and vegetated over an extended period of time. As a result, full flow capacity is being hindered in the existing system.

3. ***How does the project support housing?***

   The proposed project will replace ditches and culverts with a storm sewer system and lower the roadways, allowing conveyance to travel along the streets and not through property.

4. ***Describe the impacts on the community that resulted in direct damage(s).***

   Hurricane Harvey resulted, in some cases, in over 3 feet of flood damage to homes within the subdivision.

5. ***Describe how the proposed activities will address damage(s) of the system affected by the floods and storms.***

   The proposed project will be able to handle regular storm events more efficiently than the existing system.

6. ***List materials submitted as documentation of the flood and storm-related condition.***

7. ***Describe the proposed project.***

   The project will involve replacing the existing roadside ditch drainage system with an underground storm sewer system. Elevations of the streets will be below the elevation of the lots.

PROJECT SUMMARY

The Project Summary consists of 4 parts **for each target area and/or activity**: **(1)** Summarize Problem(s); **(2)** Location and Acquisition; **(3)** Detailed Actions to Address Problems; and **(4)** Disclosure on Non-CDBG-DR Funds.

PART 1 – Summarize the problem(s) to be addressed within the application by Target Area.

Replace the drainage ditches and culverts with a storm sewer system to allow an alternate route for conveyance.

PART 2 – Identify the location of each activity/Target Area and any associated acquisition activity.
The spelling and capitalization of the Target Area name(s) listed here must match Table 1 (e.g., "Green Acres" should not appear elsewhere as "green acres subdivision."

Project Title / Target Area:	Castlewood Addition Sections 3 and 4				
Activity:	Flood and Drainage Facilities				
On:	Castlewood Subdivision	**From:**	Lauder Rd	**To:**	Ladin Rd

- OR -

Provide a brief description of the location of the activity / Target Area.

- OR -

Provide physical address if possible.

Latitude:	29°-54'-46" N	**Longitude:**	95°-20'-42" N

	Included:	
Please attached project area map (11 x 17)	Yes: ☑	No: ☐
Please attach existing drainage area map (11x17)	Yes: ☑	No: ☐
Please attach proposed drainage area map (11x17)	Yes: ☑	No: ☐
Please attach "Sketch Plans", illustrations or annotated drawings communicating the scope of the recommended improvements	Yes: ☑	No: ☐
Please attach scope of services for final design of the improvements	Yes: ☑	No: ☐
Please attach photographs of problems found, annotated on an area map exhibit or in an appendix	Yes: ☑	No: ☐
	Acquisition Required:	
Will acquisition associated with the project site(s) be required?	Yes: ☑	No: ☐

PART 3 – Identify the action(s) to resolve the problem(s) and their anticipated outcomes. *Include details such as specific materials and quantities.*

Replacing the existing roadside ditch drainage system with an underground storm sewer system will allow for more efficient drainage in regular storm events.

Ali Keyvani, PhD., PE	Senior Project Engineer	(281) 304-0200
Name of Preparer (Printed)	**Position / Title**	**Phone Number**

Signature of Preparer	**Email Address**

PROJECT SCHEDULE

Enter the projected length (in number of months) for each applicable phase / process step below. If a phase is not applicable, enter "0" in the field. *Note: Most projects should be completed in 24 months once the associated contract for the project is executed between the Applicant and the Texas General Land Office.*

PROFESSIONAL PROCUREMENT		Months
ENVIRONMENTAL REVIEW		Months
ACQUISITION		Months
ENGINEERING DESIGN	6	Months
CONSTRUCTION	18	Months
COMPLETE CLOSEOUT		Months
EXTENDED ACTIVITY		Months

ANTICIPATED COMPLETION	24 Months

If the proposed project schedule exceeds 24 months, a justification must be provided in the space below.

BENEFICIARY INFORMATION

Does the proposed project serve Low /Moderate Income beneficiaries? Yes: ☑ No: ☐

If answer above is no, provide the following information:

	Included	
Shape file of benefited area	Yes: ☐	No: ☐
Digital Elevation Model for the current condition	Yes: ☐	No: ☐
Digital Elevation Model for the proposed condition(s)	Yes: ☐	No: ☐

TABLE 1 - BUDGET

Project Title/Target Area: Castlewood Addition Sections 3 and 4

Construction Completion Type: Contract

Activity Description 5. Flood and Drainage Facilities

Probable Construction Cost: $ 8,704,172

Estimated Engineering Cost: $ 1,740,835

Estimated Acquisition Cost: $ 1,468,860

Total: $ 14,002,867

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Tall Pines Addition Subdivision

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
				COLUMN TOTALS	$ 0	$ 0	$ 0

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

- See Attached Estimate

2. Identify and explain any/all special engineering activities.

Signature of Registered Engineer / Architect Responsible for Budget Justification

10/7/19

Date

(281) 304-0200

Phone Number

(Architect / Engineer Seal)

CONSTRUCTION COST ESTIMATE

Project: Castlewood Addition Section 3 and 4
Precinct: TWO
UPIN: 19102MF17301
CivilTech Job No: 390011
Prepared By: CivilTech Engineering, Inc.
Date: 10/07/2019

Summary of Estimate		
Stage:		Drainage Study
Total Amount for Improv:		$10,445,005.77
Contingencies:	20%	$2,089,001.15
Land Acquisition:		$1,468,860.00
Grand Total:		$14,002,866.92

Engineering Probable Opinion of Construction Costs
Castlewood Addition Subdivision (October 7, 2019)
Recommended Alternative

Item NO.	Description	Unit	Quantity	Unit Price	Amount
	GENERAL				
1	Mobilization	LS	1	$10,000.00	$10,000.00
2	Excavation	CY	3381	$10.00	$33,810.00
3	Remove/Dispose 15-inch RCP Concrete Culvert	LF	71	$10.00	$705.70
4	Remove/Dispose 18-inch RCP Concrete Culvert	LF	5118	$11.00	$56,296.36
5	Remove/Dispose 24-inch RCP Concrete Culvert	LF	1870	$15.00	$28,043.04
6	Remove/Dispose 30-inch RCP Concrete Culvert	LF	433	$18.00	$7,793.42
7	Remove/Dispose 36-inch RCP Concrete Culvert	LF	726	$20.00	$14,525.46
8	Remove/Dispose Asphalt Surface with or without base, any thickness	SY	35149	$7.50	$263,617.50
				SUBTOTAL GENERAL	**$414,791.47**
	PAVING				
1	Concrete Driveways including Excavation 6-inch thick	SF	33075	$8.00	$264,600.00
2	Reinforced concrete pavement 8-in thick	SY	35149	$70.00	$2,460,430.00
3	Curb	LF	24200	$10.00	$242,000.00
4	Sidewalk	SF	121000	$7.00	$847,000.00
5	Lime treatment subgrade	SY	40000	$4.00	$160,000.00
6	Cut	CY	8550	$7.00	$59,850.00
7	Fill	CY	35550	$10.00	$355,500.00
				SUBTOTAL PAVING	**$4,389,380.00**
	STORM AND MITIGATION				
1	24-inch diameter RCP storm sewer by open cut, to include Reinforced Concrete collar tie	LF	4600	$100.00	$460,000.00
2	30-inch diameter RCP storm sewer by open cut, to include Reinforced Concrete collar tie	LF	2200	$115.00	$253,000.00
3	36-inch diameter RCP storm sewer by open cut, to include Reinforced Concrete collar tie	LF	2450	$120.00	$294,000.00
4	42-inch diameter RCP storm sewer by open cut, to include Reinforced Concrete collar tie	LF	1000	$125.00	$125,000.00
5	48-inch diameter RCP storm sewer by open cut, to include Reinforced Concrete collar tie	LF	600	$180.00	$108,000.00
6	6x5-ft RCB by open cut	LF	2600	$450.00	$1,170,000.00
7	Type BB Inlet	EA	60	$5,000.00	$300,000.00
8	Manhole	EA	45	$4,000.00	$180,000.00
9	Storm Water Pollution Prevention Plan	LS	1	$10,000.00	$10,000.00
10	Detention Pond	AC-FT	40	$25,000.00	$1,000,000.00
				SUBTOTAL STORM	**$3,900,000.00**
	SUBTOTAL				**$8,704,171.47**
	ENGINEERING SERVICES				**$1,740,834.29**
	20% CONTINGENCY				**$2,089,001.15**
	TOTAL CONTRUCTION COSTS				**$12,534,006.92**
	LAND ACQUISITION	SF	244810	$6.00	**$1,468,860.00**
	GRAND TOTAL				**$14,002,866.92**

PRELIMINARY DRAINAGE IMPROVEMENTS
FOR
Fountainview Subdivision Sections 1 & 2
~~CITY OF HOUSTON~~, TEXAS

Harris County

CobbFendley Project No. 1812-030

HARRIS COUNTY ENGINEERING DEPARTMENT

STATE OF TEXAS
CARL E. AHRENDT
93576
LICENSED
PROFESSIONAL ENGINEER

2/6/19

February 2019

Submitted By:

CobbFendley

Texas Registration No. 274

Civil Engineering • Construction Management • GIS/CADD • Land Development • Land Surveying
Municipal • Right-of-Way • Site Development • Subsurface Utility Engineering
Hydraulics/Hydrology • Telecommunications • Transportation • Utility Coordination

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Table of Contents

Executive Summary

Harris County Engineering ~~District~~ Department (HCED) contracted with Cobb, Fendley & Associates, Inc. (UPIN 19101MF12F01) to provide Preliminary Engineering Services in the study phase of the project by performing a preliminary drainage study and propose drainage and infrastructure improvements in the Fountainview Subdivision, Sections 1 & 2, located in Harris County Precinct 1. The project study area is bound by Harris County Flood Control District (HCFCD) Unit# P133-00-00 on the north, Aldine Bender Road on the south, HCFCD Unit# P133-04-00 on the west, and HCFCD Unit# P133-03-00 on the east. The majority of the study area is residential, comprised of single family homes with concrete sidewalks and a curb and gutter storm sewer system.

There are nine individual storm sewer systems within the neighborhood that outfall to the channels which border the project area on the west and east sides. Each system is fairly short and generally made up of two leads to a single trunk line. An evaluation of the existing storm sewer system showed that the existing storm sewer pipes do not meet current County criteria due to insufficient capacity to convey the 2-year storm event or have a diameter less than the specified minimum diameter size of 24-inches. The storm sewer trunk lines range in size from 18-inch to 24-inch RCP. The inlets are primarily B inlets and are generally located at the cul de sacs of each road. In addition to the undersized storm sewer within the neighborhood, it was also determined that the receiving channels restrict the study area's ability to drain. During the 100-year storm event, flow from P133-00-00 backs up into the two tributary channels, P133-03-00 and P133-04-00. These tributary channels then cause the storm sewer system within the subdivision to fill up resulting in ponding within the neighborhood until water surface elevations in the channels recede and allow the neighborhood to drain.

Two proposed condition alternatives were investigated for improvements to the study area. Each alternative includes upsizing the existing storm sewer to meet the minimum County criteria and convey runoff resulting from a 2-year storm rainfall event. Alternative 1 includes rerouting all storm sewer systems to the east tributary to alleviate flow on the upstream end of the receiving channel, P133-00-00. Alternative 2 maintains the existing storm sewer layout. The proposed pavement in the study area would remain the same width as the existing pavement in both alternatives, resulting in no change of impervious cover.

Mitigation is required due to the increase in conveyance to the receiving streams. The quantity for necessary detention was calculated using 0.2 ac-ft/acre of benefited area. The total benefitted area is 50.87 acres and therefore, the required detention volume was calculated to be 10.17 ac-ft. This volume could be obtained by utilizing the undeveloped property on the northern boundary of the subdivision for a detention pond. The recommended alternative is Alternative 2, which will cost approximately $1,439,298.83. However, since P133-00-00 currently backflows in to the neighborhood, improvements to the storm sewer are not recommended to be constructed until after P133-00-00 is improved.

A. Study Area Location and Description

Harris County Engineering ~~District~~ Department (HCED) contracted with Cobb, Fendley & Associates, Inc. (UPIN 19101MF12F01) to provide Preliminary Engineering Services in the study phase of the project by performing a preliminary drainage study and propose drainage and infrastructure improvements in the Fountainview Subdivision, Sections 1 & 2, located in Harris County Precinct 1, see Exhibit 1 – Vicinity Map. The project study area is bound by Harris County Flood Control District (HCFCD) Unit# P133-00-00 on the north, Aldine Bender Road on the south, HCFCD Unit# P133-04-00 on the west, and HCFCD Unit# P133-03-00 on the east, see Exhibit 2 – Project Location.

The majority of the study area is residential, comprised of single family homes with concrete sidewalks and a curb and gutter storm sewer system. The neighborhood was constructed in the 1970's and is not a part of a Municipal Utility District. There is a wastewater treatment facility and a water facility north of the neighborhood that potentially services the Fountainview Subdivision; however, additional information would be required to confirm this. The remainder of the study area is undeveloped land.

B. Scope of Work

The purpose of this study is to review and evaluate the present-day condition of the drainage system servicing the project area to identify problems and areas of concern. Specific tasks include:

- Site visit
- Determine overland sheetflow parameters
- Identify outfall locations
- Determine drainage area boundaries
- Perform hydrologic calculations for the existing condition
- Perform an existing condition storm sewer capacity analysis
- Identify locations of the existing drainage system in which improvements can be made
- Provide possible alternative solutions to upgrade the drainage systems within the project location to meet current County criteria and also to mitigate impacts resulting from increased conveyance capacity

C. Methodology

A drainage map was created utilizing the City of Houston (City) 2008 LiDAR and GIS shapefile database, and hydrologic calculations were performed using land use "C" values and the equation for Time of Concentration (Eq. 1 – next page) found in the City of Houston Infrastructure Design Manual (July 2015). A "C" value of 0.55 was used for the entire project area to represent the land use of residential lots less than ¼ acre.

Eq. 1 $$TC = 10A^{0.1761}+15$$

Where:
TC = Time of concentration (minutes)
A = drainage area (acres)

The existing drainage system was evaluated based upon whether it was appropriately sized based upon current County criteria and its ability to convey the calculated runoff resulting from the 2-year storm rainfall event when utilizing top of pipe as the boundary condition for tailwater within the HouStorm hydraulic computational model.

D. Existing Condition

1. Hydrology

The project area is located within the P133A Subbasin of the Greens Bayou Watershed and is not located within the identified Effective FEMA 100-year floodplain, see Exhibit 3 – FEMA Effective Floodplain Map. It should be noted that the project is not located within the 100-year floodplain only because the FEMA Effective HEC Model for P133-00-00 terminates just downstream of the IH69 bridge crossing.

Existing Condition Drainage areas were delineated using 2008 LiDAR, 2018 Google Earth imagery, and observations from a site visit, see Exhibit 4 – Drainage Area Map. The rational method was used to determine peak flows from each drainage area, according to the City of Houston Infrastructure Design Manual (July 2015). The time of concentration formula mentioned in Section C of this report was used to calculate time of concentration for each drainage area in order to determine the rainfall intensity. Table 1 on the next page shows the existing condition hydrologic calculations for each drainage area.

Table 1 Existing Condition Hydrologic Calculations

Drainage Area Name	Area	Tc	C	I2, in/hr	I100, in/hr	Q2, cfs	Q100, cfs
A	2.44	26.70	0.55	3.31	6.82	4.43	9.15
B	4.03	27.78	0.55	3.24	6.71	7.18	14.89
C	2.50	26.75	0.55	3.30	6.82	4.53	9.36
D01	4.01	27.77	0.55	3.24	6.71	7.14	14.80
D02	4.04	27.79	0.55	3.24	6.71	7.19	14.91
E	2.49	26.75	0.55	3.30	6.82	4.53	9.35
F	13.27	30.77	0.55	3.06	6.42	22.37	46.88
G	2.32	26.60	0.55	3.31	6.83	4.23	8.73
H01	2.64	26.86	0.55	3.30	6.81	4.78	9.86
H02	2.30	26.58	0.55	3.31	6.84	4.19	8.65
J	3.99	27.76	0.55	3.24	6.71	7.10	14.72
Channel	4.53	28.05	0.55	3.22	6.68	8.02	16.64
Offsite	2.33	26.61	0.55	3.31	6.83	4.25	8.77

2. Hydraulics

The existing drainage system servicing the project location is comprised of concrete curb and gutter streets with inlets and underground storm sewer pipes within the neighborhood. There are nine individual storm sewer systems within the neighborhood that outfall to the channels that border the project location on both the east and west sides of the neighborhood, see Exhibit 5 – Existing Storm Sewer Map. Each system is fairly short and generally made up of two leads to a single trunk line.

The existing storm sewer pipes were determined to have insufficient conveyance capacity to convey the 2-year storm event or do not meet the minimum diameter (24-inches) requirement as directed by County Criteria. The storm sewer trunk lines range in size from 18-inch to 24-inch RCP. The inlets are primarily B inlets and are generally located at the cul de sacs, near the end of each road. Survey data and storm sewer flowline information were provided for this study area for the existing storm sewer system and was utilized when modeling the existing system in HouStorm.

It was unclear how the storm sewer from McCracken Road (System D) reached the outfall channel. CobbFendley assumed the storm sewer flows east along McCracken Road and outfalls to P133-03-00 underneath the McCracken Road bridge through a 24 inch RCP, based on the available survey data. The HouStorm analysis indicated that much of the storm sewer systems within the neighborhood are undersized and was unable to fully convey rainfall runoff associated with the the 2-year rainfall event.

HouStorm results for the existing condition and proposed alternatives can be found in Appendix A and Appendix B, respectively.

In addition to the undersized storm sewer within the neighborhood, it was also determined that the receiving channels limit the study area's ability to drain. A model of the neighborhood's existing storm sewer, the east and west channels, and the receiving channel was run to determine if the flow from P133-00-00 was negatively impacting the subdivision. It was determined that during the 2- and 100-year storm events, flow from P133-00-00 causes significant ponding in the surrounding area. The subdivision streets are at a lower elevation than the channel banks and therefore water from the neighborhood and the undeveloped land north of the subdivision pond in the streets of the subdivision. During the 100-year storm event, flow from P133-00-00 backs up into the east and west channels, P133-03-00 and P133-04-00, causing them to lose capacity for flow coming from the neighborhood. Consequently, these channels then cause the storm sewer system within the subdivision to fill up and causes ponding within the neighborhood streets. Exhibits 6 and 7 show the resulting ponding in the project area due to the 2- and 100-year storm events, respectively.

The east and west channels independently have enough capacity (P133-03-00 = 357 cfs and P133-04-00 = 1692 cfs), to properly convey flow from the neighborhood (approximately 86.57 cfs to P133-03-00 and 74.75 cfs to P133-04-00). These channel capacities were calculated using Manning's Equation. Table 2 below shows the calculations for the ditch capacity. The slopes of the ditch were taken from 2008 LiDAR data. Survey data will be needed to more accurately calculate the capacity of this ditch.

Table 2 –Ditch Capacity Calculations

	P133-03-00	P133-04-00
Slope, ft/ft	0.0059	0.0029
Cross Sectional Area, s.f.	280.23	95.09
Hydraulic Radius,	3.07	2.56
Capacity, cfs	1692	357

E. Proposed Alternatives

1. Alternative 1

Alternative 1 includes removing and replacing the existing storm sewer networks with a new system capable of conveying the 2-year storm event. The storm sewer systems on the west side of the subdivision would be rerouted to drain east towards P133-03-00 and converting approximately 3 acres of the undeveloped land just to the north of the subdivision into a 10.17 ac-ft pond. The proposed pond will help mitigate increased flow from the neighborhood. The detention storage volume required to mitigate the increase in conveyance capacity to P133-00-00 was calculated using 0.2 ac-ft/acre of benefitted area for the 50.87 acres within the project area. As part of this proposed drainage system design, the existing storm sewer outfalls on the west side of the subdivision will be abandoned, see Exhibit 8 – Alternative 1.

The cost to replace the storm sewer, associated pavement, and detention pond construction for Alternative 1 is $3,129,386, shown in Table 3. A complete cost breakdown can be seen in Table 4 – Alternative 1 Detailed Cost.

2. Alternative 2

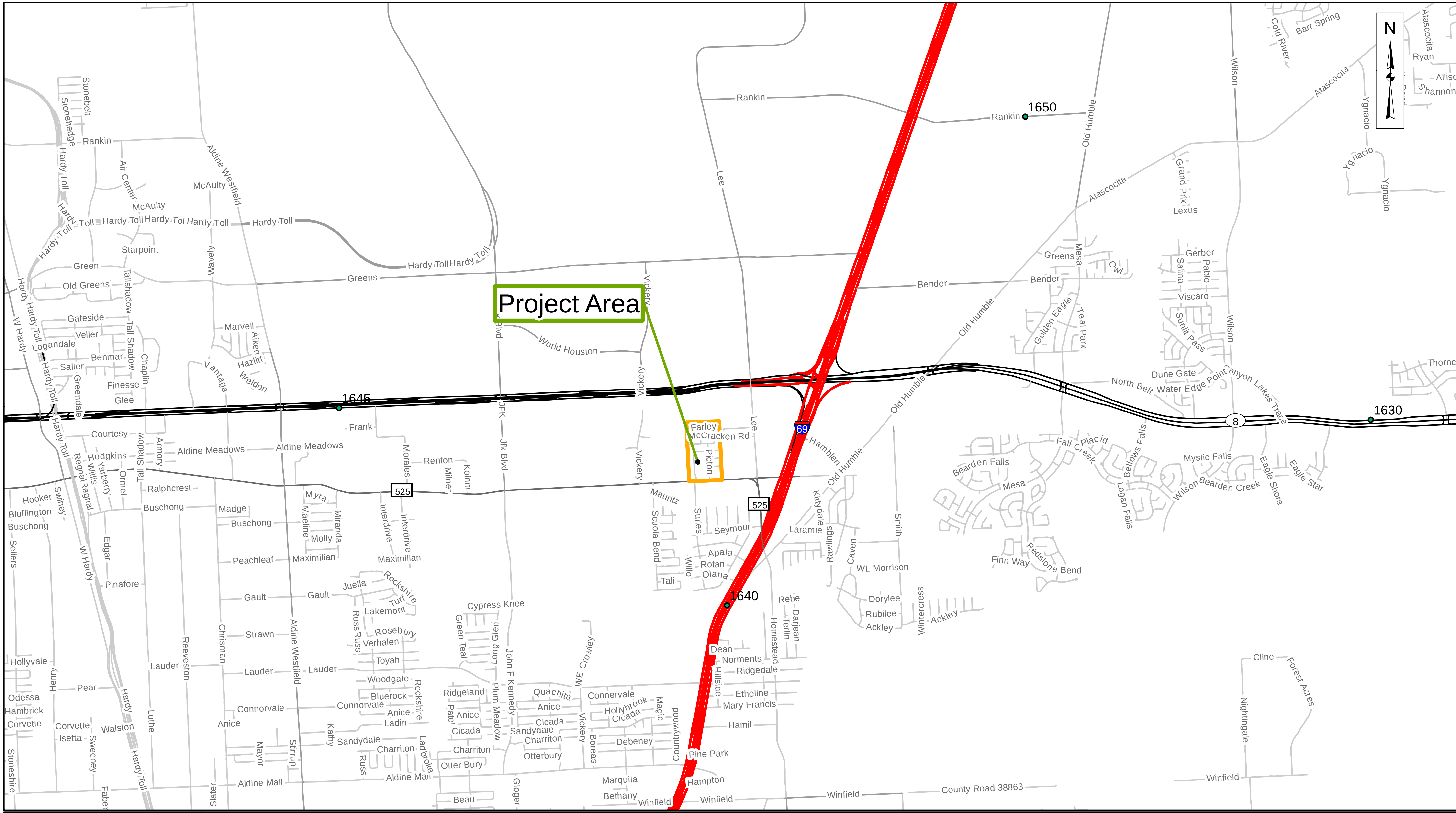
Alternative 2 includes replacing the existing storm sewer systems with a new storm sewer system capable of conveying the 2-year rainfall event without modifying the current storm sewer layout. Approximately 3 acres of the undeveloped land just to the north of the subdivision will be converted into a 10.17 ac-ft pond. The proposed pond will be utilized to mitigate increased flow from the neighborhood. Similarly, to Alternative 1, this detention rate was calculated using 0.2 ac-ft/acre of benefitted area for the 50.87 acres within the project area, see Exhibit 9 – Alternative 2.

The cost to replace the storm sewer, associated pavement, and detention pond construction for Alternative 2 is $2,206,966, shown in Table 5. A complete cost breakdown can be seen in Table 6 – Alternative 2 Detailed Cost.

F. Conclusions

After analyzing all of the data collected, we have the following conclusions

- The majority of the existing storm sewer does not have capacity to convey runoff during a 2-year rainfall event
- The receiving channels that flow south to north on either side of the subdivision have adequate capacity to convey flow from the neighborhood flow but backflow from P133-00-00 prevents the system from functioning properly.
- The presented alternatives recommend upsizing existing storm sewer to convey the 2-year storm event, incorporating a detention pond to mitigate increases in flow prior to outfalling into P133-00-00; therefore, Alternative 2 was selected as the recommended alternative and has the lowest cost to replace the existing drainage system and maintains the current storm sewer layout.
- It should be noted that although the recommended Alternative (Alternative 2) meets the County drainage criteria and provides detention storage volume to mitigate flow increases the flooding problem within the neighborhood will not be resolved until improvements are made to P133-00-00 which result in reduced water surface elevations allowing P133-03-00 and P133-04-00 to convey flow properly.



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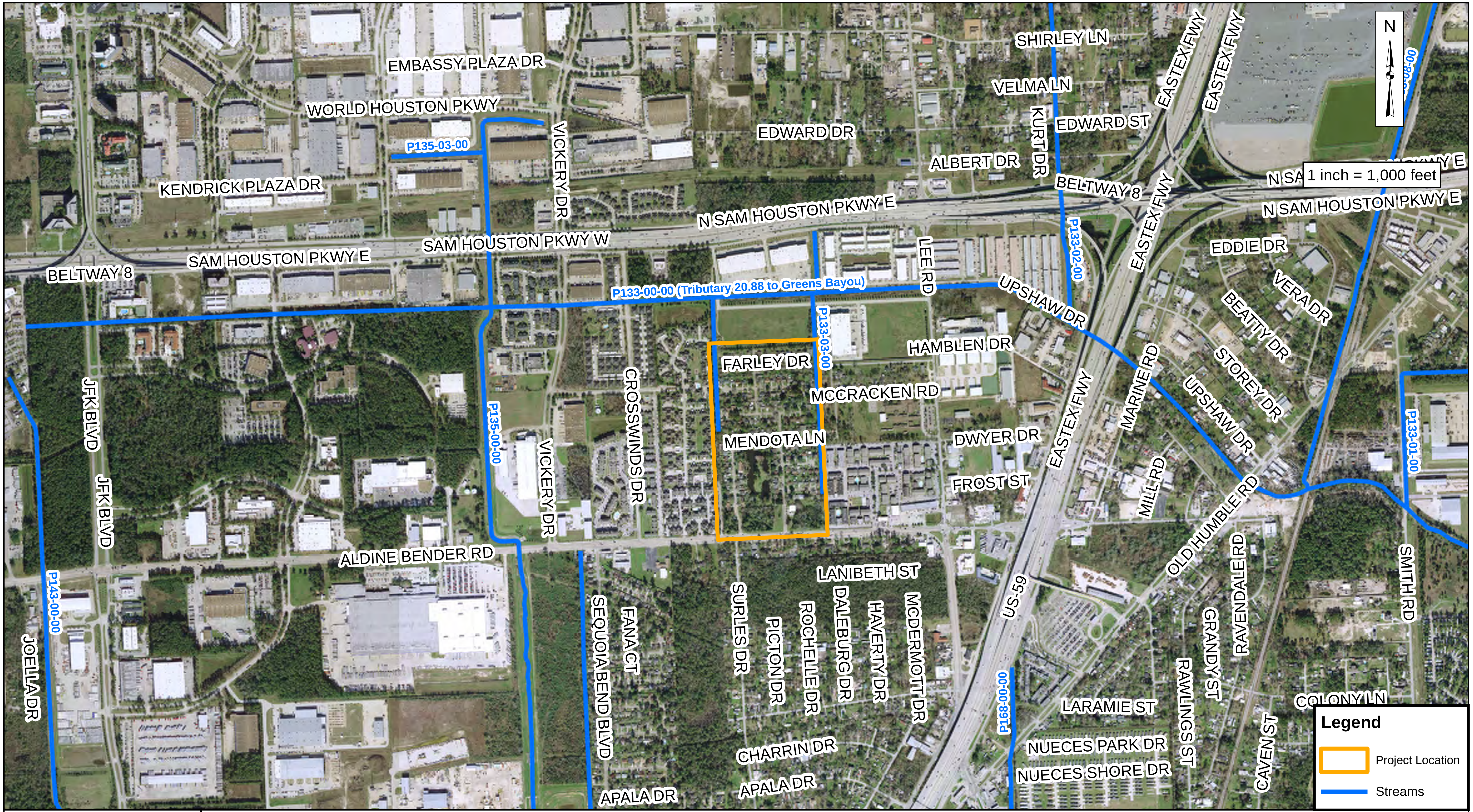
Fountainview Subdivision Drainage Improvements
Vicinity Map

Date: January 2019	EXHIBIT 1



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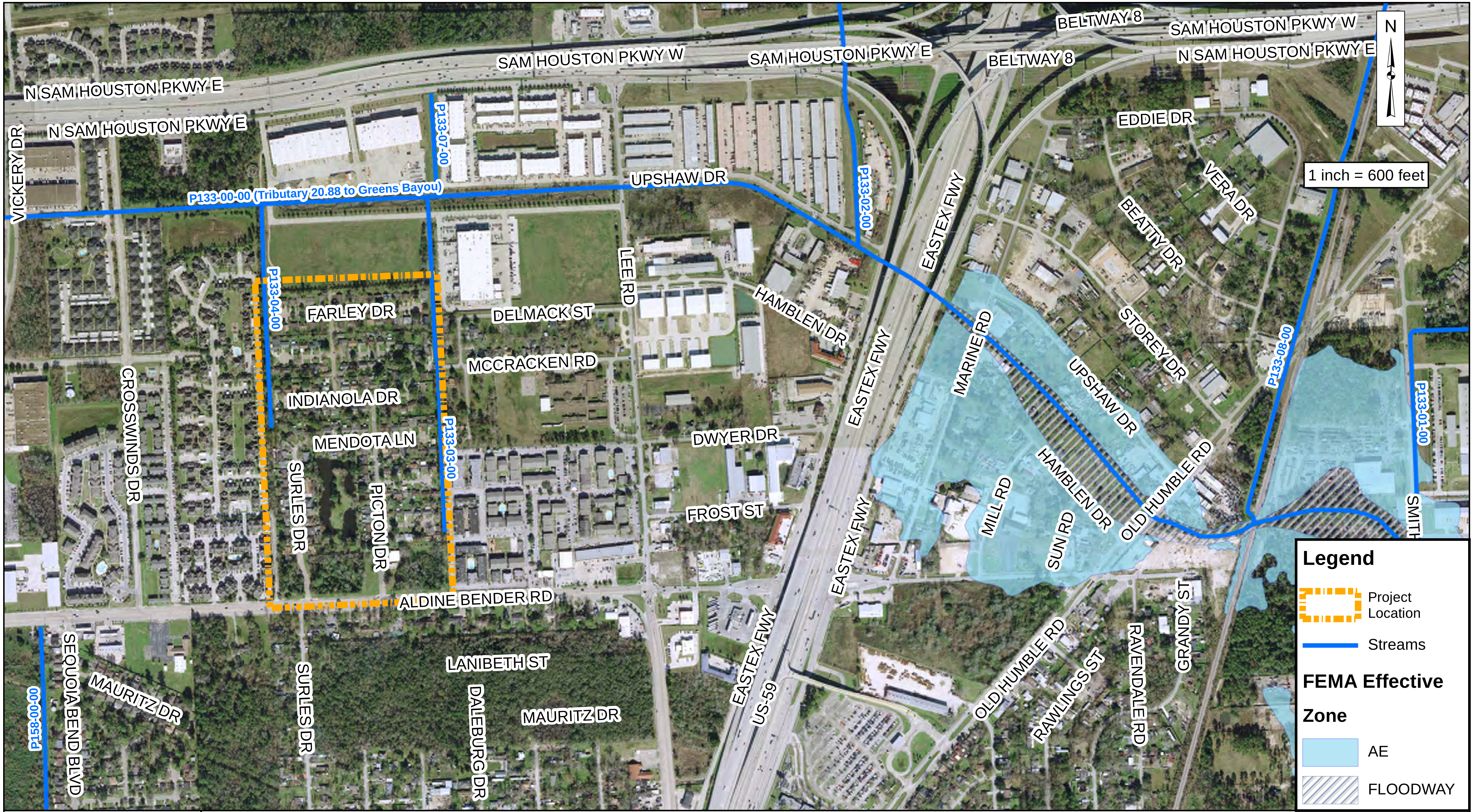
Fountainview Subdivision Drainage Improvements
Project Location Map

Date: January 2019

EXHIBIT 2



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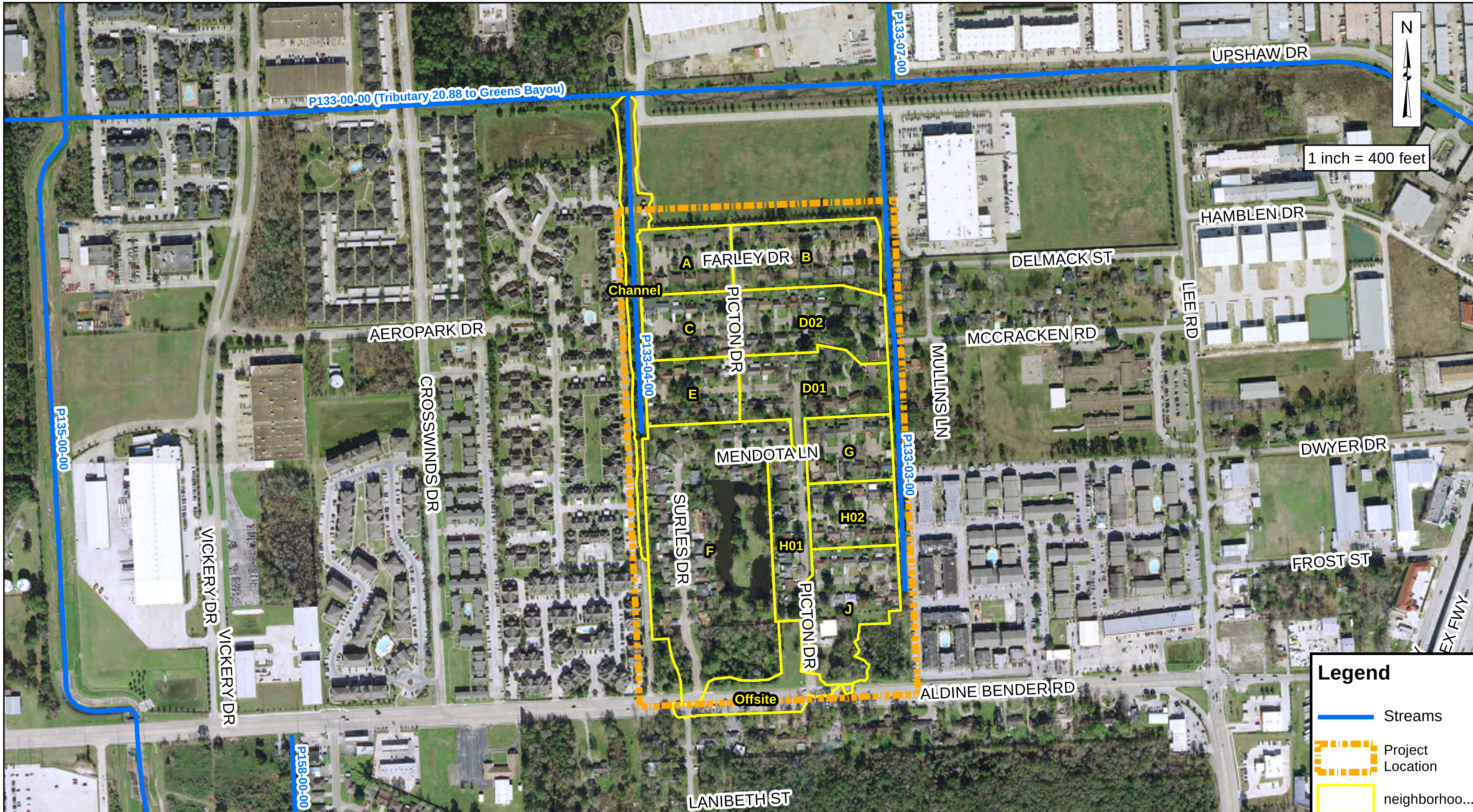
Fountainview Subdivision Drainage Improvements
FEMA Effective Floodplain

Date: January 2019	EXHIBIT 3



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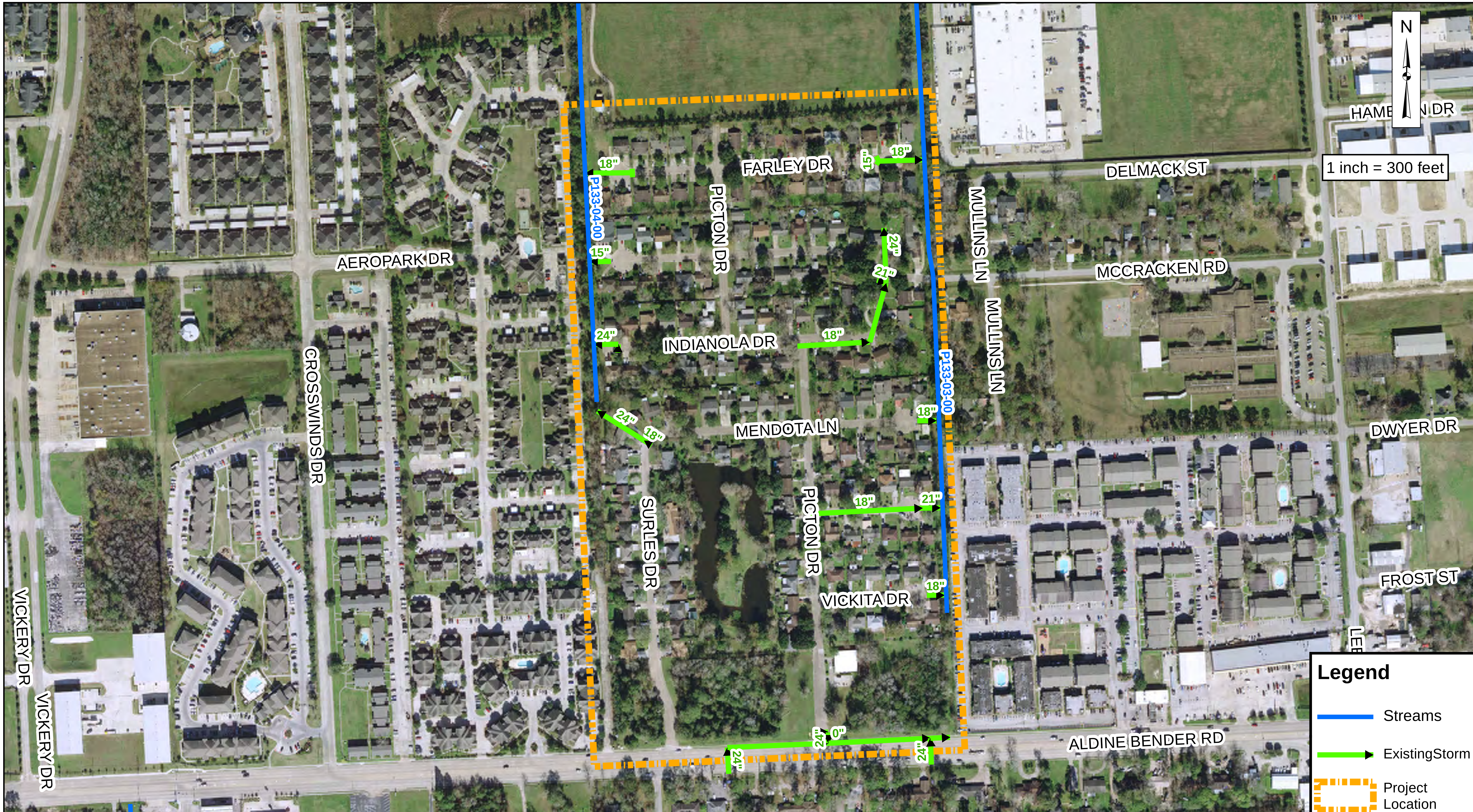
Fountainview Subdivision Drainage Improvements
Drainage Area Map

Date: January 2019	EXHIBIT 4



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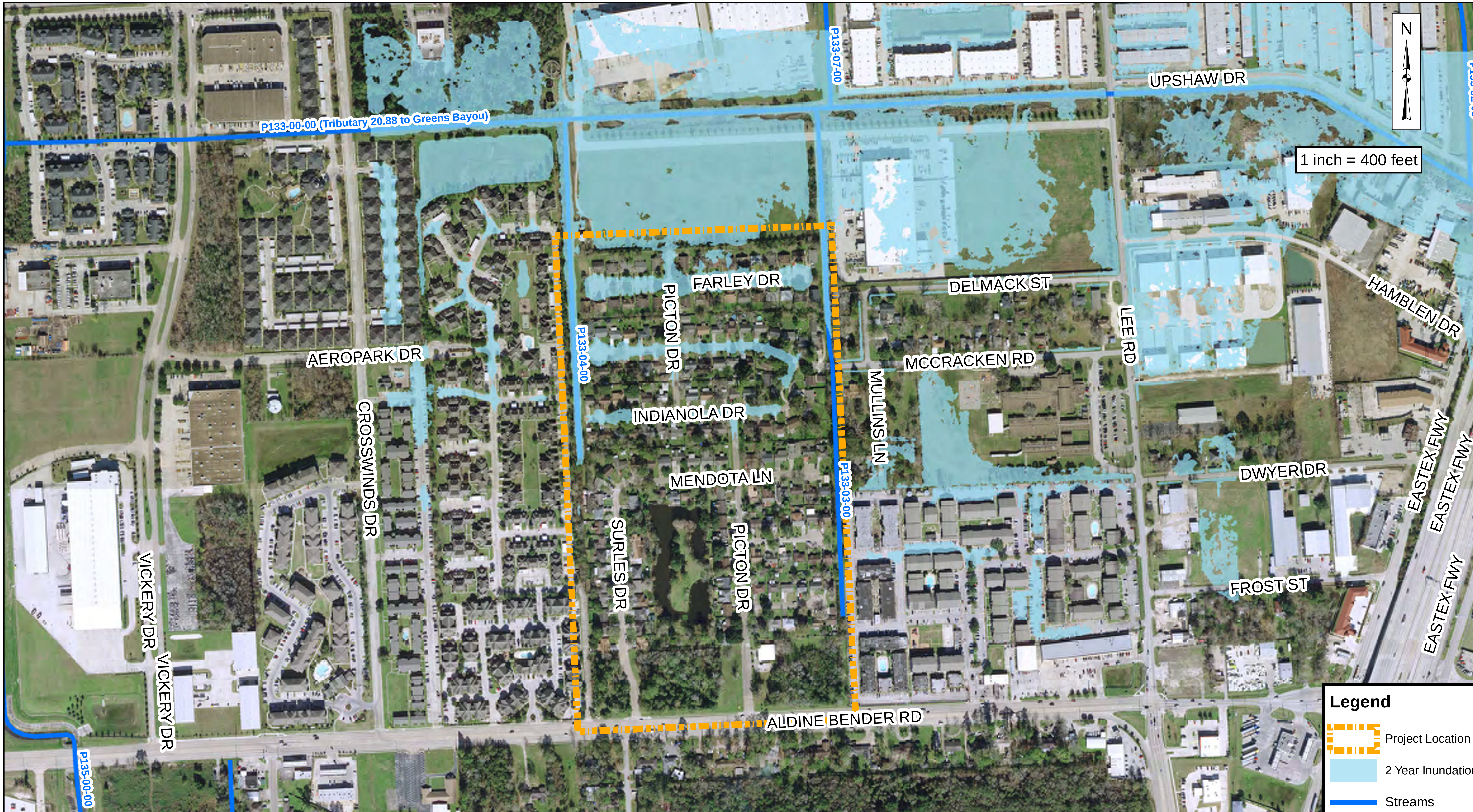
Fountainview Subdivision Drainage Improvements
Existing Storm Sewer Map

Date: January 2019	EXHIBIT 5



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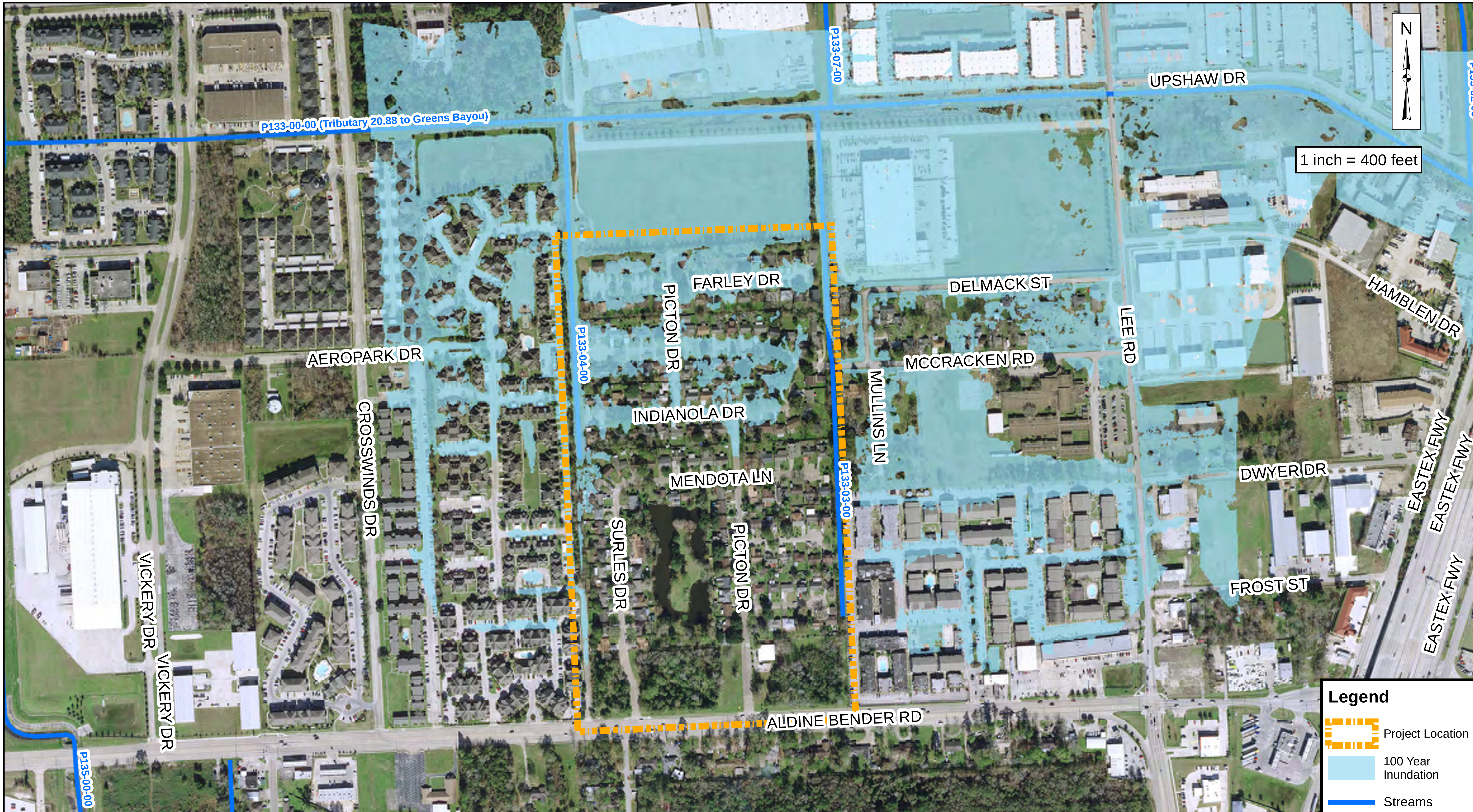
Fountainview Subdivision Drainage Improvements
Existing 2 Year Inundation Map

Date: January 2019	EXHIBIT 6



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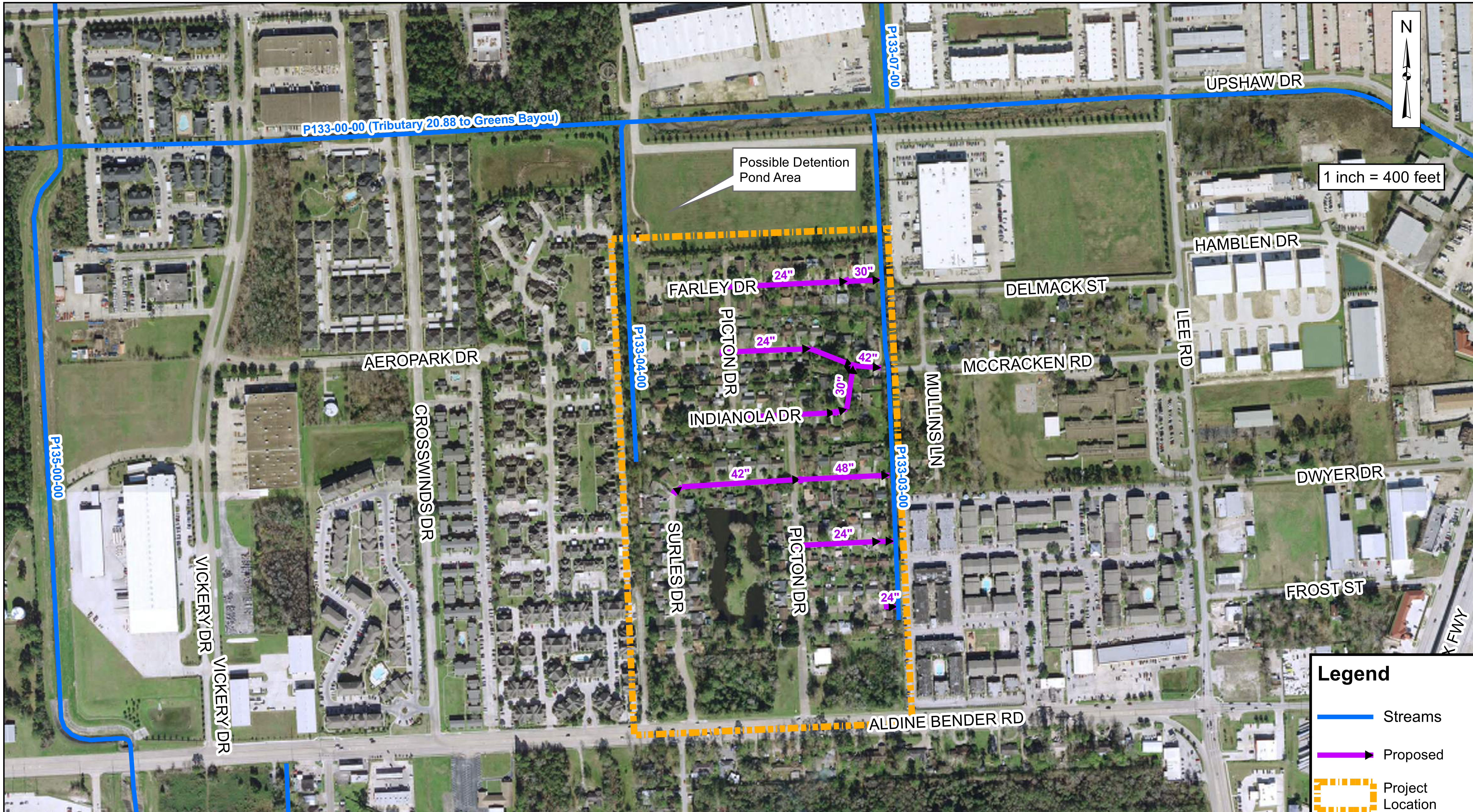
Fountainview Subdivision Drainage Improvements
Existing 100 Year Inundation Map

Date: January 2019	EXHIBIT 7



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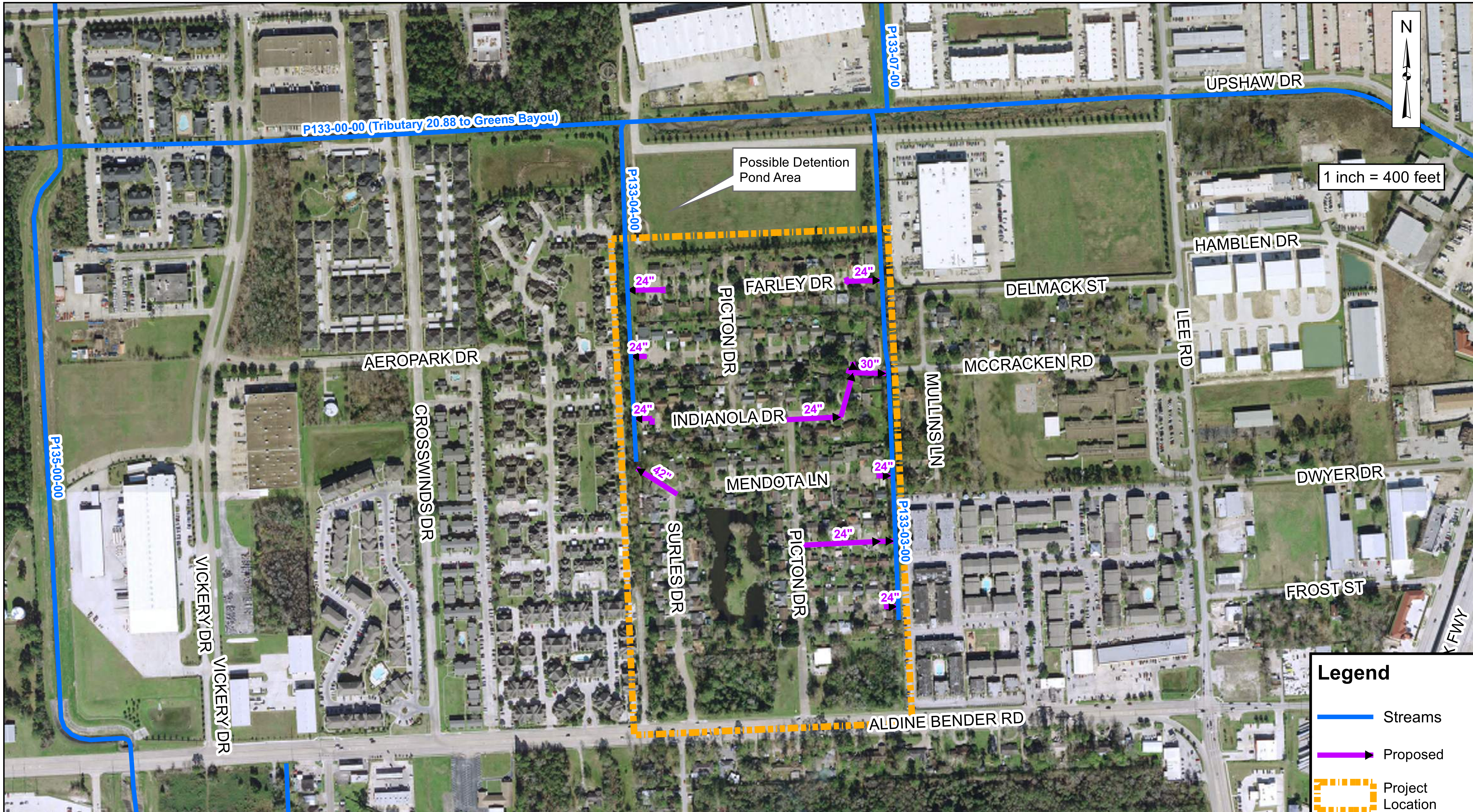
Fountainview Subdivision Drainage Improvements
Alternative 1

Date: January 2019	EXHIBIT 8



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Fountainview Subdivision Drainage Improvements
Alternative 2

Date: January 2019	EXHIBIT 9

Table 3

Pre-Engineering Services Contracts

Project Cost Estimate Breakdown (FY17 Dollars)

Alternative 1

1	**410 (Summarized based on FY 17 List of Unit Prices)**		**$**	**1,362,353.46**
	1.1	Total Unit Price, Paving Items	$	338,009.15
	1.2	Total Unit Price, Storm Sewer Items	$	1,024,344.32
	1.3	Total Unit Price, Water Items	$	-
	1.4	Total Unit Price, Wastewater Items	$	-
2	**Contingency (30% of 410)**		**$**	**408,706.04**
3	**Construction Management (15% of 410)**		**$**	**204,353.02**
4	**Engineering Fee Estimate (20% of Sum of 410 and Contingency)**		**$**	**354,211.90**
5	**Land Acquisition (Engineer's Best Estimate)**		**$**	**799,761.60**
	Total Project Cost		**$**	**3,129,386.02**

Table 4 - Alternative 1 Detailed Cost

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
PAVING				
PAVING REMOVAL ITEMS				
REMOVE AND DISPOSE OF EXISTING PAVEMENT AND CURB - ASSUMES ALL CONCRETE PAVEMENT THICKNESS WITH OR WITHOUT ASPHALT OVERLAY	SY	5,290	$ 6.00	$ 31,742.73
REMOVE AND DISPOSE OF EXISTING DRIVEWAYS AND SIDEWALKS	SY	1,767	$ 5.00	$ 8,833.34
PAVING ITEMS				
6" REINFORCED CONCRETE PAVEMENT (COMPLETE IN PLACE)	SY	5,290	$ 40.00	$ 211,618.20
LIME STABILIZED SUBGRADE, 6" THICK	SY	5,290	$ 3.00	$ 15,871.37
LIME (6%, 7% BY WEIGHT)	TON	65.47	$ 160.00	$ 10,475.10
6" CONCRETE CURB	LF	3,527	$ 4.00	$ 14,107.88
PAVING SUB-TOTAL				$ 292,648.61
ADD 5% FOR ANCILLARY ITEMS UNDER PAVING ITEMS IN 410				$ 14,632.43
SUBTOTAL FOR PAVING				$ 307,281.04
ADD 10% FOR GENERAL ITEMS UNDER PAVING ITEMS IN 410				$ 30,728.10
PAVING TOTAL				$ 338,009.15
STORM SEWER				
STORM SEWER REMOVAL ITEMS				
REMOVE STORM SEWER PIPE (ALL TYPES)	LF	1,887	$ 20.00	$ 37,745.20
REMOVE INLETS (ALL TYPES)	EA	17	$ 370.00	$ 6,290.00
REMOVE MANHOLES (ALL TYPES, ALL DEPTHS)	EA	20	$ 390.00	$ 7,800.00
STORM SEWER ITEMS				
CURB INLETS (ALL TYPES)	EA	20	$ 2,780.00	$ 55,600.00
MANHOLES (FOR 42" DIA. PIPE OR SMALLER) (ALL TYPES)	EA	19	$ 3,470.00	$ 65,930.00
MANHOLES (FOR 48" TO 72" DIA. PIPE) (ALL TYPES)	EA	1	$ 6,000.00	$ 6,000.00
24-INCH RCP	LF	2,335	$ 95.00	$ 221,787.95
30-INCH RCP	LF	377	$ 120.00	$ 45,232.80
42-INCH RCP	LF	655	$ 180.00	$ 117,941.40
48-INCH RCP	LF	375	$ 210.00	$ 78,838.20
STORM SEWER SUB-TOTAL				$ 846,565.55
ADD 10% FOR ANCILLARY ITEMS UNDER STORM SEWER ITEMS IN 410				$ 84,656.56
SUBTOTAL OF STORM SEWER				$ 931,222.11
ADD 10% FOR GENERAL ITEMS UNDER STORM SEWER ITEMS IN 410				$ 93,122.21
STORM SEWER TOTAL				$ 1,024,344.32
DETENTION				
DETENTION POND (DRY)	AC-FT	10.17	$ 20,000.00	$ 203,400.00
LAND ACQUISITION				
$6 PER SQUARE FOOT	SF	133,294	$ 6.00	$ 799,761.60

NOTES:

1. Unit Costs for Bid items related to Bridge Work, Tunneling, Wing Wall Structures, Cash Allowances etc. will be providied
2. Any significant items not included in the list shall be added by Engineer as needed.

*3. Please include the "Item Reference Number" in modified 410. The numbers serve as reference for each item and will be

Table 5

Pre-Engineering Services Contracts

Project Cost Estimate Breakdown (FY17 Dollars)

Alternative 2

1	**410 (Summarized based on FY 17 List of Unit Prices)**		**$**	**822,926.72**
	1.1	Total Unit Price, Paving Items	$	129,862.50
	1.2	Total Unit Price, Storm Sewer Items	$	693,064.22
	1.3	Total Unit Price, Water Items	$	-
	1.4	Total Unit Price, Wastewater Items	$	-
2	**Contingency (20% of 410)**		**$**	**246,878.02**
3	**Construction Management (15% of 410)**		**$**	**123,439.01**
4	**Engineering Fee Estimate (20% of Sum of 410 and Contingency)**		**$**	**213,960.95**
6	**Land Acquisition (Engineer's Best Estimate)**		**$**	**799,761.60**
	Total Project Cost		**$**	**2,206,966.29**

Table 6 - Alternative 2 Detailed Cost

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
PAVING				
PAVING REMOVAL ITEMS				
REMOVE AND DISPOSE OF EXISTING PAVEMENT AND CURB - ASSUMES ALL CONCRETE PAVEMENT THICKNESS WITH OR WITHOUT ASPHALT OVERLAY	SY	2,006	$ 6.00	$ 12,038.22
REMOVE AND DISPOSE OF EXISTING DRIVEWAYS AND SIDEWALKS	SY	960	$ 5.00	$ 4,800.00
PAVING ITEMS				
6" REINFORCED CONCRETE PAVEMENT (COMPLETE IN PLACE)	SY	2,006	$ 40.00	$ 80,254.80
LIME STABILIZED SUBGRADE, 6" THICK	SY	2,006	$ 3.00	$ 6,019.11
LIME (6%, 7% BY WEIGHT)	TON	24.83	$ 160.00	$ 3,972.61
6" CONCRETE CURB	LF	1,338	$ 4.00	$ 5,350.32
PAVING SUB-TOTAL				$ 112,435.06
ADD 5% FOR ANCILLARY ITEMS UNDER PAVING ITEMS IN 410				$ 5,621.75
SUBTOTAL FOR PAVING				$ 118,056.82
ADD 10% FOR GENERAL ITEMS UNDER PAVING ITEMS IN 410				$ 11,805.68
PAVING TOTAL				$ 129,862.50
STORM SEWER				
STORM SEWER REMOVAL ITEMS				
REMOVE STORM SEWER PIPE (ALL TYPES)	LF	1,887	$ 20.00	$ 37,745.20
REMOVE INLETS (ALL TYPES)	EA	17	$ 370.00	$ 6,290.00
REMOVE MANHOLES (ALL TYPES, ALL DEPTHS)	EA	20	$ 390.00	$ 7,800.00
STORM SEWER ITEMS				
CURB INLETS (ALL TYPES)	EA	17	$ 2,780.00	$ 47,260.00
MANHOLES (FOR 42" DIA. PIPE OR SMALLER) (ALL TYPES)	EA	20	$ 3,470.00	$ 69,400.00
24-INCH RCP	LF	1,555	$ 95.00	$ 147,699.35
30-INCH RCP	LF	139	$ 120.00	$ 16,672.80
42-INCH RCP	LF	203	$ 180.00	$ 36,513.00
STORM SEWER SUB-TOTAL				$ 572,780.35
ADD 10% FOR ANCILLARY ITEMS UNDER STORM SEWER ITEMS IN 410				$ 57,278.04
SUBTOTAL OF STORM SEWER				$ 630,058.39
ADD 10% FOR GENERAL ITEMS UNDER STORM SEWER ITEMS IN 410				$ 63,005.84
STORM SEWER TOTAL				$ 693,064.22
DETENTION				
DETENTION POND (DRY)	AC-FT	10.17	$ 20,000.00	$ 203,400.00
LAND ACQUISITION				
$6 PER SQUARE FOOT	SF	133,294	$ 6.00	$ 799,761.60

NOTES:

1. Unit Costs for Bid items related to Bridge Work, Tunneling, Wing Wall Structures, Cash Allowances etc. will be providied and
2. Any significant items not included in the list shall be added by Engineer as needed.

*3. Please include the "Item Reference Number" in modified 410. The numbers serve as reference for each item and will be

Appendix A

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 1:49:41 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : A Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\A_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.55	2.44	26.70	26.70	3.29	0.000	4.421

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	CrcMh	0.550	2.44	26.70	3.29		0.00	4.421
OUT	Outlt	0.550	2.44	26.70	3.29		0.00	4.421

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	OUT	64.22	64.04	Cir 1	0.00	1.50	149.4	0.120	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	65.80	65.54	67.72	0.176	1.50	1.50	2.50	2.50	4.4	3.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	149.38

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

===================================END===

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.54(ft)
Run# 1 Insufficient capacity.

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/7/2018 5:37:17 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : B Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\Un

DESIGN FREQUENCY : 3 Years
ANALYSYS FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 3 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-1	0.55	4.03	27.78	27.78	3.58	0.000	7.937

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-1	CrcMh	0.550	4.03	27.78	3.58		0.00	7.937
OUT	Outlt	0.550	4.03	27.78	3.58		0.00	7.937

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-1	OUT	64.60	63.76	Cir	1	0.00	1.50	140.1	0.600	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1 65.80 64.96 0.00 0.566 1.20 1.20 5.24 5.24 7.9 8.2 0.000
===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	140.05

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

===

OUTPUT FOR ANALYSYS FREQUENCY of: 2 Years
===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-1	0.55	4.03	27.78	27.78	3.23	0.000	7.152

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-1	CrcMh	0.550	4.03	27.78	3.23		0.00	7.152
OUT	Outlt	0.550	4.03	27.78	3.23		0.00	7.152

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-1	OUT	64.60	63.76	Cir 1	0.00	1.50	140.1	0.600	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	65.69	64.85	0.00	0.460	1.09	1.09	5.19	5.19	7.2	8.2	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	140.05

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

====================================END==

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 3 Years
Tailwater set to uniform depth elevation = 64.96(ft)
Critical elevation (Design) missing or invalid at node Id= B-1 Run # 1
Critical elevation (Analysis) missing or invalid at node Id= B-1 Run # 1

Runoff Frequency of: 2 Years

Tailwater set to uniform depth elevation = 64.85(ft)
Critical elevation (Design) missing or invalid at node Id= B-1 Run # 1
Critical elevation (Analysis) missing or invalid at node Id= B-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 1:52:03 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : C Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\C_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-1	0.55	2.50	26.75	26.75	3.29	0.000	4.525

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-1	CrcMh	0.550	2.50	26.75	3.29		0.00	4.525
OUT	Outlt	0.550	2.50	26.75	3.29		0.00	4.525

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-1	OUT	67.00	65.52	Cir 1	0.00	1.50	67.2	2.202	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1*	67.55	66.07	70.50	0.184	0.55	0.55	7.64	7.64	4.5	15.7	0.000

* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	67.23

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

======================================END======================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.07(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 1:53:47 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : D Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\D_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-1	0.55	4.01	27.77	27.77	3.23	0.000	7.118
D-2	0.55	4.04	27.79	27.79	3.23	0.000	7.168

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
D-1	CrcMh	0.550	4.01	27.77	3.23		0.00	7.118
D-2	CrcMh	0.550	8.05	28.56	3.18		0.00	14.077
OUT	Outlt	0.550	8.05	28.56	3.18		0.00	14.077

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	D-1	D-2	65.74	65.63	Cir	1	0.00	1.50	192.1	0.057	0.013
2	D-2	OUT	65.27	64.18	Cir	1	0.00	2.00	140.8	0.774	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
==

Run Hyd. Gr.line Crit.Elev Depth Velocity Junc
 # US DS US Fr.Slope Unif. Actual Unif. Actual Q Cap Loss
 (ft) (ft) (ft) (%) (ft) (ft) (f/s) (f/s) (cfs) (cfs) (ft)

----
1   67.77 66.51 69.24   0.455   1.50   1.50 4.03 4.03   7.1   2.5 0.000
2*   66.51 65.42 69.27   0.384   1.24   1.24 6.87 6.87   14.1   20.0 0.000
==
* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	192.12
Circular	Concrete	2.0	0.0	1	140.78

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	2
Outlet	0.0	0.0	0.0	0.0	0.0	1

=====================================END===

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.42(ft)
Run# 1 Insufficient capacity.

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:16:34 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : E Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\E_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
E-1	0.55	2.49	26.75	26.75	3.29	0.000	4.507

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
E-1	CrcMh	0.550	2.49	26.75	3.29		0.00	4.507
OUT	Outlt	0.550	2.49	26.75	3.29		0.00	4.507

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	E-1	OUT	64.88	64.86	Cir 1	0.00	2.00	77.4	0.026	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.89	66.86	68.88	0.039	2.00	2.00	1.43	1.43	4.5	3.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

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NOTE:

The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	77.36

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1	

===================================END=======================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.86(ft)
Run# 1 Insufficient capacity.

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:18:40 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : F Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\F_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F-1	0.55	13.27	30.77	30.77	3.05	0.000	22.296

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F-1	CrcMh	0.550	13.27	30.77	3.05		0.00	22.296
OUT	Outlt	0.550	13.27	30.77	3.05		0.00	22.296

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F-1	OUT	64.50	64.49	Cir	1	0.00	2.00	175.6	0.006	0.011

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	67.70	66.49	68.50	0.690	2.00	2.00	7.10	7.10	22.3	2.0	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Plastic	2.0	0.0	1	175.61

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====================================END===

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.49(ft)
Run# 1 Insufficient capacity.

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:23:27 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : G Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\G_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-1	0.55	2.32	26.60	26.60	3.30	0.000	4.211

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-1	CrcMh	0.550	2.32	26.60	3.30		0.00	4.211
OUT	Outlt	0.550	2.32	26.60	3.30		0.00	4.211

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-1	OUT	66.04	65.57	Cir 1	0.00	1.50	60.5	0.776	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1*	66.75	66.28	69.54	0.159	0.71	0.71	5.12	5.12	4.2	9.3	0.000

* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	60.53

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.28(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:27:05 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : H Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\H_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-1	0.55	2.64	26.86	26.86	3.28	0.000	4.768
H-2	0.55	2.30	26.58	26.58	3.30	0.000	4.177

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
H-1	CrcMh	0.550	2.64	26.86	3.28		0.00	4.768
H-2	CrcMh	0.550	4.94	28.99	3.15		0.00	8.572
OUT	Outlt	0.550	4.94	28.99	3.15		0.00	8.572

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	H-1	H-2	66.49	65.82	Cir 1	0.00	1.50	365.8	0.183	0.013
2	H-2	OUT	65.27	65.26	Cir 1	0.00	1.75	56.6	0.018	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
==

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1	67.83	67.17	69.99	0.204	1.34	1.35	2.87	2.84	4.8	4.5	0.000
2	67.17	67.01	69.02	0.290	1.75	1.75	3.56	3.56	8.6	2.1	0.000

==

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	365.84
Circular	Concrete	1.75	0.0	1	56.6

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet		0.0	0.0	0.0	0.0	0.0	1

====================================END====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 67.01(ft)
Run# 2 Insufficient capacity.
Run# 1 Insufficient capacity.

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:48:40 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : J Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\J_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-1	0.55	3.99	27.76	27.76	3.23	0.000	7.084

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-1	CrcMh	0.550	3.99	27.76	3.23		0.00	7.084
OUT	Outlt	0.550	3.99	27.76	3.23		0.00	7.084

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-1	OUT	67.34	67.33	Cir 1	0.00	1.50	55.3	0.018	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	69.08	68.83	70.84	0.451	1.50	1.50	4.01	4.01	7.1	1.4	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	55.31

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1	

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 68.83(ft)
Run# 1 Insufficient capacity.

Appendix B

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:06:08 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : A 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\A_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.55	2.44	26.70	26.70	3.29	0.000	4.421

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	CrcMh	0.550	2.44	26.70	3.29		0.00	4.421
OUT	Outlt	0.550	2.44	26.70	3.29		0.00	4.421

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	OUT	64.22	64.04	Cir 1	0.00	1.50	149.4	0.120	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1 65.80 65.54 67.72 0.176 1.50 1.50 2.50 2.50 4.4 3.7 0.000
===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	149.38

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

===

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.55	2.44	26.70	26.70	6.82	0.000	9.157

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	CrcMh	0.550	2.44	26.70	6.82		0.00	9.157
OUT	Outlt	0.550	2.44	26.70	6.82		0.00	9.157

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	OUT	64.22	64.04	Cir 1	0.00	1.50	149.4	0.120	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	66.67	65.54	0.00	0.753	1.50	1.50	5.18	5.18	9.2	3.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	149.38

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.54(ft)
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= A-1 Run # 1

Runoff Frequency of: 100 Years

Tailwater set to uniform depth elevation = 65.54(ft)
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= A-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:28:10 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : B 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\B_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-1	0.55	4.03	27.78	27.78	3.23	0.000	7.152

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-1	CrcMh	0.550	4.03	27.78	3.23		0.00	7.152
OUT	Outlt	0.550	4.03	27.78	3.23		0.00	7.152

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-1	OUT	64.60	63.76	Cir	1	0.00	1.50	140.1	0.600	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

1 65.69 64.85 68.10 0.460 1.09 1.09 5.19 5.19 7.2 8.2 0.000
===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	140.05

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

===

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-1	0.55	4.03	27.78	27.78	6.71	0.000	14.876

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-1	CrcMh	0.550	4.03	27.78	6.71		0.00	14.876
OUT	Outlt	0.550	4.03	27.78	6.71		0.00	14.876

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-1	OUT	64.60	63.76	Cir 1	0.00	1.50	140.1	0.600	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	68.04	65.26	0.00	1.989	1.50	1.50	8.42	8.42	14.9	8.2	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	140.05

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

==================================END==================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 64.85(ft)
Critical elevation (Analysis) missing or invalid at node Id= B-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 65.26(ft)

Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= B-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:29:36 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : C 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\C_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.
==

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-1	0.55	2.50	26.75	26.75	3.29	0.000	4.525

Cumulative Junction Discharge Computations
==

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-1	CrcMh	0.550	2.50	26.75	3.29		0.00	4.525
OUT	Outlt	0.550	2.50	26.75	3.29		0.00	4.525

Conveyance Configuration Data
===

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-1	OUT	67.00	65.52	Cir 1	0.00	1.50	67.2	2.202	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
===

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

1* 67.55 66.07 70.50 0.184 0.55 0.55 7.64 7.64 4.5 15.7 0.000

==

* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	67.23

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

==

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-1	0.55	2.50	26.75	26.75	6.82	0.000	9.375

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-1	CrcMh	0.550	2.50	26.75	6.82		0.00	9.375
OUT	Outlt	0.550	2.50	26.75	6.82		0.00	9.375

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-1	OUT	67.00	65.52	Cir 1	0.00	1.50	67.2	2.202	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1*	67.84	66.36	0.00	0.790	0.84	0.84	9.23	9.23	9.4	15.7	0.000

* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	67.23

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====================================END===

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.07(ft)

Critical elevation (Analysis) missing or invalid at node Id= C-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 66.36(ft)
Critical elevation (Analysis) missing or invalid at node Id= C-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:31:07 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : D 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\D_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-1	0.55	4.01	27.77	27.77	3.23	0.000	7.118
D-2	0.55	4.04	27.79	27.79	3.23	0.000	7.168

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
D-1	CrcMh	0.550	4.01	27.77	3.23		0.00	7.118
D-2	CrcMh	0.550	8.05	28.56	3.18		0.00	14.077
OUT	Outlt	0.550	8.05	28.56	3.18		0.00	14.077

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	D-1	D-2	65.74	65.63	Cir	1	0.00	1.50	192.1	0.057	0.013
2	D-2	OUT	65.27	64.18	Cir	1	0.00	2.00	140.8	0.774	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
==
Run Hyd. Gr.line Crit.Elev Depth Velocity Junc

```
 #   US     DS     US     Fr.Slope Unif. Actual Unif. Actual  Q      Cap  Loss
    (ft)  (ft)   (ft)    (%)     (ft)  (ft)  (f/s) (f/s)  (cfs)   (cfs) (ft)
--------------------------------------------------------------------------------
1   67.77  66.51  69.24   0.455   1.50   1.50  4.03  4.03    7.1    2.5 0.000
2*   66.51  65.42  69.27   0.384   1.24   1.24  6.87  6.87   14.1   20.0 0.000
=====================================================================================================
* Supercritical flow.


        SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
       ========================================================
NOTE:
 The convey length should be from upstream to downstream inside box.
 This length may also be used as Pay Item.
 Using hydraulic length, from node center to node center, may result in profile error,
 and this length should not be used as Pay Item.

LINKS:
=================================================================================
Type of Convey   Material   Rise   Span  Number of Links   Quantity
 Structure              (ft)   (ft)   of this type      (ft)
---------------------------------------------------------------------------
  Circular      Concrete   1.5    0.0       1          192.12
  Circular      Concrete   2.0    0.0       1          140.78

NODES:
===================================================================================================
 Type of Inlet       Type of Grate Inlet  Grate Grate  Grate  Grate    Quantity
  Structure                   Length Width Length Area  Perimeter  (each)
                          (ft)    (ft)   (ft)  (ft)   (ft)
----------------------------------------------------------------------------------------
Circular Manhole                0.0     0.0    0.0   0.0    0.0       2
Outlet                     0.0     0.0    0.0   0.0    0.0       1

=============================================================================================


       OUTPUT FOR ANALYSYS FREQUENCY of:  100   Years
       ======================================================


Runoff Computation for Analysis Frequency.
=============================================================================================
ID     C Value    Area     Tc    Tc Used    Intensity    Supply Q    Total Q
             (acre)  (min)   (min)      (in/hr)      (cfs)       (cfs)
-------------------------------------------------------------------------------
D-1     0.55       4.01   27.77    27.77       6.71        0.000       14.804
D-2     0.55       4.04   27.79    27.79       6.71        0.000       14.911
-------------------------------------------------------------------------------


Cumulative Junction Discharge Computations
===================================================================================================
Node     Node  Weighted  Cumulat. Cumulat. Intens.   User     Additional    Total
```

I.D.	Type	C-Value	Dr.Area	Tc	Supply Q	Q in Node	Disch.
		(acres)	(min)	(in/hr)	cfs)	(cfs)	(cfs)
D-1	CrcMh	0.550	4.01	27.77	6.71	0.00	14.804
D-2	CrcMh	0.550	8.05	28.15	6.67	0.00	29.549
OUT	Outlt	0.550	8.05	28.15	6.67	0.00	29.549

Conveyance Configuration Data

Run	Node	I.D.	FlowLine Elev.								
#	US	DS	US	DS	Shape	#	Span	Rise	Length	Slope	n_value
			(ft)	(ft)			(ft)	(ft)	(ft)	(%)	
1	D-1	D-2	65.74	65.63	Cir	1	0.00	1.50	192.1	0.057	0.013
2	D-2	OUT	65.27	64.18	Cir	1	0.00	2.00	140.8	0.774	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run	Hyd. Gr.line		Crit.Elev		Depth		Velocity			Junc	
#	US	DS	US	Fr.Slope	Unif.	Actual	Unif.	Actual	Q	Cap	Loss
	(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(f/s)	(f/s)	(cfs)	(cfs)	(ft)
1	72.35	68.56	0.00	1.969	1.50	1.50	8.38	8.38	14.8	2.5	0.000
2	68.56	66.18	0.00	1.692	2.00	2.00	9.41	9.41	29.5	20.0	0.000

* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	192.12
Circular	Concrete	2.0	0.0	1	140.78

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)

Circular Manhole	0.0	0.0	0.0	0.0	0.0	2
Outlet	0.0	0.0	0.0	0.0	0.0	1

==================================END==

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.42(ft)
Critical elevation (Analysis) missing or invalid at node Id= D-2 Run # 2
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= D-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 66.18(ft)
Run# 2 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= D-2 Run # 2
Run# 1 Insufficient capacity.
Upstream HGL exceeds critical elevation (Design) at node Id= D-1 Run # 1
Critical elevation (Analysis) missing or invalid at node Id= D-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:32:37 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : E 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\E_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
E-1	0.55	2.49	26.75	26.75	3.29	0.000	4.507

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
E-1	CrcMh	0.550	2.49	26.75	3.29		0.00	4.507
OUT	Outlt	0.550	2.49	26.75	3.29		0.00	4.507

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	E-1	OUT	64.88	64.86	Cir	1	0.00	2.00	77.4	0.026	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

1 66.89 66.86 68.88 0.039 2.00 2.00 1.43 1.43 4.5 3.7 0.000
==

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	77.36

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
==

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
E-1	0.55	2.49	26.75	26.75	6.82	0.000	9.337

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
E-1	CrcMh	0.550	2.49	26.75	6.82		0.00	9.337
OUT	Outlt	0.550	2.49	26.75	6.82		0.00	9.337

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	E-1	OUT	64.88	64.86	Cir 1	0.00	2.00	77.4	0.026	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.99	66.86	0.00	0.169	2.00	2.00	2.97	2.97	9.3	3.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	77.36

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

==================================END==================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.86(ft)
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= E-1 Run # 1

Runoff Frequency of: 100 Years

Tailwater set to uniform depth elevation = 66.86(ft)
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= E-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:34:42 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : F 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\F_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.
==

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F-1	0.55	13.27	30.77	30.77	3.05	0.000	22.296

Cumulative Junction Discharge Computations
==

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F-1	CrcMh	0.550	13.27	30.77	3.05		0.00	22.296
OUT	Outlt	0.550	13.27	30.77	3.05		0.00	22.296

Conveyance Configuration Data
===

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F-1	OUT	64.50	64.49	Cir 1	0.00	2.00	175.6	0.006	0.011

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
===

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1	67.70	66.49	68.50	0.690	2.00	2.00	7.10	7.10	22.3	2.0	0.000

==

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Plastic	2.0	0.0	1	175.61

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

===

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
==

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F-1	0.55	13.27	30.77	30.77	6.42	0.000	46.879

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F-1	CrcMh	0.550	13.27	30.77	6.42		0.00	46.879
OUT	Outlt	0.550	13.27	30.77	6.42		0.00	46.879

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F-1	OUT	64.50	64.49	Cir 1	0.00	2.00	175.6	0.006	0.011

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	71.84	66.49	0.00	3.048	2.00	2.00	14.92	14.92	46.9	2.0	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Plastic	2.0	0.0	1	175.61

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

==================================END==================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.49(ft)
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= F-1 Run # 1

Runoff Frequency of: 100 Years

Tailwater set to uniform depth elevation = 66.49(ft)
Run# 1 Insufficient capacity.
Upstream HGL exceeds critical elevation (Design) at node Id= F-1 Run # 1
Critical elevation (Analysis) missing or invalid at node Id= F-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:36:06 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : G 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\G_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-1	0.55	2.32	26.60	26.60	3.30	0.000	4.211

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-1	CrcMh	0.550	2.32	26.60	3.30		0.00	4.211
OUT	Outlt	0.550	2.32	26.60	3.30		0.00	4.211

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-1	OUT	66.04	65.57	Cir 1	0.00	1.50	60.5	0.776	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

1* 66.75 66.28 69.54 0.159 0.71 0.71 5.12 5.12 4.2 9.3 0.000
===
* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===
NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:
===

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	60.53

NODES:
===

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

==

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
===

Runoff Computation for Analysis Frequency.
==

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-1	0.55	2.32	26.60	26.60	6.83	0.000	8.720

Cumulative Junction Discharge Computations
===

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-1	CrcMh	0.550	2.32	26.60	6.83		0.00	8.720
OUT	Outlt	0.550	2.32	26.60	6.83		0.00	8.720

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-1	OUT	66.04	65.57	Cir 1	0.00	1.50	60.5	0.776	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	67.20	66.73	0.00	0.683	1.16	1.16	5.95	5.95	8.7	9.3	0.000

* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	60.53

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1	

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.28(ft)

Critical elevation (Analysis) missing or invalid at node Id= G-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 66.73(ft)
Critical elevation (Analysis) missing or invalid at node Id= G-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:37:59 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : H 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\H_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
===

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-1	0.55	2.64	26.86	26.86	3.28	0.000	4.768
H-2	0.55	2.30	26.58	26.58	3.30	0.000	4.177

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
H-1	CrcMh	0.550	2.64	26.86	3.28		0.00	4.768
H-2	CrcMh	0.550	4.94	28.99	3.15		0.00	8.572
OUT	Outlt	0.550	4.94	28.99	3.15		0.00	8.572

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	H-1	H-2	66.49	65.82	Cir	1	0.00	1.50	365.8	0.183	0.013
2	H-2	OUT	65.27	65.26	Cir	1	0.00	1.75	56.6	0.018	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
==
Run Hyd. Gr.line Crit.Elev Depth Velocity Junc

#	US (ft)	DS (ft)	US (ft)	Fr.Slope (%)	Unif. (ft)	Actual (ft)	Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Loss (ft)
1	67.83	67.17	69.99	0.204	1.34	1.35	2.87	2.84	4.8	4.5	0.000
2	67.17	67.01	69.02	0.290	1.75	1.75	3.56	3.56	8.6	2.1	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	365.84
Circular	Concrete	1.75	0.0	1	56.6

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet	0.0	0.0	0.0	0.0	0.0	1	

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-1	0.55	2.64	26.86	26.86	6.81	0.000	9.883
H-2	0.55	2.30	26.58	26.58	6.84	0.000	8.647

Cumulative Junction Discharge Computations

Node I.D. Node Type Weighted C-Value Cumulat. Dr.Area (acres) Cumulat. Tc (min) Intens. (in/hr) User Supply Q cfs) Additional Q in Node (cfs) Total Disch. (cfs)

H-1	CrcMh	0.550	2.64	26.86	6.81	0.00	9.883
H-2	CrcMh	0.550	4.94	27.95	6.69	0.00	18.188
OUT	Outlt	0.550	4.94	27.95	6.69	0.00	18.188

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	H-1	H-2	66.49	65.82	Cir	1	0.00	1.50	365.8	0.183	0.013
2	H-2	OUT	65.27	65.26	Cir	1	0.00	1.75	56.6	0.018	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	70.96	67.75	0.00	0.878	1.50	1.50	5.59	5.59	9.9	4.5	0.000
2	67.75	67.01	0.00	1.306	1.75	1.75	7.56	7.56	18.2	2.1	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	365.84
Circular	Concrete	1.75	0.0	1	56.6

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 67.01(ft)
Run# 2 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= H-2 Run # 2
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= H-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 67.01(ft)
Run# 2 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= H-2 Run # 2
Run# 1 Insufficient capacity.
Upstream HGL exceeds critical elevation (Design) at node Id= H-1 Run # 1
Critical elevation (Analysis) missing or invalid at node Id= H-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:39:12 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : J 100-Year Existing
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\J_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-1	0.55	3.99	27.76	27.76	3.23	0.000	7.084

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-1	CrcMh	0.550	3.99	27.76	3.23		0.00	7.084
OUT	Outlt	0.550	3.99	27.76	3.23		0.00	7.084

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-1	OUT	67.34	67.33	Cir	1	0.00	1.50	55.3	0.018	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

1 69.08 68.83 70.84 0.451 1.50 1.50 4.01 4.01 7.1 1.4 0.000
===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	55.31

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

===

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-1	0.55	3.99	27.76	27.76	6.71	0.000	14.733

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-1	CrcMh	0.550	3.99	27.76	6.71		0.00	14.733
OUT	Outlt	0.550	3.99	27.76	6.71		0.00	14.733

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-1	OUT	67.34	67.33	Cir 1	0.00	1.50	55.3	0.018	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	69.91	68.83	0.00	1.950	1.50	1.50	8.34	8.34	14.7	1.4	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	1.5	0.0	1	55.31

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0		1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 68.83(ft)
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= J-1 Run # 1

Runoff Frequency of: 100 Years

Tailwater set to uniform depth elevation = 68.83(ft)
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= J-1 Run # 1

Appendix C

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:11:04 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : A Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\A_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.55	2.44	26.70	26.70	3.29	0.000	4.421

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	CrcMh	0.550	2.44	26.70	3.29		0.00	4.421
OUT	Outlt	0.550	2.44	26.70	3.29		0.00	4.421

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	OUT	63.80	63.54	Cir 1	0.00	2.00	149.4	0.174	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	64.76	64.50	67.72	0.038	0.96	0.96	2.95	2.95	4.4	9.5	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	149.38

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

==================================END==================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 64.50(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 3:44:36 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : AB Alternative 1 Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\Al

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
===

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A	0.55	2.44	26.70	26.70	3.29	0.000	4.421
B	0.55	4.03	27.78	27.78	3.23	0.000	7.152

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A	CrcMh	0.550	2.44	26.70	3.29		0.00	4.421
B	CrcMh	0.550	6.47	29.66	3.12		0.00	11.090
OUT	Outlt	0.550	6.47	29.66	3.12		0.00	11.090

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A	B	62.92	61.95	Cir 1	0.00	2.00	533.5	0.182	0.013
2	B	OUT	60.95	60.76	Cir 1	0.00	2.50	140.5	0.135	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1	63.87	62.54	0.00	0.038	0.95	0.95	3.01	3.01	4.4	9.7 0.000
2	62.54	62.35	0.00	0.072	1.59	1.59	3.36	3.36	11.1	15.1 0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	533.5
Circular	Concrete	2.5	0.0	1	140.49

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	2
Outlet	0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 62.35(ft)
Critical elevation (Design) missing or invalid at node Id= B Run # 2
Critical elevation (Design) missing or invalid at node Id= A Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 3:56:39 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : CDE Alternative 1 Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\Un

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C	0.55	2.50	26.75	26.75	3.29	0.000	4.525
E	0.55	2.49	26.74	26.74	3.29	0.000	4.508
D-1	0.55	4.01	27.77	27.77	3.23	0.000	7.118
D-2	0.55	4.04	27.79	27.79	3.23	0.000	7.168

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C	CrcMh	0.550	2.50	26.75	3.29		0.00	4.525
E	CrcMh	0.550	2.49	26.74	3.29		0.00	4.508
D-1	CrcMh	0.550	6.50	29.37	3.13		0.00	11.200
D-2	CrcMh	0.550	13.04	30.55	3.07		0.00	21.994
OUT	Outlt	0.550	13.04	30.55	3.07		0.00	21.994

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C	D-2	64.81	63.79	Cir	1	0.00	2.00	564.9	0.181	0.013
2	E	D-1	64.96	64.10	Cir	1	0.00	2.00	475.1	0.181	0.013
3	D-1	D-2	63.10	62.79	Cir	1	0.00	2.50	236.4	0.131	0.013
4	D-2	OUT	60.79	60.68	Cir	1	0.00	3.50	118.0	0.093	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.61	65.79	0.00	0.040	0.96	2.00	3.02	1.44	4.5	9.7	0.000
2	65.92	64.72	0.00	0.039	0.96	0.96	3.01	3.01	4.5	9.7	0.000
3	64.72	62.98	0.00	0.074	1.62	1.62	3.33	3.33	11.2	14.9	0.000
4	62.98	62.87	0.00	0.047	2.19	2.19	3.48	3.48	22.0	30.8	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	2	1040.07
Circular	Concrete	2.5	0.0	1	236.44
Circular	Concrete	3.5	0.0	1	118.01

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	4
Outlet		0.0	0.0	0.0	0.0	0.0	1

====================================END====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 62.87(ft)
Critical elevation (Design) missing or invalid at node Id= D-2 Run # 4
HGL elevation below invert. Downstream HGL set to soffit elevation at Run# 1
Critical elevation (Design) missing or invalid at node Id= C Run # 1
Critical elevation (Design) missing or invalid at node Id= D-1 Run # 3
Critical elevation (Design) missing or invalid at node Id= E Run # 2

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 4:15:24 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : FG Alternative 1
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\Al

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
===

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F	0.55	13.27	30.77	30.77	3.05	0.000	22.296
G	0.55	2.32	26.60	26.60	3.30	0.000	4.211

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F	CrcMh	0.550	13.27	30.77	3.05		0.00	22.296
G	CrcMh	0.550	15.59	33.37	2.92		0.00	25.049
OUT	Outlt	0.550	15.59	33.37	2.92		0.00	25.049

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F	G	63.33	62.84	Cir 1	0.00	3.50	537.2	0.091	0.013
2	G	OUT	61.84	61.57	Cir 1	0.00	4.00	375.4	0.072	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

1	65.56	64.18	0.00	0.049	2.23	2.23	3.45	3.45	22.3	30.5	0.000
2	64.18	63.91	0.00	0.030	2.34	2.34	3.27	3.27	25.0	38.7	0.000

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SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

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NOTE:

The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	3.5	0.0	1	537.22
Circular	Concrete	4.0	0.0	1	375.42

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet		0.0	0.0	0.0	0.0	0.0	1

=================================END=======================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 63.91(ft)
Critical elevation (Design) missing or invalid at node Id= G Run # 2
Critical elevation (Design) missing or invalid at node Id= F Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:11:51 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : B Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\B_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-1	0.55	4.03	27.78	27.78	3.23	0.000	7.152

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-1	CrcMh	0.550	4.03	27.78	3.23		0.00	7.152
OUT	Outlt	0.550	4.03	27.78	3.23		0.00	7.152

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-1	OUT	63.50	63.26	Cir 1	0.00	2.00	140.1	0.171	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	64.81	64.57	68.10	0.099	1.31	1.31	3.28	3.28	7.2	9.4	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
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NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	140.05

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

===================================END===================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 64.57(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:12:41 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : C Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\C_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-1	0.55	2.50	26.75	26.75	3.29	0.000	4.525

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-1	CrcMh	0.550	2.50	26.75	3.29		0.00	4.525
OUT	Outlt	0.550	2.50	26.75	3.29		0.00	4.525

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-1	OUT	65.14	65.02	Cir	1	0.00	2.00	67.2	0.178	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.11	65.99	70.50	0.040	0.97	0.97	3.00	3.00	4.5	9.6	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	67.23

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

===================================END===

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.99(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:17:02 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : D Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\D_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-1	0.55	4.01	27.77	27.77	3.23	0.000	7.118
D-2	0.55	4.04	27.79	27.79	3.23	0.000	7.168

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
D-1	CrcMh	0.550	4.01	27.77	3.23		0.00	7.118
D-2	CrcMh	0.550	8.05	28.75	3.17		0.00	14.030
OUT	Outlt	0.550	8.05	28.75	3.17		0.00	14.030

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	D-1	D-2	64.69	64.36	Cir	1	0.00	2.00	192.1	0.172	0.013
2	D-2	OUT	63.86	63.68	Cir	1	0.00	2.50	140.8	0.128	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
==
Run Hyd. Gr.line Crit.Elev Depth Velocity Junc
 # US DS US Fr.Slope Unif. Actual Unif. Actual Q Cap Loss
 (ft) (ft) (ft) (%) (ft) (ft) (f/s) (f/s) (cfs) (cfs) (ft)

1	65.99	65.81	69.24	0.098	1.30	1.45	3.28	2.91	7.1	9.4	0.000
2	65.81	65.63	69.27	0.116	1.95	1.95	3.41	3.41	14.0	14.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	192.12
Circular	Concrete	2.5	0.0	1	140.78

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	2
Outlet	0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.63(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:18:21 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : E Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\E_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
E-1	0.55	2.49	26.75	26.75	3.29	0.000	4.507

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
E-1	CrcMh	0.550	2.49	26.75	3.29		0.00	4.507
OUT	Outlt	0.550	2.49	26.75	3.29		0.00	4.507

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	E-1	OUT	64.99	64.86	Cir 1	0.00	2.00	77.4	0.168	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	65.97	65.84	68.88	0.039	0.98	0.98	2.93	2.93	4.5	9.3	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	77.36

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.84(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:22:35 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : F Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\F_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F-1	0.55	13.27	30.77	30.77	3.05	0.000	22.296

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F-1	CrcMh	0.550	13.27	30.77	3.05		0.00	22.296
OUT	Outlt	0.550	13.27	30.77	3.05		0.00	22.296

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F-1	OUT	63.14	62.99	Cir 1	0.00	3.50	175.6	0.085	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	65.42	65.27	68.50	0.049	2.28	2.28	3.35	3.35	22.3	29.5	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	3.5	0.0	1	175.61

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

===================================END===

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.27(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:26:15 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : G Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\G_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-1	0.55	2.32	26.60	26.60	3.30	0.000	4.211

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-1	CrcMh	0.550	2.32	26.60	3.30		0.00	4.211
OUT	Outlt	0.550	2.32	26.60	3.30		0.00	4.211

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-1	OUT	65.18	65.07	Cir 1	0.00	2.00	60.5	0.182	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.11	66.00	69.54	0.034	0.93	0.93	2.96	2.96	4.2	9.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:
==

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	60.53

NODES:
==

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.00(ft)

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 11/8/2018 2:34:55 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : H Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\H_

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-1	0.55	2.64	26.86	26.86	3.28	0.000	4.768
H-2	0.55	2.30	26.58	26.58	3.30	0.000	4.177

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
H-1	CrcMh	0.550	2.64	26.86	3.28		0.00	4.768
H-2	CrcMh	0.550	4.94	28.88	3.16		0.00	8.589
OUT	Outlt	0.550	4.94	28.88	3.16		0.00	8.589

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	H-1	H-2	65.75	65.11	Cir 1	0.00	2.00	365.8	0.175	0.013
2	H-2	OUT	65.11	65.01	Cir 1	0.00	2.00	56.6	0.177	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

----
1 66.94 66.59 69.99 0.044 1.00 1.48 3.02 1.91 4.8 9.5 0.000
2 66.59 66.49 69.02 0.143 1.48 1.48 3.44 3.44 8.6 9.5 0.000
===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:
===

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	2	422.44

NODES:
===

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet		0.0	0.0	0.0	0.0	0.0	1

================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.49(ft)

Appendix D

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:07:00 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : A 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\A_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.55	2.44	26.70	26.70	3.29	0.000	4.421

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	CrcMh	0.550	2.44	26.70	3.29		0.00	4.421
OUT	Outlt	0.550	2.44	26.70	3.29		0.00	4.421

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	OUT	63.80	63.54	Cir 1	0.00	2.00	149.4	0.174	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1	64.76	64.50	67.72	0.038	0.96	0.96	2.95	2.95	4.4	9.5	0.000

===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
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NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	149.38

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

===

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.55	2.44	26.70	26.70	6.82	0.000	9.157

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	CrcMh	0.550	2.44	26.70	6.82		0.00	9.157
OUT	Outlt	0.550	2.44	26.70	6.82		0.00	9.157

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	OUT	63.80	63.54	Cir 1	0.00	2.00	149.4	0.174	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	65.39	65.13	0.00	0.162	1.59	1.59	3.43	3.43	9.2	9.5	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	149.38

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====END=====

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 64.50(ft)
Critical elevation (Analysis) missing or invalid at node Id= A-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 65.13(ft)

Critical elevation (Analysis) missing or invalid at node Id= A-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:24:17 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : AB Alternative 1 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\Al

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A	0.55	2.44	26.70	26.70	3.29	0.000	4.421
B	0.55	4.03	27.78	27.78	3.23	0.000	7.152

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A	CrcMh	0.550	2.44	26.70	3.29		0.00	4.421
B	CrcMh	0.550	6.47	29.66	3.12		0.00	11.090
OUT	Outlt	0.550	6.47	29.66	3.12		0.00	11.090

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A	B	62.92	61.95	Cir	1	0.00	2.00	533.5	0.182	0.013
2	B	OUT	60.95	60.76	Cir	1	0.00	2.50	140.5	0.135	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
==

Run Hyd. Gr.line Crit.Elev Depth Velocity Junc

#	US (ft)	DS (ft)	US (ft)	Fr.Slope (%)	Unif. (ft)	Actual (ft)	Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Loss (ft)
1	63.87	62.54	66.92	0.038	0.95	0.95	3.01	3.01	4.4	9.7	0.000
2	62.54	62.35	65.45	0.072	1.59	1.59	3.36	3.36	11.1	15.1	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	533.5
Circular	Concrete	2.5	0.0	1	140.49

NODES:

Type of Inlet Structure	Type of Grate Inlet	Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet	0.0	0.0	0.0	0.0	0.0	1	

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A	0.55	2.44	26.70	26.70	6.82	0.000	9.157
B	0.55	4.03	27.78	27.78	6.71	0.000	14.876

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)

A	CrcMh	0.550	2.44	26.70	6.82	0.00	9.157
B	CrcMh	0.550	6.47	29.24	6.57	0.00	23.367
OUT	Outlt	0.550	6.47	29.24	6.57	0.00	23.367

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A	B	62.92	61.95	Cir	1	0.00	2.00	533.5	0.182	0.013
2	B	OUT	60.95	60.76	Cir	1	0.00	2.50	140.5	0.135	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	64.47	63.71	0.00	0.162	1.55	1.76	3.49	3.12	9.2	9.7	0.000
2	63.71	63.26	0.00	0.322	2.50	2.50	4.76	4.76	23.4	15.1	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	533.5
Circular	Concrete	2.5	0.0	1	140.49

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet		0.0	0.0	0.0	0.0	0.0	1

====================================END====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 62.35(ft)
Critical elevation (Analysis) missing or invalid at node Id= B Run # 2
Critical elevation (Analysis) missing or invalid at node Id= A Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 63.26(ft)
Run# 2 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= B Run # 2
Critical elevation (Analysis) missing or invalid at node Id= A Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:25:14 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : CDE Alternative 1 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\Al

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
===

Runoff Computation for Design Frequency.
===

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C	0.55	2.50	26.75	26.75	3.29	0.000	4.525
E	0.55	2.49	26.74	26.74	3.29	0.000	4.508
D-1	0.55	4.01	27.77	27.77	3.23	0.000	7.118
D-2	0.55	4.04	27.79	27.79	3.23	0.000	7.168

Cumulative Junction Discharge Computations
===

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C	CrcMh	0.550	2.50	26.75	3.29		0.00	4.525
E	CrcMh	0.550	2.49	26.74	3.29		0.00	4.508
D-1	CrcMh	0.550	6.50	29.37	3.13		0.00	11.200
D-2	CrcMh	0.550	13.04	30.55	3.07		0.00	21.994
OUT	Outlt	0.550	13.04	30.55	3.07		0.00	21.994

Conveyance Configuration Data
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Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C	D-2	64.81	63.79	Cir	1	0.00	2.00	564.9	0.181	0.013
2	E	D-1	64.96	64.10	Cir	1	0.00	2.00	475.1	0.181	0.013
3	D-1	D-2	63.10	62.79	Cir	1	0.00	2.50	236.4	0.131	0.013
4	D-2	OUT	60.79	60.68	Cir	1	0.00	3.50	118.0	0.093	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.61	65.79	68.81	0.040	0.96	2.00	3.02	1.44	4.5	9.7	0.000
2	65.92	64.72	68.96	0.039	0.96	0.96	3.01	3.01	4.5	9.7	0.000
3	64.72	62.98	68.10	0.074	1.62	1.62	3.33	3.33	11.2	14.9	0.000
4	62.98	62.87	66.29	0.047	2.19	2.19	3.48	3.48	22.0	30.8	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	2	1040.07
Circular	Concrete	2.5	0.0	1	236.44
Circular	Concrete	3.5	0.0	1	118.01

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	4
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100   Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C	0.55	2.50	26.75	26.75	6.82	0.000	9.375

E	0.55	2.49	26.74	26.74	6.82	0.000	9.339
D-1	0.55	4.01	27.77	27.77	6.71	0.000	14.804
D-2	0.55	4.04	27.79	27.79	6.71	0.000	14.911

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C	CrcMh	0.550	2.50	26.75	6.82		0.00	9.375
E	CrcMh	0.550	2.49	26.74	6.82		0.00	9.339
D-1	CrcMh	0.550	6.50	29.01	6.59		0.00	23.558
D-2	CrcMh	0.550	13.04	29.83	6.51		0.00	46.696
OUT	Outlt	0.550	13.04	29.83	6.51		0.00	46.696

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C	D-2	64.81	63.79	Cir 1	0.00	2.00	564.9	0.181	0.013
2	E	D-1	64.96	64.10	Cir 1	0.00	2.00	475.1	0.181	0.013
3	D-1	D-2	63.10	62.79	Cir 1	0.00	2.50	236.4	0.131	0.013
4	D-2	OUT	60.79	60.68	Cir 1	0.00	3.50	118.0	0.093	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.40	64.43	0.00	0.170	1.59	1.59	3.49	3.49	9.4	9.7	0.000
2	66.55	65.77	0.00	0.169	1.59	1.67	3.50	3.33	9.3	9.7	0.000
3	65.77	64.43	0.00	0.327	2.50	2.50	4.80	4.80	23.6	14.9	0.000
4	64.43	64.18	0.00	0.214	3.50	3.50	4.85	4.85	46.7	30.8	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

```
===========================================================================
Type of Convey   Material   Rise   Span  Number of Links   Quantity
 Structure              (ft)   (ft)   of this type       (ft)
---------------------------------------------------------------------
  Circular      Concrete   2.0    0.0       2           1040.07
  Circular      Concrete   2.5    0.0       1           236.44
  Circular      Concrete   3.5    0.0       1           118.01
```

NODES:

```
=====================================================================================
 Type of Inlet       Type of Grate Inlet  Grate Grate  Grate  Grate    Quantity
  Structure                   Length Width Length Area  Perimeter  (each)
                          (ft)    (ft)   (ft)  (ft)   (ft)
-------------------------------------------------------------------------------
Circular Manhole               0.0     0.0    0.0   0.0    0.0       4
Outlet                     0.0     0.0    0.0   0.0    0.0       1
=====================================END==========================================
```

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 62.87(ft)
Critical elevation (Analysis) missing or invalid at node Id= D-2 Run # 4
HGL elevation below invert. Downstream HGL set to soffit elevation at Run# 1
Critical elevation (Analysis) missing or invalid at node Id= C Run # 1
Critical elevation (Analysis) missing or invalid at node Id= D-1 Run # 3
Critical elevation (Analysis) missing or invalid at node Id= E Run # 2

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 64.18(ft)
Run# 4 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= D-2 Run # 4
Critical elevation (Analysis) missing or invalid at node Id= C Run # 1
Run# 3 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= D-1 Run # 3
Critical elevation (Analysis) missing or invalid at node Id= E Run # 2

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:27:26 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : FG Alternative 1 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\Al

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F	0.55	13.27	30.77	30.77	3.05	0.000	22.296
G	0.55	2.32	26.60	26.60	3.30	0.000	4.211

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F	CrcMh	0.550	13.27	30.77	3.05		0.00	22.296
G	CrcMh	0.550	15.59	33.37	2.92		0.00	25.049
OUT	Outlt	0.550	15.59	33.37	2.92		0.00	25.049

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F	G	63.33	62.84	Cir	1	0.00	3.50	537.2	0.091	0.013
2	G	OUT	61.84	61.57	Cir	1	0.00	4.00	375.4	0.072	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
==
Run Hyd. Gr.line Crit.Elev Depth Velocity Junc

#	US (ft)	DS (ft)	US (ft)	Fr.Slope (%)	Unif. (ft)	Actual (ft)	Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Loss (ft)
1	65.56	64.18	68.83	0.049	2.23	2.23	3.45	3.45	22.3	30.5	0.000
2	64.18	63.91	67.84	0.030	2.34	2.34	3.27	3.27	25.0	38.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	3.5	0.0	1	537.22
Circular	Concrete	4.0	0.0	1	375.42

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F	0.55	13.27	30.77	30.77	6.42	0.000	46.879
G	0.55	2.32	26.60	26.60	6.83	0.000	8.720

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)

F	CrcMh	0.550	13.27	30.77	6.42	0.00	46.879
G	CrcMh	0.550	15.59	32.61	6.26	0.00	53.674
OUT	Outlt	0.550	15.59	32.61	6.26	0.00	53.674

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F	G	63.33	62.84	Cir	1	0.00	3.50	537.2	0.091	0.013
2	G	OUT	61.84	61.57	Cir	1	0.00	4.00	375.4	0.072	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	67.35	66.09	0.00	0.215	3.50	3.50	4.87	4.87	46.9	30.5	0.000
2	66.09	65.57	0.00	0.138	4.00	4.00	4.27	4.27	53.7	38.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	3.5	0.0	1	537.22
Circular	Concrete	4.0	0.0	1	375.42

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 63.91(ft)
Critical elevation (Analysis) missing or invalid at node Id= G Run # 2
Critical elevation (Analysis) missing or invalid at node Id= F Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 65.57(ft)
Run# 2 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= G Run # 2
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= F Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:28:52 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : B Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\B_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-1	0.55	4.03	27.78	27.78	3.23	0.000	7.152

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-1	CrcMh	0.550	4.03	27.78	3.23		0.00	7.152
OUT	Outlt	0.550	4.03	27.78	3.23		0.00	7.152

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-1	OUT	63.50	63.26	Cir 1	0.00	2.00	140.1	0.171	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

1 64.81 64.57 68.10 0.099 1.31 1.31 3.28 3.28 7.2 9.4 0.000
==

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	140.05

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

==

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
==

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-1	0.55	4.03	27.78	27.78	6.71	0.000	14.876

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-1	CrcMh	0.550	4.03	27.78	6.71		0.00	14.876
OUT	Outlt	0.550	4.03	27.78	6.71		0.00	14.876

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-1	OUT	63.50	63.26	Cir 1	0.00	2.00	140.1	0.171	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	65.86	65.26	0.00	0.429	2.00	2.00	4.74	4.74	14.9	9.4	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	140.05

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 64.57(ft)
Critical elevation (Analysis) missing or invalid at node Id= B-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 65.26(ft)

Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= B-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:30:10 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : C 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\C_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-1	0.55	2.50	26.75	26.75	3.29	0.000	4.525

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-1	CrcMh	0.550	2.50	26.75	3.29		0.00	4.525
OUT	Outlt	0.550	2.50	26.75	3.29		0.00	4.525

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-1	OUT	65.14	65.02	Cir	1	0.00	2.00	67.2	0.178	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1 66.11 65.99 70.50 0.040 0.97 0.97 3.00 3.00 4.5 9.6 0.000
===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	67.23

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

===

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-1	0.55	2.50	26.75	26.75	6.82	0.000	9.375

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-1	CrcMh	0.550	2.50	26.75	6.82		0.00	9.375
OUT	Outlt	0.550	2.50	26.75	6.82		0.00	9.375

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-1	OUT	65.14	65.02	Cir 1	0.00	2.00	67.2	0.178	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	66.75	66.63	0.00	0.170	1.61	1.61	3.46	3.46	9.4	9.6	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	67.23

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

=====================================END=====================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.99(ft)
Critical elevation (Analysis) missing or invalid at node Id= C-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 66.63(ft)

Critical elevation (Analysis) missing or invalid at node Id= C-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:31:51 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : D 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\D_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.
==

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-1	0.55	4.01	27.77	27.77	3.23	0.000	7.118
D-2	0.55	4.04	27.79	27.79	3.23	0.000	7.168

Cumulative Junction Discharge Computations
==

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
D-1	CrcMh	0.550	4.01	27.77	3.23		0.00	7.118
D-2	CrcMh	0.550	8.05	28.75	3.17		0.00	14.030
OUT	Outlt	0.550	8.05	28.75	3.17		0.00	14.030

Conveyance Configuration Data
===

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	D-1	D-2	64.69	64.36	Cir	1	0.00	2.00	192.1	0.172	0.013
2	D-2	OUT	63.86	63.68	Cir	1	0.00	2.50	140.8	0.128	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
===
Run Hyd. Gr.line Crit.Elev Depth Velocity Junc

#	US (ft)	DS (ft)	US (ft)	Fr.Slope (%)	Unif. (ft)	Actual (ft)	Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Loss (ft)
1	65.99	65.81	69.24	0.098	1.30	1.45	3.28	2.91	7.1	9.4	0.000
2	65.81	65.63	69.27	0.116	1.95	1.95	3.41	3.41	14.0	14.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	192.12
Circular	Concrete	2.5	0.0	1	140.78

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-1	0.55	4.01	27.77	27.77	6.71	0.000	14.804
D-2	0.55	4.04	27.79	27.79	6.71	0.000	14.911

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)

```
--------------------------------------------------------------------------------
D-1    CrcMh  0.550     4.01  27.77    6.71          0.00      14.804
D-2    CrcMh  0.550     8.05  28.45    6.64          0.00      29.418
OUT    Outlt  0.550     8.05  28.45    6.64          0.00      29.418
--------------------------------------------------------------------------------


Conveyance Configuration Data
========================================================================================
Run   Node  I.D.    FlowLine Elev.
 #   US     DS      US      DS   Shape #  Span  Rise   Length  Slope  n_value
                   (ft)    (ft)         (ft)  (ft)    (ft)    (%)
--------------------------------------------------------------------------------
1   D-1     D-2    64.69   64.36   Cir 1  0.00   2.00   192.1   0.172  0.013
2   D-2     OUT    63.86   63.68   Cir 1  0.00   2.50   140.8   0.128  0.013
--------------------------------------------------------------------------------


Conveyance Hydraulic Computations.  Tailwater = 0.000 (ft)
========================================================================================
Run  Hyd. Gr.line  Crit.Elev          Depth       Velocity             Junc
 #    US     DS      US    Fr.Slope Unif. Actual Unif. Actual  Q      Cap   Loss
    (ft)   (ft)    (ft)     (%)     (ft)  (ft)   (f/s) (f/s)  (cfs)    (cfs) (ft)
--------------------------------------------------------------------------------
1     67.71  66.90  0.00     0.425   2.00   2.00  4.71  4.71    14.8     9.4 0.000
2     66.90  66.18  0.00     0.510   2.50   2.50  5.99  5.99    29.4    14.7 0.000
========================================================================================

        SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
       ==================================================
NOTE:
 The convey length should be from upstream to downstream inside box.
 This length may also be used as Pay Item.
 Using hydraulic length, from node center to node center, may result in profile error,
 and this length should not be used as Pay Item.

LINKS:
==========================================================================
Type of Convey   Material   Rise   Span  Number of Links   Quantity
 Structure               (ft)   (ft)   of this type      (ft)
----------------------------------------------------------------------
  Circular      Concrete   2.0    0.0       1           192.12
  Circular      Concrete   2.5    0.0       1           140.78

NODES:
=======================================================================================
 Type of Inlet       Type of Grate Inlet  Grate Grate  Grate  Grate    Quantity
  Structure                    Length Width Length Area  Perimeter  (each)
                           (ft)    (ft)   (ft)  (ft)   (ft)
--------------------------------------------------------------------------------
Circular Manhole                  0.0     0.0     0.0   0.0    0.0       2
Outlet                      0.0     0.0    0.0   0.0    0.0       1
====================================END=========================================
```

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.63(ft)
Critical elevation (Analysis) missing or invalid at node Id= D-2 Run # 2
Critical elevation (Analysis) missing or invalid at node Id= D-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 66.18(ft)
Run# 2 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= D-2 Run # 2
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= D-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:34:02 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : E 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\E_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
E-1	0.55	2.49	26.75	26.75	3.29	0.000	4.507

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
E-1	CrcMh	0.550	2.49	26.75	3.29		0.00	4.507
OUT	Outlt	0.550	2.49	26.75	3.29		0.00	4.507

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	E-1	OUT	64.99	64.86	Cir 1	0.00	2.00	77.4	0.168	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)

1 65.97 65.84 68.88 0.039 0.98 0.98 2.93 2.93 4.5 9.3 0.000
===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	77.36

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

===

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
E-1	0.55	2.49	26.75	26.75	6.82	0.000	9.337

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
E-1	CrcMh	0.550	2.49	26.75	6.82		0.00	9.337
OUT	Outlt	0.550	2.49	26.75	6.82		0.00	9.337

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	E-1	OUT	64.99	64.86	Cir 1	0.00	2.00	77.4	0.168	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.65	66.52	0.00	0.169	1.66	1.66	3.36	3.36	9.3	9.3	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	77.36

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

==================================END==================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.84(ft)
Critical elevation (Analysis) missing or invalid at node Id= E-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 66.52(ft)

Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= E-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:35:29 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : F 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\F_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.
==

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F-1	0.55	13.27	30.77	30.77	3.05	0.000	22.296

Cumulative Junction Discharge Computations
==

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F-1	CrcMh	0.550	13.27	30.77	3.05		0.00	22.296
OUT	Outlt	0.550	13.27	30.77	3.05		0.00	22.296

Conveyance Configuration Data
===

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F-1	OUT	63.14	62.99	Cir	1	0.00	3.50	175.6	0.085	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
===

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1 65.42 65.27 68.50 0.049 2.28 2.28 3.35 3.35 22.3 29.5 0.000
==

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===
NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	3.5	0.0	1	175.61

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

==

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
==

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F-1	0.55	13.27	30.77	30.77	6.42	0.000	46.879

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F-1	CrcMh	0.550	13.27	30.77	6.42		0.00	46.879
OUT	Outlt	0.550	13.27	30.77	6.42		0.00	46.879

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	F-1	OUT	63.14	62.99	Cir 1	0.00	3.50	175.6	0.085	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	66.87	66.49	0.00	0.215	3.50	3.50	4.87	4.87	46.9	29.5	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	3.5	0.0	1	175.61

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

==================================END==================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 65.27(ft)
Critical elevation (Analysis) missing or invalid at node Id= F-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 66.49(ft)

Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= F-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:36:54 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : G 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\G_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-1	0.55	2.32	26.60	26.60	3.30	0.000	4.211

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-1	CrcMh	0.550	2.32	26.60	3.30		0.00	4.211
OUT	Outlt	0.550	2.32	26.60	3.30		0.00	4.211

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-1	OUT	65.18	65.07	Cir	1	0.00	2.00	60.5	0.182	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1 66.11 66.00 69.54 0.034 0.93 0.93 2.96 2.96 4.2 9.7 0.000
==

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
==

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	60.53

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1

==

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
==

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-1	0.55	2.32	26.60	26.60	6.83	0.000	8.720

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-1	CrcMh	0.550	2.32	26.60	6.83		0.00	8.720
OUT	Outlt	0.550	2.32	26.60	6.83		0.00	8.720

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-1	OUT	65.18	65.07	Cir 1	0.00	2.00	60.5	0.182	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	66.67	66.56	0.00	0.147	1.49	1.49	3.47	3.47	8.7	9.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	60.53

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet	0.0	0.0	0.0	0.0	0.0	1	

==================================END==================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.00(ft)
Critical elevation (Analysis) missing or invalid at node Id= G-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 66.56(ft)

Critical elevation (Analysis) missing or invalid at node Id= G-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:38:39 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : H 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\H_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
===

Runoff Computation for Design Frequency.
==

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-1	0.55	2.64	26.86	26.86	3.28	0.000	4.768
H-2	0.55	2.30	26.58	26.58	3.30	0.000	4.177

Cumulative Junction Discharge Computations
==

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
H-1	CrcMh	0.550	2.64	26.86	3.28		0.00	4.768
H-2	CrcMh	0.550	4.94	28.88	3.16		0.00	8.589
OUT	Outlt	0.550	4.94	28.88	3.16		0.00	8.589

Conveyance Configuration Data
===

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	H-1	H-2	65.75	65.11	Cir	1	0.00	2.00	365.8	0.175	0.013
2	H-2	OUT	65.11	65.01	Cir	1	0.00	2.00	56.6	0.177	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)
===
Run Hyd. Gr.line Crit.Elev Depth Velocity Junc

#	US (ft)	DS (ft)	US (ft)	Fr.Slope (%)	Unif. (ft)	Actual (ft)	Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Loss (ft)
1	66.94	66.59	69.99	0.044	1.00	1.48	3.02	1.91	4.8	9.5	0.000
2	66.59	66.49	69.02	0.143	1.48	1.48	3.44	3.44	8.6	9.5	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	2	422.44

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	2
Outlet	0.0	0.0	0.0	0.0	0.0	1	

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-1	0.55	2.64	26.86	26.86	6.81	0.000	9.883
H-2	0.55	2.30	26.58	26.58	6.84	0.000	8.647

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)

H-1	CrcMh	0.550	2.64	26.86	6.81	0.00	9.883
H-2	CrcMh	0.550	4.94	28.65	6.62	0.00	18.000
OUT	Outlt	0.550	4.94	28.65	6.62	0.00	18.000

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	H-1	H-2	65.75	65.11	Cir	1	0.00	2.00	365.8	0.175	0.013
2	H-2	OUT	65.11	65.01	Cir	1	0.00	2.00	56.6	0.177	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	68.06	67.37	0.00	0.189	1.73	2.00	3.41	3.15	9.9	9.5	0.000
2	67.37	67.01	0.00	0.628	2.00	2.00	5.73	5.73	18.0	9.5	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	2	422.44

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole	0.0	0.0	0.0	0.0	0.0	2
Outlet	0.0	0.0	0.0	0.0	0.0	1

===END===

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 66.49(ft)
Critical elevation (Analysis) missing or invalid at node Id= H-2 Run # 2
Critical elevation (Analysis) missing or invalid at node Id= H-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 67.01(ft)
Run# 2 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= H-2 Run # 2
Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= H-1 Run # 1

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 1/6/2019 3:39:50 PM

PROJECT NAME : Fountainview
JOB NUMBER : 1812-030
PROJECT DESCRIPTION : J 100-Year Proposed
PROJECT File: D:\cfa\2018\12030.Fountainview_Sec_1_&_Sec_2\ENG\H&H\HouStorm\J_

DESIGN FREQUENCY : 2 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-1	0.55	3.99	27.76	27.76	3.23	0.000	7.084

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-1	CrcMh	0.550	3.99	27.76	3.23		0.00	7.084
OUT	Outlt	0.550	3.99	27.76	3.23		0.00	7.084

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-1	OUT	66.93	66.83	Cir 1	0.00	2.00	55.3	0.181	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)

1 68.21 68.11 70.84 0.097 1.28 1.28 3.34 3.34 7.1 9.7 0.000
===

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES
===

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	55.31

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
===

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-1	0.55	3.99	27.76	27.76	6.71	0.000	14.733

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-1	CrcMh	0.550	3.99	27.76	6.71		0.00	14.733
OUT	Outlt	0.550	3.99	27.76	6.71		0.00	14.733

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-1	OUT	66.93	66.83	Cir 1	0.00	2.00	55.3	0.181	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	69.06	68.83	0.00	0.421	2.00	2.00	4.69	4.69	14.7	9.7	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Circular	Concrete	2.0	0.0	1	55.31

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Circular Manhole		0.0	0.0	0.0	0.0	0.0	1
Outlet		0.0	0.0	0.0	0.0	0.0	1

===================================END===================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Tailwater set to uniform depth elevation = 68.11(ft)
Critical elevation (Analysis) missing or invalid at node Id= J-1 Run # 1

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 68.83(ft)

Run# 1 Insufficient capacity.
Critical elevation (Analysis) missing or invalid at node Id= J-1 Run # 1

Upper Greens Bayou - Smith Road Area HMGP Flood Mitigation Project,
Parkland Estates & Humble Road Place

Thursday, June 7, 2018

Existing Conditions

<u>HC Description:</u> Construct detention pond, construct underground trunk line and extreme event overflow

The project area is located partially in the 100-Yr floodplain, partially in the 500-Yr floodplain, and partly outside the 500-Yr floodplain. Designated area subject to inundation by the 1-percent-annual-chance "Zone AE" and area of minimal flood hazard "Zone X".

