FINAL

City of Tomball Drainage Master Plan

City of Tomball, Harris County, TX

City of Tomball Contract# 2023-10008

Prepared By:

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Report Updates / Corrections:

July 7, 2025

Pg. 9: Table 1 – 2

Impact Fee values updated.

Pg. 99: Table 18 – 1

Current Basin Fee values updated.

Appendix A:

Drainage Design Criteria Manual submitted as Final.

Appendix B:

Specifications submitted as Final.

TABLE OF CONTENTS

TABLES

EXHIBITS

APPENDICES

ELECTRONIC DELIVERABLES

1.0 EXECUTIVE SUMMARY

Civil Systems Engineering, Inc was contracted by the City of Tomball, which was executed on May 15th, 2023, to perform engineering studies related to drainage infrastructure. The objective of these studies is to update/develop a comprehensive Drainage Master Plan (DMP) to better identify drainage problem areas, potential solutions, serve as a guidance document for drainage infrastructure needs and approach for both private and public improvements, and assembly of a drainage capital improvement projects plan. Additionally, the studies included a review of the City's current Drainage Criteria Manual, Drainage Standards, Drainage Impact Fees, and alternative funding strategies used for drainage infrastructure improvements. This effort, as applicable, was performed in conformance with Local Government Code, Title 12, Planning and Development, Chapter 395, Financing Capital Improvements Required by New Development in Municipalities, Counties, and Certain Other Local Governments.

1.1 Project Study Area

The project study area covers the City of Tomball corporate boundaries (City limits) and extraterritorial jurisdiction (ETJ), as shown in **Figure 2-1**. The City of Tomball covers a total area of 36.67 square miles. The City is located within the Spring Creek and Willow Creek watersheds. The topography of the study area is typical of areas located in the Gulf Coastal Plain . It is generally flat, sloping gently towards receiving drainage ditches and streams.

TABLE 1-1. TOMBALL MAJOR DRAINAGE BASINS SUMMARY

DITCH UNIT NO	DITCH/ STREAM NAME	BASIN AREA (ACRE/ SQ. MILES)	DITCH OWNER	FEMA MAPPING DETAILS
M100-00-00	Willow Creek	54 SQ.MI.	HCFCD	DETAIL STUDY, ZONE AE/FWY
M112-00-00	Roan Gully / Tributary 6.52 to Willow Creek	2,455 AC	HCFCD	DETAIL STUDY, ZONE AE/FWY
M116-00-00	Tributary 8.16 to Willow Creek	1,169 AC	HCFCD	DETAIL STUDY, ZONE AE/FWY
M118-00-00	N/A	1,013 AC	COT	N/A
M121-00-00	N/A	1,848 AC	HCFCD	
M121-01-00	M121 WEST	958 AC	COT	N/A
M121-02-00	M121 EAST	647 AC	COT	N/A
M124-00-00	Tributary 13.50 to Willow Creek	2,660 AC	COT/ HCFCD	DETAIL STUDY, ZONE AE/FWY
M125-00-00	N/A	787 AC	COT	N/A
J100-00-00	Spring Creek	284 SQ.MI.	HCFCD	DETAIL STUDY, ZONE AE/FWY
J131-00-00	Boggs Gully	2,543 AC	HCFCD	DETAIL STUDY, ZONE AE/FWY

DITCH UNIT NO	DITCH/ STREAM NAME	BASIN AREA (ACRE/ SQ. MILES)	DITCH OWNER	FEMA MAPPING DETAILS
J131-01-00	Tributary 1.25 to Boggs Gully	367 AC	HCFCD	DETAIL STUDY, ZONE AE/FWY
J131-03-00	N/A	367 AC	HCFCD	N/A *
J132-00-00	N/A	50 AC	HCFCD	N/A *
J133-00-00	N/A	248 AC	HCFCD	N/A *

N/A – Unstudied stream.
N/A * – Unstudied stream with reach of Zone AE/A due to receiving stream backwater.

1.2 Suggested Improvements

Existing conditions were evaluated for each of the City's drainage subbasins to identify problematic areas and apply multiple storm frequencies, including 2, 5, 10, 25, 50, and 100-year storm events. Problematic areas were identified as those with the potential for structural flooding and/or impassable roadways. Additional modeling incorporated future development based on the future land uses, the City's major thoroughfare plan, and other applicable planning documents to evaluate potential impacts to the City's existing drainage systems. Suggested improvements were developed to mitigate both existing and future drainage issues within the study area and are further described in their respective subbasin sections of this report. Through coordination with City staff, a Capital Improvement Plan for 5-year, 10-year and long-range planning horizons is developed considering implementation strategy, identified repetitive loss locations, cost, and other factors.

CIP PROGRAM YEAR	SUGGESTED IMPROVEMENT BASIN	OPINION OF PROBABLE COSTS TO IMPLEMENT (2024)
5-Year	J131, M118, M121	$31,164,288
10-Year	M116, M118, M121, M124, M125, J131, J133	$39,116,390
>10-Year	M112, M116, M118, M121, M124, J131	$168,155,637
Total		$238,436,316

Notes:
1. Cost assumes no change from existing conditions from time of cost preparation.
2. Assumes design and construction occur in a single fiscal year.
3. Annual rate of 8% was used for inflation and escalation for each year past original year of cost preparation to implementation.
4. All estimates assume City of Tomball is sole implementor with overlapping jurisdiction of the drainage basins potential for partnering with other agencies.
5. Some projects may require implementation by private developers upon approval by City.
6. CSE has not evaluated, researched, or appraised property for rights-of-way and easements necessary for the construction and maintenance of the proposed improvements.
7. Pricing excludes cost for well abandonment or the cost of pipeline relocations.

Improvements evaluated as part of this DMP are preliminary and are intended to be used for the purposes of planning purposes based on the best available information at the time of the study. Further detailed analysis and engineering shall be performed as part of the implementation of these preferred alternatives.

1.3 Drainage Criteria and Standards

As part of this DMP, the current City of Tomball Drainage Criteria Manual (DCM) was reviewed and updates were proposed. The DCM was originally published and adopted in 2011 and updated in June 2021. The DCM establishes rules and regulations that must be consistently followed and enforced throughout the City for drainage design and implementation.

DCM suggested updates/ modifications include:

- Adopt principle of "No Adverse Impact"
  - No peak flow increases to receiving conveyance
  - No impact to receiving conveyance water surface elevation and/or ponding
- Increase minimum detention rate from 0.55 ac-ft/ac to 0.75 ac-ft/ac with analysis of No Adverse Impact
- Roadway Drainage Criteria Hierarchy for primary conveyance/storm sewer
  - Limiting Ponding Width based on roadway classification to establish minimum required passable lanes during any particle rainfall event
  - 25-Year (2-Year Current) minimum design frequency for minor roadway
- Add provisions to allow other pipe materials for storm sewer construction, such as High-Density Polyethylene (HDPE) and Polypropylene (PP)

1.4 Project Funding

In addition to traditional City infrastructure project funding mechanisms, options are available to build project funding reserves and to reduce or eliminate City "out of pocket" cost of implementation. These include:

Grants – FEMA, Texas Water Development Board (TWDB), FHWA RAISE, Texas General Land Office (GLO), US Housing and Urban Development (HUD), etc. A CIP plan having adopted plans such as these, aid in the success in most grant awards along with other factors such as Benefit Cost Analysis (BCA).

Joint Agency Partnership **-** A number of the drainage facilities in Tomball overlap jurisdictions providing mutual benefit for entities such as TxDOT, Harris County, and Harris County Flood Control District. This could provide opportunities for joint project implementation and cost sharing.

Drainage Impact Fee – Drainage impact fees are permissible under the guidelines and procedures defined in Local Government Code, Title 12, Planning and Development, Chapter 395, Financing Capital Improvements Required by New Development in Municipalities, Counties, and Certain Other Local Governments. As of 2024, the City of Tomball has established Drainage Impact Fees for four (4) basins, which were adopted on June 10, 2009. The City has indicated a desire to change, modify or eliminate the current basin impact fee schedule.

The current fees are listed in **Table 1-2**.

TABLE 1-2. CITY OF TOMBALL CURRENT BASIN IMPACT FEES

Basin	**Impact Fee ($ / acre)**
M118	$5,757.81
M121East	$7,886.69
M121West	$6,692.00
M125	$436.88

2.0 INTRODUCTION

2.1 Scope

The City of Tomball (City) is a fast-growing municipality in northwest Harris County, about 40 miles north of Houston, accessible via State Highway 249 and FM 2920. The City is comprised of approximately 12 square miles of land within the city limits with additional developable land in its extra-territorial jurisdiction.

Tomball has a population of about 13,500 people and daily visitor traffic of about 30,000. Recent developments include new residential and commercial centers and the expansion of major roadways. The City is expected to continue to grow, both in population and economic vitality, resulting in the need for additional drainage infrastructure improvements. The previous City of Tomball drainage master plan was published in 2014 and does not reflect current conditions. The combination of the age of the previous master drainage study, anticipated City growth, latest methodologies and technologies, and drainage improvements since the previous master plan requires that a new drainage master plan be developed.

The objective of this study is to develop a comprehensive Drainage Master Plan (DMP) and make recommendations of needed capital projects to address existing and future drainage issues, drainage infrastructure needs, and flood relief. In addition, this study will investigate and update the current drainage impact fee structure. The resulting drainage master plan and the recommended drainage impact fee and stormwater utility fee structure will provide sufficient information for the City to plan, fund, and implement future drainage/flood control. This effort shall be in conformance with Local Government Code, Title 12, Planning and Development, Chapter 395, Financing Capital Improvements Required by New Development in Municipalities, Counties, and Certain Other Local Governments.

2.2 Design Criteria

The Tomball DMP analyses were developed utilizing standard accepted engineering methodologies and practices for hydrology and hydraulics. The larger basin hydrology was performed in accordance with Harris County Flood Control District (HCFCD) hydrologic methods. Localized analyses were performed utilizing the updated City criteria presented within this study. Hydraulic analyses were performed using accepted engineering methodologies, calculations, and public domain hydraulic software.

2.3 Project Study Area

The project study area covers the City of Tomball corporate boundaries (City limits) and extraterritorial jurisdiction (ETJ), as shown in **Figure 2-1**. The City of Tomball covers a total area of 36.67 square miles. The City is located within the Spring Creek and Willow Creek watersheds. The topography of the study area is typical of areas located in the Gulf Coastal

Plain. It is generally flat, sloping gently towards receiving drainage ditches and streams. The flat topography imposes problems on the design of practical drainage systems because the hydraulic grades for drainage ditches are limited. Further, the southern portions of the City are located within the natural "Willow Flats" area of Willow Creek Watershed, which includes flat overland flow paths without any naturally defined drainage ditches or conveyance systems. Over the past few decades, the City as a solo agency and in cooperation with Harris County Flood Control District (HCFCD) has added some drainage infrastructure to aid in providing conveyance systems to this area.

The watershed boundary within the City is generally located along FM 2920 (Main St.). North of FM 2920, the general overland slopes from south to north. South of FM 2920, the overland generally slopes from north to south.

The urbanized portion of the City is primarily served by roadside ditches with some of the newer roadways utilizing storm sewer systems. Open drainage ditches serve as the primary outfall channels for the City and its internal drainage systems. These ditches outfall either directly into, or into a lateral of, Willow Creek or Spring Creek.

2.4 Project Description

This Drainage Master Plan is presented based on an evaluation of the existing drainage infrastructure within the City and its ETJ, relief of existing flooding and drainage problems, and future infrastructure needs to accommodate the roadway improvement and City's growth demands. Several factors were considered in evaluating the existing drainage infrastructure, identifying flooding problem areas, inadequate drainage systems, and determining optimal drainage improvements. These include:

- Historical documented flooding areas obtained from the City, County, and public.
- Public infrastructure areas that are considered high flood risk, as identified by the City and Harris County.
- Current and future roadway/drainage infrastructure projects by the City of Tomball and Harris County.
- Previously constructed, ongoing, and future drainage CIP projects by City of Tomball and Harris County Flood Control District.

2.5 Design Criteria and References

The hydrologic and hydraulic analyses were performed in accordance with the methodology and procedures established in the following documents:

- *City of Tomball Community Development Department Minimum Standards for Stormwater Drainage Design* adopted September 6, 2011.

- *City of Tomball Infrastructure Master Plan & Capital Recovery Fee Determination 2012 to 2022* dated April 2014 by CLR, Inc., Gunda Corporation, and Rydan & Associates LLC.
- *Hydraulic Design Manual,* Texas Department of Transportation, Revised September 2019.
- *Harris County Initial Countywide FIS Study, effective date September 28, 1990.*
- Flood Insurance Study Harris County, Texas and Incorporated Areas, FEMA, Effective August June 18, 2007, (updated various dates thru 10th Revision dated 11/15/2019).
- Flood Insurance Study Montgomery County, Texas and Incorporated Areas, FEMA, Effective August 18, 2014.
- Google Earth imagery for Harris & Montgomery Counties.
- USDA National Agriculture Imagery Program (NAIP) aerial imagery dated 2022.
- NOAA Atlas 14 "Precipitation-Frequency Atlas of the United States", Volume 11, Version 2.0 – Texas, dated September 27, 2018.
- 2018 Upper Coast LiDAR topography DEM – 1 m resolution, NAVD88 vertical datum, March 2018 acquisition, Strategic Mapping Program (Stratmap), TNRIS.org.

2.6 Project Datum

The project datum for the drainage study is referenced to the North American Vertical Datum (NAVD) of 1988, 2001 adjustment. This vertical datum correlates with the current LiDAR topography and the FEMA effective modeling for Harris County and City of Tomball. The project horizontal datum is referenced to the Texas State Plane coordinate system, Texas South Central (FIPS 4204), feet. The project surface adjustment factor is 1.00013 (grid to surface).

2.7 City Infrastructure Master Plan

As part of the drainage master plan, the proposed population growth, development patterns, and roadway infrastructure improvements were considered for the proposed alternative scenarios so that drainage infrastructure can be planned to accommodate the future needs of the City.

2.7.1 Major Thoroughfare Plan

Major Thoroughfare Plan (MTP) is developed and used as a planning tool to identify new roadway connections and existing roadway infrastructure updates proposed to meet the community needs. These plans identify a functional classification or hierarchy system to designate a roadway's role within the local and regional transportation network.

The current City of Tomball MTP used for this study is dated May 17, 2021. This MTP encompasses the City boundaries and its ETJ. The adjacent current 2023 City of Houston MTP was adopted by Houston City Council on September 27, 2023.

The MTPs were used to ensure that any future new roadway or widening has drainage infrastructure planned to accommodate the roadway's storm sewer depths and outfall requirements.

2.7.2 **Parks Master Plan**

The City Parks Master Plan includes the listing of the existing parks and planning for future development of new parks. Currently, the City owns approximately 43.5 acres of developed parkland. There are also three (3) Harris County parks within the City and its ETJ.

There is potential for dual use of parkland with drainage in the form of detention facilities. Other dual usage or shared areas include trails along channels and detention facilities banks. Coordination of the City's future Parks Master Plan should be performed with the implementation of drainage improvements to identify potential for partnership and dual-use. Such locations include the HCFCD J131-01-00 improvements and Broussard Park or the addition of a park facility within proposed detention facilities.

2.7.3 **Population Growth/ Forecasting**

The current approved City Master Infrastructure Plan was utilized to identify areas within the City and ETJ that will potentially experience development growth in the near future. Identification of the expected development growth areas within the City from the Master Infrastructure Plan aided in determining drainage infrastructure needs and prioritization of improvements.

2.8 Environmental Constraints

Environmental constraints, such as wetlands, waters of the US, streams and ponds, were considered within the identification of proposed improvements. The National Wetland Inventory (NWI) was used as a base for identification of these areas, supplemented by previous project identified wetland areas. It should be noted that the NWI is considered dated and does not represent current land use or field conditions; therefore, it was utilized as guidance information. Any proposed project will need current environmental investigations prior to construction to ensure adherence to federal environmental regulations.

Tomball has a vast number of oil/gas wells and pipelines within its City limits. Due to the nature of the historic drilling activity in Tomball, pipeline and oil/gas well locations should be also considered. The available oil/gas facility GIS data was obtained from the Texas Railroad Commission. However, due to the uncertainty associated with the current activity, abandonment, and ownership of these facilities, the data should be investigated and verified during the project development phase to ensure accuracy.

The NWI, previously identified wetlands, oil/gas wells, and pipelines are shown in **Exhibit 2**.

2.9 Definition

- Watershed – Area draining to a main channel such as Spring Creek or Willow Creek. These streams are designated as individual watersheds within HCFCD.
- Basins – Area draining to a tributary of the basin's main stem. Alternatively, a subwatershed to the HCFCD watersheds. The basin areas represent the drainage areas of the City's primary drainage channels.
- Sub-basin or catchment – Small drainage areas within the Basin areas that are collected by small ditches or storm sewer systems.
- FEMA – Federal Emergency Management Agency.
- COE – United States Corps of Engineers
- HCFCD – Harris County Flood Control District.
    - HCFCD is a special purpose district created by the Texas Legislature in 1937. The HCFCD jurisdictional boundaries coincide with Harris County. The HCFCD does not issue development permits, does not act as floodplain administrator in the NFIP, and has limited regulatory jurisdiction over drainage and flood-related matters in Harris County.
- TSARP – Tropical Storm Allison Recovery Project
    - Flood study remapping project conducted by FEMA and HCFCD to re-study and re-map Harris County streams and floodplains. Project included redelineation of watersheds and subareas, updated rainfall depths and distribution, new hydrologic methodologies and models for the 22 watersheds of Harris County, and new hydraulic models for approximately 1200 miles of streams. Project was initiated in 2002; models and maps were approved effective in June 2007.

2.10 FEMA Effective Floodplain

The City of Tomball is a participating municipality within the National Flood Insurance Program. The effective mapping and detailed modeling for the flood hazard areas within the City correlate with those of Harris County and Montgomery County, Texas.

The initial CCO for the City of Tomball was dated May 1976, with the final CCO dated June 1984. The initial countywide FIS effective date was September 28, 1990.

The current effective remapping was updated as part of the TSARP investigations performed between 2002 and 2004. The corresponding FIS and FIRM mapping are dated effective June 18, 2007. This current effective mapping has been updated various times for Harris County through the tenth revision dated November 15, 2019.

The City limits and ETJ are encompassed on FEMA FIRM Panels No. 48201-220L, 240M, 235M, 230L, 210L within Harris County, and 48339C-0515G, 495G, and 675G within Montgomery County.

The City of Tomball initial hydrologic and hydraulic analyses for the original Flood Insurance Study (FIS), effective December 18, 1984, were prepared by the Galveston District COE for FEMA under Inter-Agency Agreement No. H-10-77, Project Order No. 1 and amendments thereto. That work was completed in June 1982. Portions of the analyses were updated by the HCFCD to reflect rapid development and improvements made to the watersheds. That work was completed in September 1983.

2.11 Agency Coordination and Public Outreach

As part of the DMP efforts, CSE assisted City Staff with conducting multiple meetings with outside agencies such as HCFCD, HC Precinct 3, HC Precinct 4, and TxDOT. These agencies' available studies, planning, plans, and projects related to the City's drainage infrastructure planning were also included within the coordination efforts.

CSE performed a public meeting in February 2025 to present the drainage master plan to the public and City Council. Additional public meetings for the drainage impact fee study were not conducted at the direction of City Staff.

2.11.1 **Public Meeting – February 3rd, 2025**

CSE presented a brief overview of the investigations, analyses, findings, and capital improvement projects that address the City's drainage infrastructure needs during a City Council Workshop. This presentation included a roadmap of the hydrologic and hydraulic methodologies used to identify the City's drainage issues, the process used to evaluate alternatives, present selective solutions, as well as provide an overview of the drainage criteria manual updates that are being proposed. The cover sheet for this presentation is provided in **Figure 2-1**.

FIGURE 2-1. DRAINAGE MASTER PLAN CITY COUNCIL PRESENTATION

3.0 GIS APPLICATION

Geographic Information Systems (GIS) provides a powerful workspace for storing, compiling, overlaying, integrating, updating and exchanging, analyzing, displaying, and managing geospatial data. It provides a consistent method for watershed and stream network delineations using digital elevation models (DEMs) of land-surface terrain. GIS provided a vital role, from GIS data manipulation to geospatial data layers creation, in developing this project. This section presents the GIS applications, data, layers, and geodatabases utilized in the project development of the Drainage Master Plan.

ESRI ArcGIS 10.2 was used to facilitate the various engineering workflows required for the project development, including base mapping, topographic data development, drainage system delineations, drainage and hydrologic parameter extraction, hydrologic and hydraulic model development and analyses, and drainage system inventory. The suite of ArcGIS tools utilized for this project include Spatial Analyst, 3D Analyst, ArcHydro, HEC-GeoHMS, HEC-GeoRAS, and other ArcGIS extensions.

Digital base maps were compiled from various sources, such as: City of Tomball, Harris County, Harris County Flood Control District, Houston-Galveston Area Council, Texas Natural Resource Information Systems (TNRIS), TWDB, FEMA, NOAA, and USGS. The available datasets were compiled using conversion, spatial referencing, and integration operations. GIS base map data layers for this project included raster aerial photographs, vector street maps, political boundaries (cities, counties, districts), floodplain delineations, and stream and drainage ditch centerlines.

3.1 Datum and Coordinate System

The common datum, projection, and coordinate system for this project are:

- Horizontal Datum - North American Datum 1983 (NAD83) (Feet)
    - Coordinate System - State Plane Texas South Central: 4204
- Vertical Datum - North American Vertical Datum 1988 (NAVD88)
    - Datum Adjustment – 2001 adjusted

3.2 GIS Feature Layers

As part of the engineering efforts in developing the Drainage Master Plan, a set of GIS data layers were created, which provide a digital version of the Drainage Master Plan. The GIS data layers can be updated by incorporating future drainage projects and provide an easy way to locate drainage features such as:

- Watersheds and Subwatershed Basins
- Drainage Ditch Centerline
- Drainage Detention Basins

- Drainage Ditch Cross-Culvert Structure Inventory Locations
- Existing Storm Sewer Systems
- FEMA Effective Flood Hazard Areas
- Flooding Concerns and Documented Flooding Locations
- Flood Inundation Areas – 100year
- Recorded Repetitive Flood Claim Locations
- Drainage Ditch Capacity Reaches
- Drainage Ditch Improvement Reaches
- Proposed Cross-Culvert Improvement Locations
- Proposed Storm Sewer Improvement Reaches
- Proposed Detention Basins
- Impact Fee Subdivision Tracking Database
- Street Map
- Soil Map
- Land Use Map
- City Boundary
- County Boundary
- Major Thoroughfare Plan Infrastructure
- LiDAR Topography DEM
- Digital Aerial Photos

3.3 LiDAR DEM

Automated extraction of topographic parameters from DEMs has been recognized as a viable alternative to traditional surveys and manual evaluation of topographic maps, particularly as the quality and coverage of DEM data increase. A continuous DEM dataset was developed based on tiled LiDAR datasets obtained from Texas Natural Resource Information System (TNRIS). The referenced dataset includes the 2018 Upper Coast LiDAR topography DEM. This DEM dataset was a part of the Strategic Mapping Program (Stratmap) which has a March 2018 acquisition date. The DEM was produced with a 50 cm resolution and the vertical datum is referenced to NAVD88.

By examining the high-resolution LiDAR DEM imagery, natural streams and drainage ditches are generally well defined by the LIDAR data. However, the DEM required processing for hydrologic analyses by the removal of stream crossings (culverts and bridges), fill associated with development since the LiDAR acquisition date, and the inclusion of existing drainage infrastructure (channel and large trunklines) which were constructed after the LiDAR acquisition date. These modifications were performed within HEC-RAS's RasMapper program as part of terrain modification tools.

The LiDAR DEM dataset for the study area was developed based on the tiled LiDAR datasets obtained from TNRIS. The LiDAR DEM was further refined based on recent construction since the LiDAR acquisition date within the study area, such as the M121-01-00 channel.

3.4 Aerial Photographs

Aerial photographs for the study area were obtained from Texas Natural Resources Information Services (TNRIS). The ortho-imagery dataset was acquired by USGS as part of the National Agriculture Imagery Program (NAIP). The aerial photographs are dated May 2022 and are produced with 60 cm (2.0 foot) resolution. Additional information was collected utilizing Google Earth imagery for Harris County as well as Google Street View.

4.0 HYDROLOGY

4.1 Subwatershed Basins

City of Tomball is divided into multiple subwatershed basins within the Spring Creek and Willow Creek watersheds. These subwatersheds are referenced as "basins" throughout this report. Each basin is served by a mainstem channel with various tributaries, identified by HCFCD unit number nomenclature. The basin name is based on the mainstem channel identification. The City and its ETJ are drained by these basins' streams and associated tributaries to either the receiving Spring Creek and Willow Creek.

4.2 Major Drainage Basins

The City and its ETJ are located within the Spring Creek and Willow Creek watersheds. The major drainage basins, subwatershed basins of these streams, include:

BASIN MAIN STEM DITCH UNIT NO	MAIN STEM DITCH/ STREAM NAME	BASIN DRAINAGE AREA
WILLOW CREEK WATERSHED		
M100-00-00	WILLOW CREEK	54 sq. mi.
M112-00-00	TRIBUTARY 6.52 TO WILLOW CREEK	2,455 ac
M116-00-00	TRIBUTARY 8.16 TO WILLOW CREEK	1,169 ac
M118-00-00	--	1,013 ac
M121-00-00	LATERALS: M121-01-00 (M121W) & M121-02-00 (M121E)	1,848 ac (M121W - 958 ac & M121E - 647 ac)
M124-00-00	TRIBUTARY 13.50 TO WILLOW CREEK	2,660 ac
M125-00-00	--	787 ac
SPRING CREEK WATERSHED		
J100-00-00	SPRING CREEK	284 sq. mi.
J131-00-00	BOGGS GULLY	2,543 ac
J132-00-00	--	50 ac
J133-00-00	--	248 ac

4.2.1 Willow Creek (HCFCD M100-00-00)

Willow Creek (M100-00-00) is a tributary of Spring Creek. It drains northeastward for a length of approximately 20 miles, from its headwaters west of Tomball to its confluence with Spring Creek. The stream's watershed encompasses approximately 54 square miles.

4.2.2 Spring Creek (HCFCD J100-00-00)

Spring Creek (J100-00-00) forms the northern boundary of Harris County, bordering Montgomery and Waller Counties. The watershed drains approximately 284 square miles in an easterly direction to its confluence with the West Fork of the San Jacinto River upstream of Lake Houston.

4.3 Drainage Area Delineations

Drainage area delineations for City's major basins are based on the TSARP hydrologic subarea delineations for Willow Creek and Spring Creek. These basin delineations were refined and subdivided based on high resolution LIDAR topographic data, aerial photography, as-built plans, and field investigations.

4.4 Hydrologic Methods

Multiple hydrologic methods are utilized for flow computations based on drainage area size. These methods, including HCFCD Clark's Unit Hydrograph Method and Rational Method duplicate the methodologies utilized by Harris County and Harris County Flood Control District. The hydrologic parameters, such as flow lengths, slopes, and time of concentrations, were developed based on the LiDAR DEM dataset.

4.4.1 HCFCD Clark's Unit Hydrograph Method

Since the City's subbasins are incorporated within the HCFCD watershed models, the hydrologic analysis for the subbasins utilized HCFCD methodology and parameter computations. This includes the Clark's Hydrograph Method within HEC-HMS (v.4.11) to compute the runoff discharges along the streams. The HCFCD parameter computations and methodology were detailed within the HCFCD Hydrology and Hydraulics Guidance Manual (2009) and the HCFCD Policy Criteria & Procedure Manual (2004, updated 2018). The following presents the parameters and supporting calculation methods used for the HCFCD Clark's Hydrograph Method.

Rainfall depths are based on the "NOAA Atlas 14, Volume 11 Precipitation-Frequency Atlas of the United States, Texas". The Atlas 14 rainfall depths were obtained from the NOAA Atlas 14 Point Precipitation Frequency Estimates: TX are published within HCFCD PCPM. The City of Tomball is located within Harris County Region 1. The 24-hour rainfall depths utilized in the hydrologic analysis are presented in **Table 4-1**. For comparison purposes against previously rainfall data, the pre-Atlas 14 rainfall depths are also provided in **Table 4-1**. As shown, the 24-hour rainfall totals have significantly increased for all storm events within the Tomball area. This includes 3.9 inch increase for the 100-year storm event.

TABLE 4-1. RAINFALL DEPTHS: 24-HOUR TOTALS – HARRIS COUNTY, REGION 1

STORM EVENT (YR)	PRE-ATLAS 14 RAINFALL DEPTHS (IN)	ATLAS 14 RAINFALL DEPTHS (IN)
2	4.1	4.8
5	5.8	6.5
10	7.1	8.2
25	9.0	10.9
50	10.6	13.4
100	12.4	16.3
500	17.1	24.2

Land Use of the contributing drainage area was determined from recent aerials. The watershed is mostly developed (88-percent) which consists of a mixture of residential, multi-family, and commercial areas. A significant portion of the watershed has been developed within the past 20 years; therefore, a higher than typical amount of the existing development has on-site detention. The HCFCD parameters account for this development with detention.

Infiltration losses were computed using the Green and Ampt Loss Method with parameters documented within HCFCD effective Clear Creek Watershed HEC-HMS modeling. The loss parameters for the HEC-HMS inputs are provided in **Table 4-2**. The percent impervious for each subarea was determined from aerials.

TABLE 4-2. WATERSHED SOIL DATA

PARAMETER	VALUE
METHOD	Initial Deficit
INITIAL DEFICIT	0.10
SUCTION (IN)	12.45
CONDUCTIVITY (IN/HR)	0.024

Time of Concentrations & Storage (TC, TC&R) parameters were determined by utilizing the HCFCD parameter calculations for the Clark's Method TC&R and TC values. These parameters are listed in **Table 4-3**.

TABLE 4-3. WATERSHED PARAMETER DESCRIPTION

PARAMETER	ID	UNIT
Drainage Area	DA	Sq. Mile
Watershed Length	L	Mile
Length to Centroid	Lca	Mile
Channel Slope	S	Ft/ Mile
Overland Slope	So	Ft/ Mile
Urban Development	DLU	%
Channel Improvement	DCI	%
Channel Conveyance	DCC	%
Ponding	DPP	%
Development Affected by Detention	DET	%
Impervious	IMP	%

4.4.2 **Rational Method**

Peak discharge for drainage areas smaller than 200 acres were computed using the Rational Method. The Rational Method parameters include the drainage area, runoff coefficient (C-value), time of concentration, and rainfall; Rational Method equation is provided in *Equation 1*.

$$Q = CIA \qquad \textit{Equation 1}$$

In which: Q (cfs) is the computed peak runoff discharge,
C is the runoff coefficient,
I (in/hr) is the rainfall intensity,
A (ac) is the drainage area

Time of Concentrations were determined by utilizing a velocity method based on travel time. Travel time for flow path for each segment was computed and summed. A ten-minute (10 min) minimum time of concentration was considered for developed drainage areas and 15 minutes for undeveloped drainage areas.

Runoff coefficients (C-value) for the roadway and contributing drainage areas are based on land use types. The drainage area development types and impervious cover were determined and measured from aerials. The representative imperviousness of each land use type is shown in **Table 4-4**. Drainage area composite C-values were computed from representative runoff coefficients (C-values).

TABLE 4-4. LAND USE IMPERVIOUSNESS & RUNOFF COEFFICIENTS

Land Use Description	Imp (%)	Runoff Coeff 'C'
Pavement/Sidewalk	100	0.90
Grass/ Undeveloped	0	0.30
Development Strip	65	0.65
Light Industrial	65	0.65
Dense Industrial, Commercial, & Business Districts	80	0.80
Developed w/ Detention	40	0.35
Residential	40	0.50

Rainfall Intensity calculations for the Rational Method are dependent on the time of concentration and the intensity coefficients (e, b, and d), which are storm frequency and location specific. The intensity coefficients were taken from the HCFCD Atlas 14 PCPM IDF Curves Update Technical Memorandum by HDR, Inc. for HCFCD, which are based on rainfall frequency-duration data contained in the NOAA Atlas 14 Point Precipitation Frequency. These values are consistent with Harris County for Region 1, which includes the City of

Tomball. The equation for computing the rainfall intensity is provided in Equation 2. The multiple frequency intensity coefficient values utilized for Tomball are shown in **Table 4-5.**

$$I = \frac{b}{(d+Tc)^e} \qquad \textit{Equation 2}$$

In which: T_C (min) is the time of concentration,
I (in/hr) is the rainfall intensity
e, b, d are coefficients based on rainfall frequency-duration curves

TABLE 4-5. RATIONAL METHOD E, B, D COEFFICIENTS: HARRIS COUNTY, REGION 1

Coefficient	2-year	5-year	10-year	25-year	50-year	100-year	500-year
e (in)	0.7372	0.7058	0.6819	0.6446	0.617	0.587	0.5111
b	48.27	51.78	54.26	54.97	54.84	53.93	50.89
d (mins)	9.3	8.19	7.44	6.27	5.45	4.53	2.69

Peak Discharges were computed for multiple frequencies, including 2-, 5-, 10-, 25-, 50-, and 100-year storm events, for contributing drainage areas to each cross-drainage structure.

5.0 HYDRAULICS

5.1 Major Drainage Systems

The City and its ETJ are located within the Spring Creek and Willow Creek watersheds. The major drainage ditches serve as outfall receiving systems for the City's internal drainage systems. These drainage ditches are listed in **Table 5-1**.

TABLE 5-1. MAJOR DRAINAGE SYSTEMS

DITCH UNIT NO	DITCH/ STREAM NAME	DITCH OWNER	FEMA MAPPING
WILLOW CREEK WATERSHED			
M100-00-00	WILLOW CREEK	HCFCD	DETAIL STUDY, AE/FWY
M112-00-00	TRIBUTARY 6.52 TO WILLOW CREEK	HCFCD	DETAIL STUDY, AE/FWY
M116-00-00	TRIBUTARY 8.16 TO WILLOW CREEK	HCFCD	DETAIL STUDY, AE/FWY
M118-00-00	--	COT	N/A
M121-00-00	--	HCFCD	N/A
M121-01-00	M121 WEST	COT	N/A
M121-02-00	M121 EAST	COT	N/A
M124-00-00	TRIBUTARY 13.50 TO WILLOW CREEK	HCFCD	DETAIL STUDY, AE/FWY
M125-00-00	--	HCFCD	N/A
SPRING CREEK WATERSHED			
J100-00-00	SPRING CREEK	HCFCD	DETAIL STUDY, AE/FWY
J131-00-00	BOGGS GULLY	HCFCD	DETAIL STUDY, AE/FWY
J131-01-00	TRIBUTARY 1.25 TO BOGGS GULLY	HCFCD	DETAIL STUDY, AE/FWY
J132-00-00	--	HCFCD	N/A
J133-00-00	--	HCFCD	N/A

5.2 Hydraulic Methodologies

Hydraulic methods utilized for channel analysis consist of HEC-RAS 1D and/or 2D unsteady modeling. For storm sewer analysis, various methods can be utilized, including steady and unsteady state methods. The steady state methods, such as GeoPAK, ORD DU, HouStorm, StormCAD, and spreadsheets, are to be utilized for design capacity and HGL calculations. Unsteady methods, including programs such as EPA-SWMM, XP-SWMM, and ICM, are utilized for analysis calculations and extreme event (100-year) design computations. This DMP utilized 1D/2D HEC-RAS, EPA-SWMM, and spreadsheet storm sewer calculations for determination of existing and proposed drainage systems.

5.3 Overall 2d HEC-RAS Model

The City overall area was analyzed using a 2D HEC-RAS model to determine overland flood patterns, potential flooding problematic areas, and identify locations of ponding and inundation. The 2D HEC-RAS model utilized a rain-on-mesh in conjunction with land use and soils to determine runoff volumes. **Figures 5-1** and **5-2** illustrate the 2D modeling mesh utilized for the overall Tomball modeling.

The terrain model for the 2D HEC-RAS model was generated from the 2018 LiDAR DEM. Modifications to the terrain model were performed to better represent the existing drainage and infrastructure within the City. These modifications included cutting through roadways to represent cross-culverts, incorporating construction such as subdivisions since the LiDAR flight, and cutting the terrain to represent major drainage facilities (eg. channels and large boxes). Breaklines were utilized within the mesh to represent high points and flow path locations as well as to coordinate the mesh faces with the direction of flow along channels and significant flow paths.

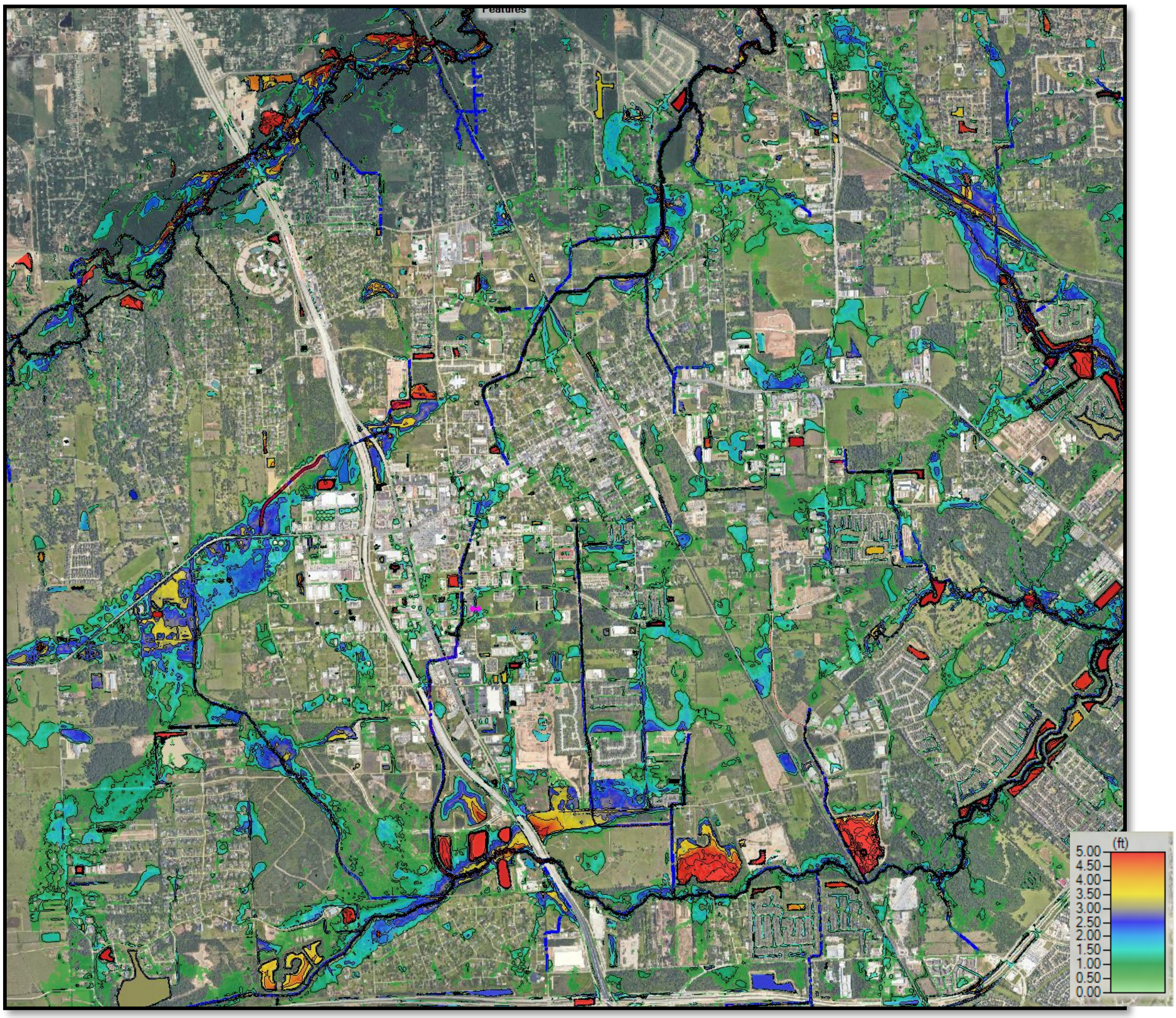


FIGURE 5-1. 100-YEAR PEAK INUNDATION DEPTHS

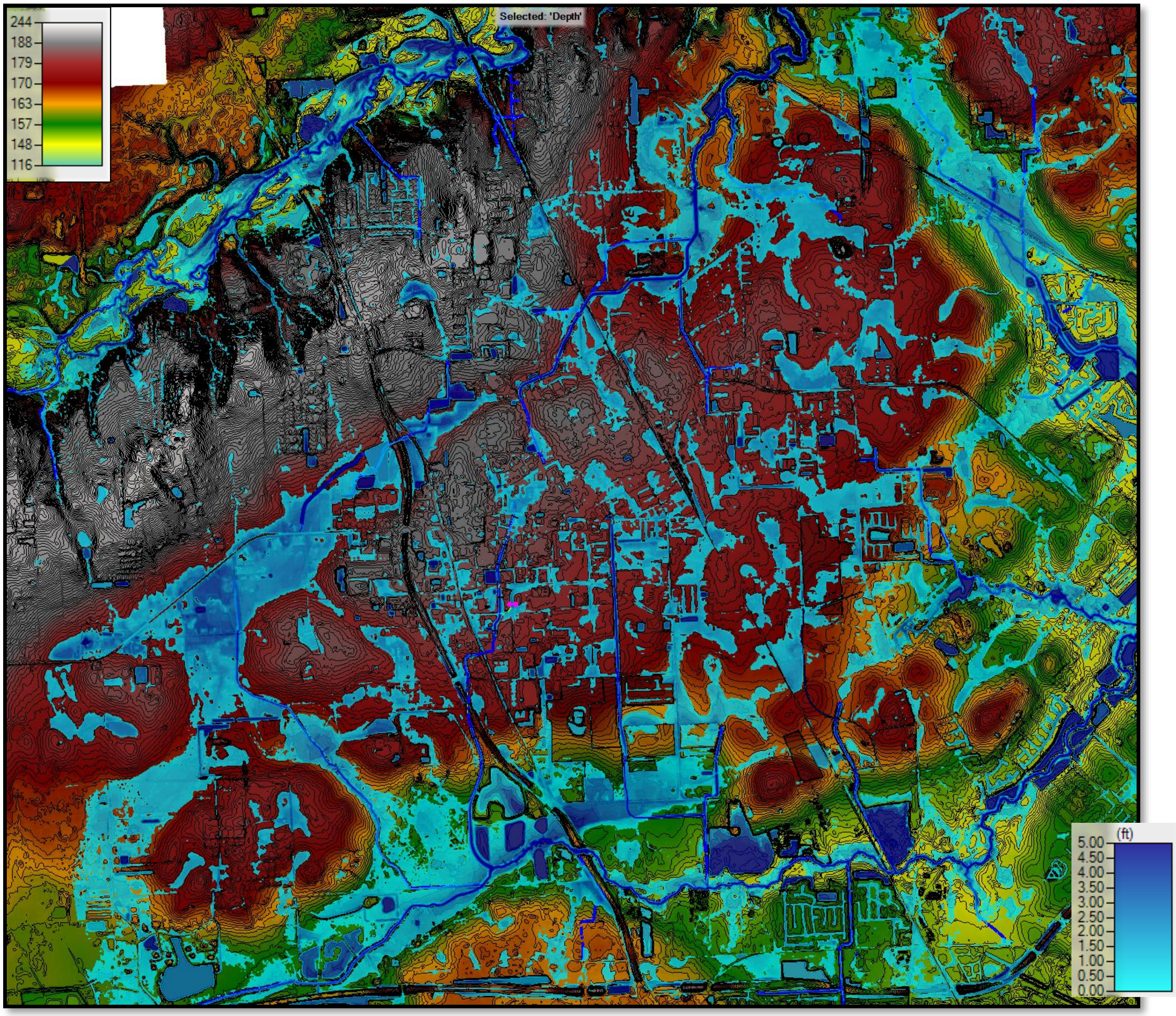


FIGURE 5-2. 100-YEAR PEAK INUNDATION DEPTHS OVERLAID ON LIDAR TOPO

6.0 FLOOD RISK AREAS

Flood risk areas are identified by various methods. These include detailed hydraulic modeling, inundation mapping based on modeling, residential complaints and reporting, FEMA flood claim records, historic rainfall events and highwater marks, and City personnel input and identification of areas. Additionally, future infrastructure improvements, major thoroughfare plan, and critical infrastructure (hospitals, emergency response facilities) were considered within the assessment for this Drainage Master Plan.

6.1 Historic Flooding Events

Tomball has experienced numerous flooding events. As part of the study, repetitive flood losses, reported street floodings, and recorded highwater were utilized to aid in the identification of flood problematic areas. These identified problematic and historic flooding locations are presented in **Exhibit 3**.

As part of recent historic rainfall events, HCFCD recorded information within Harris County, including the Tomball area. These include Tax Day April 2016, Tropical Storm Allison June 5 – 9, 2001 and Hurricane Harvey August 25 – 29, 2017.

6.1.1 **Tropical Storm Allison: June 5 – 9, 2001**

TS Allison rainfall totals, as documented within *Off the Charts! The Tropical Storm Allison Public Report* by HCFCD, included a 12-hour peak rainfall of 10-12 inches within the Tomball area. The rainfall totals for the storm event are illustrated in **Figure 6-1**.

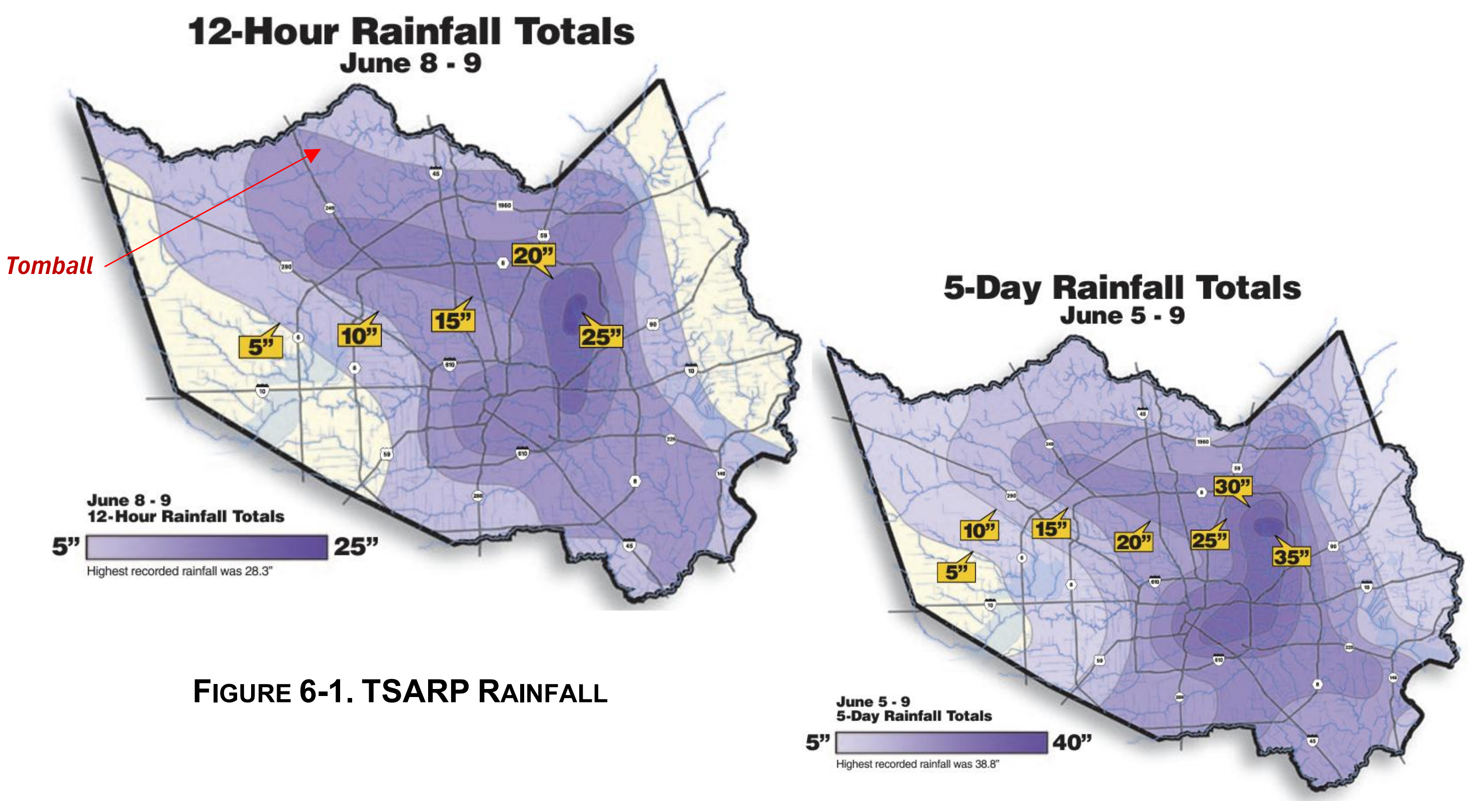
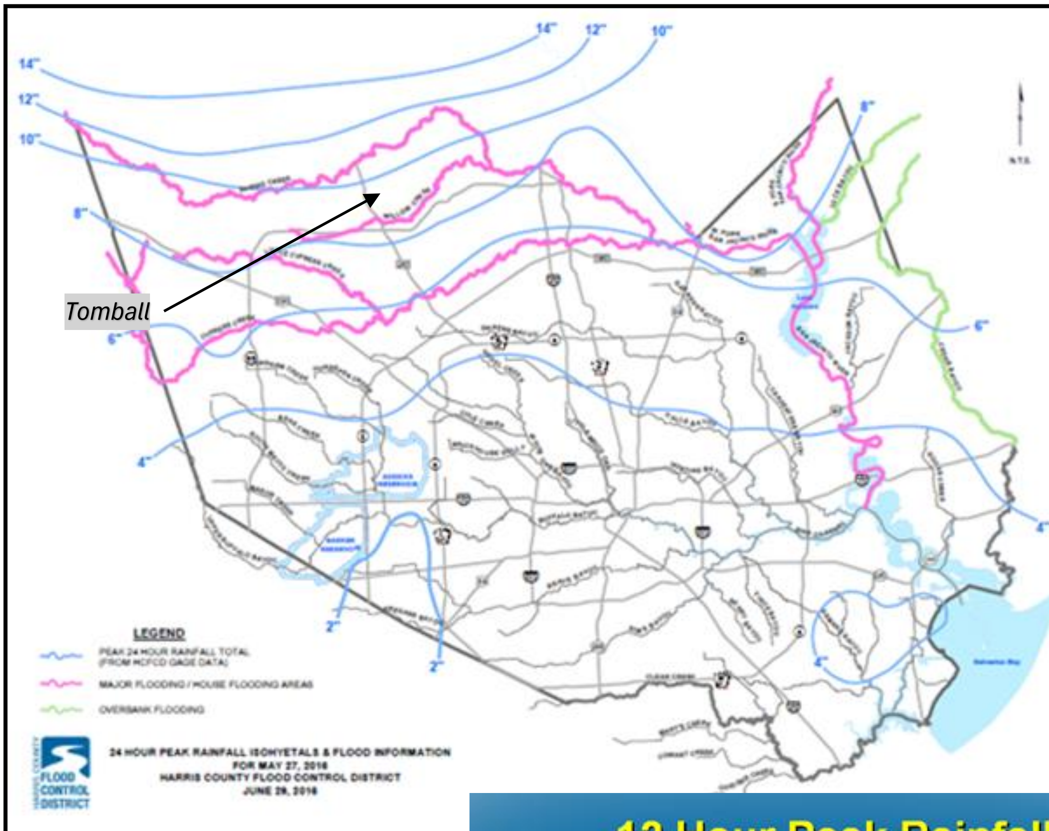


FIGURE 6-1. TSARP RAINFALL

6.1.2 **Memorial Day Flood: May 27, 2016**

The 24 Hour Rainfall Totals – Storm Frequency (Source HCFCD), are shown in the following figures for the Memorial Day, May 2016 flood. Within the Tomball area, 9 – 11 inches were recorded. For a 12- hour peak rainfall time duration, this storm represented over a 100-year event (> 1% AEP). The rainfall totals for the storm event are illustrated in **Figure 6-2**.



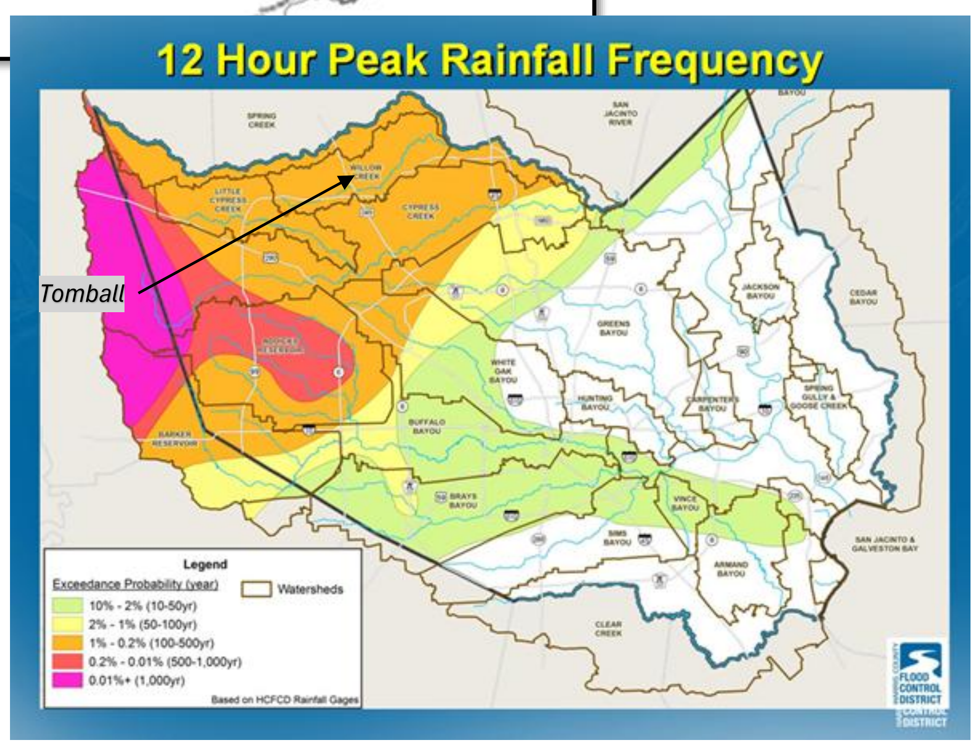


FIGURE 6-2. MEMORIAL DAY FLOOD RAINFALL

6.1.3 **Hurricane Harvey: August 27 – 30, 2017**

Recent significant events include ***Hurricane Harvey***, dated August 27 – 30, 2017. Within the City of Tomball, approximately 347 properties were inundated. The measured 4-day peak rainfall within the City of Tomball for this event exceeded a 1000-year storm event (0.1% AEP). The rainfall totals for the storm event are illustrated in **Figure 6-3**.

Along Willow Creek, record flooding occurred from SH 249 downstream to the stream's confluence with Spring Creek. This flood event surpassed the previous record floods of October 1994 and April (Tax Day) 2016 events. The water levels along Willow Creek exceeded the October 1994 event by 2 – 3 feet. Upstream of SH 249, the water levels were still considered flood stages, but did not exceed previous recorded events of October 1994 and Tax Day 2016 events. At SH 249 in Tomball and downstream reaches, the stream's water levels were generally between the 100-year (1%) and 500-year (0.2%) storm events. Upstream of SH 249, the stream water levels were generally below the 50-year (2%) storm event.

Spring Creek at SH 249 exceeded the previous record flood level of 2016 Memorial Day flood event by approximately 1 foot with flood stages above the 100-year for the majority of the stream's reach.

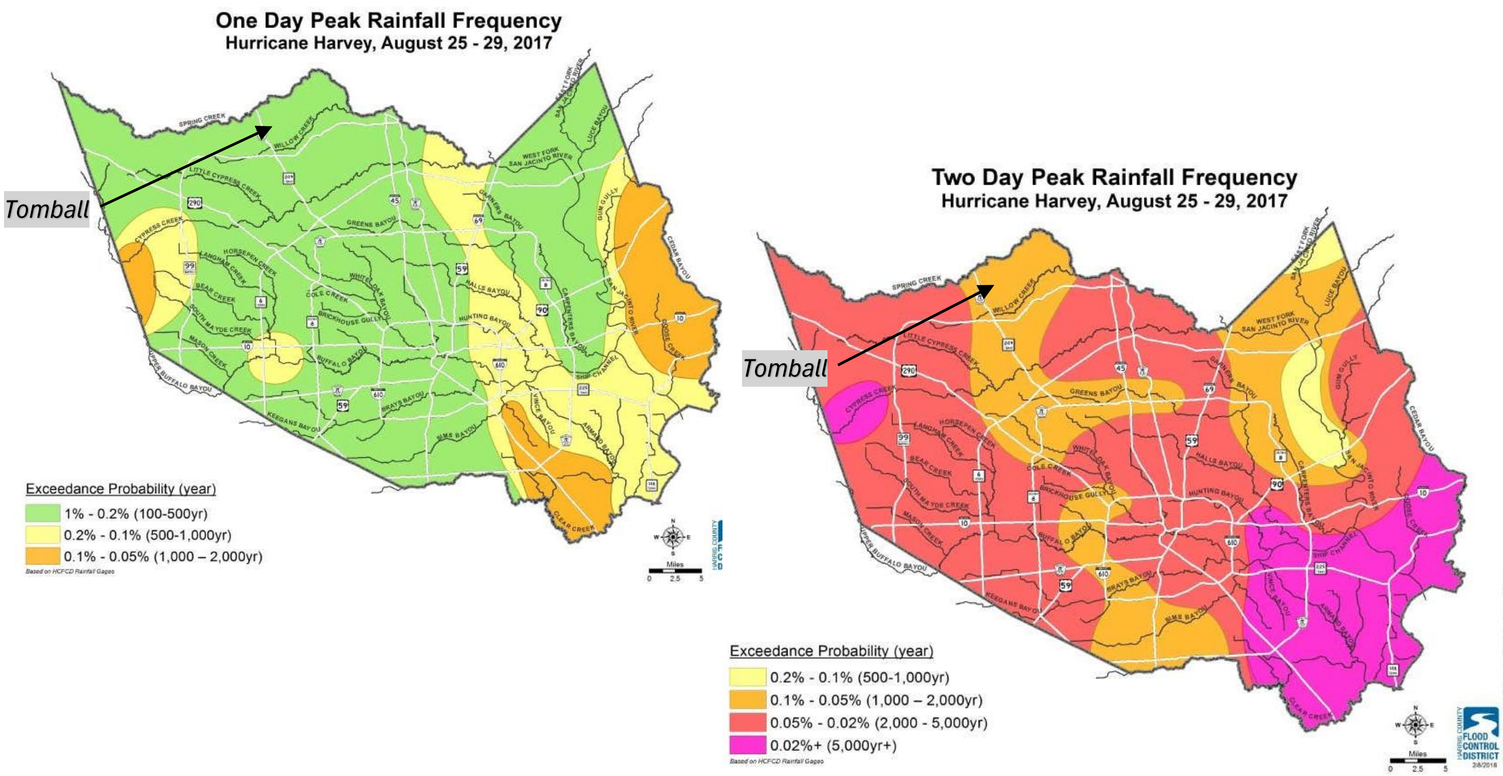
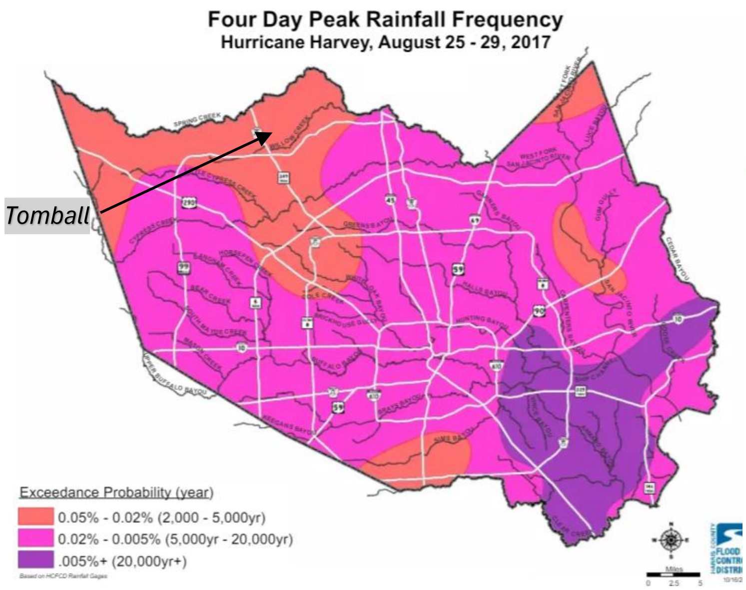


FIGURE 6-3. HURRICANE HARVEY RAINFALL



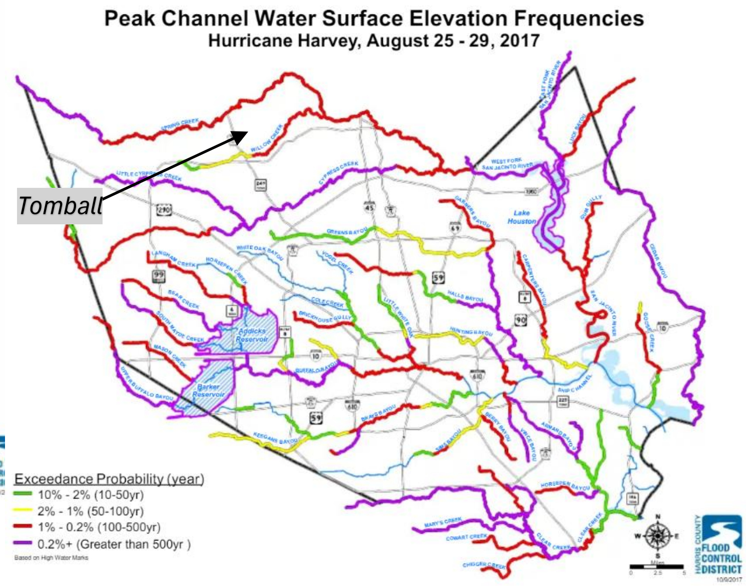


FIGURE 6-4. (CONT.)
HURRICANE HARVEY RAINFALL

6.2 Reported Flooded Streets

The City of Tomball has records of reported street flooding locations for recent storm events. These reports are made by residents and by City police department. The following table lists the street flooding locations reported during Hurricane Harvey, as reported by the City police department.

TABLE 6-1. REPORTED STREET FLOODING LOCATIONS: HARVEY 2017

LOCATIONS *(Harvey – August 2017 Storm Event)*	
Agg-Persimmon	Tomball Cemetery Road - 22100 block
Streets around Tomball Little League Fields	Zion - 12900 block
Belmont at Cherry	Cherry Laurel at South Cherry
Cherry Street: 1900 block to the 2600 block	Hicks at SH 249
FM 2920 Calvert-Park	South Magnolia - 400 block
FM 2920 - 11200 block	Coral RV Park on South Cherry
Flax Court	29200 Quinn
Persimmon - 1100 block	Main and Peach
Holderrieth at SH 249	Huffsmith-Kohrville and Mahaffey
Hicks - 1500 block	SH 249 at the Spring Creek Bridge
Huffsmith-Kohrville - 22300 block	14128 Buckingham Lane
Lawrence - 900 block	Dartford Square - 1100 South Cherry
Lovett-Carrell	200 West Main
Holderrieth at South Cherry	

A recent storm event occurred on May 2, 2024, which included approximately 4.9 – 5.7 inches within 6 hours within the City. This equated to an approximate 10- to 25-year storm event. The City provided the following locations as reported street flooding locations.

TABLE 6-2. REPORTED STREET FLOODING LOCATIONS: MAY 2, 2024

LOCATIONS	FLOODING DESCRIPTIONS
300 Belmont St	Water to Bottom of Vehicles
300 Willowick St	Roadway Flooded
11200 FM 2920 Rd	Eastbound Lane Submerged
Hicks East Of Tomball Pkwy	Approx 1 Foot of Water in Roadway
Calvert/FM 2920	Standing Water
Surrey Ct / Lovett St	Roadway Fully Under Water; Cars Submerged
Agg Rd / Medical Complex	High Water
FM 2920/FM 2978 SW Corner	High Water – Lanes Submerged; Drivers Having To Use Outside Lanes
Agg Rd Between S Persimmon & S Cherry St	Water Covering the Road
Pine St / Oxford	High Water
Holderreith / S Cherry	Water Impassable
Holderreith at SH 249 & from Railroad to Huffsmith-Kohrville	Shutdown From Construction Crew
400 Holderrieth Blvd	Water on Road
100 School St	Submerged
S Magnolia / James St	Roadway Underwater
Tomball Pkwy/Hicks	2 Ft of Water on Roadway
Fm 2920 / Calvert	Westbound Lanes Unpassable
S Persimmon @ Medical Complex N And S	Underwater Northbound & Southbound lanes
Lovett / Misty Meadows	Water In Roadway

7.0 MITIGATION / IMPROVEMENTS STRATEGIES

A comprehensive and systematic approach is required to effectively investigate and provide improvement strategies to reduce the existing flood risks within flood-prone areas. This approach includes investigating the individual components of the overall drainage system, analyzing deficiencies and adequacies within the system, and proposed alternative improvements and mitigation strategies to provide flooding relief, reduce damages, and implement drainage infrastructure for future needs. As part of the Drainage Master Plan, each basin was analyzed to determine the associated flood risks and inadequacies for existing and future conditions.

