FINAL SCOPE TECHNICAL MEMORANDUM

Addendum to Final Pre-Engineering Report N-2013T-0013

CIP Project WBS No. N-100030-0001-3

OMEGA Contract WBS No.: N-000100-005-3
Work Order No. 12 and 13
Antoine Drive North from Victory to Bridge Forest

Prepared For: City of Houston - Public Works
Planning and Development Services Division

PLANNING & DEVELOPMENT DEPARTMENT

Prepared By: Omega Engineers, Inc.

OMEGA ENGINEERS, INC.

STATE OF TEXAS
EDELMIRO CASTILLO
49753
REGISTERED
PROFESSIONAL ENGINEER

12/28/2015

16360 Park Ten Place
Suite 325
Houston, TX 77084
Firm No.: F-2147

December 2015

Contents

1.0 Executive Summary **1**
2.0 Background **2**
2.1 Project Limits and Description 2
3.0 Summary of Candidate Project **3**
Need Area N-2013T-0013 (Antoine North) 3
4.0 Summary of the Need Area **3**
5.0 Brief Summary of the Problems **3**
Candidate Project 4
6.0 Alternative 1A **4**
6.1 Pavement 4
6.2 Traffic 4
6.3 Shared Use Paths 7
7.0 Real Estate Acquisition/Right-of-Way **7**
8.0 Drainage **7**
9.0 Utilities **10**
10.0 Recommended Alternative Summary **10**
11.0 Public Comments **10**

Appendices

Appendix 1: Cost Estimates

Appendix 2: Traffic & Utilities Layouts

Appendix 3: Existing & Proposed Typical Section & Layouts

Appendix 4: Traffic Report

Appendix 5: Drainage Report

Appendix 6: Public Meeting Exhibits

1.0 Executive Summary

The City of Houston Infrastructure Planning Branch of the Public Works Planning and Development Services Division has contracted with OMEGA Engineers, Inc., (OMEGA) to perform Single Phase Engineering Services in order to qualify various project areas for further development and inclusion into the City's CIP under WBS No. N-000100-0005-3, Outline Agreement No. 4600011900, Work Order No. 3. The study area in this Technical Memorandum is N-2013T-0013, Antoine Drive from US 290 to Bridge Forest.

This Final Scope Technical Memorandum focuses on updates to the candidate project (Alternative 1A) for both Antoine North, and Antoine South Road. The Final Technical Scope Memorandum provides detailed data, layouts, and exhibits pertinent to Alternative 1A.

At the direction of the COH the proposed lane configuration and other project elements for the study area was updated to address the public input that was obtained during the public meeting held on October 20th, 2015 for resident and stakeholders along Antoine study area. The configuration was also revised to meet the updated COH Infrastructure Design Manual 2015. Other factors taken in consideration in finalization this scope update; third party traffic study resources mainly the Northwest Houston Mobility Study 2015. In addition to another third party report (Antoine Drive-Corridor Analysis) prepared by Walter P. Moore, along with comments and recommendations generated by COH-IPB.

Alternative 1A consists of the construction of Antoine Drive from Victory Drive to Bridge Forrest to a four-lane divided roadway section with shared use path within the existing 100-foot ROW. Proposed Pavement, Drainage and Utility Improvements are described in the following sections.

This Final Scope Memorandum has incorporated ideas, concepts, and suggestions raised at the public meeting event and the input acquired later by mail and email messages from the resident and stakeholders at the study area, as appropriate.
In addition, certain design related public comments should be taken in consideration and incorporated during final design phase following further research and deliberation.
The public meeting comments included drainage concerns, vehicular and pedestrian traffic issues, bike lanes, right-of-way requirements, and roadway improvement aesthetics.

The probable construcition cost for the Alternative 1A – 4 lanes with wide medians, ROW: 100 has a **Total Candidate Cost of $22,492,795.58**.

2.0 Background

2.1 Project Limits and Description

The City of Houston Infrastructure Planning Branch of the Public Works Planning and Development Services Division has contracted with OMEGA Engineers, Inc., (OMEGA) to perform Single Phase Engineering Services in order to qualify various project areas for further development and inclusion into the City's CIP under WBS No. N-000100-0005-3, Outline Agreement No. 4600011900, Work Order No. 3. The study area in this Technical Memorandum is N-2013T-0013, Antoine Drive from US 290 to Bridge Forest.

This project went through three stages of planning and development. The first phase (Planning 1) was dedicated to research, data, gathering, and evaluating existing conditions and possible solutions to deficiencies found and to improve the condition of the study area like roadway capacity, pavement condition, mobility, pedestrian facilities, safety, and storm drainage. In the second phase (Planning 2), multiple alternative solutions were presented in conceptual form, to facilitate discussion and reach a consensus on which alternatives should be further developed, at the end of the Planning 2 presentation, Alternative 1A was selected by the committee for further development.

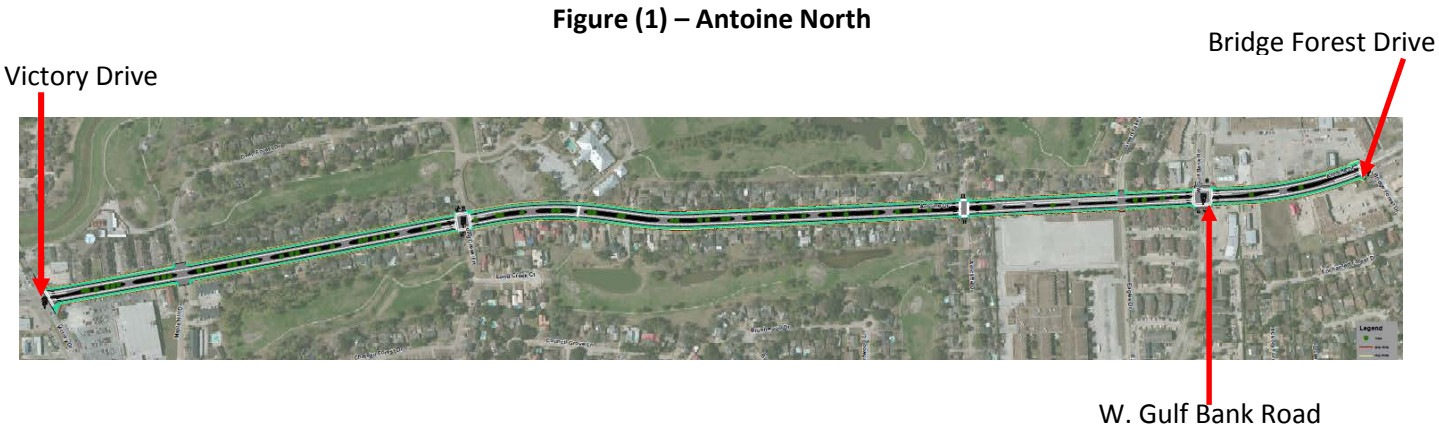
Due to the size of the project and the cost, OMEGA was instructed by COH-IPB during Planning 3 work, to break the Project into 2 projects; Antoine North, and Antoine South.

Planning 3 focuses on the candidate project (Alternative 1A) for both Antoine North, and Antoine South Road. Along with comments and recommendations generated by COH-IPB during this process, all previous work relative to Planning 1, 2, and 3 has been incorporated into the pre-engineering report submitted to the COH-IPB on October 2014.

This Final Scope Technical Memorandum focuses on updates to the candidate project (Alternative 1A) for both Antoine North, and Antoine South Road. The Final Technical Scope Memorandum provides detailed data, layouts, and exhibits pertinent to Alternative 1A.

At the direction of the COH the proposed lane configuration and other project elements for the study area was updated to address the public input that was obtained during the public meeting held on October 20th, 2015 for resident and stakeholders along Antoine study area. Also, to meet the updated COH Infrastructure Design Manual 2015. Other factors taken in consideration in finalization this scope update; third party traffic study resources mainly the Northwest Houston Mobility Study 2015. In addition to another third party report (Antoine Drive-Corridor Analysis) prepared by Walter P. Moore, along with comments and recommendations generated by COH-IPB.

Figure (1) – Antoine North



3.0 Summary of Candidate Project

Name of Project: Need Area No:	Antoine (North) N-2013T-0013
Project Scope & Description	Reconstruct existing Antoine Road 4 lanes with shared use paths; replace traffic signals, and provide necessary upgrades to storm sewer system and utilities.
Project Limits	Victory Drive to Bridge Forest Drive
Type	Major Thoroughfares/Collector Street
Council District	C and A
Key Map No.	411Q, U, Y, 451C, G
Super Neighborhood	Greater Inwood and Oak Forest/Garden Oaks
Project Length	1.3 miles
Project Cost	$22,492,795.58
Number of Sub-Projects	NA
Sub-Project 1 Cost	NA
Sub-Project 2 Cost	NA

Need Area N-2013T-0013 (Antoine North)

4.0 Summary of the Need Area

The need area is a 1.3-mile section located approximately 13-miles southwest of downtown Houston. Antoine Drive from Victory Drive to Bridge Forest Drive is an Urban Boulevard Section with two-lanes (four- by 12-feet) in each direction and raised medians. The median width ranges from eight- to 22-feet within a 100-foot Right-of-Way (ROW). Antoine Drive is designated as a Major Thoroughfare (T-4-100) in the 2012 Major Thoroughfare and Freeway Plan (MTFP). The speed limit throughout the study area is 35-miles per hour (mph).

The roadways within the study area consist of concrete pavement, pedestrian facilities, METRO system facilities, and schools. The pedestrian system includes a four-foot concrete sidewalk, wheel chair ramps, and pedestrian traffic control.

5.0 Brief Summary of the Problems

- ✓ The following provides a list of the existing problems recognized in this need area.
- ✓ The pavement is generally in fair condition with PCR of 70.3. There are numerous sections with a range of deficiencies such as asphaltic patches that are in poor condition.

- ✓ The sidewalks are in fair condition with sections missing along the northern portion of the study area.
- ✓ The 4-lane roadway has insufficient capacity for the projected 2035 traffic volumes.
- ✓ The existing drainage system was found inadequate to convey the 2-year design standard and the 100-year extreme event.
- ✓ Utilities: Existing wastewater and water lines in the project area are generally over 30 years old and require replacement.

Candidate Project

6.0 Alternative 1A

The Recommended Alternative "Alternative 1A" was selected by the City of Houston Infrastructure Planning Branch (IPB-COH) based on various criteria unique to this alignment.

This alternative has been updated based on The City of Houston Infrastructure Planning Branch to incorporate the recommendations for Antoine corridor from The City Mobility Planning-Houston Northwest Sub-regional Study, January 2015.

Alternative 1A consists of the construction of Antoine Drive from Victory Drive to Bridge Forrest e to a four-lane divided roadway section with shared use path within the existing 100-foot ROW. Proposed Pavement, Drainage and Utility Improvements are described in the following sections.

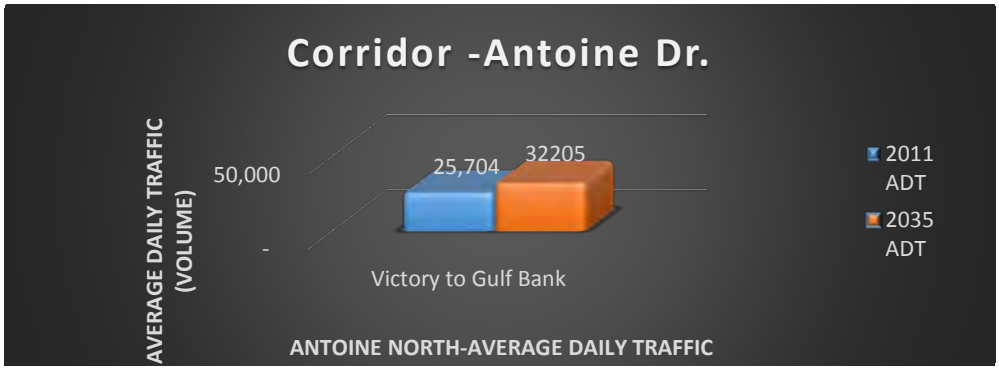
6.1 Pavement

As similar to the existing pavement, the proposed pavement is concrete. Please see Alternative 1A exhibits in Appendix 2 – Traffic Layouts.

This alternative will address many deficiencies found in Planning 1. It will increase the PCR and rebuild the pedestrian circulation system to meet current ADA standards and add off-road bike lanes (Shared Use Paths). Additionally, this alternative will improve storm water collection and drainage systems by reconstructing the curb and gutter along both sides of the road including the replacement of broken manholes.

6.2 Traffic

Incorporating the previous report with items which impact the traffic portion of the study including COH input, Houston NW Mobility Study, Walter P Moore corridor study and public meeting input along with intersection improvements have incorporated into the technical memorandum.



Antoine Drive (2011 ADT)						
Street	Segment	2011 ADT	Existing No. of Lanes	2011 V/C Ratio^1	2011 V/C Ratio^1	2011 Rdwy Level of Service^2
				NB	SB	
Antoine Drive	Victory to Gulf Bank	25,704	4	0.92	0.89	D

^1 2011 Volume/Capacity (V/C) Ratio Given by the City w/Existing Lanes

^2 2011 Rdwy LOS with Existing No. of Lanes

Note: All Existing 2011 LOSs Calculated as Per COH MTFP Policy Statement Criteria.

Antoine Dr (2035 ADT)						
Street	Segment	2035 ADT	2035 V/C Ratio^3	2035 V/C Ratio^3	Existing No. of Lanes	2035 Rdwy Level of Service^4
			NB	SB		
Antoine Drive	Victory to Gulf Bank	32205	1.16	1.11	4	F

^3 2035 Volume/Capacity (V/C) Ratio Given by the City w/Existing Lanes

^4 2035 Rdwy LOS with Existing No. of Lanes (MT,Major Thoroughfare-Currently Listed for 4lanes-100' ROW)

Note: All Future 2035 LOSs Calculated as Per COH MTFP Policy Statement Criteria.

To avoid ROW acquisition along the Antoine Drive corridor and to address community concerns, the corridor improvement was recommended to remain four lane roadway from Tidwell Road to Bridge Forest. The current capacity was shown to save intersection delay along the corridor and reduced intersection LOS from D to E at a certain location.

Level-of-Service (LOS)	Control Delay (seconds/vehicle)		Description
	Signalized Intersection	Un-signalized Intersection	
A	≤10.0	≤10.0	Very low vehicle delay, free traffic flow, good signal progression
B	10.1 to 20.0	10.1 to 15.0	Good signal progression, more vehicle stops and higher delay than LOS A
C	20.1 to 35.0	15.1 to 25.0	Stable traffic flow, fair signal progression, significant number of vehicle stops
D	35.1 to 55.0	25.1 to 35.0	Noticeable traffic congestion, longer delays and unfavorable signal progression
E	55.1 to 80.0	35.1 to 50.0	Limit of acceptable vehicle delay, unstable traffic flow, poor signal progression
F	> 80.0	> 50.0	Unacceptable delay, extremely unstable flow, heavy congestion, traffic exceeds capacity

Table 1._Level-of-Service Criteria for Signalized and Un-signalized Intersections

Traffic operations at study area intersections were analyzed using the existing 2013 turning movement volumes and assuming the existing roadway geometry and traffic control. Alternative 1A is referred to as Alternative 3 in the Traffic report. Please see Appendix 4.

Results of the traffic operations analysis including control delay and LOS by intersection approach are summarized in Tables 2 and 3 for existing and proposed during AM and PM peak hours:

Antoine Drive Intersections	Existing (2013)		Projected (2035)		Projected (2035) Alternative 1	
	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS
Antoine Dr and Bridge Forest Dr	7.3	A	9.1	A	9.1	A
Antoine Dr and W Gulf Bank Rd	16.7	B	18.9	B	19.1	B
Antoine Dr and Long Creek Ln	6.3	A	5.4	A	5.3	A
Antoine Dr and Victory Dr	27.4	C	35.4	D	32.3	C
Antoine Dr and W Little York Rd	20.2	C	23.6	C	27.4	C
Antoine Dr and De Soto St	7.6	A	8.1	A	9.1	A
Antoine Dr and W Tidwell Rd	35.4	D	50.4	D	74.7	E
Antoine Dr and Pinemont Dr	40.3	D	58.8	E	33.5	C
Antoine Dr and Acorn St	2.8	A	5.4	A	7.5	A
Antoine Dr and W 43rd St	17.8	B	22.0	C	26.4	C
Antoine Dr and Saxon Dr	3.1	A	7.7	A	4.7	A
Antoine Dr and US Hwy 290 North	35.1	D	54.4	D	51.5	D
Antoine Dr and US Hwy 290 South	49.4	D	72.8	E	41.0	D

Table 2._Intersection Level of Service for Antoine Drive Study Corridor Morning (AM) Peak Hour

Based on the results, there are one intersection that will have a negative change in LOS during the morning with W Tidwell Road Drive having the least benefit changing from 35.4.1 (Sec/Veh) – D to 74.7 (Sec/Veh) – E.

Antoine Drive Intersections	Existing (2013)		Projected (2035)		Projected (2035) Alternative 3	
	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	Delay (Sec/Veh)
Antoine Dr and Bridge Forest Dr	5.2	A	6.0	A	6.7	A
Antoine Dr and W Gulf Bank Rd	23.0	C	29.3	C	28.9	C
Antoine Dr and Long Creek Ln	6.5	A	7.0	A	7.2	A
Antoine Dr and Victory Dr	46.4	D	68.1	E	69.0	E
Antoine Dr and W Little York Rd	19.8	B	20.2	C	21.2	C
Antoine Dr and De Soto St	10.4	B	5.8	A	11.2	B
Antoine Dr and W Tidwell Rd	37.7	D	47.4	D	42.0	D
Antoine Dr and Pinemont Dr	27.9	C	40.0	D	24.7	C
Antoine Dr and Acorn St	3.4	A	7.7	A	6.8	A
Antoine Dr and W 43rd St	30.6	C	39.6	D	30.8	C
Antoine Dr and Saxon Dr	7.9	A	25.2	D	24.8	C
Antoine Dr and US Hwy 290 North	29.5	C	50.8	D	33.2	C
Antoine Dr and US Hwy 290 South	25.7	C	50.9	D	23.3	C

Table 3._Intersection Level of Service for Antoine Drive Study Corridor Evening (PM) Peak Hour

The results shown in Table 3 indicate four intersections with negative change in LOS. The intersections with the least benefit is Victory Drive changing from 46.4 (Sec/Veh) – LOS D to 69.0 (Sec/Veh) – LOS E

Intersections along the Antoine Drive corridor were reviewed for minimum corner clearances and median lengths as recommended by the City of Houston Infrastructure Design Manual and the following intersection improvements are recommended:

1) **Intersection: Antoine Drive and Bridge Forest Drive**
   a) No changes made
2) **Intersection: Antoine Drive and W Gulf Bank Road**
   a) No changes made
3) **Intersection: Antoine Drive and Long Creek Lane**
   a) No changes made
4) **Intersection: Antoine Drive and Victory Drive**
   a) Add eastbound right-turn lane to 250'
   b) Add westbound right-turn lane (150')

An access management assessment of the corridor intersections has determined that all of the intersections have one or more non-compliant access management measures as described in the City of Houston Infrastructure Design Manual. The majority of the intersections do not meet the minimum corner clearances or median lengths as recommended (or required) by the City of Houston Infrastructure Design Manual.

6.3 Shared Use Paths

According to the COH Bikeway master plan. Antoine Drive has a planned bike lanes. For safety and design considerations these bike lanes were taken off-road and to be incorporated with the sidewalks. This will create an 11-ft wide shared use path on both sides of Antoine for bicyclists and pedestrians. These shared use paths will also improve the pedestrian circulation, mobility and safety along Antoine and bring these facilities up to ADA standards.

7.0 Real Estate Acquisition/Right-of-Way

Omega used a combination of resources to estimate Right-of-Way acquisitions. Sources range from field investigations, using Geographic Information Systems (GIS) and Harris County Appraisal District (HCAD). Acquisition of additional Right-of-Way (ROW) will be required in order to execute Alternative 1. The existing ROW varies along the study area from 100-ft to 120-ft. Based on HCAD Real Property Records, the price per square-foot range from $5.00 to $7.50. For analysis purposes, a strip area of the parcels was determine and then the HCAD rate was multiplied by three (3) to match City of Houston recommendation.

Alternative 1A (100-ft ROW) will not require land acquisition from Bridge Forest to Victory.

8.0 Drainage

Antoine Drive from Bridge Forest to US 290 in Northwest Houston is a four lane divided boulevard roadway with curb and gutter and storm sewer drainage. The project reach is approximately 22,300-feet in length

with ten storm sewer systems and drainage outfalls: two (2) into Vogel Creek (E121-00-00), four (4) into White Oak Bayou (E100-00-00), two (2) into Cole Creek (E117-00-00), and two (2) into Brickhouse Gully (E115-00-00). Flood Insurance Study mapped 100-year floodplains from all four outfall channels inundates a significant portion of the study reach. Of the ten storm sewer systems the two shortest systems are 18-years old and the remaining systems vary from 38 to 58 years old. The analysis found that most of the storm sewer systems have discharge capacities that are less than the current 2-year design standard.

There are identified CDP 2-Yr Proposed Storm Upgrades for six storm sewer systems along Antoine Drive.

The proposed condition consists of rebuilding Antoine Drive to 6-lanes with shared use paths and wide median in a proposed 120-ft ROW from Northwest Fwy to Tidwell and 4-lanes with shared use paths in each direction and wide median in a proposed 100-ft ROW from Tidwell to Bridge Forest. Please see attached typical sections for your reference. Antoine is divided to two projects, Antoine North and Antoine South within the original project limits. The breaking point between the two projects is at Victory Drive.

Storm sewer trunk lines were sized for proposed conditions such that the 2-year runoff did not exceed the normal flow capacity of the storm sewer and that the 100-year HGL did not exceed the ROW elevations. Alternative drainage systems were studied at two outfalls. The first alternative considered rerouting the drainage along Antoine that currently drains to W Gulf Bank Road. The rerouted drainage would flow southward to the Long Creek Lane storm sewer system. The benefit of this alternative would eliminate the need to replace the storm sewer system and the associated street repairs along W Gulf Bank Road. The second alternative considered diverting flow from Antoine Drive at DeSoto Street to White Oak Bayou. The benefit of this alternative would eliminate the need to replace the existing storm sewer along Antoine Drive north of DeSoto Street to White Oak Bayou because the size of the existing system is adequate for the reduced drainage area.

Storm water detention volume needs were computed based on the additional impervious cover created by the added pavement width of the proposed roadway. The volume was computed based on a factor 0.5 ac-ft. /acre of additional impervious cover. The total volume of storm water detention needed is 6.77 ac-ft. It is understood that the City has purchase land within Inwood Forest that will provide regional storm water storage volume and compensate for impacts created by this project.

Cost estimates were prepared for each studied outfall and alternative drainage scenario. The total estimate drainage cost for maintaining the existing drainage outfalls is $5.48M. Note that this cost does not include the associated street repairs that would be required along W Gulf Bank Road. The total estimated drainage cost with the alternative drainage conditions is $4.94M, a savings of $535K plus the repairs of W Gulf Bank Road would not be needed. However, any associated repairs for the DeSoto Street diversion have not been included. Storm water detention costs were also estimated based on the storage volume required. Specific locations for storm water detention were not identified because of the regional facility the City will be constructing in the Inwood Forest area. The total cost for storm water detention is estimated to be $2.25M.

The study reach has been divided into two sub-projects, with the divides set at Victory Drive. The estimated drainage system costs for the reach from Bridge Forest to Victory is $0.90M using existing outfalls, and $0.96M using the alternative outfall. Storm water detention cost estimate for this reach is $0.55M. The estimated drainage system costs for the reach from Victory to US 290 is approximately $4.57M. There is no alternative system for this reach. Storm water detention cost estimate for this reach is $1.69M.

Note, these cost estimates are intended to be included with the overall project costs and therefore do not include a contingency factor, construction management costs, engineering fees, and design management costs.

Proposed Drainage Systems

Drainage will be provided in underground storm sewers. The proposed storm sewer trunk lines were determine with HouStorm, a computer program that models storm sewers with drainage areas, nodes and links. Using defined drainage areas and the 1-ft topographic contours for approximate slopes, storm sewer trunk lines were sized for the length of the study area. The trunk lines were sized so that the 2-year HGL remained below an assumed gutter elevation and that the 100-year HGL remained below the natural ground elevation at the ROW. The starting water surface elevation for each storm sewer was set at the soffit of the proposed storm sewer for both the 2-year and 100-year storm events, because the 100-year water surface elevation at each outfall is above the banks of the channel, as indicated by the mapped floodplains. Additionally, above ground storm water conveyance within the ROW during the 100-year storm event was not considered because proposed roadway profiles have not been prepared.

The increased impervious cover increases the storm water runoff which needs to be mitigated with storm water detention. The amount of storm water detention is determined by using the factor of 0.5 ac-ft of storage volume for every acre of additional impervious cover. This factor is from the City of Houston Infrastructure Design Manual, Chapter 9 Stormwater Design Requirements. Multiplying the additional pavement width of 28-ft by the reach length provides the amount of additional impervious cover. Using the detention rate of 0.5 ac-ft/ac, the amount of storage volume was determined. The following table lists the outfalls and required storm water storage volume based on the roadway length associated with each outfall.

Outfall	Roadway Length	Require Storage Volume	
	LF	CF	Ac-Ft
W Gulf Bank Road	1,280	14,080	0.32
Long Creek Lane	3,500	38,500	0.88
Maple Hill Road	1,320	14,520	0.33
Victory Drive	760	8,360	0.19
White Oak Bayou North	550	6,050	0.14
White Oak Bayou South	4,940	54,340	1.25
Cole Creek North	1,650	26,400	0.61
Cole Creek South	3,000	48,000	1.10
Brickhouse Gully North	3,800	60,800	1.40
Brickhouse Gully South	1,500	24,000	0.55
Total	**22,300**	**295,050**	**6.77**

The storm water detention basins needed to mitigate the impact created by additional impervious cover will be provided in a regional storm water facility being created by the City of Houston within the Inwood Forest area.

The storm sewer trunk lines were sized using the existing drainage outfalls. Alternative analyses were performed on two systems where significant cost savings may be realized.

Alternative 1:

The drainage along Antoine at W Gulf Bank Road was routed southward and combined with the outfall at Long Creek Lane. With this alternative the existing storm sewer and roadway paving along W Gulf Bank Road would not need to be rebuilt. Additionally, the capacity of the existing storm sewer along W Gulf Bank Road would become adequate to maintain the 100-year flows below ROW elevations.

Alternative 2:

The White Oak Bayou South storm sewer runs from the railroad tracks northward and discharges directly into White Oak Bayou. This alternative truncates the upstream end of the drainage area from south of DeSoto Street and diverts the storm water through a proposed new storm sewer pipe toward the east to outfall directly into White Oak Bayou. By removing the drainage area south of DeSoto Street the White Oak Bayou South storm sewer system will have sufficient capacity to maintain the 100-year HGL below street ROW elevations.

The following table lists the results of the modeling and calculations. The table includes for each outfall the size and length of the existing storm sewer system, the proposed storm sewer system, and the required replacement pipes. The required replacement pipes lists only those storm sewer segments that need to be replaced, whereas the proposed storm sewer system lists the entire system and includes those existing pipes that do not need to be replaced. Appendix A of the Drainage Report contains the HouStorm models of the proposed storm sewer systems, and Exhibits 2A, 2B, 2C, 2D and 2E shows the various drainage areas and outfalls for the proposed conditions.

9.0 Utilities

Water and wastewater improvements discussed in this section were recommended by the City of Houston. These recommendations are unchanged from the previous report. The water improvement consists of replacing the existing line with a proposed 16” equivalent (23,595-ft.). The wastewater recommendation is to incorporate 8,456-ft with a 24” line and, 5,244-ft of 36” line. The respective exhibits for water and wastewater recommendations can be seen in Appendix- D.