- The Parkland Estates subdivision is primarily located outside of the 500-Yr floodplain but a small area to the north falls inside the 500-Yr floodplain.
- The Humble Road Place subdivision has areas inside the 100-Yr floodplain, inside the 500-Yr floodplain, and outside the FEMA 500-Yr floodplain.
- FEMA Zone AE – "Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Mandatory flood insurance purchase requirements and floodplain management standards apply."
- FEMA Zone X – "Minimal risk areas outside the 1-percent and .2-percent-annual-chance floodplains. No BFEs or base flood depths are shown within these zones."
- Parkland Estates subdivision – no floodway; 500-Yr floodplain and outside 500-Yr floodplain.
- Humble Road Place subdivision – floodway; Located inside the flood zone to the south along Greens Bayou.

- There are two FEMA model/streams. The southern stream runs from the west to the east and the northern stream runs from the north to the southeast of the subdivisions.
  - Greens Bayou:
    - Stream P100-00-00
    - High water marks for the Hurricane Harvey event, located approximately 9,500 ft. DS of the Humble Road Place subdivision, are 0.2' lower than the 100-Yr WSEL. Likewise, high water marks, approximately 8,600 ft. US of the Humble Road Place subdivision, are 0.1' lower than the 100-Yr WSEL.
    - Local drainage systems typically drain from northwest to southeast and empty into Greens Bayou. Small drainage ditches and retention ponds are used to release water into Greens Bayou.
    - There appears to be no backwater impacts from Greens Bayou into the project area.
  - Tributary to Greens Bayou:
    - Stream P133-00-00
    - No high water marks for this stream during the Hurricane Harvey event.
    - Local drainage systems typically drain from northwest to southeast and empty into the tributary to Greens Bayou. Small drainage ditches, roadside ditches and retention ponds are used to release water into the tributary to Greens Bayou.
    - There is a major backwater impact at the railroad bridge crossing of the tributary to Greens Bayou. The railroad bridge forces all floodplain flow through its single bridge opening and causes a backwater of over 1.5' in the 100-year storm. This backwater causes overflows into the project area that then must make their way through the subdivisions South and eventually into Greens Bayou, approximately one mile away.

Local Information:

- Parkland Estates subdivision:
  - As-builts were not available for this area.
  - Roadside drainage ditches and driveway culverts capture and convey drainage in this area. The actual conveyance path for drainage in this area could not be determined but it is assumed that the local drainage flows into a neighboring system and then either into Greens Bayou to the south or the tributary to Greens Bayou to the north.
  - Road elevations and existing ground elevations are essentially the same and houses are primarily slab on grade design. There are no detention ponds nearby, therefore storm water takes a direct path to either Greens Bayou or the tributary to Greens Bayou.
- Humble Road Place Subdivision:
  - As-builts were not available for this area.
  - Roadside drainage ditches and driveway culverts capture and convey drainage in this area. The actual conveyance path for drainage in this area could not be determined. It is assumed that the local drainage flows into a neighboring system and then into the tributary to Greens Bayou to the north for the northern area of this subdivision or that it flows directly into Greens Bayou in the southern area of this subdivision.
  - Road elevations and existing ground elevations are essentially the same and houses are primarily slab on grade design. There are no detention ponds nearby, therefore storm water takes a direct path to either Greens Bayou or the tributary to Greens Bayou.

Existing Conditions:

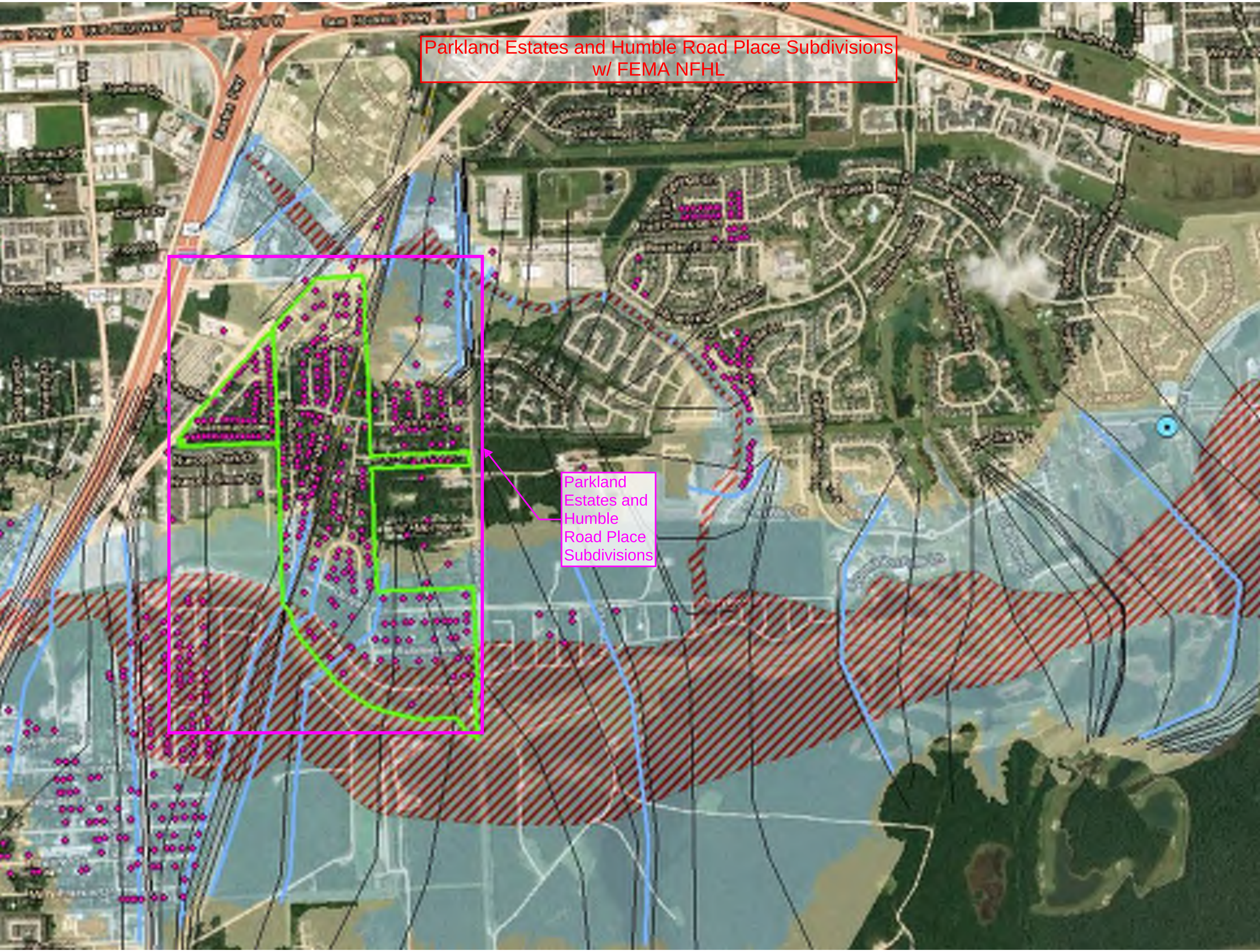
- Parkland Estates subdivision:
  - Hurricane Harvey Flood Event (Sept 2017) (100-Yr event).
    - In this area, the Hurricane Harvey flooding event appeared to be approximately a 100-Yr riverine flooding event. The high water marks located both upstream and downstream of the subdivision are less than the 100-Yr event by 0.1’ and 0.2’ respectively.
    - Per GIS, 54 homes within the Parkland Estates subdivision reported flood damage.
    - Of the homes that reported flooding 16 fell within the 500-Yr floodplain and the remainder were located outside the 500-Yr floodplain.
    - The degree of flooding impacts ranged from 4” to 30” with an average of almost 12.5”.
- Humble Road Place Subdivision:
  - Hurricane Harvey Flood Event (Sept 2017) (100-Yr event).
    - In this area, the Hurricane Harvey flooding event appeared to be approximately a 100-Yr riverine flooding event. The high water marks located both upstream and downstream of the subdivision are less than the 100-Yr event by 0.1’ and 0.2’ respectively.
    - Per GIS, 202 homes within the Humble Road Place subdivision reported flood damage.
    - Of the homes that reported flooding 48 fell within the 500-Yr floodplain, 52 fell within the 100-Yr floodplain, 12 fell within the regulatory floodway and the remainder were located outside the 500-Yr floodplain.
    - The degree of flooding impacts ranged from 2” to 72” with an average of almost 30.3”.
    - In general flood depths progressively decreased the farther from the floodway the building was located, which is to be expected.
- Tax Day Flood Event (April 2016):
  - No flooding in either subdivision was reported during the Tax Day flooding event.

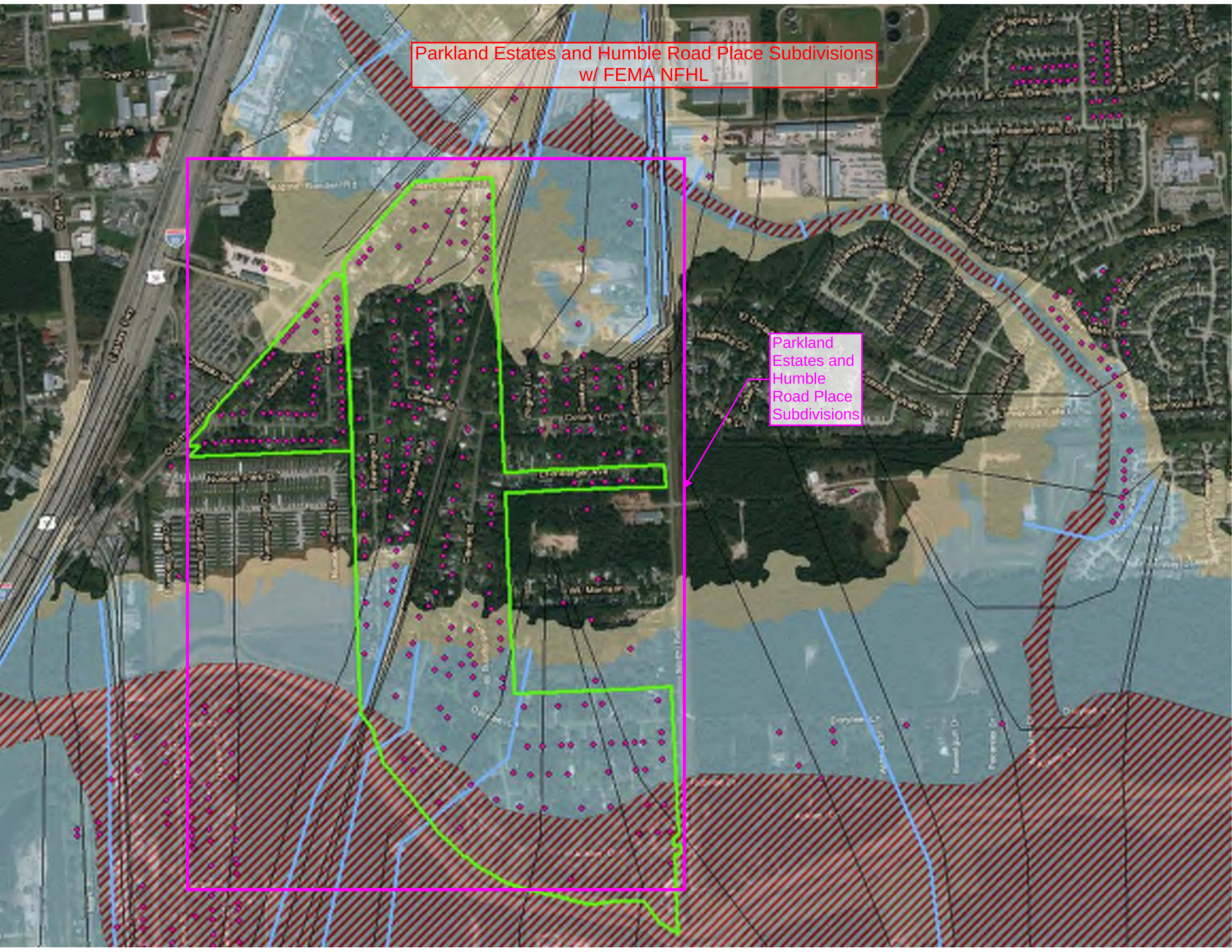
- Storm Sewer System:
    - Parkland Estates subdivision:
        - No As-Built plans were provided to show the design of the storm sewer system for the Parkland Estates subdivision.
        - Aerial imagery was examined thoroughly. The existing drainage system is assumed to be designed to the standards for when the development was built (not long after 1953).
        - One item that was noted during the examination of the aerial imagery is that the flow path of the water once it enters the roadside ditches could not be determined. The outlet for the water collected in the roadside ditches could not be found either. It is assumed that the vegetation in the area is obstructing our ability to find this outlet.
    - Humble Road Place Subdivision:
        - No As-Built plans were provided to show the design of the storm sewer system for the Humble Road Place subdivision.
        - Aerial imagery was examined thoroughly. The existing drainage system is assumed to be designed to the standards for when the development was built (not long after 1953).
        - One item that was noted during the examination of the aerial imagery is that the flow path of the water once it enters the roadside ditches could not be determined. The outlet for the water collected in the roadside ditches could not be found either. It is assumed that the vegetation in the area is obstructing our ability to find this outlet.
- Riverine Flooding Impacts:
    - Greens Bayou:
        - The north bank of Greens Bayou is approximately at elevation 57'.
        - Greens Bayou does overflow its banks during storms events that are less than a 100-Yr event.
    - Tributary to Greens Bayou:
        - The south bank of the tributary to Greens Bayou is approximately at elevation 63'.
        - The tributary to Greens Bayou has some overflow of its banks during storm events that are less than a 100-Yr event in this area. Downstream of Smith Road however, the overflow is much more contained until it feeds into Greens Bayou.
    - The majority of the flooded structures are in an area between Greens Bayou and the tributary to Greens Bayou. Much of this area is not shown as being in the 100-year or 500-year floodplain. However, it was apparent that the FIS model was based on older data and doesn't accurately depict the railroad and roadway high ground constrictions in the area. Therefore, a 2D HEC-RAS model was developed to better track the potential overflow. Exhibits showing the 2D model flooding patterns are attached. Results matched the reported flooding information well.
    - The main overflow point identified by 2D HEC-RAS occurs between the railroad tracks and Old Humble Road. The water sheet flows down the subdivision between the railroad and Old Humble Road until it drains into Greens Bayou approximately one-mile South.
    - This overflow is essentially shallow sheet flow in the range of 0 to 2 feet.
- H&H Analysis & Assumptions:
    - 2D model was created to analyze potential overflows and backwater impacts from Greens Bayou and the Tributary to Greens Bayou.
    - Because it was assumed that the enclosed systems were adequately designed, the 2D model only included the riverine flows, it did not model rainfall on mesh.
    - Lidar was utilized for the model terrain. The lidar data does not include channel bathymetry. Therefore, the channels shown in the model are smaller than the~~y~~ actual channels and would be a limitation of the 2D model. It is likely the impacts of this are negligible in the larger events but there may be some impacts to the model results for smaller events.
    - Manning's n-values for the channel used the same as the FEMA model.

- Upstream and Downstream boundary conditions for the model utilized FEMA model water surface elevations for the 50, 100, and 500 year events on Greens Bayou and FEMA model discharges for the Tributary to Greens Bayou.

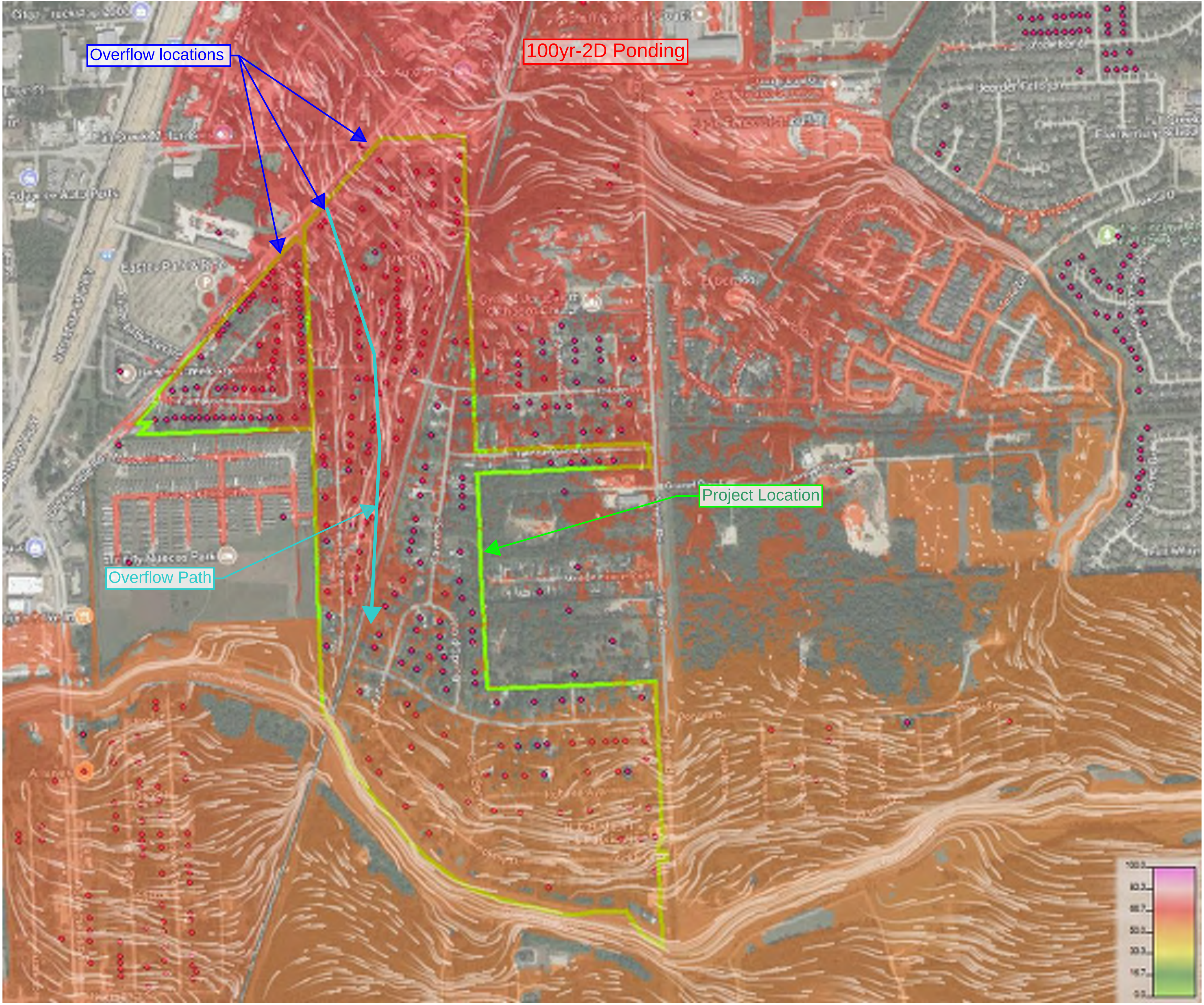
Existing Conditions Conclusion:

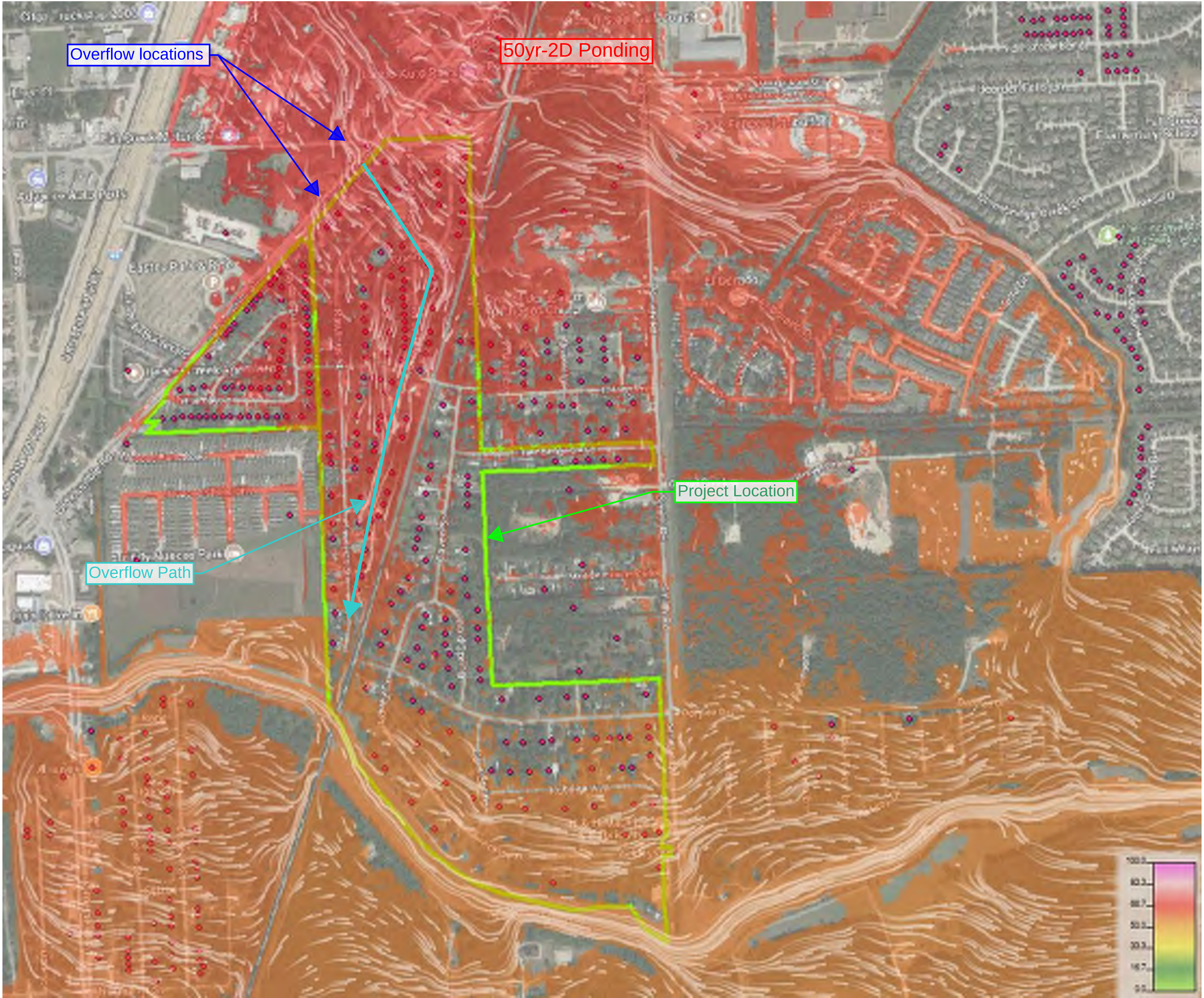
- After reviewing the FEMA models, NFHL Mapping, Damage Points, and High Water Elevations, it appears that this is not a localized drainage issue that would be remedied by constructing a detention pond or upsizing local drainage systems for the Parkland Estates subdivision or the Humble Road Place subdivisions.
- Instead, it appears that this area is inundated by overflow from the tributary to Greens Bayou that overflows its bank due to a constriction at the nearby railroad bridge and then enters the subdivisions. This was confirmed with the 2D model.
- Flooding only occurred during the Hurricane Harvey event. The event in this area was approximately a 100-Yr storm event.
- Based on models, this area is also impacted in the 50-Yr, 100-Yr, and 500-Yr events. See attached exhibits for existing 2D model ponding limits for each of these events.
- It appears that the project area is inundated with overflow from Greens Bayou Tributary that then travels South through the subdivisions between the railroad and Old Humble Road until it drains into Greens Bayou approximately one-mile South. This overflow into the subdivisions causes flooding and damage to the houses located in the developments.


Parkland Estates and Humble Road Place Subdivisions
w/ FEMA NFHL
Parkland
Estates and
Humble
Road Place
Subdivisions


Parkland Estates and Humble Road Place Subdivisions
w/ FEMA NFHL
Parkland Estates and Humble Road Place Subdivisions

500yr-2D Ponding
Overflow locations
Project Location
Overflow Path


Overflow locations
100yr-2D Ponding
Project Location
Overflow Path


Overflow locations
50yr-2D Ponding
Project Location
Overflow Path

Upper Greens Bayou - Smith Road Area HMGP Flood Mitigation Project,
Parkland Estates & Humble Road Place

July 13, 2018

Proposed Conditions

<u>HC Description:</u> Construct detention pond, construct underground trunk line and extreme event overflow. It was determined that the flooding source was not due to local drainage deficiencies; thus, simple localized storm water improvements would not suffice. Instead, it was determined that the flooding was due to overflow from the Tributary to Green Bayou (located between Upshaw Drive and Hamblen Drive, just east of I-69). From the 2D model of the existing conditions, it appears that the project area is inundated with overflow from Greens Bayou Tributary that then travels South through the subdivisions between the railroad and Old Humble Road until it drains into Greens Bayou approximately one-mile to the south. This overflow into the subdivisions causes flooding and damage to the houses located in the developments.

- 2D model was created to analyze potential overflows and backwater impacts from Greens Bayou and the Tributary to Greens Bayou.
- Because it was assumed that the enclosed systems were adequately designed, the 2D model only included the riverine flows, it did not model rainfall.
- Manning's n-values for the channel used the same as the FEMA model.
- Upstream and Downstream boundary conditions for the model utilized FEMA model water surface elevations for the 50, 100, and 500 year events on Greens Bayou and FEMA model discharges for the Tributary to Greens Bayou.

<u>Proposed Solution Alternatives and Findings:</u>

To try and eliminate the overflows into the Parkland Estates and Humble Road Place subdivisions, a berm is proposed along the Northern edge of the subdivision, as close to the subdivision as possible and within the County ROW where possible. See the image below to see the proposed berm alignment. The berm starts at the high ground along I-69 and runs easterly to Old Humble Road where it turns NE and crosses Aldine Bender Rd. It then runs East along the North edge of Aldine Bender Road and turns South just before the railroad tracks until it ties into the railroad high ground. It then runs East and terminates at Smith Road. This would require a small (approximately 6 inches) roadway raise at the intersection of Old Humble Road and Aldine Bender Road.

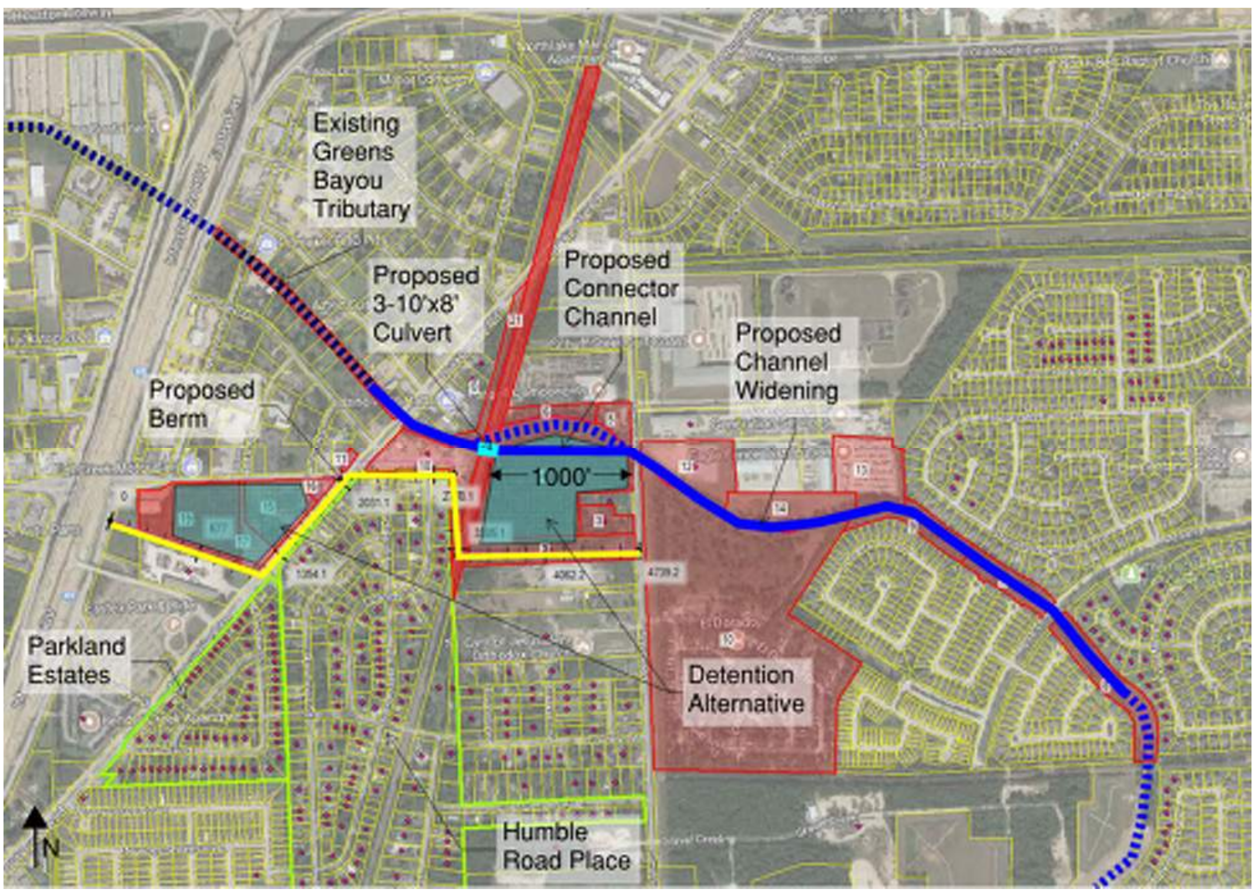
The berm was modeled to determine the impacts that it would have on surrounding properties. As suspected, blocking the overflows into the neighborhoods with a berm would cause a rise upstream and downstream of the berm. This is because the flow that was overtopping and diverting south now will have to proceed down the tributary until it's confluence with Greens Bayou. The average rise for each storm event by doing the berm only is listed below.

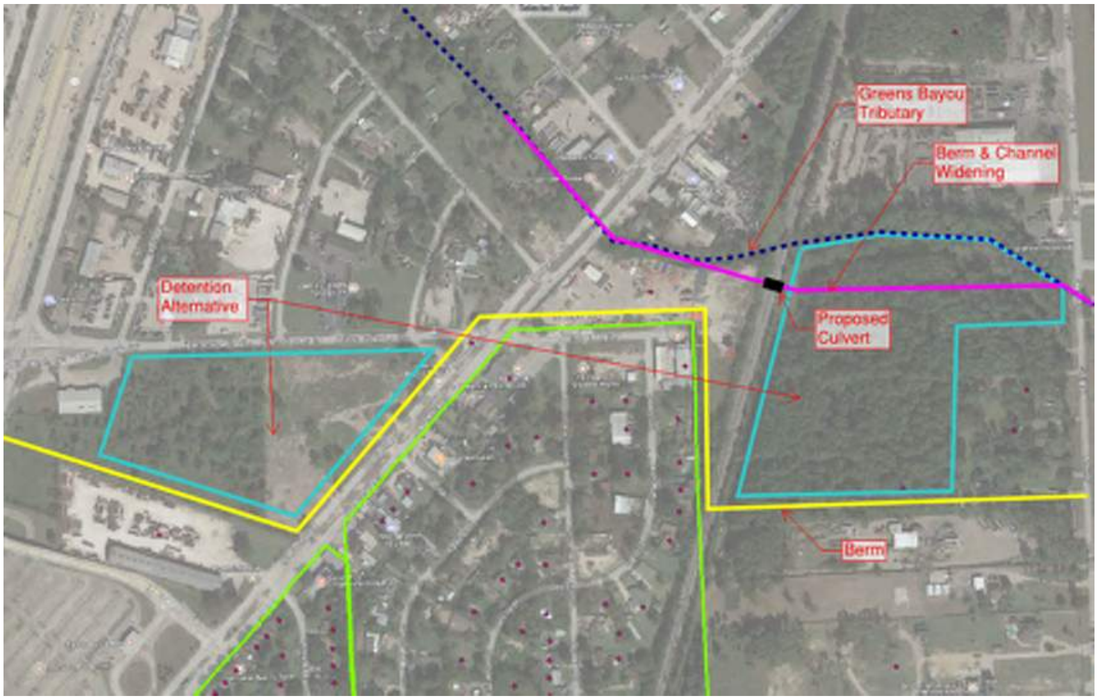
- 0.35' in the 50-Yr
- 0.45' in the 100-Yr
- 0.41' in the 500-Yr

Because additional improvements would be required to mitigate the rise due to the berm, several different solutions were considered. The selected solution and one alternative are listed below.

1. Selected Project – Construct the berm widen existing channel from 1000' north of Old Humble Road to 1000' south of Mesa Drive in conjunction with a connector channel and new drainage structure under the railroad.
2. Alternative Project – Construct the berm and excavate two large detention areas (not modeled). No channel widening would be done for the alternative project.

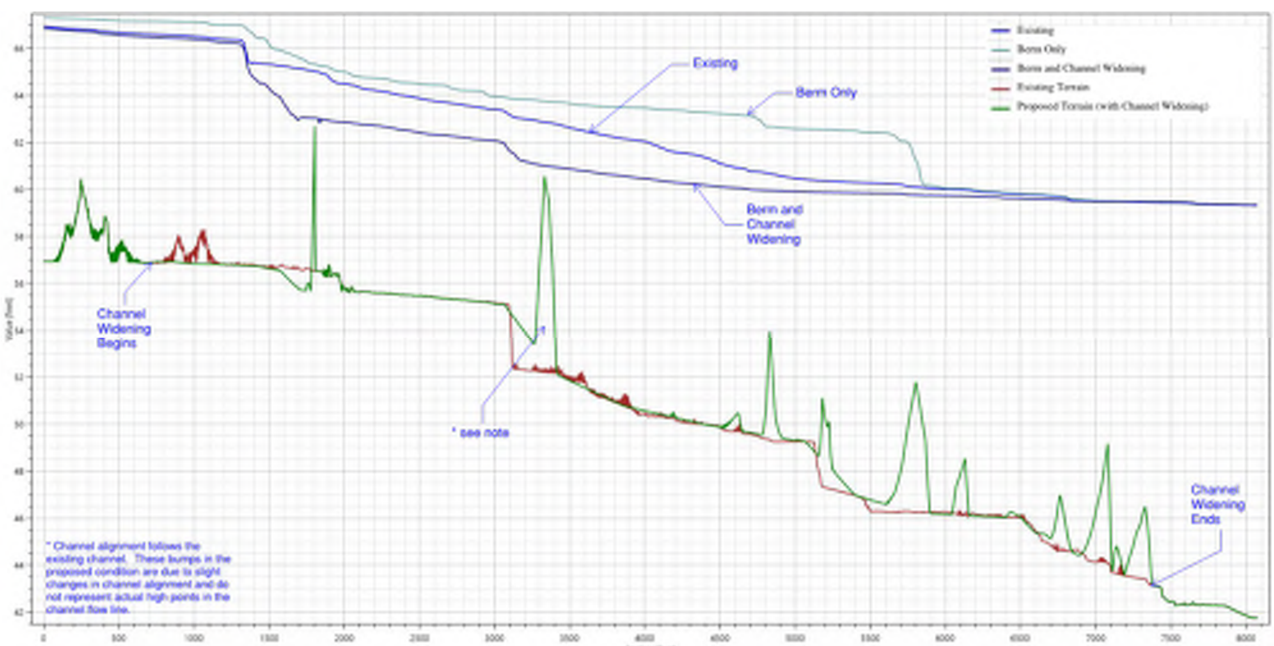
The exhibits below show where these two options are located.



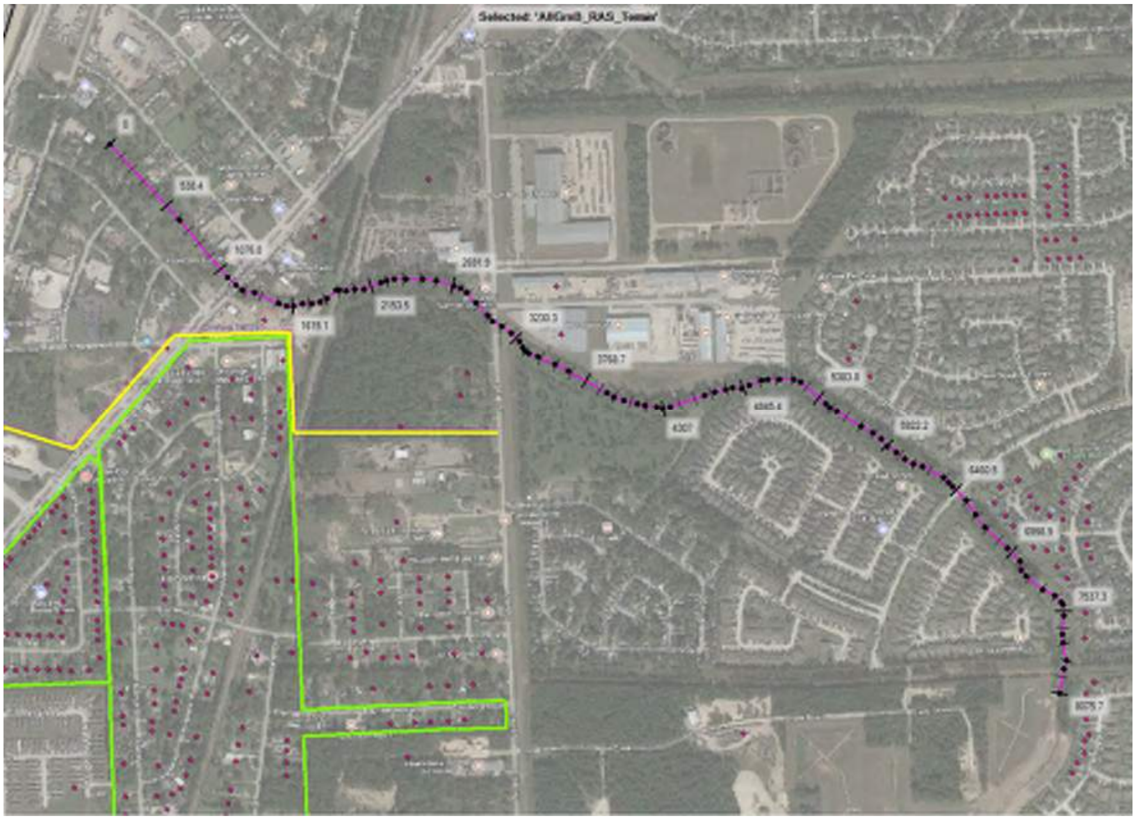


While a berm is a possible solution to the problem, the localized improvements that were looked at as part of this analysis cause negative impacts on other developments nearby (upstream, downstream, and on the other side of the channel). Numerous different alternatives were considered to try and mitigate the rise caused by the proposed berm. The localized improvements considered in those alternatives reduced the amount of rise, but did not fully mitigate it everywhere. The berm with channel widening solution was the only option that mitigating the rise caused by the berm. The detention option was considered as the alternative, but not modeled.

The 100-year water surface elevation model results are represented in the figure below. These numbers are intended to represent the water surface at the stream centerline, the water surface will vary spatially across the floodplain due to undulations in the topography. The dark blue line indicates the existing condition.



The image below shows the alignment of the water surface profile (shown above) within the project area.



Assumptions:

- No replacement of Old Humble Rd, RR, or Smith Rd bridges will be required. The openings through the bridges are roughly the same as the proposed channel. Some channel shaping may be needed, but it would be minor and require no bridge modifications.
- The connector channel between the RR and Smith Rd is needed to pull the flow away from the Forged Components property. It is possible that this portion of the existing channel could be widened as opposed to constructing the connector channel and culvert. This is considered a conservative assumption and can be value engineered during the next phase of design.
- Berm top width of 10'. Could possibly be narrower, and could provide roadway raise instead of to the side of the roads.
- More detailed data and modeling in the next phase of design could affect results. The proposed solution is intentionally conservative, as can be seen by comparing Option 2 to the Existing conditions in the above profile exhibit. Value engineering could reduce the size of the proposed channel widening to minimize the excavation while still achieving the desired benefit.

QUANTITIES

Berm:

- Channel widening improvement adjacent to Grand Parkway
  - 10' top
  - 3:1 side slopes
  - Height = 0.5'-4.5' (2.25' avg) (Deepest area at ditch along north side of Aldine Rd)

- Berm Length = 4,760’
- Berm XS Area = 38 sq ft / lft average yields 6,650 cu yd
    - Area = 2 x (0.5 x 6.75’ x 2.25’) + 10’ x 2.25’ = 38 sq ft
    - Volume = 38 sq ft x 4,760’ / 27 cu ft/cu yd = 6,650 cu yd
- **Total Fill = 6,650 cu yd**
- Drainage/Construction Easement, assume 30’ along the full corridor will be needed
    - 4,760’ x 30’ / 43,560 sf/ac = 3.3 acres

Storm Structures:

- 3-10'x8' RCB, 65 LF (under railroad)

Excavation:

- Channel widening improvement adjacent to Grand Parkway
    - 20' flat bottom
    - 2:1 side slopes (0’-5’ depth), 3:1 side slopes (+5’ depth)
    - Depth = 8’-12’ (10’ avg)
    - Upstream Channel Length = 1,000’ (upstream of RR)
    - Connector Channel Length = 1,200’ (between RR and Smith Rd)
    - Downstream Channel Length = 4,200’ (downstream of Smith Rd)
    - Upstream Channel Excavation = 95 sq ft / lft average yields 3,520 cu yd
        - See typical cross-section exhibits below for cut area
        - Volume = 95 sq ft x 1,000’ / 27 cu ft/cu yd = 3,520 cu yd
    - Connector Channel Excavation = 530 sq ft / lft average yields 23,560 cu yd
        - See typical cross-section exhibits below for cut area
        - Volume = 530 sq ft x 1,200’ / 27 cu ft/cu yd = 23,560 cu yd
    - Downstream Channel Excavation = 330 sq ft / lft average yields 51,340 cu yd
        - See typical cross-section exhibits below for cut area
        - Volume = 330 sq ft x 4,200’ / 27 cu ft/cu yd = 51,340 cu yd
    - **Total Excavation = 78,420 cu yd**
    - Drainage/Construction Easement, assume 60’ to 120’ (100’ average) along the channel widening corridor downstream of the railroad will be needed
        - (1200’+4200’) x 100’ / 43,560 sf/ac = 12.4 acres

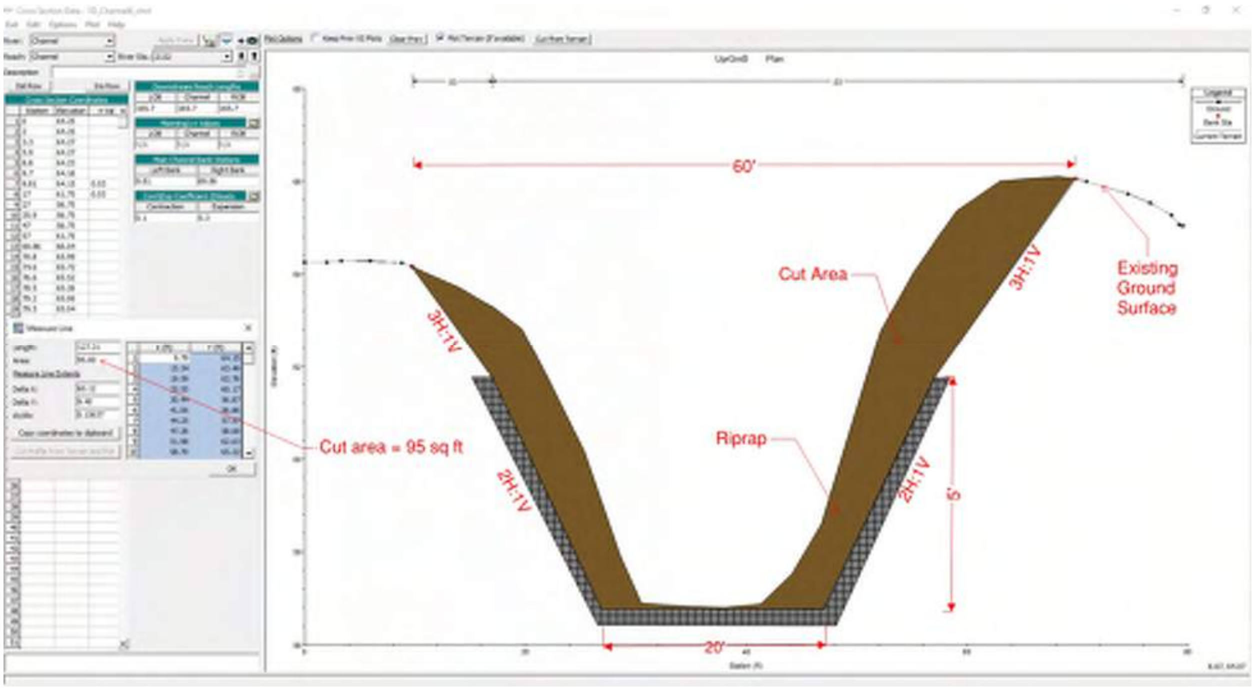
Slope Protection (riprap)

- 2:1 sideslopes
    - 20’ flat bottom, 40’ top width
    - Average depth 5’
    - Length 6,400’
    - Riprap Depth = 24” (D100=18”, VEL<6fps)
    - **Total Riprap = 19,000 cu yd (also equal to excavation required to install)**
        - 40’ x 6400’ x 2’ / 27 cu ft/cu yd = 19,000 cu yd

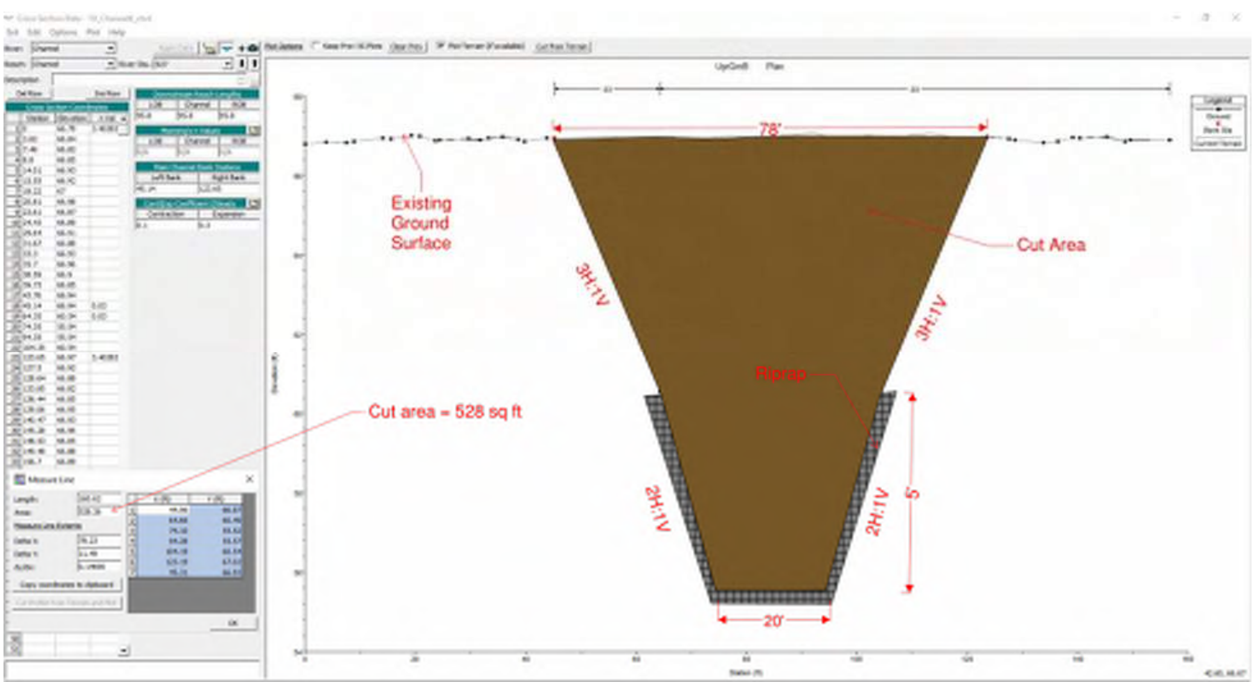
Affected Parcels:

- See parcel exhibit and table below

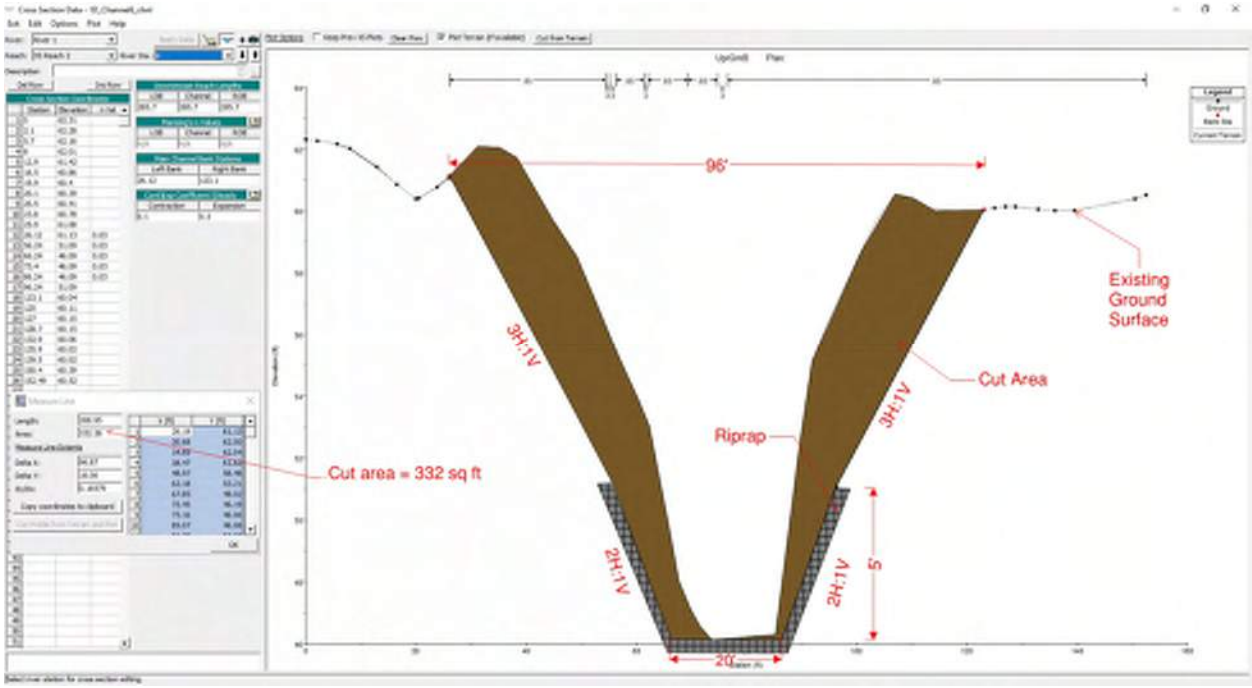
Upstream Channel XSEC (typical)



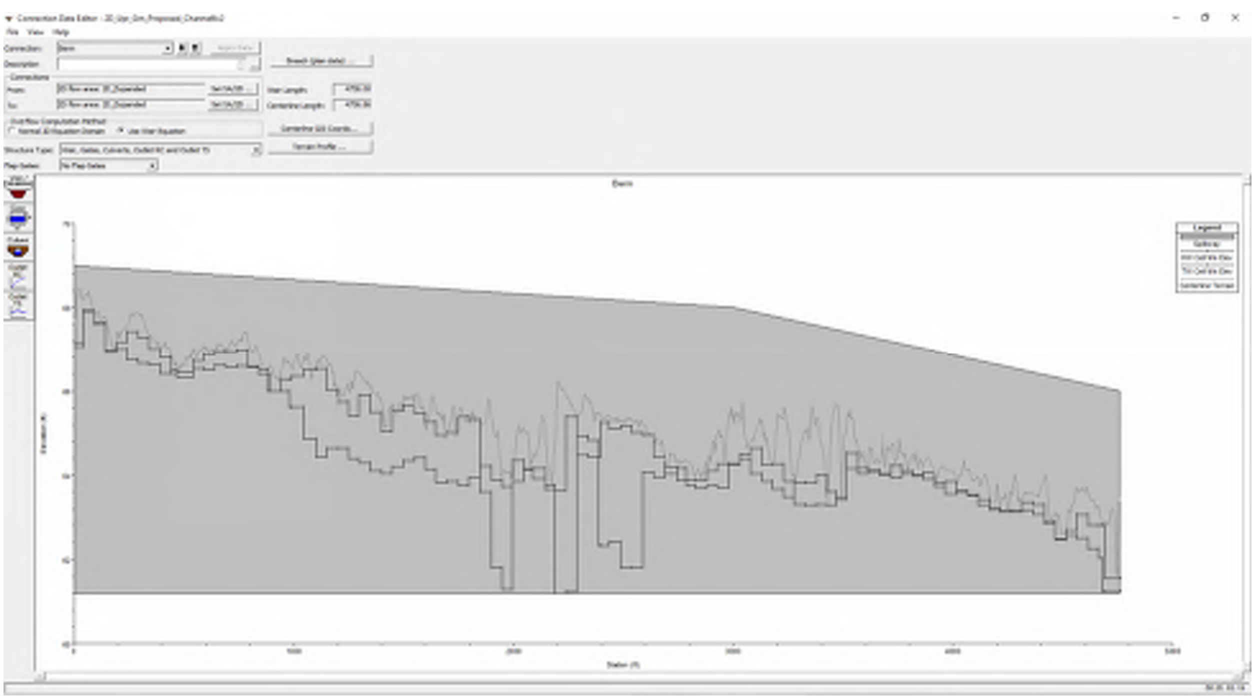
Connector Channel XSEC (typical)



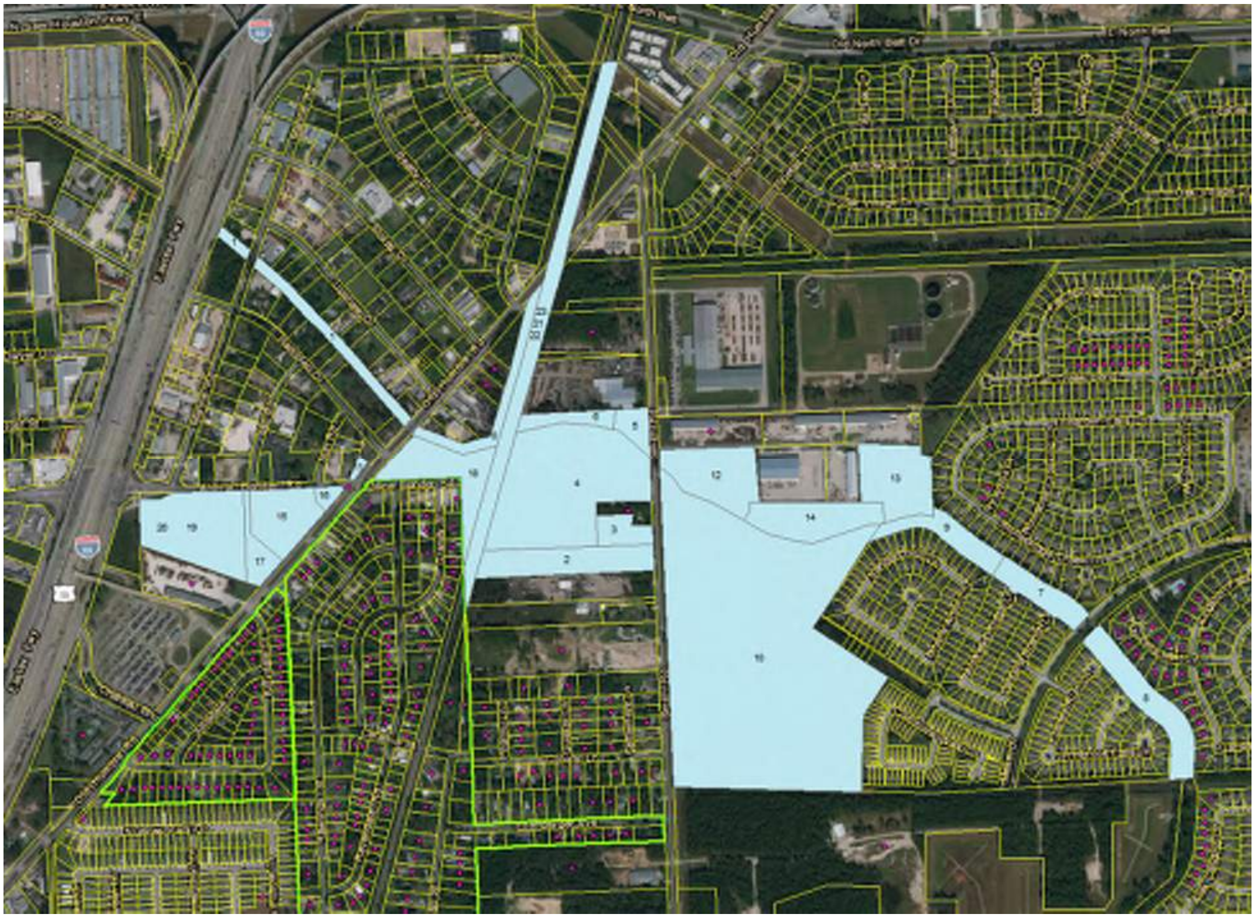
Downstream Channel XSEC (typical)



Berm Profile

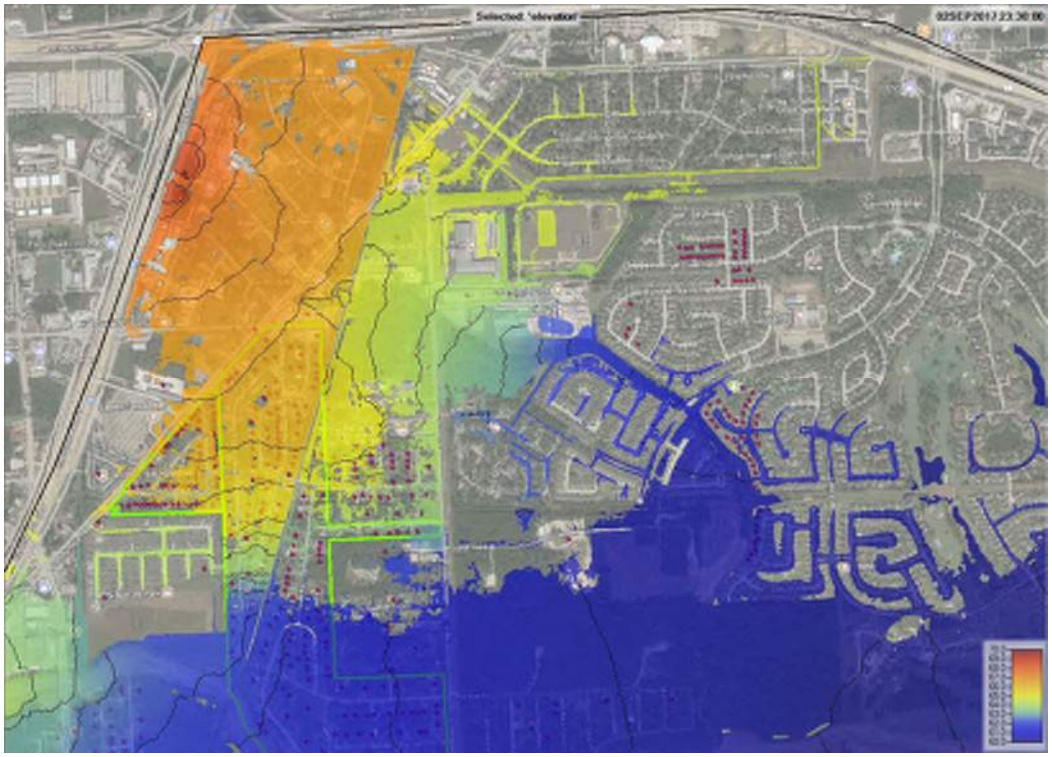


Parcels Potentially Impacted by Right-of-Way Takings and Easements

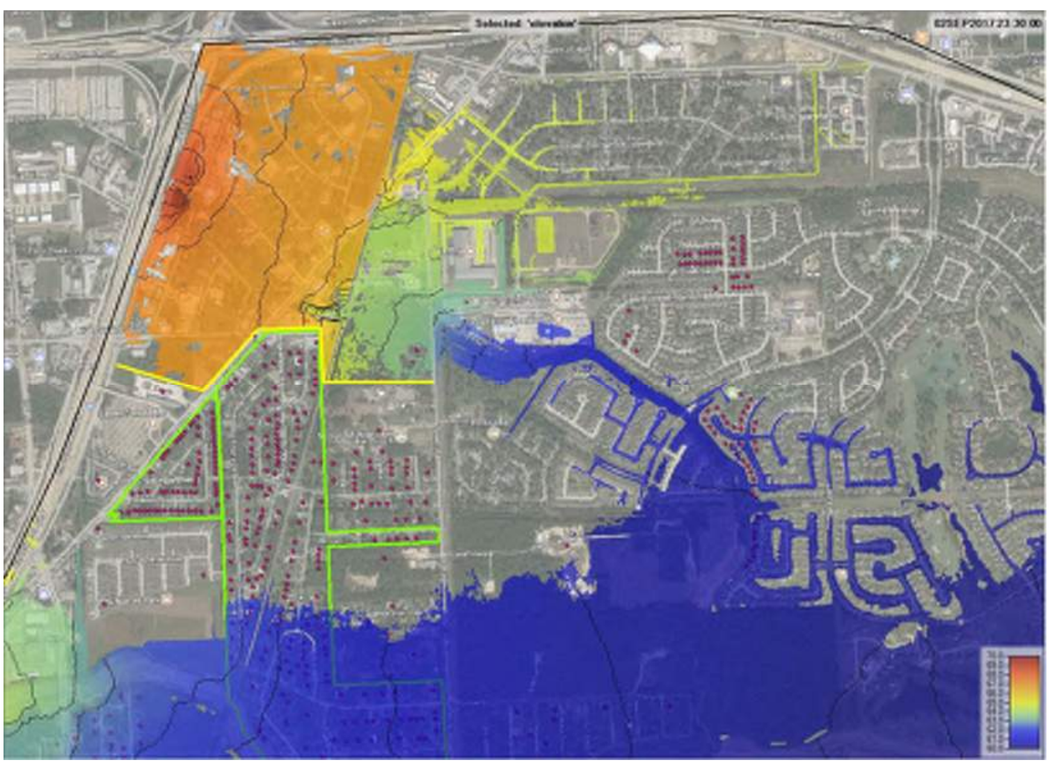


ID	OBJECTID	HCAD_NUM	City	Zip	LocName
0	15773	0710440210420	HUMBLE	77396	OLD HUMBLE
1	15938	0710440140342	HUMBLE	77396	EASTEX
2	18224	0451220000075	HUMBLE	77396	SMITH
3	18225	0451220000071	HUMBLE	77396	SMITH
4	18300	0451220000070	HUMBLE	77396	SMITH
5	18301	0451220000026	HUMBLE	77396	SMITH
6	18461	0451220000202	HUMBLE	77396	SMITH
7	19918	1293630010042	HUMBLE	77396	MESA
8	19922	1330050010070	HUMBLE	77396	MESA
9	19923	1294630010052	HUMBLE	77396	OFF STONEBRIDGE CREEK
10	19989	0441570010001	HUMBLE	77396	SMITH
11	20333	0710440200407	HUMBLE	77396	OLD HUMBLE
12	20371	1330900010004	HUMBLE	77396	SMITH (SETTEGAST)
13	20372	1330900010007	HUMBLE	77396	SMITH (SETTEGAST)
14	20505	1330900010001	HUMBLE	77396	SMITH (SETTEGAST)
15	21675	0440250000404	HUMBLE	77396	OLD HUMBLE
16	21676	0440250000385	HUMBLE	77396	ALDINE BENDER RD
17	21728	0440250000408			
18	21730	0710440210408	HUMBLE	77396	ALDINE BENDER
19	21855	0440250000376	HUMBLE	77396	OLD HUMBLE
20	21856	0440250000030	HUMBLE	77396	ALDINE BENDER
21	21878	0451220000152	HUMBLE	77396	RR PROPERTY
22	21879	0451220000150	HUMBLE	77396	R R PROPERTY
23	21880	0451220000151	HUMBLE	77396	R R PROPERTY

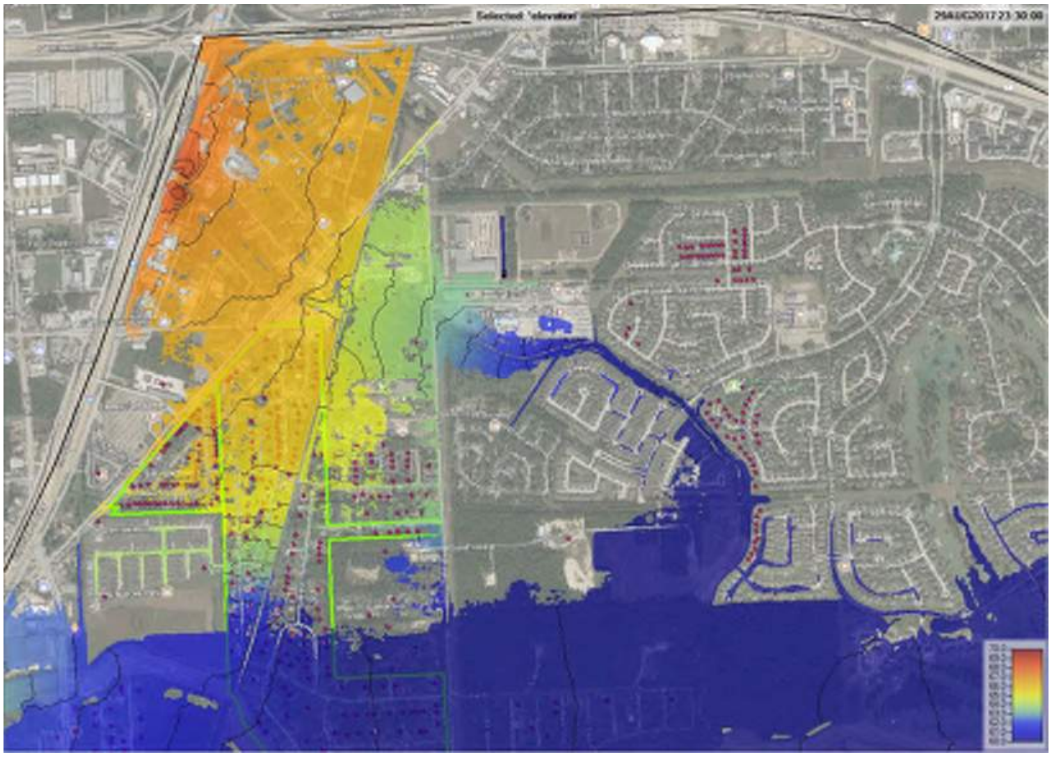
500yr Existing Condition Inundation Map



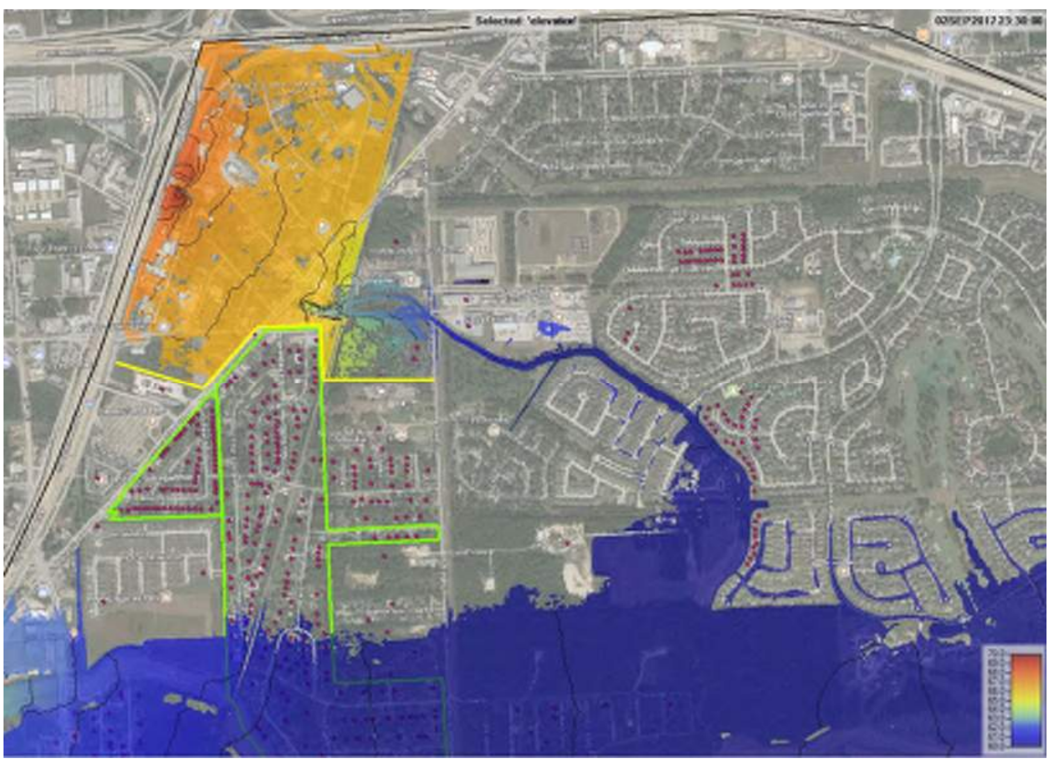
500yr Proposed Condition Inundation Map



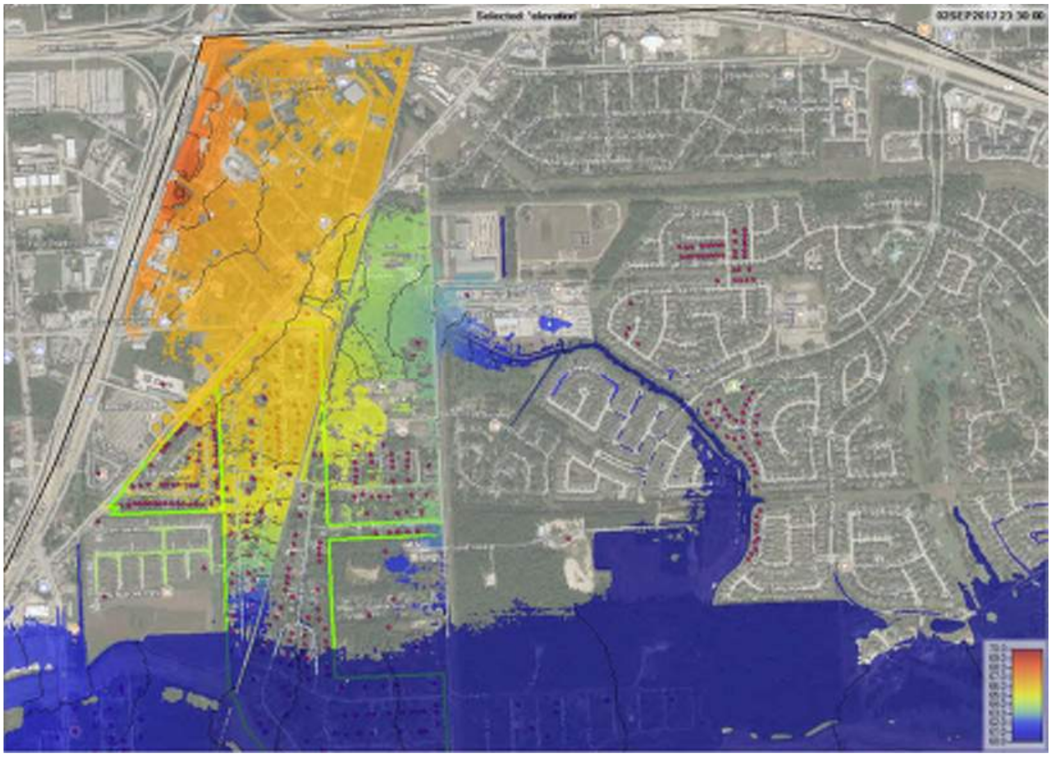
100yr Existing Condition Inundation Map



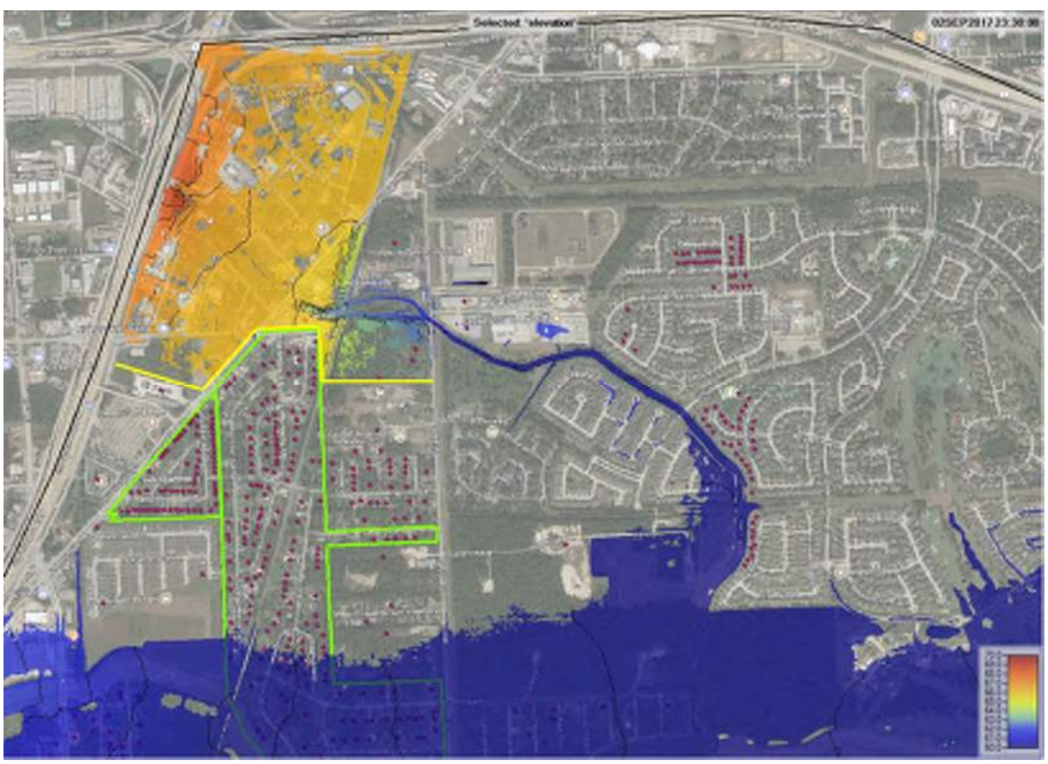
100yr Proposed Condition Inundation Map



50yr Existing Condition Inundation Map



50yr Proposed Condition Inundation Map



Appendix 5-4H:
San Jacinto Master Drainage Plan

APPENDIX 5-4H SJMDP

The San Jacinto Regional Master Drainage Plan report can be accessed at the following location.

Citation:

Halff Associates, Inc. & Freese and Nichols, Inc. "San Jacinto Regional Watershed Master Drainage Plan." 2020. Document.

Website:

https://www.hcfcd.org/Activity/Active-Projects/San-Jacinto-River/C-17-San-Jacinto-River-Watershed-Study

Appendix 5-4I:
Coastal Texas Protection and Restoration Feasibility Study

APPENDIX 5-4I COASTAL TEXAS PROTECTION AND RESTORATION FEASIBILITY STUDY FINAL REPORT

The Coastal Texas Protection and Restoration Feasibility Study Final Report can be accessed at the following location.

Citation:

USACE. “Coastal Texas Protection and Restoration Feasibility Study Final Report.” 2021. Document.

Website:

https://coastalstudy.texas.gov/draft-proposal/index.html

Appendix 5-4J: Houston Fifth Ward

FIFTH WARD MASTER DRAINAGE PLAN
TECHNICAL MEMORANDUM

CITY OF HOUSTON, TEXAS

WBS No. M-000100-0015-3 Work Order No. 21
CobbFendley Project No. 1311-013-21

STATE OF TEXAS
CANDYCE WARD
108949
LICENSED
PROFESSIONAL ENGINEER

10/9/2020

October 2020

Submitted By:
CobbFendley
Texas Registration No. 274

Civil Engineering ◆ Construction Management ◆ GIS/CADD ◆ Land Development ◆ Land Surveying
Municipal ◆ Right-of-Way ◆ Site Development ◆ Subsurface Utility Engineering
Hydraulics/Hydrology ◆ Telecommunications ◆ Transportation ◆ Utility Coordination

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Exhibits

1. Study Area Location and Description

The City of Houston (City) contracted with Cobb Fendley & Associates, Inc to perform an Existing Condition Analysis for the drainage systems associated with the area commonly referred to as the Greater Fifth Ward Super Neighborhood near downtown Houston. The study area is in City Council District B just northeast of downtown and can be found on Key Map grids 494A through 494L, see Exhibit 1 – Project Location Map.

Under the Capital Improvement Projects program, several areas of concern were identified as drainage concerns or as needing street repairs performed. As such, the City determined these were "Need Areas" and assigned individual project numbers to each. Drainage studies were performed for each of these Need Areas (M-2013-B01, N-2013L-B01, and N-2014L-B02), but an overall solution was not possible on an individual project basis. As such, this project combines those areas into what is now referred to as the Greater Fifth Ward Drainage Masterplan. As a drainage masterplan, it is now possible to combine the improvements associated with each individual area into a larger, more comprehensive, solution which serves the area with a regional solution, rather than having to obtain additional right-of-way (ROW) in order to have several small detention ponds scattered throughout the region.

The project location is primarily residential, comprised of single-family homes. The majority of drainage systems in the project location are comprised of concrete curb and gutter streets with underground storm sewer systems, but there are also a few areas with asphalt streets and roadside ditches. Buffalo Bayou (HCFCD Unit# W100-00-00) serves as the primary outfall location at 3 different locations.

2. Scope of Work

The purpose of this study is to review and evaluate existing conditions for the project area in order to facilitate solutions which will address the flooding problems. Specific tasks include

- Define the existing condition drainage area boundaries
- Identify existing drainage systems and outfall locations
- Develop drainage area map
- Determine hydrologic drainage parameters
- Perform existing condition drainage system capacity analysis
- Identify existing drainage problem locations

It should be noted that findings within this report are preliminary and were intended to find possible solutions to address the identified deficiencies. Any proposed improvements will be verified through a more detailed proposed condition analysis.

3. Methodology

3.1. Hydrology

The July 2019 City of Houston Infrastructure Design Manual was followed for the hydrologic analysis. The total study area is comprised of approximately 1,309 acres. Newly obtained LiDAR data for this project location was utilized to study the overland terrain allowing for identification of sheetflow patterns in order to determine drainage area boundaries. To perform hydrologic calculations, the rational method was used to calculate peak flow rates for the 2-, 10-, 100-, and 500-year Atlas-14 rainfall event using City of Houston Time of Concentration calculation. The calculated rational method drainage area peak flows were used to calibrate the flows for each rainfall event which were generated within runoff mode of the XP-SWMM model. The drainage area map is provided in Exhibit 2 and existing condition Hydrologic calculations are provided in Exhibit 3

3.2. Hydraulics

XP-SWMM models were created for the 2-, 10-, and 100-year rainfall events to simulate conveyance through interconnected drainage systems within the Greater Fifth Ward area. These XP-SWMM models are comprehensive models which allow interconnection of all drainage systems (roadside ditches, culverts, storm sewer trunks) with Buffalo Bayou as the primary outfall location. The drainage system network was created by utilizing collected survey data, City of Houston GIMS data, and as-built plan sets. The topographic survey was collected through the use of a new LiDAR data set with detailed high definition points to identify overland terrain as well as cross sectional roadside ditch details. Storm sewer manholes were identified from the LiDAR data and top of rim elevations were determined. Storm sewer sizing and flowline elevation was manually obtained via on-site measurements and observations. The outfall boundary condition for the XP-SWMM model utilized rating curves to establish the backwater effect on the drainage system at each outfall location. The rating curves utilize established water surface elevations for the various rainfall events with respect to expected flows for each event. For instance, the 2-year rainfall event utilizes the top of pipe elevation, the 10- and 100-year models utilize the 10- and 100-year water surface elevations and flows from the Effective FEMA HEC-RAS models.

4. Existing Condition

According to the Effective FEMA 100- and 500-year floodplain data (FEMA Floodplain Map Number 48201C0690N, Effective 1/6/2017), water surface elevations remain within the banks of Buffalo Bayou throughout the extents of the project area; therefore, the project is primarily located outside the 100-, and 500-year floodplains. However, the northern most portion of the project area is located within the Hunting Bayou 500-year floodplain. Although storm sewer systems within this area convey flow south towards Buffalo Bayou, the Hunting Bayou (north of the project location) 500-year water surface elevations reach as far south as the Southern Pacific Railroad as shown in Exhibit 4 – Floodplain map.

The existing storm sewer system ranges in size from 18” reinforced concrete pipes (RCPs) to 12’x 10’ reinforced concrete boxes (RCBs) and there is a small section of open channel where Ingraham Gully (HCFCD Unit# G122-00-00) was previously located, which was primarily enclosed in RCBs years ago.

Analysis of the existing storm sewer systems and roadside ditches (where applicable) indicated the majority of the existing drainage infrastructure within the project area is undersized and does not have adequate capacity to convey the 2-year Atlas 14 rainfall event to the outfall locations, resulting in significant street ponding in areas, see Exhibit 5 – Existing Condition Storm Sewer Layout. Compounded with the undersized drainage system, overland sheetflow is unable to be conveyed directly to the channel in some locations as well. Areas north of the railroad tracks are unable to convey overland sheetflow south towards Buffalo Bayou because the railroad tracks are elevated and act similar to a dam, preventing flow further south. As such, water is stored above ground until it can either enter the storm sewer system/culverts under the tracks or reaches an elevation in which it eventually flows north into Hunting Bayou. As shown in Exhibit 6A, B and C –2-, 10- 100-year Overland Ponding Map respectively, there is significant ponding north of the railroad tracks and along the historical flow path of what used to be Ingraham Gully. Coincidentally, these ponding areas identified on the overland ponding map coincide with the majority of the repetitive loss claims.

5. Proposed Condition

The proposed project was developed to encompass the four project areas included in this assessment, M-2013-B01, N-2013L-B01, M-2017-TDO03, and N-2014L-B02, along with any additional area that would logically drain to the proposed storm sewer. This solution was selected because it addresses the extreme event sheet flow deficiencies and uses a continuous trunk throughout the entire project area. The proposed storm sewer system, which largely runs along Gregg St, will have sufficient capacity to convey the 2-year rainfall event and keep the extreme event contained within the ROW along the proposed storm sewer trunkline, see Exhibit 7A, B, C, D, and E, – Proposed Ponding Maps. This proposed storm sewer trunk will provide relief necessary for the undersized pipes in the north side of the project area. The proposed storm sewer ranges in size from a 54" RCP at the upstream end to 3 – 11' x 10' RCBs at the outfall, see Exhibit 8. The roadways required to be reconstructed to install the proposed storm sewer, will be replaced with equivalent sections to the existing condition.

For constructability, this proposed project has been broken in to 4 sub-projects, see Exhibit 8. The sub-projects are ordered from downstream to upstream. The first sub-project is from the outfall to Buffalo Bayou to just north of IH-10. The second sub-project continues from the end of sub-project 1 and ends just north of the railroad. The third sub-project includes the remaining portion north of the railroad. The fourth sub-project is located just east of sub-project 2.

The proposed project has a combined overall cost of $67,193,376, see Exhibit 9 for a per sub-project cost. The proposed project reduces the length of impassible streets in the 100-year by 9.29 miles, reduced the risk of flooding in the 100-year for 915 structures, see Exhibit 10 for a Benefitted Population Map.

6. Mitigation Analysis

In order to determine if the project had an adverse impact to Buffalo Bayou, the increase in flow from the proposed project was incorporated in to the effective HEC-HMS and HEC-RAS models. Since the proposed project was analyzed using Atlas-14 and the effective HEC-HMS and HEC-RAS models have not yet been updated, the difference between the existing and propose XP-SWMM hydrographs was input in to the effective HEC-HMS model to determine if the project caused the flows in Buffalo Bayou to increase.

The proposed project is located in the most downstream basin in the effective HEC-HMS model, sub-basin W100O, which has a 100-year (TP-40) peak flow of 5,230 cfs and peaks at Day 1 18:30. Just upstream of the tie in with this sub basin, Buffalo Bayou has a peak flow of 59,034 and peaks at Day 2 2:15. Downstream of the tie in, the peak flow is 61,636 and peaks at Day 2 1:45.

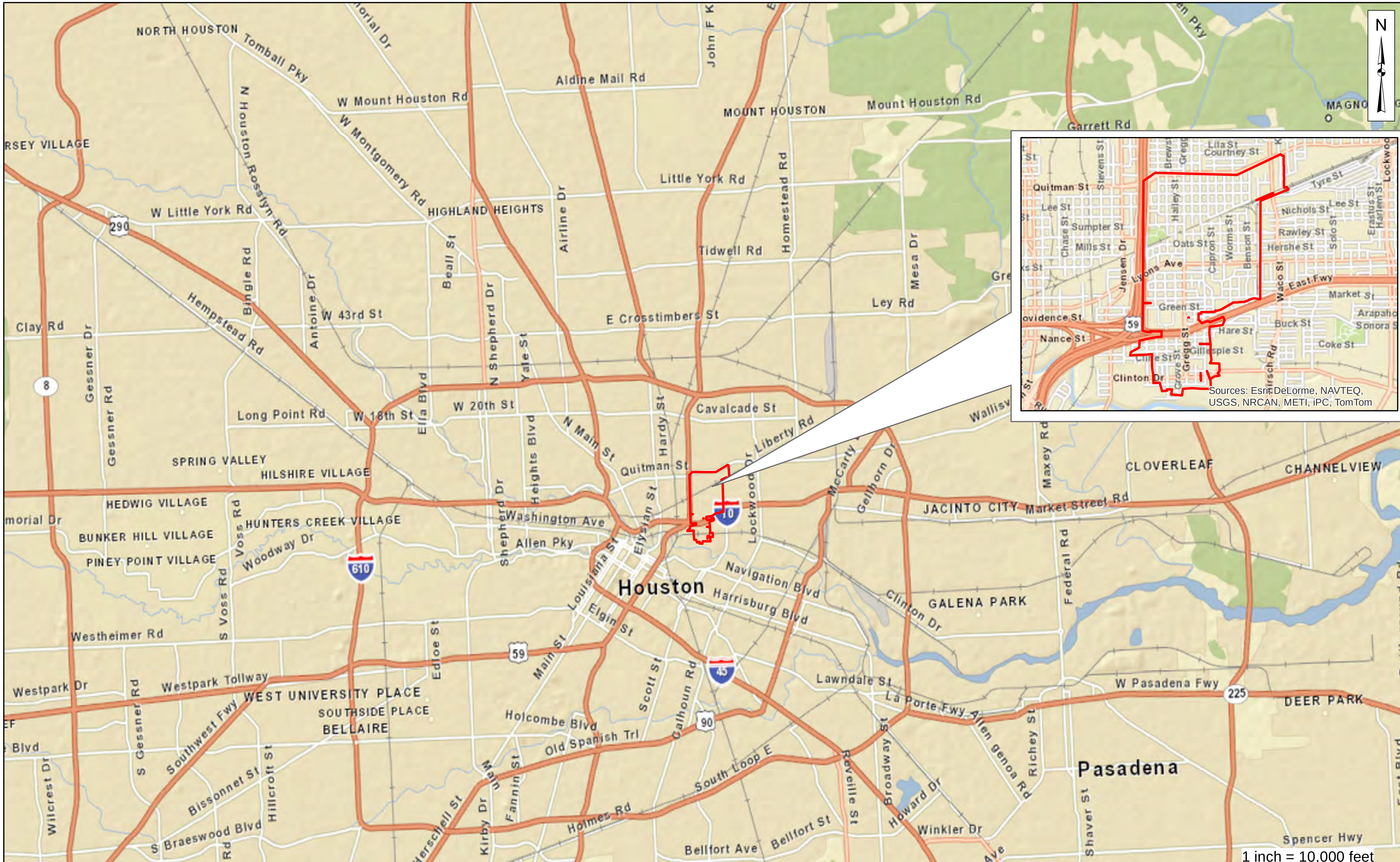
The proposed project allows the area to drain more effectively, which increases peak flow and causes the area to peak earlier. When taking the proposed project in to account, sub basin W100O has a proposed peak flow of 6,064 and peaks at Day 1 18:00, an increase of 834 cfs. When combined with the mainsteam of Buffalo Bayou, which is unchanged from the existing condition, Buffalo Bayou downstream of the tie in with W100O has a peak flow of 61,306 and peaks at Day 2 2:00, a decrease of 330 cfs. This shows that the proposed project does not increase the peak flows along the mainsteam of Buffalo Bayou.

Additionally, any detention that was included in the proposed storm sewer system delayed the peak, which causes it to negatively affect the flows in Buffalo Bayou. If detention is included in this project, it would be more effective along Buffalo Bayou and not included as part of the proposed storm sewer system.

7. Additional Considerations

It is noteworthy to mention that this project location is immediately adjacent to the Texas Department of Transportation's North Houston Highway Improvement Project (NHHIP) which is currently under design. The NHHIP project is intended to relocate Interstate 45 so that it no longer passes directly through downtown Houston but will divert towards the east side of downtown and merge with US-69. It should also be noted that the current IH-10 storm sewer system does not have any connections with the City of Houston storm sewer system in this area. Drainage improvements recommended in the proposed condition analysis should include consideration for this future construction to ensure the recommendations do not negatively impact the progress of the future freeway construction. See Exhibit 11 – TxDOT NHHIP Schematic

Recommended improvements resulting from the proposed condition analysis could potentially result in negative impacts to Buffalo Bayou, either by increased flow to the Bayou or increased water surface elevations. Typically, detention ponds are recommended to mitigate these types of impacts. It should be noted that there is a potential Superfund Site (See Exhibit 12 – Superfund Sites) in the general vicinity and additional research should be performed to determine if there is contamination prior to deciding where to locate the detention facilities if deemed necessary.



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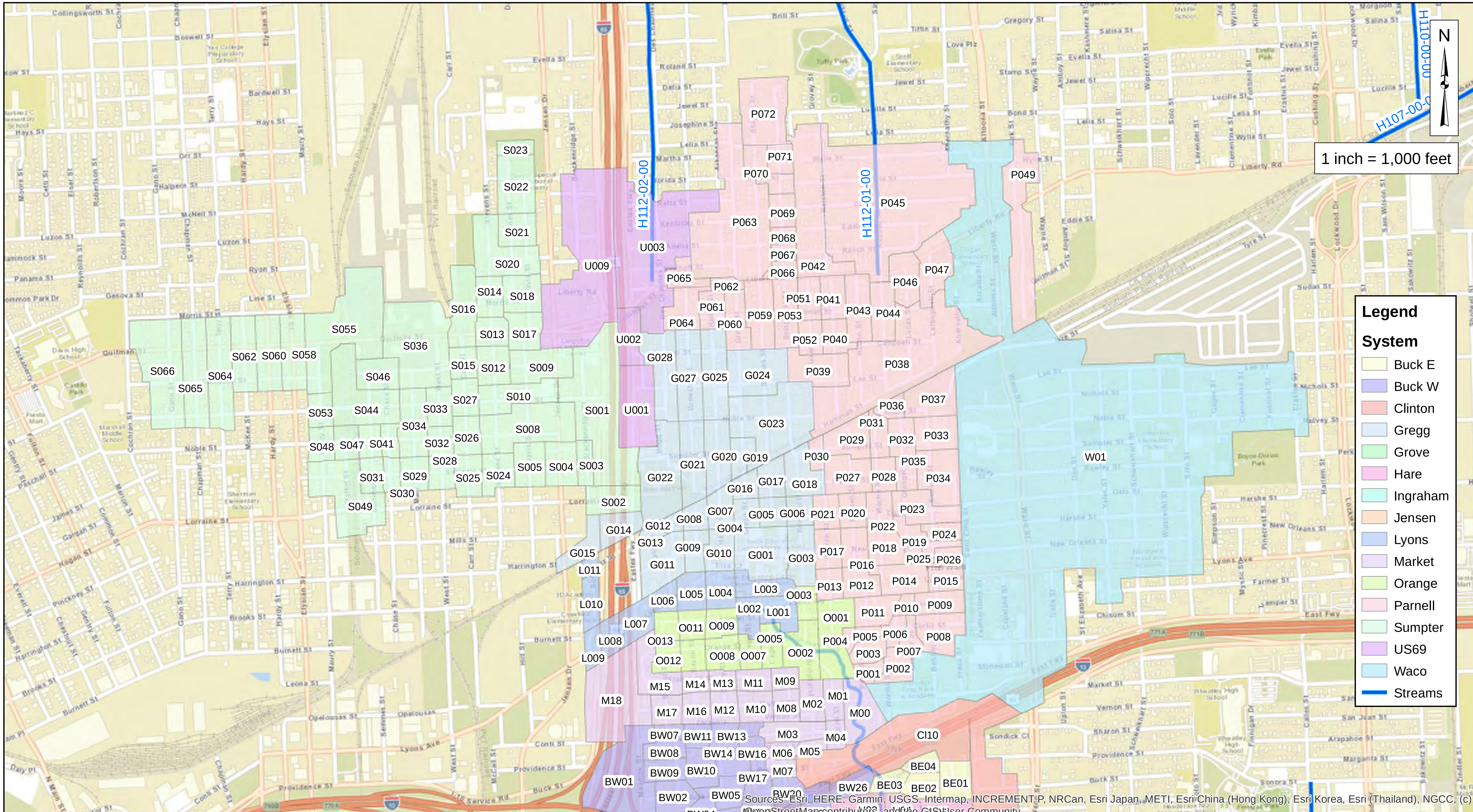
Fifth Ward Master Drainage Plan
Project Location Map

Date: April 2020	EXHIBIT 1



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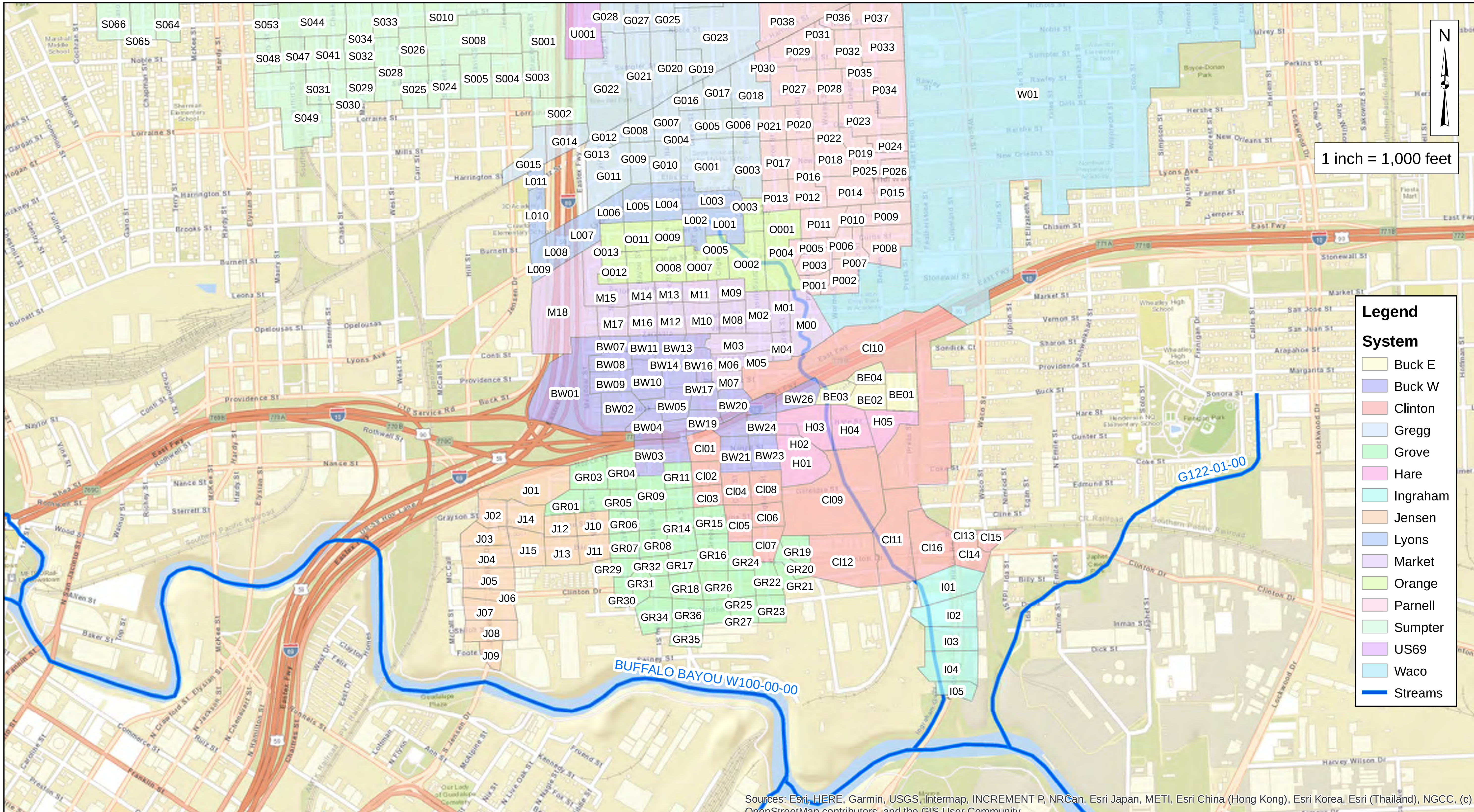
5th Ward Drainage Masterplan
Drainage Area Map North

Date: April 2020

EXHIBIT 2A



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5th Ward Drainage Masterplan
Drainage Area Map South

Date: April 2020	**EXHIBIT 2B**

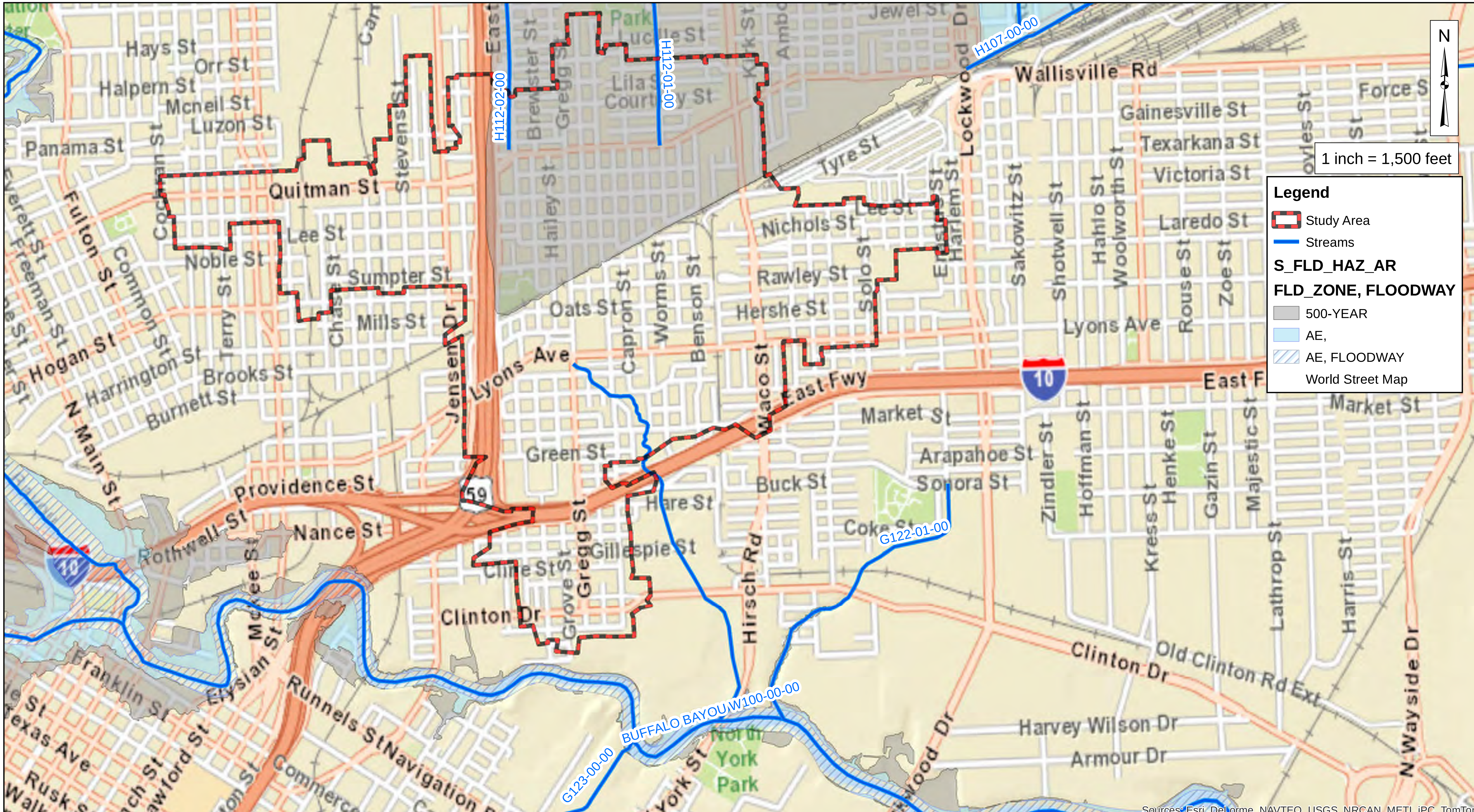
EXHIBIT 3 - Existing Condition Hydrologic Calculations

OUTFALL	Drainage Area	Area (acre)	Tc (min)	C	%IMP	2 year Intensity I (in/hr)	2 year Flow Q (cfs)	5 year Intensity I (in/hr)	5 year Flow Q (cfs)	10 year Intensity I (in/hr)	10 year Flow Q (cfs)	25 year Intensity I (in/hr)	25 year Flow Q (cfs)	50 year Intensity I (in/hr)	50 year Flow Q (cfs)	100 year Intensity I (in/hr)	100 year Flow Q (cfs)
Buck E	BE01	3.05	27.17	0.45	41.67	3.59	4.93	4.50	6.17	5.28	7.25	6.39	8.78	7.29	10.01	8.19	11.25
Buck E	BE02	2.27	26.55	0.35	25.00	3.63	2.88	4.55	3.61	5.34	4.24	6.47	5.14	7.37	5.85	8.29	6.58
Buck E	BE03	1.80	26.09	0.35	25.00	3.67	2.31	4.59	2.90	5.39	3.40	6.53	4.11	7.44	4.69	8.36	5.27
Buck E	BE04	1.49	25.72	0.45	41.67	3.70	2.47	4.63	3.09	5.43	3.63	6.57	4.39	7.49	5.01	8.42	5.63
Buck W	BW01	11.97	30.48	0.80	100.00	3.37	32.25	4.22	40.45	4.96	47.53	6.02	57.63	6.87	65.80	7.73	74.05
Buck W	BW02	3.53	27.49	0.65	75.00	3.57	8.19	4.47	10.26	5.25	12.04	6.35	14.59	7.25	16.64	8.15	18.70
Buck W	BW03	2.61	26.84	0.55	58.33	3.61	5.18	4.53	6.49	5.31	7.61	6.43	9.22	7.33	10.51	8.24	11.82
Buck W	BW04	2.19	26.48	0.65	75.00	3.64	5.18	4.56	6.48	5.35	7.61	6.48	9.21	7.38	10.51	8.30	11.81
Buck W	BW05	2.72	26.92	0.65	75.00	3.61	6.37	4.52	7.98	5.30	9.37	6.42	11.34	7.32	12.93	8.23	14.54
Buck W	BW06	1.12	25.20	0.80	100.00	3.74	3.35	4.68	4.20	5.49	4.92	6.64	5.96	7.57	6.79	8.50	7.63
Buck W	BW07	1.16	25.26	0.35	25.00	3.73	1.51	4.67	1.90	5.48	2.22	6.63	2.69	7.56	3.07	8.49	3.45
Buck W	BW08	1.98	26.28	0.65	75.00	3.65	4.70	4.58	5.89	5.37	6.91	6.50	8.37	7.41	9.54	8.33	10.72
Buck W	BW09	2.30	26.58	0.65	75.00	3.63	5.43	4.55	6.81	5.34	7.99	6.46	9.67	7.37	11.03	8.28	12.39
Buck W	BW10	2.94	27.09	0.65	75.00	3.59	6.86	4.50	8.59	5.29	10.09	6.40	12.21	7.30	13.93	8.21	15.66
Buck W	BW11	1.60	25.87	0.65	75.00	3.69	3.84	4.62	4.81	5.42	5.64	6.56	6.83	7.47	7.79	8.40	8.75
Buck W	BW12	0.98	24.97	0.65	75.00	3.76	2.40	4.70	3.00	5.52	3.52	6.68	4.26	7.61	4.85	8.54	5.45
Buck W	BW13	1.33	25.51	0.65	75.00	3.71	3.21	4.65	4.02	5.45	4.71	6.60	5.70	7.52	6.50	8.45	7.30
Buck W	BW14	1.74	26.03	0.65	75.00	3.67	4.16	4.60	5.21	5.40	6.11	6.53	7.40	7.45	8.43	8.37	9.47
Buck W	BW15	0.77	24.54	0.45	41.67	3.79	1.31	4.74	1.63	5.57	1.92	6.73	2.32	7.67	2.64	8.62	2.97
Buck W	BW16	1.82	26.12	0.65	75.00	3.67	4.34	4.59	5.44	5.39	6.38	6.52	7.73	7.44	8.81	8.36	9.90
Buck W	BW17	1.84	26.13	0.65	75.00	3.66	4.38	4.59	5.49	5.39	6.44	6.52	7.80	7.43	8.89	8.35	9.99
Buck W	BW18	1.58	25.83	0.65	75.00	3.69	3.78	4.62	4.73	5.42	5.55	6.56	6.72	7.48	7.66	8.40	8.60
Buck W	BW19	1.74	26.02	0.65	75.00	3.67	4.15	4.60	5.19	5.40	6.09	6.54	7.38	7.45	8.41	8.37	9.45
Buck W	BW20	2.01	26.31	0.55	58.33	3.65	4.03	4.57	5.05	5.37	5.92	6.50	7.17	7.41	8.18	8.33	9.19
Buck W	BW21	2.63	26.86	0.45	41.67	3.61	4.28	4.52	5.36	5.31	6.29	6.43	7.61	7.33	8.68	8.24	9.76
Buck W	BW22	1.48	25.71	0.80	100.00	3.70	4.37	4.63	5.48	5.43	6.43	6.58	7.78	7.49	8.86	8.42	9.96
Buck W	BW23	2.54	26.78	0.35	25.00	3.62	3.22	4.53	4.03	5.32	4.73	6.44	5.73	7.34	6.53	8.25	7.34
Buck W	BW24	1.61	25.87	0.65	75.00	3.68	3.85	4.61	4.82	5.42	5.65	6.56	6.84	7.47	7.80	8.40	8.76
Buck W	BW25	1.24	25.38	0.80	100.00	3.72	3.68	4.66	4.61	5.47	5.41	6.62	6.55	7.54	7.47	8.47	8.39
Buck W	BW26	2.34	26.62	0.65	75.00	3.63	5.53	4.55	6.93	5.33	8.13	6.46	9.84	7.36	11.22	8.28	12.61
Clinton	Cl01	2.41	26.67	0.65	75.00	3.62	5.67	4.54	7.11	5.33	8.34	6.45	10.10	7.36	11.51	8.27	12.94
Clinton	Cl02	1.79	26.08	0.45	41.67	3.67	2.95	4.60	3.70	5.39	4.34	6.53	5.25	7.44	5.99	8.36	6.73
Clinton	Cl03	1.60	25.86	0.45	41.67	3.69	2.65	4.62	3.32	5.42	3.90	6.56	4.72	7.47	5.38	8.40	6.04
Clinton	Cl04	2.38	26.65	0.55	58.33	3.63	4.75	4.54	5.95	5.33	6.98	6.46	8.45	7.36	9.63	8.27	10.83
Clinton	Cl05	2.38	26.65	0.65	75.00	3.63	5.60	4.54	7.02	5.33	8.23	6.46	9.97	7.36	11.37	8.27	12.77
Clinton	Cl06	1.86	26.15	0.45	41.67	3.66	3.06	4.59	3.83	5.38	4.50	6.52	5.44	7.43	6.21	8.35	6.97
Clinton	Cl07	2.37	26.64	0.65	75.00	3.63	5.59	4.54	7.00	5.33	8.21	6.46	9.94	7.36	11.34	8.27	12.74
Clinton	Cl08	2.62	26.85	0.35	25.00	3.61	3.31	4.53	4.14	5.31	4.86	6.43	5.89	7.33	6.72	8.24	7.55
Clinton	Cl09	17.40	31.54	0.18	0.00	3.30	10.35	4.15	12.98	4.87	15.26	5.91	18.51	6.75	21.14	7.60	23.80
Clinton	Cl10	38.56	34.02	0.50	50.00	3.17	61.02	3.97	76.63	4.68	90.13	5.68	109.44	6.49	125.09	7.31	140.97
Clinton	Cl11	8.36	29.53	0.45	41.67	3.43	12.90	4.30	16.17	5.05	19.00	6.12	23.03	6.98	26.28	7.86	29.57
Clinton	Cl12	8.40	29.55	0.80	100.00	3.43	23.03	4.30	28.87	5.05	33.91	6.12	41.11	6.98	46.92	7.86	52.79
Clinton	Cl13	0.29	23.06	0.90	100.00	3.92	1.04	4.90	1.30	5.75	1.52	6.95	1.84	7.91	2.09	8.88	2.35
Clinton	Cl14	2.53	26.77	0.80	100.00	3.62	7.31	4.53	9.16	5.32	10.75	6.44	13.02	7.34	14.84	8.25	16.68
Clinton	Cl15	1.36	25.56	0.80	100.00	3.71	4.05	4.64	5.07	5.45	5.95	6.60	7.20	7.52	8.21	8.44	9.22
Clinton	Cl16	5.78	28.62	0.45	41.67	3.49	9.07	4.37	11.37	5.13	13.35	6.22	16.17	7.10	18.45	7.98	20.75
GREGG	G001	2.86	27.03	0.45	41.67	3.60	4.63	4.51	5.80	5.29	6.80	6.41	8.24	7.31	9.40	8.21	10.56
GREGG	G002	2.85	27.03	0.45	41.67	3.60	4.62	4.51	5.79	5.29	6.80	6.41	8.23	7.31	9.38	8.21	10.55
GREGG	G003	3.02	27.15	0.45	41.67	3.59	4.88	4.50	6.11	5.28	7.17	6.39	8.69	7.29	9.91	8.20	11.14
GREGG	G004	1.89	26.19	0.45	41.67	3.66	3.12	4.58	3.91	5.38	4.58	6.51	5.55	7.43	6.33	8.34	7.11
GREGG	G005	1.99	26.28	0.45	41.67	3.65	3.27	4.58	4.09	5.37	4.80	6.50	5.81	7.41	6.62	8.33	7.44
GREGG	G006	1.99	26.29	0.45	41.67	3.65	3.27	4.58	4.10	5.37	4.81	6.50	5.83	7.41	6.64	8.33	7.47
GREGG	G007	2.65	26.87	0.45	41.67	3.61	4.31	4.52	5.40	5.31	6.33	6.43	7.67	7.33	8.75	8.24	9.83
GREGG	G008	1.72	26.00	0.45	41.67	3.67	2.85	4.60	3.57	5.40	4.18	6.54	5.06	7.45	5.77	8.37	6.49
GREGG	G009	2.29	26.57	0.45	41.67	3.63	3.74	4.55	4.69	5.34	5.50	6.47	6.66	7.37	7.59	8.28	8.54
GREGG	G010	3.05	27.17	0.45	41.67	3.59	4.93	4.50	6.18	5.28	7.25	6.39	8.78	7.29	10.02	8.19	11.26
GREGG	G011	5.44	28.47	0.45	41.67	3.50	8.56	4.38	10.73	5.15	12.60	6.24	15.26	7.12	17.41	8.00	19.58
GREGG	G012	1.03	25.06	0.45	41.67	3.75	1.74	4.69	2.18	5.51	2.56	6.66	3.10	7.59	3.53	8.53	3.97
GREGG	G013	0.98	24.96	0.45	41.67	3.76	1.66	4.70	2.07	5.52	2.43	6.68	2.94	7.61	3.35	8.54	3.77
GREGG	G014	2.96	27.11	0.80	100.00	3.59	8.52	4.50	10.67	5.28	12.53	6.40	15.17	7.30	17.30	8.20	19.45
GREGG	G015	2.75	26.95	0.45	41.67	3.60	4.46	4.52	5.59	5.30	6.56	6.42	7.95	7.32	9.06	8.23	10.18
GREGG	G016	1.64	25.92	0.45	41.67	3.68	2.72	4.61	3.41	5.41	4.00	6.55	4.85	7.46	5.53	8.39	6.21
GREGG	G017	2.56	26.80	0.45	41.67	3.62	4.16	4.53	5.22	5.32	6.12	6.44	7.41	7.34	8.45	8.25	9.50
GREGG	G018	4.06	27.80	0.45	41.67	3.54	6.48	4.44	8.12	5.21	9.53	6.32	11.54	7.20	13.17	8.10	14.81
GREGG	G019	1.97	26.26	0.45	41.67	3.66	3.23	4.58	4.05	5.37	4.75	6.50	5.75	7.41	6.56	8.33	7.37
GREGG	G020	4.47	28.02	0.45	41.67	3.53	7.10	4.42	8.90	5.19	10.45	6.29	12.66	7.18	14.44	8.07	16.24
GREGG	G021	5.22	28.38	0.45	41.67	3.50	8.23	4.39	10.32	5.16	12.12	6.25	14.68	7.13	16.75	8.02	18.84
GREGG	G022	9.15	29.77	0.45	41.67	3.41	14.06	4.28	17.63	5.03	20.71	6.09	25.11	6.96	28.65	7.83	32.24
GREGG	G023	12.84	30.68	0.45	41.67	3.36	19.40	4.21	24.33	4.95	28.59	6.00	34.67	6.85	39.59	7.71	44.56
GREGG	G024	6.78	29.01	0.45	41.67	3.46	10.56	4.34	13.24	5.10	15.55	6.18	18.84	7.05	21.50	7.93	24.19
GREGG	G025	5.82	28.64	0.45	41.67	3.49	9.13	4.37	11.45	5.13	13.45	6.22	16.29	7.10	18.59	7.98	20.91
GREGG	G027	5.81	28.63	0.45	41.67	3.49	9.12	4.37	11.43	5.13	13.43	6.22	16.27	7.10	18.56	7.98	20.88
GREGG	G028	6.17	28.78	0.45	41.67	3.48	9.65	4.36	12.10	5.12	14.21	6.20	17.21	7.08	19.64	7.96	22.09
Grove	GR01	1.97	26.27	0.35	25.00	3.65	2.52	4.58	3.16	5.37	3.71	6.50	4.49	7.41	5.12	8.33	5.75
Grove	GR02	1.44	25.67	0.55	58.33	3.70	2.94	4.63	3.68	5.44	4.32	6.58	5.23	7.50	5.96	8.43	6.69
Grove	GR03	2.77	26.97	0.35	25.00	3.60	3.50	4.51	4.38	5.30	5.14	6.42	6.23	7.32	7.10	8.22	7.98
Grove	GR04	2.63	26.86	0.35	25.00	3.61	3.33	4.52	4.17	5.31	4.89	6.43	5.93	7.33	6.76	8.24	7.60
Grove	GR05	1.55	25.80	0.65	75.00	3.69	3.71	4.62	4.65	5.42	5.45	6.56	6.60	7.48	7.52	8.41	8.46
Grove	GR06	1.60	25.87	0.65	75.00	3.68	3.84	4.61	4.81	5.42	5.65	6.56	6.84	7.47	7.79	8.40	8.76
Grove	GR07	1.93	26.23	0.65	75.00	3.66	4.59	4.58	5.75	5.38	6.75	6.51	8.17	7.42	9.31	8.34	10.46
Grove	GR08	1.90	26.19	0.65	75.00	3.66	4.51	4.58	5.65	5.38	6.63	6.51	8.03	7.42	9.15	8.34	10.29
Grove	GR09	2.56	26.80	0.65	75.00	3.62	6.01	4.53	7.54	5.32	8.84	6.44	10.71	7.34	12.21	8.25	13.72
Grove	GR10	1.37	25.57	0.65	75.00	3.71	3.30	4.64	4.13	5.45	4.84	6.59	5.86	7.52	6.68	8.44	7.50
Grove	GR11	1.79	26.07	0.45	41.67	3.67	2.95	4.60	3.69	5.39	4.33	6.53	5.25	7.44	5.98	8.36	6.72
Grove	GR12	1.47	25.70	0.35	25.00	3.70	1.90	4.63	2.38	5.43	2.80	6.58	3.38	7.50	3.86	8.42	4.33
Grove	GR13	1.34	25.53	0.45	41.67	3.71	2.24	4.65	2.80	5.45	3.28	6.60	3.98	7.52	4.53	8.45	5.09