The improvements were analyzed as individual components and then combined into overall alternative scenarios to provide a comprehensive and cohesive drainage system for each basin. It is imperative that all these components are assessed collectively as a cohesive system scenario to ensure comprehensive flood risk management. By addressing each aspect of the drainage and flood mitigation infrastructure, the City of Tomball can significantly enhance its resilience to flooding and protect its residents and assets. The proposed alternative scenarios are developed and presented to aid in developing the City's infrastructure planning and capital improvement program.

7.1 Improvement Components

The individual drainage improvement elements considered and/or analyzed as part of this study include:

1. **Channel Improvements**: Enhance the capacity of outfall channels by widening and deepening them to improve flow efficiency.
2. **Flow Diversion**: Construct new diversion channels to redirect excess stormwater away from critical areas.
3. **Lateral Ditch Improvements**: Improve lateral ditches to handle larger volumes of runoff and enhance overall drainage efficiency.
4. **Major Storm Sewer Corridors**: Construct large storm sewer systems along major roadways to provide conveyance corridors with adequate capacity to handle adjacent contributing areas and improvements during significant storm events.
5. **Regional Detention Basin**: Build regional detention basins to attenuate peak flows, reduce water surface elevations along a drainage system, and reduce peak flow impacts to receiving channels. Facilities can be utilized
6. **Backflow Prevention Devices**: Install backflow prevention devices at outfall channels to prevent reverse flows from floodway systems into local drainage systems.
7. **Stream Crossing Modifications**: Modify stream hydraulic crossing structures to improve their capacity and reduce flood risks.

8. **Regular Maintenance Programs**: Implement regular maintenance programs for all drainage infrastructure to ensure optimal performance and prevent blockages.
9. **Integration of Green Infrastructure**: Integrate green infrastructure solutions, such as bioswales, rain gardens, and permeable pavements, to increase infiltration and reduce surface runoff.
10. **Enforcement of Floodplain Management Regulations**: Enforce strict floodplain management regulations to control development and minimize flood risks in vulnerable areas.
11. **Update of Drainage Criteria**: Implement more stringent drainage criteria, including increased design frequencies and minimum detention storage requirements, to provide enhanced drainage protection.
12. **Zoning Ordinances**: Implement zoning ordinances that restrict development in high-risk flood areas and promote the use of open spaces for flood mitigation.

Additionally, various alternative mitigation measures were evaluated to reduce flood inundation within identified flood-prone areas. These measures include:

- Enhancing outfall channels to improve flow efficiency and capacity.
- Implement City's updated storm sewer criteria enhancements, including 25-year storm sewer design.
- Constructing regional detention basins (RDF) to attenuate peak flows and reduce the burden on the outfall systems.
- Modifying stream crossings to reduce excessive head loss and align with the channel design conveyance capacity.

Proposed mitigation and improvement measures developed as part of the drainage master plan are presented for each basin in the following sections.

7.2 Proposed Alternatives and CIP

The proposed alternatives for each basin are described in the following Basin Sections. Additionally, each basin alternative scenario is presented in the exhibits and appendices with cost.

7.3 Challenges with Implementing CIP Projects

This DMP is a planning level study meant as a comprehensive evaluation of the existing drainage conditions throughout the city to develop alternative improvements to adequately address the City's drainage infrastructure needs. Preliminary design and final engineering efforts to address the identified problems and implement these CIP projects will encounter general challenges. Overcoming these challenges will require further research and design efforts. General challenges facing these CIP projects are listed below.

- Avoidance and/or relocation of existing public utilities (water, wastewater, natural gas)
- Avoidance and/or relocation of underground, private utilities (telecommunication)
- Avoidance and/or relocation of oil/gas petrochemical facilities (pipelines, wells, etc.)
- Limitations during construction activities due to overhead facilities
- Traffic control during construction around existing development may limit access and require longer schedules due to phased construction approaches
- Acquisition of right-of-way and/or easements for drainage improvements
- Additional maintenance of new or improveed drainage infrastructure

8.0 M116 BASIN

The M116 Basin represents the contributing drainage area to the M116 channel (HCFCD M116-00-00), which consists of approximately 1,168 acres located in the eastern portion of the study area. The basin is located within the City of Tomball, City of Tomball ETJ, and unincorporated Harris County. The M116 basin is generally bounded by FM 2920 (Main Street) to the north and east, Hufsmith-Kohrville Road (HKR) to the west, and Willow Creek (M100-00-00) to the south. The M116 basin generally drains in the northwest to southeast direction towards Willow Creek. The M116 Basin delineation is shown in the Basin Exhibits.

The M116 basin drainage area is served by HCFCD Unit No. M116-00-00, which outfalls to Willow Creek beyond the City's ETJ to the east of the City. The M116 basin is formed from a portion of the TSARP subwatershed M116A_C. Portions of this subwatershed were removed and included within the M118 Basin due to recent development and implementation of the M518 regional detention basin.

8.1 Basin Description

The M116 basin is part of the Willow Creek Watershed. The M116 Basin drainage area is served by HCFCD M116-00-00 channel. The M116-00-00 channel is routed behind Klein ISD Elementary School, east of Willow Creek Estates, and through the County Club Greens subdivision and golf course. The channel reach between Mahaffey Road and County Club Greens is narrow, not located within right-of-way or an easement, and does not adhere to current HCFCD standards. Portions through County Club Green include wet amenity features and control structures.

A substantial portion of the contributing drainage area for M116 west of HKR has been diverted to the recently constructed M118 Basin drainage system. As the M118 Basin drainage infrastructure continues to be constructed, additional contributing area to the M116 Basin will be further diverted from west of HKR.

8.1.1 **Drainage Inventory**

The existing M116 Basin drainage system is served by the mainstem HCFCD M116-00-00 channel. The existing M116 channel is an earthen, trapezoidal, shallow channel. The downstream reaches of the channel are overgrown with heavy vegetation and trees. The side slopes are steep with erosion at the cut bank reaches. The channel runs through the Tomball Country Club, through the golf course lakes, and is crossed by several golf cart bridges. Upstream of Mahaffey Road, the channel has been rectified and widened to provide drainage for adjacent development and the upstream Hufsmith-Kohrville Road outfall.

8.1.2 **Crossing Structures**

The following table presents the inventory of the drainage crossings within the M116-00-00 Channel.

TABLE 8-1. M116 DRAINAGE CROSSING INVENTORY

Station	Crossing Name	Existing Structure
--	Mahaffey Road	2- 4' x 2' RCB
6869.1	Tomball Country Club Road	3- 90" RCP
6207.1	Golf Cart Bridge	54" RCP
5674.8	Golf Cart Bridge	38' Bridge
5393.0	Golf Cart Bridge	34' Bridge
5125.0	Golf Cart Bridge	32' Bridge
4761.1	Golf Cart Bridge	3- 48" RCP & 2- 30" RCP
4440.6	Shop Access Bridge	48' Bridge
4263.8	Shop Access Bridge	40' Bridge
2717.6	Walden Way	3-36" RCP

8.2 Basin History

Prior to extensive development within the basin, the drainage area consisted mostly of wooded areas within the downstream reaches near Willow Creek and agricultural areas within the upstream reaches. North of Spell Road, the basin extended across Hufsmith-Kohrville Road (HKR) west to South Persimmon Street and north to FM 2920 (Main St.).

Upstream of HKR and north of Mahaffey Road, no defined channel existed and the drainage area generally sheet flowed from north of FM 2920 (Main St) in a south-southeasterly direction towards the HKR and Mahaffey Road intersection. South of Mahaffey Road, small swales and ditches collected and conveyed runoff towards HKR. Small swales and ditches east of HKR directed the flow from HKR eastward towards the M116 channel upper reaches.

Over the past several decades, the basin has experienced extensive changes. These include channel improvements, major crossing structures, and development. The following presents a brief description and timeline of the major changes within the basin.

- Pre 1980:
  - Development within the basin was limited to sparse large residential tracts and agricultural land.
  - Country Club Greens golf course was built along the upper reaches of M116 channel.
- 1986 Comprehensive Plan Update – Extension of the natural channel upstream to HKR with an earthen, six-foot bottom width trapezoidal section. The original M116 basin comprised of a drainage area of 2,074 acres.

- The 1996, 2002, and 2007 Infrastructure Master Plans all proposed the extension of M116-00-00 and some form of detention west of HKR to serve upper portions of the basin.
- The 2009 Medical Complex Drive Preliminary Engineering Report (Segment 5&6) identified segment 6 to continue the Medical Complex Drive from HKR and connect to FM 2920 along Mahaffey Road. The report proposed a detention pond adjacent to Medical Complex Drive to mitigate impacts to M116-00-00.
- In 2011, channel improvements for the upper reaches were improved as part of the Klein ISD Multi-School Site development project.
- In 2011, the culvert crossing at Mahaffey Road was constructed.
- 2012 DMP indicated no future improvements
- M118 Master Drainage Study and M118 Preliminary Engineering Report.
    - Report and proposed drainage improvements presented to divert drainage area west of HKR away from M116 basin towards M118 channel.
- Construction of Medical Complex Drive and S. Persimmons St
    - Roadways were constructed with 100-year capacity storm sewer systems designed to divert flow from M116 Basin to M118 Basin.

8.3 Outside Agency Projects & Coordination

Coordination with Harris County, HCFCD, and TXDOT was performed to identify recent and future projects within the basin. The following projects were identified:

- Hufsmith-Kohrville Road (HKR) Road Segment 6 (UPIN 14104MF08T01) – FM 2920 to Mahaffey (recently constructed)
- Hufsmith-Kohrville Road (HKR) Road Segment 5 (future)
- TxDOT State Highway Improvement FM 2978 (CSJ 3050-03-005) (recently constructed)
- HCFCD Coordination Meeting Minutes (March 18, 2024): M116-00-00 has no identified improvement projects. M500-10-00 Stormwater Detention Basin is a flood reduction project located upstream of the confluence of M116-00-00 and M100-00-00.
- HC Pct 3 Coordination Meeting Minutes (March 26, 2024): Mahaffey Road is not currently in their CIP.

8.4 Drainage Issues & Problematic Areas

The primary sources of house and road flooding in the M116 basin include:

- Rising water from Willow Creek
- Backwater from Willow Creek into M116 channel, impeding the channel's conveyance capacity

- Limited drainage infrastructure and depth upstream of the golf course.

As the basin continues to transform from rural areas into urban and commercial development, the impacts of the flooding, including roadway inundation, will increase based on the current state of the channel.

8.4.1 **Historic Flooding**

Since the effective floodplain delineation is located only along the downstream reaches of M116, a majority of the recorded structure floodings have occurred outside of the FEMA floodplain. The major flood events and number of houses flooded within the basin were collected from the City of Tomball and Harris County. These are listed below.

Event	Number of Houses Flooded (estimate)	Rainfall Frequency (year)
October 1994	94	10-25
TS Allison 2001	77	10-25
Tax Day 2016	240	25-100
Memorial Day 2016	130	10-25
Harvey Aug 2017	310 + 200*	50-500+

* Number flooded for the first time on the watershed border east of Huffsmith-Kohrville Road.

8.4.2 **Channel Capacity**

The channel capacity along M116 varies from upstream to downstream. From the stream's confluence with Willow Creek upstream to the golf course, the channel is restrictive, unimproved with heavy vegetation. This channel segment is located within either no or limited right-of-way. The modeling shows that the channel has less than a 10-year capacity, which is supported by the observed erosion and cut-banks along the reach.

The mid-reach of the channel is located within the Tomball Country Club golf course. The channel section still has limited capacity; however, the adjacent golf course along the channel banks provides floodplain storage without substantial structural flooding. The channel runs through series of lakes, which increases the channel's capacity and flood storage capabilities through the reach.

Upstream of the golf course, the channel reverts to an undefined channel section upstream to Mahaffey Road. Through this reach, the channel is shallow, and has less than a 10-year capacity.

Upstream of Mahaffey Road, the channel reach has been improved upstream to its terminus near HKR. This reach capacity has been increased due to adjacent development to provide full conveyance.

8.4.3 **FM 2920 At HKR Road**

City staff has indicated that conveyance from FM 2920 to HKR Road was blocked during the construction of the HKR intersection with FM 2920. A visual inspection of 1978 aerial imagery reveals a cross-culvert under FM 2920 was installed. Historical USGS maps indicate a natural drainage path conveying runoff from the north to south and ultimately toward Willow Creek. Current contour elevation data show virtually no slope along the southern roadside ditch of FM 2920, thus both FM 2920 roadside ditches would fill up with water before spilling eastward toward HKR and continuing to HCFCD Channel M116-00-00 and Willow Creek (M100-00-00).

A review of the HKR Segment 6 construction plans called for the removal of the culverts and regrading the FM 2920 southern roadside ditch back to the west. Furthermore, it appears the drainage system along HKR was not programmed to accept any drainage from FM 2920.

From the review of FM 2978 (CSJ 3050-03-005) construction plans, a cross culvert was planned at the FM 2920 intersection, allowing the pass through of the northern FM 2920 roadside ditch. However, upon field reconnaissance, CSE was unable to locate the presence of this culvert.

Therefore, both northern and southern drainage ditches do not have an outfall location. Once both roadside ditches stage up with runoff, contour elevation data suggests the nearest relief is a man-made drainage ditch located on private property that directs the flow to FM 2978 and ultimately Spring Creek. Based on a drainage study in 2009 for private property, the watershed diversion was coordinated with the FM 2978 construction plans and HCFCD.

8.4.4 **M116 Channel South of Mahaffey**

The M116-00-00 channel south of Mahaffey Road is located between Estates at Willow Creek and Lincoln Manufacturing, Inc. The Estates at Willow Creek plat provided a 140-foot-wide drainage easement adjacent to Mahaffey Road in the northeast corner of the subdivision; however, the 11.98-acre Lincoln Manufacturing, Inc. development to the east did not convey a drainage easement. Therefore, the M116-00-00 channel converges into a small, non-conforming ditch upstream of Country Club Greens.

8.5 Proposed Alternatives

Currently, HCFCD has not identified any improvement needs for HCFCD M116-00-00 and does not anticipate any plans within the near future. However, improvements were considered within the basin due to the existing channel’s limited capacity near Mahaffey Road and no drainage outfall along FM 2920 west of FM 2978

8.5.1 **M116-00-00 Channel Improvement/ Re-alignment**

The M116 channel crossing at Mahaffey Road has limited capacity, no drainage ROW/ easement, and no defined channel infrastructure downstream (south) of Mahaffey Road to the Country Club Greens. Proposed channel improvements were investigated to provide capacity and outfall depth for this reach. The improvement would accommodate Mahaffey Road and future Medical Complex Blvd expansion as well as any future adjacent development. The improvement includes re-routing or diverting the M116-00-00 channel to an underground storm sewer along Mahaffey Road eastward to a new downstream channel section. The channel would proceed south to ultimately align with the existing M116-00-00 channel at Country Club Greens subdivision. This will establish a channel conveyance corridor and outfall depth within an easement for future maintenance access.

8.5.2 **FM 2920 & FM 2978 Intersection**

The area along FM 2920 west of FM 2978 and the highways' intersection do not currently have a drainage outfall. Further coordination meetings with Texas Department of Transportation and Harris County Pct. 3 are required to alleviate the drainage concern and outfall needs. Potential improvements to be explored with the agencies include a cross-culvert under FM 2978 to provide drainage to M112-00-00, connections to FM 2978 storm sewer system, and/or hydraulic connection to HKR roadside ditches to provide an outfall.

9.0 M118 BASIN

The M118 Basin represents the contributing drainage area to the M118 (City Ditch) channel, located in the southeastern portions of the City. The M118 Basin comprises of approximately 1,003 acres. The M118 basin is generally bounded by Burlington Northern and Santa Fe Railroad (BNSF) tracks along the western perimeter, Timkin Road to the north, Tomball ISD facility to the northeast, Hufsmith-Kohrville Road (HKR Road) to the east, and Willow Creek (M100-00-00) to the south. The M118 Basin generally drains in a north to south direction towards Willow Creek. The M118 Basin delineation is shown in the Basin Exhibits.

9.1 Basin Description

The M118 basin is part of the Willow Creek Watershed. The M118 Basin drainage area is served by City's M118-00-00 channel, M118-01-00 trunkline storm sewer within S. Persimmon Street ROW, and City's M518-01 Detention Basin. The M118 channel is routed through the detention basin which outfalls to Willow Creek east of the BNSF tracks and west of Hufsmith-Kohrville Road. The M118 Basin was formed from the upper reaches of M116 Basin and Willow Creek subareas with the construction of the M118 channel and S. Persimmon trunkline.

The M118 Basin was previously not suitable for significant development due to a lack of conveyance, drainage ditches, and available outfall depth. Until recently, the M118 Basin consisted mostly of undeveloped rural and agricultural land with scattered rural residential sites. The M118 channel and storm sewer trunkline drainage system was developed to provide drainage for the basin, including future roadway infrastructure and development. Upon implementation of the basin drainage systems, development began and can be served by the regional detention basin. Upon construction of the M118 channel and the S. Persimmon trunkline, portions of the previous M116 Basin has been redirected into the M118 Basin.

9.1.1 **Drainage Inventory**

The existing M118 Basin drainage system includes the M518-01 detention basin, M118 channel, and S. Persimmon St. box culvert trunkline. The M518-01 detention facility is located south of Holderrieth Road at the basin's confluence with Willow Creek. The detention facility serves as regional detention for the M118 Basin, providing mitigating storage volume for the construction of the M118 drainage infrastructure (channel and storm sewers) and development within the basin. M118-00-00 is an earthen trapezoidal channel that extends from the M518-01 basin north past S. Persimmon St. As part of the Persimmon St. construction, a dual 10' x 8' RCB trunkline was constructed to provide 100-year conveyance within the basin.

The estimated current volume of M518-01 basin is 287 ac-ft using a static water surface elevation of 137 ft and a 100-yr water surface elevation of 145 ft.

9.1.2 **Crossing Structures**

The following table presents the inventory of the drainage crossings within the M118 Channel.

TABLE 9-1. M118 DRAINAGE CROSSING INVENTORY

Ditch ID	Station	Crossing Name	Existing Structure	NBI
M118-00-00	50+90	S. Persimmon Street	3 - 10'x8' RCBs	121020W06008076
M118-00-00	33+82	Holderrieth Road	3 - 10'x8' RCBs	121020W32218079

9.2 Basin History

The primary conveyance vision for the M118 Basin was originally prepared in 1986 as a drainage ditch transversing the service area between BNSF Railroad and Hufsmith-Kohrville Road. Conveyance improvements were continually reported in following studies, however, channel improvements began in the mid to late 2000s with construction south of Holderrieth Road. Excavation and removal of the current M518-01 regional detention basin initiated as a third-party borrow pit.

9.2.1 **Basin Delineation**

Basin Delineations

The M118 Basin is formed from a portion of the TSARP subwatershed M116A_C and the northwestern portion of TSARP subwatershed M110G; refer to HCFCD TSARP Watershed History for subwatershed delineation description. As part of previous drainage studies, M118 was delineated based on topography, physical/ geometric constraints, development patterns, and planned drainage infrastructure.

M118 Basin drainage areas are based on previous studies, such as the referenced M118 Preliminary Engineering Report 2004, M118 Master Drainage Plan 2012, and S. Persimmons and Medical Complex Blvd Study 2018. Further delineation refinement and subdivision were performed using 2018 LiDAR topographic data, aerials, existing drainage, field visit and record drawings obtained from City and HCFCD.

Land use was determined based on a combination of city-provided Existing Land Use Map, Future Land Use Map, site observations, previous studies, record drawings, and aerial photographs.

Basin Drainage Development

The M118 channel and M518 detention facility were constructed to provide drainage infrastructure and regional detention facility for the future M118 Basin development. Extension of the M118 channel north of Holderrieth Road commenced during the development of the Tomball Business and Technology Park. As development spurred in upper reaches of the M118 Basin with the use of pumped detention ponds, the need for an ultimate conveyance network cultivated. A secondary conveyance system for the M118 Basin was completed via the S. Persimmon Street storm sewer trunk line, designated as M118-01-00. A CDBG-DR project extended conveyance further north to Lizzie Lane, thus spurring development along the drainage corridor by solving some of the M118 Basin deficiencies.

Changes to the M118 Basin have occurred since the 2018 S. Persimmon St & Medical Complex Blvd Drainage Study. Major changes include the Raburn Reserve development, private development along S. Persimmon Street and within the Tomball Business and Technology Park, Holderrieth Road widening, and continued excavation of the M518-01 stormwater detention basin.

Existing Basin Conditions

The main drainage artery for the basin is the M118-00-00 channel. As previously discussed, the M118-01-00 storm sewer trunk line provided a conveyance solution for upper reaches of the basin. Existing drainage areas were delineated for the entire M118 Basin as shown in Basin Exhibits.

The storm sewer trunk line under S. Persimmon Street, identified as M118-01-00, requires a separated hydraulic analysis to identify flood prone urban areas, overflows, ponding areas, and identification of potential system improvements. The trunkline system was analyzed and sized using EPA-SWMM as part of the roadway project to account for the extreme event sizing for the system as well as the hydrograph attenuation, backwater and HGL restrictions for the project. For this system, the peak flows were generated using the Rational Method based on pre-Atlas 14 rainfall intensities.

Future Basin Conditions

Future basin conditions include roadway improvements within the basin. From coordination with the City and Harris County, these potential infrastructure improvements include:

- Hufsmith-Kohrville Road reconstruction and widening from Willow Creek north to Mahaffey Road. Segments of this roadway within the M118 basin are currently being planned to outfall into the M118 Channel and M118 Basin.
- S. Persimmon Street reconstruction and widening from Medical Complex Blvd north to FM 2920. As part of these roadway improvements, the drainage corridor trunkline system under S. Persimmon will be extended north.
- Agg Road reconstruction and widening from the railroad to S Persimmon St as part of the Medical Complex Blvd major thoroughfare plan.

Additionally, the M118 Basin is expected to have further land development throughout the basin as drainage infrastructure is provided to accommodate development needs and storm sewer depths.

9.2.2 **Basin Development History**

The City's future land plan for the M118 Basin highlights an industrial theme, and over recent years, the basin has undergone a substantial transformation. These include channel improvements, major roadway improvements, and the implementation of regional detention.

- Pre 1980 – Mainly undeveloped, rural and agricultural land with minimal residential structures.
- Construction of Tomball Business and Technology Park began in 2014 to extend M118-00-00 upstream of Holderrieth Road and expand the M518-01 Basin.
- Construction of S. Persimmon Street & Medical Complex Blvd (E&P 2017-10005) was completed in 2022 for the installation of M118-01-00 storm sewer trunkline system down S. Persimmon Street. This conveyance system included 2-10'X8' RCBs from M118-00-00 up to Medical Complex, 1-10'x8' RCB north of Medical Complex, and 6'x6' RCB's for east and west laterals along Medical Complex based on pre-Atlas 14 rainfall depths.
- M518-01 Excavation and Removal originally began in the early 2000s allowing third-party contractors to excavate the future detention pond and utilize it as a borrow pit. In 2018, the M518-01 regional detention basin design was modified by changing the basin to a wet-bottom facility, allowing the excavation and removal to continue and increasing the storage volume of the detention basin to 299 acre-feet. Modifications to the detention basin geometry using a revised boundary survey provides a design storage volume of 295 acre-feet.
- CDBG Persimmon & Lizzie Lane Drainage Improvements Project (E&P 2019-10015 and GLO 19-076-029-B386) extended the 10' X 8' RCB trunkline system along S. Persimmon Street from Medical Complex Boulevard north to Sutton Lane. Storm sewer was downsized to 54" RCP with vertical drops up to the City's outfall channel excavated as part of Lizzie Lane improvements (E&P 2003-10020) installed in 2004.

9.2.3 **Previous Drainage Studies**

The following presents a brief description and timeline of the major changes within the basin.

- 1996 Infrastructure Master Plan
- 1999 HCFCD Willow Creek Study did not address M118 as a separate drainage area the study did not recommend improvements for "Ditch C"
- M118-00-00 Drainage Study in the Willow Creek Watershed

- 1986 Comprehensive Plan Update – Identified in the report as “Ditch C”, the M118 Basin has an estimated contributing area of 934 acres generally bound by BNSF tracks to the west, a projection of Lizzie Lane to the north, HKR to the east and Willow Creek to the south. “Ditch C” was planned with a varying bottom width (35 feet to 6 feet) between S. Persimmon Street and HKR up to the projection of Mahaffey Road for a total of 9,200 linear feet from the mouth of Willow Creek. Bridges were proposed at Agg Road and Holderrieth Road.
- <u>2002 Infrastructure Master Plan</u> – This plan continued the proposal of the M118-00-00 channel up to the projection of Agg Road as well as implementation of subregional detention for “Ditch C” accounting for 150 acres of development.
- <u>2004 Preliminary Engineering Report</u> for the Proposed M118-00-00 Channel Alignment was prepared for the proposed detention basin and M118-00-00 Channel extending up to Sutton Lane. The report was unavailable at the time of this report.
- <u>2007 Infrastructure Master Plan</u> – This plan made no modifications to the proposed channel and subregional detention improvements identified for M118-00-00.
- <u>2009 Preliminary Engineering Report</u> reanalyzed the M118 Basin to provide conveyance and regional detention to allow for future development with no adverse impacts to Willow Creek. This report delineated the M118 Basin drainage area of 741 acres with similar boundaries, notably the projection of Mahaffey Road as the northern limits of the service area. The report assumed the small lot residential and commercial use for the developed service area. Identified roadway crossings were proposed as bridge crossings instead of multiple box culverts.
- <u>2009 Medical Complex Drive Preliminary Engineering Report</u> identified Segment 4 of Medical Complex Drive (MCD) to extend from BNSF Railroad to HKR. The report proposed a detention pond parallel to the BNSF tracks as the M118-00-00 channel did not extend up to the limits of the roadway.
- <u>2012 M118 Drainage Master Plan</u> provided an overview of the M118 Basin characteristics and updated project progress. The report indicated no current flooding issues of concern for the M118 Basin and stated the full capacity of channel and detention facility and channel improvements are not required to serve existing drainage requirements. At the time of this report, the improved channel south of Holderrieth was mostly complete and the TEDC was expected to fund the channel construction north of Holderrieth Road as part of a planned business park.
- <u>2012 Drainage Master Plan & Capital Recovery Fee Determination</u> identified the M118 Basin consisting of an area of approximately 732 acres. The report stated M118-00-00 channel and detention basin were under construction with the expectation of the channel construction completed by 2014.
- <u>2014 M118-00-00 Impact Analysis</u> evaluated the phased construction of the M118-00-00 channel and detention basin to drainage and regional detention for future

development west of Hufsmith-Kohrville Road and south of Medical Complex Drive. The analysis proposed the first phase of construction to include the ultimate dry-bottom detention basin and construction of the channel past S. Persimmon Street. The second and ultimate phase included extension of M118-00-00 up to Medical Complex Drive. The report stated the 230-acre-feet of storage volume fully mitigated impacts of the developed flow to Willow Creek.

- <u>2018 S. Persimmon St & Medical Complex Blvd Drainage Study</u> modified the conveyance route for the central and upper reaches of M118 Basin by proposing an alternative for an underground 100-yr conveyance network along S. Persimmon Street. This drainage study also expanded the ultimate service area to 980 acres. Furthermore, a 150-foot-wide development strip was incorporated for the M118-01-00 service areas east of S. Persimmon Road south of MCD due to the ultimate M118-00-00 service area extending up to MCD.
- <u>2021 Willow Creek Watershed Plan Summary Report</u> by HCFCD noted the City of Tomball's ongoing effort to complete the M118-00-00 to assist in reducing flood levels and providing outfall depths for development. M118-00-00 was not identified as a problem area.

9.3 Outside Agency Projects & Agency Coordination

As previously discussed, agency coordination was performed with Harris County and Harris County Flood Control District. The following includes the current and future construction activities within the basin area:

- HKR Road Segment 4 (north of Holderrieth Rd to Mahaffey Rd) is in design
  - HC Pct 3 Coordination Meeting Minutes (March 26, 2024): Medical Complex Drive was not programmed to accept Hufsmith-Kohrville road drainage. A separate outfall to M118-00-00 was identified in DMP along an un-improved right-of-way (M118 CIP 7)
- HKR Road Segment 3B (north of Ezekiel Rd to Holderrieth Rd) is in design
- Holderrieth Road Drainage Improvements Project (UPIN 18104MF0R901) is completed
- M500-10-01-E001 – F106 Boudreaux Stormwater Detention Basin is in design
- HC Pct 3 Coordination Meeting Minutes (March 26, 2024): Mahaffey Road is not currently in their CIP.

9.4 Drainage Issues & Problematic Area

Prior to the construction of the M118 channel and Persimmon St. conveyance trunkline system, the natural drainage patterns within the M118 Basin were to drain northwest to southeast towards either M116-00-00 or southerly to Willow Creek via overland sheetflow and shallow flow paths. Since the basin did not have natural drainage systems, it experienced drainage issues associated with

- Upper reaches of the M118 Basin (Lizzie Lane) lack conveyance and outfall depth
- Tracts that cannot hydraulically connect to M118-01-00 due to the lack of an available outfall until M118-00-00 is extended north

9.4.1 **Historic Flooding**

The M118 Basin has a history of poor drainage and localized ponding due to the lack of drainage infrastructure. Historic flood and repetitive losses recorded are low in the area but can be attributed to an overall lack of development.

Upper Reaches (Lizzie Lane)

Older residential lots located along Lizzie Lane experienced ponding, which is due to shallow roadside ditches along Lizzie Lane and no receiving storm sewer or drainage channel. The City's Lizzie Lane project (E&P 2003-10020) proposed an outfall channel south of Lizzie Lane. At the time, this aligned with the proposed M116-00-00 channel alignment documented in the 2002 Infrastructure Master Plan. However, the outfall channel terminated at S. Persimmon Street as the M116-00-00 channel only existed east of Mahaffey Road and did not extend west of Hufsmith-Kohrville Road.

Further improvements were performed for the area as part of a HUD CDBG-DR grant. The grant request was submitted following the 2016 Tax Day and Memorial Day flood events and approved through the Texas GLO. The smaller, more localized drainage areas prohibited storm water from draining effectively during these heavy rainfall events, which inundated the drainage system. The funding was provided to improve storm water conveyance and reduce the impact of future flooding. The proposed grant project included extension of the storm sewer trunk line (10'x8' box and 54-inch pipe) as well as roadside ditch improvements up to the existing M118-01-01 channel south of Lizzie Lane.

S. Persimmon Street

S. Persimmon Street was improved as part of the extension of Medical Complex Drive Segment 4B (E&P 2017-10005) from the M118-00-00 Channel crossing up to Medical Complex Drive. Pre-project photographs of S. Persimmon Street show inundated roadside ditches and localized ponding on private property. Based on overland topography, tracts along S. Persimmon Street were in localized low-lying areas.

9.5 Proposed Alternatives

Proposed alternative components investigated include detention basins, storm sewer, and drainage channels. The following presents the evaluated proposed components:

- M518-01 Stormwater Detention Basin

  - The existing detention facility needs to be configured for final, ultimate storage capacity.
- M118-01-01 Channel Improvements
    - Reconstruction of the existing Lizzie Lane detention facility located just south of Lizzie Lane. The facility will be deepened to provide additional conveyance and storage capacity to serve upper portions of the basin
- M518-02 Stormwater Detention Basin
  - Construct a sub-regional stormwater detention basin within the upper portions of the M118 Basin to partially reduce impacts to the Persimmon St trunkline system.
- M118-01-00 Persimmon St. trunkline extension
  - Extension of the existing 10' x 8' RCB along Persimmon St from north of Medical Complex Blvd to proposed M518-02 Basin.
- Agg Road/ Pitchford Rd trunklines
  - Storm sewer trunkline proposed along Agg Road west of Persimmon/ Medical Complex Blvd intersection, connecting the area to the S. Persimmon trunkline.
  - Storm sewer trunkline proposed along Pitchford Road to service the western portion of the basin. The trunkline will connect to the proposed Agg Road system.
  - Lateral connections from Pitchford Rd to M118-01-00 were determined to be unfeasible due to capacity restraints in the upper portions of the storm sewer system.
- M118-00-00 Channel extension
  - Existing channel to be extended from Tomball Business and Technology Park north to Medical Complex Blvd. The channel will serve the area between Persimmon St. and Hufsmith-Kohrville Road.

These projects are further detailed below and listed with the coordinated CIP alternative ID number.

9.5.1 **(1) M518-01 Detention Basin**

Complete excavation, bank construction and final stabilization of the wet-bottom regional detention pond to achieve ultimate storage capacity of 295 acre-feet to serve the entire M118 Basin. The detention pond banks have been modified from the 2018 Original M118 Amenity Lake based on a revised boundary survey and anticipation of Hufsmith-Kohrville Road widening.

9.5.2 **(2) M118-00-00 Channel Extension to Medical Complex Drive**

Acquire right-of-way and construct the upper reach of M118-00-00 channel from the Tomball Business and Technology Park to Medical Complex Drive to provide outfall depth and 100-year conveyance. This channel will be connected to upper reaches of the basin with a hydraulic connection to Medical Complex Drive (see M118 CIP #3).

9.5.3 **(3) Medical Complex Drive Storm Sewer Extension to M118-00-00**

Construct new storm sewer from Medical Complex Drive to the head of M118-00-00 (M118 CIP #2) within an unimproved right-of-way. The storm sewer will provide a secondary outfall for the M118-01-01 trunkline and function as split flow between M118-01-00 and M118-00-00 in an effort to relieve the existing conveyance system along S. Persimmon Street.

9.5.4 **(4) M118-01-00 (S. Persimmon) Storm Sewer Extension to Lizzie Lane**

Utilizing the existing 54-inch storm sewer previously installed, extend a parallel storm sewer trunkline along S. Persimmon Street from the termination of a 10’x8’ RCB (near Sutton Lane) to north of Lizzie Lane. The 10’x7’ storm sewer will provide additional conveyance capacity to the upper portions of the basin. Improvements are assumed to take place with roadway reconstruction and expansion.

9.5.5 **(5) M118-01-01 Channel Improvements (Phase 1)**

Excavate and deepen an existing drainage channel serving Lizzie Lane. Channel improvements will relieve Lizzie Lane during smaller storm events. Replace existing outfall connection to existing 54” storm sewer to provide maximum depth. Phased construction will depend on timing of extension for M118-01-00 storm sewer along S. Persimmon Street (M118 CIP #4) and development to the west. Install ultimate outfall structure and plug barrel(s) as required for future M118 #8.

Replace existing Lizzie Lane cross culverts and hydraulically connect M118-01-01 and M118-01-01 Lateral via culverts.

This project will require coordination with the East Water Plant expansion project.

9.5.6 **(6) S. Pitchford Storm Sewer Extension**

Construct storm sewer trunkline down S. Pitchford Road to provide conveyance for upper reaches of the M118 Basin. Improvements are assumed to take place with roadway reconstruction.

9.5.7 **(7) M118-00-00 Underground Alternate**

Based on timing of development and widening of Hufsmith-Kohrville Road, a storm sewer trunkline may replace the M118-00-00 channel extension within the limits of an unimproved right-of-way. Storm sewer would be sized to convey the 100-year design storm event and outfall into the existing M118-00-00 channel at the Tomball Business and Technology Park. This project will require coordination with Harris County Precinct 3.

9.5.8 **(8A) M518-02 Detention Basin**

Acquire tract south of M118-01-01 and existing CenterPoint transmission towers to partially mitigate runoff impacts on M118-01-00 storm sewer from private development improvements adjacent to the BNSF Railroad. Construct inflow and outflow structures connection M118-01-01 channel and M118-01-00 storm sewer. Service to the upper and westernmost portions of the basin will include storm sewer within an unimproved right-of-way south of Lizzie Lane.

Inclusion of both M518-02 stormwater detention ponds into the ultimate design will provide additional relief for upper portions of the M118 Basin and M118-01-00 storm sewer system.

9.5.9 **(8B) M118-01-01 Channel Improvements (Phase 2) and M518-02 Detention Pond**

Acquire additional right-of-way to extend Phase 1 M118-01-01 channel west toward BNSF railroad. Acquire or allow private development to construct M518-02 (B) detention facility. Upon construction of ultimate channel and detention improvements, utilize ultimate outflow structure to M118-01-00 storm sewer system.

10.0 M121 BASIN

The M121 Basin represents the contributing drainage area to the M121, M121W, and M121E channels. The M121 Basin encompasses approximately 1848 acres located in the central/ southern portions of the study area. The M121 basin is generally bounded by Business 249 to the southwest, Tomball Intermediate School, Tomball Regional Hospital and Lawrence Street to the northwest, FM 2920 to the north, Burlington Northern and Santa Fe Railroad (BNSF) tracks along the east perimeter, and Willow Creek (M100-00-00) to the south. The M121 Basin generally drains from north to south towards Willow Creek. The M121 Basin delineation is shown in the Basin Exhibits.

10.1 Basin Description

The M121 Basin drainage area is served by two north-south lateral channels currently owned by City of Tomball, M121-01-00 (commonly known as M121 West or M121W) and M121-02-00 (commonly known as M121 East or M121E), that diverge into the M121 main stem (HCFCD M121-00-00). The lateral channels (M121W & M121E) subbasins are generally bisected by South Cherry Street. The HCFCD M121-00-00 channel commences at Holderrieth Boulevard. The M121 Basin is formed exclusively from TSARP catchment M100F2. Refer to HCFCD TSARP Watershed History for subwatershed delineation description. The M121 Basin is served by a regional stormwater detention basin M500-01 owned by HCFCD, which was implemented to offset the proposed construction of the M121W (M121-01-00) channel. *The current M500-01 stormwater detention basin has no additional capacity for future development or floodplain mitigation.*

10.1.1 **Drainage Inventory**

M500-01 is located south of Holderrieth Road adjacent to the City's South Wastewater Treatment Plant and is a dry-bottom detention facility with a temporary outfall structure. M121-00-00 is a natural, moderately vegetated channel commencing at the confluence with M100-00-00 and terminating at the Holderrieth Road bridge structure. M121-01-00 is mostly an earthen trapezoidal channel except for a portion adjacent to Holderrieth Road, where it is lined with concrete. M121-01-01 and M121-01-02 are natural triangular ditches at shallow depths. M121-02-00 is a trapezoidal channel with a wide bottom, lined with concrete adjacent to Holderrieth Road and earthen north of Holderrieth Road.

10.1.2 **Crossing Structures**

The following table presents the inventory of the drainage crossings within the M121 Basin channels.

TABLE 10-1. M121 DRAINAGE CROSSING INVENTORY

Ditch ID	Station	Crossing Name	Existing Structure	NBI
M121-00-00	2600	Holderrieth Road	Two-Span Bridge	121020AA0659005
M121-01-00	3048	Private Driveway	5 - 10'x8' RCB	None
M121-01-00	4812	Holderrieth Road	5 - 10'x8' RCB	121020W32218108
M121-01-00	6630	Everpine Trail	5 - 10'x8' RCB	121020W38377109
M121-01-00	6882	Drop Structure	Inline Sheet Pile	n/a
M121-01-00	8563	Theiss Lane	3 - 10'x8' RCB	121020W63954110
M121-01-00	11023	Medical Complex Drive	3 - 10'x8' RCB	121020W05947107
M121-02-00	2950	Private Driveway	6 - 6'x7'	None
M121-02-00	4107 4896 5663	Utility Crossings	7 - 36" RCP	None

10.2 Basin History

The conveyance vision for the M121 Basin has existed since the early Comprehensive Plans for the City of Tomball, two lateral channels bisecting the basin. Development within the M121 Basin has been active in recent years following the City's CIP projects for implementing the M121-01-00 channel.

10.2.1 **Basin Development History**

- Pre 1980 – Old Town Tomball southern limits were developed to Graham Drive and Anna Street with areas south generally undeveloped, rural and agricultural land with minimal residential or commercial structures.
- In 1996, the City entered into an interlocal agreement with Harris County Flood Control District to implement a regional flood control plan. Per the agreement, the City of Tomball will maintain ownership of the M121-01-00 (west channel) and M121-02-00 (east channel), including cost of acquisition. All acquisitions south of Holderrieth Road shall be acquired and owned by Harris County Flood Control District. Furthermore, the Agreement dictates the City of Tomball is responsible for the engineering design and construction of the M121-01-00 and M121-02-00 lateral channels and the M500-01-00 stormwater detention basin. The agreement also states neither HCFCD nor the City of Tomball can acquire land adjacent to the M500-01-00 basin property until 600 ac-ft of storage volume has been achieved. Upon completion and acceptance of the channels and detention basin, the District shall assume full ownership of and responsibility ffor maintenance of the facilities.
- Post 1996 – Segments of M121-01-00 (M121W) channel were constructed by private development (in lieu of on-site detention) and multiple City CIP projects. The current condition of the M121-01-00 includes an ultimate channel width and depth from the confluence at M121-00-00 (south of Holderrieth) up to the culvert crossing at Medical

Complex Road. Portions of the channel north of Medical Complex Road were excavated; however, additional depth may be utilized for conveyance.

- Two segments of the M121-02-00 (M121E) channel were constructed by private developments upstream of Holderrieth Road; however, the ultimate channel construction was not achieved. Additionally, the constructed channel was utilized for in-line detention by the adjacent development by plugging 4 of 5 barrels of the driveway culvert crossing just north of Holderrieth Road.
- At the time of this report, the M500-01 stormwater detention basin had not been fully excavated due to environmental constraints within the basin.

10.2.2 **Previous Drainage Studies**

- 1982 Comprehensive Plan Report
- 1986 Comprehensive Plan Update – The M121 Basin was identified in the report as System “D” with an estimated contributing area of 1,426 acres generally bound by BNSF tracks to the east, Market Street to the north, Holderrieth Blvd to the west and Willow Creek to the south. “Ditch D” included a northerly extension of M121-00-00 across Holderrieth Road with two lateral ditches bisected by South Cherry Street. “Ditch D” continued east and north, generally along the M121-02-00 alignment up to Thesis Road. “Ditch D-1” lateral continued from the confluence west and north, generally along the M121-01-00 alignment up to Hardin Street. Detention for development was not included in the drainage improvement planning.
- 1996 Infrastructure Master Plan (Capital Improvement Plan)
- The 1998 M500-01-00 Detention Facility Final Report identified design related issues with potential jurisdictional wetlands, soil stability, and subsurface petroleum pipelines that impacted the ultimate storage volume capacity of the detention basin.
- 1999 HCFCD Willow Creek Study
- 2002 Infrastructure Master Plan – Both lateral channels, M121-01-00 and M121-02-00 were still in planning stages. M121-01-00 (identified as Ditch “D-1”, or M121 West) was realigned south of Holderrieth Road before the confluence with M121-0-00-00. M121-02-00 (identified as Ditch “D”, or M121 East) remained planned as a northern extension of M121-00-00. M500-01 detention facility was planned as sub-regional detention, not full regional detention. Construction plans for M500-01 were in review by HCFCD.
- 2004 Preliminary Engineering Report for the Proposed M121-00-00
- 2007 Infrastructure Master Plan
- 2009 M121 Preliminary Engineering Report
    - Recommended channel improvements allowing for full development in the M121 basin. A major portion (volume) of M500 (M121 Detention - 258.38 acres) had been excavated by private parties under contract with HCFCD,

who owns and administers this facility. The proposed improvements were constructed to alleviate localized flooding and to provide drainage infrastructure for new development in this area while eliminating the need for on-site stormwater detention.

- 2009 Medical Complex Drive Preliminary Engineering Report
- 2012 Drainage System Impact Analysis Report
- 2012 Drainage Master Plan & Capital Recovery Fee Determination
- 2018 M121 West Channel Drainage Study was a supplement to the 2009 M121 Preliminary Engineering Report and 2012 M121 Drainage System Impact Analysis Report.
- 2021 Willow Creek Watershed Plan Summary Report

10.3 Outside Agency Projects & Agency Coordination

The M500-01-00 stormwater detention facility was originally a part of an interlocal agreement with HCFCD. The development agreement included details of the purchasing and ownership of the channels and detention basins within the watershed, as previously described within this section.

Harris County Flood Control District is in the preliminary design phase of implementing the M120 Stormwater Detention Facility downstream of the M121 Basin. Per the Willow Creek Watershed Plan Summary Report, selective clearing and implementation of the M120 facility are recommended and two sites within the M121 Basin adjacent to M100-00-00 (Willow Creek) were identified as potential opportunities for detention, floodplain preservation and habitat preservation. These two locations are similarly identified in this report as M521-01 and M521-02.

10.4 Drainage Issues & Problematic Area

Prior to the implementation of the M500-01 based and M121-01-00 lateral, the M121 basin had a history of poor drainage due to the floodplain of Willow Creek and lack of available outfall depth to spur urbanization. Prior to the M121-01-00 construction, portions of the channel were being pumped during and after small rain events as a hydraulic connection did not exist due to the presence of underground oil/gas pipelines and existing roadways.

M121-02-00 service area is facing similar issues by lacking a feasible outfall and natural drainage path to incite development. Much of the M121-02-00 service area between Agg Road, S. Cherry Street, and Holderrieth Road is drained via overland sheet flow.

10.4.1 **Historic Flooding**

The M121 Basin has a history of poor drainage until the implementation of the M500-01 basin and construction of the M121-01-00 channel. The area along Holderrieth Road is still susceptible to flooding from Willow Creek. Specific problematic locations include:

S. Cherry Street

S. Cherry Street, two-lane asphalt roadway owned by Harris County Precinct 3 with shallow roadside ditches. Side streets along this minor arterial are typically two-lane asphalt roads with roadside ditches. Due to lack of depth for conveyance to M121-01-00, the roadside ditches lack capacity to convey runoff.

Magnolia Street

Per LiDAR, Magnolia Street is relatively lower than the adjacent north-south streets contributing to M121-01-00 in the Old Town Area. During recent rain events, it is evident that the roadside ditches gradually drain toward Magnolia Street. When the roadside ditches were observed bank full, the overflow was generally directed down Pine Street toward Hardin Street ditch.

Belmont Street (Keystone Townhomes)

Belmont Street west of S. Cherry Street experiences constant flooding. Belmont Street is situated lower than S. Cherry Street, therefore lacking the hydraulic head to convey runoff underground away from the pavement and structures. Existing storm sewer consists of 17-in x 13-in arched pipe. A flap gate was installed on the existing storm sewer outfall to prevent S. Cherry Street roadside ditches from backing up into the development. The townhomes require constant pumping to prevent structural flooding.

Cherry Place Court (Cherry Laurel Ln, Juniper Ct, and Hawthorne Ct)

Cherry Laurel Drive has two storm sewer outfalls: east outfall at S. Cherry Street (24-inch pipe) and west outfall at S. Pine Street (19-inch x 30-inch arched pipe). Lack of outfall depth in the S. Cherry Street and S. Pine Street roadside ditches results in the neighborhood regularly being inundated even during smaller storm events. Cherry Laurel Street also has small grate inlets along the north side of the street, which do not meet current design criteria and are significantly smaller than needed. Juniper Ct and Hawthrone Ct have a curb cut opening to outfall into the existing Hardin Street ditch. Due to the limited outfall depth, large storm events have the potential pond within the cul-de-sacs.

BNSF Railroad Cross Culvert Overflow

The BNSF Mainline has a cross culvert located approximately 400 feet south of the CenterPoint Energy substation spur. Overflow from the east side of the tracks (upper portions of the M118 Basin) spills into the M121 Basin behind St. Anne's Catholic Church and ultimately down Mulberry, causing street ponding along Mulberry and Agg Road.

M121-02-00 (Eastern Lateral)

Downstream reaches of the M121-02-00 channel have been built by private development. The original construction of M121-02-00 was utilized for in-line detention due to lack of regional detention volume availability in M500-01. Only one of the six cross culverts at the time of original development was opened with the remainder plugged. Utility crossings of the channel were left in place and not lowered to the ultimate depth, therefore restricting the conveyance capacity of the channel. Recent development north included an extension of the M121-02-00 channel and modification of the 6 – 6’x7’ culvert crossing.

Agg Road

Agg Road is a two-lane asphalt roadway with shallow roadside ditches. Per the City’s MTFP and the Medical Complex PER, this major arterial is to be widened. Shallow ditches have the potential to cause roadway base failures. A private stormwater detention facility serving Cherry Meadows Subdivision is located on the south side of Agg Road. This facility includes a pumped discharge into the roadside ditch and causes street ponding.

Thesis Lane

The contributing area for Thesis Lane includes Johnson Road and Tomball Industrial Park. The cross culvert under Thesis Lane (2 – 4’x2’ boxes) are located adjacent to the Thesis Attaway Nature Center. These cross culverts are undersized to convey this contributing area and currently direct runoff south behind Walmart and Woodleaf Reserve before entering the M121-01-00 channel.

10.5 Proposed Alternatives

Proposed alternative components investigates include expansion and construction of new detention facilities, storm sewer improvements, and reconstruction/construction of drainage channels. The following presents the evaluated proposed components:

- M500-01 Stormwater Detention Basin
    - Completion of the original basin design intent was to provide 600 ac-ft of storage volume, per the Interlocal Agreement with HCFCD, and reconstruct the facility to a wet-bottom pond to increase storage capacity.
- M521-01 and M521-02 Stormwater Detention Basin
    - M521-01 Basin is intended to mitigate the improvements of the M121-02-00 ultimate channel to offset any potential adverse impact to M100-00-00 (Willow Creek). A large portion of the excavation has been completed as part of a private mining operation; however, the existing pit is currently privately owned will require acquisition and conversion to a basin configuration.
    - M521-02 Basin is an addition stormwater detention facility proposed to provide additional regional detention, provide floodplain preservation, and contribute to the City’s Master Park Plan including recreational activities. This basin location has also been identified by HCFCD as part of Willow Creek’s overall flood reduction plan.

- M121-01-01 and M121-01-02 Sub Lateral Channels
    - Formally known as the “Hardin Street Ditch”, these sub lateral channels provide additional outfall depth opportunity for upstream improvements to hydraulically connect to the M121-01-00 channel.
- Old Town Storm Sewer Improvements
    - Construct storm sewer systems to relieve the southern portions of Old Town Tomball and reduce the area that is prone to localized ponding.
- S. Cherry Street Trunkline Systems
    - Construct storm sewer improvements such that S. Cherry Street will convey the appropriate design storm event and connect to the M121-01-00 and M121-02-00 channels.
    - S. Cherry Street improvements south of Medical Complex Drive and Agg Road have an opportunity to connect to either M121-01-00 or M121-02-00 due to recent upgrades for Holderrieth Road. Due to cover constraints along Thesis Road, which is generally draining from west to east, an outfall to M121-01-00 is not a feasible solution due to likely storm sewer cover constraints.
- Mulberry Storm Sewer Improvements
    - Construct storm sewer improvements along Mulberry to provide relief from the BNSF cross-culvert overflow and a gravity outfall opportunity for the Copper Cove development.
- Thesis Lane Storm Sewer Improvements
    - Construct storm sewer improvements to direct stormwater toward the M121-01-00 channel.

10.5.1 **(1) M500-01-00 Detention Pond Improvements (Ultimate Condition)**

M500-01-00 Detention Pond is a regional facility that was originally constructed as part of a phased approach for the M121 Basin during the implementation of M121-01-00 west lateral. Portions of the detention facility have been excavated to serve as a dry-bottom detention pond and a temporary outfall pipe has been installed in the southeast corner of the pond.

The ultimate strategy for the M500-01 detention pond is to reconstruct the existing facility to a wet-bottom detention pond with the permanent outflow structure and emergency spillway in the southeast corner adjacent to M100-00-00 (Willow Creek). Reconstruction includes removal of an existing peninsula adjacent to the South Wastewater Plant and bank repair along northern boundaries of the pond. Environmentally sensitive areas within the pond exist from previous jurisdictional determinations and will need to be accounted for in the ultimate engineering design. Conversion to a wet-bottom detention pond will provide an added storage capacity of 86 acre-feet. Upon completion, the stormwater detention facility can be transferred to HCFCD per the Interlocal Agreement previously mentioned.

10.5.2 **(2) M121-01-00 (M121 West – Segment C) Channel Reconstruction from Medical Complex Drive to Hardin Street**

The upper reach of M121-01-00, the western lateral to M121-00-00, is proposed to be reconstructed from Medical Complex Drive, upstream of the 3-10’x6’ RCB culvert crossing, to Hardin Street. The reconstruction includes lowering the channel to the ultimate depth in order to accommodate future improvements planned upstream. The reconstruction will provide approximately 2 feet of additional depth at Hardin Street. An existing CenterPoint Energy transmission tower exists adjacent to the channel and proper separation will need to be evaluated during final engineering design.

Additionally, a private pumped detention within the Dartford Square Apartment Complex, would have an opportunity to replace their existing stormwater pump system with a new gravity outfall to M121-01-00.

10.5.3 **(3) M121-01-01 (Hardin Street East) Channel Construction to Cherry Street**

M121-01-01, the eastern lateral of M121-01-00, consists of a concrete-lined channel construction from its confluence with M121-01-00 to Cherry Street. Steeper side slopes and concrete lining should be implemented to avoid relocation and replacement of existing City-owned and private utilities within the Hardin Street ROW.

Channel construction is the framework for upstream storm sewer improvements along Cherry Laurel (M121 #4), Juniper Ct (M121 #4), Hawthorn Ct (M121 #4), Hampton Place (M121 #5), S. Cherry Street (M121 #6), Magnolia Street (M121 #7), and S. Pine Street (M121 #18).

10.5.4 **(4) Cherry Laurel Storm Sewer Improvements**

Cherry Place Subdivision has three outfalls consisting of S. Pine Street, S. Cherry Street, and Hardin Street. All outfalls are programmed to drain to the proposed M121-01-01 channel. The Cherry Place Subdivision improvements consist of: 1) storm sewer improvements along Juniper Ct and Hawthorne Ct, including two curb inlets and storm sewer outfalls to M121-01-01; 2) Cherry Laurel Drive storm sewer improvements, including reconstruction of system along the northern curbline from intersection of Juniper Ct to Pine Street and replacement of curb inlets; and 3) Cherry Laurel Drive proposed storm sewer to outfall to the eastern half of S. Pine Street. The Pine Street outfall system is planned to be installed in combination with Hampton Place Storm Sewer Improvements (M121 #5).

10.5.5 **(5) Hampton Place Storm Sewer Improvements**

The existing Hampton Place development outfalls to S. Cherry Street roadside ditch via curb inlets and culverts at driveway connections. The proposed improvements consist of curb inlet replacement and redirection of storm sewer trunkline in a southwest direction towards the back of the development along S. Oak Street. The proposed storm sewer ultimately outfalls to the east side of S. Pine Street toward M121-01-01. A drainage easement will be required for storm sewer installation within an undeveloped portion of Lot 14 Block 1.

An outfall to M121-01-01 is proposed along the east side of Pine Street (west side reserved for Pine Street proposed improvements). An independent outfall from future Pine Street improvements (M121 #18) is proposed due to the timing of Pine Street roadway reconstruction.

10.5.6 **(6) South Cherry Street Storm Sewer Improvements (From Market Street to Hardin Street)**

Cherry Street is classified as minor arterial per the City's Major Thoroughfare Plan (MTFP). Based on topography and field visits, the roadway serves as the natural conveyance corridor for Old Town Tomball south of FM 2920 and west of the BNSF Railroad. The proposed improvements along Cherry Street include a storm sewer trunkline from Market Street to the headwater of M121-01-01.

Portions of Old Town Tomball within the service area of S. Cherry Street naturally drain east towards the BNSF Railroad ditch. To serve this drainage, a ditch independent of the BNSF railroad ditch is proposed to collect street runoff and convey it to McPhail Street. A lateral is proposed to convey this drainage to the S. Cherry Street storm sewer trunkline. To avoid right-of-way acquisition, the proposed collection ditch adjacent to the BNSF railroad is within a City-owned tract.

The improvements can be implemented independently with roadside ditch interceptors and street repair for the trunkline along Cherry, or it can be implemented in conjunction with Harris County Precinct 3 roadway reconstruction of Cherry Street, which will likely consist of a curb and gutter roadway section. Laterals alongside the street should be considered during future planning and engineering design to complement side street drainage.

10.5.7 **(7) Magnolia Street Storm Sewer Improvements**

Magnolia Street is a natural low point for the drainage area from Malone Street to James Street. Magnolia Street and adjacent streets are currently served by roadside ditches and driveway culverts. The proposed storm sewer improvements include the construction of a trunkline to relieve the service area and provide increased conveyance capacity. Per the City Staff, roadway reconstruction is not anticipated at this time; therefore, reconstruction will include roadside ditch interceptors and leads to the proposed trunkline. The downstream reach of the trunkline will be installed within the City of Tomball Public Works tract for a direct outfall connection to the proposed M121-01-01 ditch.

10.5.8 **(8) M121-01-02 (Hardin Street West) Channel Construction to School Street**

M121-01-02, the western lateral of M121-01-00, construction consists of a concrete-lined channel within the Hardin Street ROW from the confluence with M121-01-00 to School Street. Steeper side slopes and concrete lining should be implemented to avoid relocation and replacement of existing City-owned and private utilities within the Hardin Street ROW. Implementation of this project includes upsizing the culvert crossing at School Street.

10.5.9 **(9) Theis Lane Storm Sewer Improvements**

Theis Lane is classified as a minor arterial per the City's MTFP. Previous construction of the M121-01-00 channel cross culvert under Theis Lane included a service area up to and including Johnson Road as well as an 8'x8' box culvert for an outfall connection to M121-01-00. Project implementation includes removal of a cross culvert under Theis Lane adjacent to the Theis Attaway Nature Center that naturally drains behind the Walmart detention pond. The storm sewer trunkline proposed down Theis is programmed to be included as part of roadway reconstruction.

Additionally, the Tomball Industrial Park pumped detention facility would have an opportunity to replace their existing stormwater pump system with a new gravity outfall to the Thesis Lane storm sewer trunkline.

10.5.10 **(10) M521-01-00 Detention Pond Improvements (Ultimate Condition)**

The M521-01-00 Detention Pond will require land acquisition of an existing mining pit as well as land adjacent to the BNSF Railroad Mainline. The proposed basin tracts are adjacent to M100-00-00 (Willow Creek) and will serve as mitigation for the M121-02-00 channel improvements. A permanent outfall structure will need to be implemented. Multiple wells and pipelines exist on the property and will need to be coordinated/mitigated upon land acquisition. Final engineering and design may evaluate an equalizer pipe between M500-01 and M521-01 to aid in optimizing and balancing the storage volumes of the detention facilities due to the topography elevation differences within the area.

10.5.11 **(11) M121-02-00 (M121 East) Channel Extension to Agg Road**

The ultimate construction of M121-02-00 will require land acquisition for existing portions of the channel as well as limits of the channel extension. Channel construction is the framework for upstream storm sewer improvements along S. Cherry Street (M121 #12), Agg Road (M121 #12), Mulberry Street (M121 #13), and S. Cherry Street (M121 #14). In addition, the channel will provide outfall depth for future development between S. Cherry Street and the BNSF railroad. Channel construction will include utility and pipeline relocations. The reach upstream of the planned M121 #14 outfall from S. Cherry Street includes a concrete drop structure to limit the channel width and while providing sufficient depth for an upstream outfall for M121 #12 and M121 #13 projects.

10.5.12 **(12) S. Cherry St & Agg Rd (Anna Street to M121-02-00) Storm Sewer**

Construction of a storm sewer along S. Cherry Street south of M121-01-01 to Medical Complex Drive and along Agg Road. The ultimate design includes capacity for Mulberry storm sewer improvements (M121 #13). The improvements can be implemented independently with roadside ditch interceptors and street repair or construction in conjunction with Harris County Precinct 3 roadway reconstruction, which will likely consist of a curb and gutter roadway section. Additionally, the Cherry Meadows Subdivision pumped detention facility would have an opportunity to replace its existing stormwater pump system with a new gravity outfall to the Agg Road storm sewer trunkline.

10.5.13 **(13) Mulberry Street Storm Sewer**

Construction of a storm sewer along Mulberry St and connection to the Agg Road proposed storm sewer system (M121 #12) will help alleviate overflow from BNSF culvert crossing behind St. Anne's Catholic Church. The improvements can be implemented independently with roadside ditch interceptors and street repair or construction in conjunction with a roadway reconstruction project, such as a curb and gutter roadway section conversion. Additionally, the Copper Cove pumped detention facility would have an opportunity to replace the existing stormwater pump system with a gravity outfall to the Mulberry storm sewer trunkline.

10.5.14 **(14) S. Cherry Street (Agg Rd to Cherrywood Estates) Storm Sewer to M121-02-00**

Construction of a storm sewer improvements along S. Cherry Street. The storm sewer outfall to M121-02-00 will require land acquisition for a drainage easement north of Cherrywood Estates. The outfall will likely require coordination and/or relocation of oil/gas pipelines for connection to M121-02-00. The improvements can be implemented independently using roadside ditch interceptors and street repair or in conjunction with Harris County Precinct 3 roadway reconstruction, which will potentially consist of a curb and gutter roadway section.

10.5.15 **(15) Medical Complex Drive Storm Sewer Reconstruction**

Construction of a parallel storm sewer system along Medical Complex Drive and connect into the M121-01-00 cross culverts.

10.5.16 **(16) Michel Road Storm Sewer Reconstruction**

Construction of a new storm sewer system along Michel Road to provide sufficient outfall depth for future development. The new system should investigate utilizing the existing storm sewer outfall to M121-01-00.

10.5.17 (17) M521-02 Detention Pond

The M521-02-00 Detention Pond will require land acquisition of existing agricultural properties located within the effective floodplain. The tracts are adjacent to M100-00-00 (Willow Creek) and have the potential for multi-use benefits, including but not limited to, additional regional detention storage volume, floodplain preservation and mitigation volume, and recreational uses. Multiple wells and pipelines exist on the property and will need to be coordinated/mitigated upon land acquisition. Coordination should be performed with HCFCD for final engineering and design as the basin shall have potential joint agency benefits.

10.5.18 (18) S. Pine Street Storm Sewer Improvements

Improvements include the construction of a new storm sewer system along S. Pine Street as well as an outfall to M121-01-01 along west side of Pine Street (east side is reserved for Belmont and Cherry Laurel drainage improvements, as described above). The proposed Pine Street storm sewer improvement is providing a trunkline to relieve the service area and provide increased conveyance capacity. The improvements are anticipated to be implemented in conjunction with roadway reconstruction, such as a potential conversion to a curb and gutter roadway section.

11.0 M124 BASIN

The M124 Basin represents the contributing drainage area to the M124 channel, which is located within the western and northwestern portions of the City of Tomball and its ETJ. The basin encompasses approximately 2,930 acres. The basin extends from just south of the Lone Star College – Tomball Campus south to its confluence with Willow Creek. The basin includes drainage areas to the east and west of SH 249 freeway and is bounded primarily by J131 and M125 Basins to the east, J133 and Spring Creek Basins to the north, and Telge Road/ Cemetery Road to the west. The M124 Basin delineation is shown in the Basin Exhibits.

The drainage area is served by HCFCD channel M124-00-00 which outfalls to Willow Creek to the west of SH 249. The basin is the largest of the Tomball area basins draining to Willow Creek and includes a substantial area in the ETJ and unincorporated Harris County.

11.1 Basin Description

Much of M124 is undeveloped or lightly developed with dense commercial development in the vicinity of the SH 249/West Main Street interchange and along FM 2920. The M124 basin consists of two distinctive subbasins, generally divided by SH 249. North of SH 249, the basin is generally bounded by SH 249 to the west, Baker Road to the north, and Lawrence Street to the northwest, FM 2920 to the north, Burlington Northern and Santa Fe Railroad (BNSF) tracks along the east perimeter, and Willow Creek (M100-00-00) to the south. The M124 Basin generally drains in the north to south direction towards Willow Creek.

The M124 Basin drainage area is served by a single north-south mainstem channel, HCFCD M124-00-00. Lateral drainage to the mainstem channel is conveyed generally by roadside ditches and overland sheetflow.

11.1.1 **Drainage Inventory**

The drainage basin has three (3) distinctive reaches: upper reach (upstream of SH 249), mid-reach (between SH 249 and FM 2920), and lower reach (downstream of FM 2920). Upper reach consists of a small drainage channel that reaches from Brown Road downstream to SH 249. Within the upper reach, a regional stormwater basin M524-01 lies in line along the channel north of Hicks Road.

Recent construction by HCFCD for the mid-reach portion of the M124-00-00 channel (M124-00-00-E001) includes the first phase of the HCFCD channel widening project. The channel widening is north of the existing SH 249 two detention basins owned and maintained by TxDOT and private detention ponds serving the Tomball Town Center shopping center.

The lower reach of M124-00-00 consists of a roadside ditch along Treichel Road into a natural alignment for conveyance to M100-00-00 (Willow Creek).

11.1.2 **Crossing Structures**

The following table presents the inventory of the M124 channel drainage crossings.