10.0 Recommended Alternative Summary

Alternative 1A- 4 lane with wide medians, ROW: 100-ft

- Total Candidate project Cost : **$22,492,795.58** Project Priority Score 1A: 177.6

Figure 2 _ Alternative Study

11.0 Public Comments

The comments received from the public at the public meeting brought up by residents and other stakeholders along Antoine Drive and its vicinity were collected during the meeting and after the meeting via email and mail (Appendix 6). The most common issue that arose in the comments was Traffic related issues like Speeding, Congestions, Safety, street signs, Drainage issues, and construction phases. The comments are categorized as the following:

I. Drainage Concerns:

a. Flooding: Some areas at Antoine suffer from flooding and ponding after storm events. Residents mentioned several locations; in particular the intersection of Antoine and Green falls, and Antoine and Arncliff.
b. Curb inlets are mostly blocked be debris which cause ponding along the street.

II. Traffic Issues:

a. Speed limit and speed control was the concerns of many residents, the common observation is many drivers exceed posted speed limits and cause safety concerns. Solutions were requested like adding permanent speed meters and other enforcement measures like increasing police patrols.
b. Traffic volume will increase by widening the road, which is not preferred by many residents for many reasons; like speeding, safety, littering and noise.
c. Car accidents: because of the current street condition, residents reported the reoccurrence of accidents in particular locations like the entrance and exit of Eisenhower High School
d. Traffic congestions mainly at Antoine at Tidwell north bound and Antoine and 43rd south bound.

III. Public Transportation

Plans to extend the light rail to reach this area.

IV. Trash collection and street cleaning:

With increased mobility litter and trash will increase. Is the city committed to increase their services to keep with the growth?

V. Bike lanes:

Some residents have mentioned that walking and biking are not a viable mode of transportation in Houston given the vast area of the city and its climate, the urge the City of Houston to reconsider allocating the resources of these elements to be spent on other more urgent needs in Antoine. Also, the volume of traffic going through Antoine makes it unsafe for bikers and pedestrians to travel along the corridor. Other residents at the project area felt that the shared used paths are going to be helpful.

VI. Roadway:

the reduction from 6 to 4 lane will cause traffic to back up where the transition occurs widening the road will bring more 18 wheelers through the street, which is not a positive point knowing that a lot of properties along Antoine are residential pavement condition is bad along the corridor.

VII. Street Signage along Antoine:

As the new improvements will bring more people by different modes; driving, walking and biking. More street signage, lighting, and pedestrian safety is required.

VIII. Right of Way:

Residents wanted to know if there will be properties lost due to additional Right of Way acquisition For medians; some medians will be reduced from both sides to accommodate the new road elements and the shared use paths.

IX. Aesthetics:

a. Bridges are old and with little aesthetic value
b. Some of the medians are well groomed and others are neglected and plain

Conclusions and Recommendations

This Final Scope Memorandum has incorporated ideas, concepts, and suggestions raised at the public meeting event and the input acquired later by mail and email messages from the resident and stakeholders at the study area, as appropriate.

In addition, certain design related public comments should be taken in consideration and incorporated during final design phase following further research and deliberation.

Appendix 1

Cost Estimate

Pre-Engineering Services Contracts

Total Project Cost Estimate Breakdown (FY15 Dollars)

Need No. N-2013T-0013 ANTOINE DRIVE NORTH FROM BRIDGE FOREST TO VICTORY

Alt #: 1A

1	**410 (Summarized based on FY 15 List of Unit Prices)**		$10,812,409.65
	1.1	Total Unit Price, Paving Items	$4,415,719.77
	1.2	Total Unit Price, Storm Sewer Items	$833,175.00
	1.3	Total Unit Price, Water Items	$1,296,187.20
	1.4	Total Unit Price, Wastewater Items	$4,267,327.68
2	**Contingency (30% of 410)**		**$3,243,722.90**
3	**Construction Management (15% of 410)**		**$1,621,861.45**
4	**Engineering Fee Estimate (17% of Sum of 410 and Contingency)**		**$2,389,542.53**
5	**Design Management (15% of Engineering Fee Estimate)**		**$358,431.38**
6	**Land Acquisition (Engineer's Best Estimate)**		**$994,010.00**
	Total Project Cost		**$19,419,977.91**

Note: General Items are prorated in Paving, Storm, Water & Wastewater items.

MODIFIED SAMPLE 410

NEED AREA: N-2013T-0013 ANTOINE DRIVE NORTH FROM BRIDGE FOREST TO VICTORY **BID FORM**
ALTERNATIVE: 1A **PART B**

Document 00410B Note 1

BID FORM - PART B

1.0 TOTAL BID PRICE HAS BEEN CALCULATED BY BIDDER, USING THE FOLLOWING COMPONENT PRICES AND

A. STIPULATED PRICE **$ N/A**

(Total Bid Price; minus Base Unit Prices, Extra Unit Process, Cash Allowance and All Alternates, if any)

B. BASE UNIT PRICE TABLE:

Item No.	Item Reference No. Note 2	Spec No.	Item Description	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total in Figures
UNIT PRICES - PAVING ITEMS							
1	222101	2221	Remove and Dispose of Existing Pavement and Curb -Assumes all concrete pavement thicknesses with or without asphalt overlay	SY	44,417.00	$6.00	$266,502.00
2	222102	2221	Remove and Dispose of Existing Driveways and Sidewalks	SY	8,431.00	$5.00	$42,155.00
3	275106	2751	11" Reinforced Concrete Pavement (Complete in Place)	SY	43,359.00	$66.00	$2,861,694.00
4	233602	2336	Lime stabilized subgrade (8" thick)	SY	48,099.00	$4.00	$192,396.00
5	233603	2336	Lime (6, 7% By Weight)	Ton	780.46	$160.00	$124,873.60
6	277101	2771	6" Concrete Curb	LF	24,761.00	$3.00	$74,283.00
7	275201	2752	Board Expansion Joint	LF	6,915.00	$8.00	$55,320.00
8	275401	2754	6" Concrete for Driveways	SF	14,904.00	$6.00	$89,424.00
9	289301	2775	Traffic Signal/Intersection	EA	4.00	$225,000.00	$900,000.00
10	277501	2775	4-1/2" Concrete for Sidewalks	SF	138,620.00	$5.00	$693,100.00
11			Ancillary items (5%)			5.00%	$264,987.38
12			SubTotal of Paving				$5,564,734.98
13			General Items (10% of Paving Subtotal)			10.00%	$556,473.50
TOTAL - PAVING ITEMS							**$6,121,208.48**

Bidders Initials [ ]

MODIFIED SAMPLE 410

NEED AREA: N-2013T-0013 ANTOINE DRIVE NORTH FROM BRIDGE FOREST TO VICTORY **BID FORM**
ALTERNATIVE: 1A **PART B**

Item No.	Item Reference No.[Note 2]	Spec No.	Item Description	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total in Figures
UNIT PRICES - STORM SEWER ITEMS							
1	222106	2221	Remove Manholes (All Types, All Depths)	EA	13	$388.00	$5,044.00
2	222105	2221	Remove Inlets (All Types)	EA	26	$347.00	$9,022.00
3	222103	2221	Remove Storm Sewer Pipe (All Types)	LF	4814	$15.00	$72,210.00
4	263301	2633	Curb Inlets (All Types)	EA	28	$2,450.00	$68,600.00
5	226001	2260	Trench Safety System	LF	4814	$2.00	$9,628.00
6	208201	2082	Manholes (For 42" Dia. Pipe and Smaller) (All Types)	EA	6	$3,100.00	$18,600.00
7	208202	2082	Manholes (For 48" to 72" Dia. Pipe) (All Types)	EA	8	$6,000.00	$48,000.00
8	263102	2631	30-inch RCP	LF	1212	$110.00	$133,320.00
9	263103	2631	36-inch RCP	LF	486	$138.00	$67,068.00
10	263104	2631	42-inch RCP	LF	486	$159.00	$77,274.00
11	263105	2631	48-inch RCP	LF	1190	$184.00	$218,960.00
	263106	2631	54-inch RCP	LF	1440	$225.00	$324,000.00
12			Ancillary items (10%)			10.00%	$105,172.60
13			SubTotal of Storm Sewer				$1,156,898.60
14			General Items (10% of Storm Sewer Subtotal)			10.00%	$115,689.86
TOTAL UNIT PRICES - STORM SEWER ITEMS							**$1,272,588.46**

Item No.	Item Reference No.[Note 2]	Spec No.	Item Description	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total in Figures
UNIT PRICES - WASTEWATER							
1	222108	2221	Remove Existing Sanitary Sewer Manhole (All Types)	EA	11.00	$800.00	$8,800.00
2	22109	2221	Remove Existing Sanitary Sewer Pipe (All Types)	LF	8395.00	$20.00	$167,900.00
3	253107	2531	24" PVC	LF	8395.00	$360.00	$3,022,200.00
4	208204	2082	Sanitary Sewer Manholes	EA	11.00	$4,041.00	$44,451.00
5			Ancillary Items (20%)			20.00%	$648,670.20
6			SubTotal of Wastewater				$3,892,021.20
7			General Items (10% of Wastewater Subtotal)			10.00%	$389,202.12
TOTAL UNIT PRICES - WASTEWATER							**$4,281,223.32**

Bidders Initials [ ]

MODIFIED SAMPLE 410

NEED AREA: N-2013T-0013 ANTOINE DRIVE NORTH FROM BRIDGE FOREST TO VICTORY **BID FORM**
ALTERNATIVE: 1A **PART B**

Item No.	Item Reference No. Note 2	Spec No.	Item Description	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total in Figures
UNIT PRICES - WATER							
1	251105	2511	16" Water Line	LF	7,014	161	$1,129,254.00
		-	Ancillary items (20%)	LS	1	20.00%	$225,850.80
			SubTotal				$1,355,104.80
		-	General Items (10% of Water SubTotal)			10.00%	$135,510.48
TOTAL UNIT PRICES - WATER							**$1,490,615.28**

Item No.	Item Reference No. Note 2	Spec No.	Item Description	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total in Figures
UNIT PRICES - DETENTION							
1	500001	-	Excavation (Detention Pond) (Dry)	AC-FT	1.7	$20,000.00	$33,200.00
2		-	Excavation (Detention Pond) (Wet)	AC-FT			$0.00
TOTAL UNIT PRICES - DETENTION							**$33,200.00**

TOTAL BASE UNIT PRICE: Note 3 **$13,198,835.54**

C. EXTRA UNIT PRICE TABLE:

Item No.		Spec No.	Item Description	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total in Figures
UNIT PRICES - EXTRA UNIT PRICE TABLE ITEMS							
TOTAL UNIT PRICES - EXTRA UNIT PRICE TABLE ITEMS							

D. CASH ALLOWANCE TABLE:

Item No.		Spec No.	Cash Allowance Short Table		Cash Allowance in Figures (1)
TOTAL CASH ALLOWANCES					

E. ALTERNATES TABLE:

Item No.		Spec No.	Alternate Short Tittle	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total Price for Alternates in Figures
TOTAL CASH ALLOWANCES							

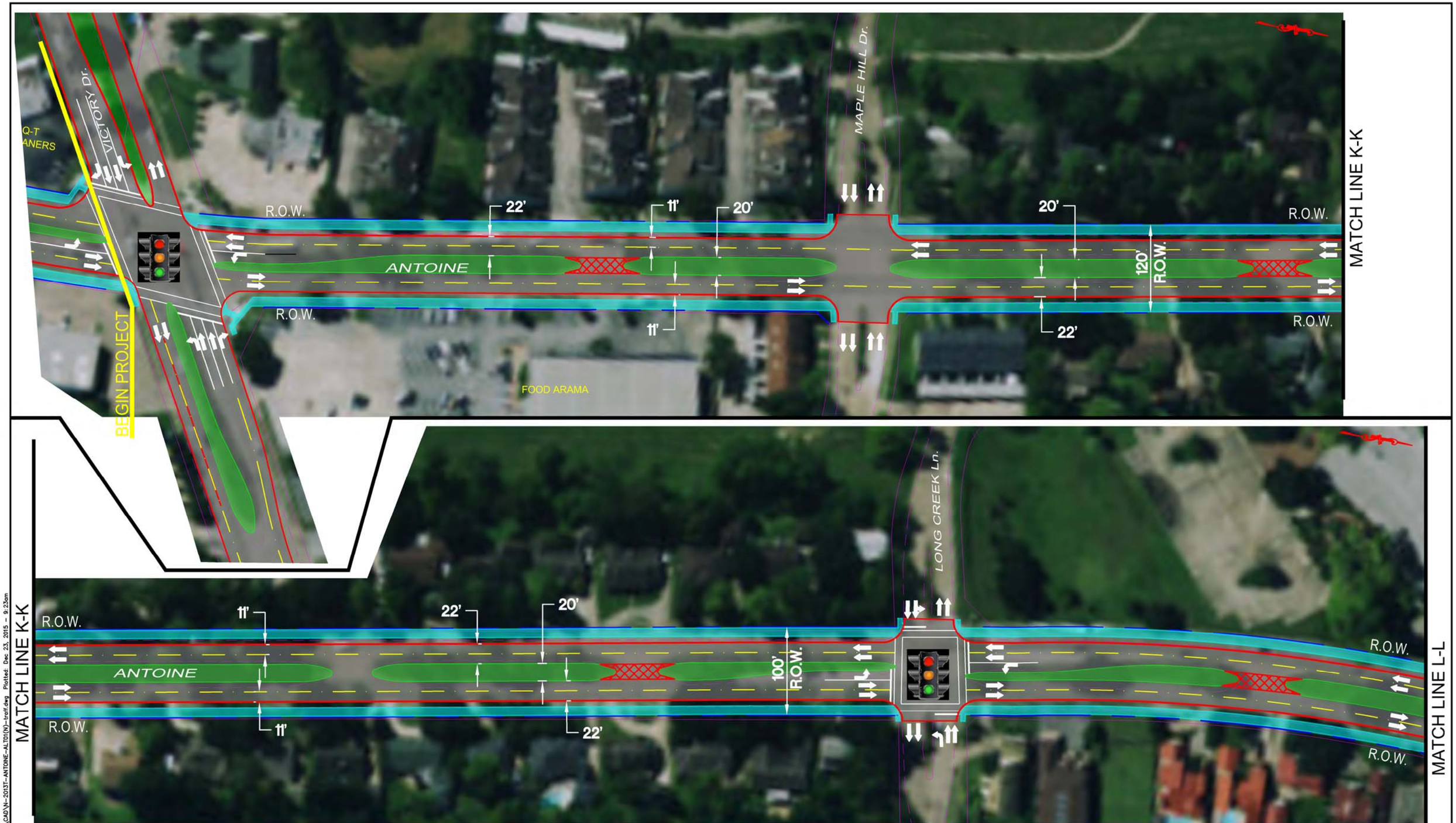
Note:

1. This is not a Standard Document 00410B (Form 410). The Form 410 was modified for the purpose of planning level cost estimates for Pre-Engineering Studies.
2. The "Item Reference No." shall be designated for each item listed. The numbers serve as reference and will be used for the future cost updates.
3. The unit prices used to develop this cost estimate are based on FY16 unit prices.

Bidders Initials [ ]

Appendix 2

Traffic & Utilities Layouts



EXISTNG R.O.W.
EXISTING EDGE OF PAVEMENT
PROPOSED R.O.W.
PROPOSED CONCRETE PAVEMENT
PROPOSED MEDIAN

POTENTIAL MEDIAN CLOSURE
PROPOSED EDGE OF PAVEMENT

0 50 100
SCALE: 1"=100'

CITY OF HOUSTON

DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

PRE-ENGINEERING FOR THOROUGHFARE IMPROVEMENTS

ANTOINE FROM US290 TO BRIDGE FOREST DR

WORK NO. N100-005-3

OMEGA ENGINEERS, INC.
16360 PARK TEN PLACE, Ste. #325
HOUSTON TEXAS, 77084
OMEGAENGINEERS.COM
TX PE Firm Reg. No. F-2147
P: 281 647 9182 F: 281 647 9184

"FOR EXHIBIT PURPOSES ONLY, NOT FOR BIDDING OR CONSTRUCTION"

SHEET TITLE: ANTOINE DR. US290 TO BRIDGE FOREST DR. (NORTH) ALTERNATIVE 1 & TRAFFIC

JOB NO.: XXXXXX

DATE: December 21, 2015

SHEET NO.: EXHIBIT 1 OF 3

H:\2013-003\WO 03\3.Antoine Road\CAD\N-2013T-ANTOINE-ALT01(N)-traff.dwg Plotted: Dec 23, 2015 - 9:23am

EXISTNG R.O.W.
EXISTING EDGE OF PAVEMENT
PROPOSED R.O.W.
PROPOSED CONCRETE PAVEMENT
PROPOSED MEDIAN

POTENTIAL MEDIAN CLOSURE
PROPOSED EDGE OF PAVEMENT

0 50 100
SCALE: 1"=100'

CITY OF HOUSTON

DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

PRE-ENGINEERING FOR THOROUGHFARE IMPROVEMENTS

ANTOINE FROM US290 TO BRIDGE FOREST DR

WORK NO. N100-005-3

OMEGA ENGINEERS, INC.
16360 PARK TEN PLACE, Ste. #325
HOUSTON TEXAS, 77084
OMEGAENGINEERS.COM
TX PE Firm Reg. No. F-2147
P: 281 647 9182 F: 281 647 9184

"FOR EXHIBIT PURPOSES ONLY, NOT FOR BIDDING OR CONSTRUCTION"

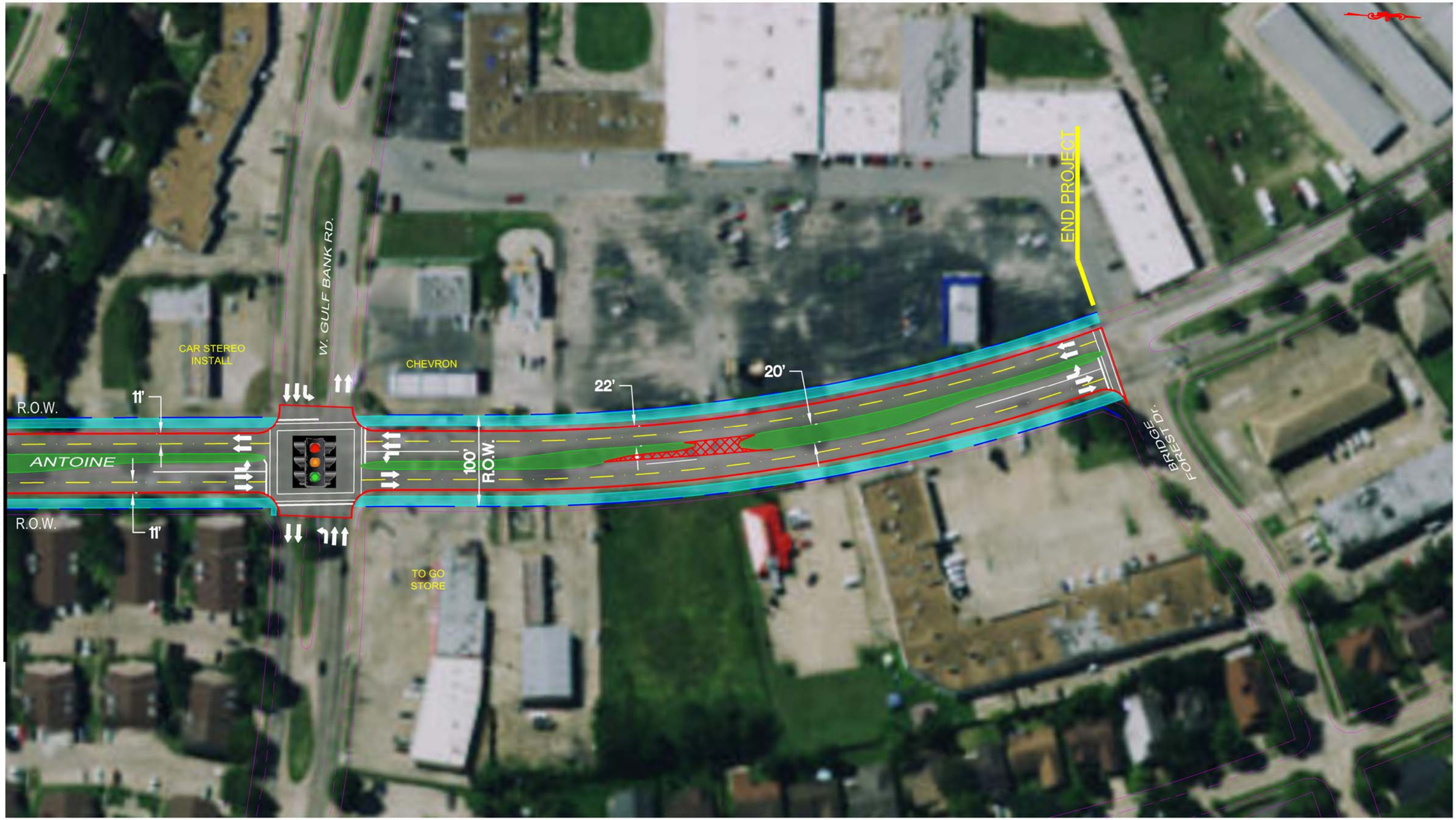
SHEET TITLE: ANTOINE DR. US290 TO BRIDGE FOREST DR. (NORTH) ALTERNATIVE 1 & TRAFFIC

JOB NO: XXXXXX

DATE: December 21, 2015

SHEET NO: EXHIBIT 2 OF 3

H:\2013-003\WO 03\Antoine Road\CADD\N-2013T-ANTOINE-ALT01(N)-traff.dwg Plotted: Dec 23, 2015 - 9:24am



EXISTNG R.O.W.
EXISTING EDGE OF PAVEMENT
PROPOSED R.O.W.
PROPOSED CONCRETE PAVEMENT
PROPOSED MEDIAN

POTENTIAL MEDIAN CLOSURE
PROPOSED EDGE OF PAVEMENT

0 50 100
SCALE: 1"=100'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
PRE-ENGINEERING FOR THOROUGHFARE IMPROVEMENTS
ANTOINE FROM US290 TO BRIDGE FOREST DR
WORK NO. N100-005-3

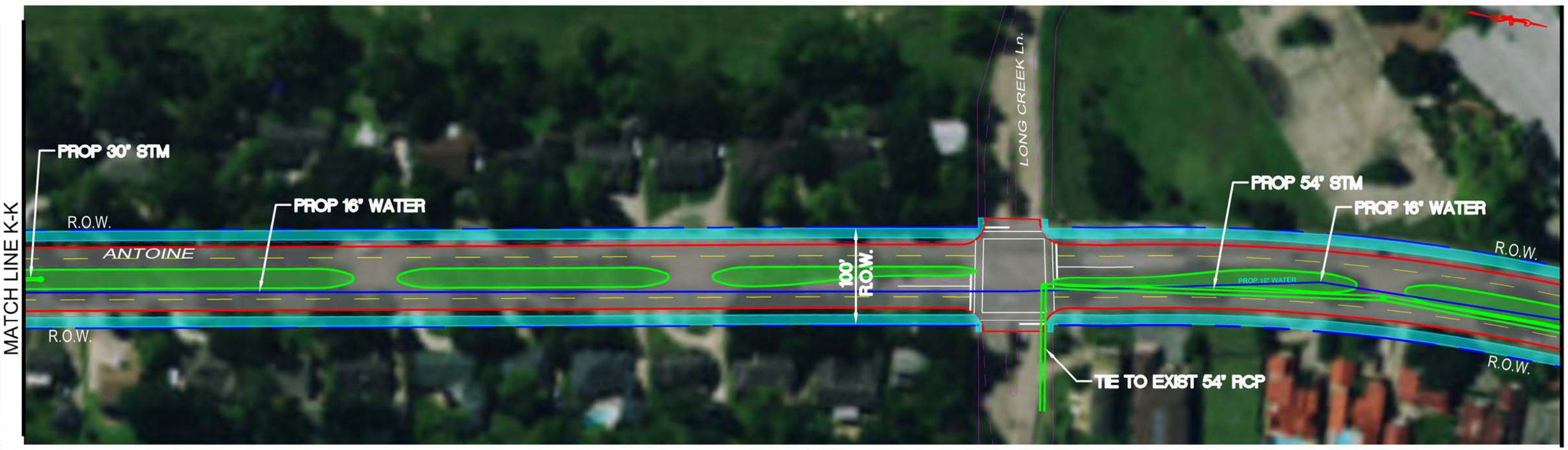
OMEGA ENGINEERS, INC.
16360 PARK TEN PLACE, Ste. #325
HOUSTON TEXAS, 77084
OMEGAENGINEERS.COM
TX PE Firm Reg. No. F-2147
P: 281 647 9182 F: 281 647 9184

"FOR EXHIBIT PURPOSES ONLY, NOT FOR BIDDING OR CONSTRUCTION"

SHEET TITLE: ANTOINE DR. US290 TO BRIDGE FOREST DR. (NORTH) ALTERNATIVE 1 & TRAFFIC

JOB NO: XXXXXX
DATE: December 21, 2015
SHEET NO: EXHIBIT 3 OF 3

H:\2013-003\WO 03\Antoine Road\CAD\N-2013T-ANTOINE-ALT01(N)-traff.dwg Plotted: Dec 23, 2015 - 9:25am



LEGEND

- PROP SAN SWR
- PROP WATER LINE
- PROP STORM SWR

0 50 100
SCALE: 1"=100'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
PRE-ENGINEERING FOR THOROUGHFARE IMPROVEMENTS
ANTOINE FROM US290 TO BRIDGE FOREST DR
WORK NO. N100-005-3

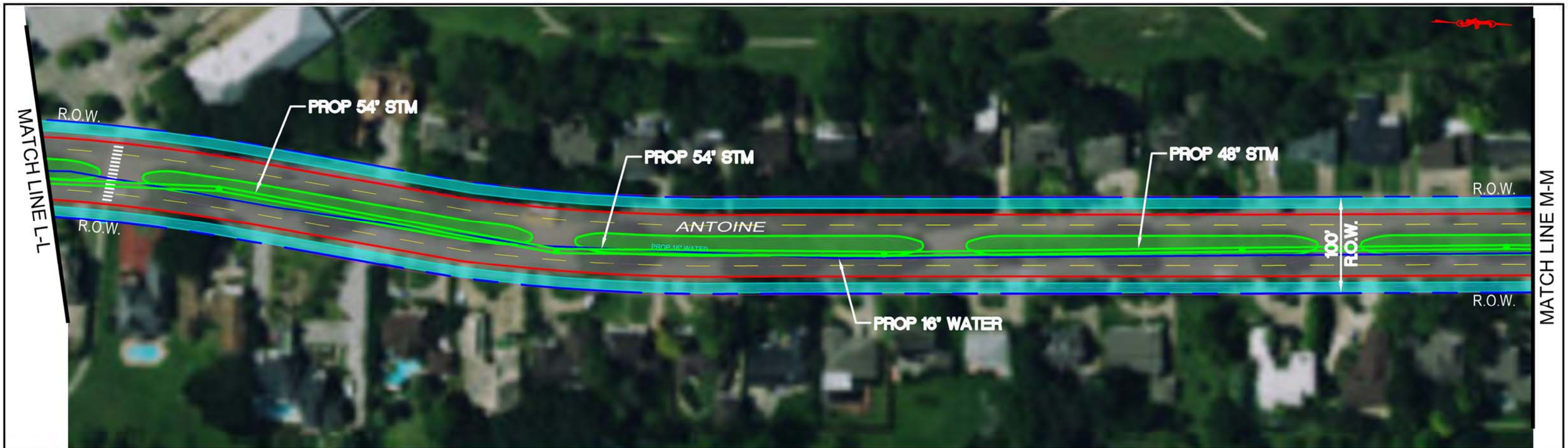
OMEGA ENGINEERS, INC.
16360 PARK TEN PLACE, Ste. #325
HOUSTON TEXAS, 77084
OMEGAENGINEERS.COM
TX PE Firm Reg. No. F-2147
P: 281 647 9182 F: 281 647 9184

