VOLUME 2
Appendix 5-E

REGION 5 NECHES
2023 REGIONAL FLOOD PLAN

JULY 2023

PREPARED FOR THE

REGION 5 NECHES FLOOD PLANNING GROUP

APPENDIX 5-E
SUPPORTING DOCUMENTATION FOR RECOMMENDED FLOOD MITIGATION PROJECTS

Drainage Study for Regional Improvements Near South and Central Beaumont

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Glossary

1D Model – A model that incorporates a system in one dimension. Examples of a one-dimensional system include storm sewers, manholes and inlets.

1D/2D Coupled Models – A model that incorporates the 1D and 2D network into one connected model. The two-dimensional flow enters the one-dimensional pipe network and vice versa.

100-Year Chance Exceedance Probability – An event that has a 1% chance of being equaled or exceeded in any one year at a given location. This can refer to both rainfall and flood events. It is shortened to 1% exceedance in this manual. Below is a table showing the comparison of the more commonly used exceedance probabilities and frequencies:

Frequency	Exceedance Probability
500-year	0.2% chance
100-year	1% chance
50-year	2% chance
25-year	4% chance
10-year	10% chance
5-year	20% chance
3-year	33% chance
2-year	50% chance

2D Model – A model that incorporates two-dimensional surface flow. A grid is developed to approximate the topography and calculate overland flow.

Acre-Feet – Used to express volume of storage usually in a detention basin. One Acre-Foot is equal to one acre times a one-foot depth or 43,560 cubic feet (325,850 gallons).

Channel – A course or passage through which stormwater may move or be directed. It is a generic term used in reference to ditches, bayous, creeks or other smaller tributaries. A channel can vary in shape and size and can be either natural or man-made.

Channel Modification – A man-made change to a channel's characteristics, typically for the purposes of reducing flood damages by increasing its overall conveyance. This can be accomplished by widening and/or deepening the channel, reducing the friction by removing woody vegetation or by lining the channel with various materials.

Confluence – The intersection of two or more streams, or where one flows into another.

Conveyance – The ability of a channel or other drainage element to move stormwater.

Detention – The temporary storage of stormwater.

Detention Basin – An area of land, usually adjacent to a channel, that is designed to receive and hold above-normal stormwater volumes. Most stormwater detention basins in Jefferson County are excavated. The detained stormwater then slowly drains, over time, out of the detention basin as the flow in the channel and associated water surface elevations recede.

Drainage – Runoff which flows over land as a result of precipitation. This includes sheet flow, flow in streets, and flows which concentrate in local drainage systems with or without defined channels.

Existing Conditions – Current conditions in a watershed, channel, or detention basin.

Federal Emergency Management Agency (FEMA) – The federal agency responsible for providing leadership and support to reduce loss of life and property and to protect our institutions from all types of hazards. This is accomplished through a comprehensive, risk based, all hazards emergency management program consisting of mitigation, preparedness, response, and recovery. In relation to flooding hazards, FEMA is the federal agency responsible for administering the National Flood Insurance Program (NFIP).

Flood Damage Reduction or Flood Reduction – Due to practical limitations, structural and nonstructural measures can only reduce flood damages by lowering flood levels or removing houses and businesses from flood prone areas. Floods can neither be prevented nor controlled.

Flood Insurance Rate Maps (FIRM) – Prepared by FEMA, Flood Insurance Rate Maps, or FIRMs, show areas that have the highest probability of flooding and illustrate the extent of flood hazards in a flood-prone community. These maps are used to determine flood insurance rates for communities participating in the National Flood Insurance Program (NFIP). Properties located in mapped zones AE, AO, A, or VE are required to have flood insurance if the owner has a federally backed mortgage on the property

Flood Insurance Study (FIS) – A study FEMA initiates to undertake a new hydraulic and/or hydrologic analysis for streams within a community. Often, these studies incorporate the new information into the FEMA Flood Insurance Rate Maps (FIRMs).

Floodplain – From time to time, bayous and creeks naturally come out of their banks due to heavy rainfall and inundate the adjacent land. This area that is inundated is referred to as a floodplain. Residences and businesses within the floodplain are considered to be at risk of being damaged by flooding. The floodplain is typically expressed by stating its frequency of occurrence. For example, the 1% (100-year) floodplain represents an area of inundation having a 1% chance of being equaled or exceeded in any given year, whereas the 2% (50-year) flood plain has a 2% chance of being equaled or exceeded in any given year. FEMA Flood Insurance Rate Maps (FIRMs) show the 1% (100-year) and 0.2% (500-year) floodplains.

Flowline – A line formed representing the lowest point in the bottom of and along a specified length of a channel or storm sewer.

Hydraulics – The study of moving fluid. In the case, hydraulics refers to analyzing the movement of stormwater flows in channels, pipes and detention basins to determine certain properties like stormwater depths and stormwater velocities.

Hydrology – The study of the rainfall-stormwater runoff process. Hydrological procedures are used to estimate the expected amount of stormwater entering a drainage system from a certain amount of rain falling over a certain watershed area.

Light Detection and Ranging (LiDAR) – A commercial technology that uses a laser mounted in an airplane to measure the elevation of the ground.

Outfall – An outfall is simply the pipe, channel, or opening where water "falls out" and then into another body of water, typically a drainage channel. In a typical stormwater detention basin, the outfall is at or connected to the lowest point of the basin so that detained water drains completely.

Peak Flow – The maximum flow of stormwater flowing through a channel at a given location, based on a certain amount of rainfall falling in that area.

Ponding – The process, occurring after a rainfall, when water gathers in low lying areas throughout a watershed. Frequently referring to water standing in the streets when the capacity of the storm sewer is exceeded.

Right-of-Way – Land used by a public agency for public purposes, such as building roads or improving channels. An interest in real property, either in fee or easement.

Runoff – The stormwater from rainfall not absorbed by the ground that flows into the local drainage system, and ultimately, streams and bayous.

Structures at Risk – Structures at risk of structural flooding. A slab height of 0.5 feet was assumed for finished floor elevations. Therefore, any structural footprint that contained greater than 0.5 feet was assumed to be a structure at risk for the evaluated storm event.

Tailwater – The water surface elevation in the outfall channel at the outflow structure which varies with time. The tailwater affects both the outflow structure design and the stage-outflow relationship of the detention basin.

Watershed – A geographical region of land or "drainage area" that drains to a common channel or outlet, mostly creeks and bayous in Jefferson County. Drainage of the land can occur directly into a bayou or creek, or through a series of systems that may include storm sewers, roadside ditches, and/or tributary channels.

Water Surface Elevation – The distance the water surface in a creek or bayou is above mean sea level, measured at a given location along a creek or bayou

1. Executive Summary

The purpose of the Drainage Study for Regional Improvements near South and Central Beaumont is to support the City of Beaumont (City) and Drainage District No. 6 (District) in their efforts to understand the root cause of flooding in the areas of south and central Beaumont and to recommend improvements to reduce flood risk in the area. To accomplish this goal requires an understanding of the limitations and deficiencies of the drainage system that serves the region and objective prioritization of improvement recommendations in the form of Capital Improvement Plan (CIP) projects that are both functionally efficient and financially effective. Beaumont is an area with reported severe structural flooding and street problems due to its low topographic elevations, inadequate storm sewer capacity and overland sheet flow paths. This analysis will evaluate reported issues within the Hillebrandt Bayou watershed and develop improvement concepts for four large-scale storm sewer diversions and ten potential sites for stormwater detention.

Existing Conditions Model Analysis

Detailed 2-dimensional models were developed using InfoWorks ICM to understand the complex drainage issues observed within the region. Two-dimensional models offer unique insight into how overland stormwater conveyance is tightly coupled to, and influenced by, the subsurface storm sewer system and outfall channels. The performance of the existing stormwater infrastructure within the region was evaluated for the Atlas 14 500-, 100-, and 10-year 24-hour storm events and found to be functionally deficient in several locations.

In general, the region is subject to widespread roadway inundation and structural flooding during the 100-year, 24-hour event (as well as lesser events) and subject to excessively long time-to-drain durations. Limited outfall capacities yield high ponding depths in the lowest regions of the City for the 500-, 100-, and 10-year 24-hour events. Many of the severely inundated areas are located at the upstream end of the Hillebrandt Bayou watershed where the outfall capacities are most likely to be overwhelmed by downstream conditions. Commercial and residential development along existing channels provide minimal room for increased channel capacity without an extensive property buyout plan taking effect. Existing conditions metrics were generated to quantify the performance of the storm infrastructure within the problem areas identified for improvement. The performance metrics include total parcels located within the floodplain, inundated roadway miles, total inundated structures, and total inundated acreage within the problem area.

Proposed Improvement Projects

Four proposed conveyance improvements were developed in accordance with the District's desire to reduce structural flooding for affected areas within the City. The proposed conveyance improvements divert large amounts of flow away from the Hillebrandt Bayou watershed, through the eastern part of the City, and discharge into the Neches River. A total of approximately 26 miles of storm sewer improvements were evaluated in this analysis. The purpose of each diversion project is to provide broad relief to the existing DD6 channel systems by reducing the volume of water draining towards the Hillebrandt Bayou outfall. Retrofitting existing neighborhoods to meet current design criteria for extreme events can be a difficult process. It is for this reason that the proposed improvement projects will greatly improve the drainage conditions and reduce flooding potential, but not completely meet design criteria in all areas.

Table E1. Diversion Improvement Projects

Project Name	Storm Sewer Miles	DD6 Channel(s)	
		Upstream	Downstream
South Park Diversion	7.0	104, 104B	008, Neches River
Tevis Diversion	5.5	115	Neches River
Blanchette Diversion	6.2	110B	Neches River
Lucas Diversion	7.1	100, 122	010, Neches River

In addition to the conveyance improvements, ten proposed sub-regional detention basins were evaluated along the banks of Hillebrandt Bayou and its tributaries. The proposed detention basins, with a total combined storage volume of 4,983 ac-ft, are intended to increase the City's downstream storage capacity and improve drainage conditions adjacent to the sites. All 10 basins were assumed to be dry bottom basins with a pilot channel. Specific pilot channel routes would need to be considered in detailed design, but generally, potential pilot channel routes were drawn to maximize the depth, and therefore volume, of the proposed detention basins.

Table E2. Detention Improvement Projects

Basin #	1	2	3	4	5	6	7	8	9	10
Storage Volume (ac-ft)	1,319	445	1,286	411	374	161	203	225	312	247

Considerations were made for all improvements regarding existing subsurface utility conflicts, ROW easements, and the existing topography within the problem areas.

Opinion of Probable Construction Cost (OPCC)

The total construction cost for each proposed improvement is shown in **Table E3**, and **Appendix B** shows the detailed line items for each cost estimate. The total cost of all the proposed improvements is $680,650,320.

Table E3. Cost Estimate Summary of All Proposed Improvements

Proposed Improvement:	Cost Estimate:
South Park Diversion	$ 99,908,750
Tevis Diversion	$ 97,327,200
Blanchette Diversion	$ 99,173,000
Lucas Diversion	$ 130,286,230
Basin 1	$ 52,776,700
Basin 2	$ 13,204,220
Basin 3	$ 49,249,150
Basin 4	$ 28,822,380
Basin 5	$ 20,138,510
Basin 6	$ 9,760,190
Basin 7	$ 19,743,250
Basin 8	$ 8,573,230
Basin 9	$ 21,723,270
Basin 10	$ 29,964,240
Est. Total Cost of Construction =	**$ 680,650,320**

Project Benefits and Performance Metrics

The existing conditions results were evaluated and quantified in the form of existing conditions performance metrics. These metrics include parcels, structures, and roadway miles that are inundated for the Atlas-14 500-, 100-, and 10-year 24-hour storm events. Proposed conditions were developed for each improvement project in InfoWorks ICM for the Atlas 14 500-, 100-, and 10-year 24-hour storm events. Each project's design concept was iterated to provide the most effective connectivity and location within the City's existing infrastructure footprint. Proposed conditions performance metrics were compared to existing conditions metrics, providing parcels, structures, and roadway miles removed from inundation for each proposed improvement.

Impact Analysis

An impact analysis was performed on each of the four proposed conveyance improvements. The model output was compared between existing and proposed conditions to ensure no impact to water surface elevations. Multiple channel sections within the Hillebrandt Bayou watershed were evaluated for each conveyance improvement. Hydrographs were generated at each section for existing and proposed conditions to understand the impact each improvement has on nearby channel hydraulics.

Property Buy Out Estimates

In coordination with DD6 staff, areas to be considered for potential property buy outs were identified. These areas were further evaluated against the existing conditions model results and FEMA floodplain extents to determine areas severely impacted by flooding. Approximately 68 residential properties were identified for buy outs along 21st Street, Holland Drive, Bryan Drive, and Bayou Road. 37 of the identified properties are located within either the A (100-year) or X (500-year) FEMA flood zones, and 8 structures have been reported to local and federal officials as repetitive flooding losses. The estimated total cost to buy out the 68 properties is $14.4MM, and the average buyout cost is $211,750.00 per property.

2. Study Area

The study area is roughly bound by the Jefferson County line on the north, Pignut Road, Kidd Road, and Fannett Road on the south, Tolivar Canal Road, Meeker Road, and Pine Island Road on the west, and the Neches River on the east. The study area limits are shown in **Figure 1** and **Exhibit 1**. The modeled storm water infrastructure consists of approximately 2,210,540 linear feet of storm sewer. The storm sewer systems outfall to either Hillebrandt Bayou or the Neches River.

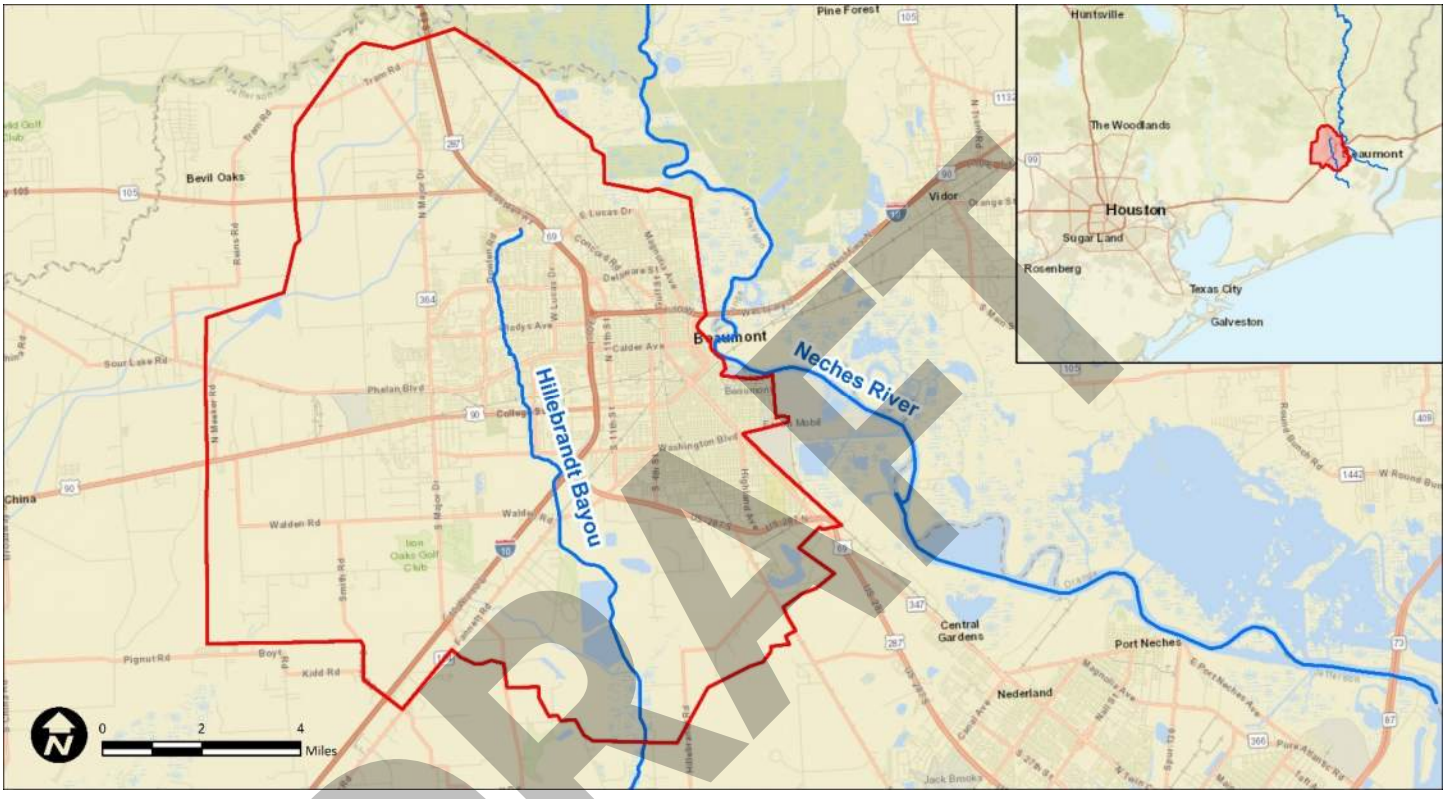

Figure 1. Study Area Limits

3. Data Collection

3.1 Stormwater Infrastructure

Storm sewer information from the City of Beaumont Master Drainage Plan (MDP) completed by LAN in 2019 was used as the starting point for this model update and analysis. All subsurface model elements were updated to the latest InfoWorks ICM version 11.0 during model development. Data sources for the existing storm sewer system primarily included City record drawings in digital format comprising of CAD files, scanned plan sheets, and reports by others. The modeled area was slightly expanded along the western and southern boundaries of the City and required the storm sewer infrastructure to be split across six cohesive models.

3.2 LiDAR Datasets

The ground elevations, or the 2D surface within the InfoWorks model, were updated to reflect the latest ground elevation changes within the study area. LiDAR datasets for the *Neches River Basin* and *Jefferson, Liberty, & Chambers Counties* were used for current elevations from when the data was collected in 2017. The digital elevation model (DEM) datasets were collected at a resolution of 1 meter. All LiDAR information was provided by the Texas Natural Resources Information System (TNRIS).

3.3 Atlas 14 Rainfall

Updated Atlas 14 standard rainfall data was provided by the District, except for the 5- and 15-minute rainfall durations, which were developed based on NOAA data. A rainfall hyetograph for each storm was developed on 5-minute increments with the peak of the storm at hour 12. Refer to **Figure 2** for the rainfall hyetograph.

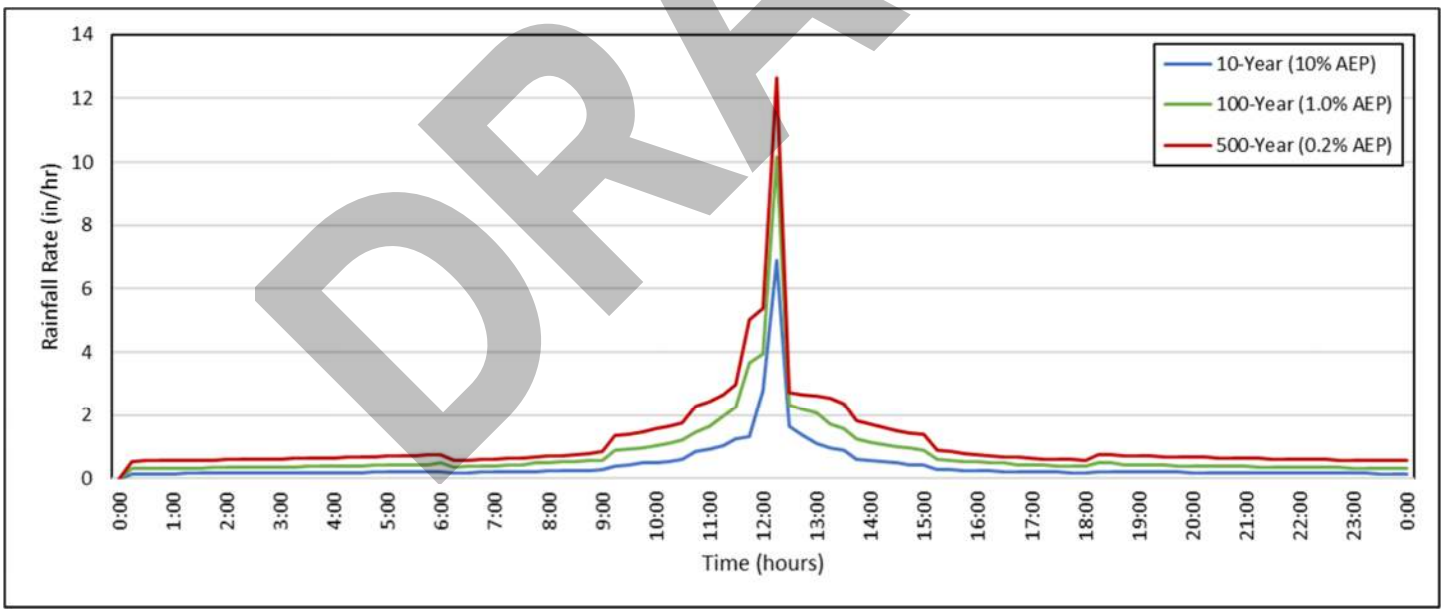

Figure 2. NOAA Atlas 14 Design Storm Rainfall Rates

3.4 Surface Infiltration and Roughness

Since many areas rely primarily on 2D surface flow, it is important to provide high resolution characteristics for ground infiltration and roughness. To achieve the highest quality representation of the land surface, 2019 four-band aerial imagery at 0.5-meter resolution was used from the National Agricultural Imagery Program (NAIP). In conjunction with the land cover raster from the National Land Cover Database (NLCD), the two datasets were

cross-referenced through GIS machine-learning techniques. By designating a training set, or locations of known land cover characteristics, the four-band imagery can relate specific land cover to any given pixel. While the four-band imagery is useful, the NLCD dataset provides more spatial information to develop the machine-learning capabilities. For instance, trees located within a residential neighborhood are less likely to impact surface flow conditions compared to dense trees or shrubs in a forest or wooded area. By using the NLCD dataset, trees can be classified into separate developed and undeveloped areas categories, and then the trees existing in developed areas can be manually reclassified as grass. Various combinations of this example were used to develop the image-classified infiltration and roughness zones. JCAD parcels were used to manually fill areas or classifications that were not appropriately represented due to the limitations of the four-band imagery.

Ultimately, the image-classification process was used to group the land cover into the five categories: grass, concrete/asphalt, dense trees, vertical structure, and bodies of water.

Surface infiltration rates were updated to reflect the relationship between percent impervious cover and infiltration losses based on data available in the Harris County Flood Control District's (HCFCD) Policy Criteria & Procedure Manual (PCPM). Manning's roughness coefficients were updated to represent the variation in flow resistance across different land cover conditions. The values used for infiltration rates and roughness coefficients for all five classifications are shown in **Table 1.**

Table 1. Ground Infiltration and Surface Roughness Values

Image Classification	% Impervious Cover	Infiltration Rate (in/hr)	Roughness Coefficient (Manning's N)
Dense Trees	5	0.096	0.2500
Grass	15	0.087	0.0400
Concrete/Asphalt	80	0.028	0.0125
Water	100	0.000	0.0200
Structure			10

4. Existing Conditions Model Analysis

4.1 Methodology

A combined 1D/2D stormwater model of the region was developed to understand the existing conditions and form the basis for future improvements. In a coupled 1D/2D model, the storm sewer network such as inlets, pipes, and manholes are represented by one-dimensional (1D) links. The storm sewer network was created with nodes and links representing features like culverts, cross culverts, bridges, storm sewer inlets, and storm sewer pipes. The features were based on available survey data, City GIS information, and previously provided data. The network is shown in **Figure 3** as well as in **Exhibit 2**. Pipe sizes and flow directions were checked for abnormalities, such as intermittent smaller pipes between two larger pipes, and negative pipe slopes.

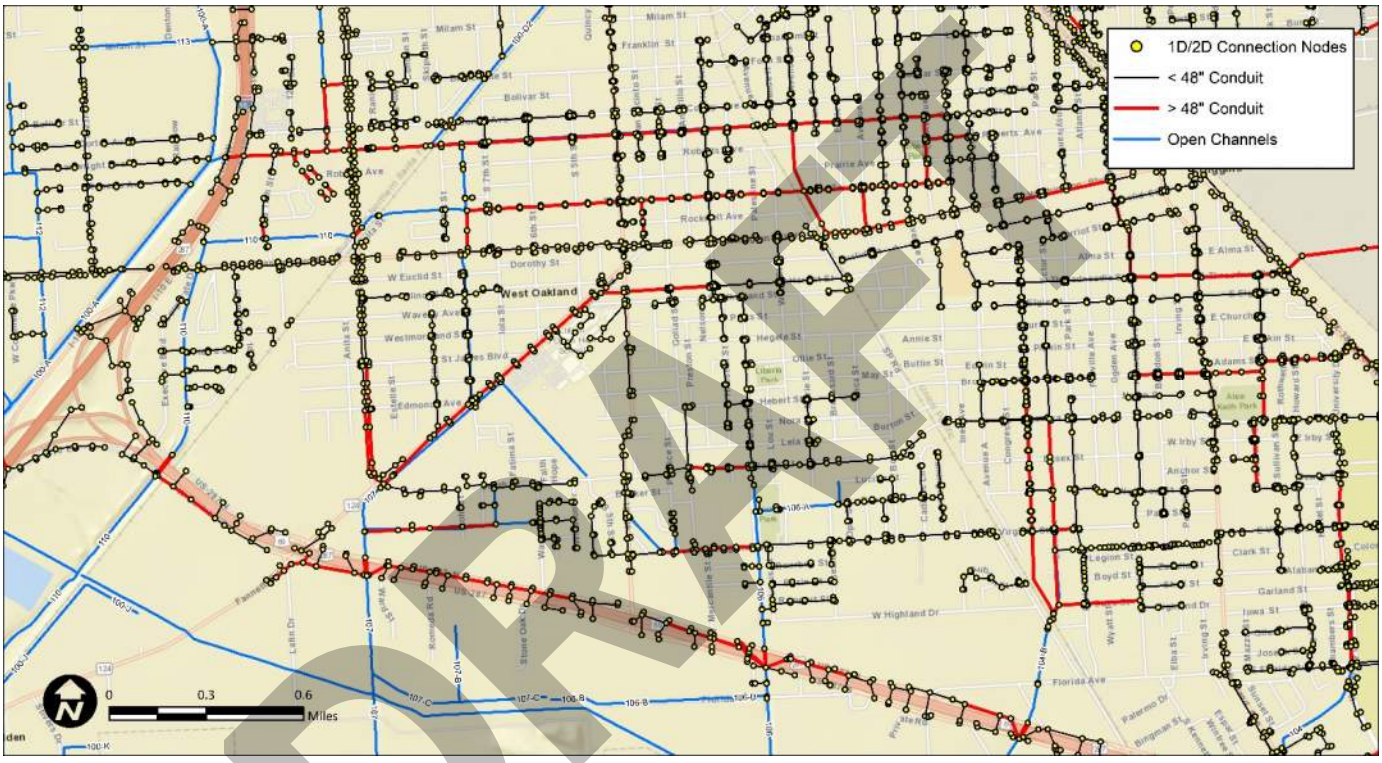

Figure 3. Pipe and Node Network from InfoWorks ICM model

Once the capacity of the 1D, subsurface network is exceeded, stormwater spills onto the 2D surface. The 2D surface represents the streets and overland topography of the neighborhood and enables a more realistic representation of overland flow. A computational mesh representing the contributing areas to the outfall was generated from LiDAR along with associated roughness zones to appropriately represent changes in land. LiDAR for the modeled area is shown in **Figure 4** and **Exhibit 3**. Additionally, surface adjustments were added to adequately capture contributing flow and remove artificial discontinuities in the channels. Rainfall hyetographs for the 10-, 100-, and 500-year storms were developed and applied to the surface.