TABLE 11-1. M124 DRAINAGE CROSSING INVENTORY

Ditch ID	Crossing Name	Existing Structure	NBI
M124-00-00	Brown Road	2 – 5'x3' RCBs	N/A
M124-00-00	Detention Pond	2 – 4'x2' RCBs	N/A
M124-00-00	Hicks Road	4 – 6'x3' RCBS	None (NBI Required)
M124-00-00	Private Driveway	5 – 6'x3' RCBs	None (NBI Required)
M124-00-00	Business 249	7 – 6'x3' RCBs	121020072003050
M124-00-00	SH 249 Frontage (NB)	Bridge (Single Span)	121020072003035
M124-00-00	SH 249 Main Lane	Bridge (Single Span)	121020072003037
M124-00-00	SH 249 Frontage (SB)	Bridge (Single Span)	121020072003034
M124-00-00	FM 2920	4 – 6'x3' RCBs	121020294101006
M124-00-00	Treichel Road	3 – 8'x7' RCBs	121020AA0644001

11.2 Basin History

- In 2002, a letter report for the construction of M124-00-00 (identified as Ditch "G" in the report) east of SH 249 to Brown-Hufsmith Road proposed conveyance and detention improvements to offset the impacts associated with the Brown-Hufsmith Road implementation.
- 2005 Business 249 Culvert Crossing added 2 – 6'x3' RCB culverts to the existing 5 – 6'x3' RCB culverts.
- A 2007 Detention Study Report for M124-00-00 (identified in the report as Ditch M124A) was prepared for a private development prior to the construction of M124-00-00 improvements east of SH 249 and Brown-Hufsmith Road as the development was reliant on the outfall provided by the M124-00-00 planned improvements. The report proposed an off-line stormwater detention basin to serve the development, however, the construction of this pond was never substantially completed or able to provide the additional storage capacity. A development agreement was in place for the City to take over the maintenance of the pond and manage storage credits for future development within the service area.
- 2008 Willow Creek Tributary M124-00-00 Feasibility Study for Extension Improvements evaluated how to extend the M124-00-00 channel from SH 249 back to the existing M124-00-00 channel south of Treichel Road, with no recommendations made outside of the City Limits or up to Willow Creek. The selected alternative was to route the new channel through HCFCD property south of FM 2920 and mitigate impacts of channel improvements and loss of floodplain storage by development with a detention basin south of Treichel Road. The report

stated a full level of service could not be met due to constraints downstream of M124-00-00 outside of City Limits.

- 2015 SH 249 from FM 2920 to Spring Creek: Hydrologic and Hydraulic Analysis for M124-00-00 evaluated and assess the existing drainage conditions in the M124-00-00 watershed to develop alternatives that alleviate flooding and accommodate the anticipated reconstruction/expansion of SH 249 (Tomball Tollway Phase 2) and limits of FM 2920 within the M124 Basin. The objective of the report was to increase the level of service of M124-00-00. The report's preferred solution was to construct a 25-year level-of-service channel with mitigation included only for Tomball Tollway Phase 2 and FM 2920 Widening Drainage Improvements. However, overtopping and flooding issues along FM 2920 would need to be resolved in a separate project, as the existing roadway drainage system is currently undersized.
- The 2018 Master Drainage Concept Plan for M124-00-00 & Preliminary Design Report for Drainage and Mitigation of Tomball Tollway Phase II Improvements along M124-00-00 was prepared to provide initial drainage improvements to serve the expansion of Tomball Tollway Phase II Improvements and identify a channel alignment and detention system that contains the existing 100-year floodplain from SH 249 to HCID #17.
- 2020 M124-00-00-E0001 Channel Improvements and Detention Basin Phase 1 construction plans were prepared. Construction included partial excavation of the ultimate M124-00-00 channel (ultimate depth not achievable due to current depth constraints downstream of FM 2920) and construction of M524 detention basins.
- The 2021 Channel Conveyance Improvements along HCFCD Unit No. M124-00-00 from SH 249 to Willow Creek PER (M124-00-00-E002) further refined the 2018 MDCP and extended the analysis of M124-00-00 to the confluence at Willow Creek. With the objective to increase the channel's level of service to 100-year event, 4 miles of channel improvements and regional detention were evaluated and proposed. The ultimate condition for M124-00-00 will consist of 14 stormwater detention basins and widening and deepening of the channel (average 10-feet deep) to achieve the 100-year level of service.

11.3 Outside Agency Projects & Agency Coordination

HCFCD has developed a proposed plan for improvements of the M124 channel from SH 249 downstream to its confluence with Willow Creek. The proposed improvements are being constructed to alleviate localized flooding and to provide drainage infrastructure for new development in this area while eliminating the need for on-site stormwater detention.

HCFCD currently has a project along HCFCD M124-00-00, which includes channel improvements from downstream (west) of SH 249 to its confluence with Willow Creek. The project is in cooperation with Harris County Precinct 4, Harris County Toll Road Authority

(HCTRA), TXDOT, Harris County Improvement District 17, and City of Tomball. The project also includes regional detention facilities to offset the channel improvement impacts.

The proposed project provides flood level reduction and outfall depth along the channel for development and roadways. Additionally, the project will provide an outfall and reduce flooding on FM 2920.

Phase I of the project has been completed, which includes limited channel improvements upstream of FM 2920. Phase II design and right-of-way acquisition are currently underway. Funding for the M124 project is from the HCFCD 2018 Bond Program, Project F-37.

See **Figure 11-1** for the M124 CIP phased construction concepts, which were extracted from the HCFCD M124 project reports.

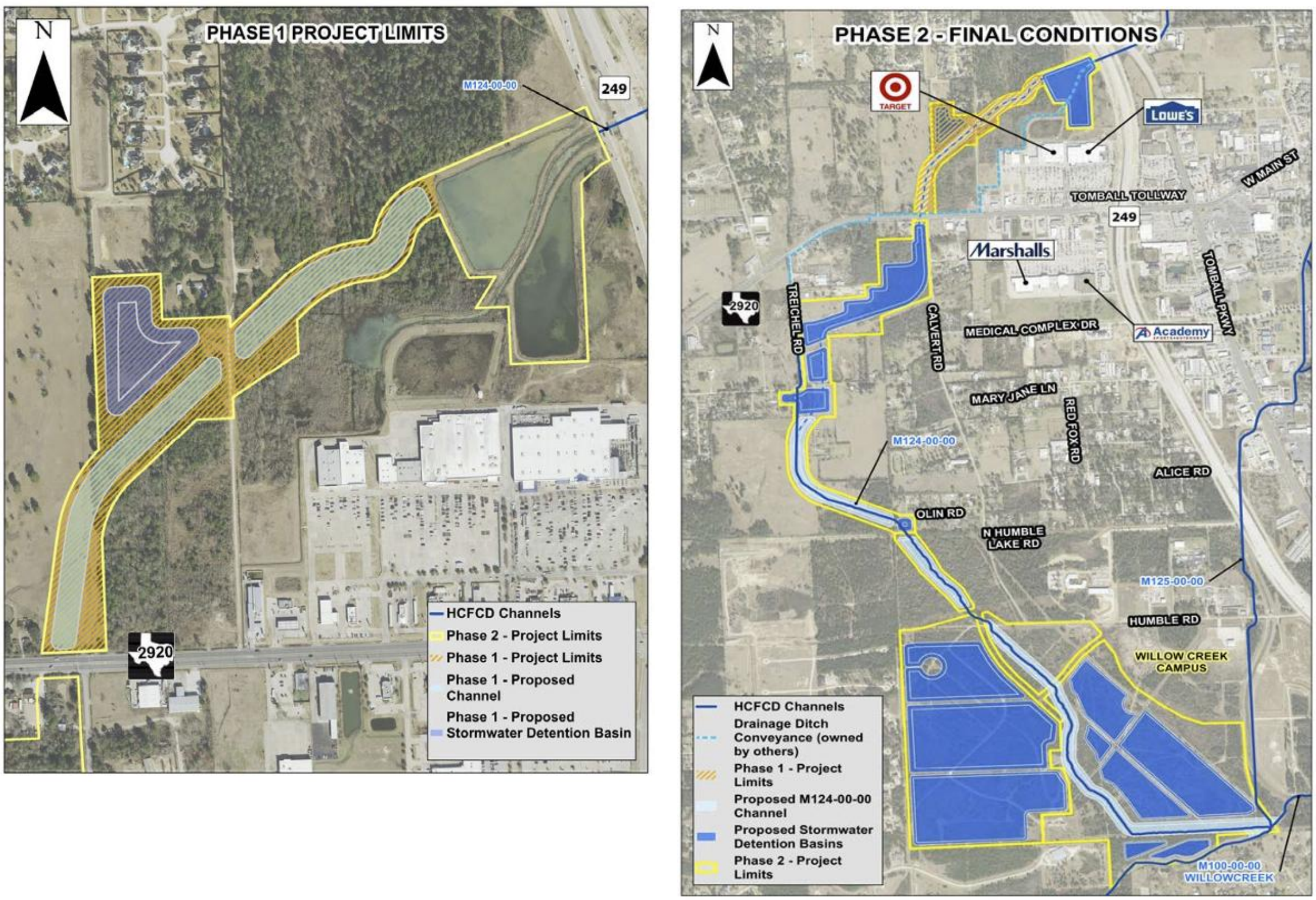


FIGURE 11-1. M124 CIP PHASED CONSTRUCTION CONCEPTS

11.4 Drainage Issues & Problematic Area

11.4.1 Historic Flooding

The M124 Basin has a history of poor drainage and flooding due to the lack of drainage depth and capacity within the existing channel.

FM 2920

FM 2920 is frequently overtopped by the M124 channel east of SH 249 near Calvert and Treichel Roads, which requires TxDOT to close the highway during these flooding events. Several studies have been conducted by TxDOT, City, and HCFCD to determine potential improvements to provide relief. The proposed HCFCD M124-00-00-E0002 and TxDOT FM 2920 Widening projects are expected to provide the necessary drainage improvements to eliminate the highway overtopping.

SH249 Bypass Basins

TxDOT detention ponds serving SH 249 Bypass and the M124-00-00 channel just upstream of SH 249 have been observed to constantly retain water and provide limited conveyance capacity. This has resulted in frequent overtopping at the Hicks Road cross culvert. It is anticipated that the HCFCD M124-00-00-E0002 and TxDOT FM 2920 Widening Projects will help provide relief to this area.

Pine County Subdivision

Pine County Subdivision is located on the west side of the City of Tomball's corporate boundaries along Tomball Cemetery Road. A drainage easement exists on the west side of lots fronting Tomball Cemetery Road that is used to capture and convey runoff from Pine Cone Lane and Pine Bark Lane cul-de-sacs. Based on visual observations, overgrown vegetation and planting has occurred within said drainage easement, blocking the intended sheet flow pattern and causing localized flooding.

Overflow from Baker Drive

Based on aerial imagery, a low-lying area between Baker Drive and Sherwood Forest Subdivision (approximately 2,150 feet east of SH 249) has existed for many years, eventually transforming into a pond due to the elevation of Baker Drive (previously Sandy Lane) and 2-36-inch cross culverts. Downstream of the cross culverts a defined channel does not exist, therefore spreading the release of the pond with an overland flow path to Brown Road in a southerly direction.

11.5 Proposed Alternatives

11.5.1 (1) M124-00-00-E0002 (HCFCD)

HCFCD is currently in design of large-scale improvements of M124-00-00. Project limits begin at the confluence with Willow Creek and extend up to SH 249. Improvements include floodplain mitigation ponds, stormwater detention ponds, culvert crossings, and channel improvements (average of 10 feet deep) to provide floodplain relief and a level of service for the 100-year design storm event. Improvements are likely to be phased into multiple construction packages, beginning with downstream pond improvements and ultimately channel improvements up to SH 249. The timeline of construction is not available at the time of this report, however, this process will take multiple years to implement the ultimate improvements.

These improvements will provide wide range benefits for the M124 Basin and will be required for any other drainage improvements between Willow Creek and SH 249 (J131#2).

11.5.2 (2) Tomball Cemetery Road & Treichel Storm Sewer to M124-00-00

Construct a storm sewer along Tomball Cemetery Road, crossing FM 2920, and down the north side of Treichel Street to the M124-00-00 improved channel. This improvement requires the implementation of the HCFCD M124-00-00 channel construction.

The Pine County Subdivision pumped detention facility may have an opportunity to optimize their existing stormwater pump system; however, the Tomball Cemetery Road storm sewer trunkline likely won't provide sufficient depth to completely eliminate the need for a pumped system.

This project will need to be coordinated with TXDOT for FM 2920 roadway improvements and Harris County Precinct 3 for local street roadway improvements.

Within the limits of the Pine Country Subdivision, planting and overgrown vegetation within the existing drainage and/or city utility easements should be removed to allow the appropriate capture and conveyance of sheet flow to the detention pond.

11.5.3 (3) M124-00-00 Channel Extension to Baker Drive

The upper reach of the existing M124-00-00 channel terminates at Brown-Hufsmith Road. Improvements within this reach of M124-00-00 were constructed as part of the Brown-Hufsmith Road roadway project and consist of an approximate 8-foot drop structure on the south side of the roadway.

This project consists of removing the drop structure for available depth upstream, reconstructing the Brown-Hufsmith culvert crossing, and extending M124-00-00 to Baker Road. A storm sewer system along Baker Road is proposed at the existing culvert crossing to provide sufficient capacity for overflow of an existing pond north of Baker Road.

In order to provide no impact to the M124-00-00 channel, alternative for mitigation may include in-line detention, expansion of the M524-01 detention basin, or additional off-line detention.

Additionally, these improvements provide an opportunity for the Springwood Estates Subdivision's private detention pond to convert from a pumped to gravity outfall system. While this tract lies within the J131 Basin, and a watershed diversion would likely require additional detention, the available depth provided in the M124-00-00 channel extension has the potential to allow excavation of the existing private detention pond to increase its storage capacity.

11.5.4 **Future CIP Project Considerations**

With downstream improvements of M124-00-00 (M124 CIP #1) deepening the channel in Phase 2 of the planned channel construction, there is opportunity for the upper reaches to be deepened. Improvements within the channel will be limited by bridge structures along SH 249 main lanes and frontage roads, as well as the culvert crossing at Business 249.

One potential solution to achieve deepening of the channel may include a vertical/rectangular channel offset through the SH 249 main lanes and frontage. Another, more economical solution is to implement a low flow "bleeder" conduit under Business 249 culvert crossing. While this solution may not have a large impact on the channel capacity, it is a lower cost solution to deepen the channel for future storm sewer along Hicks Street and potential M524-01 pond deepening for additional storage capacity.

12.0 M125 BASIN

The M125 Basin represents the contributing drainage area to the M125 channel, which is located within the western portions of the City of Tomball and its ETJ. The basin encompasses approximately 675 acres. The basin is bounded primarily by M121 West Basin to the east, J131 Basin to the north, M124 Basin to the west, and Willow Creek to the south. M125 is formed from portions of TSARP catchments M100F1 and M100F2. The drainage area is served by HCFCD channel M125-00-00, a manmade channel, which outfalls to Willow Creek west of SH 249. The M125 Basin delineation is shown in the Basin Exhibits.

12.1 Basin Description

The M125 Basin is mostly developed, consisting of residential and commercial properties. The upper portions of the basin, upstream (north) of SH 249, is considered almost fully developed, consisting of mostly commercial and multi-family development. The lower portions of the basin area, between SH 249 and Willow Creek, consist of a significant area of detention and floodplain mitigation facilities. The basin area downstream of SH 249 was also partially developed in conjunction with the extension of Holderrieth Road to serve the Harris County Precinct office and service center facilities. The M125 channel receives runoff from the SH 249 freeway and BS 249 highway north of the channel crossings. The M125 channel has been improved for its entire reach as part of a HCFCD project.

12.1.1 **Drainage Inventory**

The upper reaches of the M125-00-00 channel include an enclosed portion located within City of Tomball right-of-way. From Graham Drive to south of Michel Road, the M125-00-00 channel is an earthen, trapezoidal shaped section. M125-00-00 is enclosed beneath Business 249 and SH 249, with a short segment between the two being a concrete-lined trapezoidal channel. Downstream of SH 249, the channel remains earthen. Three ponds exist north of the M100-00-00 (Willow Creek) confluence, with one serving as a stormwater detention pond and the two remaining ponds for floodplain mitigation.

12.1.2 **Crossing Structures**

The following table presents the inventory of the M125 channel drainage crossings.

TABLE 12-1. M125 DRAINAGE CROSSING INVENTORY

Ditch ID	Crossing Name	Existing Structure	NBI
M125-00-00	Holderrieth Road	4 – 7’x3’ RCBs	121020W20338077
M125-00-00	Humble Road	2 – 12’x10’ RCBs	121020A33065013
M125-00-00	SH 249 (Enclosure)	3 – 9’x9’ RCBs	121020072003047
M125-00-00	BUS 249 (Enclosure)	2 – 8’x8’ RCBs	N/A
M125-00-00	Michel Road	2 – 10’x6’ RCBs	121020W51086011
M125-00-00	Medical Complex Drive	2 – 10’x6’ RCBs	121020W51085010

Ditch ID	Crossing Name	Existing Structure	NBI
M125-00-00	Graham Drive	1 – 10’x4’ RCB	N/A
M125-00-00	Barbara Street (Enclosure)	1 – 10’x4’ RCB	N/A
M125-00-00	Barbara Street (Enclosure)	1 – 8’x4’ RCB	N/A

12.2 Basin History

During the 1980’s, the City and HCFCD partnered to design and build the tributary channel M125-00-00 to reduce existing flooding and accommodate future development and roadway improvements, including the SH 249 expressway. As part of the M125-00-00 improvements, the M525-01-00 regional detention basin was constructed to mitigate the new channel impacts to Willow Creek. The regional facility also provides mitigation to the TXDOT SH 249 project.

- In 1987, M125-00-00 channel improvement project extended the dual 8’x8’ RCB culverts under Business 249 and rerouted the existing M125-00-00 channel alignment. The channel was partially excavated approximately 1,750 linear feet north of Michel Road. The original M125-00-00 channel was kept open.
- In 1995, M125-00-00 channel improvement rectification project extended M125-00-00 from north of Stallones Road (now Medical Complex Drive) to Graham Drive. The original M125-00-00 channel remained open.
- Based on aerial imagery and the construction plans for Medical Complex Drive between SH 249, the original M125-00-00 channel was filled. Timing and justification of this activity is unknown.
- In 2005, the SH 249 Bypass proposed 3-9’x9’ RCBs under the frontage roads and main lanes for the tollway. Parallel drainage along the frontage roads were hydraulically connected to the M125 box culverts, splitting flow between M125 conveyance and SH 249 conveyance.
- A 2008 Final Report for the Lower Reach of M125-00-00 Impact Mitigation Study evaluated the channel from the confluence of Willow Creek to the upstream side of SH 249 and detention options to mitigate impacts to Willow Creek. The study did not include ultimate build-out upstream for the City of Tomball. Two floodplain mitigation basins and a stormwater detention basin were evaluated.
- Construction plans in 2009 for the M525-01 Stormwater Detention Basin, two floodplain mitigation basins, and M125-00-00 Channel Improvements from Willow Creek to Graham Drive were completed. Upstream of the Business 249 culvert crossing, the channel design included a 6-foot bottom width with 3:1 side slope, 2-10’x6’ culvert crossings at Michel Road, and 2-10’x8’ culvert crossing at Medical Complex Drive. The HCFCD project terminated at Graham Road.
- Construction plans for M125-00-00 from Graham Road to Barbra Street were completed by a City of Tomball CIP project, which proposed M125-00-00 extension

with underground storm sewer. A 10'X4' RCB was extended from Graham Road to the south side of Barbra Street, and an 8'x4' RCB was extended to the north side of Barbra Street.

- In 2013, Tomball Tollway SH 249 main lanes were constructed and plugged the 3-9'x9' RCBs from the frontage road drainage system, therefore cutting the SH 249 contributing area at the M125-00-00 culvert crossing.

12.3 Outside Agency Projects & Agency Coordination

Coordination with Harris County, HCFCD, and TxDOT indicate that there are no current CIP projects plan within the M125 Basin.

12.4 Drainage Issues & Problematic Areas

12.4.1 **Historic Flooding**

Since the construction and additional improvements to the M125-00-00 channel, flooding with the M125 Basin is limited to localized areas. The

Cobble Creek Apartments and Lawerence Street

The realignment of M125-00-00 in the late 1980s shifted the channel in a more northerly direction, away from the current HCA Hospital, compared to the original channel alignment. The original channel alignment represents a relatively low point for this channel reach. The Cobble Creek Apartments were constructed prior to the HCFCD M125-00-00 channelization project. Due to the channel high banks being higher than Lawrence Street, the enclosed portion of the original M125-00-00 tends to back up into Lawrence Street due to the elevation differential. Furthermore, the overland flow path from the HCA Hospital follows the original M125-00-00 alignment. These factors result in constant flooding along Lawerence Street, placing the Cobble Creek Apartments at a high risk for structural flooding.

12.5 Proposed Alternatives

12.5.1 **(1) Michel Road and Lawrence Street Storm Sewer Reconstruction**

Construction of a parallel storm sewer along Lawrence and Michel Street with an outfall to M125-00-00. Install a flap gate on the existing and proposed outfall pipes to prevent backflow of the M125-00-00 channel. This improvement provides additional inlet capacity, storm sewer capacity and reduces the potential for M125-00-00 to backflow into the system as the existing channel high banks are higher than the low point along Lawrence Street.

Construction of a parallel sewer along Medical Complex Blvd with a new outfall to M125-00-00. Add inlets to all corners of the Medical Complex Drive and Lawrence Street intersection. The additional inlets and storm sewer will divert overland flow from Lawrence Street and the Medical Center area from continuing down Lawrence Street. These improvements are to prevent street ponding and adding runoff volume to the flooding location near Cobble Creek apartments during larger storm events.

12.5.2 **Future CIP Project Considerations**

With the ultimate channel section of M125-00-00 being previously constructed and a majority of the basin developed, portions of the M125 Basin include older asphalt roadways with shallow roadside ditches. Lateral connections to the M125-00-00 channel via a storm sewer, either for a roadway reconstruction project or for potential redevelopment, may be implemented to reduce localized ponding and provide outfall depth for redevelopments.

13.0 J131 BASIN

The J131 (Boggs Gully) Basin represents the contributing drainage area to the J131 channel (HCFCD J131-00-00), which is located within the northwestern portions of the City of Tomball and its ETJ. Boggs Gully basin encompasses an area of approximately 3,156 acres, generally north of FM 2920 (Main St.) including the northern portions of Old Town. The basin is bound by the Spring Creek north, FM 2978 to the east, Main Street (FM 2920) to the south, and M125 and M124 Basins to the west. The J131 Basin delineation is shown in the Basin Exhibits.

13.1 Basin Description

The basin area is served by HCFCD J131-00-00 (Boggs Gully) as a mainstem with various tributaries. Boggs Gully runs from its enclosed headwaters, serving as the outfall of FM 2920, north to its confluence with Spring Creek. HCFCD tributaries to the J131-00-00 ditch include J131-01-00, J131-03-00, J131-04-00, and J231-00-00.

HCFCD J131-01-00 is a FEMA studied stream located in the eastern portions of the basin. HCFCD J131-03-00 is a manmade channel serving the area south of Hufsmith Road and east of the BNSF RR tracks. J131-04-00 is a small roadside ditch and swale that outfalls into J131 near Ulrich Road. J231-00-00 is the original Boggs Gully alignment between BNSF RR and Zion Road prior to the Boggs Gully HCFCD CIP channel project.

The J131 Basin encompasses most of Old Town, north of FM2920, and other densely developed commercial and residential areas near the downtown area. North of Hufsmith Road, the basin consists of sparsely developed commercial and residential areas with some remaining large areas of undeveloped property, particularly in the far north and eastern areas of the basin.

13.2 Basin History

The J131 (Boggs Gully) Basin has had multiple improvement projects, including HCFCD CIP projects to improve Boggs Gully. The HCFCD projects included realignment, widening, deepening, and enclosing reaches of the basin's mainstem from Zion Road upstream to FM 2920 (Main St.).

13.2.1 **Drainage Inventory**

J131-00-00 (Enclosed from FM 2920 to Inwood Street)

Boggs Gully channel was previously enclosed from FM 2920 (Main St) north to Inwood St. by HCFCD in 1986. From FM 2920 (Main St) to Hicks St., the channel enclosure consists of 10' x 6' RCB. From Hicks St. north to the box outfall into the existing Boggs Gully channel at Inwood St., the channel enclosure consists of 12' x 8' RCB.

J131-00-00 Channel Section

The proposed Boggs Gully channel reconstruction reach extends from Inwood Street downstream to Zion Road. This reconstruction was part of a HCFCD CIP project. The reconstruction included roadway crossing improvements, concrete section from upstream of Ulrich through the BNSF RR crossing, contributing ditch outfalls (e.g., J131-03-00), and the realignment of the reach from Rudolph Road to upstream of Zion Road. The channel section within this reach generally consisted of an earthen trapezoidal section with 20' bottom width, 3:1 (H:V) side slopes, and 12 foot depth.

J231-00-00

As part of the Boggs Gully CIP reconstruction project, the channel was realigned. J231-00-00 represents the channel's original alignment from just downstream of BNSF railroad crossing to the current confluence with J131-00-00. The upstream end of J231-00-00 has been hydraulically disconnected from Boggs Gully; therefore, flow within this channel is minimized to the contributing area and not upstream flow overflow from Boggs Gully.

J131-01-00

Historically, J131-01-00 crossed Zion Road via a small drainage structure, which appears on old aerials and mapping. However, this crossing has been removed and the channel does not currently cross Zion Road. The contributing flow along the channel has been redirected along Zion Road within its south roadside ditch to outfall into Boggs Gully at the Zion Road bridge crossing.

J131-01-00 Broussard Park

J131-01-00 channel upstream of Hufsmith Road runs through the City's Broussard Park. As part of the park's construction, the channel was partially re-aligned with wet-bottom and dry-bottom detention basins constructed adjacent to the channel. However, due to wetland restrictions, the majority of the channel through the park was maintained undisturbed, without any rectification or capacity increase.

13.2.2 **Crossing Structures**

The following table presents the inventory of the J131 channel drainage crossings.

TABLE 13-1. J131 DRAINAGE CROSSING INVENTORY

Ditch ID	Station	Crossing Name	Existing Structure	NBI
J131-00-00	2829	Live Oak Lane	Bridge (3-span)	None (NBI Required)
J131-00-00	5153	UPRR	Bridge (10-span)	N/A
J131-00-00	10614	Zion Road	Bridge (3-span)	121020AA0664001
J131-00-00	15644	Rudolph Road	2 - 10'x9' RCB	121020W56091001
J131-00-00	16451	BNSF	Bridge (3-span)	N/A
J131-00-00	16852	Ulrich Road	2 - 10'x9' RCB	121020W65930001

Ditch ID	Station	Crossing Name	Existing Structure	NBI
J131-00-00	18310	W. Hufsmith Road	1 - 12'x9' RCB	N/A
J131-00-00	19087	Baker Drive	1 - 12'x9' RCB	N/A
J131-00-00	20093	Inwood Street (Enclosure)	1 - 12'x8' RCB	N/A
J231-00-00	60	J131-00-00	1 - 8'x8' RCB	N/A
J231-00-00	794	Neal Drive	N/A	N/A
J231-00-00	2601	Rudolph Road	72" RCP	N/A
J131-01-00	3028	Zion Rd	Structure Non-Existing	N/A
J131-01-00	4559	Hufsmith Rd	2 - 24" RCP	N/A
J131-03-00	50	J131-00-00	1 - 12'x7' RCB	N/A
J131-03-00	270	E. Hufsmith Road	2 - 72" RCP	N/A
J131-03-00	1742	Carrell Street	2 - 72" RCP	N/A
J131-03-00	3260	FM 2920	1 - 84" CMP	N/A
J131-03-00	4196	Timkin Road	1 - 60" CMP	N/A

13.3 Outside Agency Projects & Agency Coordination

HCFCD is currently investigating a proposed channel improvement project along J131-01-00. The project is to eliminate the existing floodplain along the channel, provide outfall depth for future Zion Road and Hufsmith Road widenings, and reduce structural flooding along the channel. The preliminary channel conveyance improvements are documented within the *Draft Preliminary Engineering Report Project ID J131-01-00-E001* by Michael Baker International for HCFCD, dated April 2024.

Harris County has indicated future plans to widen Hufsmith Road within the J131 Basin. The widening would require mitigation detention along the roadway, outfall depths at J131-01-00, and floodplain/ floodway mitigation at J131-01-00 crossing.

Previous coordination with Harris County indicated plans to widen Zion Road within the basin; however, this project has been eliminated from Harris County's future plans for the foreseeable future.

13.4 Drainage Issues & Problematic Areas

The main conveyance channel, J131-00-00, also known as Boggs Gully, was constructed to provide a 100-year conveyance for its length. However, detailed analysis by HCFCD and this study shows that the channel reach from J131-03-00 to Zion Road does not provide a 100-year capacity. Additionally, the tributaries of Boggs Gully are shown to be limited in capacity, including J131-01-00 and J131-03-00. Throughout the Boggs Gully Basin, localized flooding has been documented due to limited drainage systems and outfall depths of local received systems, such as roadside ditches and small channels. Specific problematic areas are further detailed in the following subsection.

13.4.1 **Historic Flooding**

Old Town

Old Town, north of Main St., has experienced numerous flooding events. Several properties located within the Old Town area have recorded NFIP flood claims. The area does not have sufficient internal drainage with limited/ shallow roadside ditches, undersized driveway culverts, and inadequate storm sewer systems (where these limited reaches can be found).

One of the main conveyance systems for Old Town includes N. Cherry Street roadside ditches. At the intersection of Hufsmith Road, it was observed the cross culverts of Hufsmith are undersized due to the outlet velocity seen at the slope paving north of Hufsmith and the rate at which water was conveyed to J131-00-00 (Boggs Gully).

J131-01-00 Subbasin

The existing J131-01-00 channel consists of a shallow swale that is approximately 2-3 feet deep. The ditch conveys flow from upstream of Hufsmith Road near Broussard Park westerly to Zion Road where its flow continues along Zion Road roadside ditch to its outfall into Boggs Gully. The channel has a large FEMA delineated floodplain and regulatory floodway along its alignment. However, structural flooding within the subbasin is limited due to the limited number of structures.

Lovett Road/Carrell Street

The residential areas along these two roadway corridors have experienced continuous flooding. Analysis shows that the areas are located within a topographic bowl. Drainage within the area is served by roadside ditches that are restricted by size and inadequate driveway culverts. Additionally, Lovett Street is further confined by inadequate drainage along Hufsmith Road, which receives the northern portions of the area.

Carrell Manor and Carrell Street Baptist Church

Carrell Manor was constructed in the mid-1980's and includes a backslope swale with a relief culvert along the west side of the subdivision. Per plans, this outfall is intended to cross Carrell Street and drain toward J131-03-00. However, from visual inspection, these culverts have sunken, therefore reducing their capacity to relieve the area behind Carrell Manor lot. Per City Staff, there is a public drainage easement behind Carrell Street Baptist Church, which is adjacent to Carrell Manor subdivision. This ditch requires frequent maintenance and lacks sufficient grade and capacity under current criteria.

Hufsmith Road

Hufsmith Road exists as a two-lane asphalt roadway owned and maintained by Harris County. The roadway has limited outfall depth at several locations and small, shallow roadside ditches. Due to the large contributing area to the roadway and its shallow roadside ditches, frequent roadway ponding occurs. Additionally, the shallow roadside ditches result in ponding to adjacent, contributing roadways and developed areas.

Snook Lane

Snook lane is identified in the MTFP as an existing minor arterial. Currently, Snook Lane is a two-lane asphalt roadway with shallow roadside ditches. Southern limits of Snook Lane drain to FM 2920 (which originally drained to M116 Basin) and northern limits drain to Hufsmith Road. Neither receiving roadway system has sufficient depths to accommodate existing or future development along Snook Lane. Therefore, the roadway experiences frequent ponding. Additionally, any development along Snook Lane requires pumped detention facilities due to the lack of outfall depth in the roadside ditches.

J131-03-00

Along upstream reaches of J131-03, north of FM 2920, observations from City Staff provided evidence of Timkin Road roadside ditches overtopping. The FM 2920 culvert crossing at J131-03 is undersized based on its contributing area and stream hydraulics. The City's sanitary sewer system to the North Treatment Plant travels along the centerline of J131-03-00 for its entire reach; this systems manhole obstructs flows and increases the potential for sanitary sewer overflows due to inundation from the channel. The 2023 Water and Wastewater Master Plan has identified a sanitary sewer project along J131-03-00 for upsizing within the proposed 5-year CIP.

Baker Rd north of Brown Road

The Tomball ISD Transportation Building, located in the southeast quadrants of the Quinn Road and Baker Drive intersection, naturally drains in a southeasterly direction towards J131-00-00 (Boggs Gully). Original development and parking lot expansion of the bus depot includes multiple dry detention ponds outfalling in a shallow ditch that drains towards Baker Drive. Connectivity to J131-00-00 continues along Baker Drive and Hufsmith Road via roadside ditches and driveway culverts. These roadside ditches and culverts are undersized, causing street ponding and limiting outfall depth for future development.

North Sycamore and North Peach Street

North Sycamore Street and Peach Street exist as two-lane asphalt roadway with shallow roadside ditches with limited conveyance to J131-00-00. With the BNSF railroad and FM 2920 existing at natural grade breaks for the J131 Basin and M118 Basin, the area has insufficient drainage causing localized street flooding during smaller storm events. Peach Street drains north and utilized an existing cross culvert north of Carrell Street, directing the roadway drainage into a private pond.

Willow Street

The general retail district between FM 2920, Willow Street and Tom Keating Drive began to redevelop in the early 2000s when a private drainage channel and cross culvert under Willow Street was constructed to hydraulically connect this undeveloped area to J131-03-00. At the downstream end of the culvert crossing under Willow Street, runoff is abruptly directed into driveway culverts. The roadside ditch wraps around the southernmost lot and ultimately drains into J131-03-00. The confluence at the downstream end of the cross culvert has repeatedly overcome the roadside ditch banks, causing localized ponding and increases the potential for structural flooding for adjacent residential properties.

FM 2920

FM 2920 is a TxDOT arterial highway that historically represents the relative basin divide between Spring Creek and Willow Creek watersheds. However, the highway has experienced continuous flooding, including the rainfall event in May 2024. Multiple street overlays with minimal storm sewer reconstruction, the existing roadside ditches and storm sewer systems are drastically undersized. Additionally, continual development along the corridor since the original storm sewer installation has diminished the facility's capacity.

At the time of this report, TxDOT is currently in design for the full reconstruction of FM 2920 from State Highway 249 to Willow Street. The reconstruction will incorporate drainage improvements to the storm sewer system, cross culverts, and all parallel drainage within the right-of-way. For this reason, proposed improvements within the highway ROW as part of this study were limited stream cross culverts.

Tomball Terrace Subdivision

The existing condition modelling revealed a low-lying area within the Tomball Terrace Subdivision, which is adjacent to J131-00-00 (Boggs Gully) between Baker Drive and Hufsmith Road. The subdivision was constructed in the early 1980s. In addition to the modeling indications, there are multiple repetitive loss claims along Pecan Street within the subdivision. The original outfall for the subdivision was constructed as a ditch to Hufsmith Street through private property to the north. Development on this private property enclosed the ditch, therefore limiting the outfall for the subdivision. Furthermore, offsite sheet flow from the south is collected in shallow ditch behind residential lots and collected in the S. Pecan Street storm sewer system. The storm sewer within the subdivision is outdated and undersized for current drainage standards, thus overloading the system.

13.5 Proposed Alternatives

13.5.1 **(1) J531-01 Detention Pond Improvements**

Portions of Old Town north of FM 2920 within the service area of Cherry Street are served by roadside ditches and cross culverts. The drainage solution for this area begins with the construction of a sub-regional detention pond, J531-01, as a mitigation for increased flows from the conversion to underground storm sewer for N. Cherry Street and allocation of storm volume for future Hufsmith Rd reconstruction between J131-00-00 and the BNSF Railroad. Additional volume is available for storm sewer improvements serving N. Sycamore Road.

The City has been acquiring lots within the triangular-shaped tract, with only a few outstanding lots remaining. Once the remaining lots are acquired, excavate and construct a dry-bottom detention facility to provide storage volume and outfall depth for planned upstream improvements. Construct an outfall structure to J131-00-00. The facility may provide multi-purpose functionality in conjunction with the City's Park Master Plan.

13.5.2 **(2) N Cherry Street Storm Sewer Improvements**

Upon completion of the J531-01 Detention Pond project, storm sewer improvements along N Cherry will relieve local ponding by increasing the drainage system capacity with the lowered outfall depth provided in the pond. Construct a storm sewer trunk line along N Cherry Street, either in collaboration with Harris County Precinct 3 roadway reconstruction or independently of the Precinct with ditch interceptors to maintain the current roadway configuration. Lateral systems along other streets may be evaluated during the design phase and/or installed post CIP project.

13.5.3 **(3) Commerce Street Storm Sewer Improvements**

Construct east-west lateral systems along Commerce Street. Street to remain curb and gutter and may include potential street reconstruction. This system will be connected to the downstream proposed N. Cherry Street Storm Sewer Improvements (J131#2).

13.5.4 **(4) J531-02 Detention Pond Improvements**

This alternative drainage solution includes the construction of a dry-bottom detention basin on a City owned tract. The detention basin has the potential to serve future Hufsmith Road improvements and offset impacts to North Sycamore Street storm sewer improvements (J131#5B).

Environmentally sensitive areas exist within the pond tract (see *Environmental Section*) due to apparent existing oil wells and pipelines within the tract. These facilities will need to be accounted for within the utilization of this basin tract and its engineering design.

13.5.5 **(5) N. Sycamore Storm Sewer Improvements**

Alternative A – Conveyance Improvements to J531-01

Construct storm sewer trunkline along North Sycamore right-of-way and within an acquired drainage easement parallel to the BNSF railroad. Install a storm sewer crossing at the West Hufsmith Road rail crossing and connect storm sewer to J531-01 detention facility.

To help facilitate drainage along Peach Street, lateral connections may be implemented by the City CIP project or by private development as it is within the service boundary of the proposed trunkline.

Alternative B – Conveyance Improvements to J531-02

Construct storm sewer trunkline along North Sycamore right-of-way and within an acquired drainage easement parallel to the BNSF railroad. Install a storm sewer crossing under East Hufsmith Road and connect storm sewer to J531-02 detention facility. This solution requires the construction of the J531-02 detention facility (J131 CIP 4).

To help facilitate drainage along Peach Street, lateral connections may be implemented by the City CIP project or by private development as it is within the service boundary of the proposed trunkline.

13.5.6 **(6) J131-01-00 Channel Improvements**

Due to the complexity of the subbasin, multiple future infrastructure projects, and multiple agencies involved, several alternative options were conceived for the J131-01-00 subbasin. The proposed improvement options provided existing flooding relief, addressed drainage issues and provided outfall depth for future development within the subbasin. The options also considered the potential Hufsmith Road and Zion Road improvements and the roadway needs for storm sewer depth and detention. Additionally, the options included the offsetting of the effective FEMA floodplain volumes, which would be eliminated with the drainage improvements.

Any J131-01-00 option implemented will require HCFCD coordination since the District is currently investigating improving the channel to eliminate the existing floodplain along the channel.

Alternative A – J531-04 and Storm Sewer Improvements

Construction of detention facility upstream (east) of Hufsmith Road to provide floodplain storage and outfall depth for upstream potential development. Basin outfall includes large box culvert (8’ x 8’ RCB) to Hufsmith Road. Drainage system will bypass the existing J131-01 channel alignment with dual box culvert system (2- 10’ x 8’ RCB) that runs along Hufsmith Road north to Zion Road and then west along Zion Road to its outfall into Boggs Gully at the Zion Road crossing.

The project will provide floodplain relief, eliminate the existing floodplain and floodway along J131-01, and provide outfall depth for the future reconstruction of Hufsmith Road and Zion Road. The project should be coordinated with Harris County for the reconstruction of Hufsmith Road and potential reconstruction of Zion Road to ensure sufficient capacity and depth for the roadway contributing storm sewer system.

Alternative B – J531-04, J131-01-00 and Storm Sewer Improvements

Construction of detention facility upstream (east) of Hufsmith Road to provide floodplain storage and outfall depth for upstream potential development. Basin outfall includes large box culvert (8' x 8' RCB) to Hufsmith Road. The drainage system downstream of Hufsmith Road will utilize the existing J131-01-00 alignment to Zion Road, including a 10' bottom width, 10' deep trapezoidal, earthen channel. From the channel's junction with Zion Road, the system will run west along Zion Road via 2-10' x 8' RCB to its outfall into Boggs Gully at the Zion Road crossing.

The project will provide floodplain relief, eliminate the existing floodplain and floodway along J131-01, and provide outfall depth for the future reconstruction of Hufsmith Road and Zion Road. The project should be coordinated with Harris County for the reconstruction of Hufsmith Road and potential reconstruction of Zion Road to ensure sufficient capacity and depth for the roadway contributing storm sewer system.

Alternative C – J531-03, J531-04 and Storm Sewer Improvements

Construction of detention facility upstream (east) of Hufsmith Road to provide floodplain storage and outfall depth for upstream potential development. Basin outfall includes large box culvert (8' x 8' RCB) to Hufsmith Road. Drainage system will bypass the existing J131-01 channel alignment by running south along Hufsmith with a large box culvert system (10' x 8' RCB) that runs along Hufsmith Road to the existing swale roadway outfall just east of Snook Road. A detention basin along the existing flow path is proposed from Hufsmith Road north to the existing J131-01 alignment. The basin outfall will consist of a large dual box culvert system (2- 10' x 8' RCB) that runs along the existing J131-01 alignment to Zion Road and then west along Zion Road to its outfall into Boggs Gully at the Zion Road crossing. The system will also include a connection from J131-01 at its Hufsmith Road crossing (at Broussard Park) to the proposed system along Hufsmith Road.

The project will provide floodplain relief, eliminate the existing floodplain and floodway along J131-01, and provide outfall depth for the future reconstruction of Hufsmith Road and Zion Road. The project should be coordinated with Harris County for the reconstruction of Hufsmith Road and potential reconstruction of Zion Road to ensure sufficient capacity and depth for the roadway contributing storm sewer system.

13.5.7 **(7) Zion Road Storm Sewer Improvements**

Zion Road is maintained by Harris County Precinct 3 (Road Log ID 3F54401, 3F54402, 3F54403, and 3F54404) within the City limits. Zion Road exists today as a two-lane asphalt roadway with shallow roadside ditches and limited conveyance to J131-00-00. Due to the large contributing area of Zion Road, the drainage improvements should be sized to accommodate these flows.

Proposed improvements include construction of a storm sewer trunkline from Quinn Road to Boggs Gully (J131-00-00) bridge structure. It is anticipated the drainage infrastructure improvements will be part of roadway reconstruction by Harris County Precinct 3. As part of the project, it is likely detention will be required to mitigate increased flows generated by the storm sewer improvements. The City shall coordinate with Harris County Precinct 3 during the preliminary stages to implement upsizing of the storm sewer to meet the City's drainage criteria and design/ locate proposed detention basin.

13.5.8 **(8) Hufsmith Road Storm Sewer Improvements**

Hufsmith Road is maintained by Harris County Precinct 3 (Road Log ID 3I98901) within the City limits. The segment of this CIP extends from the BNSF Railroad crossing to Lovett Street, within the J131-03-00 service area. Western segments of the roadway are planned within the J531-01 service area and eastern segments are planned within the J131-01-00 service area.

Proposed improvements include construction of storm sewer from BNSF Railroad crossing to Lovett Street. Two pond locations have been identified; Pond A within a City-owned tract and Pond B adjacent to J131-03-00 and J131-00-00 channels.

The City shall coordinate with Harris County Precinct 3 during the preliminary stages to implement upsizing of the storm sewer and selected CIP alternatives for North Sycamore improvements (J131 5) and Carrell Street/Lovett Street (J131 CIP 10 and CIP 11 improvements.

13.5.9 **(9) Snook Lane Storm Sewer Improvements**

Construction of a storm sewer system along Snook Lane is needed to provide drainage capacity and depth along the roadway. Based on available outfall depth at FM 2920 and drainage issues along FM 2920, construction of the storm sewer system will require a watershed diversion (from M116 Basin to J131 Basin) of approximately 30.7 acres. This would require acquisition of a tract for a stormwater detention facility to offset impacts from the watershed diversion and increased peak flows from the roadway drainage improvement.

This option requires an upgraded outfall along Hufsmith Road and should be coordinated with Harris County Precinct 3 and HCFCD for Hufsmith Road improvements and J131-01-00 improvements as it is anticipated multiple detention facilities will be required to serve all of these hydraulically connected components.

13.5.10 **(10 & 11) Carrell & Lovett Street Storm Sewer Improvements**

Four alternatives were considered for Carrell Street Improvements and are described below. Existing conditions show a drainage divide at the intersection of Carrell Street and Lovett Street. Due to natural topography, Carrell Street currently drains west toward J131-03-00 and Lovett Street currently drains north toward Hufsmith Rd, ultimately to J131-03-00. All alternatives include a new storm sewer within Carrell Street Baptist Church tract south of Carrell Street to improve ongoing maintenance efforts of the existing shallow swale.

Carrel Street 10A & Lovett Street 11A

Install two independent storm sewer systems along Carrell Street and Lovett Street while maintaining existing service areas. Lovett Street improvements will require the reconstruction of Hufsmith Rd and coordination with Harris County Precinct 3.

Carrell Street 10B & Lovett Street 11B

- Provide a storm sewer system serving both Carrell Street and Lovett Street independent of the Hufsmith Road reconstruction project. In order to provide outfall depth for this drainage solution, J131-03-00 requires reconstruction from the confluence with J131-00-00 to Carrell Street. Replace the existing outfall structure and remove the drop structure upstream of the J131-00-00 outfall. Reconstruct J131-03-00 to a rectangular, concrete-lined channel with a minimum 4-foot vertical drop. Concrete-lining of the entire cross-section will be required along the entire reconstruction length. Replace existing culvert crossings at Hufsmith Road and Carrell Street. Install concrete-lined drop structure upstream of Carrell Street culvert crossing.
- Install storm sewer system serving all of Carrell Street and Lovett Street. Pipe upsizing is required to achieve the hydraulic grade line one-foot below the gutter line in the northern reach of the Lovett Street system, as the storm sewer is being directed opposite of the natural topography.
- Channel reconstruction will require land acquisition between Hufsmith Rd and Carrell Street to provide maintenance berms (30-foot-wide along the western bank and 20-foot-wide along eastern bank).
- Reconstruction of the channel will require the relocation of a 15-inch wastewater line that exists within the channel bottom. This segment of sewer has been identified in the City of Tomball 2023 Water and Wastewater Master Plan as requiring upsizing (Project #5).

Carrell Street 10C & Lovett Street 11C

- Similar to alternative 10 B & 11B, provide a storm sewer system serving Carrell Street and Lovett Street independent of the Hufsmith Road reconstruction project. In order to provide outfall depth for this drainage solution, J131-03-00 will be enclosed from J131-00-00 to FM 2920 culvert crossing. While this is the most expensive solution, it minimizes the right-of-way footprint, potentially eliminates the need to additional utility easements for the sanitary sewer relocation and provides an opportunity to enhance this drainage corridor as a walking trail/path.

13.5.11 **(12) Willow Street Ditch Regrade and Culvert Crossing to J131-03-00**

Willow Street culvert crossing north of FM 2920 collects a private drainage easement for Commercial Property, Tom Keating Drive and southern portions of Lovett Street with an ultimate outfall to J131-03-00. Downstream of the Willow Street culvert crossing, a perpendicular bend in roadside ditches conveys runoff back toward FM 2920 and bends back north toward J131-03-00.

Regrade Willow Street eastern ditch toward Texas Street, adjacent to a City-owned tract. Construct a culvert crossing under Willow Street. Excavate a new ditch toward J131-03-00 within the unimproved right-of-way of Texas Street.

13.5.12 **(13) Baker Drive and Brown Road Storm Sewer to J131-00-00**

Tomball ISD Transportation Facility stormwater detention pond outfalls in a southeast direction toward Baker Drive through private property. Construction of a storm sewer along Baker Drive and W. Hufsmith Road to J131-00-00 will provide outfall depth and conveyance capacity for the service area.

13.5.13 **(14) FM 2920 Culvert Crossing Reconstruction**

Installation of a parallel culvert crossing under FM 2920 to increase culvert capacity and relieve upstream drainage. This project requires coordination with TxDOT for FM 2920 Roadway Reconstruction project.

13.5.14 **(15) Stanolind Road Culvert Crossing**

Replace the existing culvert to provide positive drainage and relieve localized ponding near BNSF Railroad Tracks.

13.5.15 **(16) Pecan Street Outfall Reconstruction**

Reconstruction of curb inlets at the existing Pecan Street outfall. Remove and replace existing arch pipe outfall at Pecan Street. Construction of the outfall within a new drainage easement directly into J131-00-00.

13.5.16 **(17) Hicks Street and Inwood Drive Diversion from Tomball Terrace Subdivision**

To reduce the off-site sheet flow directed into the Tomball Terrace Subdivision and continual inundation observed and reported along Pecan Street, construct a new storm sewer system along Hicks Street, Inwood Street, and reconstruct storm sewer along the east side of Baker Drive with a new outfall downstream of the culvert crossing at J131-00-00. Construct a new ditch within City right-of-way along southern edge of Tomball Terrace Subdivision and route north to new Hicks Street storm sewer. Replace existing curb inlets at Baker Drive intersections with Inwood Street and North Pecan Street.

14.0 J132 BASIN

The J132 Basin services the area north of Zion Road east and east of the BNSF railroad. The J132 basin encompasses approximately 50 acres. As part of the J132 Basin area, a separate J132A Basin was delineated to represent the area north of Zion Road and west of the BNSF. The J132A Basin encompasses approximately 125 acres. The J132 and J132A Basin delineations are shown in the Basin Exhibits.

14.1 Basin Description

The basin is divided into two subbasins by the BNSF railroad. East of the railroad, the drainage system consists of roadside ditches that drain to the shallow J132-00-00 ditch, which runs south to north to its outfall into Spring Creek. The channel serves the Hunterwood Subdivision. The J132-00-00 ditch has previously been rectified by the City of Tomball.

West of the railroad, the J132A channel is a natural channel that runs from the north end of Martens Road north adjacent to the BNSF alignment to Spring Creek. The drainage system consists of a natural ravine-style drainage channel. The upper portions of the subbasin include residential development with the lower (northern) portions of the subbasin consisting of rural residential tracts. The J132A Basin serves the Country Meadow subdivision as well as the east side of Quinn Road north of Zion Road.

The are some inter-connections between the J132 and J132 basins with flow paths towards the BNSF railroad and cross-culverts under the railroad. These connections provide an overflow connectivity from J132 Basin to J132A within the upper portions of the J132 Basin area.

14.2 Basin History

The J132-00-00 channel was a natural conveyance path based on historical topographical surveys and aerial imagery. With the BNSF Railroad immediately to the west, it served as a general flow path toward Spring Creek. As part of Hunterwood Subdivision development (approved plans 1984), the channel was improved and new outfall installed to J100-00-00 (Spring Creek).

14.2.1 **Drainage Inventory**

The J132 channel, per as-built drawings, was designed with a flat-bottom width of 4 feet and a top width of approximately 40 feet at a relatively gentle slope at the downstream reach and a V-shaped ditch in the upstream reaches with a steep slope of over 0.01 ft/ft gradient. Small ditch laterals run from Lost Creek Road to the J132-00-00 channel, serving as the roadway outfall systems. A multiple barrel, 3-36” RCP structure is located at Julia Lane crossing. The channel outfall consists of 2-36” CMP that are constructed with an approximate 40 foot drop into Spring Creek.

The J132 channel is a well-defined, natural channel that deepens into a ravine-style section as it approaches its confluence with Spring Creek. No roadways cross the channel.

14.2.2 **Crossing Structures**

The following table presents the inventory of the J132 channel drainage crossings.

TABLE 14-1. J132 DRAINAGE CROSSING INVENTORY

Ditch ID	Crossing Name	Existing Structure	NBI
J132-00-00	Outfall to J100-00-00	2 – 36” CMP	N/A
J132-00-00	Julia Lane	3 – 36” RCP	N/A

14.3 Outside Agency Projects & Agency Coordination

No improvements were identified by HCFCD for this channel.

14.4 Drainage Issues & Problematic Area

No drainage problems were identified for these two channel areas.

14.5 Proposed Alternatives

Although no capacity increase is proposed along the channel, a stability project is recommended to re-establish the channel configuration and reduce future failures and maintenance issues.

15.0 J133 BASIN

The J133 Basin services the area east of SH 249 to Quinn Road from north of Baker Road, across Zion Road, north to Spring Creek. The J133 Basin is approximately 248 acres. Improvements along this channel and within the basin have previously been performed by the City of Tomball and the adjacent development. The J133 Basin delineation is shown in the Basin Exhibits.

15.1 Basin Description

Based on aerials and land use maps, the J133 Basin is mostly developed. Hydraulic analysis for the J133 channel shows that the drainage ditch has 100-year capacity for the ditch length. However, a field review of the basin locations showed erosion/ stability issues along the channel reach; this finding was supported by City officials.

As part of the J133 Basin, the Tomball Hills Subdivision was investigated. This area lies immediately to the west of the J133 Basin and is served by a storm sewer system that outfalls directly into Spring Creek downstream of SH 249. This area delineation is also shown with the J133 Basin in the Basin Exhibits.

15.2 Basin History

Improvements to the J133-00-00 channel were completed in the early 1990s as part of a City CIP project. The channel was designed with a 6-foot-wide flat bottom and includes multiple drop structures along the reach upstream of the culvert crossing. Channel improvements included an enclosed reach, connecting area south of Zion Road. Quinn Road acts as the general basin divide between the J131 Basin and the J133 Basin.

Immediately following improvements to the channel, the North Star Subdivision commenced construction, including a phased, multi-cell detention facility that outfalls to J133-00-00 downstream of the culvert crossing and into an unimproved reach of the channel.

Sherwood Forest Subdivision began constructing homes prior to the 1980s and before Zion Road was installed. Based on historical topographic maps, the subdivision generally drained either north to J133-00-00 or south to the M124 Basin. Spring Pines Estates was constructed in the early 2000s and included a detention pond at the upstream end of the J133-00-00 enclosed section. This detention facility has had multiple erosion failures over the years, impacting the adjacent sanitary sewer system. The last pond remediation was completed in 2016, which diverted Sherwood Forest runoff directly into the J133-00-00 enclosed section under Zion Road.

Immediately adjacent to the J133 Basin is the Tomball Hills Subdivision. This neighborhood was constructed in the late 1970s along J100-00-00 (Spring Creek) and SH 249 (originally SH

149). The subdivision has relatively steep gradients as it abuts the southern bank of Spring Creek. The outfall for the subdivision is located at the cul-de-sac along Stella Lane, the northernmost portion of the development.

15.2.1 **Drainage Inventory**

The existing J133-00-00 is an earthen trapezoidal channel that reaches approximately 3,900 linear feet from north of Zion Road to Spring Creek.

15.2.2 **Crossing Structures**

The following table presents the inventory of the J133 channel drainage crossings.

TABLE 15-1. J133 DRAINAGE CROSSING INVENTORY

Ditch ID	Crossing Name	Existing Structure	NBI
J133-00-00	Unimproved Crossing	2 - 7' x 5' RCBs	N/A
J133-00-00	US J133-00-00	1 - 10’ x 5’ RCB	N/A
J133-00-00	Enclosed Reach	84” RCP	N/A
J133-00-00	Zion Road	72” RCP	N/A

15.3 Outside Agency Projects & Agency Coordination

No improvements were identified by HCFCD for this channel. Harris County Precinct indicated no roadway improvements within this basin area.

15.4 Drainage Issues & Problematic Area

The drainage area has localized drainage issues due to overflows and limited capacity of storm sewer/drainage systems. The sandy soils within the area pose additional issues through excessive erosion of the existing drainage infrastructure.

15.4.1 **Historic Flooding**

Localized historic flooding has been documented within Tomball Hills Subdivision, specifically along Camille Drive, and Sherwood Subdivision.

15.4.2 **J133-00-00 Channel Erosion Failures**

J133-00-00 channel consists of sandy, dispersive soils, causing frequent erosion to the North Star Estates Subdivision. Cohesionless and dispersive soils subjected to high shear stresses due to channel velocities lead to significant erosion and potential instability within the channel. The City has recently implemented a mechanically-stabilized earthen wall behind a specific residential lot, however, erosive issues continue in the lower and upper reaches of the J133-00-00 channel.

15.4.3 **Tomball Hills Subdivision (J100)**

Due to the shallow grade and lack of storm sewer along Zion Road, it appears an overflow from south of Zion Road travels down Alice Lane to the knuckle at Camille Drive. From visual observation, it appears inlet repairs have been previously implemented to assist in the collection of runoff from the contributing areas and overflow from Zion Road. Lack of inlet capacity and storm sewer capacity cause street ponding and increase the risk of potential structural flooding for residential properties located at this low point.

15.4.4 **Sherwood Forest Subdivision**

Sherwood Forest Subdivision has reported multiple drainage and localized flooding issues. These stem from various causes, such as inadequate ditch capacity, small driveway culverts, and flow path blockages. The City has previously investigated and addressed these issues through re-grading of roadside ditches, replacement of driveway culverts, addition of a detention basin at the north end of Wickerford Drive, and improvement of the area's outfall at Wickford Drive to the J133-00-00 channel.

15.4.5 **Spring Pines Subdivision**

Spring Pines has previously experienced drainage issues with regards to the erosion failures within its detention basin caused by overtaxing of the basin due to overflows from Sherwood Forest Subdivision. The City has previously investigated and addressed localized drainage and erosion issues through the interception and re-direction of Sherwood Forest overflow, restoring of the detention basin configuration, and basin overflow interceptor structure to reduce erosion.

15.5 Proposed Alternatives

Although no capacity increase is proposed along the channel, a stability project is recommended to re-establish the channel configuration and reduce future failures and maintenance issues.

15.5.1 **(1) J133-00-00 Channel Rehabilitation**

J133-00-00 channel consists of sandy, dispersive soils, causing frequent erosion to the North Star Estates Subdivision. Channel rehabilitation may include soft and hard revetments to restore the channel banks and prevent future erosion. Soft revetment options may include geotextile fabric and other bio engineered, flexible channel lining systems. Hard revetments options may include gabion mattresses, low-profile retaining walls, concrete-lining, module blocks, or hardened geosynthetics. Revetment types should consider channel velocities, sheer stress, and economics for suitable solution alternatives.

15.5.2 **(1) Tomball Hills Subdivision Storm Sewer**

Construct two pairs of flanking inlets (west and south) as well as reconstructing the sag inlets at the Camille Drive and Alice Lane knuckle for increased inlet capacity. Construct parallel storm sewer system along northern curb line of Camille Drive and eastern side of Stella Lane curb line such that existing storm sewer system remains in place. Acquire a drainage easement for a new outfall combining the existing and proposed parallel storm sewer to J100-00-00 (Spring Creek).

During final design, alternative locations for a new outfall location may be evaluated for an economical solution.

16.0 DRAINAGE CRITERIA AND STANDARDS

The City of Tomball, Texas, authorized an update to the City's Drainage Criteria Manual (DCM), which was originally published and adopted in 2011, updated in June 2021. The DCM establishes rules and regulations that must be consistently followed and enforced throughout the City for drainage design and implementation.

16.1 Disclaimer

This manual is intended to provide criteria for the most commonly encountered drainage and control designs in City of Tomball. The manual was written for users with knowledge and experience in the applications of standard engineering principles and practice of stormwater design and management. The purpose of the Drainage Criteria Manual is to provide a property owner, developer, and/ or engineer with information and instruction necessary for creating drainage plans that will promote the owner's interests and objectives while protecting the health and safety of the community.

The DCM policies and design criteria shall not create liability on the part of City of Tomball or any office or employee thereof for any flood damage, property damage, or personal injury that results from reliance on these policies or any administrative decision lawfully made.

16.2 No Adverse Impact

No adverse impact is the principle that the actions of any community or property owner, public or private, should not adversely impact the property and rights of others. No adverse impact management offers a way to prevent the worsening of flooding and other negative impacts on the community. Adverse impacts as they relate to drainage improvements can be measured by flow rate, water surface elevation, velocity, flow type, erosion and sedimentation, or other measurable adverse impacts to a community's well-being.

For all drainage projects located in the City of Tomball and its ETJ, the following criteria must be met for drainage plan approval:

- Peak Flow: No increase to peak flow leaving the project. This is determined by comparing pre-project versus post-project flow rates.
- Water Surface: No increase to the water surface elevations upstream, downstream, or to adjacent properties as this would result in increased flooding.
- Velocity: No increase to the velocity so as to cause scour or erosion within or around the project site.
- Flow type: Consideration of flow type changes (e.g., overland sheetflow versus concentrated point discharge) with regard to receiving system and potential erosion.

16.3 Drainage Facility Maintenance

All detention facilities constructed by a property owner or developer shall be maintained by the property owner or developer, their legal heir(s), grantee(s), successor(s), or assignee(s). The maintenance party responsible at the time of development must be noted on the Engineering Plans.

The maintenance of detention and drainage facilities is critical for ensuring that these facilities will operate as intended during rainfall events. The property owner or developer shall ensure that the drainage facilities are functioning as designed and being properly maintained.

The City of Tomball will not be responsible for the maintenance of any detention pond within the City unless specific criteria have been met and the City has formally accepted the facility for maintenance.

16.4 Design Criteria Manual Updates

This Design Criteria Manual update supersedes the previous document of the same name date June 7, 2021. All items listed herein are intended to supersede those documents.

The City of Tomball recognizes the need to control flooding and detain excess runoff from orderly development. Due to updates to technology and methodologies used to analyze hydrologic and hydraulic conditions, this update is intended to capture best practices in development and redevelopment while continuing to provide sufficient criteria to decrease the likelihood of flooding due to development and construction.

Below are major revisions to the DCM. A copy of the DCM can be found in **Appendix A**.

- Application of Rational Method – Calculation of Runoff Coefficient using composite C factor calculations
- Time of Concentration (Tc) Determination – Replaced area-based Tc methodology with velocity-based Tc methodology
- Added Roadway Drainage Criteria Hierarchy – Roadway classification will determine allowable ponding widths using a 25-year design storm event with design HGL one foot below gutter elevations
- Storm Sewer Placement – Storm sewer shall be placed under the outside curb or edge of pavement, as opposed to the center of the roadway, for consideration of future maintenance and traffic control
- Detention Criteria
    - A minimum 0.75 ac-ft/ac storage rate is required for all development, regardless of development size
    - Provided detention criteria for SFR tracts with a single structure based on tract size and impervious cover

- A minimum 0.75 ac-ft/ac for all development, regardless of development size
- For projects over 5 acres, either the Small Watershed Method (Malcolm's Method) or Clarks Unit Hydrograph shall be used to estimate detention volume with appropriate computer modelling software
- Approval of detention through ponding in truck courts/parking area at the discretion of City staff.
- Minimum detention pond maintenance berm widths based on pond depth.

16.5 Technical Specifications

Part of the drainage master plan included review of City drainage standards and specifications based on adjacent municipality standards, constructability, and maintenance issues and needs. The updated specifications (redlined copy) are provided in **Appendix B**. Below are descriptions of major revisions to the City drainage specifications.

Private development has been using thermoplastic pipe, specifically high-density polyethylene (HDPE) pipe and polypropylene (PP) pipe, for stormwater drainage application for many years due to the lightweight composition and cost efficiency. In the past, state and local governments did not allow such materials to be used in transportation projects, rather they used conventional reinforced concrete pipe sections. However, the Texas Department of Transportation and Harris County Engineering Department have recently adopted the use of PP pipe and HDPE pipe. In general, polypropylene pipe provides a more rigid section than the HDPE option. One key component to the use of thermoplastic pipe is proper installation related to the soil envelope, or the bedding and backfill, of the drainage conduit.

Specific use of PP and HDPE pipe in lieu of current standards within City right-of-way shall be as follows:

- Storm Drain (Trunkline and Inlet Leads) – PP Pipe
- Cross Culverts – PP Pipe
- Parallel Culverts – PP Pipe or HDPE Pipe

The City's Technical Specifications and Construction Standards have been revised to accommodate the use of thermoplastic pipe within the right-of-way. Listed below are specifications that have been added and/or revised. These specifications and construction standards are included in **Appendix B**.

- Section 02505 – High Density Polyethylene (HDPE) Solid and Profile Wall Pipe
- Section 02509 – Thermoplastic Pipe Culverts and Drains
- Section 02631 – Storm Sewers
- COT STM-40 Storm Bedding and Backfill for Thermoplastic Pipe

17.0 CAPITAL IMPROVEMENT PLAN

A drainage master plan presents potential projects for future implementation to reduce existing flooding and provide drainage infrastructure for future municipal infrastructure improvements and potential development needs. The drainage Capital Improvement Plan (CIP) includes short-term and long-term strategic plans for the City's drainage infrastructure development based on cost, benefit, prioritization, and funding availability. The City's drainage CIP listing is derived from the projects proposed within the drainage master plan and categories based on a prioritization evaluation.

17.1 Proposed Project Cost Estimates

The cost for the proposed improvements for the proposed drainage improvements was estimated based on unit cost rates and quantity estimations of proposed improvement elements. Probable construction costs associated with the proposed improvements were estimated based on project bid unit cost information obtained from Texas Department of Transportation Department (TxDOT), Harris County Flood Control District (HCFCD), and local recent construction projects. The unit costs obtained include such items as: channel excavation, detention excavation, culvert/ storm sewer pipes and boxes, inlets and manholes, culvert end treatments, concrete paving, pavement cut-n-restore, etc. A 25-percent consultant (engineering) fee and 30-percent contingency fee, both based on the preliminary project subtotal amount, were added into the cost estimate. The contingency percentage is set based on the preliminary stage of the cost estimate and the potential for unit cost escalation prior to construction. Additionally, right-of-way acquisition was included in the overall cost estimate based on acreage unit cost with a 10-percent added contingency. The itemized unit cost is provided within **Appendix C**. Detailed cost estimates for each project are provided in **Appendix C**. A CIP cost summary based on these detailed estimates is provided in **Appendix D**.

17.2 Prioritization

As part of the CIP development, prioritization of the projects was performed. A set of prioritization criteria was developed to select future drainage projects that provide a drainage benefit/ relief of existing flooding, contribute to the improvement of the community's well-being, support the development of the community, maintain the benefits of existing drainage systems, help protect natural habitat and landscapes, and provide multiple-use opportunities for flood control facilities. The prioritization criteria generally considered basic criteria such as historical flooding, system inadequacy, downstream improvements independency, regional benefits, cost, and funding sources as well as City staff input.