Grove	GR14	1.75	26.04	0.65	75.00	3.67	4.19	4.60	5.24	5.40	6.15	6.53	7.45	7.45	8.49	8.37	9.54
Grove	GR15	2.26	26.55	0.65	75.00	3.63	5.35	4.55	6.70	5.34	7.86	6.47	9.52	7.37	10.86	8.29	12.20
Grove	GR16	2.87	27.04	0.65	75.00	3.60	6.72	4.51	8.42	5.29	9.88	6.41	11.97	7.31	13.65	8.21	15.34
Grove	GR17	1.58	25.84	0.65	75.00	3.69	3.79	4.62	4.75	5.42	5.58	6.56	6.75	7.48	7.69	8.40	8.64
Grove	GR18	2.00	26.30	0.45	41.67	3.65	3.29	4.57	4.12	5.37	4.84	6.50	5.86	7.41	6.68	8.33	7.51
Grove	GR19	1.81	26.10	0.80	100.00	3.67	5.31	4.59	6.66	5.39	7.81	6.52	9.46	7.44	10.78	8.36	12.11
Grove	GR20	1.18	25.30	0.65	75.00	3.73	2.86	4.67	3.58	5.48	4.20	6.63	5.09	7.56	5.80	8.49	6.51
Grove	GR21	0.77	24.56	0.35	25.00	3.79	1.03	4.74	1.29	5.56	1.51	6.73	1.83	7.67	2.08	8.61	2.34
Grove	GR22	2.02	26.32	0.35	25.00	3.65	2.58	4.57	3.24	5.37	3.80	6.50	4.60	7.41	5.24	8.32	5.89
Grove	GR23	1.98	26.28	0.65	75.00	3.65	4.70	4.58	5.89	5.37	6.91	6.50	8.36	7.41	9.53	8.33	10.72
Grove	GR24	1.85	26.15	0.65	75.00	3.66	4.41	4.59	5.52	5.39	6.48	6.52	7.84	7.43	8.94	8.35	10.05
Grove	GR25	1.83	26.13	0.30	16.67	3.67	2.02	4.59	2.53	5.39	2.96	6.52	3.59	7.43	4.09	8.35	4.60
Grove	GR26	1.99	26.28	0.45	41.67	3.65	3.27	4.58	4.09	5.37	4.80	6.50	5.81	7.41	6.62	8.33	7.44
Grove	GR27	1.79	26.08	0.30	16.67	3.67	1.97	4.60	2.47	5.39	2.90	6.53	3.51	7.44	4.00	8.36	4.49
Grove	GR28	1.58	25.84	0.30	16.67	3.69	1.75	4.62	2.19	5.42	2.57	6.56	3.12	7.48	3.55	8.40	3.99
Grove	GR29	1.15	25.24	0.65	75.00	3.73	2.78	4.67	3.48	5.48	4.09	6.64	4.94	7.56	5.63	8.50	6.33
Grove	GR30	1.39	25.60	0.45	41.67	3.71	2.32	4.64	2.90	5.44	3.41	6.59	4.13	7.51	4.70	8.44	5.28
Grove	GR31	1.60	25.86	0.55	58.33	3.69	3.24	4.62	4.06	5.42	4.76	6.56	5.76	7.47	6.57	8.40	7.38
Grove	GR32	1.17	25.28	0.45	41.67	3.73	1.96	4.67	2.46	5.48	2.88	6.63	3.49	7.56	3.98	8.49	4.47
Grove	GR33	1.07	25.12	0.30	16.67	3.74	1.20	4.69	1.50	5.50	1.76	6.65	2.13	7.58	2.43	8.52	2.73
Grove	GR34	2.84	27.02	0.30	16.67	3.60	3.07	4.51	3.84	5.29	4.51	6.41	5.46	7.31	6.23	8.22	7.00
Grove	GR35	1.67	25.94	0.30	16.67	3.68	1.84	4.61	2.31	5.41	2.71	6.55	3.28	7.46	3.73	8.38	4.20
Grove	GR36	2.17	26.47	0.30	16.67	3.64	2.37	4.56	2.97	5.35	3.49	6.48	4.23	7.39	4.82	8.30	5.41
Hare	H01	5.23	28.38	0.18	0.00	3.50	3.30	4.39	4.13	5.16	4.85	6.25	5.88	7.13	6.71	8.02	7.54
Hare	H02	0.61	24.17	0.18	0.00	3.82	0.42	4.78	0.53	5.61	0.62	6.79	0.75	7.73	0.85	8.68	0.95
Hare	H03	4.11	27.83	0.18	0.00	3.54	2.62	4.44	3.28	5.21	3.86	6.31	4.67	7.20	5.33	8.10	5.99
Hare	H04	4.00	27.77	0.18	0.00	3.55	2.55	4.44	3.20	5.22	3.76	6.32	4.55	7.21	5.19	8.10	5.84
Hare	H05	3.16	27.24	0.45	41.67	3.58	5.09	4.49	6.38	5.27	7.49	6.38	9.07	7.28	10.34	8.18	11.62
Ingraham	I01	4.44	28.00	0.80	100.00	3.53	12.54	4.42	15.72	5.19	18.46	6.29	22.36	7.18	25.50	8.07	28.68
Ingraham	I02	4.19	27.87	0.80	100.00	3.54	11.88	4.43	14.88	5.21	17.47	6.31	21.17	7.19	24.14	8.09	27.15
Ingraham	I03	3.26	27.31	0.80	100.00	3.58	9.32	4.48	11.68	5.26	13.71	6.37	16.60	7.27	18.93	8.17	21.28
Ingraham	I04	4.26	27.91	0.80	100.00	3.54	12.06	4.43	15.11	5.20	17.74	6.30	21.50	7.19	24.52	8.08	27.57
Ingraham	I05	1.44	25.66	0.80	100.00	3.70	4.26	4.63	5.34	5.44	6.26	6.58	7.58	7.50	8.64	8.43	9.71
Jensen	J01	6.28	28.82	0.45	41.67	3.47	9.82	4.36	12.31	5.11	14.46	6.20	17.52	7.07	19.99	7.95	22.49
Jensen	J02	1.94	26.24	0.80	100.00	3.66	5.69	4.58	7.12	5.37	8.36	6.51	10.12	7.42	11.54	8.34	12.97
Jensen	J03	2.35	26.62	0.35	25.00	3.63	2.98	4.55	3.73	5.33	4.38	6.46	5.30	7.36	6.05	8.28	6.80
Jensen	J04	2.83	27.01	0.45	41.67	3.60	4.59	4.51	5.74	5.29	6.74	6.41	8.17	7.31	9.31	8.22	10.47
Jensen	J05	2.75	26.95	0.35	25.00	3.60	3.47	4.52	4.35	5.30	5.10	6.42	6.18	7.32	7.05	8.23	7.92
Jensen	J06	1.45	25.67	0.55	58.33	3.70	2.94	4.63	3.69	5.44	4.33	6.58	5.24	7.50	5.97	8.43	6.71
Jensen	J07	2.66	26.88	0.55	58.33	3.61	5.28	4.52	6.62	5.31	7.77	6.43	9.41	7.33	10.73	8.24	12.06
Jensen	J08	2.75	26.95	0.55	58.33	3.60	5.45	4.52	6.83	5.30	8.01	6.42	9.71	7.32	11.07	8.23	12.44
Jensen	J09	1.33	25.51	0.55	58.33	3.71	2.71	4.65	3.39	5.45	3.98	6.60	4.81	7.52	5.48	8.45	6.16
Jensen	J10	1.94	26.24	0.65	75.00	3.66	4.61	4.58	5.77	5.38	6.78	6.51	8.20	7.42	9.35	8.34	10.51
Jensen	J11	2.08	26.38	0.65	75.00	3.65	4.93	4.57	6.18	5.36	7.25	6.49	8.78	7.40	10.00	8.31	11.24
Jensen	J12	1.81	26.10	0.45	41.67	3.67	2.98	4.59	3.74	5.39	4.39	6.53	5.31	7.44	6.05	8.36	6.80
Jensen	J13	2.43	26.70	0.65	75.00	3.62	5.73	4.54	7.18	5.33	8.43	6.45	10.20	7.35	11.63	8.27	13.07
Jensen	J14	2.52	26.77	0.80	100.00	3.62	7.29	4.53	9.13	5.32	10.71	6.44	12.97	7.34	14.79	8.25	16.62
Jensen	J15	3.18	27.26	0.45	41.67	3.58	5.12	4.49	6.41	5.27	7.53	6.38	9.12	7.28	10.40	8.18	11.69
LYONS	L001	3.94	27.73	0.45	41.67	3.55	6.30	4.45	7.89	5.22	9.26	6.32	11.22	7.21	12.79	8.11	14.39
LYONS	L002	1.36	25.56	0.45	41.67	3.71	2.28	4.64	2.85	5.45	3.34	6.60	4.05	7.52	4.61	8.45	5.18
LYONS	L003	4.01	27.77	0.45	41.67	3.55	6.40	4.44	8.02	5.22	9.42	6.32	11.41	7.21	13.01	8.10	14.63
LYONS	L004	2.86	27.03	0.45	41.67	3.60	4.63	4.51	5.80	5.29	6.81	6.41	8.24	7.31	9.40	8.21	10.57
LYONS	L005	2.75	26.95	0.45	41.67	3.60	4.47	4.52	5.60	5.30	6.57	6.42	7.96	7.32	9.07	8.23	10.20
LYONS	L006	1.60	25.87	0.45	41.67	3.68	2.66	4.62	3.33	5.42	3.91	6.56	4.73	7.47	5.39	8.40	6.06
LYONS	L007	3.29	27.33	0.80	100.00	3.58	9.41	4.48	11.79	5.26	13.84	6.37	16.76	7.27	19.11	8.17	21.49
LYONS	L008	1.82	26.12	0.80	100.00	3.67	5.35	4.59	6.70	5.39	7.86	6.52	9.52	7.44	10.85	8.36	12.19
LYONS	L009	1.62	25.88	0.80	100.00	3.68	4.77	4.61	5.97	5.41	7.00	6.55	8.48	7.47	9.66	8.39	10.86
LYONS	L010	2.21	26.50	0.45	41.67	3.64	3.62	4.56	4.53	5.35	5.32	6.47	6.44	7.38	7.34	8.30	8.25
LYONS	L011	0.81	24.63	0.45	41.67	3.78	1.38	4.74	1.72	5.55	2.02	6.72	2.45	7.66	2.79	8.60	3.13
LYONS	L012	7.44	29.24	0.80	100.00	3.45	20.52	4.32	25.73	5.08	30.21	6.15	36.62	7.02	41.79	7.90	47.01
MARKET	M00	4.94	28.25	0.45	41.67	3.51	7.82	4.40	9.80	5.17	11.50	6.26	13.94	7.15	15.90	8.04	17.88
MARKET	M01	2.09	26.38	0.45	41.67	3.65	3.42	4.57	4.29	5.36	5.03	6.49	6.10	7.40	6.95	8.31	7.81
MARKET	M02	2.58	26.82	0.45	41.67	3.61	4.20	4.53	5.26	5.31	6.18	6.43	7.48	7.34	8.53	8.25	9.59
MARKET	M03	3.16	27.25	0.45	41.67	3.58	5.10	4.49	6.39	5.27	7.50	6.38	9.09	7.28	10.36	8.18	11.65
MARKET	M04	1.36	25.55	0.45	41.67	3.71	2.26	4.65	2.84	5.45	3.33	6.60	4.03	7.52	4.59	8.45	5.16
MARKET	M05	0.79	24.60	0.45	41.67	3.79	1.35	4.74	1.69	5.56	1.98	6.73	2.40	7.66	2.73	8.61	3.07
MARKET	M06	1.43	25.65	0.55	58.33	3.70	2.92	4.64	3.65	5.44	4.29	6.58	5.19	7.50	5.91	8.43	6.65
MARKET	M07	1.40	25.60	0.55	58.33	3.71	2.84	4.64	3.56	5.44	4.18	6.59	5.06	7.51	5.76	8.44	6.48
MARKET	M08	2.20	26.49	0.45	41.67	3.64	3.61	4.56	4.52	5.35	5.30	6.48	6.42	7.38	7.32	8.30	8.23
MARKET	M09	1.54	25.79	0.45	41.67	3.69	2.56	4.62	3.20	5.42	3.76	6.57	4.55	7.48	5.18	8.41	5.82
MARKET	M10	2.75	26.95	0.45	41.67	3.60	4.46	4.52	5.59	5.30	6.56	6.42	7.95	7.32	9.06	8.23	10.18
MARKET	M11	1.95	26.25	0.45	41.67	3.66	3.21	4.58	4.02	5.37	4.72	6.51	5.72	7.42	6.52	8.33	7.33
MARKET	M12	2.29	26.57	0.35	25.00	3.63	2.91	4.55	3.64	5.34	4.27	6.47	5.18	7.37	5.90	8.29	6.63
MARKET	M13	1.44	25.66	0.55	58.33	3.70	2.93	4.63	3.66	5.44	4.30	6.58	5.20	7.50	5.93	8.43	6.66
MARKET	M14	1.51	25.75	0.45	41.67	3.69	2.51	4.63	3.14	5.43	3.69	6.57	4.47	7.49	5.09	8.41	5.72
MARKET	M15	4.24	27.90	0.45	41.67	3.54	6.75	4.43	8.46	5.20	9.93	6.30	12.03	7.19	13.73	8.09	15.43
MARKET	M16	2.30	26.58	0.45	41.67	3.63	3.76	4.55	4.71	5.34	5.52	6.46	6.69	7.37	7.62	8.28	8.57
MARKET	M17	2.33	26.61	0.35	25.00	3.63	2.96	4.55	3.71	5.34	4.35	6.46	5.27	7.37	6.01	8.28	6.75
MARKET	M18	12.01	30.49	0.80	100.00	3.37	32.36	4.22	40.58	4.96	47.68	6.02	57.82	6.87	66.01	7.73	74.29
ORANGE	O001	6.53	28.91	0.45	41.67	3.47	10.19	4.35	12.77	5.11	15.00	6.19	18.18	7.06	20.74	7.94	23.33
ORANGE	O002	4.59	28.08	0.45	41.67	3.52	7.28	4.42	9.13	5.19	10.72	6.28	12.98	7.17	14.81	8.06	16.66
ORANGE	O003	1.30	25.48	0.45	41.67	3.72	2.18	4.65	2.73	5.46	3.20	6.61	3.88	7.53	4.42	8.46	4.96
ORANGE	O004	1.47	25.70	0.45	41.67	3.70	2.44	4.63	3.06	5.43	3.59	6.58	4.34	7.50	4.95	8.42	5.56
ORANGE	O005	1.69	25.97	0.45	41.67	3.68	2.80	4.61	3.51	5.40	4.12	6.54	4.99	7.46	5.69	8.38	6.39
ORANGE	O006	0.65	24.26	0.45	41.67	3.81	1.11	4.77	1.39	5.60	1.63	6.77	1.97	7.72	2.24	8.66	2.52
ORANGE	O007	1.81	26.10	0.45	41.67	3.67	2.98	4.59	3.74	5.39	4.39	6.53	5.31	7.44	6.05	8.36	6.80
ORANGE	O008	2.89	27.06	0.45	41.67	3.60	4.68	4.51	5.87	5.29	6.89	6.41	8.34	7.30	9.51	8.21	10.69
ORANGE	O009	2.25	26.54	0.45	41.67	3.63	3.69	4.55	4.62	5.34	5.42	6.47	6.56	7.38	7.48	8.29	8.41
ORANGE	O010	1.98	26.28	0.45	41.67	3.65	3.25	4.58	4.07	5.37	4.78	6.50	5.78	7.41	6.59	8.33	7.41
ORANGE	O011	1.99	26.29	0.45	41.67	3.65	3.27	4.58	4.09	5.37	4.81	6.50	5.82	7.41	6.63	8.33	7.45

ORANGE	O012	2.00	26.30	0.45	41.67	3.65	3.28	4.58	4.11	5.37	4.83	6.50	5.84	7.41	6.66	8.33	7.49
ORANGE	O013	1.89	26.18	0.45	41.67	3.66	3.11	4.59	3.89	5.38	4.57	6.51	5.53	7.43	6.31	8.35	7.09
PANNELL	P001	1.27	25.43	0.45	41.67	3.72	2.13	4.66	2.67	5.46	3.13	6.61	3.79	7.54	4.32	8.47	4.85
PANNELL	P002	2.64	26.86	0.45	41.67	3.61	4.29	4.52	5.37	5.31	6.31	6.43	7.64	7.33	8.71	8.24	9.79
PANNELL	P003	1.95	26.25	0.45	41.67	3.66	3.21	4.58	4.02	5.37	4.71	6.51	5.71	7.42	6.50	8.34	7.31
PANNELL	P004	0.68	24.34	0.45	41.67	3.81	1.16	4.77	1.45	5.59	1.70	6.76	2.06	7.70	2.35	8.65	2.63
PANNELL	P005	0.97	24.94	0.45	41.67	3.76	1.63	4.70	2.04	5.52	2.40	6.68	2.90	7.61	3.31	8.55	3.71
PANNELL	P006	1.35	25.55	0.45	41.67	3.71	2.26	4.65	2.83	5.45	3.32	6.60	4.02	7.52	4.58	8.45	5.15
PANNELL	P007	1.22	25.36	0.45	41.67	3.72	2.05	4.66	2.56	5.47	3.01	6.62	3.64	7.55	4.15	8.48	4.66
PANNELL	P008	4.30	27.93	0.45	41.67	3.54	6.84	4.43	8.57	5.20	10.06	6.30	12.19	7.19	13.90	8.08	15.64
PANNELL	P009	2.84	27.02	0.45	41.67	3.60	4.60	4.51	5.77	5.29	6.77	6.41	8.20	7.31	9.35	8.22	10.51
PANNELL	P010	0.99	24.98	0.45	41.67	3.75	1.67	4.70	2.09	5.51	2.45	6.67	2.96	7.60	3.38	8.54	3.79
PANNELL	P011	3.12	27.22	0.45	41.67	3.59	5.04	4.49	6.31	5.27	7.41	6.39	8.97	7.28	10.23	8.19	11.50
PANNELL	P012	2.65	26.87	0.45	41.67	3.61	4.30	4.52	5.38	5.31	6.32	6.43	7.65	7.33	8.73	8.24	9.81
PANNELL	P013	2.09	26.38	0.45	41.67	3.65	3.43	4.57	4.29	5.36	5.04	6.49	6.10	7.40	6.95	8.31	7.81
PANNELL	P014	3.86	27.68	0.45	41.67	3.55	6.17	4.45	7.73	5.23	9.08	6.33	10.99	7.22	12.54	8.12	14.10
PANNELL	P015	2.23	26.52	0.45	41.67	3.64	3.65	4.55	4.57	5.35	5.36	6.47	6.49	7.38	7.40	8.29	8.32
PANNELL	P016	2.66	26.88	0.45	41.67	3.61	4.32	4.52	5.41	5.31	6.35	6.43	7.69	7.33	8.77	8.24	9.86
PANNELL	P017	2.68	26.89	0.45	41.67	3.61	4.35	4.52	5.45	5.31	6.39	6.43	7.74	7.33	8.83	8.23	9.92
PANNELL	P018	3.38	27.39	0.45	41.67	3.57	5.43	4.48	6.80	5.26	7.99	6.36	9.67	7.26	11.03	8.16	12.40
PANNELL	P019	2.43	26.69	0.45	41.67	3.62	3.97	4.54	4.97	5.33	5.83	6.45	7.06	7.35	8.05	8.27	9.05
PANNELL	P020	2.35	26.62	0.45	41.67	3.63	3.83	4.55	4.80	5.33	5.64	6.46	6.83	7.36	7.78	8.28	8.75
PANNELL	P021	2.29	26.57	0.45	41.67	3.63	3.75	4.55	4.69	5.34	5.51	6.47	6.67	7.37	7.61	8.28	8.55
PANNELL	P022	2.28	26.57	0.45	41.67	3.63	3.73	4.55	4.68	5.34	5.49	6.47	6.64	7.37	7.58	8.29	8.51
PANNELL	P023	4.37	27.97	0.45	41.67	3.53	6.95	4.43	8.71	5.20	10.22	6.30	12.38	7.18	14.13	8.08	15.88
PANNELL	P024	1.70	25.98	0.45	41.67	3.68	2.81	4.60	3.52	5.40	4.13	6.54	5.00	7.46	5.70	8.38	6.41
PANNELL	P025	1.13	25.22	0.45	41.67	3.73	1.91	4.68	2.39	5.49	2.80	6.64	3.39	7.57	3.86	8.50	4.34
PANNELL	P026	1.38	25.58	0.45	41.67	3.71	2.30	4.64	2.88	5.45	3.38	6.59	4.09	7.51	4.66	8.44	5.24
PANNELL	P027	4.40	27.98	0.45	41.67	3.53	6.99	4.43	8.76	5.20	10.29	6.29	12.46	7.18	14.22	8.07	15.99
PANNELL	P028	2.13	26.43	0.45	41.67	3.64	3.49	4.56	4.38	5.36	5.14	6.48	6.22	7.39	7.09	8.31	7.97
PANNELL	P029	4.03	27.78	0.45	41.67	3.55	6.42	4.44	8.05	5.22	9.45	6.32	11.45	7.21	13.05	8.10	14.68
PANNELL	P030	1.18	25.29	0.45	41.67	3.73	1.98	4.67	2.48	5.48	2.91	6.63	3.52	7.56	4.01	8.49	4.50
PANNELL	P031	2.08	26.37	0.45	41.67	3.65	3.41	4.57	4.27	5.36	5.01	6.49	6.06	7.40	6.91	8.32	7.77
PANNELL	P032	2.56	26.80	0.45	41.67	3.62	4.17	4.53	5.22	5.32	6.13	6.44	7.42	7.34	8.46	8.25	9.51
PANNELL	P033	3.68	27.58	0.45	41.67	3.56	5.89	4.46	7.38	5.24	8.66	6.34	10.49	7.23	11.97	8.13	13.46
PANNELL	P034	5.49	28.50	0.45	41.67	3.50	8.64	4.38	10.83	5.15	12.72	6.24	15.41	7.11	17.58	8.00	19.77
PANNELL	P035	1.82	26.12	0.45	41.67	3.67	3.01	4.59	3.77	5.39	4.42	6.52	5.36	7.44	6.10	8.36	6.86
PANNELL	P036	1.31	25.49	0.45	41.67	3.71	2.20	4.65	2.75	5.46	3.23	6.60	3.91	7.53	4.45	8.46	5.00
PANNELL	P037	5.05	28.30	0.45	41.67	3.51	7.98	4.40	10.00	5.16	11.74	6.26	14.22	7.14	16.23	8.03	18.25
PANNELL	P038	26.72	32.83	0.45	41.67	3.23	38.84	4.05	48.75	4.77	57.32	5.79	69.57	6.61	79.48	7.45	89.53
PANNELL	P039	4.92	28.24	0.45	41.67	3.51	7.78	4.40	9.75	5.17	11.45	6.26	13.87	7.15	15.82	8.04	17.79
PANNELL	P040	2.35	26.62	0.45	41.67	3.63	3.83	4.55	4.80	5.33	5.63	6.46	6.82	7.36	7.77	8.28	8.74
PANNELL	P041	2.73	26.93	0.45	41.67	3.61	4.43	4.52	5.54	5.30	6.51	6.42	7.88	7.32	8.99	8.23	10.10
PANNELL	P042	12.32	30.56	0.55	58.33	3.36	22.80	4.22	28.59	4.96	33.60	6.01	40.74	6.86	46.51	7.72	52.35
PANNELL	P043	4.24	27.90	0.45	41.67	3.54	6.75	4.43	8.46	5.20	9.93	6.30	12.04	7.19	13.73	8.09	15.44
PANNELL	P044	3.60	27.53	0.45	41.67	3.56	5.77	4.46	7.23	5.24	8.49	6.35	10.29	7.24	11.73	8.14	13.19
PANNELL	P046	3.54	27.50	0.45	41.67	3.57	5.69	4.47	7.13	5.24	8.36	6.35	10.13	7.24	11.55	8.14	12.99
PANNELL	P047	4.87	28.21	0.45	41.67	3.52	7.70	4.41	9.65	5.17	11.33	6.27	13.72	7.15	15.65	8.04	17.60
PANNELL	P048	8.12	29.46	0.45	41.67	3.43	12.54	4.30	15.72	5.06	18.47	6.13	22.38	6.99	25.55	7.87	28.74
PANNELL	P049	11.21	30.30	0.45	41.67	3.38	17.04	4.24	21.37	4.98	25.11	6.04	30.45	6.89	34.76	7.76	39.12
PANNELL	P050	5.19	28.37	0.45	41.67	3.51	8.19	4.39	10.27	5.16	12.06	6.25	14.61	7.13	16.67	8.02	18.74
PANNELL	P051	2.52	26.77	0.45	41.67	3.62	4.10	4.53	5.13	5.32	6.03	6.44	7.30	7.34	8.32	8.25	9.35
PANNELL	P052	2.07	26.37	0.45	41.67	3.65	3.40	4.57	4.26	5.36	5.00	6.49	6.05	7.40	6.90	8.32	7.75
PANNELL	P053	4.30	27.93	0.45	41.67	3.54	6.84	4.43	8.57	5.20	10.06	6.30	12.19	7.19	13.90	8.08	15.63
PANNELL	P059	4.78	28.17	0.45	41.67	3.52	7.57	4.41	9.48	5.18	11.13	6.27	13.49	7.16	15.39	8.05	17.30
PANNELL	P060	3.35	27.37	0.45	41.67	3.57	5.38	4.48	6.75	5.26	7.92	6.37	9.59	7.26	10.94	8.16	12.30
PANNELL	P061	2.50	26.75	0.45	41.67	3.62	4.08	4.53	5.11	5.32	6.00	6.44	7.26	7.35	8.28	8.26	9.31
PANNELL	P062	1.03	25.05	0.45	41.67	3.75	1.74	4.69	2.18	5.51	2.55	6.66	3.09	7.59	3.52	8.53	3.96
PANNELL	P063	21.10	32.11	0.55	58.33	3.27	37.97	4.11	47.65	4.83	56.01	5.86	67.96	6.69	77.63	7.53	87.42
PANNELL	P064	3.52	27.48	0.45	41.67	3.57	5.65	4.47	7.09	5.25	8.32	6.35	10.07	7.25	11.49	8.15	12.92
PANNELL	P065	2.07	26.37	0.45	41.67	3.65	3.40	4.57	4.26	5.36	5.00	6.49	6.05	7.40	6.90	8.32	7.75
PANNELL	P066	1.29	25.46	0.45	41.67	3.72	2.16	4.65	2.71	5.46	3.18	6.61	3.85	7.53	4.39	8.46	4.93
PANNELL	P067	1.08	25.14	0.55	58.33	3.74	2.23	4.68	2.79	5.50	3.28	6.65	3.96	7.58	4.52	8.51	5.07
PANNELL	P068	1.07	25.12	0.55	58.33	3.74	2.20	4.69	2.75	5.50	3.23	6.65	3.91	7.58	4.45	8.52	5.00
PANNELL	P069	2.21	26.49	0.45	41.67	3.64	3.61	4.56	4.52	5.35	5.31	6.48	6.43	7.38	7.33	8.30	8.24
PANNELL	P070	3.37	27.39	0.55	58.33	3.57	6.63	4.48	8.31	5.26	9.75	6.37	11.81	7.26	13.47	8.16	15.15
PANNELL	P071	1.89	26.18	0.45	41.67	3.66	3.11	4.59	3.90	5.38	4.57	6.51	5.53	7.43	6.31	8.35	7.09
PANNELL	P072	7.92	29.40	0.45	41.67	3.44	12.26	4.31	15.37	5.06	18.05	6.13	21.88	7.00	24.97	7.88	28.09
PANNELL	P073	39.47	34.10	0.55	58.33	3.16	68.63	3.97	86.18	4.67	101.37	5.67	123.09	6.48	140.70	7.30	158.56
SUMPTER	S001	18.02	31.64	0.45	41.67	3.30	26.74	4.14	33.56	4.86	39.44	5.90	47.84	6.74	54.64	7.59	61.52
SUMPTER	S002	3.85	27.68	0.45	41.67	3.55	6.15	4.45	7.71	5.23	9.05	6.33	10.96	7.22	12.50	8.12	14.05
SUMPTER	S003	1.85	26.14	0.45	41.67	3.66	3.05	4.59	3.82	5.39	4.48	6.52	5.42	7.43	6.18	8.35	6.95
SUMPTER	S004	3.55	27.50	0.45	41.67	3.57	5.69	4.47	7.13	5.24	8.37	6.35	10.13	7.24	11.56	8.14	12.99
SUMPTER	S005	3.50	27.47	0.45	41.67	3.57	5.62	4.47	7.05	5.25	8.27	6.36	10.02	7.25	11.43	8.15	12.85
SUMPTER	S008	9.50	29.86	0.45	41.67	3.41	14.56	4.27	18.25	5.02	21.44	6.08	26.00	6.94	29.67	7.81	33.39
SUMPTER	S009	5.09	28.32	0.45	41.67	3.51	8.03	4.40	10.07	5.16	11.82	6.26	14.32	7.14	16.34	8.03	18.37
SUMPTER	S010	5.04	28.30	0.45	41.67	3.51	7.97	4.40	9.99	5.17	11.73	6.26	14.21	7.14	16.21	8.03	18.23
SUMPTER	S012	3.22	27.29	0.45	41.67	3.58	5.18	4.49	6.50	5.27	7.63	6.38	9.24	7.27	10.53	8.18	11.84
SUMPTER	S013	2.39	26.66	0.45	41.67	3.63	3.91	4.54	4.89	5.33	5.74	6.45	6.95	7.36	7.93	8.27	8.91
SUMPTER	S014	2.78	26.97	0.45	41.67	3.60	4.50	4.51	5.64	5.30	6.62	6.42	8.02	7.32	9.15	8.22	10.28
SUMPTER	S015	2.17	26.46	0.45	41.67	3.64	3.55	4.56	4.44	5.35	5.22	6.48	6.32	7.39	7.20	8.30	8.09
SUMPTER	S016	5.30	28.41	0.45	41.67	3.50	8.35	4.39	10.46	5.15	12.28	6.24	14.88	7.12	16.98	8.01	19.09
SUMPTER	S017	3.23	27.29	0.45	41.67	3.58	5.20	4.49	6.52	5.26	7.65	6.38	9.27	7.27	10.57	8.17	11.88
SUMPTER	S018	3.63	27.55	0.45	41.67	3.56	5.81	4.46	7.28	5.24	8.55	6.35	10.36	7.24	11.81	8.14	13.28
SUMPTER	S020	6.90	29.05	0.45	41.67	3.46	10.73	4.34	13.46	5.09	15.80	6.17	19.15	7.04	21.86	7.92	24.59
SUMPTER	S021	3.16	27.25	0.45	41.67	3.58	5.10	4.49	6.38	5.27	7.49	6.38	9.08	7.28	10.35	8.18	11.63
SUMPTER	S022	5.54	28.52	0.45	41.67	3.49	8.71	4.38	10.91	5.14	12.82	6.23	15.53	7.11	17.72	8.00	19.93
SUMPTER	S023	1.38	25.58	0.45	41.67	3.71	2.30	4.64	2.88	5.45	3.38	6.59	4.09	7.51	4.67	8.44	5.24
SUMPTER	S024	3.10	27.21	0.45	41.67	3.59	5.01	4.49	6.28	5.27	7.37	6.39	8.92	7.28	10.17	8.19	11.44
SUMPTER	S025	2.89	27.06	0.45	41.67	3.60	4.68	4.51	5.86	5.29	6.88	6.41	8.33	7.30	9.50	8.21	10.68

SUMPTER	S026	2.70	26.91	0.45	41.67	3.61	4.38	4.52	5.49	5.30	6.44	6.42	7.80	7.32	8.90	8.23	10.00
SUMPTER	S027	2.54	26.78	0.45	41.67	3.62	4.13	4.53	5.17	5.32	6.07	6.44	7.35	7.34	8.38	8.25	9.42
SUMPTER	S028	2.20	26.49	0.45	41.67	3.64	3.60	4.56	4.51	5.35	5.30	6.48	6.41	7.38	7.31	8.30	8.22
SUMPTER	S029	2.46	26.72	0.45	41.67	3.62	4.02	4.54	5.03	5.32	5.90	6.45	7.15	7.35	8.15	8.26	9.16
SUMPTER	S030	1.50	25.75	0.45	41.67	3.69	2.50	4.63	3.13	5.43	3.67	6.57	4.45	7.49	5.07	8.42	5.70
SUMPTER	S031	2.07	26.36	0.45	41.67	3.65	3.39	4.57	4.25	5.36	4.99	6.49	6.04	7.40	6.88	8.32	7.74
SUMPTER	S032	1.89	26.19	0.45	41.67	3.66	3.12	4.58	3.91	5.38	4.59	6.51	5.55	7.43	6.33	8.34	7.11
SUMPTER	S033	2.52	26.77	0.45	41.67	3.62	4.10	4.53	5.14	5.32	6.03	6.44	7.31	7.34	8.33	8.25	9.36
SUMPTER	S034	4.85	28.21	0.45	41.67	3.52	7.67	4.41	9.62	5.17	11.29	6.27	13.68	7.15	15.60	8.04	17.55
SUMPTER	S036	13.03	30.72	0.45	41.67	3.35	19.66	4.21	24.66	4.94	28.98	5.99	35.14	6.84	40.12	7.70	45.16
SUMPTER	S040	1.51	25.75	0.45	41.67	3.69	2.51	4.63	3.14	5.43	3.69	6.57	4.47	7.49	5.09	8.41	5.72
SUMPTER	S041	1.88	26.18	0.45	41.67	3.66	3.10	4.59	3.88	5.38	4.55	6.52	5.51	7.43	6.28	8.35	7.06
SUMPTER	S044	8.74	29.65	0.30	16.67	3.42	8.97	4.29	11.25	5.04	13.21	6.11	16.02	6.97	18.28	7.84	20.57
SUMPTER	S046	3.38	27.39	0.45	41.67	3.57	5.44	4.48	6.81	5.25	7.99	6.36	9.68	7.26	11.04	8.16	12.41
SUMPTER	S047	2.14	26.43	0.30	16.67	3.64	2.34	4.56	2.93	5.35	3.43	6.48	4.16	7.39	4.74	8.31	5.33
SUMPTER	S048	2.21	26.50	0.45	41.67	3.64	3.62	4.56	4.53	5.35	5.32	6.47	6.44	7.38	7.34	8.30	8.25
SUMPTER	S049	9.54	29.88	0.45	41.67	3.41	14.62	4.27	18.33	5.02	21.53	6.08	26.10	6.94	29.80	7.81	33.53
SUMPTER	S053	2.08	26.37	0.45	41.67	3.65	3.41	4.57	4.27	5.36	5.01	6.49	6.06	7.40	6.91	8.32	7.77
SUMPTER	S055	15.29	31.17	0.30	16.67	3.33	15.26	4.17	19.15	4.90	22.50	5.95	27.29	6.79	31.16	7.65	35.08
SUMPTER	S058	4.79	28.18	0.45	41.67	3.52	7.58	4.41	9.50	5.18	11.15	6.27	13.51	7.15	15.41	8.05	17.33
SUMPTER	S060	4.79	28.18	0.45	41.67	3.52	7.59	4.41	9.51	5.18	11.16	6.27	13.53	7.15	15.43	8.05	17.35
SUMPTER	S062	4.80	28.18	0.45	41.67	3.52	7.59	4.41	9.52	5.18	11.17	6.27	13.54	7.15	15.44	8.05	17.36
SUMPTER	S064	7.08	29.11	0.45	41.67	3.46	11.00	4.33	13.80	5.09	16.20	6.17	19.64	7.04	22.41	7.91	25.21
SUMPTER	S065	6.90	29.05	0.45	41.67	3.46	10.74	4.34	13.47	5.09	15.82	6.17	19.17	7.04	21.87	7.92	24.60
SUMPTER	S066	11.49	30.37	0.45	41.67	3.38	17.45	4.23	21.88	4.97	25.71	6.03	31.17	6.88	35.59	7.75	40.05
US59	U001	7.36	29.21	0.65	75.00	3.45	16.50	4.32	20.68	5.08	24.29	6.15	29.44	7.02	33.60	7.90	37.79
US59	U002	3.26	27.32	0.65	75.00	3.58	7.59	4.48	9.51	5.26	11.16	6.37	13.52	7.27	15.42	8.17	17.33
US59	U003	23.61	32.45	0.45	41.67	3.25	34.55	4.08	43.36	4.80	50.98	5.82	61.87	6.65	70.68	7.49	79.60
US59	U009	25.03	32.63	0.45	41.67	3.24	36.51	4.07	45.82	4.78	53.87	5.81	65.38	6.63	74.69	7.47	84.13
WACO	W01	216.20	40.77	0.55	58.33	2.85	338.74	3.59	426.36	4.23	502.53	5.15	611.81	5.89	700.79	6.66	791.70



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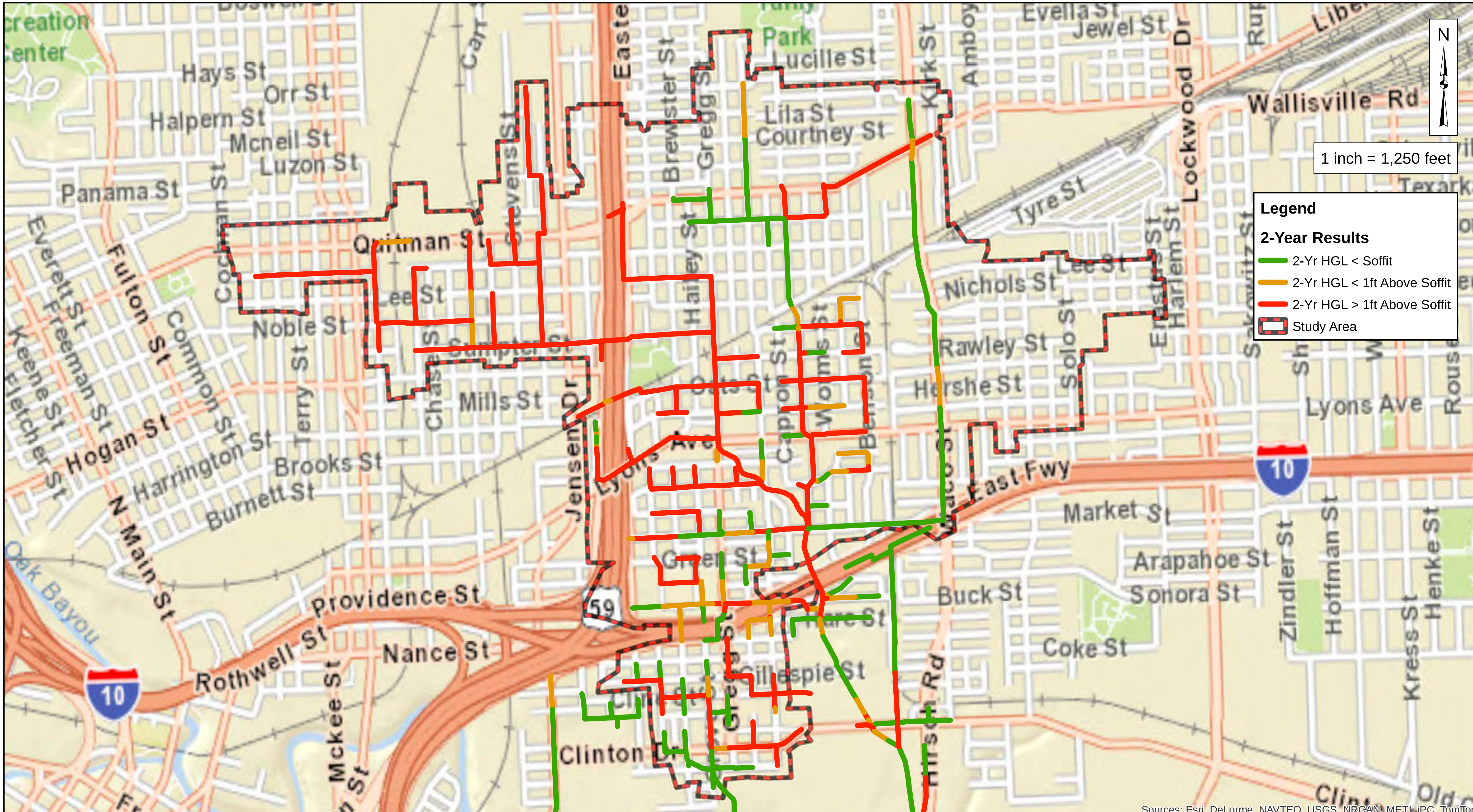
5th Ward Drainage Masterplan
Effective FEMA Floodplain Boundaries

Date: April 2020	EXHIBIT 4



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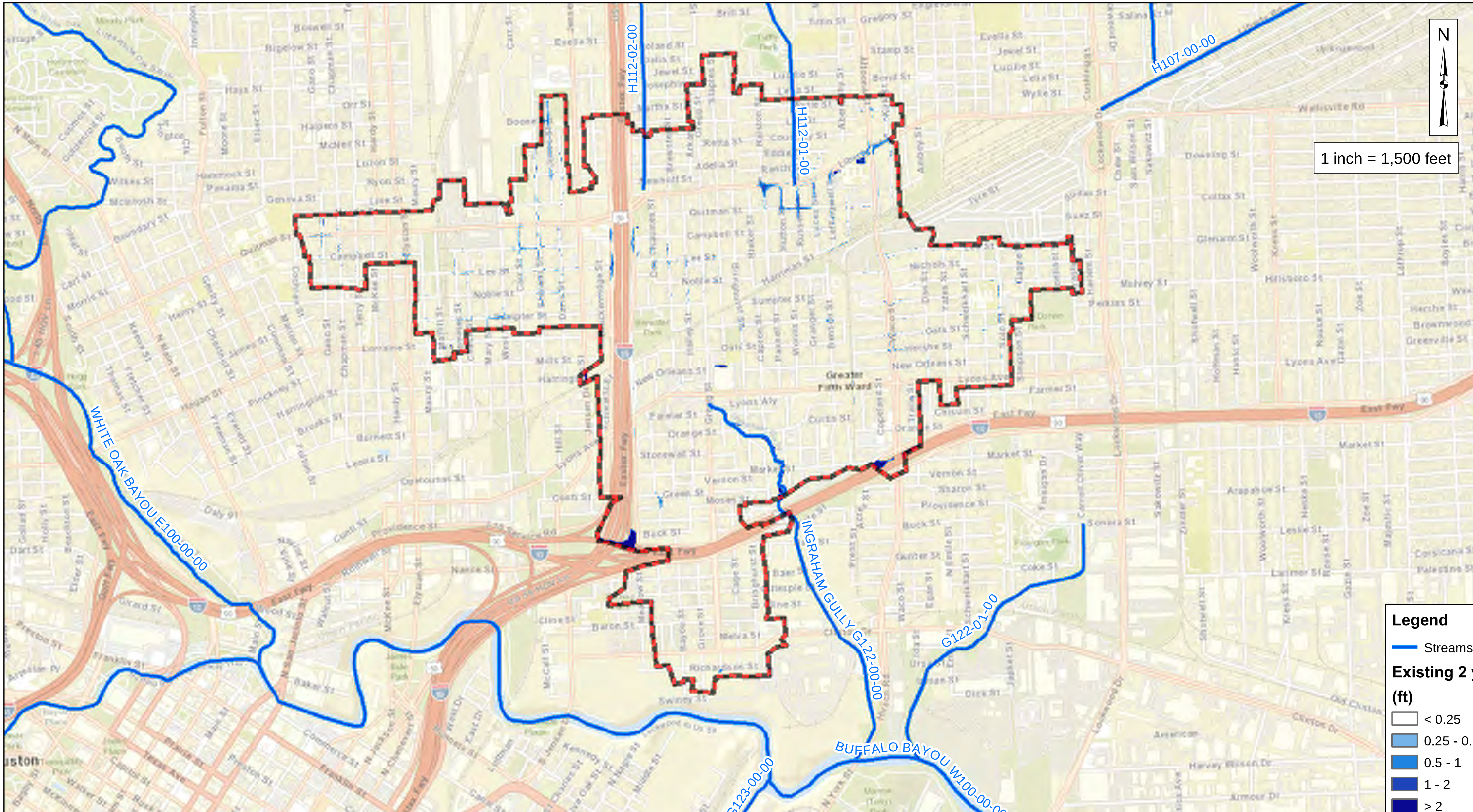
5th Ward Drainage Masterplan
Existing Condition Storm Sewer Layout

Date: May 2020	EXHIBIT 5



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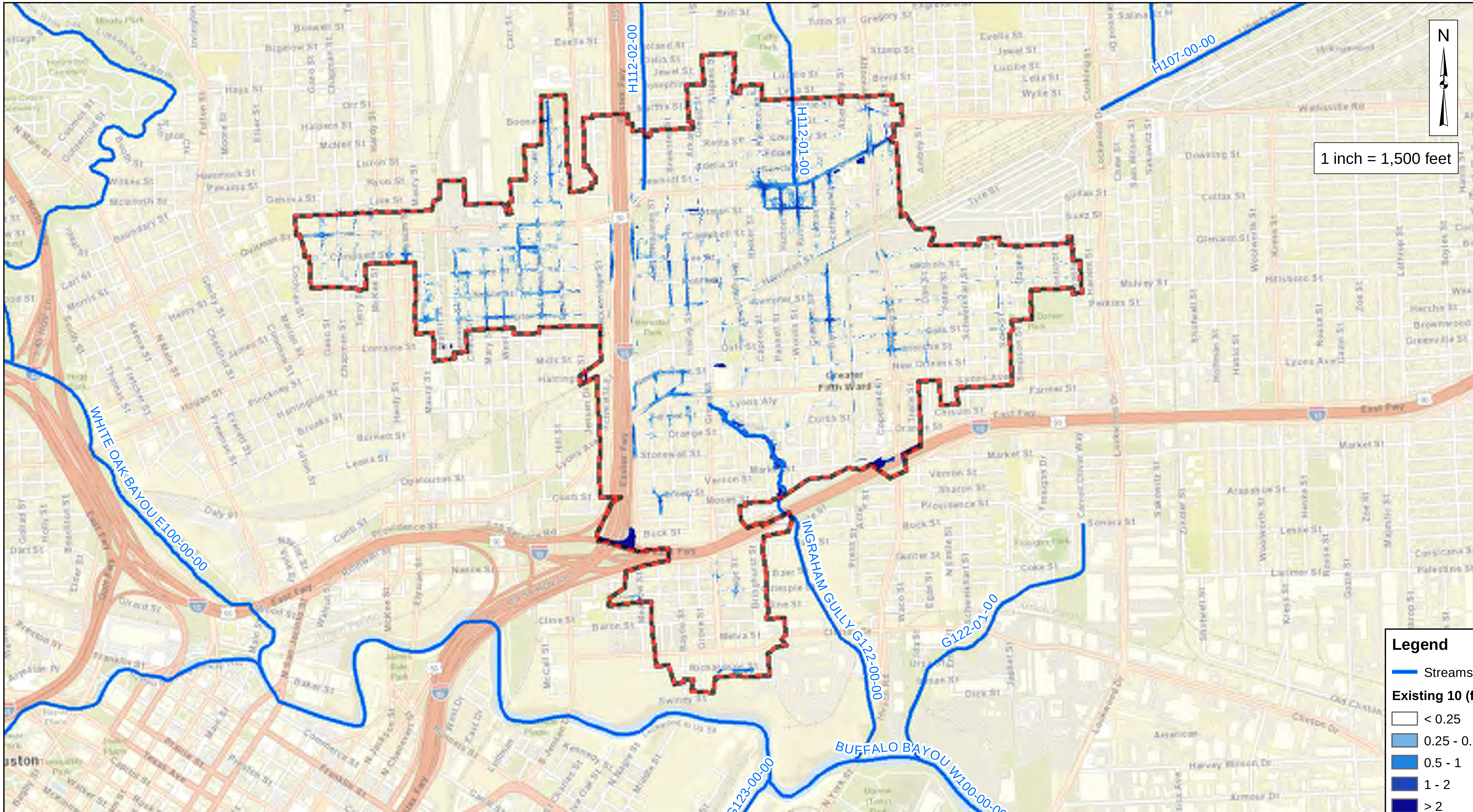
5th Ward Drainage Masterplan
Existing 2 year

Date: Sept ember 2020	EXHIBIT 6A



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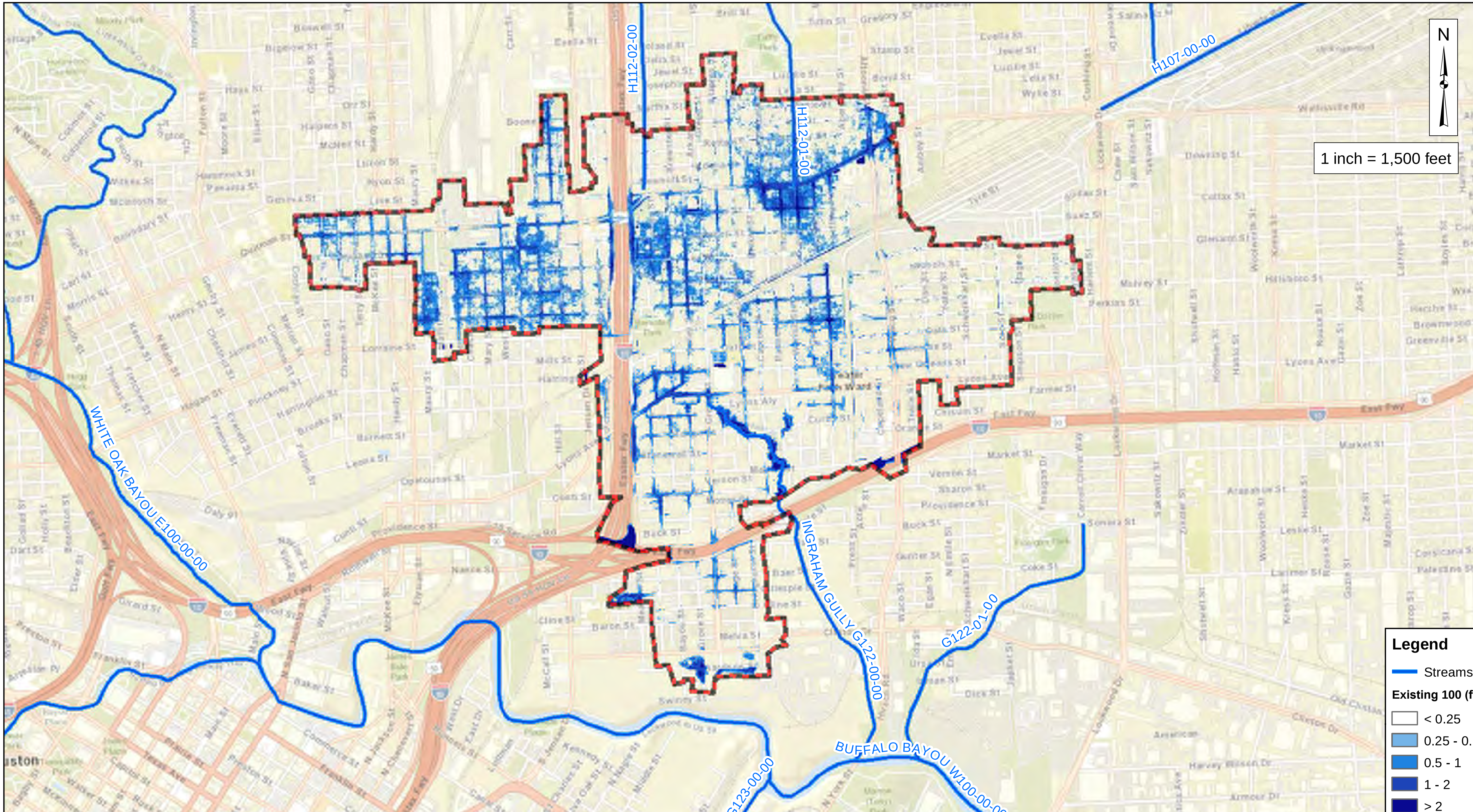
5th Ward Drainage Masterplan
Existing 10 year

Date: September 2020	**EXHIBIT 6B**



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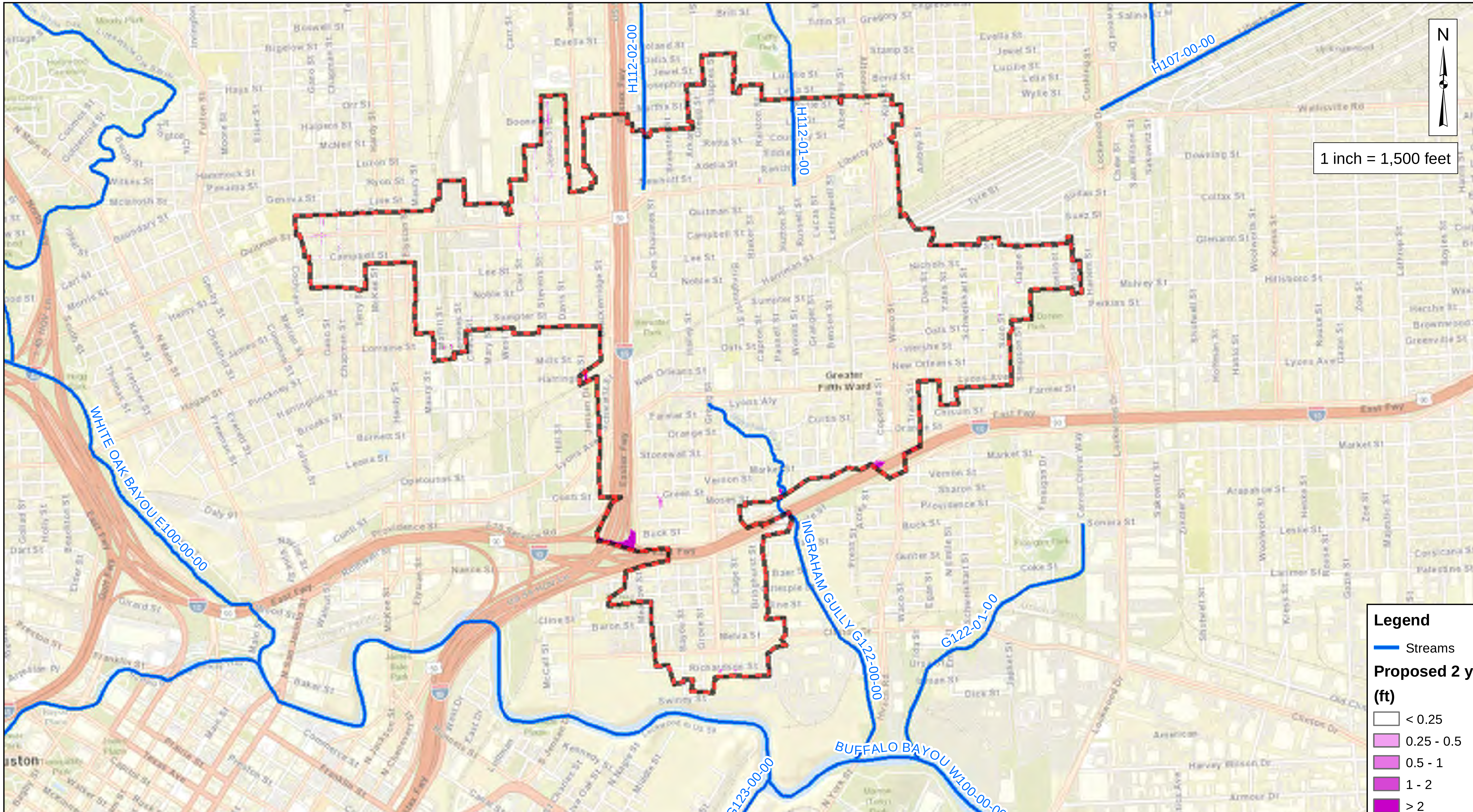
5th Ward Drainage Masterplan
Existing 100 year

Date: September 2020

EXHIBIT 6C



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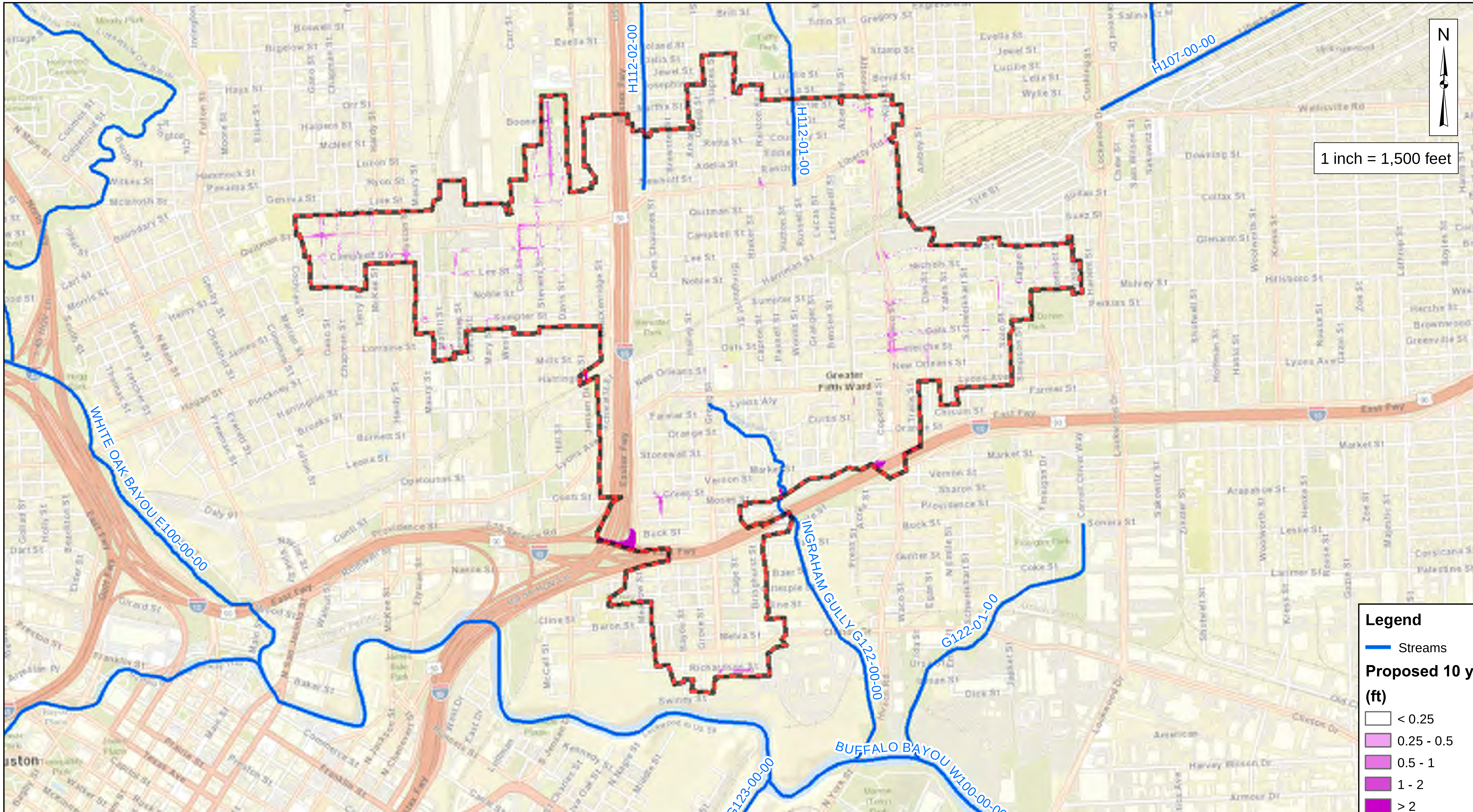
5th Ward Drainage Masterplan
Proposed 2 year

Date: September 2020

EXHIBIT 7A



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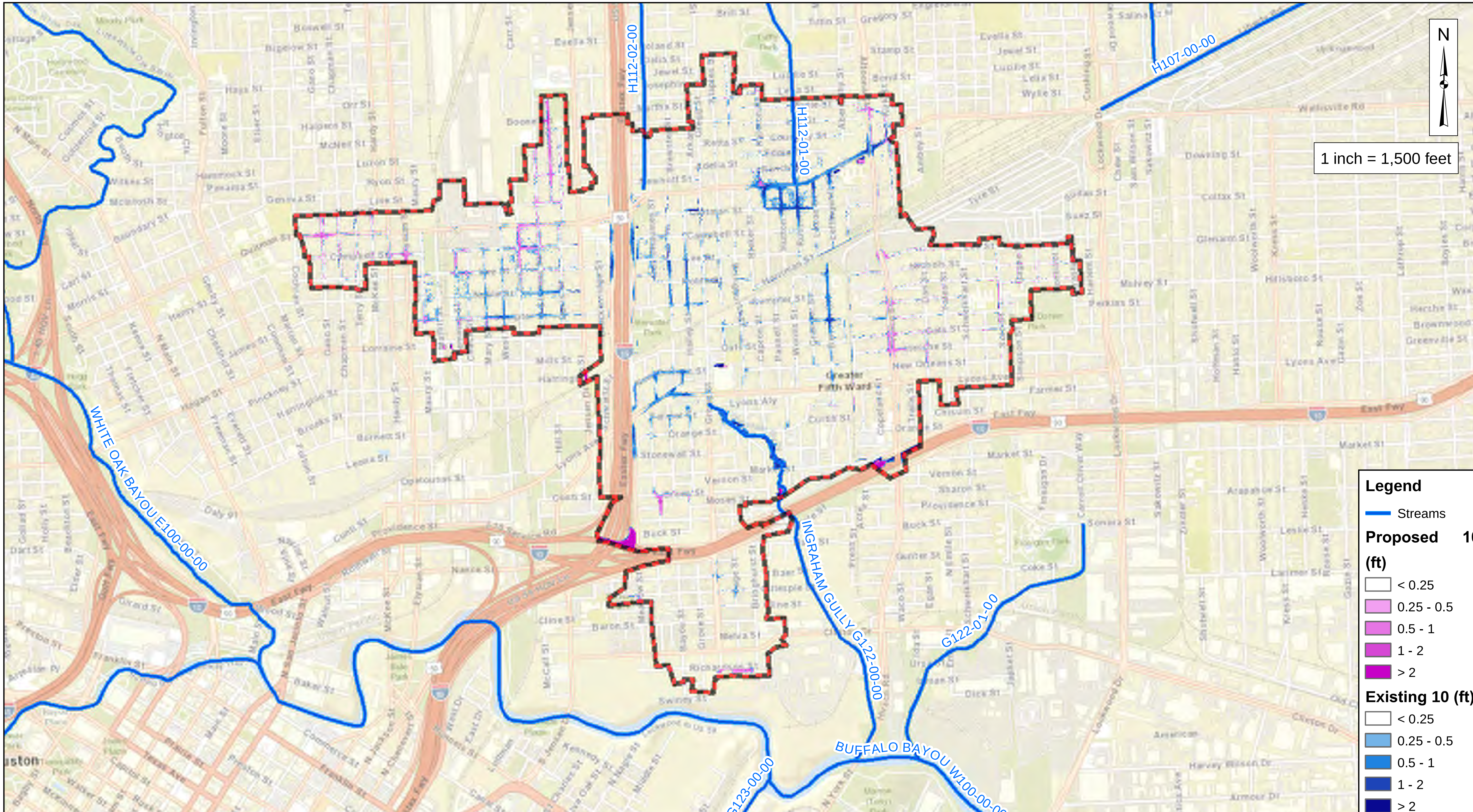
5th Ward Drainage Masterplan
Proposed 10 year

Date: September 2020	EXHIBIT 7B



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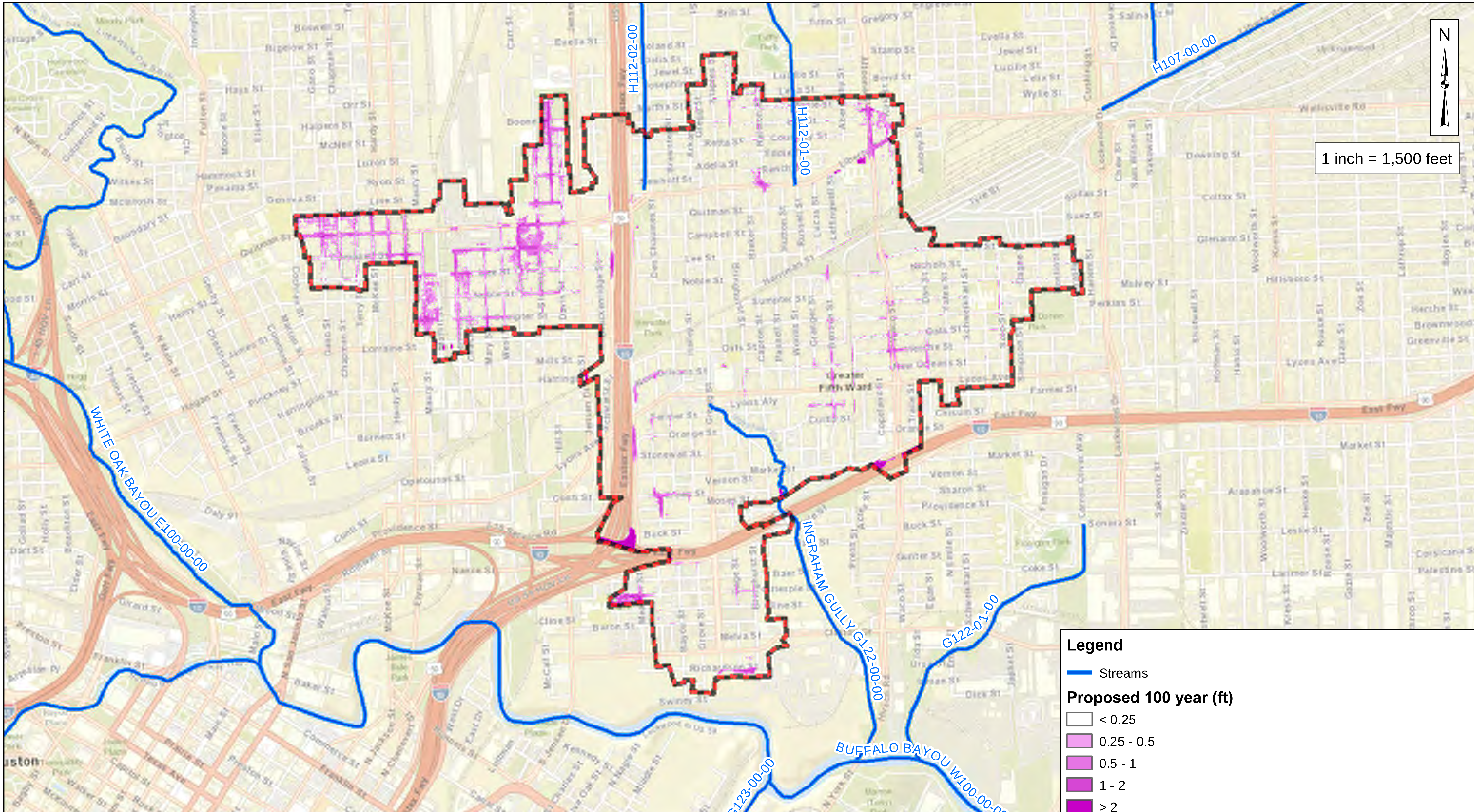
5th Ward Drainage Masterplan
Proposed 10 year with Existing

Date: July 2020	**EXHIBIT 7C**



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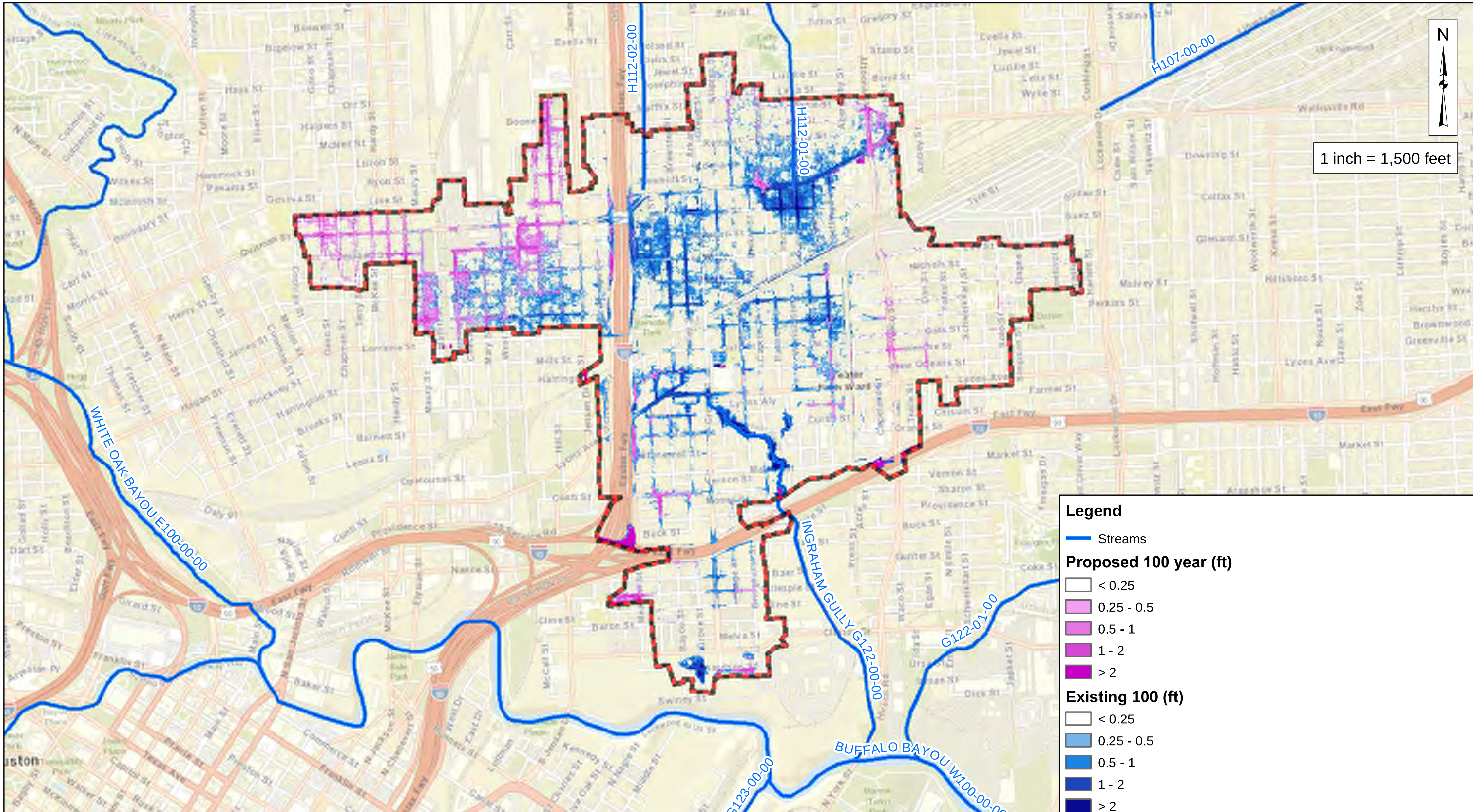
5th Ward Drainage Masterplan
Proposed 100 year

Date: September 2020

EXHIBIT 7D



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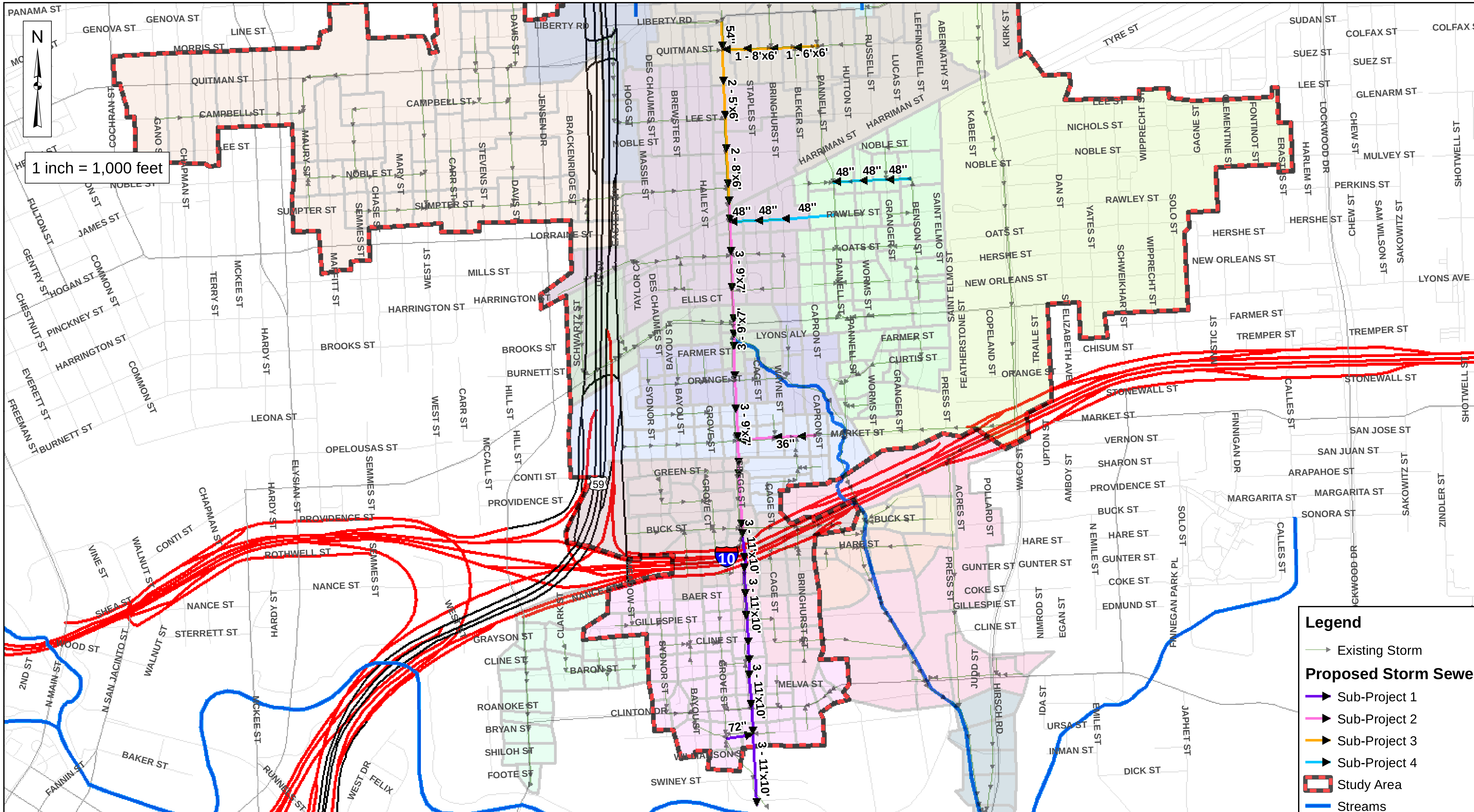
5th Ward Drainage Masterplan
Proposed 100 year with Existing

Date: September 2020	EXHIBIT 7E



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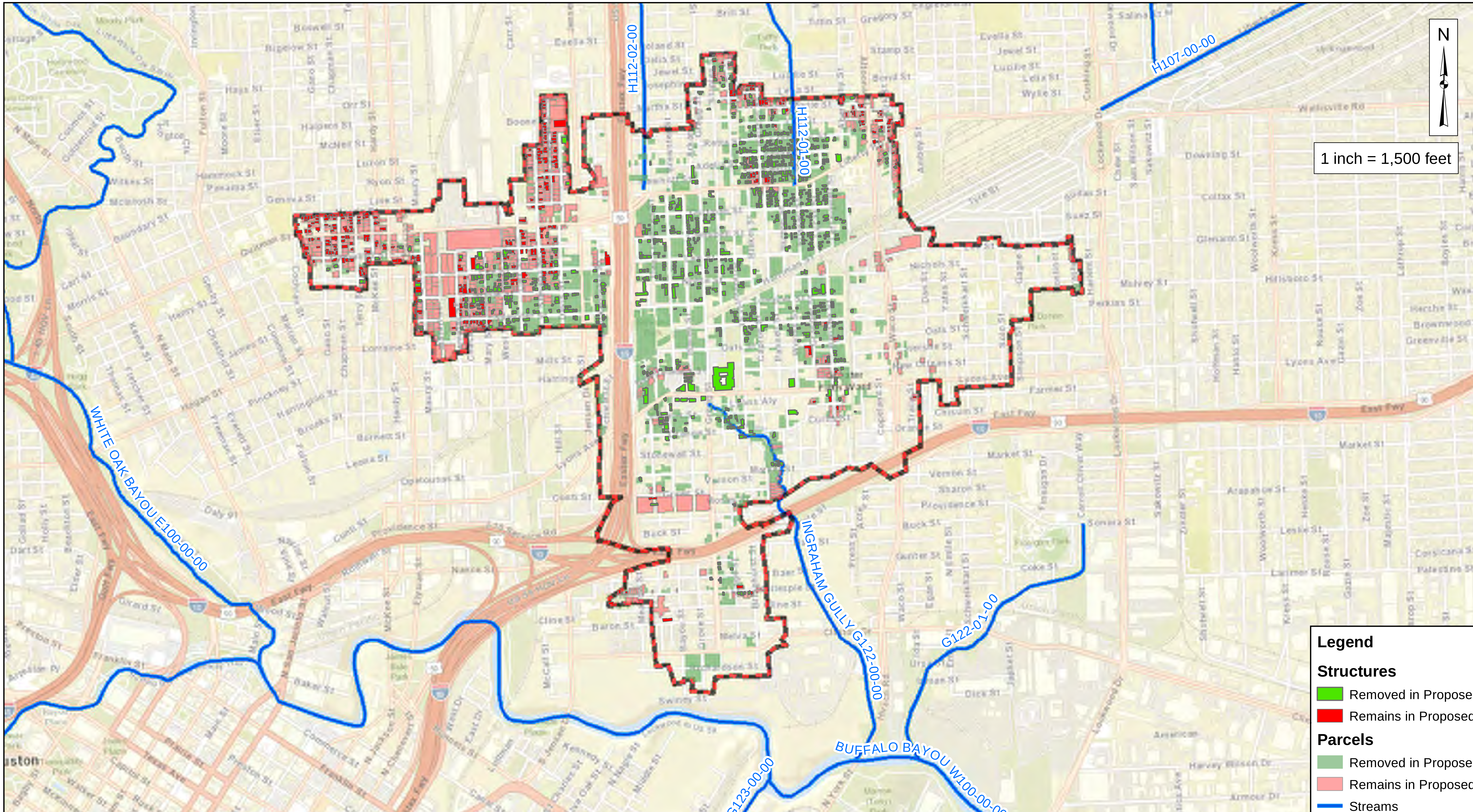
5th Ward Drainage Masterplan
Proposed Storm Sewer Map

Date: August 2020

EXHIBIT 8

Exhibit 9 - Cost/Benefit Matrix

	Cost	Flooded Quantities in Each Condition				Benefit			
	Total Cost	Flooded Streets (miles) > 6" Deep		Flooded Parcels > 3"	Flooded Structures > 3" Deep	Reductions			
		10-Year	100-Year	100-Year	100-Year	10-Year Street Miles	100-Year Street Miles	Parcels	Structures
Existing	**N/A**	3.7	13.0	2370	1240				
Sub-Project 1+2	**$ 56,322,906**	2.1	6.8	1483	768	1.58	6.24	887	472
Sub-Project 3	**$ 7,843,438**	0.9	4.1	841	338	1.22	2.72	642	430
Sub-Project 4 (2.5)	**$ 3,027,032**	0.8	3.8	771	325	0.05	0.33	70	13
TOTAL	**$ 67,193,376**					**2.86**	**9.29**	**1599**	**915**



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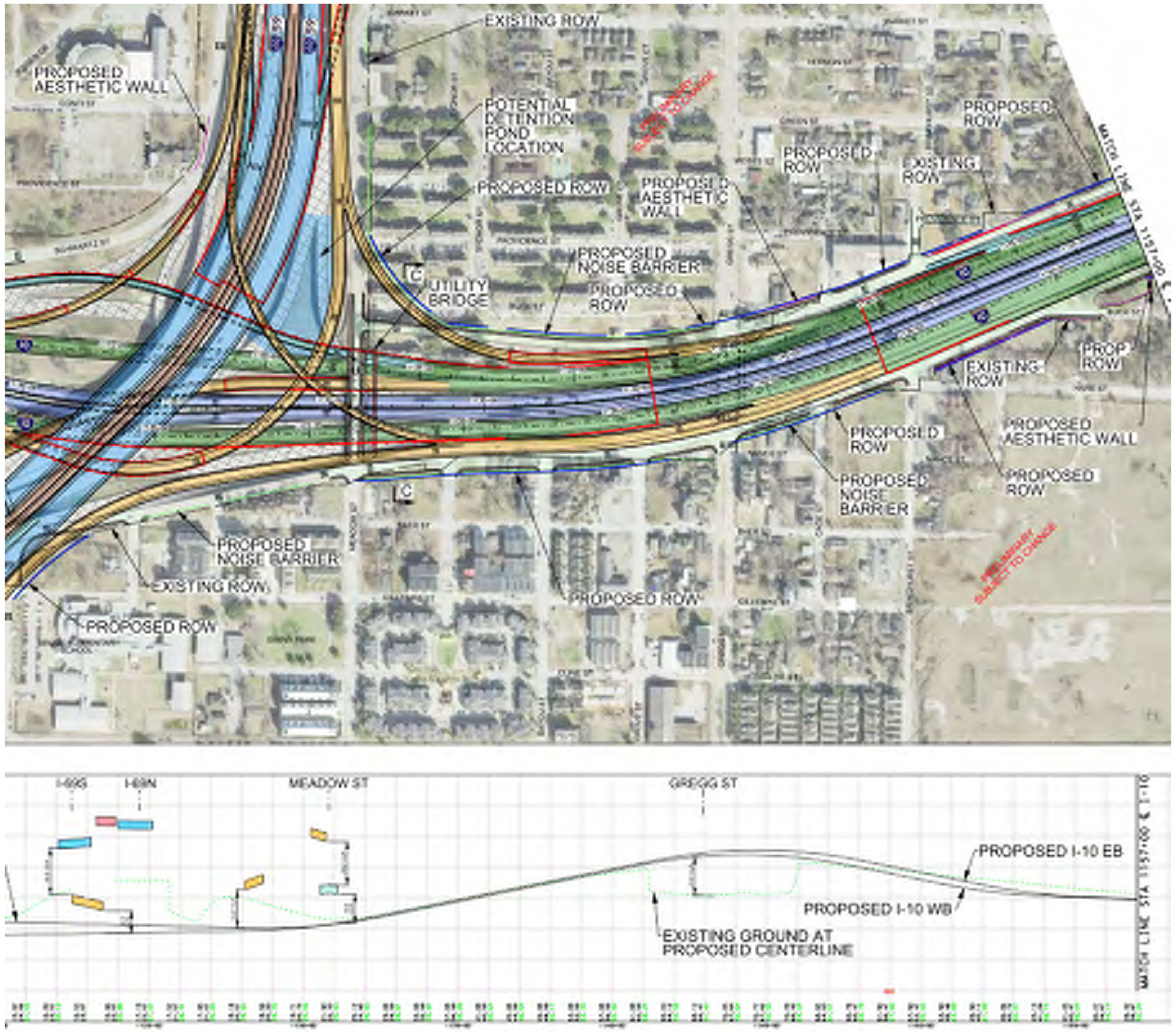
5th Ward Drainage Masterplan
Benefitted Structures

Date: September 2020	EXHIBIT 10



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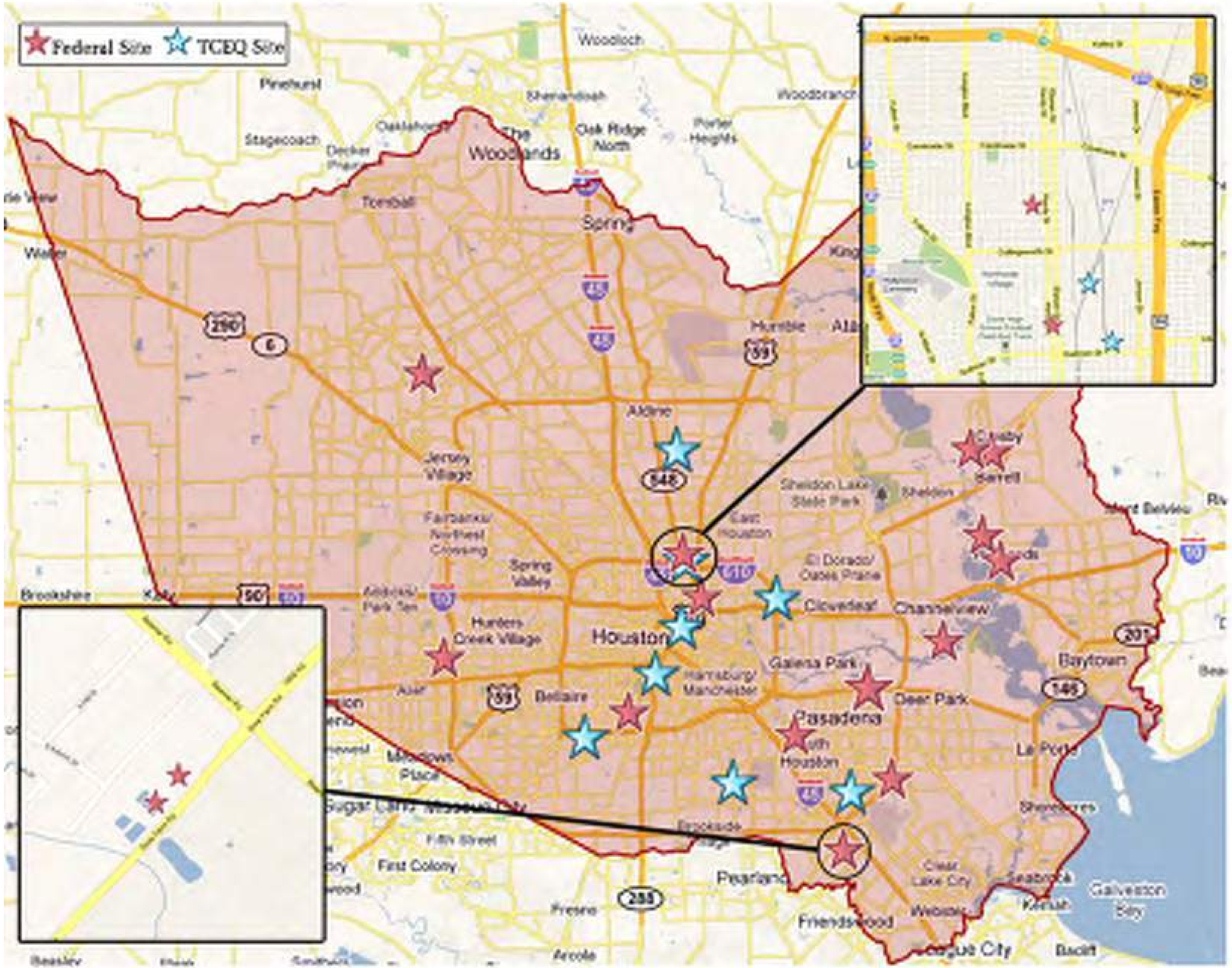
5th Ward Drainage Masterplan
TxDOT NHHIP Schematic

Date: April 2020	EXHIBIT 11



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5th Ward Drainage Masterplan
Superfund Sites

Date: April 2020	EXHIBIT 12

Houston Greater Fifth Ward Area Flood Mitigation Project
Benefit-Cost Analysis Report

Prepared for:

CITY OF HOUSTON
PUBLIC WORKS

HUITT-ZOLLARS, INC.
10350 RICHMOND AVE. SUITE 300
HOUSTON, TEXAS 77042-4248
TBPE Reg. No. F-761
(281) 496-0066
October 13, 2020

Study Purpose and Scope

The goal of the "Houston Greater Fifth Ward Area Flood Mitigation Project" is to reduce the long-term risk of loss of life, injury, damage to and loss of property, and suffering and hardship by more rapidly conveying water from the identified service areas to reduce flooding. Dynamic hydraulic and hydrologic (H&H) modeling was used to identify existing ponding impacts and illustrate the benefits of reduced ponding associated with the proposed project.

The target areas are listed as Fifth Ward and Market Square, and both projects are located within the Greater Fifth Area. The project areas are located just north of Buffalo Bayou and to the east and west side of US-59 in Houston, Harris County, TX. The limits of the studied areas are shown in Exhibit 1. The Greater Fifth Ward Area neighborhood drainage infrastructure was constructed between 1940 and 1970. The existing drainage system is a curb and gutter system and provides less than 2-year level of service (LOS) under Atlas 14 rainfall, with potential structural and street flooding during a 100-year storm event.

The H&H modeling identified flooding issues under existing conditions, including structural inundation and ponding that impacts safe roadway mobility. The impacts are further validated by other data points including FEMA National Flood Insurance Program (NFIP) data, FEMA Individual Assistance (IA) data, and/or calls for service.

The proposed project in Fifth Ward will add a new trunk line draining directly to Buffalo Bayou. The proposed work in Market Square will add new trunk lines through the neighborhood and outfall into Japhet Creek. Japhet Creek has sufficient capacity and drains to Buffalo Bayou. The proposed drainage improvement in both neighborhoods will reduce flood risk to existing properties and improve street ponding. The new trunklines will provide resiliency in the neighborhood and create reliable access for infrastructure and public transportation.

Data Collection

The following documents and data were obtained and used to guide this study:

- 2018 LiDAR dataset
- Building Footprint GIS shapefile
- COH Technical Memorandum "Fifth Ward Master Drainage Plan", prepared by CobbFendley, August 2020.
- COH Technical Memorandum "Market Square Area Paving and Drainage", Prepared by Jacobs, August 2020

Methodology

FEMA "Benefit-Cost Calculator" Version V.6.0 and FEMA guidelines and procedures were used to develop this BCA. The BCA determines the future risk reduction benefits for a specific drainage improvement project and compares those benefits to the construction cost for the drainage improvements. The Benefit-Cost Ratio (BCR) is calculated by dividing the estimated benefit for all structures by the proposed improvements' construction cost.

The 2018 Lidar, building footprint shapefile, limited survey and site visits were used to determine the lowest floor elevation of each building. Buildings that are on piers or are elevated were identified using available data and the lowest floor elevation were adjusted accordingly.

The proposed drainage improvements (see Exhibit 2) were modeled in detail using two-dimensional unsteady modeling using the XPSWMM program. The "Fifth Ward Master Drainage Plan" and "Market Square Area Paving and Drainage" Technical Memorandums provide pre-improvements and post-improvement 2-, 10-, 50 and 100-Year water surface elevations and discharge values which were used in this BCA report. The 100-yr ponding limits of existing and proposed condition are shown in Exhibit 3 and Exhibit 4, respectively.

Exhibit 5 presents the location of structures where 100-yr Water Surface Elevation (WSE) is higher than the lowest floor elevation. These Structures will directly benefit from lowering the WSE after the proposed drainage improvements are implemented (Benefited Structures). These Benefitted Structures were utilized to develop the BCA.

BCA Toolkit

The Benefitted Structures are mainly residential with each structure is identified by the latitude and longitude at its centroid.

The mitigation action and project cost are based on drainage improvements identified in the "Fifth Ward Master Drainage Plan" and "Market Square Area Paving and Drainage" Technical Memorandums.

The values for Hazard Probability Parameters (flood) such as discharge and water surface elevation, for storm events with a recurrence interval of 2-, 10-, 50 and 100-Year were used from "Fifth Ward Master Drainage Plan" and "Market Square Area Paving and Drainage" Technical Memorandums.

The BCA toolkit's default values and standard processes were used to calculate the standard building benefit. Only values for the first floor of each structure were used (one story), with no basement. Standard benefit for each building is calculated using the first floor square footage multiply by the default building replacement value.

In the BCA, it was assumed that utilities are not elevated. The BCA toolkit's default values for contents and displacement were used. No volunteer, ecosystem services, or social benefits were used in these calculations.

The total drainage improvement cost were distributed between all benefitted structures uniformly, resulting in similar BCR value for consistency.

The total project cost and benefit are the summation of all the structures' costs and benefits. The total BCR is presented in **Table 1**. The detail of each structure BCR calculation is provided in **Attachment 1**.

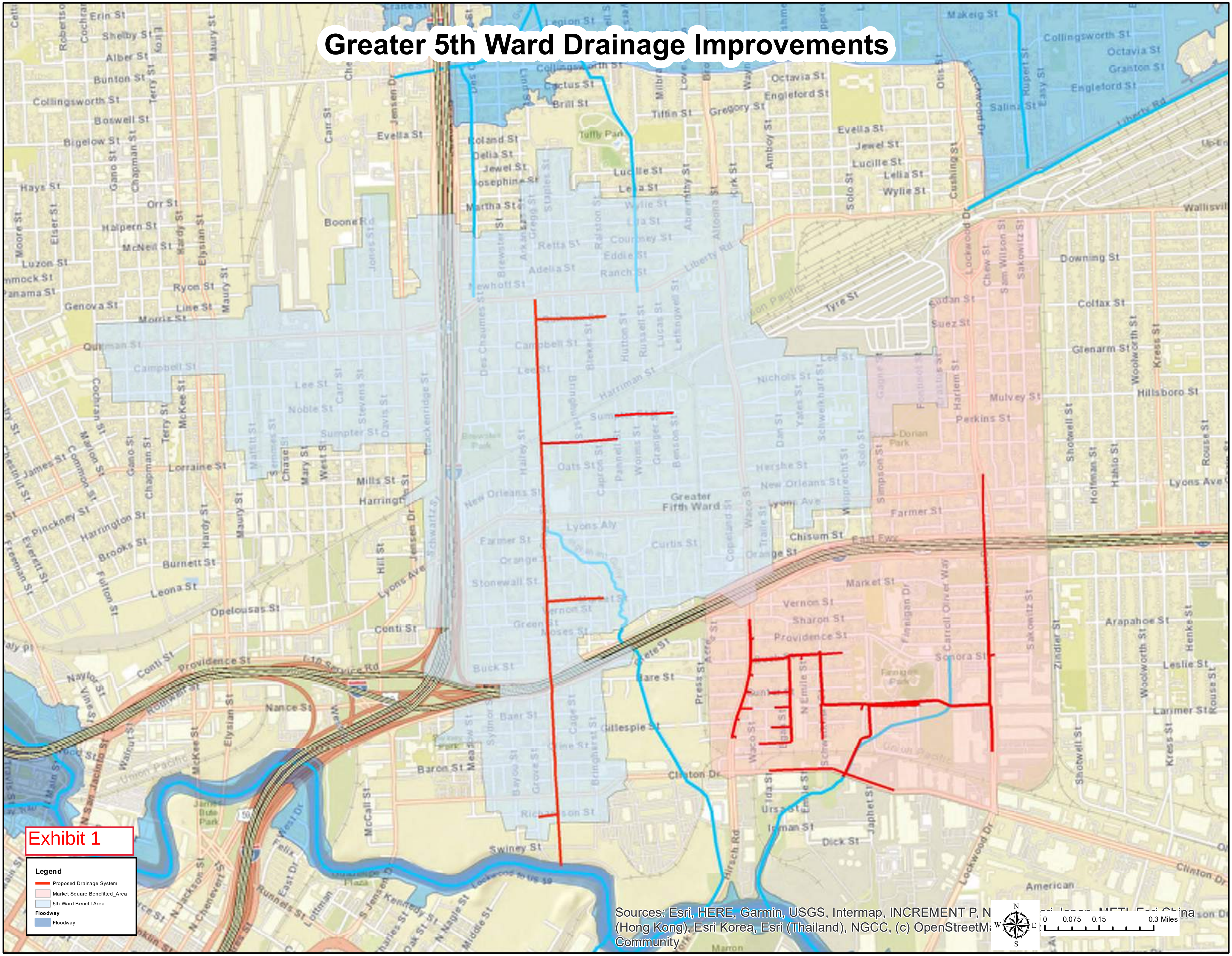
Table 1. Total Benefit-Cost Ratio

Project Name (-)	Total Benefit ($)	Total Cost ($)	Total BCR (-)
Fifth Ward	$ 117,313,214	$ 68,267,901	1.72
Market Square	$ 50,643,729	$ 21,485,586	2.35
TOTAL	$ 167,956,943	$ 89,753,487	1.87

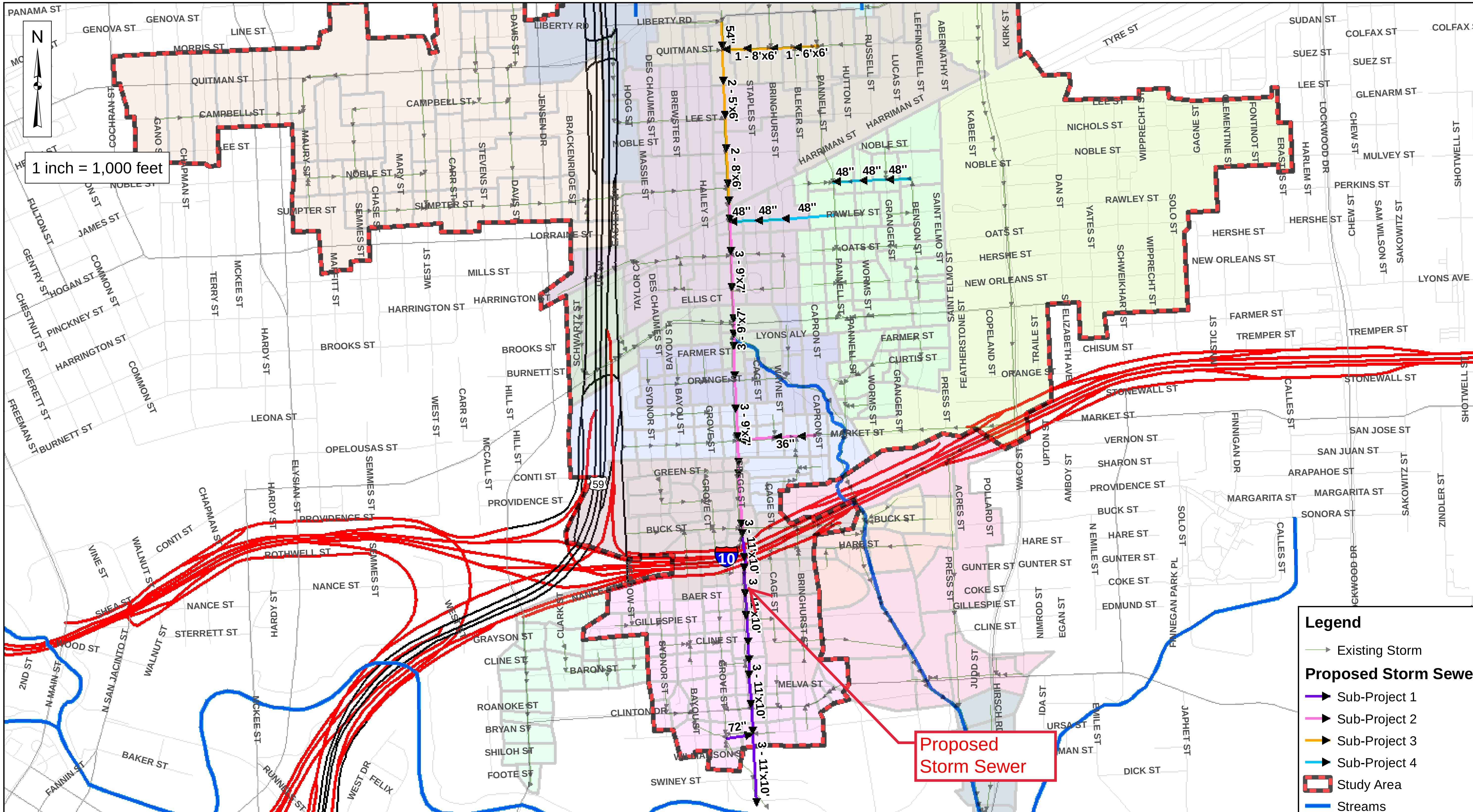
Conclusion

The "Houston Greater Fifth Ward Area Flood Mitigation Project" has a benefit-cost ratio greater than 1.

Greater 5th Ward Drainage Improvements



Fifth Ward



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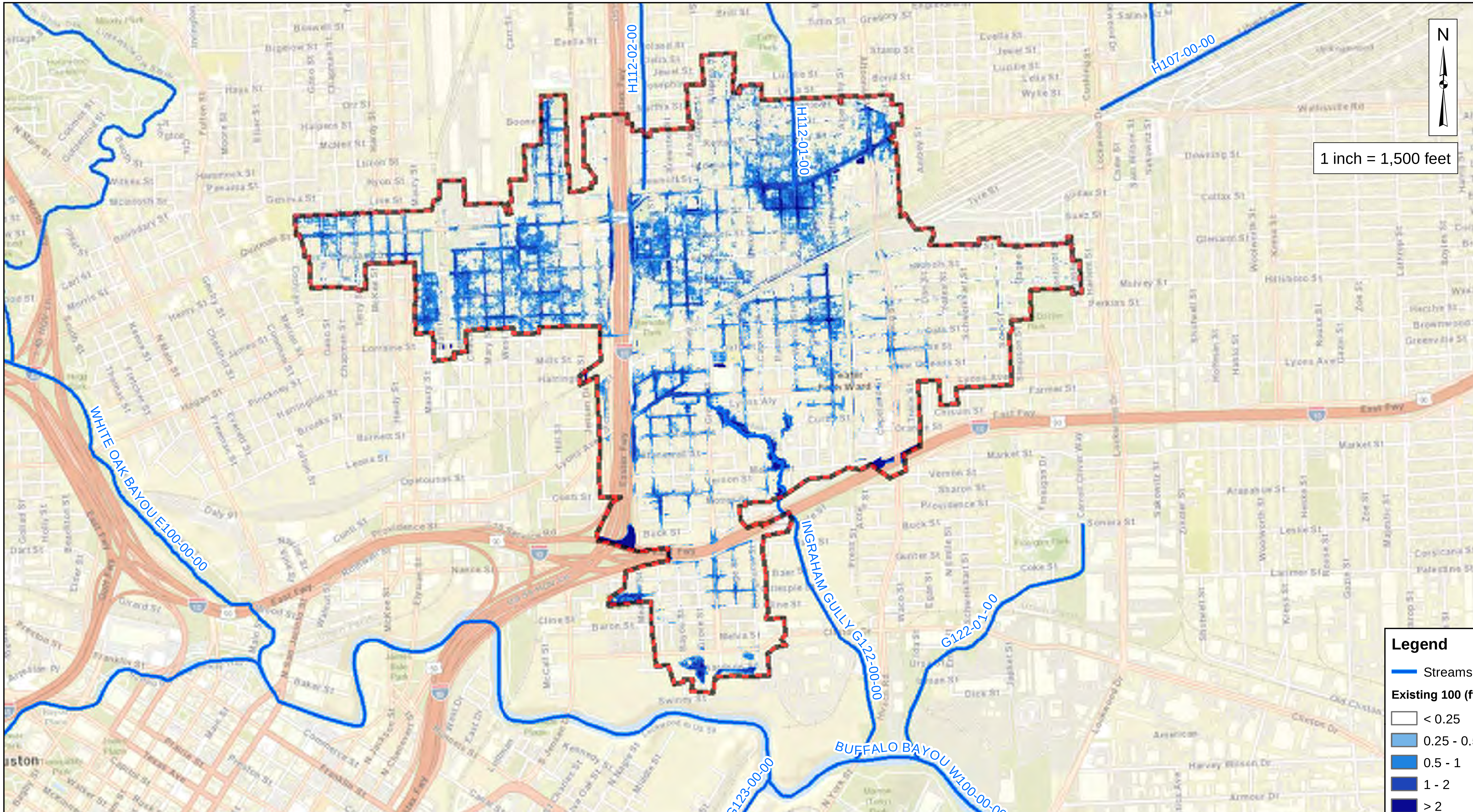
5th Ward Drainage Masterplan
Proposed Storm Sewer Map

Date: October 2020	EXHIBIT 2

Fifth Ward



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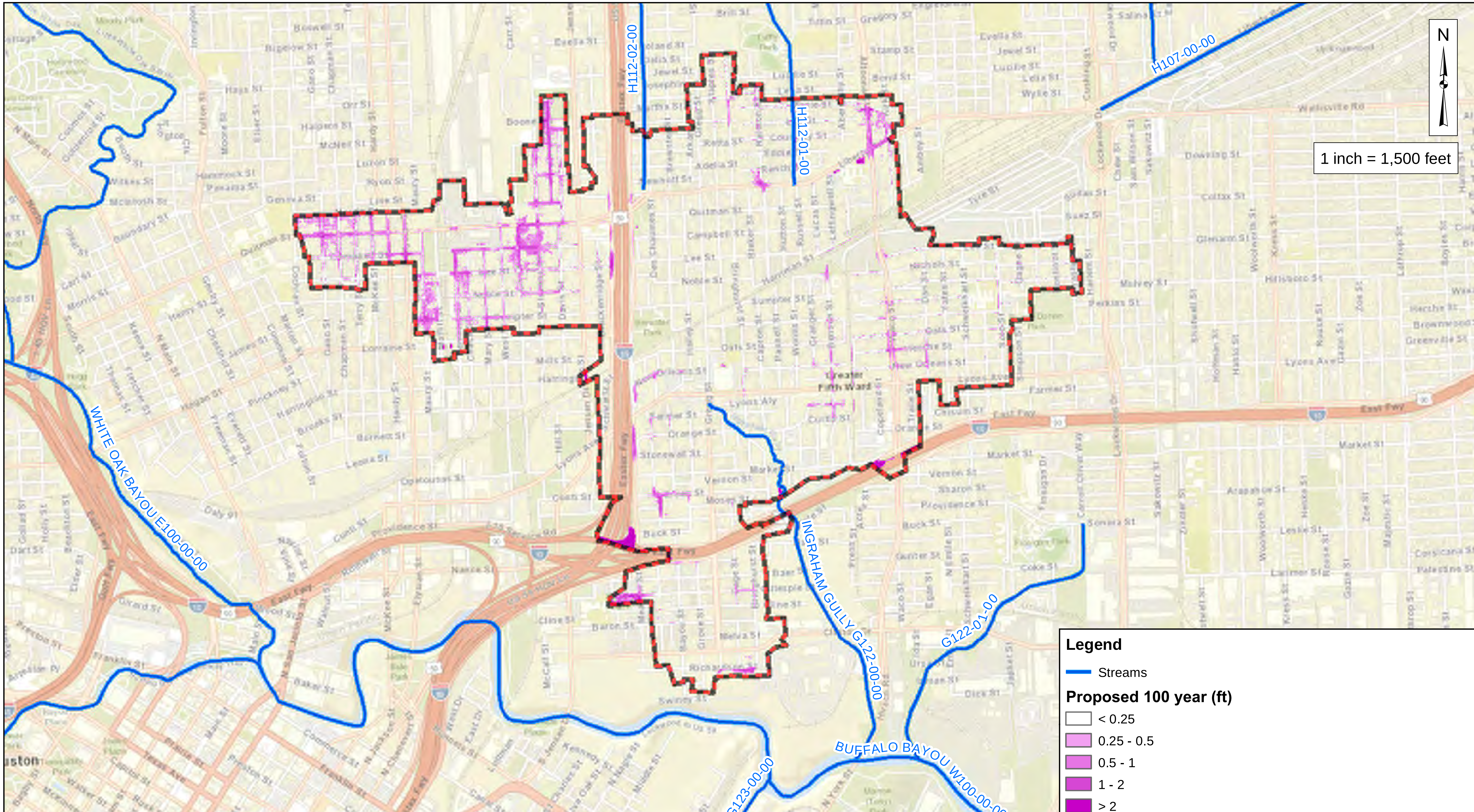
5th Ward Drainage Masterplan
Existing 100 year

Date: October 2020	**EXHIBIT 3**

Fifth Ward



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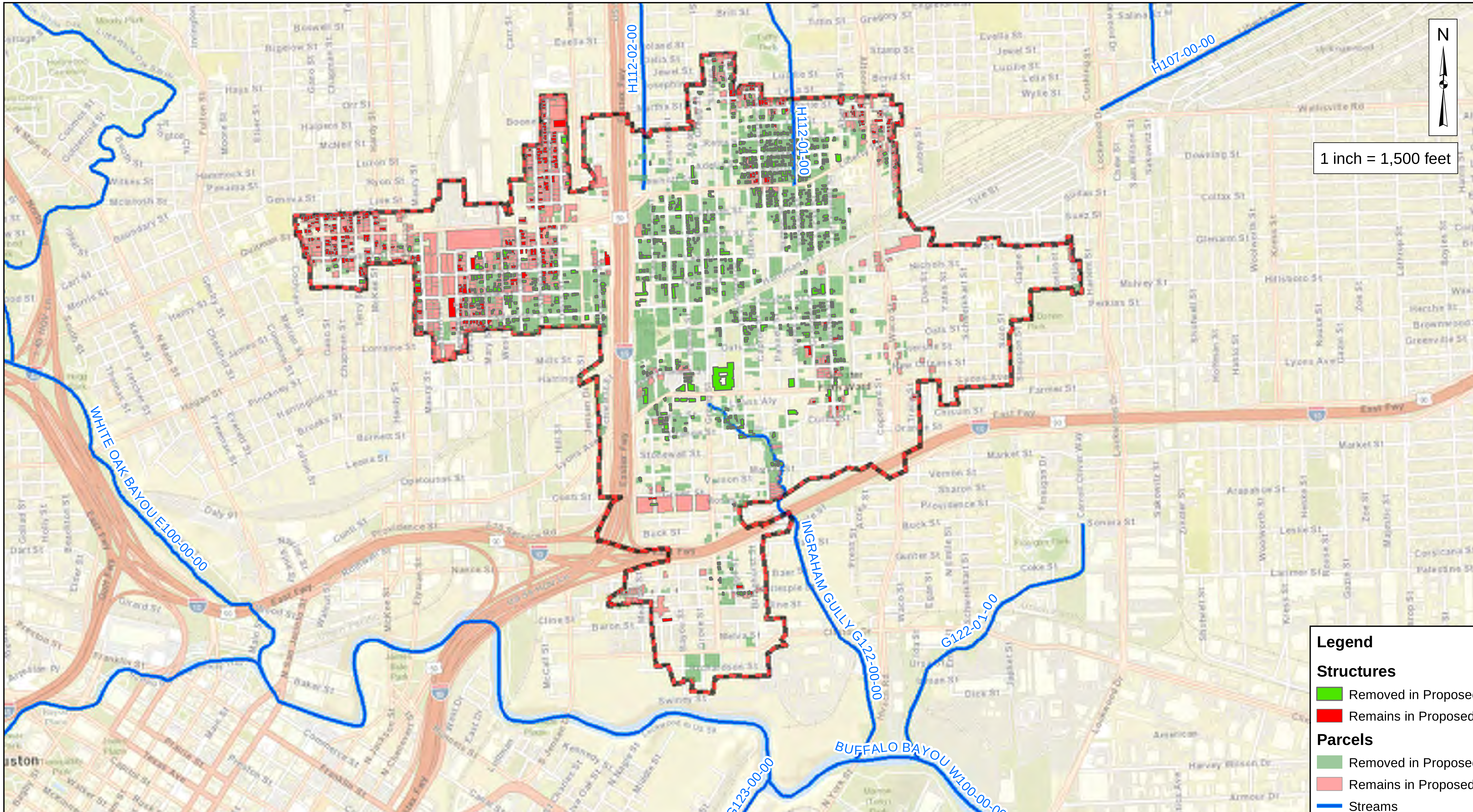
5th Ward Drainage Masterplan
Proposed 100 year

Date: October 2020 | **EXHIBIT 4**

Fifth Ward



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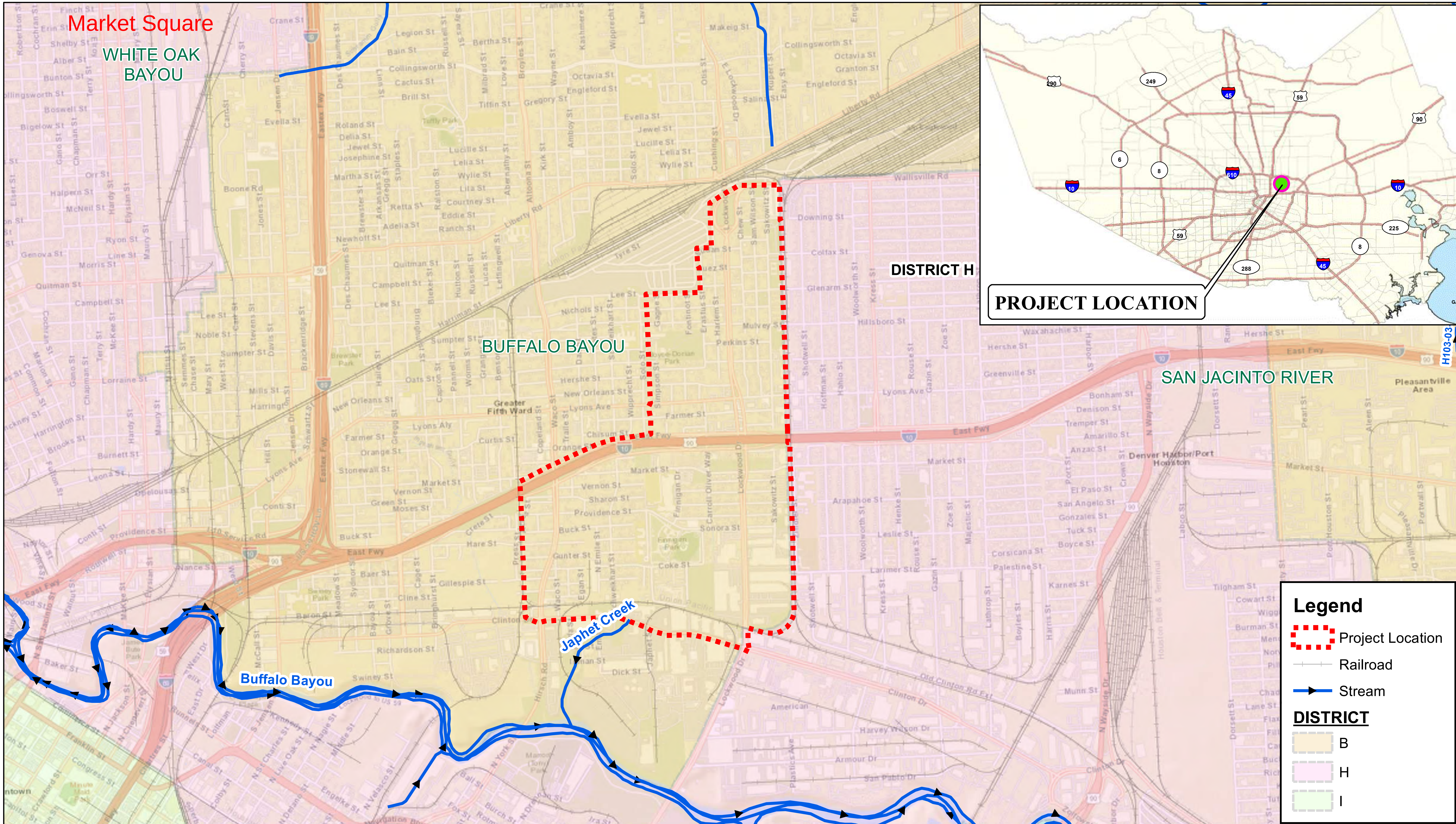
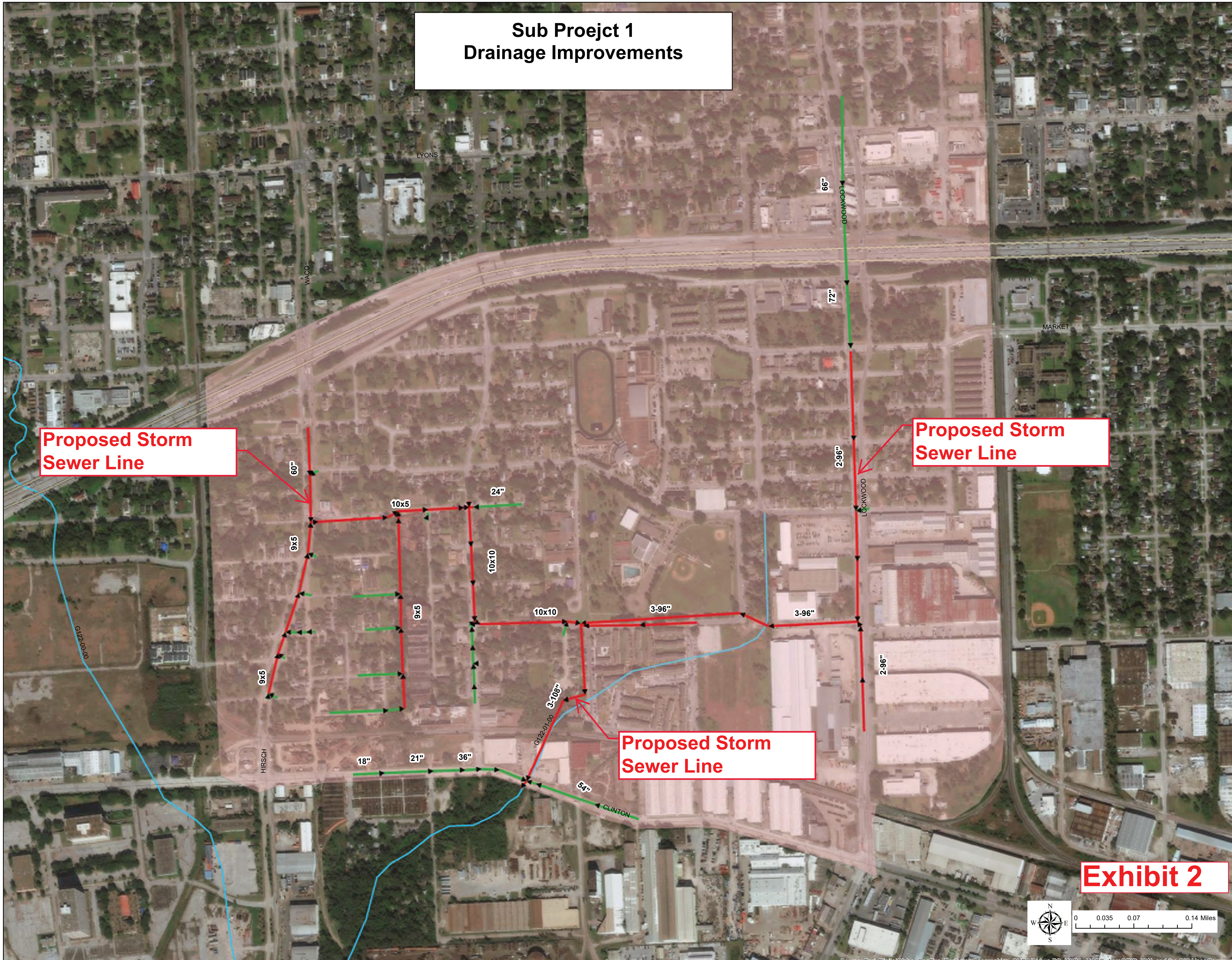
5th Ward Drainage Masterplan
Benefitted Structures

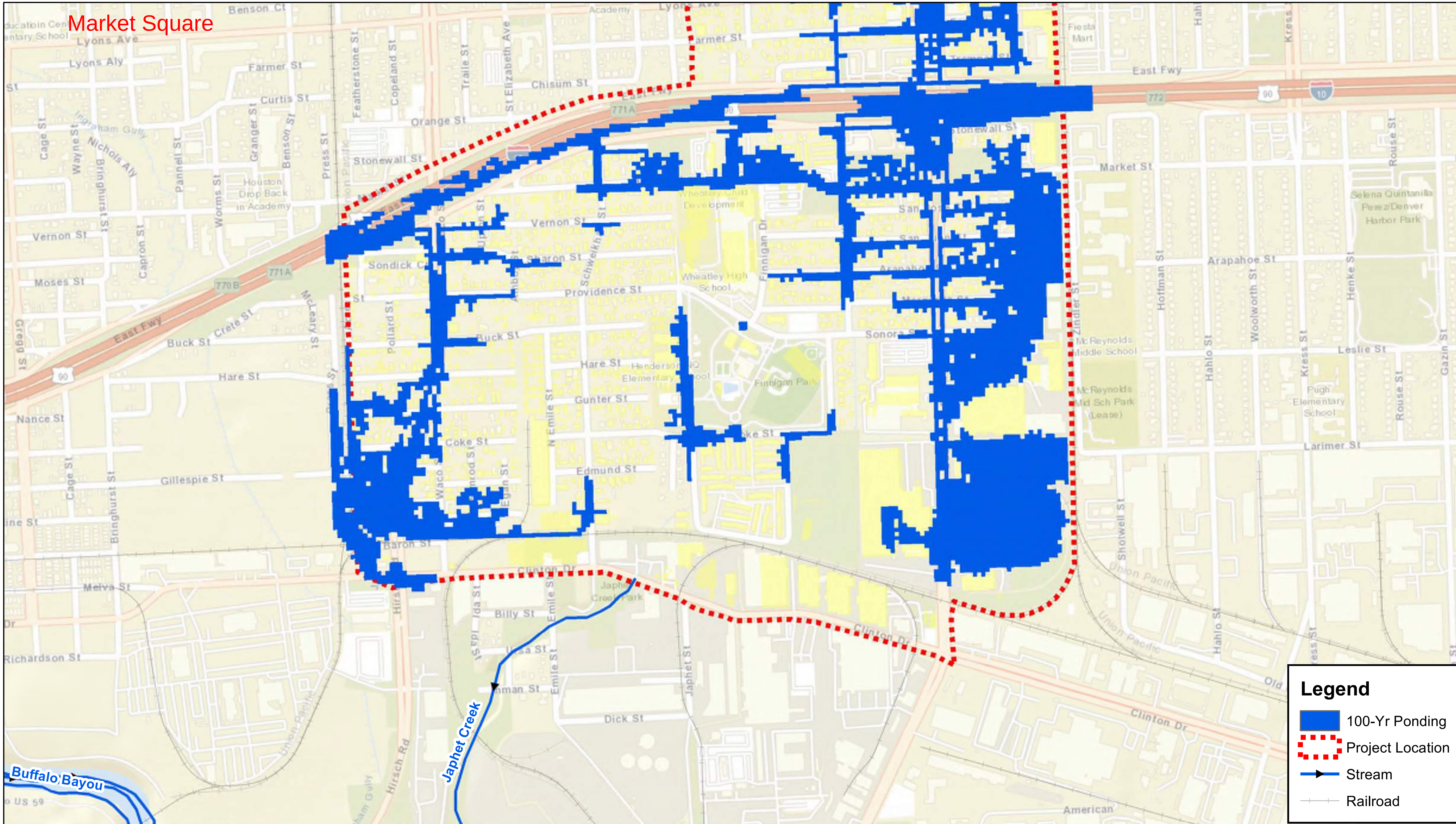
Date: October 2020

EXHIBIT 5

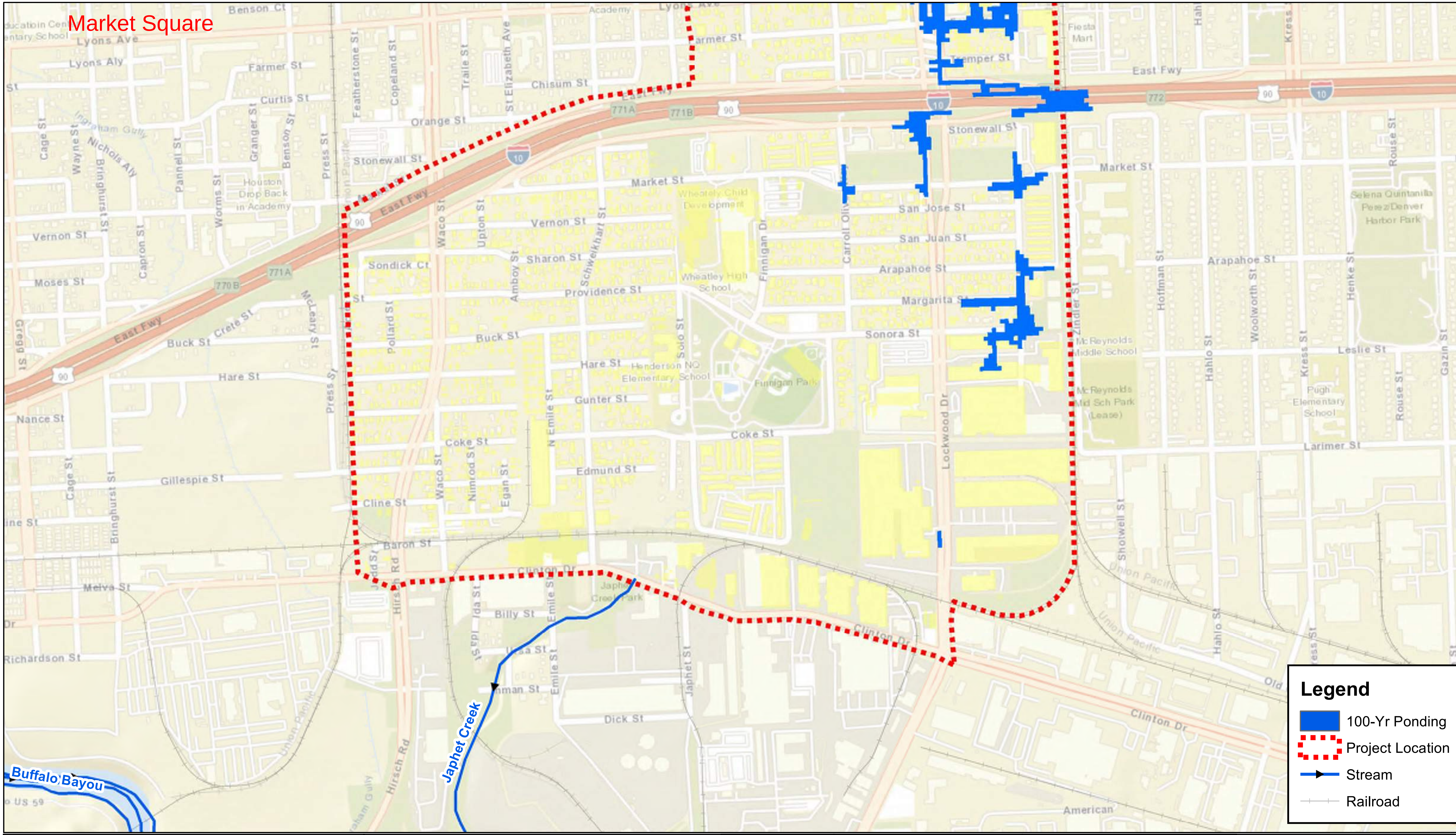


HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. N□210010□0001□3 (MARKET SQUARE)		DATE	SCALE	EXHIBIT 1
			OCTOBER 2020	0 1,000 2,000 Feet	LOCATION MAP


Sub Proejct 1
Drainage Improvements
Proposed Storm Sewer Line
Proposed Storm Sewer Line
Proposed Storm Sewer Line
LYONS
WACO
MARKET
LOCKWOOD
LOCKWOOD
HIRSCH
CLINTON
G122-00-00
G122-01-00
66"
72"
2-96"
2-96"
3-96"
3-96"
60"
9x5
9x5
9x5
10x5
24"
10x10
10x10
3-108"
18"
21"
36"
54"
Exhibit 2
N
S
E
W
0 0.035 0.07 0.14 Miles
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



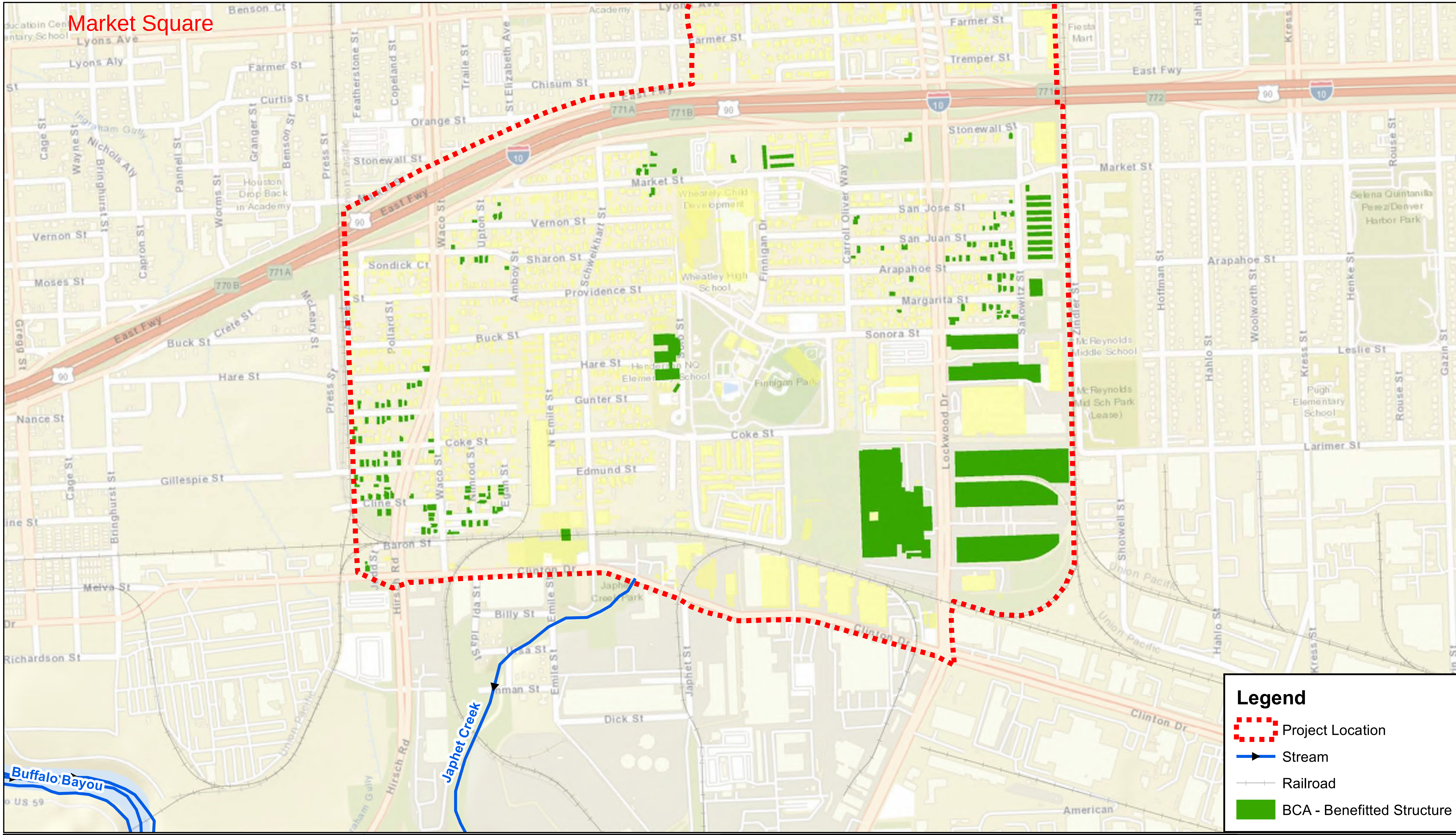
HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. N□210010□0001□3 (MARKET SQUARE)		DATE	SCALE	EXHIBIT 3
			OCTOBER 2020	0 500 1,000 Feet	100-YR PONDING LIMITS EXISTING CONDITION



HUITT-ZOLLARS

PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. N□210010□0001□3
(MARKET SQUARE)

DATE	SCALE	EXHIBIT 4
OCTOBER 2020	0 500 1,000 Feet	100-YR PONDING LIMITS PROPOSED CONDITION



HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. N□210010□0001□3 (MARKET SQUARE)		DATE	SCALE	EXHIBIT 5
			OCTOBER 2020	0 500 1,000 Feet	BENEFIT-COST ANALYSIS BENFITTED STRUCTURES

Attachment 1

Note: Due to the high number of benefitted structures and BCA Toolkit's limit, the BCR calculation is split into 6 excel files as listed below:

Fifth Ward

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9

Market Square

- Group 10
- Group 11

Appendix 5-4K: Houston Port Area

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MEMORANDUM

TO:	Maureen Crocker Assistant Director Transportation and Drainage Operations	**DATE:**	April 6, 2020
FROM:	C. Andrew Moore, P.E., CFM	**AVO:**	31051
EMAIL:	amoore@halff.com		
SUBJECT:	WO121 – Pleasantville Detention Analysis		

INTRODUCTION

The City of Houston (City) has contracted Halff Associates, Inc. (Halff) to perform a stormwater analysis of the Pleasantville area using Atlas 14 rainfall to determine how detention could reduce drainage improvements needed while increasing the level of service for the neighborhood. Goals of the study included:

- Updating the existing drainage models (previously developed by Halff) to incorporate the Atlas 14 rainfall and determining the level of service of the drainage network for both existing conditions and the recommended Alternative 1A-1.
- Identifying locations for potential detention that would provide benefit to the Pleasantville neighborhood. Selecting most feasible detention site(s) for detailed modeling.
- Updating the previously recommended subprojects identified as Alternative 1A-1 to include the detention pond. Determine the actual detention volume needed to improve drainage and storm sewer improvements needed to achieve the highest level of service possible for the neighborhood.
- Providing opinions of probable construction cost for the drainage and paving improvements for the previous recommended Alternative 1A-1 and the new Detention Alternative.