"FOR EXHIBIT PURPOSES ONLY, NOT FOR BIDDING OR CONSTRUCTION"

SHEET TITLE: ANTOINE DR. US290 TO BRIDGE FOREST DR.
PROPOSED STORM & UTILITY LAYOUT

JOB NO. XXXXXX
DATE: December 1, 2015
SHEET NO. EXHIBIT 1 OF 3

H:\2013-003\WO 03\3.Antoine Road\CAD\N-2013T-ANTOINE-ALT01(N)-util.dwg Plotted: Dec 02, 2015 - 1:36pm



LEGEND

- PROP SAN SWR
- PROP WATER LINE
- PROP STORM SWR

0 50 100
SCALE: 1"=100'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
PRE-ENGINEERING FOR THOROUGHFARE IMPROVEMENTS
ANTOINE FROM US290 TO BRIDGE FOREST DR
WORK NO. N100-005-3

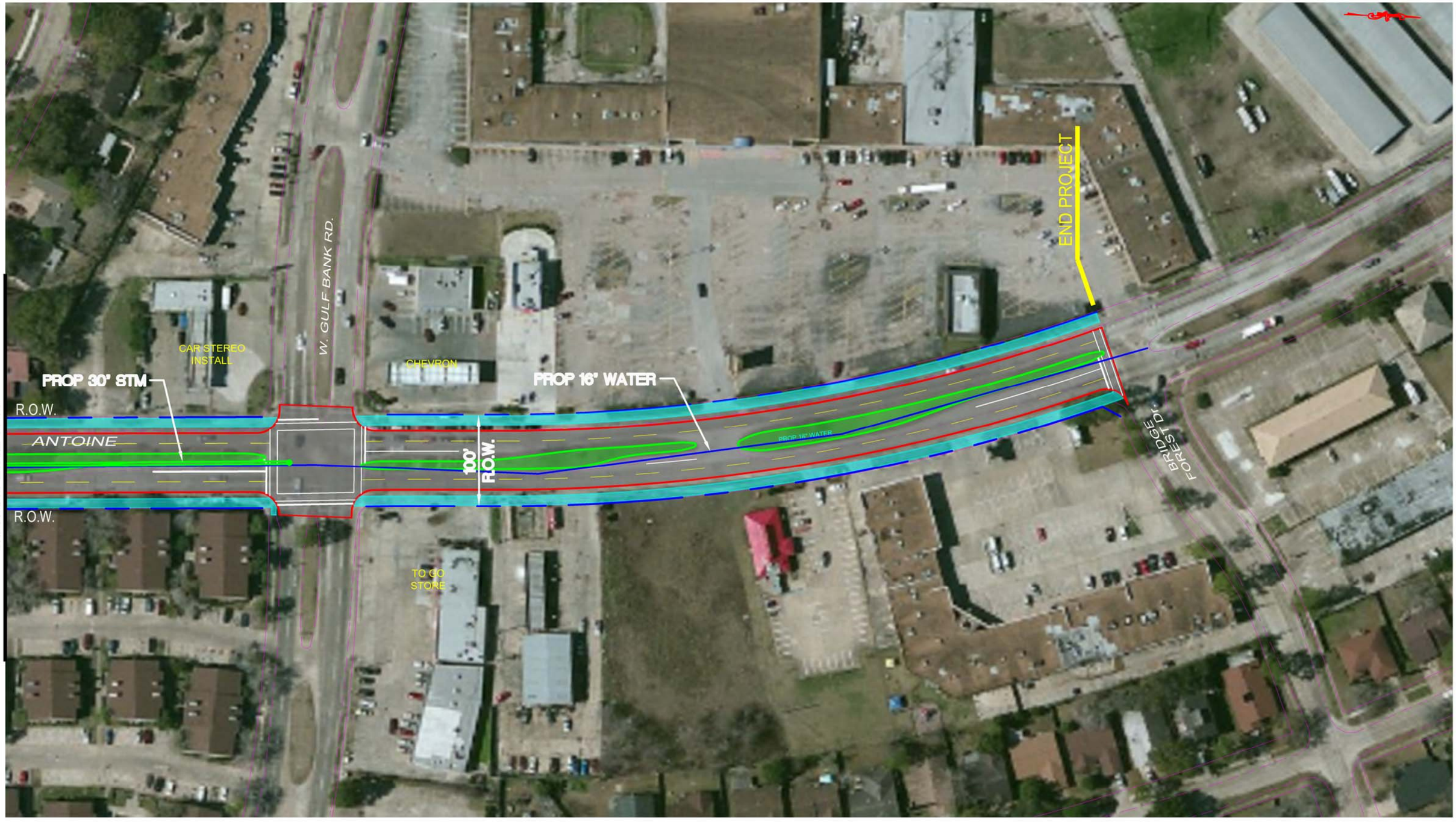
OMEGA ENGINEERS, INC.
16360 PARK TEN PLACE, Ste: #325
HOUSTON TEXAS, 77084
OMEGAENGINEERS.COM
TX PE Firm Reg. No. F-2147
P: 281 647 9182 F: 281 647 9184

"FOR EXHIBIT PURPOSES ONLY, NOT FOR BIDDING OR CONSTRUCTION"

SHEET TITLE: ANTOINE DR. US290 TO BRIDGE FOREST DR.
PROPOSED STORM & UTILITY LAYOUT

JOB NO: XXXXXX
DATE: December 1, 2015
SHEET NO: EXHIBIT 2 OF 3

H:\2013-003\WO 03\3.Antoine Road\CAD\N-2013T-ANTOINE-ALT01(N)-util.dwg Plotted: Dec 02, 2015 - 1:30pm



LEGEND

- PROP SAN SWR
- PROP WATER LINE
- PROP STORM SWR

0 50 100
SCALE: 1"=100'

CITY OF HOUSTON

DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

PRE-ENGINEERING FOR THOROUGHFARE IMPROVEMENTS

ANTOINE FROM US290 TO BRIDGE FOREST DR

WORK NO. N100-005-3

OMEGA ENGINEERS, INC.
16360 PARK TEN PLACE, Ste. #325
HOUSTON TEXAS, 77084
OMEGAENGINEERS.COM
TX PE Firm Reg. No. F-2147
P: 281 647 9182 F: 281 647 9184

"FOR EXHIBIT PURPOSES ONLY, NOT FOR BIDDING OR CONSTRUCTION"

SHEET TITLE: ANTOINE DR. US290 TO BRIDGE FOREST DR.

PROPOSED STORM & UTILITY LAYOUT

JOB NO: XXXXXX

DATE: December 1, 2015

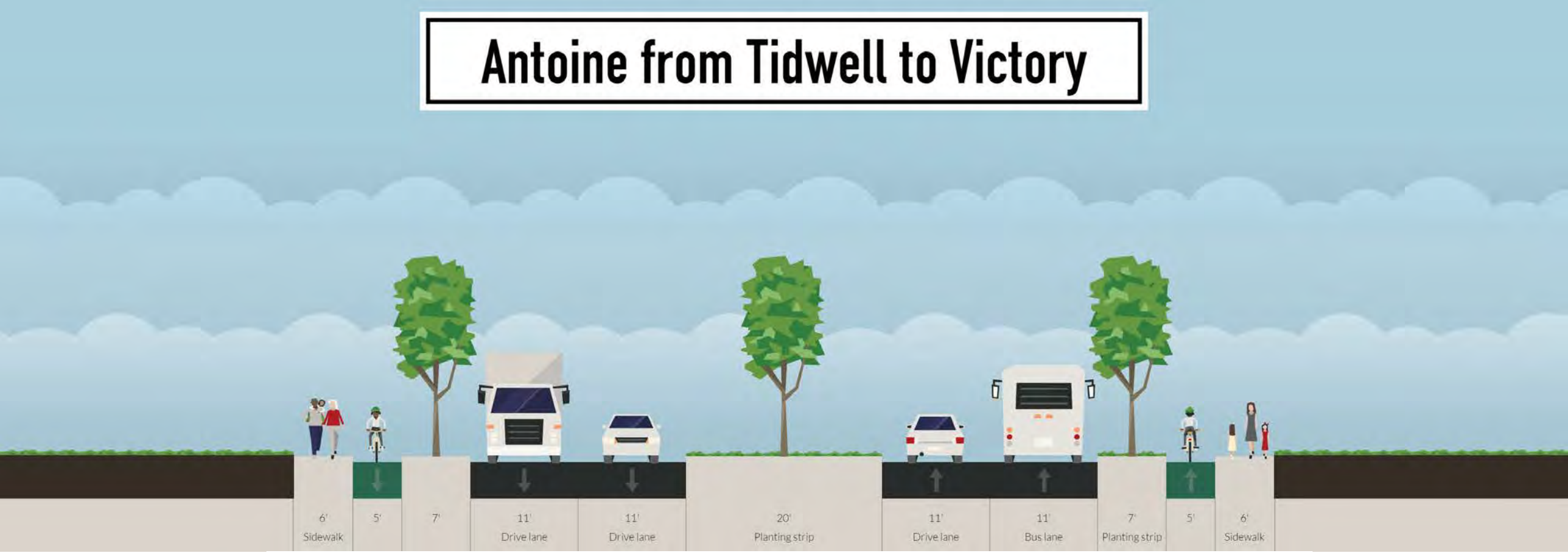
SHEET NO: EXHIBIT 3 OF 3

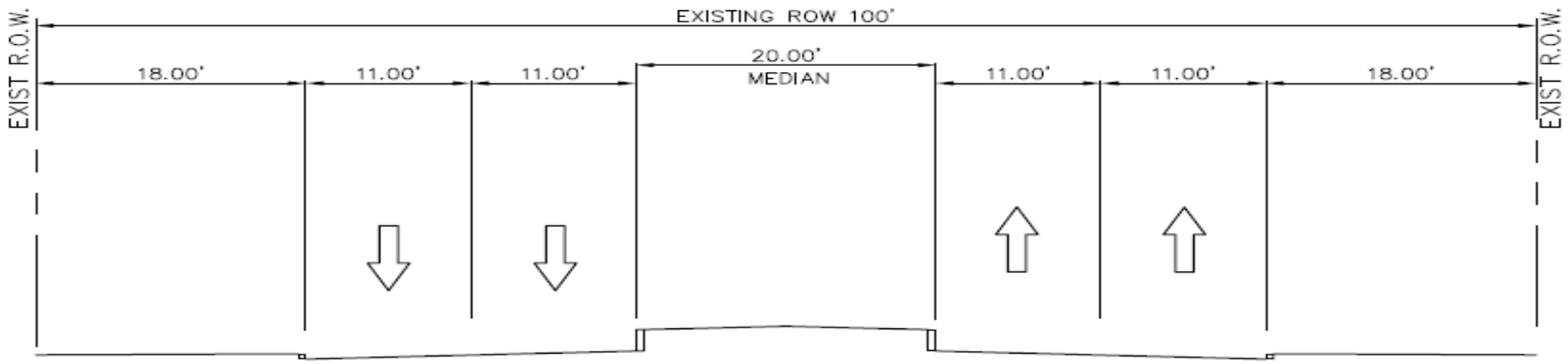
H:\2013-003\WO 03\Antoine Road\CAD\H-2013T-ANTOINE-ALT01(N)-util.dwg Plotted: Dec 02, 2015 - 1:32pm

Appendix 3

Existing & Proposed Typical Section & Layouts

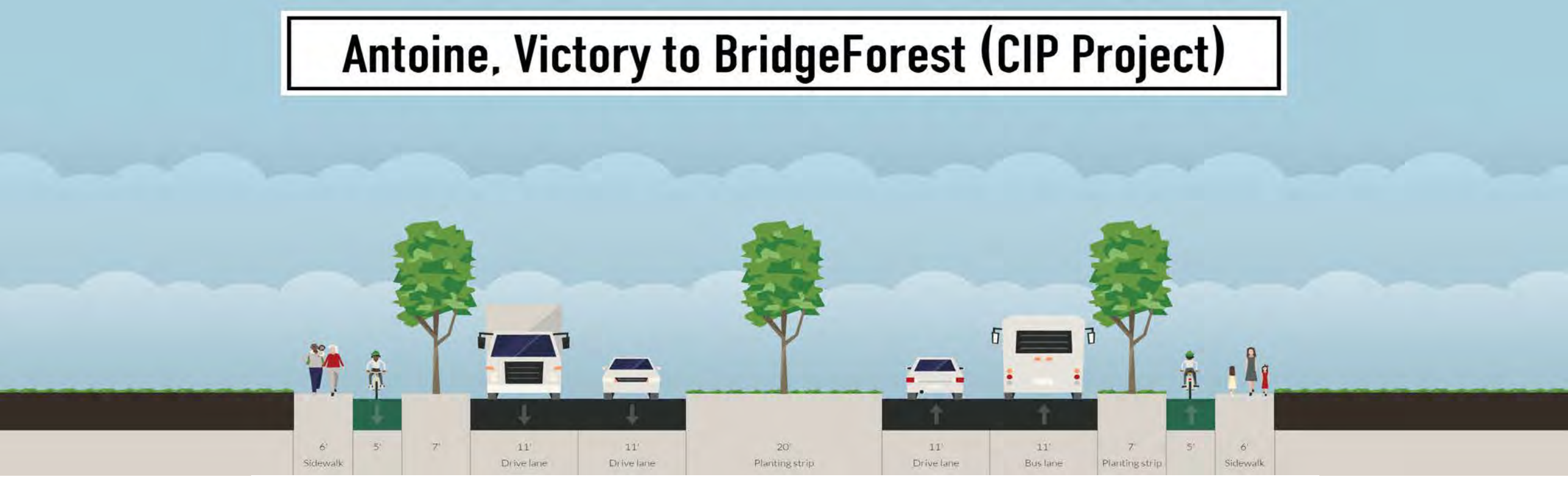
Antoine from Tidwell to Victory

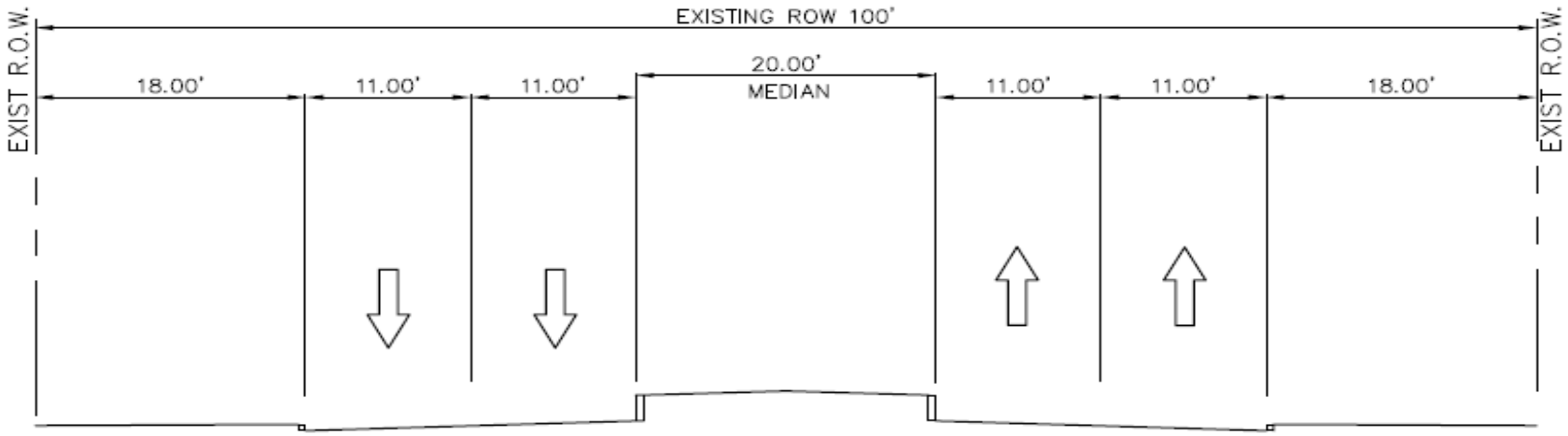




EXISTING SECTION
FROM TIDWELL TO VICTORY

Antoine, Victory to BridgeForest (CIP Project)





EXISTING SECTION
FROM VICTORY TO BRIDGEFOREST

Appendix 4

Traffic Report

TECHNICAL MEMORANDUM

TO: Edelmiro Castillo, P.E., Omega Engineers, Inc.
FROM: Rene Arredondo, P.E., PTOE, AC Group, LLC
DATE: November 23, 2015

SUBJECT: Traffic Engineering Study
Final Pre-Engineering Report – Intersection Capacity Analysis
Work Order No. 13: WBS No. N-000100-0005-3
Pre-Engineering Services for:
Corridor 2, N-2013T-0013, Antoine Drive from Bridge Forest Dr to US Hwy 290

The purpose of this traffic engineering study technical memorandum is to document the capacity analysis performed for updating the Antoine Drive corridor improvements recommended by the Northwest Houston Mobility Study. Updates to the Antoine Drive corridor included reverting the original corridor typical section from 6 lanes to 4 lanes between Tidwell Road to Bridge Forest.

Antoine Drive is a north-south, four-lane divided roadway. The posted speed limit is 35 miles per hour for the commercial area and 30 miles per hour for the residential area of the corridor. The corridor also encourages cyclists to share the road with symbolic bicyclist signs with a descriptive plaque signs of "SHARE THE ROAD" on both sides of the roadway. The study corridor between Acorn Street and Bridge Forest Drive is predominantly commercial along both sides of the corridor including some residential apartment complexes. The study corridor between Acron Street and US Highway 290 is predominantly residential with Scarborough High School located between W 43rd Street and Saxon Drive.

Traffic Analysis:

In addition to the updated intersection capacity analysis for all major intersections along Antoine Drive, specifically analysis of the 4-lane typical section between Tidwell Road and Bridge Forest, this traffic analysis included the assessment of control delay (seconds per vehicle) associated with the existing at-grade rail road crossing located north of Tidwell Road. Traffic data collected at the rail road crossing revealed approximately 6 crossing events during each peak period with the maximum roadway blockage of three minutes. Tables 3 and 4 show the results of the Tidwell Road intersection average control delay with (assuming no overpass crossing) and without (assuming overpass crossing) vehicle delay associated with 6 hourly rail crossings north of Tidwell Road.

Table 1. Level-of-Service Criteria for Signalized and Unsignalized Intersections

Level-of-Service (LOS)	Control Delay (seconds/vehicle)		Description
	Signalized Intersections	Unsignalized Intersections	
A	≤10.0	≤10.0	Very low vehicle delay, free traffic flow, good signal progression
B	10.1 to 20.0	10.1 to 15.0	Good signal progression, more vehicle stops and higher delay than LOS A
C	20.1 to 35.0	15.1 to 25.0	Stable traffic flow, fair signal progression, significant number of vehicle stops
D	35.1 to 55.0	25.1 to 35.0	Noticeable traffic congestion, longer delays and unfavorable signal progression
E	55.1 to 80.0	35.1 to 50.0	Limit of acceptable vehicle delay, unstable traffic flow, poor signal progression
F	> 80.0	> 50.0	Unacceptable delay, extremely unstable flow, heavy congestion, traffic exceeds capacity

Source: Highway Capacity Manual, Transportation Research Board, 2000.

Table 1. Intersection Level-of-Service for the Antoine Drive Study Corridor - Morning (AM) Peak Hour

Antoine Drive Intersections	Existing (2013)		Projected (2035)		Projected (2035) Alternative 1		Projected (2035) Alternative 2		Projected (2035) Alternative 3	
	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS
Antoine Dr and Bridge Forest Dr	7.3	A	9.1	A	8.6	A	8.6	A	9.1	A
Antoine Dr and W Gulf Bank Rd	16.7	B	18.9	B	16.7	B	16.7	B	19.1	B
Antoine Dr and Long Creek Ln	6.3	A	5.4	A	5.0	A	5.0	A	5.3	A
Antoine Dr and Victory Dr	27.4	C	35.4	D	29.4	C	27.7	C	32.3	C
Antoine Dr and W Little York Rd	20.2	C	23.6	C	23.7	C	23.7	C	27.4	C
Antoine Dr and De Soto St	7.6	A	8.1	A	7.4	A	7.4	A	9.1	A
Antoine Dr and W Tidwell Rd	35.4	D	50.4	D	35.9	D	29.8	C	74.7	E
Antoine Dr and Pinemont Dr	40.3	D	58.8	E	46.4	D	33.5	C	33.5	C
Antoine Dr and Acorn St	2.8	A	5.4	A	3.6	A	3.6	A	7.5	A
Antoine Dr and W 43rd St	17.8	B	22.0	C	19.3	B	19.3	B	26.4	C
Antoine Dr and Saxon Dr	3.1	A	7.7	A	4.7	A	4.7	A	4.7	A
Antoine Dr and US Hwy 290 North	35.1	D	54.4	D	55.5	E	51.5	D	51.5	D
Antoine Dr and US Hwy 290 South	49.4	D	72.8	E	72.8	E	41.0	D	41.0	D

1 - Alternative 1 includes the widening of Antoine Drive from a 4-lane section to a 6-lane section
2 - Alternative 2 includes the widening of Antoine Drive from a 4-lane section to a 6-lane section and additional intersection improvements including cross street turn lanes
3 - Alternative 3 includes the maintaining a 4-lane section from Tidwell Road to Bridge Forest and additional intersection improvements including cross street turn lanes

Table 2. Intersection Level-of-Service for the Antoine Drive Study Corridor - Evening (PM) Peak Hour

Antoine Drive Intersections	Existing (2013)		Projected (2035)		Projected (2035) Alternative 1		Projected (2035) Alternative 2		Projected (2035) Alternative 3	
	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	Delay (Sec/Veh)
Antoine Dr and Bridge Forest Dr	5.2	A	6.0	A	5.2	A	5.2	A	6.7	A
Antoine Dr and W Gulf Bank Rd	23.0	C	29.3	C	24.2	C	24.2	C	28.9	C
Antoine Dr and Long Creek Ln	6.5	A	7.0	A	6.0	A	6.0	A	7.2	A
Antoine Dr and Victory Dr	46.4	D	68.1	E	41.0	D	35.0	C	69.0	E
Antoine Dr and W Little York Rd	19.8	B	20.2	C	19.3	B	19.3	B	21.2	C
Antoine Dr and De Soto St	10.4	B	5.8	A	4.1	A	4.1	A	11.2	B
Antoine Dr and W Tidwell Rd	37.7	D	47.4	D	32.4	C	26.4	C	42.0	D
Antoine Dr and Pinemont Dr	27.9	C	40.0	D	32.9	C	24.3	C	24.7	C
Antoine Dr and Acorn St	3.4	A	7.7	A	4.7	A	4.7	A	6.8	A
Antoine Dr and W 43rd St	30.6	C	39.6	D	26.8	C	26.8	C	30.8	C
Antoine Dr and Saxon Dr	7.9	A	25.2	D	24.8	C	24.8	C	24.8	C
Antoine Dr and US Hwy 290 North	29.5	C	50.8	D	50.7	D	33.2	C	33.2	C
Antoine Dr and US Hwy 290 South	25.7	C	50.9	D	50.9	D	23.3	C	23.3	C

1 - Alternative 1 includes the widening of Antoine Drive from a 4-lane section to a 6-lane section
2 - Alternative 2 includes the widening of Antoine Drive from a 4-lane section to a 6-lane section and additional intersection improvements including cross street turn lanes
3 - Alternative 3 includes the maintaining a 4-lane section from Tidwell Road to Bridge Forest and additional intersection improvements including cross street turn lanes

Table 3. Intersection Level-of-Service for the Antoine Drive Study Corridor – Morning (AM) Peak Hour

Antoine Drive Intersections	Projected (2035) Alternative 3		Projected (2035) Alternative 4 AM							
	Delay (Sec/Veh)	Delay (Sec/Veh)	Delay (Sec/Veh)	LOS						
Antoine Dr and W Tidwell Rd	74.7	E	95.8	F						

3 - Alternative 3 includes the maintaining a 4-lane section from Tidwell Road to Bridge Forest and additional intersection improvements (including a Rail Road Overpass)
4 - Alternative 4 includes the additional delay that Tidwell will incur as a result of the railroad crossing north of Tidwell

Table 4. Intersection Level-of-Service for the Antoine Drive Study Corridor – Evening (PM) Peak Hour

Antoine Drive Intersections	Projected (2035) Alternative 3		Projected (2035) Alternative 4 PM							
	Delay (Sec/Veh)	LOS	Delay (Sec/Veh)	LOS						
Antoine Dr and W Tidwell Rd	42.0	D	72.0	E						

3 - Alternative 3 includes the maintaining a 4-lane section from Tidwell Road to Bridge Forest and additional intersection improvements (including a Rail Road Overpass)
4 - Alternative 4 includes the additional delay that Tidwell will incur as a result of the railroad crossing north of Tidwell

Access Management Assessment:

As described in the Texas Department of Transportation (TxDOT) Access Management Manual, proper access management assists in protecting the substantial public investment in transportation by persevering roadway efficiency and enhancing traffic safety, thus reducing the need for expensive improvements. Furthermore, access management can significantly reduce traffic accidents, personal injury, and property damage.

The City of Houston Infrastructure Design Manual does include access management design criteria under Chapter 15 "Traffic and Signal Design Requirements". The access management criteria include driveway widths (both residential and commercial), driveway spacing (both residential and commercial), corner clearance upstream and downstream of the intersections, and median lengths along principal streets. AC Group assessed each of the intersections within the study corridor for compliance with the City of Houston Infrastructure Design Manual. It was determined that a majority of the intersections do not comply with driveway spacing or corner clearance.

In addition to driveway spacing non-compliance, the existing median breaks also fall short of the 600' median break spacing at multiple locations and should be considered for closure. Several median breaks serve public streets on both sides of Antoine Drive and others serve large trip generators therefore a more thorough median break closure study is recommended that further evaluates utilization, need, and purpose.