The proposed CIP drainage projects were divided into CIP categories of 5-year, 10-year, and long-range planning horizons based on the prioritization evaluations and discussions with

City staff. A summary of CIP projects for the aforementioned planning horizons is summarized in **Table 17-1**.

TABLE 17-1. DMP CIP COST SUMMARY PER BASIN

BASIN	5-YEAR PLAN	10-YEAR PLAN	LONG-RANGE PLAN	CIP TOTAL (2024 $)
M116	$-	$231,338	$7,583,931	$7,815,269
M118	$4,394,715	16,166,527	$9,621,315	$30,182,557
M121	$10,051,638	10,752,970	$92,104,021	$112,908,629
M124	$-	$3,837,708	$13,705,488	$17,543,196
M125	$-	$952,710	$-	$952,710
J100	$-	$845,385	$-	$845,385
J131	$16,717,935	$3,958,253	$45,140,882	$65,817,070
J132	$-	$-	$-	$-
J133	$-	$2,371,500	$-	$2,371,500
TOTAL	31,164,288	39,116,390	168,155,637	$238,436,316

17.3 Financing / Funding Alternatives

Financing alternatives should be investigated by the City for the proposed drainage improvements. Additional outside funding sources are potentially available to complement the City's drainage CIP program. These include grant programs from State and Federal agencies, such as TWDB, GLO, FEMA, etc. Below are potential alternative sources for funding the proposed drainage projects, including grants or fees from external and local funding sources. Other funding alternatives are available besides the ones detailed below.

17.3.1 Federal & State Grants

The Flood Mitigation Assistance (FMA) Program is a federal grant program administered by the Texas Water Development Board (TWDB), under an Agreement with the Federal Emergency Management Agency (FEMA). This program provides federal funding to assist States and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other insurable structures under the National Flood Insurance Program (NFIP). The FMA program was created as part of the National Flood Insurance Reform Act of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NFIP. The FMA is a pre-disaster grant program. There are two types of work that can be funded: Planning Grants and Project Grants. The proposed drainage improvements would need to meet the specific grant standards to be eligible.

The Federal Emergency Management Agency (FEMA), through the Texas Division of Emergency Management, has provided substantial federal funding for the purchase of flooded homes through FEMA's Pre-Disaster Mitigation (PDM) program and Hazard Mitigation Grant Program (HMGP). Federal funding for home buyouts usually requires local matching funds of at least 25%. It is important to note that, although some grant funds are made available only after a disaster declaration, these buyout grants do not provide immediate flood recovery assistance. These programs typically take eight to twelve months after the flood event to even get started and then may take place over a period of many years following a flood event.

17.3.2 **Loan Financing Assistance Program**

Financial assistance, in the form of low-interest rate loans administrated by TWDB through the Texas Water Development Fund, is potentially available as a funding source to the City for drainage improvement projects. Potential loan repayment sources may include taxes, fees, and/or bond issuances.

17.3.3 **Inter-agency Agreements/ Shared Funding**

Several projects proposed will provide infrastructure improvements and benefits for adjacent agencies, such as Harris County, Harris County Flood Control District, and Texas Department of Transportation. The City may partner with the respective agency (s) to assist in funding and/or construction of the improvements.

18.0 BASIN IMPACT FEE

The City of Tomball has multiple drainage basins with current impact fees associated with previously proposed drainage CIP projects. These basin impact fees were calculated based on the City's 2007 CIP report. These basin impact fees were adopted on May 18, 2009, by the City of Tomball. These impact fees are imposed upon new development based on a dollar per acre amount constructed within the respective drainage basin. As part of the 2007 CIP projects, impact fee rates were established with a maximum fee rate. The current basin impact fees and maximum basin fees are listed in **Table 18-1.**

TABLE 18-1. CITY OF TOMBALL CURRENT BASIN DEVELOPMENT FEES

Basin	Effective Date	Current Basin Fee	Service Unit
M118	6/01/2009	$5,757.81	Per Acre
M121East	6/01/2009	$7,886.69	Per Acre
M121West	6/01/2009	$6,692.00	Per Acre
M125	6/01/2009	$436.88	Per Acre

18.1 Collection of Basin Impact Fees

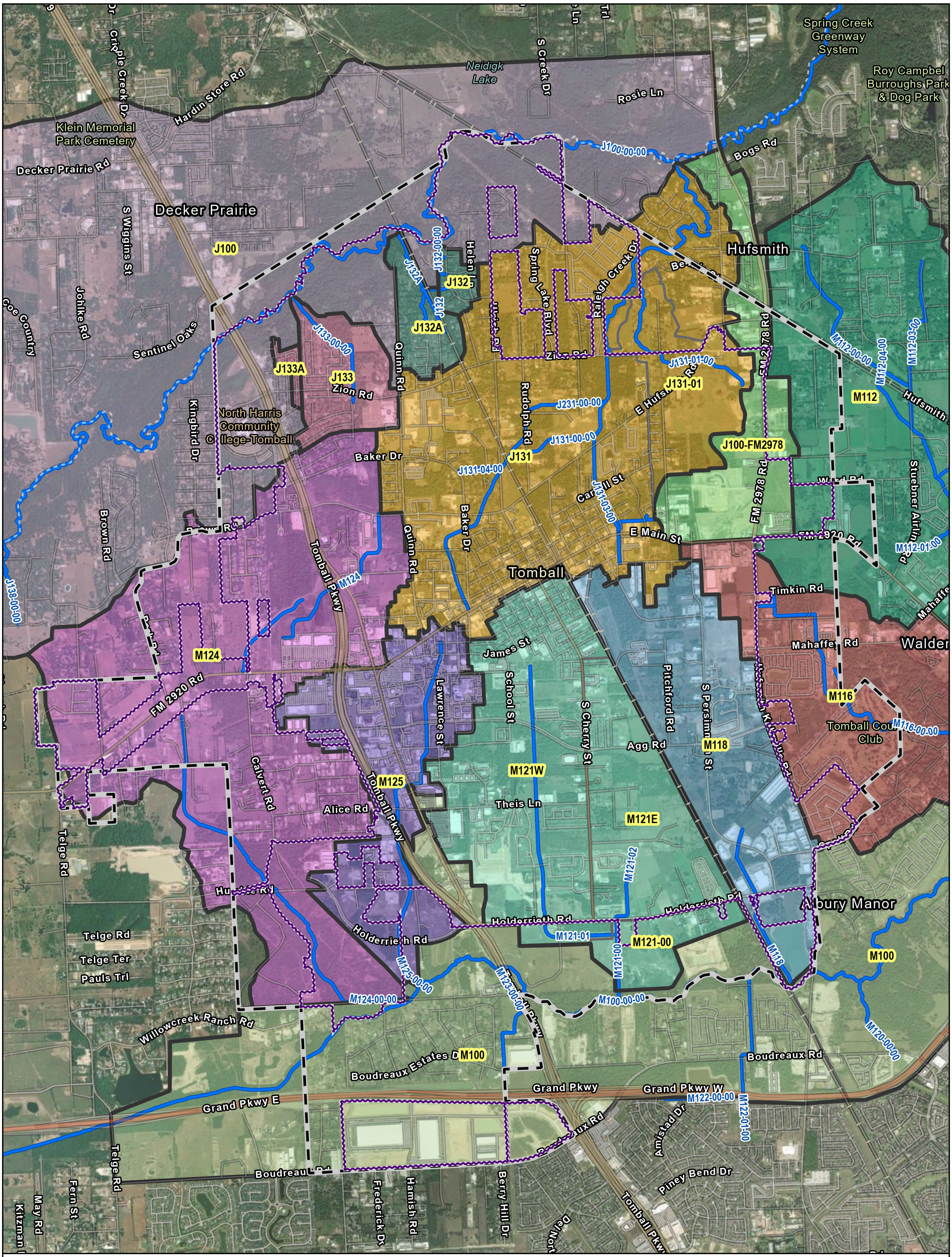
The current available records of collected basin impact fees, received through June 2024, were obtained from the City. These fee records were investigated and the total amount of impact fees received per basin are summarized in **Table 1-2**.

TABLE 18-2. CITY OF TOMBALL CURRENT BASIN DEVELOPMENT FEES

Basin	Collected Basin Fees
M118	$440,713.72
M121East	$51,567.62
M121West	$1,093,876.85
M125	$39,442.53

Known locations of impact fees collected have been identified on Basin Impact Maps included as exhibits in **Appendix E**.

EXHIBITS



DRAINAGE BASINS

M112	J131
M116	J132
M118	J133
M121	J100-FM2978
M124	J100
M125	M100

SPRING CREEK & WILLOW CREEK BOUNDARIES
NOT SHOWN IN ENTIRETY

LEGEND

- BASIN DIVIDE
- MAJOR SUBBASIN
- CHANNEL ALIGNMENTS
- TOMBALL ETJ
- TOMBALL CITY LIMITS

N

0 1,500 3,000 FT

THE CITY OF TOMBALL TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

OVERALL BASIN MAP

EXHIBIT 1

LEGEND - CONSTRAINTS

- IDENTIFIED WETLANDS
- WATER BODIES
- NWI AREAS
- RRC OIL/GAS WELL SITES
- RRC PIPELINES
- CHANNEL ALIGNMENTS
- TOMBALL CITY LIMITS
- TOMBALL ETJ

N

0 1,500 3,000 FT

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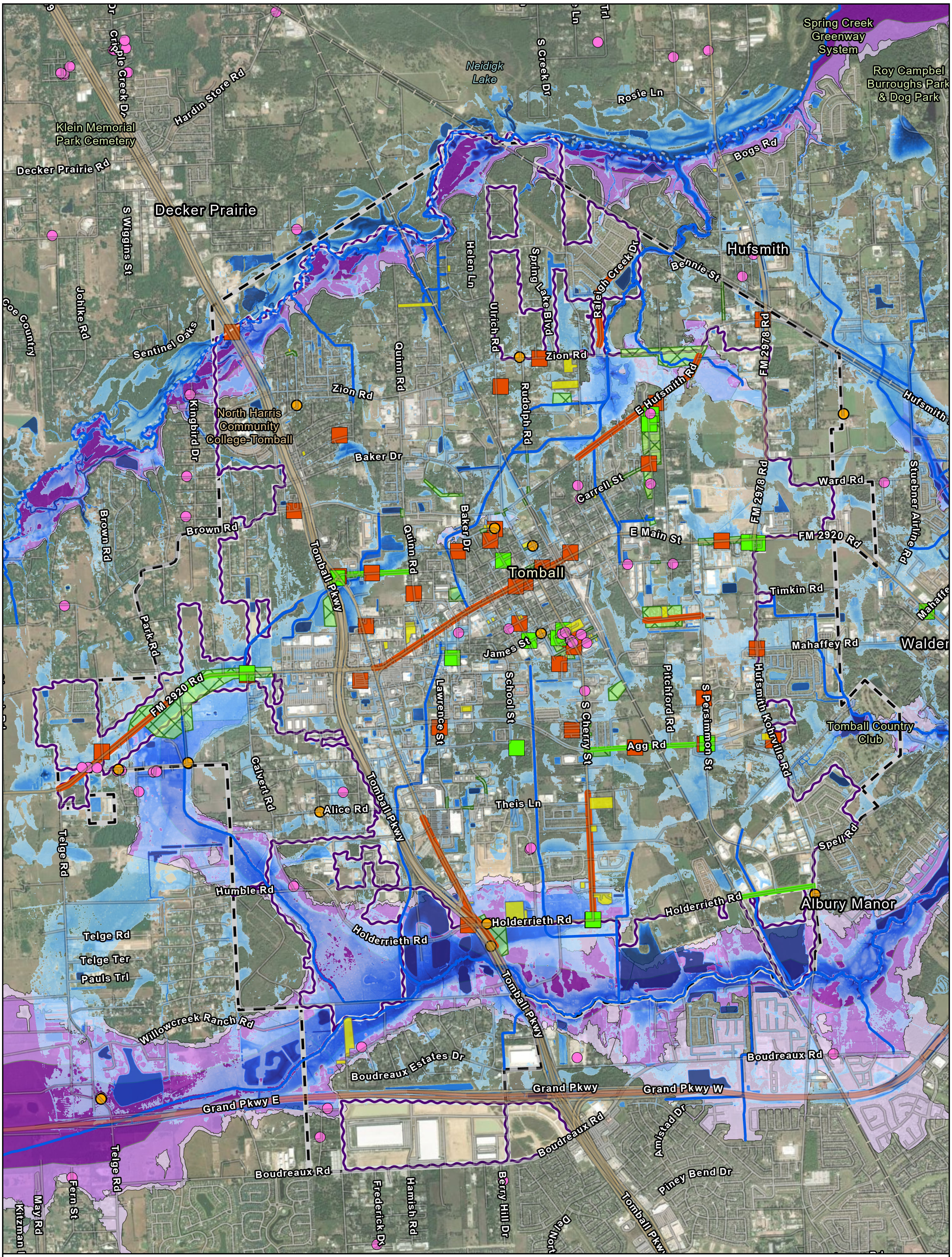
CITY OF TOMBALL DRAINAGE MASTER PLAN

CONSTRAINT MAP ENVIRONMENTAL & OIL/GAS

EXHIBIT 2



LEGEND - FLOOD LOSSES

- FEMA PRE-ALLISON LOSSES
- FEMA TS ALLISON LOSSES
- FEMA CLAIMS - PROPERTIES
- KNOWN DRAINAGE PROBLEM AREAS

FLOODED INTERSECTIONS

- HARVEY AUG 2017
- MAY 2 2004

FLOODED ROADWAYS

- HARVEY AUG 2017
- MAY 2 2024

- CHANNEL_ALIGN
- TOMBALL CITY LIMITS
- TOMBALL ETJ

FEMA FLOOD HAZARD AREA

- FLOODWAY
- 100 YR FLOODPLAIN (1% AEP)
- 500 YR FLOODPLAIN (0.2% AEP)

INUNDATION DEPTHS

10 FT

0.5 FT

INUNDATION BASED ON 2D HEC-RAS MODELING

N

FT

0 1,500 3,000

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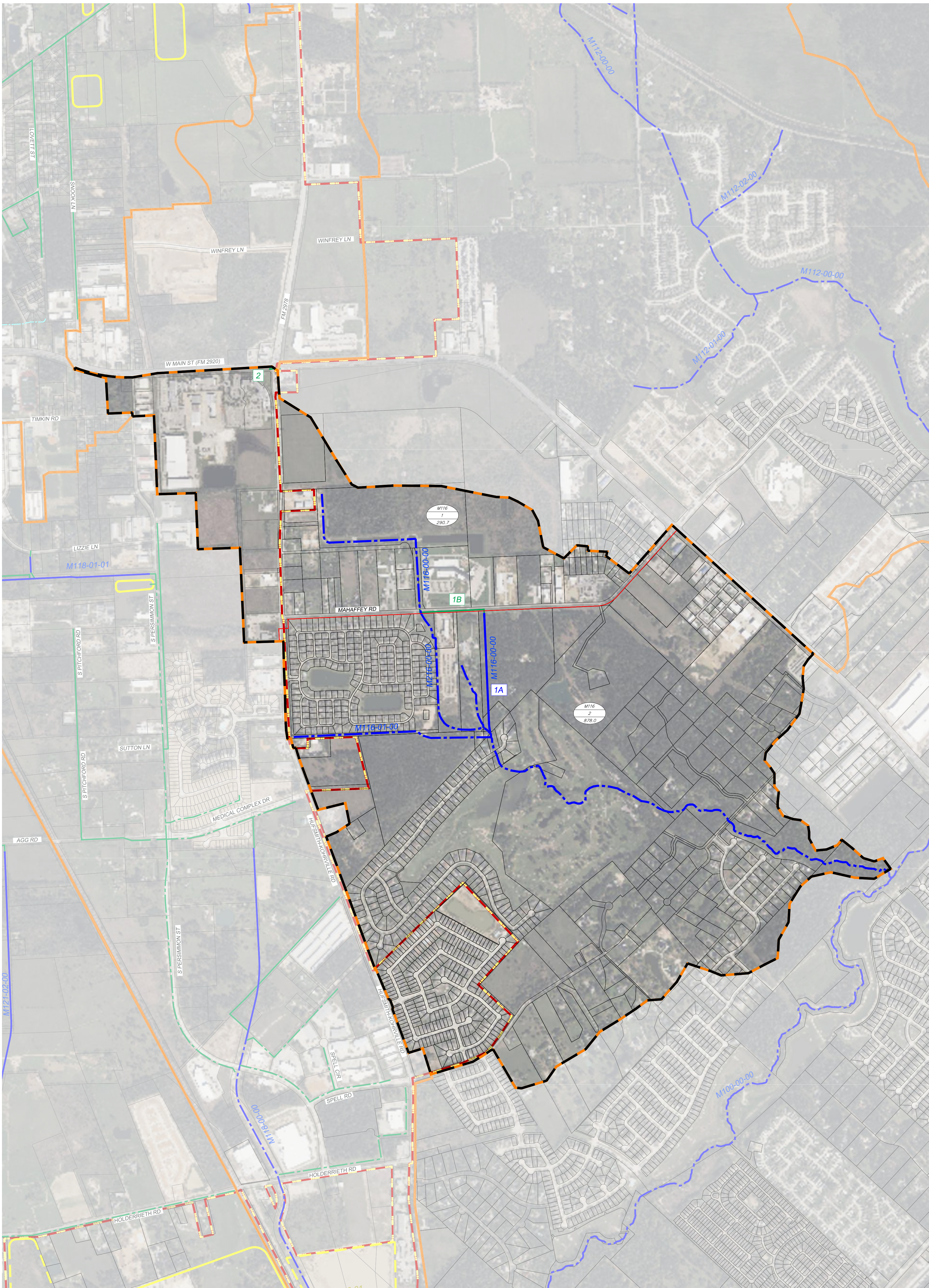
CITY OF TOMBALL DRAINAGE MASTER PLAN

FLOOD RISK MAP KNOWN PROBLEM AREAS

EXHIBIT 3



STORM SEWER DESIGN CRITERIA

1. DESIGN STORM EVENT: 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

CIP LEGEND

1 CHANNEL CIP
2 STORM SEWER CIP
3 DETENTION CIP

LEGEND

- EXISTING STORM SEWER
- EXISTING CHANNEL
- EXISTING DETENTION
- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- TRIBUTARY DIVIDES
- PROPOSED STORM SEWER
- PROPOSED CHANNEL
- PROPOSED DETENTION
- CITY LIMITS

M121 / 3A / 50.0
- BASIN ID
- SUBBASIN ID
- DRAINAGE AREA IN ACRES

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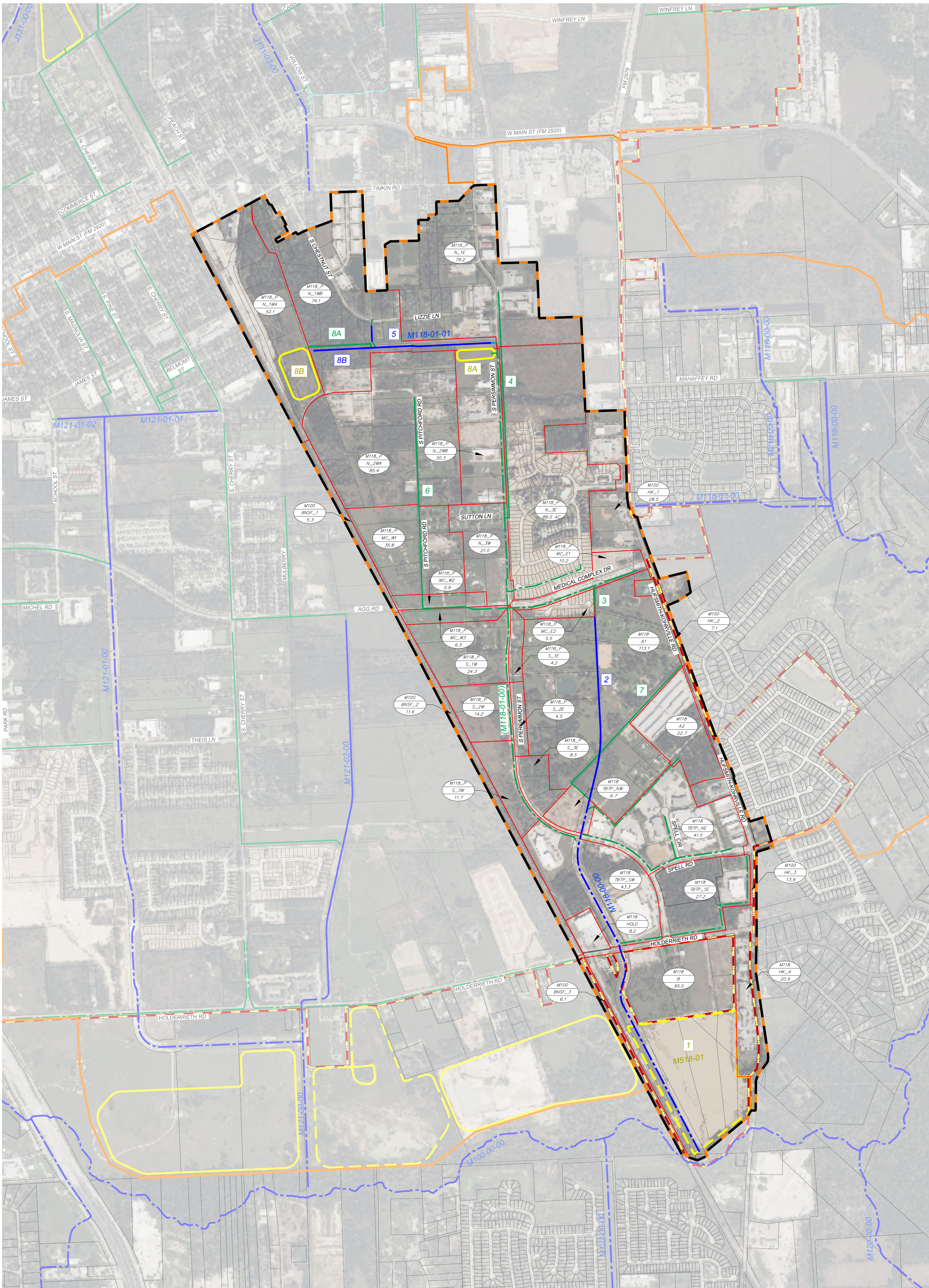
CITY OF TOMBALL
DRAINAGE MASTER PLAN

M116 DRAINAGE CAPITAL IMPROVEMENTS PLAN & SUBBASIN DELINEATION

SCALE: 1" = 0.25 mi	March 2025
EXHIBIT NO. 4	M116 BASIN

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG



STORM SEWER DESIGN CRITERIA

1. DESIGN STORM EVENT: 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. 100-YR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. ALL WATERSHED DETENTION ASSUMED WITHIN M518-01 AND M518-02 ULTIMATE BASINS

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

CIP LEGEND

1 CHANNEL CIP
2 STORM SEWER CIP
3 DETENTION CIP

LEGEND

EXISTING STORM SEWER
EXISTING CHANNEL
EXISTING DETENTION
BASIN BOUNDARY
SUBBASIN BOUNDARY
TRIBUTARY DIVIDES
PROPOSED STORM SEWER
PROPOSED CHANNEL
PROPOSED DETENTION
CITY LIMITS

M121 / 3A / 50.0
BASIN ID
SUBBASIN ID
DRAINAGE AREA IN ACRES

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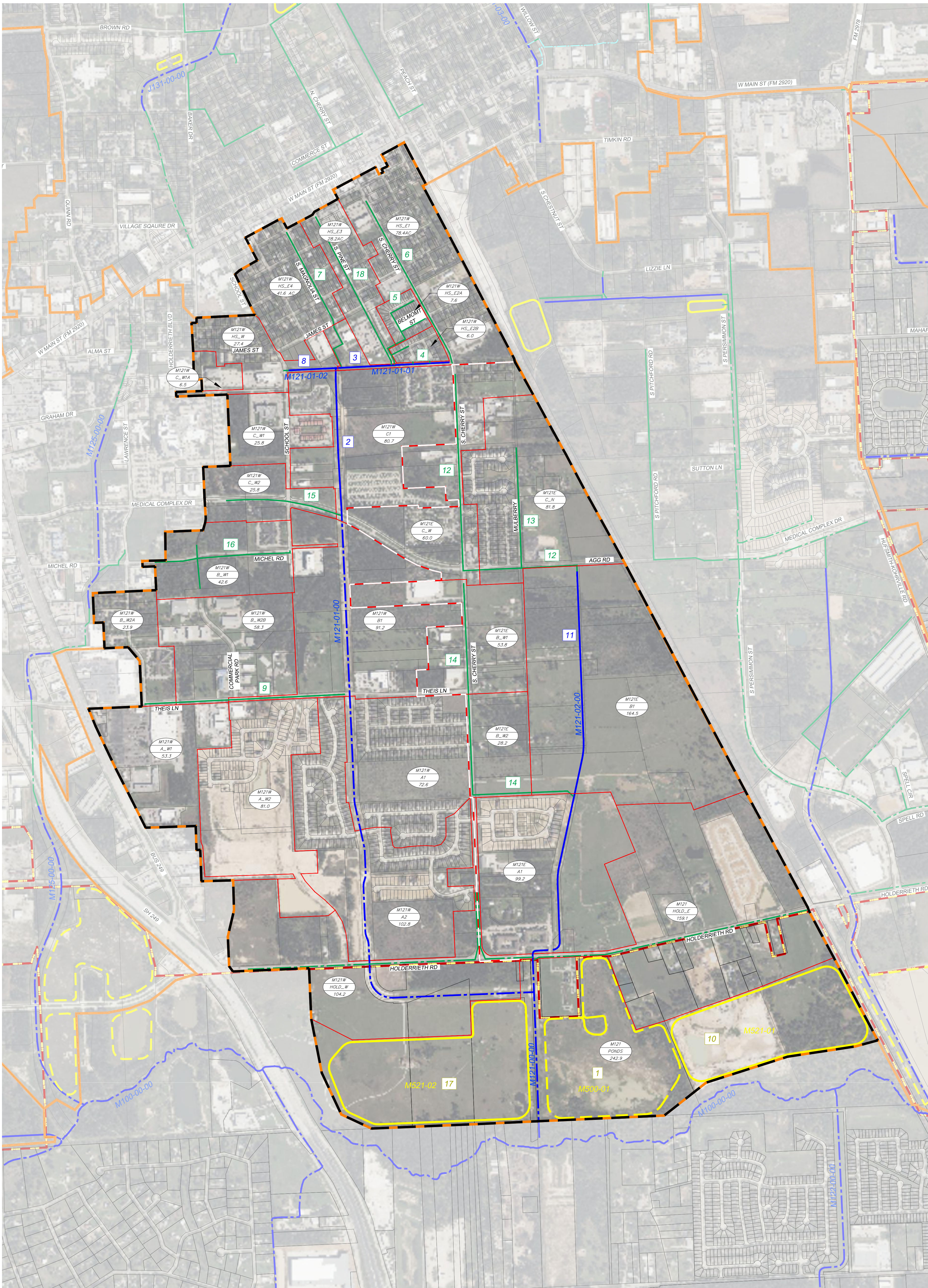
CITY OF TOMBALL
DRAINAGE MASTER PLAN

M118 DRAINAGE CAPITAL IMPROVEMENTS PLAN & SUBBASIN DELINEATION

SCALE: 1" = 0.25 mi	March 2025
EXHIBIT NO. 5	M118 BASIN

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YEAR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. 25-YR HGL 1 FOOT BELOW GUTTER
5. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
6. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
7. MITIGATION OF M121-02-00 WILL BE ACCOMMODATED IN M521-01 DETENTION POND

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

CIP LEGEND

1 CHANNEL CIP
2 STORM SEWER CIP
3 DETENTION CIP

LEGEND

EXISTING STORM SEWER
EXISTING CHANNEL
EXISTING DETENTION
BASIN BOUNDARY
SUBBASIN BOUNDARY
TRIBUTARY DIVIDES
PROPOSED STORM SEWER
PROPOSED CHANNEL
PROPOSED DETENTION
CITY LIMITS

M121 / 3A / 50.0 — BASIN ID, SUBBASIN ID, DRAINAGE AREA IN ACRES

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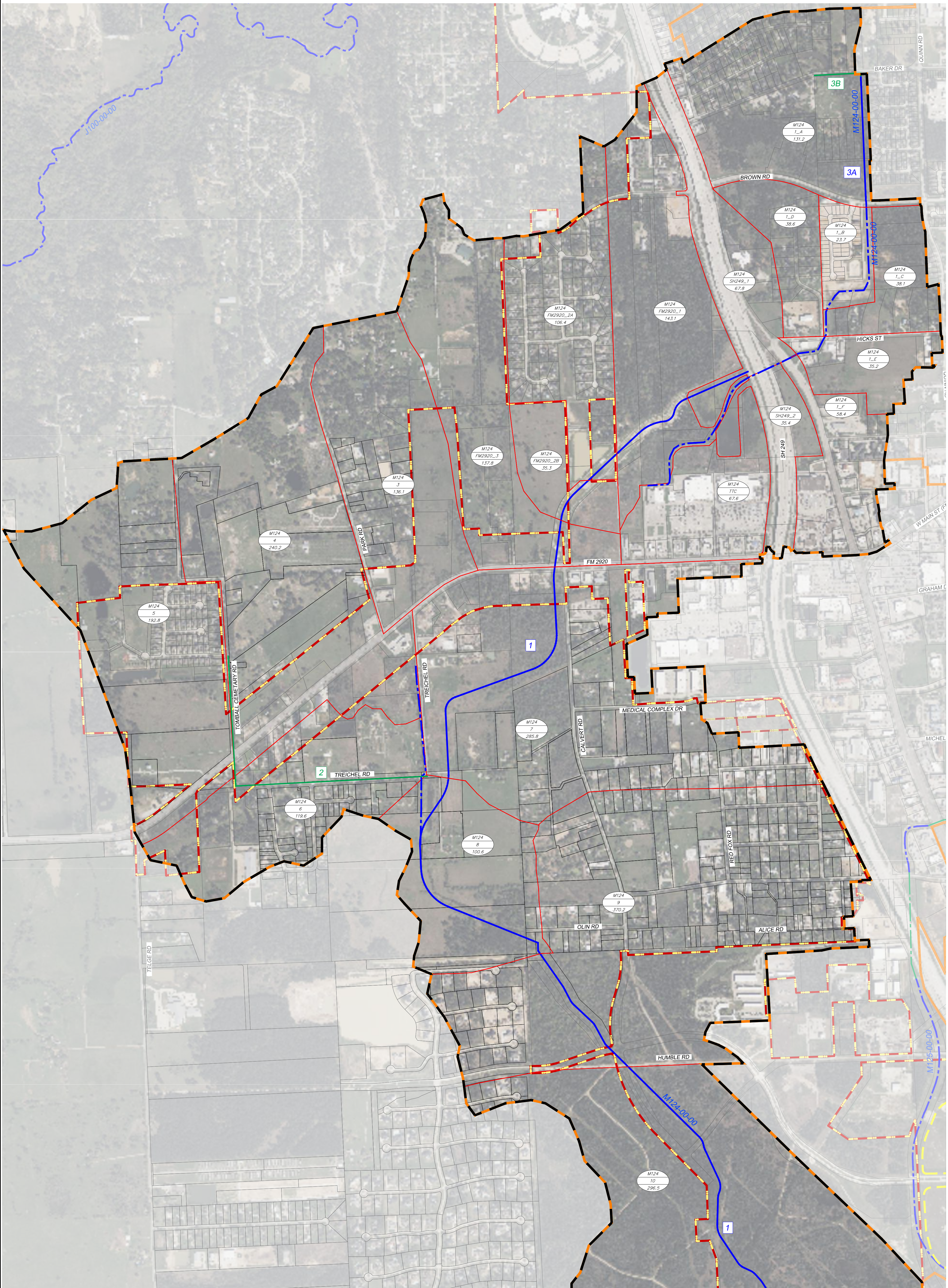
CITY OF TOMBALL
DRAINAGE MASTER PLAN

M121 DRAINAGE CAPITAL IMPROVEMENTS PLAN & SUBBASIN DELINEATION

SCALE: 1" = 0.25 mi | March 2025

EXHIBIT NO. 6 | M121 BASIN

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG



STORM SEWER DESIGN CRITERIA

1. DESIGN STORM EVENT: 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. 100-YR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. HCFCD PROJECT M124-00-00-E002 (FROM WILLOW CREEK TO SH 249)

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

CIP LEGEND

1 CHANNEL CIP
2 STORM SEWER CIP
3 DETENTION CIP

LEGEND

EXISTING STORM SEWER
EXISTING CHANNEL
EXISTING DETENTION
BASIN BOUNDARY
SUBBASIN BOUNDARY
TRIBUTARY DIVIDES
PROPOSED STORM SEWER
PROPOSED CHANNEL
PROPOSED DETENTION
CITY LIMITS

M121 3A 50.0
BASIN ID
SUBBASIN ID
DRAINAGE AREA IN ACRES

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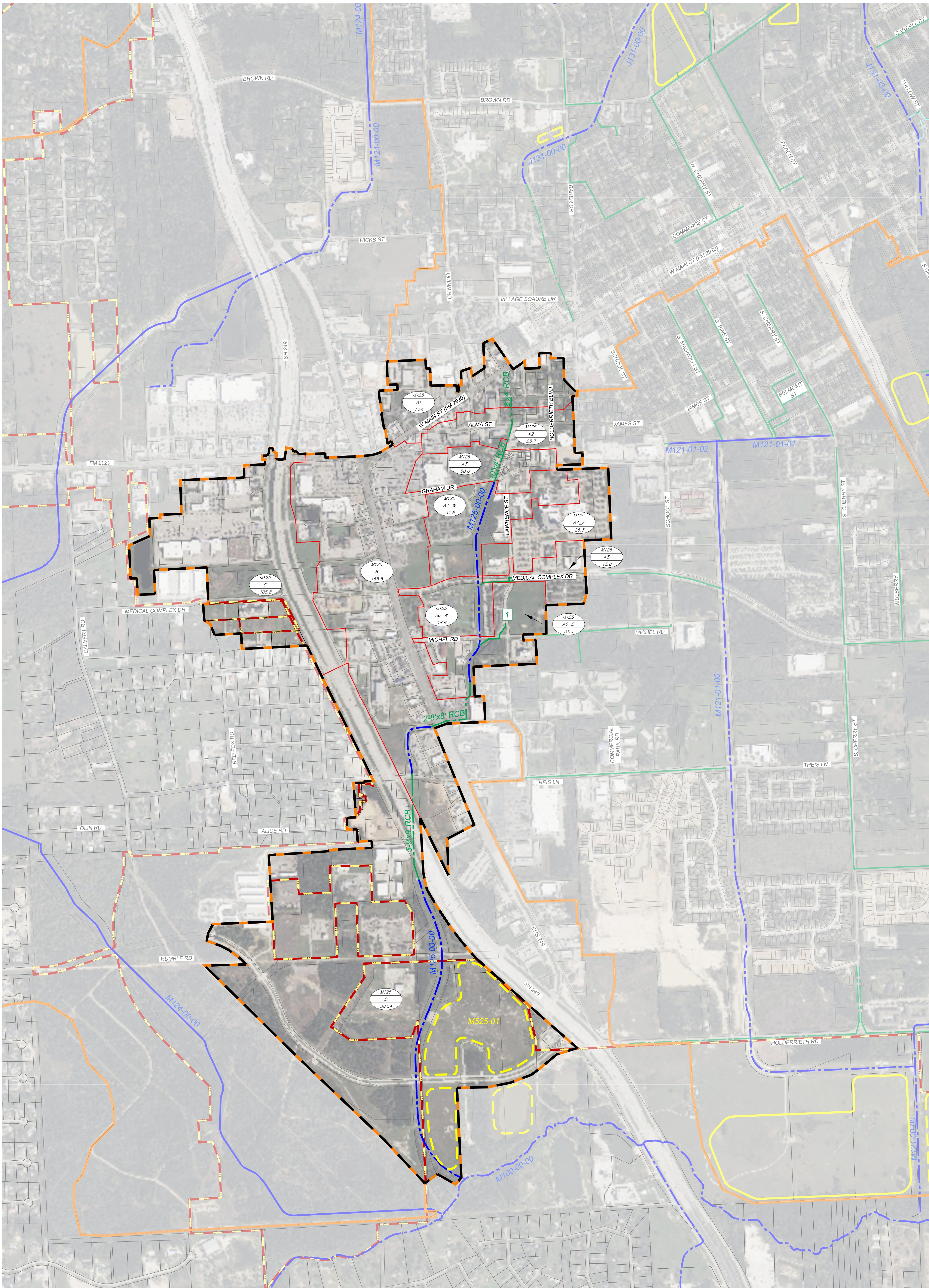
CITY OF TOMBALL
DRAINAGE MASTER PLAN

M124 DRAINAGE CAPITAL IMPROVEMENTS PLAN & SUBBASIN DELINEATION

SCALE: 1" = 0.25 mi	March 2025
EXHIBIT NO. 7	M124 BASIN

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG



STORM SEWER DESIGN CRITERIA

1. DESIGN STORM EVENT: 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. 25-YR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

CIP LEGEND

1	CHANNEL CIP
2	STORM SEWER CIP
3	DETENTION CIP

LEGEND

- EXISTING STORM SEWER
- EXISTING CHANNEL
- EXISTING DETENTION
- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- TRIBUTARY DIVIDES
- PROPOSED STORM SEWER
- PROPOSED CHANNEL
- PROPOSED DETENTION
- CITY LIMITS
- BASIN ID
- SUBBASIN ID
- DRAINAGE AREA IN ACRES

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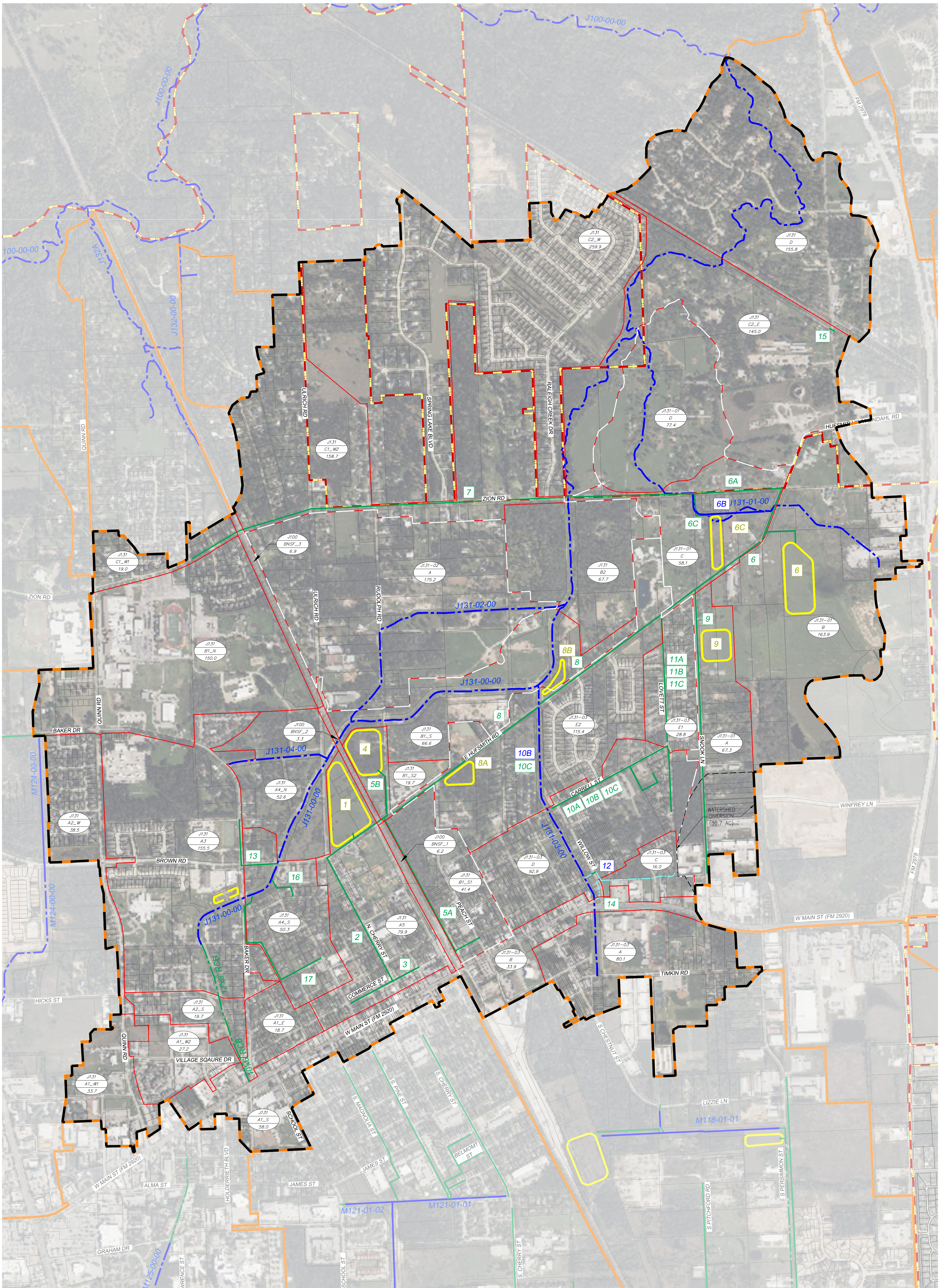
CITY OF TOMBALL
DRAINAGE MASTER PLAN

M125 DRAINAGE CAPITAL IMPROVEMENTS PLAN & SUBBASIN DELINEATION

SCALE: 1" = 0.25 mi	March 2025
EXHIBIT NO. 8	M125 BASIN

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG



DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG

STORM SEWER DESIGN CRITERIA

1. DESIGN STORM EVENT: 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. IMPROVEMENTS WILL BE MITIGATED IN J531 DETENTION PONDS

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

CIP LEGEND

1 CHANNEL CIP
2 STORM SEWER CIP
3 DETENTION CIP

LEGEND

EXISTING STORM SEWER
EXISTING CHANNEL
EXISTING DETENTION
BASIN BOUNDARY
SUBBASIN BOUNDARY
TRIBUTARY DIVIDES
PROPOSED STORM SEWER
PROPOSED CHANNEL
PROPOSED DETENTION
CITY LIMITS
M121 BASIN ID
3A SUBBASIN ID
50.0 DRAINAGE AREA IN ACRES

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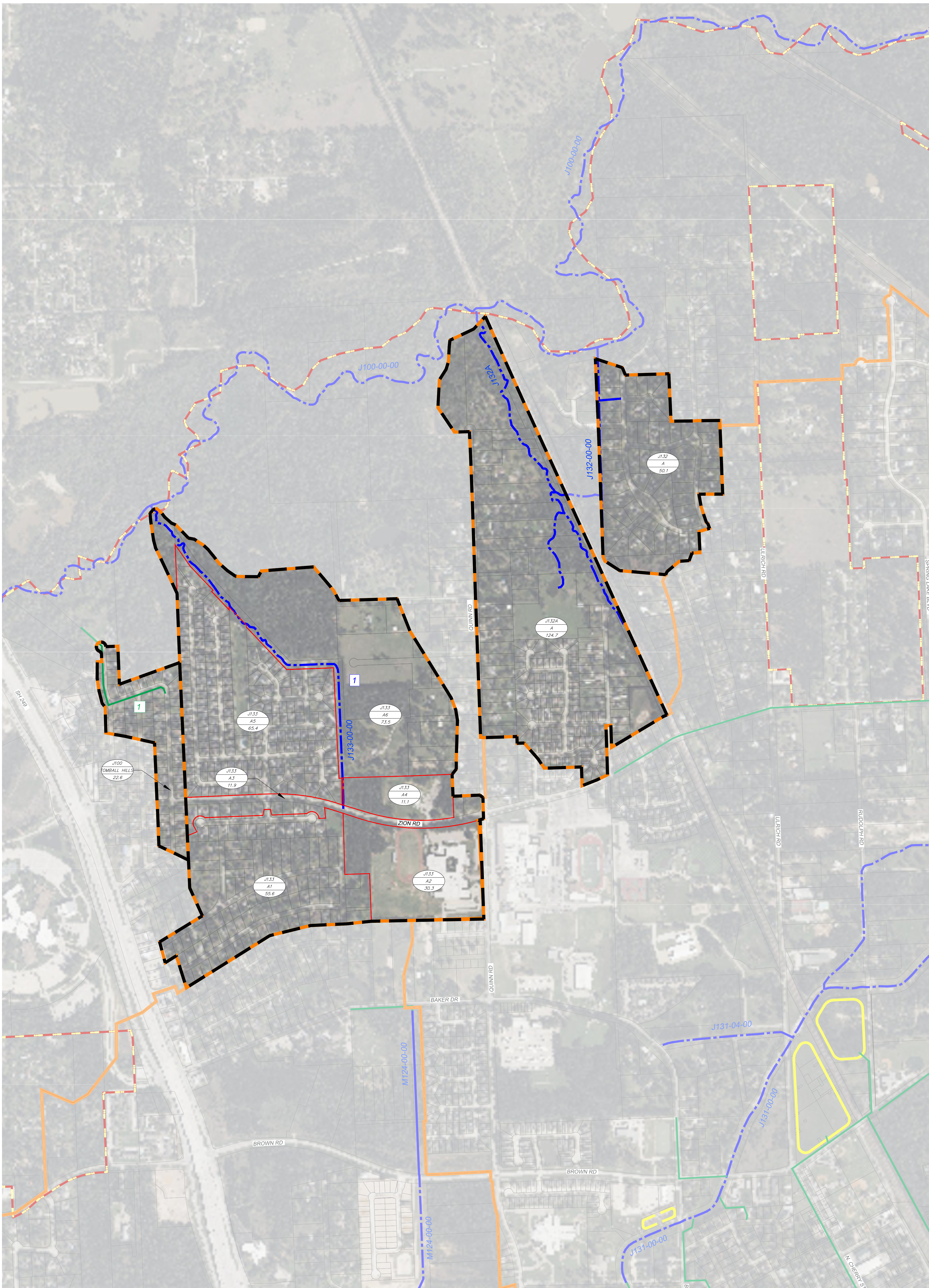
CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

J131 DRAINAGE CAPITAL IMPROVEMENTS PLAN & SUBBASIN DELINEATION

SCALE: 1" = 0.25 mi	March 2025
EXHIBIT NO. 9	J131 BASIN



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YEAR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. 25-YR HGL 1 FOOT BELOW GUTTER
5. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
6. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

500' 0 500' 1,000'

SCALE H: 1" = 1,000'

CIP LEGEND

1 CHANNEL CIP
2 STORM SEWER CIP
3 DETENTION CIP

LEGEND

- EXISTING STORM SEWER
- EXISTING CHANNEL
- EXISTING DETENTION
- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- TRIBUTARY DIVIDES
- PROPOSED STORM SEWER
- PROPOSED CHANNEL
- PROPOSED DETENTION
- CITY LIMITS

M121 / 3A / 50.0
- BASIN ID
- SUBBASIN ID
- DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

J100, J132 & J133 DRAINAGE CAPITAL IMPROVEMENTS PLAN & SUBBASIN DELINEATION

SCALE: 1" = 1,000'	March 2025
EXHIBIT NO. 10	J100, J132 & J133 BASINS

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG

APPENDIX A

DRAINAGE DESIGN CRITERIA MANUAL

(Updated March 2025)

City of Tomball

Minimum Standards for Stormwater Drainage Design

Adopted: September 6, 2011

Updated: March 31, 2025

Table of Contents

Appendices

DRAINAGE POLICY

A. Design Requirements

1. The City of Tomball administers drainage criteria, supplemented by Harris County and the Harris County Flood Control District (HCFCD), to ensure newly developed and adjacent areas are protected from structural flooding during a 100-year storm event. This is achieved through the application of various drainage infrastructure elements, including storm sewers, roadside ditches, open channels, detention and overland (sheet) run-off management. The combined system is designed to prevent structural flooding from extreme events up to a 100-year storm.

2. Recognizing that each site has unique characteristics that may affect drainage design, these criteria establish minimum requirements that may be modified, provided that the objectives for drainage standards are maintained. For projects that require a site specific approach and where unique innovative engineering solutions can achieve drainage performance goals, a request for consideration of alternative design standards - such as pipe flow capacity, overland sheet flow management, and detention storage. All such requests shall be reviewed and approved by the City of Tomball Staff to ensure compliance with drainage objectives and regulatory standards.

B. Temporary ponding in streets and roadside ditches is an anticipated and integral component of the overall drainage system, designed to enhance overall stormwater management efficiency. Storm sewers and roadside ditches are designed to balance hydraulic capacity with economic feasibility. These drainage elements are designed to convey less intense and more frequent rainfall events to allow for traffic movement during these events. During larger storm events that exceed the hydraulic capacity of the storm sewer system, excess runoff is managed through controlled overland flow and temporary storage to mitigate risk of structural flooding and enhance flood resilience against extreme weather .

C. The No Adverse Impact (NAI) principle must be complied to ensure that the actions taken by any community, property owner, or developer – whether public or private – don not adversely impact the property, rights, or safety of others. NAI management offers a way to prevent increased flooding, erosion, or other detrimental impacts on the community. Adverse impacts related to drainage improvements are quantified through metrics such as flow rate, water surface elevation, velocity, flow type, erosion, sedimentation, and other measurable adverse impacts to community's well-being.

   All proposed New Development, Redevelopment, or Site Modifications must adhere to the following drainage requirements:

   - Existing overland flow patterns shall not be altered so that increase or redirect existing sheet flow to adjacent private or public property.

- The project shall not increase the water surface either upstream or downstream.
- The project shall not increase the flow velocity in and around the project site in a way that causes downstream erosion or infrastructure damage.

Where existing sheet flow is obstructed by construction (e.g., site elevation changes due to fill placement), the developer must re-route the sheet flow **within** the property boundaries to maintain the original drainage configuration or discharge into the public right-of-way (ROW) as permitted. **Except in cases dictated by natural or existing drainage patterns, no sheet flow from developed property shall be allowed to drain onto adjacent private property.** No development shall create or transfer adverse drainage impacts onto neighboring properties.

The estimated volume of displaced sheet flow shall be accurately calculated to ensure that the rerouted flow pattern maintains sufficient capacity, preventing any adverse impact on adjacent properties. No sheet flow from the developed property shall be allowed to drain onto the adjacent right-of-way (ROW).

Any increase in discharge volume shall only be directed to the ROW at a designated and approved point of connection, ensuring that the receiving drainage system has adequate capacity to handle the additional flow. All increased discharge must be conveyed through a properly designed subsurface drainage system, preventing uncontrolled surface runoff and minimizing the risk of erosion, flooding, or infrastructure damage.

D. The City of Tomball is an active participant in the National Flood Insurance Program (NFIP). The flood insurance program makes flood insurance available to property owners within the City. Low-cost insurance is available for communities that implement flood risk reduction measures. Compliance with NFIP regulations helps mitigate structural flooding, enhancing community resilience and reducing long-term flood damage costs. The City's drainage design criteria are aligned with NFIP requirements to ensure responsible development practices. All developments within the City limits must adhere to the City of Tomball Code of Ordinances to support NFIP regulations. incorporating appropriate flood mitigation measures to minimize risk and maintain eligibility for the program.

E. Approval of a storm drainage plan and design is an integral component of the review process for all New Developments, the site plan review process for Redevelopments, and the permitting process for Site Modifications. The City of Tomball Staff is responsible for conducting comprehensive plat review, approval, and storm drainage design evaluations to ensure compliance with local drainage criteria, flood mitigation standards, and regulatory requirements. Properly designed drainage systems must be integrated into all development projects to minimize flood risks, protect public infrastructure, and maintain the integrity of the city's stormwater management system.

F. The City of Tomball will consider joint project funding with private entities for the construction of drainage systems that enhance existing infrastructure or develop new drainage solutions. However, the City's top funding priority will be projects included in the Capital Improvement Plan (CIP).

   Where feasible, the City will seek to leverage municipal funding with contributions from private entities, civic organizations, and other public agencies—including Harris County, the Harris County Flood Control District (HCFCD), the Texas Water Development Board (TWDB), Federal Emergency Management Agency (FEMA), and the U.S. Army Corps of Engineers, and other available funding sources—to maximize project impact and efficiency.

   For drainage systems that have been identified as deficient but are not currently scheduled for funding under the CIP, the City will consider authorizing privately funded improvements, provided they align with the City's drainage objectives, regulatory standards, and long-term infrastructure plans.

G. The drainage criteria outlined in this document shall apply to all projects located within the City of Tomball limits and its Extraterritorial Jurisdiction (ETJ). In cases where these criteria conflict with the drainage regulations of Harris County, the Harris County Flood Control District (HCFCD), Montgomery County, or other governing jurisdictions, the most restrictive criteria shall take precedence. This ensures that the highest standards for flood protection, stormwater management, and infrastructure resilience are upheld across all applicable areas.Property owners and public agencies are responsible for not adversely impacting the community, neighbors, future property owners, or City facilities in terms of flood risks, erosion, infiltration and siltation.

I. REFERENCES

A. City of Tomball Construction Standards and Technical Specifications, September 2017.

B. Flood Damage Prevention Ordinance, Chapter 10 Article VIII of the City of Tomball Code of Ordinances, January 2025, and any subsequent revisions.

C. Regulations of Harris County, Texas, for the Approval and Acceptance of Infrastructure (Harris County Infrastructure Regulations), Current Edition.

D. Policy, Criteria, and Procedure Manual for Approval and Acceptance of Infrastructure, Harris County Flood Control, 2019.

E. NOAA ATLAS 14 – Precipitation-Frequency Atlas of the United States, Volume 11, Version 2, Texas, 2018.

F. Hydrology and Hydraulics Guidance Manual, Harris County Flood Control, 2009

G. Urban Drainage Design Manual- Hydraulic Engineering Circular No. 22 (HEC-22) Fourth Edition, Federal Highway Administration (FHWA), 2024.

H. Design and Construction of Urban Stormwater Management Systems, ASCE Manual of Practice No. 77, 1993.

I. Harris County Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management, Harris County Flood Control and Harris County Public Infrastructure Department, 2011.

J. Hydraulic Design Manual, Texas Department of Transportation, 2019.

II. DEFINITIONS AND ACRONYMS

A. Conduit – Any closed infrastructure to convey drainage water such as underground storm sewers, pipes, and culverts.

B. Open Channel - A structure designed to convey storm water using gravity flow with a free surface exposed to the atmosphere.

C. Continuity Equation – $Q = VA$

Where:
Q - discharge in cfs,
V - flow velocity fps
A - conveyance area in square feet.

C. Critical Elevation – The maximum hydraulic grade line elevation that a drainage system is allowed when design flow is conveyed through the system. This elevation is related to the level of service of the primary system.

D. Design Storm Event – The rainfall intensity for the design annual exceedance probability (AEP) upon which the drainage facility is designed.

E. Development – A tract of land that has been improved (such as grading, paving, building structures, or otherwise changing the runoff characteristics of the land), exclusive of land being used and continuing to be used for agricultural purposes. The term of development includes New Development, Redevelopment, and Site Modifications.

1. New Development: Development of an undeveloped parcel of land.

2. Redevelopment: A change in land use that alters the impervious cover from one type of development to either the same type or another type, or greenfield, and alters the drainage patterns internally or externally to the Development.

3. Site Modifications: A site improvement that alters the area of impervious surface (e.g., an addition to an existing structure or creating additional parking), or a change in existing storm water collection, conveyance or runoff conditions for the developed site.

F. Disturbed Area – An area of the land or tract that changes the drainage characteristics. This includes any changes in land grading, paving, building structure, or otherwise changing the runoff characteristics of the land. This does not include altering the surface for routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the site (e.g., the routine grading of existing dirt roads, asphalt overlays of existing roads, the routing clearing of existing ROW, and similar maintenance activities)

G. Drainage Area – The surface area defined by topographic divides that contributes rainfall runoff to a common outlet or point of interception. The drainage area represents the drainage system service area and is not limited by the project boundary or street ROW. The possibility of overland flow contributions from adjacent drainage areas during certain extreme events shall be considered for accurate assurance.

H. Drainage Area Map – The map of watershed which is subdivided into subarea served by a sub drainage system.

I. FEMA – Federal Emergency Management Agency.

J. FIRM – Flood Insurance Rate Map published by FEMA

K. HCED – Harris County Engineering Department.

L. HCFCD – Harris County Flood Control District.

M. Hydraulic Grade Line – A line representing the pressure head (water surface elevation) available at any given point within the drainage system.

N. Impervious Surface – An impervious surface is any land surface that has been compacted or covered with materials that prevent or significantly impede the infiltration of water into the underlying natural soil strata. Impervious surfaces increase surface runoff by reducing the amount of stormwater absorbed into the ground, contributing to increased flood risks and reduced groundwater recharge.

   Surface materials that are considered impervious include, but not limited to, bricks, pavers, concrete, asphalt, compacted or decomposed shale, gravel, or granite, or other similar materials. Surface features utilizing such materials and considered impervious include, but not be limited to, decks (whether on pier and beam or directly over soil), foundations (whether pier and beam or slab), building roofs, parking and driveway areas, sidewalks, compacted or rolled areas, paved recreation areas, swimming pools, dry or wet detention ponds, shade structures and other features or surfaces that are built or laid on the surface of the land and have the effect of increasing, concentrating, or otherwise altering water runoff so that runoff is not readily absorbed.

   A surface may be classified as permeable if a soil infiltration test demonstrates that the underlying soil allows water infiltration at a rate of 0.5 inches per hour or greater. The infiltration report must be signed and sealed by a Professional Engineer (P.E.) licensed in the State of Texas with evidence that the surface permits water to percolate through to undisturbed soil strata.

O. Manning's Equation - $V = \frac{K}{n} R^{2/3} S^{1/2}$

Where:

v - velocity in feet per second

k - conversion factor (1.49)
R - hydraulic radius (conveyance area/wetted perimeter) in feet
S - friction slope (head loss/length)
n - Manning's roughness coefficient (see ***Table 1*** below)

Table 1 – Manning's "n" Values

Description	**Manning's "n" Value**
Channel	
Grass-Lined	0.040
Riprap-Lined	0.040
Concrete-Lined	0.015
Natural or Overgrown Channels	Usually 0.050-0.080
Conduit	
Concrete Pipe	0.013
Concrete Box	0.013
Dual Wall Polypropylene Pipe	0.012
Corrugated profile-wall polyethylene pipe	0.012

P. Rainfall Frequency – The statistical likelihood or probability of a specific amount of rainfall for a rainfall event with defined characteristics occurring within a defined period and at a particular location. The National Weather Service (NWS) provides authoritative rainfall frequency data through publications such as NOAA Atlas 14, which offers precipitation frequency estimates for various return periods and durations based on historical rainfall records. For storm drainage design, the following rainfall frequencies are typically applied:

1. <u>2-year frequency</u> – a rainfall intensity having a 50 percent probability of occurrence in any given year with 2-year return period.

2. <u>5-year frequency</u> – a rainfall intensity having a 20 percent probability of occurrence in any given year with a 5-year return period.

3. <u>10-year frequency</u> – a rainfall intensity having a 10 percent probability of occurrence in any given year with a 10-year return period.

4. <u>25-year frequency</u> – a rainfall intensity having a 4 percent probability of occurrence in any given year with a 25-year return period.

5. <u>100-year frequency</u> – a rainfall intensity having a 1 percent probability of occurrence in any given year with a100-year return period.

6. <u>500-year frequency</u> – a rainfall intensity having a 0.2 percent probability of occurrence in any given year with a 500-year return period.

Rainfall frequency data, combined with rainfall intensity-duration-frequency (IDF) curves, is essential for determining peak runoff rates and sizing storm drainage systems to mitigate flooding risks effectively.

Q. Rational Method Formula – A method for calculating the peak runoff flow rate for a storm drain system with the following formula:

$$Q = CiA$$

Where:

Q - Peak runoff flow rate in cubic feet per second

C - Runoff coefficient (dimensionless) representing the fraction of rainfall that becomes runoff (See Table 2)

A - Drainage area (acres)

i - Rainfall intensity (inches per hour) for the design storm and duration equal to the time of concentration (T_c)

R. Regional Detention Facility (RDF) – A detention facility designed to collect, temporarily store, and manage surface runoff from a regional drainage area which is often covers more than one development or from one of the major creeks or tributaries. RDF is typically constructed as part of regional flood control and drainage systems to mitigate flooding risks, control peak discharge rates, and improve water quality.

S. Sheet Flow – Overland stormwater runoff that flows as broad and shallow across surfaces and is not conveyed in a defined channel, ditch, or conduit. Sheet flow commonly occurs when the capacity of the existing drainage or conduit system is exceeded, causing water to spread overland in an uncontrolled manner. This type of flow is a critical consideration in floodplain management and drainage design, as it can lead to erosion, sediment transport, and localized flooding in low-lying areas.

T. Structural Flooding – Flooding condition where the water surface elevation from a storm event surpasses the top of the building's slab elevation (for slab-on-grade construction) or the top of the first-floor elevation (for pier-and-beam construction), causing water to enter and inundate the interior of the structure. This condition is a key indicator in flood risk assessments and is used to evaluate the effectiveness of flood mitigation strategies.

U. Variance – A onetime formal exception to a particular rule or rules granted for extenuating circumstances, approved by City of Tomball Staff.

III. DESIGN REQUIREMENTS

Design of drainage facilities shall meet the requirements of the City of Tomball Standard Specifications and Minimum Construction Standards for Community Improvements (Standard Construction Details). The Regulations of Harris County, Texas, for the Approval and Acceptance of Infrastructure and the Harris County Flood Control District Policy, Criteria and Procedure Manual are used to complement the City of Tomball standards. All outfall pipes, ditches, and structures that enter HCED or HCFCD ROW shall be designed in accordance with the applicable agency's criteria and standards. In cases where criteria conflict arises, the more stringent requirement of these shall be utilized.

A. Determination of Runoff Peak Flow

All drainage improvements shall be designed in accordance with the storm frequency criteria established by the City of Tomball, Harris County Engineering Department, and Harris County Flood Control District. A 25-year storm frequency (4% probability of occurrence) shall be used for the design of storm sewer systems and roadside ditches; a 100-year storm frequency (1% probability of occurrence) shall be applied to outfall systems and detention basins. The peak stormwater runoff rates shall be calculated at each inlet, pipe, roadside ditch, channel, bridge, culvert, outfall, or other designated design point in compliance with the applicable standards for the specified storm frequency requirements.

a. Rational Method for Areas Less than 600 acres

The Rational Method will be utilized to estimate peak flows for project areas up to 600 acres with individual drainage areas not exceeding 200 acres.

For drainage areas exceeding 200 acres, subdivision of the overall area into smaller drainage areas will be required for peak flow computation. This method will be applied to design storm sewer systems serving areas up to 600 acres.

In cases where the study area includes flood-prone regions and requires a FEMA submittal, hydrologic and hydraulic models must comply with FEMA-approved methodologies and standards.

b. The Run-Off Coefficient C values

The C values Rational Method Formula will vary based on the land use. Land use types and C-values which can be used are as follows:

Table 2 – Runoff Coefficients

Land Use Type	Runoff Coefficient, C
Residential Districts	
Lots more than ½ acre	0.35
Lots ¼ – ½ acre	0.45
Lots less than ¼ acre	0.55
Townhomes	0.60
Multi-Family Areas	
Less than 20 Service Units/Acre	0.65
20 Service Units/Acre or Greater	0.80
Business Districts	0.80
Industrial Districts	
Light Areas	0.65
Heavy Areas	0.75
Railroad Yard Areas	0.30
Parks/Open Areas	0.18
Undeveloped	0.30
Agricultural/Pastures	0.20
Lakes/Wet Detention Ponds*	0.95
Dry Detention Ponds	0.85
Compacted Gravel	0.80
Pavement/ROW/Roofs**	0.90

*Includes wet detention facilities computed from the top of slope
**Includes concrete and asphalt

Composite "C" values for mixed-use drainage areas are allowed for use in the Rational Formula. These values are to be obtained by calculating a weighted average of all the different "C" values of the sub-areas contributing to each mixed-use drainage area. Any calculations of these Composite "C" values are to be provided as part of the drainage calculations and provided in the plans.

$$C_w = \frac{\sum_{j=1}^{n} C_j A_j}{\sum_{j=1}^{n} A_j}$$

Where:
C_w - Weighted runoff coefficient
C_j - Runoff coefficient for area j
A_j – Sub drainage area (acres)
n - Number of distinct land uses

If the alternate form is to be submitted, the calculation of C shall be provided as part of the drainage calculations.

a. Determination of Time of Concentration:

Time of Concentration (in minutes) is the time required for peak runoff, from the entire upstream contributing area, to reach the point of interest. Time of Concentration can be calculated based upon an analysis of the actual travel time from the most remote point in the drainage area. The travel path should be clearly denoted and shown in the design plans.

$$Tc = \frac{D}{60v} + T_i$$

Where: Tc = time of concentration (minutes)

$\overline{I_\iota}$ = initial time (minutes) - 10 minutes for developed flows and 15 minutes for undeveloped flows

D = travel distance on flow path (feet)

v = velocity (ft/sec)

The following minimum and maximum velocities shall be used when calculating the Time of Concentration T_C:

Table 3 – Tc Velocities

SURFACE TYPE	Velocity (ft/sec)
Storm Sewer	3.00
Ditch/Channel	2.00
Paved Area	1.50
Overland	0.50

c. Rainfall Intensity

Harris County Flood Control District (HCFCD) have revised Intensity Duration Frequency (IDF) Curves based on National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation-Frequency Atlas of the United States. HCFCD developed three (3) Hydrologic Regions based on the Atlas 14 rainfall distribution. The City of Tomball requires the rainfall intensity for storm sewer design to be determined using the Region 1 data.