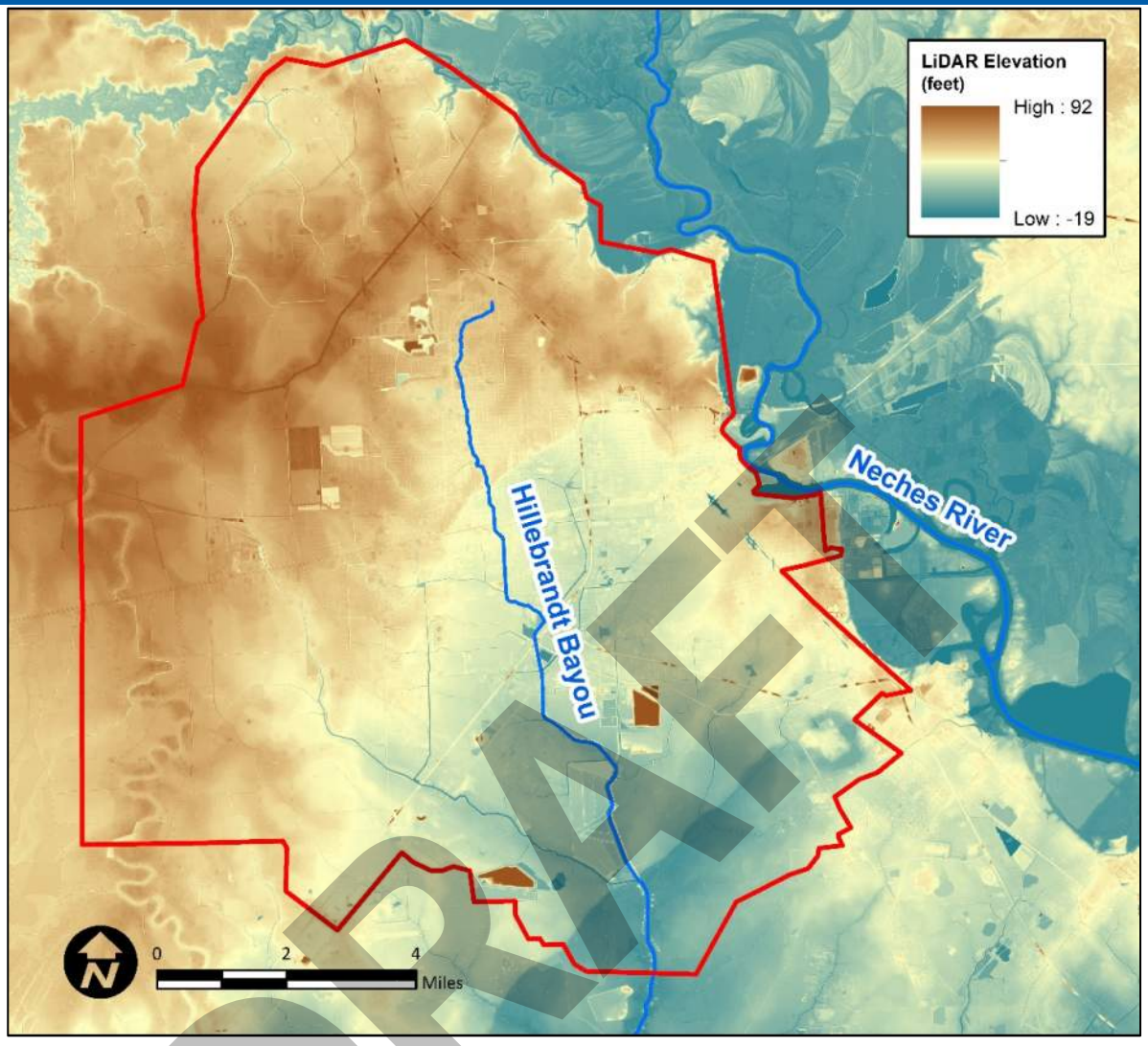

Figure 4. 2017 LiDAR Ground Model

4.2 Existing Conditions

In general, the region is subject to widespread roadway inundation during the 100-year, 24-hour storm event. Many of the roadways within the region are impassible during lesser events and subject to excessively long time to drain durations. Roadways can remain impassable for hours following the storm event, leading to decreased mobility within the region. The western part of the City, which drains to Hillebrandt Bayou is also subject to high tailwater conditions. The high tailwater condition leads to structural flooding and excessively high ponding depths and durations. The 10-year, 24-hour storm event produces ponding that exceeds the storm sewer capacity in most areas. Besides the storm sewer capacity being exceeded, drainage is further impeded by overland flow blockages such as canals, roadway crossings, and highways. Severe ponding generally occurs at low spots along major street thoroughfares or within residential areas. The existing ponding inundation results for the 10-, 100-, and 500-year 24-hour storm events are shown in **Exhibits 4, 5, and 6**, respectively.

The acreage of land inundated, number of parcels in the floodplain, number of inundated structures, and miles of inundated roadway are the performance metrics that were used to evaluate the efficacy of the proposed improvements for each storm event. An area of influence for each proposed improvement was defined based on the extents of WSEL reductions. The performance metrics were determined based on each area of influence, as defined below. In this case, the floodplain, or inundated area, is defined as areas in which the ponding is at least 0.5 feet (6 inches) deep. The finished floor elevations of structures were assumed to be 0.5 feet above the natural ground elevation; if the WSEL at the centroid of the structural footprint was greater than the assumed finished floor elevation, that structure was included in the inundated structures count.

- The **South Park & Basin 2** area of influence is roughly bound by Washington Boulevard on the north, West Cardinal Drive on the south, Martin Luther King Jr Parkway on the east, and Burlington Northern Santa Fe Railroad on the west. This area of influence is 3,674 acres and includes a total of 7,242 parcels, 109 roadway miles, and 5,845 structures. The existing parcels in the floodplain, inundated roadway miles, and inundated structures for the South Park & Basin 2 area of influence are shown in **Exhibits 7, 8, and 9**, respectively.
- The **Tevis** area of influence is roughly bound by Calder Avenue, Harrison Avenue, Interstate 10, and Ashley Street on the north, Cross Drive, Bristol Drive, Union Pacific Railroad, South Street, and South Bowie Street on the south, Neches River on the east, and Channel 100 on the west. This area of influence is 1,826 acres and includes a total of 3,703 parcels, 63 roadway miles, and 3,250 structures. The existing parcels in the floodplain, inundated roadway miles, and inundated structures for the Tevis area of influence are shown in **Exhibits 10, 11, and 12**, respectively.
- The **Blanchette & Basin 1** area of influence is roughly bound by College Street and Union Pacific Railroad on the north, Humble Road, Burlington Northern Santa Fe Railroad, West Euclid Street, Washington Boulevard, Neches Street, Kansas City Southern Railroad, and State Highway Spur No. 380 on the south, Pennsylvania Avenue on the east, and Wooten Road on the west. This area of influence is 5,376 acres and includes a total of 6,613 parcels, 114 roadway miles, and 5,302 structures. The existing parcels in the floodplain, inundated roadway miles, and inundated structures for the Blanchette & Basin 1 area of influence are shown in **Exhibits 13 and 16, 14 and 17, and 15 and 18**, respectively.
- The **Lucas** area of influence is roughly bound by Delaware Street, Folsom Drive, Crow Road, Concord Road, Bennett Road, and Maida Road on the north, Phelan Boulevard, Hooks Avenue, Harrison Avenue, Interstate 69, Delaware Street, Bethlehem Avenue and Tyler Street on the south, and Stacewood Drive on the west. This area of influence is 5,500 acres and includes a total of 9,787 parcels, 132 roadway miles, and 9,080 structures. The existing parcels in the floodplain, inundated roadway miles, and inundated structures for the Lucas area of influence are shown in **Exhibits 19, 20, and 21**, respectively.
- The **Basins 3-10** area of influence is roughly bound by channels 100-E, 109-A, and 100-J on the north, Interstate 10, Burlington Northern Santa Fe Railroad, Frint Drive, channel 305, and Steinhagen Road on the south, Hillebrandt Road on the east, and South Major Drive, Interstate 10, Brooks Road, and Fannett Road on the west. This area of influence is 11,296 acres and includes a total of 1,124 parcels, 41 roadway

miles, and 760 structures. The existing parcels in the floodplain, inundated roadway miles, and inundated structures for the Basins 3-10 area of influence are shown in **Exhibits 22, 23, and 24**, respectively.

A summary of the existing conditions performance metrics is shown in **Table 2**. These metrics indicate that significant portions of each area of influence are within the floodplain for all 3 design storm events.

Table 2. Existing Performance Metrics

Proposed Improvement	10 Year	100 Year	500 Year
Parcels in Floodplain			
South Park & Basin 2	1457	2981	3804
Tevis	2886	3461	3568
Blanchette & Basin 1	1111	2619	3401
Lucas	7932	8762	9074
Basins 3-10	436	861	988
Inundated Roadway Miles			
South Park & Basin 2	44	59	66
Tevis	42	53	56
Blanchette & Basin 1	46	69	79
Lucas	82	95	100
Basins 3-10	8	21	27
Inundated Structures			
South Park & Basin 2	803	1915	2594
Tevis	383	1622	2392
Blanchette & Basin 1	577	1803	2431
Lucas	694	3090	4291
Basins 3-10	123	484	612
Inundated Acreage			
South Park & Basin 2	1187	1951	2304
Tevis	623	1202	1480
Blanchette & Basin 1	1574	2977	3581
Lucas	1966	3116	3599
Basins 3-10	6320	9765	10431

5. Proposed Storm Sewer Diversions

Based on the results of the Existing Conditions model, improvement concepts were developed to improve the functionality of the study area with the goal of reducing flood risk to areas impacted by frequent and severe flooding.

Proposed storm sewer alignments were evaluated based on areas of reported frequent flooding, feasibility, minimizing conflicts with existing underground utilities, and the potential for reducing flood risk to structures. Benefits were measured by evaluating decreased ponding depths and water surface elevations in the model output. Feasibility was a consideration of space and ROW available, and elevation differences between the existing channel to be diverted and the ultimate outfall near the Neches River which is needed for proper drainage. Due to the significant distances of these proposed diversion projects, existing utilities were considered when developing the alignments to minimize major conflicts that may arise during detailed design. Large subsurface utilities such as oil and gas pipelines, sanitary sewer, and domestic drinking water lines were avoided where possible. If a potential improvement was considered feasible, models were developed to measure its potential benefit for the 10-, 100-, and 500-year storm events. For each improvement, planning level cost estimates were developed. Potential improvement alternatives are summarized below in **Table 3** and discussed further in this section.

Table 3. Diversion Improvement Alternatives

Project Name	DD6 Channel(s)		Proposed Path in Public ROW
	Upstream	Downstream	
South Park Diversion	104, 104B	008, Neches River	West Lavaca Street, Campus Street, Florida Avenue, Highland Avenue, Jim Gilligan Way
Tevis Diversion	115	Neches River	Sawyer Street, South Street, Jaguar Drive, Pecos Street, Center Street, Laurel Street, Tevis Street
Blanchette Diversion	110B	Neches River	Roberts Street, 6th Street, 4th Street, Houston Street, Avenue D, Irma Street, Neches Street, Blanchette Street
Lucas Diversion	100, 122	010, Neches River	Delaware Street, West Lucas Drive, Lufkin Street, Charles Street

5.1 South Park Diversion

This project includes storm sewer improvements that divert flow away from DD6 channels 104/104-B and redirect it to the Neches River located to the east of the proposed outfall. The proposed alignment includes significant storm sewer upgrades along West Lavaca Street, Campus Street, Ector Street, Highland Avenue, Florida Avenue, and Jim Gilligan Way. The West Lavaca storm sewer size is proposed to be an 8'x8' RCB and connect to the existing system at the Park Street intersection (36" RCP). The Campus Street storm sewer size is proposed to be a 10'x10' RCB and connect to the existing system at the Ector Street intersection (7'x6' RCB). Both the W Lavaca and Campus storm sewer improvements tie into the proposed Highland Avenue storm sewer improvements. The Highland Avenue storm sewer improvement extends from Campus Street to Florida Avenue and ranges from 10'x10' RCB to dual 9'x10' RCBs. The Florida Avenue/Jim Gilligan Way proposed storm sewer extends from the Al Price Detention Basin along Channel 104-B to the project outfall at Channel 008 (before draining into the Neches River). The Florida Ave. and Jim Gilligan Way storm sewer ranges from a 10'x10' RCB (upstream end) to triple 10'x10' RCBs (downstream outfall). The Florida Avenue proposed storm sewer will require a custom junction box at the crossing with the existing outfalls into Channel 104 (near Jimmy Simmons Boulevard). This project intends to divert water from the existing, undersized drainage systems within the Hillebrandt Bayou watershed to a new outfall with a shorter path into the Neches River. The South Park Diversion includes approximately 7.0 miles of storm sewer upgrades and provides 82.0 acre-feet of additional storm sewer capacity that contributes to increased conveyance. This project was submitted for grant funding through the Community Development Block Grant Mitigation (CDBG-MIT) Program. For the CDBG-MIT funding, the desired maximum project cost was established at $100MM. While the South Park Diversion was designed to meet the current funding requirements, the scope of the improvements and respective benefits could be increased to coincide with any changes to the project cost requirement. A schematic of the proposed storm sewer upgrades included in the South Park Diversion are shown in **Figure 5**, and in more detail on **Exhibit 25.**

This project alignment crosses numerous oil and gas pipelines along Jim Gilligan Way and the existing railroad near the outfall into Channel 008 and the Neches River. Potential siphons or other solutions will need to be considered in detail designed to properly account for the heavy utility corridor in the area.

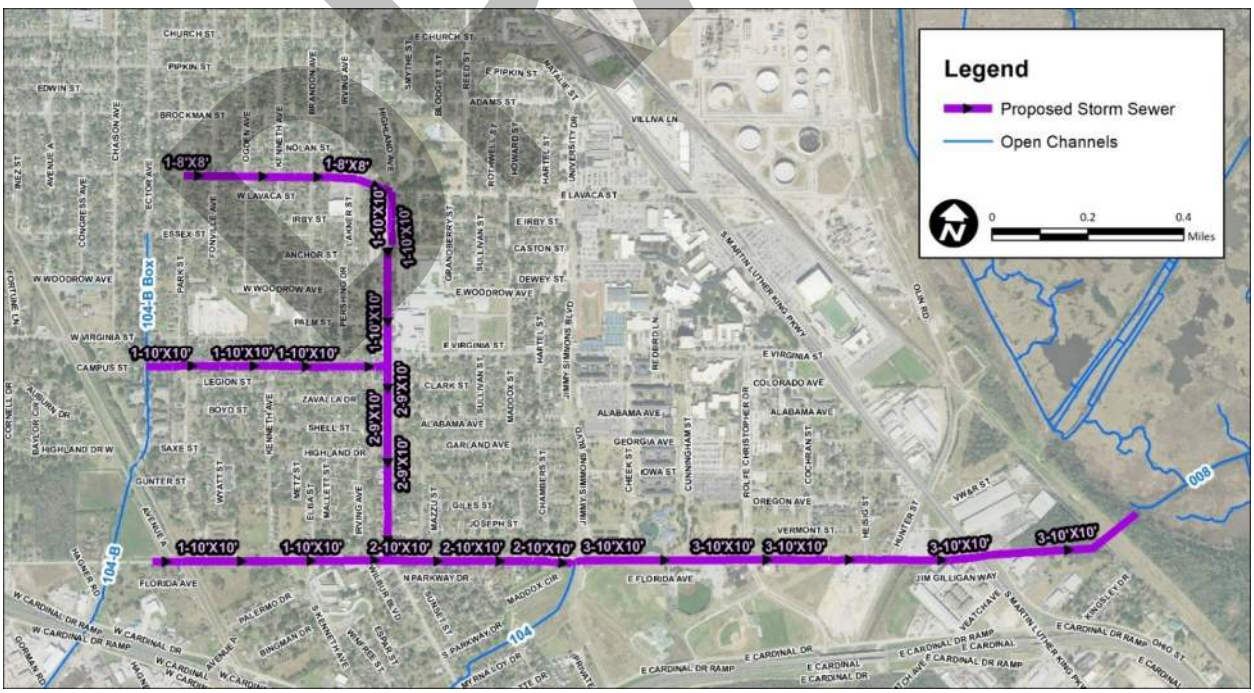

Figure 5. Proposed South Park Diversion – Storm Sewer Alignment

5.2 Tevis Diversion

This project includes storm sewer improvements that divert flow away from DD6 channel 115 and redirect it to the Neches River at the proposed outfall location near Tevis Street. The proposed alignment includes significant storm sewer upgrades along Sawyer Street, South Street, Jaguar Drive, Pecos Street, Center Street, Laurel Street and Tevis Street. This alignment includes dual 12'x10 RCBs throughout the entire project limits. The proposed alignment has been configured to tie into the existing storm sewer system at all locations where there are intersections. By tying the proposed boxes into the existing system, benefit can be provided to areas along the project path. The local benefit provided to the existing storm sewer is secondary to the primary goal of providing benefit to areas downstream of channel 115 by reducing the total flow it receives during rainfall events. The Tevis diversion includes approximately 5.5 miles of storm sewer upgrades and provides 80.4 acre-feet of additional storm sewer system capacity that contributes to increased conveyance. This project was submitted for grant funding through the CDBG-MIT Program. For the CDBG-MIT funding, the desired maximum project cost was established at $100MM. While the Tevis Diversion was designed to meet the current funding requirements, the scope of the improvements and respective benefits could be increased to coincide with any changes to the project cost requirement.

A schematic of the proposed storm sewer upgrades included in the Tevis Diversion are shown in **Figure 6**, and in more detail on **Exhibit 26**.

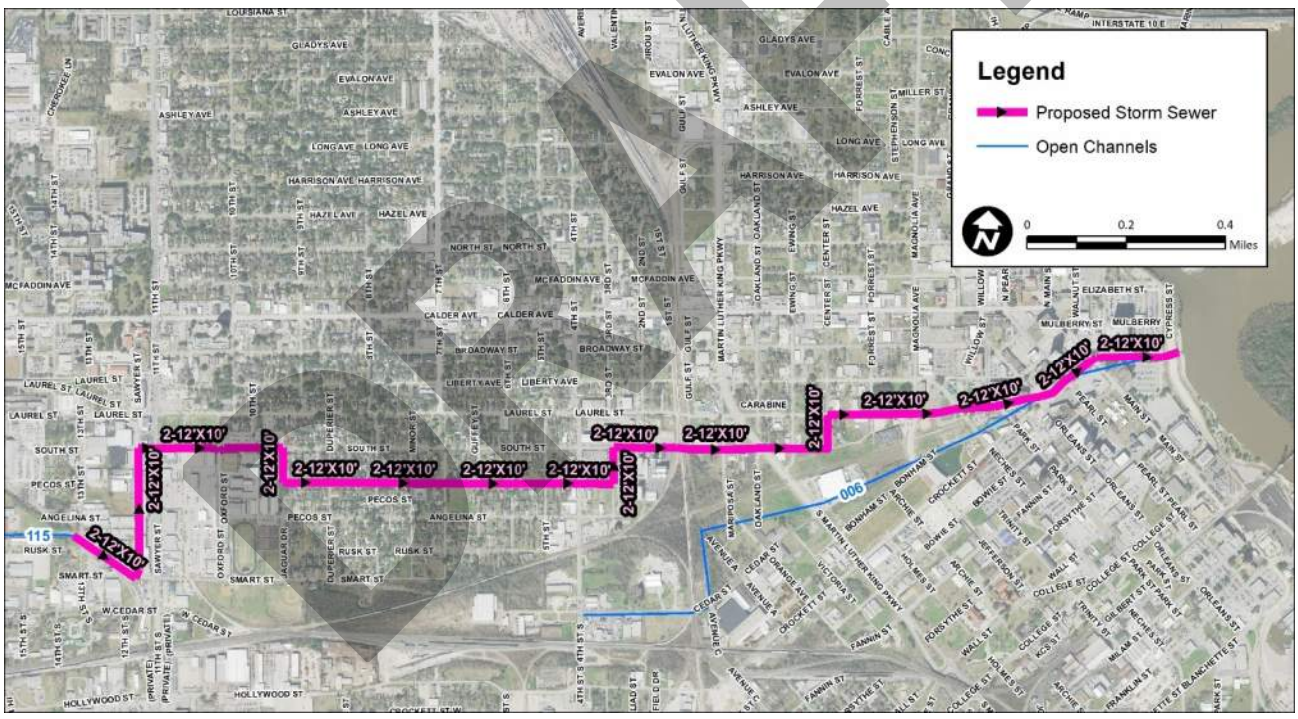

Figure 6. Proposed Tevis Diversion – Storm Sewer Alignment

5.3 Blanchette Diversion

This project includes storm sewer improvements that divert flow away from DD6 channel 110-B and redirect it to the Neches River at the proposed outfall location near Blanchette Street. The primary alignment for the storm sewer upgrades extends along Roberts Street, Avenue D, Irma Street, Neches Street and Blanchette Street. Most of the proposed storm sewer along the primary alignment is dual 12'x10' RCBs except for the dual 5'x5' RCBs located between channel 110-B and 6th Street. The secondary component of this improvement includes tying the proposed storm sewer into the existing storm sewer systems along Cartwright Street (to the north) and Terrell Avenue (to the south). Proposed 10'x5' RCBs along 6th Street, 4th Street, and Houston Street provide relief to the existing storm sewer system as flow is directed to the proposed Roberts Street trunkline storm sewer and ultimately to the Neches River. The Blanchette diversion includes approximately 6.2 miles of storm sewer upgrades and provides 80.2 acre-feet of additional storm sewer system capacity that contributes to increased conveyance. This project was submitted for grant funding through the CDBG-MIT Program. For the CDBG-MIT funding, the desired maximum project cost was established at $100MM. While the Blanchette Diversion was designed to meet the current funding requirements, the scope of the improvements and respective benefits could be increased to coincide with any changes to the project cost requirement.

A schematic of the proposed storm sewer upgrades included in the Blanchette Diversion are shown in **Figure 7**, and in more detail on **Exhibit 27.**

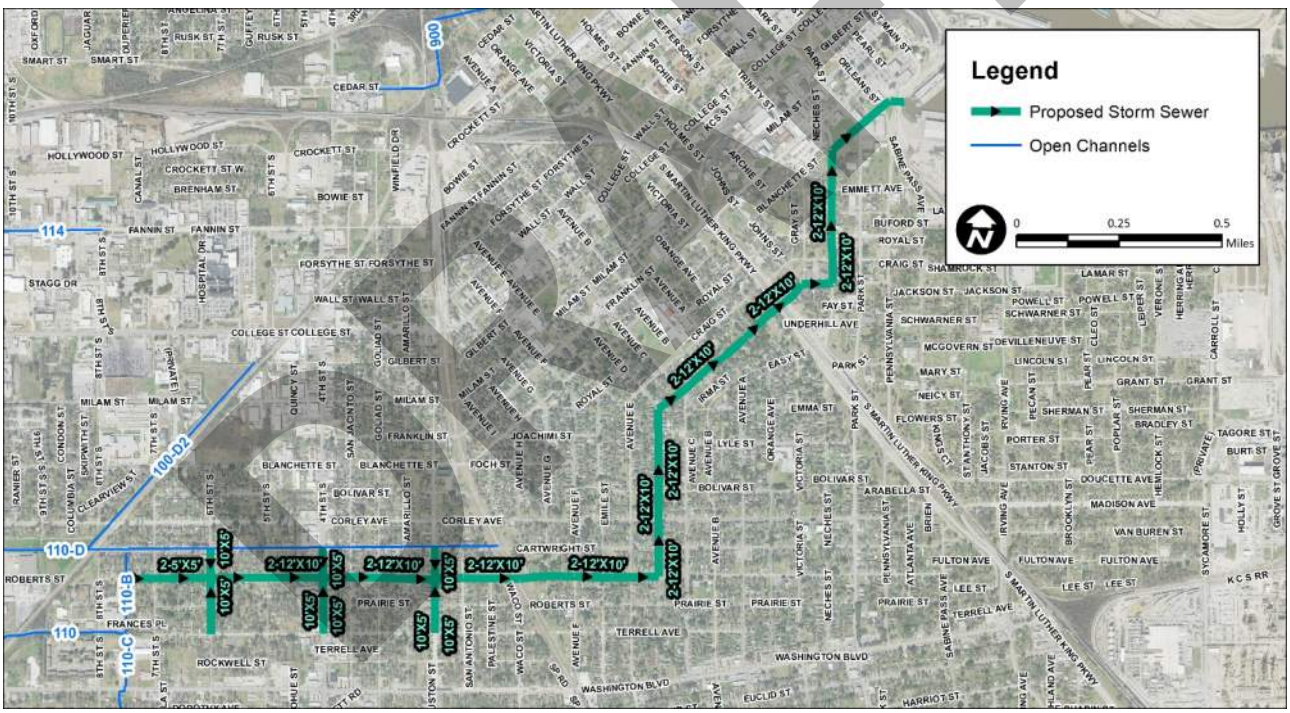

Figure 7. Proposed Blanchette Diversion – Storm Sewer Alignment

5.4 Lucas Diversion

This project includes storm sewer improvements that divert flow away from DD6 channel 100 (Caldwood Cut-Off) and channel 122, and redirect flow to channel 010 (near Charles Street) prior to discharging to the Neches River basin. The proposed alignment for the storm sewer upgrades extends along Delaware Street, West Lucas Drive, Lufkin Street and Charles Street. The proposed storm sewer throughout the entire alignment is dual 12'x10' RCB. The primary function of this improvement is to provide relief to channel 100 and ultimately reduce the flood risk to residents and businesses upstream, downstream, and along the diversion. The secondary function of this improvement is to provide relief to the existing storm sewer system along the proposed Delaware Street and West Lucas Drive alignments. The Lucas diversion includes approximately 7.1 miles of storm sewer upgrades and provides 103.2 acre-feet of additional storm sewer storage capacity that contributes to increased conveyance. A schematic of the proposed storm sewer upgrades included in the Lucas Diversion are shown in **Figure 8**, and in more detail on **Exhibit 28.**

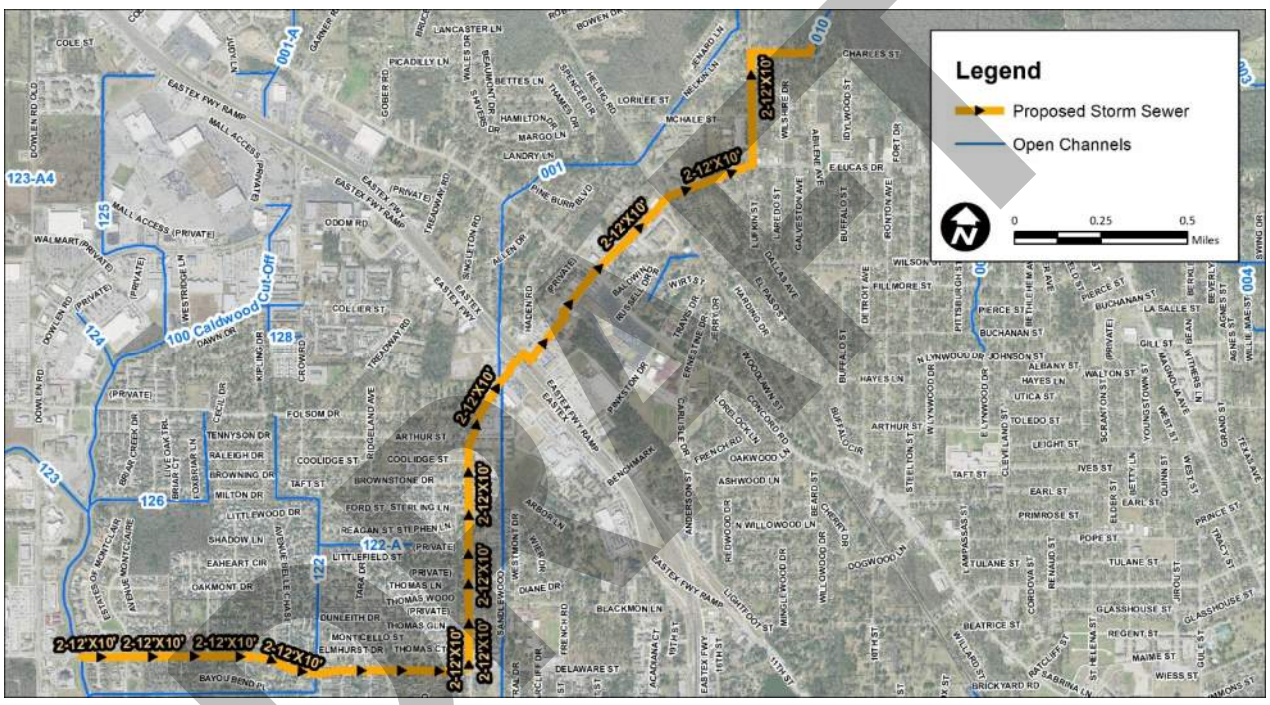

Figure 8. Proposed Lucas Diversion – Storm Sewer Alignment

6. Proposed Sub-Regional Detention Basins

The District identified three undeveloped areas where sub-regional detention basins could be placed. Based on utility conflicts, oil and gas pipeline conflicts, and topography, LAN divided these three areas into ten proposed sub-regional detention basins with a total storage volume of 4,983 acre-feet, as shown in **Exhibit 29** and **Figure 9**.