LOCATION AND PREVIOUS STUDIES

The Pleasantville area is located west of 610 East, south of Market Street Rd, east of Pearl St and north of Clinton Dr. The project area is shown on **Exhibit 1**.

The existing storm sewer system was constructed in the 1960s and 1970s. Drainage improvements, known as Subproject 1 and Subproject 1A (described below) were constructed in 2016 and 2017 per the *2013 Study*. These improvements provide relief from flooding for residents within the Pleasantville area. The improvements consisted of large RCBs that convey flow towards the outfall that is near the existing TxDOT system at IH-610 East. The existing storm

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sewer system range in size from 18" RCPs to 10'x10' RCBs. Storm water is drained via Type-B inlets throughout the drainage area . The existing storm sewer layout is shown in **Exhibit 2**.

The Pleasantville neighborhood has had several previous studies conducted to identify drainage issues and recommend solutions. These studies are summarized below:

- Pleasantville/Glendale Preliminary Engineering Report (2012 PER) – Preliminary Engineering Report completed in 2012 of the Pleasantville/Glendale neighborhood to identify existing drainage issues and propose solutions. The PER recommended neighborhood wide storm sewer upgrades and detention located on the southwest portion of the neighborhood.
- Pleasantville/Glendale Additional Services (2013 Study) – The detention ponds sought in the *2012 PER* were not pursued and therefore additional alternatives were analyzed to determine changes to the proposed storm sewer system. The study recommended Alternative 1A-1 which consisted of large trunklines throughout the neighborhood outfalling into the TxDOT system along I-610 providing a 25-year level of service (pre-Atlas 14).
- Pleasantville/Glendale Storm Sewer Design Subproject 1 (2016) – Completed in 2016, the first subproject of the neighborhood drainage that installed the main trunk line from Industrial Drive near I-610 to the west end of Guinevere Street. Project included 6'x6' RCB and 10'x10' RCB.
- Pleasantville/Glendale Storm Sewer Design Subproject 1A (2017) – Completed in 2017, the second subproject of the drainage system that installed the final piece of the storm sewer trunk along Industrial Drive and additional storm sewer along Turning Basin.

ATLAS 14 HYDROLOGY UPDATE

Hydrology calculations prepared from the previous studies were updated to account for the new rainfall documented in the NOAA Atlas 14 Precipitation-Frequency Atlas of the United States Volume 11 (*Atlas 14)* and the *City of Houston Infrastructure Design Manual* (IDM). The updated rainfall includes new e, b, d values used to calculate rainfall intensity. A table of the rainfall parameters based on the previous National Weather Service documents and NOAA Atlas 14 is shown below in **Table 1**.

Table 1. Rainfall Intensity Parameters

Rainfall Event	National Weather Service			NOAA Atlas 14		
	b	d	e	b	d	e
2-yr	75.01	16.2	0.8315	48.35	9.07	0.7244
10-yr	93.53	18.9	0.7742	54.68	6.96	0.6623
25-yr	115.9	21.2	0.7808	57.79	5.89	0.6294
100-yr	125.4	21.8	0.7500	60.66	4.44	0.5797

A graph comparing the previous IDF curves to the Atlas 14 IDF curves is shown below in **Figure 1**.

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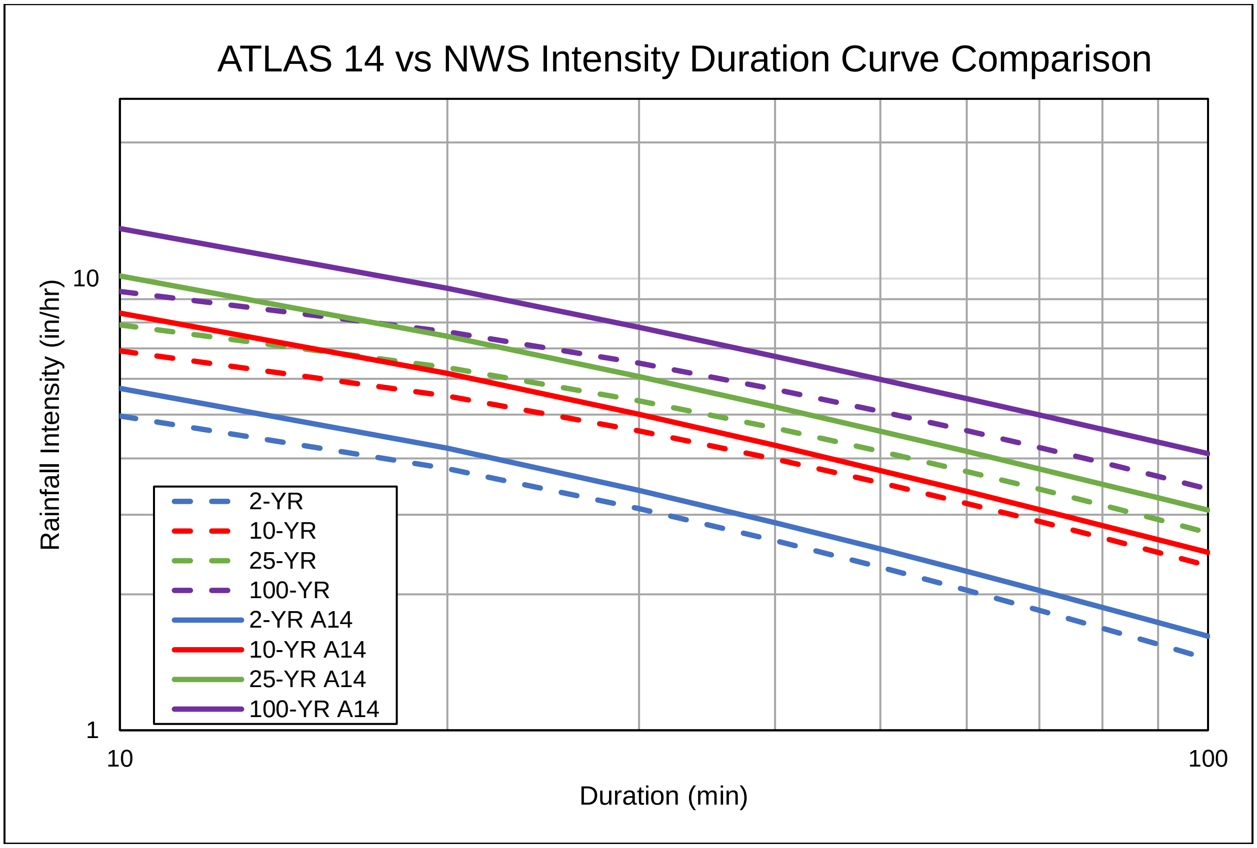

Figure 1. Comparison of Pre-Atlas 14 and Atlas 14 IDF Curves

The drainage basins delineated as part of the *2013 Study* were used to determine new flows from the updated rainfall parameters based on Atlas 14.

As of late 2019, construction began on an approximately 84-acre area east of Pearl St and south of Northton St and consists of an industrial complex with onsite detention. A figure showing the before and after pictures of the area being developed is shown below **Figure 2**.

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Figure 2. Before and After Photos of Development

Prior to development, runoff from this site sheet-flowed north into the Pleasantville neighborhood. After construction, the development appears to now drain west to the storm sewer on McCarty Street. Therefore, these drainage areas were removed from the analysis performed for this study. The existing topography of the Pleasantville area is shown in **Exhibit 3.** The removed subbasins are shown below in **Figure 3**. The drainage basins used for the hydrologic analysis in Pleasantville are shown in **Exhibit 4**.

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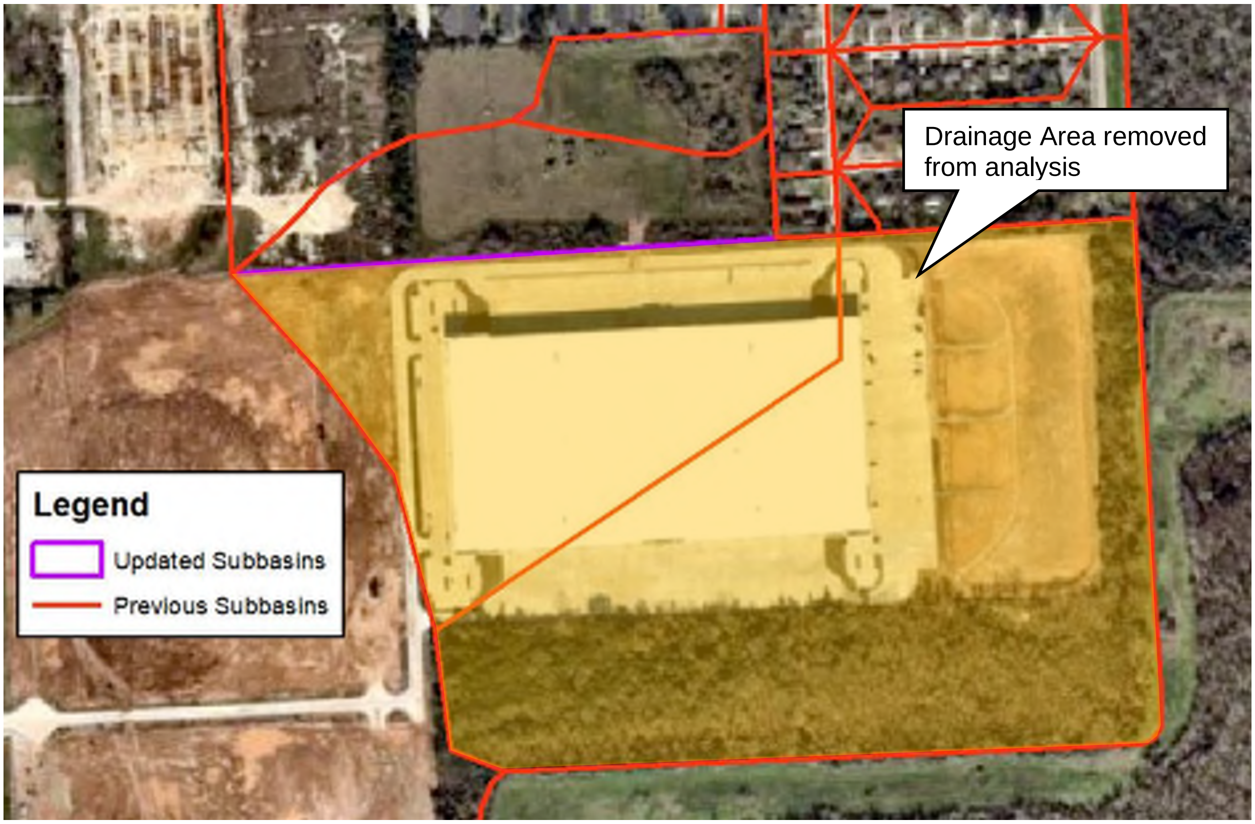

Figure 3. Previous vs Updated Subbasins - Offsite Area

Flows were determined in previous studies using the Rational Method. The methodology was updated with Atlas 14 rainfall intensity parameters. Flow hydrographs for each basin were developed using the HEC-HMS model from the *2013 Study.* In general, flow rates increased by 11% for the 2-year storm event, 11% for the 10-year storm event, 15% for the 50-year storm event, and 23% for the 100-year storm event. The Rational Method peak flow rate calculations are included in **Appendix A**.

Hydrographs for each drainage area were developed using HEC-HMS v 3.5. Drainage area size, impervious percentage and time of concentration were input to the HEC-HMS model based on the basin characteristics. The transform parameter storage coefficient "R" value was adjusted so that the resultant peak flow from the HEC-HMS model matched with the Rational Method peak flows. The "R" values were adjusted separately for each of the 2-, 10-, 25-, 50-, and 100-year storm events. The runoff hydrographs were imported into the InfoWorks ICM model which was used to calculate storm sewer capacity and flooding extents.

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ATLAS 14 HYDRAULIC UPDATE

Existing Conditions

The existing conditions ICM model was updated to include the Atlas 14 runoff hydrographs and the newly constructed storm sewer improvements from Subproject 1. The storm sewer characteristics were input into the model from the design drawings. The revised hydraulic model was then simulated for the 2-year, 10-year, 25-year, 50-year and 100-year storm events to determine the revised existing level of service based on the Atlas 14 rainfall.

Existing Results

In the *2013 Study*, the existing storm sewer system had a 25-year LOS with pre-Atlas 14 rainfall. Based on the new existing conditions results, the storm sewer system generally has less than a 2-year level of service (LOS) since there is 2-year ponding with Atlas 14 rainfall. A table of ponding depths for various intersections for the 2-year and 100-year events is shown below in **Table 2**.

Table 2. Existing Ponding Depths (Atlas 14)

Intersection	Ponding Depths (ft)	
	2YR	100YR
Bucroft - Pleasantville	0.85	2.82
Fillmore - Gellhorn	0.20	2.24
Bucroft - Gellhorn	0.32	3.18
Northton - Gellhorn	0.84	3.28
Josie - Gellhorn	1.84	2.78
Ledwicke - Guinevere	0.00	2.65
Flossie Mae - Quaker	0.00	2.35
Laurentide - Pattibob	0.00	2.39
Cowart - Ledwicke	0.00	1.58
Laurentide - Tilgham	0.00	1.80
Berndale - Candy	0.29	1.62
Laurentide - Candy	0.00	1.78
Tilgham - Teanaway	0.00	1.01
Norvic - Teanaway	0.40	1.77
Wiggins - Silverdale	0.31	2.13
Berndale - Silverdale	0.51	2.63

Several intersections have ponding depths above 0.5 feet during the 2-year. During the 100-year event, there is potential structural flooding that occurs within the Pleasantville area. The homes with flooding potential are concentrated in the east and the south ends of the neighborhood. The ponding depths also indicate that for many intersections, ponding occurs past the ROW line based

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on the assumed ROW depth (6 inches of curb + 15 inches from curb to ROW). Ponding maps for the 2-year and 100-year existing conditions are shown in **Exhibit 5** and **Exhibit 6**, respectively.

Ponding in the existing conditions is caused by undersized storm sewer throughout the neighborhood, lack of overland sheet flow patterns, and limited outfall capacity of the TxDOT system. While the main trunk line was upsized during the construction of Subproject 1, the rest of the storm sewer is still undersized for both the frequent and extreme events. The neighborhood also is located a low area and that has no positive overland flow outfall. The neighborhood is blocked by I-610 to the east and the dredge sites to the south. Runoff that is not conveyed in the storm sewer does not flow out of the neighborhood but remains above ground until the storm system has the capacity to convey the flow.

Alternative 1A-1 (*2013 Study)*

Alternative 1A-1 was previously analyzed in the *2013 Study* and included improvements on the existing storm sewer systems in Pleasantville. The alternative was analyzed in this study to determine the level of service based on Atlas 14 rainfall. The proposed improvements consisted of upsizing trunklines along Gellhorn Dr, Ledwicke Dr and east of Pleasantville Dr along with the receiving lateral systems upsized. The proposed storm sewer improvement sizes range from a 24" RCP to a 120" RCP. The Alternative 1A-1 storm sewer layout is shown in **Exhibit 7**.

The cost estimate for the alternative was updated to reflect increases in unit prices. The opinion of probable construction cost of the paving and storm sewer improvements is approximately **$27.1 million**. The estimate includes:

- $4.8 million for roadway reconstruction assuming full pavement where storm sewer is placed.
- $15.3 million for storm sewer improvements
- $6.2 million for mobilization and contingencies

The opinion of probable cost is shown in **Appendix B.1**.

Alternative 1A-1 Results

The alternative was simulated in the updated ICM model with the Atlas 14 hydrology to determine the revised level of service based on the 2-year, 10-year, 25-year, 50-year and 100-year storm events.

The improvements recommended in Alternative 1A-1 show a reduction in ponding throughout the project. There is no significant ponding for the 2-year event while the 100-year event shows ponding depths are reduced by up to 1.1 feet. In addition to reduction of ponding depths as a result of Alternative 1A-1, there are no flow increases into the TxDOT system. A table of ponding depths for various intersections for the 2-year and 100-year events compared to the existing conditions is shown below in **Table 3**.

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Table 3. Existing vs Alternative 1A-1 Ponding Depths

Intersection	EX Depths (ft)		Alt1A-1 Depths (ft)	
	2YR	100YR	2YR	100YR
Bucroft - Pleasantville	0.85	2.82	0.14	2.10
Fillmore - Gellhorn	0.20	2.24	0.00	0.96
Bucroft - Gellhorn	0.32	3.18	0.00	2.41
Northton - Gellhorn	0.84	3.28	0.00	2.45
Josie - Gellhorn	1.84	2.78	0.00	2.92
Ledwicke - Guinevere	0.00	2.65	0.00	2.70
Flossie Mae - Quaker	0.00	2.35	0.00	2.34
Laurentide - Pattibob	0.00	2.39	0.00	2.34
Cowart - Ledwicke	0.00	1.58	0.00	1.57
Laurentide - Tilgham	0.00	1.80	0.00	1.73
Berndale - Candy	0.29	1.62	0.00	1.65
Laurentide - Candy	0.00	1.78	0.00	1.70
Tilgham - Teanaway	0.00	1.01	0.00	0.76
Norvic - Teanaway	0.40	1.77	0.00	1.55
Wiggins - Silverdale	0.31	2.13	0.00	2.27
Berndale - Silverdale	0.51	2.63	0.00	2.71

Based on the results from **Table 3**, Alternative 1A-1 provides a benefit for the 2-year event when compared to the existing conditions. The benefit is diminished slightly during the 100-year storm event in which a number of intersections are reduced by less than 0.5 feet. Ponding maps for the 2-year and 100-year are shown in **Exhibit 8** and **Exhibit 9** respectively.

While Alternative 1A-1 improves the drainage system, the capacity of the main trunk line is still limited due to the limited capacity of the TxDOT system. Without improving the system downstream or creating additional storage within the neighborhood, the alternative is limited to a 10-year level of service.

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PRELIMINARY DETENTION LOCATIONS

Six sites were initially investigated as potential locations for detention ponds to assist in reducing ponding elevations throughout the neighborhood. The initial sites were identified based on availability of open land and are shown in **Figure 4**. A preliminary grading plan was developed for each site with consideration to potential invert elevations of the existing storm sewer and typical HCFCD design criteria including side slopes and maintenance berms. The preliminary grading plans provided a maximum available detention volume. The preliminary grading plans of the initial locations are shown in **Figure 4** and Appendix B.

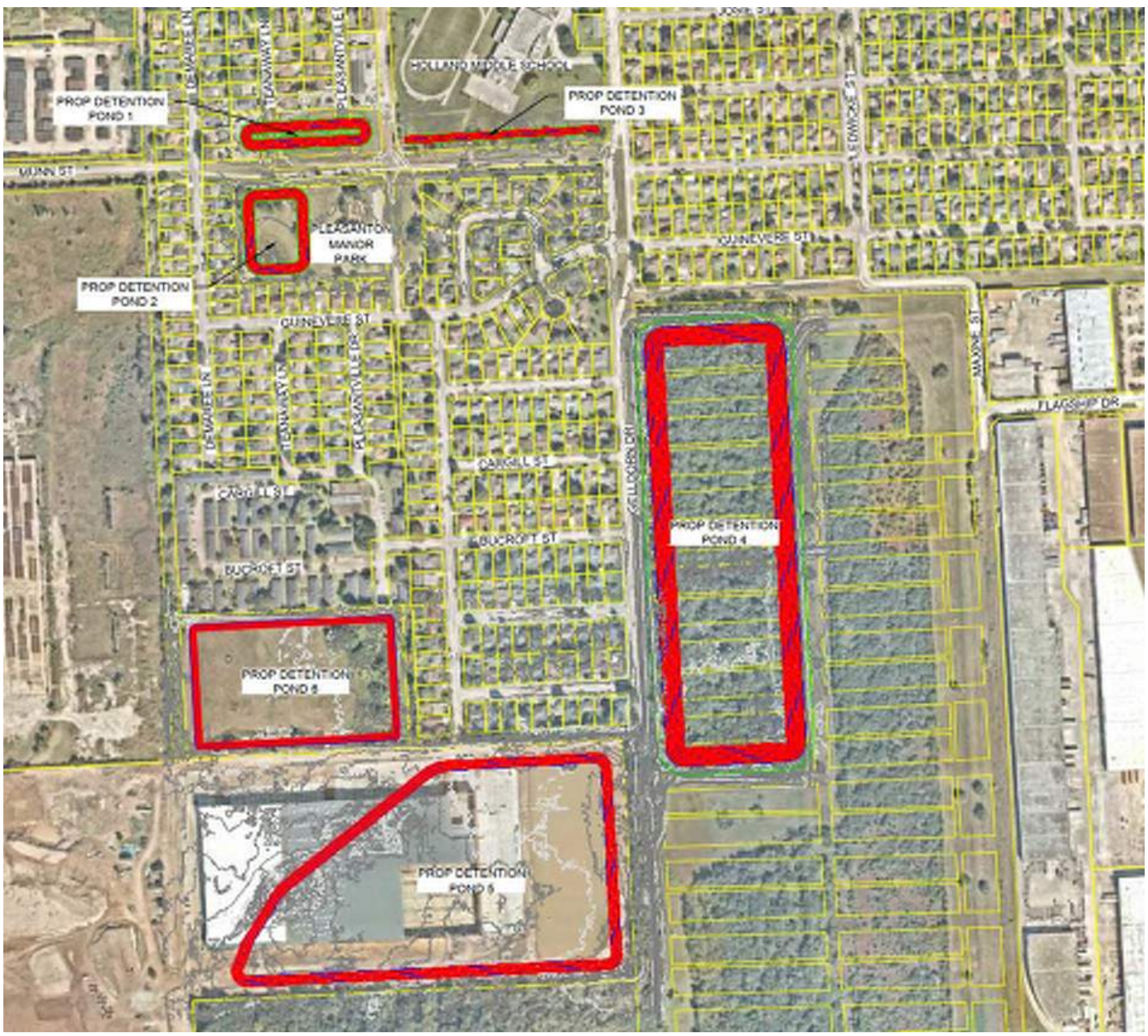

Figure 4: Potential Detention Pond Locations

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The sites were then further screened based on landowner, potential detention benefit of the pond alone, and conflicting utilities to determine which sites were most feasible for further study. The screening is summarized below and in **Table 4**.

- Pond #1 – Located on the northwest side of the neighborhood at the end of Pleasantville Drive and Teanaway Lane. The pond provides approximately 8.4 acre-feet of detention across 1.1 acres owned by the City of Houston and private owners. The pond has the potential to outfall into the recently constructed 6'x6' RCB constructed in Subproject #1. By constructing the pond without any other improvements in the neighborhood, regional benefits are negligible due to the size and location on the upstream end of the neighborhood.
- Pond #2 – Located on the existing Pleasanton Manor Park on the west side of the neighborhood, the pond provides approximately 17 acre-feet of detention on 1.7 acres. The pond has the potential to outfall into the recently constructed 6'x6' RCB constructed in Subproject #1. By constructing the pond without any other improvements in the neighborhood, regional benefits are negligible due to the size and location on the upstream end of the neighborhood.
- Pond #3 – Located on a small piece of land owned by the Houston Independent School District, the pond provides approximately 0.75 acre-feet of detention on 1.1 acres. The pond has the potential to outfall into the recently constructed 10'x8' RCB constructed as part of Subproject #1. However, the pond location near the school and lack of available volume shows no benefit for this site.
- Pond #4 – Located on the existing Port of Houston Authority site near the downstream trunkline, the pond provides up to 350 acre-feet of detention on 19 acres. The pond can outfall into the existing 10'x10' RCB along Ledwicke Street. By constructing the pond, the existing 100-year ponding is reduced up to 1.2 feet and reduces downstream flows. The pond has the potential of improving the level of service in the neighborhood and reducing the local infrastructure costs. The City indicated that the Port of Houston was receptive to using the area for detention. The site has a USACE easement that is used for placing dredge material which could affect acquisition for the detention pond. The site is also raised 3 to 6 feet higher than the adjacent roadways of the neighborhood. Therefore, additional excavation may be required.
- Pond #5 – This pond location was identified in the *2012 PER* as a potential location of detention. As previously discussed, a large industrial facility has been constructed on this site.
- Pond #6 – This pond was identified in the *2012 PER* as a potential location of detention for offsite flow. The pond is located on the southwestern portion of the neighborhood and could provide up to 51 acre-feet of detention and would outfall into the storm sewer along Pleasantville Drive. The existing 100-year water surface elevation is reduced up to 3-inches. However, the location of the pond only provides local benefits in the southwestern portion of the neighborhood.

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Table 4: Preliminary Detention Location Summary

Site Number	Max. Volume	Land Owner Type	Reduction in Ponding	Public Utility Conflicts
Pond #1	8.4 acre-feet	COH & Private	0.16 ft	Yes
Pond #2	17.0 acre-feet	COH	0.16 ft	No
Pond #3	0.75 acre-feet	Houston ISD	0.16 ft	No
Pond #4	350 acre-feet	Port of Houston	1.2 ft	No
Pond #5	------	Private	------	Yes
Pond #6	50.6 acre-feet	Private	0.25 ft	Yes

Of the initial sites, Pond #4 was the only detention pond that provided benefit to the whole neighborhood and was therefore recommended for further investigation and more detailed modeling.

DETENTION ALTERNATIVE

The proposed detention pond, Pond #4, can provide up to 350 ac-feet of detention improving the level of service and reducing ponding in the neighborhood. The Detention Alternative consists of a combination of detention and storm sewer improvements within Pleasantville. Proposed pipe sizes range from a 24” RCP to a 10’x10’ RCB and also include upsizing inlets from B Inlets to 5-foot BB Inlets. The improvements consisted of upsizing the Ledwicke St trunkline system and the lateral systems from the adjacent streets, the lateral system along Norvic St, and the systems along Pleasantville Dr, Bucroft St and Gellhorn Dr. The proposed storm sewer layout is shown in **Exhibit 10**.

The opinion of probable construction cost including the paving, detention, and storm sewer improvements is approximately **$24.3 million**. The estimate includes:

- $3.8 million for roadway reconstruction assuming full pavement where storm sewer is placed.
- $10.5 million for storm sewer improvements
- $3.7 million for detention construction
- $6.3 million for mobilization and contingencies

The opinion of probable cost is shown in **Appendix B.2**.

Detention Alternative Results

The Detention Alternative resultant ponding depths in both the 2-year and 100-year storm events are reduced from existing conditions. Most of the ponding during the 2-year event is below top of gutter and within the street during the 100-year event. Ponding depths are reduced during the 100-year event by up 2.5 feet. In addition to reducing ponding depths there is no increase of flow into the TxDOT system. A table of ponding depths for various intersections for the 2-year and 100-year events compared to the existing conditions is shown below in **Table 5**.

Table 5. Existing vs Detention Alternative Ponding Depths

Intersection	EX Depths (ft)		Det. Alt Depths (ft)	
	2YR	100YR	2YR	100YR
Bucroft - Pleasantville	0.85	2.82	0.49	1.10
Fillmore - Gellhorn	0.20	2.24	0.00	0.00
Bucroft - Gellhorn	0.32	3.18	0.00	0.76
Northton - Gellhorn	0.84	3.28	0.00	0.91
Josie - Gellhorn	1.84	2.78	0.48	2.45
Ledwicke - Guinevere	0.00	2.65	0.00	1.38
Flossie Mae - Quaker	0.00	2.35	0.00	1.65
Laurentide - Pattibob	0.00	2.39	0.00	1.56
Cowart - Ledwicke	0.00	1.58	0.00	1.14
Laurentide - Tilgham	0.00	1.80	0.00	1.13
Berndale - Candy	0.29	1.62	0.00	1.37
Laurentide - Candy	0.00	1.78	0.00	1.12
Tilgham - Teanaway	0.00	1.01	0.00	1.00
Norvic - Teanaway	0.40	1.77	0.00	1.38
Wiggins - Silverdale	0.31	2.13	0.32	1.72
Berndale - Silverdale	0.51	2.63	0.37	2.42

The Detention Alternative provided more benefit during the 100-year event compared to Alternative 1A-1, with the entire neighborhood achieving a 100-year level of service. Ponding depths during the 2-year event are slightly less beneficial when compared to Alternative 1A but overall provide a substantial reduction in ponding. Ponding maps for the 2-year and 100-year existing conditions are shown in **Exhibit 11** and **Exhibit 12** respectively.

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CONCLUSION

The Pleasantville Neighborhood has a history of drainage concerns. Previous studies have indicated that significant improvements are needed throughout the neighborhood and have included both detention and storm sewer.

Altas 14 rainfall has increased rainfall rates and reduced the level of service of the existing drainage system. The existing conditions drainage network level of service was reduced from a 10-year (pre-Atlas 14) to less than a 2-year level of service as a result of Atlas 14 rainfall.

The Alternative 1A-1 from the *2013 Study* has a 10-year level of service based on Atlas 14 rainfall. The updated opinion of probable construction cost for Alternative 1A-1 is $27.1 million.

A preliminary screening of six potential detention sites within the area resulted in one potential location which provides substantial benefit. The Port of Houston property between Gellhorn and Lanewell provides a possible location for detention and can provide up to 350 acre-feet of detention. The City should continue discussion with the Port Authority and with the USACE to determine the feasibility of obtaining a portion of this land for detention. The City should also conduct an environmental assessment as the land could have hazardous material and may be costly to excavate.

If a 350 acre-foot detention pond is constructed on the Port property in conjunction with storm sewer improvements within Pleasantville, the neighborhood can be made to achieve a 100-year level of service and a potential reduction in overall construction cost. The opinion of probable construct cost for the Detention Alternative is $24.3 million.

The City should continue to explore funding opportunities and partnerships for constructing the detention facility. Potential funding partners may include the HCFCD, the Port of Houston, and the General Land Office. If the facility is constructed, the future subprojects or the neighborhood can be revised as shown in the Detention Alternative.

If you have any questions or need additional information, please do not hesitate to contact me.

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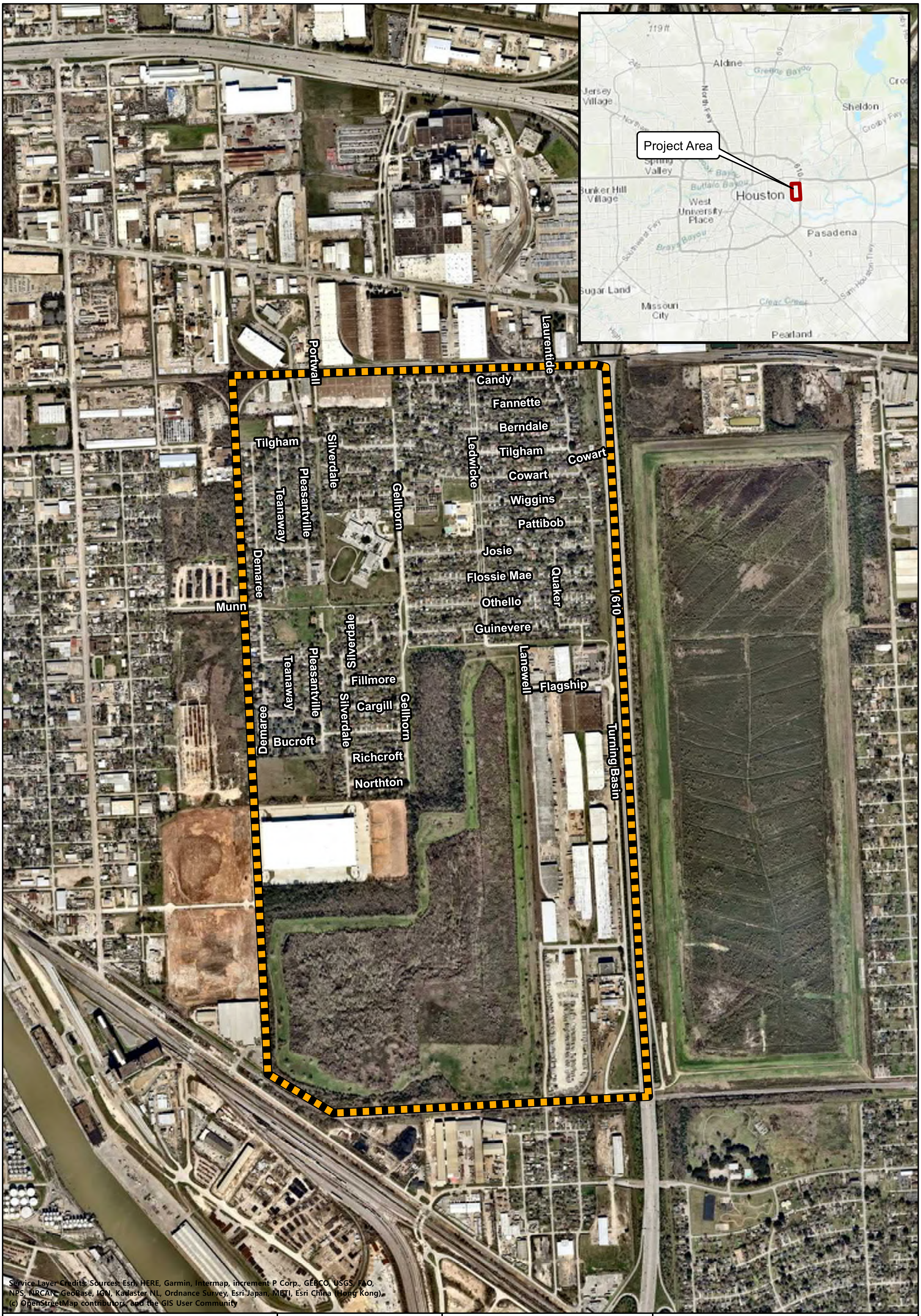
C. Andrew Moore, P.E., CFM
TX PE No. 124910
Water Resources Team Leader

STATE OF TEXAS
C. ANDREW MOORE
124910
LICENSED
PROFESSIONAL ENGINEER



LEGEND

Project Area

Notes:

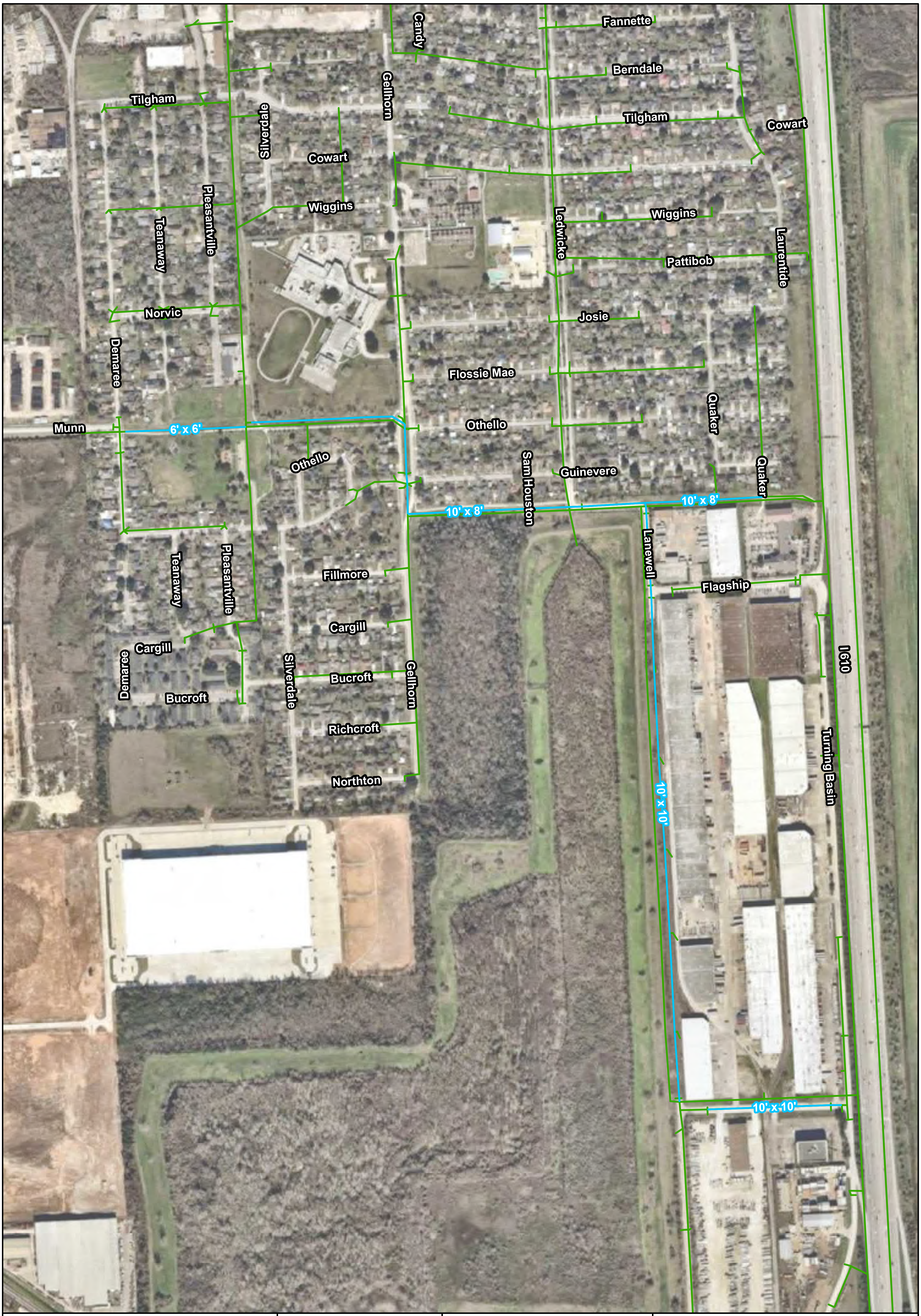
HALFF

0 500 1,000 2,000 Feet

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Project Area

Exhibit 1



LEGEND

Subproject 1 - Existing Storm Sewer

Existing Storm Sewer

Notes:

1. Subproject 1 storm sewer was constructed in 2016 and 2017.

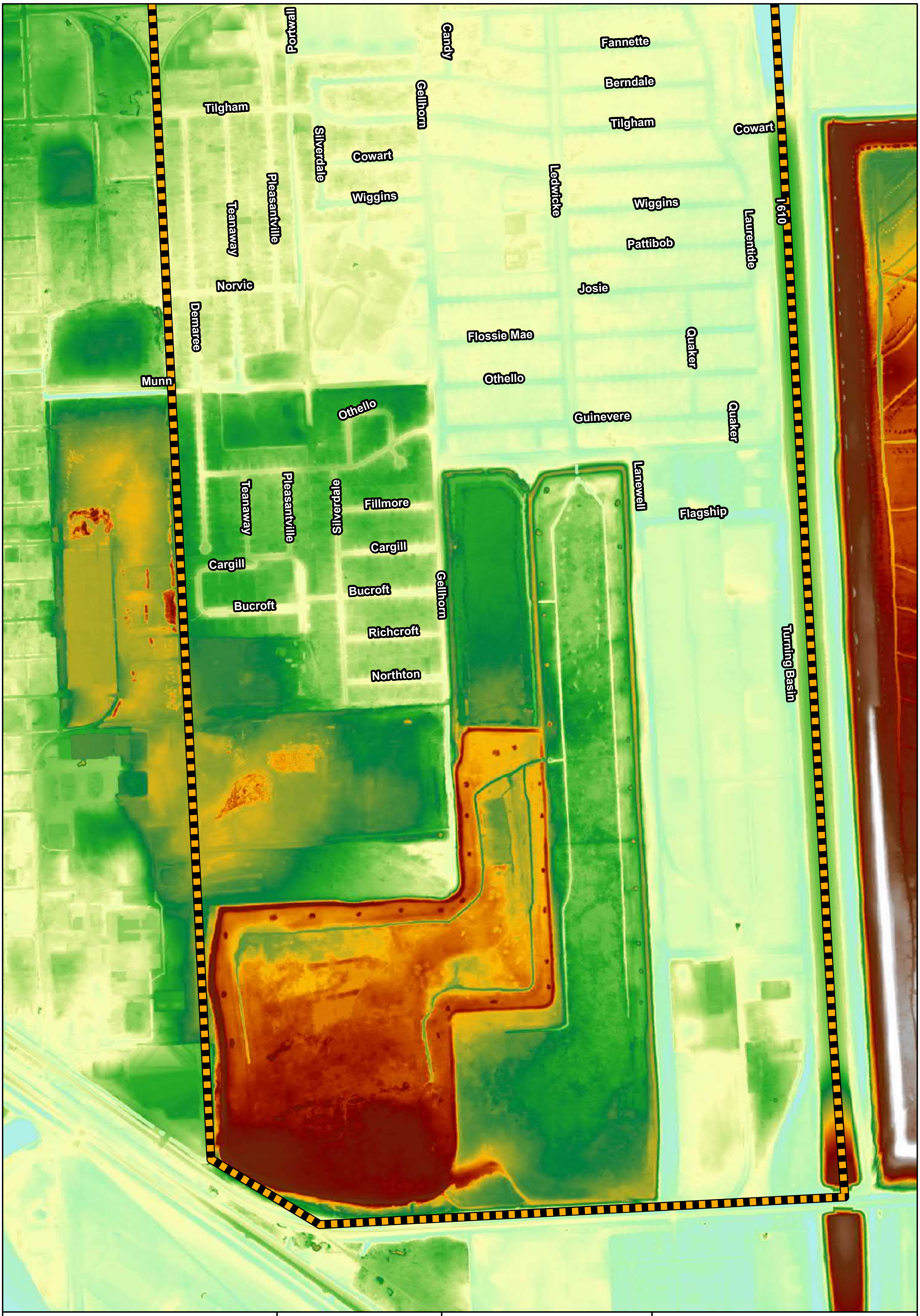
HALFF

0 250 500 1,000 Feet

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Existing Storm Sewer Layout

Exhibit 2



LEGEND

Project Area

Terrain

Feet

High : 22.77

Low : 5.18

Notes:

HALFF

0 300 600 1,200 Feet

WORK ORDER 121

PLEASANTVILLE DETENTION ANALYSIS

Terrain

Exhibit 3

LEGEND

Basins

Notes:

HALFF

0 400 800 1,600 Feet

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Drainage Areas

Exhibit 4

LEGEND

Existing Storm Sewer

DEPTH (FT)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- > 3.00

Notes:

HALFF

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Existing 2-YR Ponding with Depths

Exhibit 5

Legend

— Existing Storm Sewer

DEPTH (FT)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- > 3.00

Notes:

HALFF

0 250 500 1,000 Feet

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Existing 100-YR Ponding with Depths

Exhibit 6

LEGEND

Alternative 1A-1 Storm Sewer

Existing Storm Sewer

Notes:

1. Alternative 1A-1 Improvements were derived from "2013 Study"

HALFF

0 250 500 1,000 Feet

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Alternative 1A-1 Improvements

Exhibit 7

LEGEND

Alternative 1A-1 Storm Sewer

Existing Storm Sewer

DEPTH (FT)

0.25 - 0.50

0.50 - 1.00

1.00 - 2.00

2.00 - 3.00

> 3.00

Notes:

HALFF

WORK ORDER 121

PLEASANTVILLE DETENTION ANALYSIS

Alternative 2-YR Ponding with Depths

Exhibit 8

LEGEND

Alternative 1A-1 Storm Sewer

Existing Storm Sewer

DEPTH (FT)

0.25 - 0.50

0.50 - 1.00

1.00 - 2.00

2.00 - 3.00

> 3.00

Notes:

HALFF

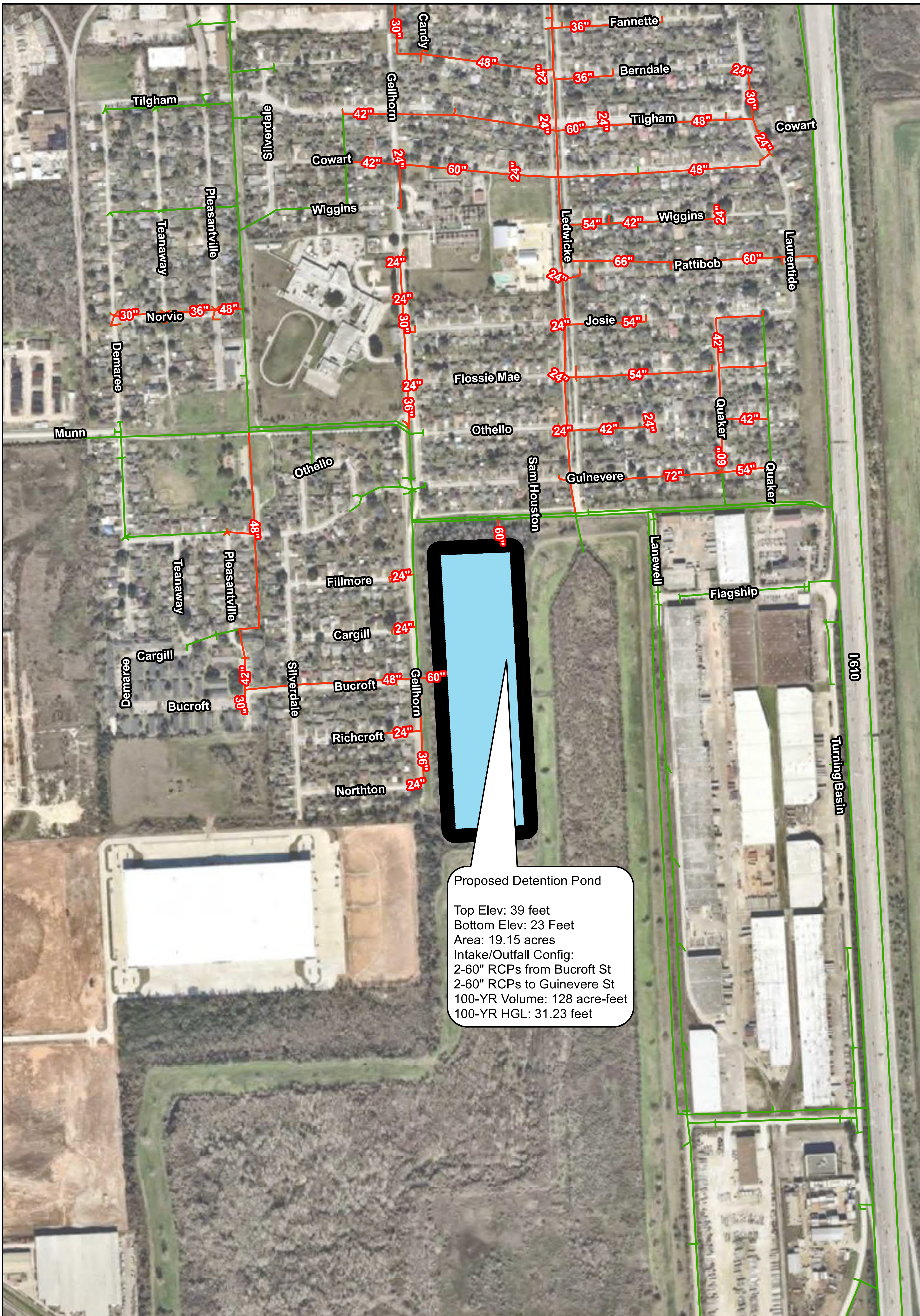
0 250 500 1,000 Feet

WORK ORDER 121

PLEASANTVILLE DETENTION ANALYSIS

Alternative 1A-1 100-YR Ponding with Depths

Exhibit 9



LEGEND

- Proposed Pond
- Proposed Storm Sewer
- Existing Storm Sewer

Notes:

HALFF

0 250 500 1,000 Feet

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Detention Alternative

Exhibit 10

LEGEND

- Proposed Pond
- Proposed Storm Sewer
- Existing Storm Sewer

DEPTH (FT)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- > 3.00

Notes:

HALFF

0 250 500 1,000 Feet

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Proposed 2-YR Ponding with Depths

Exhibit 11

LEGEND

Proposed Pond

Proposed Storm Sewer

Existing Storm Sewer

DEPTH (FT)

0.25 - 0.50

0.50 - 1.00

1.00 - 2.00

2.00 - 3.00

> 3.00

Notes:

HALFF

0 250 500 1,000 Feet

WORK ORDER 121
PLEASANTVILLE DETENTION ANALYSIS

Proposed 100-YR Ponding with Depths

Exhibit 12

APPENDIX A

Atlas 14 Rational Method Calculations																	
Basin Name	Area (sqmi)	Area (AC)	C	% Impr	TC (min)	TC (hr)	I2 (in/hr)	Q2 (cfs)	I10 (in/hr)	Q10 (cfs)	I25 (in/hr)	Q25 (cfs)	I50 (in/hr)	Q50 (cfs)	I100 (in/hr)	Q100 (cfs)
001P	0.0013	0.85	0.75	92	24.72	0.41	3.77	2.4	5.54	3.5	6.71	4.3	7.64	4.9	8.59	5.5
003P	0.0015	0.95	0.20	0	24.91	0.42	3.76	0.7	5.52	1.0	6.68	1.3	7.61	1.4	8.55	1.6
002P	0.0027	1.74	0.65	75	26.03	0.43	3.67	4.2	5.40	6.1	6.53	7.4	7.45	8.4	8.37	9.5
007P	0.0013	0.86	0.65	75	24.74	0.41	3.77	2.1	5.54	3.1	6.71	3.7	7.64	4.3	8.58	4.8
009P	0.0015	0.97	0.65	75	24.95	0.42	3.76	2.4	5.52	3.5	6.68	4.2	7.61	4.8	8.55	5.4
011P	0.0015	0.97	0.65	75	24.95	0.42	3.76	2.4	5.52	3.5	6.68	4.2	7.61	4.8	8.55	5.4
006P	0.0015	0.97	0.65	75	24.94	0.42	3.76	2.4	5.52	3.5	6.68	4.2	7.61	4.8	8.55	5.4
014P	0.0057	3.62	0.25	8	27.54	0.46	3.56	3.2	5.24	4.7	6.35	5.7	7.24	6.6	8.14	7.4
012P	0.0040	2.56	0.65	75	26.80	0.45	3.62	6.0	5.32	8.9	6.44	10.7	7.34	12.2	8.25	13.7
004P	0.0013	0.81	0.30	17	24.63	0.41	3.78	0.9	5.56	1.3	6.72	1.6	7.66	1.8	8.60	2.1
015P	0.0141	9.00	0.60	67	29.72	0.50	3.42	18.5	5.03	27.3	6.10	33.0	6.96	37.7	7.83	42.4
016P	0.0040	2.57	0.74	90	26.81	0.45	3.61	6.9	5.31	10.1	6.44	12.2	7.34	14.0	8.25	15.7
017P	0.0018	1.14	0.34	24	25.23	0.42	3.73	1.5	5.49	2.1	6.64	2.6	7.57	3.0	8.50	3.3
018P	0.0101	6.47	0.73	89	28.89	0.48	3.47	16.5	5.11	24.2	6.19	29.4	7.06	33.5	7.95	37.7
019L	0.0029	1.88	0.78	96	26.18	0.44	3.66	5.3	5.38	7.9	6.52	9.5	7.43	10.8	8.35	12.2
021L	0.0034	2.19	0.55	58	26.48	0.44	3.64	4.4	5.35	6.4	6.48	7.8	7.38	8.9	8.30	10.0
020L	0.0027	1.73	0.55	58	26.01	0.43	3.67	3.5	5.40	5.1	6.54	6.2	7.45	7.1	8.37	8.0
038P	0.0048	3.06	0.55	58	27.18	0.45	3.59	6.0	5.28	8.9	6.39	10.8	7.29	12.3	8.19	13.8
043P	0.0014	0.89	0.68	80	24.80	0.41	3.77	2.3	5.54	3.4	6.70	4.1	7.63	4.6	8.57	5.2
044P	0.0009	0.59	0.55	58	24.10	0.40	3.83	1.2	5.62	1.8	6.80	2.2	7.74	2.5	8.69	2.8
045P	0.0007	0.46	0.55	58	23.72	0.40	3.86	1.0	5.66	1.4	6.85	1.7	7.80	2.0	8.76	2.2
046P	0.0038	2.43	0.55	58	26.69	0.44	3.62	4.8	5.33	7.1	6.45	8.6	7.35	9.8	8.27	11.0
047L	0.0017	1.11	0.55	58	25.18	0.42	3.74	2.3	5.49	3.3	6.65	4.0	7.57	4.6	8.51	5.2
026L	0.0020	1.30	0.55	58	25.47	0.42	3.72	2.7	5.46	3.9	6.61	4.7	7.53	5.4	8.46	6.0
025L	0.0020	1.28	0.55	58	25.44	0.42	3.72	2.6	5.46	3.8	6.61	4.7	7.53	5.3	8.46	6.0
027L	0.0012	0.79	0.55	58	24.59	0.41	3.79	1.6	5.56	2.4	6.73	2.9	7.66	3.3	8.61	3.7
022L	0.0040	2.55	0.55	58	26.79	0.45	3.62	5.1	5.32	7.5	6.44	9.0	7.34	10.3	8.25	11.6
028L	0.0023	1.48	0.55	58	25.72	0.43	3.70	3.0	5.43	4.4	6.57	5.4	7.49	6.1	8.42	6.9
034L	0.0021	1.32	0.55	58	25.51	0.43	3.71	2.7	5.46	4.0	6.60	4.8	7.52	5.5	8.45	6.2
039L	0.0022	1.41	0.55	58	25.62	0.43	3.70	2.9	5.44	4.2	6.59	5.1	7.51	5.8	8.44	6.5
048L	0.0025	1.58	0.55	58	25.83	0.43	3.69	3.2	5.42	4.7	6.56	5.7	7.48	6.5	8.40	7.3
060P	0.0025	1.58	0.55	58	25.84	0.43	3.69	3.2	5.42	4.7	6.56	5.7	7.48	6.5	8.40	7.3
061L	0.0028	1.81	0.55	58	26.11	0.44	3.67	3.7	5.39	5.4	6.52	6.5	7.44	7.4	8.36	8.3
029L	0.0021	1.36	0.55	58	25.56	0.43	3.71	2.8	5.45	4.1	6.60	4.9	7.52	5.6	8.45	6.3
032L	0.0020	1.29	0.55	58	25.45	0.42	3.72	2.6	5.46	3.9	6.61	4.7	7.53	5.3	8.46	6.0
035L	0.0013	0.85	0.55	58	24.71	0.41	3.78	1.8	5.55	2.6	6.71	3.1	7.64	3.6	8.59	4.0
040L	0.0032	2.08	0.55	58	26.38	0.44	3.65	4.2	5.36	6.1	6.49	7.4	7.40	8.5	8.32	9.5
049L	0.0032	2.08	0.55	58	26.37	0.44	3.65	4.2	5.36	6.1	6.49	7.4	7.40	8.4	8.32	9.5
062L	0.0014	0.92	0.55	58	24.85	0.41	3.76	1.9	5.53	2.8	6.69	3.4	7.62	3.8	8.56	4.3

Atlas 14 Rational Method Calculations																
Basin Name	Area (sqmi)	Area (AC)	C	% Impr	TC (min)	TC (hr)	I2 (in/hr)	Q2 (cfs)	I10 (in/hr)	Q10 (cfs)	I25 (in/hr)	Q25 (cfs)	I50 (in/hr)	Q50 (cfs)	I100 (in/hr)	Q100 (cfs)
023L	0.0019	1.25	0.55	58	25.40	0.42	3.72	2.6	5.47	3.8	6.62	4.5	7.54	5.2	8.47	5.8
024L	0.0024	1.54	0.42	37	25.79	0.43	3.69	2.4	5.42	3.5	6.57	4.3	7.48	4.8	8.41	5.4
030L	0.0018	1.16	0.55	58	25.27	0.42	3.73	2.4	5.48	3.5	6.63	4.2	7.56	4.8	8.49	5.4
031L	0.0032	2.02	0.46	43	26.32	0.44	3.65	3.4	5.37	5.0	6.50	6.0	7.41	6.8	8.32	7.7
033L	0.0030	1.94	0.55	58	26.24	0.44	3.66	3.9	5.37	5.7	6.51	7.0	7.42	7.9	8.34	8.9
036L	0.0029	1.85	0.55	58	26.15	0.44	3.66	3.7	5.38	5.5	6.52	6.6	7.43	7.6	8.35	8.5
041L	0.0023	1.50	0.55	58	25.73	0.43	3.70	3.0	5.43	4.5	6.57	5.4	7.49	6.2	8.42	6.9
037L	0.0051	3.27	0.37	28	27.32	0.46	3.58	4.3	5.26	6.3	6.37	7.6	7.27	8.7	8.17	9.8
050L	0.0020	1.27	0.55	58	25.42	0.42	3.72	2.6	5.46	3.8	6.61	4.6	7.54	5.2	8.47	5.9
063L	0.0028	1.78	0.55	58	26.07	0.43	3.67	3.6	5.39	5.3	6.53	6.4	7.44	7.3	8.36	8.2
064L	0.0017	1.12	0.55	58	25.20	0.42	3.74	2.3	5.49	3.4	6.64	4.1	7.57	4.7	8.50	5.2
076L	0.0016	1.02	0.55	58	25.03	0.42	3.75	2.1	5.51	3.1	6.67	3.7	7.60	4.2	8.53	4.8
065L	0.0023	1.46	0.55	58	25.69	0.43	3.70	3.0	5.43	4.4	6.58	5.3	7.50	6.0	8.42	6.8
075L	0.0028	1.78	0.55	58	26.07	0.43	3.67	3.6	5.39	5.3	6.53	6.4	7.44	7.3	8.36	8.2
082L	0.0022	1.41	0.55	58	25.62	0.43	3.70	2.9	5.44	4.2	6.59	5.1	7.51	5.8	8.44	6.5
081L	0.0024	1.52	0.55	58	25.77	0.43	3.69	3.1	5.43	4.5	6.57	5.5	7.49	6.3	8.41	7.0
089L	0.0030	1.90	0.55	58	26.20	0.44	3.66	3.8	5.38	5.6	6.51	6.8	7.42	7.8	8.34	8.7
095L	0.0032	2.04	0.55	58	26.33	0.44	3.65	4.1	5.36	6.0	6.50	7.3	7.40	8.3	8.32	9.3
108L	0.0032	2.06	0.55	58	26.36	0.44	3.65	4.1	5.36	6.1	6.49	7.4	7.40	8.4	8.32	9.4
094L	0.0019	1.20	0.55	58	25.33	0.42	3.73	2.5	5.47	3.6	6.63	4.4	7.55	5.0	8.48	5.6
088L	0.0034	2.20	0.55	58	26.49	0.44	3.64	4.4	5.35	6.5	6.48	7.8	7.38	8.9	8.30	10.0
080L	0.0034	2.20	0.55	58	26.49	0.44	3.64	4.4	5.35	6.5	6.48	7.8	7.38	8.9	8.30	10.0
107L	0.0026	1.64	0.55	58	25.91	0.43	3.68	3.3	5.41	4.9	6.55	5.9	7.47	6.7	8.39	7.5
074L	0.0012	0.77	0.55	58	24.55	0.41	3.79	1.6	5.56	2.4	6.73	2.9	7.67	3.3	8.61	3.7
109L	0.0014	0.91	0.55	58	24.83	0.41	3.77	1.9	5.53	2.8	6.69	3.3	7.63	3.8	8.57	4.3
112L	0.0021	1.34	0.55	58	25.52	0.43	3.71	2.7	5.45	4.0	6.60	4.8	7.52	5.5	8.45	6.2
111L	0.0026	1.66	0.55	58	25.93	0.43	3.68	3.4	5.41	4.9	6.55	6.0	7.46	6.8	8.39	7.6
110L	0.0012	0.80	0.55	58	24.61	0.41	3.78	1.7	5.56	2.4	6.72	2.9	7.66	3.4	8.60	3.8
113L	0.0020	1.26	0.55	58	25.42	0.42	3.72	2.6	5.46	3.8	6.61	4.6	7.54	5.2	8.47	5.9
114L	0.0026	1.67	0.55	58	25.94	0.43	3.68	3.4	5.41	5.0	6.55	6.0	7.46	6.8	8.38	7.7
115L	0.0017	1.11	0.55	58	25.18	0.42	3.74	2.3	5.49	3.3	6.65	4.0	7.57	4.6	8.51	5.2
116L	0.0007	0.44	0.55	58	23.64	0.39	3.86	0.9	5.67	1.4	6.86	1.6	7.81	1.9	8.77	2.1
128H	0.0021	1.36	0.55	58	25.56	0.43	3.71	2.8	5.45	4.1	6.60	4.9	7.52	5.6	8.45	6.3
136H	0.0025	1.62	0.48	47	25.88	0.43	3.68	2.9	5.41	4.2	6.55	5.1	7.47	5.8	8.39	6.5
141H	0.0027	1.74	0.51	51	26.02	0.43	3.67	3.2	5.40	4.7	6.54	5.7	7.45	6.5	8.37	7.3
140L	0.0027	1.74	0.55	58	26.03	0.43	3.67	3.5	5.40	5.2	6.53	6.3	7.45	7.1	8.37	8.0
135L	0.0035	2.22	0.55	58	26.51	0.44	3.64	4.4	5.35	6.5	6.47	7.9	7.38	9.0	8.29	10.1
127L	0.0037	2.39	0.55	58	26.66	0.44	3.63	4.8	5.33	7.0	6.45	8.5	7.36	9.7	8.27	10.9
139L	0.0020	1.27	0.55	58	25.43	0.42	3.72	2.6	5.46	3.8	6.61	4.6	7.54	5.3	8.47	5.9

Atlas 14 Rational Method Calculations																
Basin Name	Area (sqmi)	Area (AC)	C	% Impr	TC (min)	TC (hr)	I2 (in/hr)	Q2 (cfs)	I10 (in/hr)	Q10 (cfs)	I25 (in/hr)	Q25 (cfs)	I50 (in/hr)	Q50 (cfs)	I100 (in/hr)	Q100 (cfs)
106L	0.0045	2.85	0.49	48	27.02	0.45	3.60	5.0	5.29	7.4	6.41	8.9	7.31	10.2	8.22	11.4
087L	0.0074	4.71	0.34	23	28.14	0.47	3.52	5.6	5.18	8.2	6.28	10.0	7.16	11.4	8.05	12.8
105G	0.0079	5.04	0.42	37	28.29	0.47	3.51	7.5	5.17	11.0	6.26	13.3	7.14	15.2	8.03	17.1
079L	0.0038	2.41	0.55	58	26.67	0.44	3.62	4.8	5.33	7.1	6.45	8.5	7.36	9.7	8.27	10.9
126L	0.0024	1.54	0.55	58	25.79	0.43	3.69	3.1	5.42	4.6	6.57	5.6	7.48	6.3	8.41	7.1
134L	0.0023	1.46	0.55	58	25.69	0.43	3.70	3.0	5.43	4.4	6.58	5.3	7.50	6.0	8.42	6.8
125G	0.0023	1.45	0.55	58	25.67	0.43	3.70	2.9	5.44	4.3	6.58	5.2	7.50	6.0	8.43	6.7
133G	0.0021	1.37	0.55	58	25.57	0.43	3.71	2.8	5.45	4.1	6.59	5.0	7.52	5.7	8.44	6.3
104G	0.0010	0.62	0.67	78	24.18	0.40	3.82	1.6	5.61	2.3	6.78	2.8	7.73	3.2	8.68	3.6
092L	0.0016	1.00	0.42	37	24.99	0.42	3.75	1.6	5.51	2.3	6.67	2.8	7.60	3.2	8.54	3.6
086L	0.0004	0.24	0.42	36	22.75	0.38	3.94	0.4	5.79	0.6	7.00	0.7	7.96	0.8	8.94	0.9
073L	0.0026	1.67	0.55	58	25.95	0.43	3.68	3.4	5.41	5.0	6.54	6.0	7.46	6.9	8.38	7.7
078L	0.0007	0.48	0.55	58	23.78	0.40	3.85	1.0	5.66	1.5	6.84	1.8	7.79	2.0	8.75	2.3
072P	0.0024	1.54	0.55	58	25.79	0.43	3.69	3.1	5.42	4.6	6.56	5.6	7.48	6.3	8.41	7.1
077P	0.0030	1.89	0.55	58	26.19	0.44	3.66	3.8	5.38	5.6	6.51	6.8	7.43	7.7	8.34	8.7
059P	0.0014	0.87	0.55	58	24.77	0.41	3.77	1.8	5.54	2.7	6.70	3.2	7.64	3.7	8.58	4.1
058P	0.0017	1.09	0.55	58	25.16	0.42	3.74	2.2	5.49	3.3	6.65	4.0	7.58	4.5	8.51	5.1
085P	0.0029	1.84	0.55	58	26.14	0.44	3.66	3.7	5.39	5.5	6.52	6.6	7.43	7.5	8.35	8.5
091P	0.0021	1.37	0.55	58	25.57	0.43	3.71	2.8	5.45	4.1	6.59	5.0	7.52	5.7	8.44	6.4
090P	0.0015	0.95	0.55	58	24.91	0.42	3.76	2.0	5.52	2.9	6.68	3.5	7.61	4.0	8.55	4.5
084P	0.0033	2.09	0.55	58	26.38	0.44	3.65	4.2	5.36	6.2	6.49	7.5	7.40	8.5	8.31	9.5
093P	0.0021	1.38	0.55	58	25.58	0.43	3.71	2.8	5.45	4.1	6.59	5.0	7.51	5.7	8.44	6.4
057P	0.0017	1.11	0.46	44	25.19	0.42	3.74	1.9	5.49	2.8	6.64	3.4	7.57	3.9	8.51	4.4
083P	0.0034	2.15	0.45	42	26.44	0.44	3.64	3.5	5.35	5.2	6.48	6.3	7.39	7.2	8.30	8.1
056P	0.0003	0.18	0.55	58	22.37	0.37	3.98	0.4	5.83	0.6	7.05	0.7	8.03	0.8	9.01	0.9
051P	0.0012	0.78	0.55	58	24.56	0.41	3.79	1.6	5.56	2.4	6.73	2.9	7.67	3.3	8.61	3.7
052P	0.0009	0.56	0.55	58	24.03	0.40	3.83	1.2	5.63	1.7	6.81	2.1	7.75	2.4	8.70	2.7
053P	0.0011	0.70	0.55	58	24.40	0.41	3.80	1.5	5.58	2.2	6.75	2.6	7.69	3.0	8.64	3.3
054P	0.0009	0.55	0.55	58	24.00	0.40	3.83	1.2	5.63	1.7	6.81	2.1	7.76	2.3	8.71	2.6
070P	0.0038	2.43	0.55	58	26.69	0.44	3.62	4.8	5.33	7.1	6.45	8.6	7.35	9.8	8.27	11.0
069P	0.0025	1.63	0.55	58	25.90	0.43	3.68	3.3	5.41	4.8	6.55	5.9	7.47	6.7	8.39	7.5
068P	0.0026	1.70	0.55	58	25.97	0.43	3.68	3.4	5.40	5.0	6.54	6.1	7.46	7.0	8.38	7.8
067P	0.0027	1.71	0.55	58	25.99	0.43	3.68	3.4	5.40	5.1	6.54	6.1	7.45	7.0	8.38	7.9
066P	0.0033	2.14	0.51	52	26.43	0.44	3.64	4.0	5.35	5.8	6.48	7.1	7.39	8.1	8.31	9.1
096P	0.0026	1.64	0.55	58	25.91	0.43	3.68	3.3	5.41	4.9	6.55	5.9	7.47	6.7	8.39	7.6
097P	0.0020	1.27	0.55	58	25.44	0.42	3.72	2.6	5.46	3.8	6.61	4.6	7.53	5.3	8.47	5.9
098P	0.0023	1.50	0.55	58	25.74	0.43	3.70	3.0	5.43	4.5	6.57	5.4	7.49	6.2	8.42	6.9
099P	0.0023	1.48	0.55	58	25.72	0.43	3.70	3.0	5.43	4.4	6.57	5.4	7.49	6.1	8.42	6.9
100P	0.0014	0.89	0.55	58	24.80	0.41	3.77	1.8	5.54	2.7	6.70	3.3	7.63	3.7	8.57	4.2

Atlas 14 Rational Method Calculations																	
Basin Name	Area (sqmi)	Area (AC)	C	% Impr	TC (min)	TC (hr)	I2 (in/hr)	Q2 (cfs)	I10 (in/hr)	Q10 (cfs)	I25 (in/hr)	Q25 (cfs)	I50 (in/hr)	Q50 (cfs)	I100 (in/hr)	Q100 (cfs)
101P	0.0007	0.47	0.55	58	23.75	0.40	3.86	1.0	5.66	1.5	6.85	1.8	7.80	2.0	8.76	2.3
102P	0.0022	1.38	0.26	10	25.59	0.43	3.71	1.3	5.45	2.0	6.59	2.4	7.51	2.7	8.44	3.0
123P	0.0102	6.52	0.35	25	28.91	0.48	3.47	7.9	5.11	11.7	6.19	14.1	7.06	16.1	7.94	18.1
122P	0.0010	0.61	0.49	48	24.17	0.40	3.82	1.1	5.61	1.7	6.79	2.0	7.73	2.3	8.68	2.6
121P	0.0024	1.56	0.55	58	25.82	0.43	3.69	3.2	5.42	4.7	6.56	5.6	7.48	6.4	8.40	7.2
120P	0.0009	0.55	0.55	58	24.00	0.40	3.83	1.2	5.63	1.7	6.81	2.1	7.76	2.3	8.71	2.6
119P	0.0008	0.53	0.55	58	23.96	0.40	3.84	1.1	5.63	1.7	6.82	2.0	7.76	2.3	8.72	2.6
118P	0.0005	0.32	0.55	58	23.19	0.39	3.90	0.7	5.73	1.0	6.93	1.2	7.89	1.4	8.86	1.6
117P	0.0008	0.52	0.51	52	23.91	0.40	3.84	1.0	5.64	1.5	6.82	1.8	7.77	2.1	8.73	2.3
A-4	0.0026	1.65	0.55	58	25.92	0.43	3.68	3.3	5.41	4.9	6.55	5.9	7.46	6.8	8.39	7.6
A-5	0.0022	1.38	0.55	58	25.59	0.43	3.71	2.8	5.45	4.1	6.59	5.0	7.51	5.7	8.44	6.4
A-8	0.0080	5.10	0.31	18	28.32	0.47	3.51	5.5	5.16	8.2	6.26	9.9	7.14	11.3	8.03	12.7
A-10	0.0045	2.91	0.55	58	27.07	0.45	3.60	5.7	5.29	8.4	6.40	10.2	7.30	11.7	8.21	13.1
154H	0.0015	0.96	0.55	58	24.93	0.42	3.76	2.0	5.52	2.9	6.68	3.5	7.61	4.0	8.55	4.5
153H	0.0034	2.20	0.35	25	26.49	0.44	3.64	2.8	5.35	4.1	6.48	4.9	7.38	5.6	8.30	6.3
170H	0.0154	9.86	0.27	12	29.96	0.50	3.40	9.1	5.01	13.5	6.07	16.3	6.93	18.6	7.80	21.0
171H	0.0024	1.54	0.47	45	25.79	0.43	3.69	2.7	5.42	3.9	6.57	4.7	7.48	5.4	8.41	6.1
172H	0.0040	2.58	0.41	35	26.82	0.45	3.61	3.8	5.31	5.6	6.43	6.8	7.34	7.8	8.25	8.7
156H	0.0058	3.70	0.55	58	27.59	0.46	3.56	7.2	5.23	10.6	6.34	12.9	7.23	14.7	8.13	16.5
162H	0.0017	1.09	0.55	58	25.15	0.42	3.74	2.2	5.49	3.3	6.65	4.0	7.58	4.5	8.51	5.1
163H	0.0012	0.76	0.55	58	24.53	0.41	3.79	1.6	5.57	2.3	6.74	2.8	7.67	3.2	8.62	3.6
202P	0.0058	3.69	0.33	22	27.59	0.46	3.56	4.4	5.24	6.5	6.34	7.8	7.23	8.9	8.13	10.0
179H	0.0053	3.38	0.55	58	27.40	0.46	3.57	6.7	5.25	9.8	6.36	11.8	7.26	13.5	8.16	15.2
180H	0.0053	3.36	0.55	58	27.38	0.46	3.57	6.6	5.26	9.7	6.37	11.8	7.26	13.4	8.16	15.1
181H	0.0029	1.87	0.55	58	26.17	0.44	3.66	3.8	5.38	5.5	6.52	6.7	7.43	7.6	8.35	8.6
203P	0.0003	0.21	0.65	75	22.59	0.38	3.96	0.5	5.81	0.8	7.02	1.0	7.99	1.1	8.97	1.2
205P	0.0003	0.21	0.65	75	22.59	0.38	3.96	0.5	5.81	0.8	7.02	1.0	7.99	1.1	8.97	1.2
211P	0.0023	1.45	0.65	75	25.68	0.43	3.70	3.5	5.44	5.1	6.58	6.2	7.50	7.1	8.43	8.0
212P	0.0017	1.10	0.65	75	25.16	0.42	3.74	2.7	5.49	3.9	6.65	4.7	7.58	5.4	8.51	6.1
215P	0.0032	2.03	0.65	75	26.33	0.44	3.65	4.8	5.37	7.1	6.50	8.6	7.41	9.8	8.32	11.0
214P	0.0179	11.44	0.32	21	30.36	0.51	3.38	12.5	4.97	18.5	6.03	22.4	6.89	25.6	7.75	28.8
219Pb	0.0167	10.71	0.20	0	30.18	0.50	3.39	7.3	4.99	10.7	6.05	13.0	6.91	14.8	7.77	16.7
204P	0.0012	0.79	0.65	75	24.60	0.41	3.79	1.9	5.56	2.9	6.73	3.5	7.66	3.9	8.61	4.4
220Gb	0.0389	24.89	0.20	0	32.61	0.54	3.24	16.1	4.78	23.8	5.81	28.9	6.63	33.0	7.47	37.2
225Gb	0.0573	36.70	0.20	0	33.86	0.56	3.17	23.3	4.69	34.4	5.69	41.8	6.51	47.7	7.33	53.8
224G	0.0040	2.53	0.55	58	26.77	0.45	3.62	5.0	5.32	7.4	6.44	9.0	7.34	10.2	8.25	11.5
221G	0.0034	2.15	0.55	58	26.44	0.44	3.64	4.3	5.35	6.3	6.48	7.7	7.39	8.7	8.30	9.8
218G	0.0028	1.80	0.55	58	26.09	0.43	3.67	3.6	5.39	5.3	6.53	6.4	7.44	7.3	8.36	8.3
216G	0.0005	0.34	0.55	58	23.27	0.39	3.90	0.7	5.72	1.1	6.92	1.3	7.88	1.5	8.84	1.6

Atlas 14 Rational Method Calculations																
Basin Name	Area (sqmi)	Area (AC)	C	% Impr	TC (min)	TC (hr)	I2 (in/hr)	Q2 (cfs)	I10 (in/hr)	Q10 (cfs)	I25 (in/hr)	Q25 (cfs)	I50 (in/hr)	Q50 (cfs)	I100 (in/hr)	Q100 (cfs)
213G	0.0040	2.55	0.55	58	26.79	0.45	3.62	5.1	5.32	7.4	6.44	9.0	7.34	10.3	8.25	11.6
206G	0.0005	0.35	0.55	58	23.30	0.39	3.89	0.7	5.71	1.1	6.91	1.3	7.87	1.5	8.84	1.7
207G	0.0028	1.78	0.55	58	26.07	0.43	3.67	3.6	5.39	5.3	6.53	6.4	7.44	7.3	8.36	8.2
182G	0.0048	3.10	0.55	58	27.20	0.45	3.59	6.1	5.27	9.0	6.39	10.9	7.28	12.4	8.19	13.9
199G	0.0046	2.92	0.55	58	27.08	0.45	3.60	5.8	5.29	8.5	6.40	10.3	7.30	11.7	8.21	13.2
197G	0.0028	1.77	0.55	58	26.06	0.43	3.67	3.6	5.39	5.3	6.53	6.4	7.44	7.3	8.36	8.2
194G	0.0034	2.16	0.55	58	26.45	0.44	3.64	4.3	5.35	6.4	6.48	7.7	7.39	8.8	8.30	9.9
183H	0.0027	1.72	0.55	58	26.01	0.43	3.67	3.5	5.40	5.1	6.54	6.2	7.45	7.1	8.37	7.9
184H	0.0031	1.96	0.55	58	26.26	0.44	3.66	3.9	5.37	5.8	6.51	7.0	7.42	8.0	8.33	9.0
217G	0.0040	2.55	0.55	58	26.79	0.45	3.62	5.1	5.32	7.5	6.44	9.0	7.34	10.3	8.25	11.6
195H	0.3220	206.07	0.20	0	40.56	0.68	2.86	117.8	4.24	174.7	5.16	212.7	5.91	243.6	6.68	275.2
185H	0.0042	2.66	0.20	0	26.88	0.45	3.61	1.9	5.31	2.8	6.43	3.4	7.33	3.9	8.24	4.4
186H	0.0029	1.88	0.25	8	26.18	0.44	3.66	1.7	5.38	2.5	6.52	3.1	7.43	3.5	8.35	3.9
187L	0.0007	0.45	0.50	50	23.69	0.39	3.86	0.9	5.67	1.3	6.86	1.5	7.81	1.8	8.77	2.0
173H	0.0022	1.39	0.55	58	25.59	0.43	3.71	2.8	5.45	4.2	6.59	5.0	7.51	5.7	8.44	6.4
174L	0.0020	1.29	0.55	58	25.46	0.42	3.72	2.6	5.46	3.9	6.61	4.7	7.53	5.3	8.46	6.0
B-12	0.0021	1.32	0.55	58	25.50	0.43	3.71	2.7	5.46	4.0	6.60	4.8	7.52	5.5	8.45	6.1
166L	0.0022	1.41	0.55	58	25.62	0.43	3.70	2.9	5.44	4.2	6.59	5.1	7.51	5.8	8.43	6.5
159L	0.0022	1.42	0.55	58	25.63	0.43	3.70	2.9	5.44	4.2	6.59	5.1	7.51	5.8	8.43	6.6
B-4	0.0020	1.30	0.55	58	25.48	0.42	3.71	2.7	5.46	3.9	6.61	4.7	7.53	5.4	8.46	6.1
175L	0.0016	1.02	0.55	58	25.04	0.42	3.75	2.1	5.51	3.1	6.66	3.8	7.59	4.3	8.53	4.8
167L	0.0022	1.40	0.55	58	25.60	0.43	3.71	2.8	5.44	4.2	6.59	5.1	7.51	5.8	8.44	6.5
124G	0.0106	6.78	0.50	50	29.01	0.48	3.46	11.7	5.10	17.3	6.18	21.0	7.05	23.9	7.93	26.9
137G	0.0021	1.34	0.55	58	25.53	0.43	3.71	2.7	5.45	4.0	6.60	4.9	7.52	5.5	8.45	6.2
143G	0.0017	1.11	0.55	58	25.18	0.42	3.74	2.3	5.49	3.3	6.65	4.0	7.57	4.6	8.51	5.2
B-3	0.0023	1.50	0.55	58	25.74	0.43	3.69	3.1	5.43	4.5	6.57	5.4	7.49	6.2	8.42	7.0
B-1	0.0002	0.15	0.80	100	22.13	0.37	4.00	0.5	5.87	0.7	7.09	0.8	8.07	0.9	9.06	1.1
A-14	0.0017	1.08	0.55	58	25.13	0.42	3.74	2.2	5.50	3.3	6.65	3.9	7.58	4.5	8.52	5.0
150L	0.0026	1.65	0.55	58	25.92	0.43	3.68	3.3	5.41	4.9	6.55	5.9	7.46	6.8	8.39	7.6
144L	0.0019	1.22	0.55	58	25.36	0.42	3.72	2.5	5.47	3.7	6.62	4.5	7.55	5.1	8.48	5.7
138L	0.0023	1.47	0.55	58	25.70	0.43	3.70	3.0	5.43	4.4	6.58	5.3	7.50	6.1	8.42	6.8
145L	0.0020	1.28	0.55	58	25.45	0.42	3.72	2.6	5.46	3.8	6.61	4.7	7.53	5.3	8.46	6.0
151L	0.0035	2.23	0.55	58	26.52	0.44	3.64	4.5	5.35	6.6	6.47	8.0	7.38	9.1	8.29	10.2
160L	0.0035	2.22	0.55	58	26.51	0.44	3.64	4.4	5.35	6.5	6.47	7.9	7.38	9.0	8.29	10.1
146L	0.0027	1.76	0.55	58	26.04	0.43	3.67	3.5	5.40	5.2	6.53	6.3	7.45	7.2	8.37	8.1
147H	0.0027	1.75	0.51	51	26.04	0.43	3.67	3.3	5.40	4.8	6.53	5.8	7.45	6.6	8.37	7.4
152H	0.0022	1.42	0.49	49	25.64	0.43	3.70	2.6	5.44	3.8	6.59	4.6	7.51	5.3	8.43	5.9
161H	0.0022	1.41	0.49	49	25.63	0.43	3.70	2.6	5.44	3.8	6.59	4.6	7.51	5.3	8.43	5.9
169H	0.0027	1.73	0.51	51	26.01	0.43	3.67	3.2	5.40	4.7	6.54	5.7	7.45	6.5	8.37	7.3

Atlas 14 Rational Method Calculations																
Basin Name	Area (sqmi)	Area (AC)	C	% Impr	TC (min)	TC (hr)	I2 (in/hr)	Q2 (cfs)	I10 (in/hr)	Q10 (cfs)	I25 (in/hr)	Q25 (cfs)	I50 (in/hr)	Q50 (cfs)	I100 (in/hr)	Q100 (cfs)
168H	0.0025	1.61	0.55	58	25.87	0.43	3.68	3.3	5.42	4.8	6.55	5.8	7.47	6.6	8.40	7.4
176H	0.0025	1.60	0.55	58	25.86	0.43	3.69	3.2	5.42	4.8	6.56	5.8	7.47	6.6	8.40	7.4
177H	0.0012	0.75	0.55	58	24.52	0.41	3.79	1.6	5.57	2.3	6.74	2.8	7.68	3.2	8.62	3.6
178H	0.0012	0.79	0.44	41	24.58	0.41	3.79	1.3	5.56	1.9	6.73	2.3	7.66	2.7	8.61	3.0
189H	0.0009	0.60	0.25	8	24.15	0.40	3.82	0.6	5.61	0.8	6.79	1.0	7.73	1.2	8.69	1.3
188H	0.0014	0.92	0.23	5	24.85	0.41	3.76	0.8	5.53	1.2	6.69	1.4	7.62	1.6	8.56	1.8
190M	0.0009	0.56	0.31	19	24.04	0.40	3.83	0.7	5.62	1.0	6.80	1.2	7.75	1.4	8.70	1.5
191M	0.0007	0.42	0.50	50	23.58	0.39	3.87	0.8	5.68	1.2	6.87	1.4	7.82	1.6	8.79	1.8
A1	0.0003	0.20	0.80	100	22.53	0.38	3.96	0.6	5.81	0.9	7.03	1.1	8.00	1.3	8.98	1.4
208M	0.0026	1.69	0.39	32	25.96	0.43	3.68	2.4	5.40	3.6	6.54	4.3	7.46	4.9	8.38	5.5
222M	0.0026	1.66	0.39	32	25.94	0.43	3.68	2.4	5.41	3.6	6.55	4.3	7.46	4.9	8.38	5.5
226M	0.0025	1.62	0.38	30	25.89	0.43	3.68	2.3	5.41	3.3	6.55	4.0	7.47	4.6	8.39	5.1
227M	0.0023	1.48	0.37	29	25.72	0.43	3.70	2.1	5.43	3.0	6.57	3.7	7.49	4.2	8.42	4.7
229M	0.0032	2.03	0.36	27	26.33	0.44	3.65	2.7	5.37	3.9	6.50	4.8	7.40	5.4	8.32	6.1
103G	0.0060	3.81	0.71	85	27.66	0.46	3.55	9.6	5.23	14.1	6.33	17.1	7.22	19.5	8.12	22.0
071P	0.0018	1.16	0.55	58	25.27	0.42	3.73	2.4	5.48	3.5	6.63	4.2	7.56	4.8	8.49	5.4
055P	0.0007	0.44	0.55	58	23.66	0.39	3.86	0.9	5.67	1.4	6.86	1.7	7.81	1.9	8.77	2.1
164H	0.0009	0.55	0.55	58	24.01	0.40	3.83	1.2	5.63	1.7	6.81	2.1	7.76	2.4	8.71	2.6
132P	0.0026	1.69	0.69	81	25.97	0.43	3.68	4.3	5.40	6.3	6.54	7.6	7.46	8.7	8.38	9.7
H102A	0.0587	37.55	0.39	32	33.94	0.57	3.17	46.7	4.68	68.9	5.68	83.7	6.50	95.6	7.32	107.8
225G	0.0043	2.73	0.55	58	26.94	0.45	3.61	5.4	5.30	8.0	6.42	9.7	7.32	11.0	8.23	12.4
219P	0.0008	0.52	0.20	1	23.92	0.40	3.84	0.4	5.64	0.6	6.82	0.7	7.77	0.8	8.72	0.9
220G	0.0040	2.54	0.55	58	26.79	0.45	3.62	5.1	5.32	7.4	6.44	9.0	7.34	10.3	8.25	11.5
005P	0.0038	2.42	0.80	100	26.69	0.44	3.62	7.0	5.33	10.3	6.45	12.5	7.36	14.2	8.27	16.0
008P	0.0018	1.15	0.80	100	25.24	0.42	3.73	3.4	5.48	5.0	6.64	6.1	7.56	6.9	8.50	7.8
010P	0.0027	1.74	0.80	100	26.03	0.43	3.67	5.1	5.40	7.5	6.53	9.1	7.45	10.4	8.37	11.7
013P	0.0063	4.03	0.80	100	27.78	0.46	3.55	11.4	5.22	16.8	6.32	20.4	7.21	23.2	8.10	26.1
042P	0.0012	0.77	0.80	100	24.55	0.41	3.79	2.3	5.56	3.4	6.73	4.1	7.67	4.7	8.61	5.3
A9	0.0005	0.35	0.80	100	23.30	0.39	3.89	1.1	5.72	1.6	6.91	1.9	7.87	2.2	8.84	2.5
A7	0.0002	0.15	0.80	100	22.16	0.37	4.00	0.5	5.86	0.7	7.09	0.8	8.07	1.0	9.06	1.1
D-19	0.0002	0.15	0.55	58	22.19	0.37	3.99	0.3	5.86	0.5	7.08	0.6	8.06	0.7	9.05	0.8
D-20	0.0002	0.11	0.80	100	21.82	0.36	4.03	0.4	5.91	0.5	7.14	0.7	8.13	0.7	9.12	0.8
D-21	0.0004	0.27	0.55	58	22.94	0.38	3.93	0.6	5.76	0.9	6.97	1.0	7.93	1.2	8.90	1.3
D-22	0.0002	0.14	0.80	100	22.09	0.37	4.00	0.5	5.87	0.7	7.10	0.8	8.08	0.9	9.07	1.0
A-3	0.0003	0.17	0.55	58	22.30	0.37	3.98	0.4	5.84	0.5	7.07	0.7	8.04	0.7	9.03	0.8
A-2	0.0004	0.22	0.55	58	22.69	0.38	3.95	0.5	5.79	0.7	7.01	0.9	7.98	1.0	8.95	1.1
A-6	0.0005	0.33	0.55	58	23.23	0.39	3.90	0.7	5.72	1.0	6.92	1.3	7.88	1.4	8.85	1.6
A-12	0.0020	1.27	0.55	58	25.43	0.42	3.72	2.6	5.46	3.8	6.61	4.6	7.54	5.3	8.47	5.9
B-8	0.0012	0.79	0.55	58	24.60	0.41	3.79	1.6	5.56	2.4	6.73	2.9	7.66	3.3	8.61	3.8

Atlas 14 Rational Method Calculations																
Basin Name	Area (sqmi)	Area (AC)	C	% Impr	TC (min)	TC (hr)	I2 (in/hr)	Q2 (cfs)	I10 (in/hr)	Q10 (cfs)	I25 (in/hr)	Q25 (cfs)	I50 (in/hr)	Q50 (cfs)	I100 (in/hr)	Q100 (cfs)
B-14	0.0002	0.15	0.80	100	22.15	0.37	4.00	0.5	5.86	0.7	7.09	0.8	8.07	1.0	9.06	1.1
B-16	0.0002	0.10	0.80	100	21.70	0.36	4.04	0.3	5.93	0.5	7.16	0.6	8.15	0.7	9.15	0.8
B-10	0.0002	0.10	0.80	100	21.64	0.36	4.05	0.3	5.93	0.5	7.17	0.6	8.16	0.6	9.16	0.7
B-11	0.0001	0.06	0.80	100	21.06	0.35	4.10	0.2	6.01	0.3	7.27	0.3	8.27	0.4	9.28	0.4
B-7	0.0005	0.30	0.80	100	23.08	0.38	3.91	0.9	5.74	1.4	6.95	1.7	7.91	1.9	8.88	2.1
B-5	0.0001	0.05	0.80	100	20.93	0.35	4.11	0.2	6.03	0.2	7.29	0.3	8.29	0.3	9.31	0.4
B-6	0.0001	0.09	0.80	100	21.55	0.36	4.05	0.3	5.95	0.4	7.19	0.5	8.18	0.6	9.18	0.7
C3	0.0004	0.28	0.55	58	23.01	0.38	3.92	0.6	5.75	0.9	6.96	1.1	7.92	1.2	8.89	1.4
B-15	0.0017	1.08	0.55	58	25.14	0.42	3.74	2.2	5.50	3.3	6.65	4.0	7.58	4.5	8.51	5.1
F1	0.0001	0.09	0.20	0	21.53	0.36	4.06	0.1	5.95	0.1	7.19	0.1	8.18	0.1	9.18	0.2
B32	0.0208	13.31	0.79	98	30.78	0.51	3.35	35.1	4.94	51.8	5.99	62.8	6.84	71.7	7.70	80.7
B37	0.0026	1.66	0.79	98	25.94	0.43	3.68	4.8	5.41	7.1	6.55	8.6	7.46	9.8	8.38	11.0
B26	0.0009	0.58	0.57	61	24.07	0.40	3.83	1.2	5.62	1.8	6.80	2.2	7.74	2.5	8.70	2.8
B27	0.0018	1.15	0.34	23	25.25	0.42	3.73	1.5	5.48	2.1	6.64	2.6	7.56	2.9	8.50	3.3
B30	0.0077	4.93	0.78	97	28.24	0.47	3.51	13.5	5.17	19.9	6.26	24.1	7.15	27.5	8.04	31.0
B31	0.0112	7.17	0.79	98	29.15	0.49	3.45	19.5	5.08	28.7	6.16	34.8	7.03	39.7	7.91	44.7
B36	0.0024	1.54	0.79	98	25.79	0.43	3.69	4.5	5.42	6.6	6.57	7.9	7.48	9.1	8.41	10.2
B23	0.0006	0.38	0.49	49	23.45	0.39	3.88	0.7	5.70	1.1	6.89	1.3	7.85	1.5	8.81	1.7
B24	0.0014	0.90	0.37	28	24.81	0.41	3.77	1.2	5.53	1.8	6.70	2.2	7.63	2.5	8.57	2.8
B25	0.0013	0.83	0.45	41	24.68	0.41	3.78	1.4	5.55	2.1	6.71	2.5	7.65	2.8	8.59	3.2
B33	0.0008	0.51	0.34	23	23.89	0.40	3.84	0.7	5.64	1.0	6.83	1.2	7.77	1.3	8.73	1.5
B34	0.0004	0.26	0.56	60	22.87	0.38	3.93	0.6	5.77	0.8	6.98	1.0	7.94	1.1	8.92	1.3
B28	0.0036	2.30	0.79	98	26.58	0.44	3.63	6.6	5.34	9.7	6.46	11.7	7.37	13.4	8.28	15.0
B35	0.0023	1.47	0.79	98	25.70	0.43	3.70	4.3	5.43	6.3	6.58	7.6	7.50	8.7	8.42	9.8
B21	0.0008	0.51	0.46	44	23.89	0.40	3.84	0.9	5.64	1.3	6.83	1.6	7.77	1.8	8.73	2.1
B22	0.0017	1.09	0.36	26	25.15	0.42	3.74	1.4	5.50	2.1	6.65	2.6	7.58	2.9	8.51	3.3
B9	0.0011	0.70	0.61	69	24.40	0.41	3.80	1.6	5.58	2.4	6.75	2.9	7.69	3.3	8.64	3.7
MH-6	0.0038	2.43	0.75	92	26.69	0.44	3.62	6.6	5.33	9.7	6.45	11.8	7.35	13.4	8.27	15.1
B19	0.0041	2.62	0.73	88	26.85	0.45	3.61	6.9	5.31	10.1	6.43	12.3	7.33	14.0	8.24	15.7
IN-B8	0.0009	0.58	0.20	0	24.07	0.40	3.83	0.4	5.62	0.6	6.80	0.8	7.74	0.9	8.70	1.0
IN-B5	0.0020	1.28	0.20	0	25.44	0.42	3.72	1.0	5.46	1.4	6.61	1.7	7.53	1.9	8.46	2.2
B2	0.0024	1.54	0.20	0	25.79	0.43	3.69	1.1	5.42	1.7	6.57	2.0	7.48	2.3	8.41	2.6
IN-B6	0.0010	0.64	0.44	40	24.24	0.40	3.81	1.1	5.60	1.6	6.78	1.9	7.72	2.2	8.67	2.4
IN-B7	0.0010	0.64	0.65	75	24.24	0.40	3.81	1.6	5.60	2.3	6.78	2.8	7.72	3.2	8.67	3.6
IN-B3	0.0004	0.26	0.63	72	22.87	0.38	3.93	0.6	5.77	0.9	6.98	1.1	7.94	1.3	8.92	1.4
IN-B4	0.0004	0.26	0.55	58	22.87	0.38	3.93	0.6	5.77	0.8	6.98	1.0	7.94	1.1	8.92	1.3
IN-B1	0.0112	7.17	0.78	97	29.15	0.49	3.45	19.4	5.08	28.5	6.16	34.5	7.03	39.4	7.91	44.3
B17	0.0023	1.47	0.71	85	25.70	0.43	3.70	3.9	5.43	5.7	6.58	6.9	7.50	7.8	8.42	8.8
B20	0.0009	0.58	0.36	26	24.07	0.40	3.83	0.8	5.62	1.2	6.80	1.4	7.74	1.6	8.70	1.8

Table A.1
Atlas 14 Rational Method Flows

Atlas 14 Rational Method Calculations																
Basin Name	Area (sqmi)	Area (AC)	C	% Impr	TC (min)	TC (hr)	I2 (in/hr)	Q2 (cfs)	I10 (in/hr)	Q10 (cfs)	I25 (in/hr)	Q25 (cfs)	I50 (in/hr)	Q50 (cfs)	I100 (in/hr)	Q100 (cfs)
B18	0.0003	0.19	0.57	62	22.48	0.37	3.97	0.4	5.82	0.6	7.04	0.8	8.01	0.9	8.99	1.0
IN-B15	0.0058	3.71	0.66	77	27.60	0.46	3.56	8.7	5.23	12.9	6.34	15.6	7.23	17.8	8.13	20.0
IN-B16	0.0011	0.70	0.39	32	24.40	0.41	3.80	1.0	5.58	1.5	6.75	1.9	7.69	2.1	8.64	2.4
B13	0.0025	1.60	0.31	19	25.86	0.43	3.69	1.9	5.42	2.7	6.56	3.3	7.47	3.8	8.40	4.2
IN-B14	0.0017	1.09	0.29	15	25.15	0.42	3.74	1.2	5.50	1.7	6.65	2.1	7.58	2.4	8.51	2.7
IN-B10	0.0009	0.58	0.76	93	24.07	0.40	3.83	1.7	5.62	2.5	6.80	3.0	7.74	3.4	8.70	3.8
IN-B11	0.0011	0.70	0.45	41	24.40	0.41	3.80	1.2	5.58	1.8	6.75	2.1	7.69	2.4	8.64	2.7
IN-B12	0.0008	0.51	0.45	42	23.89	0.40	3.84	0.9	5.64	1.3	6.83	1.6	7.77	1.8	8.73	2.0
B29	0.0101	6.46	0.77	95	28.89	0.48	3.47	17.3	5.11	25.4	6.19	30.8	7.06	35.2	7.95	39.5
230M	0.0002	0.11	0.80	100	21.79	0.36	4.03	0.4	5.91	0.5	7.15	0.6	8.13	0.7	9.13	0.8
IN-A2	0.0003	0.20	0.80	100	22.53	0.38	3.96	0.6	5.81	0.9	7.03	1.1	8.00	1.3	8.98	1.4
IN-A6	0.0002	0.15	0.80	100	22.12	0.37	4.00	0.5	5.87	0.7	7.09	0.8	8.08	0.9	9.06	1.1
IN-A10	0.0005	0.29	0.80	100	23.06	0.38	3.92	0.9	5.75	1.3	6.95	1.6	7.91	1.9	8.88	2.1

APPENDIX B

HALFF ASSOCIATES, Inc.
100 I-45 North, Suite 260, Conroe, Texas 77301
Halff Associates, Inc

CLIENT:	City of Houston	**DATE:**	03/27/20
PROJECT:	Pleasantville Detention Analysis	**AVO:**	31051 - WO121
PREPARED BY:	Halff	**FILE NAME:**	31051_WO121_Costs

PLEASANTVILLE ALTERNATIVE 1A-1 IMPROVEMENTS
PRELIMINARY OPINION OF PROBABLE COSTS

Item No.	QUAN.	UNIT	DESCRIPTION	COST PER UNIT	TOTAL COST
Paving Items					
1	84548	SY	Remove and dispose concrete pavements (all thickness, w/ or w/o asphalt, including base and subgrade, w/ or w/o curb, all depths)	$ 7.00	$ 591,836.00
2	4157	SY	Remove and dispose of existing asphaltic pavements (all thickness, including base and subgrade, w/ or w/o curb, all depths)	$ 10.00	$ 41,570.00
3	84548	SY	Hot-Mix asphaltic pavement (all thickness, including surfacing, base, and subgrade)	$ 45.00	$ 3,804,660.00
4	4157	SY	Concrete pavement (all thickness, including reinforcement, asphaltic surfacing, base, and subgrade)	$ 75.00	$ 311,775.00
Subtotal Paving Items				**$**	**4,749,841.00**
Storm Sewer Items					
1	29	EA	Manholes (For 42" diameter pipe and smaller; all types)	$ 3,500.00	$ 101,500.00
2	60	EA	Manholes (For 48" to 72" diameter pipe and smaller; all types)	$ 6,500.00	$ 390,000.00
3	29	EA	Manholes (For 72" diameter pipe and larger; all types)	$ 16,500.00	$ 478,500.00
4	47	LF	Remove and dispose 12-inch diameter storm sewer, all types	$ 6.00	$ 282.00
5	16152	LF	Remove and dispose 18-inch diameter storm sewer, all types	$ 8.00	$ 129,212.00
6	2333	LF	Remove and dispose 21-inch diameter storm sewer, all types	$ 12.00	$ 27,992.40
7	5439	LF	Remove and dispose 24-inch diameter storm sewer, all types	$ 15.00	$ 81,583.50
8	1850	LF	Remove and dispose 30-inch diameter storm sewer, all types	$ 30.00	$ 55,488.00
9	921	LF	Remove and dispose 36-inch diameter storm sewer, all types	$ 32.00	$ 29,472.00
10	522	LF	Remove and dispose 42-inch diameter storm sewer, all types	$ 35.00	$ 18,252.50
11	530	LF	Remove and dispose 48-inch diameter storm sewer, all types	$ 37.00	$ 19,595.20
12	978	LF	Remove and dispose 54-inch diameter storm sewer, all types	$ 40.00	$ 39,116.00
13	1365	LF	Remove and dispose 60-inch diameter storm sewer, all types	$ 42.00	$ 57,338.40
14	1524	LF	Remove and dispose 66-inch diameter storm sewer, all types	$ 44.00	$ 67,038.40
15	671	LF	Remove and dispose 72-inch diameter storm sewer, all types	$ 48.00	$ 32,208.00
16	116	EA	Remove Storm Manhole (All depths, all types)	$ 560.00	$ 64,960.00
17	4321	LF	24-inch RCP	$ 115.00	$ 496,915.00
18	5290	LF	30-inch RCP	$ 150.00	$ 793,500.00
19	1759	LF	36-inch RCP	$ 180.00	$ 316,620.00
20	3046	LF	42-inch RCP	$ 215.00	$ 654,890.00
21	6891	LF	48-inch RCP	$ 250.00	$ 1,722,750.00
22	1625	LF	54-inch RCP	$ 315.00	$ 511,812.00
23	5055	LF	60-inch RCP	$ 375.00	$ 1,895,625.00
24	384	LF	66-inch RCP	$ 425.00	$ 163,327.50
25	3043	LF	72-inch RCP	$ 485.00	$ 1,475,806.50
26	1063	LF	78-inch RCP	$ 550.00	$ 584,650.00
27	2718	LF	120-inch RCP	$ 1,050.00	$ 2,853,501.00
28	231	LF	4-foot by 4-foot RCB	$ 280.00	$ 64,736.00
29	203	LF	6-foot by 4-foot RCB	$ 445.00	$ 90,112.50
30	703	LF	8-foot by 4-foot RCB	$ 580.00	$ 407,856.00
31	1788	LF	8-foot by 6-foot RCB	$ 770.00	$ 1,377,068.00
32	173	LF	10-foot by 8-foot RCB	$ 960.00	$ 165,888.00
33	29	EA	Storm Junction Box, Cast in place or Precast	$ 20,000.00	$ 580,000.00
34	37337	LF	Trench Safety System	$ 2.00	$ 74,673.60
Subtotal Storm Sewer Items				**$**	**15,822,269.50**
Total Project Construction Cost Summary					
Subtotal Paving Items					**$ 4,749,841.00**
Subtotal Storm Sewer Items					**$ 15,822,269.50**
Subtotal Construction Costs					**$ 20,572,110.50**
Mobilization (4% of Construction Subtotal)					**$ 822,885.00**
Contingencies (30% of Construction and Mobilization Total)					**$ 6,418,500.00**
				GRAND TOTAL	**$ 27,813,495.50**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
100 I-45 North, Suite 260, Conroe, Texas 77301
Halff Associates, Inc

CLIENT:	City of Houston	**DATE:**	03/27/20
PROJECT:	Pleasantville Detention Analysis	**AVO:**	31051 - WO121
PREPARED BY:	Halff	**FILE NAME:**	31051_WO121_Costs

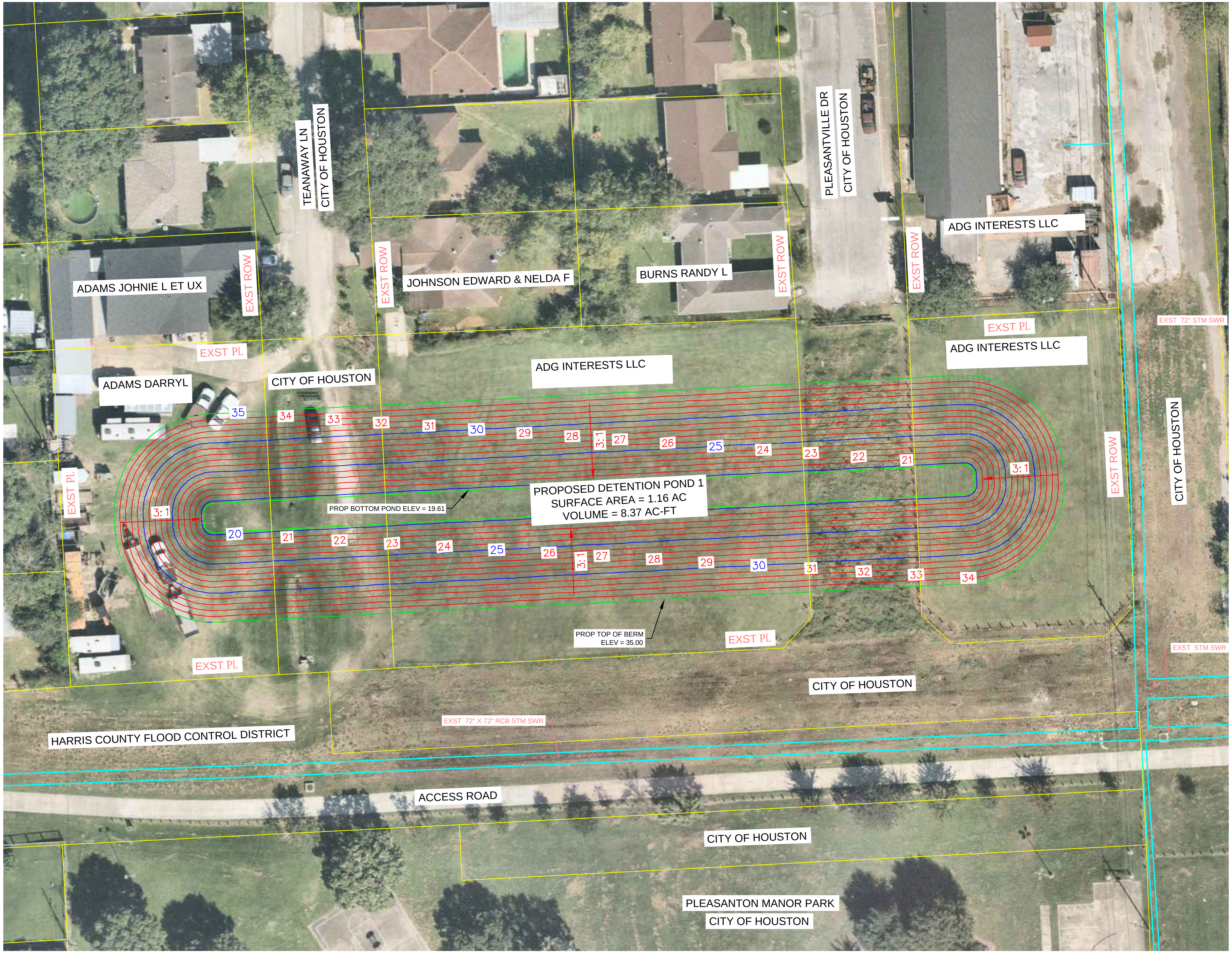
PLEASANTVILLE PROPOSED IMPROVEMENTS
PRELIMINARY OPINION OF PROBABLE COSTS

Item No.	QUAN.	UNIT	DESCRIPTION	COST PER UNIT	TOTAL COST
Paving Items					
1	60,806	SY	Remove and dispose of existing asphaltic pavements (all thickness, including base and subgrade, w/ or w/o curb, all depths)	$ 7.00	$ 425,642.00
2	7,189	SY	Removing and disposing of concrete pavements (including all thickness, w/ or w/o asphalt, including base & subgrade, w/ or w/o curb, all depths)	$ 10.00	$ 71,890.00
3	60,806	SY	Hot-Mix asphaltic pavement (all thickness, including surfacing, base, and subgrade)	$ 45.00	$ 2,736,270.00
4	7,189	SY	Concrete pavement (all thickness, including curb and gutter, base, and subgrade)	$ 75.00	$ 539,175.00
Subtotal Paving Items				**$**	**3,772,977.00**
Storm Sewer Items					
1	31	EA	Manholes (For 42" diameter pipe and smaller; all types)	$ 3,500.00	$ 108,500.00
2	25	EA	Manholes (For 48" to 72" diameter pipe and smaller; all types)	$ 6,500.00	$ 162,500.00
3	19	EA	Manholes (For 72" diameter pipe and larger; all types)	$ 16,500.00	$ 313,500.00
4	11,891	LF	Remove and dispose 18-inch diameter storm sewer, all types	$ 8.00	$ 95,128.00
5	1,467	LF	Remove and dispose 21-inch diameter storm sewer, all types	$ 12.00	$ 17,604.00
6	4,034	LF	Remove and dispose 24-inch diameter storm sewer, all types	$ 15.00	$ 60,510.00
7	1,940	LF	Remove and dispose 30-inch diameter storm sewer, all types	$ 30.00	$ 58,200.00
8	1,180	LF	Remove and dispose 36-inch diameter storm sewer, all types	$ 32.00	$ 37,760.00
9	549	LF	Remove and dispose 42-inch diameter storm sewer, all types	$ 35.00	$ 19,215.00
10	562	LF	Remove and dispose 54-inch diameter storm sewer, all types	$ 40.00	$ 22,480.00
11	824	LF	Remove and dispose 60-inch diameter storm sewer, all types	$ 42.00	$ 34,608.00
12	1,001	LF	Remove and dispose 66-inch diameter storm sewer, all types	$ 44.00	$ 44,044.00
13	66	EA	Remove Storm Manhole (All depths, all types)	$ 560.00	$ 36,960.00
14	3,584	LF	24-inch RCP	$ 115.00	$ 412,160.00
15	1,156	LF	30-inch RCP	$ 150.00	$ 173,400.00
16	2,037	LF	36-inch RCP	$ 180.00	$ 366,660.00
17	4,856	LF	42-inch RCP	$ 215.00	$ 1,044,040.00
18	4,428	LF	48-inch RCP	$ 250.00	$ 1,107,000.00
19	1,731	LF	54-inch RCP	$ 315.00	$ 545,265.00
20	3,258	LF	60-inch RCP	$ 375.00	$ 1,221,750.00
21	581	LF	66-inch RCP	$ 425.00	$ 246,925.00
22	822	LF	72-inch RCP	$ 485.00	$ 398,670.00
23	250	LF	8-foot by 5-foot RCB	$ 660.00	$ 165,000.00
24	271	LF	10-foot by 5-foot RCB	$ 850.00	$ 230,350.00
25	285	LF	10-foot by 6-foot RCB	$ 880.00	$ 250,800.00
26	513	LF	10-foot by 7-foot RCB	$ 920.00	$ 471,960.00
27	286	LF	10-foot by 8-foot RCB	$ 960.00	$ 274,560.00
28	1,286	LF	10-foot by 10-foot RCB	$ 1,300.00	$ 1,671,800.00
29	115	EA	Remove Inlet	$ 750.00	$ 86,250.00
30	115	EA	Replace Inlet (Type BB)	$ 3,500.00	$ 402,500.00
31	17	EA	Storm Junction Box, Cast in place or Precast	$ 20,000.00	$ 340,000.00
32	26,661	LF	Trench Safety System	$ 2.00	$ 53,322.00
33	457,127	CY	Excavation	$ 8.00	$ 3,657,016.00
34	922	SY	Concrete Pilot Channel (5" Thick Concrete)	$ 70.00	$ 64,540.00
35	2	EA	Headwall/Wingwall	$ 12,000.00	$ 24,000.00
Subtotal Storm Sewer Items				**$**	**14,218,977.00**

Total Project Construction Cost Summary	
Subtotal Paving Items	**$ 3,772,977.00**
Subtotal Storm Sewer Items	**$ 14,218,977.00**
Subtotal Construction Costs	**$ 17,991,954.00**
Mobilization (4% of Construction Subtotal)	**$ 719,680.00**
Contingencies (30% of Construction and Mobilization Total)	**$ 5,613,490.00**
GRAND TOTAL	**$ 24,325,124.00**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

APPENDIX C



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LEGEND

50 MAJOR CONTOUR

52 MINOR CONTOUR

PROPERTY LINE/ RIGHT OF WAY

NOTES:

1. 8.37 ACRE-FOOT DETENTION POND.
2. DETENTION POND DESIGNED AS A DRY BOTTOM POND.