The intensity calculation is based on duration equal to the time of concentration. The intensity is calculated using the following equation:

$$I = \frac{b}{(t_c + d)^e}$$

Where b, d, and e are coefficients dependent on the rainfall event based on City depth- duration- frequency values, as provided in the Table below:

Table 4 – Rational Method Intensity Coefficients

Coefficient	50 % AEP 2-Year	20 % AEP 5-Year	10 % AEP 10-Year	4 % AEP 25-Year	2 % AEP 50-Year	1 % AEP 100-Year	0.2 % AEP 500-Year
Region 1							
e	0.7372	0.7058	0.6819	0.6446	0.6170	0.5870	0.5111
b (in.)	48.27	51.78	54.26	54.97	54.84	53.93	50.89
d (min.)	9.30	8.19	7.44	6.27	5.45	4.53	2.69

Note: The rainfall data presented above is the latest available as of the date of this criteria manual issuance. The City may adopt revised data not reflected in the table. It is the engineer's responsibility to ensure that current accepted rainfall intensity calculations are being utilized for the analysis.

B. Watershed Modeling For areas greater than 640 acres

For watersheds with a drainage area exceeding 640 acres, hydrologic analysis will follow the methodology outlined in the **Harris County Flood Control District (HCFCD) Hydrology & Hydraulics (H&H) Manual**.

a. Hydrograph Development Dynamic Conditions

For development of runoff hydrograph for use in dynamic modeling, utilize the Clark Unit Hydrograph Method.

b. Hydrograph Development Static Conditions

For development of detention volume, the approved methodology for hydrograph development shall be based upon the NRCS Dimensionless Unit Hydrograph or Malcom's Small Watershed Method.

C. Sample Calculation Forms

1. **Appendix A**, City of Tomball Storm Sewer Calculation Table, is a sample calculation form for storm sewers.
2. **Appendix B**, City of Tomball Roadside Ditch Calculation Table, is a sample calculation form for roadside ditches.
3. **Appendix C**, City of Tomball Time of Concentration Calculation Table, is a sample calculation form for time of concentration.
4. **Appendix D**, City of Tomball Inlet Spread Calculation Table, is a sample calculation form for inlet spread.

D. Design of Storm Sewers

1. General Considerations

Drainage systems for curb-and-gutter pavement shall consist of underground closed conduits.

2. Design Frequency

a. Areas of New Development
The design storm event for sizing storm sewers in newly developed areas will be a 25-year rainfall. The storm sewer should be designed so that the design hydraulic grade line shall be at or below the gutter grade for a curb and gutter section, and six inches below the shoulder of a roadside ditch section. In any case where new development interferes with the natural sheet flow of the existing adjacent land, the storm system shall accommodate the runoff. Stubbed out streets next to undeveloped areas shall have storm sewer lines continuing to an approved outfall.

b. Areas of Redevelopment

The existing storm drain (sewer, ditch) will be evaluated using a 25-year design storm, assuming no development takes place. The storm drain will then be evaluated for the 25-year design event with the Development in place.

1) If the proposed Redevelopment has an equal or lesser amount of impervious surface and the existing storm drain (sewer, ditch) meets the 5-year level of service, then no modifications to the existing storm drain are required.

2) If the proposed development results in the hydraulic gradient of the existing storm drain below the gutter line, no improvements to the existing storm drain are required. Detention shall comply with Paragraph IV.G. Flow discharged to the storm drain shall be in compliance with Paragraph IV.G.5.c.

3) If the analysis of the existing conditions finds that the existing storm drain is deficient (i.e., the hydraulic grade line is above the gutter line), the applicant should check with the City to see if a CIP project is proposed that will require an impact fee. If a CIP project is not proposed for the subject system, then on-site detention will be required in accordance with Paragraph IV.G. Flow discharged to the storm drain shall be in compliance with Paragraph IV.G.5.c.

c. City of Tomball Projects (Capital Improvement Programs) or New Development/ Redevelopment that is anticipated to become City Infrastructure and ROW:

1) Proposed City capital improvements may indicate a larger diameter storm sewer is planned in the area proposed for drainage improvements. The City of Tomball Staff has information on proposed improvements and should be consulted for impact on new development.

2) Below is a brief summary of the drainage design criteria to be used in conjunction with the City's Major Thoroughfare Plan (MTFP). A drainage design hierarchy aligning with the City's latest MTFP roadway classifications is

provided below. For detailed discussion and additional criteria, refer to the following paragraphs.

Table 5 – Roadway Drainage Design Criteria

Roadway Classification (per MTFP)	Arterials	Collectors	Local[1]
Method for Determining Peak Runoff			
Less than 200 Acres	Rational Method	Rational Method	Rational Method
Greater than 200 Acres	NRCS or Malcom's SWM	NRCS or Malcom's SWM	NRCS or Malcom's SWM
Culvert Crossings			
Design Storm	50-yr	25-yr	25-yr
Check Storm	100-yr	100-yr	100-yr
Headwater Control	< or = Existing Headwater Elevation	< or = Existing Headwater Elevation	< or = Existing Headwater Elevation
Maximum Outlet Velocity	Lined: 12 fps	Lined: 12 fps	Lined: 12 fps
	Vegetated Clay: 8 fps	Vegetated Clay: 8 fps	Vegetated Clay: 8 fps
	Vegetated Sand: 6 fps	Vegetated Sand: 6 fps	Vegetated Sand: 6 fps
Minimum Outlet Velocity	Lined: 2.5 fps	Lined: 2.5 fps	Lined: 2.5 fps
	Vegetated: 2.0 fps	Vegetated: 2.0 fps	Vegetated: 2.0 fps
Storm Sewers and Inlets			
Design Storm (HGL 1' below gutter)	25-yr	25-yr	25-yr
Check Storm	100-yr	100-yr	100-yr
Design Storm Allowable Ponding Width[2]	One lane each direction (divided), one-half of travel lane in each direction (undivided)	One-half of travel lane in each direction	One-half of travel lane in each direction
Check Storm Allowable Ponding Width[3,4]	One lane each direction open to traffic	One lane each direction open to traffic	No curb overtopping
Pipe Material	Concrete	Concrete or Plastic	Concrete or Plastic
Minimum Pipe Size	Laterals: 24 inch	Laterals: 24 inch	Laterals: 24 inch
	Trunklines: 24 inch	Trunklines: 24 inch	Trunklines: 24 inch
Minimum Pipe Velocity	3 fps	3 fps	3 fps
Maximum Pipe Velocity	12 fps	12 fps	12 fps
Roadside Ditches			
Design Storm	N/A	N/A	10-yr
Check Storm	N/A	N/A	100-yr
Maximum Design Velocity	N/A	N/A	3 fps
Side Slopes	N/A	N/A	3:1 or flatter
Minimum Freeboard	N/A	N/A	Design Storm: 0.5' below edge of shoulder or grade at ROW, whichever is lower
	N/A	N/A	Check Storm: Within ROW
Outfall Ditches			
Design Storm	Design for No Impact for 100-yr Storm Event. Use City of Tomball and HCFCD Standard Details for Outfalls.		

1Pavement width of 28 feet per City Ordinance Chapter 40, Article III, Sec. 40-66

[2] Ponding widths are based on City Details COT-STR-02, COT-STR-03, COT-STR-04, and COT-STR-05. Confirm allowable ponding widths with City Engineer for alternate cross sections.
[3] Conform with Paragraph IV.C.4 for maximum allowable ponding depths
[4] Open to traffic is defined as no ponding

d. Private Drainage Systems

Drainage facilities draining private areas shall be designed in conformance with appropriate design standards. The City of Tomball will not approve nor accept for maintenance a drainage system on private property unless it drains public stormwater and is located in a drainage easement. The connection of any storm sewer, inlet, ditch or culvert to a public drainage facility will be reviewed and approved by City of Tomball. Stormwater shall not be discharged or flow over any public sidewalk or adjoining property except to existing creeks, ditches, streets, or storm sewers in public ROW or easements.

Drainage to Texas Department of Transportation (TxDOT), HCFCD channels, or Harris County roadways must be approved or documented with a permit, letter or note of no objections to the plan by the Authority Having Jurisdiction (AHJ).

3. Velocity Considerations

a. Storm sewers should be constructed to flow in subcritical hydraulic conditions if possible.

b. Minimum velocities should not be less than 3 feet (3') per second with pipe flowing full, under the design conditions.

c. Maximum velocities at the storm sewer system outfall should not exceed should not exceed 8 feet per second without the use of energy dissipation at the outfall.

d. Maximum velocities within the storm sewers should not exceed 12 feet per second.

4. Pipe Sizes and Placement

a. Soil boring with logs shall be made along the alignment of all storm sewers having a cross section equal to or greater than seventy-two inches (72") in diameter or equivalent cross sectional area. Each boring shall be taken at intervals not to exceed five hundred (500') linear feet and at a depth of less than three feet (3') below the flow line of the sewer. The required bedding will be determined from the soil boring.

b. Use storm sewer and inlet leads with at least 24-inch (24") inside diameter or equivalent cross section. Box culverts shall be at least 3 feet (3') by 2 feet (2').

Closed conduits, circular, elliptical, or box, shall be selected based on hydraulic principles and economy of size and shape.

i. Only single-family residential projects, without sharing storm outfall with others, shall be permitted to use the point of connection through a curb via a 4-inch schedule 40 pipe OR to connect to the roadside ditch with 12-inch schedule 40 pipe within the ROW. This option is only available if curb or ditch is directly fronting the single-family residential lot.

c. Larger pipes upstream should not flow directly (via inlet, junction box, manhole) into smaller pipes downstream unless construction constraints prohibit the use of a larger pipe downstream, or the upstream system is intended for use as detention.

d. Match crowns of trunk storm sewer pipe at any change in pipe size unless severe depth constraints prohibit the matching of crowns.

e. Locate storm sewers in public street rights-of-way or in approved easements. Proposed storm sewer shall be laid underneath outside curb or edge of pavement with consideration for future maintenance and lane closures. Divided streets may allow proposed storm sewer laid parallel within median.

f. Conduits shall connect to manholes and inlets preferably on straight alignment, however angled connection no greater than 10 degrees normal to the wall may be provided. Deflection in accordance with manufacturer's specifications will be allowed if on approved drawings.

g. Minimum horizontal clearance between the exterior of any storm pipe or box culvert shall be at least 48 inches from the exterior of the existing or proposed public or private utility and other appurtenances (i.e., inlet or manhole).

h. Minimum vertical clearance between the exterior of any storm pipe or box culvert shall be at least 18 inches from the exterior of the existing or proposed public or private utility and other appurtenances.

i. Siphon design connection shall not be allowed without prior approval from City Engineer.

j. Conflict manhole shall not be allowed without prior approval from City Engineer.

k. In all easements restricted to storm sewers, the conduit shall be centered within the limits of the easement. The minimum width of the easement shall be two (2) times the depth plus the diameter of the pipe rounded up to the next highest five foot (5') increment but shall never be less than twenty feet (20').

l. For storm sewers located in easements adjacent to public street rights-of-way, the minimum width shall be increased for larger pipe or conduit by requiring that a minimum distance of five feet (5') shall be maintained between the easement line and the outside edge of the sewer, and a minimum distance of two feet (2') shall be maintained from the right-of-way line to the outside edge of the sewer pipe or conduit.

5. Starting Water Surface Elevation and Hydraulic Gradient

   a. The hydraulic gradient shall be calculated based on the following outfall conditions as the starting water surface elevation:

      i. Storm Sewer

         - If engineering plans or reports exist for the tie-in storm sewer system that have incorporated the effective Atlas 14 rainfall data, the hydraulic grade lines used in those plans or report may be used in lieu of criteria below. Design engineer shall coordinate with City of Tomball Staff.

         - For the design storm event, use one foot (1') above top of outfall pipe if pipes are connected at the soffit. If pipes are connected at the flowlines, the larger receiving pipe must be used.

         - For the 100-yr extreme event, use two feet (2') above top of outfall pipe if pipes are connected at the soffit. If pipes are connected at the flowlines, the larger receiving pipe must be used.

      ii. Roadside ditch – six inches (6") below edge of pavement or top of pipe, whichever is greater.

      iii. Channel

         - For the design storm event with non-submerged outfall to the receiving channel, the starting tailwater shall be the top of pipe.

         - At drops in pipe flowline, should the upstream crown of pipe be higher than the hydraulic grade line, the hydraulic grade line shall be re-calculated assuming the starting water surface to be at the crown of pipe at that point.

         - For the 100-yr extreme event rainfall event and outfall to the receiving channel, the starting tailwater shall be the ultimate 25-year water surface elevation or 2-feet below the top of bank, whichever is higher.

iv. Detention Pond – For the design storm event with non-submerged outfall to the receiving pond, the starting tailwater for the design storm sewer shall match the equivalent storm frequency water surface elevation of the detention pond using current rainfall criteria.

v. For the hydraulic impact analysis, a variable tailwater at the downstream end of the model may be used (reference to TP-100). A variable tailwater condition is recommend for use for detention analyses.

b. Should the upstream pipe be higher than the hydraulic grade line at drop in pipes invert, then the hydraulic grade line shall be recalculated assuming the starting water surface to be at the top of the pipe at that point.

c. For the design storm, the hydraulic gradient shall at all times be one foot (1') below the gutter line for all newly developed areas.

6. Manhole Locations

a. Use manholes at the following locations:

i. Size or cross section changes.

ii. Inlet lead and conduit intersections.

iii. Changes in pipe grade.

iv. Access points shall be provided at a maximum spacing of 300 feet (300') measured along the conduit run.

b. Use manholes for existing monolithic-concrete storm sewers at the same locations as above except for intersections of inlet leads unless a manhole needed to provide maintenance access at those intersections.

c. Do not place manholes in driveways or in streets in front of or immediately adjacent to a driveway.

7. Inlets

a. Locate inlets at all low points in gutter.

b. Valley gutters across intersections are prohibited.

c. Inlet spacing is a function of gutter slope. The minimum gutter slope shall comply with Minimum Construction Standards for Community Improvements.

i. For minimum gutter slopes, the maximum spacing of inlets shall result from a gutter run of 600 feet from high point in pavement or the adjacent inlet on a continuously graded street section, with a maximum of 1200 feet (1200') of pavement draining towards any one inlet location.

ii. Inlet location should be spaced to ensure that spread does not exceed allowable ponding widths provided in Table 3.

iii. Spread – Calculate the appropriate design storm rainfall flow approaching each inlet from each direction. Additional inlets may be required if the spread exceeds the maximum allowable value. The spread in a typical prismatic curb-and-gutter street may be calculated using the following relationships:

$$Q = \frac{k_g}{n} S_x^{2.67} S_0^{0.5} T^{2.67}$$

$$T = \frac{y}{s_x}$$

Where: k_g = 0.56 (US Customary Units) or 0.376 (SI Units)
n = Mannings roughness coefficient
S_x = Transverse slope (or cross slope)(ft/ft)
S_0 = Longitudinal pavement slope (or gutter slope)(ft/ft)
T = Spread
y = Ponded depth (ft)

Refer to ***Table 5*** for allowable spread on roadways. Spread calculations must be include

iv. Use only City of Tomball standard inlets as listed in ***Table 6***.

Table 6 – Standard Storm Sewer Inlets

Inlet	Application	Nominal Capacity[1]	City DWG No.
Type A	Parking Lots/Small Areas	2.5 cfs	COT STM-16
Type B-B	Residential/Commercial	5.0 cfs	COT STM-17
Type C	Residential/Commercial	5.0 cfs	COT STM-21
Type C-1	Commercial	10.0 cfs	COT STM-21
Type C-2	Commercial	15.0 cfs	COT STM-21
Type C-3	Commercial	20.0 cfs	COT STM-21
Type D	Parking Lots	2.0 cfs	COT STM-23
Type E	Roadside ditches	20.0 cfs	COT STM-24
Type H-2	Residential Commercial	5.0 cfs	COT STM-22

[1] The nominal capacity values provided in Table 6 are to be used for initial sizing only. The actual inlet size shall be based on hydraulic analysis of the required inlet capacity. Inlet

capacities are calculated using either orifice or weir equations depending upon their location and type of inlet opening.

d. Do not use beehive grate inlets or other specialty inlets.

e. Do not use grate top inlets in unlined roadside ditches.

f. Do not place inlets in the circular portion of cul-de-sac streets without providing justification based on special conditions.

g. Place inlets at the end of proposed pavement, if drainage will enter or leave pavement.

h. Do not locate inlets adjacent to esplanade openings.

i. For new residential development, locate inlets at the center of lots, such that inlets are not located within the driveway and between the radius end points as defined by the driveway radius intersection with the curb or edge of pavement, if possible.

j. It is desirable to place inlets on side streets intersecting major streets, unless justification based on special conditions can be provided for alternate location.

k. Type “E” inlets shall not be used in the ROW, with exception for temporary locations for interim drainage in areas of future half boulevard. Use of Type “E” inlets in this application shall be confirmed by the City Engineer.

l. Only the private development directly behind the inlet shall be permitted to make one connection to that inlet and that connection (lead) shall be made to the back of the inlet. All other private development must connect directly to the storm sewer trunkline even in the trunkline must be extended to the front of such development. The extension is to be designed and constructed in accordance with Section IV.B.4 Pipe Sizes and Placement. Connection shall not be made to the front face or to the short sides of the inlet. Design the connection not to exceed the pipe capacity minute either the nominal capacity listed in ***Table 4*** or calculated inlet inflow.

m. For all new construction, convey public or private alleyway drainage to an inlet prior to entering the public street drainage system if an underground drainage system exists.

n. The engineer shall be required to demonstrate that inlets for design storm events have adequate capacity based on ponding and available opening as to effectively drain storm water from paved sections. A graphical plan and calculations of the hydraulic gradient and spread calculations shall be furnished by the design engineer.

E. Consideration of Overland Flow

All storm drainage designs will take into consideration of the overland flow of runoff to account for the possibly of system inundation, obstruction, failure, or events that exceed the design storm. A representation of the overland flow scheme must be submitted with the system design.

1. Extreme Event Analysis – The design frequency for consideration of overland sheet flow will consider extreme storm event (up to 100-year storms). These events, which may exceed the capacity of the underground storm sewer system and result in ponding and overland sheet flow, shall be routed to drain along street ROW or open areas and through the development to a primary outlet.

2. Design Analysis – An overland flow analysis of the proposed drainage system shall be prepared by the design engineer. The design engineer shall submit supporting calculations, exhibits, and drawings, which define the conveyance capacity of the roadway, define the flow paths of overland sheet flow and define ponding depths of overland sheet flow.

    a. Three analysis methods as presented in Technical Paper No. 101, Simplified 100-year Event Analyses of Storm Sewers and Resultant Water Surface Elevations for Improvement Projects in the City of Houston, Harris County, Texas Region will be acceptable to the City.

    b. Analysis using the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) will be acceptable to the City.

3. Relationship of Structures to Street – All structures shall be above the maximum ponding elevation anticipated resulting from the extreme event analysis. All structures shall be constructed as per the Flood Damage Prevention Ordinance (Chapter 10 Article VIII).

    a. Use of public streets or public ROW for detention purposes is prohibited.

    b. The maximum ponding elevation for the 100-year event at any point along the street shall not be higher than the natural ground elevation at the ROW line.

    c. The post-project maximum water surface elevations shall be no higher than the pre-project maximum water surface elevation in surrounding areas and proposed finished slab elevation shall be above the post-project maximum water surface elevation.

4. Design Considerations

Streets shall be designed so that consecutive high points in the street will provide for a gravity flow of drainage to the ultimate outlet. If a detention facility is designed to mitigate peaks flows from the extreme event, the overland flow path shall carry the extreme event sheet flow to the detention facility. If the extreme event sheet flow must enter a receiving channel, the overland flow path shall carry the extreme event sheet flow to the channel. In the event that there is no overland flow path, or the overland flow path is insufficient to carry all of the extreme event sheet flow, the inlets and storm sewer at the downstream end of the overland flow shall be sized to carry the extreme event sheet flow from the end of the overland flow path into the detention facility or receiving channel.

a. Maximum ponding depth is determined by the allowable ponding width for the street classification as listed in ***Table 5***.

b. Sheet flow between lots may be provided only in connection with a defined drainage easement.

c. A map(s) shall be provided which delineates extreme event flow direction for both offsite, and through a Development. The map shall also show the method of discharge to the primary drainage outlet or detention basin. Positive drainage must be provided to intercept offsite sheet flow.

d. In areas where ponding occurs and where no sheet flow path exists, a calculation must be provided which demonstrates how the runoff from a 100-year event will be conveyed and remain in compliance with the other terms of this Paragraph.

e. All developments shall show contours of adjacent properties within two hundred (200) feet and account for natural and existing overland flow or channelized flows.

f. Selective reaches of the proposed storm sewer may need to be increased in size to adjust the elevations of the 100-year hydraulic grade line (HGL) to not exceed the desired HGL with respect to the roadway allowable ponding widths.

g. Projects with multiple ponds must additionally show how the extreme event will be conveyed from pond to pond, either an overflow swale or underground pipe or box.

5. Interim Off-Site Sheet Flow

Drainage swales may be used for interim offsite sheet flow in lieu of closed conduits in phased projects and for projects adjacent to existing development. This is required any time the proposed development will cause ponding on an adjacent owner's property.

In areas where the project design incorporates fill adjacent to an abutting property, the design engineer and Contractor shall implement grading and/or perimeter runoff catchment devices during construction to ensure that adjacent parcels bordering the project site do not experience increased interim drainage flows or carry sediment generated as part of construction activities. The interim drainage allowed to leave the property shall not exceed the pre-developed conditions. Where applicable, these practices are in addition to the standard Storm Water Pollution Prevention design and shall include additional ditches redirecting site drainage or temporary piping. This note is not intended to replace or address any liability or responsibility under Texas Water Code 11.086.

F. Design of Roadside Ditches

1. Roadside ditch design is permissible only for single family residential lots or commercial areas equal to or larger than 0.75 acres.

2. The City Engineer may approve deviations from residential and commercial standards based on the particular characteristics of the proposed development. The developer should submit a written variance request on a form (***Appendix E***) for such a deviation along with all supporting material to the City of Tomball Staff prior to initiating detailed project design.

3. Design Frequency

   a. The design storm event for roadside ditches shall be a minimum of 5-year rainfall. Refer to ***Table 5 – Roadway Drainage Design Criteria*** for design storm events based on street classification.

   b. Design capacity for a roadside ditch shall be to a minimum of 0.5 feet below the edge of the pavement or 0.5 feet (0.5’) below the natural ground at right-of-way line, whichever is lower, including head loss across the culvert. Design capacity calculations shall include head loss calculations for driveway and roadway culverts that are placed along the roadside ditch.

   c. The design must include an extreme event analysis to indicate that structures will not be flooded, and the maximum ponding elevation for the extreme event complies with Paragraph IV.C.3

   d. Outfall drainage to existing roadside ditches shall be limited to tracts with frontage along the roadside ditch. If no frontage to the roadside ditch exists, but it can be shown with detail topographic surveys that the tract ultimately drains to the roadside ditch, then outfall will only be considered with no impact on adjacent properties or the receiving storm system.

4. Velocity Considerations

    a. For grass-lined sections, the maximum design velocity shall be 3.0 feet per second during the design event.

    b. A grass-lined or unimproved roadside ditch shall have side slopes no steeper than three (3) horizontal to one (1) vertical (3:1) or as soil conditions will permit.

    c. Minimum grades for roadside ditches shall be 0.1-foot per 100 feet.

    d. Calculation of velocity will use a Manning's roughness coefficient (n) of 0.040 for earthen sections and 0.025 for ditches with paved inverts.

    e. Use erosion control methods acceptable to the City when design velocities are expected to be greater than three feet (3') per second or where erodible soil conditions are indicated in the geotechnical report.

    f. The top of bank shall not encroach beyond the City ROW or within 2 feet of the edge of pavement.

5. Culverts

    a. Culvert standards for driveways are provided by Drawing No. COT DW-06, COT DW-07, AND COT DW-08 Minimum Construction Standards for Community Improvements.

    b. Culverts shall be placed at all driveway and roadway crossings, and at other locations where appropriate.

    c. Culverts shall be evaluated for inlet and outlet control, as well as normal depth. The highest of the three shall be designated as the computed headwater for design of the culvert section.

    d. Roadside culverts are to be sized based on drainage area. Calculations are to be provided for each block based on drainage calculations. Headlosses in culverts shall conform to TxDOT Hydraulics Manual.

    e. The minimum culvert size shall be 18 inches (18”) in residential areas and 24 inches (24") in non-residential areas. Smaller culverts may be allowed with approval from City of Tomball Staff.

    f. In the ETJ or along Harris County ROW, the Regulations for Harris County, Texas for Construction of Driveways and/or culverts on County Easements and ROW shall govern.

g. All proposed and reasonably expected future culverts shall be included in the hydraulic profile. The proposed culvert shall not create a headloss of more than 0.20 feet (0.20’) greater than the normal water surface profile without the culvert.

h. Stormwater discharging from a ditch into a storm sewer system must be received by use of an appropriate structure. (i.e., stubs with ring grates or Type E Inlets.).

i. Culverts may not be extended across property frontage to cover the roadside ditch except for driveways.

j. Safety end treatments will be required on roadways with posted speeds over 30 mph for parallel and cross culverts.

k. Parallel drainage may elect to use High-Density Polyethylene (HDPE) pipes for private driveways. Cross culverts shall be comprised of Reinforced Concrete Pipe (RCP) or Polypropylene pipe (PP) in accordance with the latest Construction Standards and Technical Specifications.

6. Invert Protection

a. Ditch invert protection shall be used when velocities exceed 3 feet (3’) per second.

b. Ditch invert protection will be used at the upstream and downstream ends of all culverts.

7. Depth and Size Limitations

a. The maximum depth for a roadside ditch shall not exceed four feet (4’) below the adjacent road centerline top of pavement. There may be instances where extreme conditions may warrant a deeper ditch. In those cases, specific written prior approval must be obtained from the City of Tomball Staff.

b. Roadside ditch bottoms shall be at least two feet (2’) wide, unless design analysis supports a narrower width and prior written approval is obtained from the City of Tomball Staff.

c. A minimum distance of two feet (2’) shall be established and maintained between the right-of-way line and the adjacent edge of the bank of a ditch.

d. Roadside ditches shall drain streets and adjacent land areas.

G. Design of Open Channels

1. Design Requirements and General Criteria

a. Open channels shall be designed and constructed according to the methods described in the HCFCD Criteria Manual and shall convey the 100-year event unless otherwise directed by the City of Tomball Staff.

b. Design standards for outfalls into channels shall conform to those in the HCFCD Criteria Manual.

2. Determination of Water Surface Elevation

a. Water surface elevations shall be calculated using Manning's Equation and the Continuity Equation.

b. For the design storm event, the water surface shall be calculated to remain within banks.

3. Design of Culverts

a. Head losses in culverts shall conform to TxDOT Hydraulics Manual, Chapter 8, Culverts.

b. Corrugated metal pipe will not be approved for permanent culverts in the City of Tomball ROW except at railroad crossings, and if used underneath the railroad crossing, the culvert shall be designed to railroad loadings.

4. Design of Outfalls – All outfall designs shall conform to the HCFCD Criteria Manual.

H. Stormwater Detention

As a normal consideration, storm water detention shall be required. The intention of stormwater detention is to mitigate the effects of New Development, Redevelopment, or Site Modifications on an existing drainage system. This section of the Manual presents background information on stormwater storage techniques and detailed guidelines and criteria for the design of stormwater storage facilities.

Stormwater detention volume requirements are based on the acreage of the Disturbed Area that results in Impervious Surface or alters stormwater runoff. Stormwater detention volumes are calculated at the minimum rates set forth in the Paragraphs below.

1. Application of Detention

   a. The use of on-site detention is required for all Developments within the City, for new or expanding utility districts within the City's ETJ, and for all Developments outfalling into City facilities. Detention may not be required if the City has developed detention capacity for a drainage watershed, and/or infrastructure improvements, to serve the drainage watershed in compliance with the requirements of this Manual. If the City has developed a plan for a regional detention facility to serve a watershed, then the development is responsible for all costs of constructing the system to convey flows from their project to the regional facility. Under these conditions, the City will consider a funding contribution in lieu of on-site detention volume constructed by the Owner.

   b. Stormwater detention requirements are invoked for redevelopments that include disturbed area resulting in increased Impervious Surface. Existing impervious area will be credited based on site conditions at the time of submittal and shown on a topographical survey. Credit for impervious cover based on historical evidence or imagery that does not exist at the time of submittal is not permitted.

   c. If the drainage system outfalls directly into a channel maintained by HCFCD and the requirements of HCFCD include payment of an impact fee, then no further impact fee will be required by the City.

   d. Project sites that discharge directly into Harris County, HCFCD, or other jurisdictions require their review and approval. For project sites that discharge directly into other jurisdiction and there is a conflict between the detention criteria, the more restrictive criteria shall govern.

   e. All calculations shall be sealed and signed by a Professional Engineer licensed to practice engineering in the State of Texas.

   f. The City no longer allows timing analysis to avoid detention requirements.

   g. A master drainage plan for the purpose of grandfathering projects regarding drainage and detention is as follows:

      A master drainage plan establishes the current and future drainage plan for a developmental site. A master drainage plan generally consists of drainage, grading, detention, and other applicable site plans. These site plans contain detailed calculations for impervious area, detention, restrictors, flow rate, etc. signed and sealed by a Registered Professional Engineer in the state of Texas.

For any master drainage plan previously approved by the City with programmed detention that is not based on the effective rainfall data, the City shall allow the development to complete construction of the ultimate detention facility under the previously approved master drainage plan for up to two (2) years from adoption of this Drainage Criteria Manual and/or effective rainfall data.

For any master drainage plan previously approved by the City with programmed detention that is not based on the effective rainfall criteria and has not completed construction of the ultimate detention facility within two (2) years from adoption of this Drainage Criteria Manual and/or effective rainfall criteria, then the detention facility must comply with the current detention requirements at the time of permitting.

h. Plat, replat, change the use of, or subdividing any tract to reduce stormwater detention requirements will not be permitted. Original tract size on plat or replat, change the use of, subdividing, HCAD and survey will be used to determine stormwater detention requirements.

2. Types of Storage Facilities

   a. Regional Detention – The City has implemented and continues to evaluate and improve regional detention facilities that collect and hold stormwater from more than one development. Participation in regional detention shall be coordinated with the City of Tomball Staff. Excavation within limits of the planned regional detention basin for the purposes of offsetting project detention may be considered and shall be coordinated with the City of Tomball Staff.

   b. In-Line Detention – A type of storage technique occurring within the channel ROW and typically near the headwaters of a watershed or basin. In-line detention within programmed channel reaches adopted in the latest Drainage Master Plan is prohibited.

   c. Off-Line Detention – This type of storage facility diverts a portion of a hydrograph from a nearby channel only when specific parameters are met. These facilities are typically adjacent to a channel with a side weir as acting as the control structure. Off-line detention may be considered on a case-by-case basis and shall be coordinated with the City of Tomball Staff.

   d. On-Site Detention – An on-site detention basin generally receives runoff from a small drainage area consisting primarily of one or more development projects. On-site detention usually consists of one or more detention ponds.

      i. Parking Lot Detention Storage – The use of parking lot storage to mitigate developed flow may be used but will require prior approval from City of

Tomball Staff. The use of parking lot storage for multifamily developments is prohibited.

e. Pumped Detention System – Stormwater detention facilities requiring mechanical pumping systems in conjunction with a gravity outfall system.

f. Underground Detention – Underground detention may be achieved in pipes, boxes, chambers, modules, or vaults.

   i. The City will recognize up to 20% of void space in aggregates for underground systems with the appropriate documentation and design documents.

   ii. All underground detention systems shall be designed such that the bottom of the underground system can be viewed from the ground surface without the need for confined space entry.

   iii. Pipe and inlet storage – Storm sewer pipe and inlet boxes may be counted as detention storage used to mitigate developed flows subject. The design engineer shall provide a detailed accounting of the pipe storage provided on the plans and prove that the pipes and inlets will fill during a storm event based upon hydraulic or other analysis.

g. Low Impact Development (LID) – techniques that may be considered on a case-by-case basis for achieving detention are Bioretention, Infiltration Trenches, Porous Pavement, Vegetative Swales, Green Roof, Hard Roof, and Rain Barrels. Design Engineer shall coordinate with City of Tomball Staff on acceptable methods of detention.

3. Calculation of Detention Volume

   a. Detention volume for redevelopment and new Development areas is calculated on the basis of increased impervious cover or alters stormwater runoff, associated with the project development.

   b. Detention Volume for a tract containing only one Single Family Residential (SFR) home, follow ***Table 7***:

Table 7– Detention Volume for a SFR Tract

SFR Tract Size	Percentage/Total Impervious Area[1]	Detention Required (Y/N)	Detention Volume	Notes
One SFR tract ≤ 15,000 SF	% Total impervious area ≤ 45% of tract	N	N/A	2-3
One SFR tract ≤ 15,000 SF	% Total impervious area > 45% of tract	Y	0.75 ac-ft/ac x impervious area in excess of 45% of tract	2-3
One SFR tract > 15,000 SF	Total impervious area ≤ 9,750 SF	N	N/A	2-3
One SFR tract > 15,000 SF	Total impervious area > 9,750 SF	Y	0.75 ac-ft/ac x impervious area in excess 9,750 SF	2-3

[1] Total impervious area = (existing + proposed) impervious area

[2] For a tract with multiple lots, the detention exemption shown in Table 7 is not applicable. Refer to Table 8 for detention volume requirements.

[3] No sheet flow shall be permitted to an alleyway, neighboring properties, nor a ditch. Without sharing storm outfall with others, a point of connection shall be through a curb via a 4-inch schedule 40 pipe or to the roadside ditch with a 12-inch schedule 40 pipe within the ROW.

[4] When a tract of land is subdivided into multiple lots, detention is required for all proposed impervious area within the lot. No residential exemption will be granted for the individual lot within this subdivision tract.

c. Detention Volume for other projects not subject to Paragraph IV.F.3.b, follow ***Table 8***:

Table 8 – Detention Volume

Tract Size	Detention Required (Y/N)	Minimum Detention Volume Rate	Detention Calculation Method	Notes
Tract ≤ 5 acre	Y	0.75 ac-ft/ac	Method 1	1-3
5 acre < Tract ≤ 200 acre	Y	0.75 ac-ft/ac	Method 2 or 3	1-3
Tract > 200 acre	Y	0.75 ac-ft/ac	HEC-HMS/HEC-RAS	1-4
Tracts in basins with available regional detention	Y	N/A	Tract Area	1-3

[1] No sheet flow shall be permitted to an alleyway, neighboring properties, nor a ditch. Without sharing storm outfall with others, a point of connection shall be through a curb via a 4-inch schedule 40 pipe or to the roadside ditch with a 12-inch schedule 40 pipe within the ROW.

[2] For project within the City limits or draining to City maintained facilities, the minimum detention rate is 0.75 ac-ft/ac.

[3] If the modelling is associated with a FEMA submittal, the models to be used must be acceptable to that agency

[4] For project over 200 acres, HEC-HMS, HEC-RAS modelling shall be performed. Refer to HCFCD Hydrology and Hydraulic Modeling and Management Standards.

d. Methods For Calculation of Detention Volume

Regardless of the results of the methodology selected, the minimum detention required for all non SFR projects as described in Paragraph IV.F.3.b and ***Table 7*** shall be 0.75 ac-ft/ac of exceeded impervious surface in addition to floodplain fill mitigation.

For all non SFR projects as described in Paragraph IV.F.3.c and over 5 acres in tract size, the design engineer shall estimate the detention required using Method 2 or Method 3 as presented below. The design engineer shall compare the calculated detention volume from Method 2 or 3 versus minimum detention volume and use whichever method provides the greater volume.

For all projects

i. Roadway Impacts and Mitigation (CIP Projects)

Due to the different characteristics of roadway and land development projects, the impacts associated with roadway project cannot by fully analyzed using typical land development techniques. For CIP projects related to new roadways, widening existing roadways, or converting from roadside ditch to storm sewer drainage, refer to HCFCD Policy Criteria and Procedure Manual Section 6.16 for routing analysis and appropriate mitigation measures.

ii. Method 1 – Simplified Method

The simplified method yields a minimum detention volume by multiplying the total increased impervious area by the minimum detention volume rate of 0.75 ac-ft/ac.

iii. Method 2 – Small Watershed Hydrograph

The Small Watershed Hydrograph Methos is a method for developing a curvilinear design hydrograph for small to moderate size drainage areas (less than 640 acres) which peaks at a designated flow rate and contains a runoff volume consistent with the design rainfall as update by Atlas 14.

The Small Watershed Hydrograph Method consists of the following equations:

$$T_p = \frac{V}{1.39Q_p}$$

$$q_i = \frac{Q_p}{2}\left[1 - cos\left(\frac{\pi\, t_i}{T_p}\right)\right] \qquad t_i \leq 1.25T_p$$

$$q_i = 4.34Q_p e^{\left(-1.3t_i/T_p\right)} \qquad t_i > 1.25T_p$$

Where: Q_p = peak discharge (cfs)
T_p = time to Q_p (seconds)
V = total volume of runoff for e design storm event (cubic feet)
t_i and q_i = the respective time and discharge which determine the shape of the hydrograph

Note: Calculator must be in radian mode.

The peak flow rate, Qp, is obtained from the Rational Method. ***Table 9*** below gives typical values for the rainfall excess based on percent impervious cover. The actual values may be interpolated from the table. The design engineer shall calculate the actual impervious cover conditions proposed on the project.

Table 9 – Direct Runoff Excess Values[1]

Impervious Cover	2-Year	10-year	25-Year	100-Year
	Direct Runoff (in)	Direct Runoff (in)	Direct Runoff (in)	Direct Runoff (in)
Total	4.8	8.2		16.3
0	2.3	4.9		12.2
20	2.7	5.5		12.9
40	3.1	6.0		13.6
60	3.5	6.5		14.3
85	4.0	7.2		15.1

[1] Harris County Flood Control District Policy Criteria and Procedure Mnaual

iv. Method 3 – Unit Hydrograph Method

The Clark Unit Hydrograph may be developed to convert excess rainfall into a runoff hydrograph. The HEC-HMS software program is acceptable to the City for models resulting in a discharge hydrograph produced from a storm event.

- Values for percent impervious for existing and proposed conditions shall be calculated by the design engineer.
- Time of concentration shall be estimated using a velocity-based method.
- Calibrate the watershed storage coefficient (R) such that the resulting peak discharge matches the Rational Method peak flow.
- Point rainfall depths for HCFCD Region 1 can be found in ***Table 10*** to be used in meteorological models:

Table 10 – Point Rainfall Depth (Inches) Duration-Frequency Values[1]

Duration	Depth (in)				
	10-year	25-Year	50-Year	100-Year	500-Year
5-min	0.81	0.96	1.07	1.19	1.49
15-min	1.62	1.91	2.13	2.36	2.95
60-min	3.07	3.64	4.06	4.51	6.58
2 Hours	4.03	4.94	5.67	6.49	10.4
3 Hours	4.66	5.85	6.84	7.99	11.5
6 Hours	5.79	7.47	8.94	10.7	15.9
12 Hours	6.95	9.13	11.1	13.4	20.1
24 Hours	8.22	10.9	13.4	16.3	24.2

[1] Harris County Flood Control District Hydrology & Hydraulics Guidance Manual

- Green and Ampt Loss Method Parameters:

  Initial Storage = 0%

  Volume Moisture Deficit (Initial Deficit) = 0.385

  Wetting Front Suction Head (Suction) = 12.45 inches

  Conductivity = 0.024 in/hr

4. Pumped Detention Systems

   a. All stormwater detention facilities requiring mechanical pumping systems shall limit the volume of pumped flow to 50% of the total basin capacity

   b. Automatic controls shall be incorporated to shut off all pumping when outfall system capacity is reached. Additionally, a gravity return line to the detention facility must be provided for additional head control in the event of failure of automatic level controls. Pumping cannot be resumed until the outfall has receded to one-half (1/2) the depth of the roadside ditch.

   c. The detention facility shall be designed to empty the storage volume within four (4) days. If drain time is longer than four days, increase in detention volume that approximate the drain time shall be designed in accordance with Harris County Engineering Department Regulations.

5. Project Routing Techniques

   All projects over 5 acres shall route the design hydrograph through the detention basin. Adjustments of storage capacity and outflow structures, if required, to ensure the maximum allowable outflow rate is not exceeded. This routing should be performed in an appropriate computer program such as HEC-HMS or EPA SWMM (or others as approved by the City of Tomball Staff). The outflow structure shall be designed to restrict discharge to the 100-year allowable design flows.

If the modelling is associated with a FEMA submittal, the models to be used must be acceptable to that agency.

For project over 200 acres, HEC-HMS and HEC-RAS modelling shall be performed. The HEC-HMS modeling shall include analysis of existing and developed runoff. Refer to HCFCD Hydrology and Hydraulic Guidance Manual.

6. Calculation of Outlet Size

   a. Discharge Rates

      i. The maximum allowable release from a development shall be determined based on pre-development conditions and limited to the capacity allowed to the subject tract of the receiving system. The undeveloped peak flow rate shall be determined using the rational method.

      ii. Flow discharge to a storm drain shall not exceed the proportional amount of pipe capacity allocated to the Development. The proportional amount of pipe capacity allocated to the Development shall be determined by the ration of area (acres) of the Development (in storm drain watershed) divided by the total drainage area (acres) of the storm drain multiple the capacity of the storm drain.

   b. Outflow Structures

      i. To restrict outflow with a short segment of pipe or reduced opening size, use the orifice equation below:

$$Q = CA\sqrt{2gH}$$

Where: Q = outflow discharge (cfs)
C = coefficient of discharge - 0.8 for short segment of pipe and 0.6 for opening in plates, standpipes, or concrete walls
A = orifice area (square feet)
g = acceleration due to gravity (32.2 feet/second^2)
h = head difference between entrance and exit in feet when orifice is fully submerged, or the difference between the water surface elevation at the entrance and the centroid of the orifice in feet when the orifice is partially submerged.

An appropriately sized restrictor system must be installed to ensure detention volume is utilized. The restrictor shall be either of the required diameter or of the equivalent cross-sectional area. The orifice diameter D shall be a minimum of 6 inches (6”). The outfall pipe containing the restrictor shall be a minimum of eighteen inches (18”) or six inches (6”) greater than the restrictor pipe size, whichever is larger. The restrictor pipe shall always be placed at the upstream end of a pipe open towards the detention pond to enable cleaning.

All gravity discharges to a roadside ditch or channel shall be designed to prevent erosion of the receiving system.

ii. To control the design outflow or the emergency overflow from a detention basin with a weir, use the following equation:

$$Q = CLH^{3/2}$$

Where: Q = weir discharge (cfs)
C = weir coefficient (refer to HCFCD PMCM)
L = horizontal length of weir (feet)
H = head on weir (feet)

A weir set below the 100-year developed water surface elevation shall be used to discharge during the 100-year design condition. The weir should be sized so that the peak discharge does not exceed the 100-year allowable discharge rate with the basin full.

7. Emergency Overflow

a. An emergency overflow structure or route is required for all detention systems. Design Engineer shall design the emergency overflow as a path for the water to follow when water levels exceed the 100-year storm event in the detention pond.

b. The emergency overflow weir or structure shall be designed to pass the 100-year ultimate developed flow assuming the primary outflow is obstructed without exceeding the low natural or finished ground elevations.

c. The extreme event must be directed toward public right-of-way or an appropriate drainage easement.

8. Structural and Geometric Parameters for Detention Ponds

a. The design engineer is responsible for the design of all structural components within the project stormwater design.

b. Side slopes shall not exceed a slope of four (4) horizontal to one (1) vertical. Site specific geotechnical recommendations may be used in lieu of minimum requirements such that appropriate safety and stability were considered.

c. Ponds with lengths over fifty (50) feet shall have a pilot channel.

d. Lined (concrete) pilot channels shall have a minimum width of six (6) feet, a minimum depth of six (6) inches, and a minimum longitudinal slope of 0.002 feet per foot.

e. Unlined (grass) pilot channels shall have a minimum depth of two (2) feet, maximum side slopes of 4:1, and a minimum longitudinal slope of 0.005 feet per foot.

f. The bottom slopes of the detention basin should be graded toward the low-flow pilot channel or outfall. The transverse slope of the bottom shall be a minimum slope of 1%, with 2% preferred.

g. Maintenance Berms will be required. At a minimum, maintenance berms shall be 10 feet from the property line, right of way, or structure. All detention ponds shall have maintenance berms as follows:

Table 11 – Detention Pond Maintenance Berms

Pond Depth (ft)	Berm Width (ft)
≥2’	10
> 2’ – 5’	15
> 5’ – 10’	20
> 10’	30

h. Extreme Event Spillways – The drainage system must be designed to adequately deal with an extreme rainfall event. The extreme event shall be designed as an event which includes or exceeds the 100-year flow. The detention basin shall be provided in addition to the outfall structure with a gravity spillway that will protect structures from flooding in the event the capacity of the basin is exceeded.

i. Freeboard – Detention ponds shall maintain a minimum freeboard of one foot (1’) between the top of bank and the 100-year water surface elevation.

In cases where a pond discharges to a shallow outfall point, the City of Tomball Staff may allow a reduction of the minimum freeboard provided the following criteria is met. Note: the following criteria is for a reduction in freeboard and is only required when less than one foot (1’) of freeboard is proposed.

i. The freeboard volume shall never be less than 25% of the total detention storage volume.

ii. The freeboard shall never be less than 6 inches.

Freeboard shall be measured from the 100-yr design water surface elevation to the minimum top of bank elevation.

j. Wet bottom basins shall meet the following criteria:

i. A minimum of six feet (6') of permanent water depth is required unless the wet bottom is for purposes of wetlands.

ii. A ten-foot (10') minimum shelf, one-foot (1') above the static water surface elevation is required.

iii. Side slopes shall be a ratio of 4:1 or flatter from above the shelf to natural ground. Side slopes shall be a ratio of 3:1 from shelf to bottom of basin. Alternatives may be approved provided the facility design demonstrates that it can be easily maintained with due consideration of public safety.

k. If approved for detention through ponding in private parking areas, the maximum depth of ponding cannot exceed six inches (6") directly over the inlet grate. In such cases, the areas shall provide signage stating that the area is subject to flooding during rainfall events.

l. If approved for detention through ponding in private transport truck only parking, the maximum depth of ponding cannot exceed fifteen inches (15") directly above the inlet. In such cases, the areas shall provide signage stating that the area is subject to flooding during rainfall events.

m. All mitigation facilities shall be located within or adjacent to the project area.

n. Level spreaders or flow dispersion trenches are prohibited.

9. Detention Facility Ownership and Easements

a. Private Facilities:

i. Pump discharges into a roadside ditch must require the following:

- Submittal of pump specifications, including capacity (GPM) of the pump, on the design drawings.

- Provide a backup pump in the event of a pump failure.

- Provide emergency power from a second source tor install a quick connect for a mobile generator.

- Provide a stilling basin to dissipate the energy from the pump outlet prior to gravity flow into the ditch or storm sewer.

ii. The City reserves the right to prohibit the use of pump discharges where their use may aggravate flooding in the public ROW.

iii. Responsibility for maintenance of the detention facility must comply with City Ordinance Section 18-287.

iv. All private properties being served shall have drainage access to the pond. Dedicated private drainage easements may be required.

v. A private maintenance agreement shall be provided when multiple tracts are being served.

b. Public Facilities:

i. Facilities will only be accepted for maintenance by the City in cases where public drainage is being provided.

ii. The City requires a maintenance work area of 30-foot width surrounding the extent of the detention area. Public rights-of-way or permanent access easements may be included as a portion of this 30-foot (30’) width.

iii. A dedication of easement shall be provided by plat or by separate instrument.

iv. Proper dedication of public access to the detention pond must be shown on the plat or by separate instrument. This includes permanent access easements with overlapping public utility easements.

IV. SUBMITTALS

A. Online Portal (SmartGOV)

The City of Tomball has adopted an online electronic submittal process as of January 1, 2024. All application/plan submittals and inspection requests must be submitted via the online permitting program "SmartGOV". Previous systems for submitting applications/plans and requesting inspections have been discontinued.

B. Submittals for review and comment

1. Submittals of one-line drawings is recommended and may be required as part of the platting process.

2. Approximate definition of lots and street patterns.

3. City of Tomball Review Sheet. (See **Appendix F**)

4. Any proposed drainage easements.

5. A copy of recorded subdivision plat, survey, metes & bounds description, and deed for property confirming date of parcel creation being prior to August 15, 1983.

6. CenterPoint Energy Address Assignment Letter

7. Floodplain information, including floodplain boundary, if any: FEMA map number, effective map date and zone.

8. Copies of any documents which show approval of exception to City design criteria.

9. Design calculations for time of concentration, composite land use factors, storm line sizes and grades, and for detention facilities, if any.

10. Design calculations for the Hydraulic Grade Line of each line or ditch, and for detention facilities, if any.

11. Drainage Area Map with the following information:

    a. Description of drainage basin and total development area.
    b. Existing contour map.
    c. Existing and Proposed drainage area and sub-drainage area boundaries.
    d. Existing and Proposed Drainage area (acres) and flow quantity (cfs) draining to each inlet and each pipe segment from storm structure (i.e. manhole, inlet, catch basin, etc.) to storm structure.
    e. Extreme event (100-year) sheet flow direction.

f. Existing condition and developed condition sheet flow direction for the surrounding properties.

12. Plan and profile sheets showing stormwater design (public facilities only).

    Projects located within a floodplain boundary or within a floodplain management area shall:

    a. Show the floodplain boundary or floodplain area, as appropriate, on the one-Drainage Area Map.
    b. Comply with all applicable submittal requirements of City Ordinance Chapter 10 Article VIII.
    c. Review and approval of this project by the City Floodplain Administrator is required.

13. Profile drawing of roadway (or overland flow path) with exaggerated vertical scale from the upper reach of drainage area to the primary drainage outlet. Show roadway profile at gutter, ground profile at the public right-of-way, and hydraulic gradient lines for the design storm event and 10—year extreme event, or an alternative equivalent drawing accepted by the City.

14. Calculation for proportional amount of pipe capacity allocated to the development along with the drainage area map used for these calculations.

15. If the detention has been provided by other projects, a Memorandum should be provided to explain how the existing detention facility serves this project.

C. Signature Stage – Submit the following for approval:

1. Review prints with all comments.

2. Original drawings.

    a. Provide City of Tomball Permit Number on cover page.
    b. Provide all information requested in Paragraph V.B.

3. All required permits from other agencies (i.e., HCFCD approval, HCED approval, TxDOT, etc.)

V. QUALITY ASSURANCE

Prepare calculations and design drawings under the supervision of a professional engineer trained and licensed under the disciplines required by the project scope. The final design drawings and all design calculations must be sealed, signed, and dated by the professional engineer, licensed by the State of Texas, responsible for the development of the drawings.

VI. SURVEY

Projects shall be tied to the National Geodetic Survey (NGS) datum adjustment which matches the Federal Emergency Management Agency (FEMA) rate maps or the most current NGS datum which matches the FEMA rate maps. In the event GPS surveying is used to establish bench marks, at least two references to bench marks relating to the rate maps shall be identified. Equations may be used to translate other datum adjustments to the required adjustment.

VII. LOW IMPACT DEVELOPMENT

Low impact development is a comprehensive land planning and engineering design approach with the goal of maintaining, as the minimum, the pre-development hydrologic regime in a watershed. A conceptual design meeting shall be held with the City of Tomball Staff. Design concepts are approved prior to proceeding to preliminary design.

APPENDIX B

DRAINAGE DESIGN SPECIFICATIONS

Section 02505

THERMOPLASTIC PIPE CULVERTS AND DRAINS

PART 1 G E N E R A L

1.01 SECTION INCLUDES

A. High density polyethylene (HDPE) pipe for gravity sewers and drains, including fittings.

B. High density polyethylene (HDPE) pipe for sanitary sewer force mains, including fittings.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for HDPE pipe under this Section. Include cost in unit prices for work, as specified in following sections:

   a. Section 02531 - Gravity Sanitary Sewers.

   b. Section 02532 - Sanitary Sewer Force Mains.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. AASHTO M 294 - Standard Specification for Corrugated Polyethylene Drainage Pipe, 18"- 48" diameter.

B. AASHTO Section 18 - Soil Thermoplastic Pipe Interaction Systems.

C. AASHTO Section 30 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewer and Other Gravity Flow Applications.

D. ASTM D 618 - Standard Practice for Conditioning Plastics for Testing.

E. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion

Materials for Wire and Cable.

F. ASTM D 2321 - Standard Recommended Practice for Underground Installation of Flexible Thermoplastic Pipe.

G. ASTM D 2657 - Standard Practice for Heat Fusion Joining Polyolefin Pipe and Fittings.

H. ASTM D 2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.

I. ASTM D 3035 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.

J. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

K. ASTM D 3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

L. STM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

M. ASTM F 714 - Standard Specification for Polyethylene Plastic (PE) Pipe (SDR-PR) Based on Outside Diameter.

N. Plastic Pipe Institute Drainage Handbook

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings showing design of pipe and fittings, laying dimensions, fabrication, fittings, flanges, and special details.

C. Submit manufacturer's installation specifications before beginning work. Maximum fill depth and backfill requirements shall be included in the manufacturer's installation specifications.

1.05 QUALITY CONTROL

A. Provide manufacturer's certificate of conformance to Specifications.

B. Furnish pipe and fittings that are homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other injurious defects. Provide pipe as uniform as commercially practical in color, opacity, density, and other physical properties.

C. City Engineer reserves right to inspect pipes or witness pipe manufacturing. Inspection shall in no way relieve manufacturer of responsibilities to provide products that comply with applicable standards and these Specifications.

1. Manufacturer's Notification: Should City Engineer wish to witness manufacture of specific pipes, manufacturer shall provide City Engineer with minimum three weeks notice of when and where production of those specific pipes will take place.

2. Failure to Inspect. Approval of products or tests is not implied by City Engineer's decision not to inspect manufacturing, testing, or finished pipes.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this section with documented experience of minimum 5 years of pipe installations that have been in successful, continuous service for same type of service as proposed Work.

PART 2 P R O D U C T S

2.01 GENERAL

A. For sewer pipe provide HDPE pipe as follows:

1. NEW CONSTRUCTION PIPE PROJECTS
GRAVITY SANITARY SEWER
DIRECT BURY

INSTALLATION SPEC NO.	GENERIC NAME	TRADE NAME OR MANUFACTURER	ASTM OR AASHTO	SDR (NUMERIC MAXIMUM)	PIPE STIFFNESS (NUMERIC MINIMUM)	SIZE RANGE
02505	Solid Wall Polyethylene (HDPE)	Chevron Plexco Phillips 66 Quail Poly Pipe	ASTM F-714	DR 17 DR 21	115 46	8" - 10" 12" - 48"
02531	Polyethylene Profile Wall	Spirolite	ASTM F-894	n/a	46	18" - 120"

2. REHABILITATION CONSTRUCTION PIPE PRODUCTS
SLIPLINING OF SANITARY SEWER

INSTALLATION SPEC NO.	GENERIC NAME	TRADE NAME OR MANUFACTURER	ASTM OR AASHTO	SDR (NUMERIC MAXIMUM)	PIPE STIFFNESS (NUMERIC MINIMUM)	SIZE RANGE
02550	Solid Wall Polyethylene (HDPE)	Chevron Plexco Quail Poly Pipe AmeriFlow by NAPCO AmeriFlow by KWH	F-714	DR 21	46	8" - 48" 3" - 12" 14" - 63"
02550	Polyethylene Profile Wall	Spirolite	F-894	n/a	46	18" - 120"

A. Furnish solid wall pipe with plain end construction for heat joining (butt fusion) conforming to ASTM D 2657. Utilize controlled temperatures and pressures for joining to produce fused leak-free joint.

B. Furnish profile-wall gravity sewer pipe with bell-and-spigot end construction conforming to ASTM D 3212. Joining will be accomplished with elastomeric gasket in accordance with manufacturer's recommendations. Use integral bell-and-spigot gasketed joint designed so that when assembled, elastomeric gasket, contained in machined groove on pipe spigot, is compressed radially in pipe bell to form positive seal. Design joint to avoid displacement of gasket when installed in accordance with manufacturer's recommendations.

C. Furnish solid wall pipe for sanitary sewer force mains with minimum working pressure rating of 150 psi, and with inside diameter equal to or greater than nominal pipe size indicated on Drawings.

D. Furnish corrugated polyethylene pipe (CPP) for gravity storm sewer pipe. Joints shall be installed such that connection of pipe sections will form continuous line free from irregularities in flow line. Suitable joints are:

1. Integral Bell and Spigot. Bell shall overlap minimum of two corrugations of spigot end when fully engaged.

2. Exterior Bell and Spigot. Bell shall be fully welded to exterior of pipe and overlap spigot end so that flow lines and ends match when fully engaged.

A. Jointing:

1. Gaskets:

a. Meet requirements of ASTM F 477. Use gasket molded into circular form or extruded to proper section and then spliced into circular form. When no contaminant is identified, use gaskets of properly cured, high-grade elastomeric compound. Basic polymer shall be natural rubber, synthetic elastomer, or blend of both.

b. Pipes allowed to be installed in potentially contaminated areas, where free product is found near elevation of proposed sewer, shall have the following gasket materials for noted contaminants:

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other Contaminants	As recommended by pipe manufacturer

2. Lubricant. Use lubricant for assembly of gasketed joints which has no detrimental effect on gasket or on pipe, in accordance with manufacturer's recommendations.

2.02 MATERIALS FOR SANITARY SEWER

A. Pipe and Fittings: High density, high molecular weight polyethylene pipe material meeting requirements of Type III, Class C, Category 5, Grade P34, as defined in ASTM D 1248. Material meeting requirements of cell classification in accordance with ASTM D 3350 are also suitable for making pipe products under these specifications.

B. Other Pipe Materials: Materials other than those specified in Paragraph 2.02A, Pipe and Fittings, may be used as part of profile construction, e.g., as core tube to support shape of profile during processing, provided that these materials are compatible with base polyethylene material and are completely encapsulated in finished product and in no way compromise performance of pipe products in intended use. Examples of suitable material include polyethylene and polypropylene.

2.03 TEST METHODS FOR SANITARY SEWER

A. Conditioning. Conditioning of samples prior to and during tests are subject to approval by City Engineer. When referee tests are required, condition specimens in accordance with Procedure A in ASTM D 618 at 73.4 degrees F plus or minus 3.6 degrees F and 50 percent relative humidity plus or minus 5 percent relative humidity for not less than 40 hours prior to test. Conduct tests under same conditions of temperature and humidity unless otherwise specified.

B. Flattening. Flatten three specimens of pipe, prepared in accordance with Paragraph 2.05A, in suitable press until internal diameter has been reduced to 40 percent of original inside diameter of pipe. Rate of loading shall be uniform and at 2 inches per minute. Test specimens, when examined under normal light and with unaided eye, shall show no evidence of splitting, cracking, breaking, or separation of pipe walls or bracing profiles.

C. Joint Tightness. Test for joint tightness in accordance with ASTM D 3212, except replace shear load transfer bars and supports with 6-inch-wide support blocks that can be either flat or contoured to conform to pipe's outer contour.

D. Purpose of Tests. Flattening and joint tightness tests are not intended to be routine quality control tests, but rather to qualify pipe to a specified level of performance.

2.04 MARKING

A. Mark each standard and random length of pipe in compliance with these Specifications with following information:

1. Pipe size.
2. Pipe class.
3. Production code.
4. Material designation.

PART 3 E X E C U T I O N

3.01 INSTALLATION

A. Conform to requirements of following Sections:

1. Section 02550 - Sliplining Sanitary Sewers.
2. Section 02531 - Gravity Sanitary Sewers.
3. Section 02532 - Sanitary Sewage Force Mains.

4. Section 02533 - Acceptance Testing for Sanitary Sewers.

B. Install pipe in accordance with the manufacturer's recommended installation procedures.

C. HDPE pipe is not approved in applications requiring augering of pipe.

D. Bedding and backfill: Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

END OF SECTION

Section 02509

THERMOPLASTIC PIPE CULVERTS
AND DRAINS

PART 1 G E N E R A L

1.01 SECTION INCLUDES

A. Corrugated High-Density Polyethylene (HDPE) pipe for culverts, including fittings.

B. Polypropylene (PP) pipe for storm sewers.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for HDPE or PP pipe under this Section. Include cost in unit prices for work, as specified in following sections:

    a. Section 02631 - Storm Sewers.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. AASHTO M 294 - Standard Specification for Corrugated Polyethylene Pipe, 300 mm to 1500 mm (12 in. to 60 in.) Diameter

B. AASHTO M 330 - Standard Specification for Polypropylene Pipe, 300 mm to 15000 mm (12 in. to 60 in.) Diameter

C. AASHTO Standard Specifications for Highway Bridges

D. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

E. ASTM D 3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

F. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

G. Plastic Pipe Institute Drainage Handbook

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. The Contractor shall submit a certificate of compliance of the pipe product that is manufactured in accordance with AASHTO M330. Supplying manufacturing facilities shall be in compliance with AASHTO's National Transportation Product Evaluation Program (NTPEP) for the specified pipe product.

C. Submit manufacturer's installation specifications before beginning work. Maximum fill depth and backfill requirements shall be included in the manufacturer's installation specifications.

1.05 QUALITY CONTROL

A. Provide manufacturer's certificate of conformance to Specifications.

B. Furnish pipe and fittings that are homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other injurious defects. Provide pipe as uniform as commercially practical in color, opacity, density, and other physical properties.

C. Engineer reserves right to inspect pipes or witness pipe manufacturing. Inspection shall in no way relieve manufacturer of responsibilities to provide products that comply with applicable standards and these Specifications.

1. Manufacturer's Notification: Should City Engineer wish to witness manufacture of specific pipes, manufacturer shall provide City Engineer with minimum three weeks notice of when and where production of those specific pipes will take place.

2. Failure to Inspect. Approval of products or tests is not implied by City Engineer's decision not to inspect manufacturing, testing, or finished pipes.

PART 2 P R O D U C T S

2.01 PIPE DESIGN

A. A "Thermoplastic Pipe Installation" detail sheet must be signed and sealed by a registered Professional Engineer licenses to practice in the State of Texas and be included in the Contract Documents when thermoplastic pipe is specified. The specifying Professional Engineer is required to confirm the conditions for the project and structural adequacy of the pipe system.

The Plastic Pipe Institute publishes an online design manual that contains information related to all aspects of design and construction of thermoplastic pipe. For structural design of plastic pipe systems see the Plastic Pipe Institute Handbook, Chapter 7 " Structural Design" (www.plasticpipe.org). Additionally, thermoplastic pipe suppliers also have information on the use of their products.

When specifying plastic pipe on a project, the specifying Design Engineer must be aware of minimum depth of fill required and how these are measured for different pipe and pavement types.

1. Corrugated High Density Polyethylene (HDPE) Pipe

   The specifying Design Engineer is responsible for ensuring that depth of fill is not less than 18 inches for pipe diameters up to 36 inches or 24 inches for pipe diameters over 36 inches. The depth of fill is measured as the distance from the top of pipe to the bottom of the flexible pavement, or from the top of the pipe to the top of rigid pavement.

2. Polypropylene Pipe

   The specifying Design Engineer is responsible for ensuring that depth of fill is not less than 12 inches for pipe diameters up to 48 inches or 24 inches for pipe diameters over 60 inches. The depth of fill is measured as the distance from the top of pipe to the bottom of the flexible pavement, or from the top of the pipe to the top of rigid pavement.

Polypropylene pipes are stiffer than corrugated high-density polyethylene (HDPE) pipes which provide for more resilience against installation related deflection and is preferred for use over HDPE on transportation projects.

2.02 CORRUGATED HIGH-DENSITY POLYETHYLENE (HDPE) PIPE

A. Corrugated high-density polyethylene pipe and fittings shall meet the requirements of AASHTO M 294.

B. Raw Materials: Corrugated high-density polyethylene pipe and fittings manufactured from virgin polyethylene (PE) compounds shall meet the requirements of cell class 435400C as defined and described in ASTM D3350, except that the maximum allowable carbon black content is 4 percent. The PE compound used shall meet the environmental stress crack resistance according to the NCLS test set forth in AASHTO M 294.

C. Designation Type: For corrugated high-density polyethylene pipes used in gravity flow drainage applications, use Type S (outer corrugated wall with smooth inner liner).

D. Section Properties: The minimum wall thickness of the inner walls of Type S pipe shall meet the requirements of AASHTO M 294, Section 7.2.2. The pipe stiffness requirement of 5 percent deflection shall conform to AASHTO M 294, Section 7.4.

2.03 POLYPROPYLENE (PP) PIPE

A. Polypropylene pipe and fittings shall meet the requirements of AASHTO M 330.

B. Raw Materials: Polypropylene compounds used to manufacture the pipe and fittings shall meet the minimum properties of AASHTO M 330, Section 6.1.1.

C. Designation Type: Polypropylene pipes used in gravity flow drainage applications shall be Type S (outer corrugated wall with smooth inner liner).

D. Section Properties: The minimum wall thickness of the inner walls for Type S pipe shall meet the requirements of AASHTO M 330, Section 7.2.2. The pipe stiffness at 5 percent deflection will meet the requirements in Section 7.4 of AASHTO M 330.

2.04 PIPE TESTING

A. The manufacturer shall perform the appropriate test procedures on representative samples of each type of pipe furnished and shall verify that the pipe complies with the specifications. A certificate of compliance shall be submitted to Engineer for review and approval. A document with the following information shall be provided: manufacturing plant, date of manufacture, pipe unit mass, material distribution, pipe dimensions, water inlet area, pipe stiffness, pipe flattening, brittleness, ASTM resin cell classification, and workmanship. Pipe shall be supplied by manufacturers and locations that are listed on TxDOT’s Material Product List for Thermoplastic pipe, joints, and fittings.