Antoine Drive and Bridge Forest Drive

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	**12’**	**24’**	**-**	
Driveway Width (Others)	**24’**	**35’**	**Yes**	
Driveway Spacing (Residential)	**20’**	**-**	**-**	
Driveway Spacing (Commercial)	**20’**	**-**	**Yes**	
Corner Clearance Spacing- Upstream *	**100’**	**-**	**No**	**NB & SB**
Corner Clearance Spacing- Downstream*	**60’**	**-**	**Yes**	
Median Length (Principal at Principal)	**500’**	**-**	**-**	
Median Length (Principal at Collector)	**500’**	**-**	**No**	**NB Only**

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and W Gulf Bank Road

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	12’	24’	Yes	
Driveway Width (Others)	24’	35’	Yes	
Driveway Spacing (Residential)	20’	-	Yes	
Driveway Spacing (Commercial)	20’	-	Yes	
Corner Clearance Spacing- Upstream *	100’	-	No	EB & WB
Corner Clearance Spacing- Downstream*	60’	-	No	NB, SB & WB
Median Length (Principal at Principal)	500’	-	No	NB, SB, EB, & WB
Median Length (Principal at Collector)	500’	-	-	

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and Long Creek Lane

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	**12’**	**24’**	**Yes**	
Driveway Width (Others)	**24’**	**35’**	**Yes**	
Driveway Spacing (Residential)	**20’**	**-**	**Yes**	
Driveway Spacing (Commercial)	**20’**	**-**	**Yes**	
Corner Clearance Spacing- Upstream *	**100’**	**-**	**No**	**WB**
Corner Clearance Spacing- Downstream*	**60’**	**-**	**No**	**NB**
Median Length (Principal at Principal)	**500’**	**-**	**-**	
Median Length (Principal at Collector)	**500’**	**-**	**No**	**NB, SB, EB, & WB**

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and Victory Drive

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	**12’**	**24’**	**-**	
Driveway Width (Others)	**24’**	**35’**	**Yes**	
Driveway Spacing (Residential)	**20’**	**-**	**-**	
Driveway Spacing (Commercial)	**20’**	**-**	**Yes**	
Corner Clearance Spacing- Upstream *	**100’**	**-**	**No**	**SB, EB, & WB**
Corner Clearance Spacing- Downstream*	**60’**	**-**	**No**	**WB**
Median Length (Principal at Principal)	**500’**	**-**	**No**	**NB, SB, & WB**
Median Length (Principal at Collector)	**500’**	**-**	**-**	

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and W Little York Road

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	**12’**	**24’**	**-**	
Driveway Width (Others)	**24’**	**35’**	**Yes**	
Driveway Spacing (Residential)	**20’**	**-**	**-**	
Driveway Spacing (Commercial)	**20’**	**-**	**No**	**WB**
Corner Clearance Spacing- Upstream *	**100’**	**-**	**No**	**NB, EB, & WB**
Corner Clearance Spacing- Downstream*	**60’**	**-**	**No**	**NB & SB**
Median Length (Principal at Principal)	**500’**	**-**	**No**	**NB & SB**
Median Length (Principal at Collector)	**500’**	**-**	**-**	

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and De Soto Street

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	12’	24’	-	
Driveway Width (Others)	24’	35’	Yes	
Driveway Spacing (Residential)	20’	-	-	
Driveway Spacing (Commercial)	20’	-	Yes	
Corner Clearance Spacing- Upstream *	100’	-	No	NB & WB
Corner Clearance Spacing- Downstream*	60’	-	No	NB & EB
Median Length (Principal at Principal)	500’	-	-	
Median Length (Principal at Collector)	500’	-	No	NB, SB, & WB

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and W Tidwell Road

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	12’	24’	-	
Driveway Width (Others)	24’	35’	Yes	
Driveway Spacing (Residential)	20’	-	-	
Driveway Spacing (Commercial)	20’	-	No	EB (Consolidation Needed)
Corner Clearance Spacing- Upstream *	100’	-	No	EB
Corner Clearance Spacing- Downstream*	60’	-	No	SB & EB
Median Length (Principal at Principal)	500’	-	No	NB, SB, EB &WB
Median Length (Principal at Collector)	500’	-	-	

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and Pinemont Drive

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	12’	24’	-	
Driveway Width (Others)	24’	35’	Yes	
Driveway Spacing (Residential)	20’	-	-	
Driveway Spacing (Commercial)	20’	-	Yes	
Corner Clearance Spacing- Upstream *	100’	-	No	NB, SB & EB
Corner Clearance Spacing- Downstream*	60’	-	No	NB, SB & WB
Median Length (Principal at Principal)	500’	-	No	NB, SB, EB & WB
Median Length (Principal at Collector)	500’	-	-	

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and Acorn Street

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	12’	24’	Yes	
Driveway Width (Others)	24’	35’	Yes	
Driveway Spacing (Residential)	20’	-	Yes	
Driveway Spacing (Commercial)	20’	-	Yes	
Corner Clearance Spacing- Upstream *	100’	-	No	NB & EB
Corner Clearance Spacing- Downstream*	60’	-	No	SB & WB
Median Length (Principal at Principal)	500’	-	-	
Median Length (Principal at Collector)	500’	-	No	NB & SB

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and W 43rd Street

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	**12’**	**24’**	**Yes**	
Driveway Width (Others)	**24’**	**35’**	**-**	
Driveway Spacing (Residential)	**20’**	**-**	**Yes**	
Driveway Spacing (Commercial)	**20’**	**-**	**-**	
Corner Clearance Spacing- Upstream *	**100’**	**-**	**No**	**NB, SB & WB**
Corner Clearance Spacing- Downstream*	**60’**	**-**	**No**	**EB**
Median Length (Principal at Principal)	**500’**	**-**	**No**	**EB & WB**
Median Length (Principal at Collector)	**500’**	**-**	**-**	

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and Saxon Drive

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	12’	24’	Yes	
Driveway Width (Others)	24’	35’	-	
Driveway Spacing (Residential)	20’	-	Yes	
Driveway Spacing (Commercial)	20’	-	-	
Corner Clearance Spacing- Upstream *	100’	-	No	EB & WB
Corner Clearance Spacing- Downstream*	60’	-	No	EB
Median Length (Principal at Principal)	500’	-	-	
Median Length (Principal at Collector)	500’	-	No	NB

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and US Highway 290 North

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	12’	24’	Yes	
Driveway Width (Others)	24’	35’	-	
Driveway Spacing (Residential)	20’	-	Yes	
Driveway Spacing (Commercial)	20’	-	-	
Corner Clearance Spacing- Upstream *	100’	-	Yes	
Corner Clearance Spacing- Downstream*	60’	-	Yes	
Median Length (Principal at Principal)	500’	-	No	SB
Median Length (Principal at Collector)	500’	-	-	

*** Upstream Approach and Downstream Departure of Intersection**

Antoine Drive and US Highway 290 South

Access Management Measures	Min	Max	Met	Comments
Driveway Width (Residential)	12’	24’	Yes	
Driveway Width (Others)	24’	35’	-	
Driveway Spacing (Residential)	20’	-	Yes	
Driveway Spacing (Commercial)	20’	-	-	
Corner Clearance Spacing- Upstream *	100’	-	No	EB (Consolidation Needed)
Corner Clearance Spacing- Downstream*	60’	-	No	SB & EB
Median Length (Principal at Principal)	500’	-	No	NB
Median Length (Principal at Collector)	500’	-	-	

*** Upstream Approach and Downstream Departure of Intersection**

Conclusions:

Maintaining a four-lane typical section between Tidwell Road and Bridge Forest was shown to have a significant increase in delay at the Tidwell Road intersection and increasing intersection delay from 29.8 seconds per vehicle (LOS C) to 74.7 seconds per vehicle (LOS E) during the morning peak hour and from 26.4 seconds per vehicle (LOS C) to 42.0 seconds per vehicle (LOS D) during the evening peak hour. The intersection of Antoine Drive and Victory Drive also increased in delay from 35.0 seconds per vehicle (LOS C) to 69.0 seconds per vehicle (LOS E) during the evening peak hour.

Synchro traffic simulation models were also used to determine delay associated with the peak hour rail road crossing blockage. Although the Synchro traffic simulation application does not evaluate effects between intersections, the average control delay for Tidwell Road was determined by adding the additional delay associated with the rail road crossing given the close vicinity of the rail road crossing. The construction of a grade-separated railroad overpass along Antoine Drive, just north of Tidwell Road, would reduce average control delay at the Tidwell Road intersection from 95.8 seconds per vehicle (LOS F) to 74.7 seconds per vehicle (LOS E) during the morning peak hours and from 72.0 Seconds per vehicle (LOS E) to 42.0 seconds per vehicle (LOS D) during the evening peak hour. A benefit-to-cost analysis using project cost and savings in delay would determine the feasibility of such an improvement.

An access management assessment of the corridor intersections has determined that all of the intersections have one or more non-compliant access management measures as described in the City of Houston Infrastructure Design Manual. The majority of the intersections do not meet the minimum corner clearances or median lengths as recommended (or required) by the City of Houston Infrastructure Design Manual.

APPENDIX A
Traffic Data Sheets

Trains by time at Antoine north of Tidwell 11-12-2015

Put an "X" next to the minute a train or crossing arms blocks the track and mark each subsequent minute until the train and crossing arms are up and the train is gone; repeat each occurrence;

7:00			8:00			4:00			5:00	
7:01			8:01			4:01			5:01	
7:02			8:02			4:02			5:02	
7:03			8:03			4:03			5:03	
7:04			8:04			4:04			5:04	
7:05			8:05			4:05	X		5:05	
7:06			8:06			4:06	X		5:06	
7:07			8:07			4:07			5:07	
7:08			8:08			4:08			5:08	
7:09			8:09			4:09			5:09	
7:10			8:10			4:10			5:10	X
7:11			8:11			4:11			5:11	X
7:12			8:12			4:12			5:12	
7:13			8:13			4:13			5:13	
7:14			8:14			4:14			5:14	
7:15			8:15			4:15			5:15	
7:16			8:16			4:16			5:16	
7:17			8:17			4:17			5:17	
7:18			8:18	X		4:18			5:18	
7:19			8:19	X		4:19			5:19	
7:20			8:20			4:20			5:20	
7:21	X		8:21			4:21			5:21	
7:22	X		8:22			4:22			5:22	
7:23			8:23			4:23			5:23	
7:24			8:24			4:24			5:24	
7:25			8:25	X		4:25			5:25	
7:26			8:26	X		4:26			5:26	
7:27			8:27	X		4:27			5:27	
7:28			8:28			4:28			5:28	
7:29			8:29			4:29			5:29	
7:30			8:30			4:30			5:30	
7:31			8:31			4:31	X		5:31	
7:32	X		8:32			4:32	X		5:32	
7:33	X		8:33	X		4:33			5:33	
7:34	X		8:34	X		4:34			5:34	X
7:35			8:35			4:35			5:35	X
7:36			8:36			4:36			5:36	
7:37			8:37			4:37			5:37	
7:38			8:38			4:38			5:38	
7:39			8:39			4:39			5:39	
7:40			8:40			4:40			5:40	
7:41			8:41	X		4:41			5:41	
7:42			8:42			4:42			5:42	
7:43			8:43			4:43			5:43	
7:44			8:44			4:44			5:44	
7:45			8:45			4:45			5:45	X
7:46			8:46			4:46			5:46	X
7:47			8:47			4:47			5:47	
7:48			8:48			4:48			5:48	
7:49			8:49			4:49	X		5:49	
7:50			8:50			4:50	X		5:50	
7:51			8:51			4:51	X		5:51	
7:52			8:52			4:52			5:52	
7:53			8:53			4:53			5:53	
7:54			8:54			4:54			5:54	
7:55			8:55			4:55			5:55	
7:56			8:56			4:56			5:56	
7:57			8:57			4:57			5:57	
7:58			8:58			4:58			5:58	
7:59			8:59			4:59			5:59	

APPENDIX B
Intersection Improvements

Antoine Drive Corridor

Intersection improvements consisted of making the various changes to the intersections listed below.

Intersection: Antoine Drive and Bridge Forest Drive

1. No changes made

Intersection: Antoine Drive and W Gulf Bank Road

1. No changes made

Intersection: Antoine Drive and Long Creek Lane

1. No changes made

Intersection: Antoine Drive and Victory Drive

1. Add eastbound right-turn lane to 250'
2. Add westbound right-turn lane (150')

Intersection: Antoine Drive and W Little York Road

1. No changes made

Intersection: Antoine Drive and De Soto Street

1. No changes made

Intersection: Antoine Drive and W Tidwell Road

1. Extend SB, EB, and WB left-turn lanes to 200'
2. Operate traffic signal with protected-permissive left-turns

Intersection: Antoine Drive and Pinemont Drive

1. Extend NB, SB, EB, and WB left-turn lanes to 200'
2. Operate traffic signal with protected-permissive left-turns

Intersection: Antoine Drive and Acorn Street

1. No changes made

Intersection: Antoine Drive and W 43rd Street

1. No changes made

Intersection: Antoine Drive and Saxon Drive

1. No changes made

Intersection: Antoine Drive and US Highway 290 North

1. Add exclusive southbound right-turn lane (250')
2. Add one westbound through lane to match three lane departure
3. Add exclusive westbound right-turn lane (250')

Intersection: Antoine Drive and US Highway 290 South

1. Add exclusive southbound right-turn lane (250')
2. Add exclusive westbound right-turn lane (250')

APPENDIX C
City of Houston – Access Management Design Criteria

C. ACCESS MANAGEMENT DESIGN

1. Driveways

a. Driveways and their associated openings should be located and designed to provide reasonable access between private property and the street right of way. The driveway should not create an unmanaged traffic hazard for drivers entering the street or for drivers on the through street, nor negatively impact normal use of street right of way.

b. The proper location and design of a driveway should be consistent with the safety and convenience of the public and must take into account nature and volume of traffic on abutting streets, dimensions and construction of abutting streets, use of developed property, dimensions of the developed property, and type and locations of improvements to the developed property.

c. Driveway design considers the effect of vehicles to/from developed property on the movement of traffic and the safety of traveling public on abutting streets.

d. Driveways are based on two property classifications: single family residential and all others.

e. Driveways to/from a property should include no more than the minimum number to provide reasonable access between the property and abutting street.

d. Driveway width is measured at the beginning of the driveway radii tangents within the driveway (see Figure 15.08.01). Driveway Radius is the rounded edge of a driveway that permits easier entry and exit by turning vehicles. Design standards for minimum driveway width and radius can be found in Table 15.08.01.

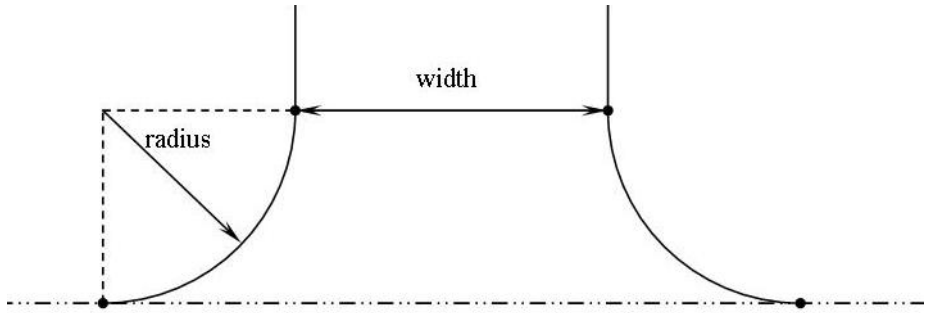


Figure 15.08.01 Driveway Radius and Width

Table 15.08.01 Driveway Design Criteria

	Single Family Residential				All Others			
	Radius (ft)		Width (ft)		Radius (ft)		Width (ft)	
	Max	Min	Max	Min	Max	Min	Max	Min
Two-Way	15	4	24	12	25	10	35	24
Joint-Access	15	4	24	12	25	10	35	24
One-Way	15	4	20	12	25	10	20	15

e. Notes on Driveway Design Criteria

(1) One-way driveways must intersect city streets between 45 and 90 degrees.
(2) Skewed, one-way drives are permitted only on one-way streets and divided streets with no median opening.
(3) Two-way driveways must intersect city streets at approximately 90 degrees.
(4) Where situations permit, AASHTO design vehicles may be used to justify driveway radii.
(5) No driveway radius shall encroach on abutting property or corner radius.
(6) Driveways shall not be permitted within limits of any intersection. (Design exception shall be required for major thoroughfare locations with existing esplanades and streets used for residential access.)
(7) For one-way driveways, the entry driveway shall precede exit driveways (in direction of adjacent travel lane).
(8) Driveway must remain tangential for a minimum of 20 feet past the property line.
(9) Where present or projected traffic operations indicate needs for alternative driveway geometrics, additional consideration may be given.

2. Driveways and Loading Docks/Wells/Berths

a. Loading docks/wells/berths are not permitted for back-in loading from an adjacent Major Thoroughfare.

b. Loading docks/wells/berths must be located on site to provide for approach and maneuvering on-site with appropriate space to accommodate dimensions of vehicles accessing site.

c. Loading docks/wells/berths must be located on site such that sufficient area is available to store commercial motor vehicle, truck-tractor, trailer, or semi-trailer or combination of such vehicles within the developed property and no

part of vehicle shall protrude over the property line or obstruct any public street or sidewalk in whole or in part.

3. Driveway and Corner Clearance Spacing

The distance between connections (driveway-driveway and driveway-street) is measured along the edge of traveled way from the closest edge of pavement of the first connection to the closest edge of pavement of the second connection (see Figure 15.08.02 for residential and Fig 15.08.03 for non-residential). Driveway spacing criteria for residential areas can be found in Table 15.08.02. Non-residential driveway placement criteria for intersections is shown in Figure 15.08.03 and Table 15.08.03.

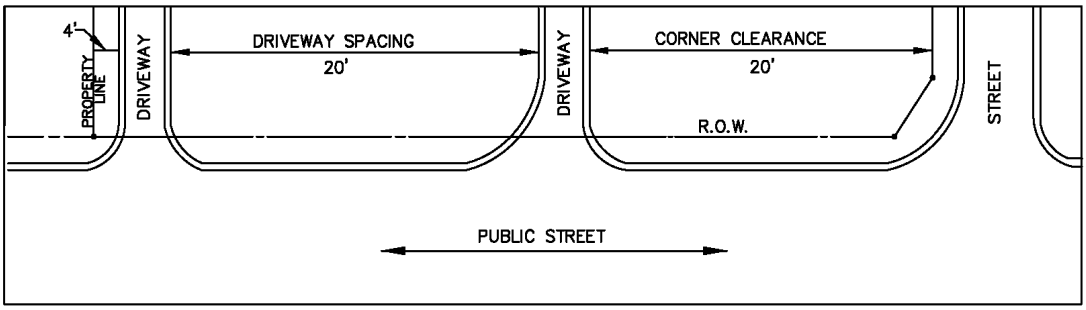


Figure 15.08.02 Driveway Spacing

Table 15.08.02 Residential Driveway Spacing Criteria				
	Between Adjacent Driveways	Between Adjacent Street ROW	Between Side Property Line	Maximum Number of Driveways
	Spacing (Minimum dimension in ft)			
Single Family Residential	20(1)	20	4	2
(1) 10 foot minimum between pair of one-way driveways (2) All proposed access connections must be placed to achieve adequate intersection sight distance for safe and efficient departure from the proposed location (comply with AASHTO standard). (3) Driveway radius cannot extend beyond property line. (4) Driveway radius cannot extend into public street on other driveway curb radius.				

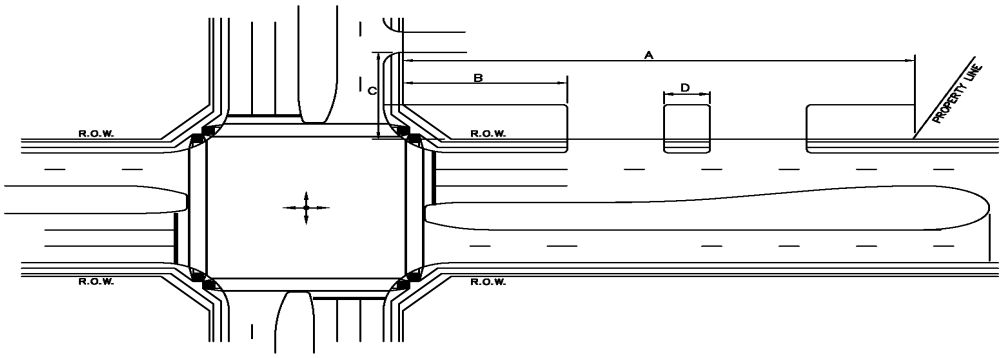


FIGURE 15.08.03
DRIVEWAY PLACEMENT

Table 15.08.03 Non-Residential Driveway Placement Criteria (1)

A Frontage (2)	Number of Driveways	B Minimum Driveway Offset (Primary Street)	C Minimum Driveway Offset (Intersecting Street)	D Minimum Driveway Spacing
Up to 170 feet	1	100 feet	60 feet	20 feet
170 to 250 feet	2	100 feet	60 feet	20 feet
250 to 450 feet	3	100 feet	60 feet	20 feet
> 450 feet	1 additional / 250’ frontage	100 feet	60 feet	20 feet

(1) Applicable to driveways designed for commercial traffic (auto, truck, and bus access).
(2) Where the development frontage is equal to or greater than the distance to first median opening, at least one driveway will be aligned with the existing and/or future location of the median opening.
(3) For CBD or Locations unable to comply, approval of the City Engineer required.
(4) All proposed access connections must be placed to achieve adequate intersection sight distance for safe and efficient departure from the proposed access connection (comply with AASHTO standard).
(5) The minimum driveway offset for all major thoroughfare shall be 100 feet.
(6) Driveway radius cannot extend beyond property line.
(7) Driveway radius cannot extend into public street or other driveway curb radius.

b. Notes regarding connection spacing:

(1) A pair of one-way driveways (entry and exit) should be considered as a two-way driveway for driveway spacing purposes.
(2) Spacing between one-way driveways requires the entry precedes the exit in the direction off the adjacent travel lane and the one-way pair meets spacing requirements from adjacent driveways or streets.
(3) For the special situation of multiple entry driveways placed on one-way street and exit driveways placed on a different street, two same street driveways should be considered as a one-way pair.
(4) Driveways on a street without a median should align with driveways on the opposite side of the street.
(5) Driveways shall not be placed in the intersection limits (see 15.03.I for definition of intersection limits).
(6) Driveway should be placed of a minimum offset distance of 75 ft from the median nose.

4. Medians

a. Median design involves mainly median type, opening, and length. Installing medians provides the potential for safer street operation, increased capacity, and improved aesthetics.

b. Median Openings
Median openings allow vehicles to cross opposing traffic lanes at designated locations. Requirements for median openings can be found in Chapter 10.08 of this manual.

c. Minimum Median Lengths
The minimum lengths of medians between openings are determined by the functional classification of the street and the type of interruption (thoroughfare, collector, local street, private driveway, etc.) of the adjacent openings. Requirements can be found in Chapter 10.08 of this Manual.

5. Treatments for Turning Movements

a. Turn lanes provide a refuge area for left and right turning vehicles. Turn lanes may be placed at intersection approaches, driveway approaches, and median openings to remove turning vehicles from the through lanes, thus reducing congestion and improving traffic operations, capacity, and safety.

b. Dedicated Left-Turn Lanes

(1) Left-turn lanes shall be considered in the following situations:

(a) All signalized intersection approaches along planned or existing streets having a classification of collector or higher;
(b) All unsignalized intersections and driveways along divided streets having a classification of collector or higher;
(c) All unsignalized intersections and driveways along undivided streets having a classification of thoroughfare or higher;
(d) All developments in excess of five acres located within 500 feet of the intersection of two or more thoroughfare facilities;
(e) New public or private school construction;
(f) Shopping centers and other traffic generators with a lease space in excess of one hundred thousand square feet;
(g) Places of worship.

(2) The use of dedicated left-turn lanes should also always be guided by a traffic study. The use of a left-turn lane requires approval from the City Engineer.

c. Dedicated Right-Turn Lanes

The use of dedicated right-turn lanes should always be guided by a traffic study.

6. Minimum Turning Treatment Storage Length

a. Storage length, as shown in Figure 15.08.04, is an important design element that ensures the provision of sufficient turn lane storage capacity to reduce instances of spillback. Left- and right-turn lane storage lengths must not be less than the minimum requirements outlined in Chapter 10.06 of this Manual.

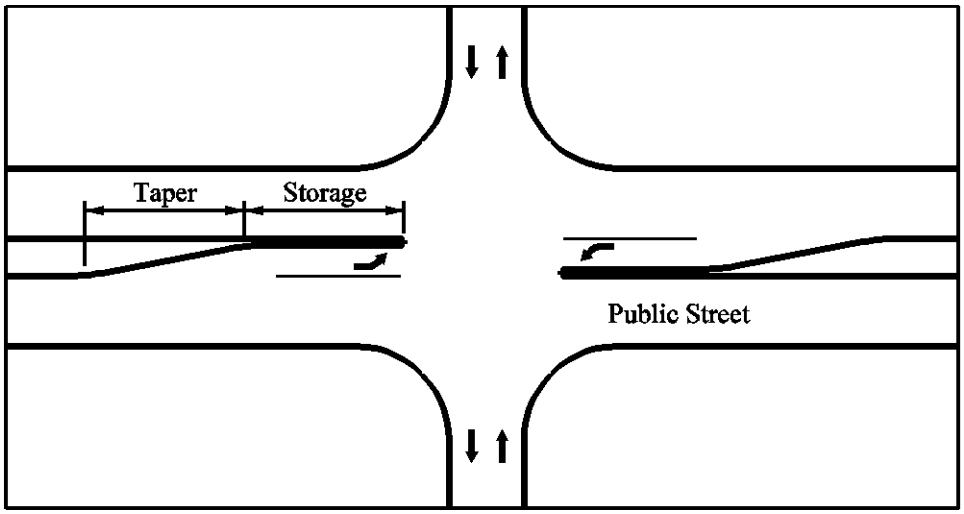


Figure 15.08.04 Turn Lane Details

b. Calculating Required Storage Length (Single Lane)

The required storage length for both left- and right-turn lanes can be obtained using traffic modeling software such as the latest version of the HCM Software (HCS) or Synchro/SimTraffic. The 95th percentile queue length is a widely accepted value for storage length. The following methods may be used to determine storage length.

Signalized Storage Length
For signalized intersections, the storage length should be determined based on results from computer analysis software.

Unsignalized Storage Length
Equation 1 is used to calculate unsignalized storage length.

$$L=(V/30)(2)(S) \qquad \text{(Equation 1)}$$

Where:
L = storage length in feet
V/30 = turning volume in a two-minute interval
2 = a factor that provides for storage of all left-turning vehicles on most cycles
S = queue storage length, in feet per vehicle

15.09 TRAFFIC SIGNS

15.09.01 GENERAL

A. This section of the Design Manual contains the criteria and formats to be used in designing and preparing plans for the installation and refurbishing of traffic signs in the City of Houston. The intent is to establish standard procedures and requirements that will be used by engineering designers and consultants when designing signing for City of Houston projects. All design shall also be in accordance with the Standard Highway Sign Designs (SHSD) for Texas and with the Texas Manual of Uniform Traffic Control Devices (TMUTCD).

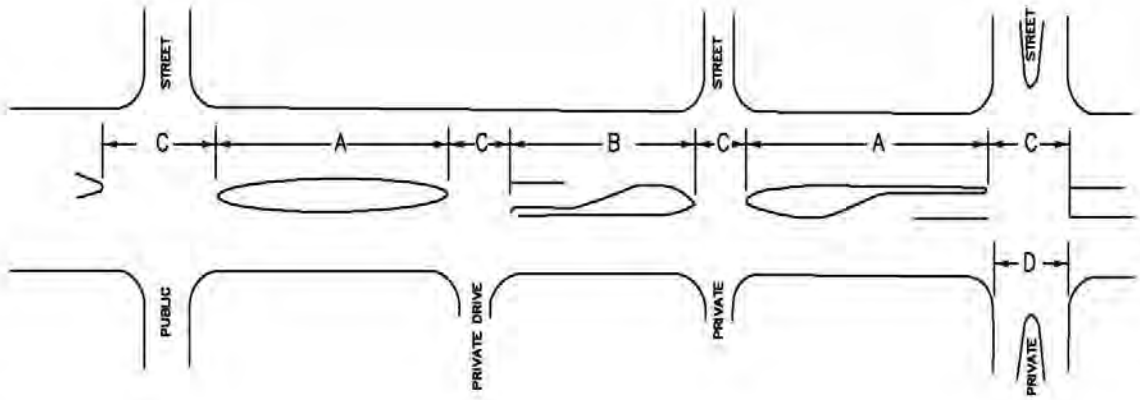
B. This document provides Designers and Consultants with:

1. the design requirements and guidelines for ensuring uniformity in sign types, mounting, size, and placement; and

2. the required format of plan sheets to allow ease of review, minimization of construction errors, and facilitation of maintenance.

15.09.02 DESIGN REQUIREMENTS

A. Description of Design/Review Process



TYPICAL MEDIAN OPENING C

MEDIAN INTERRUPTION FOR	1 LTB (1)	2 LTB (1)
PRIVATE DRIVE	52.5'	60'
UNDIVIDED STREET <40 44'	52.5' (1) 55' (2)	60' 60'
DIVIDED STREET ALL	D+22'	D+22'

NOTE:

(1) LTB–LEFT TURN BAY.
(2) DISTANCE FROM CENTERLINE OF OPENING TO MEDIAN NOSE WITH LEFT TURN LANE IS 30' FOR RIGHT ANGLE INTERSECTIONS. FOR INTERSECTIONS OTHER THAN 90', APPLY DESIGN VEHICLE TURNING TEMPLATE TO DETERMINE DIMENSION TO MEDIAN NOSE CUT OFF.