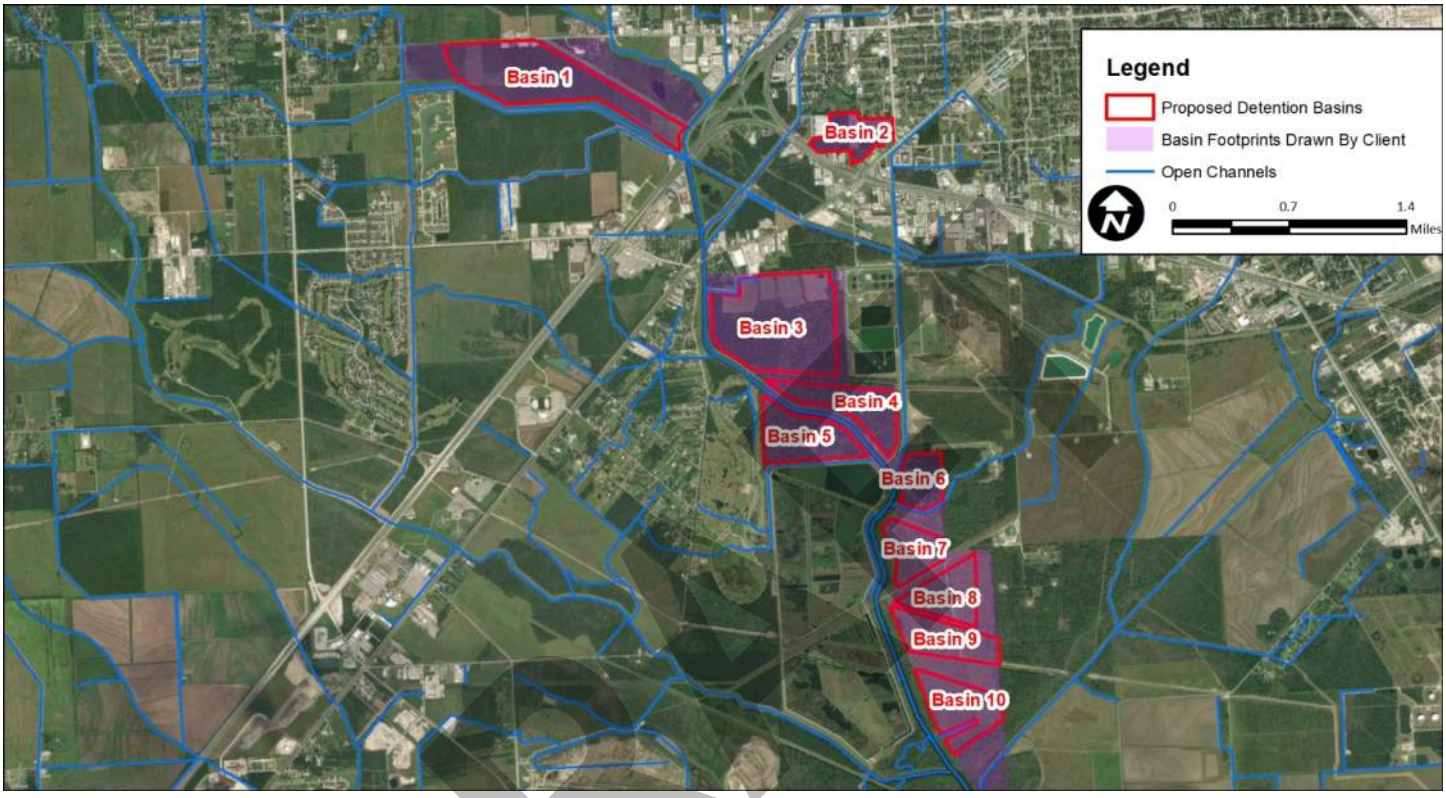

Figure 9. Proposed Regional Detention Basins

All ten basins were assumed to be dry bottom basins with a pilot channel. Specific pilot channel routes would need to be considered in detailed design, but generally, potential pilot channel routes were set to maximize the depth, and therefore volume, of the proposed detention basins. The minimum criteria for dry bottom basins used to find preliminary storage volumes to model the basins:

- Pilot channels were assumed to have a 0.2% longitudinal slope, 3:1 side slopes, and 1' depth
- The transverse (cross) slopes of the basins were assumed to be 1%, and began 20' away from the toe of slope of the basin
- The detention basins were assumed to have 3:1 side slopes

Using an assumed pilot channel route, length, and slope, the upstream and downstream basins were averaged. That average was used as the flowline elevation of a simplified version of these basins. Surfaces were created for each basin that assumed that the top of bank elevation was the lowest natural ground elevation within the basin footprint and that the basin was flat on the bottom (i.e., no longitudinal or transverse slopes). These surfaces were then burned into the LiDAR so that detention volume could be represented in the 2D surface within the stormwater model.

Basins 1 and 3-10 are adjacent to Hillebrandt Bayou. The control structures for these basins are a weir adjacent to Hillebrandt Bayou set at an elevation approximately 2' lower than the 10-year WSEL in the channel.

Basin 2 is an existing basin adjacent to undeveloped Right-Of-Way. In the proposed conditions, this basin has been extended while maintaining as much of the original configuration as possible.

For all ten basins, the outfall pipes were sized so that less than 1' of water would remain in the basin after 48 hours.

6.1 Basin 1

Basin 1 is roughly bound by Washington Boulevard on the north and Hillebrandt Bayou on the southeast. With a downstream flowline of 1.97', an upstream flowline of 13.78', and a pilot channel length of 5,985', the average flowline of Basin 1 is 7.87'. The site of Basin 1 is 190 acres, and the approximate storage volume is 1,319 ac-ft. The weir elevation is 8.73'. The outfall pipe is an 8'x5' RCB.

6.2 Basin 2

Basin 2 is an existing basin with approximately 31 acres of undeveloped land adjacent to the southern and western portions of the basin. In the proposed conditions, this basin has been extended while maintaining as much of the original configuration as possible. The expanded Basin 2 footprint is roughly bound by South 11th Street on the east, Fannett Road on the southeast, and Highway 287 on the southwest. To find the approximate flowline elevations and volume of the expanded version of the basin, the existing pilot channel was extended 1,391' to the southwest. The average flowline of Basin 2 is 5.88'. The site of Basin 2 is 55 acres, and the approximate storage volume is 445 ac-ft. Both the infall and outfall pipes are a single 10' x 5' RCB. The outfall pipe also has a flap gate to prevent backflow.

6.3 Basin 3

Basin 3 is bound by Hillebrandt Bayou on the west and is approximately 1,200' south of Fannett Road. With a downstream flowline of 1.97', an upstream flowline of 8.98', and a pilot channel length of 3,576', the average flowline of Basin 3 is 5.47'. The site of Basin 3 is 235 acres, and the approximate storage volume is 1,286 ac-ft. The weir elevation is 8.06'. The outfall pipe is an 8' x 5' RCB.

6.4 Basin 4

Basin 4 is roughly bound by Hillebrandt Bayou on the west and a pipeline easement on the north. With a downstream flowline of 1.97', an upstream flowline of 4.61', and a pilot channel length of 1,394', the average flowline of Basin 4 is 3.29'. The site of Basin 4 is 74 acres, and the approximate storage volume is 411 ac-ft. The weir elevation is 7.15'. The outfall pipe is a 60" RCP.

6.5 Basin 5

Basin 5 is roughly bound by Hillebrandt Bayou on the east and is opposite of Basin 4. With a downstream flowline of 1.97', an upstream flowline of 6.02', and a pilot channel length of 2,094', the average flowline of Basin 5 is 4.00'. The site of Basin 5 is 84 acres, and the approximate storage volume is 374 ac-ft. The weir elevation is 7.19'. The outfall pipe is a 60" RCP.

6.6 Basin 6

Basin 6 is roughly bound by Hillebrandt Bayou on the west, Ditch 106 on the south, and Ditch 107 on the northwest. With a downstream flowline of 1.97', an upstream flowline of 4.12', and a pilot channel length of 1,137', the average flowline of Basin 6 is 3.04'. The site of Basin 6 is 41 acres, and the approximate storage volume is 161 ac-ft. The weir elevation is 6.85'. The outfall pipe is a 60" RCP.

6.7 Basin 7

Basin 7 is roughly bound by Hillebrandt Bayou on the west, and pipeline easements on the north, south, and east. With a downstream flowline of 1.97', an upstream flowline of 4.62', and a pilot channel length of 1,390', the average flowline of Basin 7 is 3.30'. The site of Basin 7 is 49 acres, and the approximate storage volume is 203 ac-ft. The weir elevation is 6.37'. The outfall pipe is a 60" RCP.

6.8 Basin 8

Basin 8 is roughly bound by pipeline easements on the north and south. With a downstream flowline of 1.97', an upstream flowline of 6.76', and a pilot channel length of 2,396', the average flowline of Basin 8 is 4.37'. The site of Basin 8 is 63 acres, and the approximate storage volume is 225 ac-ft. The weir elevation is 5.98'. The outfall pipe is a 60" RCP.

6.9 Basin 9

Basin 9 is roughly bound by Hillebrandt Bayou on the west, and pipeline easements on the north and south. With a downstream flowline of 1.67', an upstream flowline of 5.08', and a pilot channel length of 1,773', the average flowline of Basin 9 is 3.38'. The site of Basin 9 is 69 acres, and the approximate storage volume is 312 ac-ft. The weir elevation is 5.61'. The outfall pipe is a 60" RCP.

6.10 Basin 10

Basin 10 is roughly bound by Hillebrandt Bayou on the west and a pipeline easement on the north. With a downstream flowline of 1.67', an upstream flowline of 4.87', and a pilot channel length of 1,657', the average flowline of Basin 10 is 3.27'. The site of Basin 10 is 77 acres, and the approximate storage volume is 247 ac-ft. The weir elevation is 4.52'. The outfall pipe is a 60" RCP.

7. Proposed Conditions Model Analysis

To evaluate the efficacy of the proposed improvements, ponding depth reductions were evaluated for each storm event. Additionally, the performance metrics acreage of land inundated, number of parcels in the floodplain, number of inundated structures, and miles of inundated roadway were found for each storm event and each area of influence and compared to those of existing conditions. These comparisons quantify the benefit that each project provides.

Additionally, an impact analysis was performed on each of the four proposed conveyance improvements. The model output was compared between existing and proposed conditions to ensure no adverse impact to water surface elevations. Multiple channel sections within the Hillebrandt Bayou watershed were evaluated for each conveyance improvement. Hydrographs were generated at each section for existing and proposed conditions to understand the impact each improvement has on nearby channel hydraulics.

7.1 South Park Diversion and Basin 2 Improvements

7.1.1 Benefits and Performance Metrics

The reductions in ponding depth, ponding extents, and performance metrics for the South Park diversion are influenced by the expansion of Basin 2 as described in Section 6.2 due to the proximity of both projects. The increased storage provided by the Basin 2 expansion provides local benefit west of the Union Pacific Railroad while also slightly reducing the amount of flow that reaches the area east of the Union Pacific Railroad (i.e., the area serviced by the South Park diversion).

Approximately 221 acres were removed from the 10-year floodplain, as shown in **Exhibit 30.** The most significant benefit to ponding depths for the 10-year event is located along channel 104 and 104-B, which experience reductions of approximately 3.5’ and 1.9’, respectively. Additional reductions between 0.5’ and 1.0’ in the 10-year are concentrated primarily along Park Street, Florida Avenue and the areas serviced by storm sewer systems discharging to the upstream end of both channels 104 and 104-B. Widespread reductions to 10-year ponding depth occur throughout the area of influence due to the relief provided to the existing storm sewer system by the proposed storm sewer upgrades. Minor depth reductions occur in the topographically low-lying portions of the study area that typically experience the most frequent street and structural flooding. **Exhibit 33** shows the 10-year water surface elevation reductions due to the proposed South Park area diversion project. 479 parcels and 6 roadway miles were removed from the 10-year floodplain, while 323 structures were removed from inundation for the 10-year storm event.

Approximately 272 acres were removed from the 100-year floodplain, as shown in **Exhibit 31**. The most significant benefit to ponding depths for the 100-year event is located along channel 104 and 104-B, which experience reductions of approximately 1.4’ and 0.75’, respectively. A large portion of the study area north of channel 104-B experiences a reduction of 0.4’ because of the storm sewer upgrades in the area. Ponding extents are reduced for the 100-year event most notably in the area south of Florida Avenue and along channel 104. This significant reduction is due to the partial diversion of the discharge from the existing Jimmy Simmons Boulevard storm sewer system. **Exhibit 34** shows the 100-year water surface elevation reductions due to the proposed South Park area diversion project. 262 parcels and 5 roadway miles were removed from the 100-year floodplain, while 462 structures were removed from inundation for the 100-year storm event.

Approximately 291 acres were removed from the 500-year floodplain, as shown in **Exhibit 32**. The most significant benefit to ponding depths for the 500-year event is located along channel 104 and 104-B which experience maximum reductions of approximately 4.6’ and 6.4’, respectively. A large portion of the study area north of channel 104-B experiences reductions of 0.3’ - 0.4’ because of the storm sewer upgrades in the area. Ponding extents are reduced for the 500-year event most notably in the area south of Florida Avenue and along channel 104. This significant reduction is due to the partial diversion of the discharge from the existing Jimmy Simmons Boulevard storm sewer system.

Exhibit 35 shows the 500-year water surface elevation reductions due to the proposed South Park area diversion project. Note that the benefit experienced for the 500-year event is less than that of other storm events due to the magnitude of flow and high tailwater conditions. 573 parcels and 5 roadway miles were removed from the 500-year floodplain, while 482 structures were removed from inundation for the 500-year storm event.

Exhibits 36, 37, & 38 show the parcels, roadway miles, and structures removed from flooding for the 10-, 100-, and 500-year storm events. The performance metrics for the South Park diversion are also summarized in **Table 4**.

Table 4. South Park Diversion & Basin 2 Performance Metrics

South Park Diversion & Basin 2 Performance Metrics									
Metric	Existing			Proposed			Delta		
	10yr	100yr	500yr	10yr	100yr	500yr	10yr	100yr	500yr
Parcels in Floodplain	1457	2981	3804	978	2719	3231	-479	-262	-573
Inundated Roadway Miles	44	59	66	38	54	61	-6	-5	-5
Inundated Structures	803	1915	2594	480	1453	2112	-323	-462	-482
Inundated Acreage	1187	1951	2304	966	1679	2013	-221	-272	-291

7.1.2 Impact Analysis

For the South Park Diversion and Basin 2 improvements, runoff hydrographs were evaluated for DD6 channels 104B and 107 at their discharge points to the south of W Cardinal Drive as shown in **Figure 10** below.

Figure 10. Hydrograph Locations – DD6 Channel 104B and 107

Figure 11 shows the comparison between existing and proposed 100-year flows in Channel 104B. Existing and proposed peak flows are approximately 1,111 cfs and 849 cfs, respectively. Channel 104B experiences peak flow reduction of approximately 262 cfs. This reduction is influenced by the proposed South Park diversion improvement that diverts flow away from Channel 104B to the Neches River.

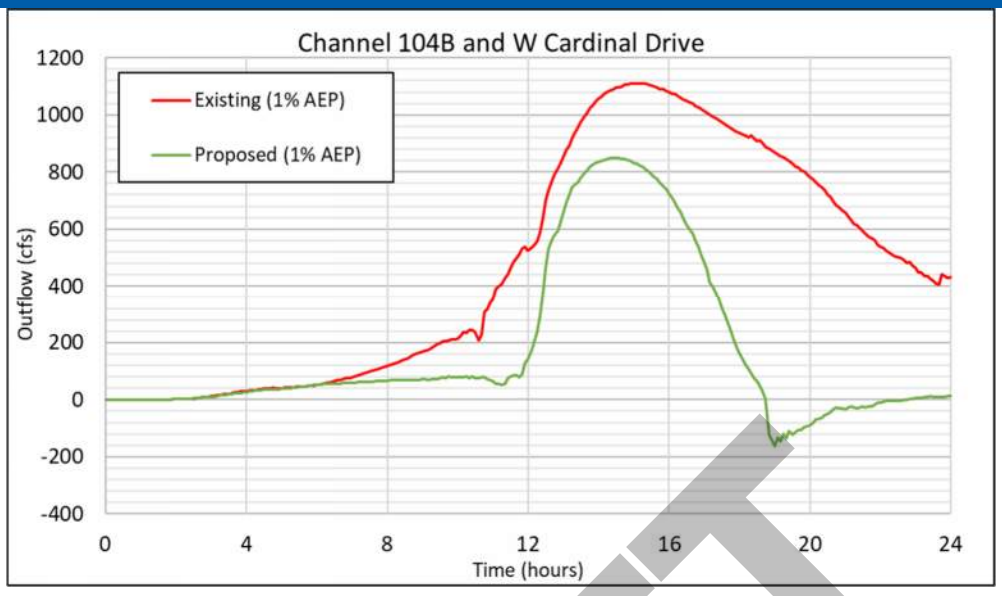

Figure 11. Channel 104B – Existing and Proposed 100-year Hydrograph Comparison

Channel 107 was evaluated because the South Park diversion improvements were modeled together with proposed Basin 2. Channel 107 is located downstream of the proposed Basin 2. **Figure 12** shows the comparison between existing and proposed 100-year flows in Channel 107. Existing and proposed peak flows are approximately 301 cfs and 310 cfs, respectively. Channel 107 experiences a peak flow increase of approximately 9 cfs. However, the peak water surface elevation does not experience a rise in Channel 107 for the 100-year storm event.

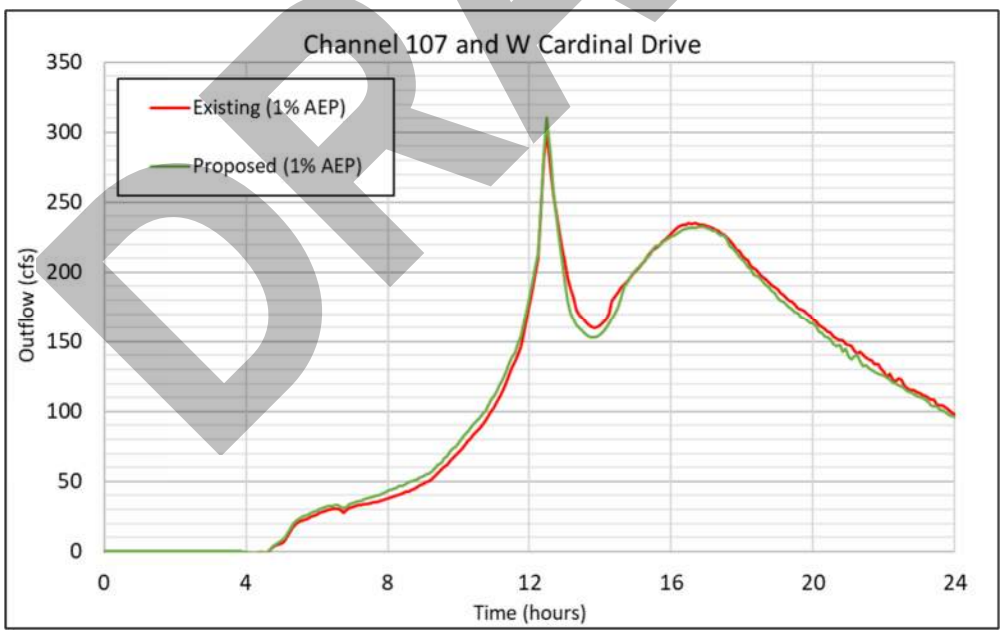

Figure 12. Channel 107 – Existing and Proposed 100-year Hydrograph Comparison

A comparison of the 1.0% (100-year) water surface elevations in existing and proposed conditions is shown in **Exhibit 34**. The comparison shows that while peak flows are increased for Channel 107, the proposed diversion and basin improve the system efficiency enough to mitigate widespread downstream impacts. The impact evaluation concludes that there are no adverse impacts or increased flood risk to nearby DD6 channels and adjacent neighborhoods as a result of the proposed South Park Diversion and Basin 2 improvements.

7.2 Tevis Diversion Improvement

7.2.1 Benefits and Performance Metrics

Approximately 122 acres were removed from the 10-year floodplain, as shown in **Exhibit 39.** The most significant benefit to ponding depths for the 10-year event is located along the upstream end of channel 115, which ranges from 1.4' to 2.5'. This is because the proposed Tevis alignment diverts flow away from this channel. Additional reductions between 0.5' and 1.0' in the 10-year storm event are concentrated primarily along Interstate 10, North 11th Street, South Street, Jaguar Drive, Pecos Street, Laurel Street, and Liberty Avenue. All of these locations are in proximity to the proposed Tevis diversion. Widespread reductions to 10-year ponding depth occur throughout the area of influence due to the relief provided to the existing storm sewer system by the proposed storm sewer upgrades. Minor depth reductions occur in the topographically low-lying portions of the study area that typically experience the most frequent street and structural flooding. **Exhibit 42** shows the 10-year water surface elevation reductions due to the proposed Tevis area diversion project. 252 parcels and 5 roadway miles were removed from the 10-year floodplain, while 159 structures were removed from inundation for the 10-year storm event.

Approximately 216 acres were removed from the 100-year floodplain, as shown in **Exhibit 40**. The area roughly bound by North 13th Street, Laurel Street, Duperior Street, and the Union Pacific Railroad experiences reductions ranging from 0.5' to 1.8'. Another area, roughly bound by Broadway Street, Gulf Street, and Park Street, experiences reductions ranging from 0.5' to 1.1'. Ponding extents are reduced for the 100-year event most notably in the area roughly bound by North 13th Street, Laurel Street, Duperior Street, and the Union Pacific Railroad. This significant reduction is local benefit due to the increased storm sewer capacity provided by the Tevis diversion. **Exhibit 43** shows the 100-year water surface elevation reductions due to the proposed Tevis area diversion project. 164 parcels and 4 roadway miles were removed from the 100-year floodplain, while 456 structures were removed from inundation for the 100-year storm event.

Approximately 124 acres were removed from the 500-year floodplain, as shown in **Exhibit 41**. The most significant benefit to ponding depths for the 500-year event occurs in the area between Gulf Street and Willow Street and along the proposed storm sewer with WSEL reductions ranging from 0.5' to 2.0'. Similarly, the area between 11th Street and 3rd Street experiences reductions of 0.5' to 1.2' due to the proposed storm sewer upgrades. Ponding is reduced by approximately 0.2' in a significant area surrounding the upstream ends of channels 100-A, 115, 116, 117, and 117-C. **Exhibit 44** shows the 500-year water surface elevation reductions due to the proposed Tevis area diversion project. Note that the benefit experienced for the 500-year event is less than that of other storm events due to the magnitude of flow and high tailwater conditions. 118 parcels and 3 roadway miles were removed from the 500-year floodplain, while 330 structures were removed from inundation for the 500-year storm event.

Exhibits 45, 46, & 47 show the parcels, roadway miles, and structures removed from flooding for the 10-, 100-, and 500-year storm events. The performance metrics for the Tevis diversion are also summarized in **Error! Reference source not found.**.

Table 5. Tevis Diversion Performance Metrics

Tevis Diversion Performance Metrics									
Metric	Existing			Proposed			Delta		
	10yr	100yr	500yr	10yr	100yr	500yr	10yr	100yr	500yr
Parcels in Floodplain	2886	3461	3568	2634	3297	3450	-252	-164	-118
Inundated Roadway Miles	42	53	56	37	49	53	-5	-4	-3
Inundated Structures	383	1622	2392	224	1166	2062	-159	-456	-330
Inundated Acreage	623	1202	1480	501	986	1356	-122	-216	-124

7.2.2 Impact Analysis

For the Tevis Diversion, runoff hydrographs were evaluated for DD6 channels 115 and 100A. Channel 115 is located at the upstream end of the proposed diversion. Channel 100A is located near the model outfall within the Hillebrandt Bayou watershed. See **Figure 13** below for the evaluated flow hydrograph locations.

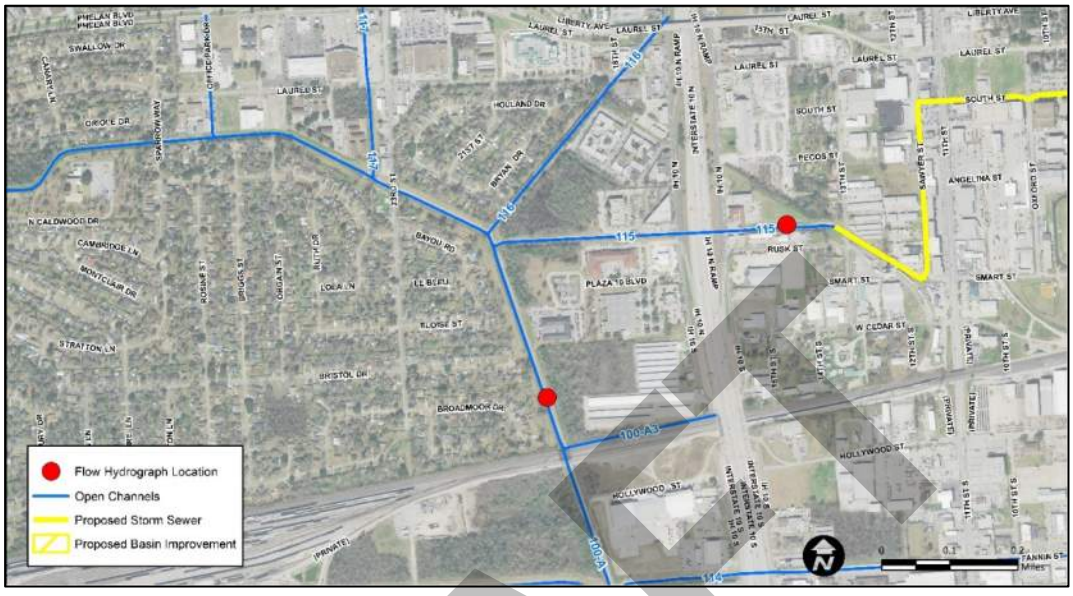

Figure 13. Hydrograph Locations – DD6 Channel 115 and 100A

Figure 14 shows the comparison between existing and proposed 100-year flows in Channel 115. Existing and proposed peak flows are approximately 228 cfs and -790 cfs, respectively. Positive flows represent existing flow moving west towards the Channel 115 confluence with channel 100A. Negative flows represent proposed flow being fully redirected away from Channel 100A and towards the Neches River. While there are increased flows towards the proposed improvements via Channel 115, there are no increased flows towards the DD6 channel system.

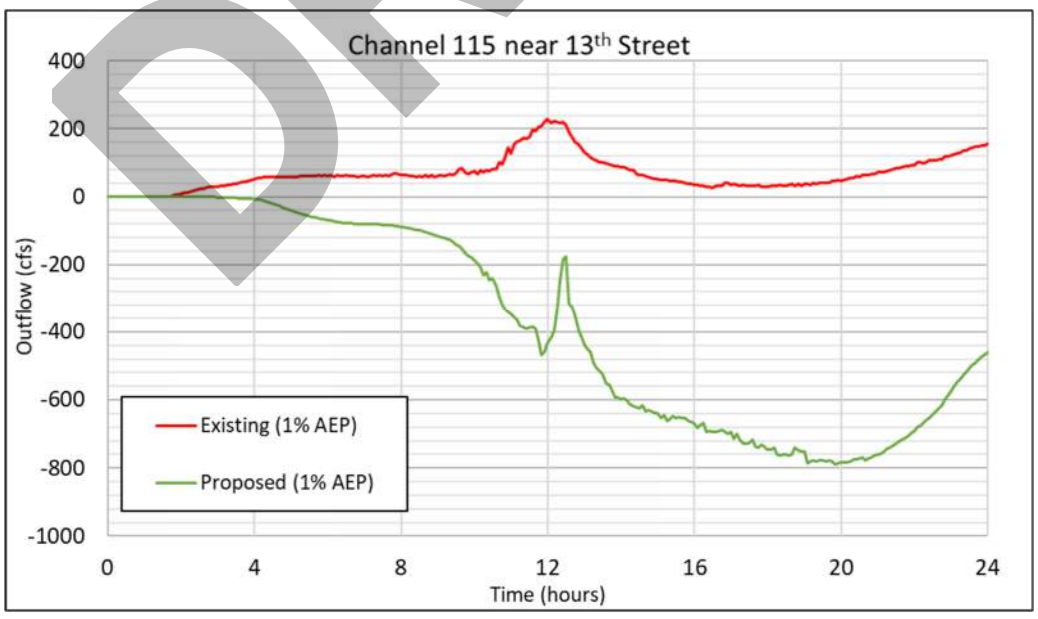

Figure 14. Channel 115 – Existing and Proposed 100-year Hydrograph Comparison

Channel 100A was evaluated to understand the broader impacts to Hillebrandt Bayou tributary systems influenced by the proposed Tevis Diversion improvements. Channel 100A was evaluated to understand the broader impacts to Hillebrandt Bayou tributary systems influenced by the proposed Tevis Diversion improvements. **Figure 15** shows the comparison between existing and proposed 100-year flows in Channel 100A. Existing and proposed peak flows are approximately 2,238 cfs and 1,411 cfs, respectively. Channel 100A experiences a peak flow reduction of approximately 827 cfs.