2.05 PIPE INSPECTION

A. The quality of materials, the process of manufacture, and the finished pipe will be subject to inspection and approval by Engineer at the manufacturing plant. In addition, the finished pipe will be subject to further random inspection by Engineer at the project site before and during installation, and prior to acceptance. The Engineer is responsible for ensuring the integrity of the installed pipes. The Engineer will ensure the pipe, bedding, structural backfill and stable foundation are installed and inspected correctly.

2.06 JOINTS

A. Joints shall be installed so that the connection of the pipe sections form a continuous line free from irregularities in the flowline.

B. Joints and Fittings shall meet the following requirements:

1. Integral Bell and Spigot: The bell shall overlap a minimum of two (2) corrugations of the spigot end when fully engaged. The spigot end shall have an O-ring gasket and meet the requirements of ASTM F477.

2. Exterior Bell and Spigot: Fully weld the bell to the exterior of the pipe and overlap the spigot end so that the flow lines and ends match when fully engaged. The spigot end shall have an O-ring gasket and meet the requirements of ASTM F477.

3. Split Couplers: For soil-tight joint connections only, join pipe with coupling bands covering at least two full corrugations on the ends of each pipe being joined.

C. The following are joint and fitting type definitions:

1. Soil-tight Joints: Joints shall meet the soil-tightness definition in AASHTO “Standard Specifications for Highway Bridge,” Section 26.4.2.4.

2. Watertight Joints: Joints shall meet the requirements of ASTM D3212.

3. If no joint type is specified in the Contract Documents, a soil-tight joint shall be provided.

2.07 MARKINGS

A. Thermoplastic pipe, fittings, and couplings furnished shall be clearly marked as follows with pipe marked at ten (10) foot intervals:

1. Manufacturer's name or trademark

2. Nominal size

3. Specification designation (i.e. AASHTO M 294 or AASHTO M 330)

4. Manufacturing plant's designation code, and date manufactured.

2.08 END SECTIONS

A. Type II Precast Safety End Treatments shall be provided for thermoplastic pipe installations beneath and adjacent to roadways. TxDOT's PSET-SC standard shall be used for cross drainage structures and TxDOT's PSET- SP standard shall be used for parallel drainage structures. Refer to City Standard Details for end section requirements.

PART 3 E X E C U T I O N

3.01 HANDLING AND STORING PIPE

A. Pipe shall be stored above ground on adequate blocking. Pipe shall be kept clean and fully drained during storage. Handle and store thermoplastic pipe in accordance with the pipe manufacturer's instructions. Proper handling methods shall be used for hoisting and lowering the pipe into the trench.

3.02 EXCAVATION

A. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities. Use bedding as indicated on Drawings. Special precautions in placing and compacting the backfill shall be taken to avoid any movement of the pipe or damage to the joints. Damaged pipe shall be removed and replaced by the Contractor at no expense to the City.

B. Minimum Trench Width: Provide enough trench width for the pipe installation and to ensure enough working room to properly and safely place and compact material placed under haunches of the pipe and other embedment materials. Provide a space between the pipe and trench wall that is greater than that of the compaction equipment used in the pipe zone.

1. When using Type I backfill, the minimum allowable trench width is the pipe outside diameter plus 12 inches.

2. When using Type II or Type III backfill, the minimum allowable trench width is specified in Table 1.

TABLE 1
MINIMUM TRENCH WIDTH

Nominal Pipe Diameter (in.)	Minimum Trench Width (in.)
18	44
24	54
30	66
36	78
42	84
48	90
60	103

3.03 TRENCHLESS INSTALLATION

A. Thermoplastic pipe is not approved for augering of pipe.

3.04 INSTALLATION

A. Laying Pipe

1. Unless approved by City, pipe sections shall not be placed in the presence of water or when trench conditions or weather is unsuitable for such work. Lay pipe sections on the bedding at the outlet end with the spigot or tongue end pointing downstream and proceed toward the inlet end with separate sections properly joined together, true to the established lines and grades. Sections of pipe shall be lowered into the trench without damaging the pipe or disturbing

the bedding and the sides of the trench. The ends of the pipe shall be cleaned before mitting, matching, and laying the pipe to form a continuous, uniform conduit. The joint assembly shall be completed in accordance to the recommendations of the pipe manufacturer. Foreign matter or earth and bedding material shall be prevented from entering the pipe during and after pipe laying operation. Pipe that is not in alignment or shows excessive settlement after laying shall be removed and re-laid without extra compensation.

2. Lay multiple installation of thermoplastic pipe with the centerlines of the individual barrels parallel. Unless otherwise shown on the Contract Documents, the clear distance between outer surfaces of adjacent pipes shall conform to the minimum requirements of Table 2.

TABLE 2
MINIMUM CLEAR DISTANCE BETWEEN PIPES

Nominal Pipe Diameter (in.)	Minimum Clear Distance Between Pipes (in.)
18	14
24	17
30	20
36	23
42	26
48	29
60	32

B. Installing Pipe in Embankment: If any portion of the pipe projects above the existing ground level, an embankment shall be constructed as shown on the Contract Documents or as directed by City, for a minimum distance outside each side of the pipe location of 5 times the diameter and to a minimum elevation of 2 feet above the top of the pipe. Excavate the trench in accordance with Section 02317 - Excavation and Backfill for Utilities.

C. Reusing Existing Appurtenances

1. When existing appurtenances are specified for reuse in the Contract Documents, the portion to be reused shall be separated from the existing culvert and moved to the new position previously prepared, by approved methods.

2. Connections shall conform to the requirements for joining sections of pipes as indicated in this Section or as shown in the Contract Documents. Headwalls and aprons for pipes attached to the headwall that are damaged during moving operations shall be repaired to their original condition, at no expense to the City. The Contractor has the option to remove and dispose of the existing headwalls and aprons and construct new headwalls at no expense to the City, in accordance with the pertinent specification and design indicated in the Contract Documents or as furnished by the City.

D. Sewer Connections and Stub Ends. Connect pipe sewer to existing sewer or sewer appurtenances as shown on the Contract Documents or as directed by the City. Mortar or concrete the bottom of existing structures, if necessary, to eliminate any drainage pockets created by the new connection. Any damage to existing structures, which are to remain in service from making the pipe sewer connection, shall be restored to the satisfaction of the City. Stub ends for connection to future work not shown on the Contract Documents shall be sealed by installing watertight plugs into the free end of the pipe. Stub end seals shall be included in the cost of the pipe.

E. Bedding and Backfilling

1. Conform to requirements of Section 02317 – Excavation and Backfill for Utilities.

F. Protecting the Pipe

1. Unless otherwise shown on the Contact Documents, or permitted in writing, heavy earthmoving equipment shall not be operated over the structure until a minimum of 4 feet of permanent or temporary compacted fill is placed over the top of the structure.

2. Before adding each new layer of loose backfill material, an inspection shall be made of the inside periphery of the structure for local or unequal deformation caused by improper construction methods until a minimum of 12 inches of cover is obtained. Evidence of local or unequal deformation will be reason for corrective measures to be completed when directed by the City.

G. Thermoplastic pipe damaged by the Contractor shall be removed and replaced at no expense to the City.

3.05 INSPECTION AND ACCEPTANCE

A. Conform to requirements of following Sections:

1. Section 02631 – Storm Sewers.

B. Inspection

1. The Contractor shall visually inspect pipes for damage, deflection (out of roundness), joint tightness, evidence of soil intrusion, and vertical alignment (ponding). If the pipe run is 30 feet or less in length, not under a roadway, and the initial visual inspection did not indicate any deflection or other deficiencies, additional testing described below shall be waived, unless otherwise noted. The Contractor shall use high intensity lights, laser distant measuring devices, and other equipment to facilitate visual inspection.

2. Final inspection shall be performed a minimum of 30 days after the backfill has been completed or earlier as needed to allow roadway surfacing when approved. Two test mandrels shall be available for each size of pipe. Size mandrels based on the inside diameter as outlined in ASTM F2881, Table 2. Metal mandrels shall have at least nine fixed fins evenly distributed around the circumference. A mandrel sized at 95% the pipe diameter shall be pulled through the entire length. If the 95% mandrel cannot be pulled entirely through, a mandrel sized at 92.5% the pipe diameter shall be pulled through the pipe. Additionally, if the 95% mandrel cannot be pulled entirely through the pipe or there is a substantial disruption in ease of mandrel movement through the pipe, visually inspect installed pipe utilizing a remote operated camera mounted on vehicle or sled able to move through the pipe. Check for joint separation, cracks, tears, buckling, deflection, and out of roundness, evidence of soil intrusion and vertical alignment (ponding water).

3. The Contractor shall notify the City when inspections are to occur.

4. The Contractor shall provide a letter to the City stating the thermoplastic pipes

were installed, inspected, and tested in compliance with the Contract Documents. The letter shall include copies of inspections and mandrel test results.

C. Remediation: The Contractor shall develop a plan to address all deficiencies of joint separation, damage, evidence of soil intrusion, vertical alignment, and when pipe deflection exceeds 5% of the nominal pipe diameter.

1. Joints: Remediate pipe showing evidence of crushing at the joints. Note differential movement, improper joint sealing, movement or settlement of pipe sections, and leakage in the inspection report. Remediate joint separation of greater than 1 inch. Repair or replace pipe sections where soil migration through the joint is occurring.

2. Cracks or Tears: Remediate cracks or splits in the interior wall of the pipe. Use remediation methods in conformance with recommendations of the pipe manufacturer and accepted and authorized by the City.

3. Buckling, Bulging, and Racking: Note in the inspection report flat spots or dents at the crown, sides, or flowline of the pipe due to racking. Note area of wall buckling and bulging in the inspection report. The City will determine if corrective action is necessary.

4. Deflection: Where pipe deflection exceeds 5% of the nominal diameter, submit to the City for review and approval an evaluation utilizing a Professional Engineer taking into consideration the severity of the deflection, structural integrity, environmental condition, and the design service life of the pipe. Remediate or replace pipe where the evaluation finds the deflection could be problematic or where pipe deflection exceeds 7.5% of the nominal diameter.

END OF SECTION

Section 02631

STORM SEWERS

PART 1 G E N E R A L

1.01 SECTION INCLUDES

A. New storm sewers and appurtenances, modifications to existing storm sewer system and installation of roadside ditch culverts.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for storm sewers, including elliptical or box, installed by open-cut, augered with or without casing, or tunneling is on linear foot basis. Measurement for storm sewers and roadside ditch culverts will be taken along center line of pipe from center line to center line of manholes or from end to end of culverts. Payment will be made for each linear foot installed complete in place, including connections to existing manholes and inlets.

2. Payment for storm sewer leads, including elliptical leads, is on a linear foot basis.

3. Payment for corrugated metal pipe storm sewer outfall, including timber bents, is on a linear foot basis.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's literature for product specifications and installation instructions.

C. Submit proposed methods, equipment, materials, and sequence of operations for sewer construction. Plan operations to minimize disruption of utilities to occupied facilities or adjacent property.

1.04 QUALITY ASSURANCE

A. Provide manufacturer's certificate to Specifications.

B. The Condition for acceptance shall be watertight storm sewer that is watertight both in pipe-to-pipe joints and in pipe-to-manhole connections.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's recommendations.

B. Handle pipe, fittings, and accessories carefully with approved handling devices. Do not drop or roll pipe off trucks or trailers. Do not use materials cracked, gouged, chipped, dented, or otherwise damaged shall not be used materials for installation.

C. Store pipe and fittings on heavy timbers or platforms to avoid contact with ground.

D. Unload pipe, fittings, and appurtenances as close as practical to location of installation to avoid unnecessary handling.

E. Keep interiors of pipe and fittings free of dirt and foreign matter.

F. Store PVC pipe out of direct sunlight.

PART 2 P R O D U C T S

2.01 PIPE

A. Provide piping materials for storm sewers shall be of sizes and types specified unless otherwise indicated on Drawings.

B. In diameters where material alternatives are available, provide pipe from single manufacturer for each pipe diameter, unless otherwise approved by City Engineer or otherwise shown on Drawings.

C. Existing pipe that has been removed during construction cannot be reused.

2.02 PIPE MATERIAL SCHEDULE

A. Use pipe materials that conform to requirements specified in one or more of the following sections as shown on the Drawings.

1. 02611 - Reinforced Concrete Pipe.

2. Section 02641 - Monolithic Reinforced Concrete Sewers.

3. Section 02612 - Precast Reinforced Concrete Box Sewers.

4. Section 02642 - Corrugated Metal Pipe use only where Corrugated Metal Pipe is shown on Drawings.

5. Section 02509 – Thermoplastic Plastic Pipe and Drains

B. Provide pipe meeting minimum class, dimension ratio, or other criteria indicated.

C. Pipe materials other than those listed above shall not be used for storm sewers.

2.03 BEDDING, BACKFILL, AND TOPSOIL MATERIAL

A. Bedding and Backfill Material: Conform to requirements of Sections 02317 - Excavation and Backfill for Utilities, Section 02320 - Utility Backfill Material, and Section 2321 - Cement Stabilized Sand.

B. Topsoil: Conform to requirements of Section 02911 - Topsoil.

C. Use cement stabilized sand material for bedding and backfill in the pipe zone for all storm sewers.

D. Above the pipe zone, use select backfill material up to pavement for storm sewers larger than 36 inches in diameter

PART 3 E X E C U T I O N

3.01 PREPARATION

A. Prepare traffic control plans and set up street detours and barricades in preparation for excavation when construction will affect traffic. Conform to requirements of Section 01555- Traffic Control and Regulation.

B. Provide barricades, flashing warning lights, and signs for excavations. Conform to requirements of Section 01555 - Traffic Control and Regulation. Maintain barricades and warning lights for streets and intersections while Work is in progress or where traffic is affected by Work.

C. Immediately notify agency or company owning utility lines, which are damaged, broken, or disturbed. Obtain approval from City Engineer and agency for repairs or relocations, either temporary or permanent.

D. Remove old pavements and structures, including sidewalks and driveways in accordance with requirements of Section 02221 - Removing Existing Pavements and Structures.

E. Install and operate dewatering and surface water control measures in accordance with Section 01578 - Control of Ground Water and Surface Water.

3.02 EXCAVATION

A. Earthwork. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities. Use bedding as indicated on Drawings.

B. Line and Grade. Establish required uniform line and grade trench from benchmarks identified by City Engineer. Maintain this control for minimum of 100 feet behind and ahead of pipe- laying operation. Use laser beam equipment to establish and maintain proper line and grade of Work. Use of appropriately sized grade boards, which are substantially, supported also acceptable.

C. Trench Excavation. Excavate pipe trenches to level as indicated on Standard Details. Backfill excavation with specified bedding material to level of lower one-third of pipe barrel. Tamp and compact backfill to provide bedding at indicated grade. Form bedding foundation to minimum depth of one-eighth of pipe diameter, but not less than 6 inches.

3.03 PIPE INSTALLATION

A. Install in accordance with pipe manufacturer's recommendations and as specified in this section.

B. Install pipe only after excavation is completed, bottom of trench is shaped, bedding material is installed, and trench has been approved by City Engineer.

C. Install pipe to line and grade indicated on Drawings. Place pipe so that it has continuous bearing of barrel on bedding material with no voids, and is laid in trench so interior surfaces of pipe follows grades and alignments indicated.

D. Install pipe with bells of pipe facing upstream of anticipated flow.

E. Form concentric joint with each section of adjoining pipe to prevent offsets.

F. Place and drive home newly laid sections with a sling or come-a-long winches to eliminate damage to sections. Unless otherwise approved by City Engineer, provide end protection to prevent damage while using backhoes or similar powered equipment to drive home newly laid sections.

G. Keep interior of pipe clean as installation progresses. Where cleaning after laying pipe is difficult because of small pipe size, use suitable swab or drag inside pipe and pull it forward past each joint immediately after joint has been completed.

H. Keep excavations free of water during construction and until final inspection.

I. When work is not in progress, cover exposed ends of pipes with pipe plug specifically designed to prevent foreign material from entering pipe.

J. For PVC Pipe:

1. Provide a minimum cover as per City Standard detail from top of pavement to top of pipe, but no less than 2 feet below ditch flowline.

2. Accomplish transitions to different material of pipe in a manhole or inlet box. No adapter, coupling for dissimilar pipe, or saddle connections allowed.

3. Provide pipe sections in standard lengths with minimum length of 13 feet. Pipe may be field modified to shorten length no less than 4 feet, unless otherwise approved by City Engineer. Field modify pipe per manufacturer's recommendations.

4. No beveling at joint allowed. Cut to be perpendicular to longitudinal axis.

5. Provide gasketed bell and spigot joints installed per manufacturer's recommendations. Gasketed pipe joints; clean and free of debris, show no leakage after installation.

3.04 PIPE INSTALLATION OTHER THAN OPEN CUT

A. Conform to requirements of Section 02448 - Pipe and Casing Augering for Sewers where required.

B. Conform to requirements of Section 02441 - Microtunneling and Pipe-Jacking Tunnels where required.

C. Not allowed for plastic sewer pipe.

3.05 INSTALLATION OF APPURTENANCES

A. Construct manholes to conform to requirements of Sections 02081 - Cast-in-place Concrete Manholes, Section 02082 - Precast Concrete Manholes, and Section 2087 - Brick Manholes for Storm Sewers. Install frames, grate rings, and covers to conform to requirements of Section 02084 - Frames, Grates, Rings, and Covers.

B. Install pipe culverts with approved end treatments. Approved end treatments include concrete headwalls, wingwalls and collars. Refer to City Standards detail for end treatment requirements.

C. Install inlets, headwalls, and wingwalls to conform to requirements of Section 02632 - Cast- in-place Inlets, Headwalls, and Wingwalls and Section 02633 - Precast Concrete Inlets, Headwalls, and Wingwalls.

D. Rehabilitate existing manholes to conform to requirements of Section 02555 - Manhole Rehabilitation. Adjust manhole covers and inlets to grade conforming to requirements of Section 02086 - Adjusting Manholes, Inlets, and Valve Boxes to Grade.

E. Dimension for Type C and Type E manholes shall be as shown on Drawings.

3.06 INSPECTION AND TESTING

A. Perform post installation television inspection in accordance with Section 02531 - Gravity Sanitary Sewers.

B. Mandrel Testing. Perform a mandrel test in accordance with Section 02533 - Acceptance Testing for Sanitary Sewers.

C. Pipe & Joint Leakage Test. Perform low-pressure air test or water test (an exfiltration test) in Section 02533 - Acceptance Testing for Sanitary Sewers.

3.07 BACKFILL AND SITE CLEANUP

A. Backfill trench after pipe installation is inspected and approved by City Engineer.

B. Backfill and compact soil in accordance with Section 02317 - Excavation and Backfill for Utilities.

C. Repair and replace removed or damaged pavement and sidewalks as specified in Section 02951 - Pavement Repair and Resurfacing.

D. In unpaved areas, grade surface as uniform slope to natural grade as indicated on Drawings. Provide minimum of 4 inches of topsoil and seed according to requirements of Section 02921—Hydromulch Seeding, or Section 02922 - Sodding, as required.

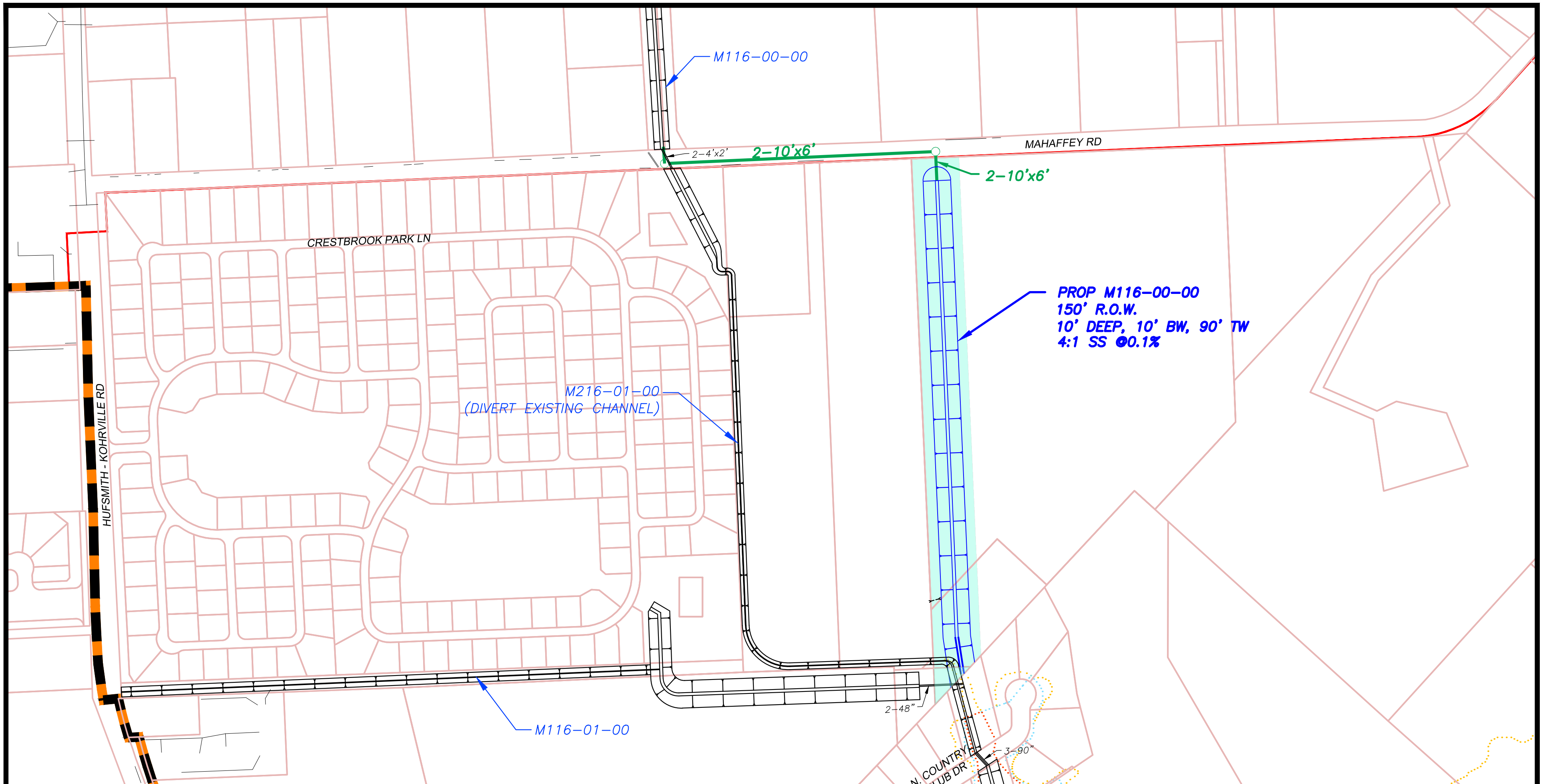
END OF SECTION

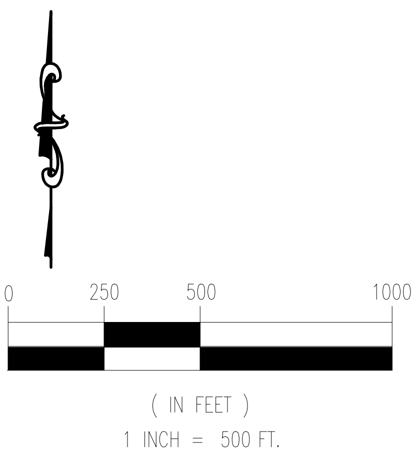
APPENDIX C

CIP PACKETS

APPENDIX C – M116

CIP PACKETS





DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YEAR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. LAND ACQUISITION (ESMT) = 264,757 SF

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M116-00-00
SUBBASIN: A

SCALE: 1" = 500'	March 2025
EXHIBIT NO. 1A & 1B	M116 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M116**	CIP Project No.	**1A**	Phase	
Project Name	M116-00-00 Diversion				
Project Category					

Project Description

Channel diversion and construction to provide appropriate conveyance capacity.

Project Justification

Channel capacity constraints due to inadequate right-of-way and easement.

Potential Funding Opportunities

Participation from HCFCD and Harris County Precinct 3

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*M116-00-00*	*1750*	*LF*	*$ 410*	*$ 717,500*
				SUBTOTAL	*$ 717,500*
		CONTINGENCY		*30%*	*$ 215,250*
		CONSULTANT		*25%*	*$ 179,375*
2	*LAND ACQUISITION (FEE)*	*6.08*	*AC*	*$ 217,800*	*$ 1,323,783*
				SUBTOTAL	*$ 1,323,783*
		CONTINGENCY		*10%*	*$ 132,378*
				ESTIMATED PROJECT TOTAL COST:	**$ 2,568,286**

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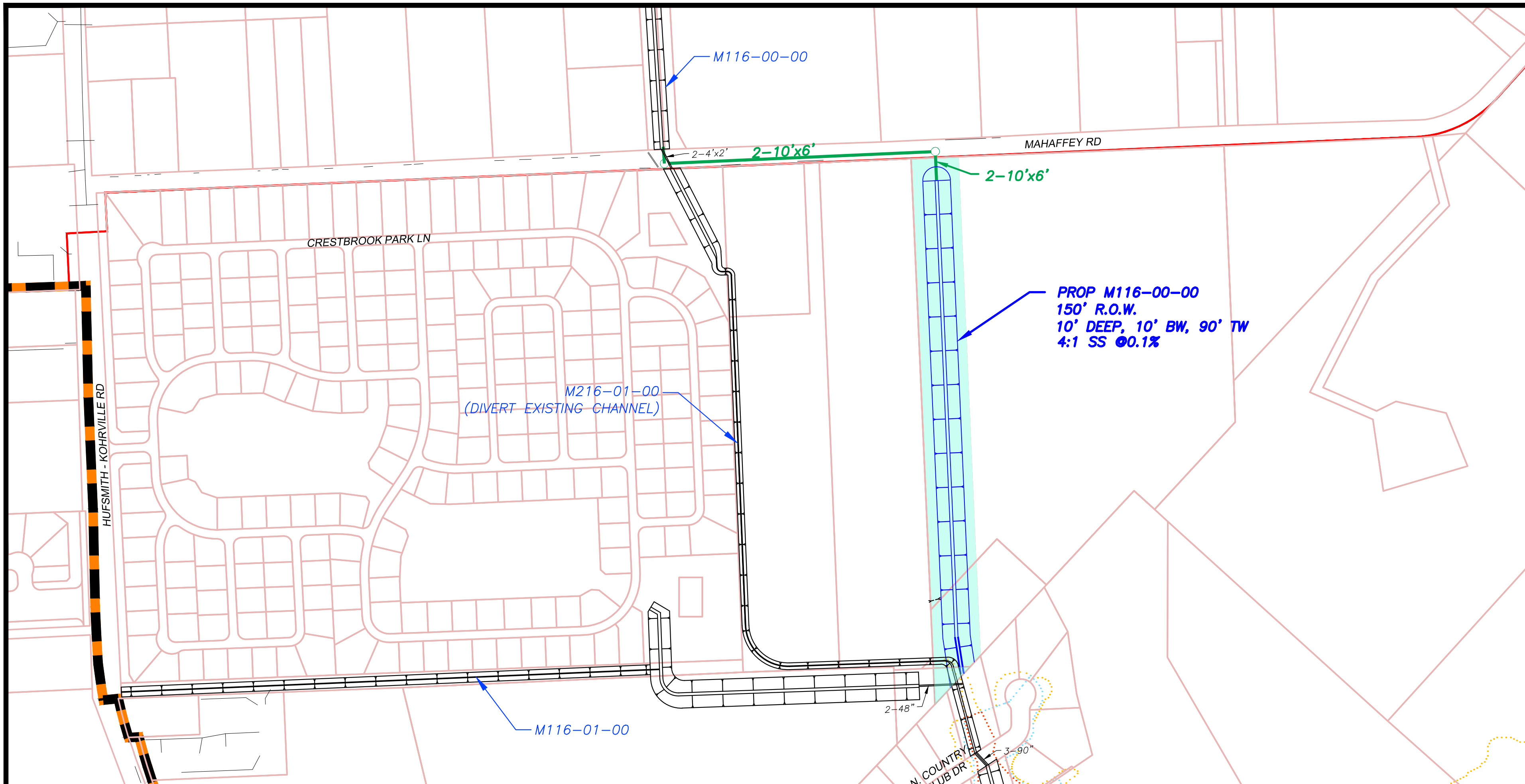

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YEAR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. LAND ACQUISITION (ESMT) = 264,757 SF

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS — FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M116-00-00
SUBBASIN: A

SCALE: 1" = 500'	March 2025
EXHIBIT NO. 1A & 1B	M116 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M116**	CIP Project No.	**2**	Phase	
Project Name	FM 2920 & FM 2978/Hufsmith-Kohrville Culverts				
Project Category					

Project Description

Construct cross culvert under Hufsmith-Kohville Road along south side of FM 2920 and FM 2978 along the north side of FM 2920.

Project Justification

Provide outfall for westbound and eastbound FM 2920 roadside ditches.

Potential Funding Opportunities

TxDOT

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	475	LF	$ 130	$ 61,750
2	STM MH (SM)	1	EA	$ 6,000	$ 6,000
3	24" SET	3	EA	$ 5,000	$ 15,000
4	PAVEMENT REPAIR - CONC	475	LF	$ 140	$ 66,500
				SUBTOTAL	$ 149,250
		CONTINGENCY		30%	$ 44,775
		CONSULTANT		25%	$ 37,313
				ESTIMATED PROJECT TOTAL COST:	**$ 231,338**

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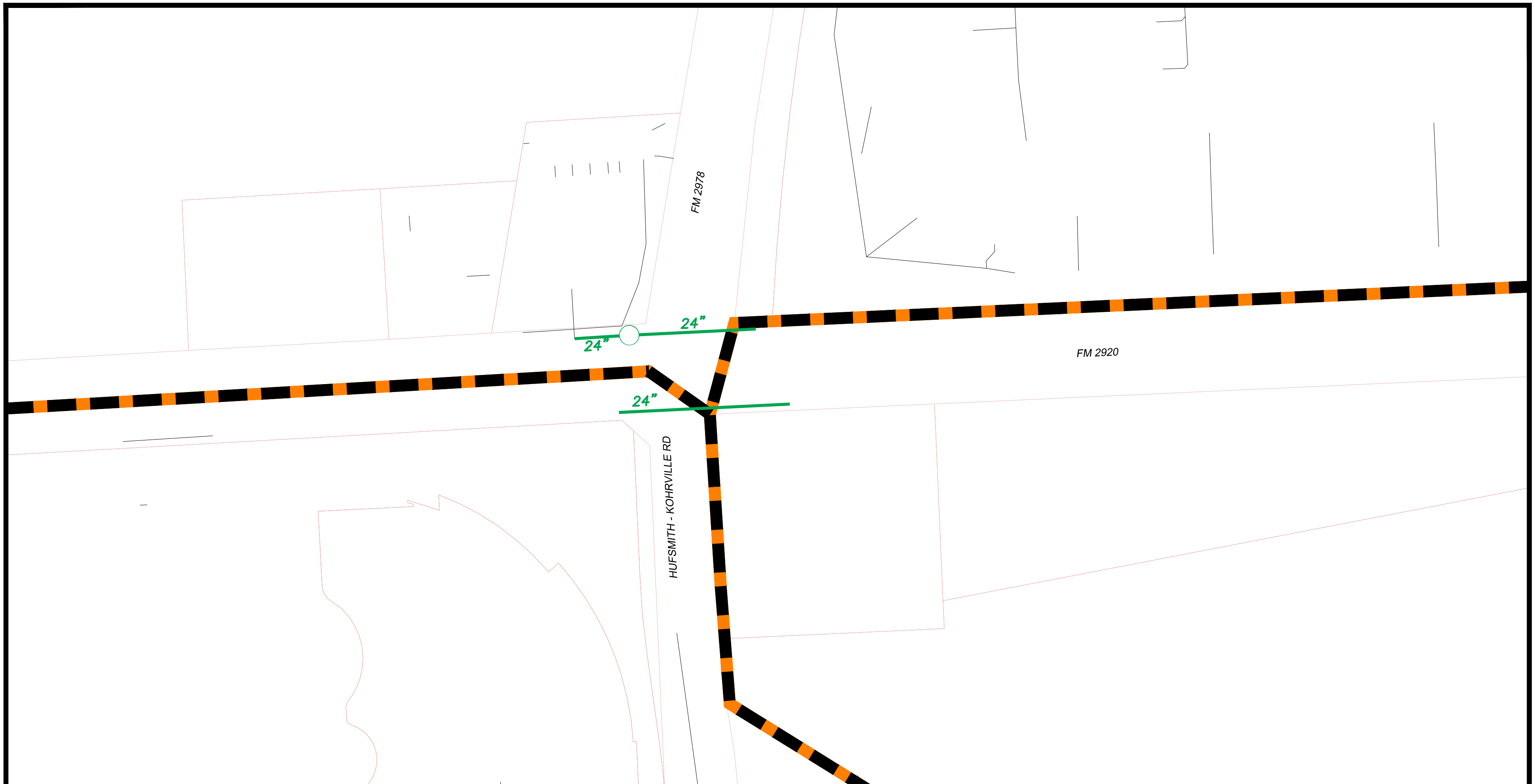

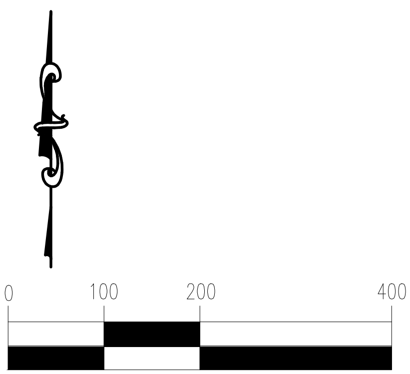

(IN FEET)

1 INCH = 200 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M116-00-00
SUBBASIN: A

SCALE: 1" = 200'	March 2025
EXHIBIT NO. 2	M116 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M116**	CIP Project No.	**1B**	Phase	
Project Name		Mahaffey Road Storm Sewer			
Project Category					

Project Description

Construct storm sewer along Mahaffey Road to connect upstream M116-00-00 to M116-00-00 diverted channel.

Project Justification

Increase culvert crossing level of service.

Potential Funding Opportunities

Harris County Precinct 3 and HCFCD potential contribution.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*10'x6' RCB*	*2050*	*LF*	*$ 1,450*	*$ 2,972,500*
2	*STM JB (LG)*	*4*	*EA*	*$ 23,500*	*$ 94,000*
3	*DITCH INTERCEPTOR*	*4*	*EA*	*$ 9,100*	*$ 36,400*
4	*PAVEMENT REPAIR - ASP*	*950*	*LF*	*$ 140*	*$ 133,000*
				SUBTOTAL	*$ 3,235,900*
		CONTINGENCY		*30%*	*$ 970,770*
		CONSULTANT		*25%*	*$ 808,975*
				ESTIMATED PROJECT TOTAL COST:	**$ 5,015,645**

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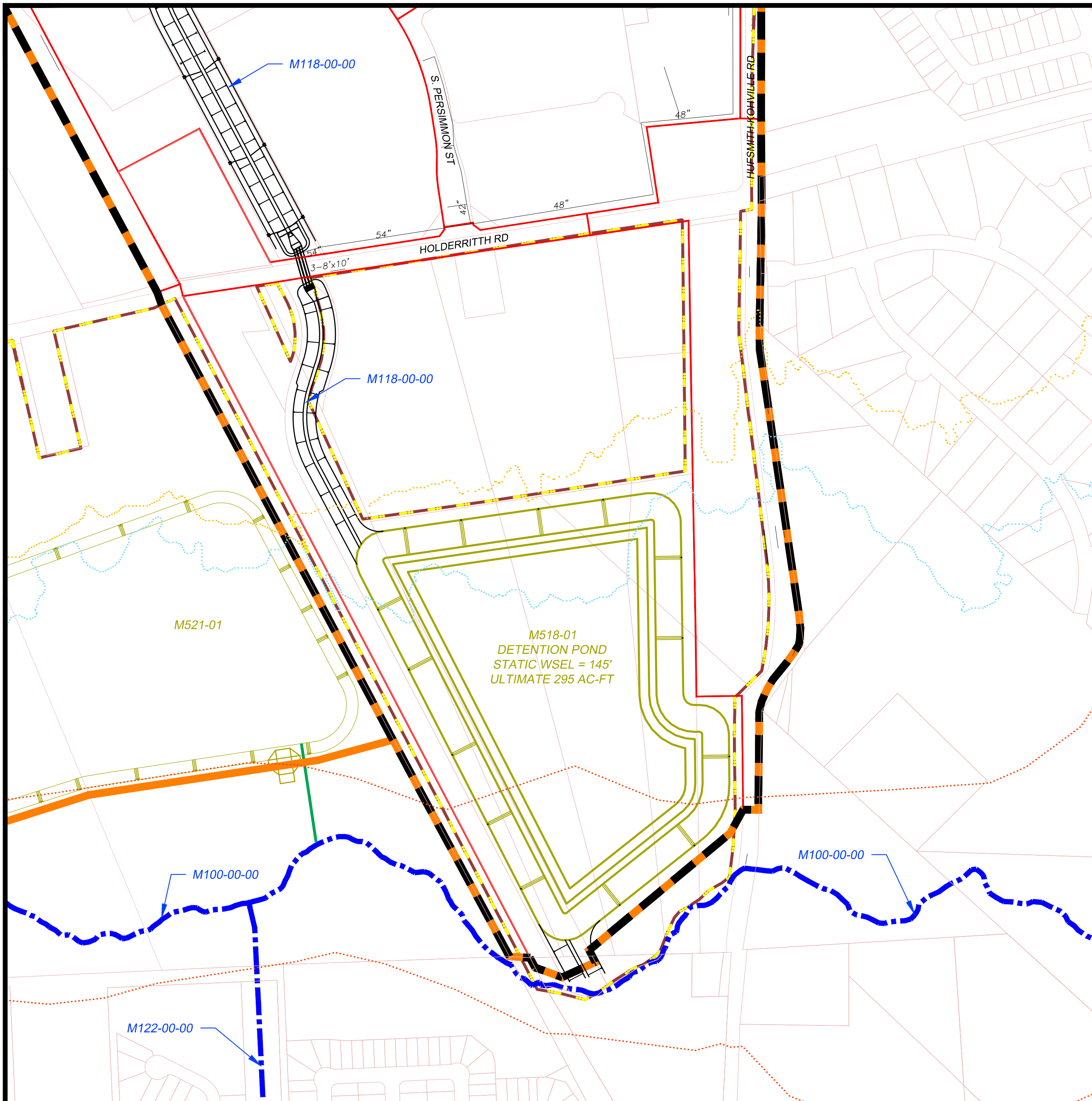
APPENDIX C – M118

CIP PACKETS



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118-00-00
SUBBASIN: B

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 1	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.	**1**	Phase	
Project Name	M518-01 Detention Pond				
Project Category					

Project Description

Complete excavation, bank construction and final stabilization of the wet-bottom regional detention pond to achieve ultimate storage capacity of 295 acre-feet to serve the entire M118 Basin.

Project Justification

Regional detention pond ultimate storage volume required for full development of the M118 Basin.

Potential Funding Opportunities

Tomball Economic Development Corporation funding assistance.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*M518-01*	*45*	*AC-FT*	*$ 40,000*	*$ 1,800,000*
				SUBTOTAL	*$ 1,800,000*
		CONTINGENCY		*30%*	*$ 540,000*
		CONSULTANT		*25%*	*$ 450,000*
				ESTIMATED PROJECT TOTAL COST:	**$ 2,790,000**

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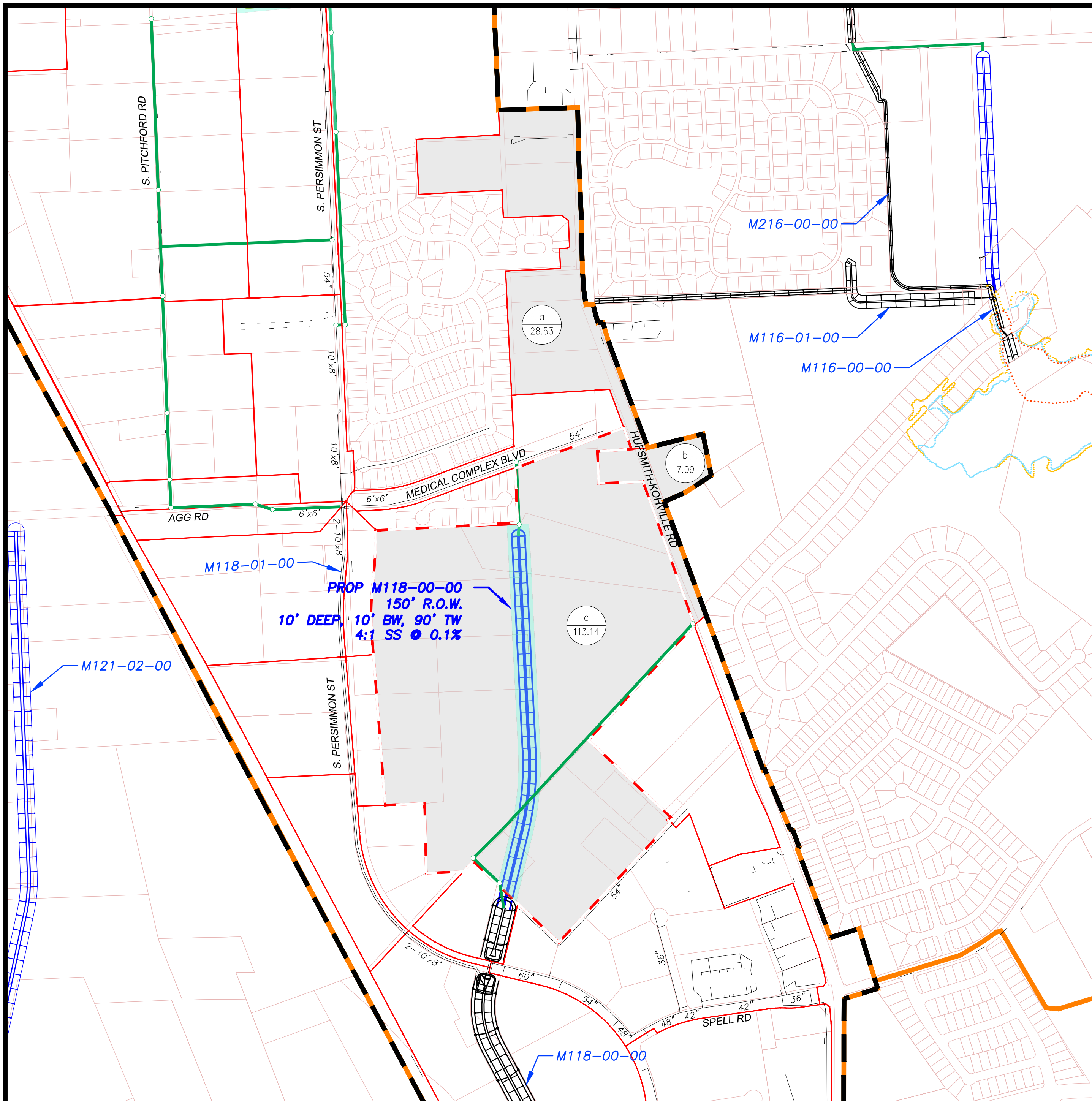

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 381,685 SF

0 500 1000 2000

(IN FEET)

1 INCH = 1000 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS — FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118-00-00
SUBBASIN: A1

SCALE: 1" = 1" = 1000'	March 2025
EXHIBIT NO. 2	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.	**2**	Phase	
Project Name		M118-00-00 Channel Extension to Medical Complex Blvd			
Project Category					

Project Description

Acquire right-of-way and construct the upper reach of M118-00-00 channel from the Tomball Business and Technology Park to Medical Complex Drive to provide outfall depth and 100-year conveyance.

Project Justification

Provide an outfall for upper reaches of the basin outside the service area of the M118-01-00 (S. Persimmon) storm sewer system. Provide hydraulic connection to Medical Complex Drive (M118 CIP 3)/

Potential Funding Opportunities

Private development.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	M118-00-00	2650	LF	$ 410	$ 1,086,500
				SUBTOTAL	$ 1,086,500
		CONTINGENCY		30%	$ 325,950
		CONSULTANT		25%	$ 271,625
2	LAND ACQUISITION (FEE)	8.76	AC	$ 217,800	$ 1,908,425
				SUBTOTAL	$ 1,908,425
		CONTINGENCY		10%	$ 190,843
				ESTIMATED PROJECT TOTAL COST:	**$ 3,783,343**

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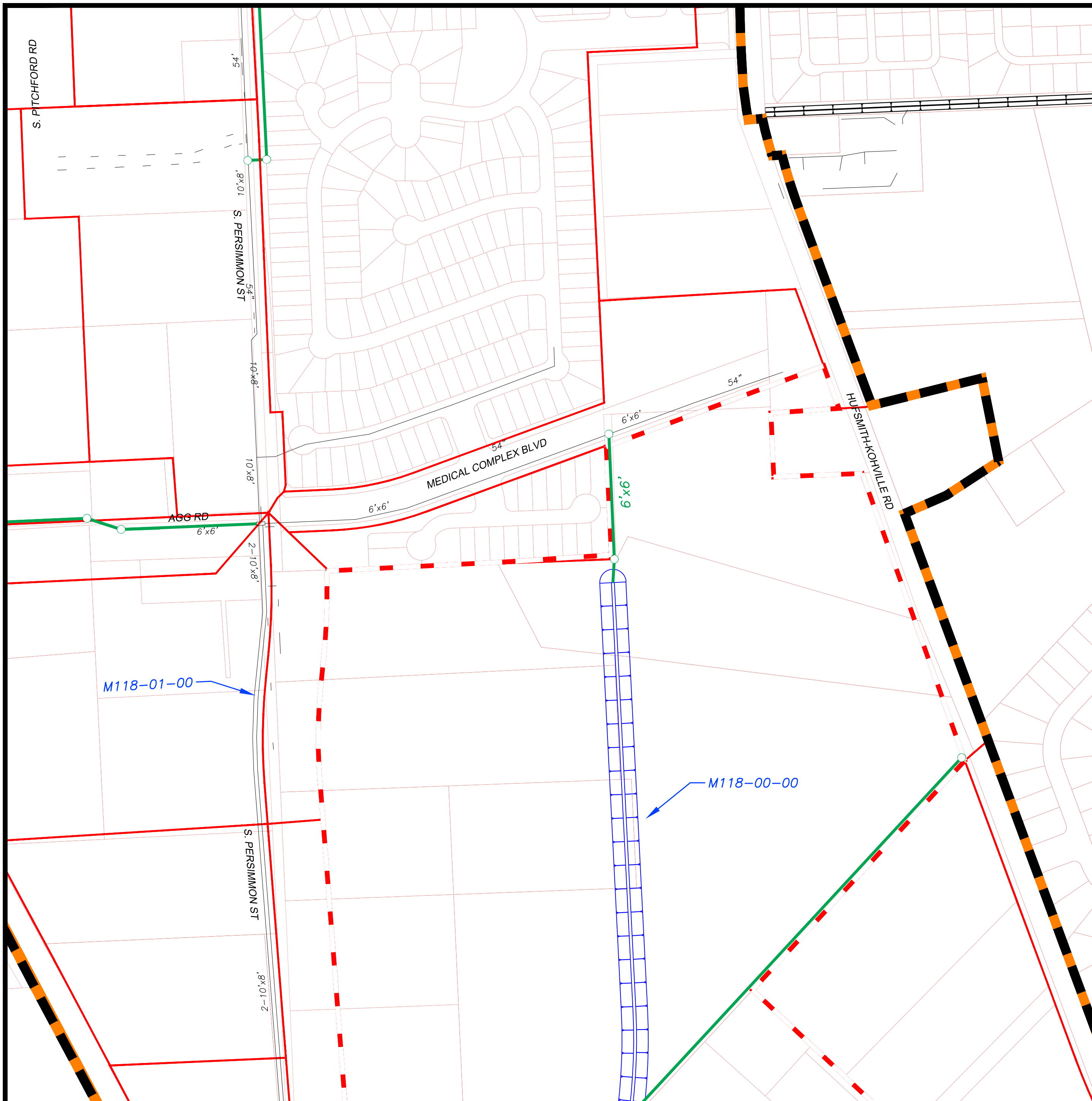

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 0 SF

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A ← DRAINAGE AREA ID

50.0 ← DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118-00-00
SUBBASIN: MC_E1

SCALE: 1" = 1" = 500'	March 2025
EXHIBIT NO. 3	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.	**3**	Phase	
Project Name		Medical Complex Blvd Storm Sewer Extension to M118-00-00			
Project Category					

Project Description

Construct new storm sewer from Medical Complex Drive to the head of M118-00-00 (M118 CIP #2) within an unimproved right-of-way.

Project Justification

The storm sewer will provide a secondary outfall for the M118-01-01 trunkline and function as split flow between M118-01-00 and M118-00-00 in an effort to relieve the existing conveyance system along S. Persimmon Street.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	6'x6' RCB	500	LF	$ 820	$ 410,000
2	STM JB (LG)	2	EA	$ 23,500	$ 47,000
3	OUTFALL TIE-IN	1	EA	$ 10,000	$ 10,000
				SUBTOTAL	$ 467,000
		CONTINGENCY		30%	$ 140,100
		CONSULTANT		25%	$ 116,750
				ESTIMATED PROJECT TOTAL COST:	**$ 723,850**

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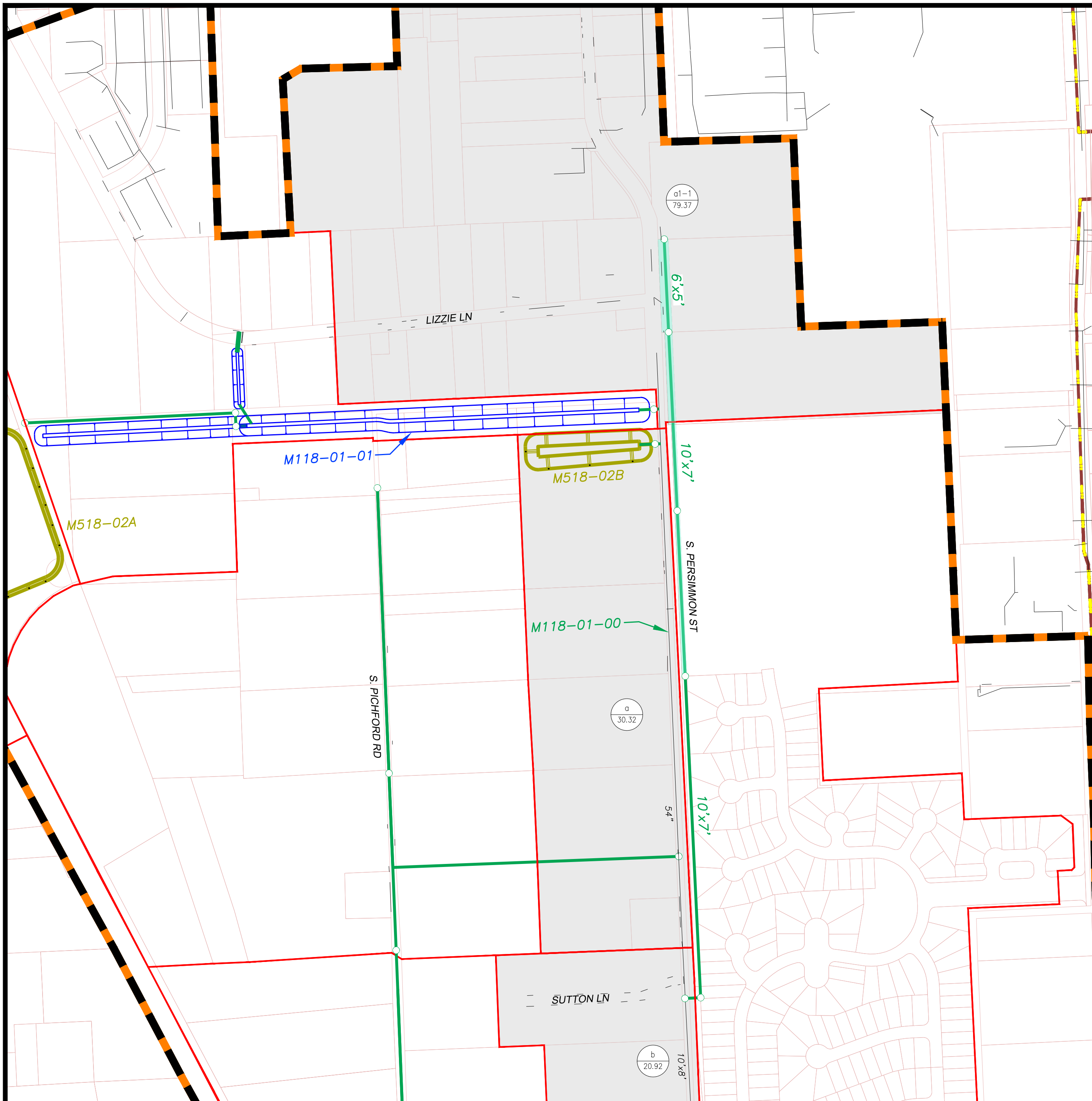

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 48,418 SF

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118-00-00
SUBBASIN: N_1, N_2WB, N_EW

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 4	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.		**4**	Phase	
Project Name	M118-00-00 (S. Persimmon)Storm Sewer Extension to Lizzie Lane				
Project Category					

Project Description

Utilizing the existing 54-inch storm sewer previously installed, extend a parallel storm sewer trunkline along S. Persimmon Street from the termination of a 10'x8' RCB (near Sutton Lane) to north of Lizzie Lane.

Project Justification

The storm sewer will provide additional conveyance capacity to upper reaches of the basin such to utilize the regional detention within M518-01.

Potential Funding Opportunities

Improvements are assumed to take place with roadway reconstruction and expansion, thereofre land acqusitions is excluded from cost estimate.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	6'x5' RCB	360	LF	$ 750	$ 270,000
2	10'x7' RCB	2760	LF	$ 1,525	$ 4,209,000
3	STM JB (MED)	1	EA	$ 12,000	$ 12,000
4	STM JB (LG)	5	EA	$ 23,500	$ 117,500
5	CURB INLET	36	EA	$ 8,600	$ 309,600
6	OUTFALL TIE-IN	1	EA	$ 10,000	$ 10,000
				SUBTOTAL	$ 4,928,100
		CONTINGENCY		30%	$ 1,478,430
		CONSULTANT		25%	$ 1,232,025
				ESTIMATED PROJECT TOTAL COST:	**$ 7,638,555**

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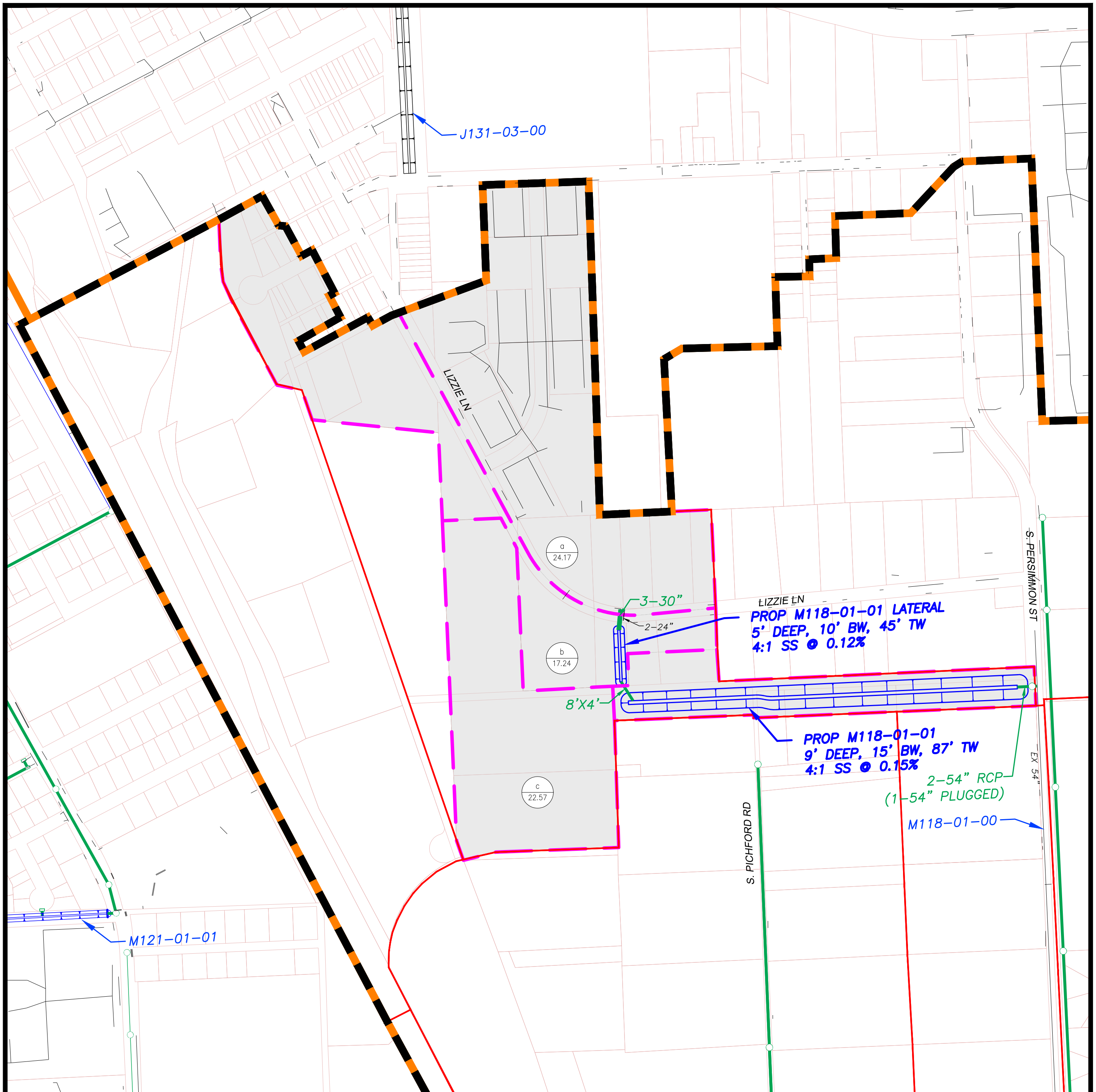

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) =0 SF

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118 (M118-01-00)
SUBBASIN: N_1WB

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 5	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.	**5**	Phase	
Project Name	M118-01-01 Channel Improvements (Phase 1)				
Project Category					

Project Description

Excavate and deepen existing City drainage channel by reconstructing outfall connection to S. Persimmon storm sewer system. Construct lateral channel from Lizzie Lane to M118-01-01 and upgrade Lizzie Lane cross culvert.

Project Justification

Provide relief for upper portions of M118 Basin, specifically Lizzie Lane.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	30" RCP	360	LF	$ 185	$ 66,600
2	54" RCP	120	LF	$ 420	$ 50,400
3	8'x4' RCB	100	LF	$ 950	$ 95,000
4	M118-01-01	1680	LF	$ 380	$ 638,400
5	M118-01-01 LATERAL	250	LF	$ 360	$ 90,000
6	PIPELINE RELOCATION	3	EA	$ 30,000	$ 90,000
7	PAVEMENT REPAIR - ASP	35	LF	$ 140	$ 4,900
				SUBTOTAL	$ 1,035,300
		CONTINGENCY		30%	$ 310,590
		CONSULTANT		25%	$ 258,825
				ESTIMATED PROJECT TOTAL COST:	**$ 1,604,715**

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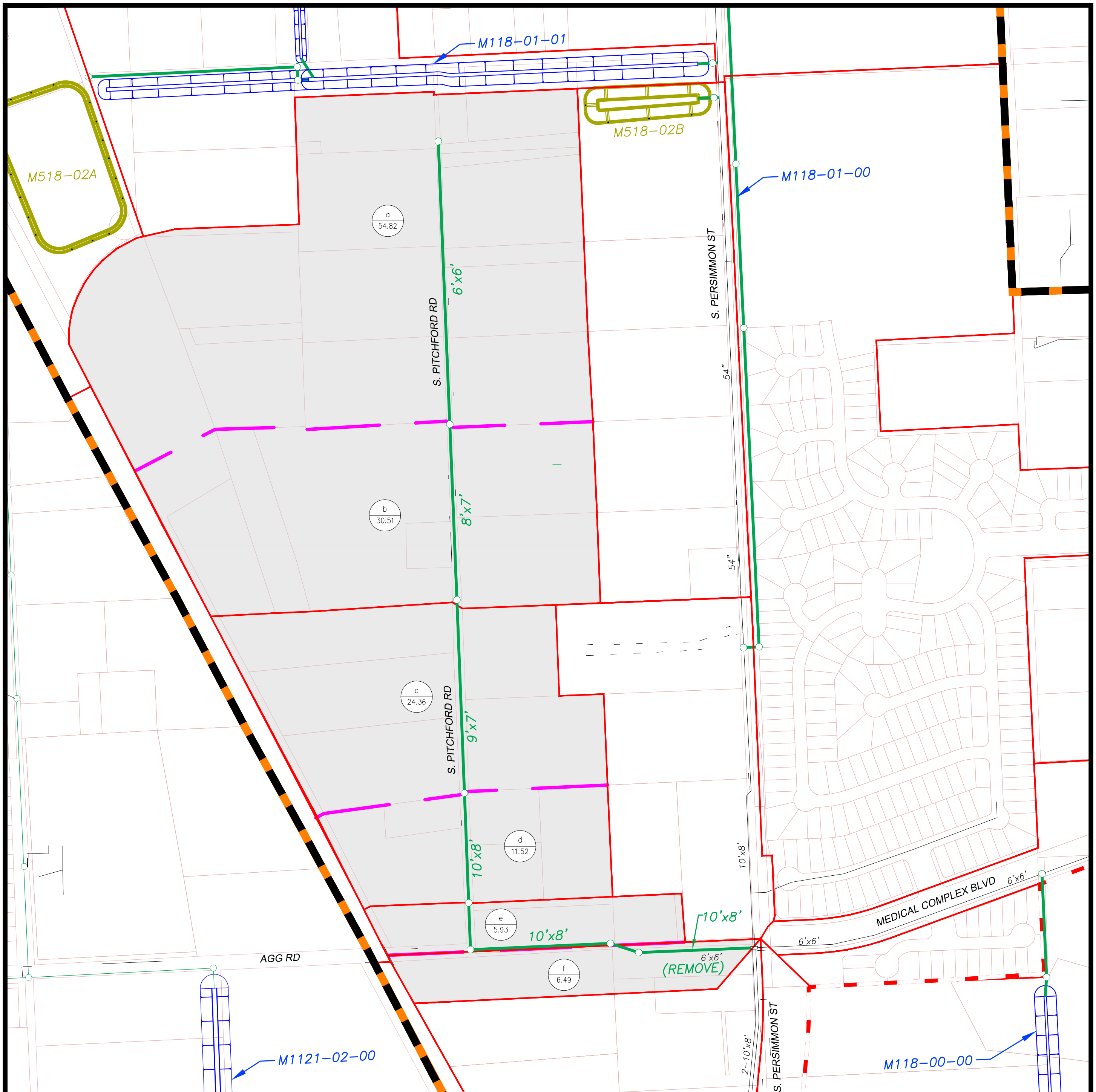

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 33,865 SF

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118-00-00
SUBBASIN: N_W2A, MC_W

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 6	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.	**6**	Phase	
Project Name	S. Pitchford Storm Sewer Extension				
Project Category					

Project Description

Construct storm sewer trunkline down S. Pitchford Road. Drainage improvements are assumed to take place with roadway reconstruction.

Project Justification

Provide conveyance for upper reaches of the M118 Basin.