HALFF

100 I-45 N SUITE 260
CONROE, TEXAS 77301
TEL (936) 756-6832
FAX (936) 756-6833
TBPE FIRM NUMBER F-312

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LONG NGUYEN	114452
NAME	P.E. NO.
DATE	1/16/20

SURVEYED BY:

FB NO. 000000

CITY OF HOUSTON

HOUSTON PUBLIC WORKS

PLEASANTVILLE DR
TEANAWAY LN

POND 1

WBS NUMBER	FOR CITY OF HOUSTON USE ONLY
X-000X00-0000-X	
DRAWING SCALE	
AS NOTED	
CITY OF HOUSTON PM	
JOHN DOE, P.E.	
SHEET NO. 1 OF 2	

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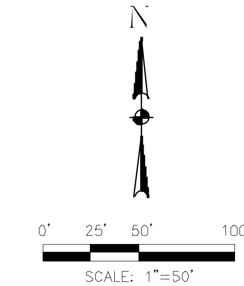

LEGEND

- 50 — MAJOR CONTOUR
- 52 — MINOR CONTOUR
- PROPERTY LINE/ RIGHT OF WAY

NOTES:

1. 17.03 ACRE-FOOT DETENTION POND.
2. DETENTION POND DESIGNED AS A DRY BOTTOM POND.

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PLEASANTON MANOR PARK POND 2

WBS NUMBER	FOR CITY OF HOUSTON USE ONLY
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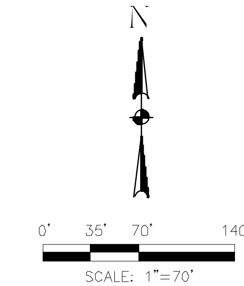
AS NOTED	
CITY OF HOUSTON PM	
JOHN DOE, P.E.	
SHEET NO. 1 OF 2	



LEGEND

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52 (red line)	MINOR CONTOUR
(yellow line)	PROPERTY LINE/ RIGHT OF WAY

NOTES:

1. 0.74 ACRE-FOOT DETENTION POND.
2. DETENTION POND DESIGNED AS A DRY BOTTOM POND.

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DATE	1/16/20

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CITY OF HOUSTON
HOUSTON PUBLIC WORKS

HOLLAND MIDDLE SCHOOL POND 3

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AS NOTED	
CITY OF HOUSTON PM	
JOHN DOE, P.E.	
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0' 75' 150' 300'
SCALE: 1"=150'

LEGEND

- 50 — MAJOR CONTOUR
- 52 — MINOR CONTOUR
- PROPERTY LINE/ RIGHT OF WAY

NOTES:

1. 349.65 ACRE-FOOT DETENTION POND.
2. DETENTION POND DESIGNED AS A DRY BOTTOM POND.

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FAX (936) 756-6833
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DATE 1/16/20

SURVEYED BY:
FB NO. 000000

CITY OF HOUSTON
HOUSTON PUBLIC WORKS

PORT OF HOUSTON AUTHORITY POND 4

WBS NUMBER: X-000X00-0000-X
DRAWING SCALE: AS NOTED
CITY OF HOUSTON PM: JOHN DOE, P.E.
SHEET NO. 1 OF 2
FOR CITY OF HOUSTON USE ONLY

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LEGEND

50	MAJOR CONTOUR
52	MINOR CONTOUR
	PROPERTY LINE/ RIGHT OF WAY

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100 I-45 N SUITE 260
CONROE, TEXAS 77301
TEL (936) 756-6832
FAX (936) 756-6833
TBPE FIRM NUMBER F-312

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DATE 1/16/20

SURVEYED BY:
FB NO. 000000

CITY OF HOUSTON
HOUSTON PUBLIC WORKS

POND 5

WBS NUMBER	FOR CITY OF HOUSTON USE ONLY
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DRAWING SCALE	
AS NOTED	
CITY OF HOUSTON PM	
JOHN DOE, P.E.	
SHEET NO. 1 OF 2	

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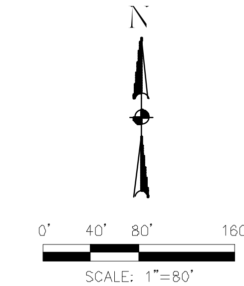

LEGEND

50 MAJOR CONTOUR

52 MINOR CONTOUR

PROPERTY LINE/ RIGHT OF WAY

NOTES:

1. 50.60 ACRE-FOOT DETENTION POND.
2. DETENTION POND DESIGNED AS A DRY BOTTOM POND.

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CONROE, TEXAS 77301
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FAX (936) 756-6833
TBPE FIRM NUMBER F-312

SURVEYED BY:
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NAME P.E. NO.
DATE 1/16/20

CITY OF HOUSTON
HOUSTON PUBLIC WORKS

POND 6

WBS NUMBER	FOR CITY OF HOUSTON USE ONLY
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DRAWING SCALE	
AS NOTED	
CITY OF HOUSTON PM	
JOHN DOE, P.E.	
SHEET NO. 1 OF 2	

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Halff Associates, Inc.
14800 St Marys Ln #160
Houston, TX 77079
TBPE Firm No. F-312

MEMORANDUM

TO:	Adam Eaton, PE, ENV SP	**DATE:**	October 28, 2020
FROM:	C. Andrew Moore, PE, CFM	**AVO:**	31051 WO163
EMAIL:	amoore@halff.com		
SUBJECT:	Pleasantville Benefit-Cost Analysis (Work Order 163)		

Introduction

This memorandum presents the findings of the Pleasantville Benefit-Cost Analysis (BCA). The purpose of this task was to perform a FEMA-compliant benefit-cost analysis for the proposed drainage improvements recommended in the "Pleasantville Detention Analysis" (Work Order 121). In addition to the drainage improvements, the proposed project includes the construction of a Community and Disaster Recovery Center.

BCA Methodology

The FEMA BCA Toolkit Version 6.0 was used to estimate the pre-project and post-project damage costs, which are necessary to calculate a benefit-cost ratio (BCR) for the recommended drainage improvements. The following building structure data were obtained from the Harris County Appraisal District's (HCAD) website: latitude/longitude, property type, land value, improvement value, building footprint, and year built. There is a total of 1,199 structures in the project area.

In the BCA Toolkit, the damage and frequency relationship was based on modeled damages, not historical damages since comprehensive historical data were not available for this site. The project's useful life was assumed to be 50 years, which is FEMA's standard value for drainage infrastructure projects. Where appropriate, the BCA Toolkit's default values were used in the calculation of the BCR. The United States Army Corps of Engineers (USACE) Generic Depth Damage Curve was used to estimate economic damages for each residential structure (one-story without basement) based on the risk of inundation. The default non-refrigerated warehouse damage curve was used to estimate economic damages for the non-residential structures in the area.

Water surface elevation (WSEL) grids were developed from the hydraulic models and used to estimate the maximum flood depth at structures within the project area. The 10-, 25-, 50-, and 100-year storm events were used for this BCA. Additional benefits that could increase the BCR of the mitigation project (i.e., volunteer, social, and ecosystem services) were not included in the BCA given a lack of supporting documentation. A structure's building replacement value per square foot was estimated in two different ways: (1) FEMA's default value ($100/sqft), and (2) the structure's improvement value from HCAD. This resulted in two different BCRs, as explained in the Results section below.

Structures that fronted along the same streets and had similar finished floor elevations and modeled water surface elevations were aggregated into groups for use in the BCA Toolkit. There were 41 groups in total.

For each group, the following were calculated: average finished floor elevation, average water surface elevation, total building square footage, average building value per square foot, and total number of residents (assumed four residents per residential structure). If one or more structures in a group experienced inundation for any storm event in existing conditions, the group was input into the BCA Toolkit. A total of 22 groups were inputted.

BCA Results

The cost estimate for the recommended project was provided by the City of Houston and totals $99,021,350.13. The cost breakdown is provided in **Table 1**.

Table 1: Cost Estimate for the City of Houston Port Area Drainage Improvements

Material/Service	Cost
Drainage Improvements	
Construction Subtotal	$24,542,146.56
Engineering Design	$3,681,321.98
Environmental Investigation and Permitting	$1,472,528.79
Disposal of Excavated Material	$18,285,080.00
Grant Administration	$1,472,528.79
TOTAL	$49,453,606.13
Community & Disaster Recovery Center	
Construction Subtotal	$39,029,720.00
Engineering Design	$5,854,458.00
Environmental Investigation and Permitting	$2,341,783.20
Grant Administration	$2,341,783.20
TOTAL	$49,567,744.40
GRAND TOTAL	**$99,021,350.53**

The total calculated benefits are $29,674,935 when using FEMA's default value for building replacement. The benefit-cost ratio for the recommended project is calculated to be 0.30.

The total calculated benefits are reduced to $13,958,141 when using the structure's improvement value from HCAD for building replacement. The BCR for the recommended project is 0.14. The FEMA BCA Toolkit spreadsheets are included electronically with this submittal.

This FEMA benefit-cost analysis is based on benefits to individual structures and the reduction in potential structural inundation achieved through the proposed improvements. It must be noted that the proposed improvements provide additional benefits that are not reflected in the benefit-cost ratio. They are as follows:

- The proposed flood control and drainage improvements in the Pleasantville neighborhood reduce ponding on major streets, increasing the number of lane miles that are passable during major events, which allows residents to leave the neighborhood and for emergency services to enter in such an event.
- The detention basin proposed as part of these improvements will be constructed on a dredge disposal site. The construction will require removal and disposal of the existing dredged material. The basin can be developed as park space that will provide health and quality of life benefits to residents of the neighborhood.

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Houston, TX 77079
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- The proposed Community and Disaster Recovery Center will serve as a "lily pad," allowing a point of refuge for residents to reduce suffering and hardship during and following events, as well as a command center to coordinate emergency services during an extreme event.

If you have any questions or need additional information, please do not hesitate to contact me.

HALFF ASSOCIATES, Inc.
Texas Firm Registration No. 312

C. Andrew Moore

C. Andrew Moore, P.E., CFM
Water Resources Team Leader

STATE OF TEXAS
C. ANDREW MOORE
124910
LICENSED
PROFESSIONAL ENGINEER

C. Andrew Moore
TBPE 124910
F-312
10/28/2020

Appendix 5-4L: Houston Kashmere Gardens

List of Exhibits

1 Introduction

Study Purpose and Scope

Huitt-Zollars (HZ) was tasked with providing professional engineering services to investigate the limitation and deficiencies of the existing drainage system for Kashmere Gardens neighborhood in the City of Houston (COH). The project is referenced as M-430100-0020-3. HZ used Need Area M-2017-002 study as a starting point, recommended adjustments to the drainage boundaries, and designated the offsite areas that affect the study area.

This letter report summarizes the finding of the existing drainage system investigation. The scope of this work includes:

- Define the existing condition drainage area boundary
- Identify the existing drainage systems and their outfalls
- Identify the FEMA floodplain boundary
- Identify the existing overland flow paths
- Survey the main trunklines to obtain storm sewer flowline elevation and pipe size.
- Develop a dynamic hydraulic model to identify the drainage issues

Project Location and Background

The project is located within the historic Kashmere Gardens which is located just south of 610 Loop in Houston, TX. The limits of detailed study were defined by HZ through early stages of the work and finalized through coordination with COH and is shown in Exhibit 1. The studied area is located between an industrial area to the east, Union Pacific rail corridor to the south, Schrum Gully (H112-00-00) to the west and Hunting Bayou (H100-00-00) to the north. The existing land use is mainly single-family residential lots and commercial developments. The Parcel Land Use map is shown in Exhibit 2.

The existing drainage system consists of storm sewer and roadside ditches in the project location and is shown in Exhibit 3. The study area is located within the Hunting Bayou watershed. Hunting Bayou and its tributaries serves as an outfall for the local drainage systems. A tributary of Hunting Bayou (H110-00-00) divides the study area into two parts. On the east side of H110-00-00, most drainage systems run from east to west direction and outfall into H110-00-00. On the west side, the major drainage systems run from south to north direction and outfall into Hunting Bayou.

During an intense rainfall event, Hunting Bayou does not provide adequate flood protection, nor does the channel serve as an adequate outfall source for the local drainage system. Beside, flat topography and channel conveyance obstructions are the other contributing factors to the frequent flooding in the Kashmere Garden area.

Data Collection

The following documents and data were obtained and relied upon in this study:

- City of Houston Infrastructure Drainage Manual (IDM), 2019
- Technical Modeling Guidelines for 2D Dynamic Stormwater Analysis, COH, Technical Paper (TP) – 102, 2019
- COH GIMS
- Record Construction Drawings from COH's Public Records Department
- Topographic survey performed by Landtech, Inc

Methodology

The hydrologic and hydraulic analysis was performed in accordance with COH IDM. Peak discharges were computed using Rational Method. Peak discharges were computed for the 2, 10, 100 and 500 year storm events. Runoff hydrographs for drainage areas were generated based on the Clark Unit Hydrograph using USACE HEC-HMS (Version 3.3) and calibrated to the Rational Method peak flows. Storm sewer and ditch analysis was performed using Innovyze XPSWMM (Version 2018.2).

Drainage system components including drainage areas, land use, storm sewer and ditches connectivity, cross-sections and flowlines obtained from COH GIMS data. The drainage systems were verified utilizing combination of provided as-built information, field reconnaissance, Lidar, aerial photography and survey data. Drainage area is shown in Exhibit 4.

FEMA Special Flood Hazard Areas

The study area is located within Hunting Bayou 100 year floodplain boundary and shaded Zone X (500-yr) boundary. The BFE elevation for the site is about 45 feet. Hunting Bayou and Channel H100-00-00 are FEMA studied streams with regulatory floodplains as shown on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) 48201C0715M dated January 06, 2017. The floodplain boundaries are shown in Exhibit 5.

Hunting Bayou Improvement Project

Harris County Flood Control District (HCFCD) is in the final stages of completing Hunting Bayou channel improvement. HCFCD project consists of approximately 3.8 miles of grass-lined channel modifications to a maximum 60-foot bottom width from downstream of the Englewood Railroad Yard to US 59 and 1000 acre-feet of detention in a 75–acre detention basin.

Based on "Hunting *Bayou Flood Risk Management Report"* dated 2014, the improvements in Hunting Bayou will reduce the 100 year Water Surface Elevation (WSE) near Lockwood Bridge by about four feet. This study assumes the HCFCD improvements are complete and as a result the WSE in Hunting Bayou has been lowered.

Site Visit

A site visit was performed on December 23, 2019 to obtain photographs and to document the existing drainage patterns and land uses at the study area.

2 Existing Drainage System

The existing drainage system consists of storm sewer and roadside ditches in the project location and is shown in Exhibit 3. The drainage systems were modeled to check if they meet the COH criteria and discussed in detail below.

Drainage Area

The total study area is approximately 873 acres and drainage areas are shown in Exhibit 4. There is about 570 acres offsite drainage with storm sewer lines draining away from the study area while their surcharges on the streets ultimately entering into the study area.

The existing ground elevations range from 41-ft at the bank of Hunting Bayou to 45-ft at the Railroad site south of Liberty Rd. The existing topography throughout this area is relatively flat with average slope of 0.07%. The Lidar Map is shown is Exhibit 6.

Exhibit 7 shows the sheet flow patterns through the project area. The general overland flow direction is from west to east and south to north on the west side of H110-00-00. On the east side, water flows from east to west direction and outfalls into H110-00-00.

Drainage Outfall Channels

Hunting Bayou is an earthen channel with the recently improved banks at the study limits. The channel serves as a major outfall for local drainage systems.

Channel H110-00-00 is a trapezoidal concrete lined channel with a rectangular pilot channel. Based on the FEMA Effective model, the channel has adequate capacity to convey the 100 year storm event without flooding outside the banks. However, the backwater from the Hunting Bayou inundates the H110-00-00 during extreme storm events.

Channel H112-00-00 is an earthen trapezoidal channel with a concrete lined rectangular pilot channel. Based on the FEMA Effective model, the channel has adequate capacity to convey the 100 year storm event without flooding outside the banks. However, the backwater from the Hunting Bayou inundates the Schrum Gully during extreme storm events.

Historic Flooding

The study area has a long flooding history according to the flood damages records. The flood damage complaints from Hurricane Harvey (2017) and previous major storms is shown in Exhibit 8. This map indicates the area is frequently prone to the flooding.

Hydraulic & Hydrologic Analysis

Exhibit 4 present the drainage areas and storm sewer systems that were modeled in XPSWMM. Drainage Systems A, to G are located on the west side of H110-00-00. Drainage Systems EH1 to EH10 are located on the east side of H110-00-00. Along Channel H100-00-00 there are several small drainage systems that have sufficient capacity and therefore were not included in the XPSWMM model (see Exhibit 4).

System EH1, EH2 and EH3 are modeled as a ditch with averaged 2-ft depth and 2-ft bottom with 3H:1V side slopes. All the other systems consist of underground storm sewer lines with curb and gutter road. System F1, G1 and EH10 outfall into COH storm sewer. Other drainage systems drain into HCFCD channels within the project location. Storm sewers and ditches were analyzed using XPSWMM model.

Runoff hydrographs were developed separately and entered in the XPSWMM model. The XPSWMM model include 2D surface for modeling the sheet flow in the street. The XPSWMM model nodes and links are shown in Exhibit 7. Model parameters including tailwater elevations, Manning’s roughness and mesh size were established in accordance with COH IDM and TP-102. An electronic copy of XPSWMM model files is provided on a USB flash drive.

3 Drainage Findings

The drainage system capacity was evaluated for 2 , and 100 year storm events and the result are provided in Exhibits 9 to 13.

West Side of H110-00-00

2 Year Storm

- Exhibits 10 and Exhibit 11 present the ponding limits and ponding depth for 2 year storm, respectively. The existing 90" storm sewer along Lavender Street in system A and the existing 96" storm sewer along Wayne Street in System D (offsite) do not have sufficient capacity to carry the 2 year storm event. This results in more than one foot of ponding depth along Collingsworth between Wayne Street and Lavender Street. Based on XPSWMM model result, there is about 100 cfs sheet flows from system D (offsite) onto System A during the 2 year Storm event along Collingsworth Street.

- The storm sewer along Wayne Street south of Crane Street consist of a 78" RCP and a 60" RCP which has more capacity than the 90" storm sewer line downstream of this section. This could potentially result in excessive sheet flow along Collingsworth.

- The 2 year HGL in System A near Jewel Street exceed the gutter elevation which is mainly due to limited capacity in existing storm sewer line.

- System C drains a small area north of Union Pacific railroad site. However, the 24" RCP storm sewers south of Lucille Street and along Liberty Road does not have sufficient capacity for a 2 year storm.

100 Year Storm

- Exhibits 11 and Exhibit 12 present the ponding limits and ponding depth for 100 year storm, respectively. There is significant ponding during 100 year storm event outside the roadway ROW which can potentially result in structural flooding. This condition can be attributed to limited storm sewer and sheet flow conveyance capacity.

- The hydraulic analysis result indicated that there is about 400 cfs offsite sheet flow along Collingsworth St enters the study area. This additional flow is causing the ponding depth to exceed the 1.5 feet above the top of curb along Collingsworth Street.

East Side of H110-00-00

2 Year Storm

- The hydraulic analysis of drainage system along Rand Street indicated that the existing roadside ditches do not have enough capacity to carry the 2 year flows.

- The 54" RCP along Cavalcade Street (System EH5) does not have adequate capacity for a 2 year Storm.

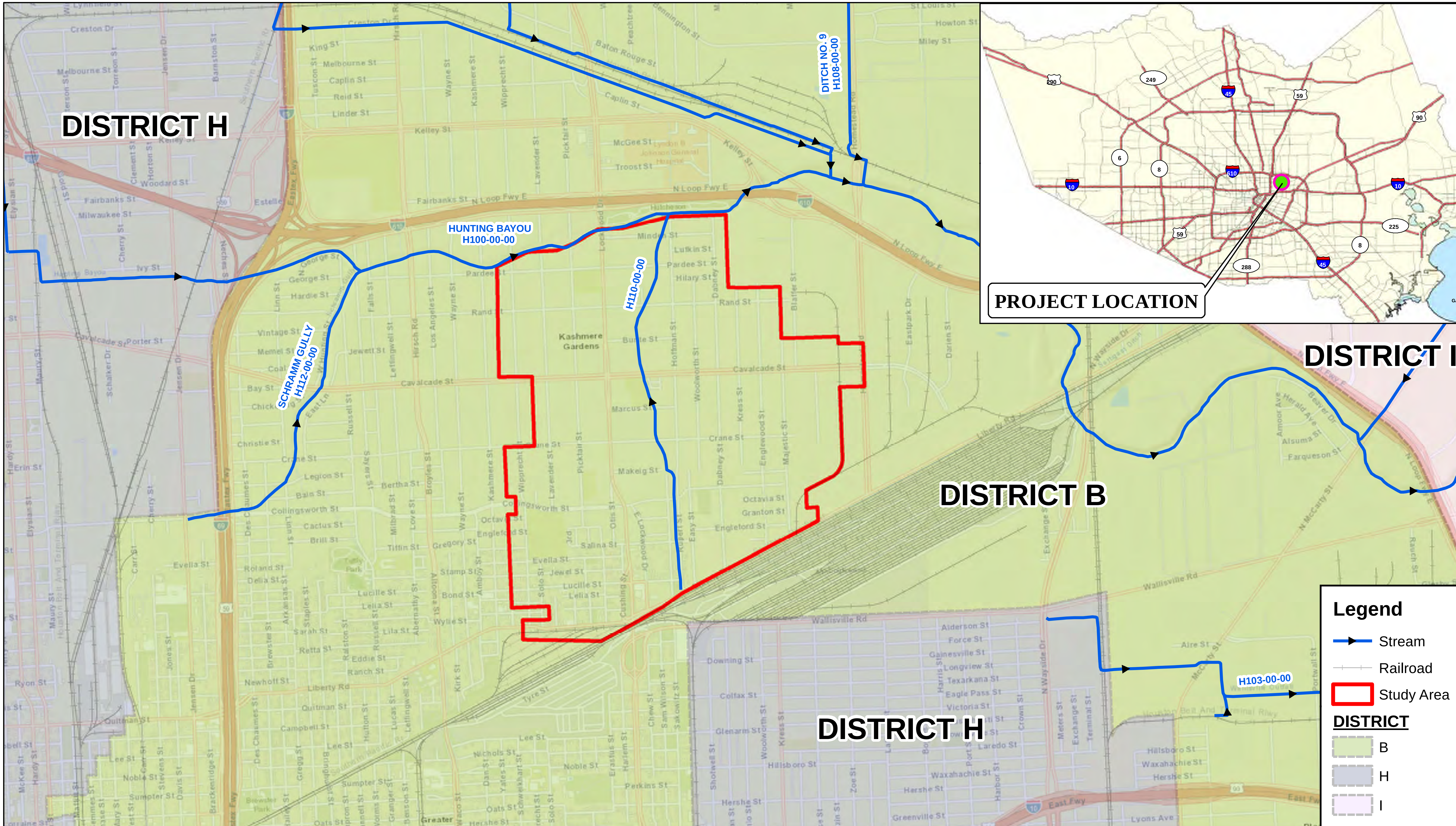
- The 36" RCP along Crane Street (System EH7) does not have adequate capacity for a 2 year Storm.

100 Year Storm

- As shown in Exhibit 13, there is considerable ponding during 100 year storm event outside the road ROW which can potentially result in structural flooding. This condition can be attributed to limited storm sewer and sheet flow conveyance capacity.

- The existing roadside ditches in System EH1 to EH3 do not have sufficient capacity for 100 year Storm. The existing roads are higher than the private property in this area, which result in excessive ponding outside the ROW during a 100 year Storm.

- The hydraulic analysis of drainage system along Cavalcade Street indicates about 2 feet of ponding depth along the roadway corridor between Kress Street and outfall location during a 100 year Storm. The ponding in the street is exacerbated by the higher grades at the bridge crossing over Channel H100-00-00.

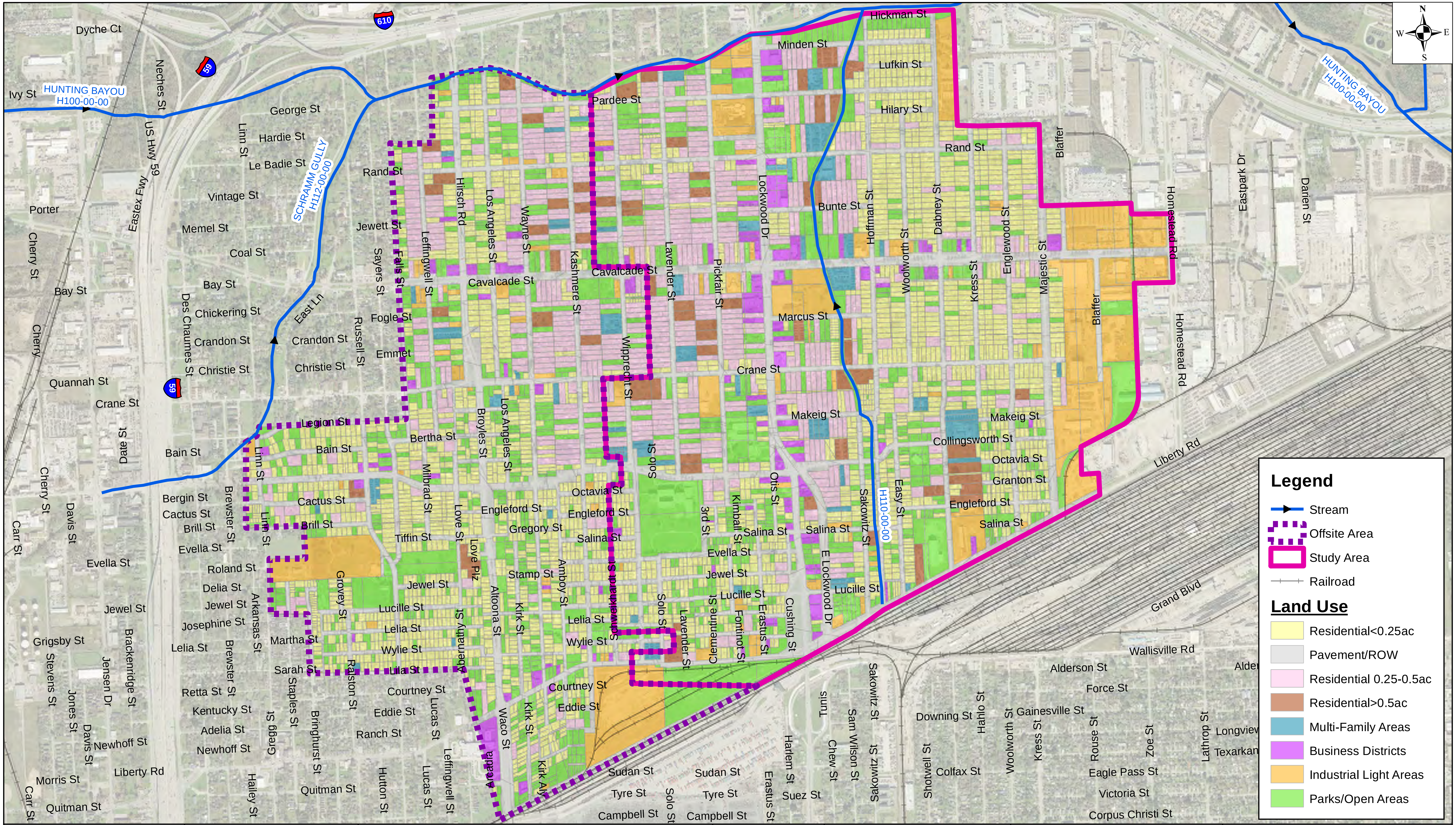


HUITT-ZOLLARS

HUITT-ZOLLARS, INC. Firm No. F-761
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

DATE	SCALE	EXHIBIT 1
FEBRUARY, 2020	0 1,000 2,000 Feet	LOCATION MAP



HUITT-ZOLLARS

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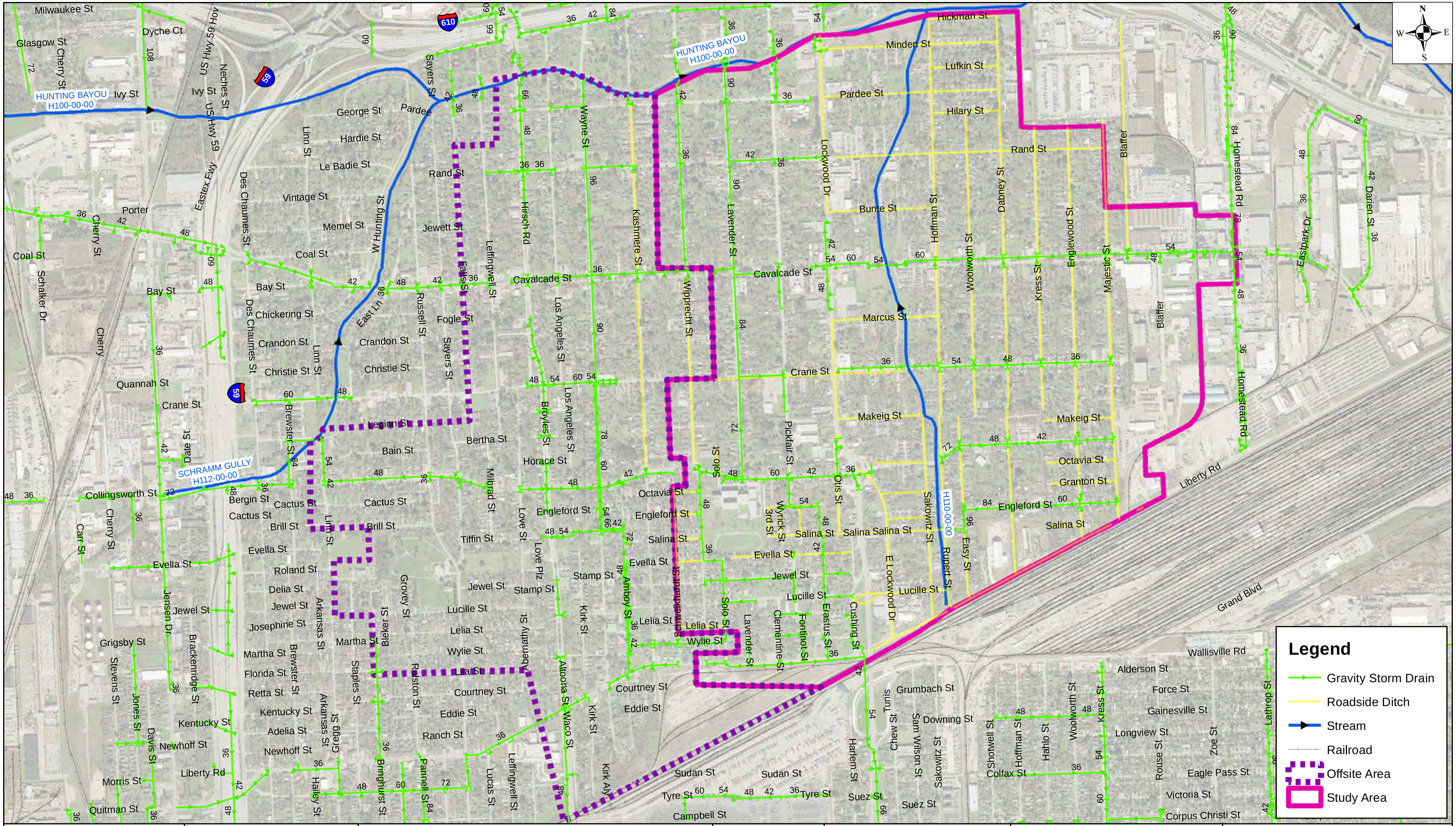
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

IDCUS PLANNERS • ENGINEERS • MANAGERS

PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 2
FEBURARY, 2020	0 500 1,000 2,000 Feet	PARCEL LAND USE



PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
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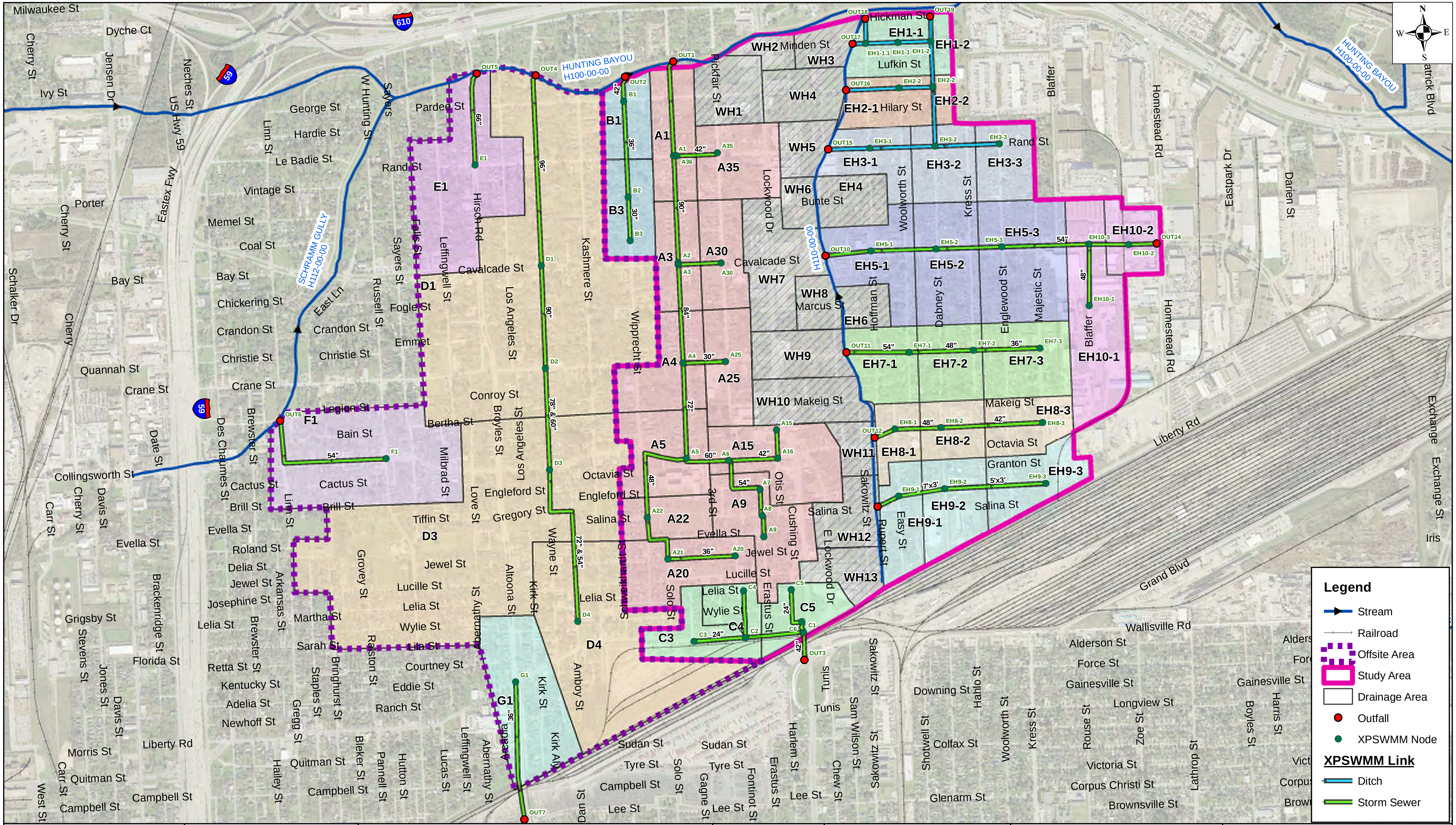
DATE	SCALE	EXHIBIT 3
FEBRUARY, 2020	0 500 1,000 2,000 Feet	EXISTING DRAINAGE SYSTEM



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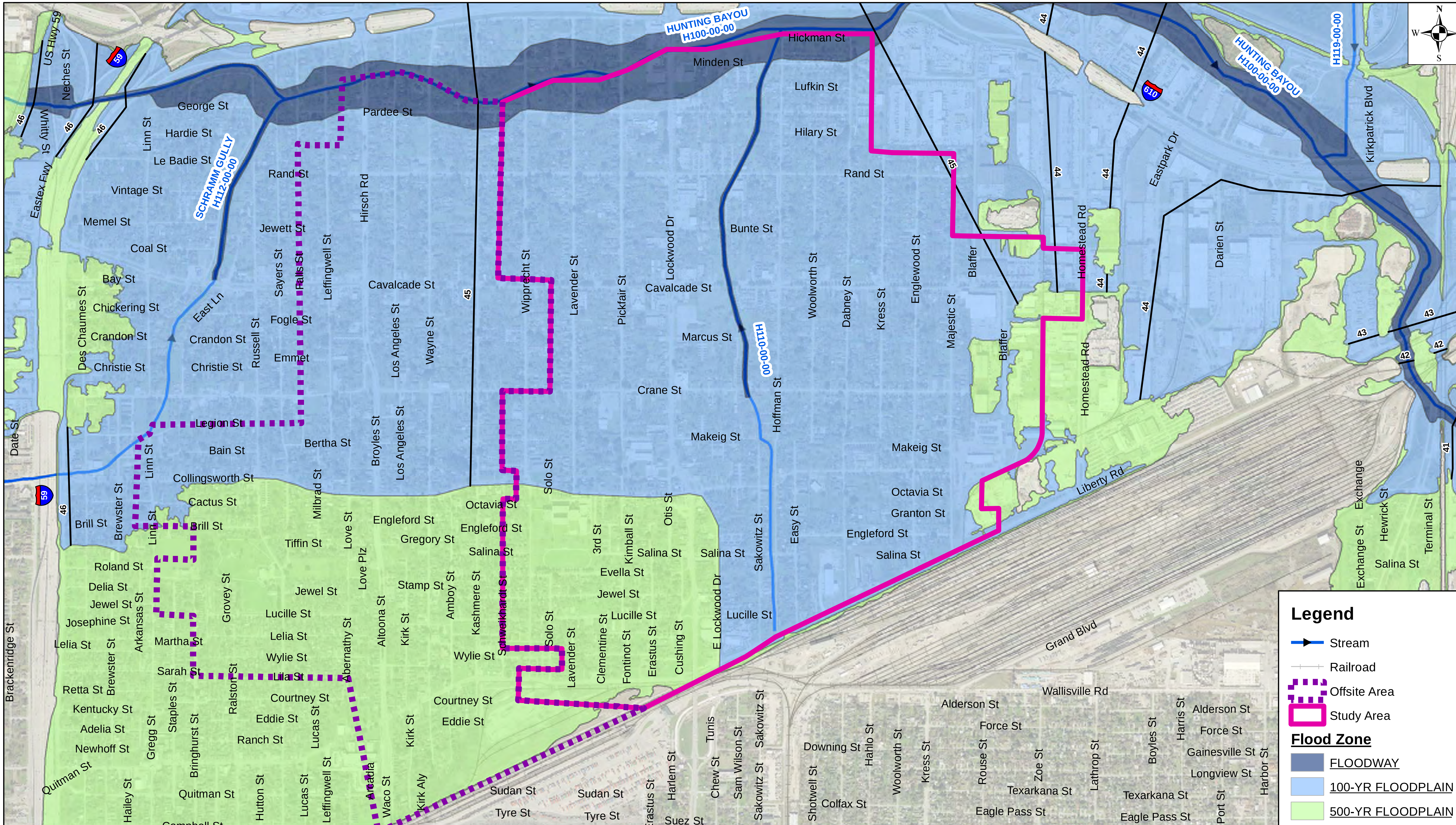
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 4
FEBRUARY, 2020	0 500 1,000 2,000 Feet	DRAINAGE AREA MAP



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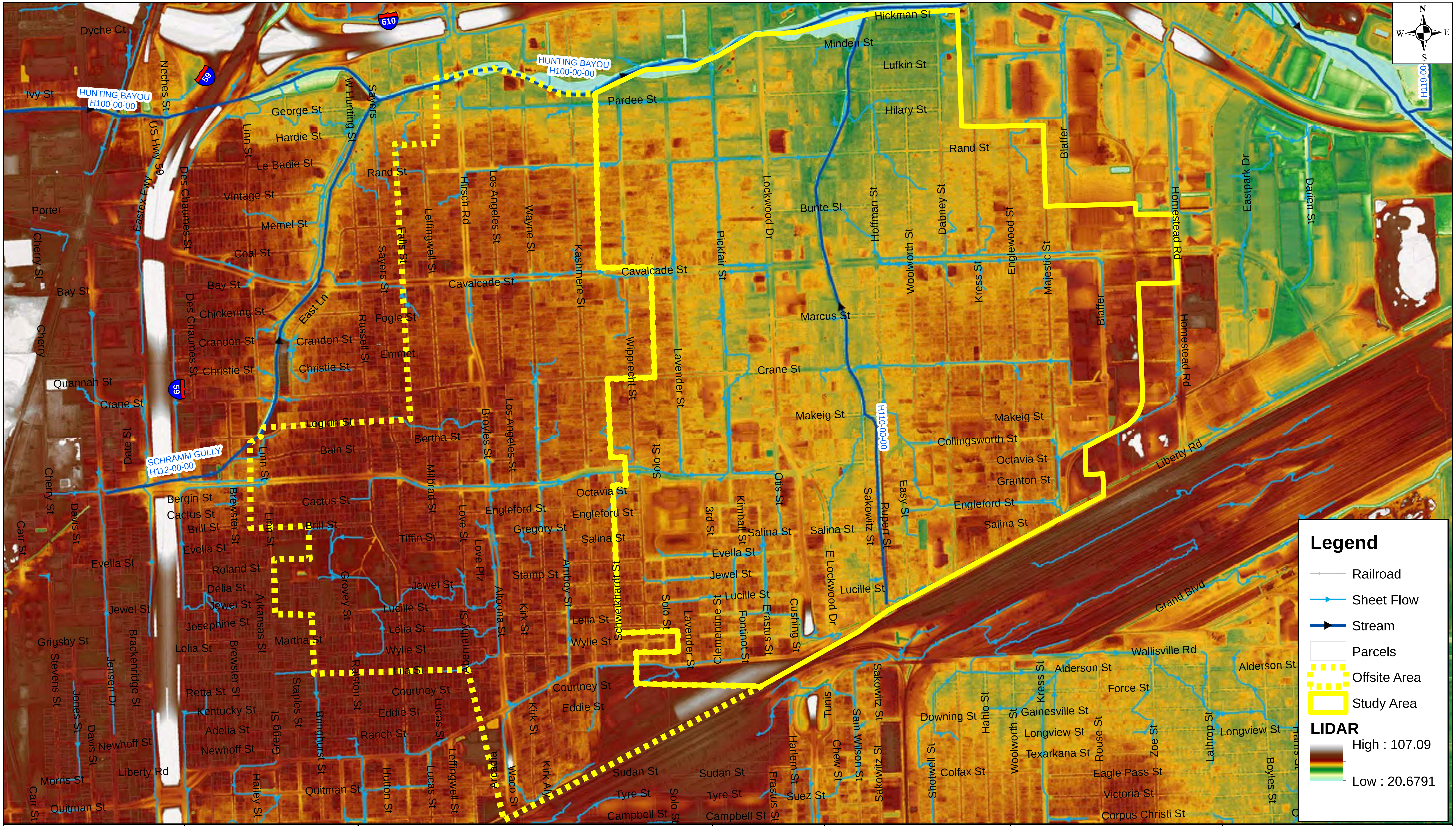
PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

DATE	SCALE	EXHIBIT 5
FEBRUARY, 2020	0 500 1,000 2,000 Feet	FIRM/FLOODPLAIN MAP



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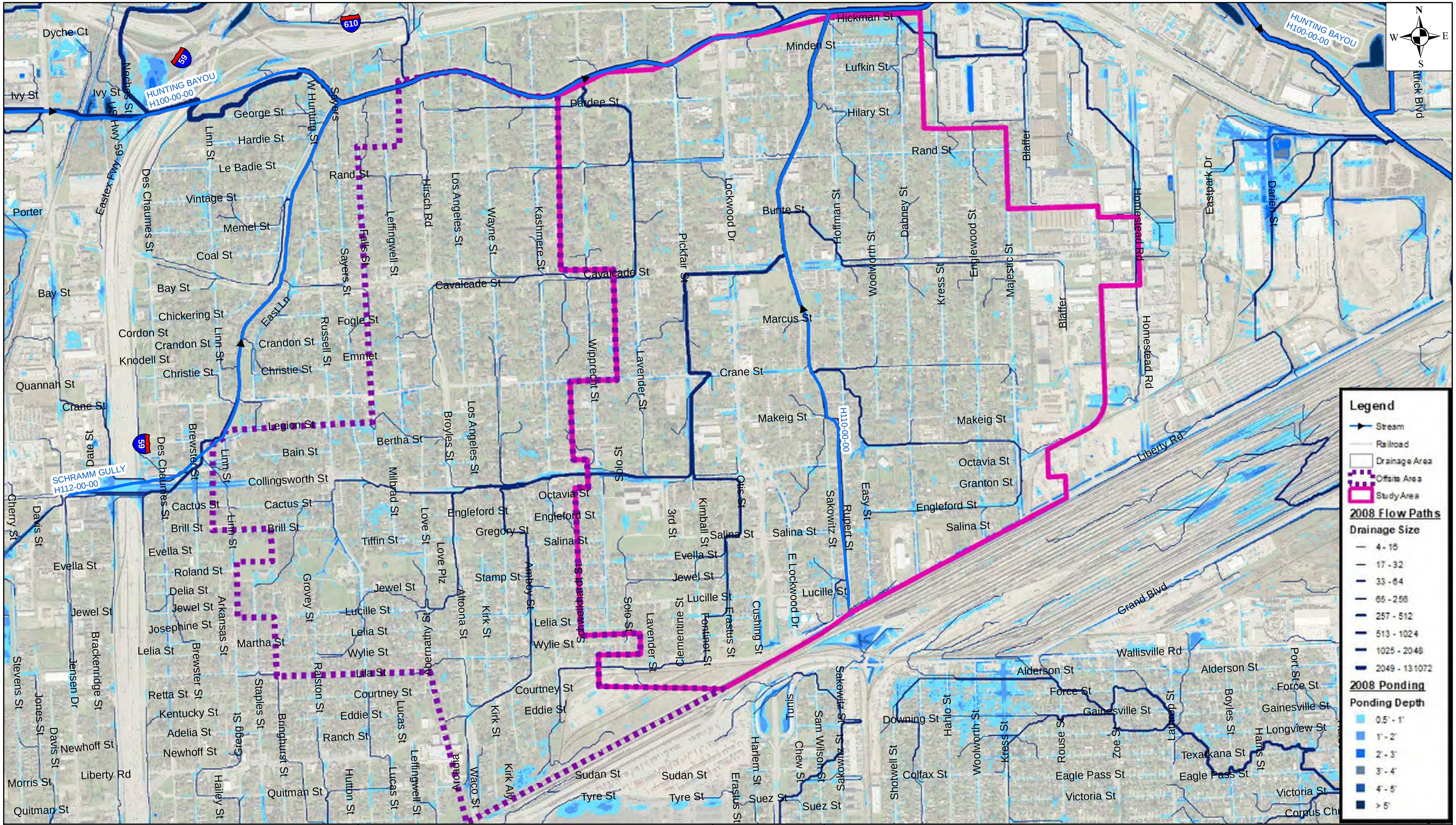
PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 6
FEBRUARY, 2020	0 500 1,000 2,000 Feet	LIDAR MAP



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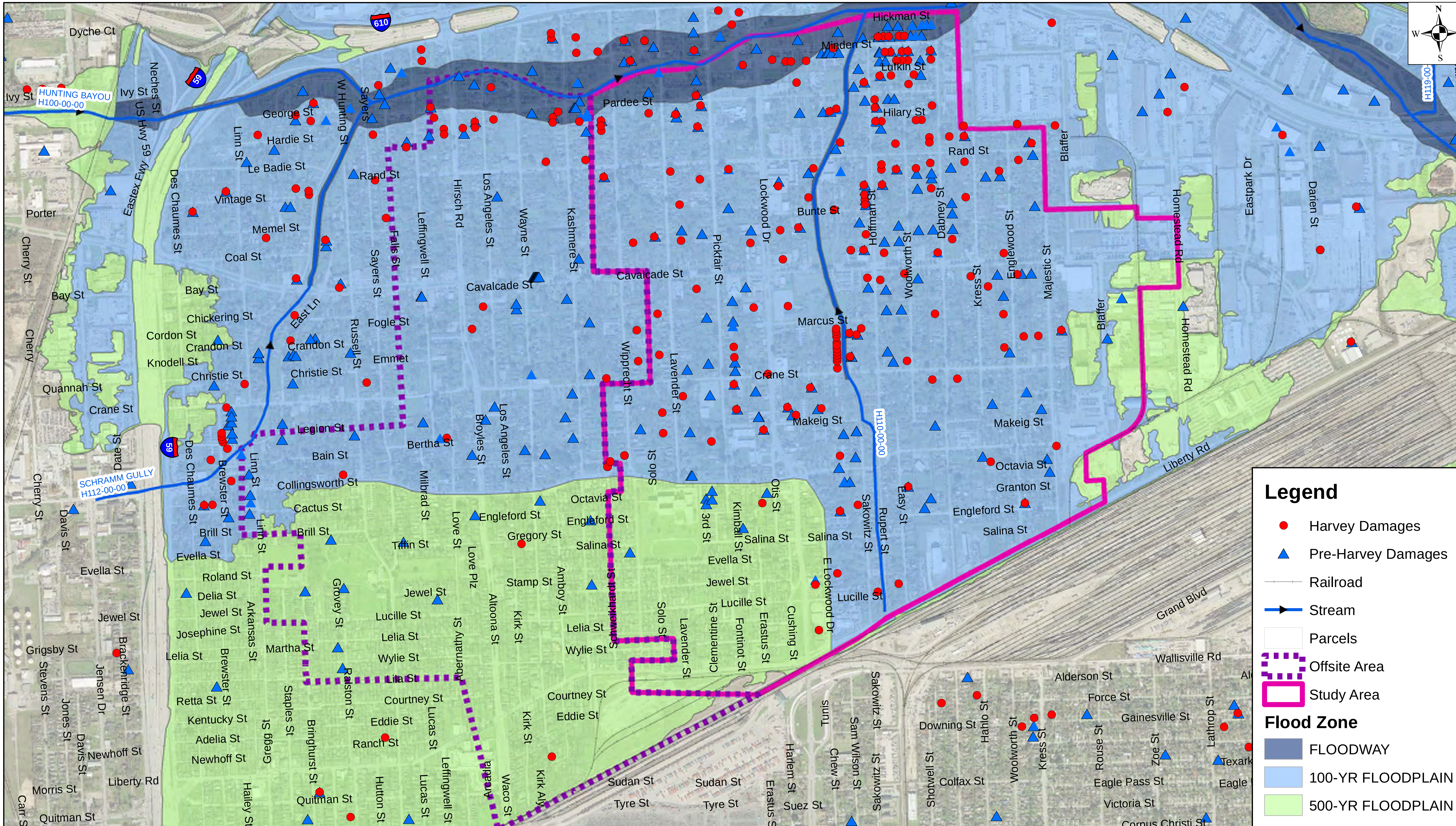
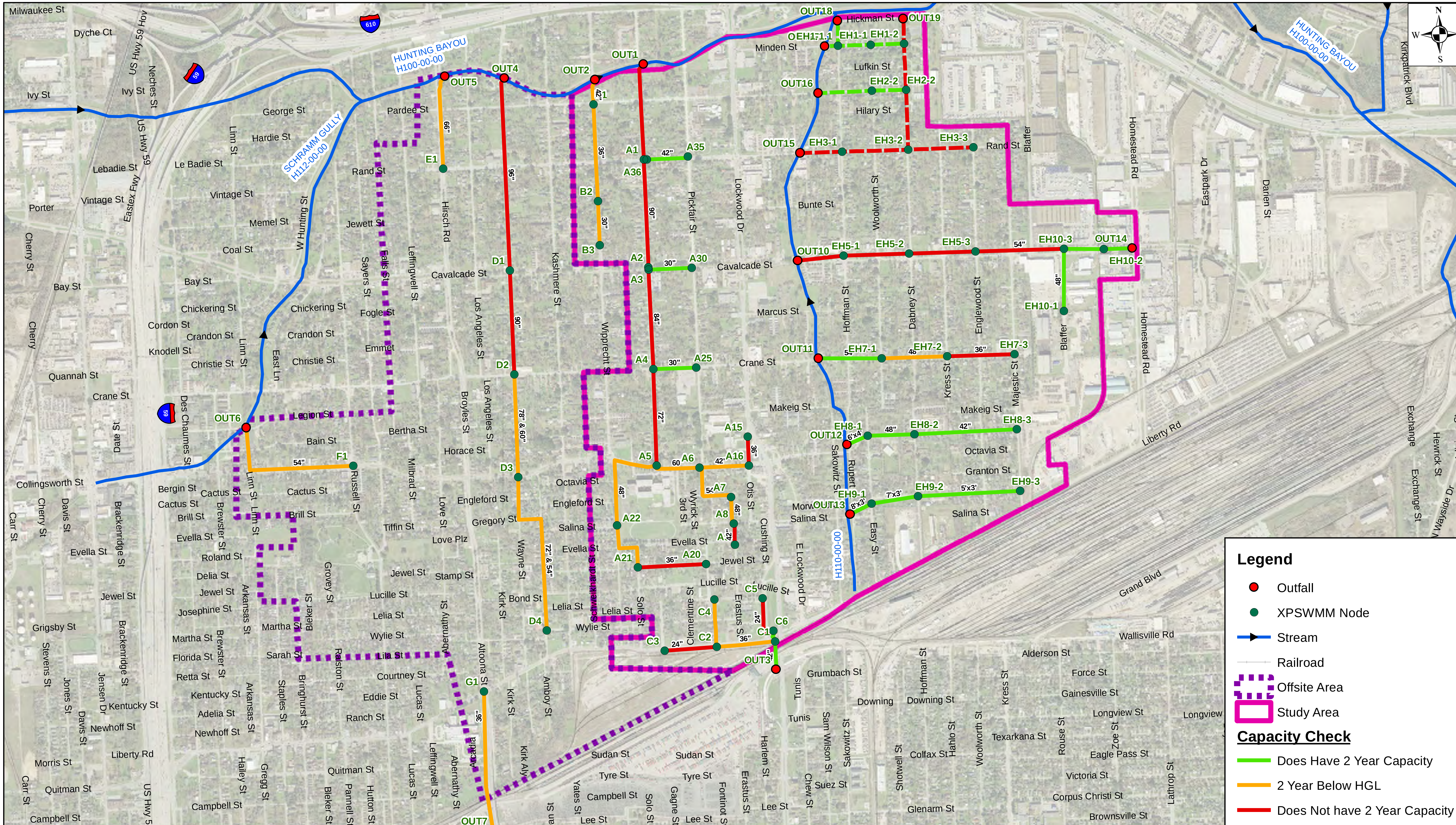
PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

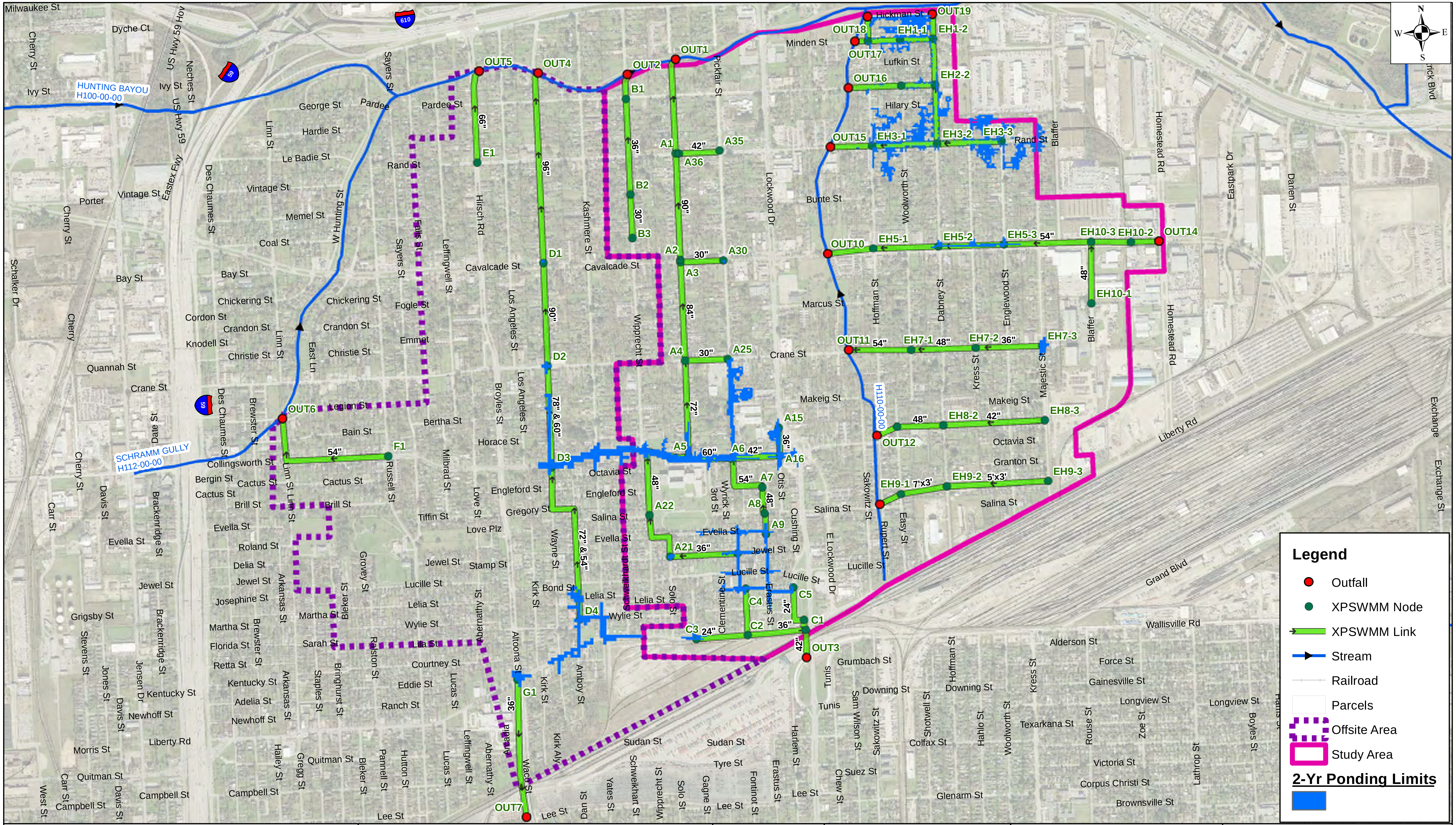
DATE	SCALE	EXHIBIT 7
FEBRUARY, 2020	0 500 1,000 2,000 Feet	SHEET FLOW PATH



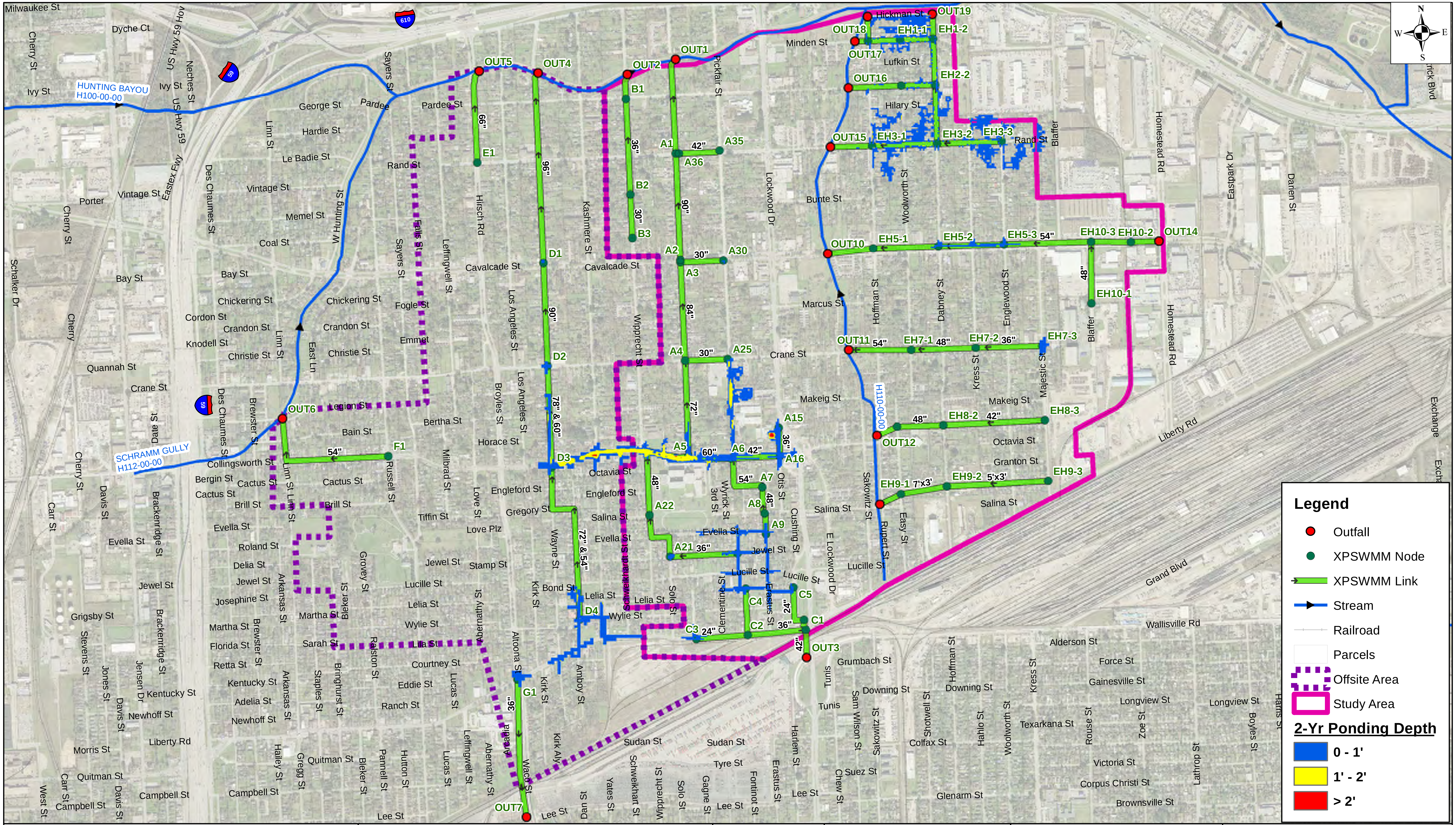
HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)		DATE FEBRUARY, 2020	SCALE 0 500 1,000 2,000 Feet	EXHIBIT 8 FEMA FLOOD COMPLAINTS



HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)		DATE	SCALE	EXHIBIT 9
			FEBRUARY, 2020	0 500 1,000 2,000 Feet	EXISTING STORM CAPACITY



HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 10
HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220			FEBRUARY, 2020	0 500 1,000 2,000 Feet	2-YR PONDING LIMITS



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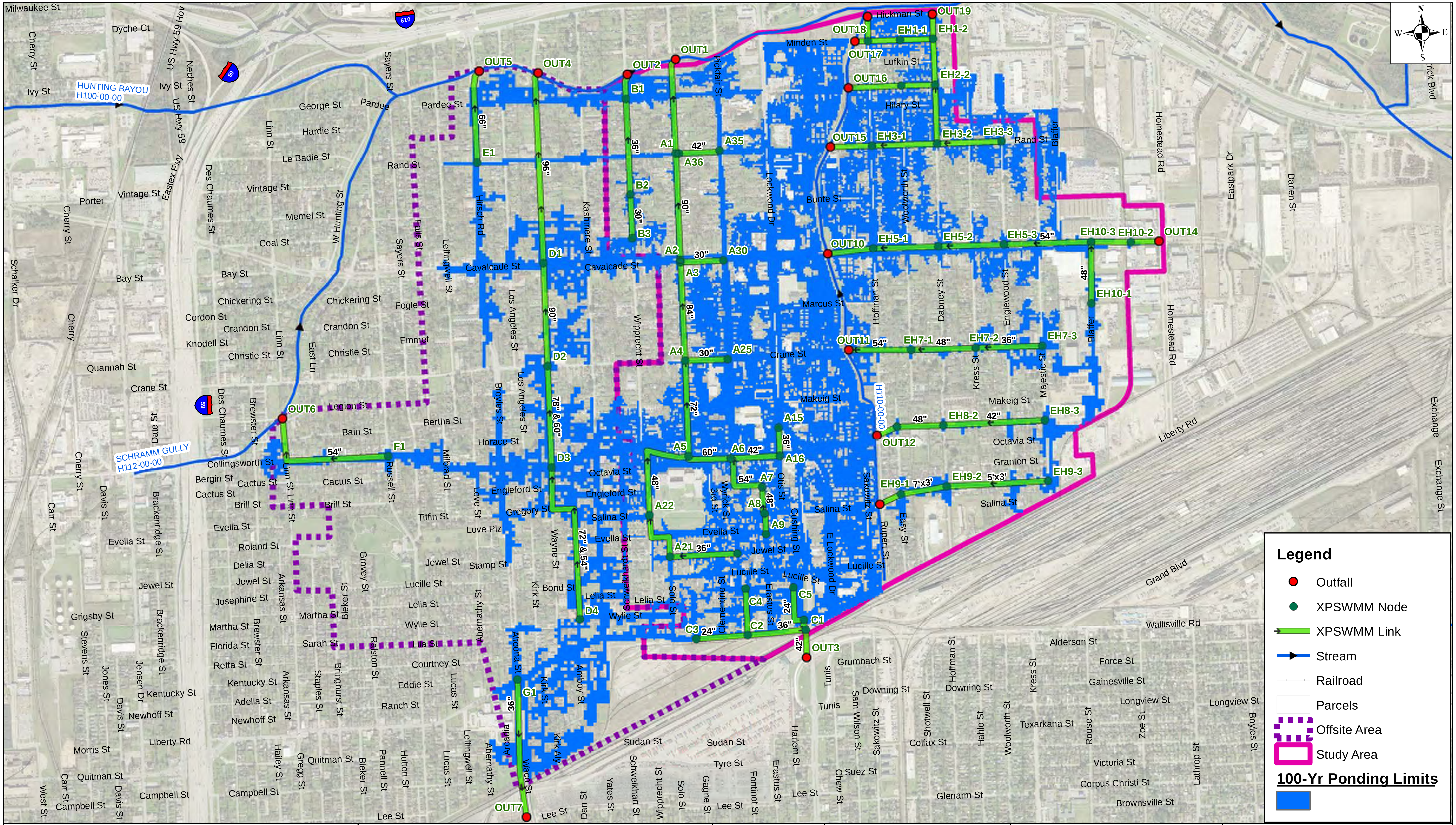
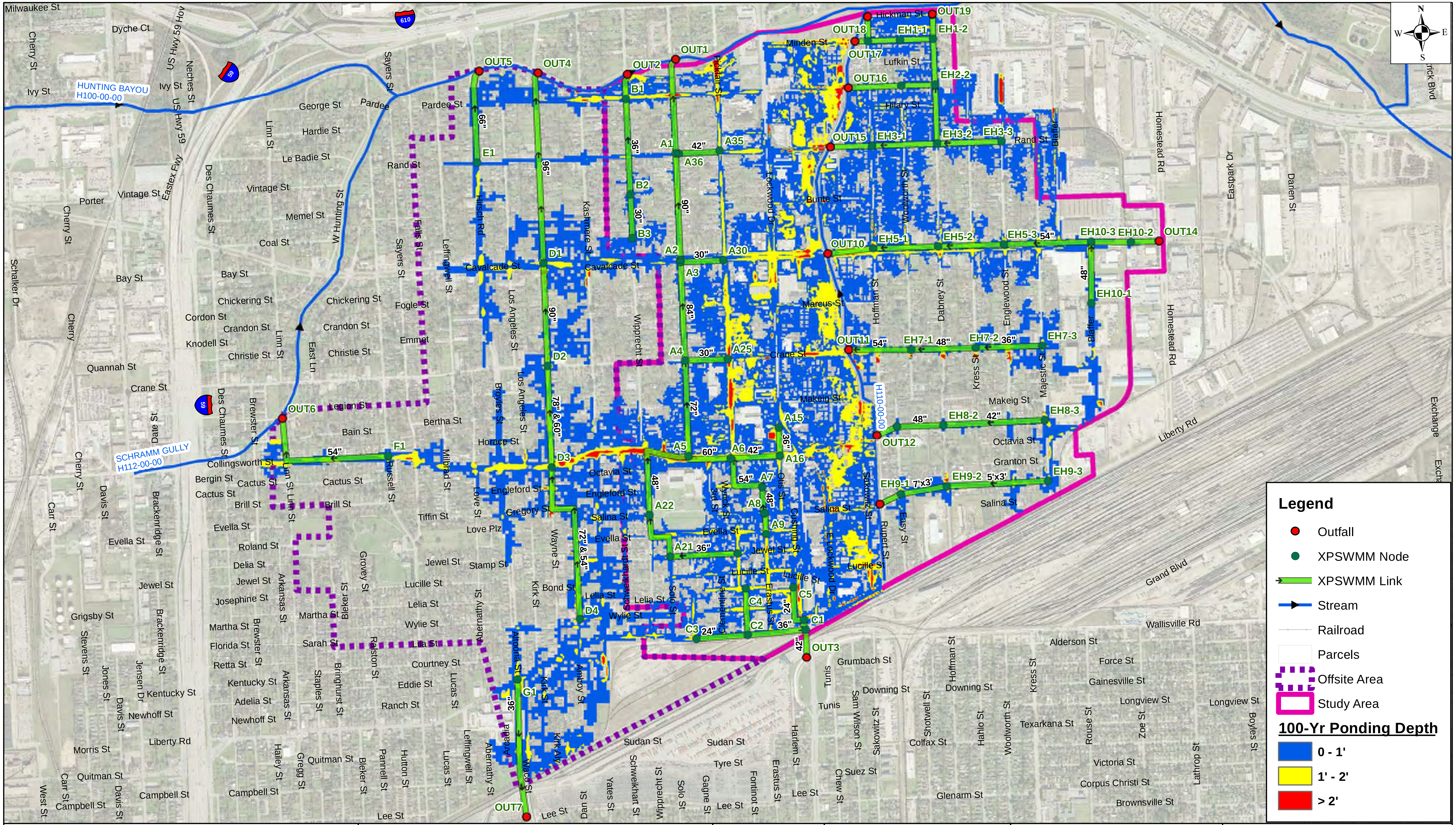
PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 11
FEBRUARY, 2020	0 500 1,000 2,000 Feet	2-YR PONDING DEPTH



HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	DATE FEBRUARY, 2020	SCALE 0 500 1,000 2,000 Feet	EXHIBIT 12 100-YR PONDING LIMITS



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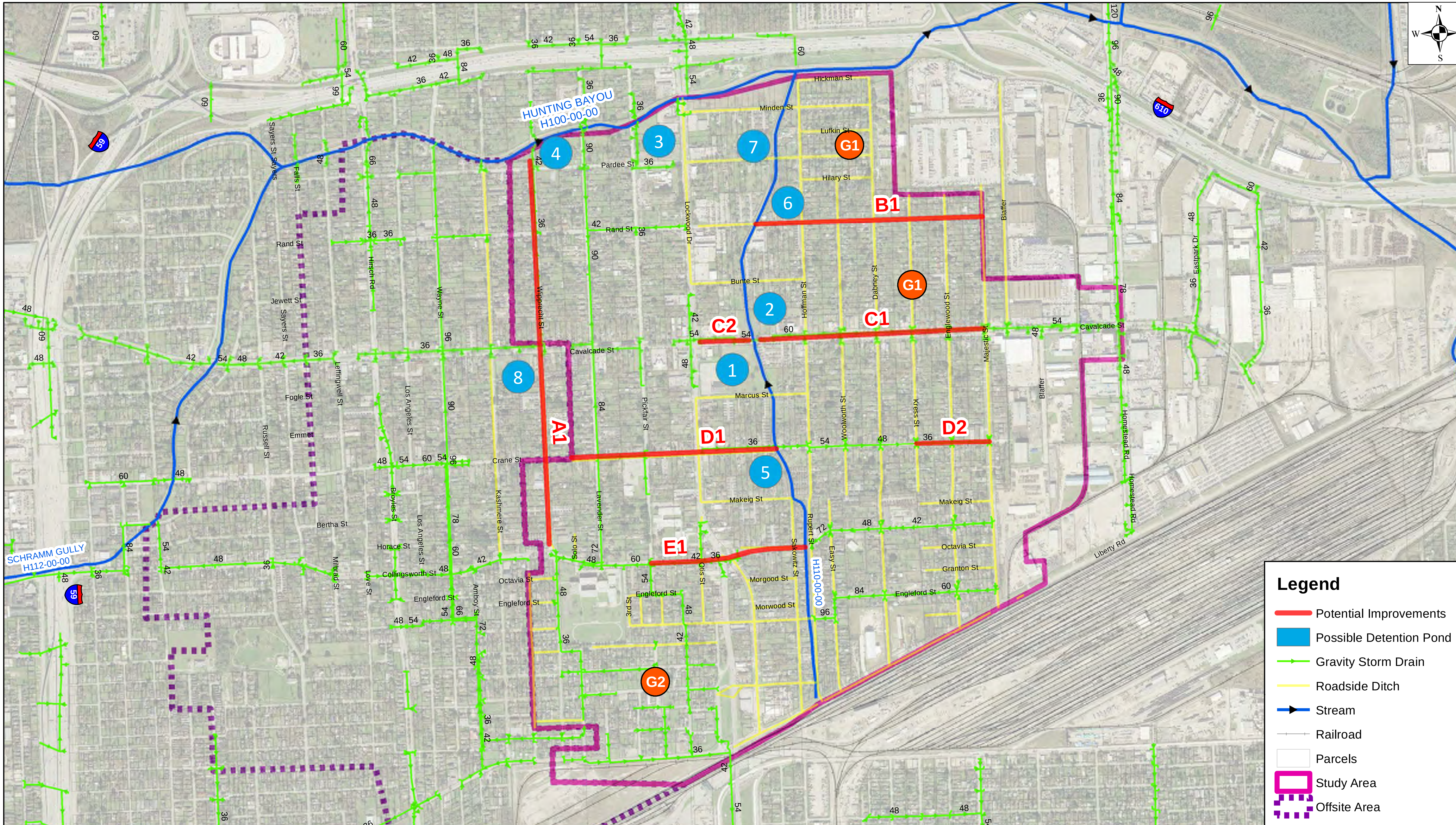
PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

DATE	SCALE	EXHIBIT 13
FEBRUARY, 2020	0 500 1,000 2,000 Feet	100-YR PONDING DEPTH



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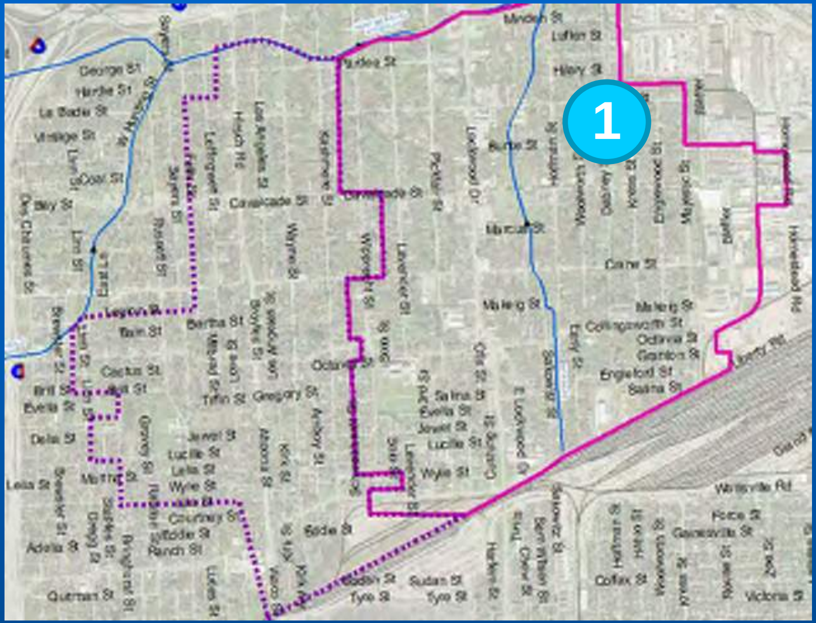
PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

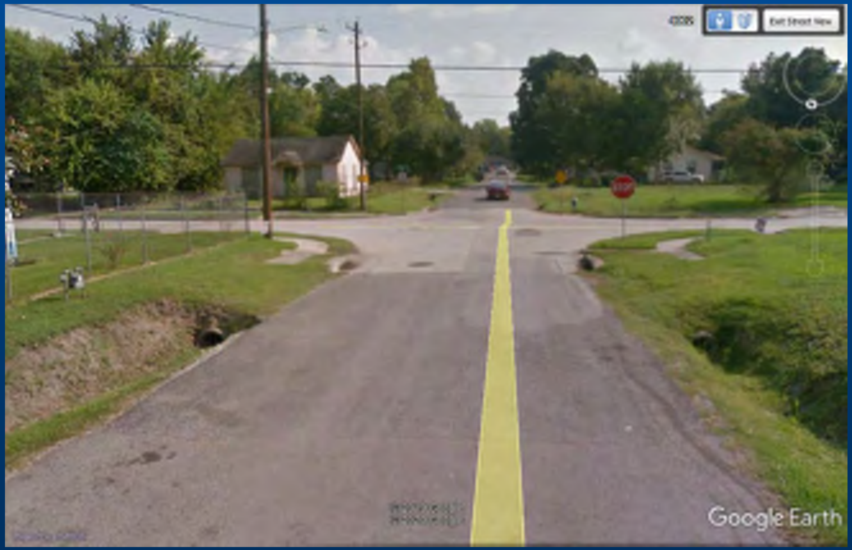
DATE	SCALE	EXHIBIT 14
FEBRUARY, 2020	0 500 1,000 2,000 Feet	POTENTIAL IMPROVEMENT PROJECT

HUITT-ZOLLARS

M-2018-E01 - KASHMERE GARDENS

Storm Drainage System

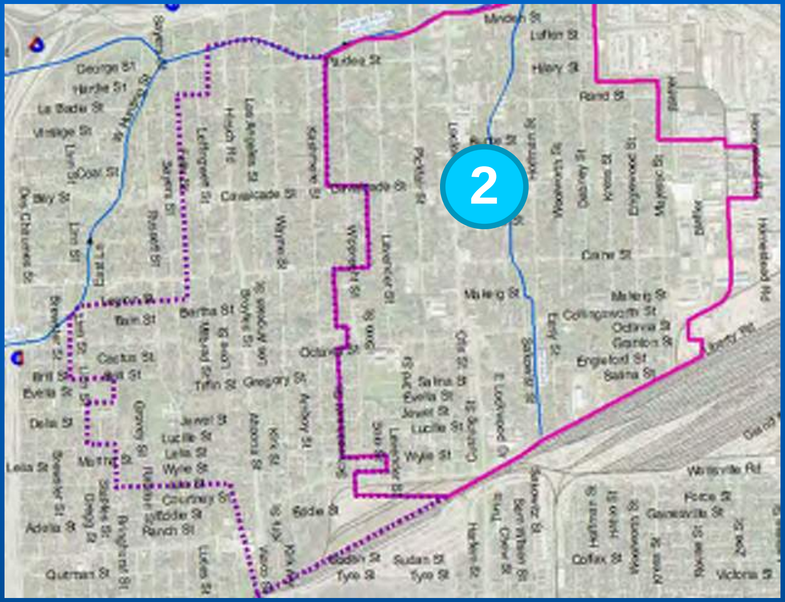




M-2018-E01 - KASHMERE GARDENS

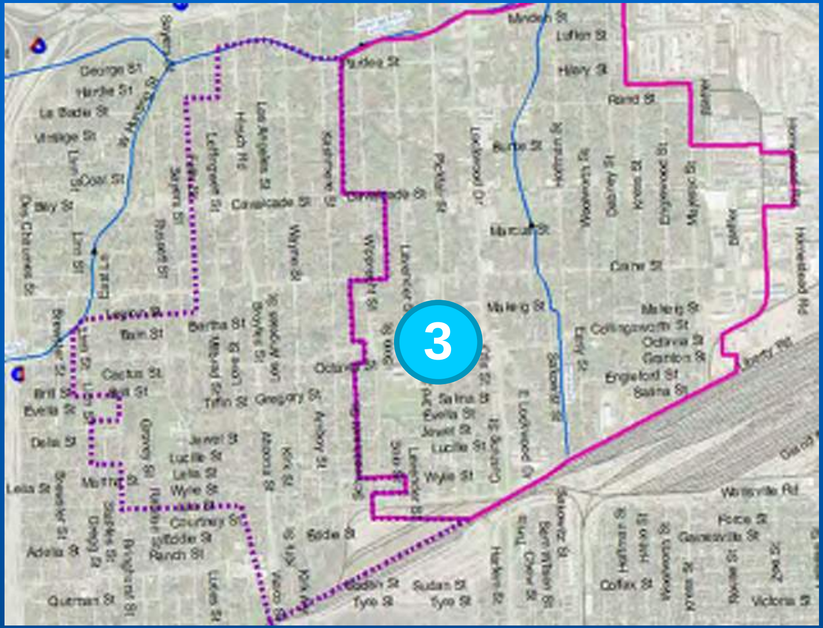
Storm Drainage System

HUITT-ZOLLARS



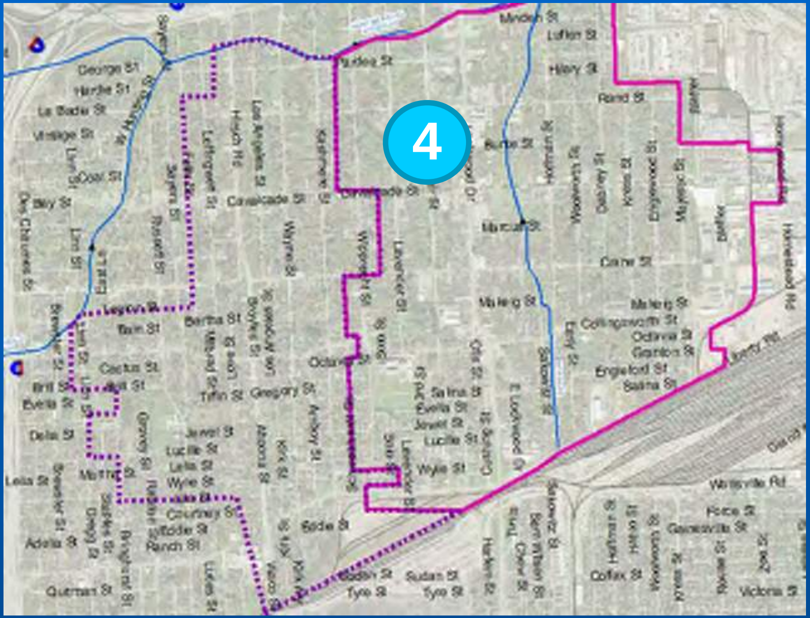
M-2018-E01 - KASHMERE GARDENS

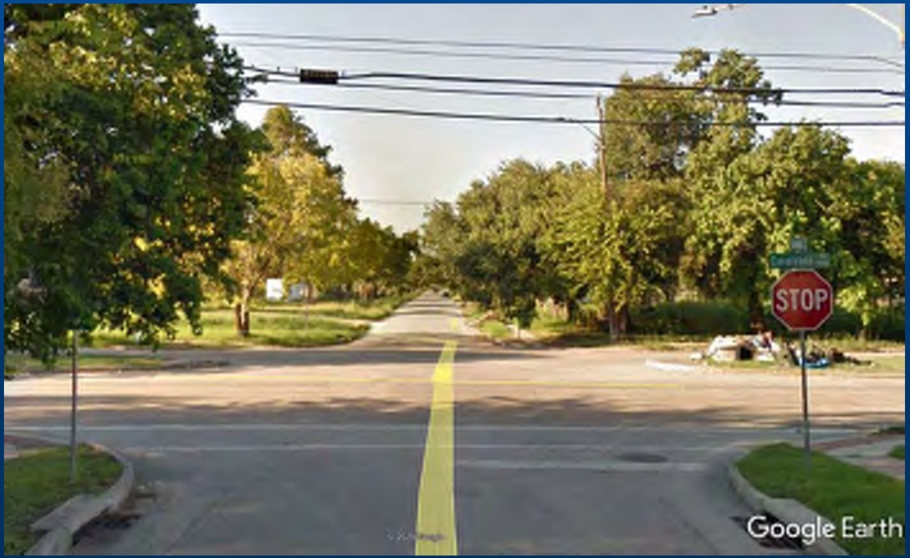
Storm Drainage System



M-2018-E01 - KASHMERE GARDENS

Storm Drainage System

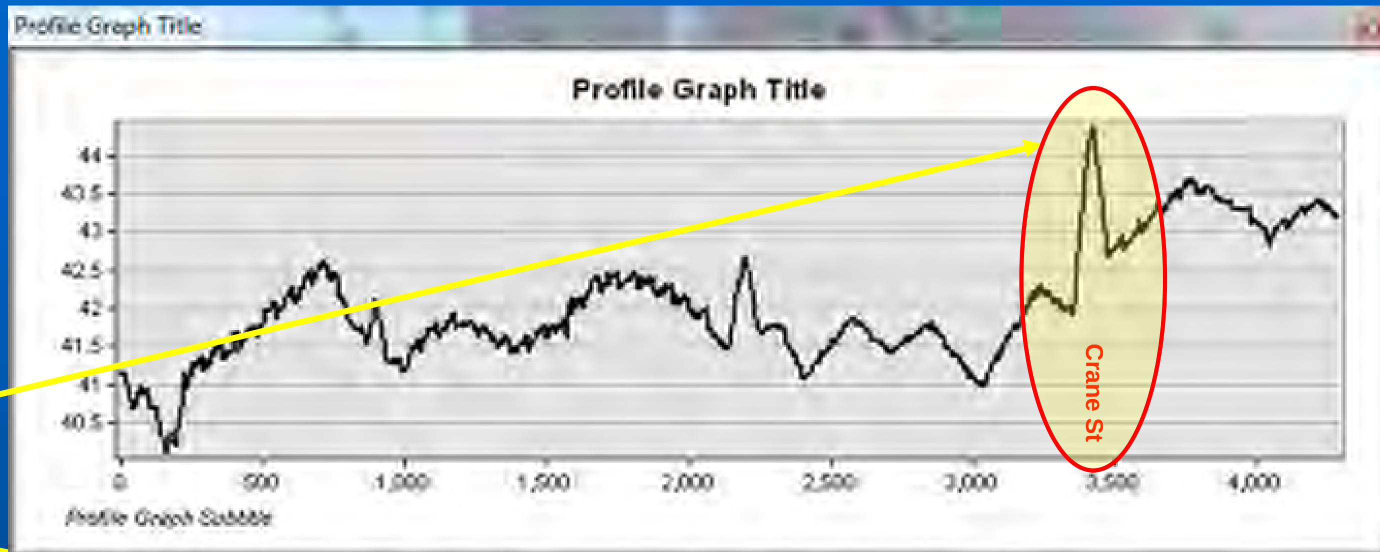


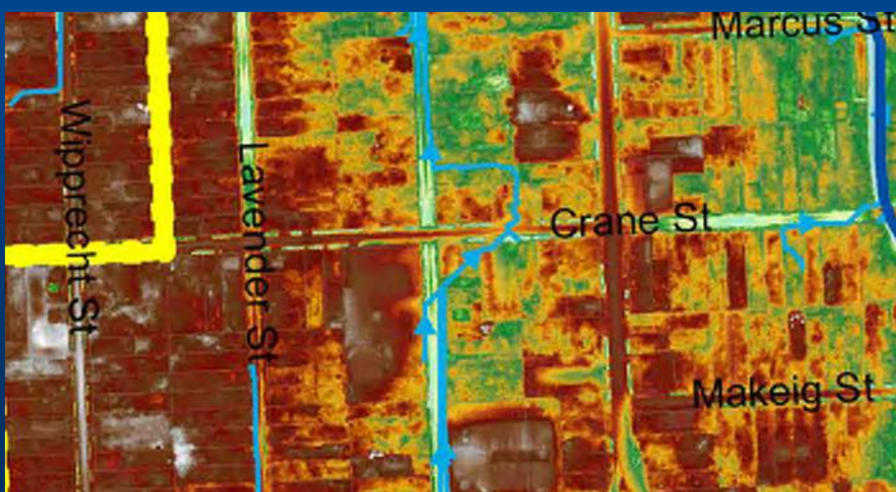


M-2018-E01 - KASHMERE GARDENS

Potential Improvements

HUITT-ZOLLARS

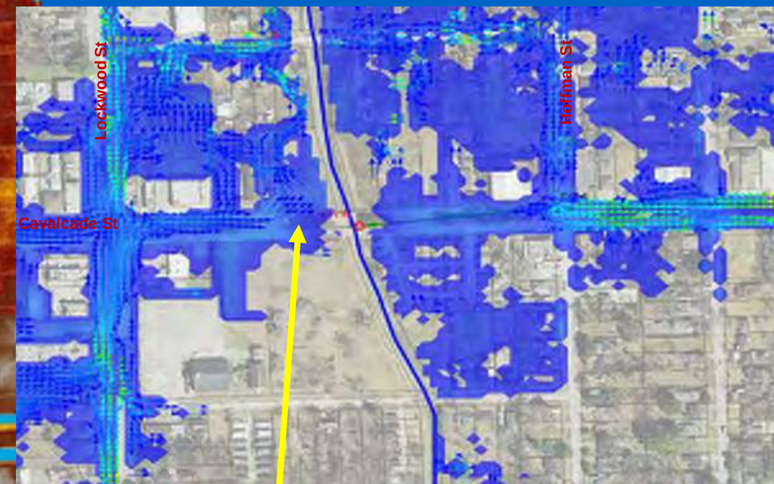




M-2018-E01 - KASHMERE GARDENS

Potential Improvements

HUITT-ZOLLARS



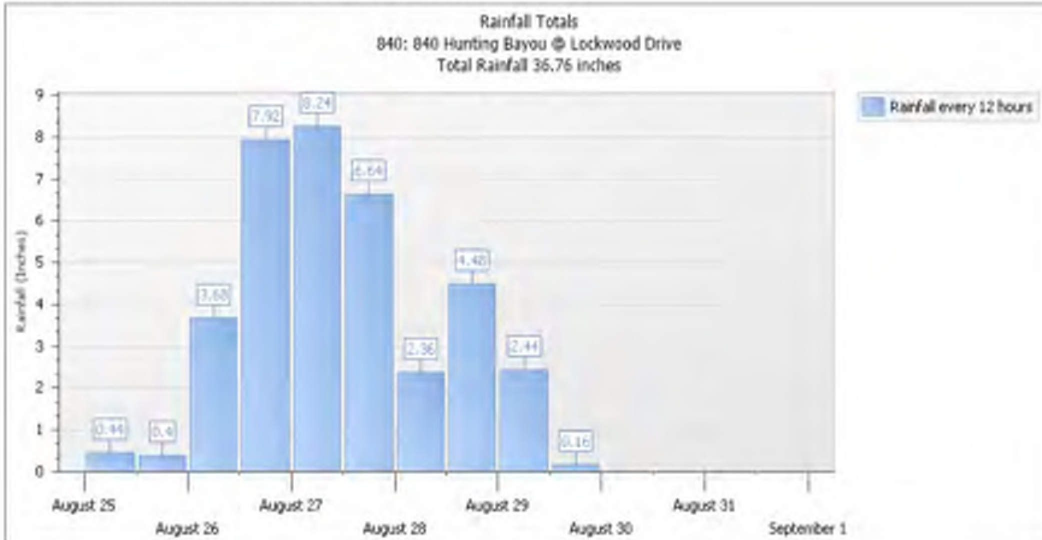
Sheet Flow is blocked from entering into H110-00-00 by higher roadway elevation at the bridge

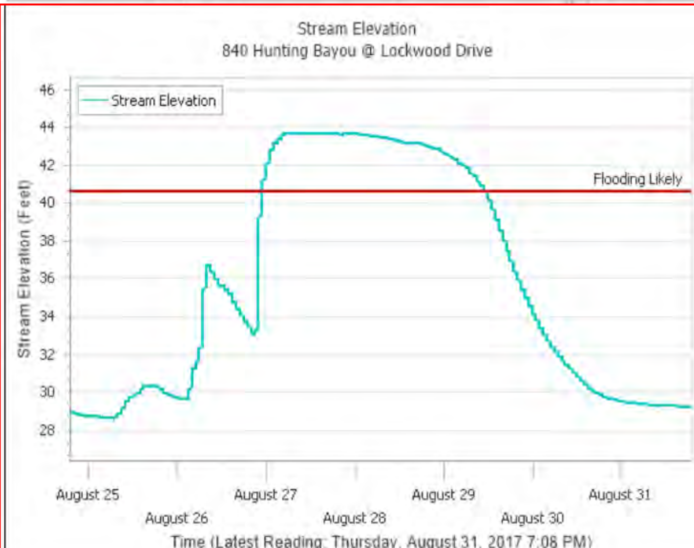
M-2018-E01 - KASHMERE GARDENS

Flooding History

HUITT-ZOLLARS

Showing rainfall totals from 8/25/2017 12:00 AM to 9/1/2017 12:00 AM CDT





Cross Section

Stream Elevation for sensor 839 is **29.22'**
Reading on 8/31/2017 7:08 PM

Stream Elevation Sensor **839**
840 Hunting Bayou @ Lockwood Drive

Key Map 454U	
Sensor ID	**839**
Sensor Type	USGS Radar
Installed	6/28/1995
Flooding Likely	40.60'
Flooding Possible	37.60'
Bottom of Stream	27.49'
Tip of Orifice	43.59'
Measuring Plate	41.93'
External Link	USGS
Benchmark	41.44'

RM 080105 stamped RM 080105 EST 2002 located on the downstream sidewalk at south end bridge, 1988 NAVD, 2001 adjustment. 78 to 01 Adjustment -1.05'
As of July 1, 2007, the elevation datum was changed from 1929 NGVD, 1978 adjustment to the 1988 NAVD, 2001 adjustment.

Flood Frequency	Elevation
10% (10-year)	41.90'
2% (50-year)	44.10'
1% (100-year)	45.00'
.2% (500-year)	46.80'

Historical Storm

Date	Event	Elevation
3/20/1972		40.70'
3/4/1992		41.50'
9/11/1998	Frances	41.40'
6/5/2001	Allison #2	42.20'
6/19/2006		41.00'
10/16/2006		41.30'
8/16/2007	Erin	42.00'
9/13/2008	Ike	42.10'
5/26/2015		40.70'
10/25/2015		38.00'
10/31/2015		41.40'
1/18/2017		40.60'
8/27/2017	Harvey	44.40'
9/19/2019	Imelda	41.40'

High water mark elevations are approximate.

HUNTING BAYOU FLOOD RISK MANAGEMENT, HARRIS COUNTY, TEXAS

GENERAL REEVALUATION REPORT AND INTEGRATED ENVIRONMENTAL ASSESSMENT

APPENDIX 2
HYDROLOGY & HYDRAULICS

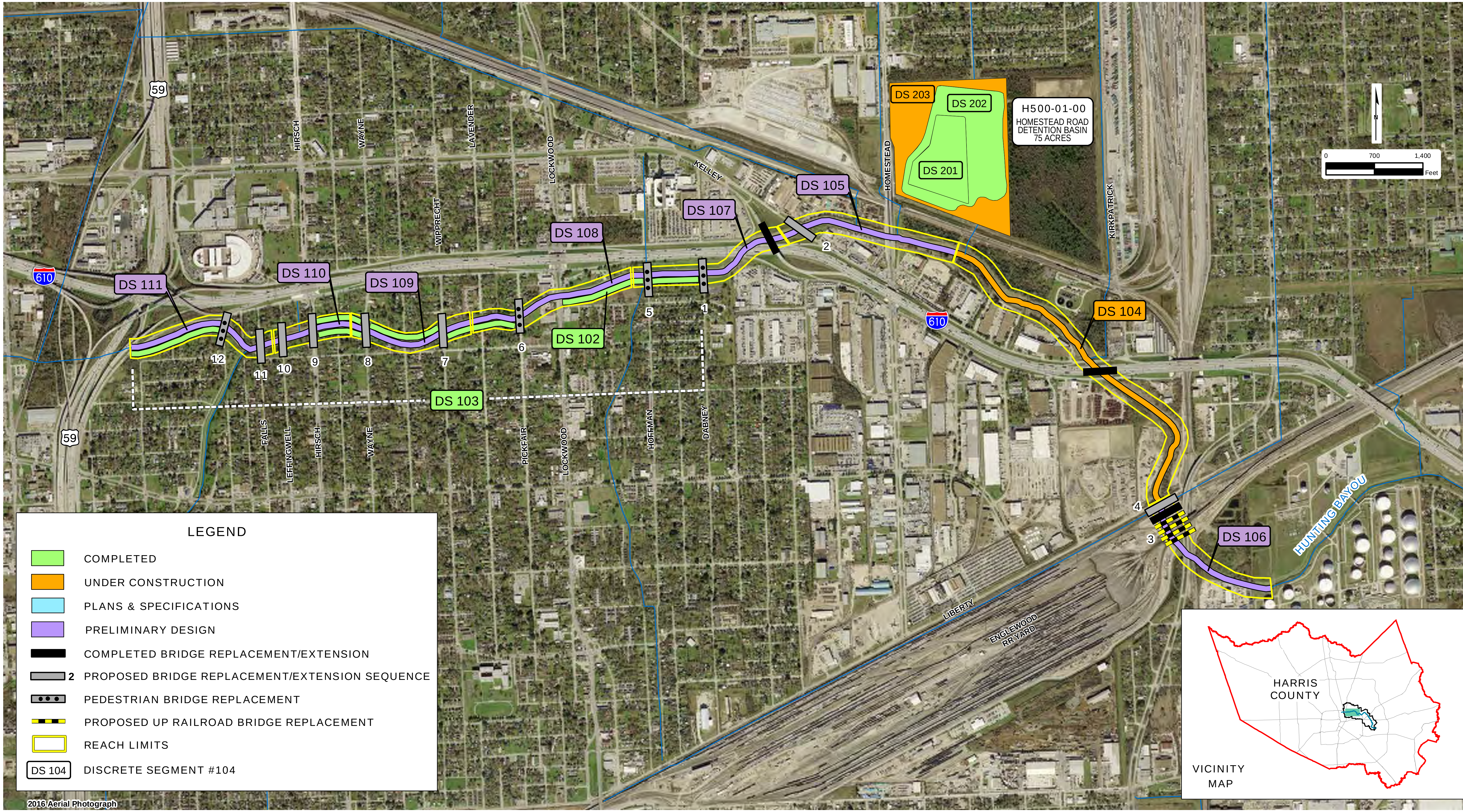
November 2014

HARRIS COUNTY FLOOD CONTROL DISTRICT

Prepared By:

AECOM TECHNICAL SERVICES, INC.

Hunting Bayou



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HARRIS COUNTY FLOOD CONTROL DISTRICT

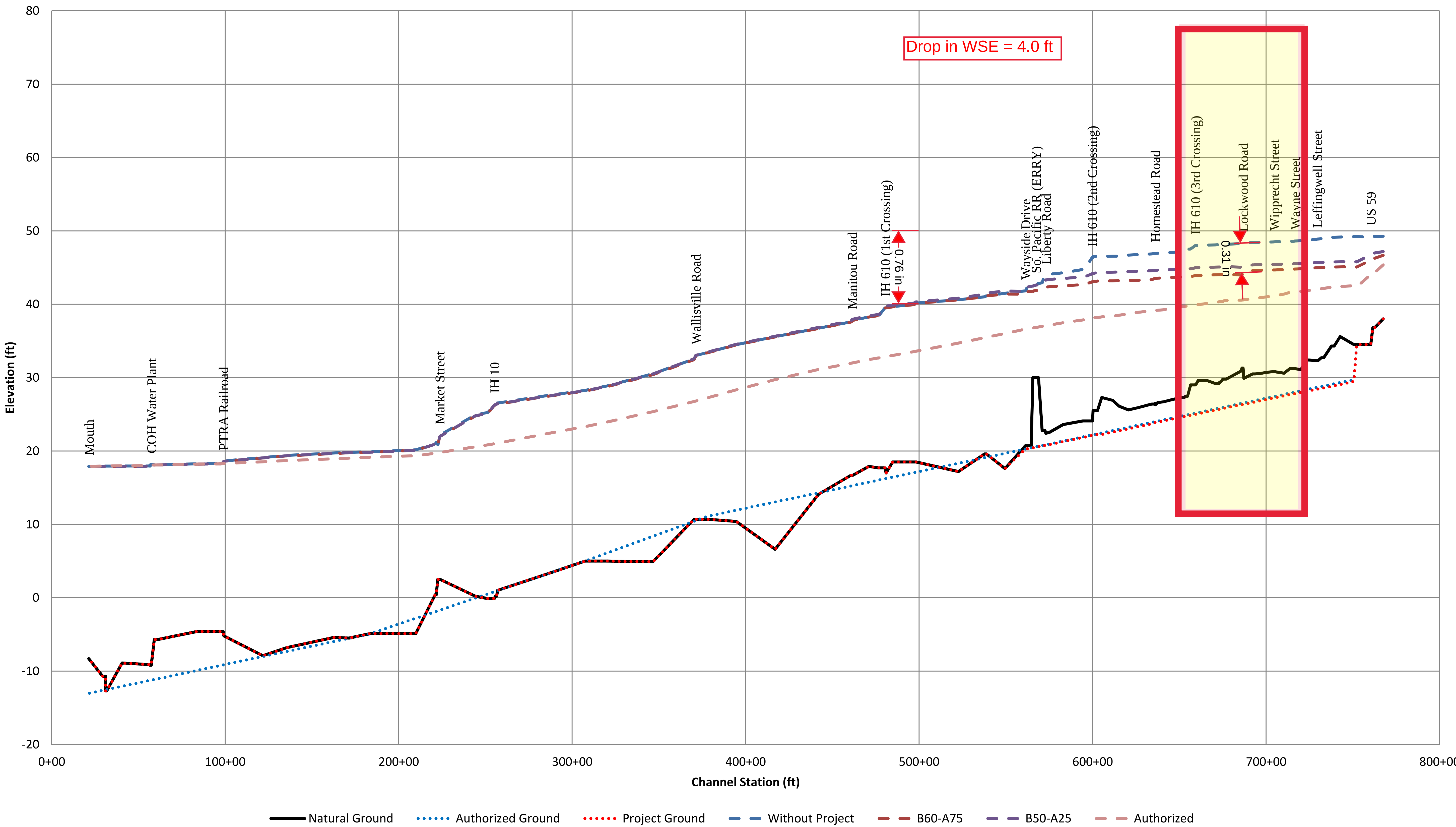
US Army Corps of Engineers
Galveston District

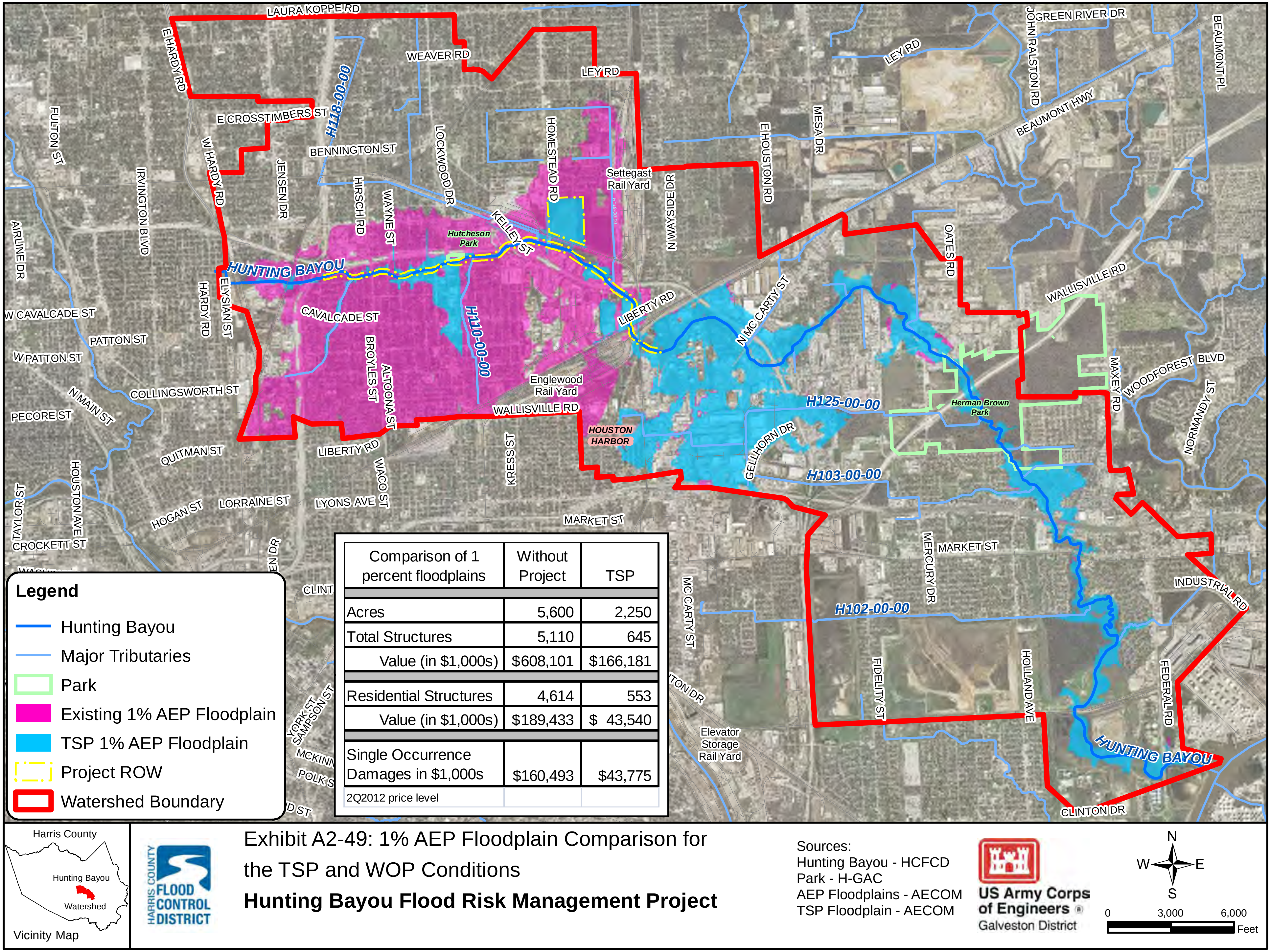
November 8, 2017

EXHIBIT A2-45

1% AEP Water Surface Profile Comparison

for Existing Without Project Conditions and B50-A25, B60-A75, and Authorized Plans





Comparison of 1 percent floodplains	Without Project	TSP
Acres	5,600	2,250
Total Structures	5,110	645
Value (in $1,000s)	$608,101	$166,181
Residential Structures	4,614	553
Value (in $1,000s)	$189,433	$ 43,540
Single Occurrence Damages in $1,000s	$160,493	$43,775
2Q2012 price level		

Path: P:_PWP\60184837_Hunting_Bayou\400_Technical_Discipline\444_GIS\H&H\Exhibit A2-45 1% AEP Floodplain Comparison for the TSP and WOP Conditions.mxd

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A2-49: 1% AEP Floodplain Comparison for the TSP and WOP Conditions

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC
AEP Floodplains - AECOM
TSP Floodplain - AECOM

US Army Corps of Engineers®
Galveston District

HUITT-ZOLLARS

Houston Kashmere Gardens Area Flood Mitigation Project
Technical Memorandum
WBS No. M-430100-0020-3
Kashmere Gardens

Prepared for:

CITY OF HOUSTON · TEXAS

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

HUITT-ZOLLARS, INC.
10350 RICHMOND AVE. SUITE 300
HOUSTON, TEXAS 77042-4248
TBPE Reg. No. F-761
(281) 496-0066

October 28, 2020

STATE OF TEXAS
AFSHIN GAZERZADEH
135980
LICENSED
PROFESSIONAL ENGINEER

List of Exhibits

1 Introduction

Study Purpose and Scope

Huitt-Zollars (HZ) was tasked with providing professional engineering services to investigate the deficiencies of the existing drainage system and recommend drainage improvements for the Kashmere Gardens neighborhood in City of Houston (COH). HZ used Need Area M-2017-002 study dated 2015 as a starting point.

This report summarizes findings from the existing condition investigation to identify problem areas and recommend appropriate drainage improvements for those areas. The scope of this work includes:

- Define the study area and identify the drainage systems
- Define the drainage area boundaries and overland flow paths
- Survey the main trunklines to obtain storm sewer flowline elevation and pipe size
- Develop a dynamic hydraulic model to identify the drainage issues
- Develop and evaluate the improvement project

Project Location and Background

The project is located within the historic Kashmere Gardens, which is located just south of North 610 Loop and east of US-59 in Houston, TX. The limits of the detailed study defined by HZ through the early stages of the work and finalized through coordination with COH, are shown in Exhibit 1. The study area is located between an industrial area to the east, Union Pacific rail corridor to the south, Schrum Gully (H112-00-00) to the west and Hunting Bayou (H100-00-00) to the north. The existing land use is mainly single-family residential lots and commercial developments. The existing land use is shown in Exhibit 2.

The existing drainage system within the study area consists of storm sewer lines, roadside ditches, and channels as shown in Exhibit 3. The study area is located within the Hunting Bayou watershed. Hunting Bayou and its tributaries H110-00-00 serve as outfalls for the local drainage systems. Channel H110-00-00, divides the study area into two parts. On the east side of H110-00-00, most drainage systems run from east to west and outfall into H110-00-00. On the west side, the major drainage systems run from south to north and outfall into Hunting Bayou.

During an intense rainfall event, Hunting Bayou has historically come out of the banks and flooded existing structures along the bayou within this study limits. The existing storm sewer lines also have limited capacity, which potentially contributed to the widespread flooding in the neighborhood in the past. The Harris County Flood Control District (HCFCD) is in the final stages of completing improvements to Hunting Bayou, which reduce the water surface elevation in the bayou.

Data Collection

The following documents and data were obtained and used to guide this study:

- City of Houston Infrastructure Drainage Manual (IDM), 2019
- Technical Modeling Guidelines for 2D Dynamic Stormwater Analysis, COH, Technical Paper (TP) – 102, 2019
- COH GIMS
- Record Construction Drawings from COH's Public Records Department
- Topographic survey performed by Landtech, Inc

Methodology

The hydrologic and hydraulic analysis was performed in accordance with the COH IDM using the Rational Method. Peak discharges were computed for the 2, 10, 100 and 500 year storm events. Runoff hydrographs for individual drainage areas within the study area were generated based on the Clark Unit Hydrograph using USACE HEC-HMS (Version 3.3) and calibrated to the Rational Method peak flows. Storm sewer and ditch analysis was performed using Innovyze XPSWMM (Version 2018.2).

Drainage system components including drainage areas, land use, storm sewer and ditch connectivity, cross-sections and flowlines were obtained from COH GIMS data. The drainage systems were verified utilizing a combination of as-built information, field reconnaissance, Lidar, aerial photography and survey data. The drainage area map is shown in Exhibit 4.

FEMA Special Flood Hazard Areas

The study area is located within the Hunting Bayou 100-year floodplain boundary and shaded Zone X (500-year) boundary. The Base Flood Elevation (BFE) for the site is about 45 feet above NAVD 88. Hunting Bayou and Channel H100-00-00 are FEMA studied streams with regulatory floodplains as shown on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) 48201C0715M dated January 06, 2017. The floodplain boundaries are shown in Exhibit 5.

Hunting Bayou Improvement Project

HCFCD is in the final stages of completing improvements to Hunting Bayou. The HCFCD project consists of approximately 3.8 miles of grass-lined channel widening from downstream of the Englewood Railroad Yard to US-59 and 1000 acre-feet of detention in a 75–acre detention basin.

Based on the "*Hunting Bayou Flood Risk Management Report"* dated 2014, the improvements in Hunting Bayou will reduce the 100-year Water Surface Elevation (WSE) near Lockwood Bridge by about four feet. This study assumes the HCFCD improvements are complete and use the lowered WSE in Hunting Bayou in the analyses.

Site Visit

A site visit was performed on December 23, 2019 to obtain photographs and to document the existing drainage patterns and land uses of the study area.

2 Existing Drainage System

The existing drainage system consists of storm sewer and roadside ditches throughout the study area and shown in Exhibit 3. The drainage systems were modeled to determine if they meet the COH criteria and are discussed in detail below.

Drainage Area

The total study area is approximately 873 acres. Additionally, there is about 570 acres offsite drainage with storm sewer lines draining away from the study area, while the surcharges on the streets of this area ultimately enter into the study area.

The existing ground elevations range from 41 feet at the bank of Hunting Bayou to 45 feet at the railroad site south of Liberty Road. The existing topography throughout this area is relatively flat with an average slope of 0.07%. The Lidar Map is shown in Exhibit 6.

Exhibit 7 shows the sheet flow patterns through the study area. The general overland flow direction is from west to east and south to north on the west side of H110-00-00 and outfall to Hunting Bayou. On the east side, water flows from east to west and outfalls into H110-00-00.

Drainage Outfall Channels

Hunting Bayou is an earthen channel with recently improved banks at the study limits. The channel serves as a major outfall for local drainage systems.

Channel H110-00-00 is a trapezoidal concrete-lined channel with a rectangular pilot channel. Based on the FEMA Effective model, the channel has adequate capacity to convey the 100-year storm event without flooding outside the banks. However, the backwater from Hunting Bayou inundates the H110-00-00 during extreme storm events.

Schrum Gully, Channel H112-00-00, is an earthen trapezoidal channel with a concrete lined rectangular pilot channel. Based on the FEMA Effective model, the channel has adequate capacity to convey the 100-year storm event without flooding outside the banks. However, the backwater from Hunting Bayou inundates Schrum Gully during extreme storm events.

Historic Flooding

The study area has a long flooding history according to flood damages records. The flood damage complaints from Hurricane Harvey (2017) and previous major storms are shown in Exhibit 8. This map indicates the area is prone to frequent flooding.

Hydraulic & Hydrologic Analysis

Exhibit 4 present the drainage areas and storm sewer systems that were modeled in XPSWMM. Drainage Systems A to J and WH1 to WH are located on the west side of H110-00-00, and Drainage Systems EH1 to EH10 are located on the east side of H110-00-00. Along H100-00-00, there are several small drainage systems that have sufficient capacity and therefore were not included in the XPSWMM model (see Exhibit 3).

System EH1, EH2 and EH3 were modeled as ditches with average 2 feet depth, 2 feet bottom width and 3H:1V side slopes. All the other systems consist of underground storm sewer lines with curb and gutter road. System F1, G1 and EH10 outfall into COH storm sewer. Other drainage systems drain into HCFCD channels.

Runoff hydrographs were developed separately and entered in the XPSWMM model. The XPSWMM model include 2D surface for modeling the sheet flow in the street. The XPSWMM model nodes and links are shown in Exhibit 4. Model parameters including tailwater elevations, Manning's roughness coefficient and mesh size were established in accordance with the COH IDM and TP-102.

The study area is located in the upper end of Hunting Bayou watershed. During a 100-yr storm, flows in Hunting Bayou peak about 1.2 hours after the flows in the study area have peaked. The fixed tailwater was set to top of pipe for 2-yr storm event. For 100-year storm event, the fixed tailwater was set to 2 feet below top of bank or 10-year WSE in the bayou whichever was lower.

Existing Condition Findings

The capacity of the drainage systems, on west and east side of H110-00-00, were evaluated for 2-year, 10-year and 100-year storm events. Exhibits 10 to 12 present the ponding depth for existing drainage system were. Table 1 & Table 2 compare the 2-year and 100-year water surface elevation with gutter elevation, natural ground at the Right-of-Way (ROW) and estimated Finished Floor Elevation (FFE). The FFE was estimated using 2018 LIDAR data.

West Side of H110-00-00

2-year Storm Event

- The existing 90" storm sewer along Lavender Street in System A and the existing 96" storm sewer along Wayne Street in System D do not have sufficient capacity to carry the 2-year storm event (see Exhibit 9). This results in more than one foot of ponding depth along Collingsworth Street between Wayne Street and Lavender Street. Based on the XPSWMM model result, there is about 50 cubic feet per second sheet flow from System D into System A during the 2-year storm event along Collingsworth Street.

- The storm sewer along Wayne Street south of Crane Street consists of a 78" Reinforced Concrete Pipe (RCP) and a 60" RCP, which has more capacity than the 90" storm sewer line downstream of this section. This is resulted in excessive sheet flow along Collingsworth Street.

- The 2-year Hydraulic Grade Line (HGL) in System A exceeds the gutter elevation along Love Street south of Collingsworth Street. This is mainly due to limited capacity in the existing storm sewer line and roadside ditches.

100-Year Storm Event

- Exhibits 12 present the ponding depth for the 100-year storm event. There is significant ponding during 100-year storm event outside the road ROW which can potentially result in structural flooding. This condition can be attributed to limited storm sewer and sheet flow conveyance capacity.

- The hydraulic analysis results indicated that there is about 250 cfs sheet flow along Collingsworth Street that enters the study area. This additional flow is causing the ponding depth to exceed 1.5 feet above the top of curb along Collingsworth Street.

East Side of H110-00-00

2-year Storm Event

- The hydraulic analysis of the drainage system along Rand Street indicated that the existing roadside ditches do not have enough capacity to carry the 2-year flows. The 2-year capacity map is shown in Exhibit 9,

- The 54" RCP along Cavalcade Street (System EH5) does not have adequate capacity for a 2-year storm event.

- The 36" RCP along Crane Street (System EH7) does not have adequate capacity for a 2-year storm event.

100-Year Storm Event

- As shown in Exhibit 12, there is considerable ponding during the 100-year storm event outside the road ROW, which can potentially result in structural flooding. This condition can be attributed to limited storm sewer and sheet flow conveyance capacity.

- The existing roadside ditches in System EH1 to EH3 do not have sufficient capacity for the100-year storm event. The existing roads are higher than the private property in this area, which results in excessive ponding outside the ROW during a 100-year Storm.

- The hydraulic analysis of the drainage system along Cavalcade Street indicates about 2 feet of ponding depth along the roadway corridor between Kress Street and the outfall location during a 100-year storm event. The ponding in the street is exacerbated by the higher grades at the bridge crossing over Channel H100-00-00.