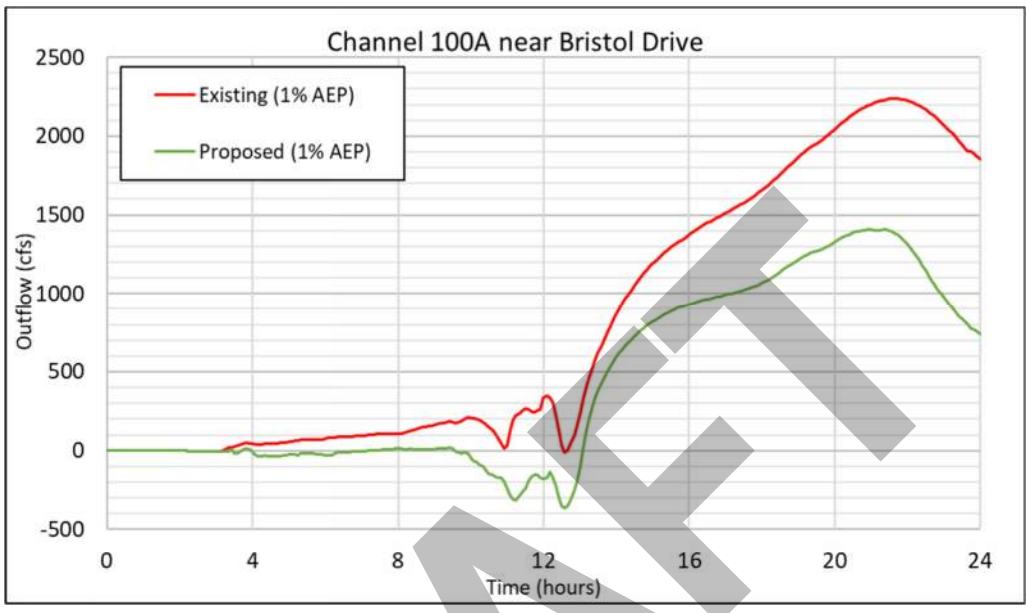

Figure 15. Channel 100A – Existing and Proposed 100-year Hydrograph Comparison

A comparison of the 1.0% (100-year) water surface elevations in existing and proposed conditions is shown in **Exhibit 43**. The comparison shows that the peak flow reductions within Channel 100A produce lower water surface elevations. The impact evaluation concludes that there are no adverse impacts or increased flood risk to nearby DD6 channels and adjacent neighborhoods as a result of the proposed Tevis Diversion.

7.3 Blanchette Diversion and Basin 1 Improvements

7.3.1 Benefits and Performance Metrics

The reductions in ponding depth, ponding extents, and performance metrics for the Blanchette diversion are influenced by Basin 1, as described in Section 6.1, due to overall project proximity. The detention volume provided by Basin 1 provides relief to Hillebrandt Bayou (Channel 100). This provides benefit to Channels 110 and 110-B, which are first- and second-order tributaries of Channel 100, respectively. Since the Blanchette storm sewer improvements divert flow away from Channel 110-B, which is a tributary of Channel 110, the addition of Basin 1 provides greater WSEL reductions near the Blanchette diversion.

Approximately 327 acres were removed from the 10-year floodplain, as shown in **Exhibits 48 and 57**. The most significant benefit to ponding depths for the 10-year event is a 3.0' reduction located along a segment of Martin Luther King Parkway between Royal Street and Fannin Street, including the intersection of US 90 and Martin Luther King Parkway. Similarly, there is a reduction of 0.5' to 1.0' in the general area bound by the Union Pacific Railroad and Avenue G. Additional reductions of 1.5' occur where channel 100-02 intersects with Cartwright Street. Consistent reductions up to 1.5' occur along roads near the proposed storm sewer upgrades. These roads include Terrel Avenue, Cartwright Street, Houston Street, San Antonio Street, 4th Street, and Washington Boulevard in the area bound by 11th Street and the Union Pacific Railroad. Widespread reductions to 10-year ponding depth occur throughout the area of influence due to the relief provided to the existing storm sewer system by the proposed storm sewer upgrades. Minor depth reductions occur in the topographically low-lying

portions of the study area that typically experience the most frequent street and structural flooding. **Exhibits 51 and 60** show the 10-year water surface elevation reductions due to the proposed Blanchette area diversion project. 457 parcels and 9 roadway miles were removed from the 10-year floodplain, while 292 structures were removed from inundation for the 10-year storm event.

Approximately 478 acres were removed from the 100-year floodplain, as shown in **Exhibits 49 and 58**. The most significant benefit to ponding depths for the 100-year event is a 4.0' reduction for the intersections of Martin Luther King Parkway and College Street and Martin Luther King Parkway and Franklin Street. The intersection of Orleans Street and Gilbert Street also experiences a 1.5' reduction. Ponding extents are reduced for the general area between Interstate 10 East and Avenue G due to the proposed storm sewer upgrades, with WSEL reductions between 0.2' and 1.0' of water. Implementation of Basin 1 also reduces ponding near Washington Boulevard and channel 111. **Exhibits 52 and 61** show the 100-year water surface elevation reductions due to the proposed Blanchette area diversion project. 658 parcels and 8 roadway miles were removed from the 100-year floodplain, while 540 structures were removed from inundation for the 100-year storm event.

Approximately 447 acres were removed from the 500-year floodplain, as shown in **Exhibits 50 and 59**. The most significant benefit to ponding depths for the 500-year event is located at the intersection of Gilbert Street and Orleans Street with a reduction of 2.0'. Similarly, the intersections of Martin Luther King Parkway and College Street and Martin Luther King Parkway and Franklin Street experience reductions of about 0.8'. The proposed storm sewer improvements along Roberts Street cause reductions between 0.2' and 1.0' of water in the area enclosed by Washington Boulevard, Avenue D, 11th Street, and Blanchette Street. **Exhibits 53 and 62** show the 500-year water surface elevation reductions due to the proposed Blanchette area diversion project. Note that the benefit experienced for the 500-year event is less than that of other storm events due to the magnitude of flow and high tailwater conditions. 684 parcels and 6 roadway miles were removed from the 500-year floodplain, while 486 structures were removed from inundation for the 500-year storm event.

Exhibits 54-56 and 63-65 show the parcels, roadway miles, and structures removed from flooding for the 10-, 100-, and 500-year storm events. The performance metrics for the Blanchette diversion are also summarized in **Table 6**.

Table 6. Blanchette Diversion & Basin 1 Performance Metrics

Blanchette Diversion & Basin 1 Performance Metrics									
Metric	Existing			Proposed			Delta		
	10yr	100yr	500yr	10yr	100yr	500yr	10yr	100yr	500yr
Parcels in Floodplain	1111	2619	3401	654	1961	2717	-457	-658	-684
Inundated Roadway Miles	46	69	79	37	61	73	-9	-8	-6
Inundated Structures	577	1803	2431	285	1263	1945	-292	-540	-486
Inundated Acreage	1574	2977	3581	1247	2499	3134	-327	-478	-447

7.3.2 Impact Analysis

For the Blanchette Diversion, runoff hydrographs were evaluated for DD6 channels 110B and 110. Channel 110B is located at the upstream end of the proposed diversion. See **Figure 16** below for the evaluated flow hydrograph locations.

Figure 16. Hydrograph Locations – DD6 Channel 110B and 110

Figure 17 shows the comparison between existing and proposed 100-year flows in Channel 110B. Existing and proposed peak flows are approximately 343 cfs and 288 cfs, respectively. Positive flows represent existing flow moving west towards Channel 110. Negative flows represent proposed flow being fully redirected away from Channel 110 and towards the Neches River. There is a peak 100-year flow reduction of approximately 55 cfs.

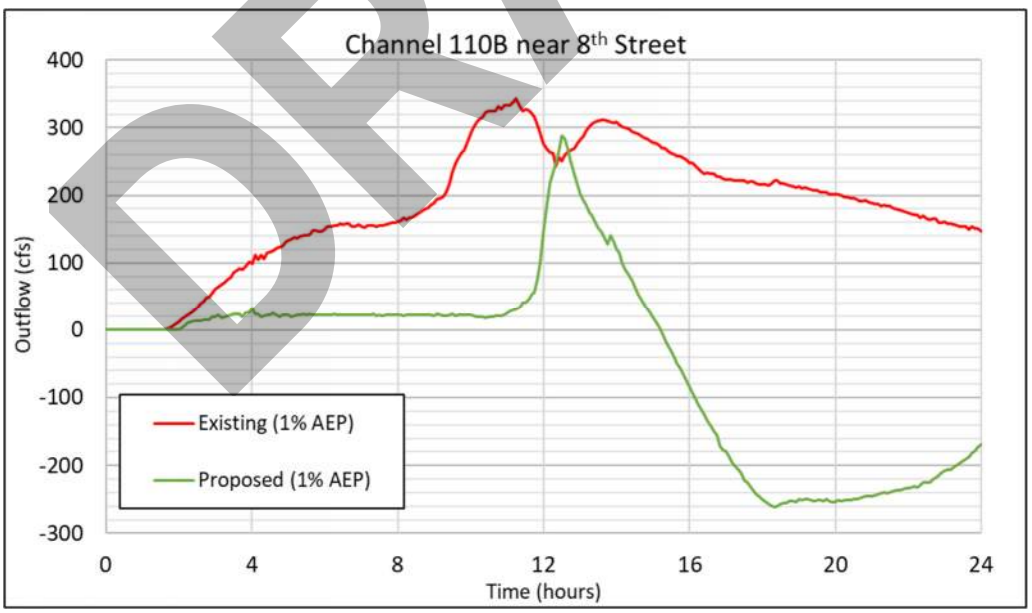

Figure 17. Channel 110B – Existing and Proposed 100-year Hydrograph Comparison

Channel 110 was evaluated to understand the broader impacts to Hillebrandt Bayou tributary systems influenced by the Blanchette Diversion and Basin 1 improvements. **Figure 18** shows the comparison between existing and proposed 100-year flows in Channel 110. Existing and proposed peak flows are approximately 437 cfs and 421 cfs, respectively. Channel 110 experiences a peak flow reduction of approximately 16 cfs.

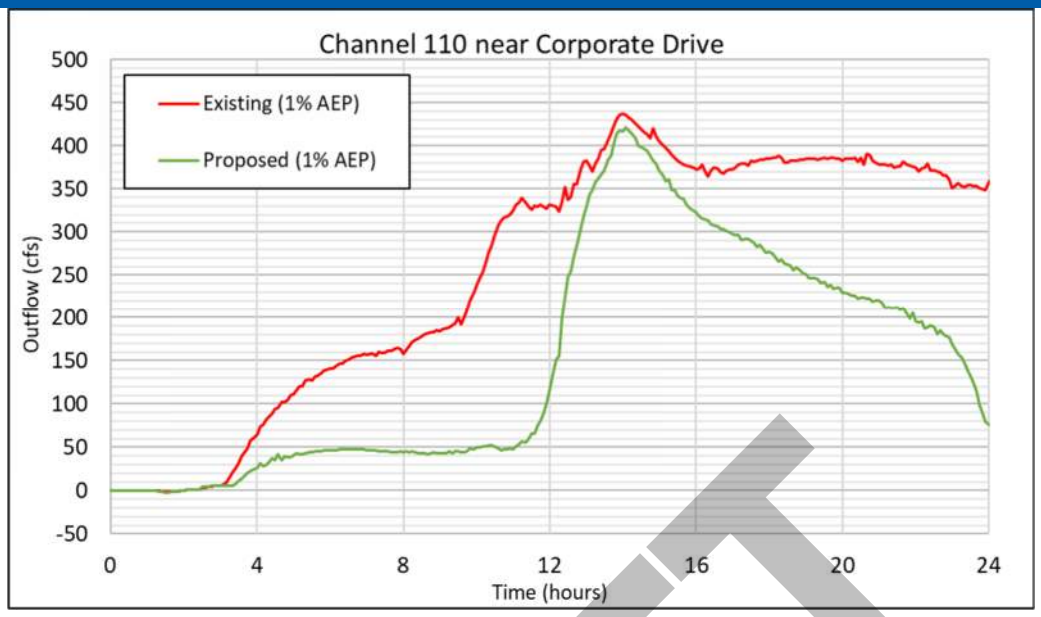

Figure 18. Channel 110 – Existing and Proposed 100-year Hydrograph Comparison

A comparison of the 1.0% (100-year) water surface elevations in existing and proposed conditions is shown in **Exhibits 52 and 61**. The comparison shows that the peak flow reductions within Channel 100A produce lower water surface elevations. The impact evaluation concludes that there are no adverse impacts or increased flood risk to nearby DD6 channels and adjacent neighborhoods from the Blanchette Diversion and Basin 1 improvements.

7.4 Lucas Diversion Improvement

7.4.1 Benefits and Performance Metrics

Approximately 330 acres were removed from the 10-year floodplain as a result of the Lucas Diversion, as shown in **Exhibit 66**. The most significant benefit to ponding depths for the 10-year event is located along the downstream end of channel 001 which experiences reductions up to 5.6'. A significant area around channel 117 also experiences reductions between 0.2' and 1.0'. Reductions up to 1.5' occur in the area surrounding Hillebrandt Bayou enclosed by Dowlen Road, Howell Street, and Wilchester Lane. **Exhibit 69** shows the 10-year water surface elevation reductions due to the proposed Lucas area diversion project. 308 parcels and 7 roadway miles were removed from the 10-year floodplain, while 196 structures were removed from inundation for the 10-year storm event.

Approximately 251 acres were removed from the 100-year floodplain, as shown in **Exhibit 67**. The most significant benefit to ponding depths for the 100-year event is 1.5' which occurs along channel 001. This benefits the neighborhoods on Nelkin Lane and Jenard Lane. The average reduction for the area surrounding channel 100 bordered by Clinton Street, Dowlen Road, and Delaware Street is approximately 0.2', with a maximum reduction of 0.5' where Delaware Street intersects Shadow Bend Avenue. The proposed storm sewer upgrades provide average reductions of about 0.8' with a maximum of 1.3' for the area between Highway 287 and Delaware Street along the proposed storm sewer. Similarly, the existing storm sewer system is aided by the proposed storm sewer upgrades, specifically along Helbig Road, which experiences reductions up to 1.0'. Minor depth reductions occur in the area enclosed by Highway 287, French Road, and Helbig Road. A similar reduction occurs in the area between Highway 287 and West Lucas Drive which is due to the partial diversion of the discharge from the existing storm sewer system. **Exhibit 70** shows the 100-year water surface elevation reductions due to the proposed Lucas area diversion project. 109 parcels and 5 roadway miles were removed from the 100-year floodplain, while 548 structures were removed from inundation for the 100-year storm event.

Approximately 214 acres were removed from the 500-year floodplain, as shown in **Exhibit 68**. General ponding is reduced by 0.5' to 1.5' along the proposed sewer upgrades in the area enclosed by Delaware Street and Folsom Drive. Similarly, the area around channel 001 including Spencer Drive, McHale Street, Lorilee Street, Nelkin Lane, Jenard Lane, and Thames Drive experience reductions between 0.5' and 2'. **Exhibit 71** shows the 500-year water surface elevation reductions due to the proposed Lucas area diversion project. Note that the benefit experienced for the 500-year event is less than that of other storm events due to the magnitude of flow and high tailwater conditions. 231 parcels and 214 acres were removed from the 500-year floodplain, while 579 structures were removed from inundation for the 500-year storm event.

Exhibits 72, 73 & 74 show the parcels, roadway miles, and structures removed from flooding for the 10-, 100-, and 500-year storm events. The performance metrics for the Lucas diversion are also summarized in **Table 7**.

Table 7. Lucas Diversion Performance Metrics

Lucas Diversion Performance Metrics									
Metric	Existing			Proposed			Delta		
	10yr	100yr	500yr	10yr	100yr	500yr	10yr	100yr	500yr
Parcels in Floodplain	7932	8762	9074	7624	8653	8843	-308	-109	-231
Inundated Roadway Miles	82	95	100	75	90	100	-7	-5	0
Inundated Structures	694	3090	4291	498	2542	3712	-196	-548	-579
Inundated Acreage	1966	3116	3599	1636	2865	3385	-330	-251	-214

7.4.2 Impact Analysis

For the Lucas Diversion, runoff hydrographs were evaluated for two separate locations along DD6 Channel 100 (Caldwood Cut-Off). The first Channel 100 location is near the upstream end of the proposed diversion. The second location is near the confluence of Channel 100 and Channel 118 near the model's outfall. See **Figure 19** below for the evaluated flow hydrograph locations.

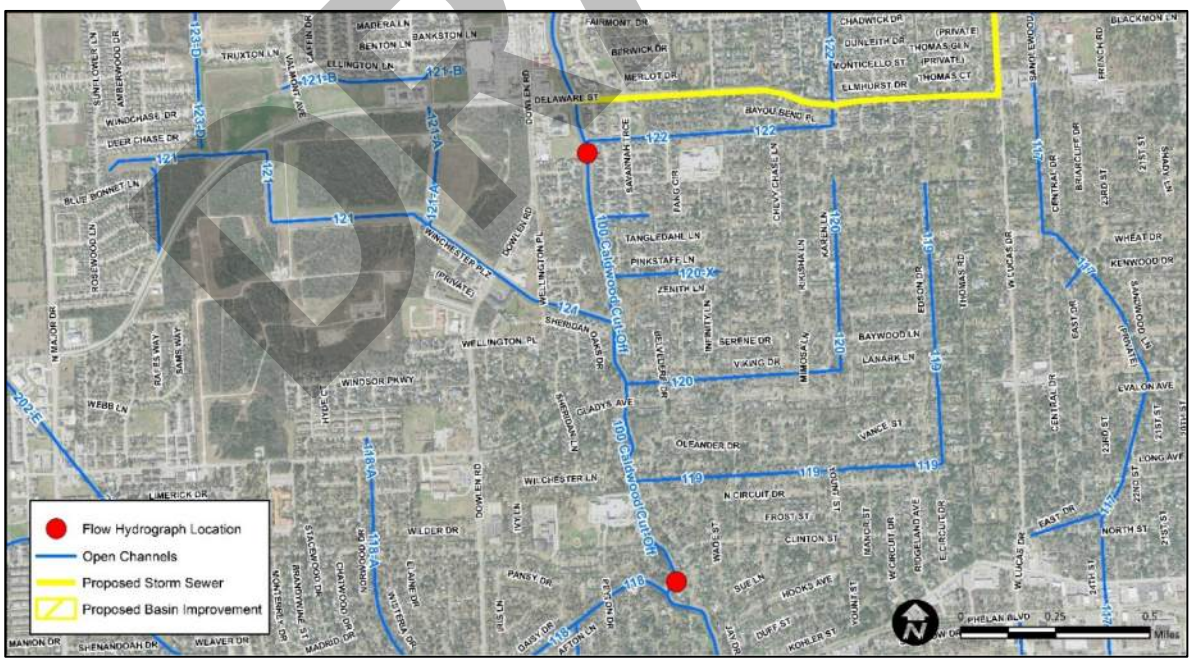

Figure 19. Hydrograph Locations – DD6 Channel 100 (Caldwood Cut-Off)

Figure 20 shows the comparison between existing and proposed 100-year flows in Channel 100 near Delaware Street. Existing and proposed peak flows are approximately 1,664 cfs and 1,892 cfs, respectively.

There is an interim peak 100-year flow increase of approximately 228 cfs. This flow increase is a result of the proposed improvements allowing flow to move downstream more efficiently. Although there are brief increases in peak flow, there are no increases to 100-year water surface elevations in Channel 100.

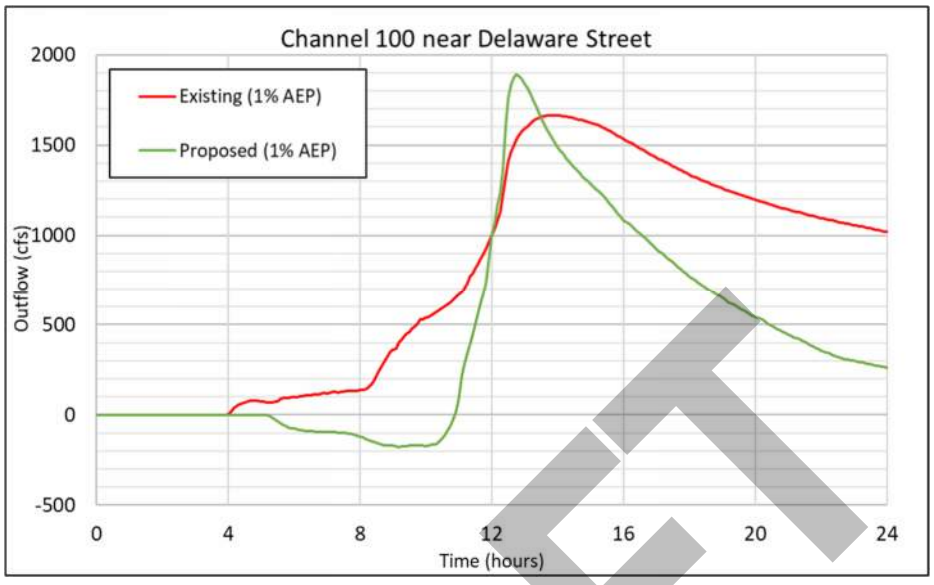

Figure 20. Channel 100 – 100-year Hydrograph Comparison

Channel 100 was evaluated to understand the broader impacts to Hillebrandt Bayou tributary systems influenced by the Lucas Diversion improvement. Error! Reference source not found. shows the comparison between existing and proposed 100-year flows in Channel 100. Existing and proposed peak flows are approximately 3,555 cfs and 3,414 cfs, respectively. Channel 100 experiences a peak flow reduction of approximately 141 cfs.

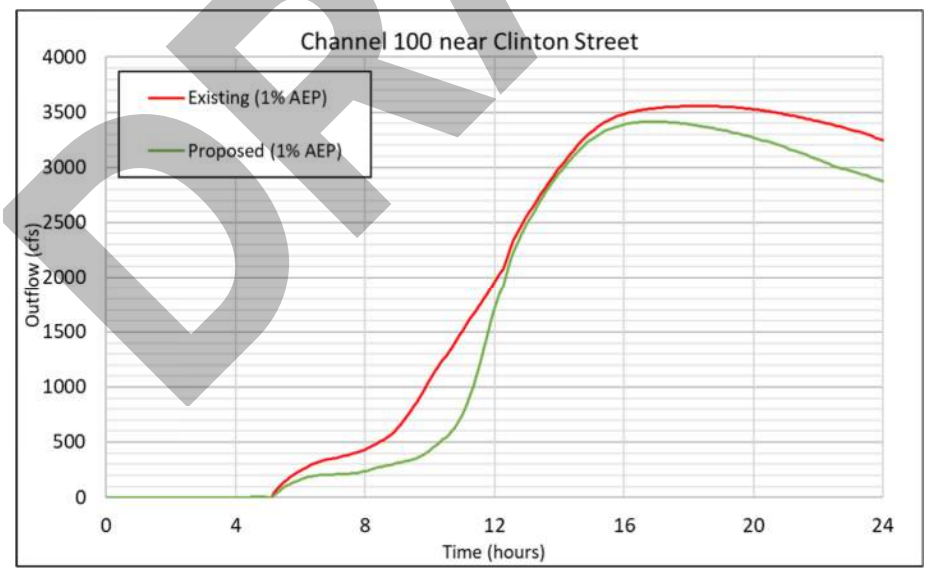

Figure 21. Channel 100 (near Clinton Street) - 100-year Hydrograph Comparison

A comparison of the 1.0% (100-year) water surface elevations in existing and proposed conditions is shown in **Exhibit 70**. The comparison shows that the peak flow reductions within Channel 100 produce lower water surface elevations. The impact evaluation concludes that there are no adverse impacts or increased flood risk to nearby DD6 channels and adjacent neighborhoods from the Lucas Diversion improvements.

7.5 Proposed Sub-Regional Detention Basins

7.5.1 Benefits and Performance Metrics

Here, "proposed sub-regional detention basins" refers to Basins 3-10. This is due to the proximity and similar operation of these 8 basins, which share an area of influence. Basin 1 is included in the Blanchette diversion area of influence, as described in Section 7.3, while Basin 2 is included in the South Park diversion area of influence, as described in Section 7.1.

Approximately 599 acres were removed from the 10-year floodplain, as shown in **Exhibit 75**. The most significant benefit to ponding depths for the 10-year event is located along the north segment of Basin 4 with a reduction of 1.0'. Ponding is reduced in the general area downstream of Hillebrandt Bayou, which generally experiences reductions of approximately 0.3', most notably along channel 103-B with reductions up to 0.5'. Note that the benefit experienced for the proposed sub-regional detention basins is less than that of other areas due to its currently undeveloped nature. Future developments will benefit from these reductions. **Exhibit 78** shows the 10-year water surface elevation reductions due to the proposed sub-regional detention basins. 54 parcels were removed from the 10-year floodplain and 16 structures were removed from inundation for the 10-year storm event.

Approximately 1,025 acres were removed from the 100-year floodplain, as shown in **Exhibit 76**. The most significant benefit to ponding depths for the 100-year event occurs off the south bank of Hillebrandt Bayou between channels 109 and 105 with a maximum reduction of 1.2'. The areas surrounding channels 104, 200, the downstream end of channel 110, including channels 103 and 103-A experience reductions of about 0.2'. **Exhibit 79** shows the 100-year water surface elevation reductions due to the proposed regional detention basins. 110 parcels and 3 roadway miles were removed from the 100-year floodplain, while 165 structures were removed from inundation for the 100-year storm event.

Approximately 890 acres were removed from the 500-year floodplain, as shown in **Exhibit 77**. The most significant benefit to ponding depths for the 500-year event is a reduction of about 1.0' for the general area enclosed by channel 105, 100, and Fannett Road. Other areas that experience a reduction of about 0.3' include the area surrounding channel 200 between Hillebrandt Bayou and Fannett Road, along with the area enclosed by East Interstate 10 and Fannett Road between channels 108 and 109. **Exhibit 80** shows the 500-year water surface elevation reductions due to the proposed regional detention basins. Note that the benefit experienced for the 500-year event is less than that of other storm events due to the magnitude of flow and high tailwater conditions. 71 parcels and 1 roadway mile were removed from the 500-year floodplain, while 70 structures were removed from inundation for the 500-year storm event.

Exhibits 81, 82 & 83 show the parcels, structures, and roadway miles removed from flooding for the 10-, 100-, and 500-year storm events. The performance metrics for the proposed Basins 3-10 are also summarized in **Table 8**.

Table 8. Basins 3-10 Performance Metrics

Basins 3-10 Performance Metrics									
Metric	Existing			Proposed			Delta		
	10yr	100yr	500yr	10yr	100yr	500yr	10yr	100yr	500yr
Parcels in Floodplain	436	861	988	382	751	917	-54	-110	-71
Inundated Roadway Miles	8	21	27	8	18	26	0	-3	-1
Inundated Structures	123	484	612	107	319	542	-16	-165	-70
Inundated Acreage	6320	9765	10431	5721	8740	9541	-599	-1025	-890

7.6 Summary of Impacts

Runoff hydrographs were generated for each of the four proposed diversion projects to ensure no adverse impacts to City or DD6 channels. Peak 100-year (1% AEP) flows were compared between existing and proposed conditions to understand potential flow impacts. Additionally, peak water surface elevations were evaluated in surrounding channels to demonstrate that unintended impacts are not being influenced by the proposed improvements. This section evaluates potential impacts in detail for each storm sewer improvement project. **Table 9** shows the summary of flows at the evaluated locations for each of the proposed diversion improvements.

Table 9. Summary of Impact Analysis – Channel Flow and Elevation Comparisons

Proposed Improvements	Channel ID	Peak 100-Year Flow (cfs)			Peak 100-Year Elevation (ft)		
		Existing	Proposed	Delta	Existing	Proposed	Delta
South Park + Basin 2	104B	1111	849	**-262**	15.33	14.88	**-0.45**
	107	301	310	**9**	15.90	15.89	**-0.01**
Tevis	115	228	-790	**-1018**	17.54	16.42	**-1.13**
	100A	2238	1411	**-827**	17.00	16.88	**-0.12**
Blanchette + Basin 1	110B	343	288	**-55**	15.39	15.02	**-0.37**
	110	437	421	**-16**	15.09	14.87	**-0.22**
Lucas	100	1664	1892	**228**	23.90	23.69	**-0.21**
	100/118	3555	3414	**-141**	21.10	20.96	**-0.14**

8. Opinion of Probable Construction Costs (OPCC)

The planning level cost estimates for each project are based on the Texas Department of Transportation (TxDOT) Beaumont District average low bid unit prices published in March of 2020 and supplemented with regional bid prices. The cost estimates for the storm sewer diversions include, but are not limited to, roadway excavation, replacement concrete, inlets, junction boxes, and sewer linear footages on a unit-price basis. Approximate utility easement and ROW-acquisition costs were considered based on the individual project footprints. The cost estimates also include a flat fee for mobilization, utility relocation, traffic control, and a 15% engineering and survey fee to account for detailed design work. A 30% contingency was applied to all OPCCs as these are planning level cost estimates that should be refined further in a preliminary engineering report prior to project construction. Due to a HMGP grant application, the unit costs for the South Park diversion each had an approximately 30% contingency applied, rather than the contingency being applied on the construction subtotal.