Potential Funding Opportunities

Private development pro-rata contribution.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*6'x6' RCB*	*1140*	*LF*	*$ 820*	*$ 934,800*
2	*8'x7' RCB*	*720*	*LF*	*$ 1,150*	*$ 828,000*
3	*9'x7' RCB*	*780*	*LF*	*$ 1,420*	*$ 1,107,600*
4	*10'x8' RCB*	*1740*	*LF*	*$ 1,560*	*$ 2,714,400*
5	*STM MH (MED)*	*1*	*EA*	*$ 7,500*	*$ 7,500*
6	*STM JB (MED)*	*5*	*EA*	*$ 12,000*	*$ 60,000*
7	*STM JB (LG)*	*4*	*EA*	*$ 23,500*	*$ 94,000*
8	*OUTFALL TIE-IN*	*2*	*EA*	*$ 10,000*	*$ 20,000*
9	*DITCH INTERCEPTOR*	*30*	*EA*	*$ 9,100*	*$ 273,000*
10	*PAVEMENT REPAIR - ASP*	*1200*	*LF*	*$ 140*	*$ 168,000*
				SUBTOTAL	*$ 6,207,300*
		CONTINGENCY		*30%*	*$ 1,862,190*
		CONSULTANT		*25%*	*$ 1,551,825*
				ESTIMATED PROJECT TOTAL COST:	**$ 9,621,315**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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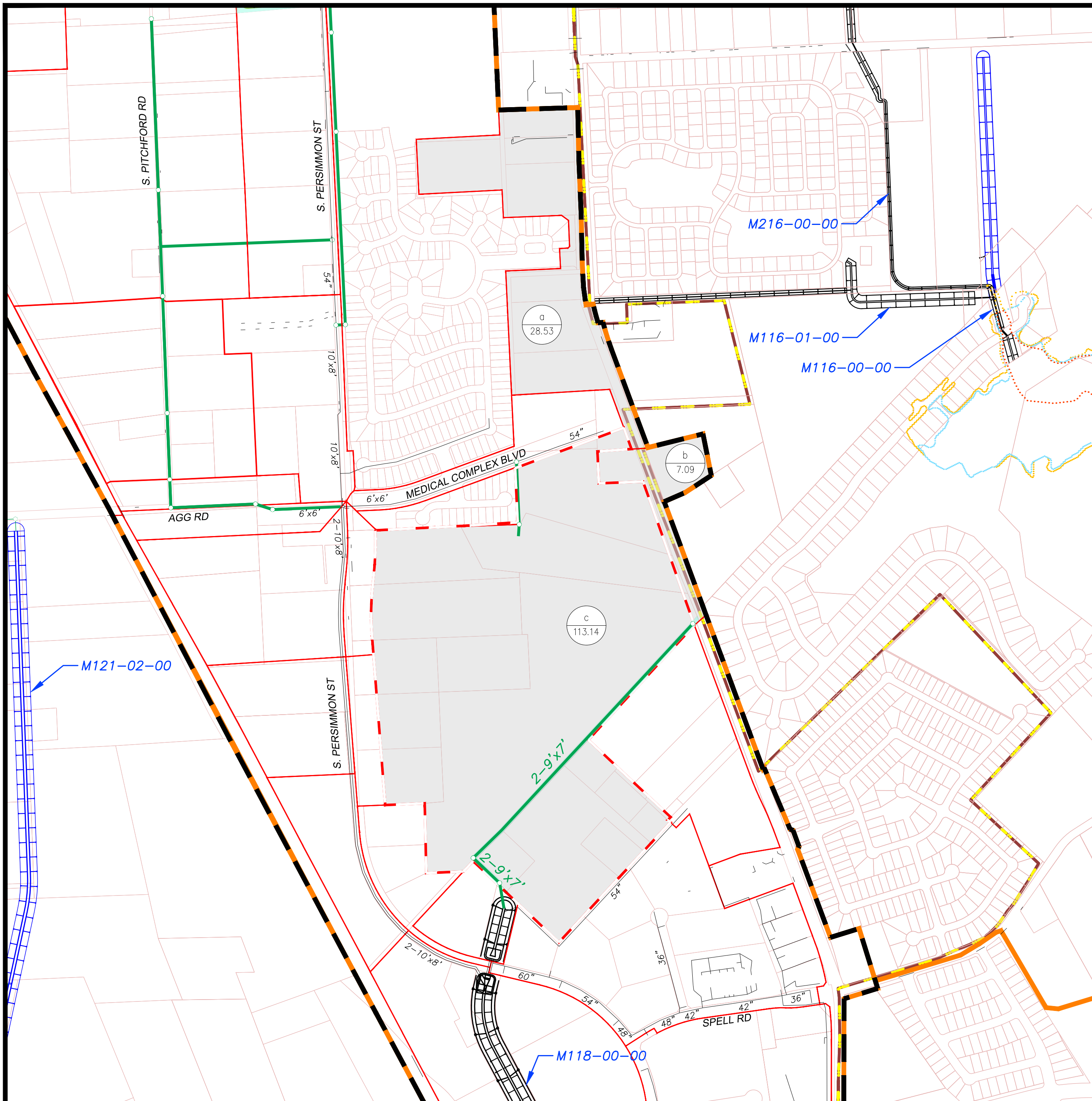
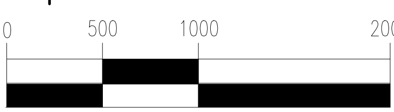


DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 76,036 SF



(IN FEET)

1 INCH = 1000 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118-00-00
SUBBASIN: HK_1, A1

SCALE: 1" = 1" = 1000'	March 2025
EXHIBIT NO. 7	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.	**7**	Phase	
Project Name		M118-00-00 Underground Alternate			
Project Category					

Project Description

Based on timing of development and widening of Hufsmith-Kohrville Road, a storm sewer trunkline may replace the M118-00-00 channel extension within the limits of an unimproved right-of-way.

Project Justification

Alternative to M118-00-00 channel construction and opportunity for stormwater outfall for Hufmsith Kohville roadway improvements.

Potential Funding Opportunities

Harris County Precinct 3 and/or private development.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	9'x7' RCB	5200	LF	$ 1,420	$ 7,384,000
2	STM JB (LG)	6	EA	$ 23,500	$ 141,000
				SUBTOTAL	$ 7,525,000
		CONTINGENCY		30%	$ 2,257,500
		CONSULTANT		25%	$ 1,881,250
3	LAND ACQUISITION (ESMT)	1.75	AC	$ 130,680	$ 228,108
				SUBTOTAL	$ 228,108
		CONTINGENCY		10%	$ 22,811
				ESTIMATED PROJECT TOTAL COST:	**$ 11,914,669**

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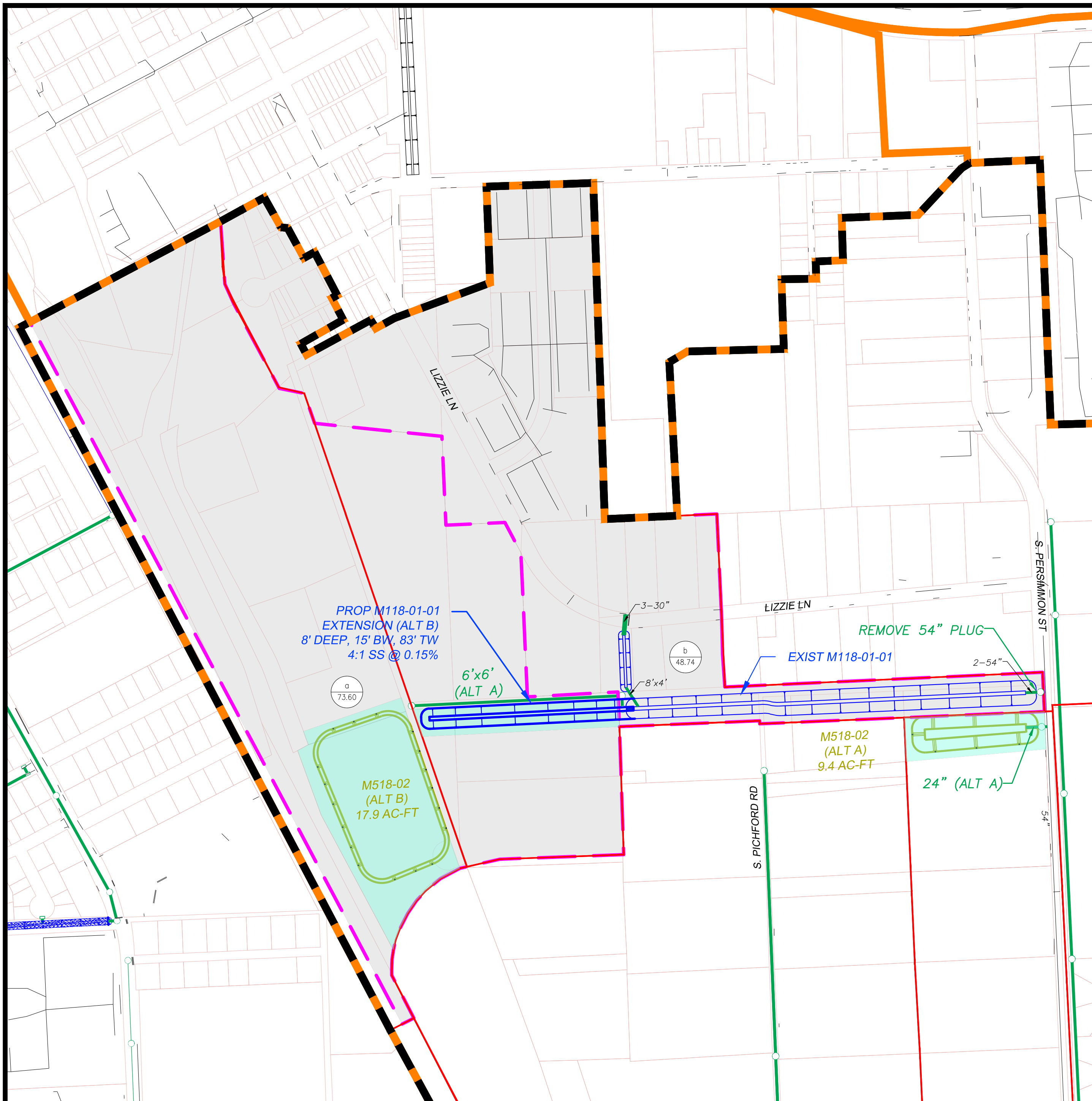

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 578,887 SF

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118 (M118-01-00)
SUBBASIN: N_1WA & N_1WB

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 8	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.	**8A**	Phase	
Project Name	M518-02 Detention Pond (Alt A)				
Project Category					

Project Description

Construct underground storm sewer from western tracts to head of M118-01-01. Construction sub-regional detention pond M518-02 and outfall structure to existing S. Persimmon St. storm sewer system.

Project Justification

Provide outfall for tract adjacent to BNSF railroad and partially mitigate increase runoff for future development.

Potential Funding Opportunities

Private development.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	90	LF	$ 130	$ 11,700
2	6'x6' RCB	960	LF	$ 820	$ 787,200
3	M518-02	9.4	AC-FT	$ 40,000	$ 376,000
4	STM MH (SM)	1	EA	$ 6,000	$ 6,000
5	OUTFALL TIE-IN	1	EA	$ 10,000	$ 10,000
6	STM JB (MED)	3	EA	$ 12,000	$ 36,000
				SUBTOTAL	$ 1,226,900
		CONTINGENCY		30%	$ 368,070
		CONSULTANT		25%	$ 306,725
7	LAND ACQUISITION (FEE)	2.22	AC	$ 217,800	$ 483,442
				SUBTOTAL	$ 483,442
		CONTINGENCY		10%	$ 48,344
				ESTIMATED PROJECT TOTAL COST:	**$ 2,433,482**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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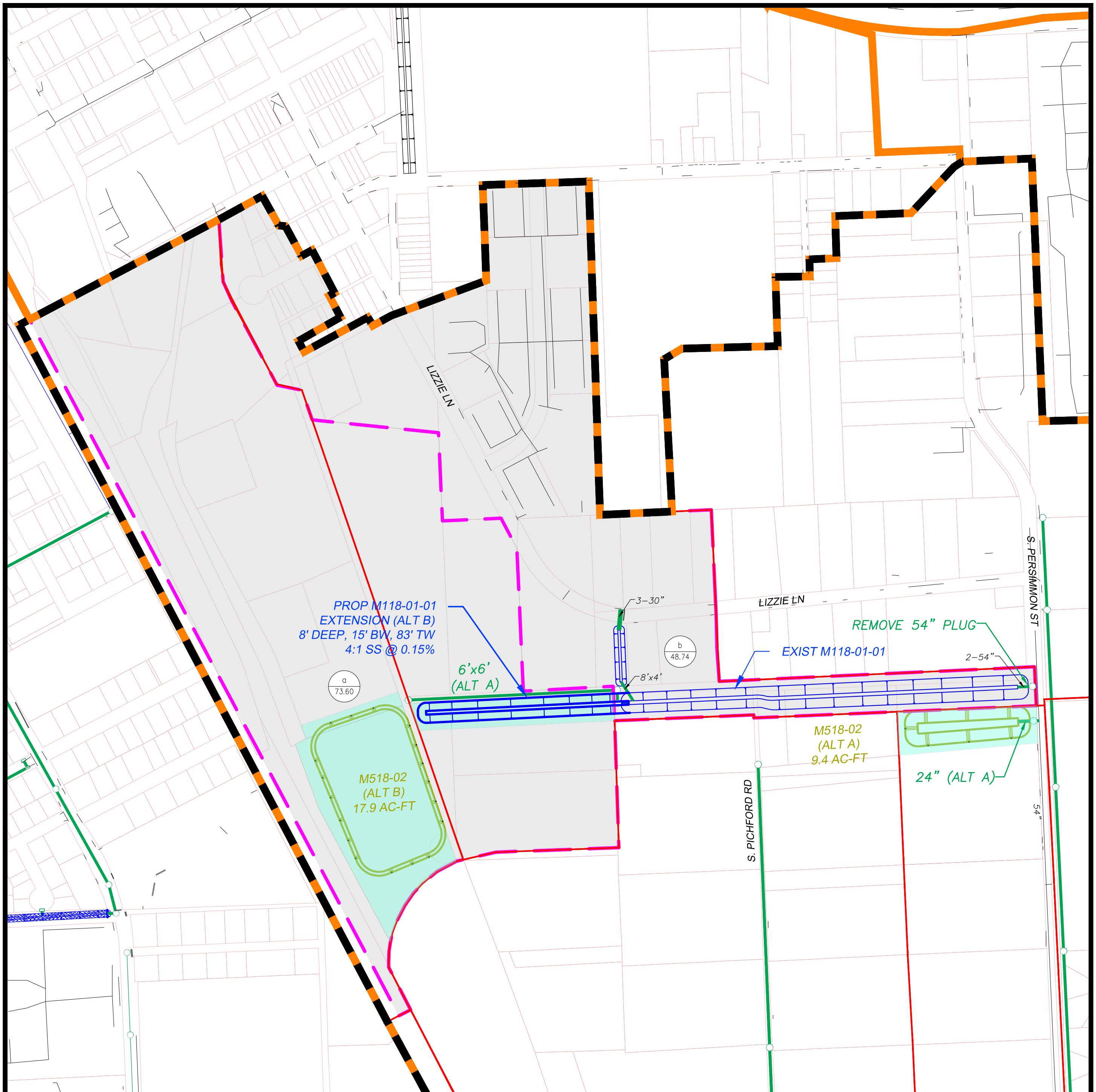

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 100-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 578,887 SF

(IN FEET)
1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A ← DRAINAGE AREA ID
50.0 ← DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M118 (M118-01-00)
SUBBASIN: N_1WA & N_1WB

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 8	M118 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M118**	CIP Project No.	**8B**	Phase	
Project Name		M118-01-01 Channel Improvements (Phase 2) and M518-02 Det. Pond (Alt B)			
Project Category					

Project Description

Extend M118-01-01 to western tract along unimproved ROW. Construct M518-02 upstream of M118-01-01.

Project Justification

Provide outfall for tract adjacent to BNSF railroad and partially mitigate increase runoff for future development.

Potential Funding Opportunities

Private development.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	M118-01-01 EXTENSION	840	LF	$ 310	$ 260,400
2	M518-02	17.9	AC-FT	$ 40,000	$ 716,000
				SUBTOTAL	$ 976,400
		CONTINGENCY		30%	$ 292,920
		CONSULTANT		25%	$ 244,100
3	LAND ACQUISITION (M118-01-01)	2.12	AC	$ 217,800	$ 462,154
4	LAND ACQUISITION (M518-02)	8.34	AC	$ 217,800	$ 1,817,263
				SUBTOTAL	$ 2,279,417
		CONTINGENCY		10%	$ 227,942
				ESTIMATED PROJECT TOTAL COST:	**$ 4,020,779**

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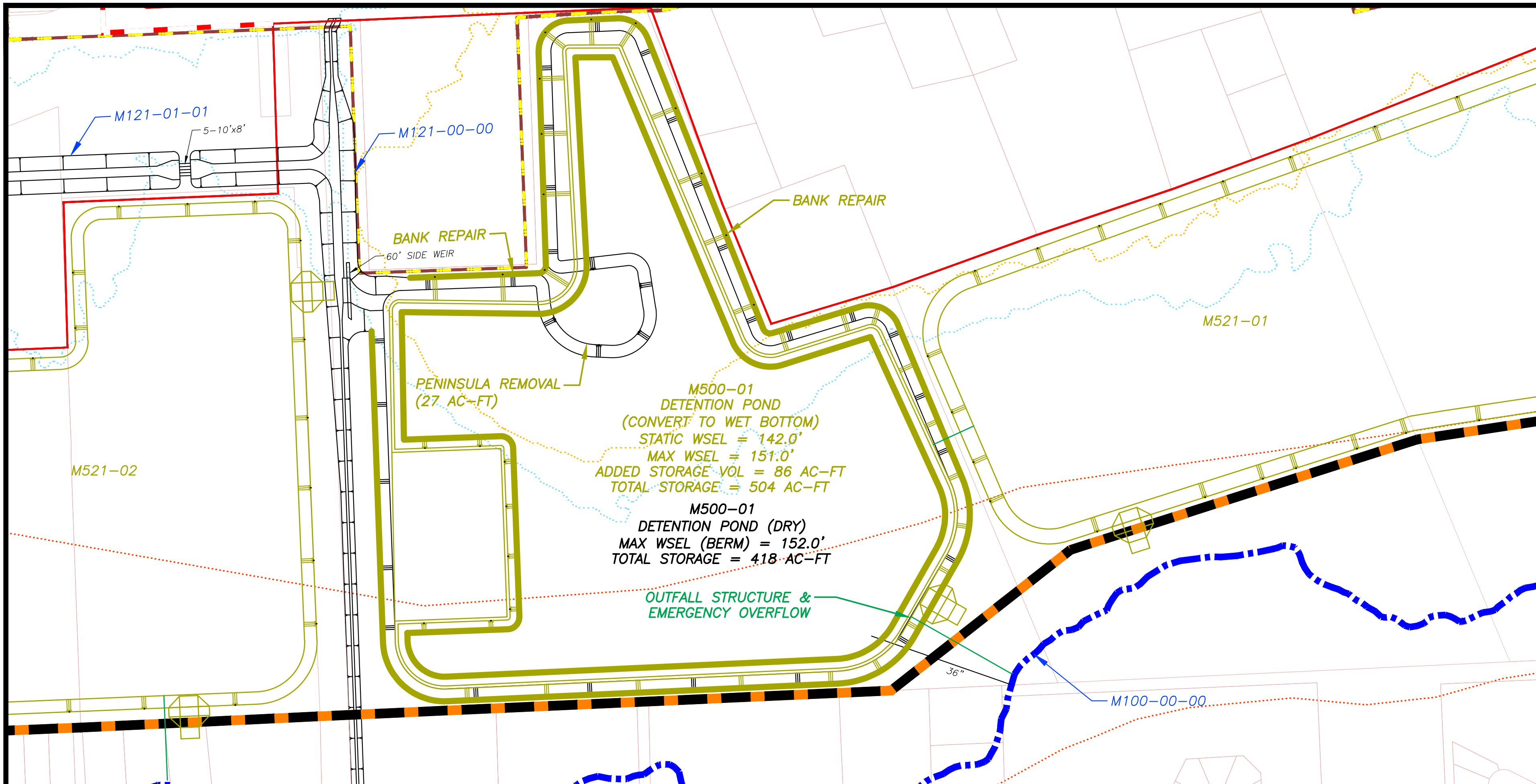
APPENDIX C – M121

CIP PACKETS



DESIGN CRITERIA

1. DESIGN STORM EVENT (DETENTION): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID
50.0 — DRAINAGE AREA IN ACRES

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121W)
SUBBASIN: HS-EIB & HS-EIC

SCALE: 1" = 500'	March 2025
EXHIBIT NO. 1	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**1**	Phase	
Project Name		M500-01 Detention Pond Excavation Ultimate Condition)			
Project Category					

Project Description

Reconstruct existing stormwater detention pond to a wet-bottom facility, including removal of existing peninsula and bank repair along northern and eastern highbanks. Install ultimate outfall to Willow Creek (M100-00-00).

Project Justification

Increase storage capacity by 86 ac-feet and complete M500-01 Stormwater Detention Basin.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*M500-01*	*86*	*AC-FT*	*$ 60,000*	*$ 5,160,000*
2	*Outfall Structure*	*1*	*EA*	*$ 25,000*	*$ 25,000*
3	*Side Weir*	*1*	*EA*	*$ 20,000*	*$ 20,000*
				SUBTOTAL	*$ 5,205,000*
		CONTINGENCY		*30%*	*$ 1,561,500*
		CONSULTANT		*25%*	*$ 1,301,250*
				ESTIMATED PROJECT TOTAL COST:	**$ 8,067,750**

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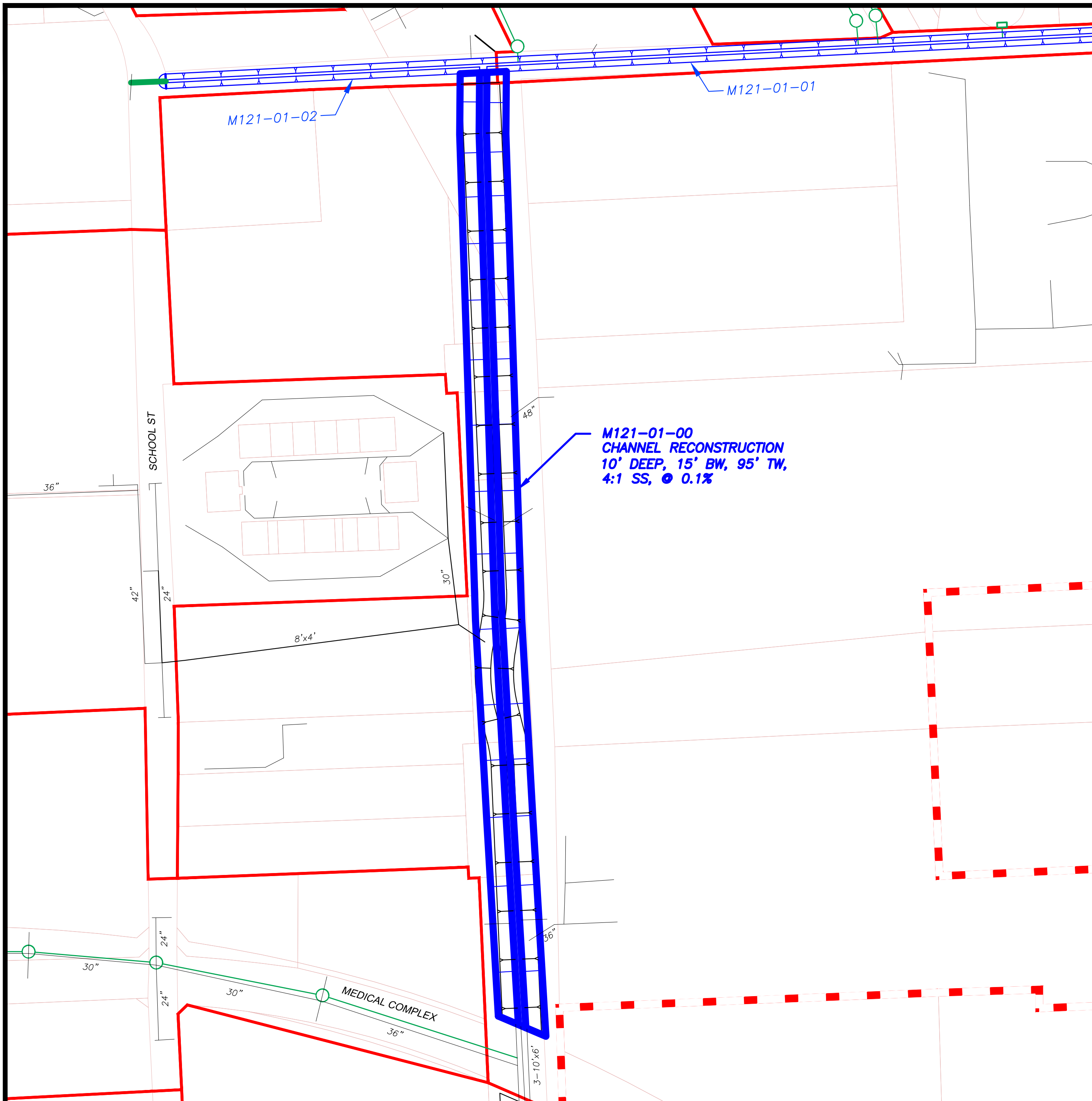

DESIGN CRITERIA

1. DESIGN STORM EVENT (CHANNEL): 100-YEAR
2. MITIGATION PROVIDED IN M500-01

0 150 300 600

(IN FEET)

1 INCH = 300 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS — FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: HS_E, HS_W, C1, & C_W

SCALE: 1" = 1" = 300'	March 2025
EXHIBIT NO. 2	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**2**	Phase	
Project Name		M121-01-00 (M121 WEST) Channel Reconstruction From Medical Complex Drive to Hardin Street			
Project Category					

Project Description

Reconstruct and reestablish channel side slopes and bottom from upstream of Medical Complex Drive crossing to head of M121-01-00 at M121-01-01 and M121-01-02 laterals.

Project Justification

Reconstruct channel reach at ultimate depth to provide outfall depth for planned upstream improvements.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*M121-01-00*	*1980*	*LF*	*$ 160*	*$ 316,800*
				SUBTOTAL	*$ 316,800*
		CONTINGENCY		*30%*	*$ 95,040*
		CONSULTANT		*25%*	*$ 79,200*
				ESTIMATED PROJECT TOTAL COST:	**$ 491,040**

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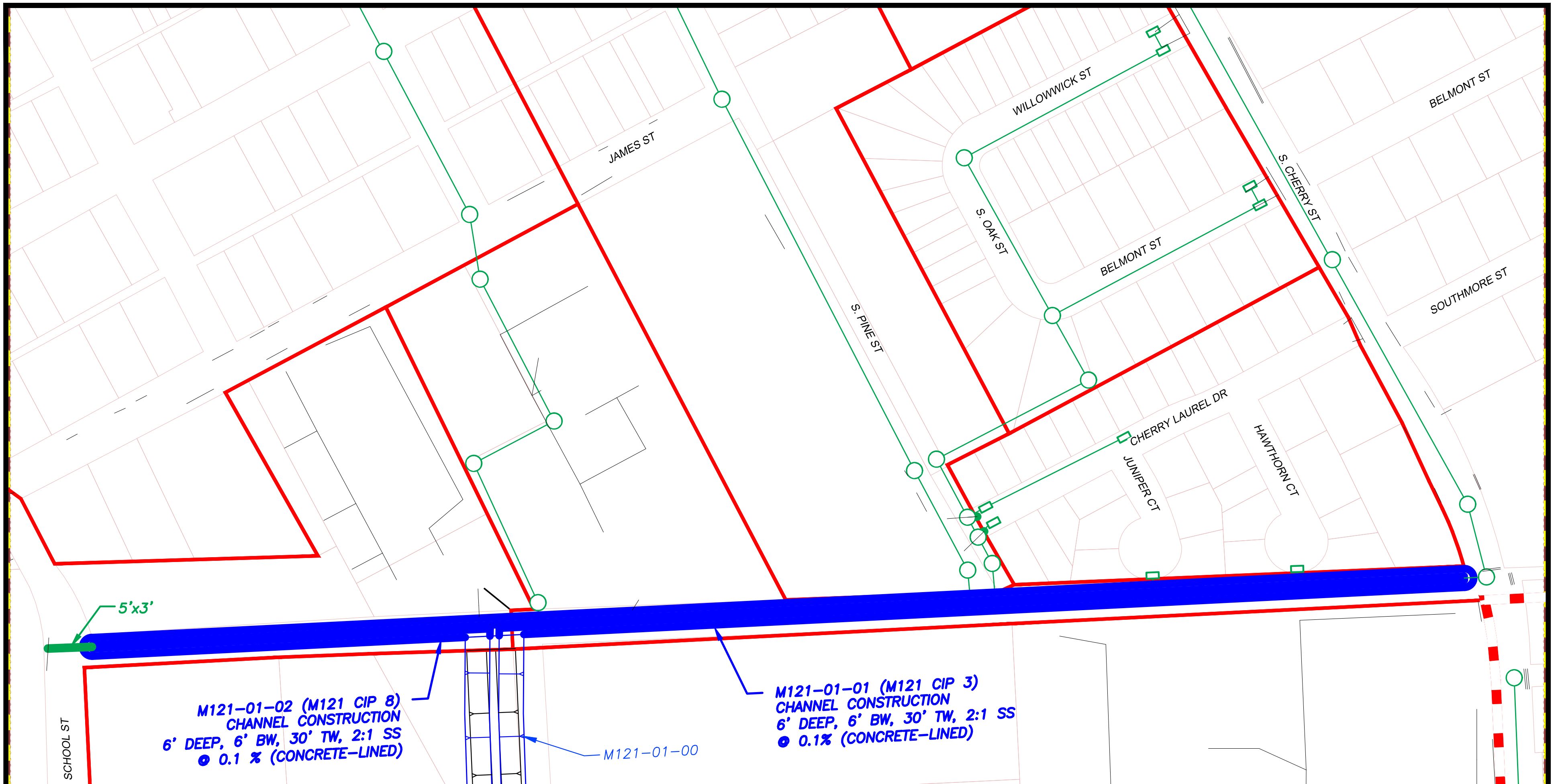
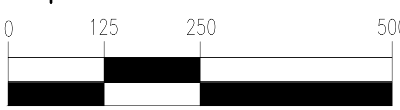


DESIGN CRITERIA

1. DESIGN STORM EVENT (CHANNEL): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. MITIGATION PROVIDED IN M500-01



(IN FEET)

1 INCH = 250 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS — FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: HS_E & HW_W

SCALE: 1" = 250'	March 2025
EXHIBIT NO. 3 & 8	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**3**	Phase	
Project Name	M121-01-01 (Hardin Street East) Channel Construction to Cherry Street				
Project Category					

Project Description

Construct eastern lateral of M121-01-00 from M121-01-00 to Cherry Street within limits of Hardin Street right-of-way. Concrete-lined channel construction proposed to limit disturbance of existing City infrastructure within Hardin Street.

Project Justification

Provide conveyance for upper reaches of M121 Basin and relieve existing flooding by providing outfall depth for upstream improvements.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*M121-01-01*	*1600*	*LF*	*$ 550*	*$ 880,000*
2	*UTILITY CONFLICTS*	*6*	*EA*	*$ 10,000*	*$ 60,000*
3	*PIPELINE RELOCATION*	*1*	*EA*	*$ 14,000*	*$ 14,000*
				SUBTOTAL	*$ 954,000*
		CONTINGENCY		*30%*	*$ 286,200*
		CONSULTANT		*25%*	*$ 238,500*
				ESTIMATED PROJECT TOTAL COST:	**$ 1,478,700**

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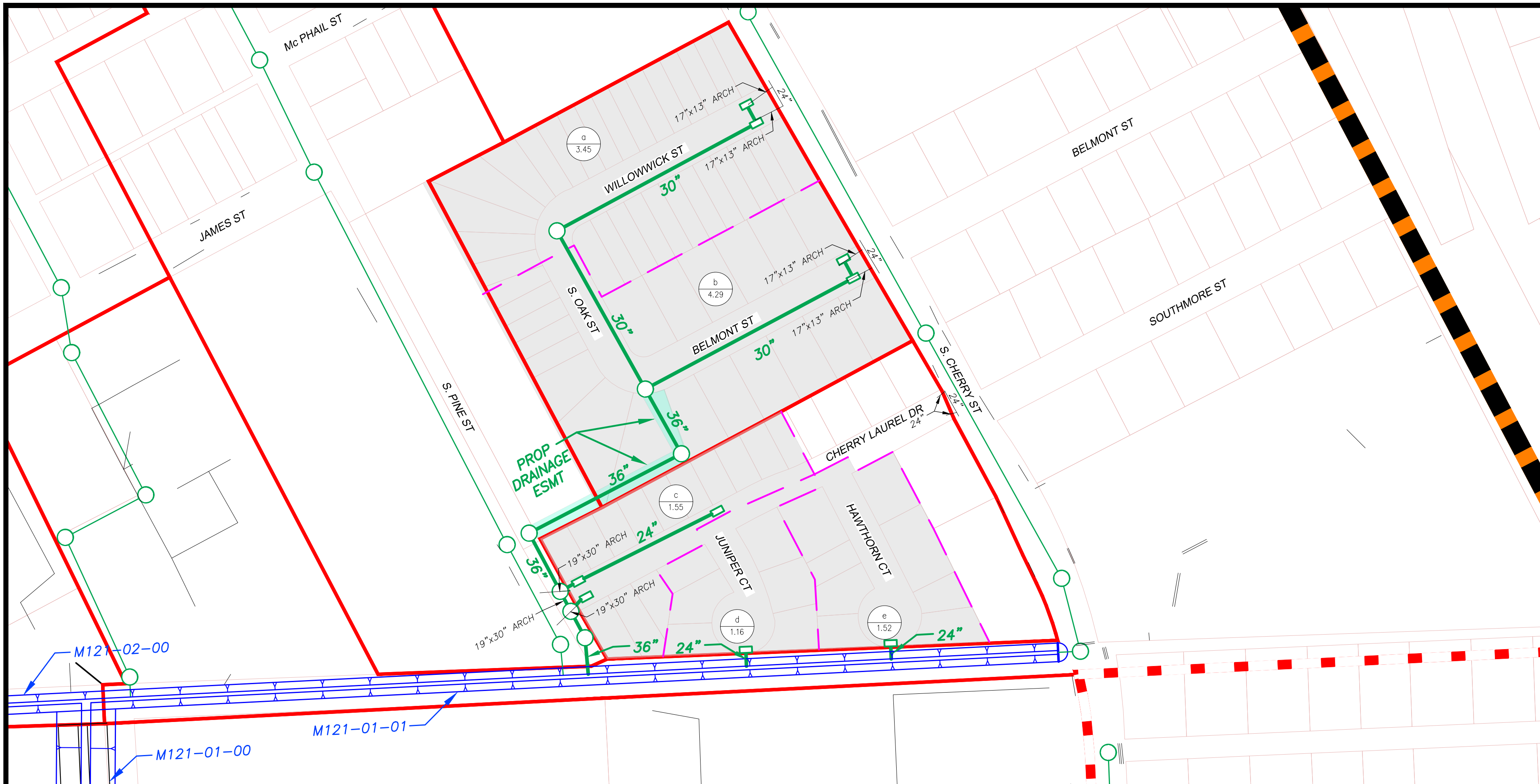

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 10,040 SF

0 125 250 500

(IN FEET)

1 INCH = 250 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: HS_E2A & HS_E2B

SCALE: 1" = 250'	March 2025
EXHIBIT NO. 4 & 5	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**4**	Phase	
Project Name	Cherry Laurel Storm Sewer Improvements				
Project Category					

Project Description

Install outfall strucutres to M121-01-01 lateral by replacing existing curb opening with standard curb inlet and storm sewer.

Project Justification

Provide local flooding relief and upgrade outfall structure to accommodate appropriate storm events.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*24" RCP*	*350*	*LF*	*$ 130*	*$ 45,500*
2	*CURB INLET (NO LEADS)*	*5*	*EA*	*$ 6,000*	*$ 30,000*
3	*PAVEMENT REPAIR - CONC*	*275*	*LF*	*$ 140*	*$ 38,500*
				SUBTOTAL	*$ 75,500*
		CONTINGENCY		*30%*	*$ 22,650*
		CONSULTANT		*25%*	*$ 18,875*
				ESTIMATED PROJECT TOTAL COST:	**$ 117,025**

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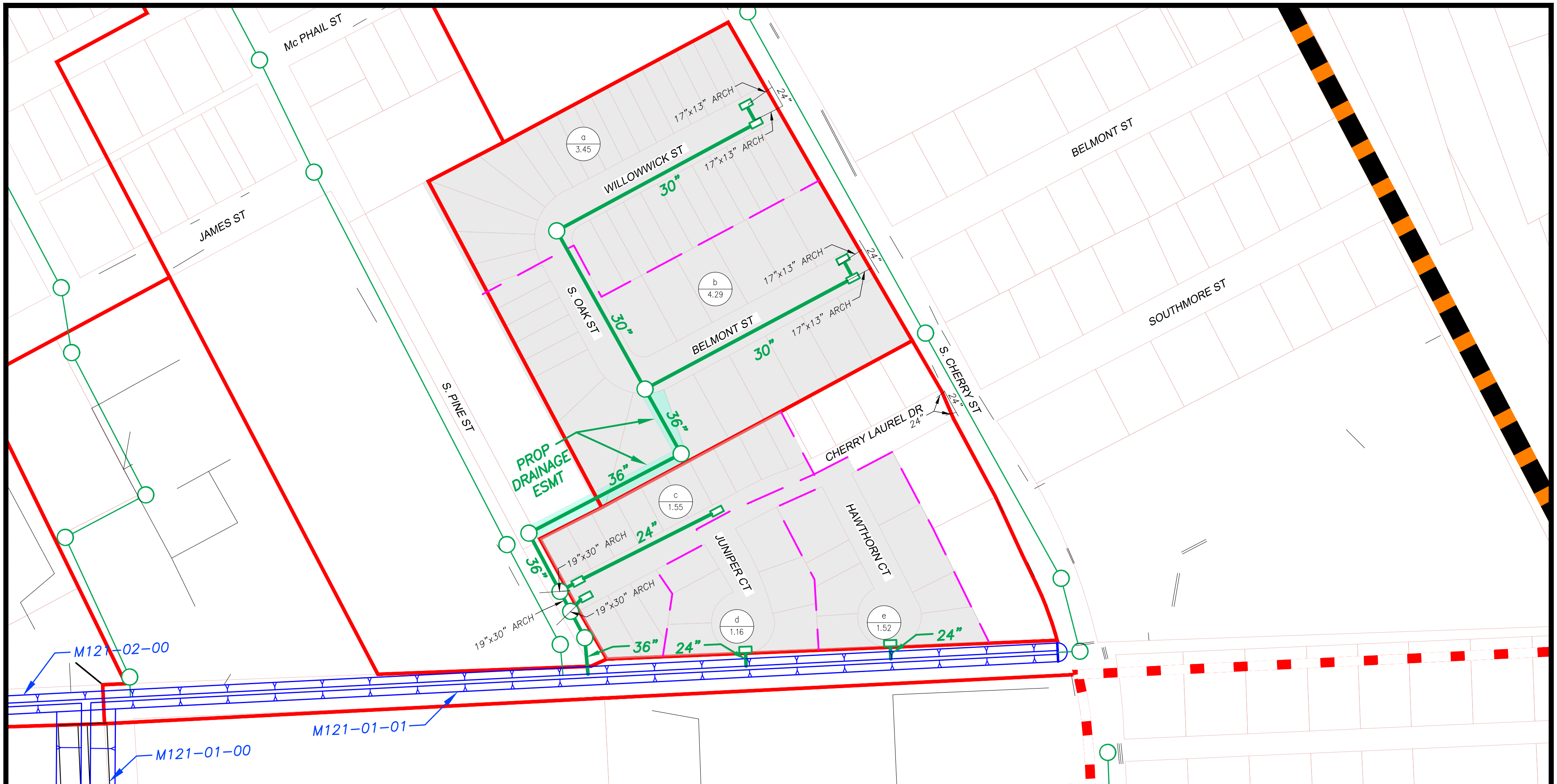

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 10,040 SF

0 125 250 500

(IN FEET)

1 INCH = 250 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: HS_E2A & HS_E2B

SCALE: 1" = 250'	March 2025
EXHIBIT NO. 4 & 5	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**5**	Phase	
Project Name		Hampton Place Storm Sewer Improvements			
Project Category					
Project Description					
Redirect multi-family complex storm sewer outfall to M121-01-00 by replacing existing inlets and constructing new storm sewer system.					
Project Justification					
Relieve flooding for multi-family complex with new outfall.					
Potential Funding Opportunities					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*30" RCP*	*1050*	*LF*	*$ 185*	*$ 194,250*
2	*36" RCP*	*650*	*LF*	*$ 200*	*$ 130,000*
3	*STM MH (SM)*	*7*	*EA*	*$ 6,000*	*$ 42,000*
4	*CURB INLET*	*4*	*EA*	*$ 8,600*	*$ 34,400*
5	*PAVEMENT REPAIR - CONC*	*1100*	*LF*	*$ 140*	*$ 154,000*
				SUBTOTAL	*$ 554,650*
		CONTINGENCY		*30%*	*$ 166,395*
		CONSULTANT		*25%*	*$ 138,663*
6	*LAND ACQUISITION (ESMT)*	*0.23*	*AC*	*$ 130,680*	*$ 30,123*
				SUBTOTAL	*$ 30,123*
		CONTINGENCY		*10%*	*$ 3,012*
				ESTIMATED PROJECT TOTAL COST:	**$ 892,843**

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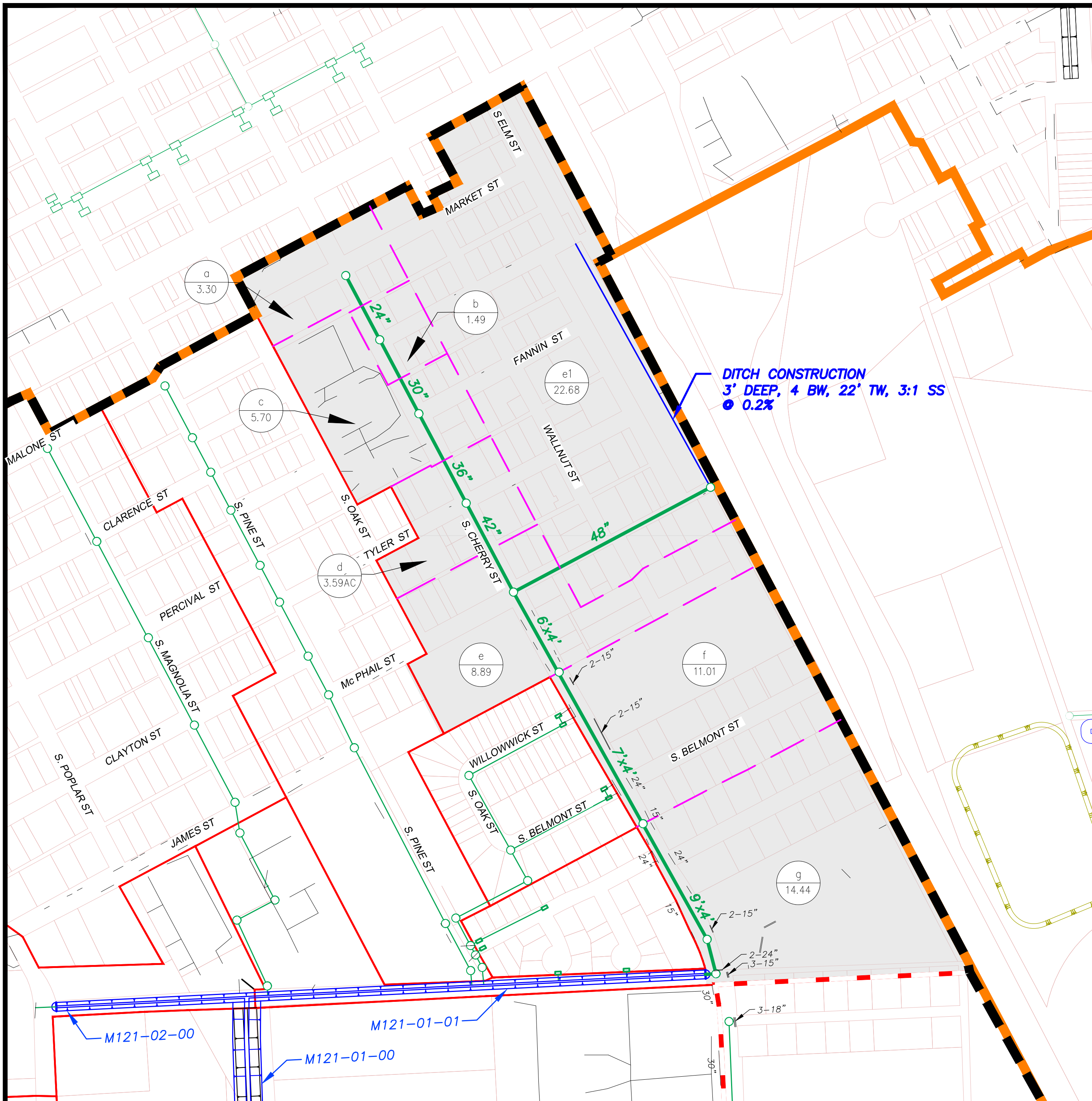

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: HS_E1

SCALE: 1" = 1" = 500'	March 2025
EXHIBIT NO. 6	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**6**	Phase	
Project Name	S. Cherry Street Storm Sewer Improvements (From Market Street to Hardin Street)				
Project Category					

Project Description

Construct storm sewer and roadside ditch interceptors along S. Cherry Street to M121-01-01.

Project Justification

Provide local flood relief for Old Town by adding conveyance capacity.

Potential Funding Opportunities

Harris County Precinct 3 during S. Cherry Street reconstruction

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	225	LF	$ 130	$ 29,250
2	30" RCP	250	LF	$ 185	$ 46,250
3	36" RCP	325	LF	$ 200	$ 65,000
4	42" RCP	325	LF	$ 300	$ 97,500
5	48" RCP	750	LF	$ 380	$ 285,000
6	6'x4' RCB	300	LF	$ 810	$ 243,000
7	7'x4' RCB	550	LF	$ 900	$ 495,000
8	9'x4' RCB	550	LF	$ 1,350	$ 742,500
9	STM MH (SM)	4	EA	$ 6,000	$ 24,000
10	STM MH (MED)	1	EA	$ 7,500	$ 7,500
11	STM JB (SM)	2	EA	$ 8,000	$ 16,000
12	STM JB (MED)	1	EA	$ 12,000	$ 12,000
13	STM JB (LG)	4	EA	$ 23,500	$ 94,000
14	DITCH INTERCEPTOR	34	EA	$ 9,100	$ 309,400
15	DITCH CONSTRUCTION	950	LF	$ 50	$ 47,500
16	PAVEMENT REPAIR - ASP	850	LF	$ 140	$ 119,000
				SUBTOTAL	$ 2,632,900
		CONTINGENCY		30%	$ 789,870
		CONSULTANT		25%	$ 658,225
				ESTIMATED PROJECT TOTAL COST:	**$ 4,080,995**

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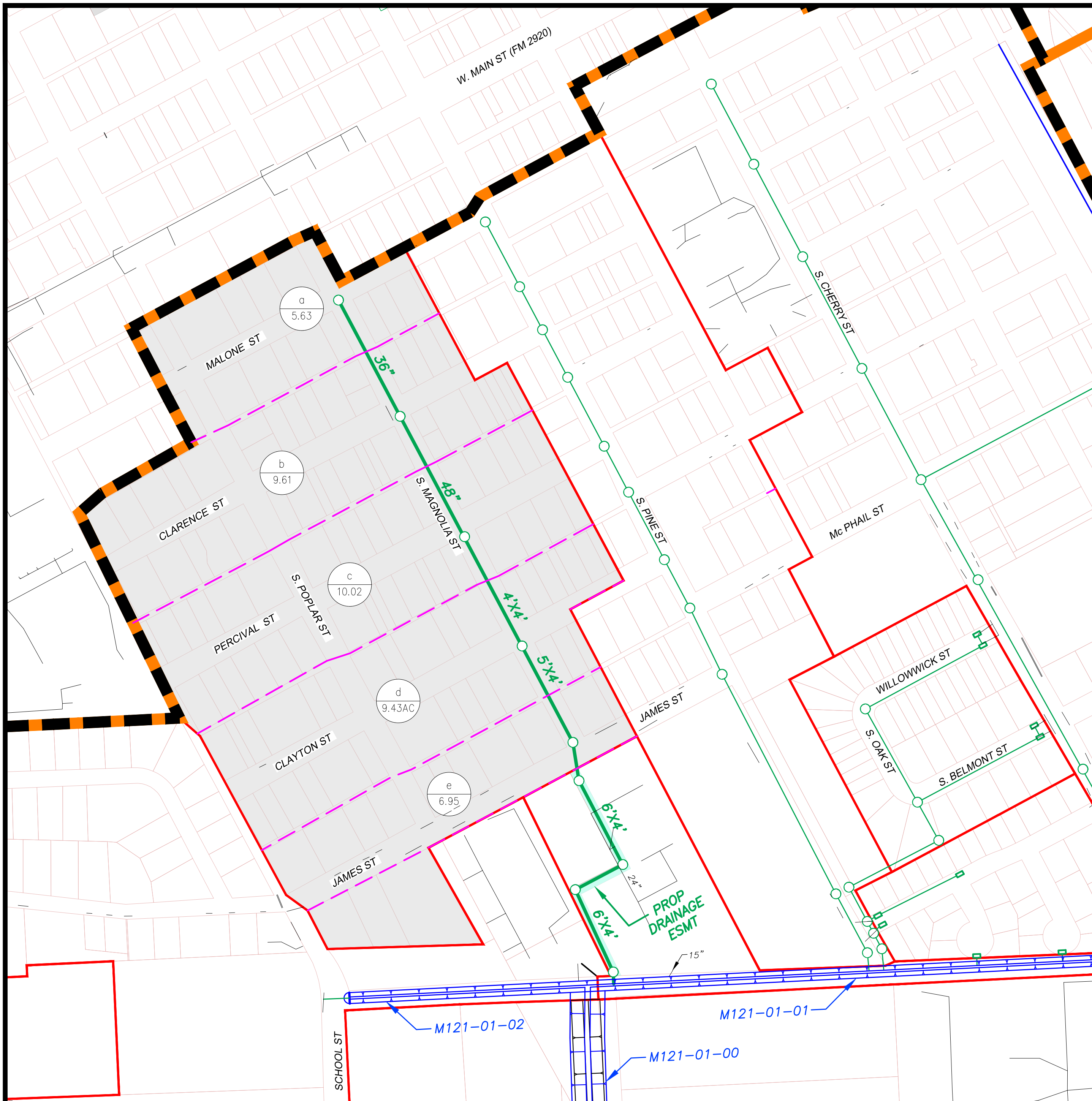

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. DRAINAGE ESMT = 17,661 SF (TRACT OWNED BY CITY OF TOMBALL)

0 200 400 800

(IN FEET)

1 INCH = 400 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: HS_E3 & HS_E4

SCALE: 1" = 1" = 400'	March 2025
EXHIBIT NO. 7	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**7**	Phase	
Project Name		Magnolia Street Storm Sewer Improvements			
Project Category					
Project Description					
Construct storm sewer system along S. Magnolia Street and retain existing roadside ditches. Outfall to M121-01-01 through City of Tomball Public Works property.					
Project Justification					
Increase capacity and relieve flooding in Old Town. Insufficient right-of-way and fully developed corridor for open channel conveyance.					
Potential Funding Opportunities					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*36" RCP*	*360*	*LF*	*$ 200*	*$ 72,000*
2	*48" RCP*	*360*	*LF*	*$ 380*	*$ 136,800*
3	*4'x4' RCB*	*320*	*LF*	*$ 500*	*$ 160,000*
4	*5'x4' RCB*	*360*	*LF*	*$ 480*	*$ 172,800*
5	*6'x4' RCB*	*620*	*LF*	*$ 810*	*$ 502,200*
6	*STM MH (SM)*	*1*	*EA*	*$ 6,000*	*$ 6,000*
7	*STM MH (MED)*	*1*	*EA*	*$ 7,500*	*$ 7,500*
8	*STM JB (SM)*	*1*	*EA*	*$ 8,000*	*$ 8,000*
9	*STM JB (MED)*	*6*	*EA*	*$ 12,000*	*$ 72,000*
10	*DITCH INTERCEPTOR*	*18*	*EA*	*$ 9,100*	*$ 163,800*
11	*PAVEMENT REPAIR - ASP*	*700*	*LF*	*$ 140*	*$ 98,000*
				SUBTOTAL	*$ 1,399,100*
		CONTINGENCY		*30%*	*$ 419,730*
		CONSULTANT		*25%*	*$ 349,775*
6	*LAND ACQUISITION (ESMT)*	*0.41*	*AC*	*$ -*	*$ -*
				SUBTOTAL	*$ -*
		CONTINGENCY		*10%*	*$ -*
				ESTIMATED PROJECT TOTAL COST:	**$ 2,168,605**

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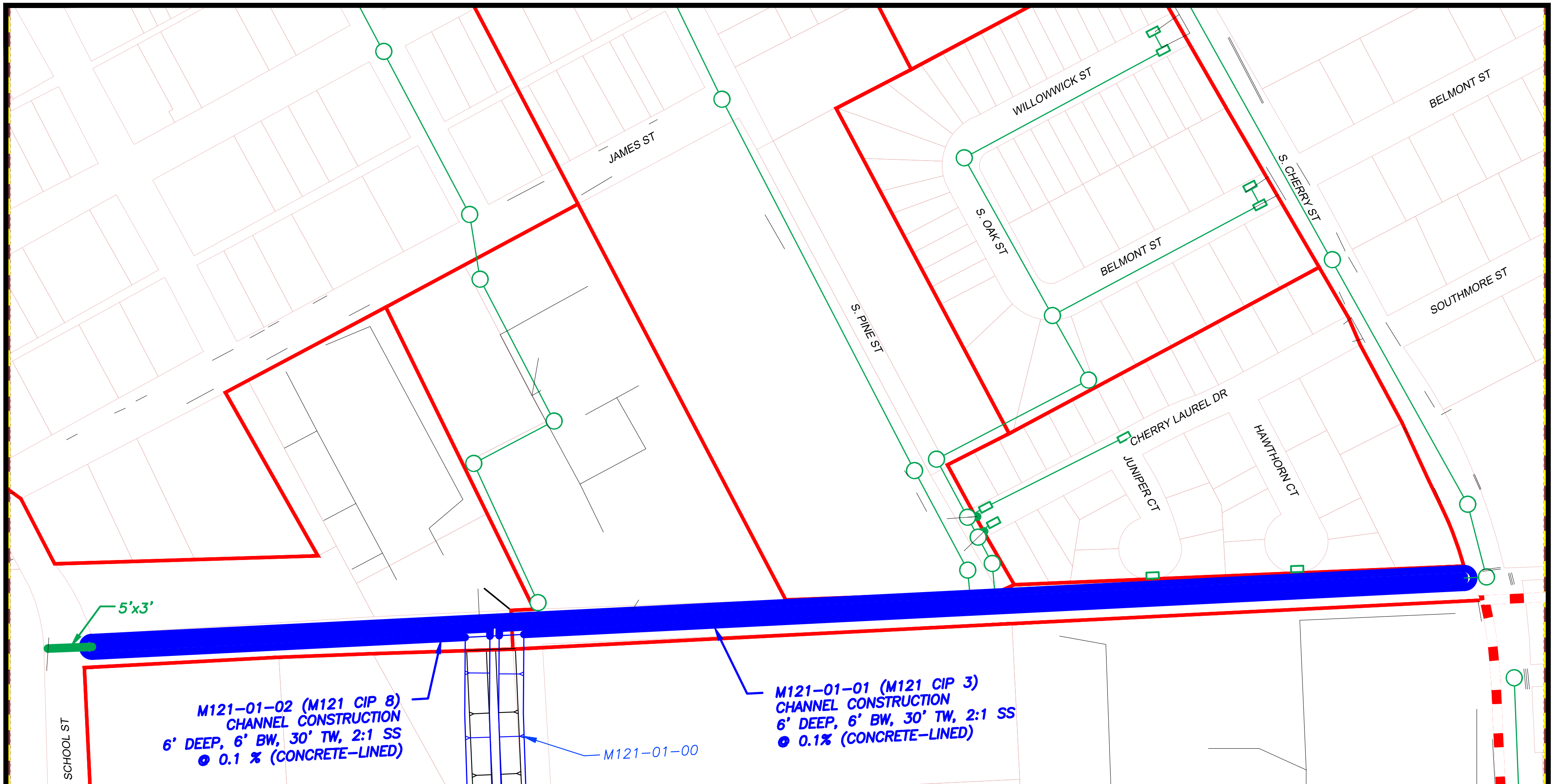

DESIGN CRITERIA

1. DESIGN STORM EVENT (CHANNEL): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. MITIGATION PROVIDED IN M500-01

0 125 250 500

(IN FEET)

1 INCH = 250 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A / 50.0 — DRAINAGE AREA ID / DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS — FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: HS_E & HW_W

SCALE: 1" = 250'	March 2025
EXHIBIT NO. 3 & 8	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**8**	Phase	
Project Name	M121-01-02 (HARDIN STREET WEST) CHANNEL TO SCHOOL STREET				
Project Category					

Project Description

Construct M121-01-03 (western lateral of M121-01-00) to School Street along Hardin Street right-of-way. Install School Street cross culvert.

Project Justification

Provide conveyance for upper reaches of M121 Basin and relieve existing flooding by providing outfall depth for upstream improvements.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*M121-01-02*	*680*	*LF*	*$ 550*	*$ 374,000*
2	*5'x3' RCB*	*80*	*LF*	*$ 605*	*$ 48,400*
3	*CURB INLET (NO LEADS)*	*2*	*EA*	*$ 6,000*	*$ 12,000*
4	*UTILITY CONFLICTS*	*5*	*EA*	*$ 10,000*	*$ 50,000*
5	*PAVEMENT REPAIR - ASP*	*30*	*LF*	*$ 140*	*$ 4,200*
6	*PIPELINE RELOCATION*	*3*	*EA*	*$ 14,000*	*$ 42,000*
				SUBTOTAL	*$ 530,600*
		CONTINGENCY		*30%*	*$ 159,180*
		CONSULTANT		*25%*	*$ 132,650*
				ESTIMATED PROJECT TOTAL COST:	**$ 822,430**

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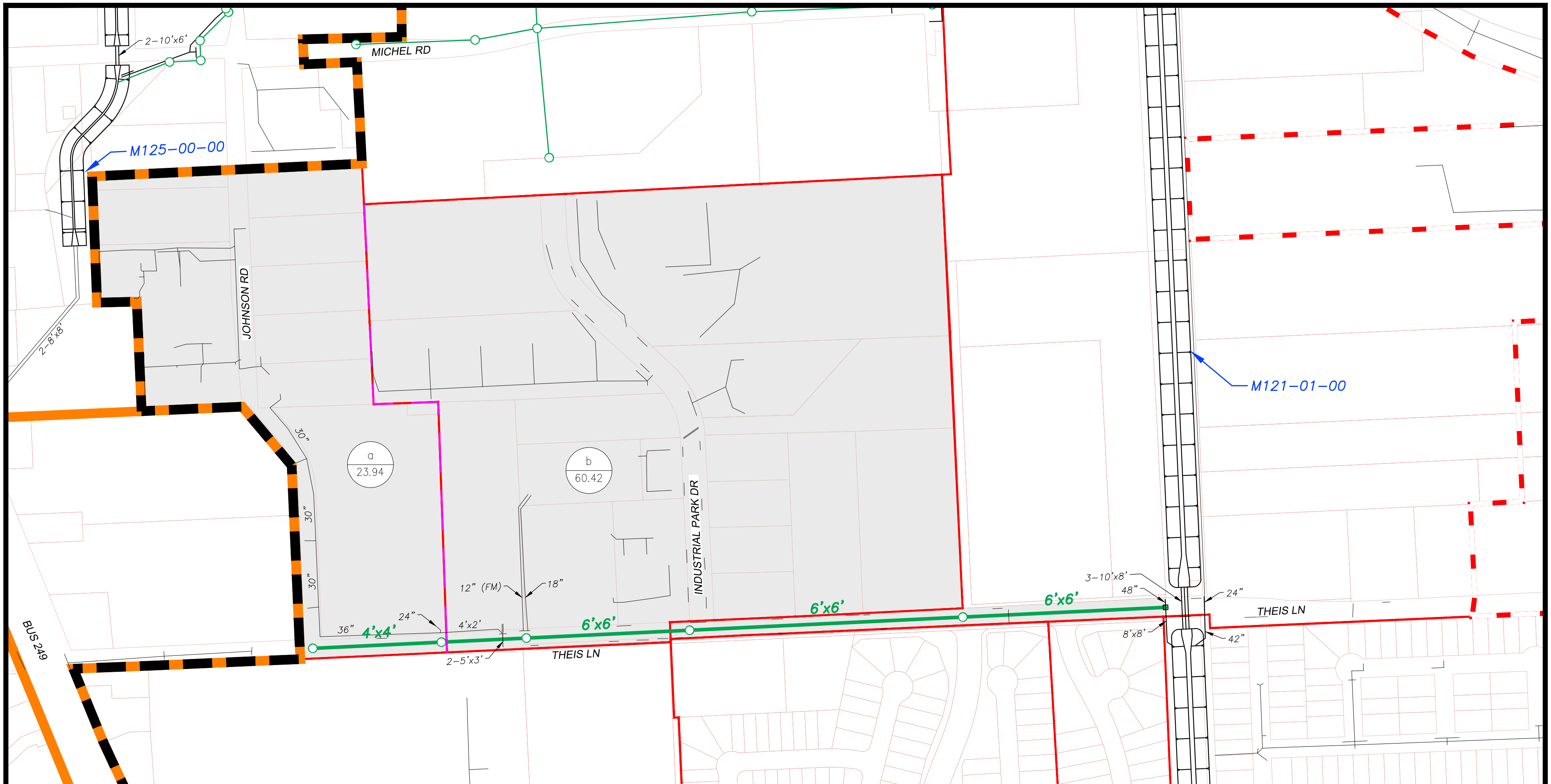

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121W)
SUBBASIN: HS-EIB & HS-EIC

SCALE: 1" = 500'	March 2025
EXHIBIT NO. 9	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**9**	Phase	
Project Name	Theis Lane Storm Sewer Reconstruction				
Project Category					

Project Description

Removal of cross culvert under Thesis Lane adjacent to Thesis Attaway Nature Center and construct storm sewer trunkline along Thesis Lane.

Project Justification

Increase capacity of minor arterial as part of roadway reconstruction and relieve runoff behind Walmart and Woodleaf Reserve subdivision.

Potential Funding Opportunities

Improvements assumed to take place with roadway reconstruction and expansion, therefore pavement repair and land acquisitions are excluded from cost estimate.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*4'x4' RCB*	*650*	*LF*	*$ 500*	*$ 325,000*
2	*6'x6' RCB*	*2080*	*LF*	*$ 820*	*$ 1,705,600*
3	*STM JB (SM)*	*2*	*EA*	*$ 8,000*	*$ 16,000*
4	*STM JB (MED)*	*3*	*EA*	*$ 12,000*	*$ 36,000*
5	*CURB INLET*	*18*	*EA*	*$ 8,600*	*$ 154,800*
6	*OUTFALL TIE-IN*	*1*	*EA*	*$ 10,000*	*$ 10,000*
				SUBTOTAL	*$ 2,247,400*
		CONTINGENCY		*30%*	*$ 674,220*
		CONSULTANT		*25%*	*$ 561,850*
				ESTIMATED PROJECT TOTAL COST:	**$ 3,483,470**

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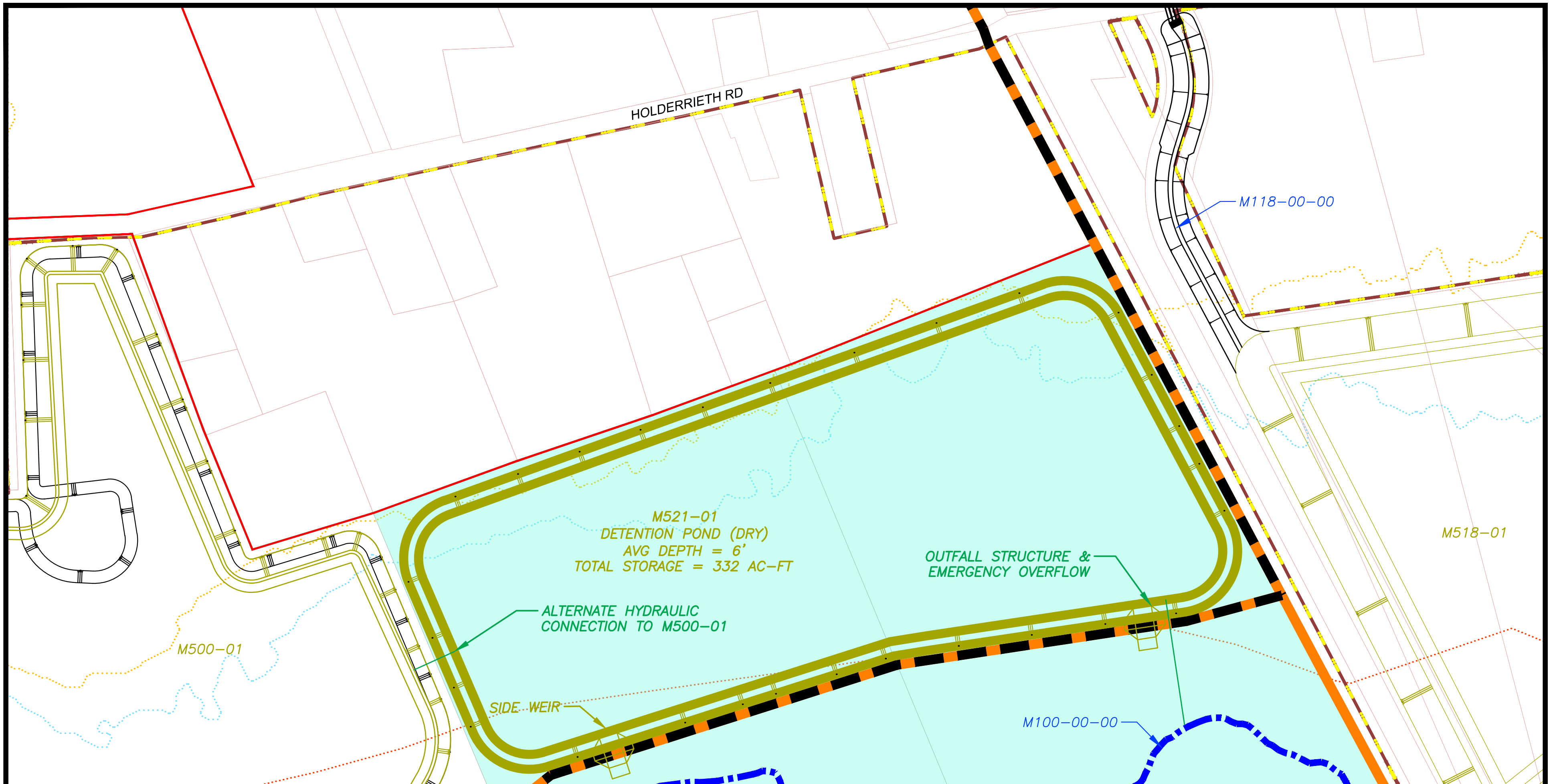

DESIGN CRITERIA

1. DESIGN STORM EVENT (DETENTION): 100-YEAR
2. MITIGATE IMPROVEMENTS TO M121-02-00 CHANNEL CONSTRUCTION
3. LAND ACQUISITION (FEE) = 4,713,967 SF

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121W)
SUBBASIN: HS-EIB & HS-EIC

SCALE: 1" = 500'	March 2025
EXHIBIT NO. 10	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost

Basin	M121	CIP Project No.	10	Phase	
Project Name		M521-01 Detention Pond			
Project Category					

Project Description

Acquire existing sand pit and tract adjacent to BNSF Railroad. Construction dry-bottom detention facilitiy.