Table 1 – West of H110-00-00, 2-yr and 100-yr XPSWMM Result

XPSWMM Node ID	Ground Elevation/ Spill Crest (ft)	Gutter/Ditch TOB Elevation (ft)	2-yr WSE (ft)	2-yr to Gutter/TOB Difference (ft)	ROW Elevation (ft)	100-yr WSL (ft)	100-yr to ROW Difference (ft)
A1	41.89	41.00	34.91	-6.09	43.25	42.83	-0.42
A3	42.13	42.00	35.95	-6.05	43.50	43.19	-0.31
A4	43.88	42.60	36.84	-5.76	43.60	43.47	-0.13
A5	41.32	41.50	37.76	-3.74	43.70	43.84	0.14
A6	42.44	42.00	37.98	-4.02	43.50	43.77	0.27
A7	43.12	43.00	38.05	-4.95	43.60	43.78	0.18
A8	43.25	42.50	38.11	-4.39	43.70	43.79	0.09
A9	42.59	42.60	38.21	-4.39	43.80	43.80	0.00
A15	42.72	42.40	38.76	-3.64	43.35	43.57	0.22
A16	42.61	42.20	38.83	-3.37	43.50	43.66	0.16
A20	42.92	42.60	39.39	-3.21	43.80	43.82	0.02
A21	43.38	42.80	38.66	-4.14	44.10	43.82	-0.28
A22	44.48	42.70	38.35	-4.35	44.20	43.96	-0.24
A25	41.75	42.80	41.71	-1.09	43.60	43.42	-0.19
A30	43.20	42.10	37.13	-4.97	43.50	43.20	-0.31
A35	41.96	41.20	35.82	-5.39	43.50	42.12	-1.38
A36	40.33	41.00	33.48	-7.52	43.25	40.62	-2.63
B1	41.14	40.40	32.36	-8.04	41.40	40.09	-1.31
B2	42.70	42.20	33.78	-8.42	43.20	42.62	-0.58
B3	43.83	42.40	35.57	-6.83	43.40	44.00	0.60
C1	44.52	43.00	37.72	-5.28	45.00	40.41	-4.59
C2	43.46	43.10	39.98	-3.12	44.20	43.88	-0.32
C3	43.38	43.10	41.93	-1.17	44.45	44.39	-0.06
C4	42.95	42.60	42.90	0.30	43.90	43.81	-0.09
C5	43.54	43.00	39.84	-3.16	44.00	43.79	-0.21
C6	42.89	42.70	38.00	-4.70	43.70	42.15	-1.55
D1	41.97	42.50	37.20	-5.31	43.50	42.34	-1.16
D2	43.62	42.90	40.20	-2.70	43.90	44.03	0.13
D3	43.60	42.50	43.74	1.24	44.20	44.50	0.30
D4	43.89	43.50	43.89	0.39	44.40	44.01	-0.39
E1	43.78	43.00	37.32	-5.68	44.00	43.78	-0.22
F1	42.59	43.70	39.57	-4.14	44.50	43.98	-0.52
G1	43.99	43.40	37.17	-6.23	44.40	44.85	0.45
I4	40.71	44.40	35.48	-8.92	42.00	41.34	-0.66

Table 2 – East of H110-00-00, 2-yr and 100-yr XPSWMM Result

XPSWMM Node ID	Ground Elevation/ Spill Crest (ft)	Gutter/Ditch TOB Elevation (ft)	2-yr WSE (ft)	2-yr to Gutter/TOB Difference (ft)	ROW Elevation (ft)	100-yr WSL (ft)	100-yr to ROW Difference (ft)
EH5-1	41.23	41.20	39.56	-1.64	42.80	42.81	0.01
EH5-2	41.96	41.60	42.06	0.46	43.40	43.46	0.06
EH5-3	42.31	41.90	42.84	0.94	43.60	43.72	0.12
EH7-1	42.20	41.70	39.94	-1.76	43.10	43.26	0.16
EH7-2	42.80	42.40	40.93	-1.47	43.80	43.90	0.10
EH7-3	43.15	42.70	41.97	-0.73	44.10	44.06	-0.04
EH8-1	41.97	41.50	39.46	-2.04	43.30	41.32	-1.98
EH8-2	42.92	42.40	40.17	-2.23	43.50	42.95	-0.55
EH8-3	43.01	42.60	41.41	-1.19	44.10	43.91	-0.19
EH9-1	41.57	41.40	39.64	-1.76	43.20	42.71	-0.49
EH9-2	42.67	42.00	39.90	-2.10	43.60	43.24	-0.36
EH9-3	42.67	42.40	40.35	-2.05	43.90	43.59	-0.31
EH1-1	41.74	41.74	41.22	-0.52	41.50	41.76	0.26
EH1-1.1	41.24	41.24	40.81	-0.43	41.60	41.54	-0.06
EH1-2	41.24	41.24	41.25	0.01	41.60	41.82	0.21
EH2-1	42.40	42.40	41.75	-0.65	42.10	42.15	0.05
EH2-1.1	41.74	41.74	41.67	-0.07	42.10	42.11	0.01
EH2-2	41.74	41.74	41.73	-0.01	41.80	42.04	0.24
EH3-1	41.74	41.74	42.05	0.31	42.30	42.36	0.06
EH3-1.1	41.24	41.24	42.01	0.77	42.20	42.26	0.06
EH3-2	42.74	42.74	42.39	-0.35	42.40	42.79	0.39
EH3-2.1	42.24	42.24	42.28	0.04	42.40	42.57	0.17
EH3-2.2	42.24	42.24	42.28	0.04	42.30	42.65	0.35
EH3-3	43.74	43.74	43.37	-0.37	43.60	43.64	0.04
EH3-3.1	43.24	43.24	43.06	-0.18	43.10	43.35	0.24

Pavement Condition Rating

Based on the record drawings, existing streets within the project area were constructed in 1980's. Some of the streets show minor cracking and signs of deterioration at specific locations while remaining streets seem to be in good condition.

The condition of a street is assessed by COH based on the physical condition of the roadway – travel surface cracking, potholes, spalling, base failure and other pavement deficiencies. Pavement Condition Index (PCI) is a numerical indicator that rates surface condition of the pavement. Exhibit 13 shows that the existing concrete pavement within the project area are in poor to fair condition.

Sanitary Sewer Lines

The existing water lines shown on Exhibit 14 were all built primarily in the 1980's. The water lines within the study area are primarily 6" to 8" diameter. There is a main 84" water which runs from north to south along Kashmere Street, Collingsworth Street and Lockwood Dr.

Water Lines

The existing sanitary sewer lines shown on Exhibit 15 were built in the 80's. The sanitary sewer lines within the study area are primarily 8"diameter. There is a main 60" sanitary sewer system which runs from north to south along Pickfair Street.

3 Proposed Condition Analysis

This technical memorandum include proposed drainage improvements within the study area. The existing condition XP-SWMM models were updated to incorporate the proposed improvements.

3.1 Proposed Improvement Projects

The drainage improvements include proposing new storm sewer trunkline, detention pond, regrading roadside ditches, driveway culvert replacement, inlet replacement and green stormwater infrastructure. The location of recommended improvements are shown in Exhibit 16 and discussed below. Exhibit 17 present the proposed storm sewer systems map that were modeled in XPSWMM.

The proposed improvements will increase the size of the existing storm sewer lines, which will reduce the risk of excessive street ponding and structural flooding. The proposed storm sewer lines will increase the discharge at the outfall to the bayou. The proposed offsite and inline detention will provide the required mitigation to have no negative impact on the receiving streams.

The proposed drainage improvements are broken down into six groups and labeled as Drainage Improvements P1 to P6, which are discussed in detail below:

Drainage Improvement P1:

- As shown Exhibit 18, the proposed drainage improvements in Systems A and B include a new 12' x 8' RCB trunkline along Wipprecht Street between Collingsworth Street and Hunting Bayou. The existing 36" RCP between Cavalcade Street and Hunting Bayou will be replaced with the proposed 12' x 8' RCB due to limited space and constructability issues.

- The existing 48" RCP pipe along Collingsworth Street will drain to the proposed 12' x 8' RCB trunckline along Wipprecht Street through 2-48" RCP. Based on record drawings, there is sufficient room to build the 2-48" RCP and avoid an existing 84" water line along Collingsworth Street (see Exhibit 18).

- The proposed 12'x8' RCB will provide additional conveyance and in-line detention, which reduce the risk of structural flooding along Lavender Street and Collingsworth Street. The new trunkline will also address the excessive street flooding along Collingsworth St during flashflood events.

Proposed Improvement P2:

- As shown in Exhibit 19, the proposed drainage improvements in Systems A include a storm sewer trunk line along Pickfair Street, Crane Street, Lockwood Dr and Marcus Street. The proposed trunk line drains to Channel H110-00-00 through the proposed Detention Pond A. There is a 60" sanitary sewer line along Pickfair Street. Based on available record drawings, the proposed 6'x3' RCB along Pickfair Street can go over the existing 60" sanitary sewer line.

- Detention Pond A is 21.72 acre-feet, 8 feet deep and located on Cavalcade Street, west of Channel H110-00-00. Pond A is shown in Exhibit 19.

- Crane Street west of Lockwood Drive is about two feet higher than adjacent streets and higher than finish floor of some of the existing homes. Crane Street blocks the sheetflow in the street from southeast to reach Channel H11-00-00 and increase the risk of structural flooding and excessive ponding in the area (see Exhibit 19). The proposed improvement include a new trunkline under the existing pavement along Crane Street, The existing pavement on Crane Street between Lockwood Drive and Pickfair Street need to be replaced and also lowered by up to two feet to facilitate sheetflow.

Proposed Improvement P3:

- As shown Exhibit 20, the proposed drainage improvements include replacing the existing 54” storm sewer with a 10’x5’ RCB along Cavalcade Street, between Blaffer Street and Dabney Street. The proposed 10’x5’ RCB will be connected to a new storm sewer along Dabney Street.

- Pond F and proposed 10’x5’ RCB along Dabney Street will provide the required mitigation in form of offsite and in-line detention. Pond F is 4.38 acre-feet, 8 feet deep and located on Cavalcade Street, east side of Channel H110-00-00. Pond F will be connected to existing 60” RCP on Cavalcade Street. Pond F will reduce the runoff discharge from drainage system EH5 to Channel H110-00-00. Pond F is shown in Exhibit 20.

- The proposed drainage improvement will improve the street ponding on Cavalcade Street during 100-Yr storm event. In addition, the new trunk line along Dabney Street will convey a portion of EH5 storm water runoff to the north and outfall to Hunting Bayou in lieu of discharging to Channel H110-00. This will relieve the drainage system of EH5 surcharge issue and result in less overland flow during flashflood events.

Proposed Improvement P4:

- The proposed drainage improvements include a new 54” RCB pipe along Hoffman Street that connects the existing 54” storm sewer along Crane Street to proposed Detention Pond C (see Exhibit 20).

- Detention Pond C is 4.05 acre-feet, 7 feet deep and located south of Crane Street on the east side of H110-00-00. The pond will serve as the detention mitigation pond and will reduce the runoff discharge to the Channel H110-00-00 from system EH7. Detail of pond layout is shown Exhibit 20.

Proposed Improvement P5:

- The proposed drainage improvements include a new 10’x8’ RCB trunkline along Dabney Street between Crane Street and Hunting Bayou. The new pipe will be connected to the existing 48” along Crane Street, the proposed 10’x5’ RCB along Cavalcade Street and the proposed 36” along Rand Street. The new storm sewer trunkline will outfall into Pond R and Hunting Bayou. The recommended improvement are shown in Exhibit 20.

- There is no existing storm sewer along Dabney Street between Crane Street and Hunting Bayou. The existing drainage system consist of roadside ditches. The existing roadside ditches along Rand Street and the street north of Rand Street do not have sufficient capacity for a 2-yr storm. There is not enough ROW to increase the size of existing roadside ditches to meet the COH criteria. The proposed 10'x8' RCB Trunkline provides sufficient conveyance capacity to drain this area for a 2-yr Storm and provide some inline detention for 100-yr storm.

- The proposed trunkline takes flows away from channel H110-00-00 and drains them directly into Hunting Bayou in downstream section. The proposed trunkline will lower HGL in existing storm sewer lines along Calvacade Street and Crane Street.

- As shown in The proposed Detention Pond R and 10'x8' RCB trunkline serve as offsite and in-line detention. Detention Pond R provides 4.7 acre-feet of storage and is located just south of Hunting Bayou between Dabney Street and Hoffman Street. COH is acquiring a property north of Hunting Bayou which is labeled in Exhibit 21 as Detention Pond Q. Detention Pond Q will provide about 10.35 acre-feet of detention which can be utilized instead of Detention Pond R if necessary.

Proposed Improvement P6:

- The proposed drainage improvements include a 36" RCP trunkline long Rand Street, between Majestic Street and Dabney Street (see Exhibit 20). The proposed 36" RCP connects to the proposed 10'x8' RCB along Dabney Street.

- The existing roadside ditch drains a large area and does not have capacity to maintain the runoff within the ditch during a 2-Yr storm event. The proposed improvement will provide the required conveyance capacity for a 2-yr storm.

Detention Pond N:

- Proposed Detention Pond N is 7 feet deep, provides 4.99 acre-feet of storage and is located at Cavalcade Street on the west side of H110-00-00. Pond N is shown in Exhibit 22. The existing 54" RCP along Cavalcade Street will drain to Detention Pond N.

- The proposed Detention Pond will provide an extreme event overflow swale connection between the street and Channel H110-00-00. The existing bridge over Channel H11-00-00 is higher than Calvacade Street and prevents the sheetflow in the street from drainage to the channel. The improvements will reduce the runoff discharge to Channel H110-00-00 and provide proper extreme event sheet flow connection between the street and to the channel.

Detention Pond M:

- Pond M will serve as detention mitigation pond for the improvement projects. Pond M is shown in Exhibit 23.

- Detention Pond M provides 3.78 acre-feet of storage, is 5 feet deep and is located on Collingsworth Street at the east side of H110-00-00 (see Exhibit 23). Pond M will be connected to existing 48" RCP along Collingsworth by 2-24" RCP. Pond M will reduce the runoff discharge to existing storm sewer and Channel H110-00-00.

Detention Pond K:

- Pond K will serve as detention mitigation pond for the overall improvement projects. Pond K is shown in Exhibit 24.

- Proposed Detention Pond K provides 2.37 acre-feet of storage, is 10 feet deep and is located on Pickfair Street south of Hunting Bayou. Pond K will be connected to existing 60" RCP along Pickfair Street. Pond K will reduce the runoff discharge to Hunting Bayou. COH is acquiring a property north of Hunting Bayou which is labeled in Exhibit 21 as Detention Pond Q. Detention pond Q will provide about 10.35 acre-feet of detention which can be utilized instead of Detention Pond K if necessary.

Detention Pond Q:

- Pond Q is shown in Exhibit 21. Detention Pond Q is 10.35 acre-feet, 11 feet deep and located on Lavender Street north of Hunting Bayou. Pond Q will reduce the runoff discharge to Hunting Bayou.

Other Proposed Improvements:

- The roadside ditch improvement includes desilting and regarding the existing ditch, replacing driveway culverts and roadway crossing culverts. The location of roadside ditch improvement is shown in Exhibit 16

- Replace existing Type "B" inlets with Type "BB" inlets. The location of inlet replacement is shown in Exhibit 16

- Install green stormwater infrastructure such as structured rain gardens, landscape improvements, sidewalk replacement and roadside ditch improvement. The location of green stormwater infrastructure is shown in Exhibit 16

Impact Analysis – WSE

Table 3 and Table 4 compares the 100-Yr WSE between existing and proposed condition. The ponding limits and depth are shown in Exhibit 25 to Exhibit 27. The proposed improvement will drop the 100-Yr WSE by up to 1.5-2 feet in the study area. This results in flooding limits be to street ROW for most of the study area.

Table 3. West of H110-00-00, Compare 100-Yr XPSWMM Result

XPSWMM Node ID	Exist 100-yr WSE (ft)	Prop 100-yr WSE (ft)	100-yr WSE Diff = (Prop-Exist) (ft)	ROW Elevation (ft)	Prop 100-yr to ROW Difference (ft)
A1	42.83	42.74	-0.09	43.25	-0.51
A3	43.19	43.16	-0.03	43.50	-0.34
A4	43.47	43.28	-0.19	43.60	-0.33
A5	43.84	43.55	-0.30	43.70	-0.16
A6	43.77	43.42	-0.36	43.50	-0.09
A7	43.78	43.56	-0.22	43.60	-0.04
A8	43.79	43.65	-0.14	43.70	-0.05
A9	43.80	43.72	-0.09	43.80	-0.08
A15	43.57	43.30	-0.27	43.35	-0.05
A16	43.66	43.37	-0.30	43.50	-0.13
A20	43.82	43.73	-0.08	43.80	-0.07
A21	43.82	43.73	-0.09	44.10	-0.37
A22	43.96	43.73	-0.23	44.20	-0.47
A23	43.94	43.65	-0.28	43.70	-0.05
A25	43.42	42.79	-0.63	43.60	-0.81
A30	43.20	43.20	0.00	43.50	-0.31
A35	42.12	42.11	-0.01	43.50	-1.39
A36	40.62	39.21	-1.41	43.25	-4.04
C1	40.41	40.04	-0.37	45.00	-4.96
C2	43.88	43.09	-0.79	44.20	-1.11
C3	44.39	44.38	-0.01	44.45	-0.07
C4	43.81	43.73	-0.08	43.90	-0.17
C5	43.79	43.72	-0.07	44.00	-0.28
C6	42.15	41.32	-0.83	43.70	-2.38
D1	42.34	42.34	0.00	43.50	-1.17
D2	44.03	44.02	-0.01	43.90	0.12
D3	44.50	44.50	0.00	44.20	0.30
D4	44.01	44.01	0.00	44.40	-0.39
E1	43.78	43.78	0.00	44.00	-0.22
F1	43.98	43.63	-0.35	44.50	-0.87
G1	44.85	44.85	0.00	44.40	0.45
I4	41.34	41.12	-0.22	42.00	-0.88

Table 4. East of H110-00-00, Compare 100-Yr XPSWMM Result

XPSWMM Node ID	Exist 100-yr WSE (ft)	Prop 100-yr WSE (ft)	100-yr WSE Diff = (Prop-Exist) (ft)	ROW Elevation (ft)	Prop 100-yr to ROW Difference (ft)
EH5-1	42.81	42.75	-0.06	42.80	-0.05
EH5-2	43.46	43.39	-0.07	43.40	-0.02
EH5-3	43.72	43.43	-0.29	43.60	-0.18
EH7-1	43.26	43.01	-0.26	43.10	-0.09
EH7-2	43.90	43.77	-0.13	43.80	-0.03
EH7-3	44.06	44.03	-0.03	44.10	-0.07
EH8-1	41.32	41.19	-0.13	43.30	-2.11
EH8-2	42.95	42.92	-0.03	43.50	-0.58
EH8-3	43.91	43.90	-0.01	44.10	-0.20
EH9-1	42.71	42.71	0.00	43.20	-0.49
EH9-2	43.24	43.24	0.00	43.60	-0.36
EH9-3	43.59	43.58	-0.01	43.90	-0.32
EH1-1	41.76	41.50	-0.26	41.50	0.00
EH1-1.1	41.54	41.50	-0.04	41.60	-0.10
EH1-2	41.82	41.50	-0.32	41.60	-0.10
EH2-1	42.15	42.09	-0.06	42.10	-0.02
EH2-1.1	42.11	42.09	-0.02	42.10	-0.01
EH2-2	42.04	41.65	-0.39	41.80	-0.15
EH3-1	42.36	42.23	-0.13	42.30	-0.07
EH3-1.1	42.26	42.18	-0.08	42.20	-0.02
EH3-2	42.79	42.31	-0.47	42.40	-0.09
EH3-2.1	42.57	42.36	-0.21	42.40	-0.04
EH3-2.2	42.65	42.21	-0.44	42.30	-0.09
EH3-3	43.64	43.14	-0.50	43.60	-0.46
EH3-3.1	43.35	42.68	-0.66	43.10	-0.42

Impact Analysis – Peak Discharge
Table 5 compares the XP-SWMM model existing and proposed condition for 10-Yr and 100-Yr peak discharge to the outfall channels. The project detention ponds provide an overall of 55 acre-feet of storage. The overall peak discharge to Hunting Bayou and Channel H110-00 is calculated by adding all outfall discharge hydrographs and not by adding the peak flow values. The total discharge in proposed condition model decreased by 7.8 and 7.5 for 10-Yr and 100-Yr at the outfall channels, respectively.

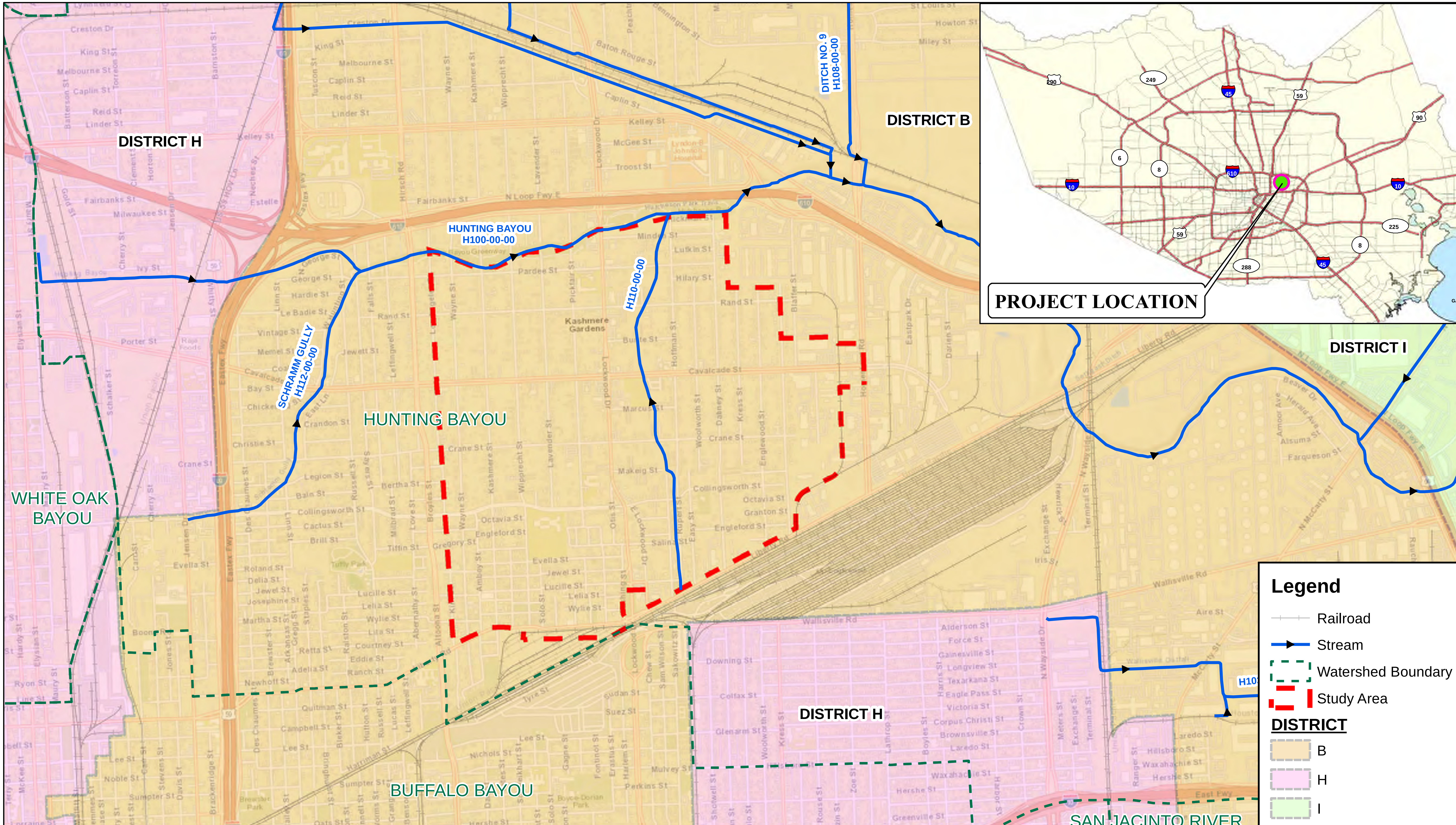
The Kashmere Gardens' proposed improvements will not adversely impact the peak discharge into outfall channels.

Table 5. Impact Analysis - Peak Discharge Difference

Kashmere Gardens Area Project	10-Yr Peak Discharge TOTAL			100-Yr Peak Discharge TOTAL		
	Exist (cfs)	**Prop (cfs)**	**= (Exist - Prop) (cfs)**	**Exist (cfs)**	**Prop (cfs)**	**= (Exist - Prop) (cfs)**
	1700.0	1692.1	-7.8	2269.7	2262.2	-7.5

* The overall peak discharge to outfall channels is calculated by adding all outfall discharge hydrographs

Construction Cost Estimate:
The estimated construction cost for proposed improvements is up to $95 million. This cost does not include any right-of-way or easement acquisition. See Appendix for the cost estimate summary.



HUITT-ZOLLARS
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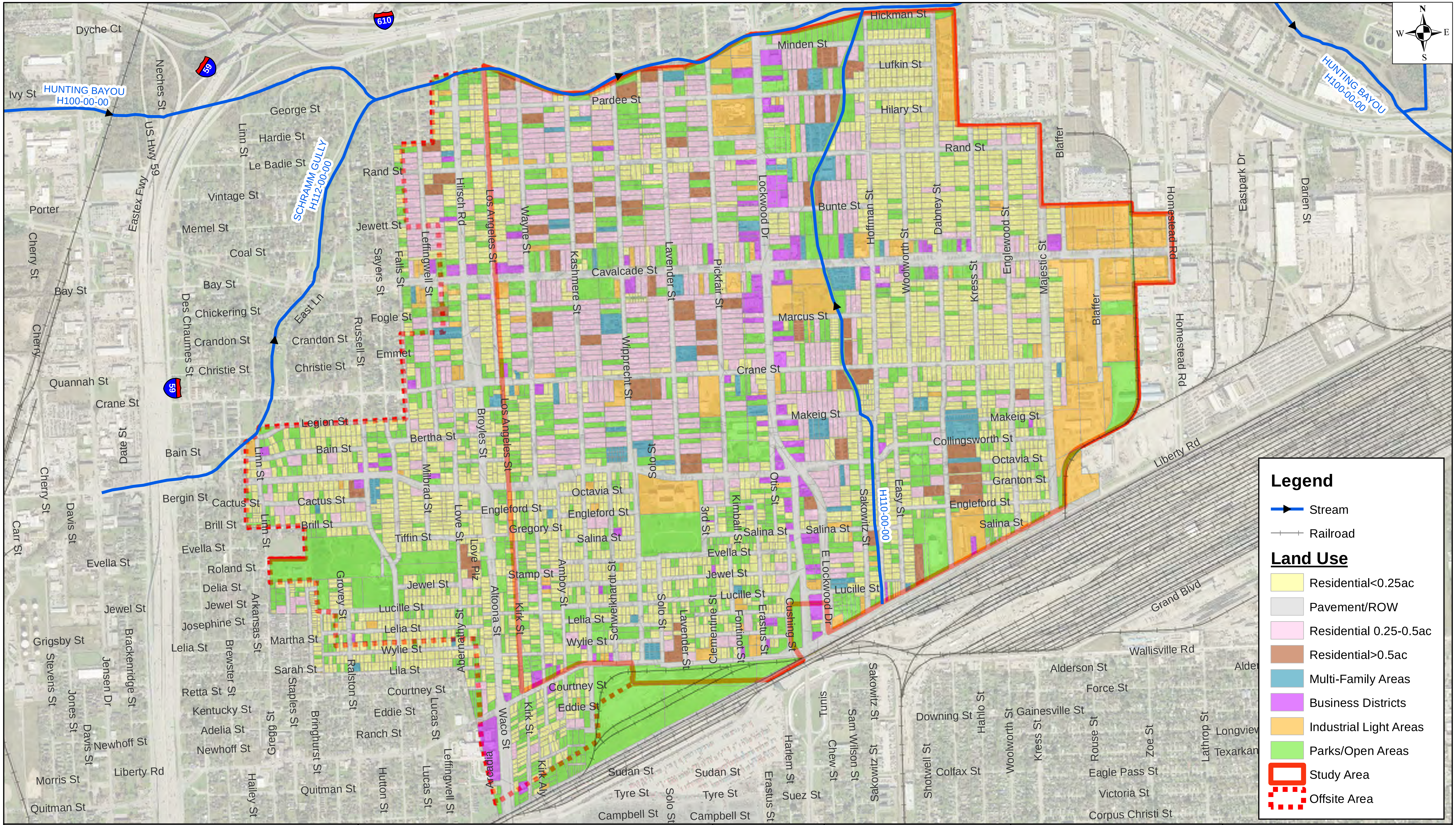
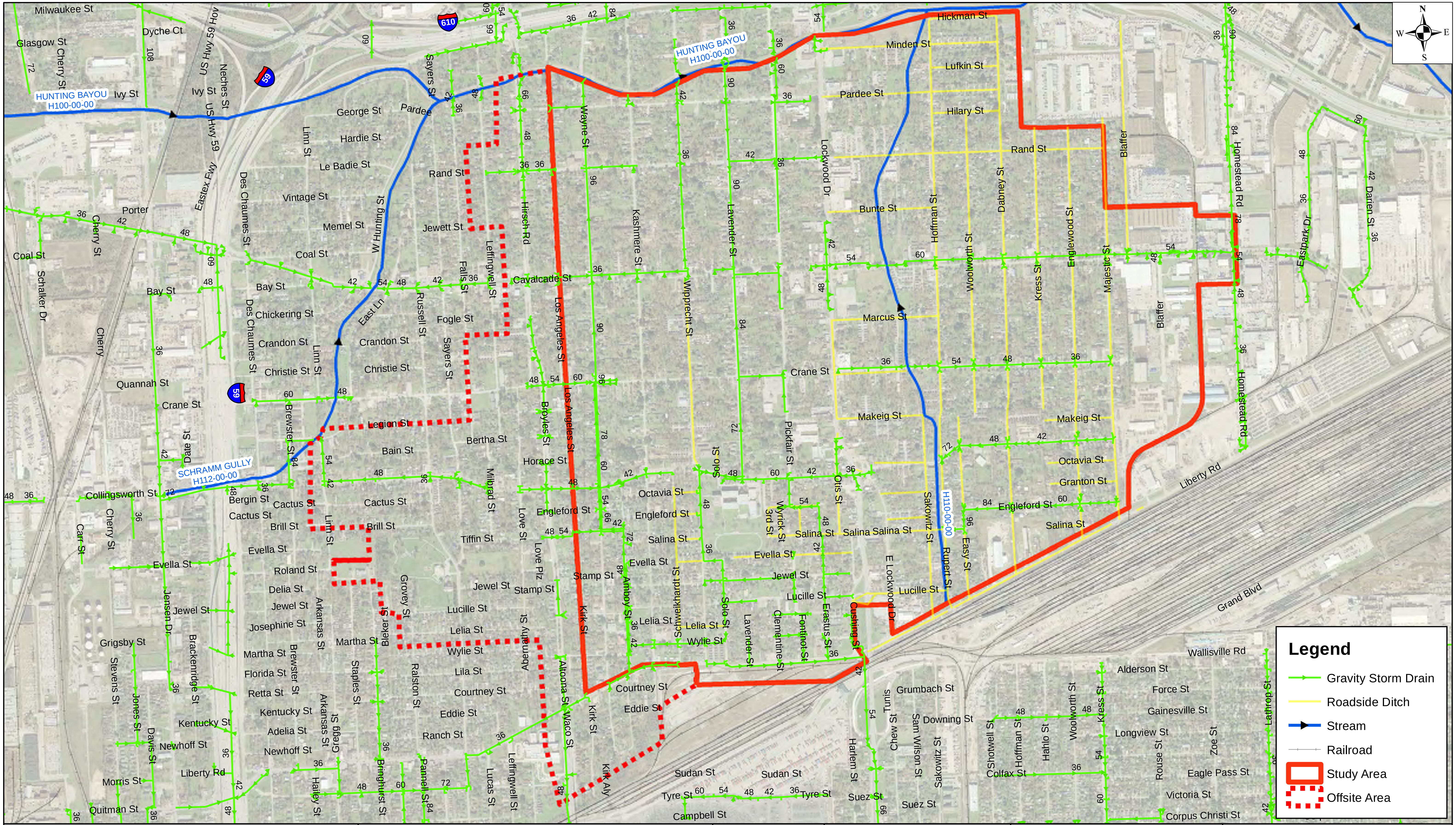
PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	DATE	SCALE	EXHIBIT 1
	OCTOBER 2020	0 1,000 2,000 Feet	LOCATION MAP



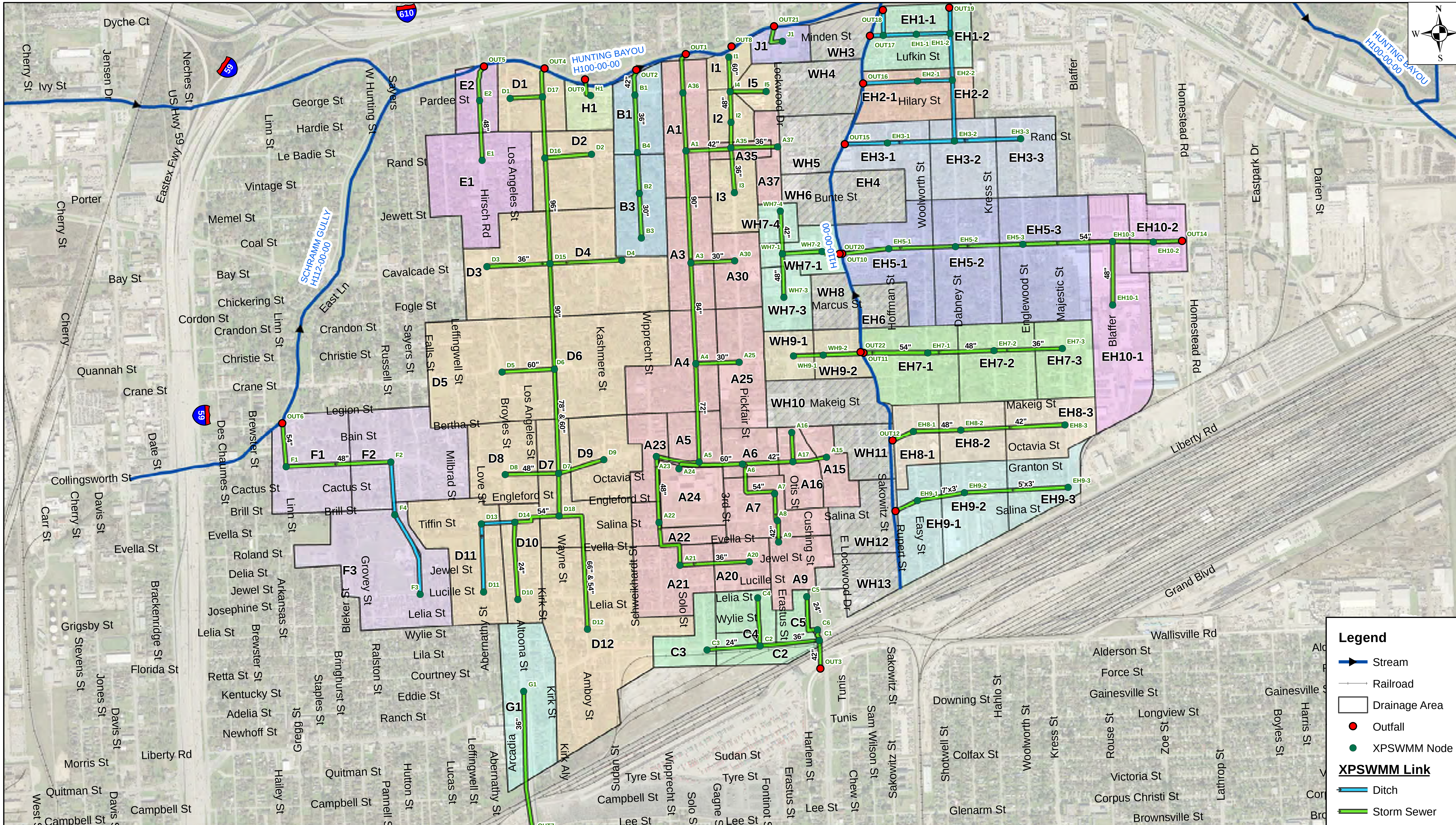
HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 2
HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220			OCTOBER 2020	0 500 1,000 2,000 Feet	PARCEL LAND USE



PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

HUITT-ZOLLARS
HUITT-ZOLLARS, INC. Firm No. F-761
10050 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

DATE	SCALE	EXHIBIT 3
OCTOBER 2020	0 500 1,000 2,000 Feet	EXISTING DRAINAGE SYSTEM



HUITT-ZOLLARS
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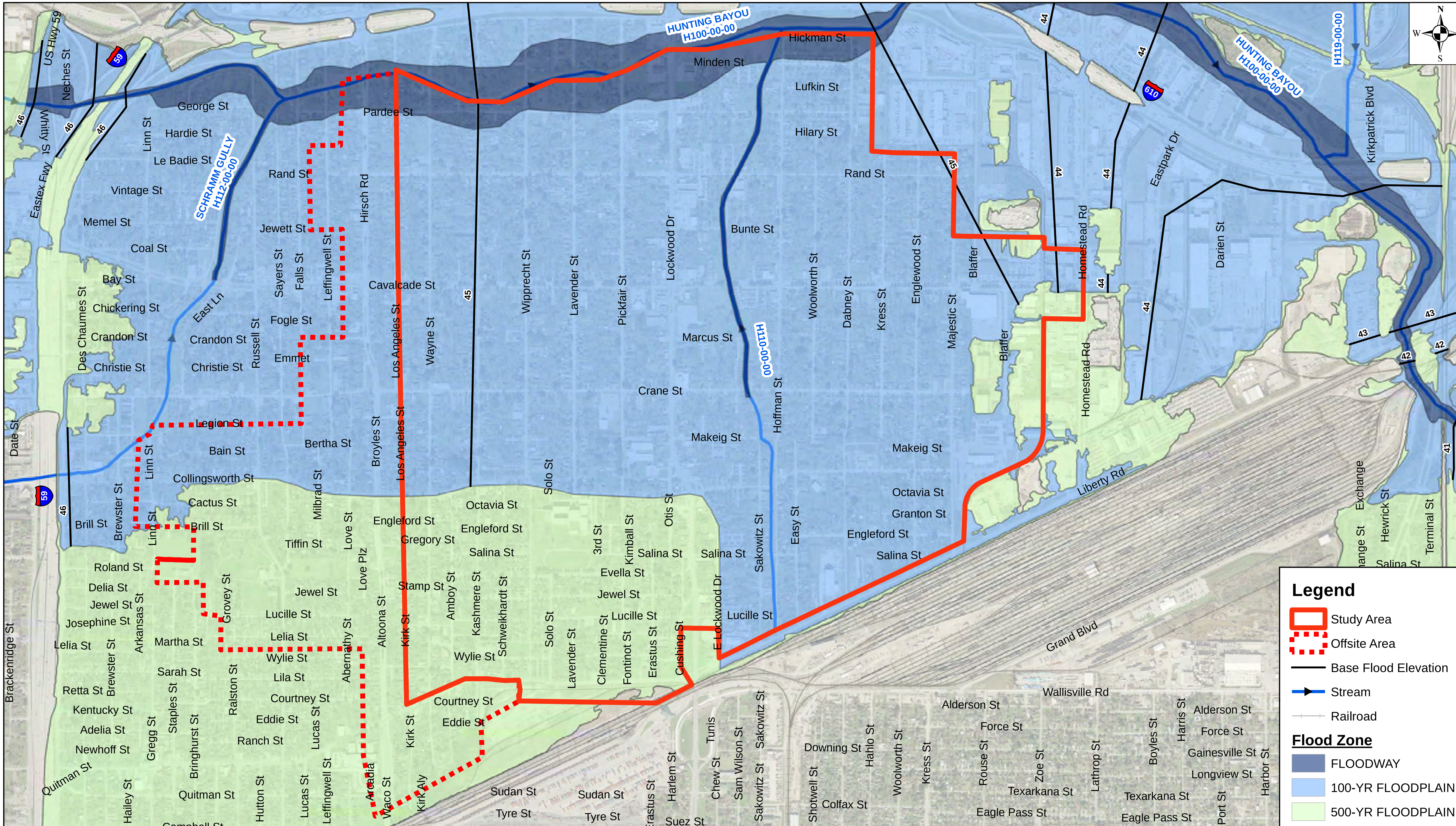
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 4
OCTOBER 2020	0 500 1,000 2,000 Feet	EXISTING DRAINAGE SYSTEM

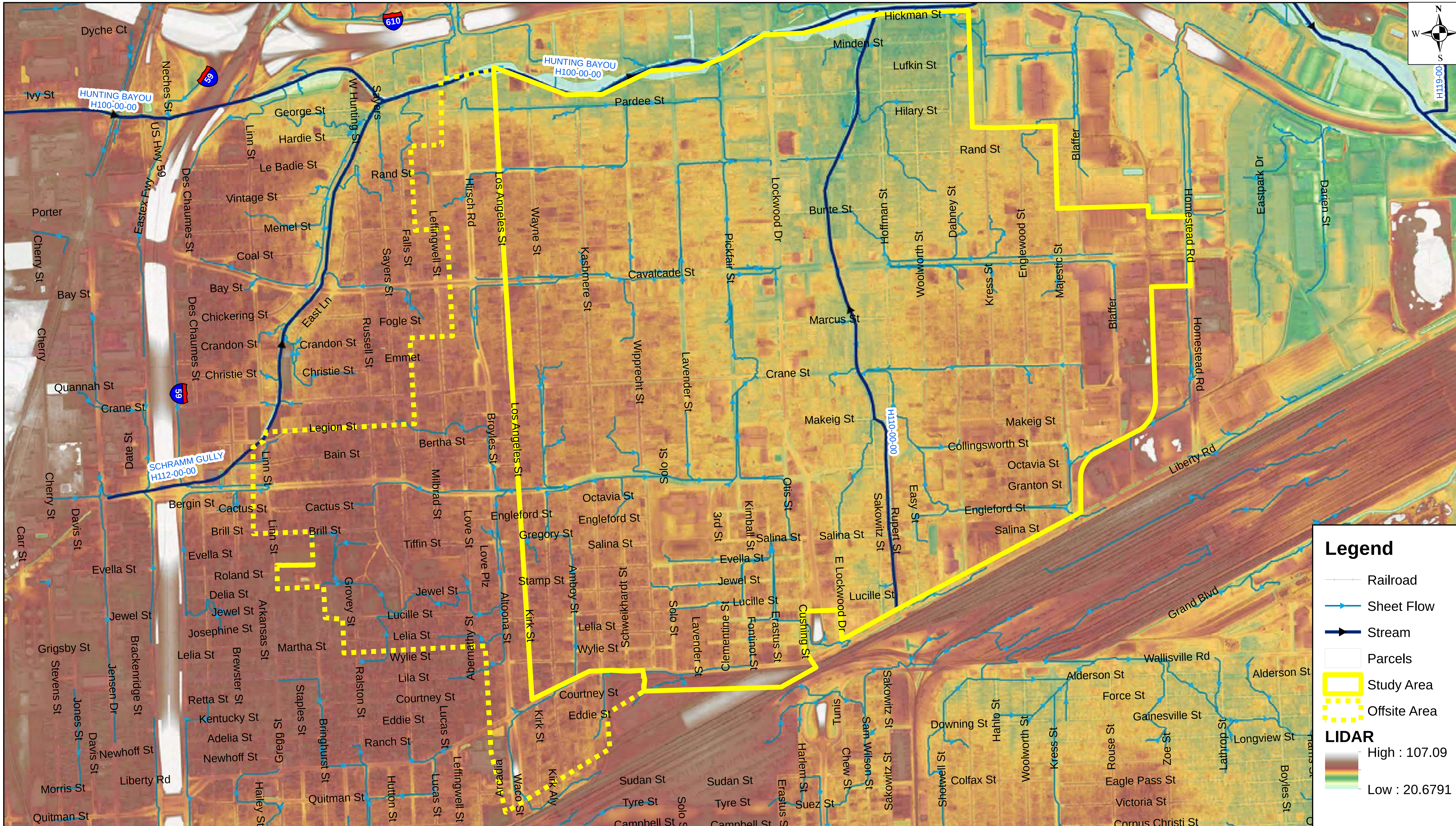


HUITT-ZOLLARS

PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 5
FEBRUARY 2020	0 500 1,000 2,000 Feet	FLOODPLAIN MAP



HUITT-ZOLLARS
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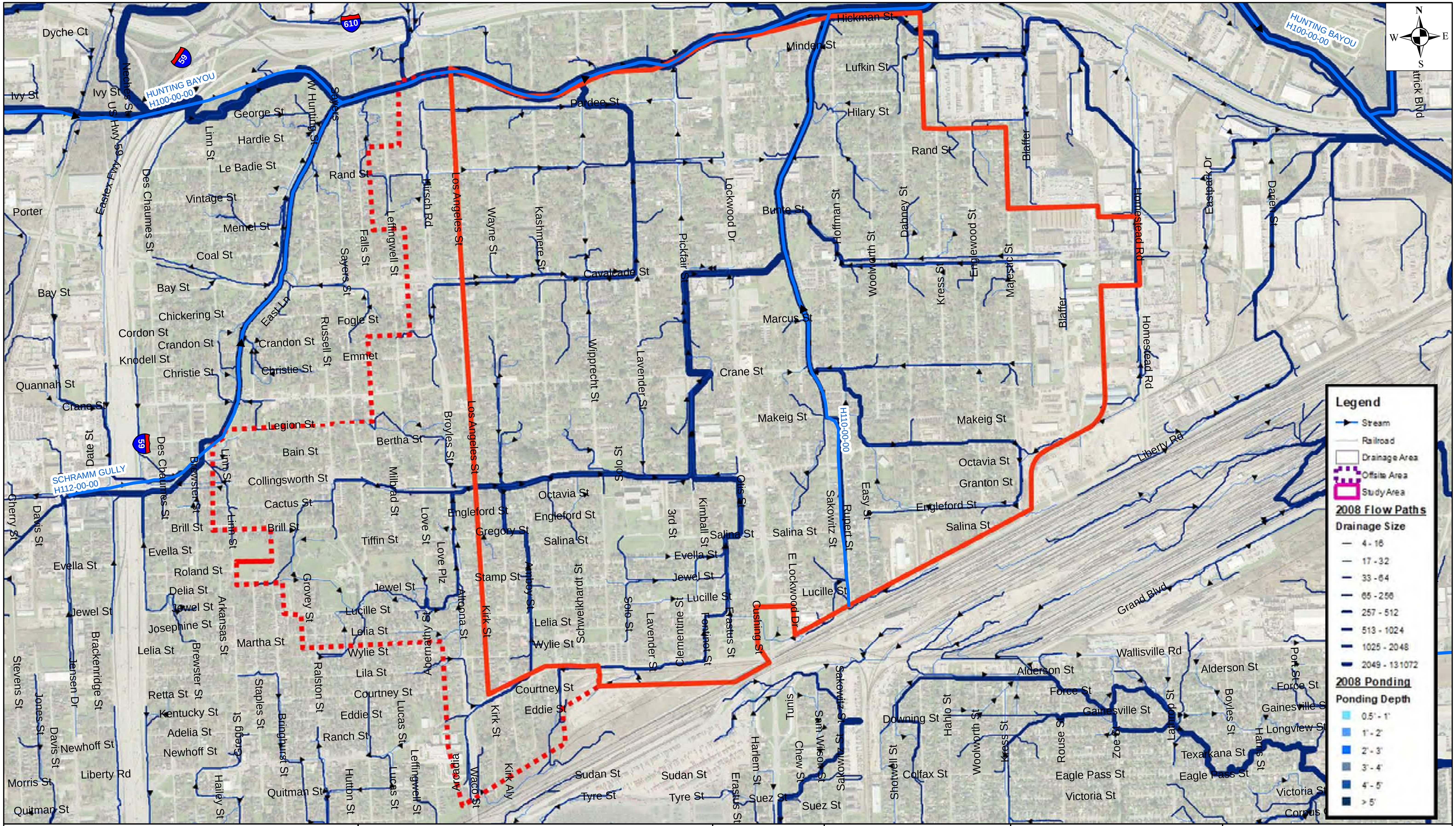
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

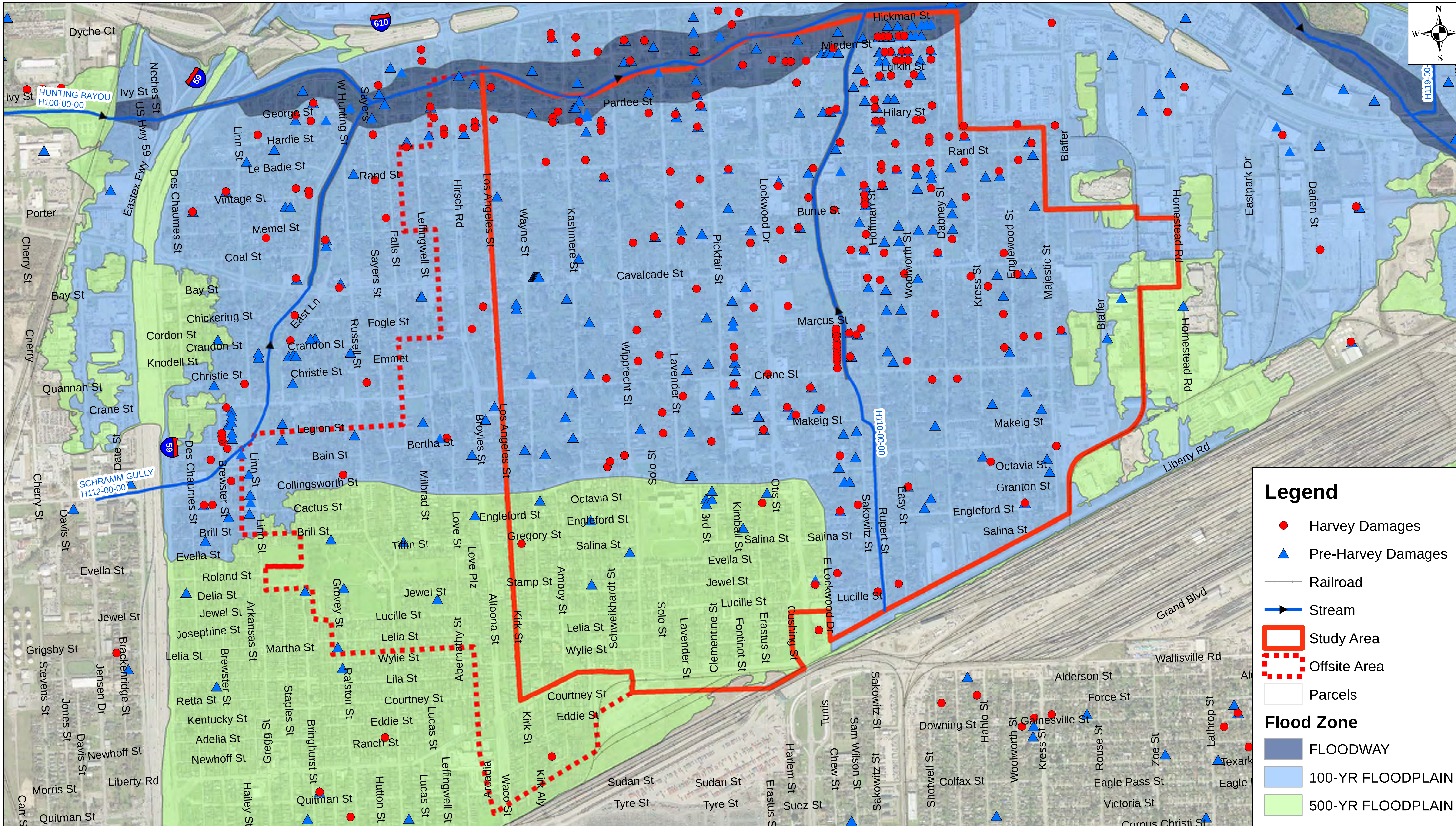
DATE	SCALE	EXHIBIT 6
OCTOBER 2020	0 500 1,000 2,000 Feet	LIDAR MAP



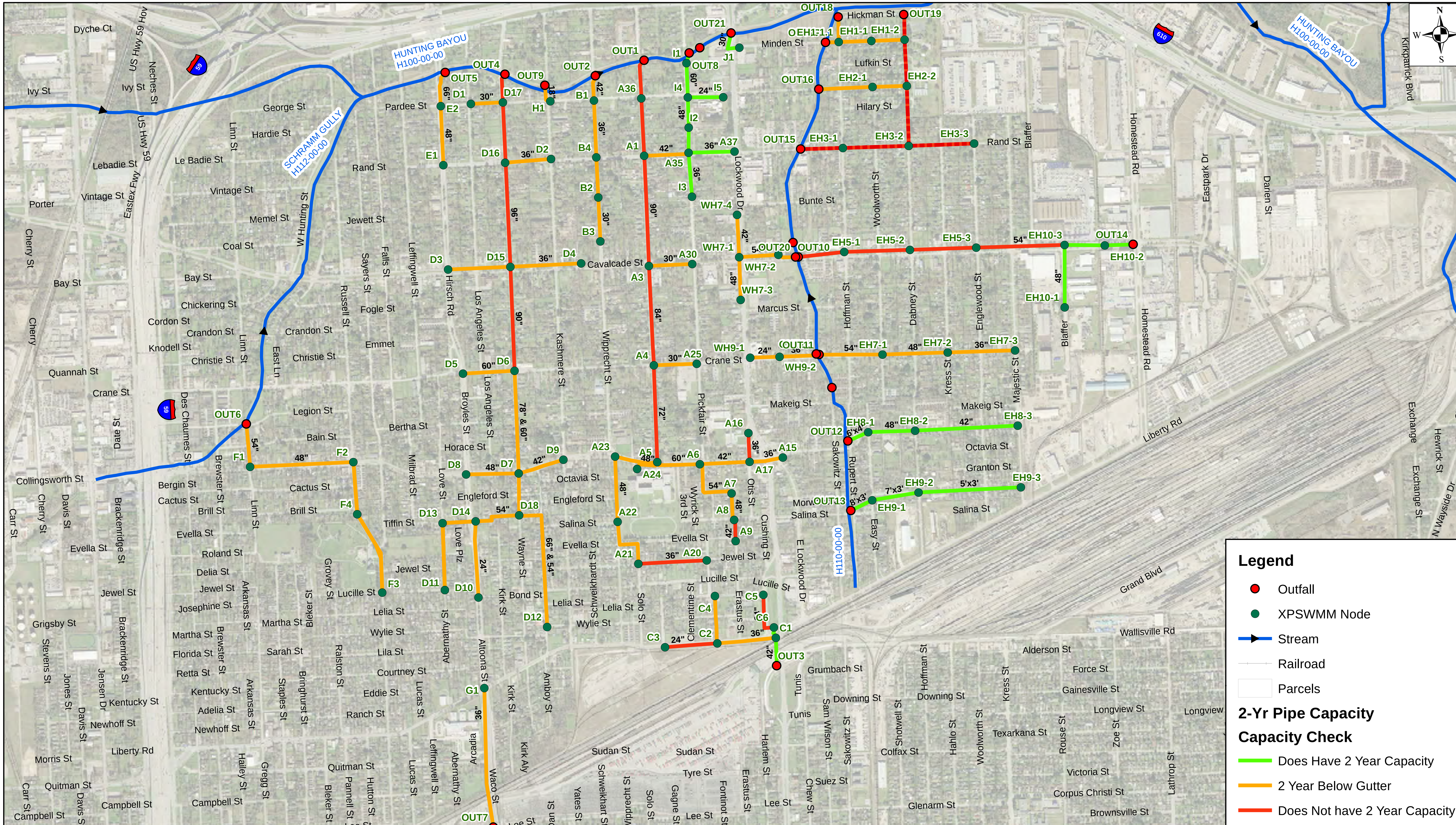
PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

HUITT-ZOLLARS

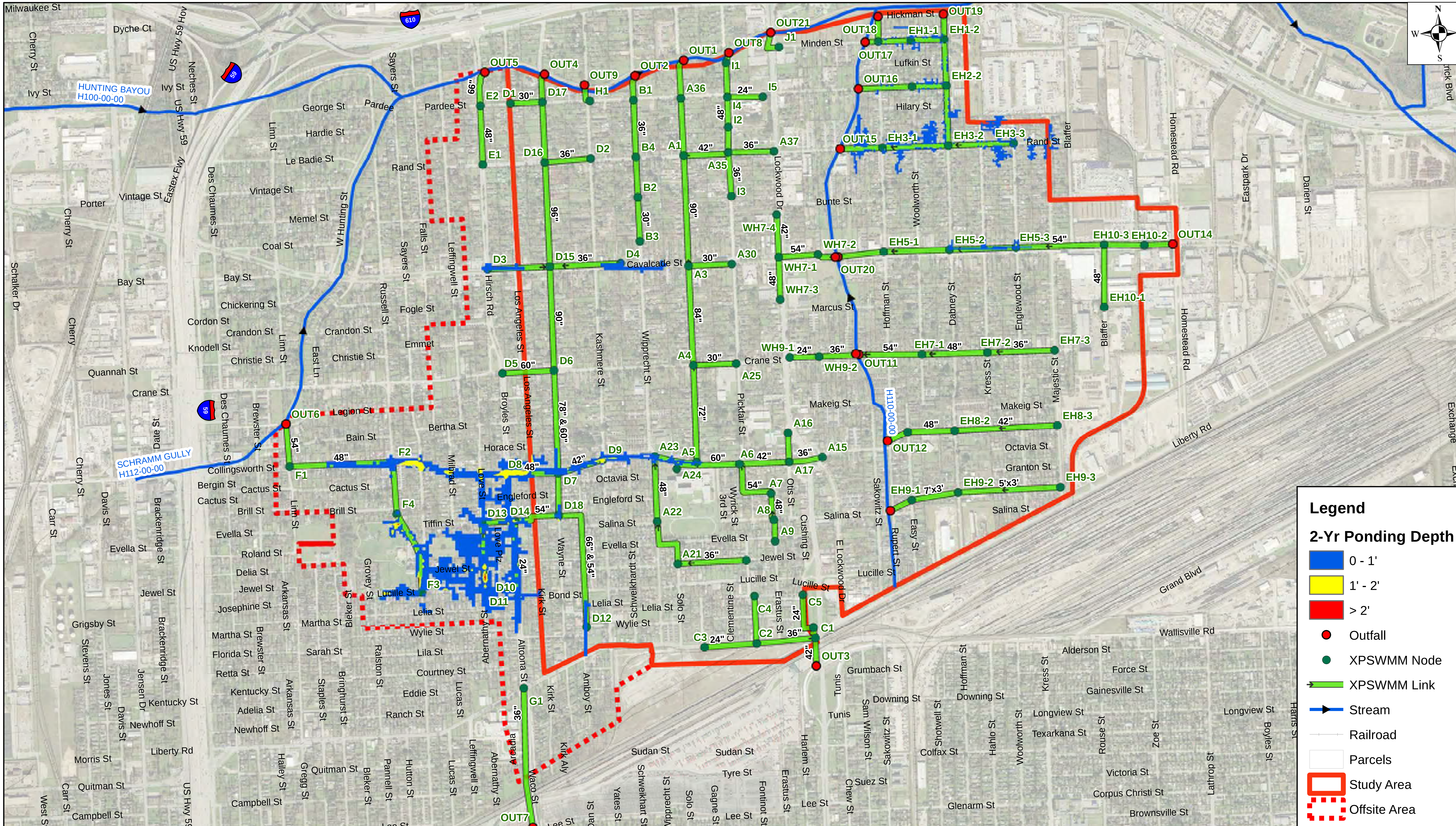
DATE	SCALE	EXHIBIT 7
OCTOBER 2020	0 500 1,000 2,000 Feet	SHEET FLOW PATH



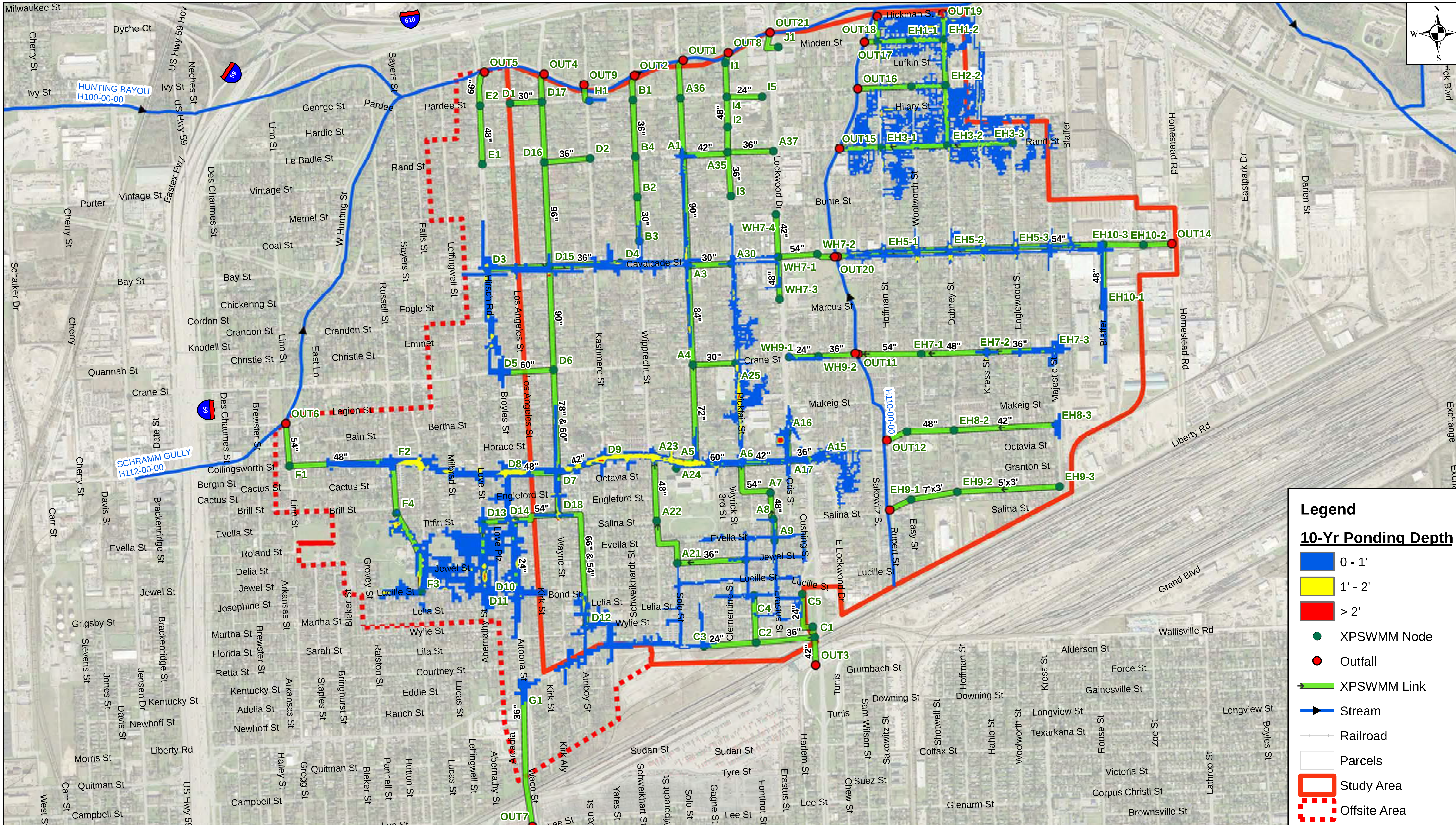
HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE OCTOBER 2020	SCALE 0 500 1,000 2,000 Feet	EXHIBIT 8 FEMA FLOOD COMPLAINTS



HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281 496.0066 Fax 713 496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	DATE OCTOBER 2020	SCALE 0 500 1,000 2,000 Feet	EXHIBIT 9 EXISTING STORM SEWER CAPACITY



HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 10
HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220			OCTOBER 2020	0 500 1,000 2,000 Feet	2-YR PONDING DEPTH EXISTING CONDITION



HUITT-ZOLLARS

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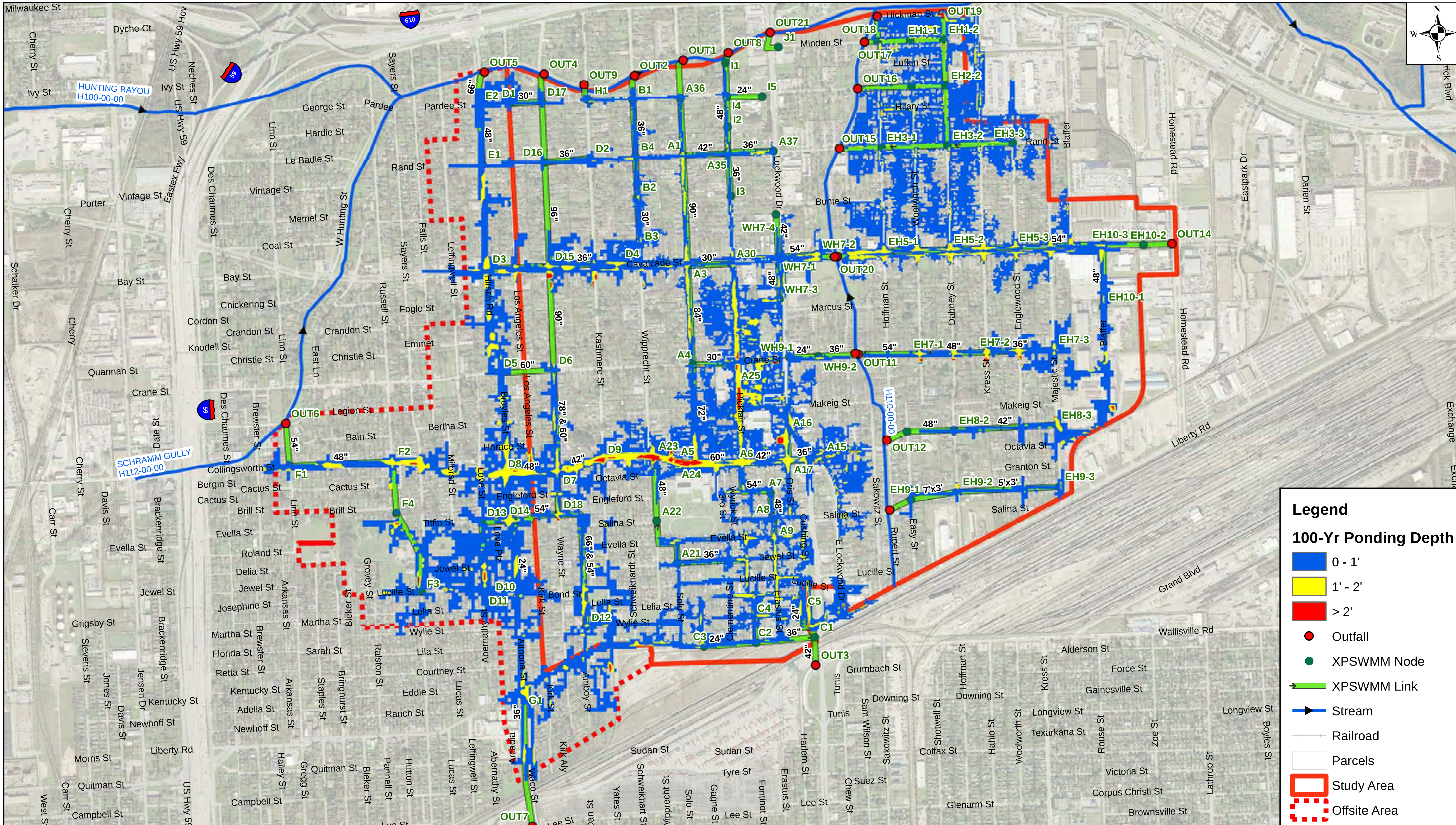
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 11
OCTOBER 2020	0 500 1,000 2,000 Feet	10-YR PONDING DEPTH EXISTING CONDITION



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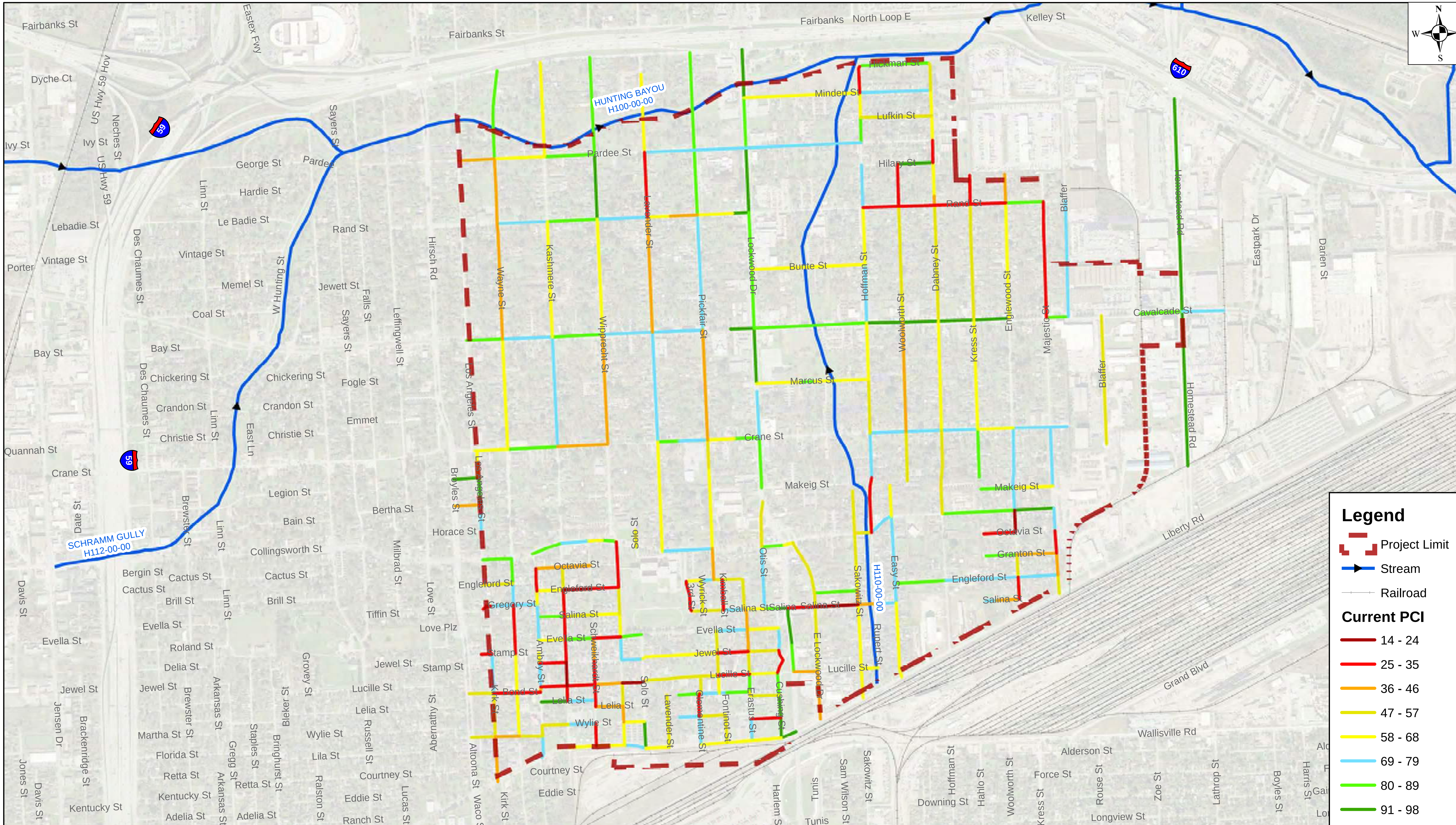
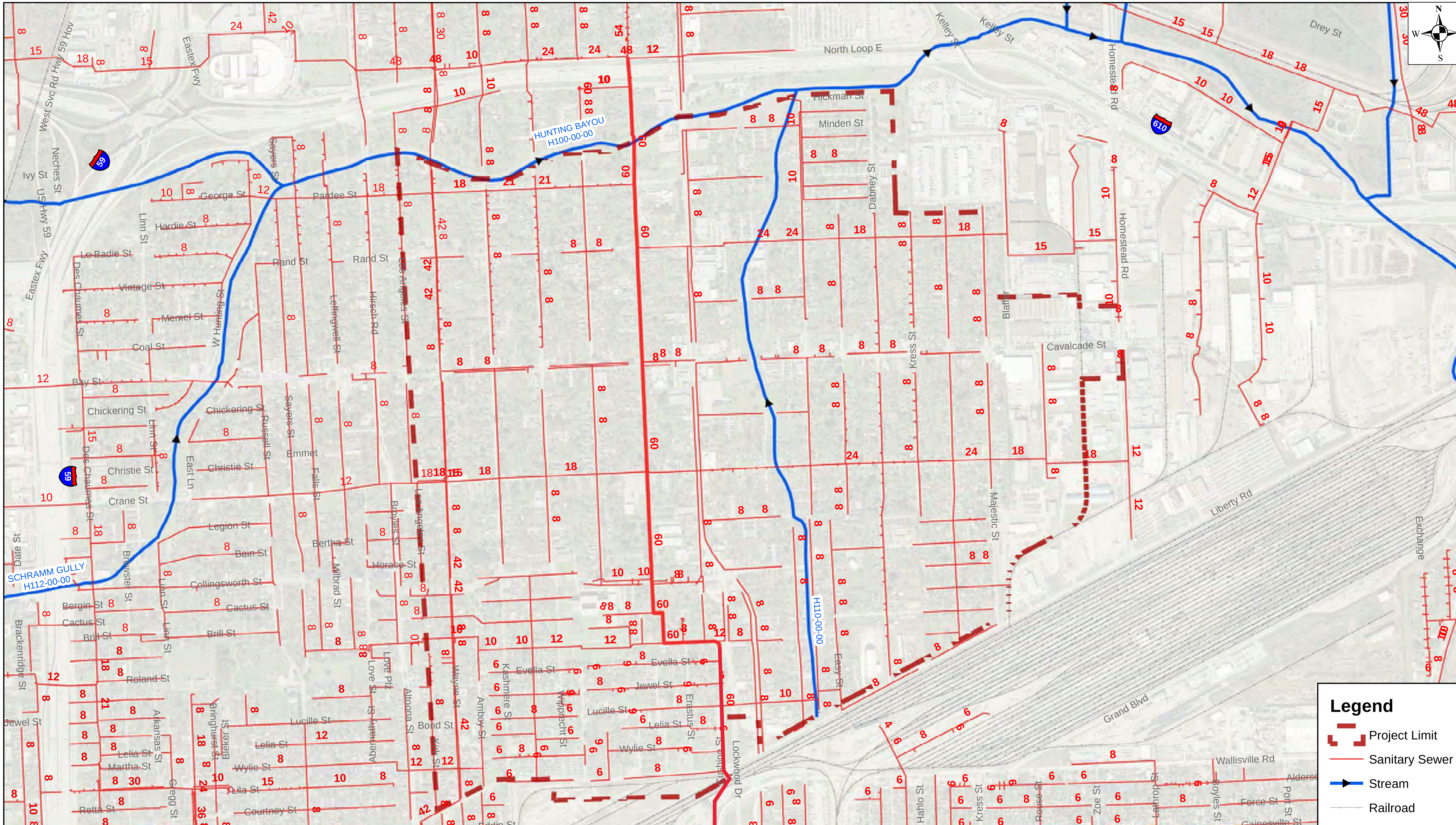
PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 12
OCTOBER 2020	0 500 1,000 2,000 Feet	100-YR PONDING DEPTH EXISTING CONDITION



HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	**PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS** **WBS: NO. M-430100-0020-3** **WO NO.3** **(KASHMERE GARDENS)**	CITY OF HOUSTON TEXAS	**DATE**	**SCALE**	**EXHIBIT 13**
			OCTOBER 2020	0 500 1,000 2,000 Feet	**STREET CONDITION PAVEMENT CONDITION INDEX (PCI)**



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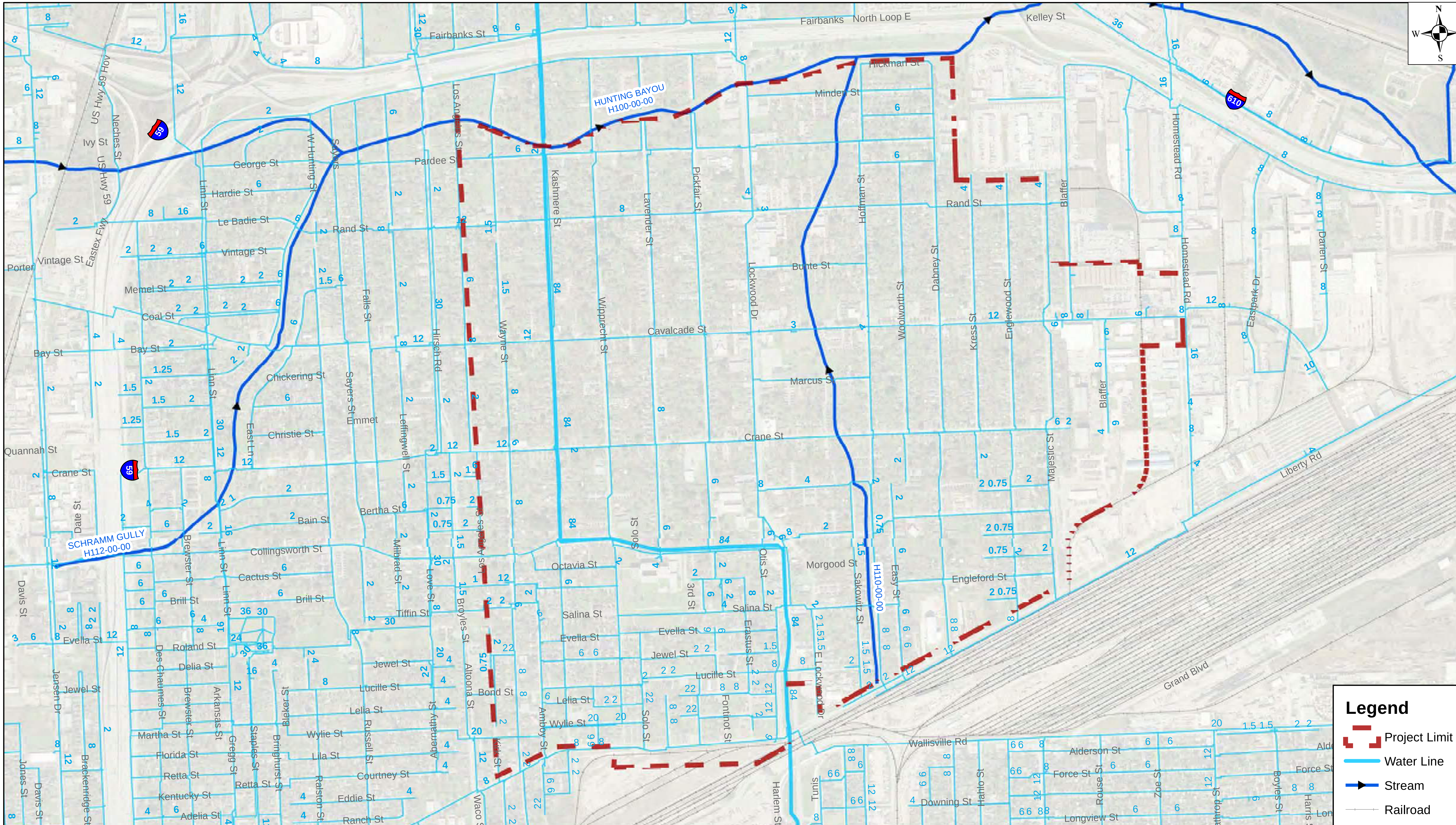
PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 14
OCTOBER 2020	0 500 1,000 2,000 Feet	SANITARY SEWER



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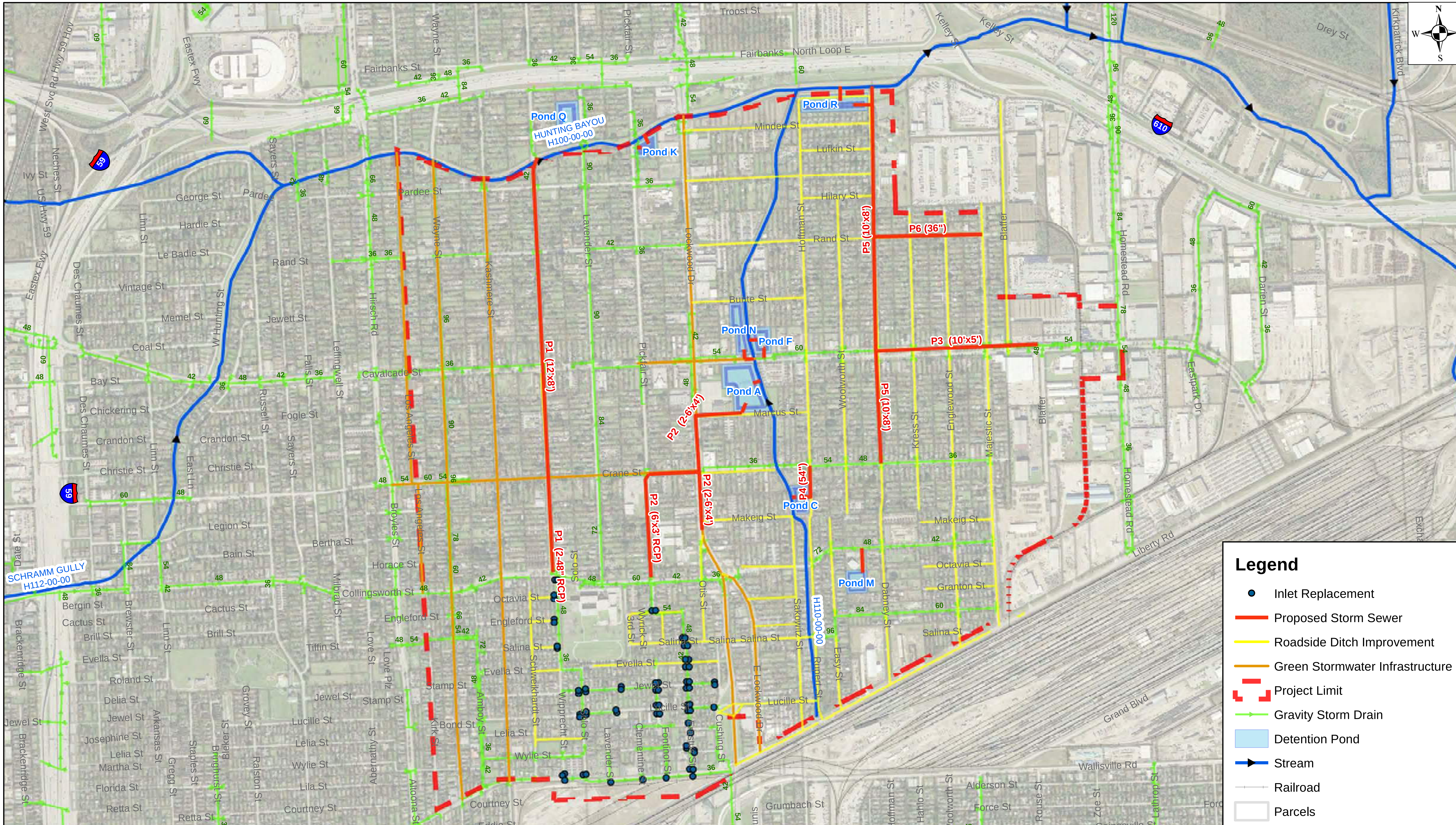
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 15
OCTOBER 2020	0 500 1,000 2,000 Feet	WATER LINE



HUITT-ZOLLARS

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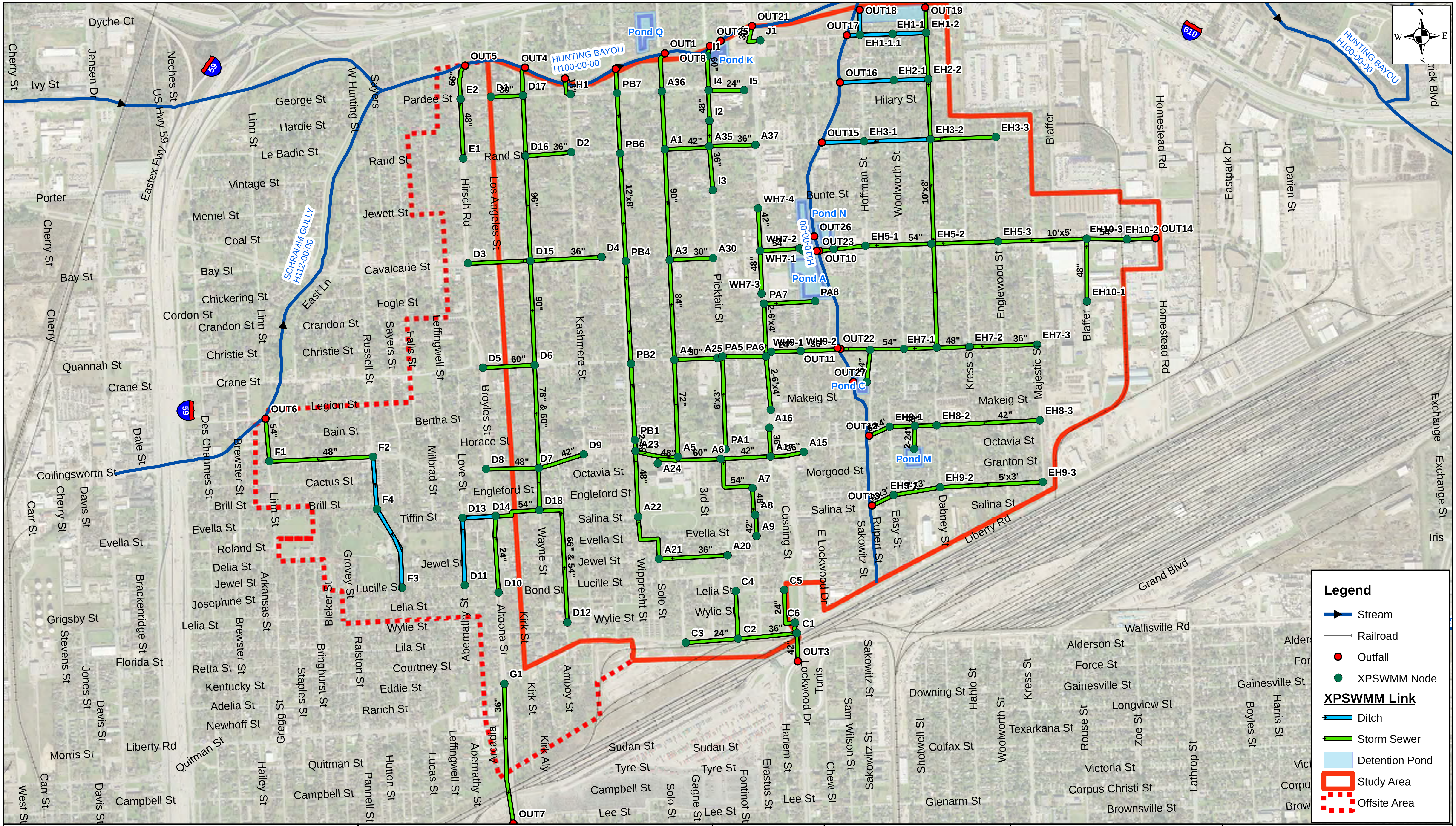
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

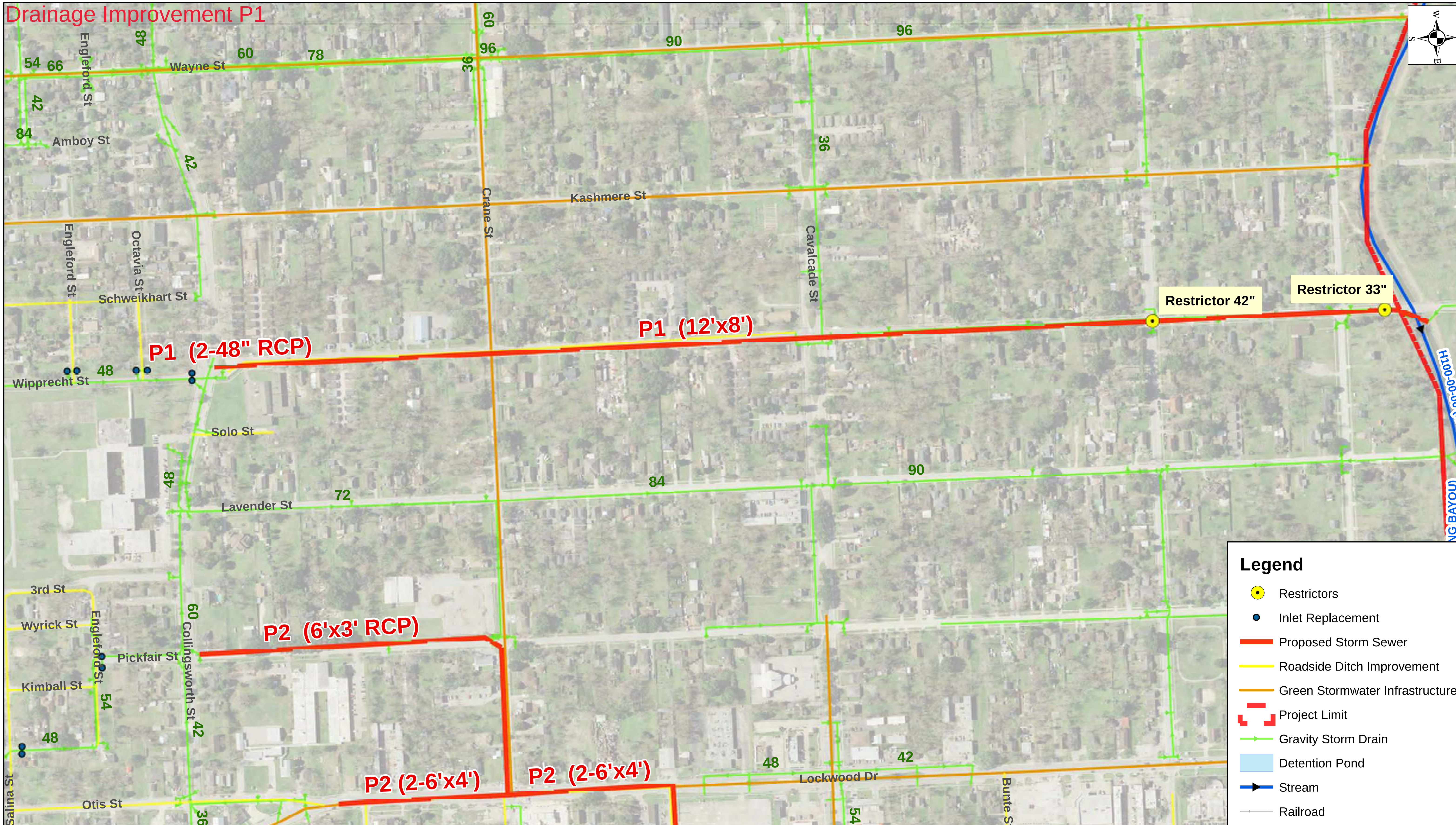
PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

DATE	SCALE	EXHIBIT 16
OCTOBER 2020	0 500 1,000 2,000 Feet	RECOMMENDED DRAINAGE IMPROVEMENT



HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 17
			OCTOBER 2020	0 500 1,000 2,000 Feet	XPSWMM MODEL PROPOSED CONDITION

HUITT-ZOLLARS, INC. Firm No. F-761
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220



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PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

DATE	SCALE	EXHIBIT 18
OCTOBER 2020	0 125 250 500 Feet	DRAINAGE IMPROVEMENT P1

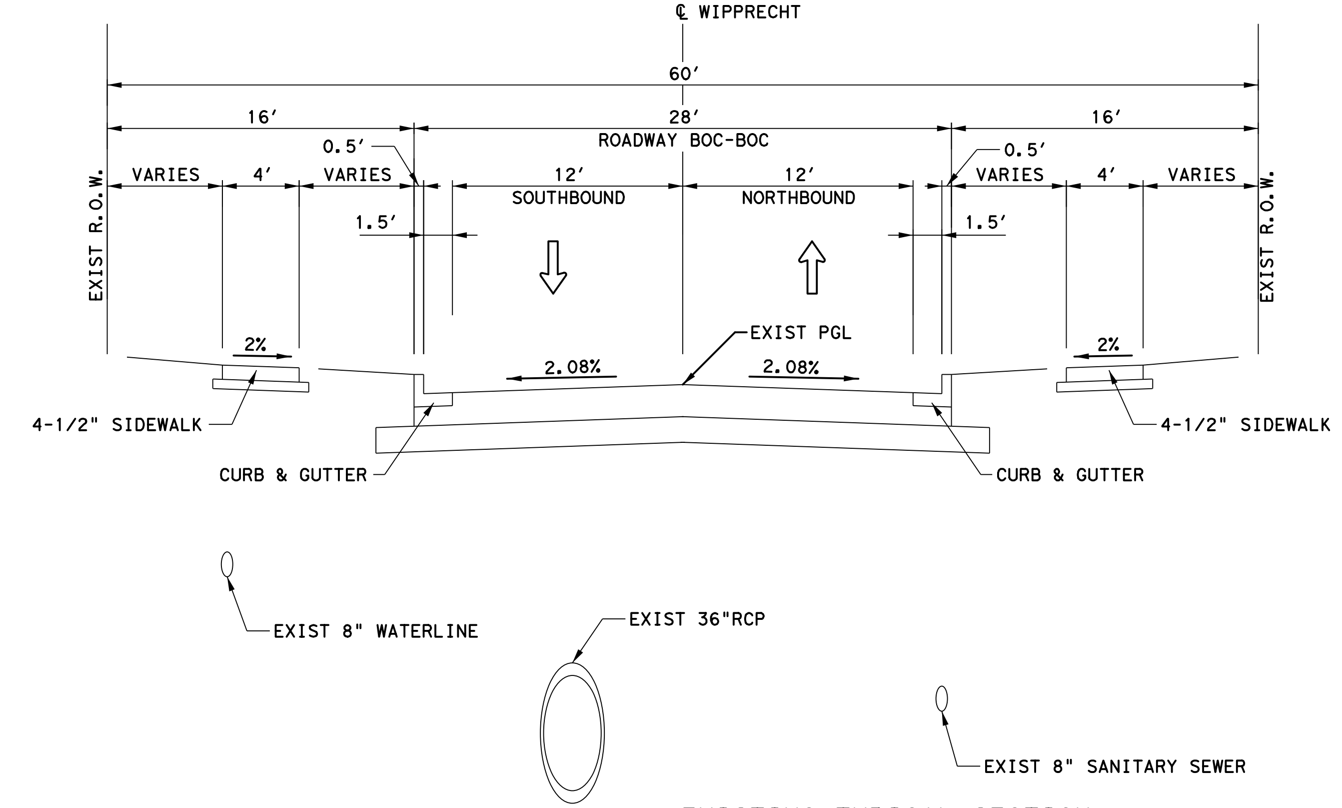
Drainage Improvement P1

Drainage Improvement P1

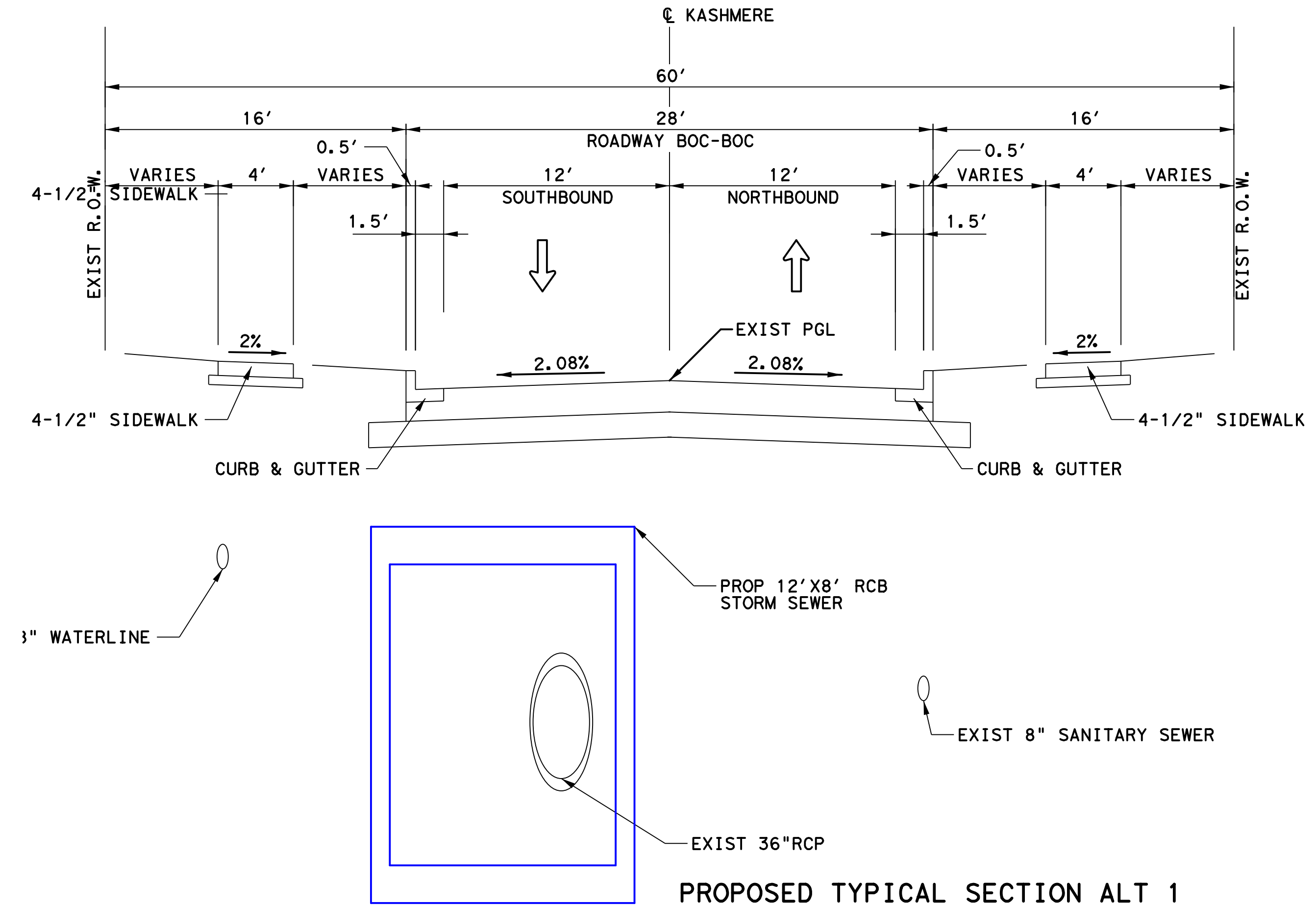
Drainage Improvement P1

WIPPRECHT STREET

(HUNTING BAYOU TO CALVACADE STREET)



EXISTING TYPICAL SECTION



PROPOSED TYPICAL SECTION ALT 1

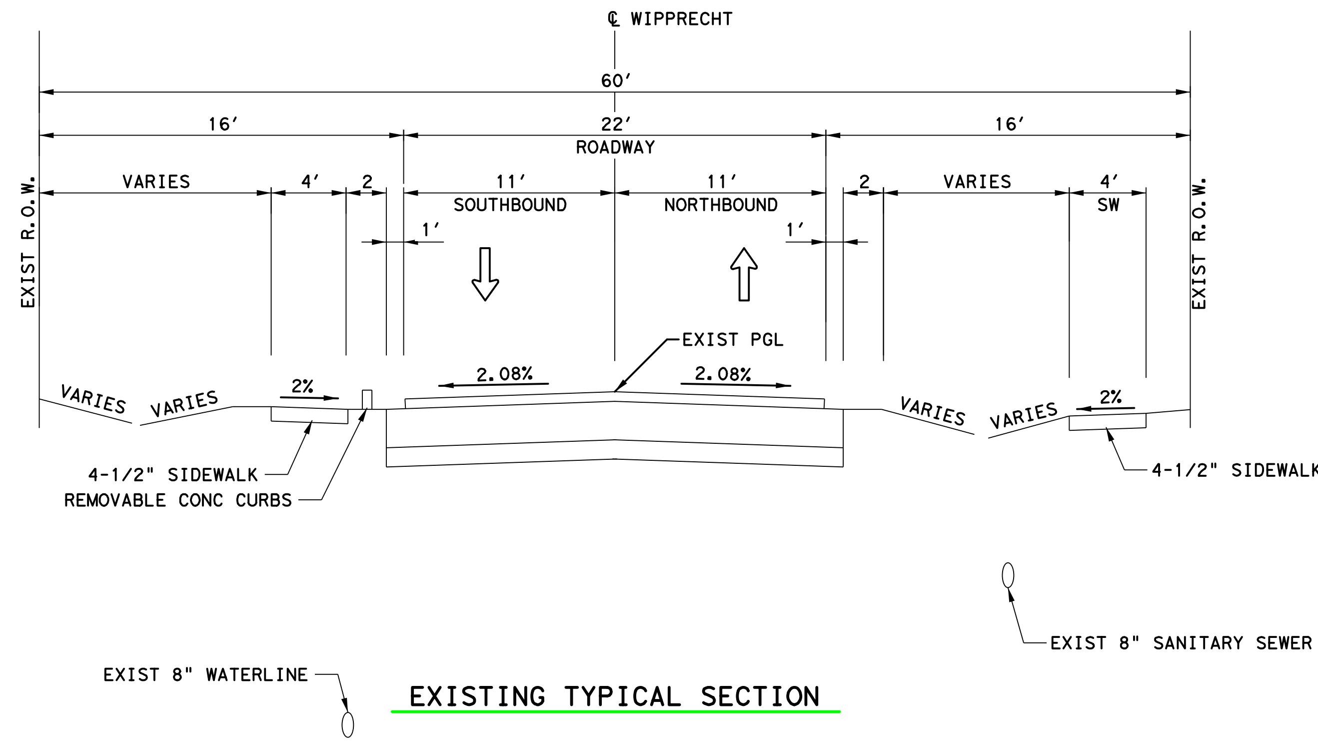
SHEET 1 OF 1

HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	TYPICAL SECTIONS
			6/8/2020	NTS	SECTION 1

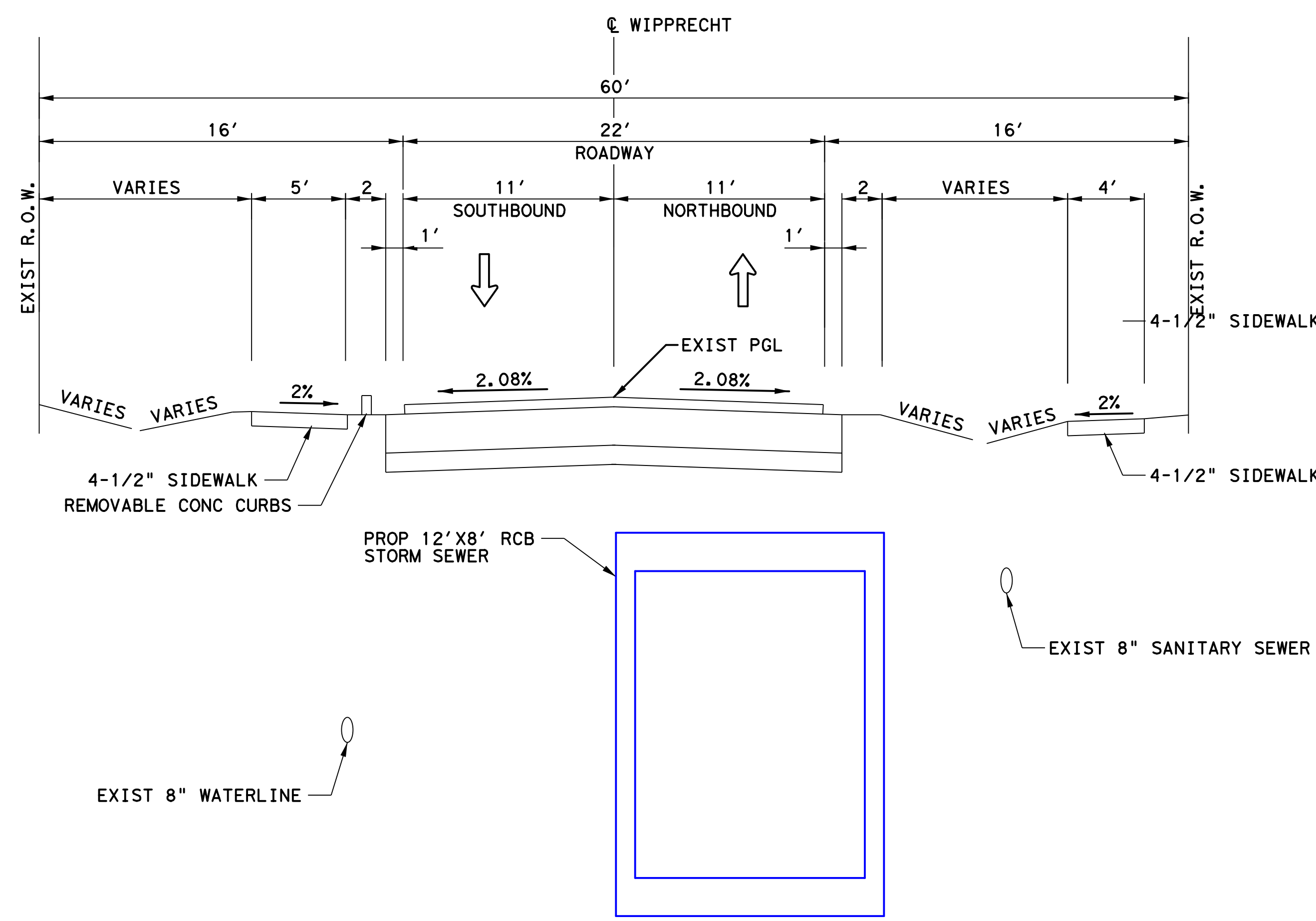
Drainage Improvement P1

WIPPRECHT STREET

(CALVACADE STREET TO COLLINGSWORTH STREET)



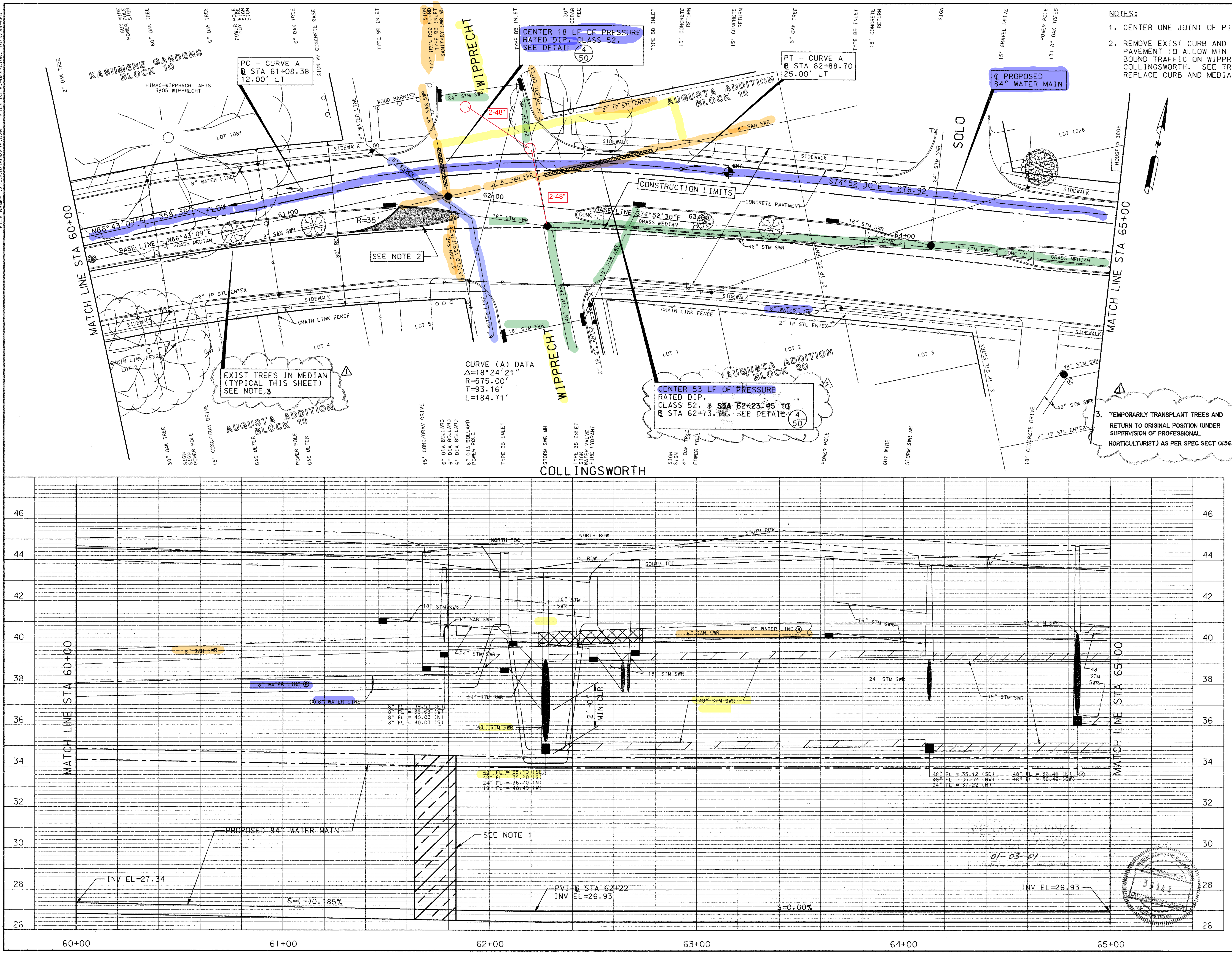
EXISTING TYPICAL SECTION



PROPOSED TYPICAL SECTION ALT 1

SHEET 1 OF 2

HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE 6/8/2020	SCALE NTS	TYPICAL SECTIONS SECTION 2



NOTES:

1. CENTER ONE JOINT OF PIPE UNDER SANITARY CROSSING.
2. REMOVE EXIST CURB AND MEDIAN AND PROVIDE TEMPORARY PAVEMENT TO ALLOW MIN 35' TURNING RADIUS FOR SOUTH BOUND TRAFFIC ON WIPPRECHT TRAVELING WEST ON COLLINGSWORTH. SEE TRAFFIC CONTROL PLANS, SHT 63. REPLACE CURB AND MEDIAN UPON COMPLETION OF THE WORK.

BENCH MARK

TBM 11
"X" CUT IN WEST MEDIAN AT THE INTERSECTION OF COLLINGSWORTH AND SOLO
ELEV = 44.22

TBM 12
"X" CUT IN SIDEWALK AT THE NORTHWEST INTERSECTION OF COLLINGSWORTH AND WIPPRECHT
ELEV = 45.01

No.	Date	Revisions
1	3/8/99	ADDENDUM No. 1
2	3/25/99	ADDENDUM No. 2

PRIVATE UTILITY LINES SHOWN

ENTEX, INC — Diana Hernandez 10/13/98

SOUTHWESTERN BELL TELEPHONE CO — 10-18-98
Valid for One Year Only

HOUSTON LIGHTING & POWER CO — 3-19-98
Approved Only for Crossing Underground Ductlines Unless Noted. Valid At Time of Review Only.