The cost estimates for the proposed sub-regional detention basins include previously described components plus clearing and grubbing, excavation and off-site disposal, excavation and fill, backslope drainage system swales, 5" and 8" concrete channel lining, concrete interceptor structures, headwalls, wingwalls, and corrugated metal pipes (CMP). Clearing and grubbing at each location was assumed to cover the entire proposed property. Proposed excavation volumes were calculated by subtracting the basin surface from the 2017 LiDAR within the basin footprint. Negative values represented excavation and off-site disposal (i.e., cut), while positive values represented fill. The backslope drainage system swales were assumed to be around the entire perimeters of the basin footprints. The 5" concrete channel lining was assumed to be 1,000 square yards per control structure, while the 8" concrete channel lining was based on the areas of the weirs. Headwalls and wingwalls were assumed to be 90 cubic yards per control structure. The CMPs were assumed to be 50' long and spaced 800' apart along the perimeter of the basin footprint. ROW acquisition costs for Basins 1-5 were based on JCAD appraisal data and multiplied by a factor of 3. ROW acquisition costs are not factors for Basins 6-10 because the full basin footprints are already owned by the City of Beaumont or DD6 and expected to be available through partnerships.

The total construction cost for each proposed improvement is shown in Table 10, and **Appendix B** shows the detailed line items for each cost estimate. The total cost of all the proposed improvements is $680,650,320.

Table 10. Opinion of Probable Construction Costs

Proposed Improvement:	Cost Estimate:	
South Park Diversion	$	99,908,750
Tevis Diversion	$	97,327,200
Blanchette Diversion	$	99,173,000
Lucas Diversion	$	130,286,230
Basin 1	$	52,776,700
Basin 2	$	13,204,220
Basin 3	$	49,249,150
Basin 4	$	28,822,380
Basin 5	$	20,138,510
Basin 6	$	9,760,190
Basin 7	$	19,743,250
Basin 8	$	8,573,230
Basin 9	$	21,723,270
Basin 10	$	29,964,240
Est. Total Cost of Construction =	**$**	**680,650,320**

9. Property Buy Out Estimates

In coordination with DD6 staff, areas to be considered for potential property buy outs were identified. These areas were further evaluated against the existing conditions model results and FEMA floodplain extents to determine areas severely impacted by flooding.

Unless it is not possible otherwise, property buy outs should always be pursued in a voluntary fashion. Individuals and neighborhoods have ties that extend well beyond the market value of their home and the process of pursuing buy outs can take a long time and considerable patience. Additionally, it is practical for communities to use buy outs in situations where they can gain substantial consensus among property owners on their willingness to sell, so that the acquired properties can be assembled into a coherent, contiguous unit of open space or drainage improvements. The alternative is a patchwork of remaining homes amid vacant lots without the ability to create a park or detention basin.

Areas that experience structural repetitive losses were prioritized because such areas will reap the most benefit from property buy outs in terms of loss reduction relative per dollar spent in repairs or improvements. The parcels identified for property buy outs are shown in **Figure 22**.

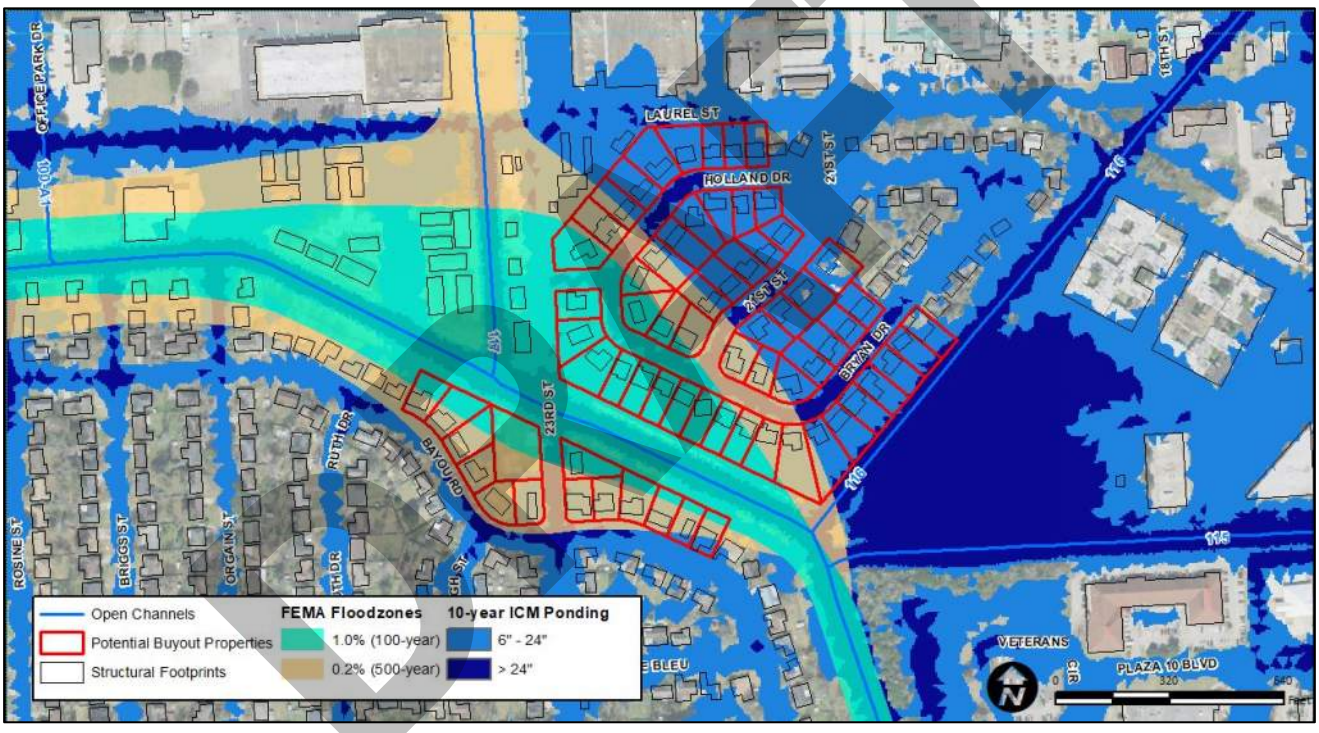

Figure 22. Potential Buy Out Properties

Approximately 68 residential properties were identified for buy outs along 21st Street, Holland Drive, Bryan Drive, and Bayou Road. Approximately 37 of the identified properties are located within either the A (100-year) or X (500-year) FEMA flood zones, and 8 structures have been reported to local and federal officials as repetitive flooding losses. The area currently drains via storm sewer (18"-24" RCP) towards DD6 channels near the confluences of channels 100A, 115, 116, and 117. The severely undersized storm sewer system coupled with elevated water surface elevations during severe storm events causes significant flood impacts to this topographically low area. 10-year ponding along the identified streets exceeds 18" in depth resulting in reduced mobility and access for residents. 100-year and 500-year rainfall causes channel water surface elevations to significantly exceed the natural ground, resulting in 3'-4' of ponding depth extending outside of public ROW limits.

Existing conditions damages for the potential property buy outs are shown in **Table 11** for the evaluated storm events.

Table 11. Property Buy Outs – Existing Conditions Damage Estimates

Storm Event	Existing Damages
10-year	$ 3,438,189
100-year	$ 7,247,878
500-year	$ 8,858,241

Using 2018 JCAD parcels, the approximate market value of the 68 identified properties sums up to $4.8MM. Associated buy out costs must be considered to account for the relocation assistance for current residents, clearing of the existing development, and other costs outside of the property acquisition. To account for these factors, a multiplier of 3.0 was applied to the fair market value of the potential buy out properties. This value is commonly used within LAN's Right of Way Department and is a widely accepted multiplier used for approximating buy out costs for planning level studies along the Gulf Coast.

The estimated total cost to buy out the 68 properties is $14.4MM, and the average buyout cost is $211,750.00 per property.

10. Conclusion

The City has two primary regional channels/rivers for the local drainage infrastructure to ultimately outfall: Hillebrandt Bayou and the Neches River. While traditional drainage channel upgrades are effective, the Hillebrandt Bayou watershed has limited available ROW to widen these channels and limited depth for deepening channels or detention basins. To provide increased conveyance, this analysis recommends four, large-scale storm sewer projects that provide flood risk reduction within the Hillebrandt Bayou watershed by diverting flow towards the Neches River. These diversions are intended to provide regional benefits across the Hillebrandt drainage system by lowering peak flows, increasing outfall capacity, and reducing excessive ponding durations within the areas of influence.

The storm sewer diversions were designed to maximize capacity within the existing ROW while meeting CDBG-MIT funding requirements including a maximum project cost of $100 million. The Lucas Diversion exceeds the funding threshold and is assumed to be completed in phases to complete the entire footprint of the diversion. The benefit provided by each of the proposed conveyance improvements could be increased if additional funding and/or project limits were considered.

In addition to the storm sewer diversions, available open space along the southside of the City of Beaumont was considered for proposed regional detention at the downstream end of the Hillebrandt Bayou watershed. The District identified three undeveloped areas where sub-regional basins could be useful for detention. Based on utility conflicts, oil and gas pipeline conflicts, and topography, LAN divided these three areas into ten recommended sub-regional detention basins that yield a total of 4,983 acre-feet of storage. This storage is intended to provide an increase to the downstream capacity of the Hillebrandt Bayou watershed.

A preliminary property buy out estimate was performed for the residential area near Laurel Street and 23rd Street to identify repetitive loss structures at severe risk of flooding. Approximately 68 structures were identified as potential candidates for property buyouts based on the level of risk and the potential to repurpose the land for drainage use. A detailed analysis of potential property buy outs could be performed that consider factors such as structures in the floodplain that are advantageous locations for being redeveloped into drainage infrastructure. ROW is very limited along the channels within the Hillebrandt Bayou watershed, and large-scale buy outs along channel banks could provide space for channel improvements that increase system conveyance and LOS.

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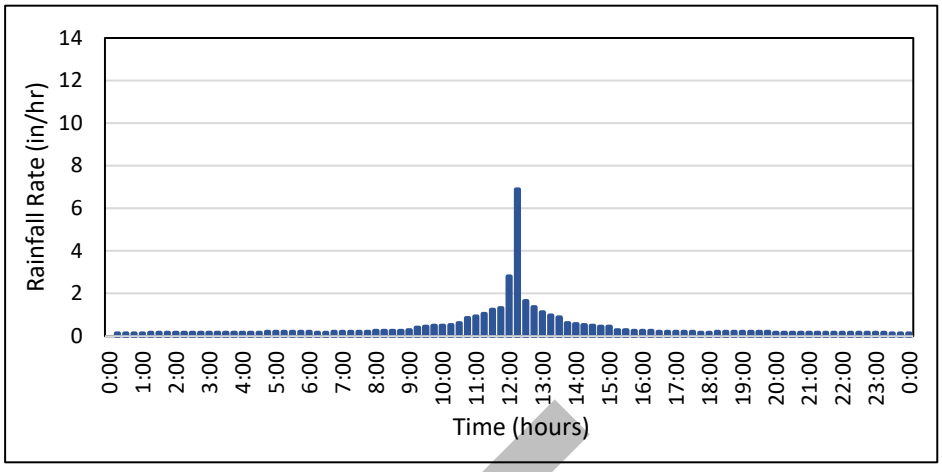
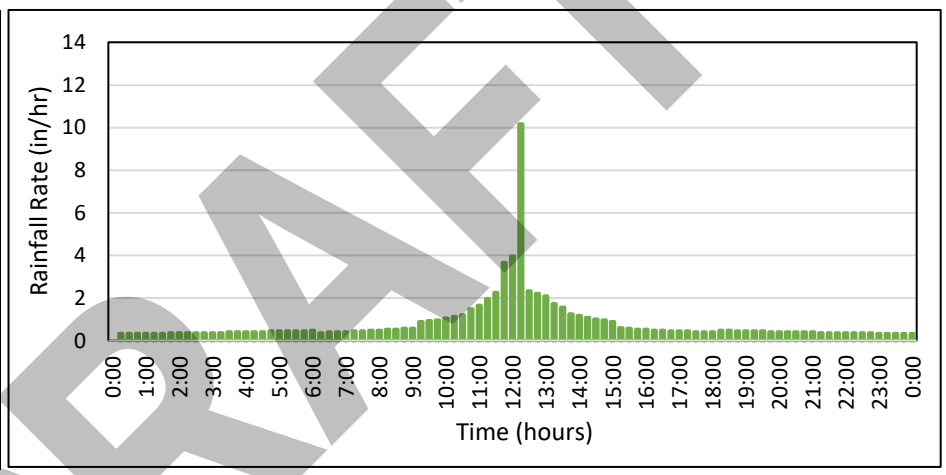
   b. Lockwood, Andrews & Newnam, Inc. (2019). “City of Beaumont Master Drainage Plan,” December 2019

Appendix A –
DD6 Standard Atlas 14 Rainfall (Supplemented by NOAA Data)

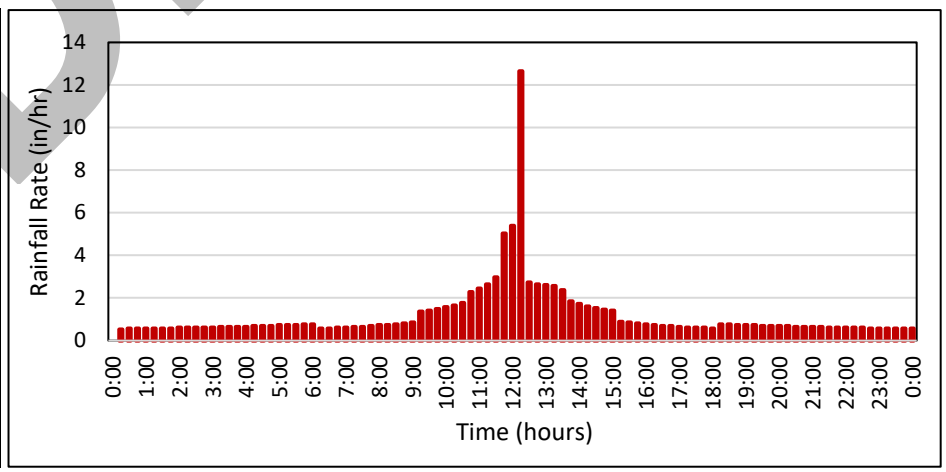
10-Year (10% AEP) Design Storm Event	
NOAA Atlas 14 Rainfall	
5-MIN	0.876
15-MIN	1.75
DD6 Standard Atlas 14 Rainfall	
1-HR	3.21
2-HR	4.44
3-HR	5.25
6-HR	6.8
12-HR	8.14
24-HR	10.06



100-Year (1.0% AEP) Design Storm Event	
NOAA Atlas 14 Rainfall	
5-MIN	1.29
15-MIN	2.56
DD6 Standard Atlas 14 Rainfall	
1-HR	4.62
2-HR	6.76
3-HR	8.37
6-HR	11.51
12-HR	14.25
24-HR	18.86



500-Year (0.2% AEP) Design Storm Event	
NOAA Atlas 14 Rainfall	
5-MIN	1.62
15-MIN	3.19
DD6 Standard Atlas 14 Rainfall	
1-HR	5.61
2-HR	8.52
3-HR	10.87
6-HR	15.55
12-HR	19.7
24-HR	27.33



Time	Rainfall (inches)			Rainfall Rate (inches/hour)		
	10-Year	100-Year	500-Year	10-Year	100-Year	500-Year
0:00	0.03	0.08	0.13	0	0	0
0:15	0.03	0.08	0.13	0.12	0.32	0.52
0:30	0.03	0.08	0.14	0.12	0.32	0.56
0:45	0.03	0.08	0.14	0.12	0.32	0.56
1:00	0.03	0.08	0.14	0.12	0.32	0.56
1:15	0.04	0.08	0.14	0.16	0.32	0.56
1:30	0.04	0.08	0.14	0.16	0.32	0.56
1:45	0.04	0.09	0.14	0.16	0.36	0.56
2:00	0.04	0.09	0.15	0.16	0.36	0.6
2:15	0.04	0.09	0.15	0.16	0.36	0.6
2:30	0.04	0.09	0.15	0.16	0.36	0.6
2:45	0.04	0.09	0.15	0.16	0.36	0.6
3:00	0.04	0.09	0.15	0.16	0.36	0.6
3:15	0.04	0.09	0.16	0.16	0.36	0.64
3:30	0.04	0.1	0.16	0.16	0.4	0.64
3:45	0.04	0.1	0.16	0.16	0.4	0.64
4:00	0.04	0.1	0.16	0.16	0.4	0.64
4:15	0.04	0.1	0.17	0.16	0.4	0.68
4:30	0.04	0.1	0.17	0.16	0.4	0.68
4:45	0.05	0.11	0.17	0.2	0.44	0.68
5:00	0.05	0.11	0.18	0.2	0.44	0.72
5:15	0.05	0.11	0.18	0.2	0.44	0.72
5:30	0.05	0.11	0.18	0.2	0.44	0.72
5:45	0.05	0.11	0.19	0.2	0.44	0.76
6:00	0.05	0.12	0.19	0.2	0.48	0.76
6:15	0.04	0.09	0.14	0.16	0.36	0.56
6:30	0.04	0.1	0.14	0.16	0.4	0.56
6:45	0.05	0.1	0.15	0.2	0.4	0.6
7:00	0.05	0.1	0.15	0.2	0.4	0.6
7:15	0.05	0.11	0.16	0.2	0.44	0.64
7:30	0.05	0.11	0.16	0.2	0.44	0.64
7:45	0.05	0.12	0.17	0.2	0.48	0.68
8:00	0.06	0.12	0.18	0.24	0.48	0.72
8:15	0.06	0.13	0.18	0.24	0.52	0.72
8:30	0.06	0.13	0.19	0.24	0.52	0.76
8:45	0.06	0.14	0.2	0.24	0.56	0.8
9:00	0.07	0.14	0.21	0.28	0.56	0.84
9:15	0.1	0.22	0.34	0.4	0.88	1.36
9:30	0.11	0.23	0.35	0.44	0.92	1.4
9:45	0.12	0.24	0.37	0.48	0.96	1.48
10:00	0.12	0.26	0.39	0.48	1.04	1.56

Time	Rainfall (inches)			Rainfall Rate (inches/hour)		
	10-Year	100-Year	500-Year	10-Year	100-Year	500-Year
10:15	0.13	0.28	0.41	0.52	1.12	1.64
10:30	0.15	0.3	0.44	0.6	1.2	1.76
10:45	0.21	0.37	0.57	0.84	1.48	2.28
11:00	0.23	0.41	0.61	0.92	1.64	2.44
11:15	0.26	0.49	0.66	1.04	1.96	2.64
11:30	0.31	0.56	0.74	1.24	2.24	2.96
11:45	0.33	0.47	0.955	1.32	3.66	5.02
12:00	0.7	0.99	1.17	2.8	3.96	5.38
12:15	1.72	2.54	3.16	6.88	10.16	12.64
12:30	0.41	0.58	0.68	1.64	2.32	2.72
12:45	0.34	0.62	0.68	1.36	2.2	2.64
13:00	0.28	0.52	0.69	1.12	2.08	2.6
13:15	0.24	0.43	0.64	0.96	1.72	2.56
13:30	0.22	0.39	0.59	0.88	1.56	2.36
13:45	0.15	0.31	0.46	0.6	1.24	1.84
14:00	0.14	0.29	0.43	0.56	1.16	1.72
14:15	0.13	0.27	0.4	0.52	1.08	1.6
14:30	0.12	0.25	0.38	0.48	1	1.52
14:45	0.11	0.24	0.36	0.44	0.96	1.44
15:00	0.11	0.22	0.35	0.44	0.88	1.4
15:15	0.07	0.15	0.22	0.28	0.6	0.88
15:30	0.07	0.14	0.21	0.28	0.56	0.84
15:45	0.06	0.13	0.2	0.24	0.52	0.8
16:00	0.06	0.13	0.19	0.24	0.52	0.76
16:15	0.06	0.12	0.18	0.24	0.48	0.72
16:30	0.05	0.12	0.17	0.2	0.48	0.68
16:45	0.05	0.11	0.17	0.2	0.44	0.68
17:00	0.05	0.11	0.16	0.2	0.44	0.64
17:15	0.05	0.11	0.15	0.2	0.44	0.6
17:30	0.05	0.1	0.15	0.2	0.4	0.6
17:45	0.04	0.1	0.15	0.16	0.4	0.6
18:00	0.04	0.1	0.14	0.16	0.4	0.56
18:15	0.05	0.12	0.19	0.2	0.48	0.76
18:30	0.05	0.12	0.19	0.2	0.48	0.76
18:45	0.05	0.11	0.18	0.2	0.44	0.72
19:00	0.05	0.11	0.18	0.2	0.44	0.72
19:15	0.05	0.11	0.18	0.2	0.44	0.72
19:30	0.05	0.11	0.17	0.2	0.44	0.68
19:45	0.05	0.1	0.17	0.2	0.4	0.68
20:00	0.04	0.1	0.17	0.16	0.4	0.68
20:15	0.04	0.1	0.17	0.16	0.4	0.68

Time	Rainfall (inches)			Rainfall Rate (inches/hour)		
	10-Year	100-Year	500-Year	10-Year	100-Year	500-Year
20:30	0.04	0.1	0.16	0.16	0.4	0.64
20:45	0.04	0.1	0.16	0.16	0.4	0.64
21:00	0.04	0.1	0.16	0.16	0.4	0.64
21:15	0.04	0.09	0.16	0.16	0.36	0.64
21:30	0.04	0.09	0.15	0.16	0.36	0.6
21:45	0.04	0.09	0.15	0.16	0.36	0.6
22:00	0.04	0.09	0.15	0.16	0.36	0.6
22:15	0.04	0.09	0.15	0.16	0.36	0.6
22:30	0.04	0.09	0.15	0.16	0.36	0.6
22:45	0.04	0.09	0.14	0.16	0.36	0.56
23:00	0.04	0.08	0.14	0.16	0.32	0.56
23:15	0.04	0.08	0.14	0.16	0.32	0.56
23:30	0.03	0.08	0.14	0.12	0.32	0.56
23:45	0.03	0.08	0.14	0.12	0.32	0.56
0:00	0.03	0.08	0.14	0.12	0.32	0.56

Appendix B –
Cost Estimates (OPCC)

South Park Diversion					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	GENERAL ITEMS				
1	Mobilization & Demobilization	LS	1	$ 4,000,000.00	$ 4,000,000
2	Traffic control and regulation/flagmen	LS	1	$ 600,000.00	$ 600,000
3	Tree protection/removal	LS	1	$ 600,000.00	$ 600,000
				SUBTOTAL GENERAL ITEMS*	**$ 5,200,000**
	ROADWAY ITEMS				
4	Roadway Excavation	CY	9,000	$ 15.00	$ 135,000
5	Remove and dispose of Concrete or Asphalt Paving with or without Curb	SY	75,000	$ 11.00	$ 825,000
5	Asphalt pavement including subgrade	SY	75,000	$ 85.00	$ 6,375,000
6	Removal & replacement of driveways (assume 20'x10')	EA	350	$ 550.00	$ 192,500
7	Roadway Striping & Signage	LS	1	$ 65,000.00	$ 65,000
8	Curbs	LF	44,000	$ 8.00	$ 352,000
				SUBTOTAL ROADWAY ITEMS*	**$ 7,944,500**
	DRAINAGE ITEMS				
9	10'x10' RCB	LF	28,200	$ 1,430.00	$ 40,326,000
10	10'x10' RCB E-80, Jack & Bore	LF	2,100	$ 3,250.00	$ 6,825,000
11	10'x9' RCB	LF	4,300	$ 1,365.00	$ 5,869,500
12	8'x8' RCB	LF	6,100	$ 930.00	$ 5,673,000
13	Outfall Structure (headwall, rip rap)	EA	1	$ 65,000.00	$ 65,000
14	Inlets, all types (Every 400-feet)	EA	120	$ 6,000.00	$ 720,000
15	Manholes (Single @ 700-feet)	EA	40	$ 6,500.00	$ 260,000
16	Junction Boxes @ major transitions	EA	16	$ 105,000.00	$ 1,680,000
17	Trench safety	LF	24,000	$ 6.50	$ 156,000
18	Groundwater control	LF	24,000	$ 50.00	$ 1,200,000
19	Flapgate	EA	1	$ 150,000.00	$ 150,000
				SUBTOTAL DRAINAGE ITEMS*	**$ 62,924,500**
	UTILITIES, WATER AND SANITARY SEWER ITEMS				
20	Sanitary Sewer Crossing Adjustment/Sleeve	EA	40	$ 6,500.00	$ 260,000
21	Sanitary Sewer 24"	LF	9,500	$ 300.00	$ 2,850,000
22	Water Line Crossing Adjustment/Sleeve	EA	40	$ 6,500.00	$ 260,000
22	Oil & Gas Pipeline Adjustment/Sleeve	EA	41	$ 75,000.00	$ 3,075,000
23	Contaminated Soils Remediation	LS	1	$ 2,250,000.00	$ 2,250,000
				SUBTOTAL WATER AND SANITARY ITEMS*	**$ 8,695,000**
	EASEMENTS AND ROW ITEMS				
24	Easement	SF	50,000	$ 1.50	$ 75,000
				SUBTOTAL EASEMENT AND ROW ITEMS*	**$ 75,000**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 84,839,000**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
25	Engineering Surveying Fees	PCNT	15.00%	$ 84,900,000.00	$ 12,735,000
26	Geotech, Materials Testing	PCNT	2.00%	$ 84,900,000.00	$ 1,698,000
26	USACE Permits	PCNT	0.10%	$ 84,900,000.00	$ 84,900
27	Contaminated Soils Testing	PCNT	0.65%	$ 84,900,000.00	$ 551,850
				SUBTOTAL ENGINEERING ITEMS	**$ 15,069,750**

OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING	**$ 99,908,750**

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* An approximate 30% contingency is included within Unit Costs and is not applied to the Total Construction Cost.