MIMIMUM MEDIAN LENGTH A, B

IF DIVIDED STREET IS:	INTERSECTING STREET CLASSIFICATION			
	MAJOR STREET/ THOROUGHFARE (A)	COLLECTOR STREET (A)	LOCAL STREET (A)	PRIVATE STREET OR DRIVEWAY (B)
PRINCIPAL THOROUGHFARE/ THOROUGHFARE	660'	660'	660'	660'
COLLECTOR STREET	660'	500'	350'	350'
LOCAL STREET	300'	300'	300'	300'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

MEDIAN DESIGN
MEDIAN LENGTH AND OPENING
(NOT TO SCALE)

APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: FEB-13-2015	DWG NO: 10.06-06

PREVIOUS NO: CH 10 FIG 3

Appendix 5

Drainage Report

P&D PROFESSIONAL SERVICES, INC.

12155 Lismore Lake Dr ◆ Cypress, Texas, 77429 ◆ (281)743-4475 ◆ (281)743-4352

MEMORANDUM

STATE OF TEXAS
RICHARD A. KRAUS
57390
REGISTERED
PROFESSIONAL ENGINEER

TO: Edelmiro Castillo, P.E., Omega Engineers, Inc.

FROM: Richard Kraus, P.E., P&D Professional Services, Inc.

DATE: November 24, 2015

RE: **Pre–Engineering Drainage Study**
Work Order No. 13: Antoine Drive
from Bridge Forest to US 290
No. N-2013T-0013 Revision #1

The purpose of this document is to summarize the findings of the existing drainage conditions, alternative drainage improvements and recommended drainage alternatives for proposed roadway improvements on Antoine Drive from Bridge Forest to US 290.

A. Executive Summary

Antoine Drive from Bridge Forest to US 290 in Northwest Houston is a four lane divided boulevard roadway with curb and gutter and storm sewer drainage. The project reach is approximately 22,300 feet in length with ten storm sewer systems and drainage outfalls: two (2) into Vogel Creek (E121-00-00), four (4) into White Oak Bayou (E100-00-00), two (2) into Cole Creek (E117-00-00), and two (2) into Brickhouse Gully (E115-00-00). Flood Insurance Study mapped 100-year floodplains from all four outfall channels inundates a significant portion of the study reach. Of the ten storm sewer systems the two shortest systems are 18-years old and the remaining systems vary from 38 to 58 years old. The analysis found that most of the storm sewer systems have discharge capacities that are less than the current 2-year design standard.

There are identified CDP 2-Yr Proposed Storm Upgrades for six (6) storm sewer systems along Antoine Drive.

The proposed condition consists of rebuilding Antoine Drive to a 6-lanes with shared use paths and wide median in a proposed 120-ft ROW from Northwest Fwy to Tidwell and 4-lanes with shared use paths in each direction and wide median in a proposed 100-ft ROW from Tidwell to Bridge forest. Please see attached typical sections for your reference. Antoine is divided to two projects, Antoine North and Antoine South within the original project limits. The breaking point between the two projects is at Victory Drive.

Storm sewer trunk lines were sized for proposed conditions such that the 2-year runoff did not exceed the normal flow capacity of the storm sewer and that the 100-year HGL did not exceed the ROW elevations. Alternative drainage systems were studied at two outfalls. The first alternative considered rerouting the drainage along Antoine that currently drains to W Gulf Bank

Road. The rerouted drainage would flow southward to the Long Creek Lane storm sewer system. The benefit of this alternative would eliminate the need to replace the storm sewer system and the associated street repairs along W Gulf Bank Road. The second alternative considered diverting flow from Antoine Drive at DeSoto Street to White Oak Bayou. The benefit of this alternative would eliminate the need to replace the existing storm sewer along Antoine Drive north of DeSoto Street to White Oak Bayou because the size of the existing system is adequate for the reduced drainage area.

Storm water detention volume needs were computed based on the additional impervious cover created by the added pavement width of the proposed roadway. The volume was computed based on a factor 0.5 ac-ft/acre of additional impervious cover. The total volume of storm water detention needed is 6.77 ac-ft. It is understood that the City has purchase land within Inwood Forest that will provide regional storm water storage volume and compensate for impacts created by this project.

Cost estimates were prepared for each studied outfall and alternative drainage scenario. The total estimate drainage cost for maintaining the existing drainage outfalls is $5.48M. Note that this cost does not include the associated street repairs that would be required along W Gulf Bank Road. The total estimated drainage cost with the alternative drainage conditions is $4.94M, a savings of $535K plus the repairs of W Gulf Bank Road would not be needed. However, any associated repairs for the DeSoto Street diversion have not been included. Storm water detention costs were also estimated based on the storage volume required. Specific locations for storm water detention were not identified because of the regional facility the City will be constructing in the Inwood Forest area. The total cost for storm water detention is estimated to be $2.25M.

The study reach has been divided into two sub-projects, with the divides set at Victory Drive. The estimated drainage system costs for the reach from Bridge Forest to Victory is $0.90M using existing outfalls, and $0.96M using the alternative outfall. Storm water detention cost estimate for this reach is $0.55M. The estimated drainage system costs for the reach from Victory to US 290 is approximately $4.57M. There is no alternative system for this reach. Storm water detention cost estimate for this reach is $1.69M.

Note, these cost estimates are intended to be included with the overall project costs and therefore do not include a contingency factor, construction management costs, engineering fees, and design management costs.

B. Study Approach

1. Existing Conditions

The analysis determined the existing conditions of the drainage systems in the need area. Parameters that were determined include the capacity of the existing system to drain the existing flows from their respective drainage areas based on City of Houston's current standards. Drainage areas for the systems were delineated based on aerial photographs, field visits, City of Houston's GIMS information, and Harris County Flood Control District maps. The drainage areas were further divided into sub-drainage areas generally corresponding with changes in

system sizes along the drainage system. The Rational Method was used to compute the 2-year design peak flows based on City of Houston criteria. Percent impervious cover for each sub-area was estimated from aerial photographs and used to determine average runoff coefficients, C-values. Times of concentration were determined from the drainage area size along the longest flow path.

The capacity of the existing drainage systems was computed using Manning's formula. For storm sewer systems, the hydraulic information such as flowline slope, size, and material was obtained from the as-built drawings provided by the City of Houston and Houston GIMS.

The existing conditions 2-year peak flows were compared with the capacity of the corresponding drainage system. If the existing condition 2-year peak flow rates exceed the capacity of the corresponding drainage system, then that portion of the drainage system was judged as being inadequate. Likewise, the drainage system was listed as adequate if the 2-year peak flow rate was less than or equal to the capacity of the drainage system. Additionally, HouStorm models were created for all existing storm sewer systems in order to confirm the adequacy of the storm sewer's capacity.

Also, noted are drainage systems that have been identified by the CDP 2-Year Proposed Storm Upgrades and active CIP projects.

Existing flood plains as shown in the effective Flood Insurance Study of Harris County were identified. Additionally, overland drainage patterns were also identified for each drainage system based on 1-ft contours from 2008 LiDAR data.

2. Proposed Alternatives and Recommendations

Using the results of the existing condition analysis and the proposed typical roadway sections the peak runoff rates were updated and proposed storm sewer trunk lines were sized along the need area reach. The storm water trunk lines were sized such that the hydraulic grade line (HGL) for the 2-year flows remained below the flow capacity of the trunk line and the 100-year HGL remained below right-of-way (ROW) elevations. The HouStorm program was used to size the proposed trunk lines.

Storm water detention volume was calculated based on 0.5 acre-feet per acre of additional impervious cover. The storm water detention volume is the amount of storage that would be needed to mitigate the impact of increased runoff from the proposed roadway improvements. The storm water detention volume would need to be provided in a detention basin located in the vicinity of the proposed roadway. The City of Houston recently purchased land in Inwood Forest along Vogel Creek and White Oak Bayou that will provide regional storm water detention. The storm water detention needed for this project will be provided within this City of Houston regional storm water storage facility.

Cost estimates were prepared for the each alternative. Unit prices were gathered from City of Houston and TxDOT sources.

C. Existing Conditions

1. Project Location and Description

The study project is Antoine Drive from Bridge Forest to US 290 in northwest Houston (Key Map 411K, L, Q, U, Y, 451C, G, L), a distance of approximately 22,300 feet. The existing Antoine Drive is typically a four lane boulevard roadway with curb and gutter and storm sewer drainage. The land use in the project area is generally mixed use with commercial, and single and multifamily residential.

2. FEMA Flood Hazard Areas

The project limits along Antoine Drive expands over several types of Special Flood Hazard Areas (SFHA) including the Unshaded FEMA Zone X, Shaded Zone X, Zone AE, and floodways.

The Unshaded FEMA Zone X represents the areas outside the 500-year floodplain generally includes Antoine Drive from north of Winding Way Drive to north of W. Tidwell Road, and from Golden Forest Drive to W 43rd Street.

The Shaded FEMA Zone X represents the areas within the 500-year floodplain generally includes Antoine Drive from south of W. Little York Road to north of Winding Way Drive, north of W. Tidwell Road to south of W. Tidwell Road, south of Cole Creek to Golden Forest Drive, W. 43rd Street to Cheshire Lane, and Saxon to US 290.

FEMA Zone AE represents the areas within the 100-year floodplain generally includes Antoine Drive from Gulf Bank Road to south of W. Little York Road, from south of W. Tidwell Road to south of Cole Creek (E117-00-00), and from south of Cheshire Lane to Saxon.

Antoine Drive from Bridge Forest to US 290 also crosses three floodways on White Oak Bayou (E100-00-00), Cole Creek (E117-00-00) and Brickhouse Gully (E115-00-00).

The need area is located within FEMA FIRM Panels No. 48201C0465L and 48201C0655L, dated June 18, 2007. **Figures 1 through 4** are FIRMettes of these panels showing the project location.

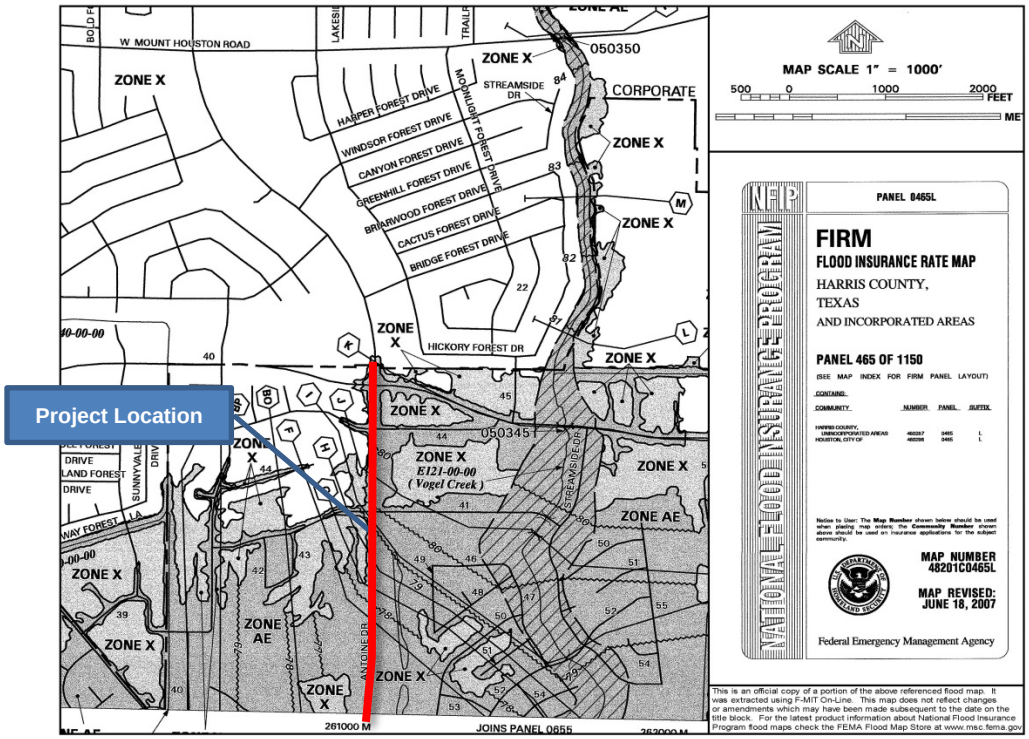


Figure 1. FIRMette of Panel 465, Harris County, Texas and Incorporated Areas

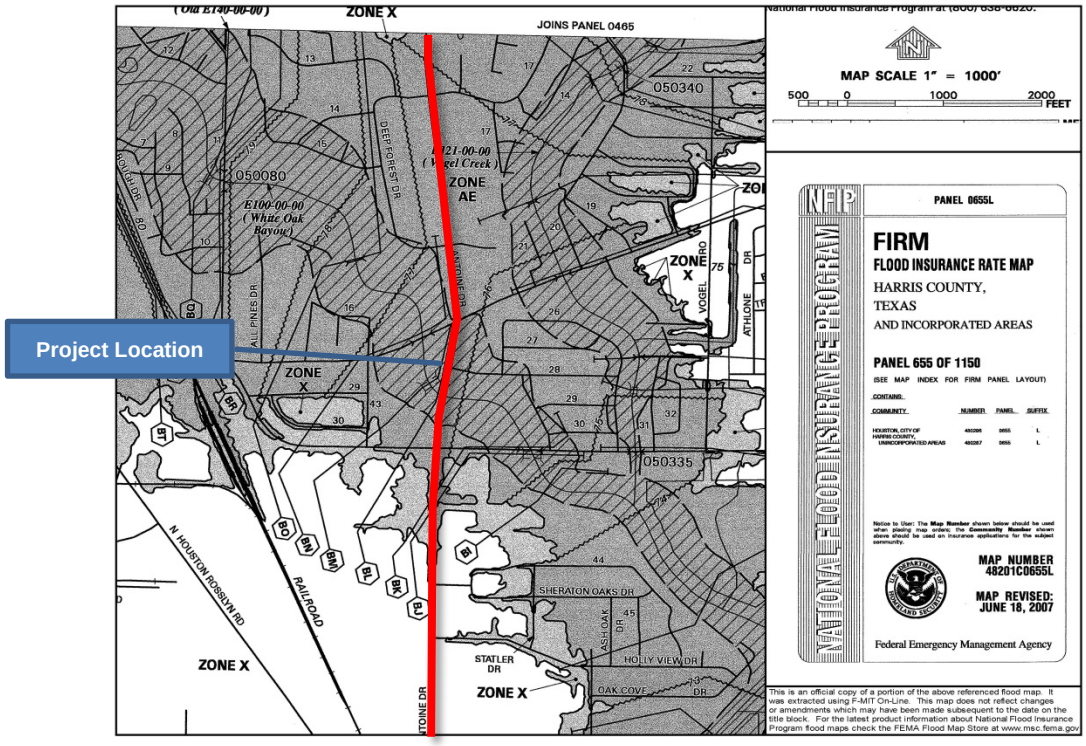


Figure 2. FIRMette of Panel 655, Harris County, Texas and Incorporated Areas

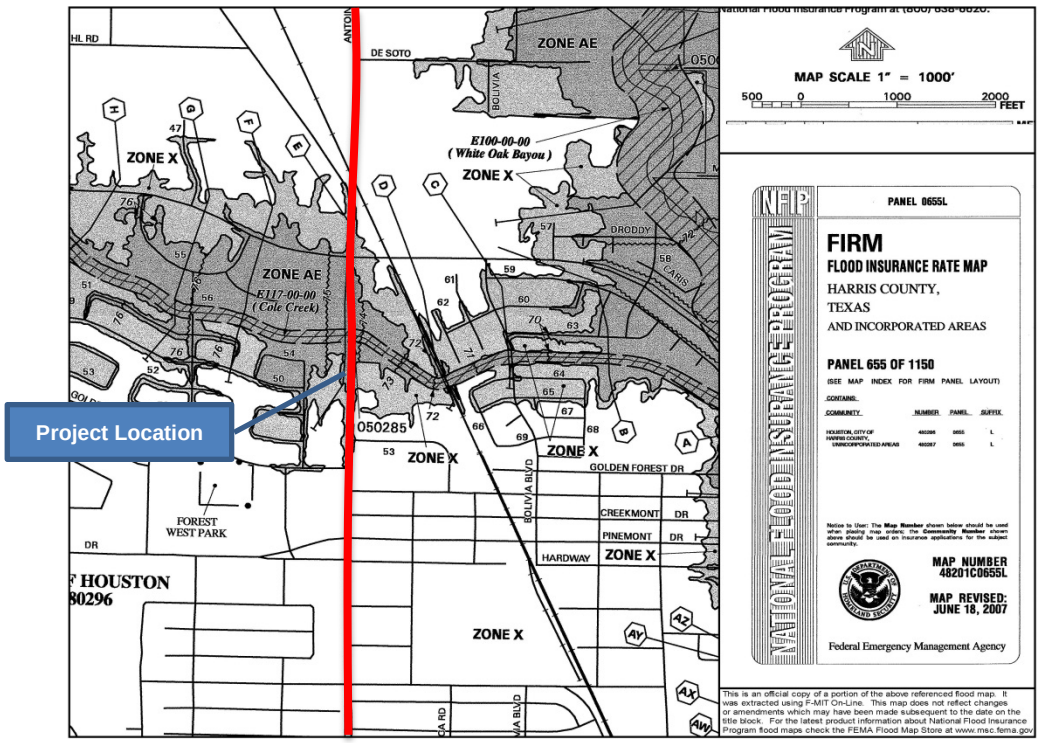


Figure 3. FIRMette of Panel 655, Harris County, Texas and Incorporated Areas

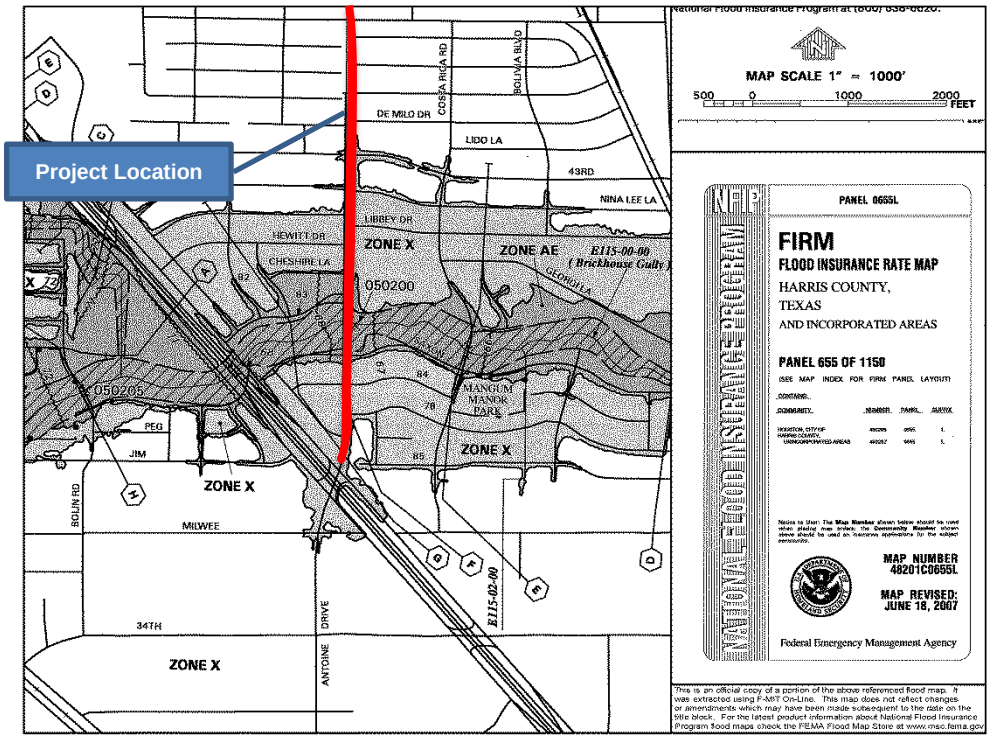


Figure 4. FIRMette of Panel 655, Harris County, Texas and Incorporated Areas

3. Existing Drainage Conditions

The drainage system for this section of Antoine Drive is primarily enclosed storm sewer systems that outfall to Vogel Creek, White Oak Bayou, Cole Creek and Brickhouse Gully. **Exhibits 1A and 1B** show the drainage area with sub-drainage areas for the project and along the drainage outfalls. Listed below by outfall locations are the various storm sewer systems and drainage area designations developed for this study that are shown on the exhibits.

- **W Gulf Bank Road:** The storm sewer system serves Antoine Drive from Bridge Forest to north of Arncliff and conveys storm water runoff from approximately 37.5 acres to Vogel Creek (E121-00-00) at West Gulf Bank Road. On Exhibit 1 this system is labeled A1. According to as-built plans, this storm sewer system was built in 1972, which makes it 41 years old.
- **Long Creek Lane:** The storm sewer system A2 serves Antoine Drive from north of Arncliff to Long Creek Lane and conveys storm water runoff from approximately 51.6 acres to a tributary to Vogel Creek (E121-00-00) south of Long Creek Lane on the east side of Antoine. This system is labeled A2 on Exhibit 1. According to as-built plans, this storm sewer system was built in 1970, which makes it 43 years old.
- **Maple Hill Drive:** The storm sewer system serves Antoine Drive from south of Long Creek Drive to south of Maple Hill Drive and conveys storm water runoff from approximately 18.4 acres to White Oak Bayou (E100-00-00) along Deep Forest Drive on the west side of Antoine drive. This system is labeled A3 on Exhibit 1. According to as-built plans, the storm sewer system was built in 1966, which makes it 47 years old.
- **Victory Drive:** The storm sewer system serves Antoine Drive at Victory Drive and conveys storm water runoff from approximately 7.9 acres to White Oak Bayou (E100-00-00) at Victory Drive on the west side of Antoine drive. Exhibit 1 labels this system A4. According to as-built plans, this storm sewer system was built in 1995, which makes it 18 years old.
- **White Oak Bayou North:** The storm sewer system serves Antoine Drive from south of Victory Drive to White Oak Bayou and conveys storm water runoff from approximately 3.4 acres directly to White Oak Bayou (E100-00-00) at Antoine Drive. Exhibit 1 labels this system A5. According to as-built plans, this storm sewer system was built in 1995, which makes it 18 years old.
- **White Oak Bayou South:** The storm sewer system serves Antoine Drive from the railroad tracks located near North Houston Rosslyn Road to White Oak Bayou and conveys storm water runoff from approximately 157.2 acres directly into White Oak Bayou (E100-00-00) at Antoine Drive. This storm sewer system also serves West Little York Road from Victory Drive to Antoine Drive. This system is labeled A6 on Exhibit 1. According to as-built plans, this storm sewer system was built in 1975, which makes it 38 years old.
- **Cole Creek North:** The storm sewer system serves Antoine Drive from the railroad tracks located near North Houston Rosslyn Road to Cole Creek and conveys storm water runoff from approximately 128.5 acres directly into Cole Creek (E117-00-00) at Antoine Drive. This storm sewer system also serves North Houston Rosslyn Road from West Little York

Road to Antoine Drive. Exhibit 1 labels this system as A7. According to as-built plans, this storm sewer system was built in 1973, which makes it 40 years old.

- **Cole Creek South:** The storm sewer system serves Antoine Drive from south of Hoover to Cole Creek and conveys storm water runoff from approximately 157.8 acres directly into Cole Creek (E117-00-00) at Antoine drive. Exhibit 1 labels this system as A8. According to as-built plans, this storm sewer system was built in 1964, which makes it 49 years old.
- **Brickhouse Gully North:** The storm sewer system serves Antoine Drive from Weeping Willow to Brickhouse Gully and conveys storm water runoff from approximately 159.1 acres directly into Brickhouse Gully (E115-00-00) at Antoine Drive. Exhibit 1 labels this system as A9. According to as-built plans, this storm sewer system was built in 1973, which makes it 40 years old.
- **Brickhouse Gully South:** The storm sewer system serves Antoine Drive from US 290 to Brickhouse Gully and conveys storm water runoff from approximately 14.1 acres directly into Brickhouse Gully (E115-00-00) at Antoine drive. Exhibit 1 labels this system as A10. According to as-built plans, this storm sewer system was built in 1955, which makes it 58 years old.

4. Drainage Capacity and Issues

A comparison of the 2-year flow from the contributing drainage areas to the capacity of the enclosed storm systems along Antoine Drive show that the drainage systems generally do not have adequate capacity. However, the calculation did show that a few drainage pipes were adequately sized. **Table 1** lists the storm water capacity of the existing drainage systems, **Table 2** lists the peak flow rates from the contributing drainage areas, and **Table 3** is a comparison of the peak flow rates to the storm water system capacity. Additionally, the existing storm sewers were modeled with HouStorm to confirm the adequacy of the storm sewer capacity. The HouStorm models are contained in **Appendix A**.

There are three bridges that exist on Antoine Drive within the project limits. The bridges are located at White Oak Bayou (E100-00-00), Cole Creek (E117-00-00), and Brickhouse Gully (E115-00-00).

The CDP 2-Yr Proposed Storm Upgrades have been identified for storm sewer Systems A1, A2, A3, A8, A9 and A10. These CDP proposed upgrades and sizes are listed on **Tables 1 and 3.**

5. Extreme Event Overland Drainage Pattern

Based on topographic contours, the generally lay of the land will direct overland sheet flows from north to south along the segment of Antoine Drive north of White Oak Bayou. South of White Oak Bayou to the railroad tracks the overland slope is in an east-northeast direction toward White Oak Bayou. The railroad tracks form a drainage divide between White Oak Bayou and Cole Creek. South of the railroad tracks to Cole Creek the general slope is from north to south, and south of Cole Creek to Hoover/Weeping Willow the general overland slope is northward to Cole Creek. South of Hoover/Weeping Willow to Brickhouse Gully the general slope is toward the south to Brickhouse Gully. From Brickhouse Gully to US 290 the general slope is northward toward Brickhouse Gully. Much of Antoine Drive in the project reach is

inundated by the 100-year flood plain of White Oak Bayou, Vogel Creek, Cole Creek, and Brickhouse Gully as shown on the preceeding FIRMettes, Figures 1 through 4.

D. Proposed Conditions

1. Proposed Roadway Typical Section

The proposed typical roadway section used to study the drainage within the study reach from US 290 to Tidwell consists of six 11-ft travel lanes and two share used paths consisting of two 5-ft bike lanes and two 6-ft sidewalks with curbs and gutters and a wide median in a proposed 120-ft ROW. The total width of impervious cover for the proposed condition is 88-feet. In comparison, the existing typical roadway section in the study reach consists of four 11-ft lanes and two 6-ft sidewalks with a total impervious width of 56-feet. This comparison shows that the impervious cover will increase by 32-SF per linear foot of pavement.

The proposed typical section used for this study from Tidwell to Bridge Forest has four 11-ft travel lanes with shared use paths consisting of two 5-ft bike lanes and two 6-ft sidewalks with curbs and gutters in each direction in a proposed 100-ft ROW. For the reach from Tidwell to Bridge Forest, the total width of impervious cover for the proposed condition is 66-feet. In comparison, the existing typical roadway section in the study reach consists of four 11-ft lanes with a total impervious width of 44-feet. This comparison shows that the impervious cover will increase by 22-SF per linear foot of pavement.

2. Proposed Drainage Systems

Drainage will be provided in underground storm sewers. The proposed storm sewer trunk lines were determine with HouStorm, a computer program that models storm sewers with drainage areas, nodes and links. Using defined drainage areas and the 1-ft topographic contours for approximate slopes, storm sewer trunk lines were sized for the length of the study area. The trunk lines were sized so that the 2-year HGL remained below an assumed gutter elevation and that the 100-year HGL remained below the natural ground elevation at the ROW. The starting water surface elevation for each storm sewer was set at the soffit of the proposed storm sewer for both the 2-year and 100-year storm events, because the 100-year water surface elevation at each outfall is above the banks of the channel, as indicated by the mapped floodplains. Additionally, above ground storm water conveyance within the ROW during the 100-year storm event was not considered because proposed roadway profiles have not bee prepared.