CABLE COMPANY

10-12-98
STATE OF TEXAS — MICHAEL MACHALA 43408 REGISTERED PROFESSIONAL ENGINEER
STATE OF TEXAS — EMMANUEL DE PAU 82627 REGISTERED PROFESSIONAL ENGINEER — 3-25-99 For ADDENDUM No. 1&2 ONLY

Binkley & Barfield, Inc.
Consulting Engineers
1710 Seamist Drive Houston, Texas 77008

Approved
Date
QUALITY CONTROL
Date 10-12-98

Lockwood, Andrews & Newnam, Inc.
1500 CityWest Blvd Houston, Tx 77042
A SUBSIDIARY OF LEO A DALY

Approved
Date 2/3/99
Job No. 0069-20-822-324

SWTP
Surface Water Transmission Program

CONTRACT 2C
COLLINGSWORTH STREET
STA 60+00 TO STA 65+00

FILE NO 9744
GFS NO S-0900-31-3

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
ENGINEERING, CONSTRUCTION, AND REAL ESTATE GROUP

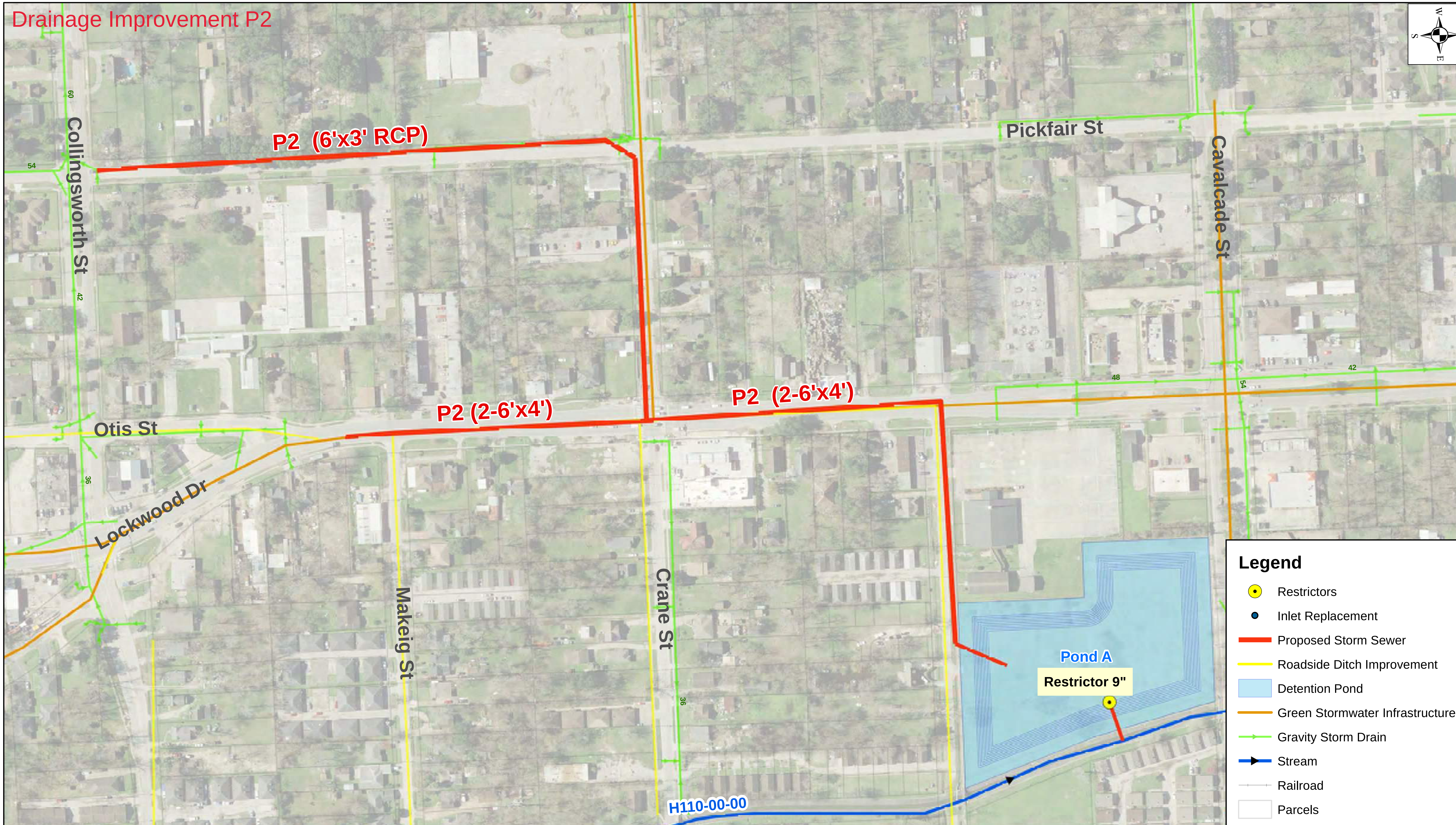
WATER ENGINEERING 2/8/99 — TRAFFIC AND SIGNAL ENGINEERING 2-11-99
WASTEWATER ENGINEERING 2/11/99 — STREET AND BRIDGE ENGINEERING
STORM SEWER ENGINEERING 2/8/99 — CONSTRUCTION
MANAGER, WATER ENGINEERING 2/16/99

OTHER DEPARTMENTS
PLANNING AND DEVELOPMENT — SPONSOR DEPARTMENT
CITY ENGINEER — DATE 2-18-99
DIRECTOR OF PUBLIC WORKS AND ENGINEERING — DATE 2/19/99

SUBMITTED:
SCALE: HORIZ: 1"=20' VERT: 1"=2'
DATE:
DESIGNED BY: WDW
DRAWN BY: RPD
SHEET NO 25 OF 68 SHEETS
SURVEY BY: RBI
FB NO: 215
DWG NO: 35141

RECORD DRAWING DO NOT MODIFY 01-03-01

FILE NAME: 1/75300/DGN/P14.DGN FILE DATE1-OPERATOR: 10/9/98-RPD



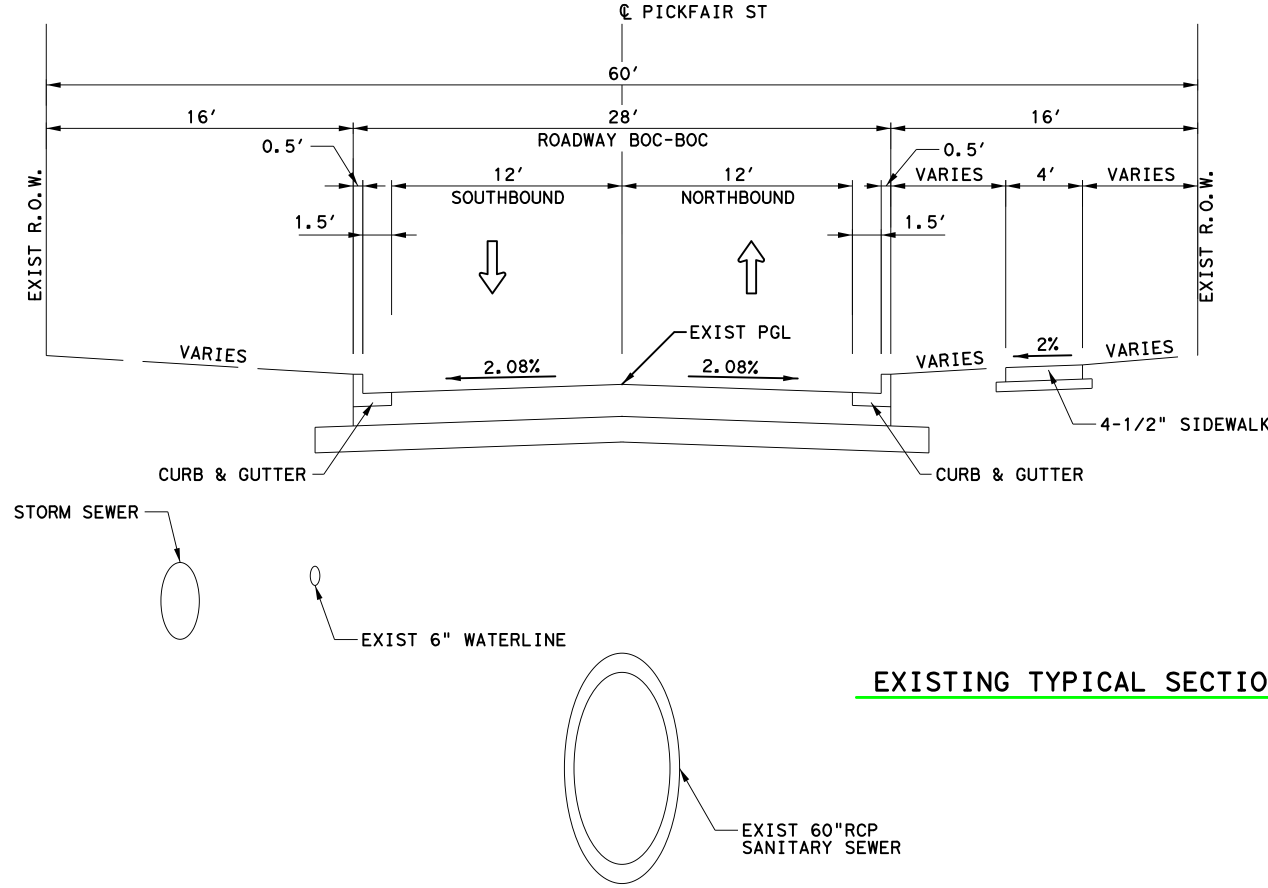
HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 19
			OCTOBER 2020	0 100 200 400 Feet	DRAINAGE IMPROVEMENT P2

Drainage Improvement P2

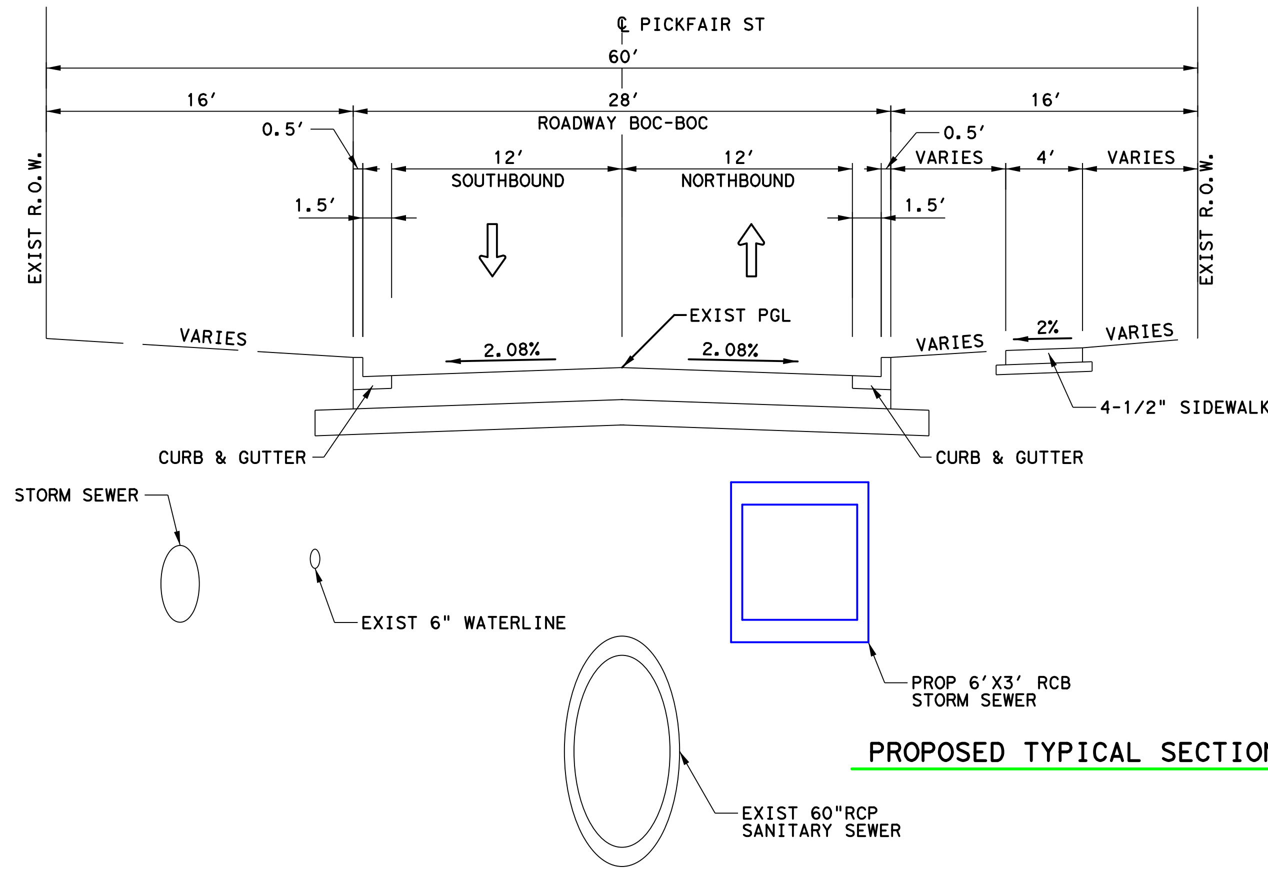
Drainage Improvement P2

PICKFAIR STREET

(CRANE STREET TO COLLINGSWORTH STREET)



EXISTING TYPICAL SECTION



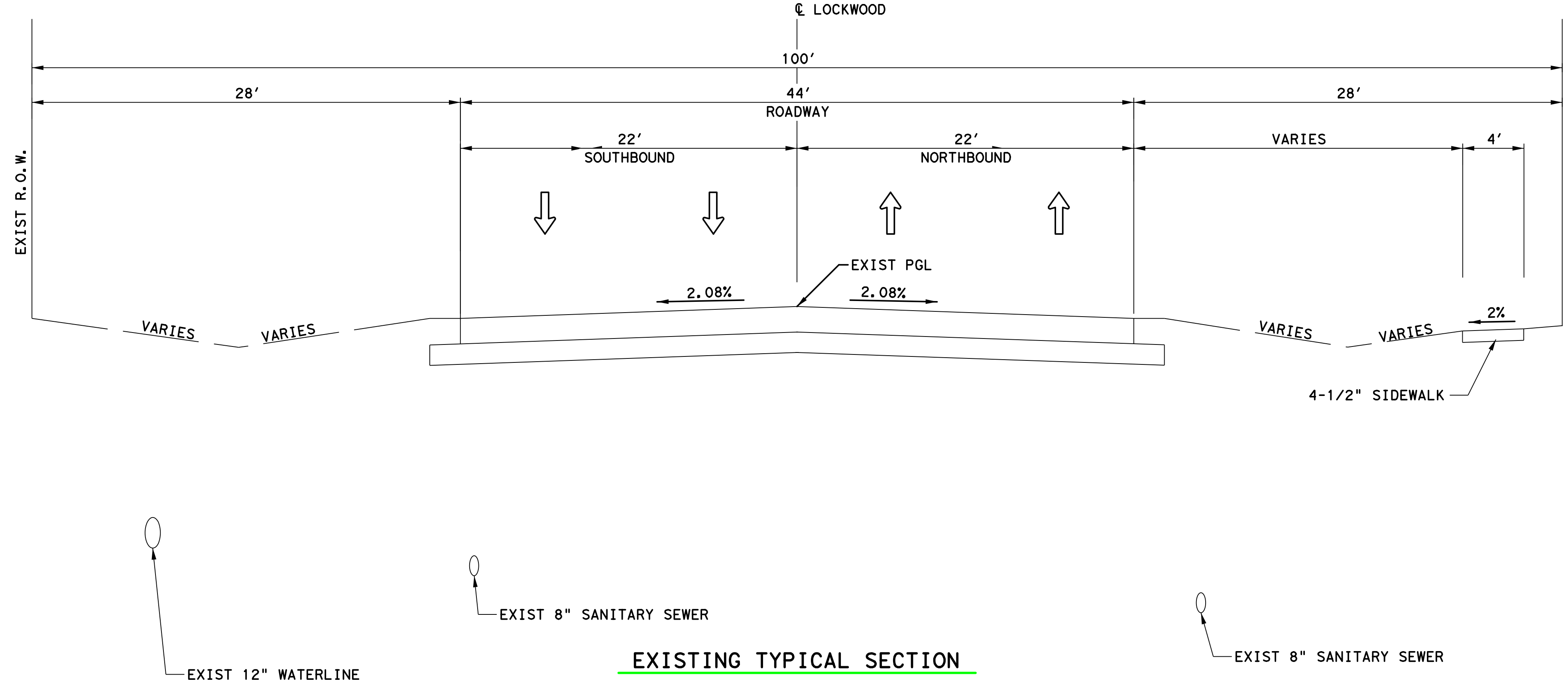
PROPOSED TYPICAL SECTION ALT 1

SHEET 1 OF 1

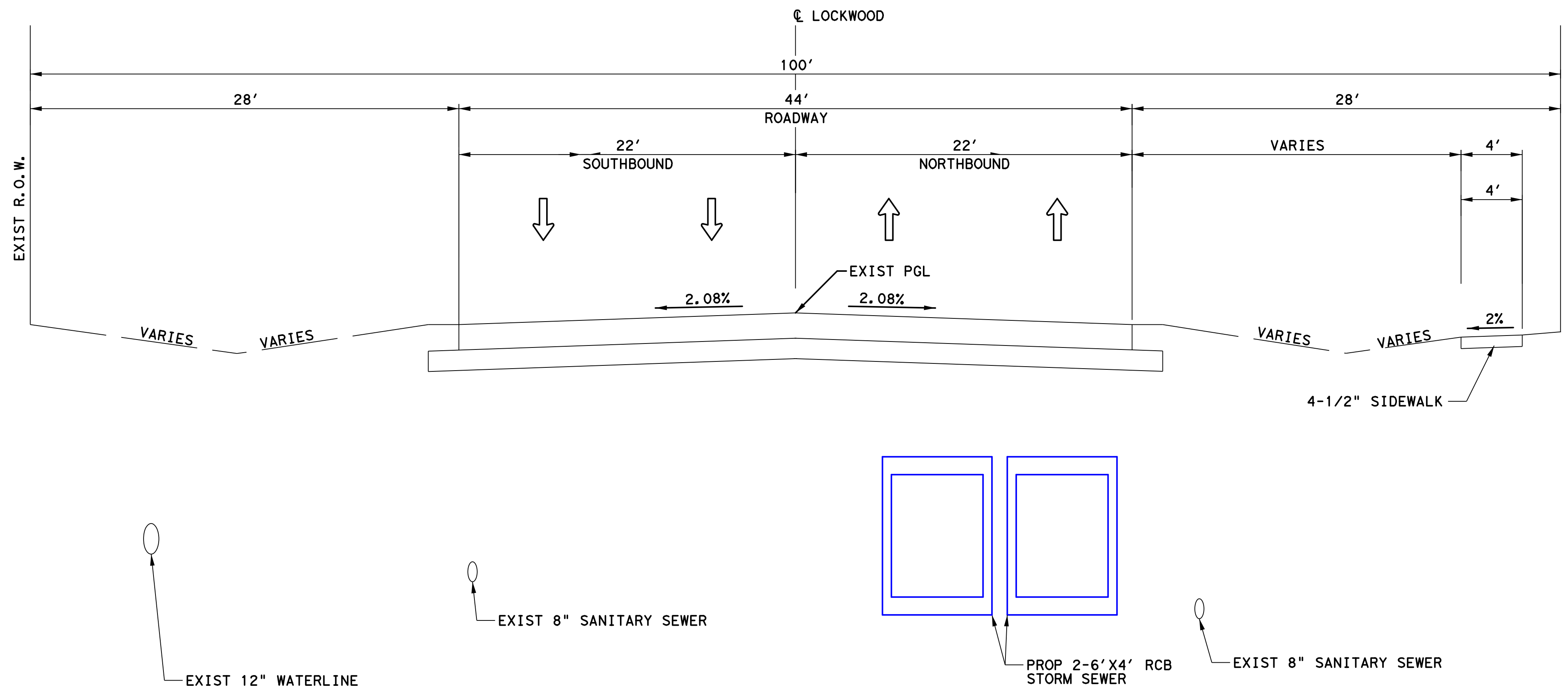
HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	TYPICAL SECTIONS
			6/8/2020	NTS	SECTION 3

Drainage Improvement P2

LOCKWOOD STREET
(CRANE STREET TO MARCUS STREET)

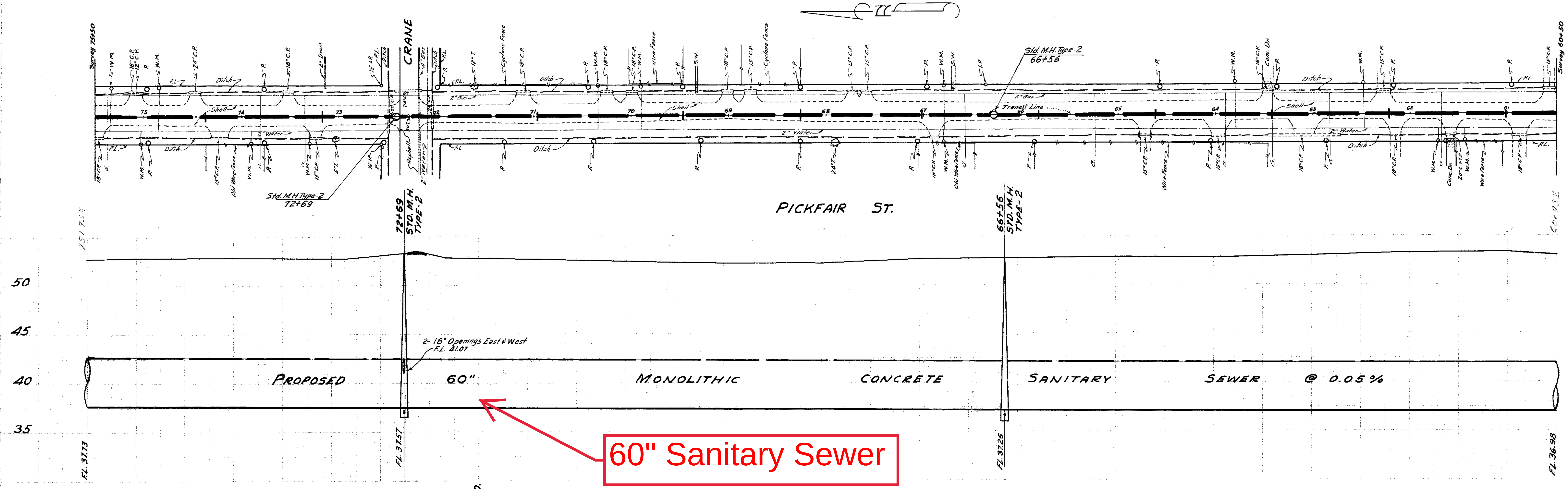


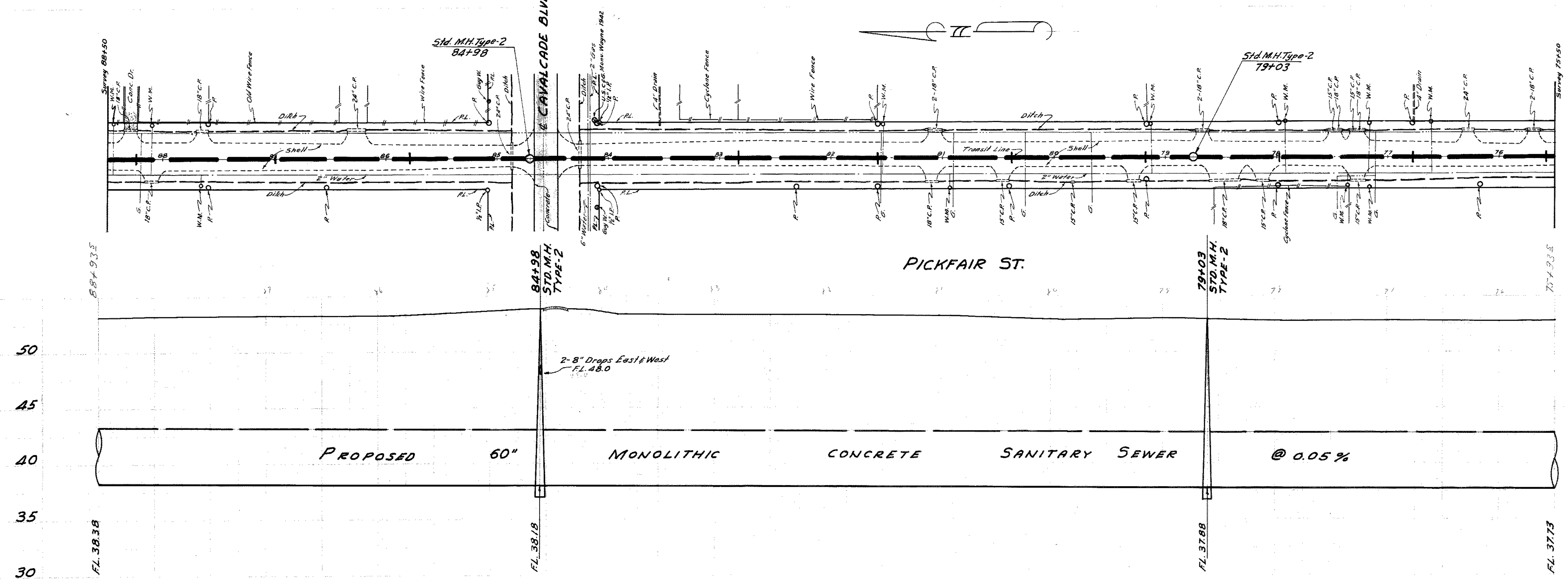
EXISTING TYPICAL SECTION



PROPOSED TYPICAL SECTION ALT 1

HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE 6/8/2020	SCALE NTS	TYPICAL SECTIONS SECTION 4

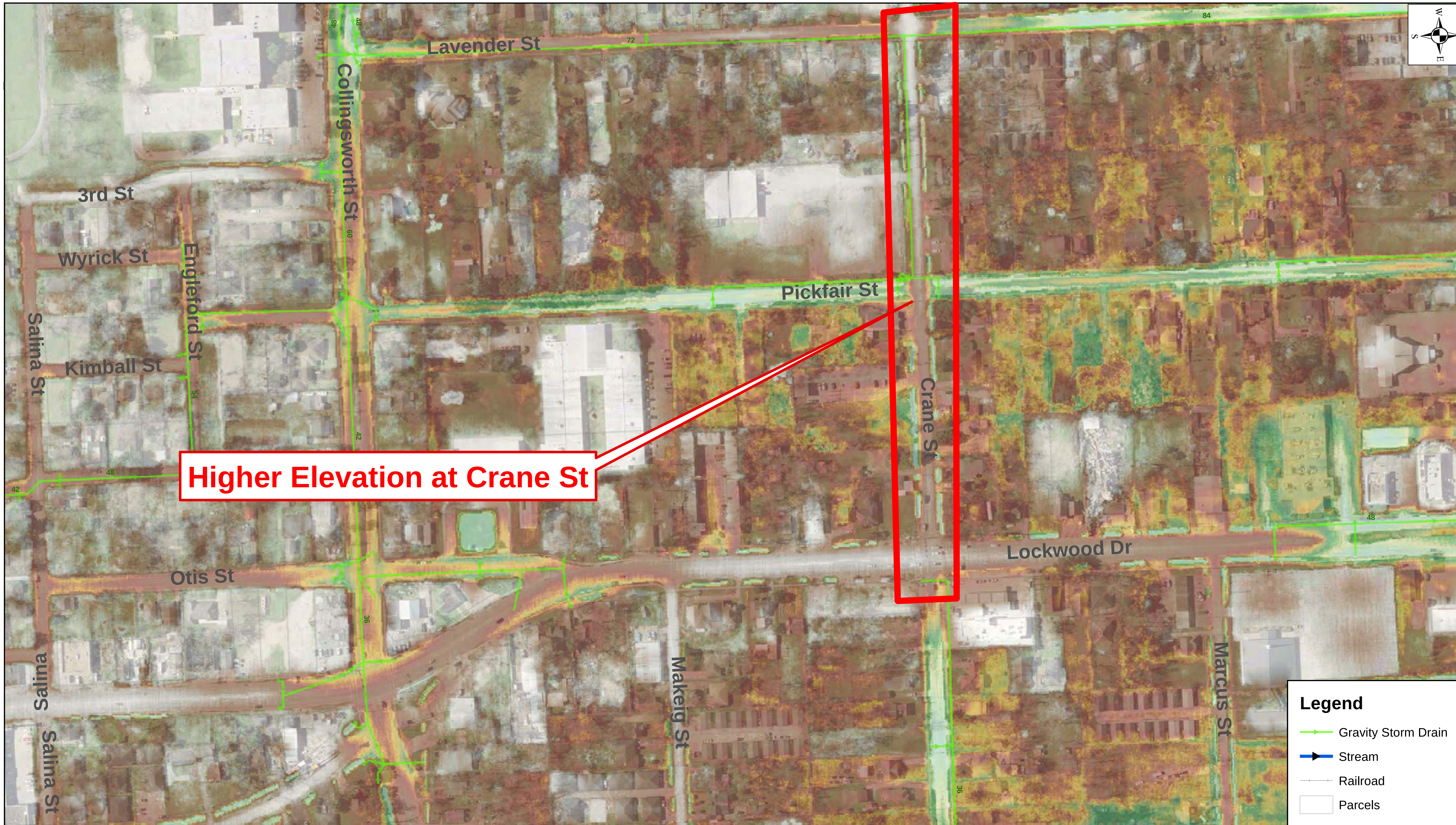




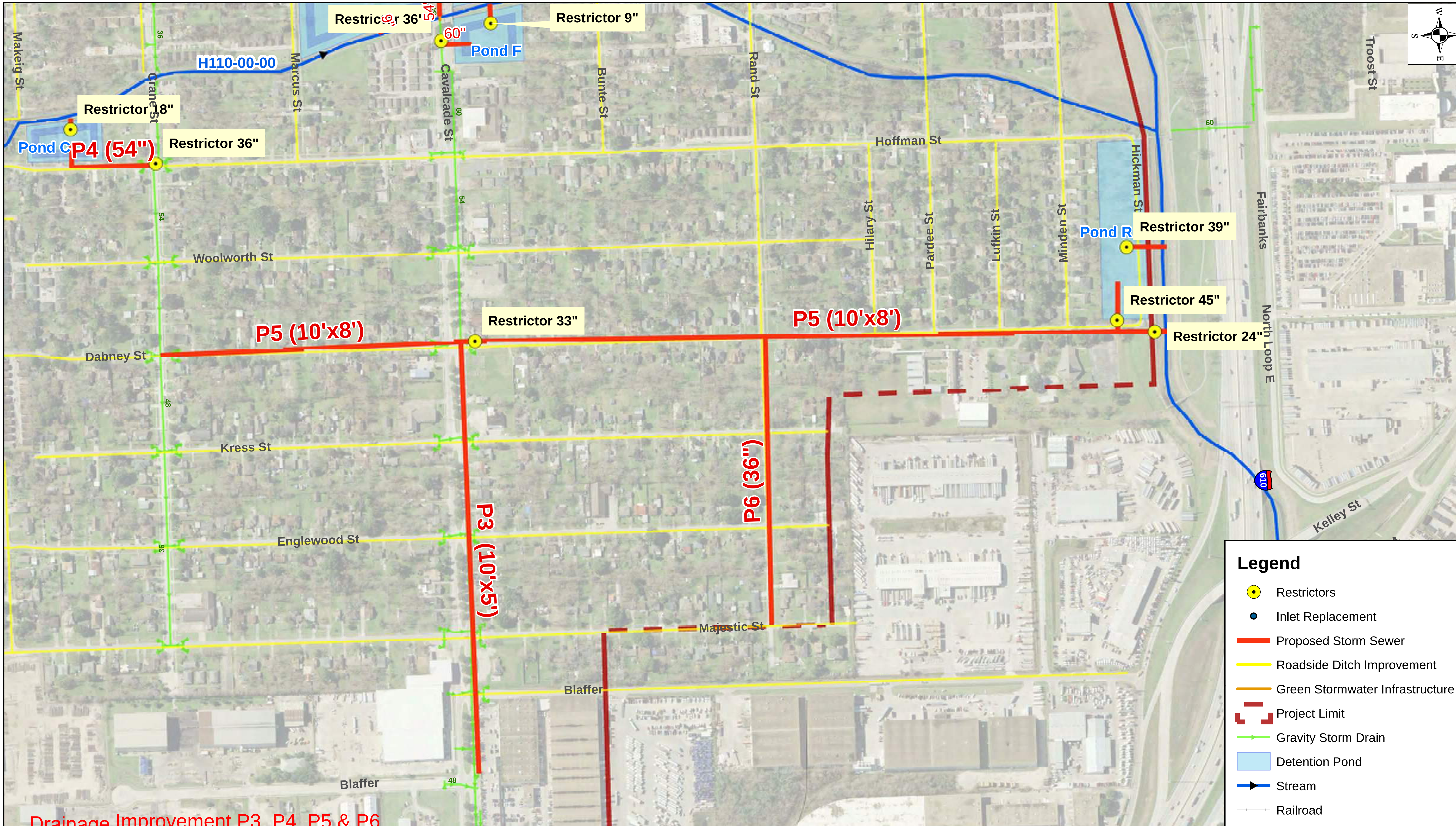
APPROVED FOR:
STORM SEWER SECTION:
SANITARY SEWER SECTION:
PAVING SECTION:
WATER DIVISION: 2-22-52
CHIEF DESIGN ENGINEER:

PROPOSED SANITARY SEWER TRUNK LINE VIA CUSHING, SALINA, KIMBALL AND PICKFAIR, FROM LIBERTY RD. TO PARDEE.

Horiz. 1" = 50' Vert. 1" = 5'
12-13-51
MEECE
B-1495
A.G. SAGARNAGA
3 4
9904



HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 19
			OCTOBER 2020	0 100 200 400 Feet	Higher Elevation at Crane Street



HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	DATE OCTOBER 2020	SCALE 0 125 250 500 Feet	EXHIBIT 20 DRAINAGE IMPROVEMENT P3, P4, P5 & P6

Drainage Improvement P3

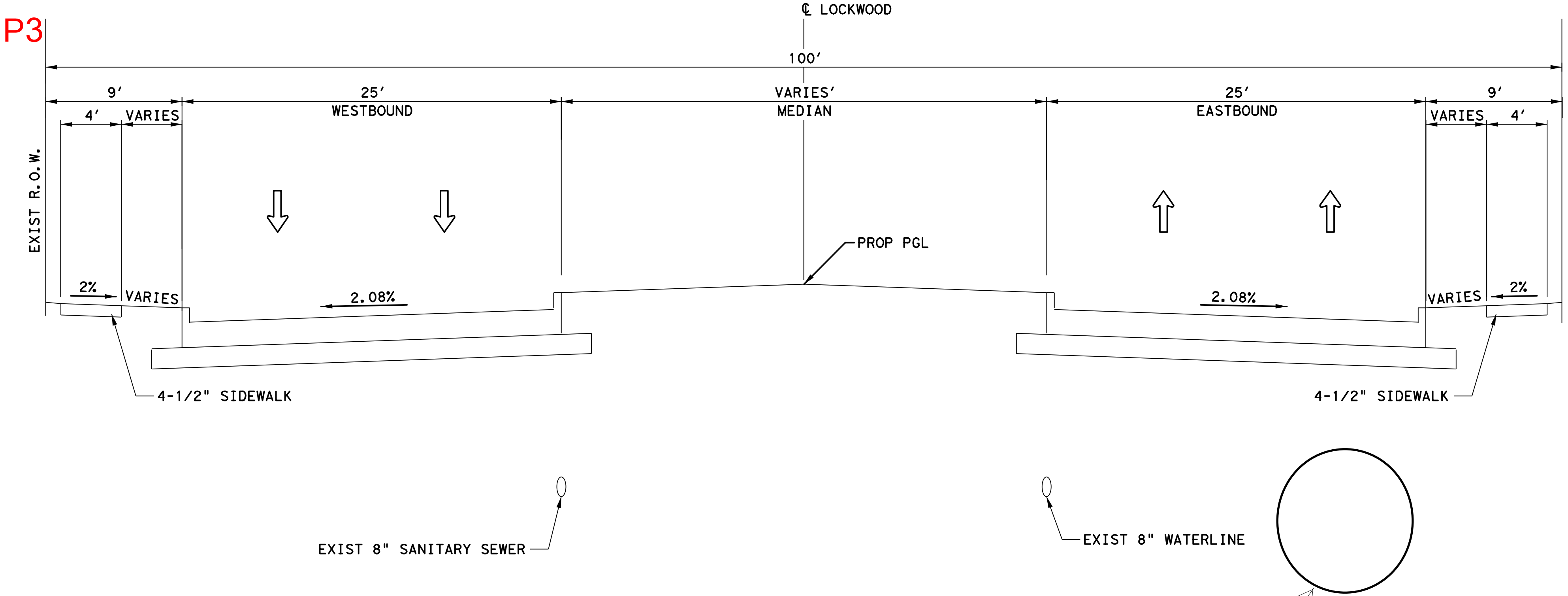

Drainage Improvement P5
KRESS ST
CAVALCADE ST
CRANE ST
DABNEY ST
PROPOSED 10'x5' RCB
PROPOSED 10'x8' RCB
PROPOSED 10'x8' RCB

Drainage Improvement P5

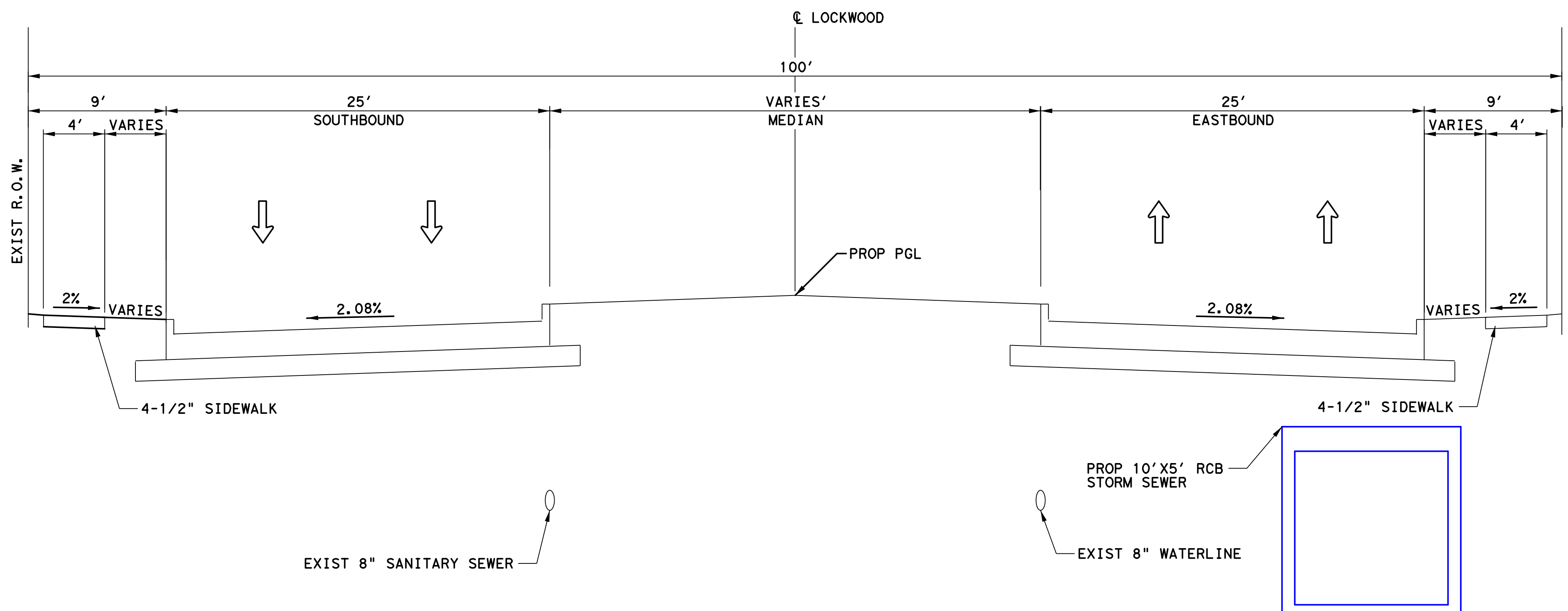
HILARY ST
Drainage Improvement P6
KRESS ST
RAND ST
DABNEY ST
PROPOSED 36'' RCP
ENGLEWOOD ST
MAJESTIC ST
BLAFFER ST
PROPOSED 10'x8' RCB

Drainage Improvement P3

CALVACADE STREET
(DABNEY STREET TO BLAFFER STREET)



EXISTING TYPICAL SECTION



PROPOSED TYPICAL SECTION ALT 1

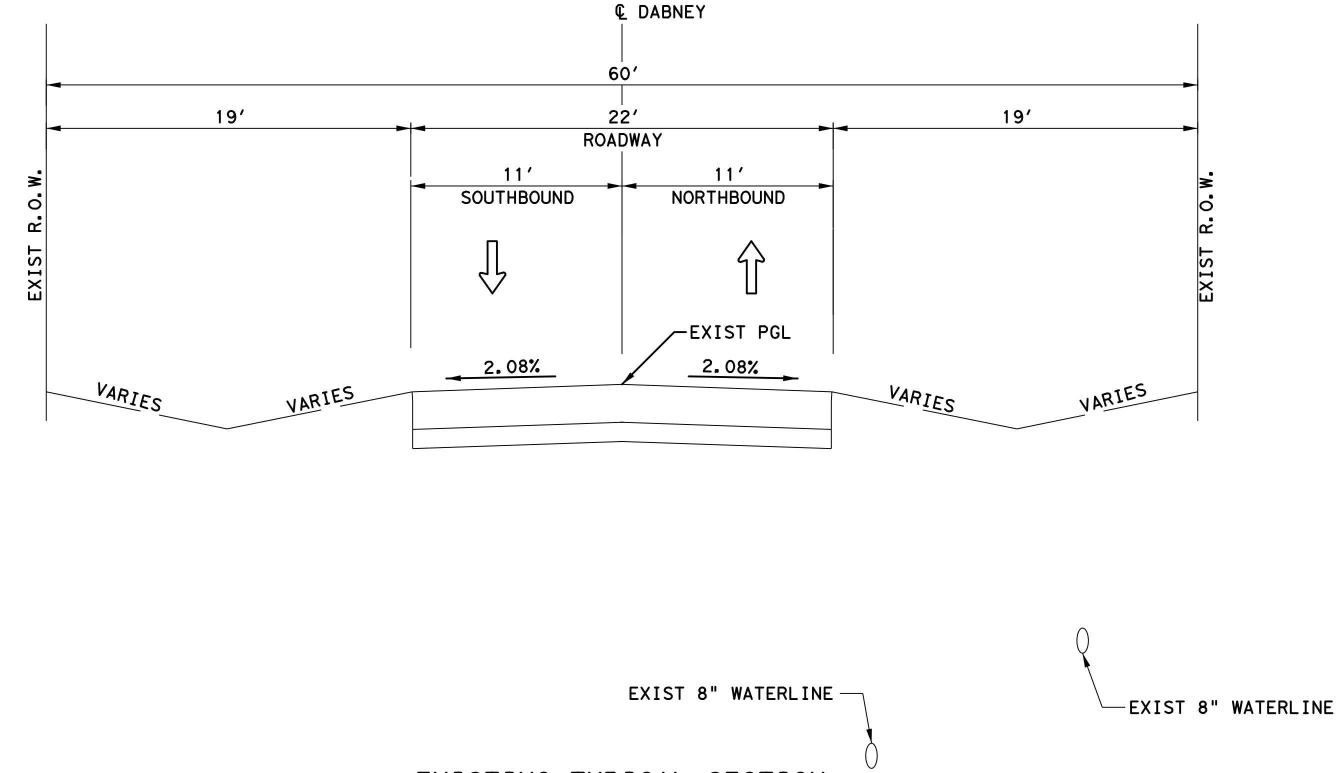
SHEET 1 OF 1

HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	TYPICAL SECTIONS
			6/8/2020	NTS	SECTION 6

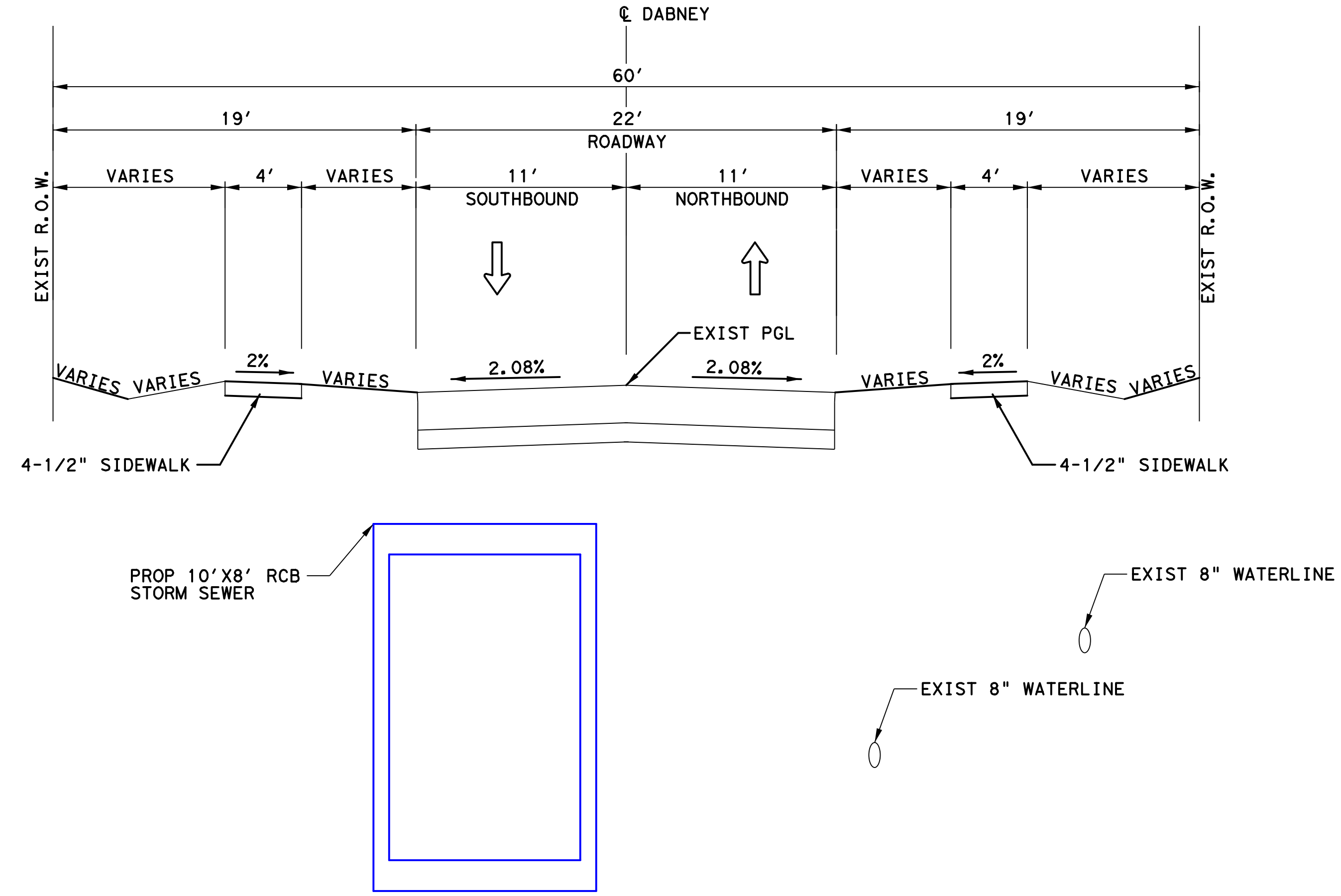
Drainage Improvement P5

DABNEY STREET

(CRANE STREET TO HUNTING BAYOU)



EXISTING TYPICAL SECTION



PROPOSED TYPICAL SECTION ALT 1

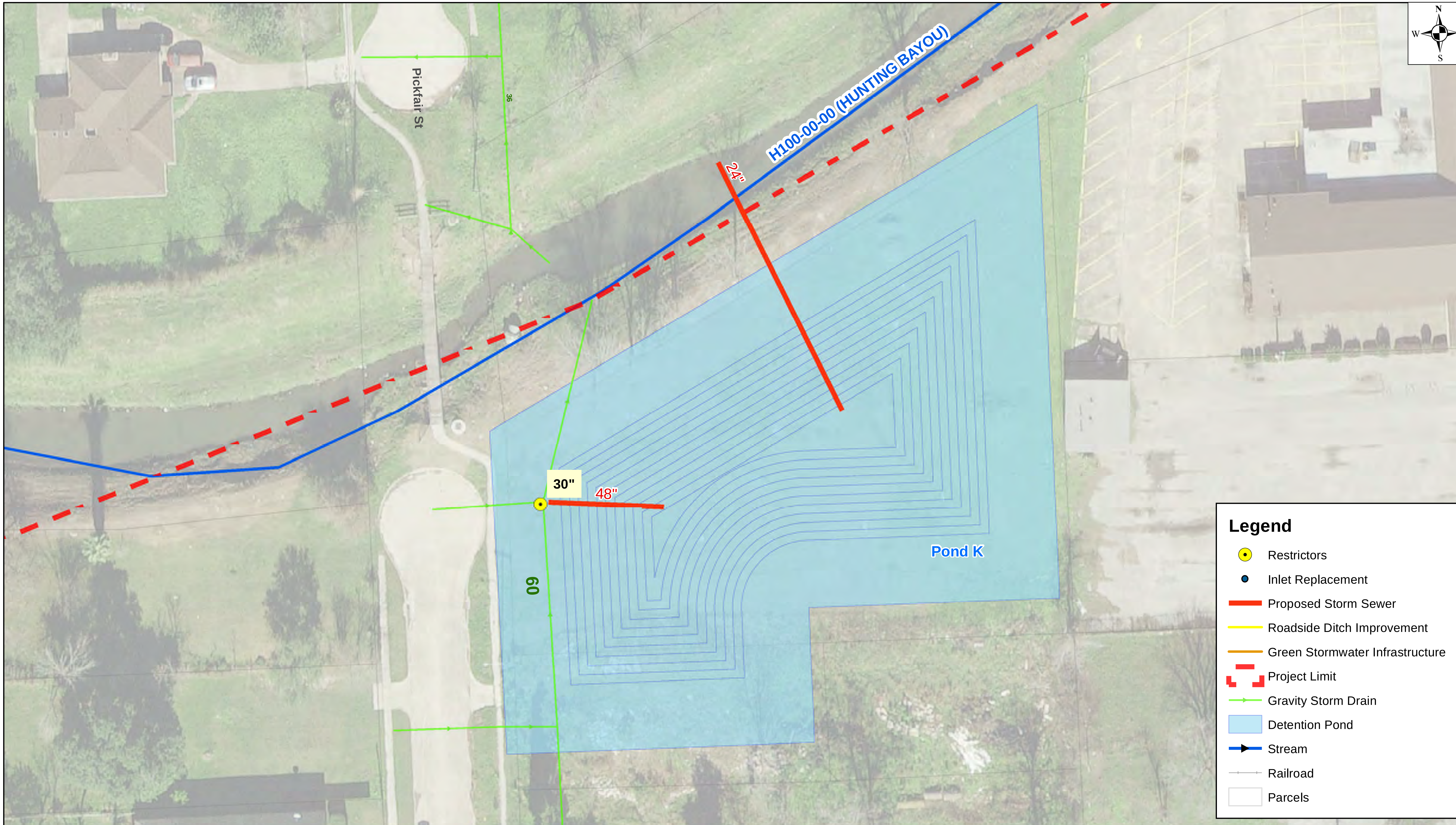
SHEET 1 OF 2

HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE 6/8/2020	SCALE NTS	TYPICAL SECTIONS SECTION 7

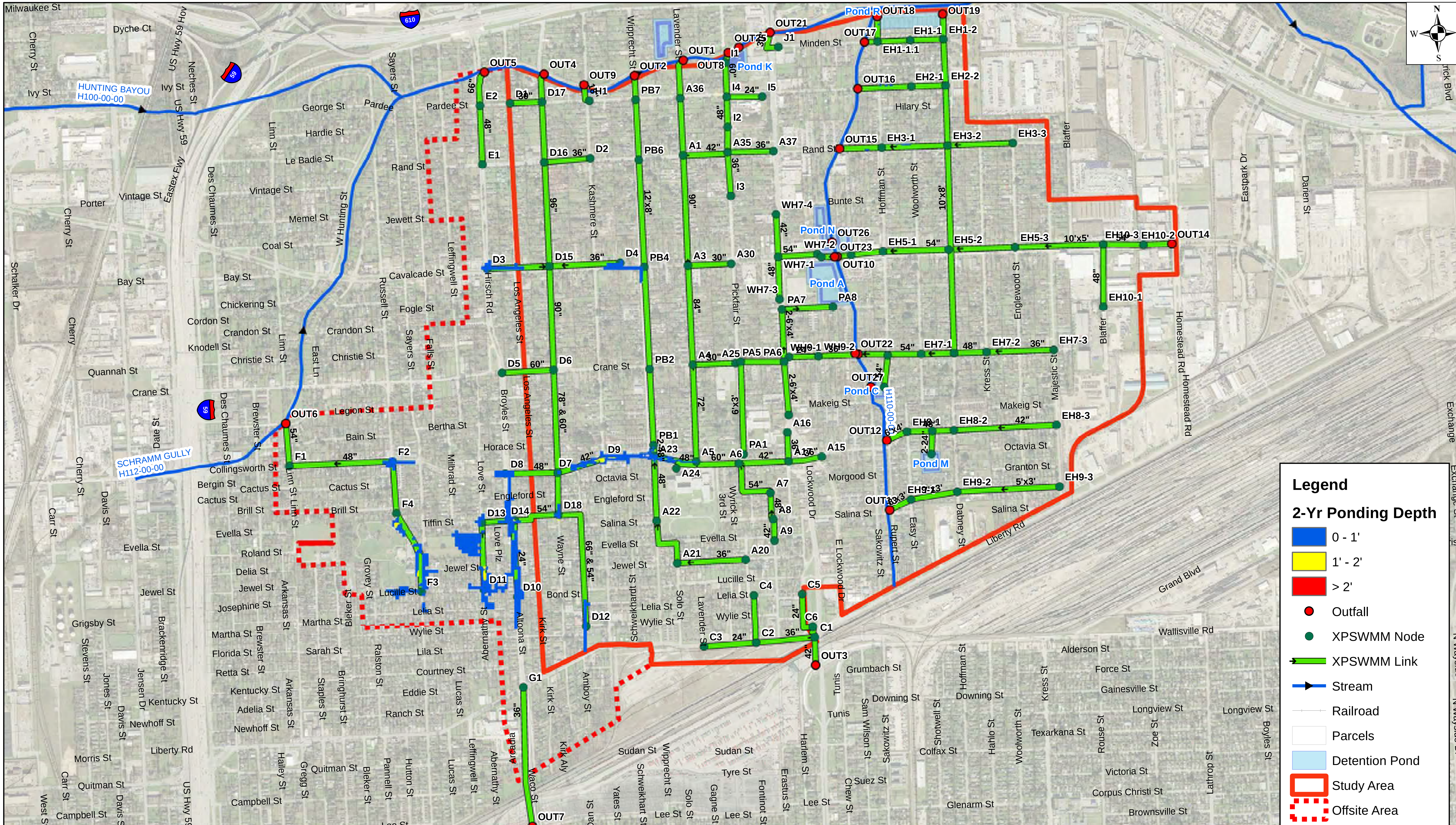
HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 21
			OCTOBER 2020	0 50 100 200 Feet	DRAINAGE IMPROVEMENT DETENTION POND Q

HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 22
			OCTOBER 2020	0 25 50 100 Feet	DRAINAGE IMPROVEMENT DETENTION POND N

HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE OCTOBER 2020	SCALE 0 25 50 100 Feet	EXHIBIT 23 DRAINAGE IMPROVEMENT DETENTION POND M



HUITT-ZOLLARS HUITT-ZOLLARS, INC. Firm No. F-761 10350 Richmond Avenue, Suite 300 Houston, TX 77042 Phone 281.496.0066 Fax 713.496.0220	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)	CITY OF HOUSTON TEXAS	DATE	SCALE	EXHIBIT 24
			OCTOBER 2020	0 12.5 25 50 Feet	DRAINAGE IMPROVEMENT DETENTION POND K



HUITT-ZOLLARS

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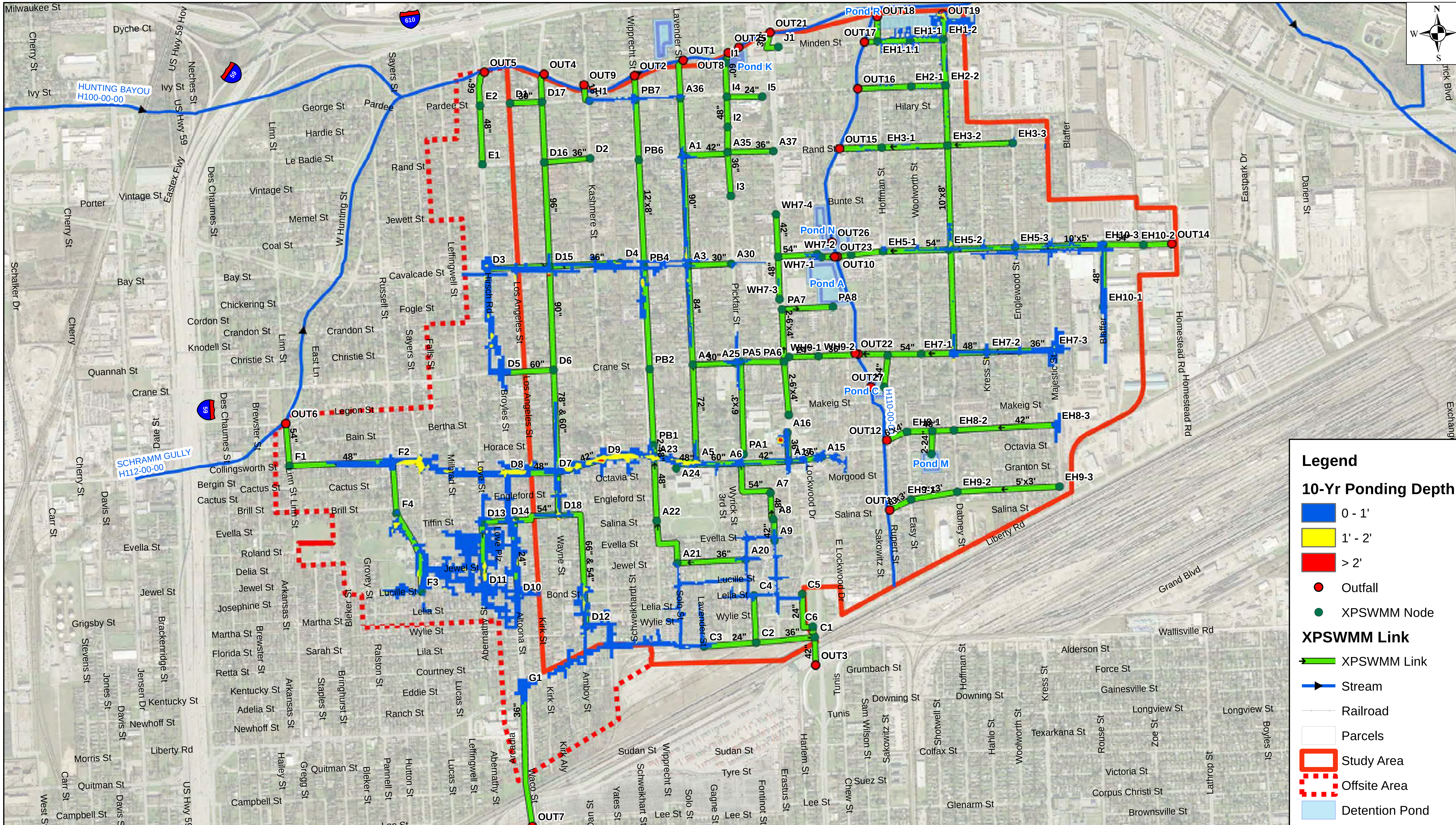
PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 25
OCTOBER 2020	0 500 1,000 2,000 Feet	2-YR PONDING DEPTH PROPOSED CONDITION



PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

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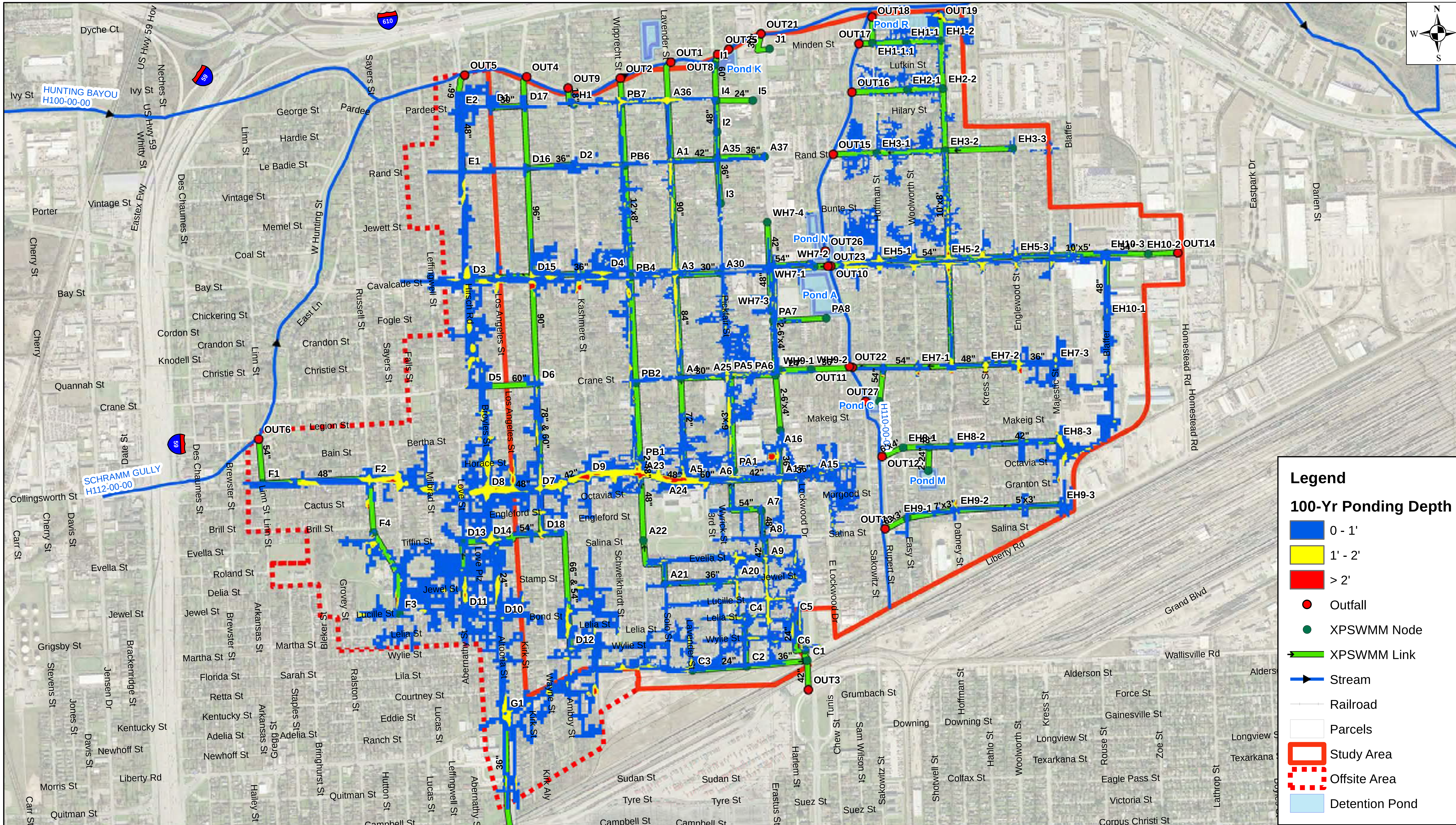
CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 26
OCTOBER 2020	0 500 1,000 2,000 Feet	10-YR PONDING DEPTH PROPOSED CONDITION



HUITT-ZOLLARS

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10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 27
OCTOBER 2020	0 500 1,000 2,000 Feet	100-YR PONDING DEPTH PROPOSED CONDITION

Attachment

Probable Construction Cost Estimate

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

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

Applicant/Subrecipient:	City of Houston					
Site/Activity Title:	Houston Kashmere Gardens Flood Mitigation					
Eligible Activity:	Flood control and drainage improvements					
Materials/Facilities/Services	**$/Unit**	**Unit**	**Quantity**	**Construction**	**Acquisition**	**Total**
Wipprecht Street (Collingsworth Street to Hunting Bayou - P1)						
Mobilization	$ 800,000.00	LS	1	$ 800,000.00	$ -	$ 800,000.00
Traffic Control & Regulation	$ 350,000.00	LS	1	$ 350,000.00	$ -	$ 350,000.00
SWPPP	$ 120,000.00	LS	1	$ 120,000.00	$ -	$ 120,000.00
Tree Mitigation	$ 65,000.00	LS	1	$ 65,000.00	$ -	$ 65,000.00
Adjusting Manholes, inlets, and valve boxes to grade	$ 750.00	EA	14	$ 10,500.00	$ -	$ 10,500.00
Service stubs or reconnections with or without stack on sanitary sewer	$ 70.00	LF	1855	$ 129,850.00	$ -	$ 129,850.00
48-Inch Diameter Manhole for RCB	$ 4,200.00	EA	16	$ 67,200.00	$ -	$ 67,200.00
Remove and Dispose Manholes all Sizes/Depth	$ 900.00	EA	11	$ 9,900.00	$ -	$ 9,900.00
Adjust Manhole Frame and Cover to New Grade	$ 750.00	EA	2	$ 1,500.00	$ -	$ 1,500.00
Remove and Dispose Inlets all Sizes/Depth	$ 600.00	EA	16	$ 9,600.00	$ -	$ 9,600.00
Remove and Dispose Culvert 12" to 18"	$ 12.00	LF	555	$ 6,657.60	$ -	$ 6,657.60
Remove and Dispose Storm Pipe 24-Inch Diameter	$ 12.00	LF	851	$ 10,212.00	$ -	$ 10,212.00
Remove and Dispose Storm Pipe 30-Inch Diameter	$ 14.00	LF	406	$ 5,684.00	$ -	$ 5,684.00
Remove and Dispose Storm Pipe 36-Inch Diameter	$ 16.00	LF	1720	$ 27,520.00	$ -	$ 27,520.00
Remove and Dispose Storm Pipe 42-Inch Diameter	$ 18.00	LF	303	$ 5,454.00	$ -	$ 5,454.00
Trench Safety System for Storm Sewer Trench Excavation	$ 5.00	LF	5042	$ 25,210.00	$ -	$ 25,210.00
Junction Box	$ 18,000.00	EA	4	$ 72,000.00	$ -	$ 72,000.00
24-inch Diameter Storm Sewer by open cut	$ 85.00	LF	482	$ 40,970.00	$ -	$ 40,970.00
12' x 8' RCB	$ 1,220.00	LF	4560	$ 5,563,200.00	$ -	$ 5,563,200.00
Type "BB" Inlet	$ 3,800.00	EA	32	$ 121,600.00	$ -	$ 121,600.00
Remove/Dispose Pavement with Base 12 inch Thick	$ 7.00	SY	15763	$ 110,344.11	$ -	$ 110,344.11
Excavation & Haul off	$ 15.00	CY	6800	$ 102,000.00	$ -	$ 102,000.00
Lime Stabilized Subgrade 8-inch Thick	$ 4.00	SY	15763	$ 63,053.78	$ -	$ 63,053.78
Lime for Lime Stabilized Subgrade (Dry Weight)	$ 150.00	TON	284	$ 42,561.30	$ -	$ 42,561.30
Reinforced Concrete Pavement 11-inch Thick	$ 70.00	SY	15763	$ 1,103,441.11	$ -	$ 1,103,441.11
Concrete Driveways Including Excavation 6-inch Thick	$ 10.00	SF	5500	$ 55,000.00	$ -	$ 55,000.00
6-Inch Concrete Curb (Monolithic)	$ 18.00	LF	9795	$ 176,310.00	$ -	$ 176,310.00
Sidewalk 4-1/2-Inch Thick	$ 6.50	SF	39278	$ 255,307.00	$ -	$ 255,307.00
Wheelchair Ramps and Sidewalks, Complete in Place	$ 20.00	SF	120	$ 2,400.00	$ -	$ 2,400.00
8-Inch Diameter Water Line by Open-Cut with Restrained Joints	$ 110.00	LF	61	$ 6,710.00	$ -	$ 6,710.00
6-Inch Diameter Water Line by Open-Cut with Restrained Joints	$ 80.00	LF	67	$ 5,360.00	$ -	$ 5,360.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$ 900.00	EA	54	$ 48,600.00	$ -	$ 48,600.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$ 1,250.00	EA	50	$ 62,500.00	$ -	$ 62,500.00
Marcus Street (Lockwood Drive to Channel H110-00-00 - P2)						
Mobilization	$ 100,000.00	LS	1	$ 100,000.00	$ -	$ 100,000.00
Traffic Control & Regulation	$ 45,000.00	LS	1	$ 45,000.00	$ -	$ 45,000.00
SWPPP	$ 15,000.00	LS	1	$ 15,000.00	$ -	$ 15,000.00
Tree Mitigation	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
Adjusting Manholes, inlets, and valve boxes to grade	$ 750.00	EA	1	$ 750.00	$ -	$ 750.00
Service stubs or reconnections with or without stack on sanitary sewer	$ 70.00	LF	180	$ 12,600.00	$ -	$ 12,600.00
Type C Manhole for 48-Inch Diameter Sewers	$ 15,000.00	EA	1	$ 15,000.00	$ -	$ 15,000.00
Junction Box	$ 18,000.00	EA	1	$ 18,000.00	$ -	$ 18,000.00
24-inch Diameter Storm Sewer by open cut	$ 85.00	LF	30	$ 2,550.00	$ -	$ 2,550.00
6' x 4' RCB	$ 580.00	LF	1048	$ 607,840.00	$ -	$ 607,840.00
Type "BB" Inlet	$ 3,800.00	EA	2	$ 7,600.00	$ -	$ 7,600.00
Remove/Dispose Conc Driveway 6-inch Thick/More	$ 3.00	SY	472	$ 1,416.63	$ -	$ 1,416.63
Remove/Dispose Pavement with Base 12 inch Thick	$ 7.00	SY	2044	$ 14,308.17	$ -	$ 14,308.17
Excavation & Haul off	$ 15.00	CY	1150	$ 17,250.00	$ -	$ 17,250.00
Lime Stabilized Subgrade 8-inch Thick	$ 4.00	SY	2044	$ 8,176.10	$ -	$ 8,176.10
Lime for Lime Stabilized Subgrade (Dry Weight)	$ 150.00	TON	37	$ 5,518.87	$ -	$ 5,518.87

Reinforced Concrete Pavement 11-inch Thick	$ 70.00	SY	2044	$ 143,081.70	$ -	$ 143,081.70
Concrete Driveways Including Excavation 6-inch Thick	$ 10.00	SF	4250	$ 42,498.89	$ -	$ 42,498.89
6-Inch Concrete Curb (Monolithic)	$ 18.00	LF	1510	$ 27,179.42	$ -	$ 27,179.42
Sidewalk 4-1/2-Inch Thick	$ 6.50	SF	7450	$ 48,426.96	$ -	$ 48,426.96
Wheelchair Ramps and Sidewalks, Complete in Place	$ 20.00	SF	80	$ 1,600.00	$ -	$ 1,600.00
8-Inch Diameter Water Line by Open-Cut with Restrained Joints	$ 110.00	LF	88	$ 9,680.00	$ -	$ 9,680.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$ 900.00	EA	7	$ 6,300.00	$ -	$ 6,300.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$ 1,250.00	EA	7	$ 8,750.00	$ -	$ 8,750.00
Fire Hydrant Assembly, All Depths, Including 6-Inch Diameter Gate Valve and Box	$ 10,000.00	EA	1	$ 10,000.00	$ -	$ 10,000.00
Lockwood Drive (Crane Street to Marcus Street - P2)						
Mobilization	$ 320,000.00	LS	1	$ 320,000.00	$ -	$ 320,000.00
Traffic Control & Regulation	$ 180,000.00	LS	1	$ 180,000.00	$ -	$ 180,000.00
SWPPP	$ 65,000.00	LS	1	$ 65,000.00	$ -	$ 65,000.00
Tree Mitigation	$ 36,000.00	LS	1	$ 36,000.00	$ -	$ 36,000.00
Adjusting Manholes, inlets, and valve boxes to grade	$ 750.00	EA	12	$ 9,000.00	$ -	$ 9,000.00
Type C Manhole for 48-Inch Diameter Sewers	$ 15,000.00	EA	4	$ 60,000.00	$ -	$ 60,000.00
Remove and Dispose Manholes all Sizes/Depth	$ 900.00	EA	6	$ 5,400.00	$ -	$ 5,400.00
Adjust Manhole Frame and Cover to New Grade	$ 750.00	EA	2	$ 1,500.00	$ -	$ 1,500.00
Remove and Dispose Inlets all Sizes/Depth	$ 600.00	EA	10	$ 6,000.00	$ -	$ 6,000.00
Remove and Dispose Storm Pipe 24-Inch Diameter	$ 12.00	LF	1011	$ 12,132.00	$ -	$ 12,132.00
Junction Box	$ 18,000.00	EA	3	$ 54,000.00	$ -	$ 54,000.00
24-inch Diameter Storm Sewer by open cut	$ 85.00	LF	820	$ 69,700.00	$ -	$ 69,700.00
6' x 4' RCB	$ 580.00	LF	2338	$ 1,356,040.00	$ -	$ 1,356,040.00
Type "BB" Inlet	$ 3,800.00	EA	16	$ 60,800.00	$ -	$ 60,800.00
Remove/Dispose Conc Driveway 6-inch Thick/More	$ 3.00	SY	881	$ 2,643.51	$ -	$ 2,643.51
Remove/Dispose Pavement with Base 12 inch Thick	$ 7.00	SY	13500	$ 94,499.84	$ -	$ 94,499.84
Excavation & Haul off	$ 15.00	CY	1250	$ 18,750.00	$ -	$ 18,750.00
Lime Stabilized Subgrade 8-inch Thick	$ 4.00	SY	13500	$ 53,999.91	$ -	$ 53,999.91
Lime for Lime Stabilized Subgrade (Dry Weight)	$ 150.00	TON	243	$ 36,449.94	$ -	$ 36,449.94
Reinforced Concrete Pavement 11-inch Thick	$ 70.00	SY	13500	$ 944,998.40	$ -	$ 944,998.40
Concrete Driveways Including Excavation 6-inch Thick	$ 10.00	SF	7931	$ 79,305.35	$ -	$ 79,305.35
6-Inch Concrete Curb (Monolithic)	$ 18.00	LF	9167	$ 165,001.19	$ -	$ 165,001.19
Sidewalk 4-1/2-Inch Thick	$ 6.50	SF	17581	$ 114,277.52	$ -	$ 114,277.52
Wheelchair Ramps and Sidewalks, Complete in Place	$ 20.00	SF	160	$ 3,200.00	$ -	$ 3,200.00
12-Inch Diameter Water Line by Open-Cut	$ 140.00	LF	132	$ 18,480.00	$ -	$ 18,480.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$ 900.00	EA	18	$ 16,200.00	$ -	$ 16,200.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$ 1,250.00	EA	20	$ 25,000.00	$ -	$ 25,000.00
Fire Hydrant Assembly, All Depths, Including 6-Inch Diameter Gate Valve and Box	$ 10,000.00	EA	4	$ 40,000.00	$ -	$ 40,000.00
Crane Street (Pickfair Street to Lockwood Drive - P2)						
Mobilization	$ 65,000.00	LS	1	$ 65,000.00	$ -	$ 65,000.00
Traffic Control & Regulation	$ 34,000.00	LS	1	$ 34,000.00	$ -	$ 34,000.00
SWPPP	$ 11,000.00	LS	1	$ 11,000.00	$ -	$ 11,000.00
Tree Mitigation	$ 6,500.00	LS	1	$ 6,500.00	$ -	$ 6,500.00
Adjusting Manholes, inlets, and valve boxes to grade	$ 750.00	EA	1	$ 750.00	$ -	$ 750.00
Service stubs or reconnections with or without stack on sanitary sewer	$ 70.00	LF	210	$ 14,700.00	$ -	$ 14,700.00
6' x 3' RCB	$ 520.00	LF	380	$ 197,600.00	$ -	$ 197,600.00
Remove/Dispose Conc Driveway 6-inch Thick/More	$ 3.00	SY	537	$ 1,612.22	$ -	$ 1,612.22
Remove/Dispose Pavement with Base 12 inch Thick	$ 7.00	SY	1309	$ 9,160.00	$ -	$ 9,160.00
Excavation & Haul off	$ 15.00	CY	655	$ 9,825.00	$ -	$ 9,825.00
Lime Stabilized Subgrade 8-inch Thick	$ 4.00	SY	1664	$ 6,656.00	$ -	$ 6,656.00
Lime for Lime Stabilized Subgrade (Dry Weight)	$ 150.00	TON	30	$ 4,492.80	$ -	$ 4,492.80
Reinforced Concrete Pavement 11-inch Thick	$ 70.00	SY	1664	$ 116,480.00	$ -	$ 116,480.00
Concrete Driveways Including Excavation 6-inch Thick	$ 10.00	SF	4837	$ 48,366.65	$ -	$ 48,366.65
6-Inch Concrete Curb (Monolithic)	$ 18.00	LF	1220	$ 21,960.00	$ -	$ 21,960.00
Sidewalk 4-1/2-Inch Thick	$ 6.50	SF	6250	$ 40,625.00	$ -	$ 40,625.00
Wheelchair Ramps and Sidewalks, Complete in Place	$ 20.00	SF	80	$ 1,600.00	$ -	$ 1,600.00
12-Inch Diameter Water Line by Open-Cut	$ 140.00	LF	213	$ 29,820.00	$ -	$ 29,820.00

3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$	900.00	EA	5	$	4,500.00	$	-	$	4,500.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$	1,250.00	EA	5	$	6,250.00	$	-	$	6,250.00
12-Inch Diameter Wet Connection	$	1,600.00	EA	1	$	1,600.00	$	-	$	1,600.00
8-Inch Diameter Wet Connection	$	1,200.00	EA	1	$	1,200.00	$	-	$	1,200.00
Fire Hydrant Assembly, All Depths, Including 6-Inch Diameter Gate Valve and Box	$	10,000.00	EA	1	$	10,000.00	$	-	$	10,000.00
Pickfair Street (Crane Street to Collingsworth Street - P2)										
Mobilization	$	150,000.00	LS	1	$	150,000.00	$	-	$	150,000.00
Traffic Control & Regulation	$	60,000.00	LS	1	$	60,000.00	$	-	$	60,000.00
SWPPP	$	25,000.00	LS	1	$	25,000.00	$	-	$	25,000.00
Tree Mitigation	$	23,000.00	LS	1	$	23,000.00	$	-	$	23,000.00
Adjusting Manholes, inlets, and valve boxes to grade	$	750.00	EA	2	$	1,500.00	$	-	$	1,500.00
Service stubs or reconnections with or without stack on sanitary sewer	$	70.00	LF	240	$	16,800.00	$	-	$	16,800.00
Type C Manhole for 48-Inch Diameter Sewers	$	15,000.00	EA	2	$	30,000.00	$	-	$	30,000.00
Remove and Dispose Manholes all Sizes/Depth	$	900.00	EA	4	$	3,600.00	$	-	$	3,600.00
Remove and Dispose Inlets all Sizes/Depth	$	600.00	EA	10	$	6,000.00	$	-	$	6,000.00
Remove and Dispose Storm Pipe 24-Inch Diameter	$	12.00	LF	1800	$	21,600.00	$	-	$	21,600.00
Junction Box	$	18,000.00	EA	5	$	90,000.00	$	-	$	90,000.00
24-inch Diameter Storm Sewer by open cut	$	85.00	LF	283	$	24,055.00	$	-	$	24,055.00
6' x 3' RCB	$	520.00	LF	1218	$	633,360.00	$	-	$	633,360.00
Type "BB" Inlet	$	3,800.00	EA	10	$	38,000.00	$	-	$	38,000.00
Remove/Dispose Conc Driveway 6-inch Thick/More	$	3.00	SY	684	$	2,052.84	$	-	$	2,052.84
Remove/Dispose Pavement with Base 12 inch Thick	$	7.00	SY	4567	$	31,966.67	$	-	$	31,966.67
Excavation & Haul off	$	15.00	CY	2650	$	39,750.00	$	-	$	39,750.00
Lime Stabilized Subgrade 8-inch Thick	$	4.00	SY	4567	$	18,266.67	$	-	$	18,266.67
Lime for Lime Stabilized Subgrade (Dry Weight)	$	150.00	TON	82	$	12,330.00	$	-	$	12,330.00
Reinforced Concrete Pavement 11-inch Thick	$	70.00	SY	4567	$	319,666.67	$	-	$	319,666.67
Concrete Driveways Including Excavation 6-inch Thick	$	10.00	SF	6159	$	61,585.28	$	-	$	61,585.28
6-Inch Concrete Curb (Monolithic)	$	18.00	LF	2974	$	53,530.63	$	-	$	53,530.63
Sidewalk 4-1/2-Inch Thick	$	6.50	SF	13448	$	87,411.48	$	-	$	87,411.48
Wheelchair Ramps and Sidewalks, Complete in Place	$	20.00	SF	80	$	1,600.00	$	-	$	1,600.00
8-Inch Diameter Water Line by Open-Cut with Restrained Joints	$	110.00	LF	60	$	6,600.00	$	-	$	6,600.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$	900.00	EA	10	$	9,000.00	$	-	$	9,000.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$	1,250.00	EA	10	$	12,500.00	$	-	$	12,500.00
8-Inch Diameter Wet Connection	$	1,200.00	EA	1	$	1,200.00	$	-	$	1,200.00
6-Inch Diameter Wet Connection	$	1,000.00	EA	1	$	1,000.00	$	-	$	1,000.00
Fire Hydrant Assembly, All Depths, Including 6-Inch Diameter Gate Valve and Box	$	10,000.00	EA	2	$	20,000.00	$	-	$	20,000.00
Calvacade Street (Dabney Street to Blaffer Street - P3)										
Mobilization	$	450,000.00	LS	1	$	450,000.00	$	-	$	450,000.00
Aluminum Signs (Ground Mounted)-Furnish & Install	$	150,000.00	LS	1	$	150,000.00	$	-	$	150,000.00
SWPPP	$	85,000.00	LS	1	$	85,000.00	$	-	$	85,000.00
Tree Mitigation	$	25,000.00	LS	1	$	25,000.00	$	-	$	25,000.00
Adjusting Manholes, inlets, and valve boxes to grade	$	750.00	EA	14	$	10,500.00	$	-	$	10,500.00
Trench Safety System for Sanitary Sewer Trench Excavation	$	2.00	LF	3236	$	6,472.00	$	-	$	6,472.00
Service stubs or reconnections with or without stack on sanitary sewer	$	70.00	LF	992	$	69,440.00	$	-	$	69,440.00
Type C Manhole On Box Culvert	$	4,200.00	EA	5	$	21,000.00	$	-	$	21,000.00
Remove and Dispose Storm Pipe 24-Inch Diameter	$	12.00	LF	250	$	3,000.00	$	-	$	3,000.00
Junction Box 10 FTx 10 FT	$	18,000.00	EA	1	$	18,000.00	$	-	$	18,000.00
24-inch Diameter Storm Sewer by open cut	$	85.00	LF	250	$	21,250.00	$	-	$	21,250.00
10' x 5' RCB	$	780.00	LF	1831	$	1,428,180.00	$	-	$	1,428,180.00
Type "BB" Inlet	$	3,800.00	EA	8	$	30,400.00	$	-	$	30,400.00
Remove/Dispose Pavement with Base 12 inch Thick	$	7.00	SY	14123	$	98,861.00	$	-	$	98,861.00
Excavation & Haul off	$	15.00	CY	7355	$	110,325.00	$	-	$	110,325.00
Lime Stabilized Subgrade 8-inch Thick	$	4.00	SY	14123	$	56,492.00	$	-	$	56,492.00
Lime for Lime Stabilized Subgrade (Dry Weight)	$	150.00	TON	254	$	38,132.10	$	-	$	38,132.10
Reinforced Concrete Pavement 11-inch Thick	$	70.00	SY	14123	$	988,610.00	$	-	$	988,610.00
Concrete Driveways Including Excavation 6-inch Thick	$	10.00	SF	5030	$	50,300.00	$	-	$	50,300.00
6-Inch Concrete Curb (Monolithic)	$	18.00	LF	7542	$	135,756.00	$	-	$	135,756.00

Sidewalk 4-1/2-Inch Thick	$	6.50	SF	16445	$	106,892.50	$	-	$	106,892.50
Wheelchair Ramps and Sidewalks, Complete in Place	$	20.00	SF	120	$	2,400.00	$	-	$	2,400.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$	900.00	EA	18	$	16,200.00	$	-	$	16,200.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$	1,250.00	EA	20	$	25,000.00	$	-	$	25,000.00
Hoffman Street (Crane Street to Pond C - P4)										
Mobilization	$	22,000.00	LS	1	$	22,000.00	$	-	$	22,000.00
Traffic Control & Regulation	$	10,000.00	LS	1	$	10,000.00	$	-	$	10,000.00
SWPPP	$	8,500.00	LS	1	$	8,500.00	$	-	$	8,500.00
Tree Mitigation	$	5,600.00	LS	1	$	5,600.00	$	-	$	5,600.00
Service stubs or reconnections with or without stack on sanitary sewer	$	70.00	LF	85	$	5,950.00	$	-	$	5,950.00
48-Inch Diameter Manhole for RCB	$	4,200.00	EA	2	$	8,400.00	$	-	$	8,400.00
24-inch Diameter Storm Sewer by open cut	$	85.00	LF	42	$	3,570.00	$	-	$	3,570.00
54-inch Diameter Storm Sewer by open cut	$	320.00	LF	375	$	120,000.00	$	-	$	120,000.00
Type "BB" Inlet	$	3,800.00	EA	2	$	7,600.00	$	-	$	7,600.00
Remove/Dispose reinforced concrete with or without base including existing Metro bus pad	$	7.00	SY	750	$	5,250.00	$	-	$	5,250.00
Lime Stabilized Subgrade 8-inch Thick	$	4.00	SY	750	$	3,000.00	$	-	$	3,000.00
Lime for Lime Stabilized Subgrade (Dry Weight)	$	150.00	TON	14	$	2,025.00	$	-	$	2,025.00
Reinforced Concrete Pavement 11-inch Thick	$	70.00	SY	750	$	52,500.00	$	-	$	52,500.00
Concrete Driveways Including Excavation 6-inch Thick	$	10.00	SF	350	$	3,500.00	$	-	$	3,500.00
6-Inch Concrete Curb (Monolithic)	$	18.00	LF	283	$	5,094.00	$	-	$	5,094.00
Sidewalk 4-1/2-Inch Thick	$	6.50	SF	2850	$	18,525.00	$	-	$	18,525.00
Wheelchair Ramps and Sidewalks, Complete in Place	$	20.00	SF	40	$	800.00	$	-	$	800.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$	900.00	EA	4	$	3,600.00	$	-	$	3,600.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$	1,250.00	EA	4	$	5,000.00	$	-	$	5,000.00
Dabney Street (Crane Street to Hunting Bayou - P5)										
Mobilization	$	690,000.00	LS	1	$	690,000.00	$	-	$	690,000.00
Traffic Control & Regulation	$	225,000.00	LS	1	$	225,000.00	$	-	$	225,000.00
SWPPP	$	98,000.00	LS	1	$	98,000.00	$	-	$	98,000.00
Tree Mitigation	$	60,000.00	LS	1	$	60,000.00	$	-	$	60,000.00
Adjusting Manholes, inlets, and valve boxes to grade	$	750.00	EA	10	$	7,500.00	$	-	$	7,500.00
Service stubs or reconnections with or without stack on sanitary sewer	$	70.00	LF	1596	$	111,720.00	$	-	$	111,720.00
48-Inch Diameter Manhole for RCB	$	4,200.00	EA	4	$	16,800.00	$	-	$	16,800.00
Trench Safety System for Storm Sewer Trench Excavation	$	5.00	LF	4168	$	20,840.00	$	-	$	20,840.00
Junction Box 10 FTx 10 FT	$	18,000.00	EA	6	$	108,000.00	$	-	$	108,000.00
24-inch Diameter Storm Sewer by open cut	$	85.00	LF	240	$	20,400.00	$	-	$	20,400.00
10' x 8' RCB	$	1,150.00	LF	4168	$	4,793,200.00	$	-	$	4,793,200.00
Type "BB" Inlet	$	3,800.00	EA	22	$	83,600.00	$	-	$	83,600.00
Remove/Dispose Pavement with Base 12 inch Thick	$	7.00	SY	13968	$	97,772.89	$	-	$	97,772.89
Excavation & Haul off	$	15.00	CY	6580	$	98,700.00	$	-	$	98,700.00
Lime Stabilized Subgrade 8-inch Thick	$	4.00	SY	13968	$	55,870.22	$	-	$	55,870.22
Lime for Lime Stabilized Subgrade (Dry Weight)	$	150.00	TON	251	$	37,712.40	$	-	$	37,712.40
Reinforced Concrete Pavement 11-inch Thick	$	70.00	SY	13968	$	977,728.89	$	-	$	977,728.89
Concrete Driveways Including Excavation 6-inch Thick	$	10.00	SF	4200	$	42,000.00	$	-	$	42,000.00
6-Inch Concrete Curb (Monolithic)	$	18.00	LF	8966	$	161,388.00	$	-	$	161,388.00
Sidewalk 5-1/2-Inch Thick	$	6.50	SF	38404	$	249,626.00	$	-	$	249,626.00
Wheelchair Ramps and Sidewalks, Complete in Place	$	20.00	SF	120	$	2,400.00	$	-	$	2,400.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$	900.00	EA	40	$	36,000.00	$	-	$	36,000.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$	1,250.00	EA	48	$	60,000.00	$	-	$	60,000.00
Rand Street (Dabney Street to Majestic Street - P6)										
Mobilization	$	125,000.00	LS	1	$	125,000.00	$	-	$	125,000.00
Traffic Control & Regulation	$	45,000.00	LS	1	$	45,000.00	$	-	$	45,000.00
SWPPP	$	35,000.00	LS	1	$	35,000.00	$	-	$	35,000.00
Tree Mitigation	$	15,000.00	LS	1	$	15,000.00	$	-	$	15,000.00
Service stubs or reconnections with or without stack on sanitary sewer	$	70.00	LF	126	$	8,820.00	$	-	$	8,820.00
Type C Manhole for 36-Inch Diameter Sewers	$	4,200.00	EA	10	$	42,000.00	$	-	$	42,000.00

24-inch Diameter Storm Sewer by open cut	$ 85.00	LF	225	$ 19,125.00	$ -	$ 19,125.00
36-inch Diameter Storm Sewer by open cut	$ 160.00	LF	1350	$ 216,000.00	$ -	$ 216,000.00
Type "BB" Inlet	$ 3,800.00	EA	14	$ 53,200.00	$ -	$ 53,200.00
Remove/Dispose Pavement with Base	$ 7.00	SY	4596	$ 32,169.67	$ -	$ 32,169.67
Excavation & Haul	$ 18.00	CY	1532	$ 27,574.00	$ -	$ 27,574.00
Lime Stabilized Subgrade 8-inch Thick	$ 4.00	SY	4596	$ 18,382.67	$ -	$ 18,382.67
Lime for Lime Stabilized Subgrade (Dry Weight)	$ 150.00	TON	83	$ 12,408.30	$ -	$ 12,408.30
Reinforced Concrete Pavement 11-inch Thick	$ 70.00	SY	4596	$ 321,696.67	$ -	$ 321,696.67
Concrete Driveways Including Excavation 6-inch Thick	$ 10.00	SF	560	$ 5,600.00	$ -	$ 5,600.00
6-Inch Concrete Curb (Monolithic)	$ 18.00	LF	2902	$ 52,236.00	$ -	$ 52,236.00
Sidewalk 4-1/2-Inch Thick	$ 6.50	SF	12859	$ 83,583.50	$ -	$ 83,583.50
Wheelchair Ramps and Sidewalks, Complete in Place	$ 20.00	SF	80	$ 1,600.00	$ -	$ 1,600.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Short Side	$ 900.00	EA	6	$ 5,400.00	$ -	$ 5,400.00
3/4-Inch to 1-Inch Diameter Water Taps and Copper Service Line with Meter Box, Long Side	$ 1,250.00	EA	7	$ 8,750.00	$ -	$ 8,750.00
Roadside Ditch Improvements						
Mobilization	$ 450,000.00	LS	1	$ 450,000.00	$ -	$ 450,000.00
Traffic Control & Temporary Pavement	$ 150,000.00	LS	1	$ 150,000.00	$ -	$ 150,000.00
SWPPP	$ 98,000.00	LS	1	$ 98,000.00	$ -	$ 98,000.00
Desilt Roadside Ditch	$ 12.00	LF	45500	$ 546,000.00	$ -	$ 546,000.00
Replace Driveway Culvert & Pavement	$ 6,500.00	EA	546	$ 3,549,000.00	$ -	$ 3,549,000.00
Inlet Replacement						
Mobilization	$ 55,000.00	LS	1	$ 55,000.00	$ -	$ 55,000.00
Traffic Control & Temporary Pavement	$ 35,000.00	LS	1	$ 35,000.00	$ -	$ 35,000.00
SWPPP	$ 40,000.00	LS	1	$ 40,000.00	$ -	$ 40,000.00
Replace B inlets with BB inlets	$ 3,800.00	EA	65	$ 247,000.00	$ -	$ 247,000.00
Sawcut Pavement/Curb and Replace	$ 8,500.00	EA	65	$ 552,500.00	$ -	$ 552,500.00
DETENTION POND Q						
Mobilization	$ 50,000.00	LS	1	$ 50,000.00	$ -	$ 50,000.00
Traffic Control & Temporary Pavement	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
SWPPP	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
Tree Mitigation	$ 2,000.00	LS	1	$ 2,000.00	$ -	$ 2,000.00
Excavation and Haul	$ 25.00	CY	16617	$ 415,433.33	$ -	$ 415,433.33
Backslope Drain & Swale	$ 41,543.33	LS	1	$ 41,543.33	$ -	$ 41,543.33
Outfall & Extreme Event Overflow	$ 62,315.00	LS	1	$ 62,315.00	$ -	$ 62,315.00
Intake Pipe	$ 124,630.00	LS	1	$ 124,630.00	$ -	$ 124,630.00
Hydromulch Seeding	$ 5,000.00	AC	3	$ 12,500.00	$ -	$ 12,500.00
Sodding	$ 5.00	SY	1500	$ 7,500.00	$ -	$ 7,500.00
Concrete Pilot Channel	$ 35,000.00	LS	1	$ 35,000.00	$ -	$ 35,000.00
DETENTION POND K						
Mobilization	$ 25,000.00	LS	1	$ 25,000.00	$ -	$ 25,000.00
Traffic Control & Temporary Pavement	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
SWPPP	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
Tree Mitigation	$ 2,000.00	LS	1	$ 2,000.00	$ -	$ 2,000.00
Excavation and Haul	$ 25.00	CY	3824	$ 95,590.00	$ -	$ 95,590.00
Backslope Drain & Swale	$ 9,559.00	LS	1	$ 9,559.00	$ -	$ 9,559.00
Outfall & Extreme Event Overflow	$ 14,338.50	LS	1	$ 14,338.50	$ -	$ 14,338.50
Intake Pipe	$ 28,677.00	LS	1	$ 28,677.00	$ -	$ 28,677.00
Hydromulch Seeding	$ 5,000.00	AC	1	$ 5,000.00	$ -	$ 5,000.00
Sodding	$ 5.00	SY	500	$ 2,500.00	$ -	$ 2,500.00
Concrete Pilot Channel	$ 20,000.00	LS	1	$ 20,000.00	$ -	$ 20,000.00
DETENTION POND R						
Mobilization	$ 35,000.00	LS	1	$ 35,000.00	$ -	$ 35,000.00
Traffic Control & Temporary Pavement	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
SWPPP	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
Tree Mitigation	$ 2,000.00	LS	1	$ 2,000.00	$ -	$ 2,000.00
Excavation and Haul	$ 25.00	CY	7663	$ 191,583.33	$ -	$ 191,583.33
Backslope Drain & Swale	$ 19,158.33	LS	1	$ 19,158.33	$ -	$ 19,158.33
Outfall & Extreme Event Overflow	$ 28,737.50	LS	1	$ 28,737.50	$ -	$ 28,737.50
Intake Pipe	$ 57,475.00	LS	1	$ 57,475.00	$ -	$ 57,475.00
Hydromulch Seeding	$ 5,000.00	AC	2	$ 10,000.00	$ -	$ 10,000.00
Sodding	$ 5.00	SY	800	$ 4,000.00	$ -	$ 4,000.00
Concrete Pilot Channel	$ 25,000.00	LS	1	$ 25,000.00	$ -	$ 25,000.00
DETENTION POND N						

Mobilization	$ 38,000.00	LS	1	$ 38,000.00	$ -	$ 38,000.00
Traffic Control & Temporary Pavement	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
SWPPP	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
Tree Mitigation	$ 2,000.00	LS	1	$ 2,000.00	$ -	$ 2,000.00
Excavation and Haul	$ 25.00	CY	8051	$ 201,263.33	$ -	$ 201,263.33
Backslope Drain & Swale	$ 20,126.33	LS	1	$ 20,126.33	$ -	$ 20,126.33
Outfall & Extreme Event Overflow	$ 30,189.50	LS	1	$ 30,189.50	$ -	$ 30,189.50
Intake Pipe	$ 60,379.00	LS	1	$ 60,379.00	$ -	$ 60,379.00
Hydromulch Seeding	$ 5,000.00	AC	2	$ 10,000.00	$ -	$ 10,000.00
Sodding	$ 5.00	SY	650	$ 3,250.00	$ -	$ 3,250.00
Concrete Pilot Channel	$ 15,000.00	LS	1	$ 15,000.00	$ -	$ 15,000.00
DETENTION POND F						
Mobilization	$ 32,000.00	LS	1	$ 32,000.00	$ -	$ 32,000.00
Traffic Control & Temporary Pavement	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
SWPPP	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
Tree Mitigation	$ 2,000.00	LS	1	$ 2,000.00	$ -	$ 2,000.00
Excavation and Haul	$ 25.00	CY	7066	$ 176,660.00	$ -	$ 176,660.00
Backslope Drain & Swale	$ 17,666.00	LS	1	$ 17,666.00	$ -	$ 17,666.00
Outfall & Extreme Event Overflow	$ 26,499.00	LS	1	$ 26,499.00	$ -	$ 26,499.00
Intake Pipe	$ 52,998.00	LS	1	$ 52,998.00	$ -	$ 52,998.00
Hydromulch Seeding	$ 5,000.00	AC	1	$ 7,000.00	$ -	$ 7,000.00
Sodding	$ 5.00	SY	500	$ 2,500.00	$ -	$ 2,500.00
Concrete Pilot Channel	$ 12,000.00	LS	1	$ 12,000.00	$ -	$ 12,000.00
DETENTION POND A						
Mobilization	$ 150,000.00	LS	1	$ 150,000.00	$ -	$ 150,000.00
Traffic Control & Temporary Pavement	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
SWPPP	$ 15,000.00	LS	1	$ 15,000.00	$ -	$ 15,000.00
Tree Mitigation	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
Excavation and Haul	$ 25.00	CY	35042	$ 876,040.00	$ -	$ 876,040.00
Backslope Drain & Swale	$ 87,604.00	LS	1	$ 87,604.00	$ -	$ 87,604.00
Outfall & Extreme Event Overflow	$ 131,406.00	LS	1	$ 131,406.00	$ -	$ 131,406.00
Intake Pipe	$ 262,812.00	LS	1	$ 262,812.00	$ -	$ 262,812.00
Hydromulch Seeding	$ 5,000.00	AC	5	$ 25,000.00	$ -	$ 25,000.00
Sodding	$ 5.00	SY	1800	$ 9,000.00	$ -	$ 9,000.00
Concrete Pilot Channel	$ 35,000.00	LS	1	$ 35,000.00	$ -	$ 35,000.00
DETENTION POND C						
Mobilization	$ 30,000.00	LS	1	$ 30,000.00	$ -	$ 30,000.00
Traffic Control & Temporary Pavement	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
SWPPP	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
Tree Mitigation	$ 2,000.00	LS	1	$ 2,000.00	$ -	$ 2,000.00
Excavation and Haul	$ 25.00	CY	6534	$ 163,350.00	$ -	$ 163,350.00
Backslope Drain & Swale	$ 16,335.00	LS	1	$ 16,335.00	$ -	$ 16,335.00
Outfall & Extreme Event Overflow	$ 24,502.50	LS	1	$ 24,502.50	$ -	$ 24,502.50
Intake Pipe	$ 49,005.00	LS	1	$ 49,005.00	$ -	$ 49,005.00
Hydromulch Seeding	$ 5,000.00	AC	1	$ 6,500.00	$ -	$ 6,500.00
Sodding	$ 5.00	SY	450	$ 2,250.00	$ -	$ 2,250.00
Concrete Pilot Channel	$ 12,000.00	LS	1	$ 12,000.00	$ -	$ 12,000.00
DETENTION POND M						
Mobilization	$ 280,000.00	LS	1	$ 280,000.00	$ -	$ 280,000.00
Traffic Control & Temporary Pavement	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
SWPPP	$ 8,000.00	LS	1	$ 8,000.00	$ -	$ 8,000.00
Tree Mitigation	$ 2,000.00	LS	1	$ 2,000.00	$ -	$ 2,000.00
Excavation and Haul	$ 25.00	CY	6098	$ 152,460.00	$ -	$ 152,460.00
Backslope Drain & Swale	$ 15,246.00	LS	1	$ 15,246.00	$ -	$ 15,246.00
Outfall & Extreme Event Overflow	$ 22,869.00	LS	1	$ 22,869.00	$ -	$ 22,869.00
Intake Pipe	$ 45,738.00	LS	1	$ 45,738.00	$ -	$ 45,738.00
Hydromulch Seeding	$ 5,000.00	AC	1	$ 6,500.00	$ -	$ 6,500.00
Sodding	$ 5.00	SY	450	$ 2,250.00	$ -	$ 2,250.00
Concrete Pilot Channel	$ 12,000.00	LS	1	$ 12,000.00	$ -	$ 12,000.00
Park & Trail						
Mobilization	$ 120,000.00	LS	1	$ 120,000.00	$ -	$ 120,000.00
Traffic Control & Temporary Pavement	$ 5,000.00	LS	1	$ 5,000.00	$ -	$ 5,000.00
SWPPP	$ 15,000.00	LS	1	$ 15,000.00	$ -	$ 15,000.00
Tree Mitigation	$ 65,000.00	LS	1	$ 65,000.00	$ -	$ 65,000.00
Trailhead, Bench, Trash Can, Canopy	$ 185,000.00	EA	5	$ 925,000.00	$ -	$ 925,000.00

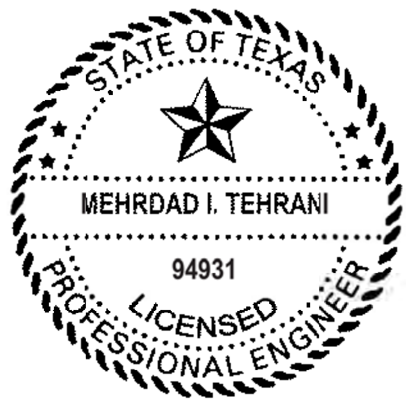
Trail	$ 10.50	SF	38400	$ 403,200.00	$ -	$ 403,200.00
SUB TOTAL				$ 42,199,190.00	$ -	$ 42,199,190.00
Risk Assessment Mark-Ups						
Construction Contingency (30%)	$ 12,659,757.00	EA	1	$ 12,659,757.00	$ -	$ 12,659,757.00
SUB TOTAL				$ 12,659,757.00	$ -	$ 12,659,757.00
Soft Costs						
Engineering (Design and Bidding) (15%)	[redacted]	[redacted]	1	$ 8,228,842.05	$ -	$ 8,228,842.05
Environmental Inve[redacted]	[redacted]	[redacted]	1	$ 3,291,536.82	$ -	$ 3,291,536.82
Grant Administration (6%)	$ 3,291,536.82	EA	1	$ 3,291,536.82	$ -	$ 3,291,536.82
SUB TOTAL				$ 14,811,915.7	$ -	$ 14,811,915.69
TOTAL				$ 69,670,862.69	$ -	$ 69,670,862.69

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

Maintenance for the proposed improvements will be supported by the City's Storm Water Func and Dedicated Drainage and Street Renewal Operating Funds. These funds are dedicated to: inspecting, cleaning, and repairing of storm sewers; inspecting, regrading, and desilting of roadside ditches; inspecting, regrading, desilting, mowing, and repairing minor erosion in off-road ditches and detention ponds. Maintenance and Operations funds support minimizing flooding and improving [redacted]ety, and economic vitality.

[redacted]ng activities.

An environmental a[redacted]he project area. Design & construction management services will also be required.



Seal

Date:	10/6/2020
Phone Number:	2814960066

Signature of Registered Engineer/Architect Responsible For Budget Justification:

M. Tehrani

TBPE Reg. No. F-761

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

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

Applicant/Subrecipient:	City of Houston					
[redacted]	Houston Kashmere Gardens Flood Mitigation					
Eligible Activity:	Acquisition					
Materials/Facilities/Services	**$/Unit**	**Unit**	**Quantity**	**Construction**	**Acquisition**	**Total**
			DETENTION POND Q			
Pond A	$ -	LS	1	$ -	$ 1,224,000.00	$ 1,224,000.00
Pond C	$ -	LS	1	$ -	$ 818,000.00	$ 818,000.00
Pond F	$ -	LS	1	$ -	$ 773,000.00	$ 773,000.00
Pond K	$ -	LS	1	$ -	$ 130,000.00	$ 130,000.00
Pond N	$ -	LS	1	$ -	$ 680,000.00	$ 680,000.00
SUB TOTAL				$ -	$ 3,625,000.00	$ 3,625,000.00
TOTAL				$ -	[redacted]	3,625,000.00

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

2. Identify and explain any special engineering activities.

STATE OF TEXAS
MEHRDAD I. TEHRANI
94931
LICENSED
PROFESSIONAL ENGINEER

Seal

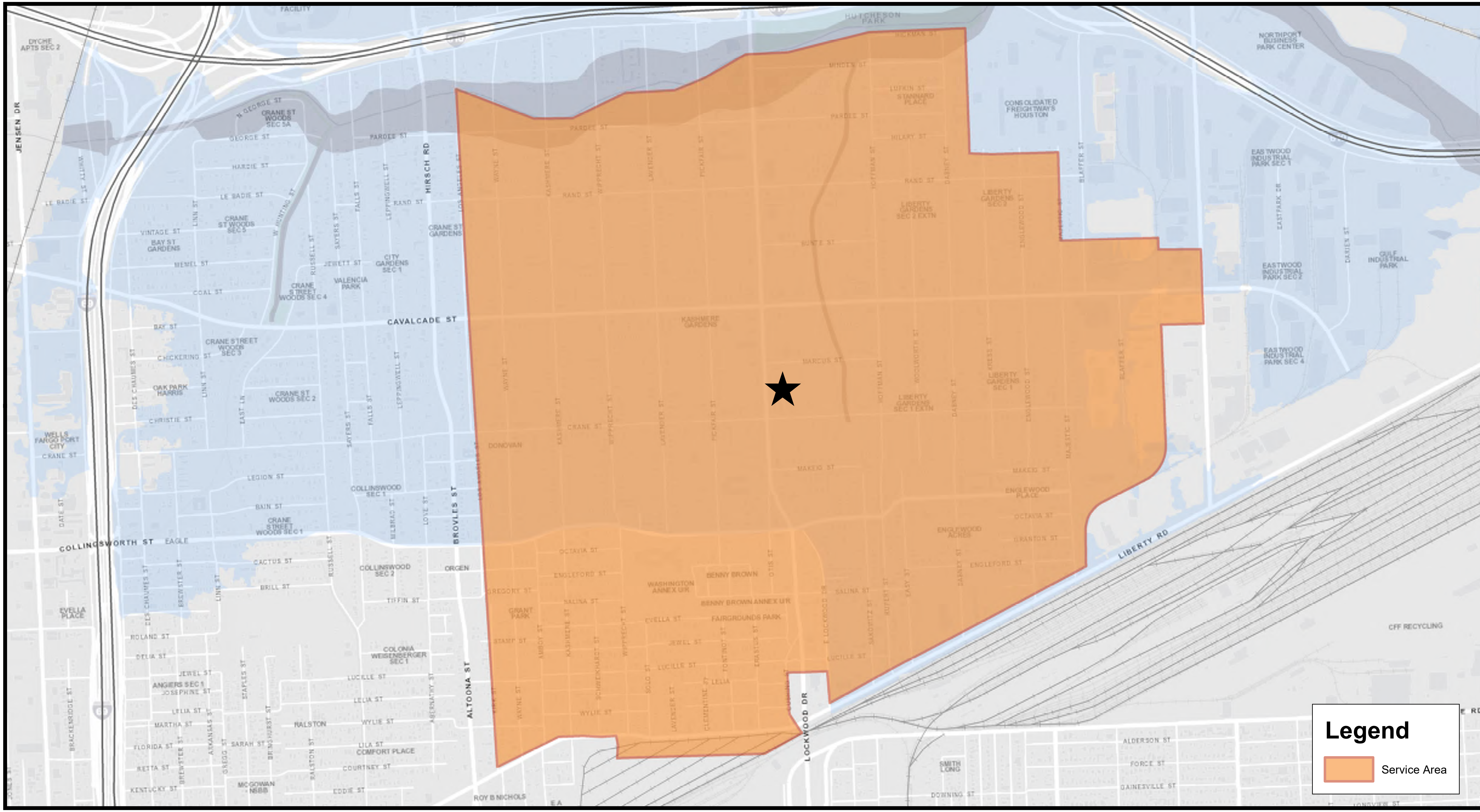
Date:	10/6/2020
Phone Number:	2814960066

Signature of Registered Engineer/Architect Responsible For Budget Justification:

M. Tehrani

TBPE Reg. No. F-761

Houston Kashmere Gardens Area Flood Mitigation - Location Map



★ Latitude: 29.797898
Longitude: -95.316330

Address: 4018 Lockwood Dr
Houston, TX 77026

County: Harris

Houston Kashmere Gardens Area Flood Mitigation Project
Benefit-Cost Analysis Report

Prepared for:

CITY OF HOUSTON
PUBLIC WORKS

HUITT-ZOLLARS, INC.
10350 RICHMOND AVE. SUITE 300
HOUSTON, TEXAS 77042-4248
TBPE Reg. No. F-761
(281) 496-0066

October 6, 2020

Study Purpose and Scope

The goal of the "Houston Kashmere Gardens Area Flood Mitigation Project" is to reduce the risks associated with extreme storm events hurricanes/tropical storms in the Kashmere Gardens area. This project will reduce localized and regional flooding by increasing the conveyance capacity in existing drainage systems. Dynamic hydraulic and hydrologic (H&H) modeling was used to identify existing ponding impacts and illustrate the benefits of reduced ponding associated with the proposed drainage improvements.

The target area is located within the historic Kashmere Gardens Area neighborhood which is located just south of North 610 Loop and east of US-59 in Houston, Harris County, TX. The limits of the study area are shown in Exhibit 1. The Kashmere Gardens Area neighborhood drainage infrastructure was constructed beginning in the 1930's. Harris County Flood Control District (HCFCD) Channel H110-00-00 provides drainage for much of the area, conveying water to Hunting Bayou. The existing drainage system is a mix of curb and gutter and roadside ditch systems and provides less than 2-year level of service (LOS) under Atlas 14 rainfall, with potential structural flooding during a 100-year storm event.

The H&H modeling identified flooding issues under existing conditions, including structural inundation and ponding that impacts safe roadway mobility. The impacts are further validated by other data points including FEMA National Flood Insurance Program (NFIP) data, FEMA Individual Assistance (IA) data, and/or calls for service.

Exhibit 2 presents the proposed drainage improvements in detail. The proposed project will replace and improve existing storm sewers lines, convert some existing roadside ditches to curb and gutter with storm sewers, improve existing roadside ditches and driveway culverts, and replace existing inlets with larger inlets. The proposed improvements will increase the capacity of the existing system, increasing the LOS to 50-year, reduce ponding on street throughout the neighborhood, and reduce flood risk to existing structures. This BCA is based on the proposed drainage improvements benefit on existing structures only.

Data Collection

The following documents and data were obtained and used to guide this study:

- 2018 LiDAR dataset
- Building Footprint GIS shapefile
- COH Technical Memorandum "Kashmere Gardens Area Storm Water Drainage Improvements – Proposed Condition", prepared by Huitt-Zollars, October 2020.

Methodology

FEMA "Benefit-Cost Calculator" Version V.6.0 and FEMA guidelines and procedures were used to develop this BCA. The BCA determines the future risk reduction benefits for a specific drainage improvement project and compares those benefits to the construction cost for the drainage improvements. The Benefit-Cost Ratio (BCR) is calculated by dividing the estimated benefit for all structures by the proposed improvements' construction cost.

The 2018 Lidar, building footprint shapefile, limited survey and site visits were used to determine the lowest floor elevation of each building. Buildings that are on piers or are elevated were identified using available data and the lowest floor elevation were adjusted accordingly.

The proposed drainage improvements (see Exhibit 2) were modeled in detail using two-dimensional unsteady modeling using the XPSWMM program. The "Kashmere Gardens Area Storm Water Drainage Improvements – Proposed Condition" Technical Memorandum provide pre-improvements and post-improvement 2-, 10-, 50 and 100-Year water surface elevations and discharge values which were used in this BCA report. The 100-yr ponding limits of existing and proposed condition are shown in Exhibit 3 and Exhibit 4, respectively.

Exhibit 5 presents the location of structures where 100-yr Water Surface Elevation (WSE) is higher than the lowest floor elevation. These Structures will directly benefit from lowering the WSE after the proposed drainage improvements are implemented (Benefited Structures). These Benefitted Structures were utilized to develop the BCA.

BCA Toolkit

The Benefitted Structures are mainly residential with each structure is identified by the latitude and longitude at its centroid.

The mitigation action and project cost are based on drainage improvements identified in the "Kashmere Gardens Area Storm Water Drainage Improvements – Proposed Condition" Technical Memorandum.

The values for Hazard Probability Parameters (flood) such as discharge and water surface elevation, for storm events with a recurrence interval of 2-, 10-, 50 and 100-Year were used from "Kashmere Gardens Area Storm Water Drainage Improvements – Proposed Condition" Technical Memorandum.

The BCA toolkit's default values and standard processes were used to calculate the standard building benefit. Only values for the first floor of each structure were used (one story), with no basement. Standard benefit for each building is calculated using the first floor square footage multiply by the default building replacement value.

In the BCA, tt was assumed that utilities are not elevated. The BCA toolkit's default values for contents and displacement were used. No volunteer, ecosystem services, or social benefits were used in these calculations.

The total drainage improvement cost were distributed between all benefitted structures uniformly, resulting in similar BCR value for consistency.

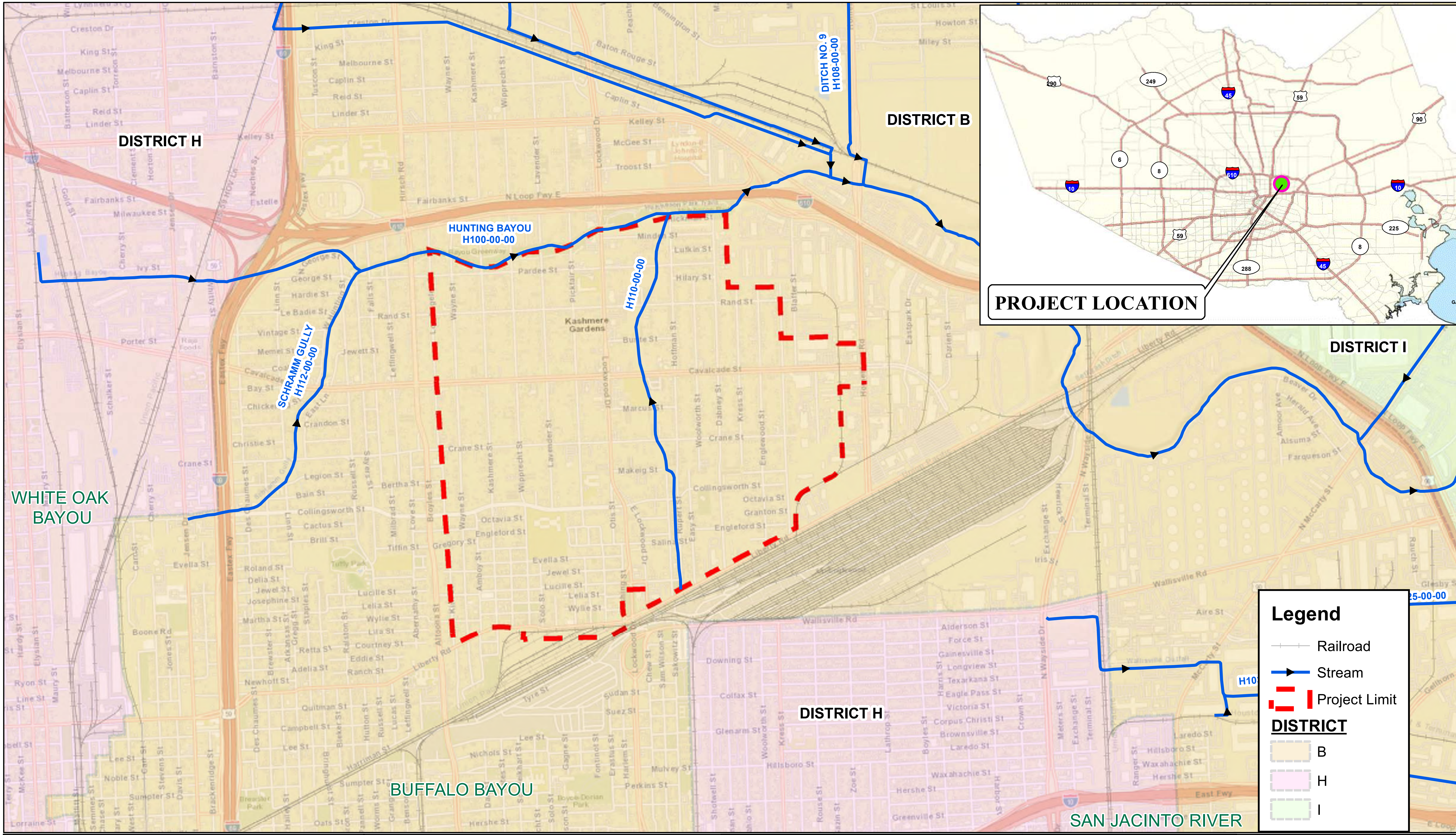
The total project cost and benefit are the summation of all the structures' costs and benefits. The total BCR is presented in **Table 1**. The detail of each structure BCR calculation is provided in **Attachment 1**.

Table 1. Total Benefit-Cost Ratio

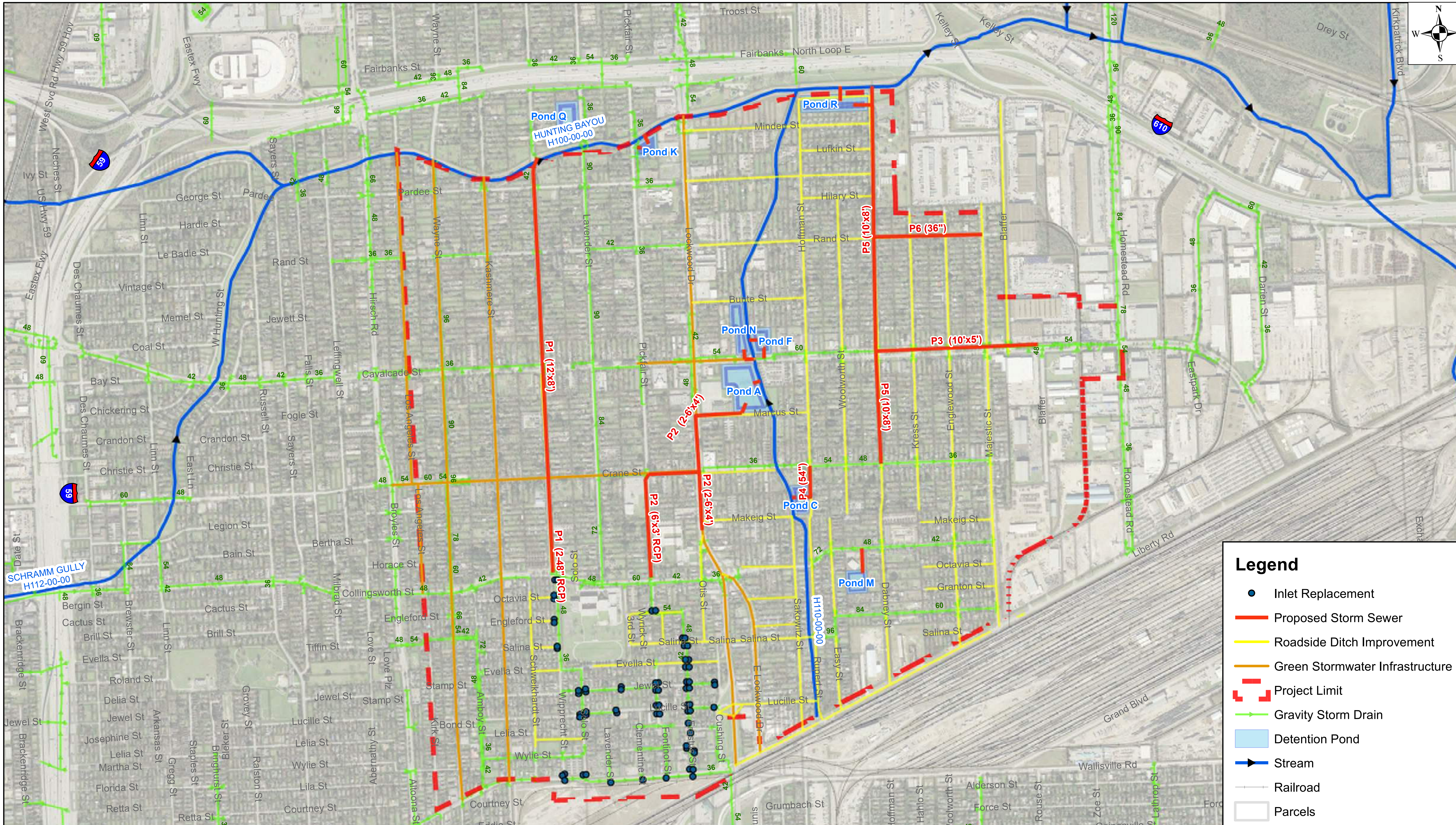
Total Benefit ($)	Total Cost ($)	Total BCR (-)
$103,849,955	$94,879,859	1.09

Conclusion

The "Houston Kashmere Gardens Area Flood Mitigation Project" has a benefit-cost ratio greater than 1.



HUITT-ZOLLARS	PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS WBS: NO. M-430100-0020-3 WO NO.3 (KASHMERE GARDENS)		DATE	SCALE	EXHIBIT 1
			OCTOBER 2020	0 1,000 2,000 Feet	LOCATION MAP

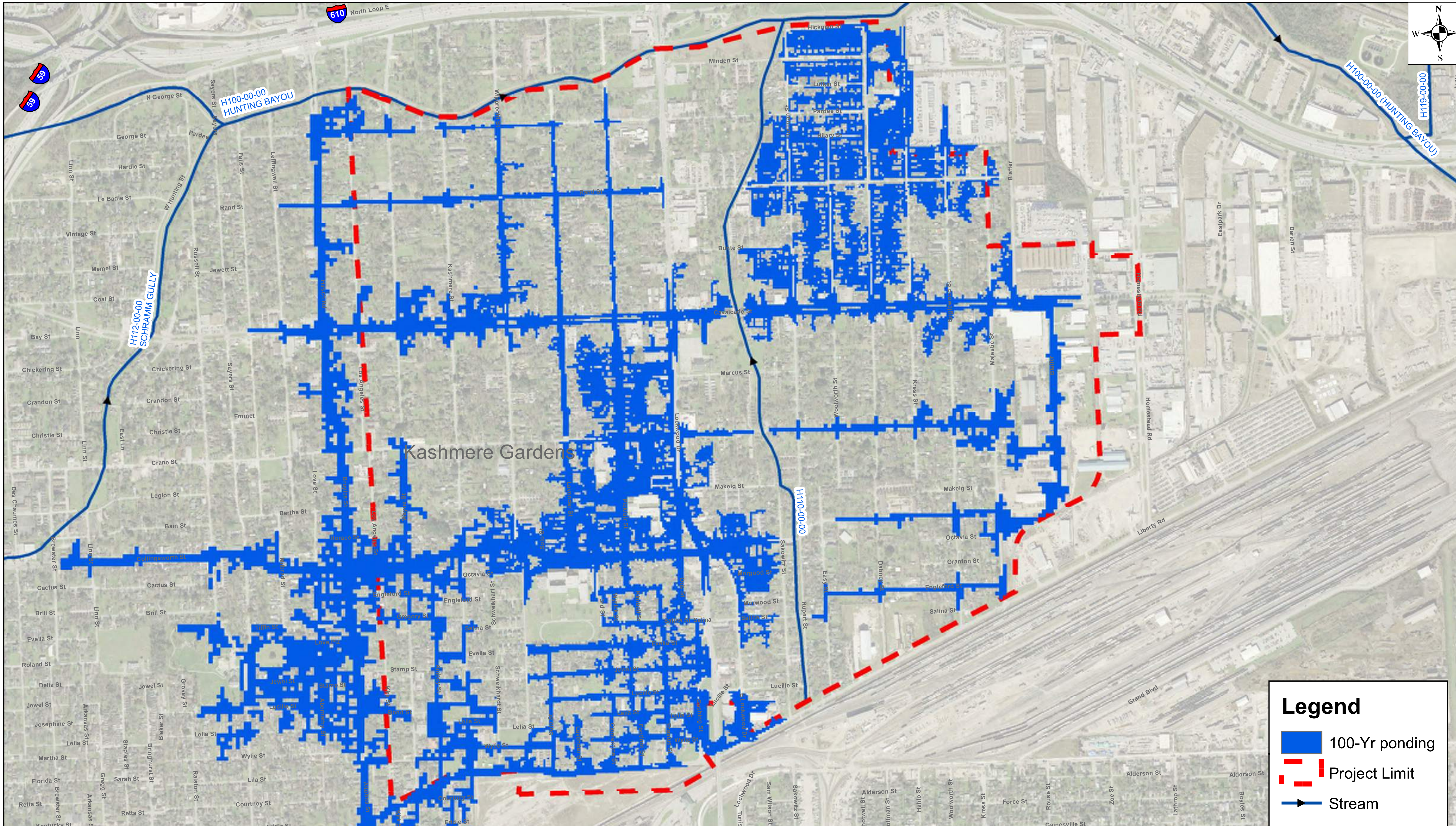


HUITT-ZOLLARS

HUITT-ZOLLARS, INC. Firm No. F-761
10350 Richmond Avenue, Suite 300 Houston, TX 77042
Phone 281.496.0066 Fax 713.496.0220

PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

DATE	SCALE	EXHIBIT 2
OCTOBER 2020	0 500 1,000 2,000 Feet	RECOMMENDED IMPROVEMENT



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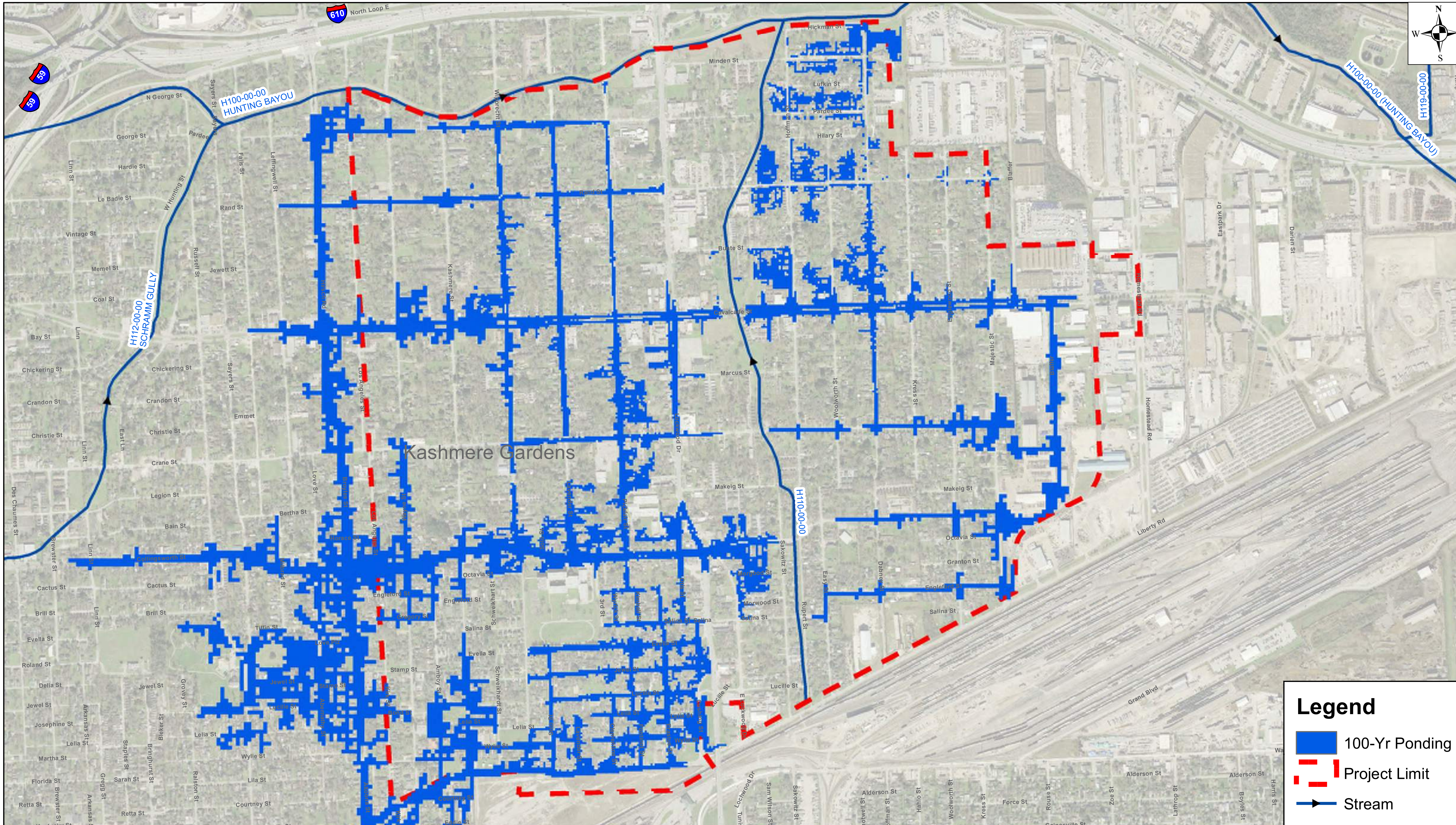
PRE-ENGINEERING SERVICES OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

DATE	SCALE	EXHIBIT 3
OCTOBER 2020	0 500 1,000 2,000 Feet	100-YR PONDING LIMITS EXISTING CONDITION



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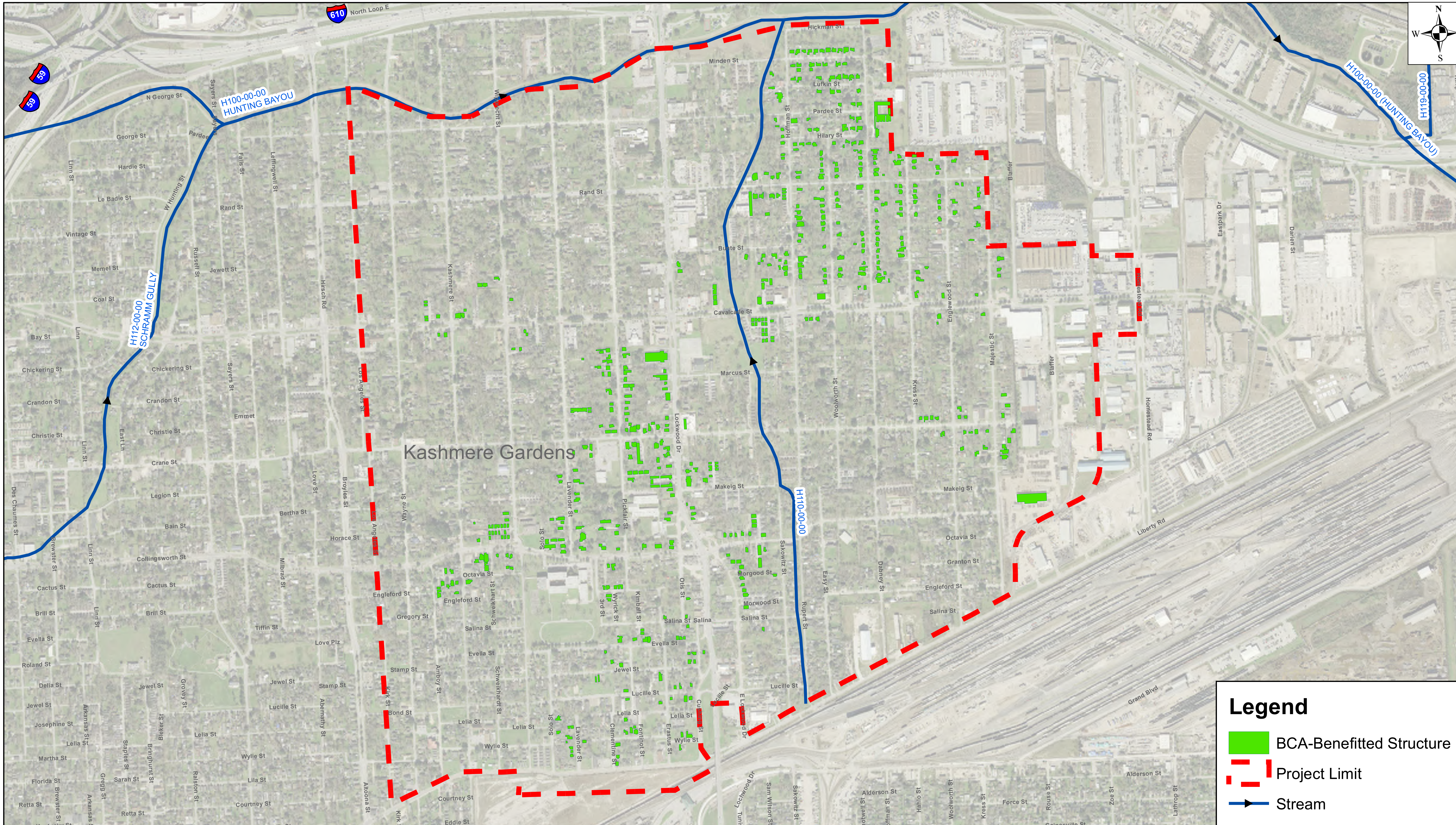
**PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)**

DATE	SCALE	EXHIBIT 4
OCTOBER 2020	0 500 1,000 2,000 Feet	100-YR PONDING LIMITS PROPOSED CONDITION



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PRE-ENGINEERING SERVICES
OF STORM WATER DRAINAGE IMPROVEMENTS
WBS: NO. M-430100-0020-3
WO NO.3
(KASHMERE GARDENS)

CITY OF HOUSTON TEXAS

DATE	SCALE	EXHIBIT 5
OCTOBER 2020	0 500 1,000 2,000 Feet	BENEFIT-COST ANALYSIS BENEFITTED STRUCTURES

Attachment 1

Note: Due to the high number of benefitted structures and BCA Toolkit's limit, the BCR calculation is split into 6 excel files as listed below:

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6

Appendix 5-4M: Houston Sunnyside Area

Memo

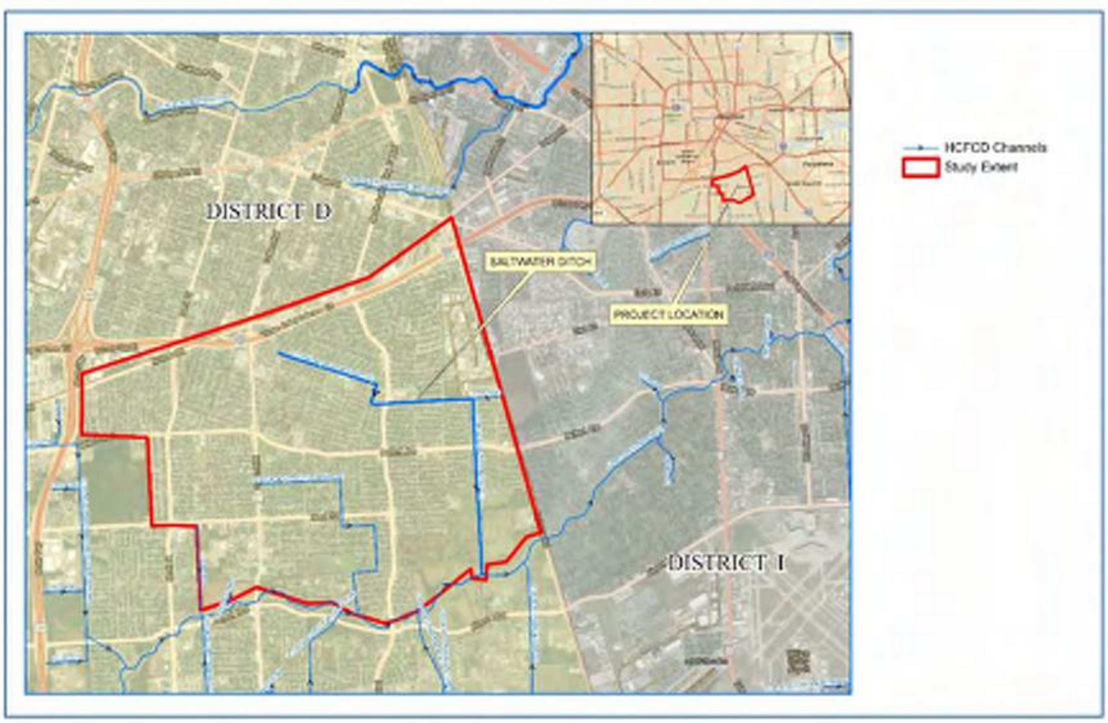
Date:	Monday, April 06, 2020
Project:	City of Houston Drainage Pre-Engineering Services for Storm Water Improvements Work Order # 9 – South Park/Salt Water Ditch Drainage Analysis
To:	Adam Eaton, PE
From:	Jeremy Blevins, PE, CFM
Subject:	Existing Conditions Technical Memorandum

We are writing you to provide the results of the existing conditions analysis of the Salt Water Ditch drainage areas. The following paragraphs provide background information on the project area, describe the methodologies used in the analysis, and summarize the results of the existing conditions analysis.