Tevis Diversion					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	GENERAL ITEMS				
1	Mobilization & Demobilization	LS	1	$ 3,000,000.00	$ 3,000,000
2	Traffic control and regulation/flagmen	LS	1	$ 500,000.00	$ 500,000
3	Tree protection/removal	LS	1	$ 500,000.00	$ 500,000
				SUBTOTAL GENERAL ITEMS	**$ 4,000,000**
				Contingency 30%	**$ 1,200,000**
				Subtotal W/Contingency	**$ 5,200,000**
	ROADWAY ITEMS				
4	Roadway Excavation	CY	4,000	$ 10.00	$ 40,000
5	Remove and dispose of Concrete or Asphalt Paving with or without Curb	SY	31,000	$ 8.00	$ 248,000
6	Asphalt pavement including subgrade	SY	31,000	$ 65.00	$ 2,015,000
7	Removal & replacement of driveways (assume 20'x10')	EA	200	$ 400.00	$ 80,000
8	Roadway Striping & Signage	LS	1	$ 50,000.00	$ 50,000
9	Curbs	LF	11,000	$ 6.00	$ 66,000
				SUBTOTAL ROADWAY ITEMS	**$ 2,499,000**
				Contingency 30%	**$ 750,000**
				Subtotal W/Contingency	**$ 3,249,000**
	DRAINAGE ITEMS				
10	12'x10' RCB	LF	28,900	$ 1,720.00	$ 49,708,000
11	12'x10' RCB, E-80 Rated	LF	400	$ 3,420.00	$ 1,368,000
12	Outfall Structure (headwall, rip rap)	EA	4	$ 50,000.00	$ 200,000
13	Inlets, all types (Every 400-feet)	EA	90	$ 4,500.00	$ 405,000
14	Remove and dispose of concrete channel lining	SY	7,000	$ 10.00	$ 70,000
15	Channel excavation	CY	7,000	$ 15.00	$ 105,000
16	Channel concrete slope paving, 6" thickness	SY	7,000	$ 150.00	$ 1,050,000
17	Manholes (Single @ 700-feet)	EA	30	$ 5,000.00	$ 150,000
18	Junction Boxes @ major transitions	EA	17	$ 80,000.00	$ 1,360,000
19	Trench safety	LF	16,540	$ 5.00	$ 82,700
20	Groundwater control	LF	16,540	$ 25.00	$ 413,500
21	Flapgate	EA	2	$ 65,000.00	$ 130,000
				SUBTOTAL DRAINAGE ITEMS	**$ 55,042,200**
				Contingency 30%	**$ 16,513,000**
				Subtotal W/Contingency	**$ 71,555,200**
	UTILITIES, WATER AND SANITARY SEWER ITEMS				
22	Sanitary Sewer Crossing Adjustment/Sleeve	EA	25	$ 5,000.00	$ 125,000
23	Water Line Crossing Adjustment/Sleeve	EA	35	$ 5,000.00	$ 175,000
				SUBTOTAL WATER AND SANITARY ITEMS	**$ 300,000**
				Contingency 30%	**$ 90,000**
				Subtotal W/Contingency	**$ 390,000**
	EASEMENTS AND ROW ITEMS				
24	Easement	SF	28,000	$ 0.75	$ 21,000
				SUBTOTAL EASEMENT AND ROW ITEMS	**$ 21,000**
				Contingency 30%	**$ 7,000**
				Subtotal W/Contingency	**$ 28,000**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 80,422,200**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
25	Engineering/Survey/Geotechnical/ESA/Material Testing/Construction Management	PCNT	15.00%	$ 80,500,000.00	$ 12,075,000
26	Grant Administration	PCNT	6.00%	$ 80,500,000.00	$ 4,830,000
				SUBTOTAL ENGINEERING ITEMS	**$ 16,905,000**

OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING	**$ 97,327,200**

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Blanchette Diversion					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	GENERAL ITEMS				
1	Mobilization & Demobilization	LS	1	$ 3,000,000.00	$ 3,000,000
2	Traffic control and regulation/flagmen	LS	1	$ 500,000.00	$ 500,000
3	Tree protection/removal	LS	1	$ 500,000.00	$ 500,000
				SUBTOTAL GENERAL ITEMS	**$ 4,000,000**
				Contingency 30%	**$ 1,200,000**
				Subtotal W/Contingency	**$ 5,200,000**
	ROADWAY ITEMS				
4	Roadway Excavation	CY	5,000	$ 10.00	$ 50,000
5	Remove and dispose of Concrete or Asphalt Paving with or without Curb	SY	45,000	$ 8.00	$ 360,000
6	Asphalt pavement including subgrade	SY	45,000	$ 65.00	$ 2,925,000
7	Removal & replacement of driveways (assume 20'x10')	EA	380	$ 400.00	$ 152,000
8	Roadway Striping & Signage	LS	1	$ 50,000.00	$ 50,000
9	Curbs	LF	30,000	$ 6.00	$ 180,000
				SUBTOTAL ROADWAY ITEMS	**$ 3,717,000**
				Contingency 30%	**$ 1,116,000**
				Subtotal W/Contingency	**$ 4,833,000**
	DRAINAGE ITEMS				
10	12'x10' RCB	LF	29,100	$ 1,720.00	$ 50,052,000
11	12'x10' RCB, E-80 Rated	LF	500	$ 3,420.00	$ 1,710,000
12	Outfall Structure (headwall, rip rap)	EA	2	$ 50,000.00	$ 100,000
13	Inlets, all types (Every 400-feet)	EA	110	$ 4,500.00	$ 495,000
14	Manholes (Single @ 700-feet)	EA	30	$ 5,000.00	$ 150,000
15	Junction Boxes @ major transitions	EA	20	$ 80,000.00	$ 1,600,000
16	Trench safety	LF	19,000	$ 5.00	$ 95,000
17	Groundwater control	LF	19,000	$ 25.00	$ 475,000
18	Flapgate	EA	2	$ 65,000.00	$ 130,000
				SUBTOTAL DRAINAGE ITEMS	**$ 54,807,000**
				Contingency 30%	**$ 16,443,000**
				Subtotal W/Contingency	**$ 71,250,000**
	UTILITIES, WATER AND SANITARY SEWER ITEMS				
19	Sanitary Sewer Crossing Adjustment/Sleeve	EA	45	$ 5,000.00	$ 225,000
20	Water Line Crossing Adjustment/Sleeve	EA	55	$ 5,000.00	$ 275,000
				SUBTOTAL WATER AND SANITARY ITEMS	**$ 500,000**
				Contingency 30%	**$ 150,000**
				Subtotal W/Contingency	**$ 650,000**
	EASEMENTS AND ROW ITEMS				
21	Easement	SF	20,000	$ 0.75	$ 15,000
				SUBTOTAL EASEMENT AND ROW ITEMS	**$ 15,000**
				Contingency 30%	**$ 5,000**
				Subtotal W/Contingency	**$ 20,000**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 81,953,000**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
22	Engineering/Survey/Geotechnical/ESA/Material Testing/Construction Management	PCNT	15.00%	$ 82,000,000.00	$ 12,300,000
23	Grant Administration	PCNT	6.00%	$ 82,000,000.00	$ 4,920,000
				SUBTOTAL ENGINEERING ITEMS	**$ 17,220,000**

OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING	**$ 99,173,000**

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Lucas Diversion							
Item	Item Description	Unit	Approx. Qty.		Unit Price		Total Price
	GENERAL ITEMS						
1	Mobilization & Demobilization	LS	1	$	3,000,000.00	$	3,000,000
2	Traffic control and regulation/flagmen	LS	1	$	500,000.00	$	500,000
3	Tree protection/removal	LS	1	$	500,000.00	$	500,000
					SUBTOTAL GENERAL ITEMS	**$**	**4,000,000**
					Contingency 30%	**$**	**1,200,000**
					Subtotal W/Contingency	**$**	**5,200,000**
	ROADWAY ITEMS						
4	Roadway Excavation	CY	9,000	$	10.00	$	90,000
5	Remove and dispose of Concrete or Asphalt Paving with or without Curb	SY	93,000	$	8.00	$	744,000
6	Reinforced Concrete Pavement Including Subgrade (Complete Reconstruction) 11-Inch	SY	93,000	$	85.00	$	7,905,000
7	Roadway Striping & Signage	LS	1	$	50,000.00	$	50,000
8	Curbs	LF	19,000	$	6.00	$	114,000
					SUBTOTAL ROADWAY ITEMS	**$**	**8,903,000**
					Contingency 30%	**$**	**2,671,000**
					Subtotal W/Contingency	**$**	**11,574,000**
	DRAINAGE ITEMS						
9	12'x10' RCB	LF	36,684	$	1,720.00	$	63,096,480
10	Outfall Structure (headwall, rip rap)	EA	1	$	50,000.00	$	50,000
11	Inlets, all types (Every 400-feet)	EA	100	$	4,500.00	$	450,000
12	Manholes (Single @ 700-feet)	EA	30	$	5,000.00	$	150,000
13	Junction Boxes @ major transitions	EA	4	$	80,000.00	$	320,000
14	Trench safety	LF	19,000	$	5.00	$	95,000
14	Groundwater control	LF	19,000	$	25.00	$	475,000
15	Flapgate	EA	1	$	65,000.00	$	65,000
					SUBTOTAL DRAINAGE ITEMS	**$**	**64,701,480**
					Contingency 30%	**$**	**19,411,000**
					Subtotal W/Contingency	**$**	**84,112,480**
	UTILITIES, WATER AND SANITARY SEWER ITEMS						
16	Sanitary Sewer Crossing Adjustment/Sleeve	EA	30	$	5,000.00	$	150,000
17	Water Line Crossing Adjustment/Sleeve	EA	45	$	5,000.00	$	225,000
18	Oil & Gas Pipeline Adjustment/Sleeve	EA	-	$	55,000.00	$	-
					SUBTOTAL WATER AND SANITARY ITEMS	**$**	**375,000**
					Contingency 30%	**$**	**113,000**
					Subtotal W/Contingency	**$**	**488,000**
	EASEMENTS AND ROW ITEMS						
19	Easement	SF	13,000	$	0.75	$	9,750
					SUBTOTAL EASEMENT AND ROW ITEMS	**$**	**9,750**
					Contingency 30%	**$**	**3,000**
					Subtotal W/Contingency	**$**	**12,750**
	OPINION OF PROBABLE COSTRUCTION COST					**$**	**101,387,230**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items						
20	Engineering Fees	PCNT	10.00%	$	101,400,000.00	$	10,140,000
21	Geotech, ESA's and Topo Survey Fees	PCNT	2.00%	$	101,400,000.00	$	2,028,000
21	Construction Management / Material Testing Fees	PCNT	10.50%	$	101,400,000.00	$	10,647,000
22	Grant Administration	PCNT	6.00%	$	101,400,000.00	$	6,084,000
					SUBTOTAL ENGINEERING ITEMS	**$**	**28,899,000**

OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING	**$**	**130,286,230**

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Basin 1					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	207	$ 6,000.00	$ 1,242,000
2	Excavation & Off-Site Disposal	CY	2,140,000	$ 12.00	$ 25,680,000
3	Excavation & Fill (On-Site Material)	CY	11,300	$ 6.00	$ 67,800
4	Backslope Drainage System Swales	LF	18,200	$ 2.00	$ 36,400
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	10,500	$ 110.00	$ 1,155,000
7	Concrete Interceptor Structure	SY	280	$ 120.00	$ 33,600
8	8'x5' RCB	LF	230	$ 600.00	$ 138,000
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	1,150	$ 76.00	$ 87,400
				SUBTOTAL DRAINAGE ITEMS	**$ 28,610,700**
				Contingency 30%	**$ 8,584,000**
				Subtotal W/Contingency	**$ 37,194,700**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 37,194,700**
	EASEMENTS AND ROW ITEMS				
11	ROW Acquistion	LS	1	$ 8,979,000.00	$ 8,979,000
				SUBTOTAL EASEMENT AND ROW ITEMS*	**$ 8,979,000**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
12	Engineering Surveying Fees	PCNT	15.00%	$ 37,200,000.00	$ 5,580,000
13	Geotech, Materials Testing	PCNT	2.00%	$ 37,200,000.00	$ 744,000
14	USACE Permits	PCNT	0.10%	$ 37,200,000.00	$ 37,200
15	Contaminated Soils Testing	PCNT	0.65%	$ 37,200,000.00	$ 241,800
				SUBTOTAL ENGINEERING ITEMS	**$ 6,603,000**

OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING	**$ 52,776,700**

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Basin 2					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	31	$ 6,000.00	$ 186,000
2	Excavation & Off-Site Disposal	CY	260,000	$ 12.00	$ 3,120,000
3	Excavation & Fill (On-Site Material)	CY	20	$ 6.00	$ 120
4	Backslope Drainage System Swales	LF	5,600	$ 2.00	$ 11,200
5	Concrete Interceptor Structure	SY	90	$ 120.00	$ 10,800
6	24" CMP	LF	350	$ 76.00	$ 26,600
				SUBTOTAL DRAINAGE ITEMS	**$ 3,354,720**
				Contingency 30%	**$ 1,007,000**
				Subtotal W/Contingency	**$ 4,361,720**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 4,361,720**
	EASEMENTS AND ROW ITEMS				
7	ROW Acquisition	LS	1	$ 7,839,000.00	$ 7,839,000
				SUBTOTAL EASEMENT AND ROW ITEMS*	**$ 7,839,000**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
8	Engineering Surveying Fees	PCNT	15.00%	$ 4,400,000.00	$ 660,000
9	Geotech, Materials Testing	PCNT	2.00%	$ 4,400,000.00	$ 88,000
10	USACE Permits	PCNT	0.10%	$ 4,400,000.00	$ 4,400
11	Contaminated Soils Testing	PCNT	0.65%	$ 4,400,000.00	$ 28,600
				SUBTOTAL ENGINEERING ITEMS	**$ 781,000**

OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING	**$ 12,981,720**

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Basin 3					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	248	$ 6,000.00	$ 1,488,000
2	Excavation & Off-Site Disposal	CY	2,140,000	$ 12.00	$ 25,680,000
3	Excavation & Fill (On-Site Material)	CY	600	$ 6.00	$ 3,600
4	Backslope Drainage System Swales	LF	13,500	$ 2.00	$ 27,000
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	38,900	$ 110.00	$ 4,279,000
7	Concrete Interceptor Structure	SY	210	$ 120.00	$ 25,200
8	8'x5' RCB	LF	240	$ 600.00	$ 144,000
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	850	$ 76.00	$ 64,600
				SUBTOTAL DRAINAGE ITEMS	**$ 31,881,900**
				Contingency 30%	**$ 9,565,000**
				Subtotal W/Contingency	**$ 41,446,900**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 41,446,900**
	EASEMENTS AND ROW ITEMS				
11	ROW Acquisition	LS	1	$ 436,000.00	$ 436,000
				SUBTOTAL EASEMENT AND ROW ITEMS*	**$ 436,000**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
12	Engineering Surveying Fees	PCNT	15.00%	$ 41,500,000.00	$ 6,225,000
13	Geotech, Materials Testing	PCNT	2.00%	$ 41,500,000.00	$ 830,000
14	USACE Permits	PCNT	0.10%	$ 41,500,000.00	$ 41,500
15	Contaminated Soils Testing	PCNT	0.65%	$ 41,500,000.00	$ 269,750
				SUBTOTAL ENGINEERING ITEMS	**$ 7,366,250**

OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING	**$ 49,249,150**

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Basin 4					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	84	$ 6,000.00	$ 504,000
2	Excavation & Off-Site Disposal	CY	790,000	$ 12.00	$ 9,480,000
3	Excavation & Fill (On-Site Material)	CY	1,080	$ 6.00	$ 6,480
4	Backslope Drainage System Swales	LF	11,100	$ 2.00	$ 22,200
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	76,400	$ 110.00	$ 8,404,000
7	Concrete Interceptor Structure	SY	170	$ 120.00	$ 20,400
8	60" RCP	LF	240	$ 315.00	$ 75,600
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	700	$ 76.00	$ 53,200
				SUBTOTAL DRAINAGE ITEMS	**$ 18,736,380**
				Contingency 30%	**$ 5,621,000**
				Subtotal W/Contingency	**$ 24,357,380**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 24,357,380**
	EASEMENTS AND ROW ITEMS				
11	ROW Acquistion	LS	1	$ 134,000.00	$ 134,000
				SUBTOTAL EASEMENT AND ROW ITEMS*	**$ 134,000**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
12	Engineering Surveying Fees	PCNT	15.00%	$ 24,400,000.00	$ 3,660,000
13	Geotech, Materials Testing	PCNT	2.00%	$ 24,400,000.00	$ 488,000
14	USACE Permits	PCNT	0.10%	$ 24,400,000.00	$ 24,400
15	Contaminated Soils Testing	PCNT	0.65%	$ 24,400,000.00	$ 158,600
				SUBTOTAL ENGINEERING ITEMS	**$ 4,331,000**

OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING	**$ 28,822,380**

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Basin 5					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	93	$ 6,000.00	$ 558,000
2	Excavation & Off-Site Disposal	CY	630,000	$ 12.00	$ 7,560,000
3	Excavation & Fill (On-Site Material)	CY	1,360	$ 6.00	$ 8,160
4	Backslope Drainage System Swales	LF	9,500	$ 2.00	$ 19,000
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	41,600	$ 110.00	$ 4,576,000
7	Concrete Interceptor Structure	SY	150	$ 120.00	$ 18,000
8	60" RCP	LF	250	$ 315.00	$ 78,750
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	600	$ 76.00	$ 45,600
				SUBTOTAL DRAINAGE ITEMS	**$ 13,034,010**
				Contingency 30%	**$ 3,911,000**
				Subtotal W/Contingency	**$ 16,945,010**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 16,945,010**
	EASEMENTS AND ROW ITEMS				
11	ROW Acquisition	LS	1	$ 176,000.00	$ 176,000
				SUBTOTAL EASEMENT AND ROW ITEMS*	**$ 176,000**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
12	Engineering Surveying Fees	PCNT	15.00%	$ 17,000,000.00	$ 2,550,000
13	Geotech, Materials Testing	PCNT	2.00%	$ 17,000,000.00	$ 340,000
14	USACE Permits	PCNT	0.10%	$ 17,000,000.00	$ 17,000
15	Contaminated Soils Testing	PCNT	0.65%	$ 17,000,000.00	$ 110,500
				SUBTOTAL ENGINEERING ITEMS	**$ 3,017,500**
	OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING				**$ 20,138,510**

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Basin 6					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	47	$ 6,000.00	$ 282,000
2	Excavation & Off-Site Disposal	CY	280,000	$ 12.00	$ 3,360,000
3	Excavation & Fill (On-Site Material)	CY	140	$ 6.00	$ 840
4	Backslope Drainage System Swales	LF	5,800	$ 2.00	$ 11,600
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	22,100	$ 110.00	$ 2,431,000
7	Concrete Interceptor Structure	SY	100	$ 120.00	$ 12,000
8	60" RCP	LF	240	$ 315.00	$ 75,600
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	400	$ 76.00	$ 30,400
				SUBTOTAL DRAINAGE ITEMS	**$ 6,373,940**
				Contingency 30%	**$ 1,913,000**
				Subtotal W/Contingency	**$ 8,286,940**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 8,286,940**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
11	Engineering Surveying Fees	PCNT	15.00%	$ 8,300,000.00	$ 1,245,000
12	Geotech, Materials Testing	PCNT	2.00%	$ 8,300,000.00	$ 166,000
12	USACE Permits	PCNT	0.10%	$ 8,300,000.00	$ 8,300
13	Contaminated Soils Testing	PCNT	0.65%	$ 8,300,000.00	$ 53,950
				SUBTOTAL ENGINEERING ITEMS	**$ 1,473,250**
	OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING				**$ 9,760,190**

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Basin 7					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	56	$ 6,000.00	$ 336,000
2	Excavation & Off-Site Disposal	CY	460,000	$ 12.00	$ 5,520,000
3	Excavation & Fill (On-Site Material)	CY	300	$ 6.00	$ 1,800
4	Backslope Drainage System Swales	LF	6,500	$ 2.00	$ 13,000
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	60,800	$ 110.00	$ 6,688,000
7	Concrete Interceptor Structure	SY	110	$ 120.00	$ 13,200
8	60" RCP	LF	370	$ 315.00	$ 116,550
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	450	$ 76.00	$ 34,200
				SUBTOTAL DRAINAGE ITEMS	**$ 12,893,250**
				Contingency 30%	**$ 3,868,000**
				Subtotal W/Contingency	**$ 16,761,250**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 16,761,250**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
11	Engineering Surveying Fees	PCNT	15.00%	$ 16,800,000.00	$ 2,520,000
12	Geotech, Materials Testing	PCNT	2.00%	$ 16,800,000.00	$ 336,000
12	USACE Permits	PCNT	0.10%	$ 16,800,000.00	$ 16,800
13	Contaminated Soils Testing	PCNT	0.65%	$ 16,800,000.00	$ 109,200
				SUBTOTAL ENGINEERING ITEMS	**$ 2,982,000**
	OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING				**$ 19,743,250**

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Basin 8					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	104	$ 6,000.00	$ 624,000
2	Excavation & Off-Site Disposal	CY	370,000	$ 12.00	$ 4,440,000
3	Excavation & Fill (On-Site Material)	CY	30	$ 6.00	$ 180
4	Backslope Drainage System Swales	LF	8,100	$ 2.00	$ 16,200
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	900	$ 110.00	$ 99,000
7	Concrete Interceptor Structure	SY	140	$ 120.00	$ 16,800
8	60" RCP	LF	600	$ 315.00	$ 189,000
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	550	$ 76.00	$ 41,800
				SUBTOTAL DRAINAGE ITEMS	**$ 5,597,480**
				Contingency 30%	**$ 1,680,000**
				Subtotal W/Contingency	**$ 7,277,480**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 7,277,480**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
11	Engineering Surveying Fees	PCNT	15.00%	$ 7,300,000.00	$ 1,095,000
12	Geotech, Materials Testing	PCNT	2.00%	$ 7,300,000.00	$ 146,000
12	USACE Permits	PCNT	0.10%	$ 7,300,000.00	$ 7,300
13	Contaminated Soils Testing	PCNT	0.65%	$ 7,300,000.00	$ 47,450
				SUBTOTAL ENGINEERING ITEMS	**$ 1,295,750**
	OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING				**$ 8,573,230**

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Basin 9					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	77	$ 6,000.00	$ 462,000
2	Excavation & Off-Site Disposal	CY	630,000	$ 12.00	$ 7,560,000
3	Excavation & Fill (On-Site Material)	CY	120	$ 6.00	$ 720
4	Backslope Drainage System Swales	LF	8,900	$ 2.00	$ 17,800
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	52,400	$ 110.00	$ 5,764,000
7	Concrete Interceptor Structure	SY	150	$ 120.00	$ 18,000
8	60" RCP	LF	460	$ 315.00	$ 144,900
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	600	$ 76.00	$ 45,600
				SUBTOTAL DRAINAGE ITEMS	**$ 14,183,520**
				Contingency 30%	**$ 4,256,000**
				Subtotal W/Contingency	**$ 18,439,520**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 18,439,520**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
11	Engineering Surveying Fees	PCNT	15.00%	$ 18,500,000.00	$ 2,775,000
12	Geotech, Materials Testing	PCNT	2.00%	$ 18,500,000.00	$ 370,000
12	USACE Permits	PCNT	0.10%	$ 18,500,000.00	$ 18,500
13	Contaminated Soils Testing	PCNT	0.65%	$ 18,500,000.00	$ 120,250
				SUBTOTAL ENGINEERING ITEMS	**$ 3,283,750**
	OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING				**$ 21,723,270**

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Basin 10					
Item	Item Description	Unit	Approx. Qty.	Unit Price	Total Price
	DRAINAGE ITEMS				
1	Clearing and Grubbing	AC	88	$ 6,000.00	$ 528,000
2	Excavation & Off-Site Disposal	CY	700,000	$ 12.00	$ 8,400,000
3	Excavation & Fill (On-Site Material)	CY	240	$ 6.00	$ 1,440
4	Backslope Drainage System Swales	LF	10,900	$ 2.00	$ 21,800
5	Concrete Channel Lining, 5" Nominal Thickness	SY	1,000	$ 85.00	$ 85,000
6	Concrete Channel Lining, 8" Nominal Thickness	SY	93,400	$ 110.00	$ 10,274,000
7	Concrete Interceptor Structure	SY	170	$ 120.00	$ 20,400
8	60" RCP	LF	310	$ 315.00	$ 97,650
9	Headwalls and Wingwalls	CY	90	$ 950.00	$ 85,500
10	24" CMP	LF	700	$ 76.00	$ 53,200
				SUBTOTAL DRAINAGE ITEMS	**$ 19,566,990**
				Contingency 30%	**$ 5,871,000**
				Subtotal W/Contingency	**$ 25,437,990**
	OPINION OF PROBABLE COSTRUCTION COST				**$ 25,437,990**
	Engineering/SWPPP/Geotechnical/Surveying/Construction Items				
11	Engineering Surveying Fees	PCNT	15.00%	$ 25,500,000.00	$ 3,825,000
12	Geotech, Materials Testing	PCNT	2.00%	$ 25,500,000.00	$ 510,000
12	USACE Permits	PCNT	0.10%	$ 25,500,000.00	$ 25,500
13	Contaminated Soils Testing	PCNT	0.65%	$ 25,500,000.00	$ 165,750
				SUBTOTAL ENGINEERING ITEMS	**$ 4,526,250**
	OPINION OF PROBABLE COSTRUCTION COST WITH ENGINEERING				**$ 29,964,240**

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Northwest 1

Northwest 2

East 1

East 2

East 3

Southwest

Neches River

Hillebrandt Bayou

DRAFT

0 1 2 Miles

Legend

Study Area

Open Channels

ICM Model Regions

East 1

East 2

East 3

Northwest 1

Northwest 2

Southwest

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

Modeled Extents (InfoWorks ICM)

Exhibit # 1

Document Path: N:\120\120-12232-000\9-0-Data-GIS-Modeling\9-01-GIS\2-ArcMapProjects\Report\Exhibits\1 Modeled Extents V2.mxd

Neches River

Hillebrandt Bayou

0 1 2 Miles

Legend

Study Area
Open Channels
Detention Basin

Existing Storm Sewer
< 48" Conduit
> 48" Conduit

Existing Storm Sewer Network

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

DRAINAGE DISTRICT NO. 6 JEFFERSON COUNTY, TEXAS DD6

Exhibit # 2

Neches River

Hillebrandt Bayou

0 1 2 Miles

Legend

Study Area

Open Channels

LiDAR Elevation (ft)

High : 92.0

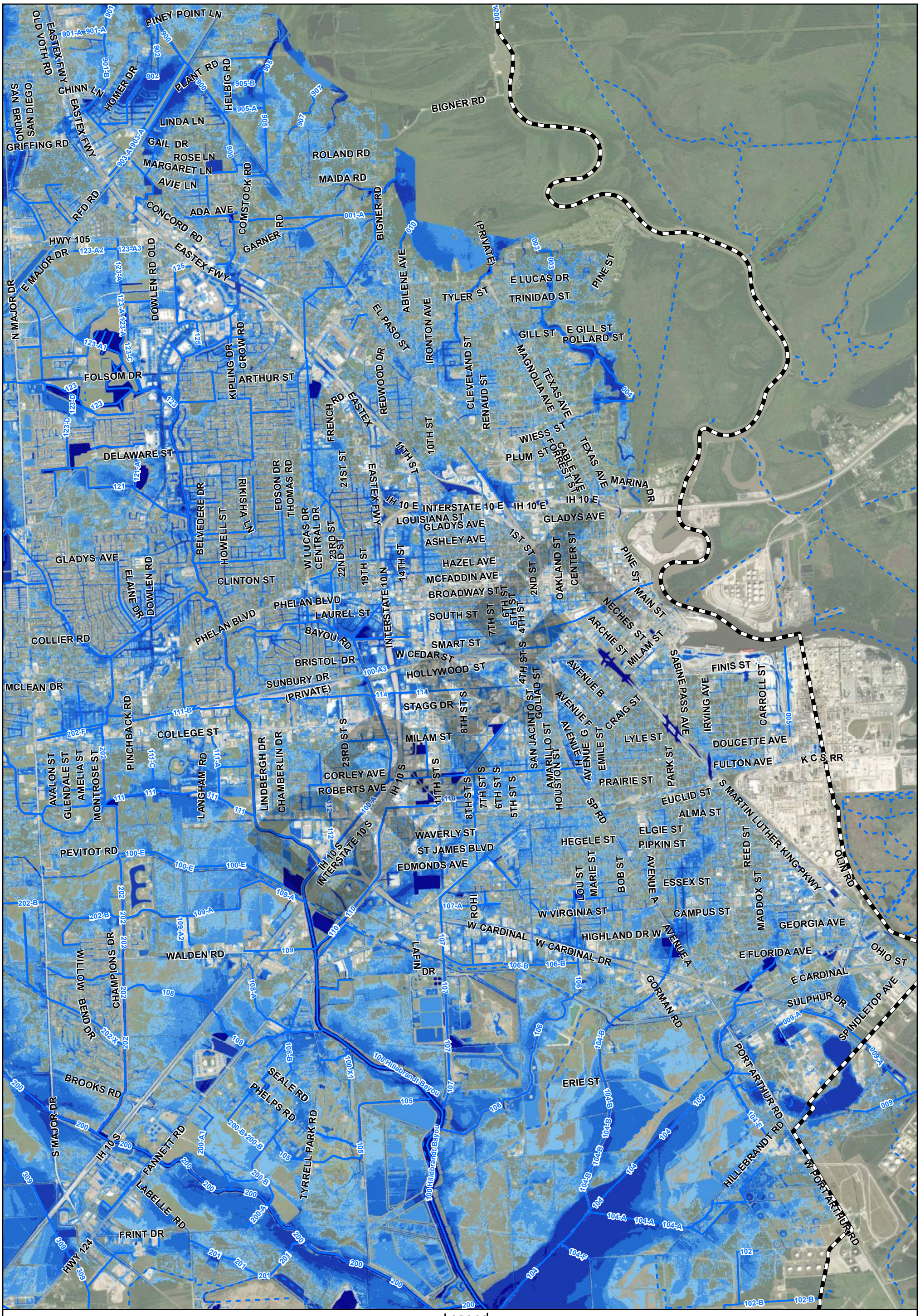
Low : -19.0

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

LiDAR Overview of ICM Model

DRAINAGE DISTRICT NO. 6 DD6 JEFFERSON COUNTY, TEXAS

Exhibit # 3



Legend

DD6_Boundary

Open Channels:

Existing Ponding
10-YR Depth (ft)

- 0.25 - 0.50
- 0.50 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- > 5.0