The increased impervious cover increases the storm water runoff which needs to be mitigated with storm water detention. The amount of storm water detention is determined by using the factor of 0.5 ac-ft of storage volume for every acre of additional impervious cover. This factor is from the City of Houston Infrastructure Design Manual, Chapter 9 Stormwater Design Requirements. Multiplying the additional pavement width of 28-ft by the reach length provides the amount of additional impervious cover. Using the detention rate of 0.5 ac-ft/ac, the amount of storage volume was determined. The following table lists the outfalls and required storm water storage volume based on the roadway length associated with each outfall.

Outfall	Roadway Length	Require Storage Volume	
	LF	CF	Ac-Ft
W Gulf Bank Road	1,280	14,080	0.32
Long Creek Lane	3,500	38,500	0.88
Maple Hill Road	1,320	14,520	0.33
Victory Drive	760	8,360	0.19
White Oak Bayou North	550	6,050	0.14
White Oak Bayou South	4,940	54,340	1.25
Cole Creek North	1,650	26,400	0.61
Cole Creek South	3,000	48,000	1.10
Brickhouse Gully North	3,800	60,800	1.40
Brickhouse Gully South	1,500	24,000	0.55
Total	**22,300**	**295,050**	**6.77**

The storm water detention basins needed to mitigate the impact created by additional impervious cover will be provided in a regional storm water facility being created by the City of Houston within the Inwood Forest area.

The storm sewer trunk lines were sized using the existing drainage outfalls. Alternative analyses were performed on two systems where significant cost savings may be realized.

Alternative 1: The drainage along Antoine at W Gulf Bank Road was routed southward and combined with the outfall at Long Creek Lane. With this alternative the existing storm sewer and roadway paving along W Gulf Bank Road would not need to be rebuilt. Additionally, the capacity of the existing storm sewer along W Gulf Bank Road would become adequate to maintain the 100-year flows below ROW elevations.

Alternative 2: The White Oak Bayou South storm sewer runs from the railroad tracks northward and discharges directly into White Oak Bayou. This alternative truncates the upstream end of the drainage area from south of DeSoto Street and diverts the storm water through a proposed new storm sewer pipe toward the east to outfall directly into White Oak Bayou. By removing the drainage area south of DeSoto Street the White Oak Bayou South storm sewer system will have sufficient capacity to maintain the 100-year HGL below street ROW elevations.

The following table lists the results of the modeling and calculations. The table includes for each outfall the size and length of the existing storm sewer system, the proposed storm sewer system, and the required replacement pipes. The required replacement pipes lists only those storm sewer segments that need to be replaced, whereas the proposed storm sewer system lists the entire system and includes those existing pipes that do not need to be replaced. **Appendix A** contains the HouStorm models of the proposed storm sewer systems, and **Exhibits 2A, 2B, 2C, 2D and 2E** shows the various drainage areas and outfalls for the proposed conditions.

Existing Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	**Pipe Size/Length**		
Outfall from W GulfBank to VogelCreek – System A1			
W. Gulf Bank	24” RCP – 442 LF	36” RCP – 284 LF	36” RCP – 284 LF
W. Gulf Bank	27” RCP – 165 LF	42” RCP – 477 LF	42” RCP – 477LF
W. Gulf Bank	30” RCP – 154 LF	48” RCP – 1298 LF	48” RCP – 1298 LF
W. Gulf Bank	36” RCP – 1,298 LF		
Antoine	24” RCP –380 LF	36” RCP – 380 LF	36” RCP – 380 LF
Outfall from W GulfBank to VogelCreek – System A2			
Antoine	24” RCP – 1,251 LF	24” RCP – 61 LF	36” RCP – 487 LF
Antoine	30” RCP – 676 LF	36” RCP – 487 LF	42” RCP – 1,379 LF
Antoine	42” RCP – 764 LF	42” RCP – 2143 LF	
Antoine	54” RCP – 23 LF	54” RCP – 23 LF	
Long Creek Lane	24” RCP – 99 LF	24” RCP – 99 LF	
Long Creek Lane	30” RCP – 522 LF	30” RCP – 522 LF	
Long Creek Lane	42”&54” RCP – 310 LF	42”&54” RCP – 310 LF	
Alternative: Outfall from W Gulf Bank Road To Long Creek Lane – System A2a			
Antoine	24” RCP – 1,251 LF	24” RCP – 61 LF	30” RCP – 380 LF
Antoine	30” RCP – 676 LF	30” RCP – 380 LF	36” RCP – 486 LF
Antoine	42” RCP – 764 LF	36” RCP – 486 LF	42” RCP – 486 LF
Antoine	54” RCP – 23 LF	42” RCP – 486 LF	48” RCP – 1,190 LF
Antoine		48” RCP – 1,190 LF	54” RCP – 1,440 LF
Long Creek Lane	24” RCP – 99 LF	54” RCP – 1,463 LF	
Long Creek Lane	30” RCP – 522 LF	24” RCP – 99 LF	
Long Creek Lane	42”&54” RCP – 310 LF	30” RCP – 261 LF	
		42”&54” RCP – 310 LF	
Outfall from Maple Hill Rd to White Oak Bayou – System A3			
Antoine	21” RCP – 552 LF	30” RCP – 608 LF	30” RCP – 608 LF
Antoine	24” RCP – 56 LF		
Maple Hill Rd	24” RCP – 224LF	30” RCP – 224 LF	30” RCP – 224 LF
Maple Hill Rd	42” RCP – 513 LF	42” RCP – 513 LF	
Outfall from Victory Dr to White Oak Bayou – System A4			
Victory Dr.	24” RCP – 343 LF	24” RCP – 343 LF	No change needed
Outfall from Antoine to White Oak Bayou North – System A5			
Antoine	24” RCP – 183 LF	24” RCP – 183 LF	No change needed
Outfall from Antoine to White Oak Bayou South – System A6			
Antoine	24” RCP – 79 LF	24” RCP – 79 LF	42” RCP – 900 LF
Antoine	30” RCP – 360 LF	42” RCP – 900 LF	54” RCP – 533 LF
Antoine	36” RCP – 540 LF	54” RCP – 533 LF	60” RCP – 478 LF
Antoine	42” RCP – 533 LF	72” RCP – 2,005 LF	72” RCP – 2,005 LF
Antoine	48” RCP – 478 LF	6’x6’ RCB – 547 LF	6’x6’ RCB – 547 LF
Antoine	54” RCP – 531 LF		

Existing Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	**Pipe Size/Length**		
Antoine	60” RCP – 462 LF		
Antoine	66” RCP – 1,011 LF		
Antoine	72” RCP – 492 LF		
Antoine	72” CMP – 56 LF		
Alternative: Outfall from Antoine to White Oak Bayou S. and Desoto St. Diversion – System A6a & A6b			
Antoine	24” RCP – 79 LF	White Oak Bayou South	White Oak Bayou South
Antoine	30” RCP – 360 LF	24” RCP – 79 LF	
Antoine	36” RCP – 540 LF	54” RCP – 531 LF	
Antoine	42” RCP – 533 LF	60” RCP – 462 LF	
Antoine	48” RCP – 478 LF	66” RCP – 1,011 LF	
Antoine	54” RCP – 531 LF	72” RCP – 492 LF	
Antoine	60” RCP – 462 LF	72” CMP – 56 LF	72” CMP – 56 LF
Antoine	66” RCP – 1,011 LF	Desoto St. Diversion	Desoto St. Diversion
Antoine	72” RCP – 492 LF	30” RCP – 360 LF	30” RCP – 360 LF
Antoine	72” CMP – 56 LF	36” RCP – 540LF	36” RCP – 540LF
DeSoto St.		42” RCP – 3400 LF	42” RCP – 3400 LF
Outfall from Antoine to Cole Creek North – System A7			
Antoine	66” RCP – 1,498 LF	72” RCP – 1,498 LF	72” RCP – 1,498 LF
Outfall from Antoine to Cole Creek South – System A8			
Antoine	24” RCP – 138 LF	30”RCP – 138 LF	30”RCP – 138 LF
Antoine	48” RCP – 500 LF	66”RCP – 723 LF	66”RCP – 723 LF
Antoine	60” RCP – 2,091 LF	78” RCP – 795 LF	78” RCP – 795 LF
Antoine		84” RCP – 1,073 LF	84” RCP – 1,073 LF
Outfall from Antoine to Brickhouse Gully North – System A9			
Antoine	24” RCP – 384 LF	30” RCP – 384LF	30” RCP – 384LF
Antoine	30” RCP – 257 LF	48” RCP – 257 LF	48” RCP – 257 LF
Antoine	36” RCP – 539 LF	54” RCP – 539 LF	54” RCP – 539 LF
Antoine	42” RCP – 288 LF	60” RCP – 288 LF	60” RCP – 288 LF
Antoine	54” RCP – 323 LF	72” RCP – 1057 LF	72” RCP – 1057 LF
Antoine	60” RCP – 1,689 LF	78” RCP – 955 LF	78” RCP – 955 LF
Outfall from Antoine to Brickhouse Gully South – System A10			
Antoine	18” RCP – 822 LF	24” RCP – 822 LF	24” RCP – 822 LF
Antoine	21” RCP – 307 LF	30” RCP – 334 LF	30” RCP – 334 LF
Antoine	24” RCP – 27 LF		

3. Cost Estimates

Cost estimates were prepared for proposed storm sewer systems and alternatives. Unit costs were derived from City of Houston and TxDOT sources. The following table lists the cost estimates for each outfall and a total estimated cost for each alternative. The cost estimate details are provided in attached **Tables 4 through 15**.

Proposed Storm Sewer Systems

Existing Outfall	Estimated Cost	Alternative Outfall	Estimated Cost
W Gulf Bank Road	$472,684	W Gulf Bank Road to Long Creek Lane	$854,840
Long Creek Lane	$319,932		
Maple Hill Road	$109,372	Maple Hill Road – No Change	$109,372
Victory Drive	$0	Victory Drive – No Change	$0
White Oak Bayou North	$0	White Oak Bayou North – No Change	$0
White Oak Bayou South	$1,342,200	White Oak Bayou South with DeSoto Street Diversion	$745,200
Cole Creek North	$598,802	Cole Creek North - No Change	$598,802
Cole Creek South	$1,250,362	Cole Creek South – No Change	$1,250,362
Brickhouse Gully North	$1,247,548	Brickhouse Gully North – No Change	$1,247,548
Brickhouse Gully South	$135,872	Brickhouse Gully South – No Change	$135,872
TOTAL	**$5,476,772**	**TOTAL**	**$4,941,996**

It should be noted that the estimated cost for the proposed storm sewer outfalling at W Gulf Bank Road does not include the costs incurred to rebuild the street. Likewise, the Alternative Outfall to White Oak Bayou at DeSoto Street does not include costs to rebuild the street.

Cost estimates were prepared for the storm water detention facilities needed to mitigation the impact created by the added impervious cover. Since the detention will be provided within the regional facility the City of Houston is creating in the Inwood Forest area, specific locations of the facilities have not been identified. Three storm water detention facilities for this project were estimated based on the sub-projects that have been identified (see below for a description of the sub-projects). The cost estimate included land and construction costs. The land required is based on assuming an average detention basin depth of 4 feet and a 50% contingency for side slopes and berms. The estimated land cost used is three times the average valuation for property according the HCAD records. Construction cost estimates consisted of cost for excavation, control structure, and a contingency of $1 per squre foot of required land. The three storm water detention facilities are meant to mitigate the impact for the proposed improvements from Bridge Forest to Victory, and from Victory to Tidwell, and from Tidwell to US 290. There is no difference in storm water mitigation for the different storm sewer alternative previouse presented. The following table lists the total estimated cost for each basin, **Table 16** provides the details.

Proposed Storm Water Detention Facilities

Reach	Storage Volume (ac-ft)	Land Area (acres)	Estimate Cost
Bridge Forest to Victory	1.66	0.62	$553,762
Victory to Tidwell	1.77	0.66	$589,042
Tidwell to US 290	3.34	1.25	$1,103,939
Total	**6.77**	**2.53**	**$2,246,743**

These costs estimates are intended to be included with the overall project costs, and therefore do not include a contingency factor, construction management costs, engineering fees, or design management costs.

4. Sub-Projects

The proposed improvements along Antoine Drive have been divided into three segments. The most northern segment extends from Bridge Forest to Victory; the middle segment extends from Victory to Tidwell; and the southern segment extends from Tidwell to US 290. Cost estimates for these three segments have been prepared and are included as Tables 14a, 14b, and 14c for the three segments using existing outfalls. Tables 15a, 15b, and 15c are the cost estimates for the three segments using the alternative outfalls.

Proposed Storm Sewer Systems by Sub-Project

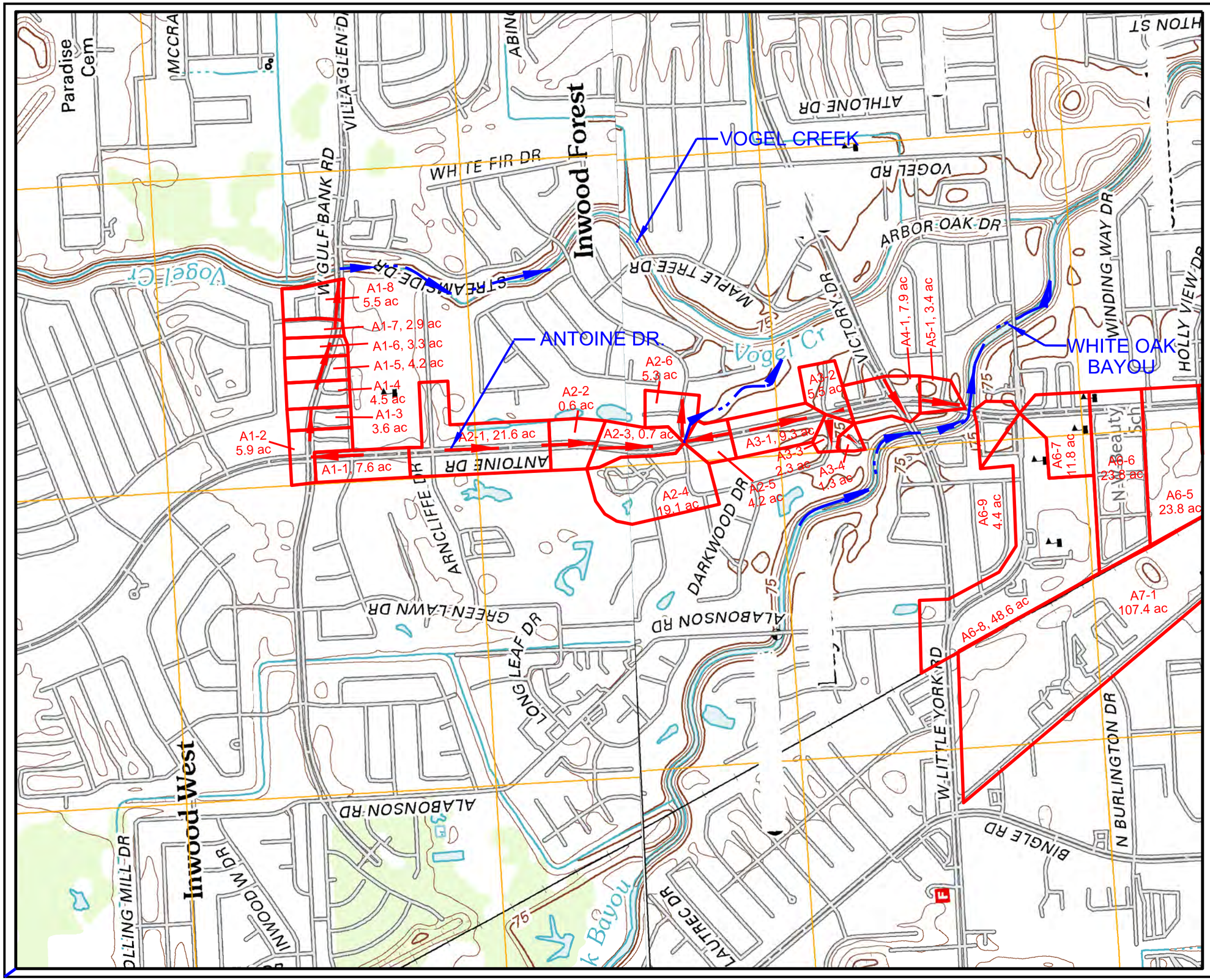
Existing Outfall	Estimated Cost	Alternative Outfall	Estimated Cost
Bridge Forest to Victory	$901,988	Bridge Forest to Victory	$964,212
Victory to Tidwell	$1,650,674	Victory to Tidwell	$1,053,674
Tidwell to US 290	$2,924,110	Tidwell to US 290	$2,924,110
Total	**$5,476,772**	**Total**	**$4,941,996**

The City of Houston has provided a rate for land cost for the storm water detention facilities based on required storage volume. The rate is $8,840 per ac-ft of storage. The following table applies this rate to the required storm water storage volume for each basin.

Proposed Land Cost per City of Houston given rate

Reach	Storage Volume (ac-ft)	Land Cost ($/ac-ft)	Estimate Cost
Bridge Forest to Victory	1.66	$8,840	$14,674
Victory to Tidwell	1.77	$8,840	$15,647
Tidwell to US 290	3.34	$8,840	$29,526
Total	**6.77**	**$8,840**	**$59,847**

Note, this land cost was not used in the estimated costs for the detention basins.



LEGEND

- DRAINAGE AREA BOUNDARY
- DRAINAGE AREA NOT INCLUDED IN PROJECT
- DITCH FLOW
- FLOW DIRECTION
- A1-8 DRAINAGE AREA ID

N

0 1000 2000

SCALE : 1" = 1000'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

OMEGA ENGINEERS, INC.
Engineering & Construction Management Company
16350 PARK TEN PLACE, SUITE 120
HOUSTON, TX 77084
(281)647-9184

P&D PROFESSIONAL SERVICES, INC.
T.B.P.E. FIRM REGISTRATION NUMBER F-14117
12155 LISMORE LAKE DRIVE, CYPRESS, TX 77429
(281) 743-4475

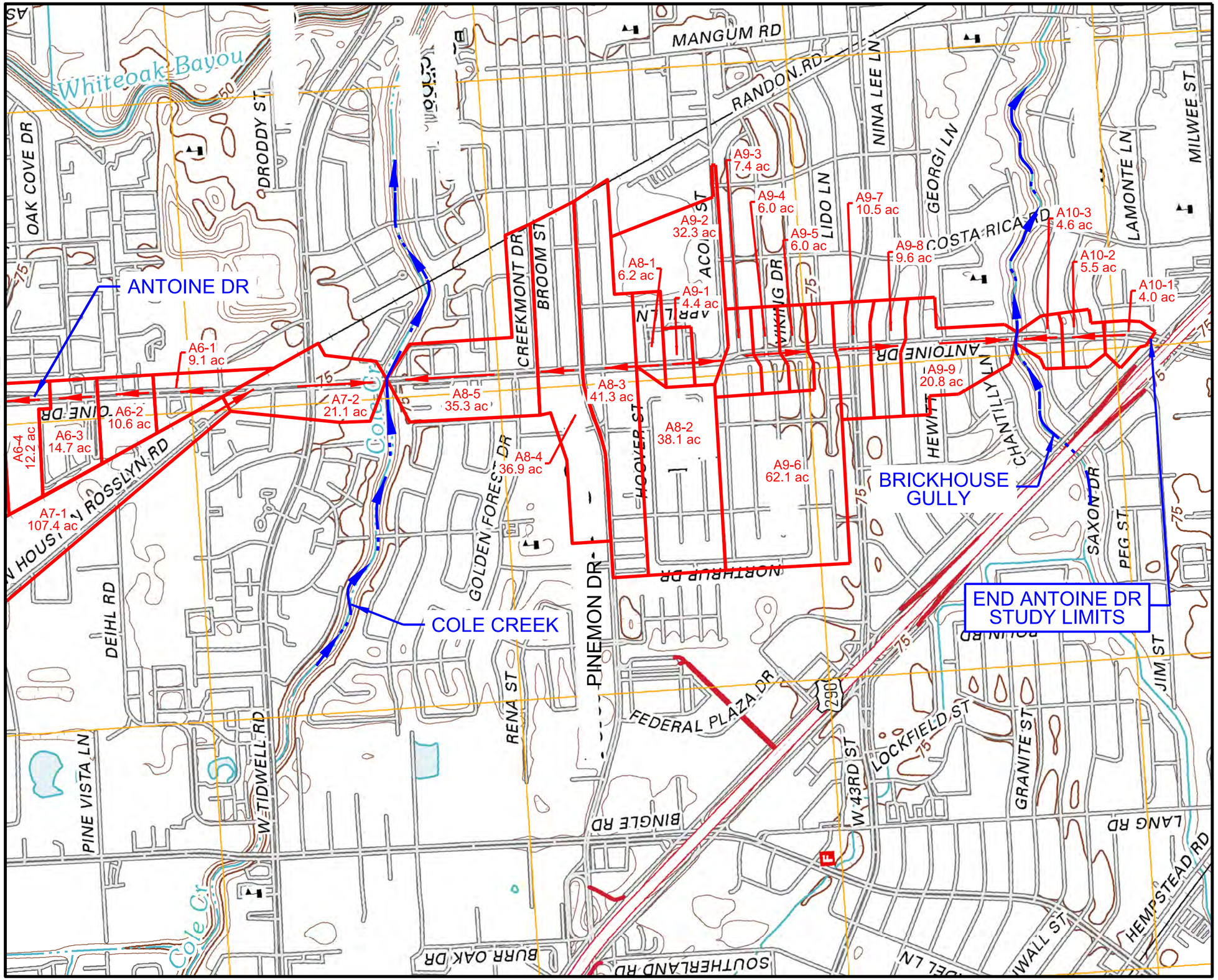
THESE DOCUMENTS ARE FOR INTERIM REVIEW AND NOT FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.
RESPONSIBLE ENGINEER;
P&D PROFESSIONAL SERVICES, INC.
TBPE FIRM REGISTRATION NO. F-14117
PAULA N. PRICE, P.E.
TEXAS REGISTRATION NO. 90265

ANTOINE DRIVE
DRAINAGE AREA MAP
ALTERNATIVE 1

SHEET 1 OF 2

DRAWING SCALE : 1"=1,000'
DATE: NOVEMBER 12, 2015

MATCH LINE



LEGEND

- DRAINAGE AREA BOUNDARY
- DRAINAGE AREA NOT INCLUDED IN PROJECT
- DITCH FLOW
- FLOW DIRECTION
- A1-8 DRAINAGE AREA ID

0 1000 2000

SCALE : 1" = 1000'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

OMEGA ENGINEERS, INC.
Engineering & Construction Management Company
16350 PARK TEN PLACE, SUITE 120
HOUSTON, TX 77084
(281)647-9184

P&D PROFESSIONAL SERVICES, INC.
T.B.P.E. FIRM REGISTRATION NUMBER F-14117
12155 LISMORE LAKE DRIVE, CYPRESS, TX 77429
(281) 743-4475

THESE DOCUMENTS ARE FOR INTERIM REVIEW AND NOT FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.
RESPONSIBLE ENGINEER;
P&D PROFESSIONAL SERVICES, INC.
TBPE FIRM REGISTRATION NO. F-14117
PAULA N. PRICE, P.E.
TEXAS REGISTRATION NO. 90265

ANTOINE DRIVE
DRAINAGE AREA MAP
EXHIBIT 1B

SHEET 2 OF 2

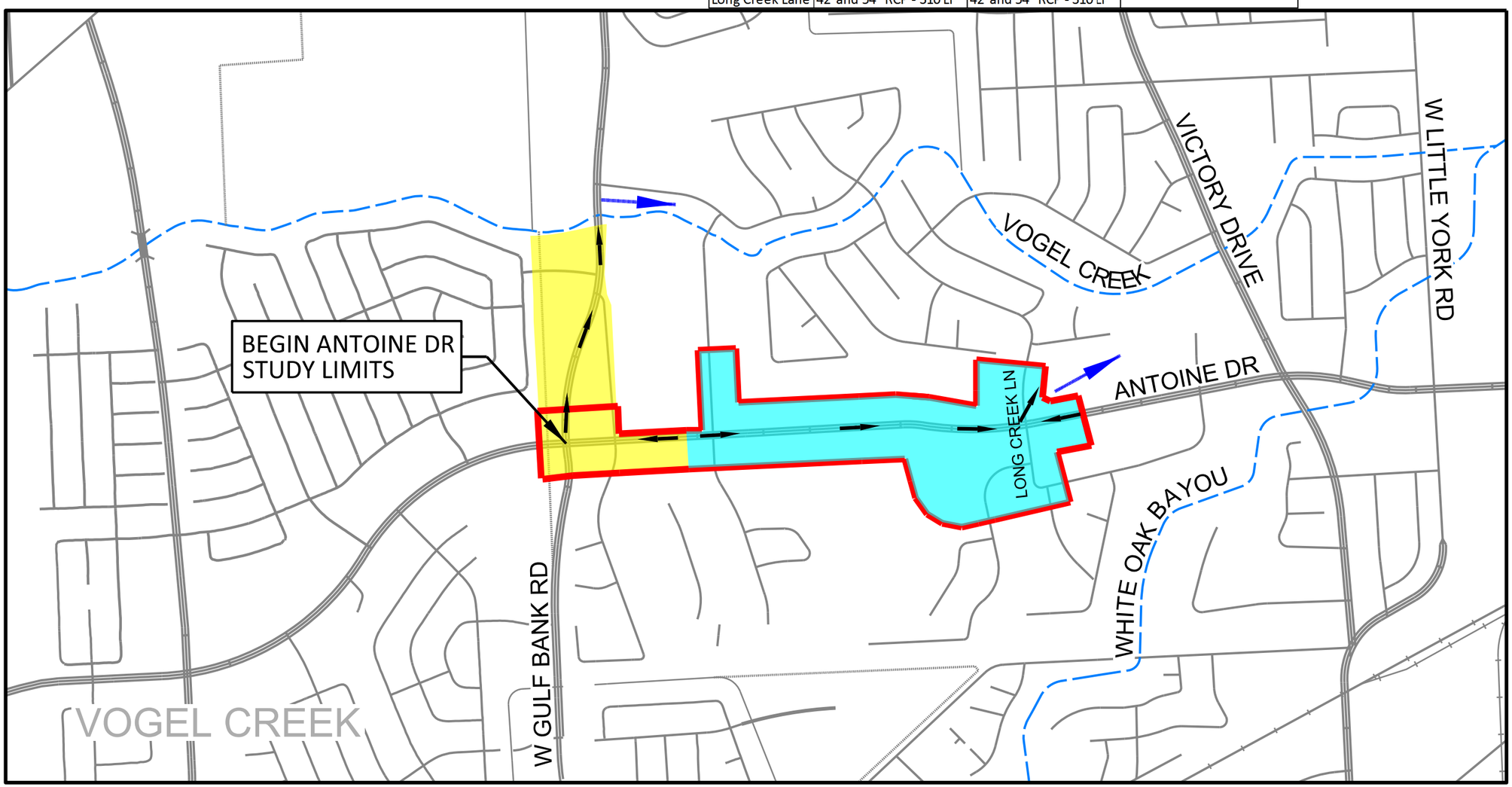
DRAWING SCALE : 1"=1,000'
DATE: NOVEMBER 12, 2015