Data Collection

The South Park neighborhood includes approximately 5,000 acres of development within the southern portion of the City of Houston. The project area is roughly bounded by Loop 610 South on the north, State Highway 288 on the west, Mykawa Road on the east and Sims Bayou on the south. The entire project area is located within City Council District D. Figure 1 below provides a vicinity map of the project area.

Figure 1: Vicinity Map



Memo

Date:	Wednesday, October 21, 2020
Project:	City of Houston Drainage Pre-Engineering Services for Storm Water Improvements Work Order # 9 – South Park/Sunnyside Drainage Analysis
To:	Adam Eaton, PE
From:	Jeremy Blevins, PE, CFM
Subject:	Proposed Conditions Technical Memorandum

This technical memorandum (TM) provides the results of the proposed conditions analysis of the South Park/Sunnyside study area. An existing conditions analysis was completed by HDR in April 2020, and this proposed conditions analysis is a continuation of that study to provide recommendations for flood risk reduction in the study area. Additionally, Harris County Engineering Department (HCED) has undertaken a project to enclose Salt Water Ditch as a closed conduit system. Coordination with HCED is on-going as a part of this study. The following paragraphs provide background information on the study area, describe the methodologies used in the analysis, and summarize the results of the proposed conditions analysis.

Proposed Improvements

Based on the results of the existing conditions analysis, the following improvements were recommended for further refinement and detailed study:

- Improve the storm sewer network and associated outfalls along Pershing Street.
- Improve the storm sewer trunk line along Southbank and the associated laterals north and south of Salt Water Ditch.
- Improve the storm sewer trunk line along Crestmont Street and the associated laterals north and south of Salt Water Ditch.
- Improve the storm sewer systems on Willow Glen Drive and South Wayside Drive.
- Improve the storm sewer systems on Belmark Street and South Wayside Drive.
- Incorporate the improvements included in the City's project along Comal Street and Brandon Street.
- Improve the outfall at Scott Street and Holmes Road.
- Improve the storm sewer trunk line along Scott Street that outfalls to C118-03-00.
- Improve the storm sewer trunk line system along McLean Street north of C118-03-00.
- Improve the storm sewer trunk line system along Cullen Boulevard north of C122-00-00.
- Determine the detention volume needed to mitigate improvements and investigate inline detention opportunities beneath Martin Luther King Boulevard. Evaluate interconnectivity between Martin Luther King Boulevard and Salt Water Ditch.
- Identify and investigate opportunities to implement green infrastructure and low impact development (LID) opportunities associated with the proposed improvements, including above-ground detention sites.

- Identify and investigate options to intercept and accommodate overland sheet flow from offsite areas.
- Identify and investigate other potential improvements to alleviate risk to excessive ponding, address deficiencies in the storm sewer network, and create overland sheet flow connectivity to Salt Water Ditch, C122-00-00, C118-03-00, and Sims Bayou in addition to the improvements listed above, as necessary.

The proposed improvements were also coordinated with the proposed channel improvements to Salt Water ditch, as recommended by HCED.

It was the City's intent to submit proposed improvements for the South Park/Sunnyside area for funding under the Texas General Land Office's CDBG-MIT competition program. The improvements identified during the existing conditions analysis were further refined and analyzed to identify a set of improvements that would provide the most benefit over a large portion of the South Park/Sunnyside area, while fitting to the funding constraints of the CDBG-MIT competition. The proposed improvements are listed below and are shown in Exhibit 1.

PROPOSED INCREASE IN STORM SEWER SIZE:

- Increase all lines on Jutland Road, Herschellwood Drive, and St. Lo Road (that flow into the line between Northridge Drive and Lyndhurst Drive) to 48-inch RCP.
- Increase the line between Northridge Drive and Lyndhurst Drive from Jutland Road to Martin Luther King Boulevard to a 6' x 5' box culvert.
- Increase all lines along Martin Luther King Boulevard from Lyndhurst Drive to the outfall into Sims Bayou to two 10' x 10' box culverts.
- Increase the line on Cullen Boulevard from Briscoe Street to Belfort Avenue to a 10' x 5' box culvert.
- Increase the line on Cullen Boulevard from the start of the line below Belfort Avenue to the outfall into Sims Bayou to two 10' x 8' box culverts.

PROPOSED NEW STORM SEWER LINE:

- Add two 10' x 8' box culverts from the intersection of Belfort Avenue and Cullen Boulevard to the existing storm sewer system on Cullen Boulevard to the south. This connects the Belfort and Cullen systems.
- Starting at the existing line between Lyndhurst Drive and Northridge Drive (near the intersection of Lyndhurst Drive and Sharondale Street) add a 6' x 5' box culvert to connect to the existing line on Lyndhurst Drive. This makes this system flow to Martin Luther King Boulevard instead of directly to Saltwater Ditch.
- Add a 60-inch RCP on Southbank Street from approximately Lyndhurst Drive to Belarbor Street. This connects the redirected line on Southbank Street to the existing line (also to be redirected) further south on Southbank Street.
- Add a 60-inch RCP on Crestmont Street from approximately Lyndhurst Drive to Belarbor Street. This connects the redirected line on Crestmont Street to the existing line (also to be redirected) further south on Crestmont Street.
- Add a 10' x 8' box culvert between Beldart Street and Flamingo Drive, from Southbank Street to Martin Luther King Boulevard. This new line connects the redirected lines from

Southbank Street and Crestmont Street to the larger Martin Luther King Boulevard system.

The proposed improvement to Salt Water Ditch being designed by HCED was not directly included in this analysis, as the proposed improvements for the City CDBG-MIT grant application must be stand alone and have construction cost of $100 million or less.

Proposed Conditions Results

The proposed improvements were input into the existing conditions models to assess the potential benefits within the study area. These improvements were modeled first without the proposed channel enclosure of Salt Water Ditch in order to assess the benefits of this project as a stand-alone project. Ponding maps were developed for the 2-year, 10-year, 25-year, 50-year, and 100-year storm events. Those ponding maps are shown in Exhibits 2 through 6, respectively.

The inundation boundaries for the proposed conditions models were processed in GIS to assess the benefit of the proposed project. Based on the results of the models, it is expected that approximately 1,935 fewer houses will experience structural flooding during a 1% annual chance storm event. Likewise, it is expected that 12.6 fewer miles of roadway will experience ponding during a 1% annual chance storm event. The improvements will increase the level of service from 10-year to 25-year across the area. Table 1 below provides a summary of these results.

Table 1: Summary of Proposed Conditions Results

Item	Existing	Proposed
Level of Service	10-year	25-year
Structures Impacted (100-Year)	6,821	4,886
Parcel Inundation (100-Year)	9,123	7,598
Roadway Inundation (100-Year)	92.3 mi	79.7 mi

A comparison of flow hydrographs at the outfall to Sims Bayou indicates an increase in flow due to the proposed improvements. In order to mitigate those potential adverse impacts, it is necessary to provide storm water detention. Based on a comparison of flow hydrographs, approximately 800 acre-feet of stormwater detention is necessary to mitigate those potential adverse impacts associated with the storm sewer improvements.

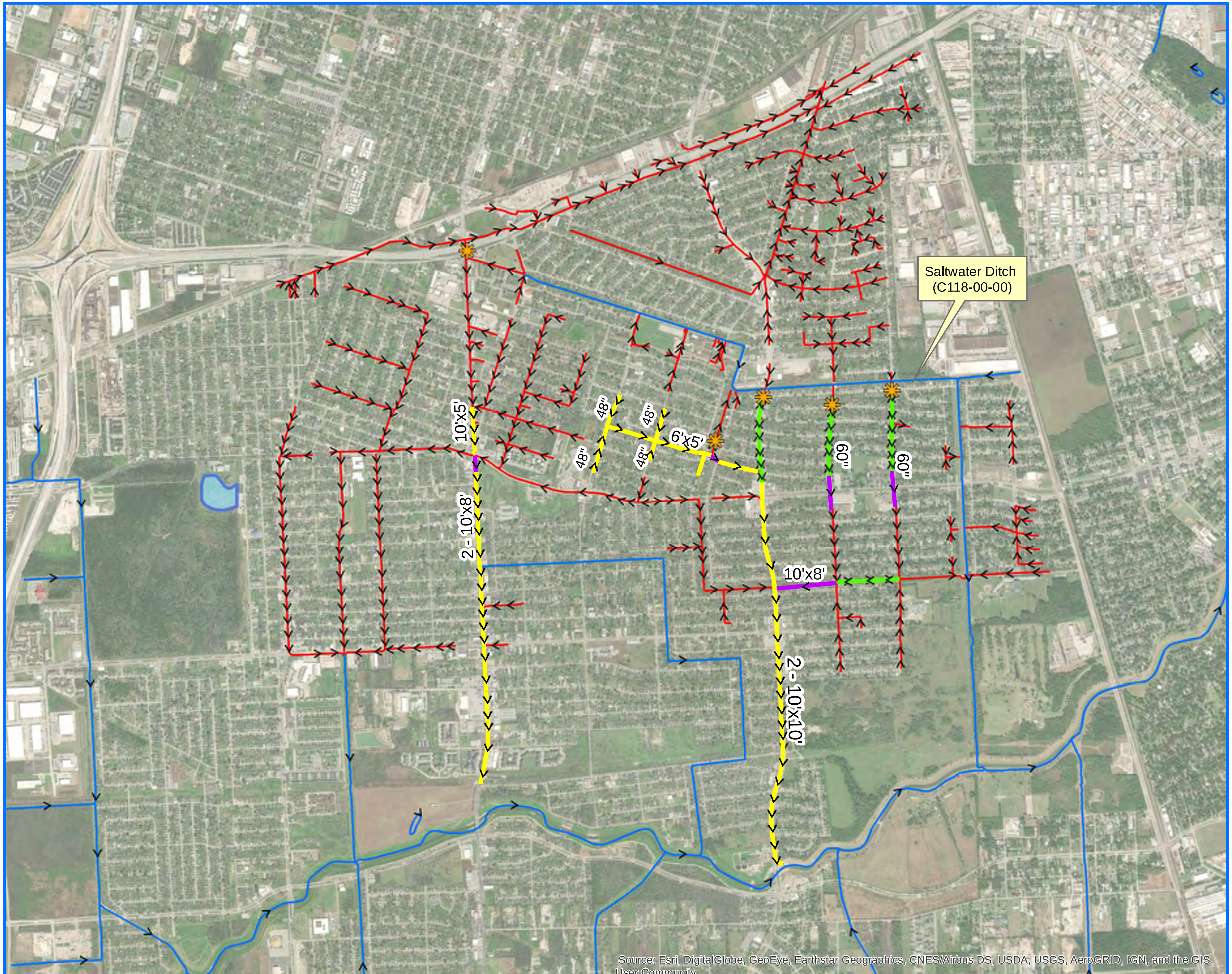
It is important to note that this value does not include any stormwater detention that is necessary to mitigate the potential impacts of the channel enclosure of Salt Water Ditch, which is currently under design by HCED. Additional stormwater detention will be necessary to satisfy requirements for that HCED project. Various detention basin locations have been identified, and coordination with Houston Parks Department and adjacent property owners is on-going.

The proposed improvements were also modeled with the improvements to Salt Water Ditch to determine the overall benefits of the combined improvements. HCED provided the model for their improvements, which were added the existing conditions model with the proposed improvements presented in this TM. The model results indicate that improvements to both the local storm drainage networks and the Salt Water Ditch channel will increase the overall level of service in the area to approximately 50-year. Ponding maps of the combined improvements for the 2-year, 10-year, 25-year, 50-year, and 100-year storm events are presented in Exhibits 7 through 11, respectively.

Opinion of Probable Construction Costs

Based on the proposed improvements presented in this memorandum, it is anticipated that the probable construction cost are approximately $83.9 million. Project administration, design fees, and grant administration costs are expected to be approximately $22.6 million. Land acquisition costs are expected to be $4.7 million. Adding all these values together brings the total project costs to approximately $111.2 million. The detailed opinion of probable construction costs is attached to this memorandum.

A benefit-cost analysis (BCA) was conducted to provide a benefit-cost ration (BCR) that compared the costs of the proposed improvements against the benefits achieved. Benefits were calculated by determining pre- and post-project costs of structural losses, with the difference being the overall benefit. Based on the analysis, the proposed improvements will provide approximately $142.1 million in benefits, against a present value cost of $118.9M (OPCC plus operations and maintenance costs over a 50-year analysis period). This provides a BCR of 1.20 for the improvements.



0 2,000 4,000
Feet

- Proposed: Detention Pond
- Proposed: Disconnect Line
- Proposed Storm Sewer Line Reversal
- Proposed New Storm Sewer Line
- Proposed Storm Sewer Line Size Increase
- HCFCD Channels
- Existing Storm Sewer

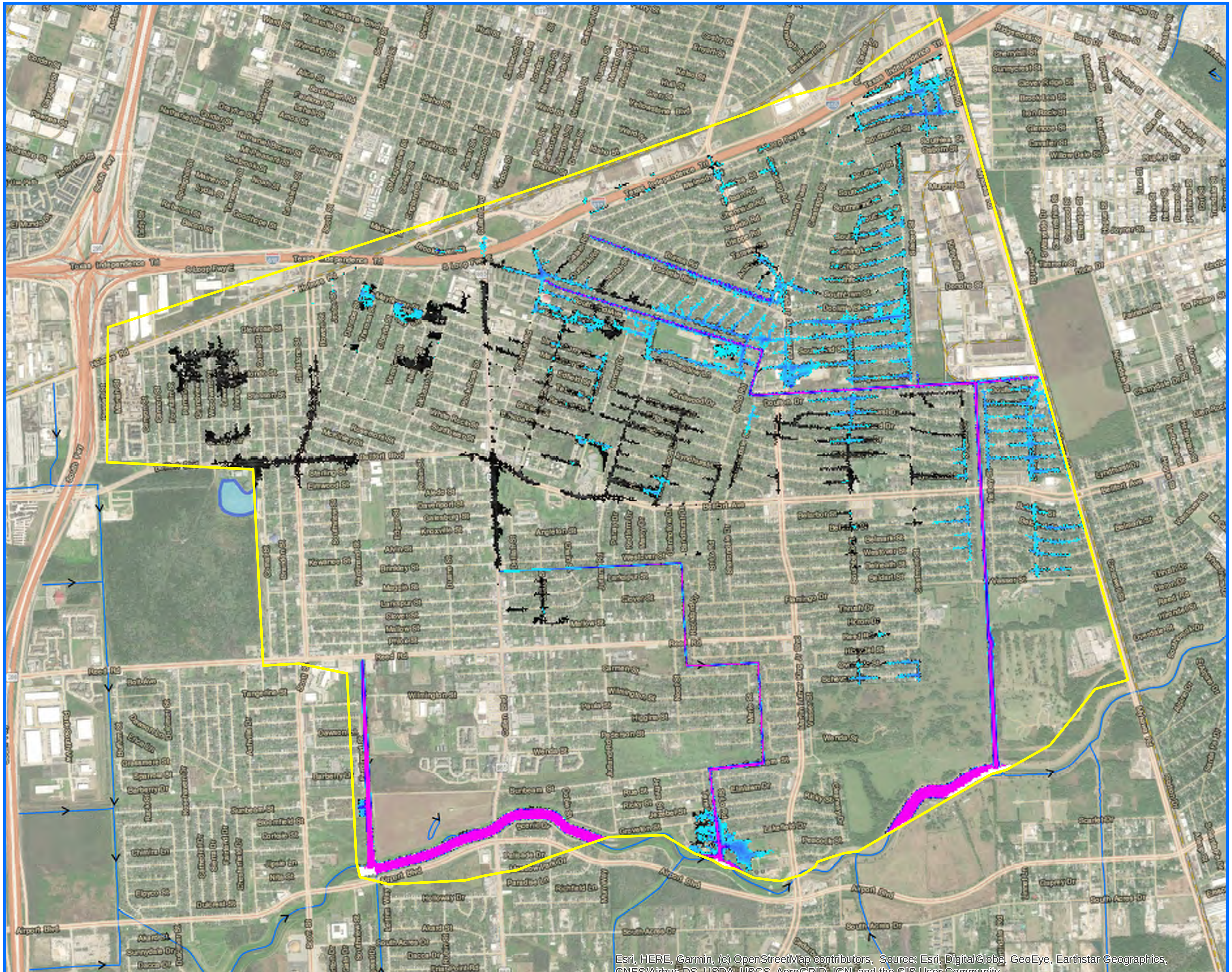
EXHIBIT 1

SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

HARRIS COUNTY, TX

PROPOSED IMPROVEMENTS

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis Extent

HCFCD Channels

Proposed: Detention Pond

Proposed Condition Ponding Depth (feet)

High : 5

Low : 0

Existing Condition Ponding Depth (feet)

High : 5

Low : 0

EXHIBIT 2

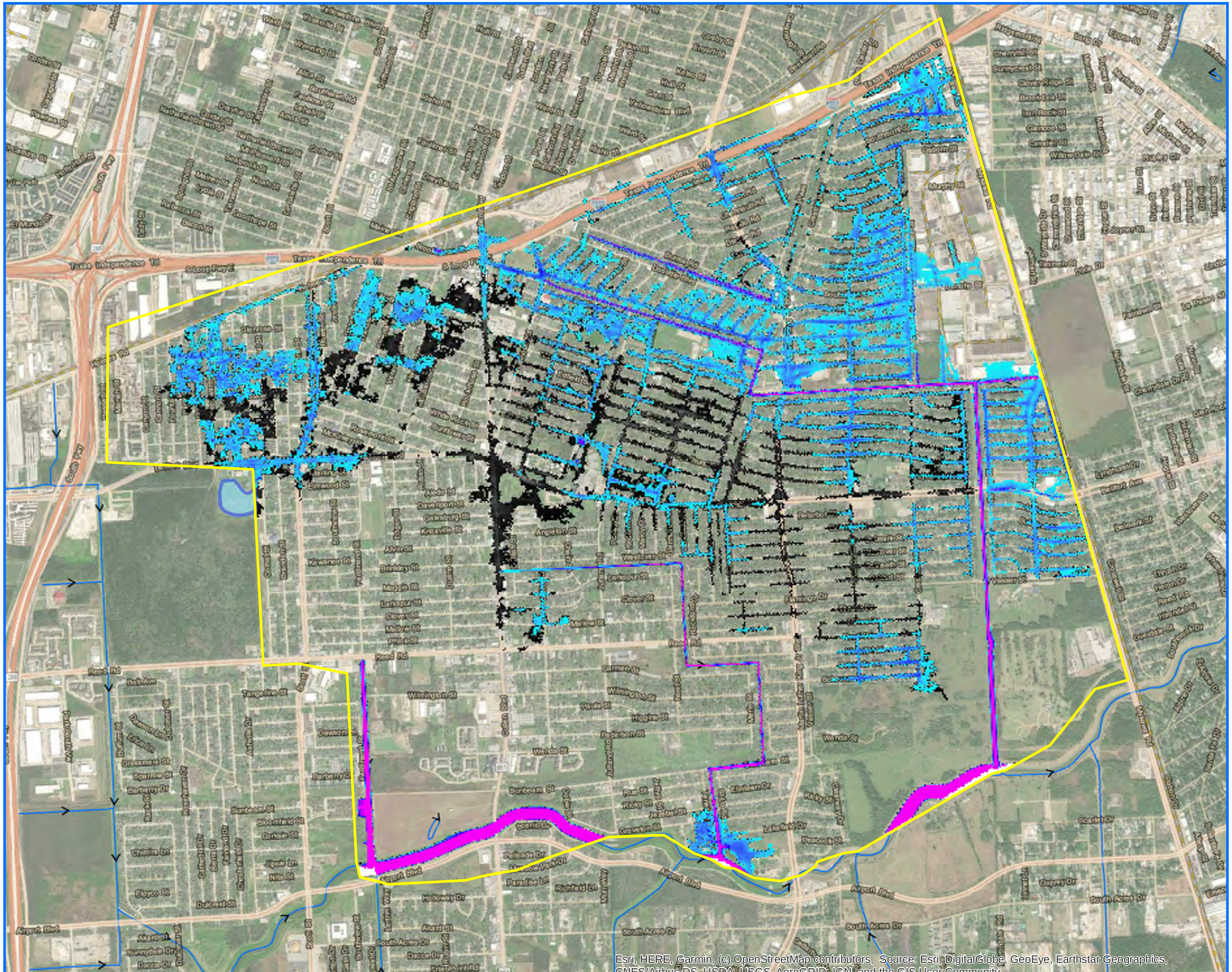
SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS
HARRIS COUNTY, TX

07/10/2020 SCENARIO

PONDING RESULTS

2-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis Extent

HCFCD Channels

Proposed: Detention Pond

Proposed Condition Ponding Depth (feet)

High : 5

Low : 0

Existing Condition Ponding Depth (feet)

High : 5

Low : 0

EXHIBIT 3

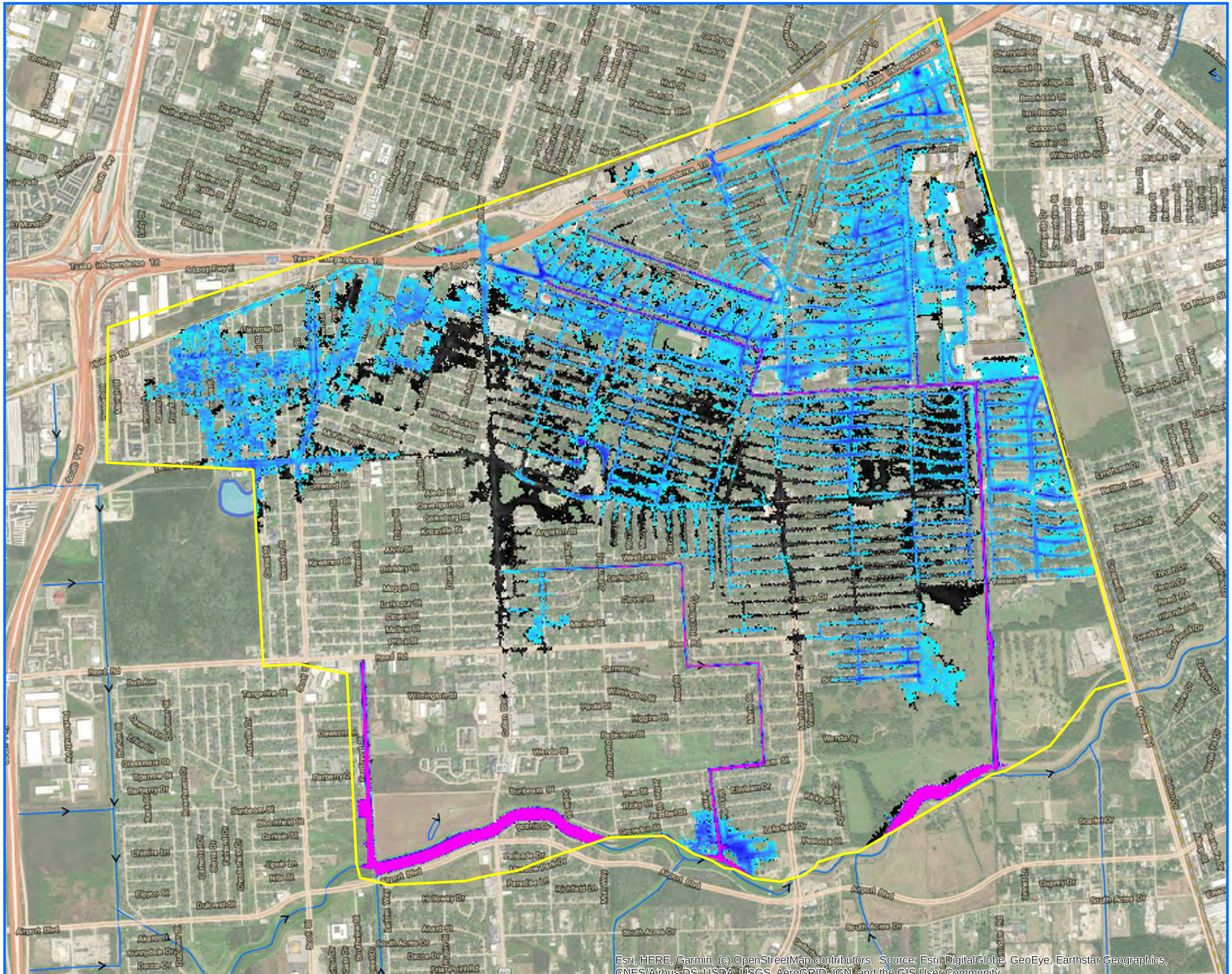
SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS
HARRIS COUNTY, TX

07/10/2020 SCENARIO

PONDING RESULTS

10-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



0 2,000 4,000
Feet

2D Analysis Extent

HCFCD Channels

Proposed: Detention Pond

Proposed Condition Ponding Depth (feet)

High : 5

Low : 0

Existing Condition Ponding Depth (feet)

High : 5

Low : 0

EXHIBIT 4

SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

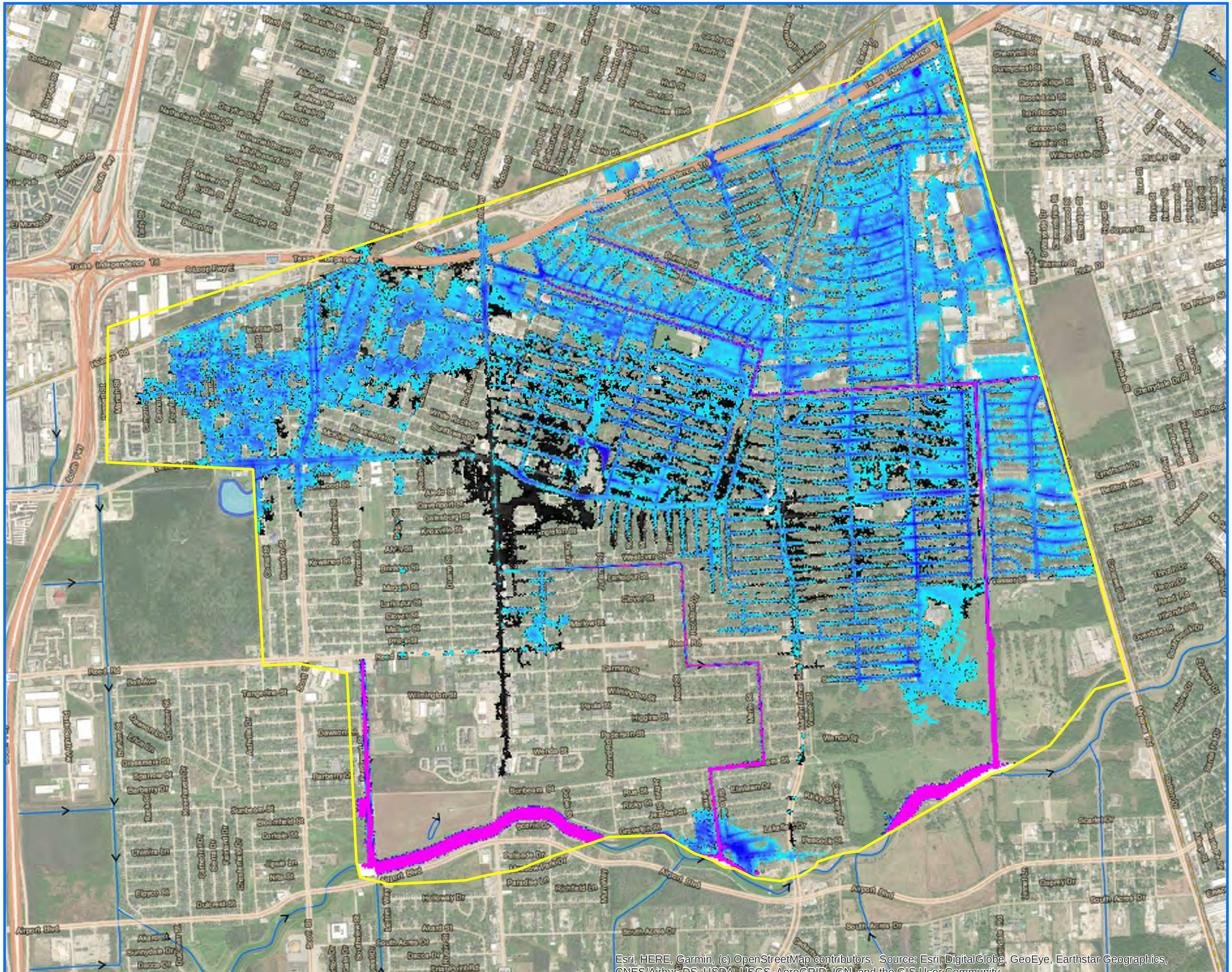
HARRIS COUNTY, TX

07/10/2020 SCENARIO

PONDING RESULTS

25-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis Extent

Proposed: Detention Pond

Proposed Condition Ponding Depth (feet)

High : 5

Low : 0

Existing Condition Ponding Depth (feet)

High : 5

Low : 0

HCFCD Channels

EXHIBIT 5

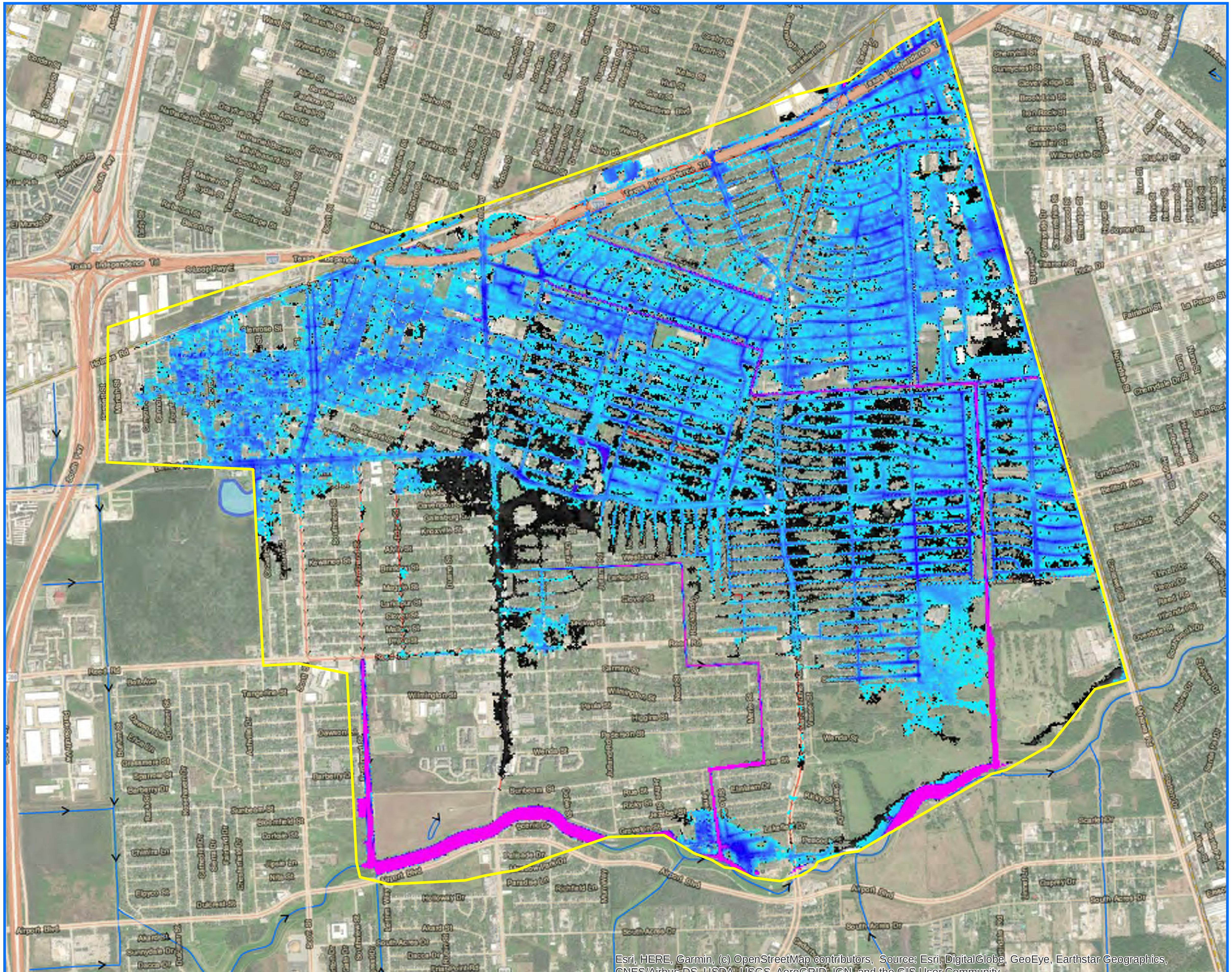
SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

07/10/2020 SCENARIO

PONDING RESULTS

50-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis

Proposed: Detention Pond

Proposed Condition Ponding Depth (feet)

High : 5

Low : 0

Existing Condition Ponding Depth Value

High : 5

Low : 0

HCFCD Channels

Storm Sewer System

EXHIBIT 6

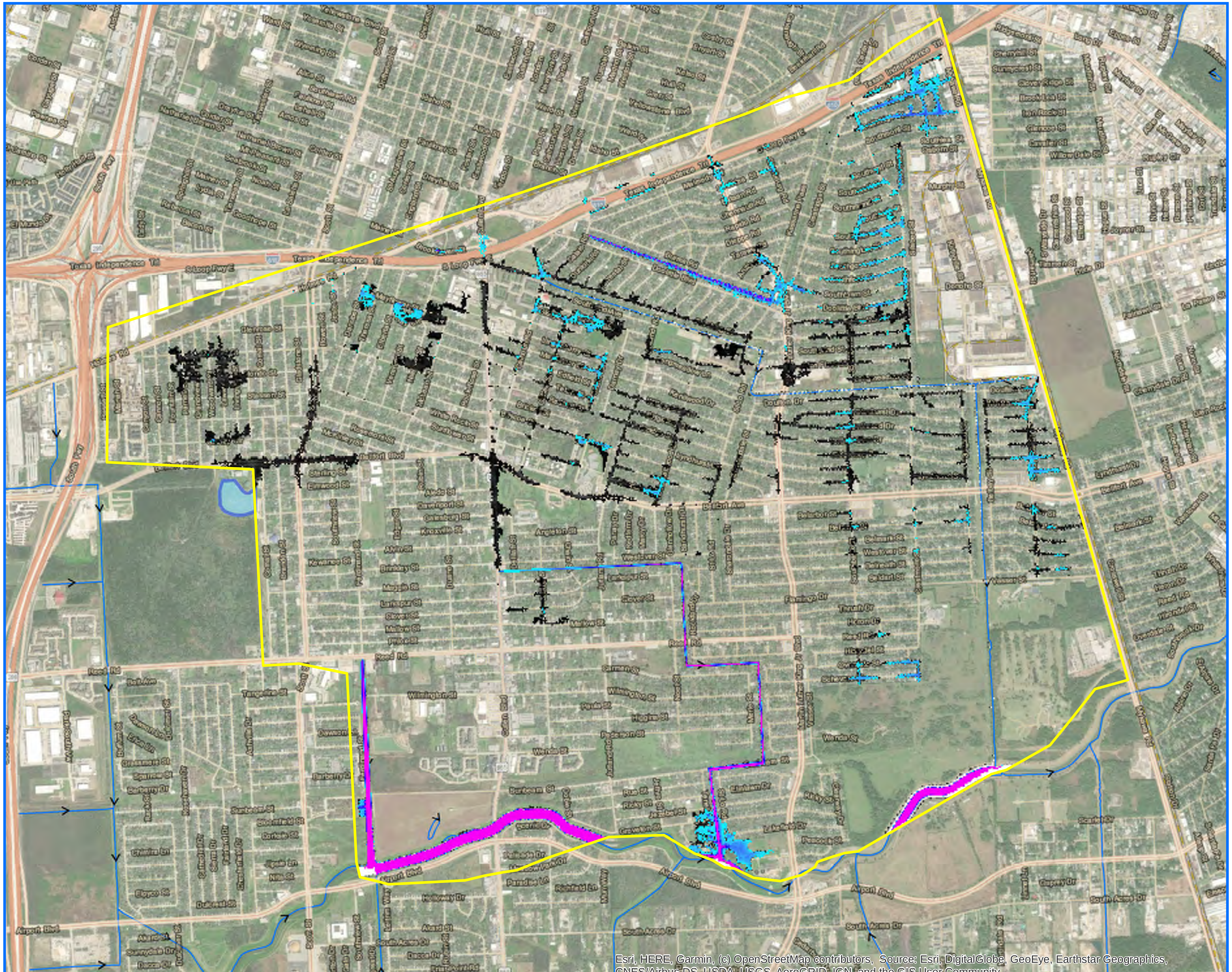
SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

07/10/2020 SCENARIO

PONDING RESULTS

100-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis Extent

HCFCD Channels

Proposed: Detention Pond

Proposed Condition Ponding Depth (feet)

High : 5

Low : 0

Existing Condition Ponding Depth (feet)

High : 5

Low : 0

EXHIBIT 7

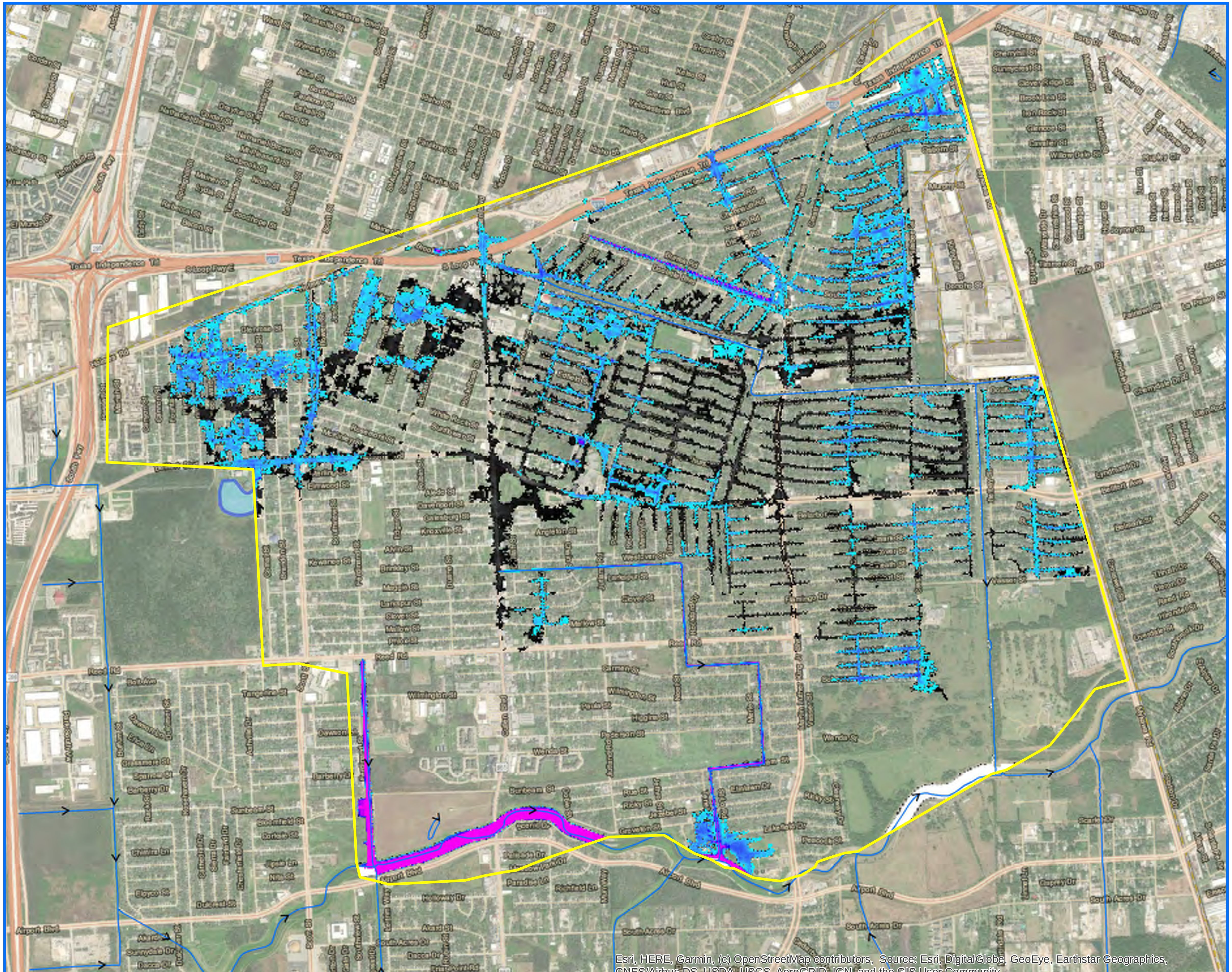
SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

SALT WATER DITCH IMPROVEMENTS & STORM SEWER IMPROVEMENTS

PONDING RESULTS

2-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis

Proposed: Detention

HCFCD Channels

Proposed Condition Ponding

Value

High : 5

Low : 0

Existing Condition Ponding

(feet)

High : 5

Low : 0

EXHIBIT 8

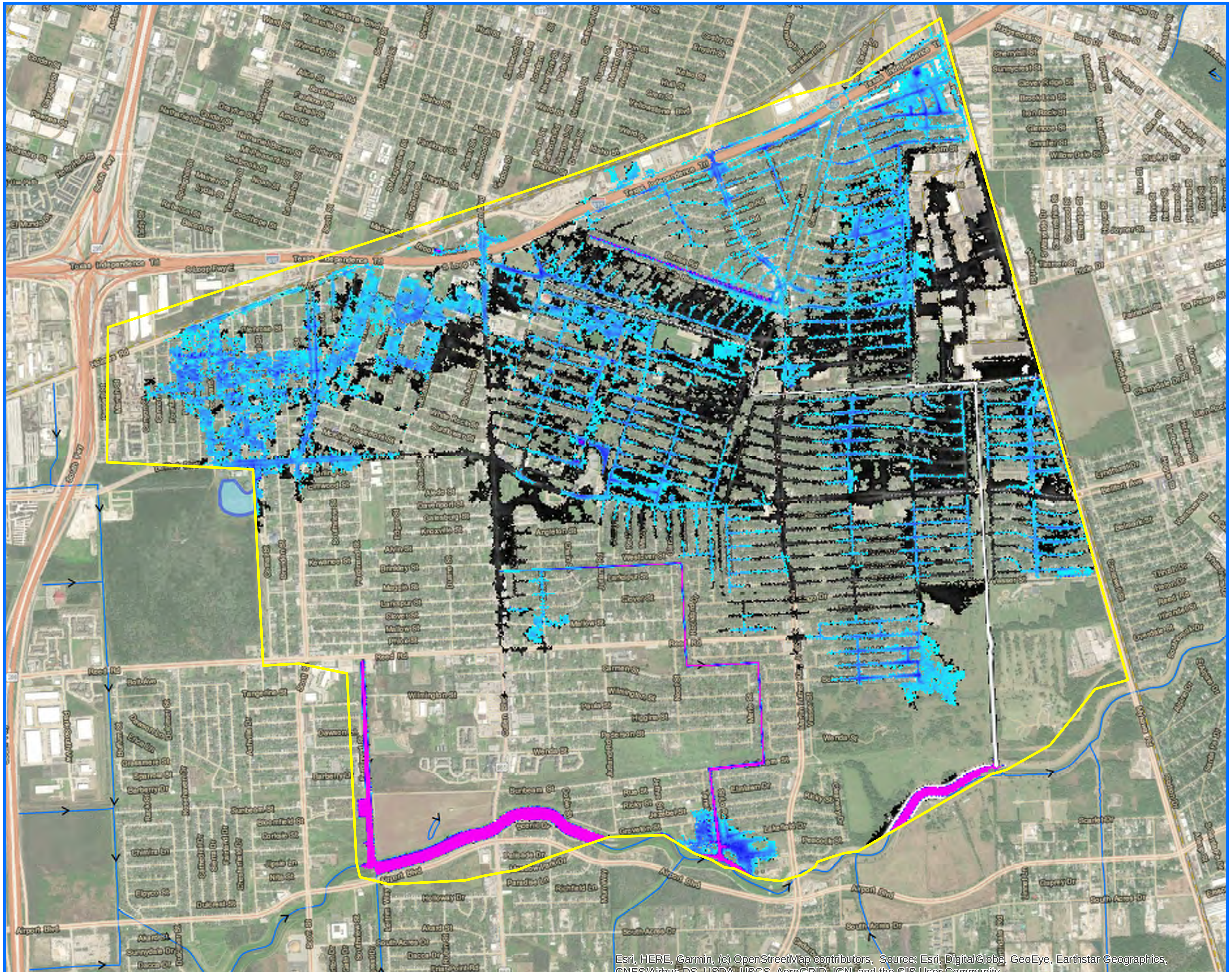
SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

SALT WATER DITCH IMPROVEMENTS & STORM SEWER IMPROVEMENTS

PONDING RESULTS

10-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis Extent

HCFCD Channels

Proposed: Detention Pond

Proposed Condition Ponding Depth (feet)

High : 5

Low : 0

Existing Condition Ponding Depth (feet)

High : 5

Low : 0

EXHIBIT 9

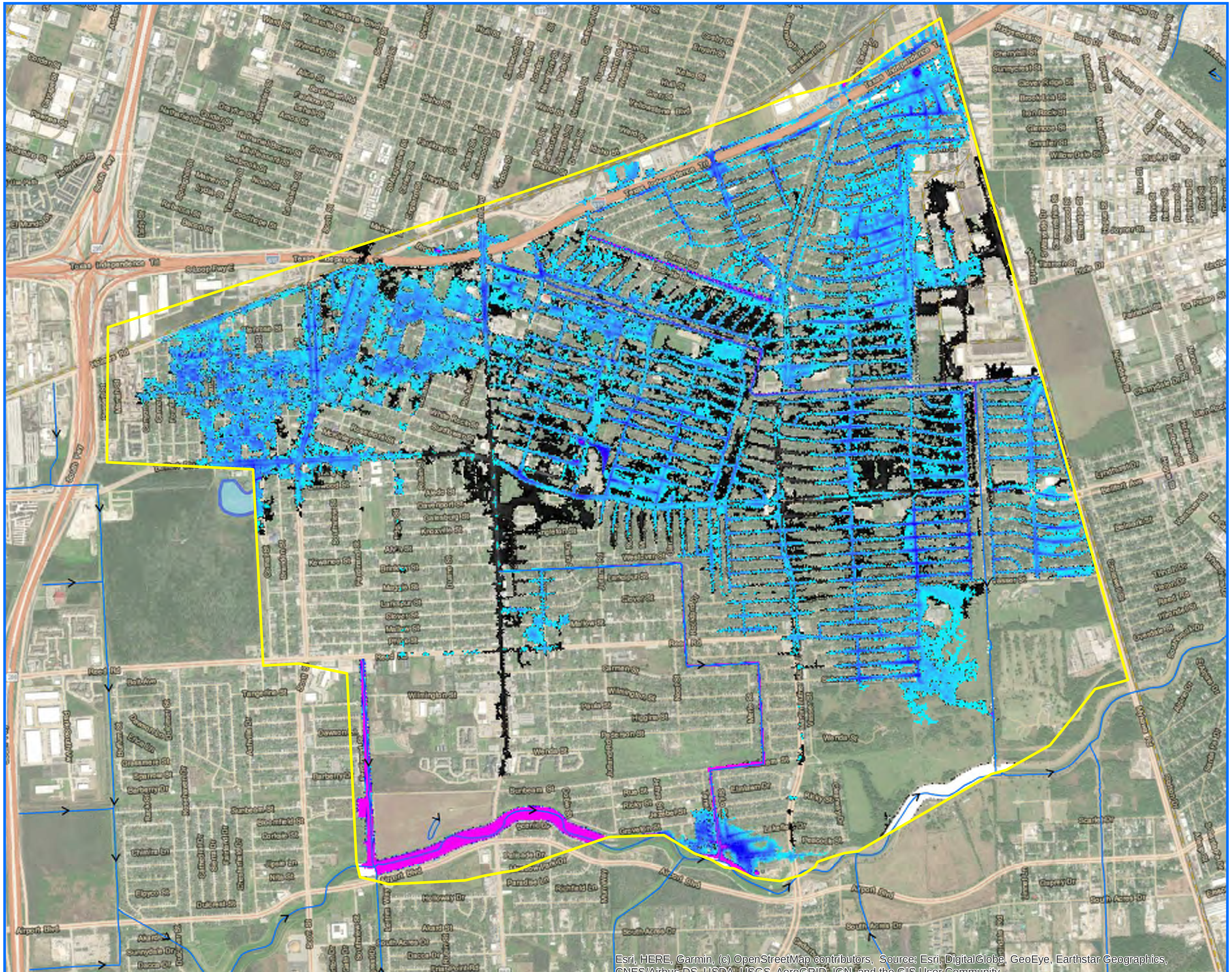
SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

SALT WATER DITCH IMPROVEMENTS & STORM SEWER IMPROVEMENTS

PONDING RESULTS

25-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis Extent

Proposed: Detention Pond

HCFCD Channels

Proposed Condition Ponding Depth

Value

High : 5

Low : 0

Existing Condition Ponding Depth

(feet)

High : 5

Low : 0

EXHIBIT 10

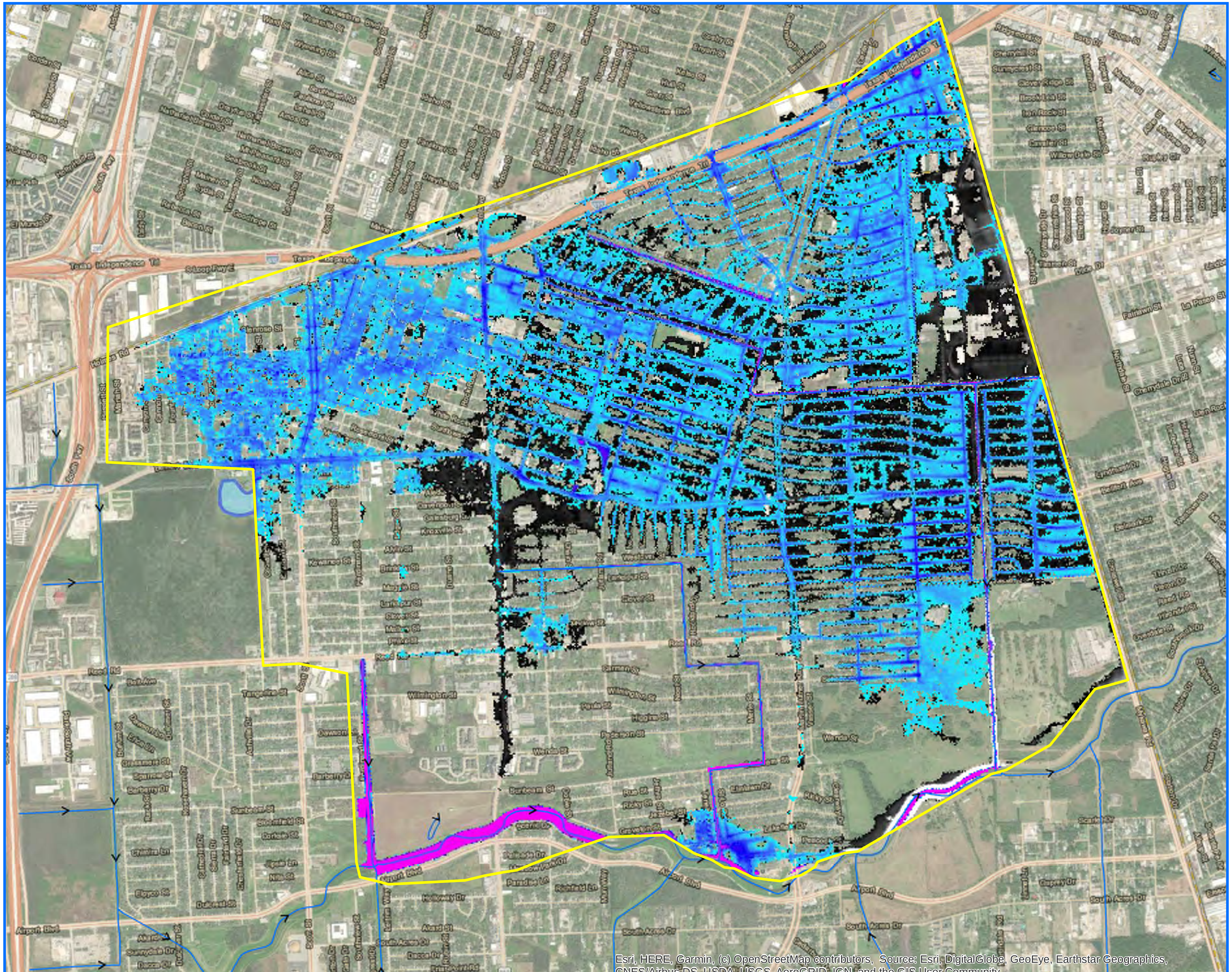
SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

SALT WATER DITCH IMPROVEMENTS & STORM SEWER IMPROVEMENTS

PONDING RESULTS

50-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services



N

0 2,000 4,000
Feet

2D Analysis Extent

Proposed: Detention Pond

HCFCD Channels

Proposed Condition Ponding Depth

Value

High : 5

Low : 0

Existing Condition Ponding Depth

Value

High : 5

Low : 0

EXHIBIT 11

SOUTH PARK/SUNNYSIDE DRAINAGE ANALYSIS

SALT WATER DITCH IMPROVEMENTS & STORM SEWER IMPROVEMENTS

PONDING RESULTS

100-YEAR STORM EVENT

HT&J, LLC
Professional Engineering Services

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

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

Applicant/Subrecipient:	City of Houston					
Site/Activity Title:	City of Houston Sunnyside/Southpark Drainage Improvements					
Eligible Activity:	Flood control and drainage improvements					
Materials/Facilities/Services	**$/Unit**	**Unit**	**Quantity**	**Construction**	**Acquisition**	**Total**
General items						
Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	$ 1,021,000.00	LS	1	$ 1,021,000.00	$ -	$ 1,021,000.00
Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	$ 590,000.00	LS	1	$ 590,000.00	$ -	$ 590,000.00
Utility Conflicts / Relocation/Adjustment/Landscaping	$ 4,572,500.00	LS	1	$ 4,572,500.00	$ -	$ 4,572,500.00
					Subtotal General Items:	$ 6,183,500.00
Paving items						
Existing Concrete pavement removal, complete in place the sum of:	$ 7.00	SY	21,550	$ 150,850.00	$ -	$ 150,850.00
6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	$ 80.00	SY	21,550	$ 1,724,000.00	$ -	$ 1,724,000.00
11" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	$ 100.00	SY	-	$ -	$ -	$ -
8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	$ 4.00	SY	26,410	$ 105,640.00	$ -	$ 105,640.00
Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	$ 165.00	TON	755	$ 124,575.00	$ -	$ 124,575.00
6" concrete curb, including reinforcement and joints, complete in place the sum of:	$ 5.00	LF	14,920	$ 74,600.00	$ -	$ 74,600.00
5' concrete sidewalk, complete in place the sum of:	$ 65.00	SY	8,150	$ 529,750.00	$ -	$ 529,750.00
Concrete curb ramp per ADA requirements, complete in place the sum of:	$ 2,000.00	EA	70	$ 140,000.00	$ -	$ 140,000.00
Driveway Reconnection	$ 125,900.00	LS	1	$ 125,900.00	$ -	$ 125,900.00
					Subtotal Paving Items:	$ 2,975,315.00
Drainage items						
Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	$ 30.00	LF	41,205	$ 1,236,150.00	$ -	$ 1,236,150.00
Remove existing storm sewer inlet/manhole, complete in place the sum of:	$ 600.00	EA	372	$ 223,200.00	$ -	$ 223,200.00
48" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 250.00	LF	3,280	$ 820,000.00	$ -	$ 820,000.00
60" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 350.00	LF	6,150	$ 2,152,500.00	$ -	$ 2,152,500.00
96" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 500.00	LF	-	$ -	$ -	$ -
5'x4' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 325.00	LF	-	$ -	$ -	$ -
6'x5' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 490.00	LF	3,110	$ 1,523,900.00	$ -	$ 1,523,900.00
9'x6' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 800.00	LF	-	$ -	$ -	$ -
10'x5' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 808.00	LF	985	$ 795,880.00	$ -	$ 795,880.00
10'x6' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 845.00	LF	-	$ -	$ -	$ -
10'x7' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 865.00	LF	-	$ -	$ -	$ -
10'x8' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 900.00	LF	15,440	$ 13,896,000.00	$ -	$ 13,896,000.00
10'x9' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 905.00	LF	-	$ -	$ -	$ -
10'x10' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	$ 916.00	LF	19,500	$ 17,862,000.00	$ -	$ 17,862,000.00
Manholes (For 48" to 72" Dia. Pipe) (All Typ)	$ 6,340.00	EA	46	$ 291,640.00	$ -	$ 291,640.00
Manholes (For 78" Dia. Pipe and Larger) (All Types)	$ 16,500.00	EA	80	$ 1,320,000.00	$ -	$ 1,320,000.00
Inlets (Type BB with grate)	$ 3,000.00	EA	242	$ 726,000.00	$ -	$ 726,000.00
Detention Excavation, piping, stabilization, complete in place	$ 20.00	CY	-	$ -	$ -	$ -
Detention Excavation, piping, stabilization, complete in place	$ 10.00	CY	-	$ -	$ -	$ -
Detention Excavation, haul off, piping, stabilization, complete in place	$ 12.00	CY	1,209,750	$ 14,517,000.00	$ -	$ 14,517,000.00
					Subtotal Drainage Items:	$ 55,364,270.00
TOTAL				$ 64,523,085.00	$ -	$ 64,523,085.00
					Estimated Probable Cost of Construction:	$ 64,523,085.00
					30% Contingency:	$ 19,356,925.50
					Total Estimated Probable Cost of Construction:	$ 83,880,010.50
Engineering (Design, Bidding, Survey, Geotechnical, Construction Phase Services) (15%)						$ 12,582,001.58
Environmental Investigation and Permitting (6%)						$ 5,032,800.63
Grant Administration (6%)						$ 5,032,800.63
OPCC Including Professional Services						$ 93,945,611.76

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

2. Identify and explain any special engineering activities.

Date:	
Phone Number:	

Seal

Signature of Registered Engineer/Architect Responsible For Budget Justification:

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

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

Applicant/Subrecipient:	City of Houston					
Site/Activity Title:	City of Houston Sunnyside/Southpark Drainage Improvements					
Eligible Activity:	Acquisition					
Materials/Facilities/Services	**$/Unit**	**Unit**	**Quantity**	**Construction**	**Acquisition**	**Total**
Pond 1	$ -	LS	1	$ -	$ 4,250,406.00	$ 4,250,406.00
Pond 2	$ -	LS	1	$ -	$ 473,628.00	$ 473,628.00
					Subtotal Acquisition:	$ 4,724,034.00
TOTAL				$ -	$ 4,724,034.00	$ 4,724,034.00

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

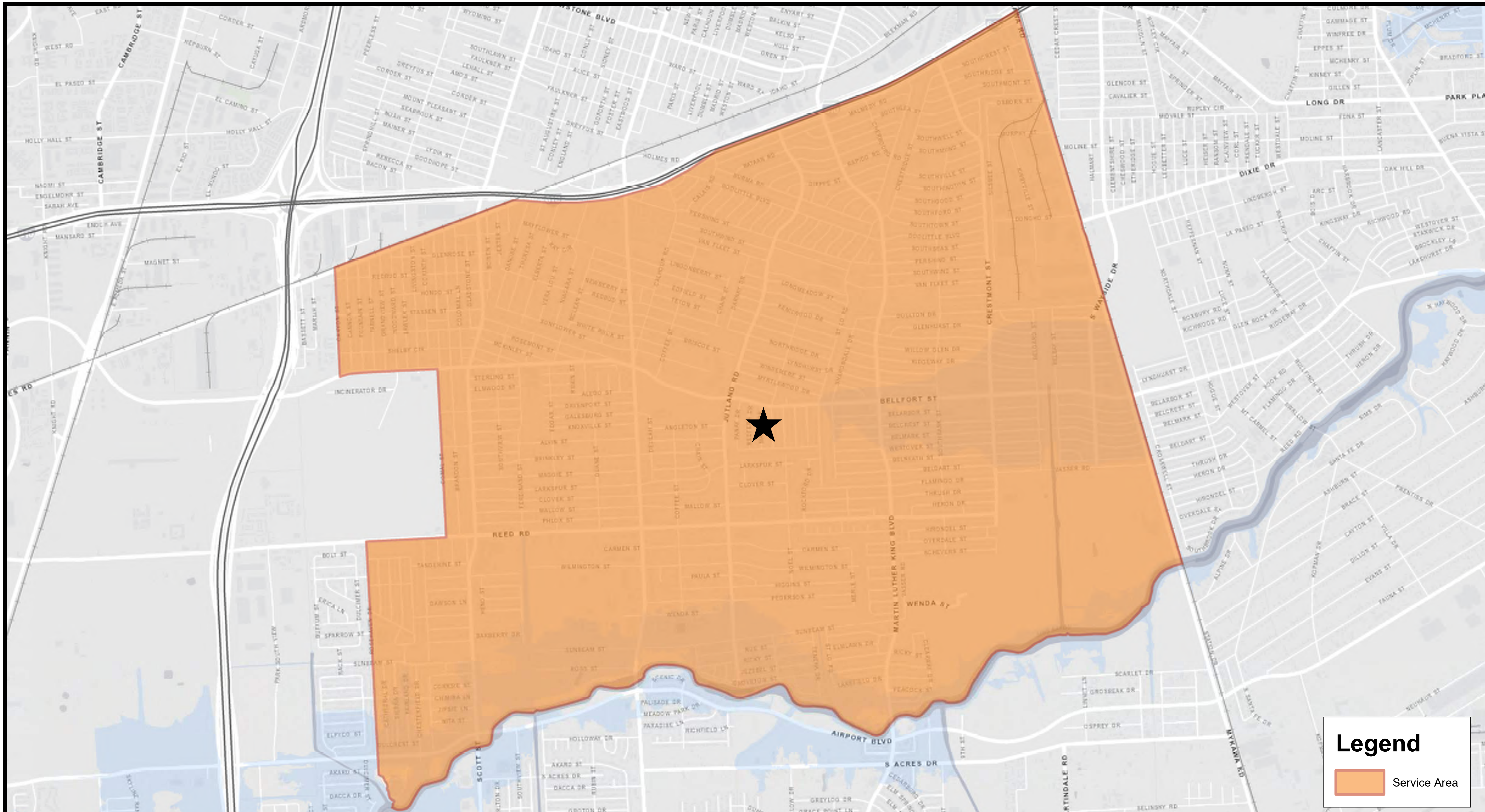
2. Identify and explain any special engineering activities.

Date:	
Phone Number:	

Seal

Signature of Registered Engineer/Architect Responsible For Budget Justification:

Houston Sunnyside Area Flood Mitigation - Location Map



N

★ Latitude: 29.665045
Longitude: -95.345983

Address: 8127 Marcy Dr
Houston, TX 77033

County: Harris

Memo

Date:	Monday, October 12, 2020
Project:	City of Houston Drainage Pre-Engineering Services for Storm Water Drainage Projects Work Order #9 – Sunnyside Drainage Analysis
To:	Adam Eaton, PE, ENV SP
From:	Jeremy Blevins, PE, CFM, Jeremy Cook, & Taylor Hackbart
Subject:	Benefit-Cost Analysis for Sunnyside Area Flood Mitigation CDBG-MIT Application

Introduction

A benefit cost analysis (BCA) has been performed by HDR Engineering to support a potential CDBG-MIT application to obtain federal funds for a project located in Houston, Texas. The mitigation project includes storm sewer and roadway improvements along with the construction of regional detention basins. These improvements will reduce flooding in the South Park and Sunnyside area of Houston.

The BCA utilized an MS Excel based spreadsheet to estimate the present value stream of expected annual benefits and costs of the Sunnyside Drainage Improvement Project over a project life of 50 years. The MS Excel spreadsheet is developed by HDR based on the methodology presented in the FEMA BCA Toolkit version 6.0. All values were updated to current value as needed and adjusted to present value using OMB discount rates (OMB Circular A-94).

The steps HDR used to develop the BCA model are outlined below and are followed by a discussion of the findings.

Methodology

The BCA model was developed in 3 steps. First, hydrology and hydraulic (H&H) models were developed. The H&H models were used to first delineate the flooding extents and then to identify the magnitude of flood impacts. Following completion of the H&H modeling, data for impacted structures was collected. Finally, the H&H and structure data were used to develop the BCA model.

H&H Inputs

STRUCTURE INPUTS

Following completion of the H&H modeling, the pre-project100-yr floodplain was used to inventory all structures impacted by flooding. This inventory captures all residential and non-residential buildings within the 100-yr floodplain. Impacted structures were assigned flood depths for each of the 5 return periods (2-year, 10-year, 25-year, 50-year, and 100-year storm events) under the pre- and post-improvement conditions.

Data for each structure was obtained and linked with the flood depths in order to translate depth of flooding into monetary estimates of flood related damages with each return period. Data needs include surveyed finished floor elevations; building type (residential, non-residential); foundation type; number of stories; non-residential building type; building size (square feet); and assessed value. Damages were only applied to the first story of each impacted structure.

The Harris County Appraisal District provided GIS coverage of parcels including structure information, valuation, and square footage. Foundation heights were determined based on common structure type designs established by FEMA.

BCA MODEL DEVELOPMENT

The complete structure and H&H data was entered into the MS Excel model to estimate pre and post-improvement flood damages. The model computes flood reduction benefits at each structure from the difference in pre and post mitigation damages for each of the five return periods. These individual structure flood hazard mitigation benefits were then aggregated to a comprehensive hazard mitigation benefit. This was then be compared to a present value cost of the project (includes planning, final design, construction, and annual operations and maintenance over 50-years).

Structure damages in the area were evaluated using depth damage estimations developed for the area by FEMA. These estimations relate the level of flooding to the dollar amount of damage to each structure. Key inputs for residential displacement include the number of people per household, lodging costs per day, and meal costs per day.

Findings

MITIGATION PROJECT COSTS

The estimated costs for completing The Project are shown below in Table 1. The total implementation cost of $111.3 million combined with annual O&M of $551,258 over 50 years yields a total present value cost of $118.9 million for the project.

Table 1: Sunnyside Drainage Improvement Total Estimated Project Cost (2020 $s, 7% discount factor, 50 yr period of analysis)

Cost Component	Cost
Total Project Cost	$111,251,647
Annual O&M	$551,258
Total Present Value Cost	$118,859,419

DAMAGE REDUCTION BENEFITS

Table 2 below provides a summary of the total damages under pre and post mitigation conditions. The total annualized damages pre mitigation are $34,938,161 with post mitigation annual damages reduced by $286,567 to $13,637.

Table 2: Sunnyside Drainage Improvement Structure Related Flood Mitigation Damages (2020 $s)

Recurrence Interval	Pre Mitigation Damages		Post Mitigation Damages	
	Total	Annualized	Total	Annualized
2 yr	$33,463,627	$21,632,867	$22,886,853	$14,698,587
10 yr	$87,404,776	$6,437,276	$58,999,065	$4,477,153
25 yr	$131,694,187	$2,965,004	$94,374,843	$2,271,273
50 yr	$166,887,614	$1,850,700	$136,653,993	$1,516,050
100 yr	$205,233,445	$2,052,314	$168,191,767	$1,681,901
Total Annualized		$34,938,161		$24,644,964

BENEFIT-TO-COST ANALYSIS SUMMARY

A summary of the final benefit-to-cost analysis is shown below in **Table** 3. As previously stated the present value cost of the project is $118.9 million when considering a 7% discount factor and 50 year analysis period. As evaluated by the analysis, the project would provide $142 million in flood mitigation benefits resulting in a favorable benefit to cost ratio of 1.20.

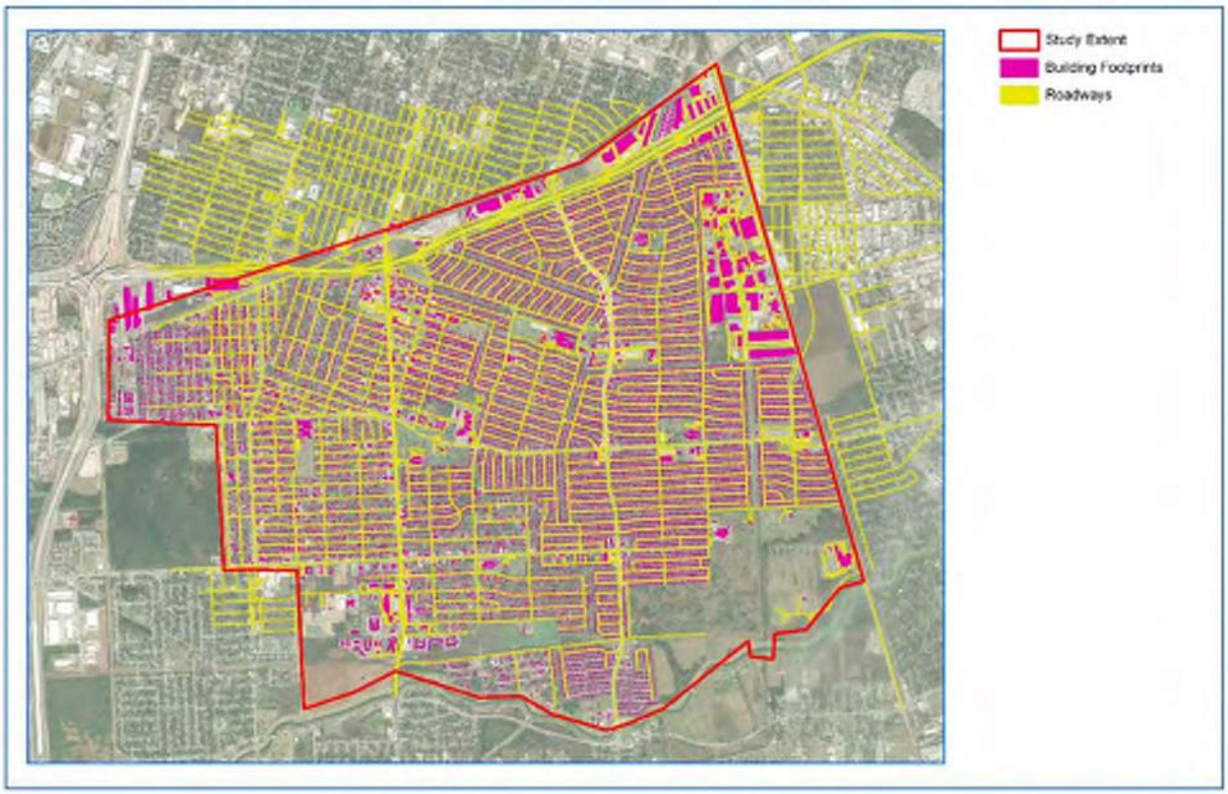
Table 3: Sunnyside Drainage Improvement Benefit-to-Cost Summary

Component	Present Value
Total Present Value Cost	$118,859,419
Total Present Value Benefits	$142,053,800
Net Present Value	$36,195,606
Benefit-to-Cost Ratio (BCR)	1.20

A large majority of the project area is located within the Sims Bayou watershed, while a small portion of the area drains to the Loop 610 drainage system and thence to HCFCD Unit D105-00-00 and ultimately Brays Bayou. The portion of the project area within the Sims Bayou watershed is drained via underground storm sewer or roadside ditches to one of three tributaries of Sims Bayou: 1) HCFCD Unit C118-00-00 (Salt Water Ditch); 2) HCFCD Unit C122-00-00; and 3) HCFCD Unit C128-00-00.

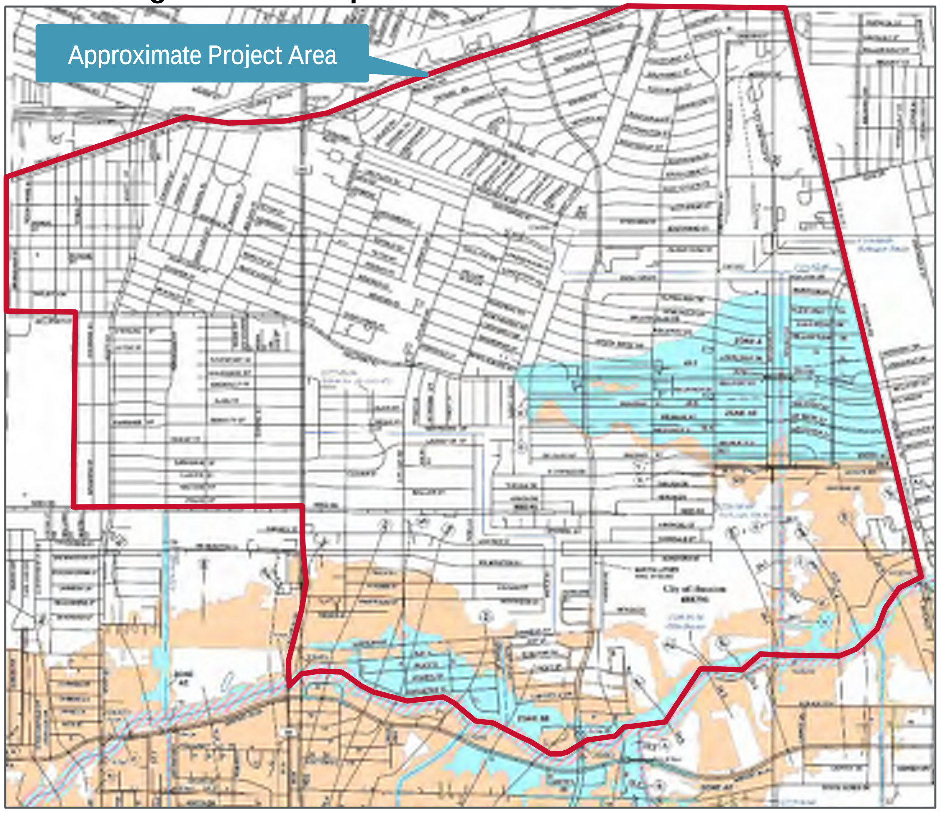
The South Park neighborhood is mainly single-family residential development with some commercial development along major thoroughfares and with local schools located within the project area. Figure 2 below provides a map of land use used in the existing conditions models within the project area.

Figure 2 - Land Use Map for XP-SWMM Model



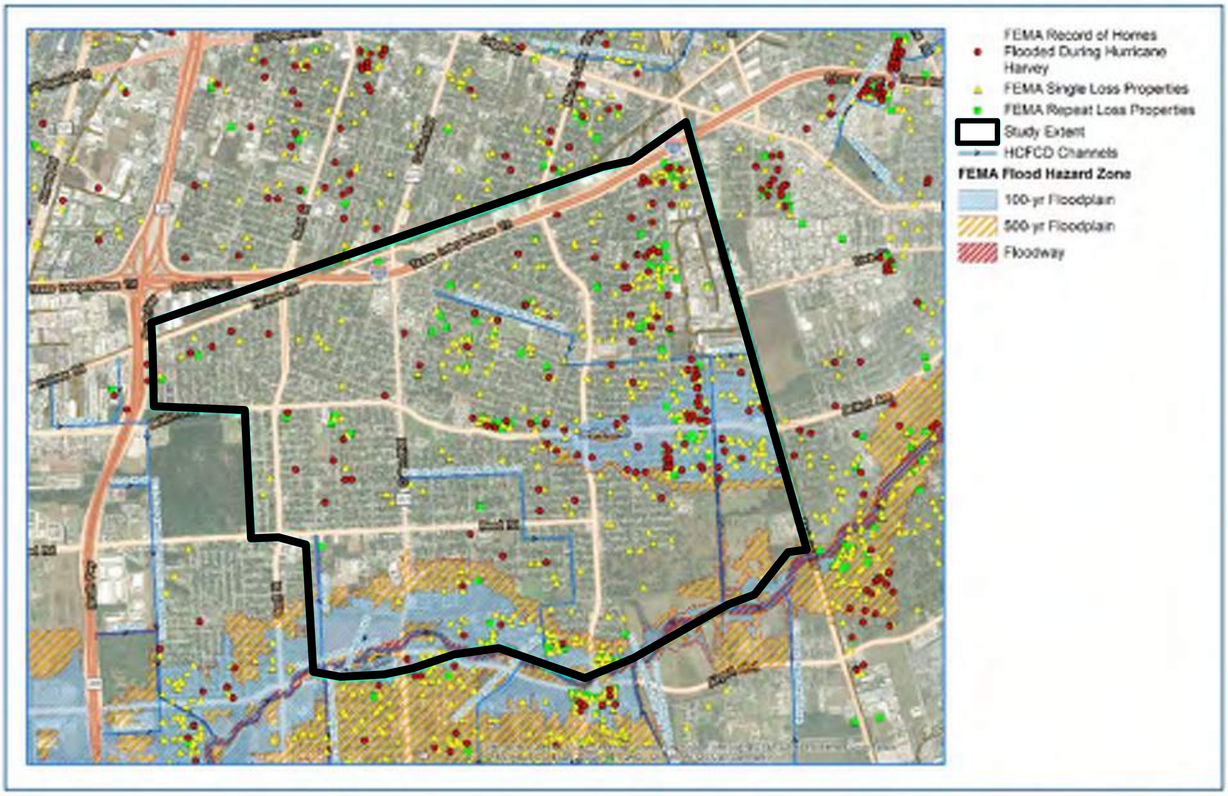
Most of the project area is located outside of the FEMA effective floodplain based on Flood Insurance Rate Map Panel No. 48201C0890M dated May 2, 2019. Figure 3 below provides a snapshot of the referenced FIRM panel. The limit of detailed study of HCFCD Unit C118-00-00 ends just upstream of Bellfort St., and a large area upstream of this limit is designated as Zone A (Approximate Floodplain). HCFCD Units C122-00-00 and C128-00-00 are both unstudied tributaries of Sims Bayou.

Figure 3 – Excerpt from FIRM Panel 48201C0890M



Significant structural flooding has occurred throughout the project area, as documented via FEMA flood insurance claims. The most significant historical structural flooding occurred during Hurricane Harvey. Figure 4 provides a map of FEMA flood insurance claims, including single loss and repetitive loss properties. While there have been significant numbers of flood insurance claims, it is not indicative of the total number of flooded structures, as this neighborhood is relatively low income with many structures likely not having flood insurance policies.

Figure 4 - FEMA Flood Claims

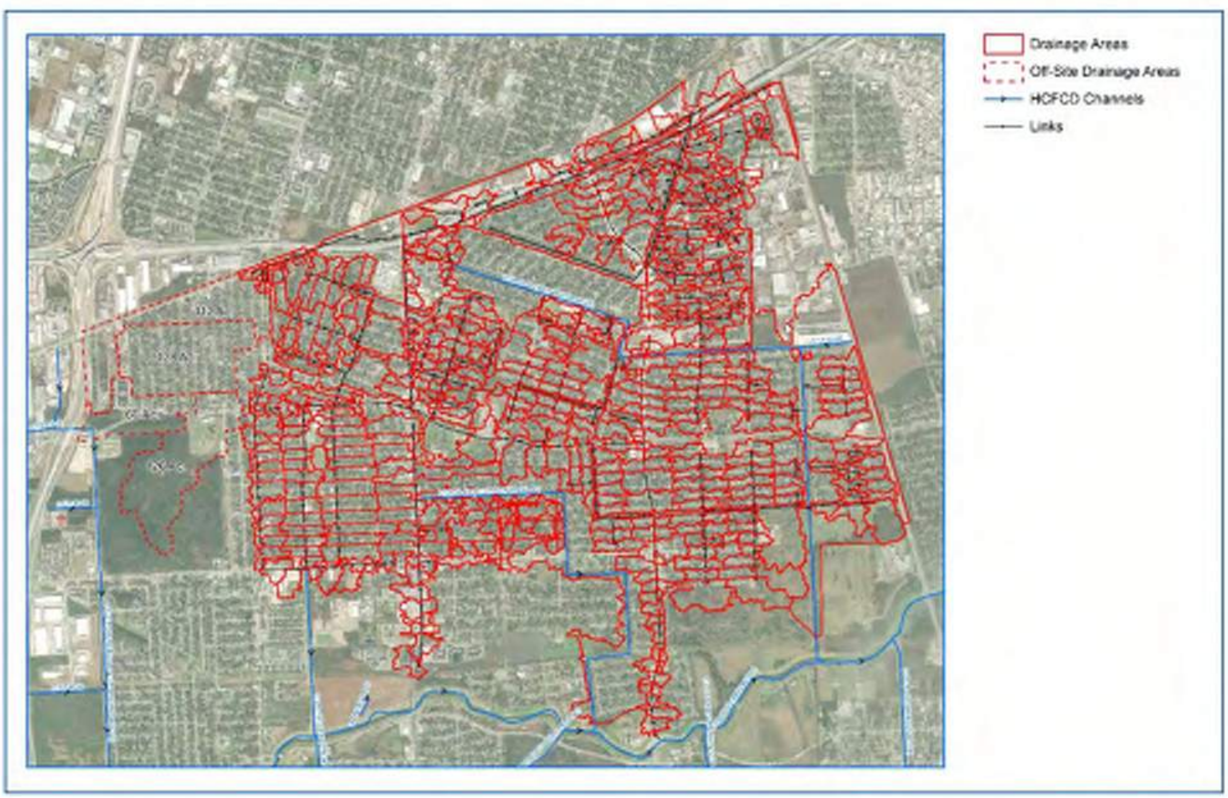


The topography of the project area is relatively flat with land sloping to the south and southeast, which is typical for the Houston area. A large majority of the project area drains to tributary channels including HCFCD Units C118-00-00, C122-00-00, and C128-00-00. Those tributaries drain to Sims Bayou. The northeast portion of the project area drains to an enclosed storm sewer system along Loop 610, which in turn drains to Brays Bayou.

The 2018 LIDAR was obtained from the Houston-Galveston Area Council, which is shown below in Figure 5 as a color-shaded topographic map with red representing higher elevations and green representing lower elevations. Gray shading represents areas that have been significantly elevated via fill, such as highway embankments and landfills. The 2018 LIDAR data was processed using the ArcHydro extension of ArcGIS in order to delineate overland flow patterns and sub-drainage areas within the project area. Those drainage areas and flow paths are shown below on Figure 6.

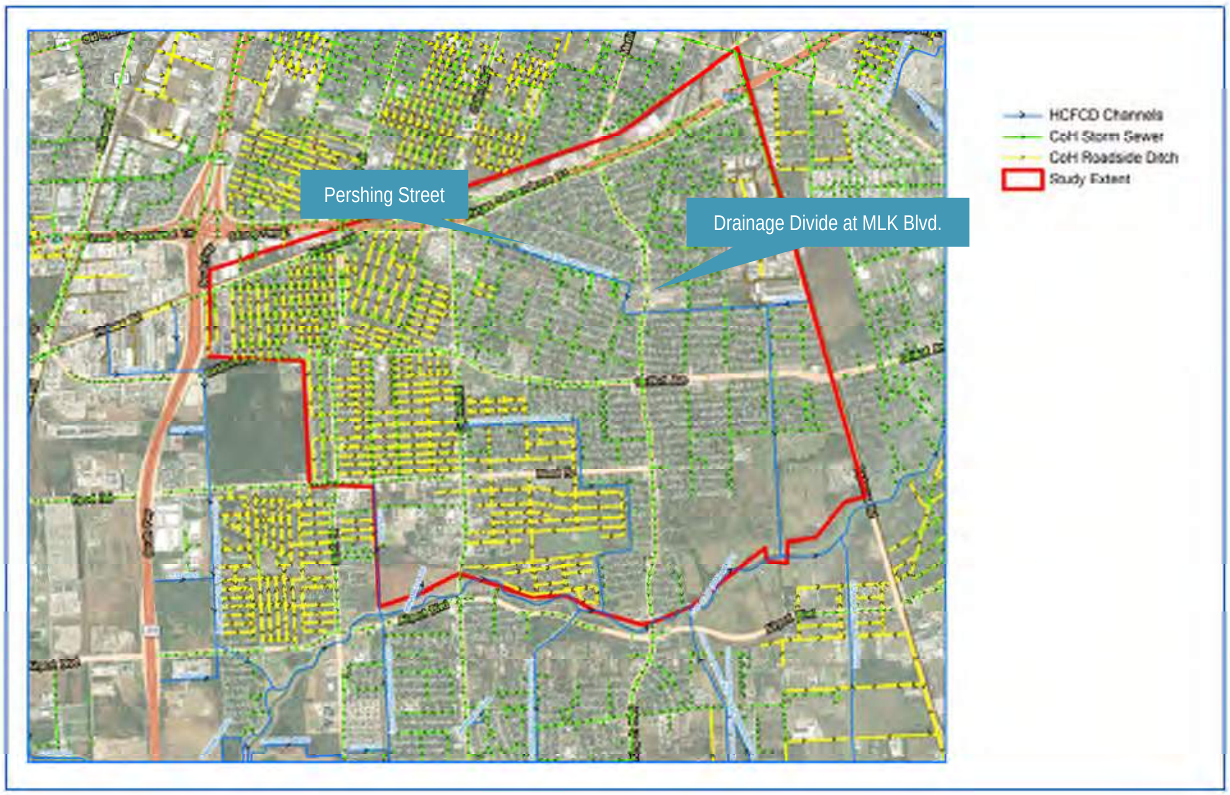
Figure 5 - Shaded Topographic Data (2018 H-GAC)

Figure 6 - Drainage Areas & Flow Paths



Existing storm sewer data was obtained from the City of Houston GIMS data, record drawings, and field visits. City of Houston GIMS data was inconclusive in the area near the drainage divide for the system that drains to Brays Bayou, and field visits were completed to verify that the system draining to Loop 610 is not interconnected with the system draining to Salt Water Ditch near the intersection of Martin Luther King Boulevard and Van Fleet Street. Likewise, City of Houston GIMS data indicated that there were multiple outfalls between residential structures draining from Pershing Street into the upstream portion of Salt Water Ditch west of Martin Luther King Boulevard, and field visits were completed to identify if those structures were in place and if they were functioning as designed. According to GIMS data, approximately 12 side-lot outfalls drain from Pershing Street to Salt Water ditch; however, only 3 of those outfalls were located in the field. Drainage boundaries were adjusted as required based on field observations. Figure 7 below provides an overview of the drainage infrastructure within the project area.

Figure 7 - City of Houston GIMS Data



As shown a large portion of the project area is drained via underground storm sewers, and the western portion of the project area is drained via a combination of storm sewer trunk lines and roadside ditches.

Existing Conditions Analysis

In order to assess the risk of structural flooding within the project area, the City of Houston tasked HDR and its subconsultant, HT&J, LLC, with building an existing conditions hydrology and hydraulic model of the project area. Time of Concentration (Tc) was calculated using the

City of Houston method, **TC = $10A^{0.1761}$ + 15**, where A is the area of the individual drainage sub-basin. The peak flow was calculated using the Rational Method, where the rainfall intensity was calculated using the City of Houston (Harris County) b, d, and e factors developed to reflect Atlas 14 rainfall.

The NOAA Atlas 14 rainfall data was applied with global rainfall in XPSWMM for all the scenarios and the storm events. The Clark unit hydrograph method was used to transform the rainfall into runoff. Since the drainage area for each sub-basin varies and is typically less than 20 acres, the peak flow calculated using the rational method was considered reasonable and appropriate for the individual sub-basins. Thus calculated peak flow was used to develop the hydrology for the XPSWMM model. The Clark unit hydrograph method requires Tc and storage coefficient (R). The TC calculated using the above equation was used and the storage coefficient (R) was adjusted to calibrate the peak flow of each drainage area to match the flow calculated with the Rational Method.

Several iterations were made to minimize any discrepancies in the peak flows calculated using rational method and the peak flow generated in XPSWMM for each sub-basin, and difference was limited within a percentage point.

An XP-SWMM model was built based on as-built drawings and GIMS data. Elevation data for the storm sewer was adapted from 2018 LIDAR data and record drawings. Upon inspection of multiple sets of record drawings and a comparison of corresponding vertical datums, it was determined that there was a wide variance in vertical datum adjustments to the Geoid 12B datum upon which the 2018 LIDAR is based. Because of this, depths to pipe inverts were measured from the record drawings and subtracted from elevations obtained from the 2018 LIDAR throughout the project area in order to establish the elevations of the storm sewers in the existing conditions XP-SWMM model.

Nodes and links were inserted into the model to simulate the existing storm sewer system and manholes. Inlets and inlet leads were not included in the model in order to simplify the model. Runoff hydrographs were inserted into the model at nodes based on the drainage area delineation. The model was run for the 2-year (50% annual chance), 10-year (10% annual chance), 50-year (2% annual chance), and 100-year (1% annual chance) storm events. The model results are shown below on Figures 8 through 14 for the 2-year, 10-year, 50-year, and 100-year storm events.

Figure 8 - 2-Year Storm Event Ponding Map

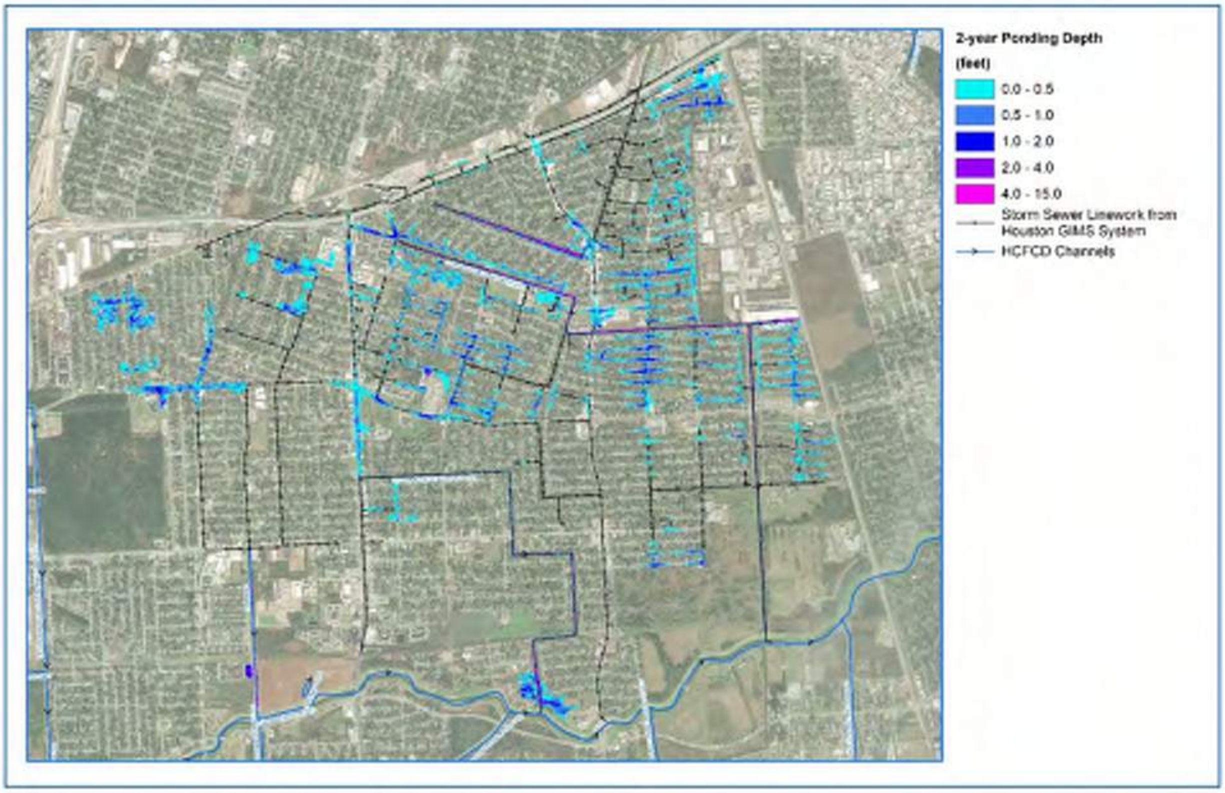


Figure 9 - 10-Year Storm Ponding Results

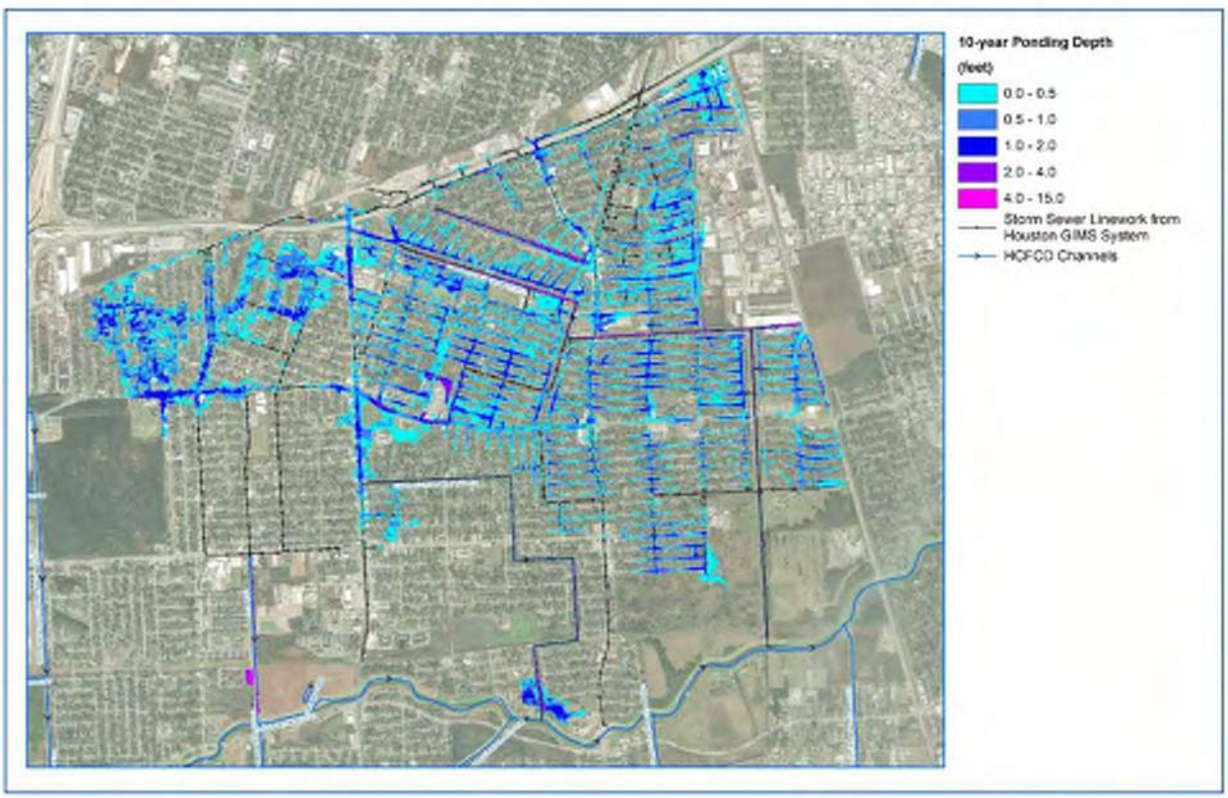


Figure 10 - 50-Year Ponding Results

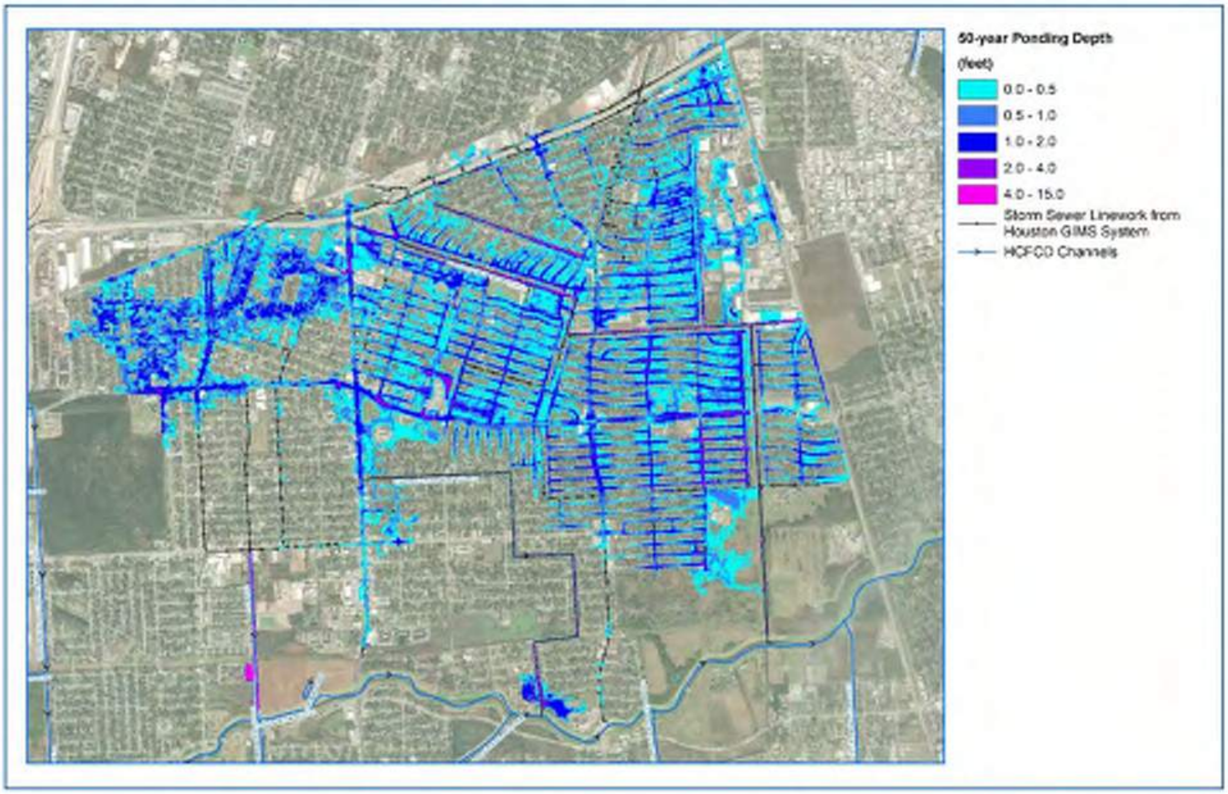
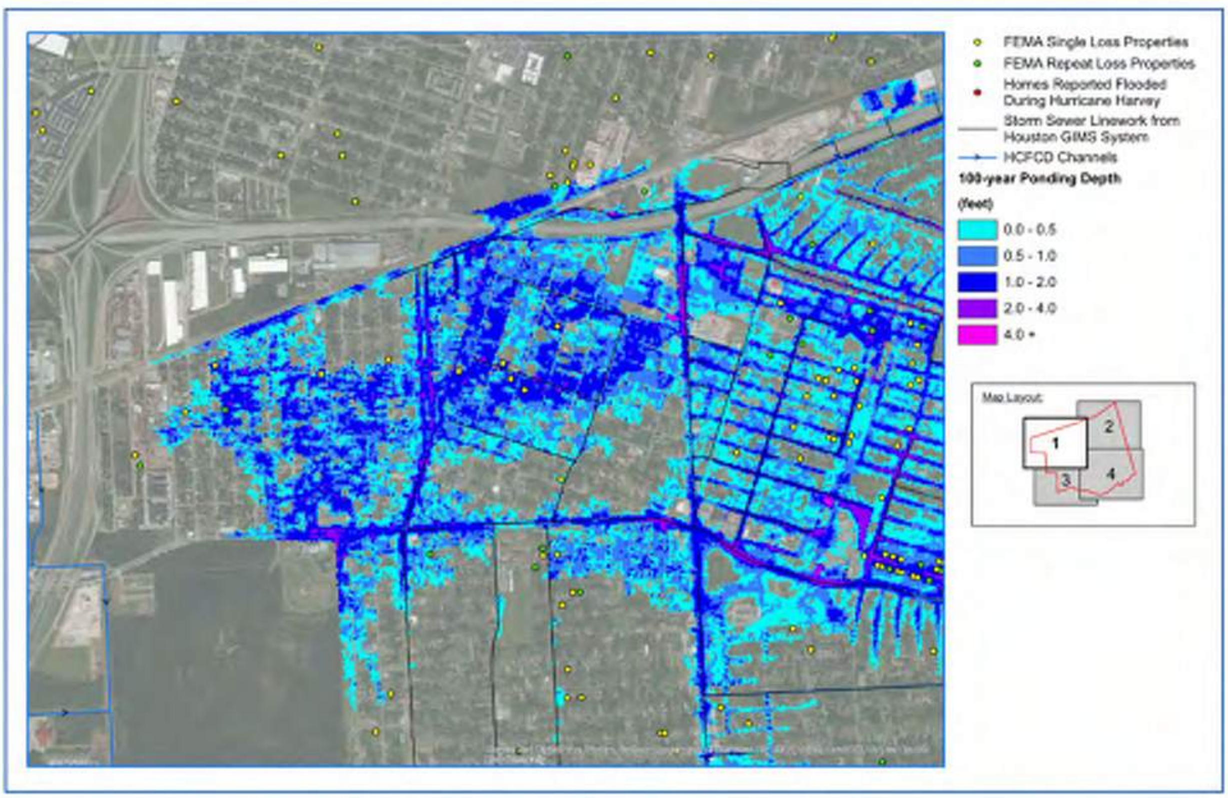


Figure 11 - 100-Year Ponding Results - NW Quadrant



HDR

Figure 12 - 100-Year Ponding Results - NE Quadrant

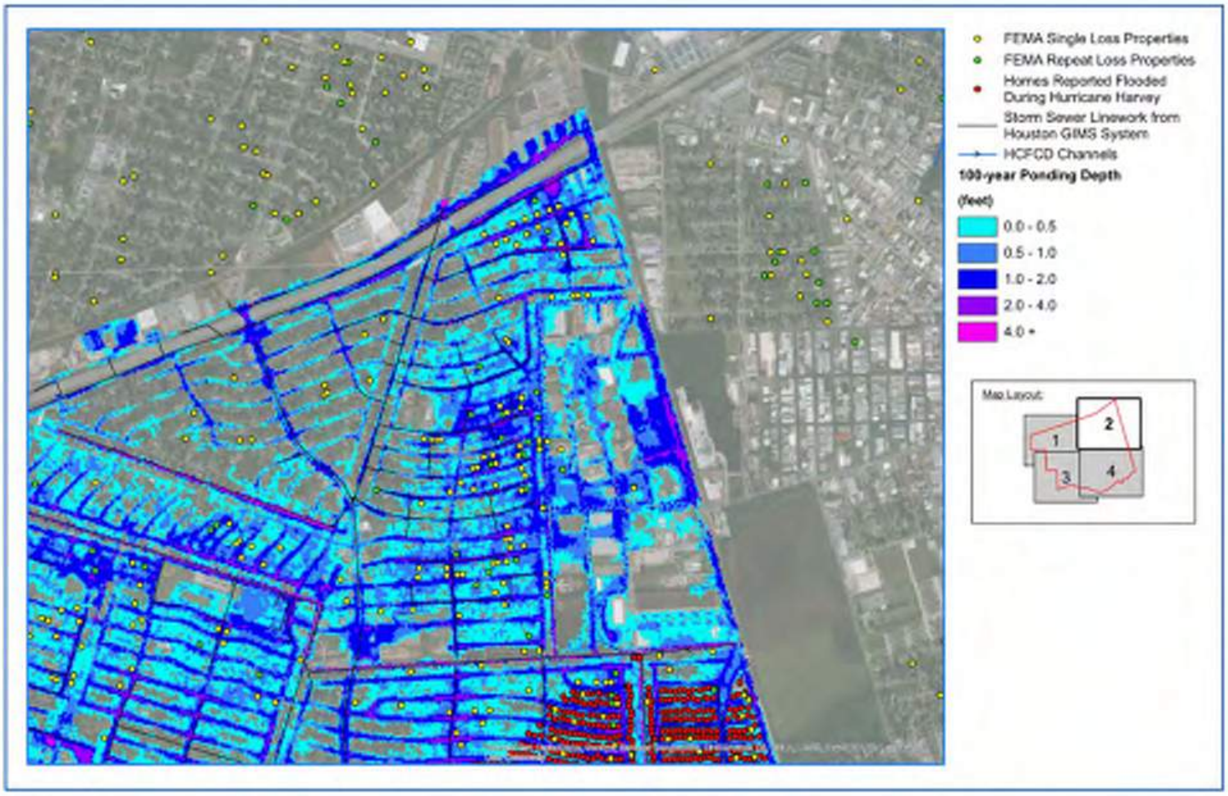


Figure 13 - 100-Year Ponding Results - SW Quadrant

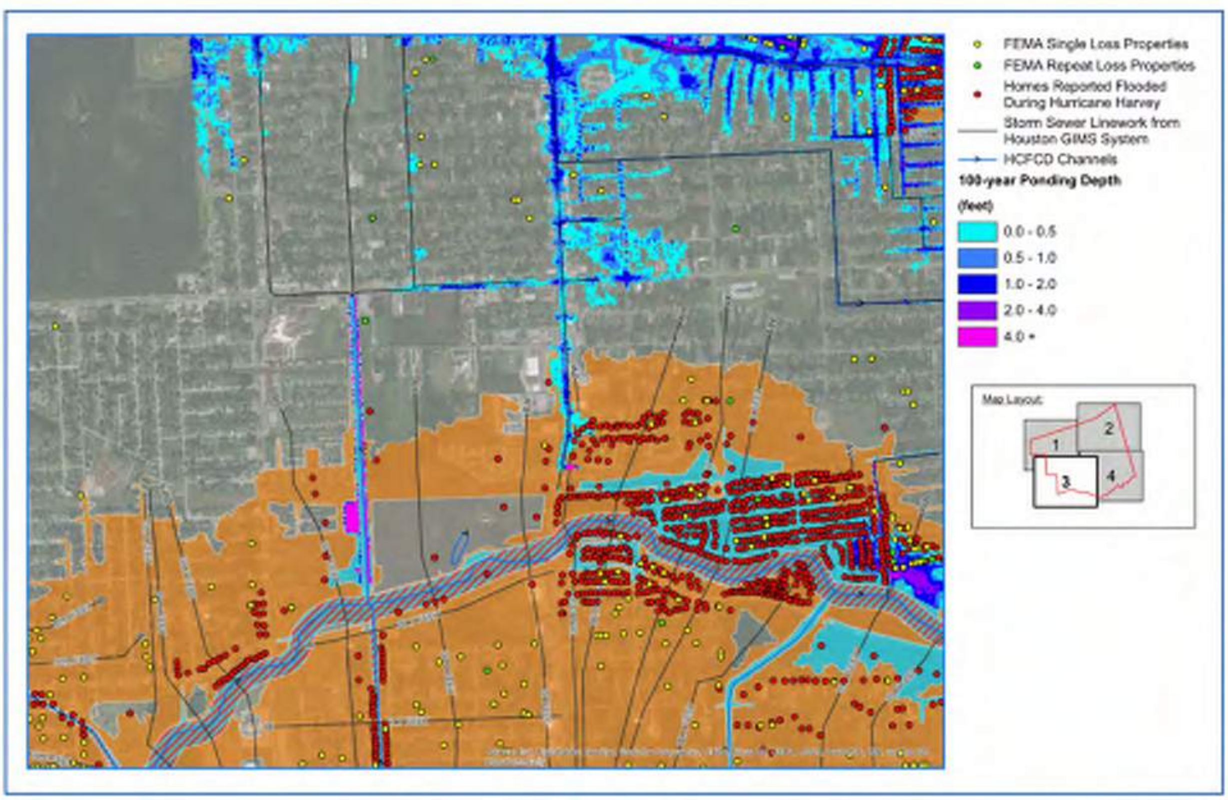
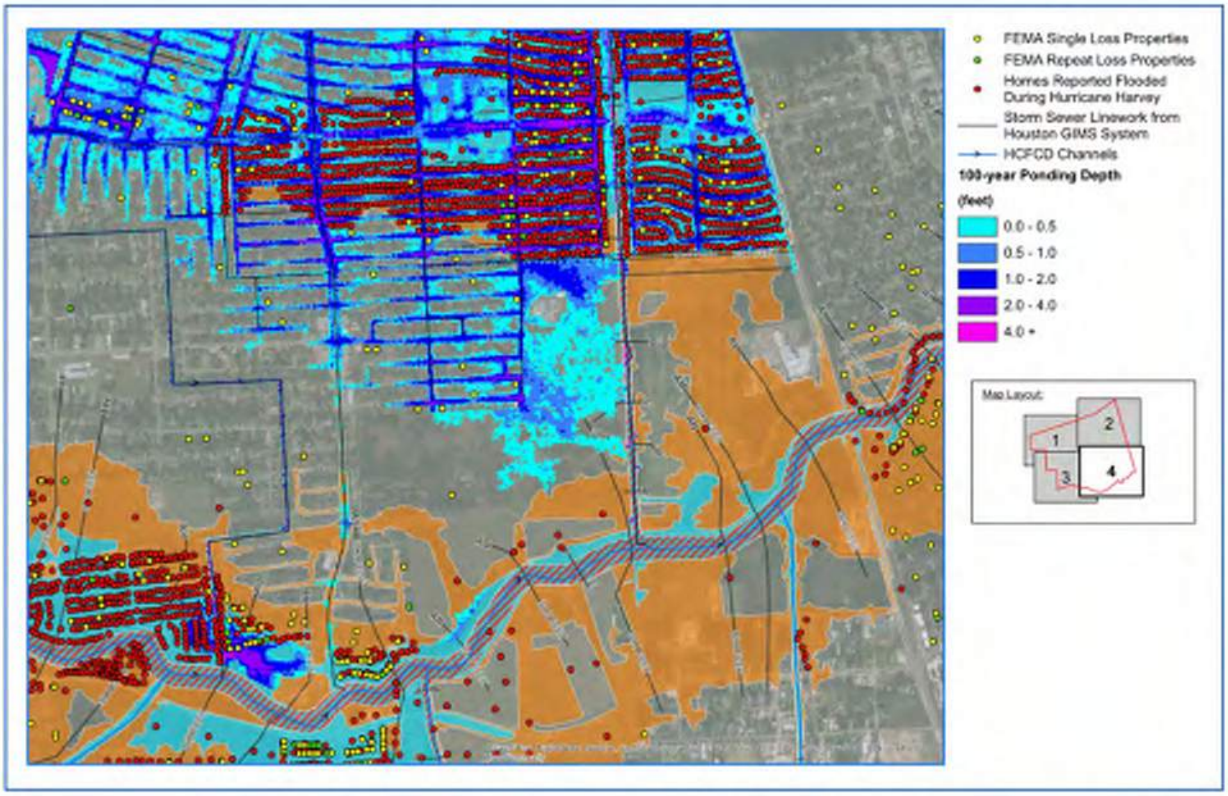


Figure 14 - 100-Year Ponding Results - SE Quadrant



As shown in Figure 8, there is significant street flooding and ponding in multiple areas during a 2-year storm event, which signifies that the existing drainage infrastructure does not satisfy current City of Houston criteria for NOAA Atlas 14. As shown in Figures 9 and 10, structural flooding is anticipated for storm events ranging from the 10-year to 50-year storm event. Figures 11 through 14 show that the City of Houston extreme event drainage criteria are not satisfied, as the 100-year ponding level is not contained within the City rights-of-way, and a significant level of structural flooding is expected. The 100-year storm event was compared with structural flooding from Hurricane Harvey to validate the results of the model, as shown in Figures 10 through 14. Based on the flooding records from Hurricane Harvey and multiple storm event analysis, structural flooding appears to be caused by a combination of riverine flooding along Salt Water Ditch and limited storm sewer capacity within the South Park neighborhood.

Conclusion

Based on the results of this analysis, we have developed a series of improvements which may reduce the risk of structural flooding within the project area. Those improvements are listed below and are recommended for additional study.

- Incorporate channel improvements and new channel enclosure as recommended by the Harris County Engineering Department study on Salt Water Ditch.
- Improve the storm sewer network and associated outfalls along Pershing Street.

- Improve the storm sewer trunk line along Southbank and the associated laterals north and south of Salt Water Ditch.
- Improve the storm sewer trunk line along Crestmont Street and the associated laterals north and south of Salt Water Ditch.
- Improve the storm sewer systems on Willow Glen Drive and South Wayside Drive.
- Improve the storm sewer systems on Belmark Street and South Wayside Drive.
- Incorporate the improvements included in the City's project along Comal Street and Brandon Street.
- Improve the outfall at Scott Street and Holmes Road.
- Improve the storm sewer trunk line along Scott Street that outfalls to C118-03-00.
- Improve the storm sewer trunk line system along McLean Street north of C118-03-00.
- Improve the storm sewer trunk line system along Cullen Boulevard north of C122-00-00.
- Determine the detention volume needed to mitigate improvements and investigate inline detention opportunities beneath Martin Luther King Boulevard. Evaluate interconnectivity between Martin Luther King Boulevard and Salt Water Ditch.
- Identify and investigate opportunities to implement green infrastructure and low impact development (LID) opportunities associated with the proposed improvements, including above-ground detention sites.
- Identify and investigate options to intercept and accommodate overland sheet flow from offsite areas.
- Identify and investigate other potential improvements to alleviate risk to excessive ponding, address deficiencies in the storm sewer network, and create overland sheet flow connectivity to Salt Water Ditch, C122-00-00, C118-03-00, and Sims Bayou in addition to the improvements listed above, as necessary.