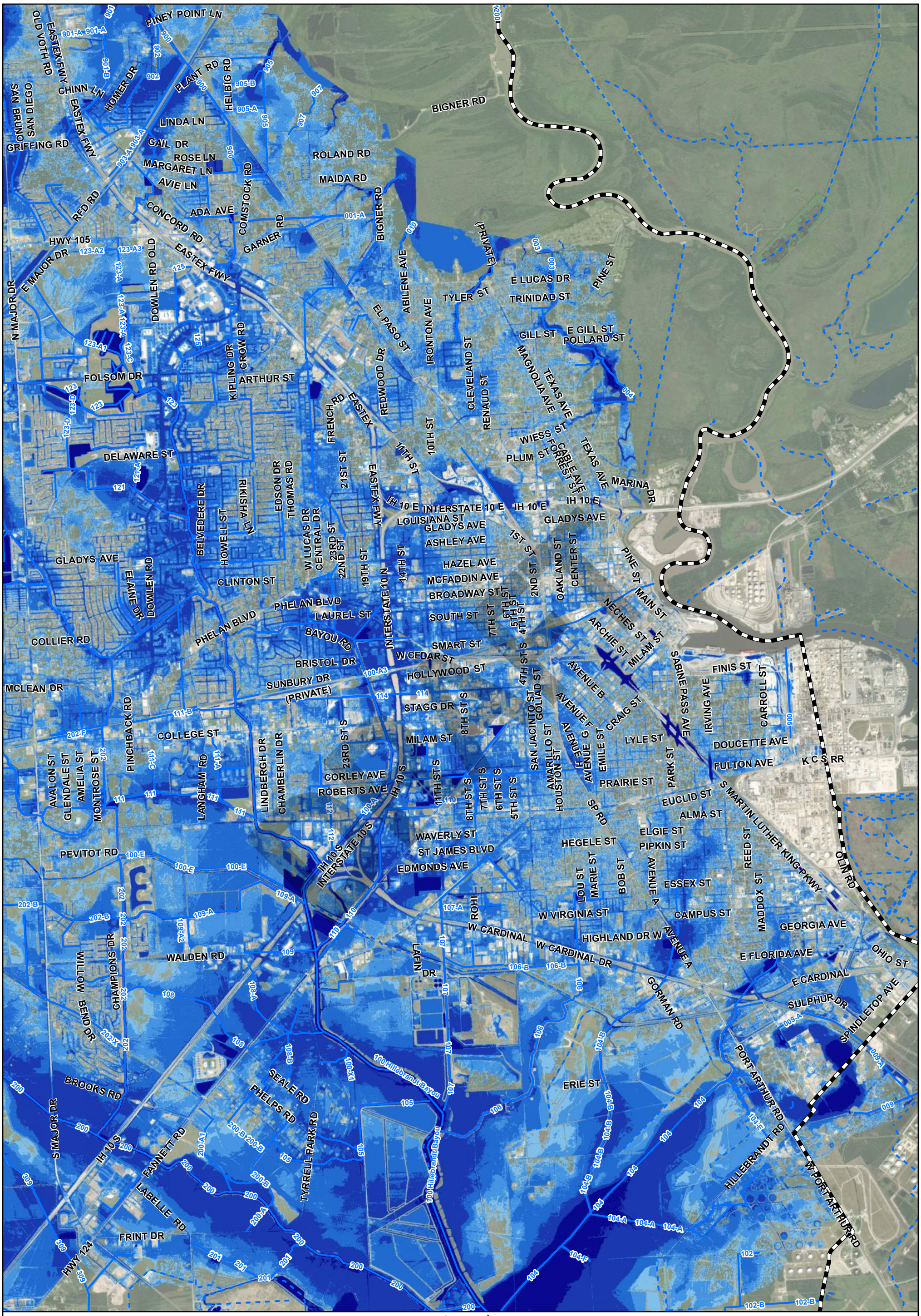
0 1 2 Miles

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

10-Year Existing Ponding Overview of Study Area

DD6 DRAINAGE DISTRICT NO 6 JEFFERSON COUNTY, TEXAS

Exhibit # 4



0 1 2 Miles

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

Legend

DD6_Boundary

Open Channels:

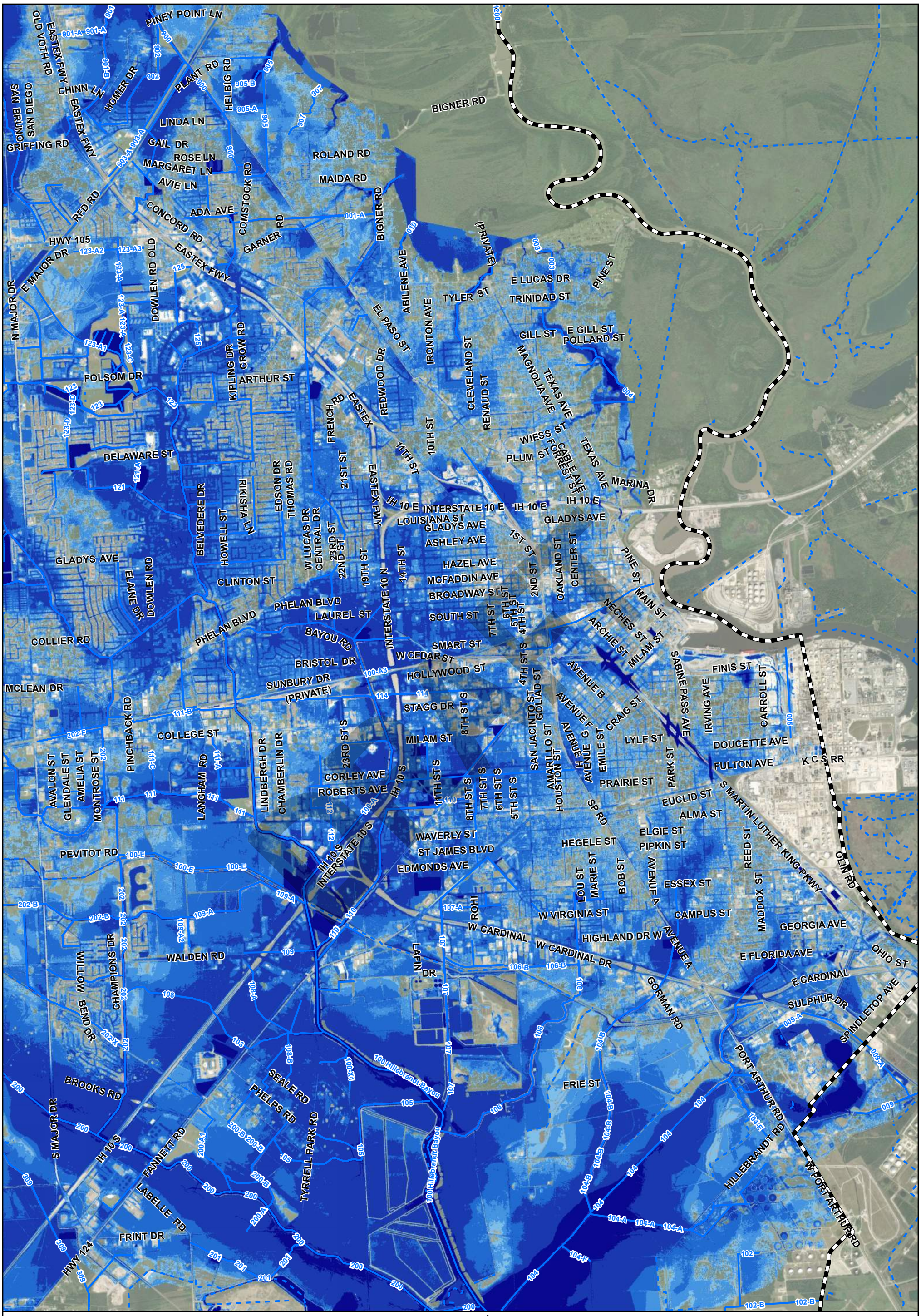
Existing Ponding
100-YR Depth (ft)

- 0.25 - 0.50
- 0.50 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- > 5.0

100-Year Existing Ponding Overview of Study Area

DRAINAGE DISTRICT NO. 6 — DD6 — JEFFERSON COUNTY, TEXAS

Exhibit # 5



0 1 2 Miles

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

Legend

DD6_Boundary

Open Channels:

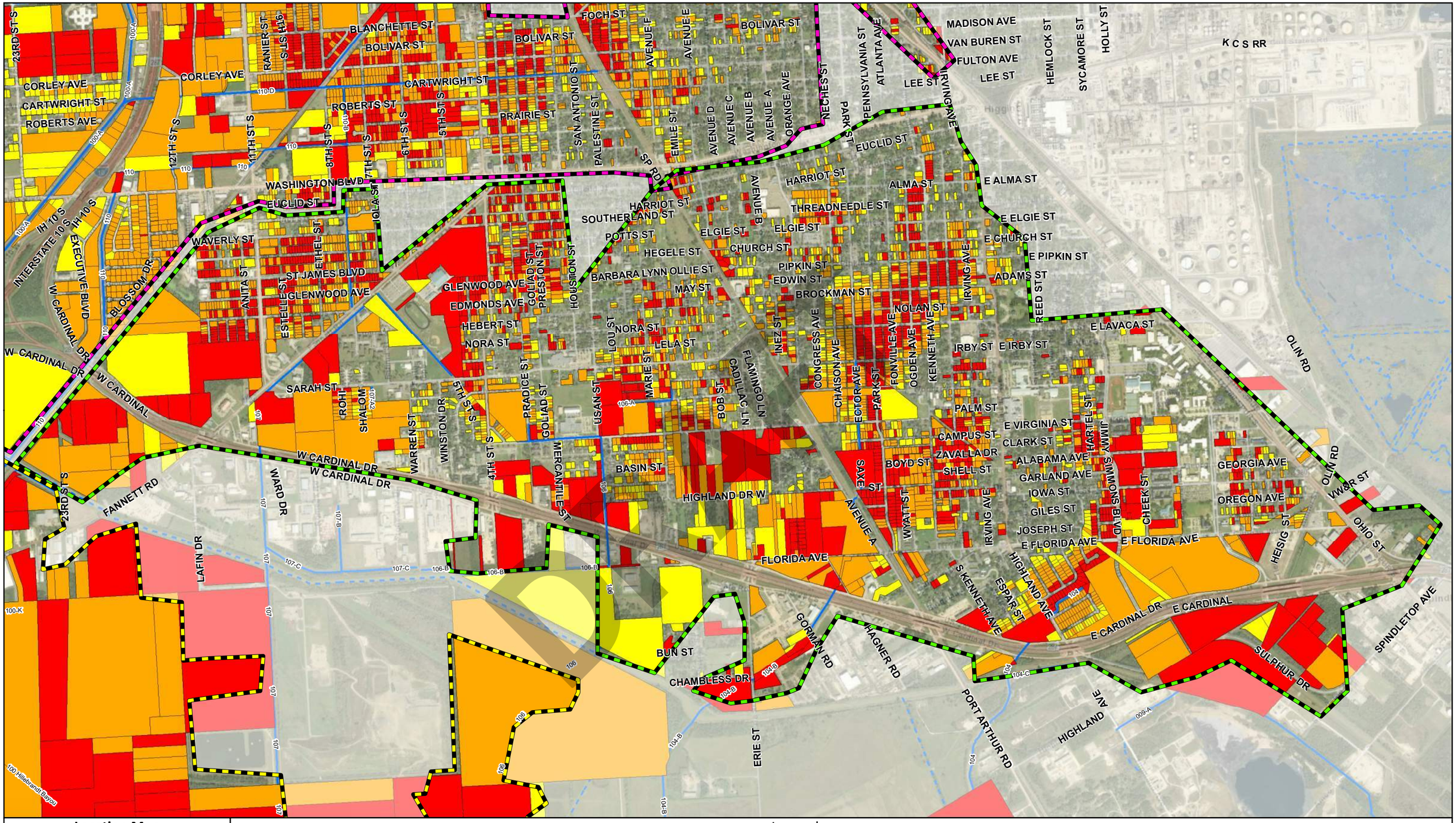
Existing Ponding
500-YR Depth (ft)

- 0.25 - 0.50
- 0.50 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- > 5.0

500-Year Existing Ponding Overview of Study Area

DD6 — Drainage District No. 6, Jefferson County, Texas

Exhibit # 6



Location Map

0 4,000 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

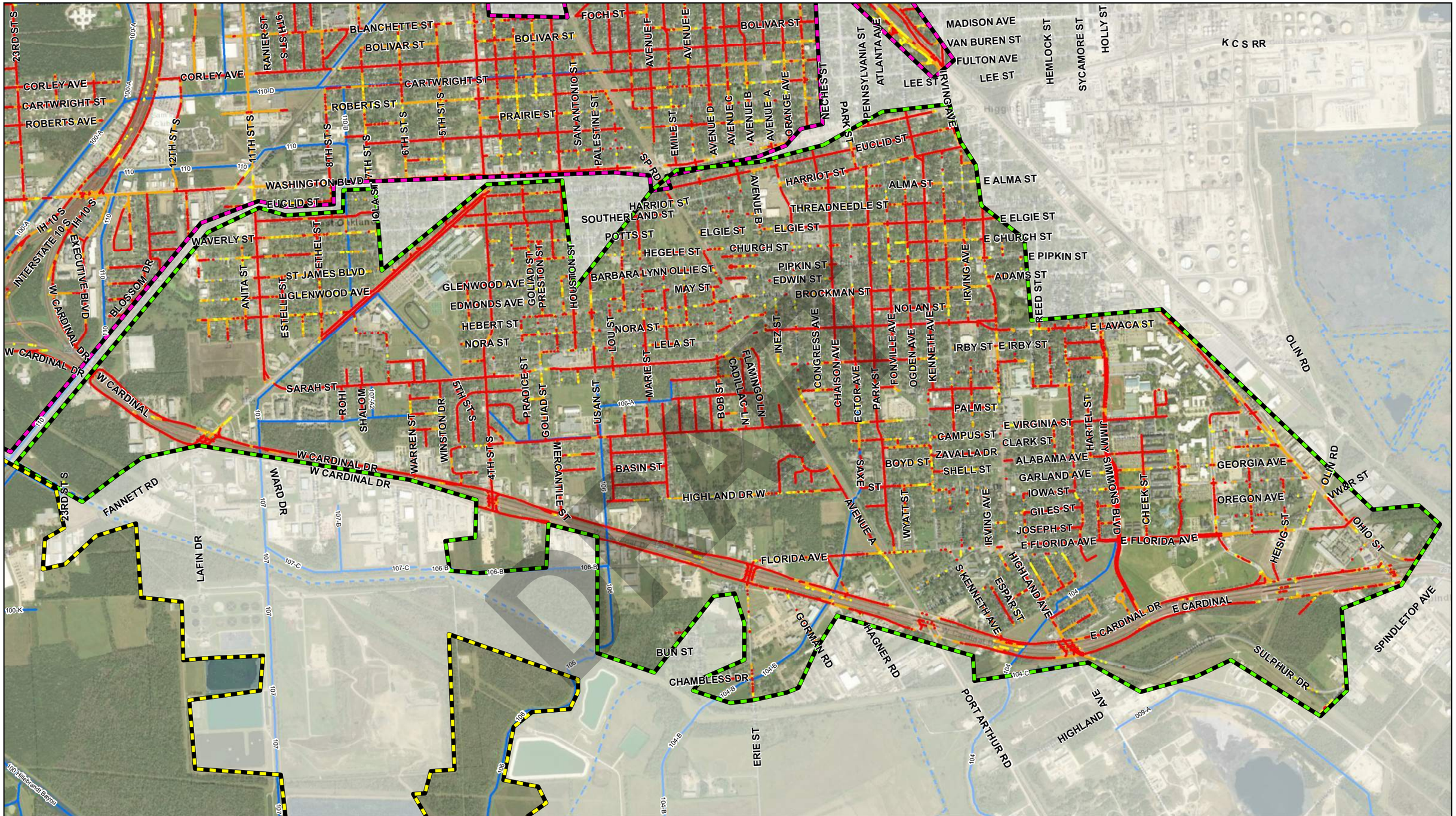
Existing Parcels in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Parcels in Floodplain
South Park Diversion & Basin 2

DD6 Drainage District No. 6 Jefferson County, Texas

Exhibit # 7



Location Map

0 4,000 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

Existing Roadway in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Roadway in Floodplain South Park Diversion & Basin 2

DRAINAGE DISTRICT NO. 6 DD6 JEFFERSON COUNTY, TEXAS

Exhibit # 8

Location Map

0 4,000 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

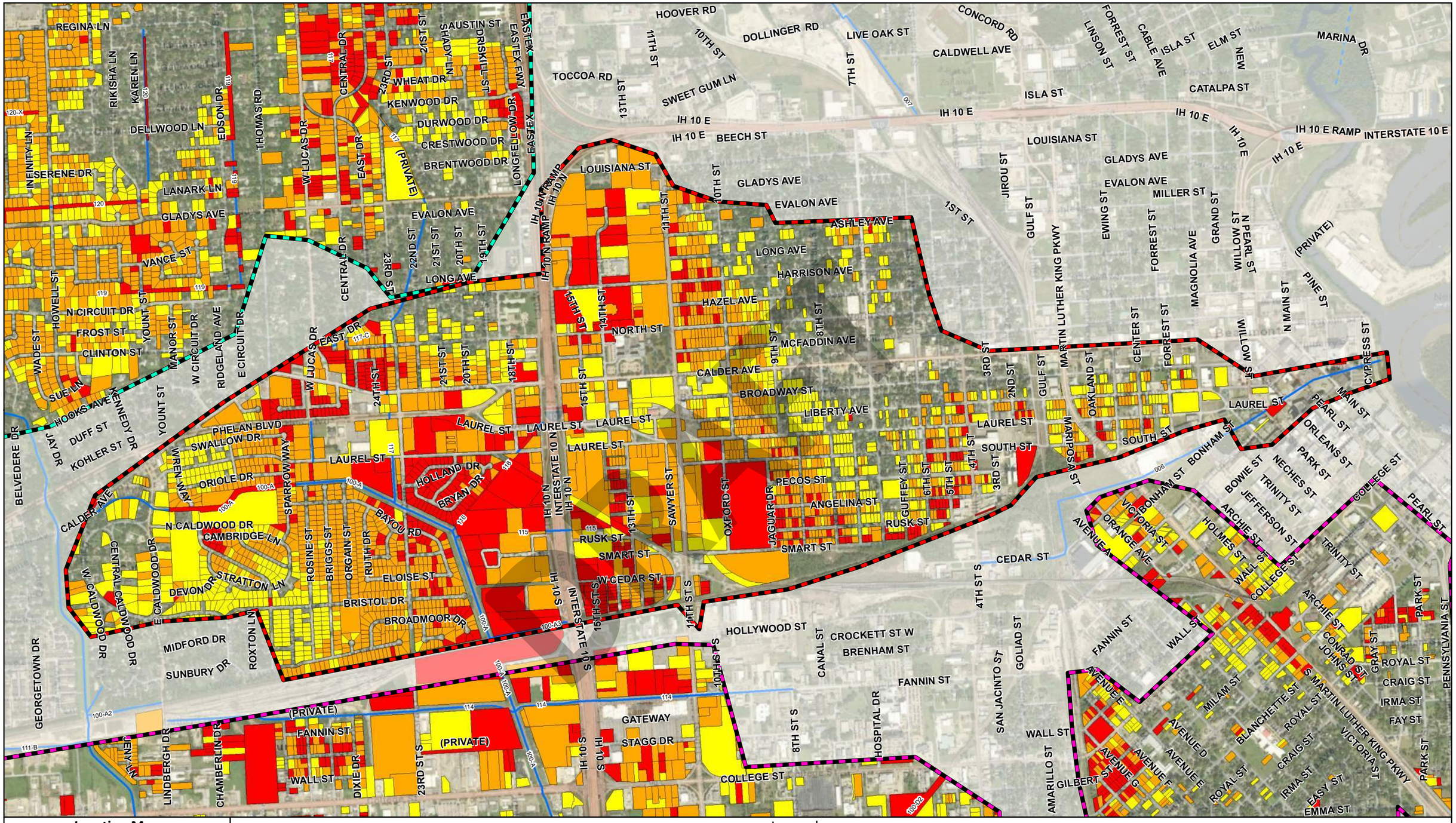
Existing Inundated Structures
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

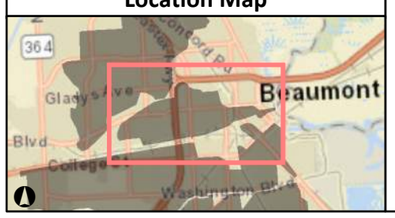
Existing Inundated Structures
South Park Diversion & Basin 2

DD6

Exhibit # 9



Location Map



0 3,300 Feet

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

Legend

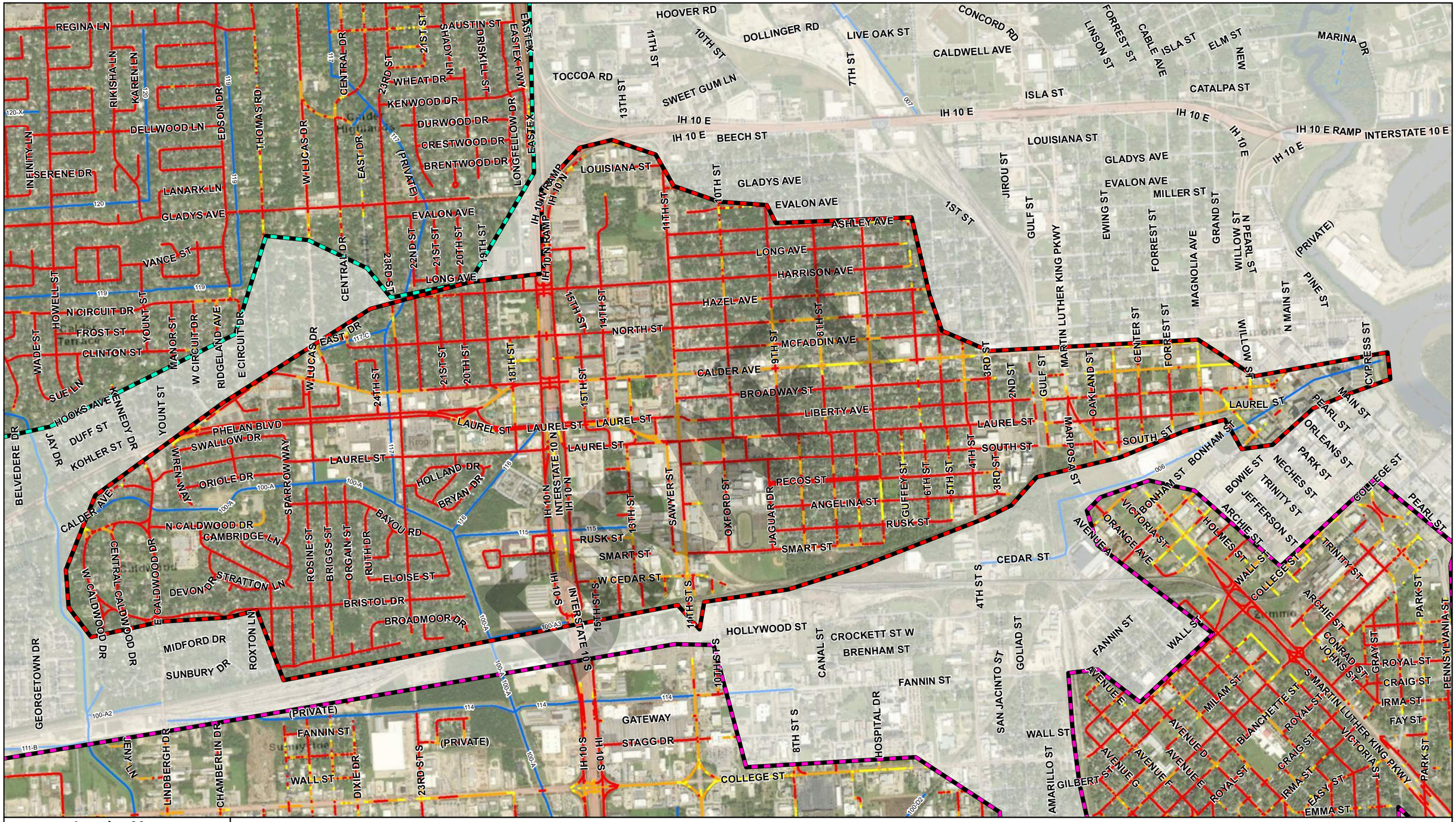
Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

Existing Parcels in Floodplain
- 10-Year
- 100-Year
- 500-Year

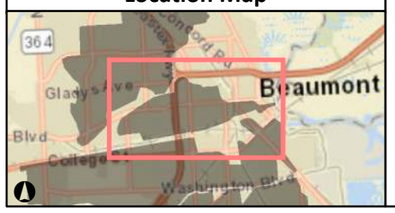
Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Parcels in Floodplain
Tevis Diversion

Exhibit # 10



Location Map



0 3,300 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

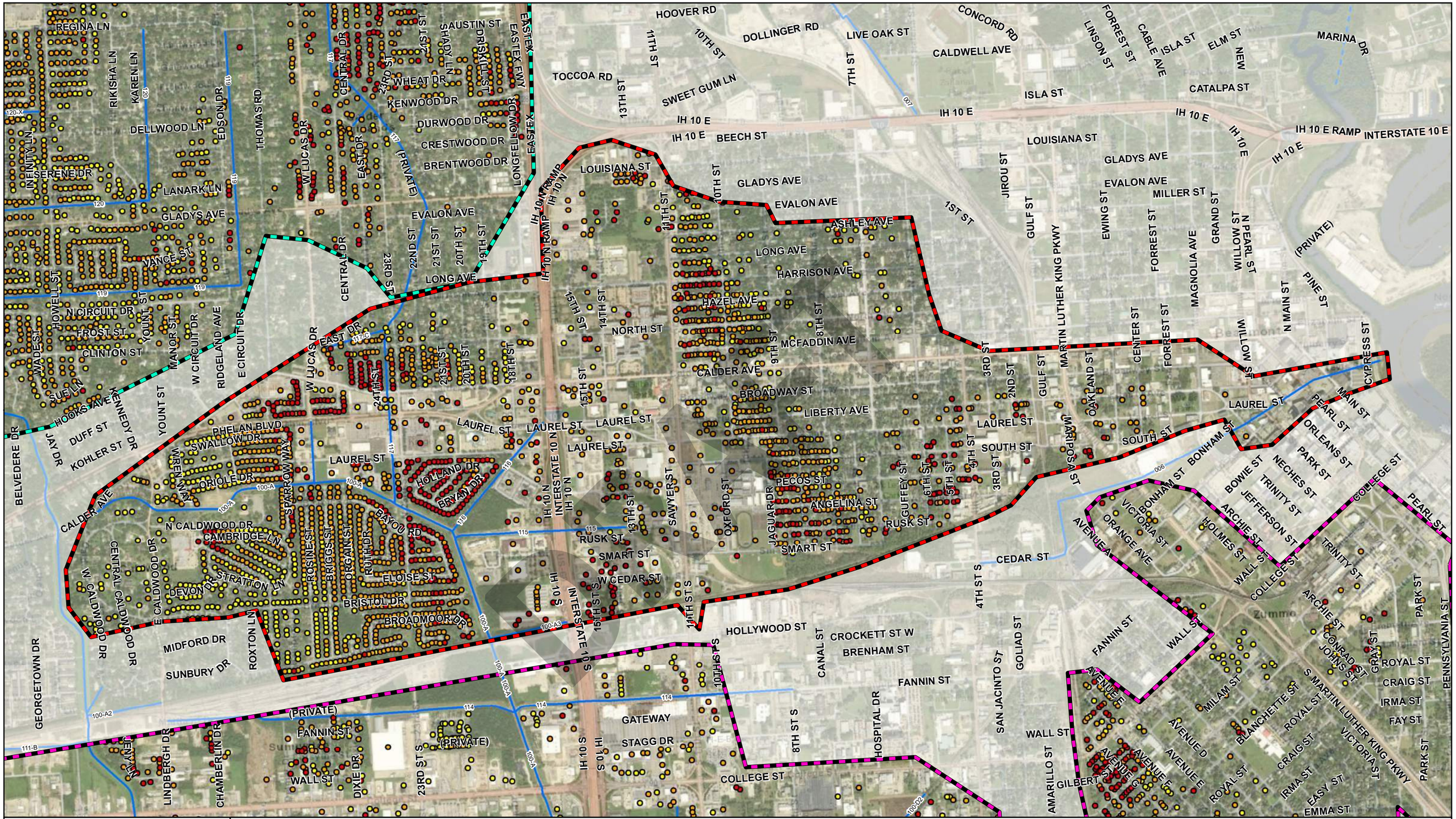
Existing Roadway in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

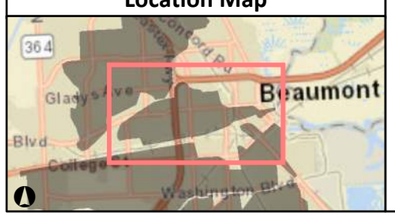
Existing Roadway in Floodplain
Tevis Diversion