Eexisting Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	Pipe Size / Length		
Outfall from W Gulf Bank to Vogel Creek - System A1			
W. Gulf Bank	24" RCP - 442 LF	36" RCP - 284 LF	36" RCP - 284 LF
W. Gulf Bank	27" RCP - 165 LF	42" RCP - 477 LF	42" RCP - 477 LF
W. Gulf Bank	30" RCP - 154 LF	48" RCP - 1298 LF	48" RCP - 1298 LF
W. Gulf Bank	36" RCP - 1298 LF		
Antoine	24" RCP - 380 LF	36" RCP - 380 LF	36" RCP - 380 LF

Eexisting Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	Pipe Size / Length		
Outfall from Long Creek Lane to Tributary to Vogel Creek - System A2			
Antoine	24" RCP - 1251 LF	24" RCP - 61 LF	36" RCP - 487 LF
Antoine	30" RCP - 676 LF	36" RCP - 487 LF	42" RCP - 1379 LF
Antoine	42" RCP - 764 LF	42" RCP - 2143 LF	
Antoine	54" RCP - 23 LF	54" RCP - 23 LF	
Long Creek Lane	24" RCP - 99 LF	24" RCP - 99 LF	
Long Creek Lane	30" RCP - 522 LF	30" RCP - 522 LF	
Long Creek Lane	42"and 54" RCP - 310 LF	42"and 54" RCP - 310 LF	
Outfall from W Gulf Bank Road to Long Creek Lane to Tributary to Vogel Creek -System A2a			
Antoine	24" RCP - 1251 LF	24" RCP - 61 LF	30" RCP - 380 LF
Antoine	30" RCP - 676 LF	30" RCP - 380 LF	36" RCP - 486 LF
Antoine	42" RCP - 764 LF	36" RCP - 486 LF	42" RCP - 486LF
Antoine	54" RCP - 23 LF	42" RCP - 486 LF	48" RCP - 1190 LF
Antoine		48" RCP - 1190 LF	54" RCP - 1440 LF
Antoine		54" RCP - 1463 LF	
Long Creek Lane	24" RCP - 99 LF	24" RCP - 99 LF	
Long Creek Lane	30" RCP - 261 LF	30" RCP - 261 LF	
Long Creek Lane	42"and 54" RCP - 310 LF	42"and 54" RCP - 310 LF	

LEGEND

- DRAINAGE AREA BOUNDARY (W GULF BANK RD TO VOGEL CREEK)
- DRAINAGE AREA BOUNDARY (LONG CREEK LN TO VOGEL CREEK)
- ALTERNATIVE- DRAINAGE AREA BOUNDARY -FROM W GULF BANK LN TO LONG CREEK LN -TO VOGEL CREEK
- STORM WATER OUTFALLS
- EXIST FLOW DIRECTION



0 1000 2000

SCALE : 1" = 1000'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

OMEGA ENGINEERS, INC.
Engineering & Construction Management Company
16350 PARK TEN PLACE, SUITE 120
HOUSTON, TX 77084
(281)647-9184

P&D PROFESSIONAL SERVICES, INC.
T.B.P.E. FIRM REGISTRATION NUMBER F-14117
12155 LISMORE LAKE DRIVE, CYPRESS, TX 77429
(281) 743-4475

THESE DOCUMENTS ARE FOR INTERIM REVIEW AND NOT FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.
RESPONSIBLE ENGINEER:
P&D PROFESSIONAL SERVICES, INC.
TBPE FIRM REGISTRATION NO. F-14117
PAULA N. PRICE, P.E.
TEXAS REGISTRATION NO. 90265

ANTOINE DRIVE
DRAINAGE AREA MAP

EXHIBIT 2A

SHEET 1 OF 5

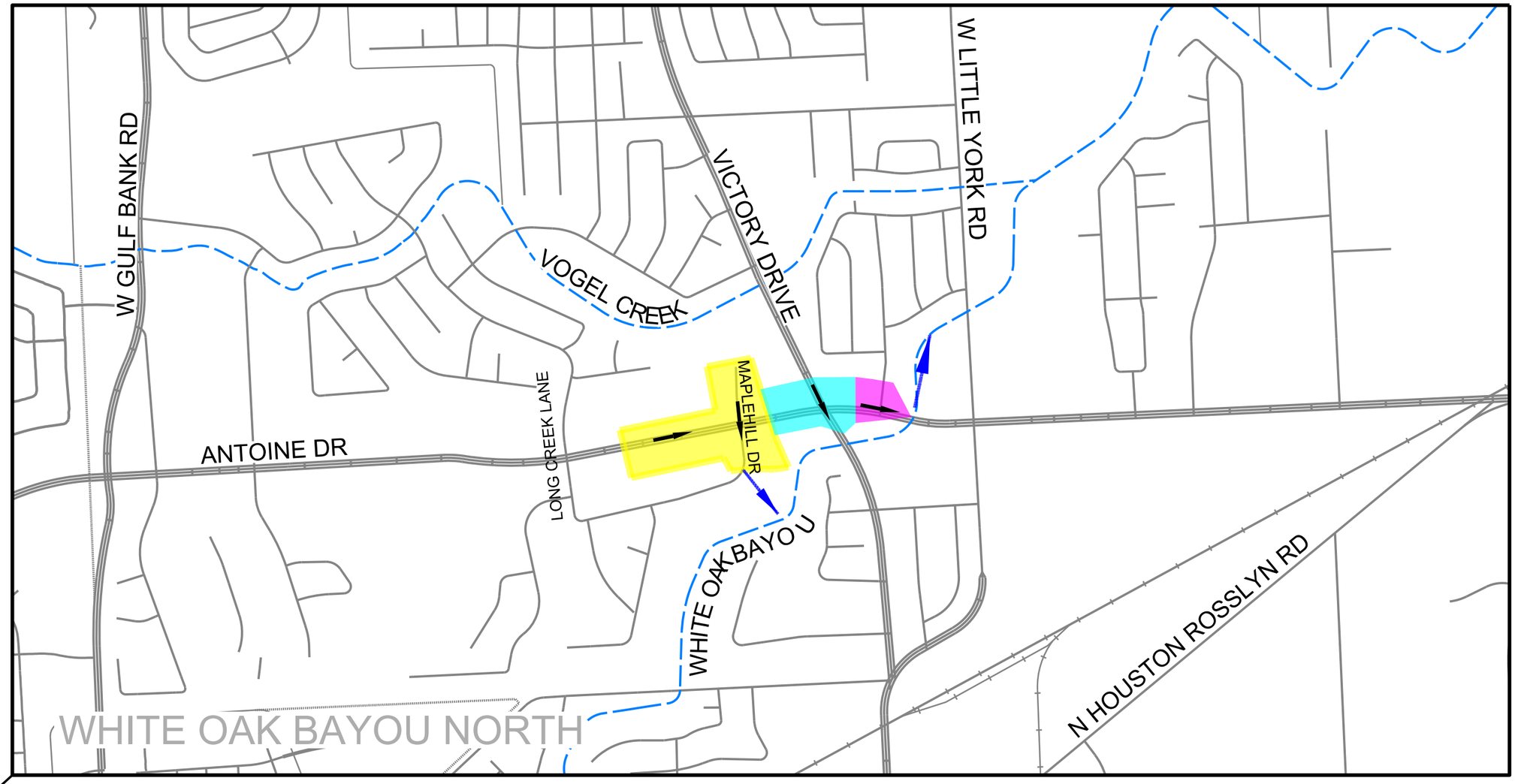
DRAWING SCALE : 1"=1,000'
DATE: NOVEMBER 12, 2015

ANTOINE DRAIN MAP PP 01.DGN

Eexisting Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	Pipe Size / Length		
Outfall from Maple Hill Rd to White Oak Bayou -System A3			
Antoine	21" RCP - 552 LF	30" RCP - 608 LF	30" RCP - 608 LF
Antoine	24" RCP - 56 LF		
Maple Hill Rd	24" RCP - 224 LF	30" RCP - 224 LF	30" RCP - 224 LF
Maple Hill Rd	42" RCP - 513 LF	42" RCP - 513 LF	
Outfall from Victory Dr to White Oak Bayou -System A4			
Victory	24" RCP - 343 LF	24" RCP - 343 LF	No change needed
Outfall from Antoine to White Oak Bayou North -System A5			
Antoine	24" RCP - 183 LF	24" RCP - 183 LF	No change needed

LEGEND

- DRAINAGE AREA BOUNDARY (MAPLE HILL RD TO WHITE OAK BAYOU)
- DRAINAGE AREA BOUNDARY (VICTORY DR TO WHITE OAK BAYOU)
- DRAINAGE AREA BOUNDARY (ANTOINE DR TO WHITE OAK BAYOU)
- STORM WATER OUTFALLS
- EXIST FLOW DIRECTION



0 1000 2000

SCALE : 1" = 1000'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

OMEGA ENGINEERS, INC.
Engineering & Construction Management Company
16350 PARK TEN PLACE, SUITE 120
HOUSTON, TX 77084
(281)647-9184

P&D PROFESSIONAL SERVICES, INC.
T.B.P.E. FIRM REGISTRATION NUMBER F-14117
12155 LISMORE LAKE DRIVE, CYPRESS, TX 77429
(281) 743-4475

THESE DOCUMENTS ARE FOR INTERIM REVIEW AND NOT FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.
RESPONSIBLE ENGINEER:
P&D PROFESSIONAL SERVICES, INC.
TBPE FIRM REGISTRATION NO. F-14117
PAULA N. PRICE, P.E.
TEXAS REGISTRATION NO. 90265

ANTOINE DRIVE
DRAINAGE AREA MAP

EXHIBIT 2B

SHEET 2 OF 5

DRAWING SCALE : 1"=1,000'
DATE: NOVEMBER 12, 2015

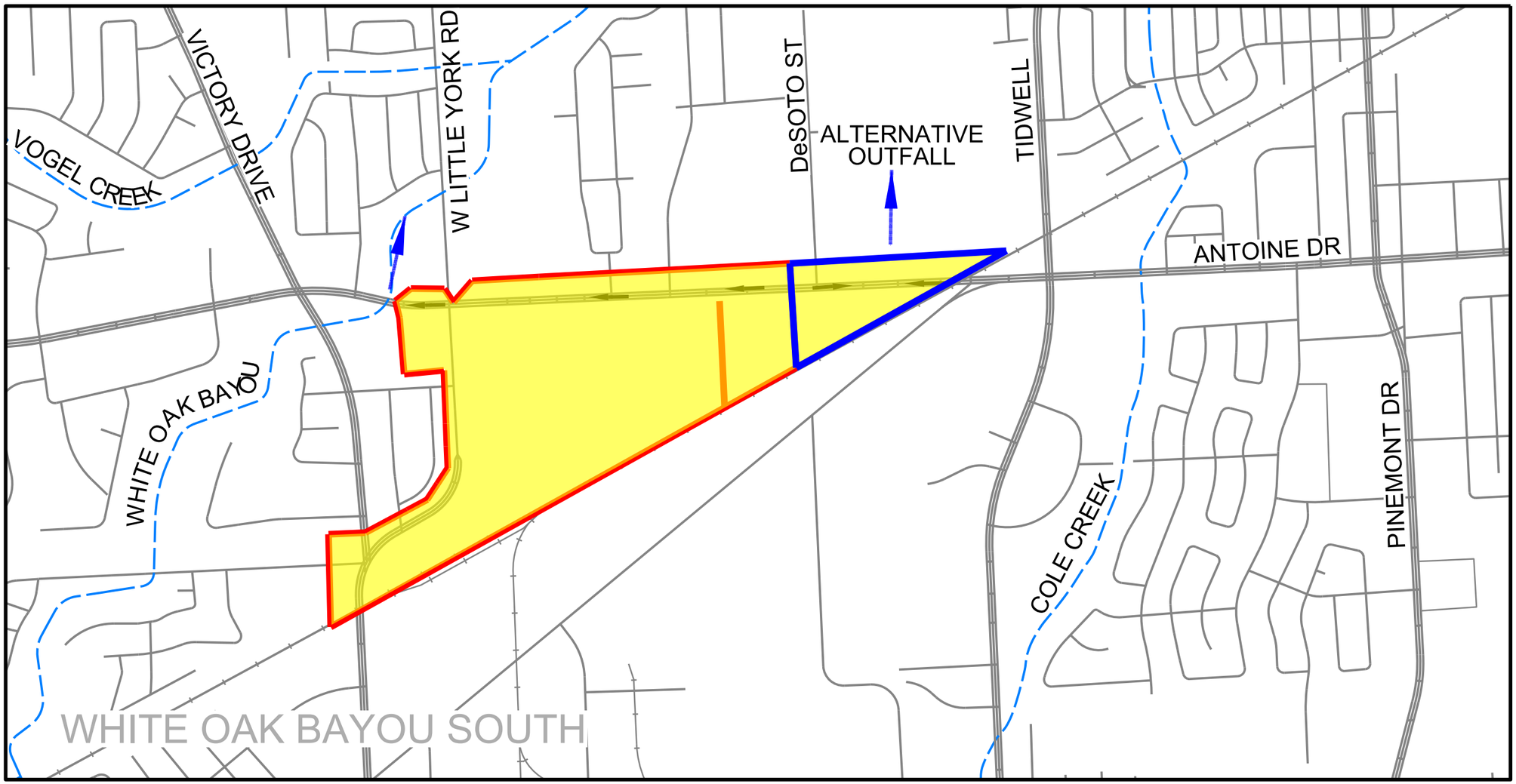
ANTOINE DRAIN MAP PP 02.DGN

Eexisting Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	Pipe Size / Length		
Outfall from Antoine to White Oak Bayou South -System A6			
Antoine	24" RCP -79 LF	24" RCP -79 LF	42" RCP - 900 LF
Antoine	30" RCP - 360 LF	42" RCP - 900 LF	54" RCP - 533LF
Antoine	36" RCP - 540 LF	54" RCP - 533LF	72" RCP - 2005 LF
Antoine	42" RCP - 533 LF	72" RCP - 2005 LF	6x6 BOX - 547 LF
Antoine	48" RCP - 478 LF	6x6 BOX - 547 LF	
Antoine	54" RCP - 531LF		
Antoine	60" RCP - 462 LF		
Antoine	66" RCP - 1011 LF		
Antoine	72" RCP - 492 LF		
Antoine	72" CMP - 56 LF		

Eexisting Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	Pipe Size / Length		
Alternative: Outfall from Antoine to White Oak Bayou S and DeSoto St Diversion -Sys A6a & A6b			
Antoine	24" RCP -79 LF	White Oak Bayou South	White Oak Bayou South
Antoine	30" RCP - 360 LF	24" RCP -79 LF	
Antoine	36" RCP - 540 LF	54" RCP - 531LF	
Antoine	42" RCP - 533 LF	60" RCP - 462 LF	
Antoine	48" RCP - 478 LF	66" RCP - 1011 LF	
Antoine	54" RCP - 531LF	72" RCP - 492 LF	
Antoine	60" RCP - 462 LF	72" CMP - 56 LF	72" CMP - 56 LF
Antoine	66" RCP - 1011 LF	Desoto St Diversion	Desoto St Diversion
Antoine	72" RCP - 492 LF	30" RCP - 360 LF	30" RCP - 360 LF
Antoine	72" CMP - 56 LF	36" RCP - 540 LF	36" RCP - 540 LF
DeSoto		42" RCP - 3400 LF	42" RCP - 3400 LF

LEGEND

- DRAINAGE AREA BOUNDARY (RR TRACK TO WHITE OAK BAYOU)
- ALTERNATIVE DRAINAGE AREA BOUNDARY (DESOTO TO WHITE OAK BAYOU)
- ALTERNATIVE DRAINAGE AREA BOUNDARY (RR TO DESOTO TO WHITE OAK BAYOU)
- STORM WATER OUTFALLS
- EXIST FLOW DIRECTION



0 1000 2000

SCALE : 1" = 1000'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

OMEGA ENGINEERS, INC.
Engineering & Construction Management Company
16350 PARK TEN PLACE, SUITE 120
HOUSTON, TX 77084
(281)647-9184

P&D PROFESSIONAL SERVICES, INC.
T.B.P.E. FIRM REGISTRATION NUMBER F-14117
12155 LISMORE LAKE DRIVE, CYPRESS, TX 77429
(281) 743-4475

THESE DOCUMENTS ARE FOR INTERIM REVIEW AND NOT FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.
RESPONSIBLE ENGINEER:
P&D PROFESSIONAL SERVICES, INC.
TBPE FIRM REGISTRATION NO. F-14117
PAULA N. PRICE, P.E.
TEXAS REGISTRATION NO. 90265

ANTOINE DRIVE
DRAINAGE AREA MAP

EXHIBIT 2C

SHEET 3 OF 5

DRAWING SCALE : 1"=1,000'

DATE: NOVEMBER 12, 2015

ANTOINE DRAIN MAP PP 03.DGN

Eexisting Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	Pipe Size / Length		
Outfall from Antoine to Cole Creek North -System A7			
Antoine	66" RCP -1498 LF	72" RCP -1498 LF	72" RCP -1498 LF
Outfall from Antoine to Cole Creek South -System A8			
Antoine	24" RCP -138 LF	30" RCP - 138 LF	30" RCP - 138 LF
Antoine	48" RCP - 500 LF	66" RCP - 723 LF	66" RCP - 723 LF
Antoine	60" RCP - 2091 LF	78" RCP - 795 LF	78" RCP - 795 LF
Antoine		84" RCP - 1073 LF	84" RCP - 1073 LF

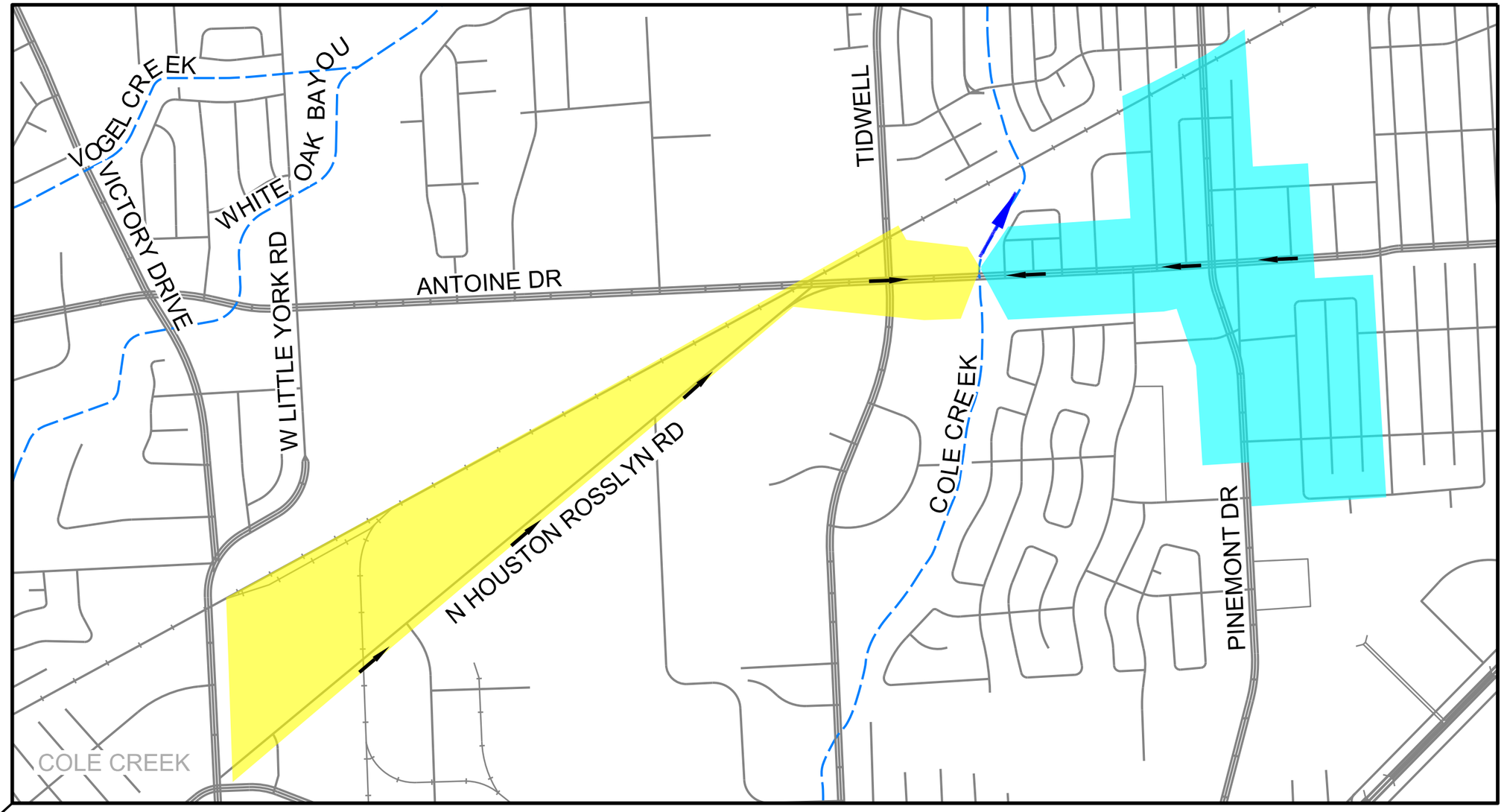
LEGEND

DRAINAGE AREA BOUNDARY (ANTOINE DR TO COLE CREEK NORTH)

DRAINAGE AREA BOUNDARY (ANTOINE DR TO COLE CREEK SOUTH)

STORM WATER OUTFALLS

EXIST FLOW DIRECTION



0 1000 2000

SCALE : 1" = 1000'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

OMEGA ENGINEERS, INC.
Engineering & Construction Management Company
16350 PARK TEN PLACE, SUITE 120
HOUSTON, TX 77084
(281)647-9184

P&D PROFESSIONAL SERVICES, INC.
T.B.P.E. FIRM REGISTRATION NUMBER F-14117
12155 LISMORE LAKE DRIVE, CYPRESS, TX 77429
(281) 743-4475

THESE DOCUMENTS ARE FOR INTERIM REVIEW AND NOT FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.
RESPONSIBLE ENGINEER;
P&D PROFESSIONAL SERVICES, INC.
TBPE FIRM REGISTRATION NO. F-14117
PAULA N. PRICE, P.E.
TEXAS REGISTRATION NO. 90265

ANTOINE DRIVE
DRAINAGE AREA MAP

EXHIBIT 2D

SHEET 4 OF 5

DRAWING SCALE : 1"=1,000'

DATE: NOVEMBER 12, 2015

ANTOINE DRAIN MAP PP 04.DGN

Eexisting Storm Sewer System		Proposed Storm Sewer	Required Replacement Pipes
Pipe Location	Pipe Size / Length		
Outfall from Antoine to Brickhouse Gully North -System A9			
Antoine	24" RCP -384 LF	30" RCP - 384 LF	30" RCP - 384 LF
Antoine	30" RCP - 257 LF	48" RCP - 257 LF	48" RCP - 257 LF
Antoine	36" RCP - 539 LF	54" RCP - 539 LF	54" RCP - 539 LF
Antoine	42" RCP - 288 LF	60" RCP - 288 LF	60" RCP - 288 LF
Antoine	54" RCP - 323 LF	72" RCP - 1057 LF	72" RCP - 1057 LF
Antoine	60" RCP -1689 LF	78" RCP - 955 LF	78" RCP - 955 LF
Outfall from Antoine to Brickhouse Gully South -System A10			
Antoine	18" RCP -822 LF	24" RCP - 822 LF	24" RCP - 822 LF
Antoine	21" RCP - 307 LF	30" RCP - 344 LF	30" RCP - 344 LF
Antoine	24" RCP - 27 LF		

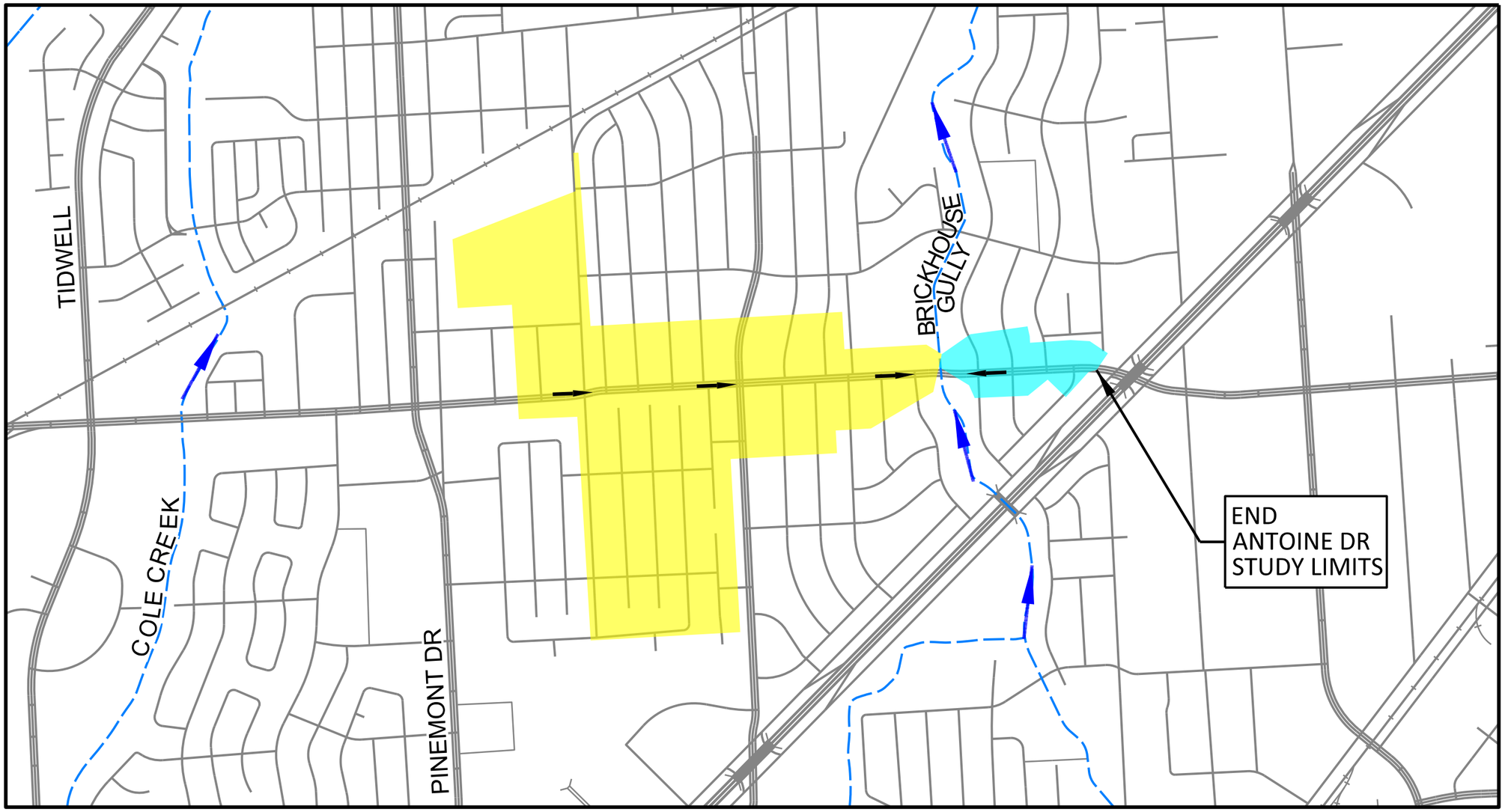
LEGEND

DRAINAGE AREA BOUNDARY (ANTOINE DR TO BRICKHOUSE GULLY NORTH)

DRAINAGE AREA BOUNDARY (ANTOINE DR TO BRICKHOUSE GULLY SOUTH)

STORM WATER OUTFALLS

EXIST FLOW DIRECTION



0 1000 2000

SCALE : 1" = 1000'

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

OMEGA ENGINEERS, INC.
Engineering & Construction Management Company
16350 PARK TEN PLACE, SUITE 120
HOUSTON, TX 77084
(281)647-9184