DD6 — Drainage District No. 6 — Jefferson County, Texas

Exhibit # 11



Location Map



0 3,300 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

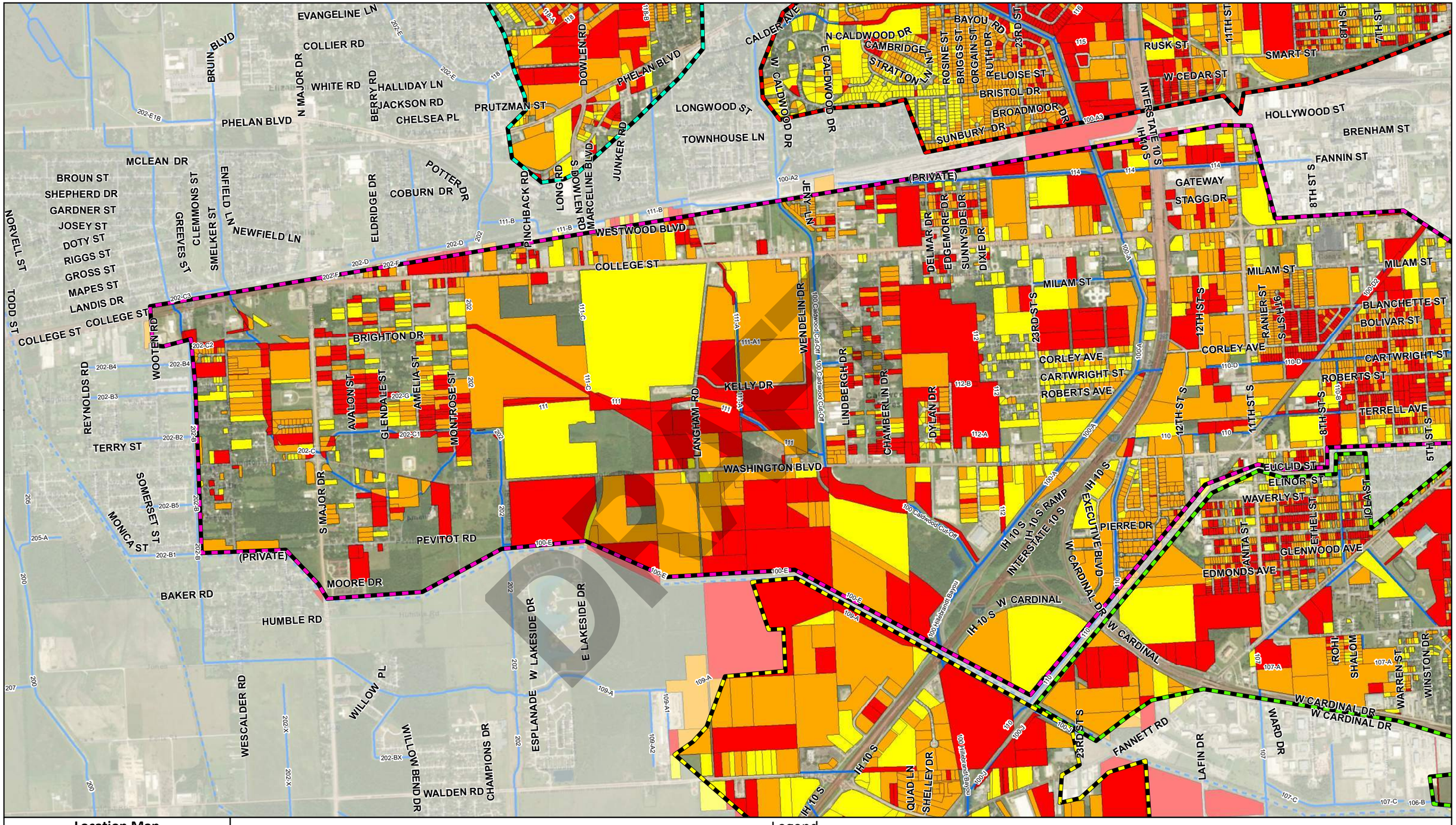
Existing Inundated Structures
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Inundated Structures
Tevis Diversion

DRAINAGE DISTRICT NO. 6 JEFFERSON COUNTY, TEXAS DD6

Exhibit # 12



Location Map

0 4,300 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

Existing Parcels in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Parcels in Floodplain
Blanchette Diversion & Basin 1 - West

DD6 Drainage District No. 6 Jefferson County, Texas

Exhibit # 13

Location Map

0 4,300 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

Existing Roadway in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Roadway in Floodplain
Blanchette Diversion & Basin 1 - West

DD6 Drainage District No. 6 Jefferson County, Texas

Exhibit # 14

Location Map

0 4,300 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

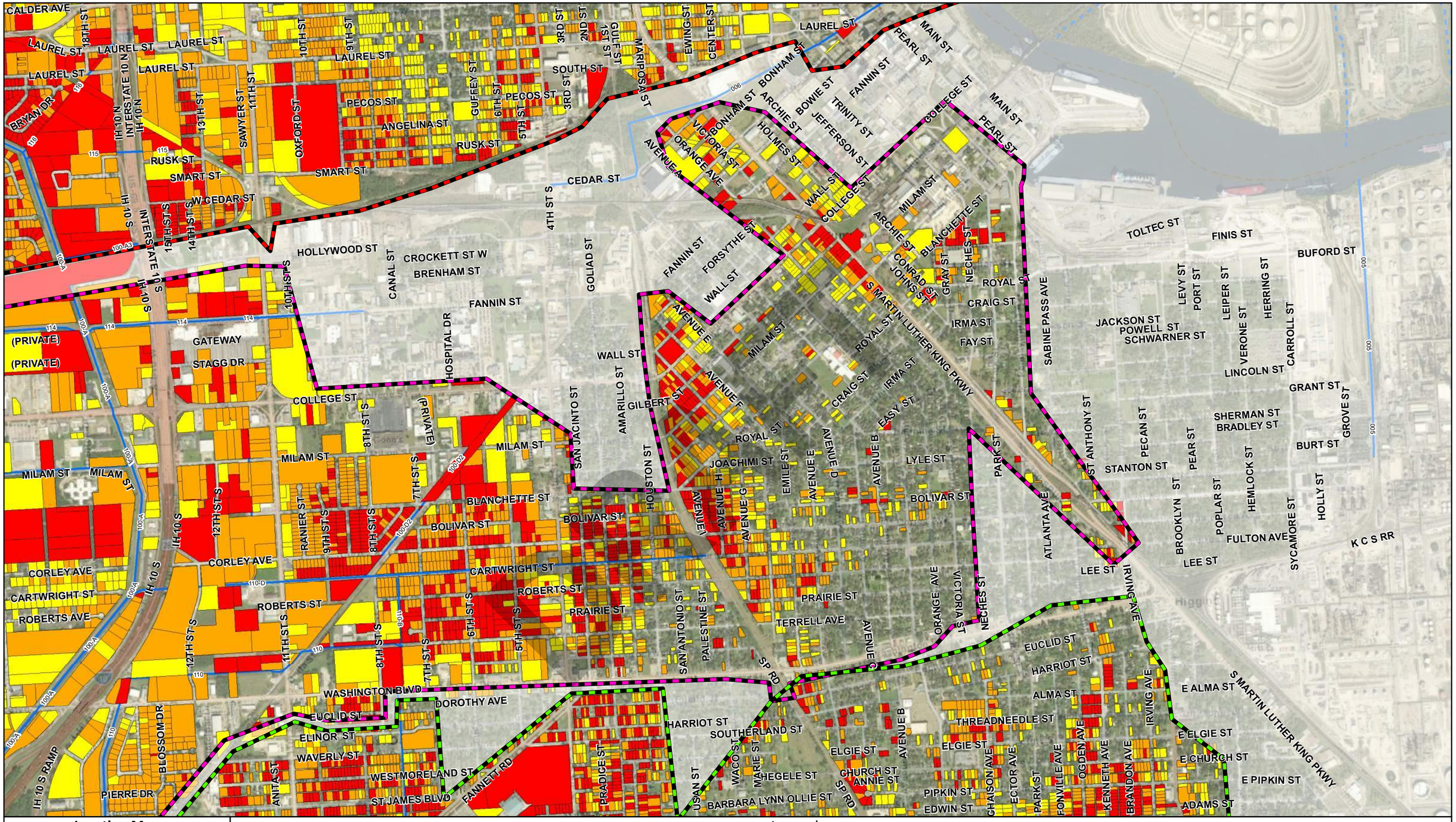
Existing Inundated Structures
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Inundated Structures
Blanchette Diversion & Basin 1 - West

DD6 Drainage District No. 6 Jefferson County, Texas

Exhibit # 15



Location Map

0 3,300 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

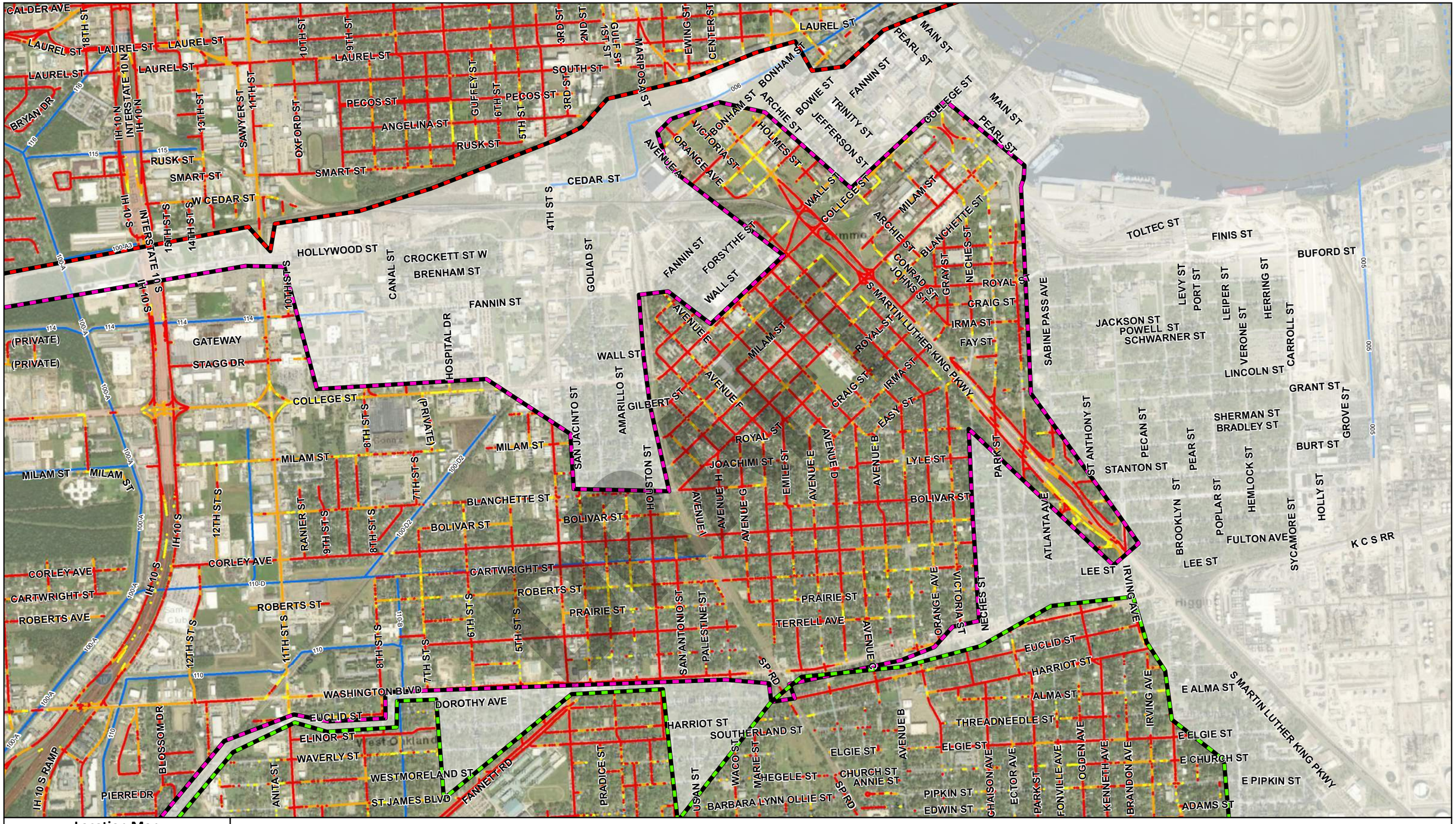
Existing Parcels in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Parcels in Floodplain
Blanchette Diversion & Basin 1 - East

DD6

Exhibit # 16



Location Map

0 3,300 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

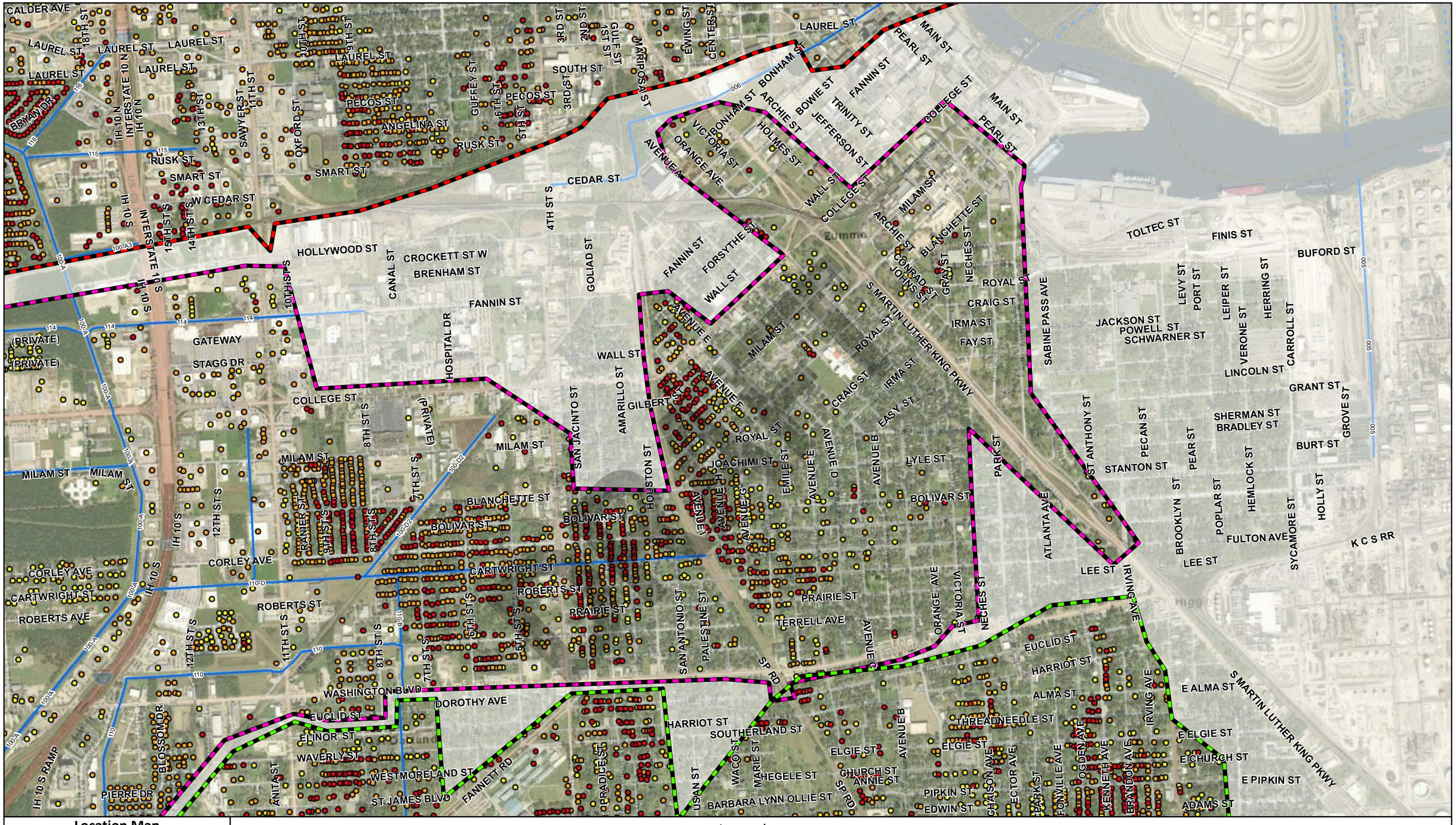
Existing Roadway in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

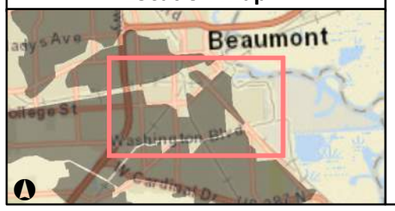
Existing Roadway in Floodplain
Blanchette Diversion & Basin 1 - East

DD6

Exhibit # 17



Location Map



0 3,300 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

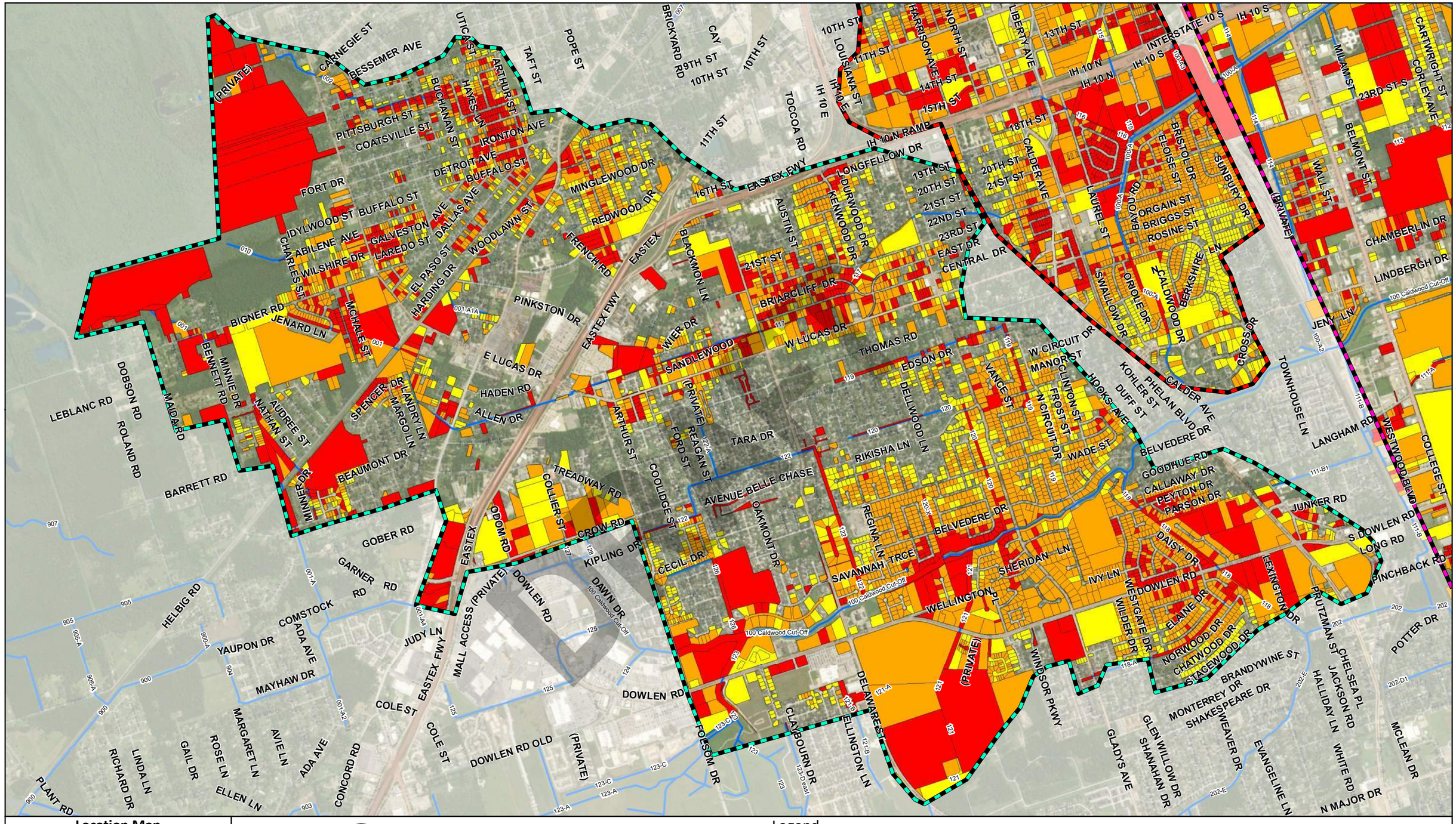
Existing Inundated Structures
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Inundated Structures
Blanchette Diversion & Basin 1 - East

DD6

Exhibit # 18



Location Map

0 4,700 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

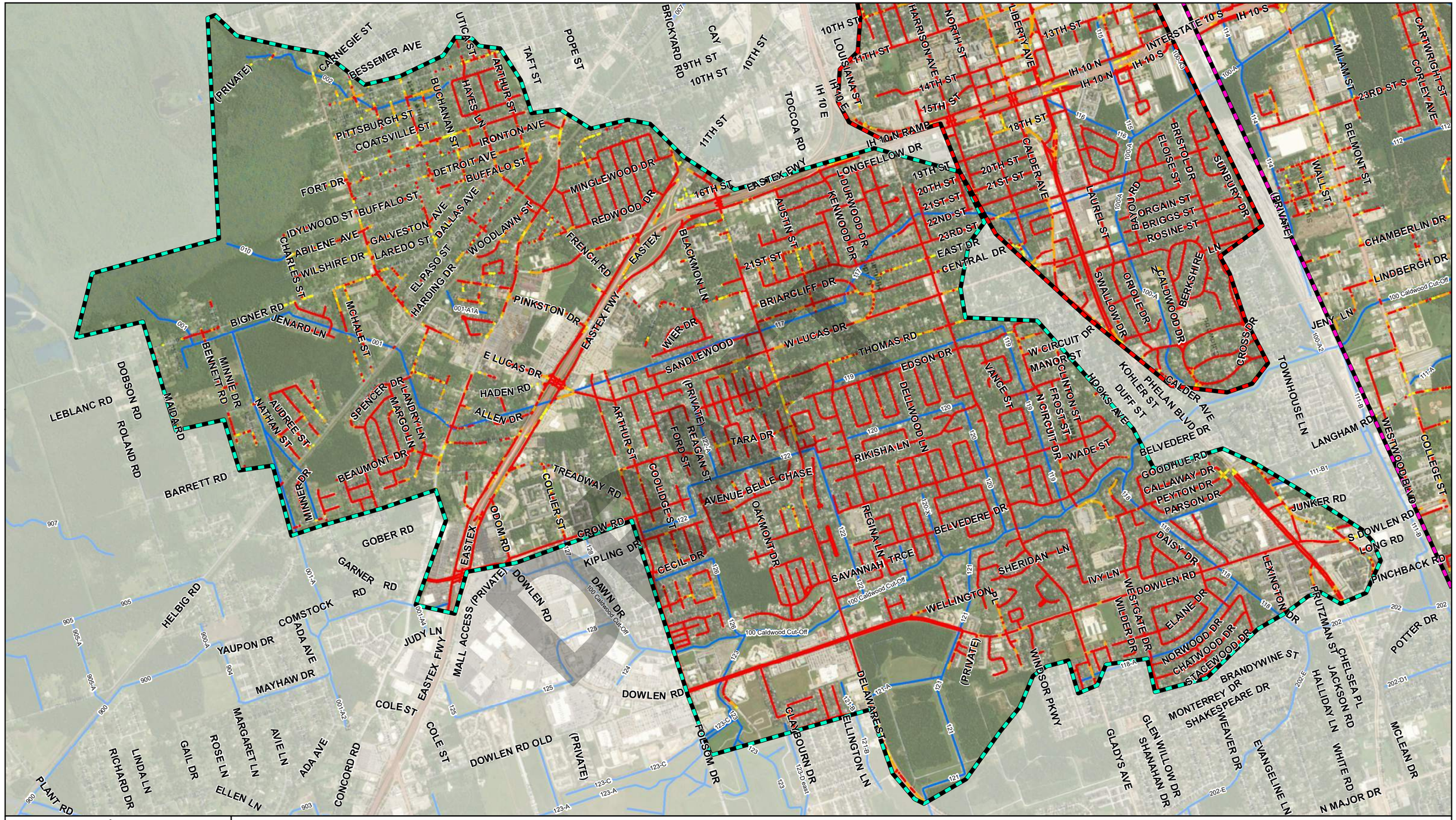
Existing Parcels in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Parcels in Floodplain
Lucas Diversion

DD6 Drainage District No. 6 Jefferson County, Texas

Exhibit # 19



Location Map

0 4,700 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

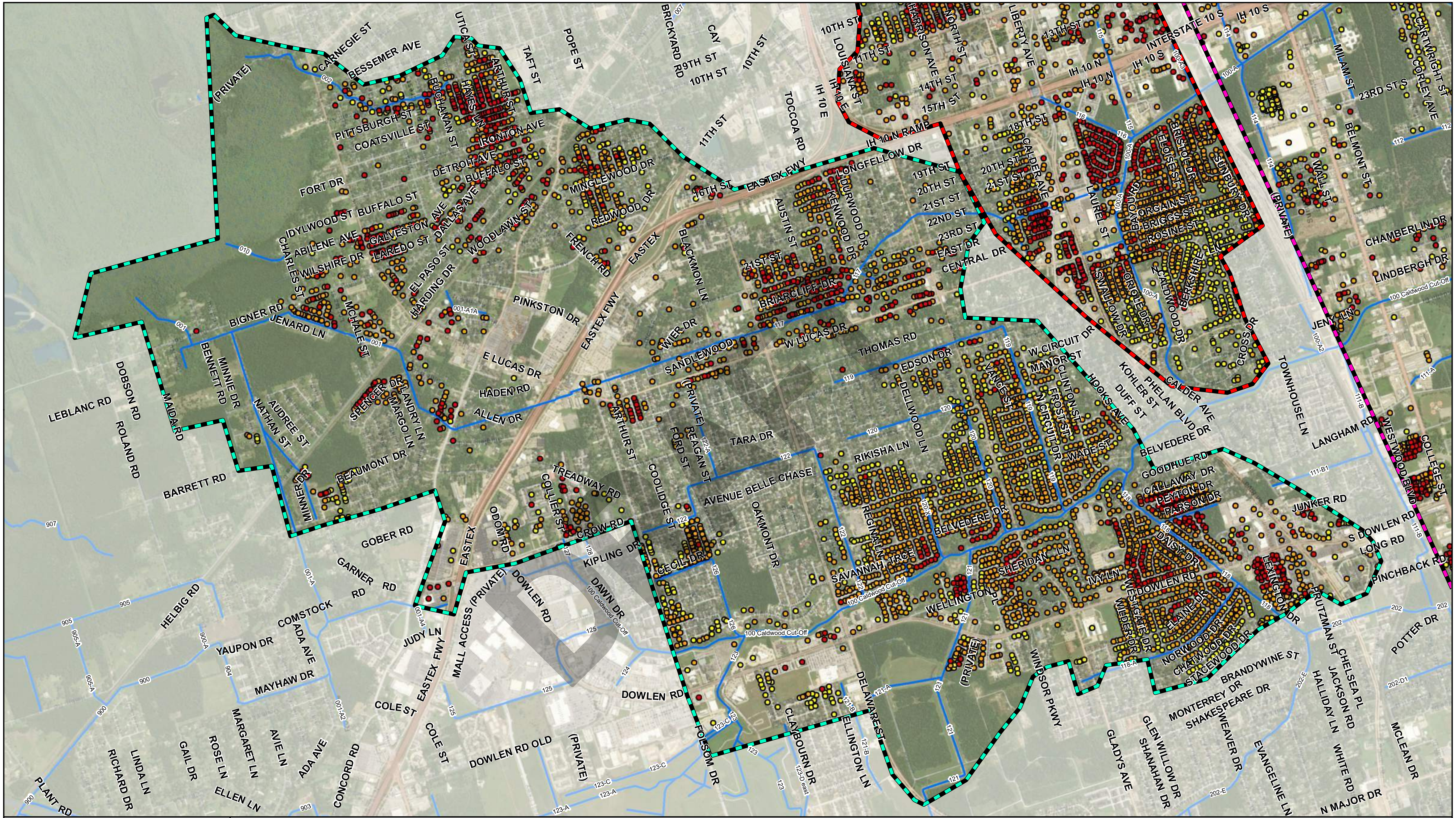
Existing Roadway in Floodplain
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Roadway in Floodplain
Lucas Diversion

DRAINAGE DISTRICT NO. 6 JEFFERSON COUNTY, TEXAS DD6

Exhibit # 20



Location Map

0 — 4,700 Feet

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

Legend

Project Areas of Influence
- Basins 3-10
- Blanchette Diversion & Basin 1
- Lucas Diversion
- South Park Diversion & Basin 2
- Tevis Diversion

Existing Inundated Structures
- 10-Year
- 100-Year
- 500-Year

Open Channels
- DD6 Channel
- Non-DD6 Channel

Existing Inundated Structures
Lucas Diversion

DRAINAGE DISTRICT NO. 6 — DD6 — JEFFERSON COUNTY, TEXAS

Exhibit # 21