P&D PROFESSIONAL SERVICES, INC.
T.B.P.E. FIRM REGISTRATION NUMBER F-14117
12155 LISMORE LAKE DRIVE, CYPRESS, TX 77429
(281) 743-4475

THESE DOCUMENTS ARE FOR INTERIM REVIEW AND NOT FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.
RESPONSIBLE ENGINEER;
P&D PROFESSIONAL SERVICES, INC.
TBPE FIRM REGISTRATION NO. F-14117
PAULA N. PRICE, P.E.
TEXAS REGISTRATION NO. 90265

ANTOINE DRIVE
DRAINAGE AREA MAP

EXHIBIT 2E

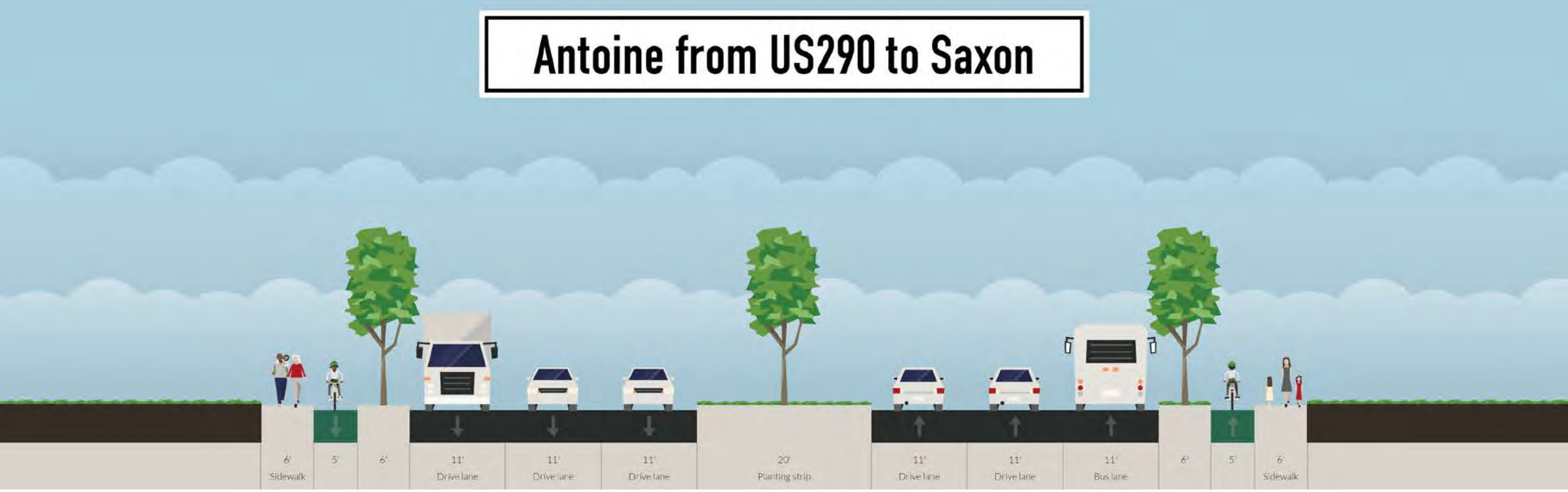
SHEET 5 OF 5

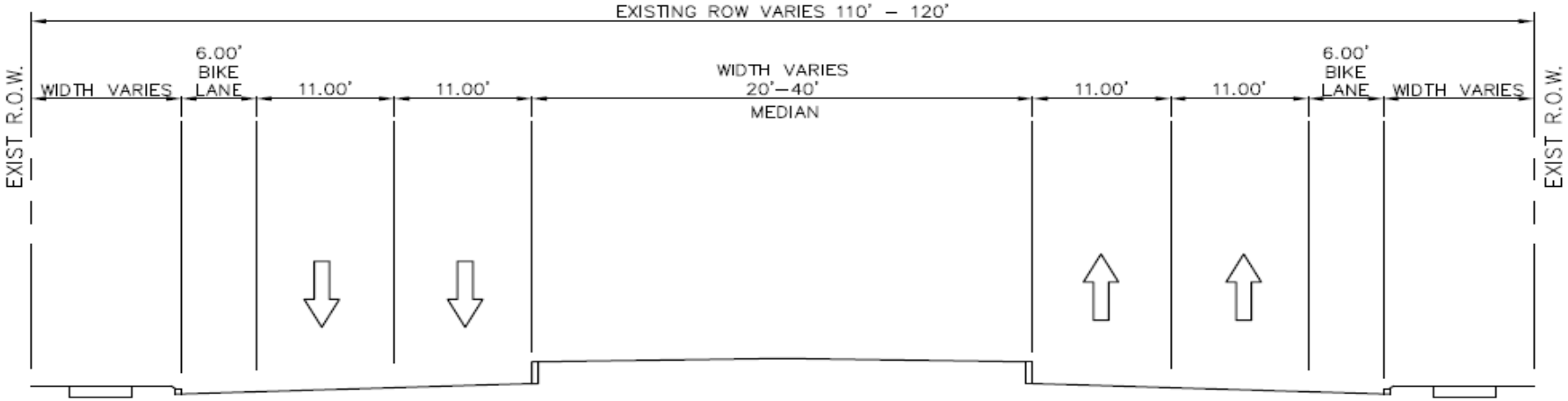
DRAWING SCALE : 1"=1,000'

DATE: NOVEMBER 12, 2015

ANTOINE DRAIN MAP PP 05.DGN

Antoine from US290 to Saxon

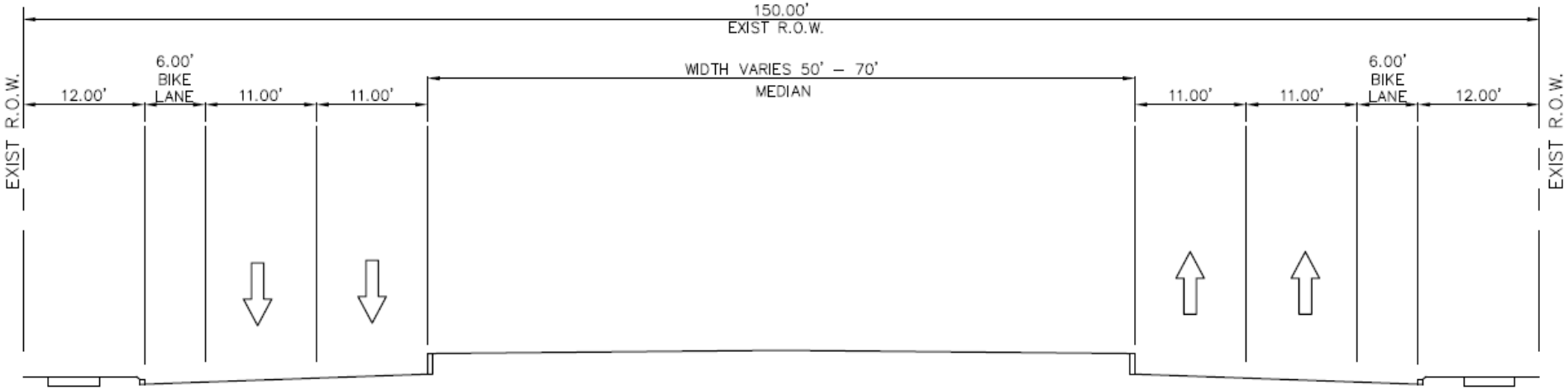




EXISTING SECTION

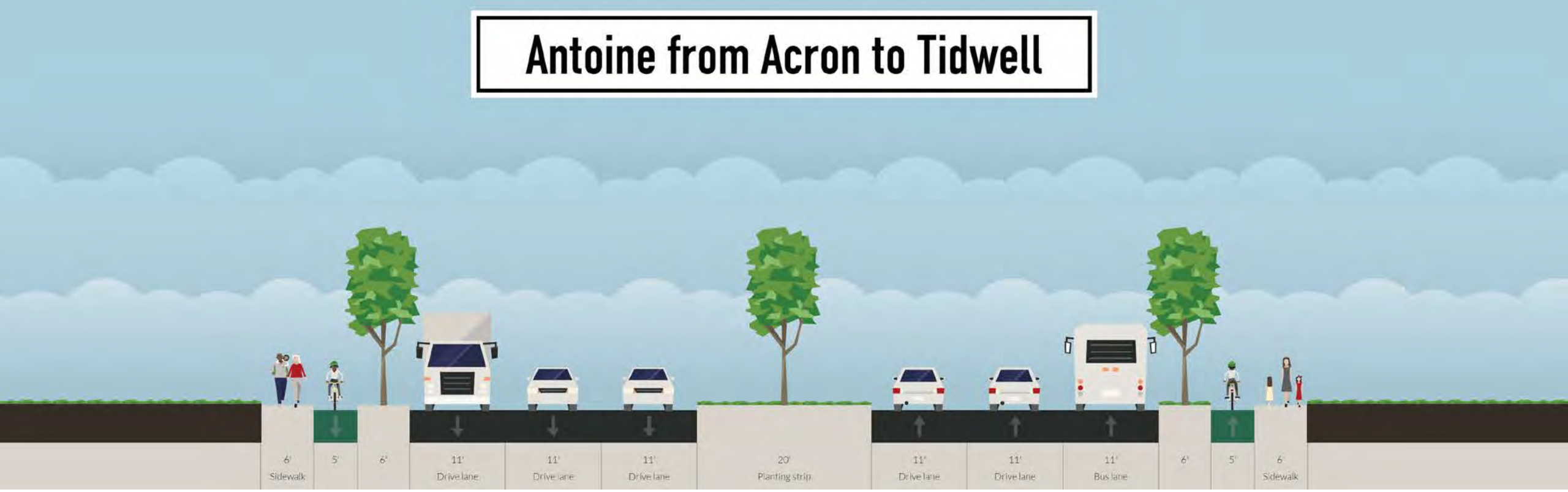
FROM US290 TO SAXON

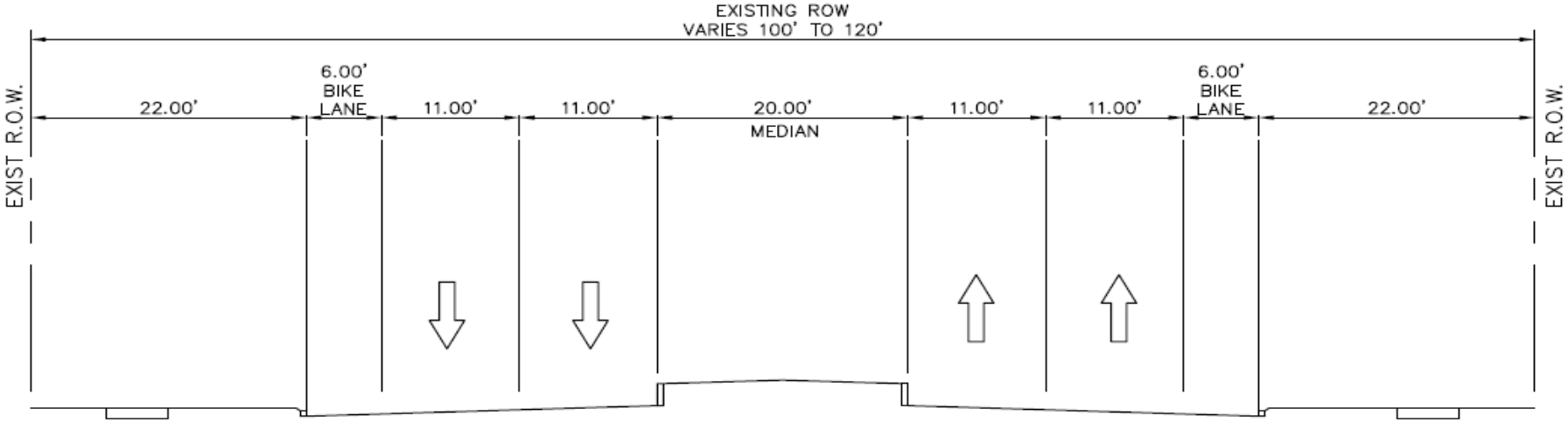
Antoine from Saxon to Acron



EXISTING SECTION
FROM SAXON TO ACORN

Antoine from Acron to Tidwell

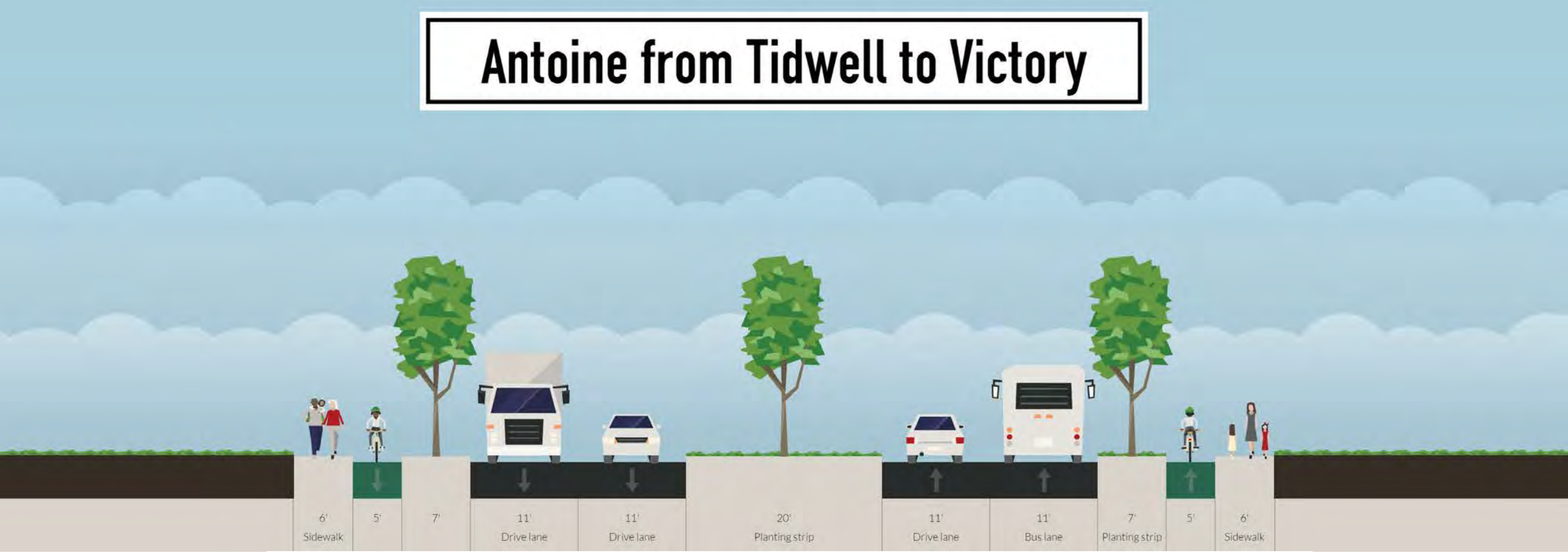


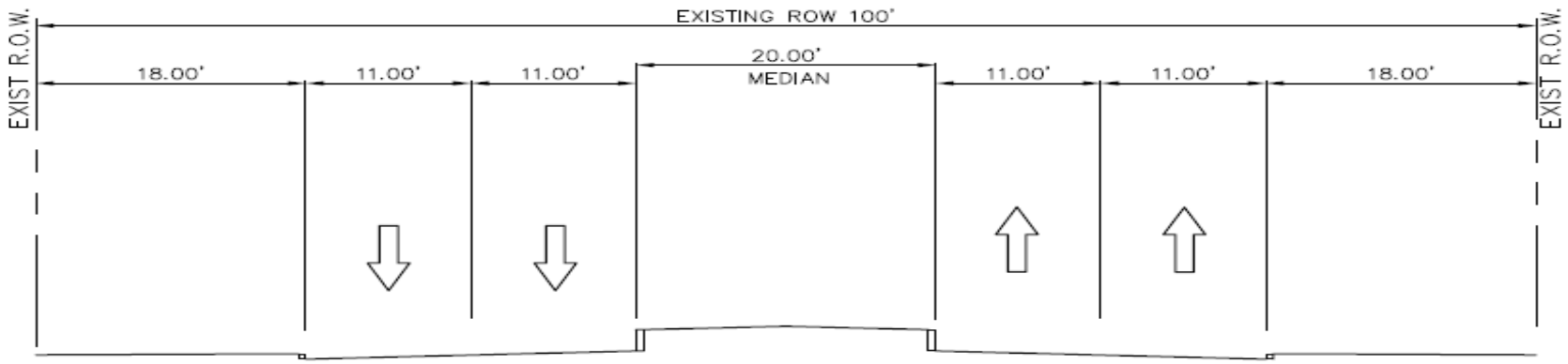


EXISTING SECTION

FROM ACORN TO TIDWELL

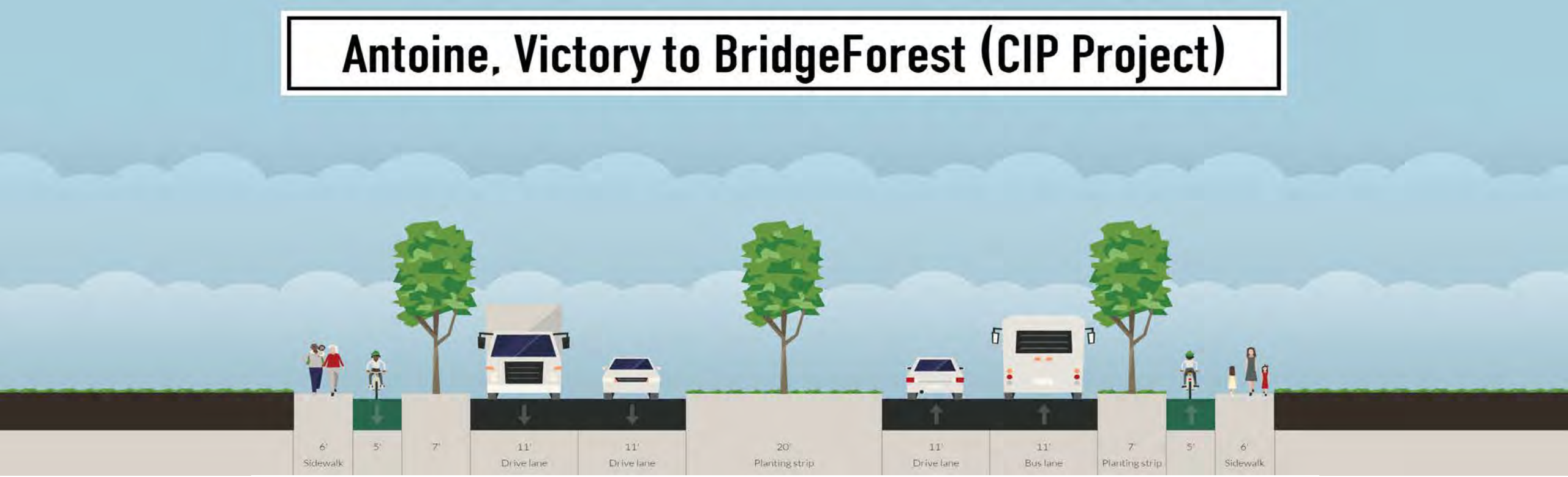
Antoine from Tidwell to Victory

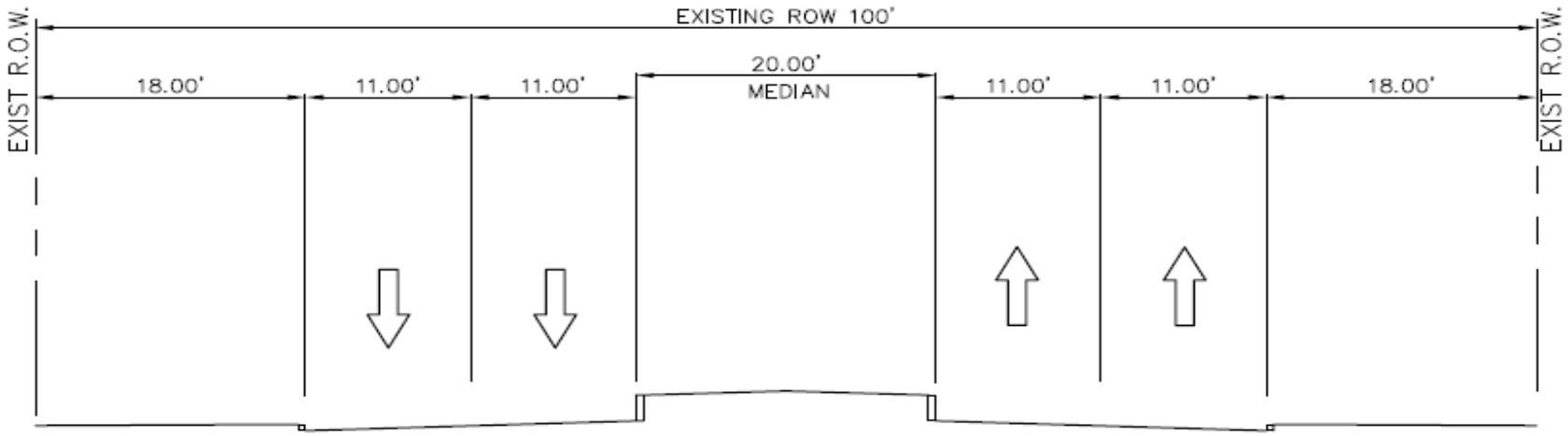




EXISTING SECTION
FROM TIDWELL TO VICTORY

Antoine, Victory to BridgeForest (CIP Project)





EXISTING SECTION
FROM VICTORY TO BRIDGEFOREST

Appendix 6

Public Meeting Exhibits

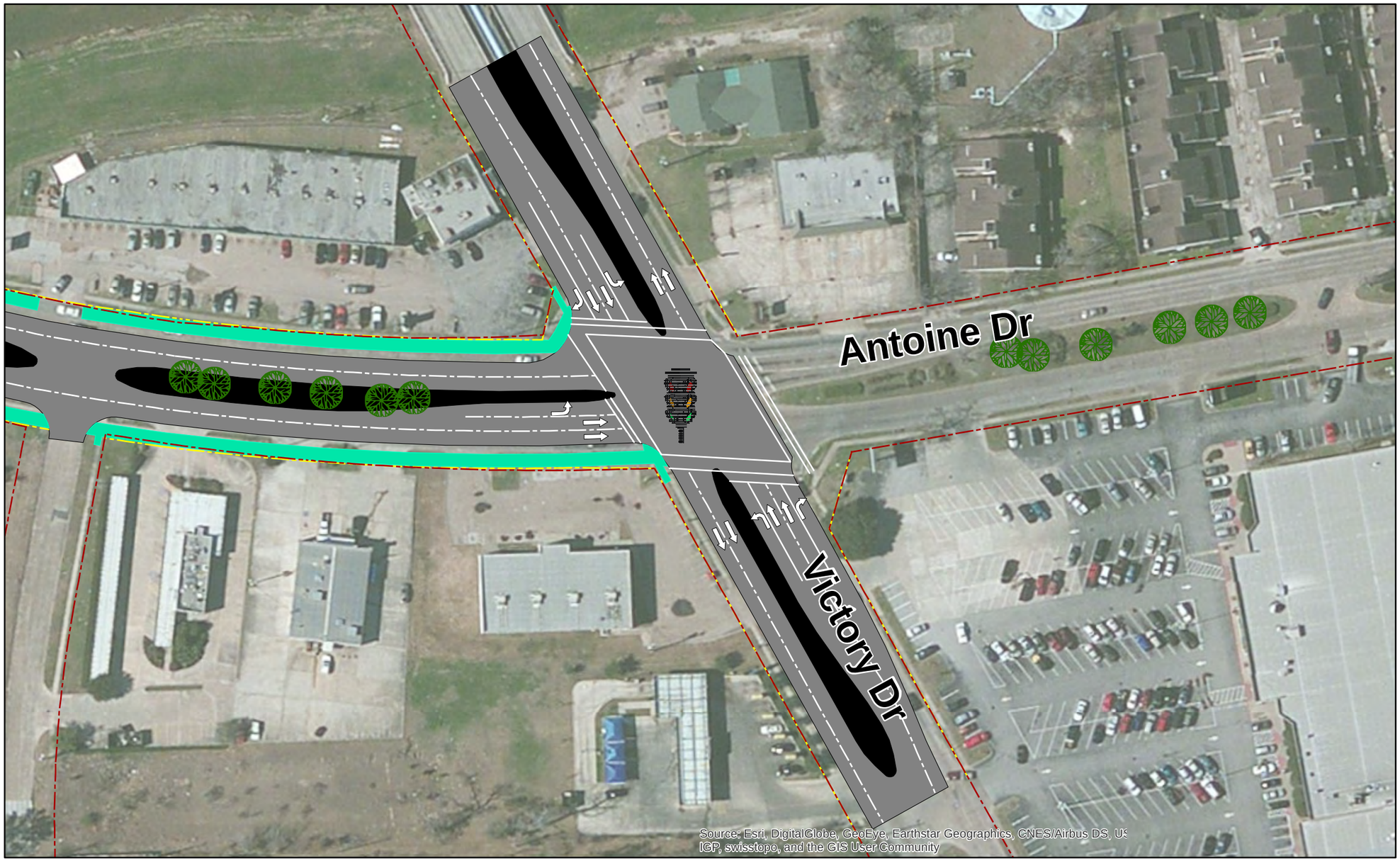
Antoine at Victory
Proposed Intersection Improvements

REBUILD HOUSTON

better streets. better drainage. better future.

Legend

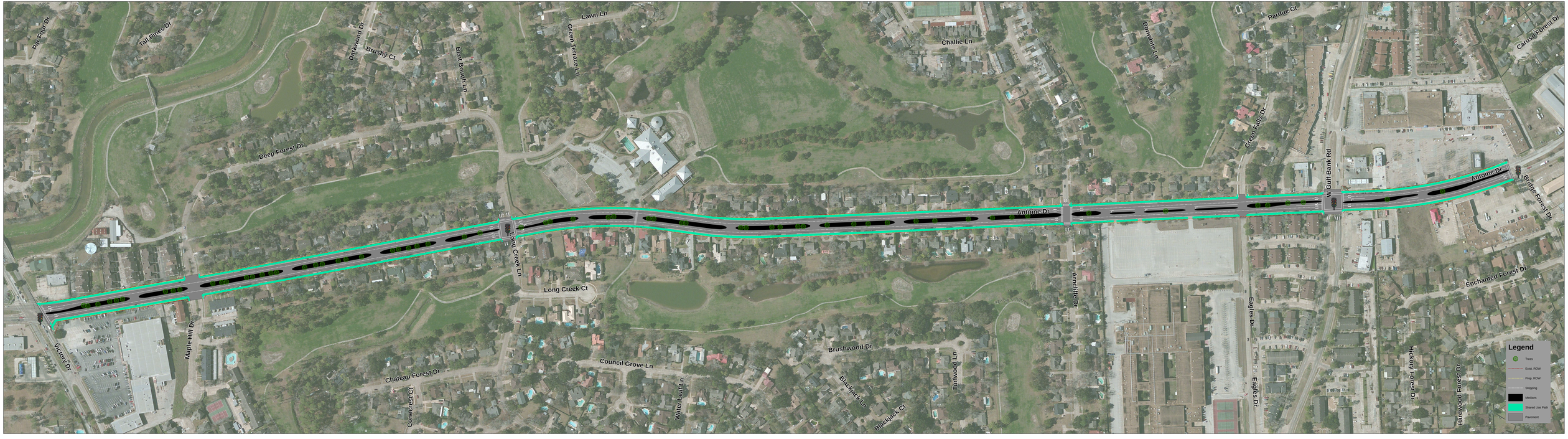
- Trees
- Existing ROW
- Proposed ROW
- Medians
- Sidewalk
- Pavement



N

0 125 250 500 Feet

ANTOINE ROAD (NORTH) RECONSTRUCTION



FROM VICTORY TO BRIDGE FOREST