Project Justification

Mitigate runoff impacts for M121-02-00 channel construction.

Potential Funding Opportunities

HCFCD Partnership

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	M521-01	332	AC-FT	$ 40,000	$ 13,280,000
2	Outfall Structure	1	EA	$ 25,000	$ 25,000
3	Side Wier	1	EA	$ 20,000	$ 20,000
				SUBTOTAL	$ 13,325,000
		CONTINGENCY		30%	$ 3,997,500
		CONSULTANT		25%	$ 3,331,250
4	LAND ACQUISITION (FEE)	108.22	AC	$ 87,120	$ 9,427,934
				SUBTOTAL	$ 9,427,934
		CONTINGENCY		10%	$ 942,793
				ESTIMATED PROJECT TOTAL COST:	**$ 31,024,477**

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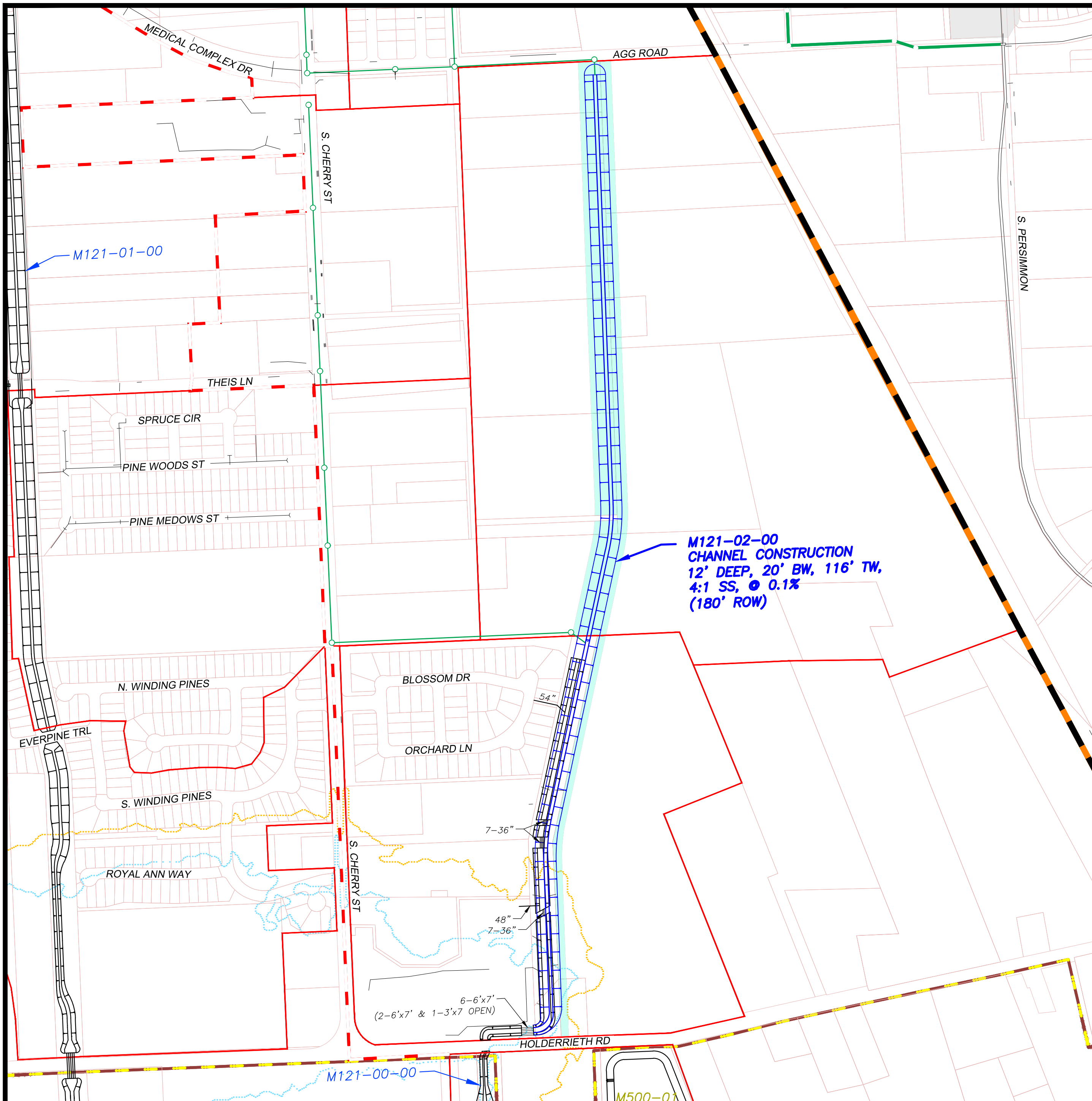
Pricing excludes reloaction of pipelines and abandonment of wells.

All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (CHANNEL): 100-YEAR
2. MITIGATION PROVIDED IN M521-01

0 400 800 1600

(IN FEET)

1 INCH = 800 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-02-00)
SUBBASIN: B & C

SCALE: 1" = 1"=800'	March 2025
EXHIBIT NO. 11	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**11**	Phase	
Project Name		M121-02-00 (M121 East) Channel Extension to Agg Road			
Project Category					
Project Description					
Construct ultimate M121-02-00 (M121 East) channel from Holderreith Road to Agg Road.					
Project Justification					
Provide conveyance and outfall depth for eastern reaches of M121 Basin. Provide opportunity for upstream storm sewer improvements.					
Potential Funding Opportunities					
Potential private development partnership.					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*M121-02-00*	*5400*	*LF*	*$ 650*	*$ 3,510,000*
2	*PIPELINE RELOCATION*	*8*	*EA*	*$ 32,000*	*$ 256,000*
				SUBTOTAL	*$ 3,510,000*
		CONTINGENCY		*30%*	*$ 1,053,000*
		CONSULTANT		*25%*	*$ 877,500*
3	*LAND ACQUISITION (FEE)*	*15.28*	*AC*	*$ 217,800*	*$ 3,328,025*
				SUBTOTAL	*$ 3,328,025*
		CONTINGENCY		*10%*	*$ 332,803*
				ESTIMATED PROJECT TOTAL COST:	**$ 9,101,328**

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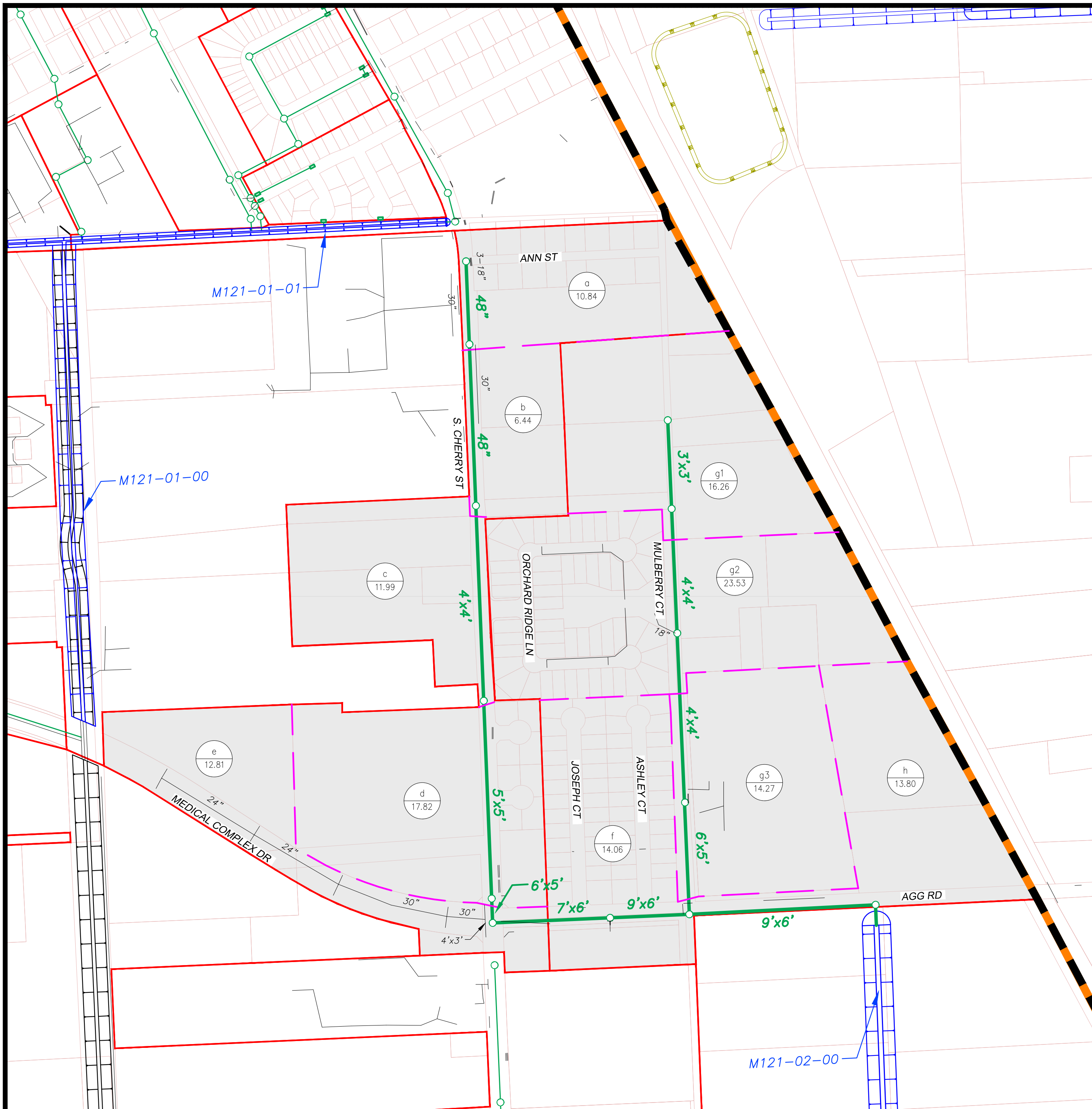

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-02-00)
SUBBASIN: C_W & C_N

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 12 & 13	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**12**	Phase	
Project Name	S. Cherry Street & Agg Road (from Anne Street to M121-00-00) Storm Sewer				
Project Category					
Project Description					
Construction storm sewer improvements along Cherry Street and Agg Road. Cost assumes improvements are installed without roadway reconstruction.					
Project Justification					
Increase conveyance capacity and relieve local flooding. Provide outfall depth for future development.					
Potential Funding Opportunities					
Partnership with Harris County Precinct 3 during roadway reconstruction project.					
Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*48" RCP*	*980*	*LF*	*$ 380*	*$ 372,400*
2	*4'x4' RCB*	*780*	*LF*	*$ 500*	*$ 390,000*
3	*5'x5' RCB*	*780*	*LF*	*$ 670*	*$ 522,600*
4	*6'x5' RCB*	*60*	*LF*	*$ 750*	*$ 45,000*
5	*7'x6' RCB*	*480*	*LF*	*$ 1,020*	*$ 489,600*
6	*9'x6' RCB*	*1140*	*LF*	*$ 1,450*	*$ 1,653,000*
7	*STM MH (MED)*	*2*	*EA*	*$ 7,500*	*$ 15,000*
8	*STM JB (SM)*	*1*	*EA*	*$ 8,000*	*$ 8,000*
9	*STM JB (MED)*	*2*	*EA*	*$ 12,000*	*$ 24,000*
10	*STM JB (LG)*	*4*	*EA*	*$ 23,500*	*$ 94,000*
11	*DITCH INTERCEPTOR*	*22*	*EA*	*$ 9,100*	*$ 200,200*
12	*PAVEMENT REPAIR - ASP*	*1500*	*LF*	*$ 140*	*$ 210,000*
				SUBTOTAL	*$ 4,023,800*
		CONTINGENCY		*30%*	*$ 1,207,140*
		CONSULTANT		*25%*	*$ 1,005,950*
				ESTIMATED PROJECT TOTAL COST:	**$ 6,236,890**

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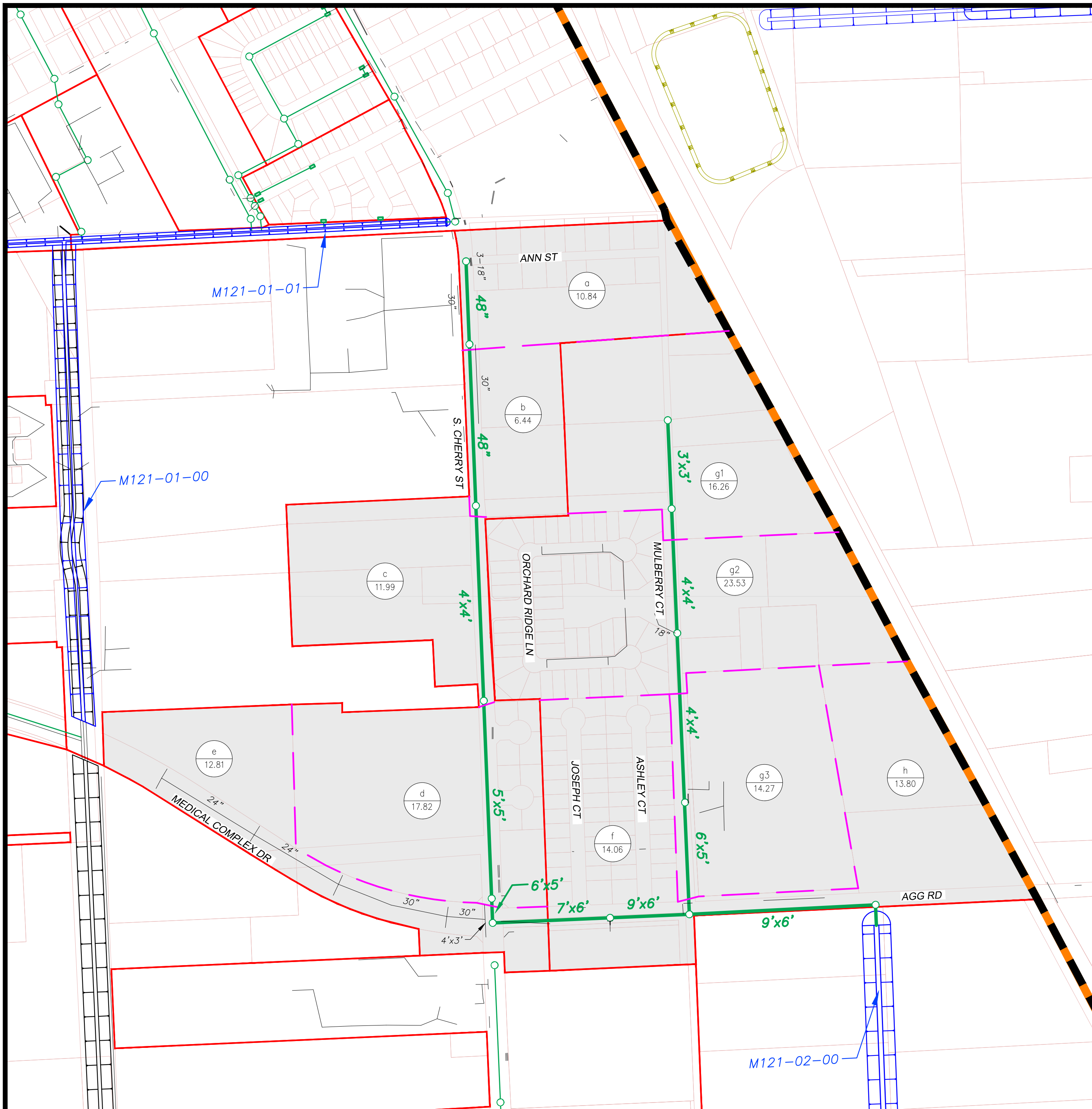

DESIGN CRITERIA
1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-02-00)
SUBBASIN: C_W & C_N

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 12 & 13	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**13**	Phase	
Project Name	Mulberry Street Strom Sewer				
Project Category					

Project Description

Construct storm sewer along Mulberry Street and connect with M121 CIP #11.

Project Justification

Provide flooding relief and increased conveyance capacity for developments along Mulberry Street. Relieve BNSF cross culvert overflow.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	3'x3' RCB	840	LF	$ 395	$ 331,800
2	4'x4' RCB	660	LF	$ 500	$ 330,000
3	6'x5' RCB	420	LF	$ 750	$ 315,000
4	STM JB (SM)	2	EA	$ 8,000	$ 16,000
5	STM JB (MED)	2	EA	$ 12,000	$ 24,000
6	DITCH INTERCEPTOR	10	EA	$ 9,100	$ 91,000
7	PAVEMENT REPAIR - ASP	200	LF	$ 140	$ 28,000
				SUBTOTAL	$ 1,135,800
		CONTINGENCY		30%	$ 340,740
		CONSULTANT		25%	$ 283,950
				ESTIMATED PROJECT TOTAL COST:	**$ 1,760,490**

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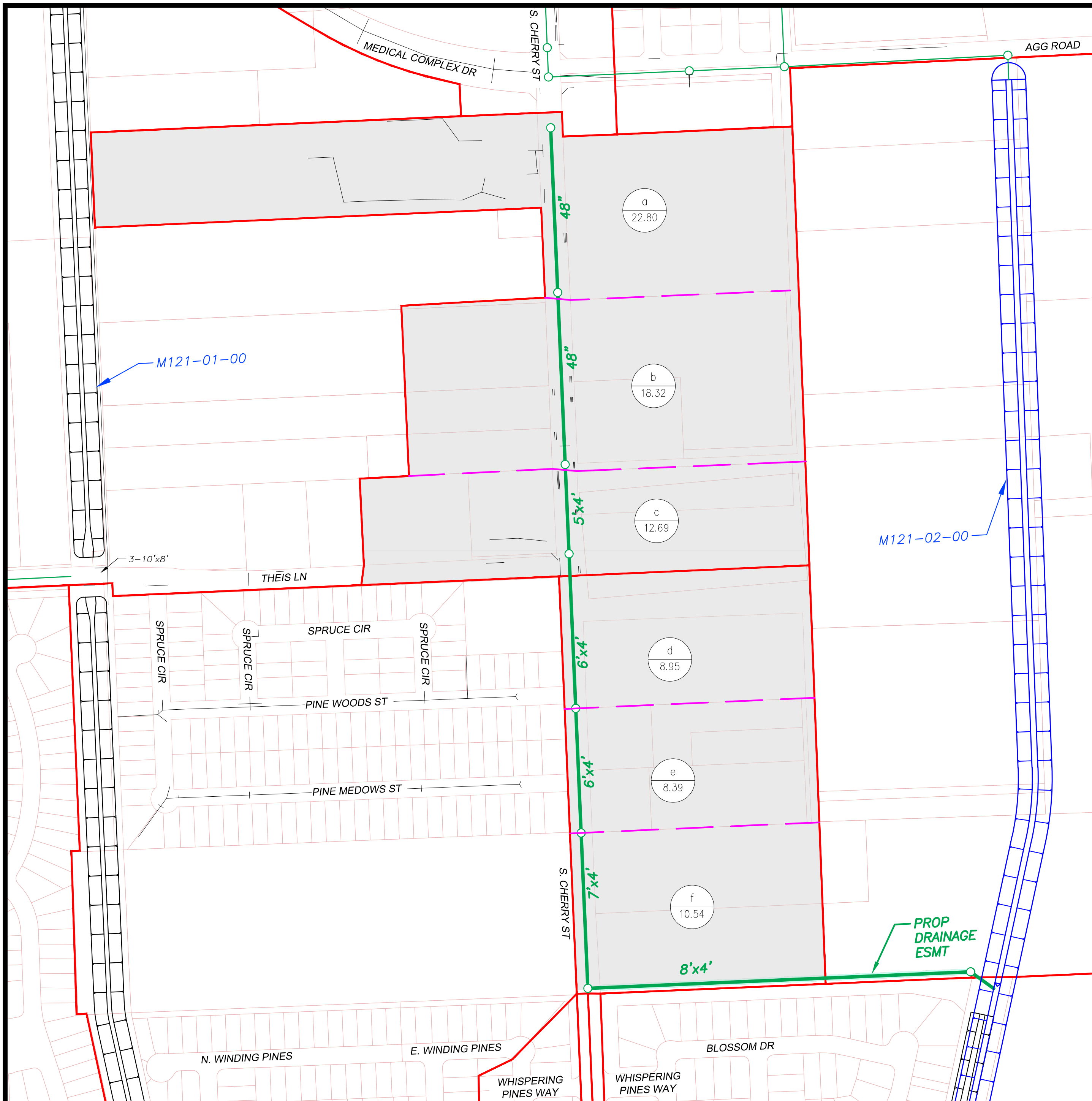

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. MITIGATION PROVIDED IN M521-01
7. PROPOSED ACQUISITION (ESMT) = 25,715 SF

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

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CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-02-00)
SUBBASIN: B_W

SCALE: 1" = 1" = 500'	March 2025
EXHIBIT NO. 14	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**14**	Phase	
Project Name		S. Cherry Street (from Agg Road to Cherrywood Estates) Storm Sewer to M121-02-00			
Project Category					

Project Description

Construct storm sewer along S. Cherry Street to Cherrywood Estates. Cost assumes improvements are installed without roadway reconstruction.

Project Justification

Increase conveyance capacity and relieve local flooding. Provide outfall depth for future development.

Potential Funding Opportunities

Partnership with Harris County Precinct 3 during roadway reconstruction project.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	48" RCP	1100	LF	$ 380	$ 418,000
2	5'x4' RCB	300	LF	$ 480	$ 144,000
3	6'x4' RCB	900	LF	$ 810	$ 729,000
4	7'x4' RCB	500	LF	$ 900	$ 450,000
5	8'x4' RCB	1400	LF	$ 950	$ 1,330,000
6	STM MH (MED)	2	EA	$ 7,500	$ 15,000
7	STM JB (MED)	3	EA	$ 12,000	$ 36,000
8	STM JB (LG)	3	EA	$ 23,500	$ 70,500
9	DITCH INTERCEPTOR	20	EA	$ 9,100	$ 182,000
10	PAVEMENT REPAIR - ASP	750	LF	$ 140	$ 105,000
				SUBTOTAL	$ 3,479,500
		CONTINGENCY		30%	$ 1,043,850
		CONSULTANT		25%	$ 869,875
11	LAND ACQUISITION (ESMT)	0.59	AC	$ 130,680	$ 77,140
				SUBTOTAL	$ 77,140
		CONTINGENCY		10%	$ 7,714
				ESTIMATED PROJECT TOTAL COST:	**$ 5,478,078**

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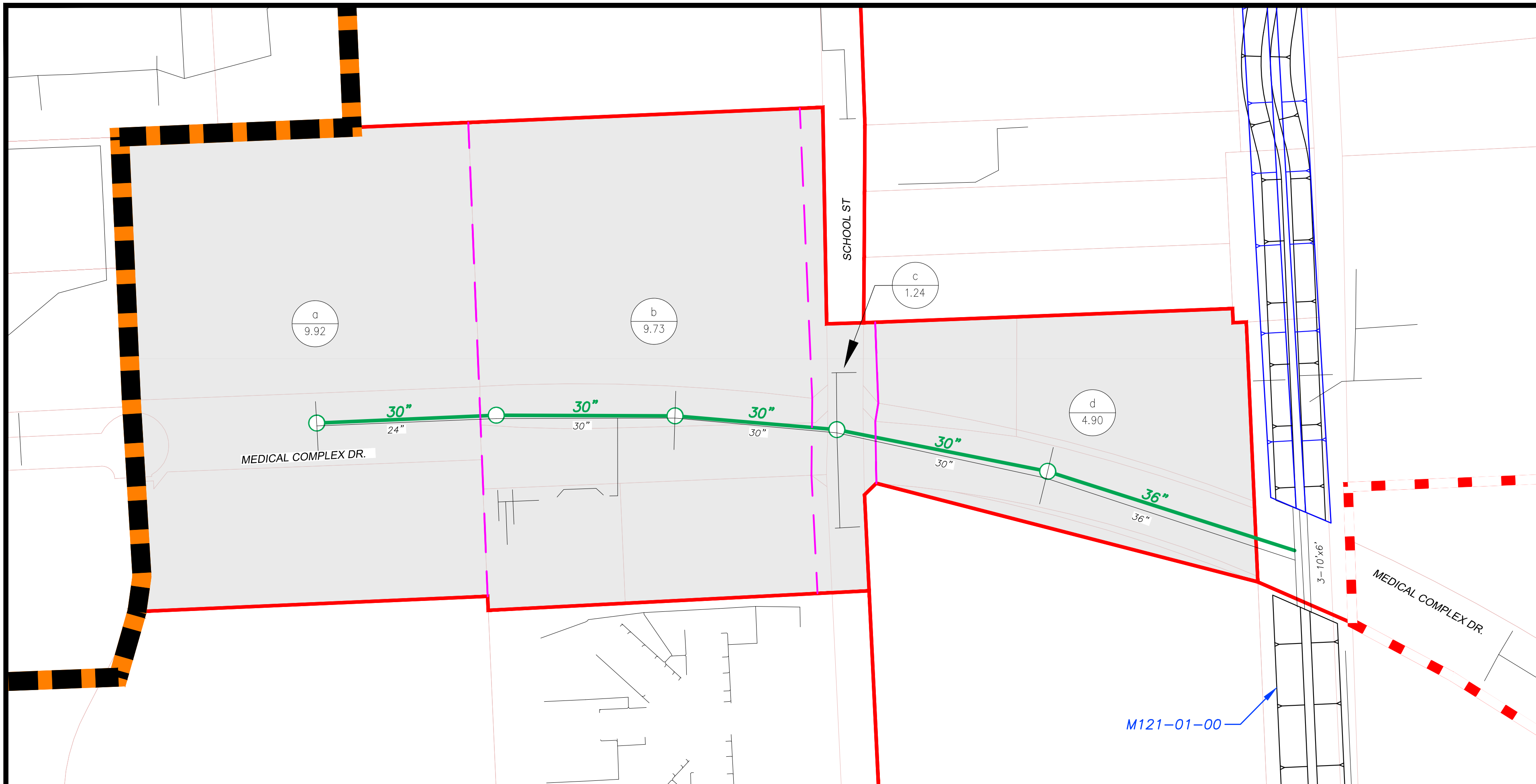

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. MITIGATION PROVIDED IN M500-01

0 125 250 500

(IN FEET)

1 INCH = 250 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: C_W2

SCALE: 1" = 250'	March 2025
EXHIBIT NO. 15	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.		**15**	Phase	
Project Name		Medical Complex Drive Storm Sewer Reconstruction			
Project Category					

Project Description

Construct parallel storm sewer trunkline along Medical Complex Drive with an outfall connection to M121-01-00 cross culverts.

Project Justification

Increase capacity of roadway to meet updated drainage stanards and relieve street ponding.

Potential Funding Opportunities

Potential private development partnership.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	30" RCP	1125	LF	$ 185	$ 208,125
2	36" RCP	425	LF	$ 200	$ 85,000
3	STM MH (SM)	5	EA	$ 6,000	$ 30,000
4	OUTFALL TIE-IN	1	EA	$ 10,000	$ 10,000
6	PAVEMENT REPAIR - ASP	140	LF	$ 140	$ 19,600
				SUBTOTAL	$ 352,725
		CONTINGENCY		30%	$ 105,818
		CONSULTANT		25%	$ 88,181
				ESTIMATED PROJECT TOTAL COST:	**$ 546,724**

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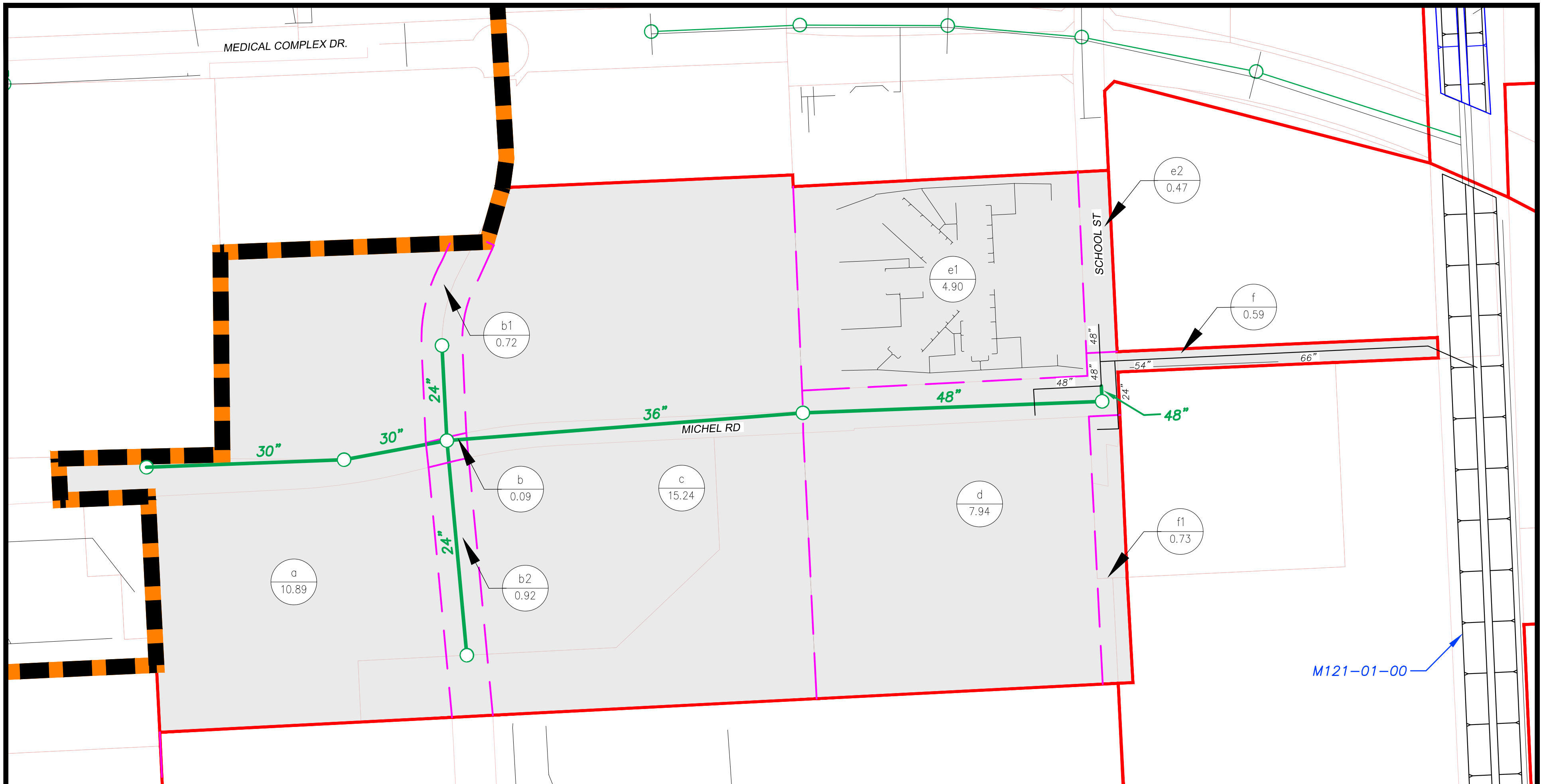

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. DEVELOPMENT WILL REQUIRE ON-SITE DETENTION
4. 25-YEAR HGL 1 FOOT BELOW GUTTER
5. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
6. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 150 300 600

(IN FEET)

1 INCH = 300 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: B_W1

SCALE: 1" = 300'	March 2025
EXHIBIT NO. 16	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**16**	Phase	
Project Name		Michel Road Storm Sewer Reconstruction			
Project Category					
Project Description					
Construction storm sewer along Michel Street within existing roadside ditch.					
Project Justification					
Provide outfall depth for future development.					
Potential Funding Opportunities					
Potential private development partnership.					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*24" RCP*	*560*	*LF*	*$ 130*	*$ 72,800*
2	*30" RCP*	*540*	*LF*	*$ 185*	*$ 99,900*
3	*36" RCP*	*690*	*LF*	*$ 200*	*$ 138,000*
4	*48" RCP*	*590*	*LF*	*$ 380*	*$ 224,200*
5	*STM MH (SM)*	*5*	*EA*	*$ 6,000*	*$ 30,000*
6	*STM MH (MED)*	*2*	*EA*	*$ 7,500*	*$ 15,000*
7	*DITCH INTERCEPTOR*	*8*	*EA*	*$ 9,100*	*$ 72,800*
8	*PAVEMENT REPAIR - ASP*	*100*	*LF*	*$ 140*	*$ 14,000*
9	*OUTFALL TIE-IN*	*1*	*EA*	*$ 10,000*	*$ 10,000*
				SUBTOTAL	*$ 676,700*
		CONTINGENCY		*30%*	*$ 203,010*
		CONSULTANT		*25%*	*$ 169,175*
				ESTIMATED PROJECT TOTAL COST:	**$ 1,048,885**

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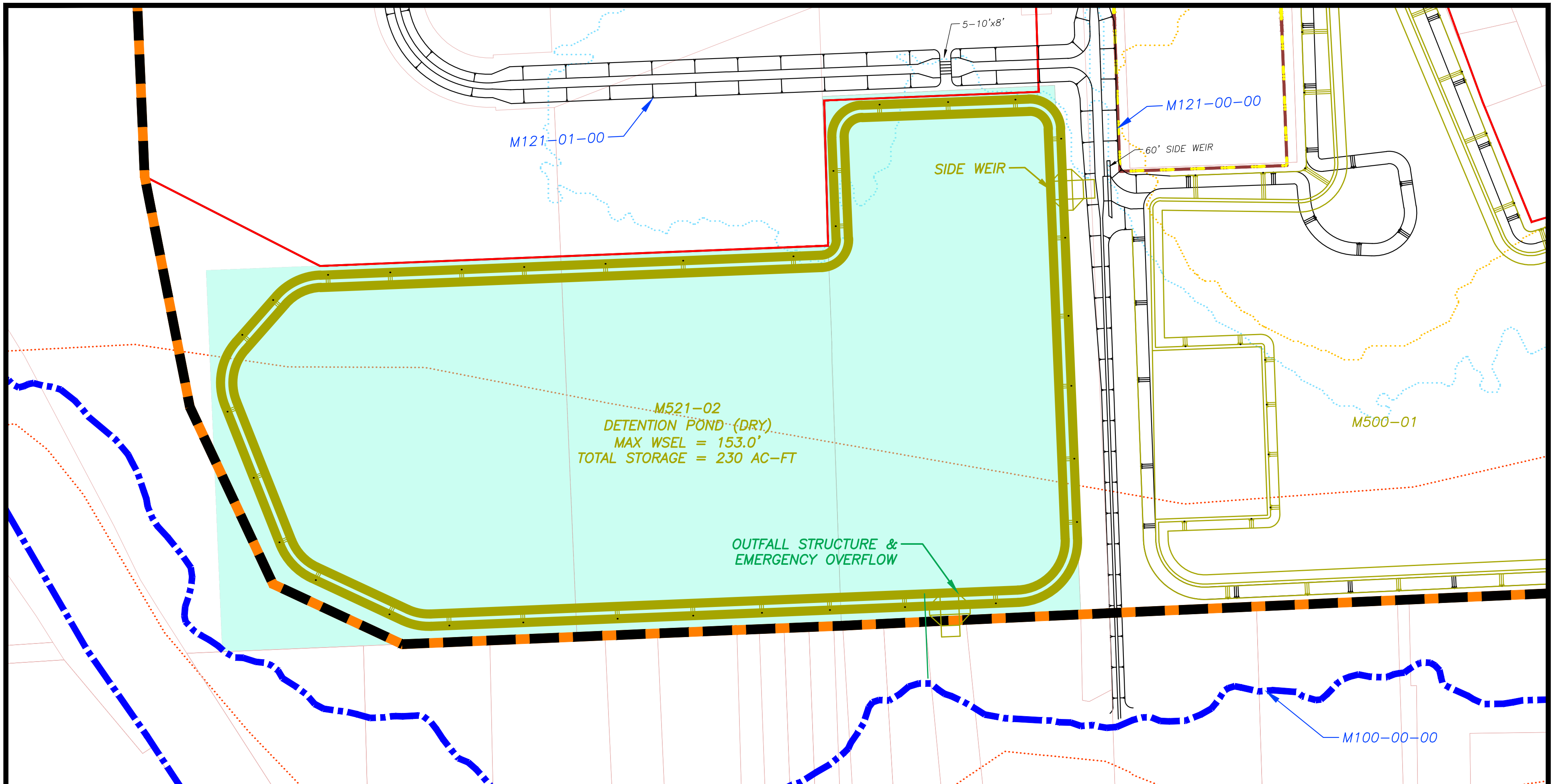

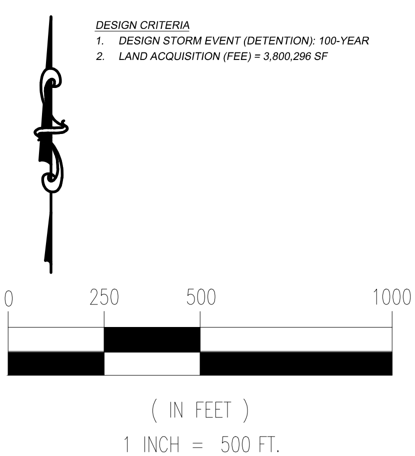

DESIGN CRITERIA
1. DESIGN STORM EVENT (DETENTION): 100-YEAR
2. LAND ACQUISITION (FEE) = 3,800,296 SF

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A ← DRAINAGE AREA ID
50.0 ← DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121W)
SUBBASIN: HS-EIB & HS-EIC

SCALE: 1" = 500'	March 2025
EXHIBIT NO. 17	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**17**	Phase	
Project Name	M521-02 Detention Pond				
Project Category					

Project Description

Construct detention pond.

Project Justification

Provide regional detention for M121 Basin and/or floodplain mitigation from Willow Creek.

Potential Funding Opportunities

HCFCD and Grants

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*M521-02*	*230*	*AC-FT*	*$ 40,000*	*$ 9,200,000*
2	*Outfall Structure*	*1*	*EA*	*$ 25,000*	*$ 25,000*
3	*Side Wier*	*1*	*EA*	*$ 20,000*	*$ 20,000*
				SUBTOTAL	*$ 9,245,000*
		CONTINGENCY		*30%*	*$ 2,773,500*
		CONSULTANT		*25%*	*$ 2,311,250*
4	*LAND ACQUISITION (FEE)*	*87.24*	*AC*	*$ 217,800*	*$ 19,001,478*
				SUBTOTAL	*$ 19,001,478*
		CONTINGENCY		*10%*	*$ 1,900,148*
				ESTIMATED PROJECT TOTAL COST:	**$ 35,231,375**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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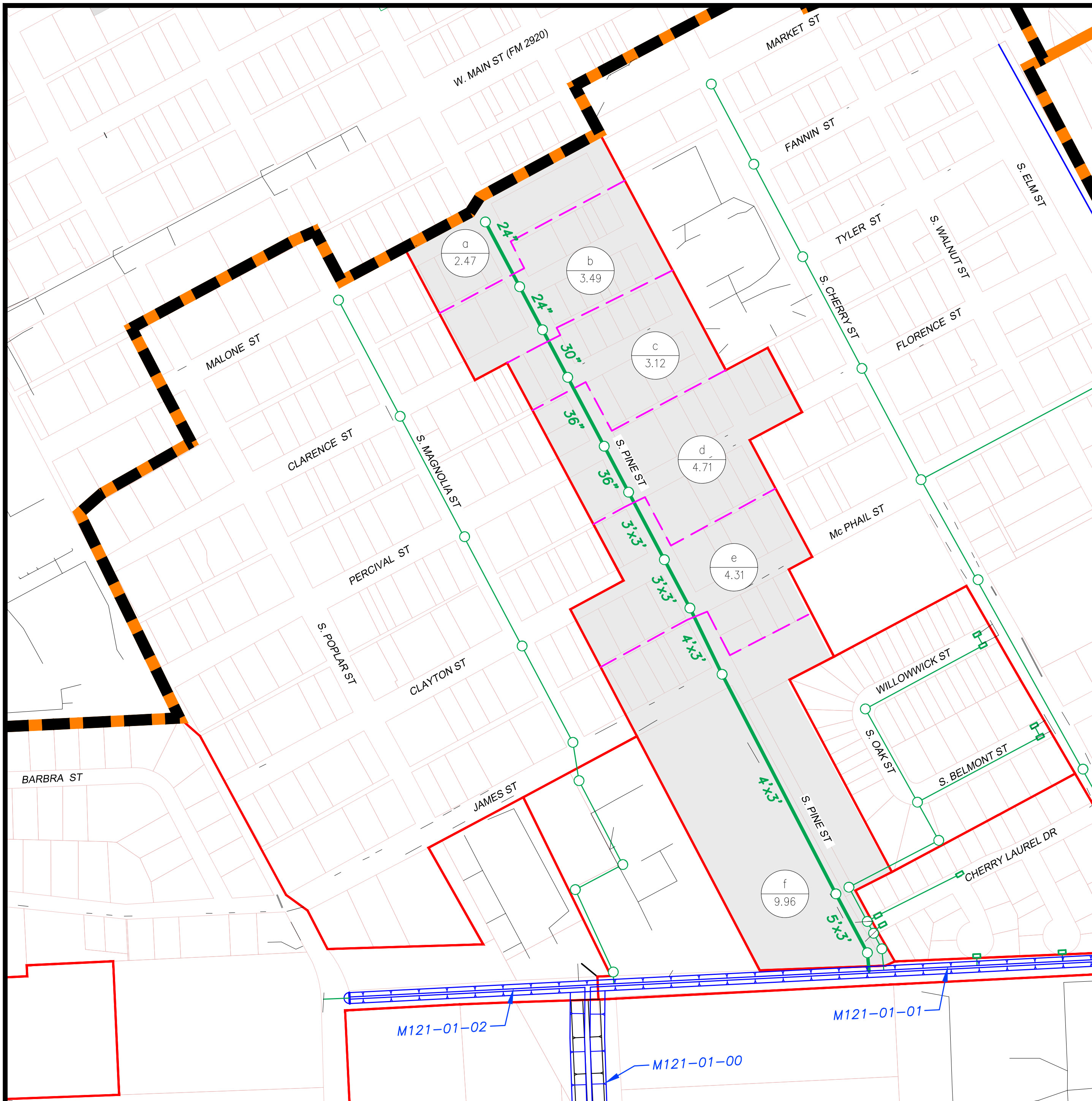
Pricing excludes reloaction of pipelines and abandonment of wells.

All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 200 400 800

(IN FEET)

1 INCH = 400 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M121 (M121-01-00)
SUBBASIN: HS_E3

SCALE: 1" = 1" = 400'	March 2025
EXHIBIT NO. 18	M121 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M121**	CIP Project No.	**18**	Phase	
Project Name		S. Pine Street Storm Sewer Improvements (From Malone Street to Hardin Street)			
Project Category					

Project Description

Construct a storm sewer system along Pine Street while maintaining existing roadside ditches. Improvements are assumed as part of roadway reconstruction.

Project Justification

Increase capacity of conveynace system to improved channel to relieve flooding in Old Town.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	300	LF	$ 130	$ 39,000
2	30" RCP	120	LF	$ 185	$ 22,200
3	36" RCP	320	LF	$ 200	$ 64,000
4	3'x3' RCB	300	LF	$ 395	$ 118,500
5	4'x3' RCB	820	LF	$ 450	$ 369,000
6	5'x4' RCB	200	LF	$ 480	$ 96,000
7	STM MH (SM)	3	EA	$ 6,000	$ 18,000
8	STM MH (MED)	2	EA	$ 7,500	$ 15,000
9	STM JB (SM)	4	EA	$ 8,000	$ 32,000
10	STM JB (MED)	2	EA	$ 12,000	$ 24,000
11	CURB INLET	30	EA	$ 8,600	$ 258,000
				SUBTOTAL	$ 1,055,700
		CONTINGENCY		30%	$ 316,710
		CONSULTANT		25%	$ 263,925
				ESTIMATED PROJECT TOTAL COST:	**$ 1,636,335**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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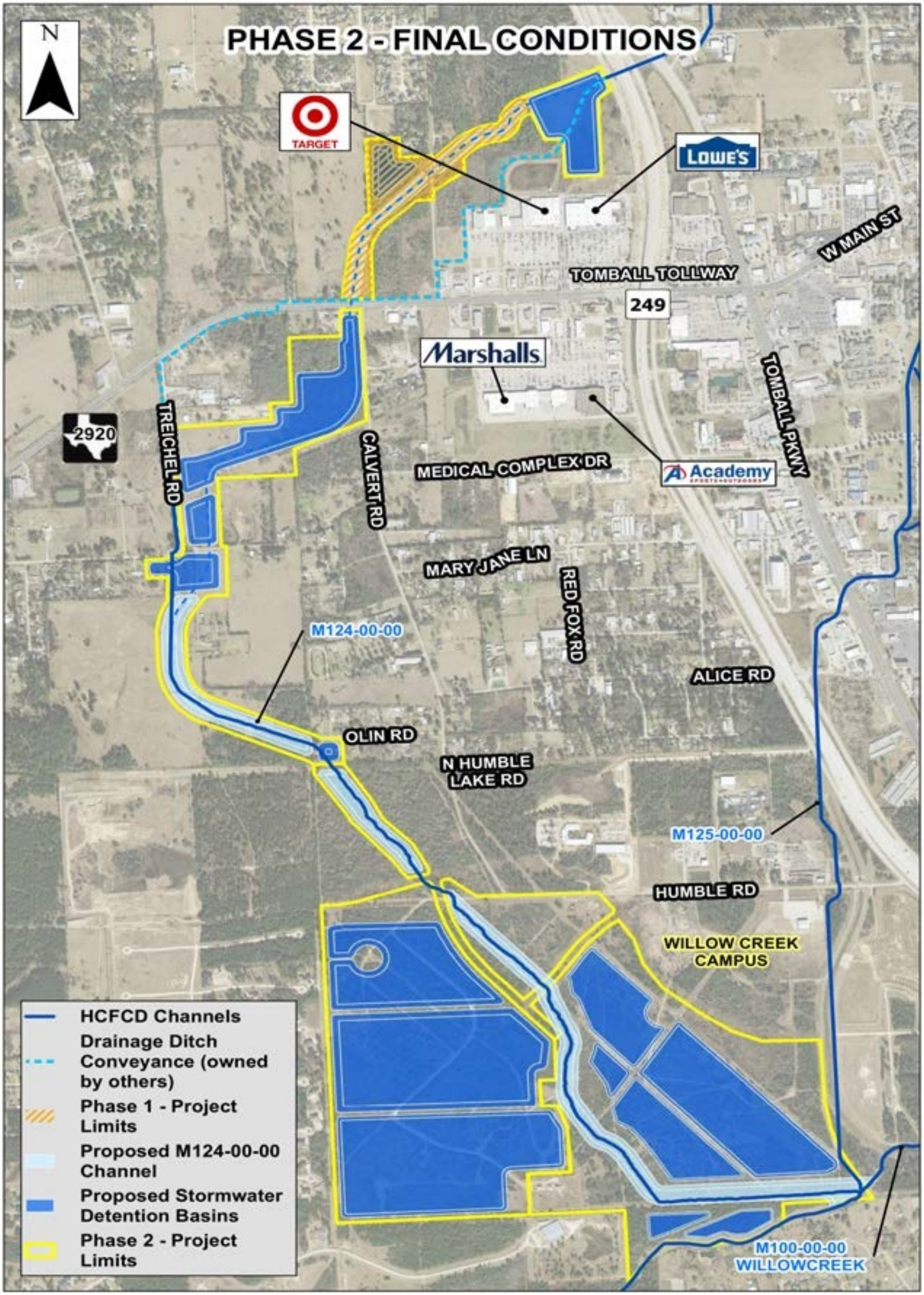
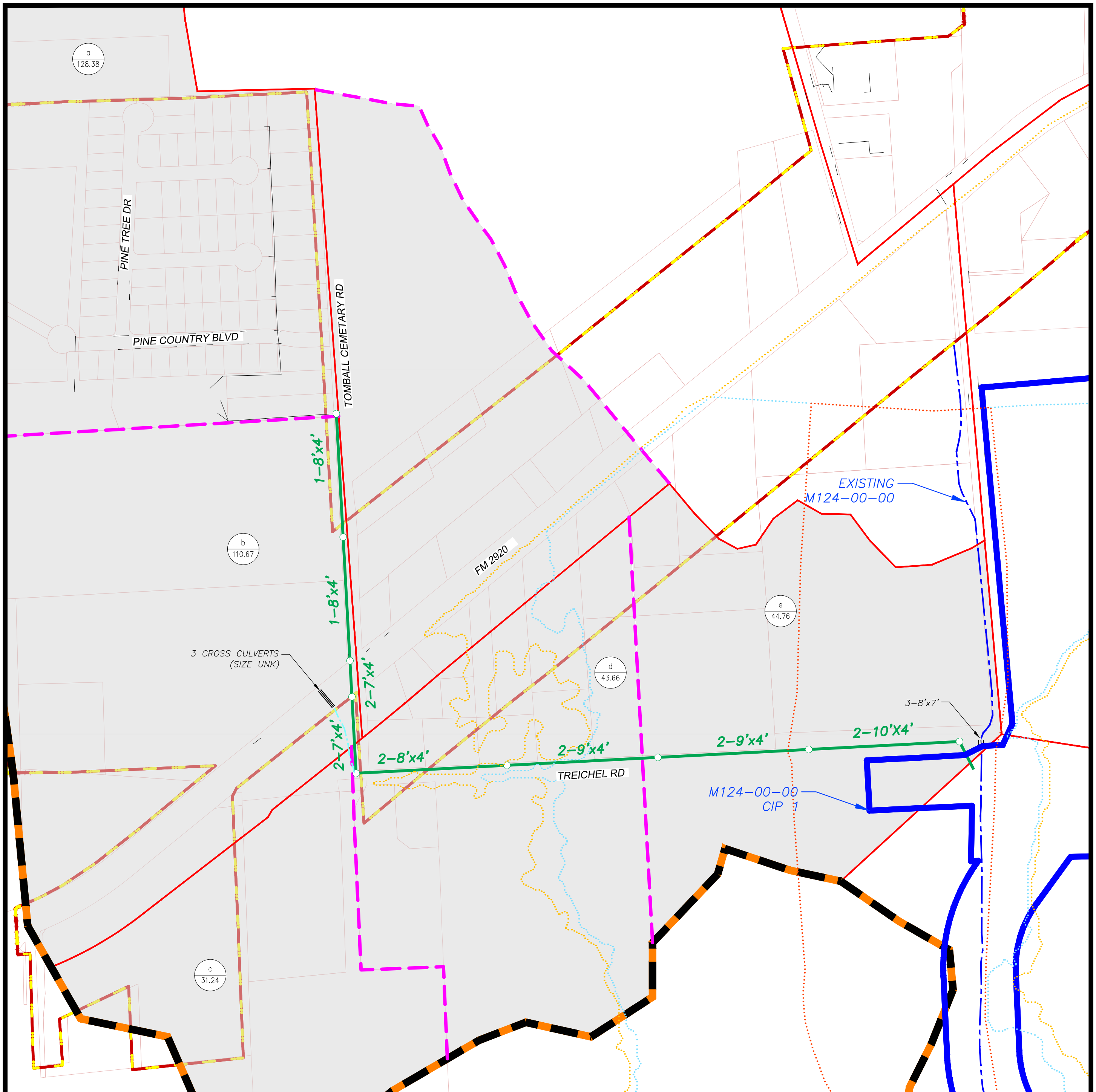
All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.

APPENDIX C – M124

CIP PACKETS


PHASE 2 - FINAL CONDITIONS
N
TARGET
LOWE'S
W MAIN ST
TOMBALL TOLLWAY
249
Marshalls
2920
TREICHEL RD
CALVERT RD
MEDICAL COMPLEX DR
Academy
TOMBALL PKWY
MARY JANE LN
RED FOX RD
M124-00-00
ALICE RD
OLIN RD
N HUMBLE LAKE RD
M125-00-00
HUMBLE RD
WILLOW CREEK CAMPUS
HCFCD Channels
Drainage Ditch Conveyance (owned by others)
Phase 1 - Project Limits
Proposed M124-00-00 Channel
Proposed Stormwater Detention Basins
Phase 2 - Project Limits
M100-00-00 WILLOWCREEK



DESIGN CRITERIA

1. DESIGN STORM EVENT (CHANNEL): 100-YEAR
2. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
3. MITIGATION FOR INCREASED FLOW....
4. LAND ACQUSITION = 0 SF

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID
50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M124-00-00
SUBBASIN: 5 & 6

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 3	M124 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M124**	CIP Project No.	**2**	Phase	
Project Name	Tomball Cemetery Road & Treichel Storm Sewer to M124-00-00				
Project Category					

Project Description

Construct storm sewer along Tomball Cemetery Road, crossing FM 2920, and along the north side of Treichel Street to the M124-00-00 improved channel. Construction

Project Justification

Provide flooding relief for Pine Country Subdivision, increase capacity from roadside ditches, and provide outfall depth for future development.

Potential Funding Opportunities

TxDOT and/or Harris County Precinct 3 joint venture.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	7'X4' RCB	940	LF	$ 900	$ 846,000
2	8'X4' RCB	2275	LF	$ 950	$ 2,161,250
3	9'X4' RCB	2500	LF	$ 1,350	$ 3,375,000
4	10'X4' RCB	1520	LF	$ 1,300	$ 1,976,000
5	STM JB (LG)	16	EA	$ 23,500	$ 376,000
6	PAVEMENT REPAIR - ASP	200	LF	$ 140	$ 28,000
7	PIPELINE RELOCATION	1	EA	$ 30,000	$ 30,000
8	OUTFALL STRUCTURE	2	EA	$ 25,000	$ 50,000
				SUBTOTAL	$ 8,842,250
		CONTINGENCY		30%	$ 2,652,675
		CONSULTANT		25%	$ 2,210,563
				ESTIMATED PROJECT TOTAL COST:	**$ 13,705,488**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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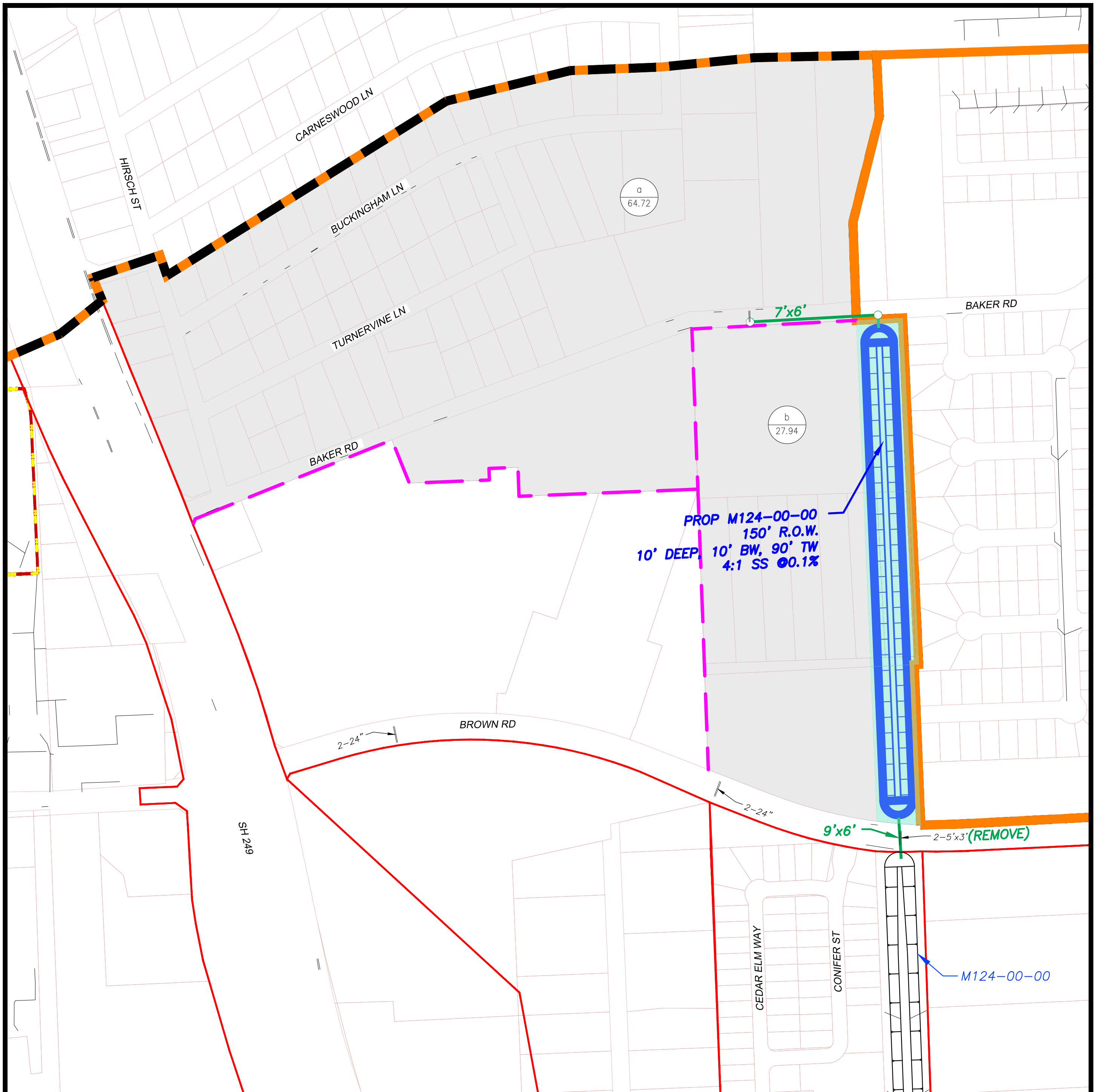
All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (CHANNEL): 100-YEAR
2. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
3. MITIGATION TO BE EVALUATED AND INCLUDED AS IN-LINE DETENTION OR IN CITY OF TOMBALL M124 STORMWATER DETENTION BASIN
4. LAND ACQUSITION = 276,729 SF

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID
50.0 — DRAINAGE AREA IN ACRES

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M124-00-00
SUBBASIN:1_A

SCALE: 1" = 1" = 500'	March 2025
EXHIBIT NO. 3	M124 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M124**	CIP Project No.	**3**	Phase	
Project Name		M124-00-00 Channel Extension to Baker Drive			
Project Category					
Project Description					
Removing exisitng drop structure south of Brown-Hufsmith, reconstructing Brown-Hufsmith culvert crossing, and M124-00-00 channel extension to Baker Drive. Construct storm sewer to replace existing culvert crossing at Baker Drive.					
Project Justification					
Provide flooding relief and outfall depth for future development. Collect and convey overflow from existing private pond north of Baker Drive.					
Potential Funding Opportunities					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*M124-00-00*	*1700*	*LF*	*$ 410*	*$ 697,000*
2	*7'x6' RCB*	*450*	*LF*	*$ 1,020*	*$ 459,000*
3	*9'x6' RCB*	*150*	*LF*	*$ 1,450*	*$ 217,500*
4	*STM JB (LG)*	*2*	*EA*	*$ 23,500*	*$ 47,000*
6	*PAVEMENT REPAIR - ASP*	*525*	*LF*	*$ 140*	*$ 73,500*
				SUBTOTAL	*$ 1,494,000*
		CONTINGENCY		*30%*	*$ 448,200*
		CONSULTANT		*25%*	*$ 373,500*
7	*LAND ACQUISITION*	*6.35*	*AC*	*$ 217,800*	*$ 1,383,644*
				SUBTOTAL	*$ 1,383,644*
		CONTINGENCY		*10%*	*$ 138,364*
				ESTIMATED PROJECT TOTAL COST:	**$ 3,837,708**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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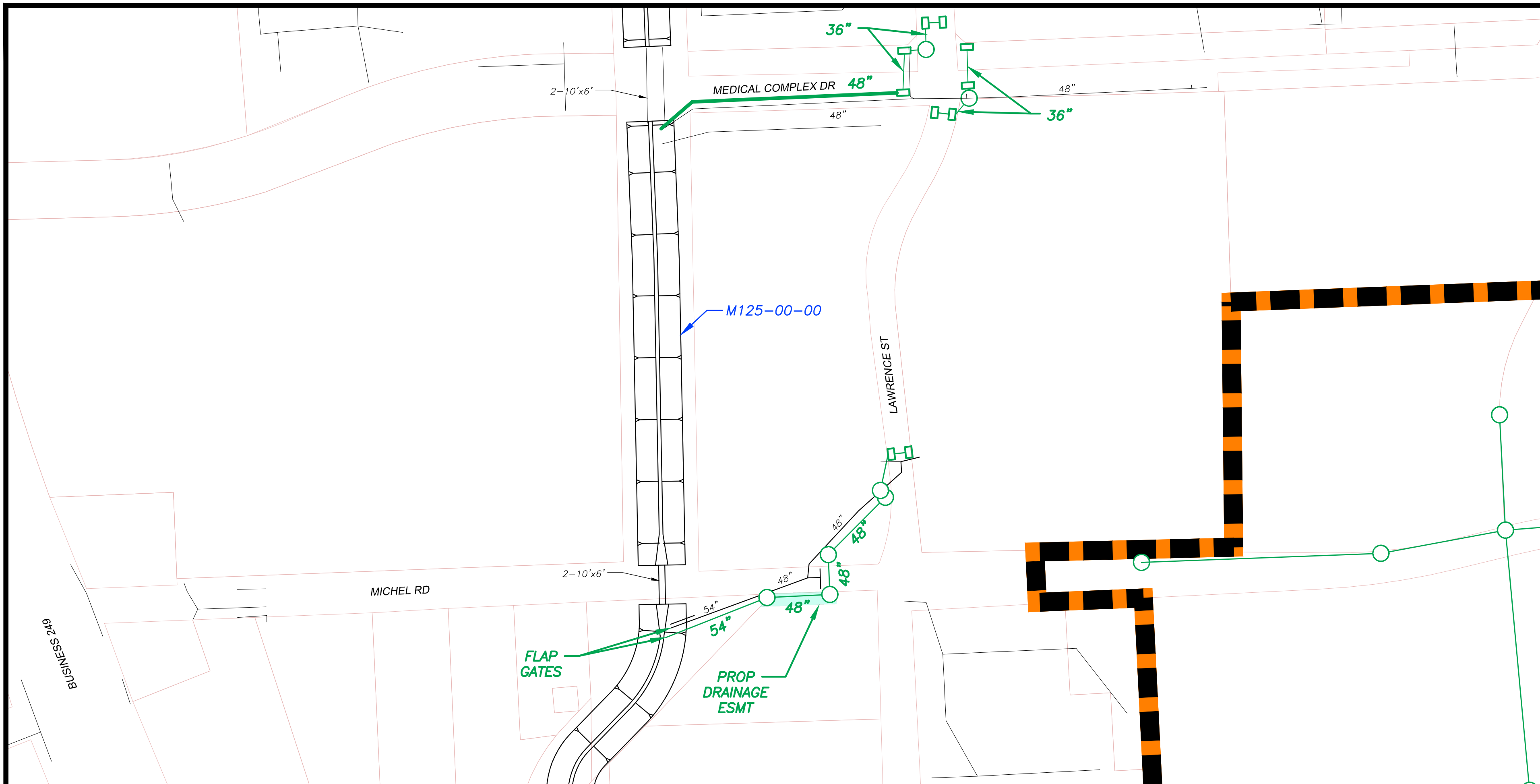
APPENDIX C – M125

CIP PACKETS



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 2,260 SF

0 125 250 500

(IN FEET)

1 INCH = 250 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
CITY LIMITS		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS · FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: M125
SUBBASIN: A6_E

SCALE: 1" = 250'	March 2025
EXHIBIT NO. 1	M125 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**M125**	CIP Project No.	**1**	Phase	
Project Name		Cobble Creek Apartments			
Project Category					
Project Description					
Construct parallel storm sewer along Lawrence Street and Michel Road to M125-00-00. Construct inlets at Medical Complex Drive and Lawrence Street intersection with parrallel storm sewer along Medical Complex Drive to M125-00-00.					
Project Justification					
Relieve low-lying apartment complex from structural flooding and divert overland flow from Medical Complex.					
Potential Funding Opportunities					
Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*36" RCP*	*340*	*LF*	*$ 200*	*$ 68,000*
2	*48" RCP*	*700*	*LF*	*$ 380*	*$ 266,000*
3	*54" CMP*	*240*	*LF*	*$ 180*	*$ 43,200*
4	*STM MH (MED)*	*2*	*EA*	*$ 7,500*	*$ 15,000*
5	*STM MH (LG)*	*5*	*EA*	*$ 9,000*	*$ 45,000*
6	*CURB INLET*	*10*	*EA*	*$ 8,600*	*$ 86,000*
7	*FLAP GATE*	*2*	*EA*	*$ 10,000*	*$ 20,000*
8	*PAVEMENT REPAIR - CONC*	*576*	*LF*	*$ 140*	*$ 80,640*
				SUBTOTAL	*$ 623,840*
		CONTINGENCY		*30%*	*$ 187,152*
		CONSULTANT		*25%*	*$ 155,960*
9	*LAND ACQUISITION*	*0.05*	*AC*	*$ 130,680*	*$ 6,780*
				SUBTOTAL	*$ 6,780*
		CONTINGENCY		*10%*	*$ 678*
				ESTIMATED PROJECT TOTAL COST:	**$ 974,410**

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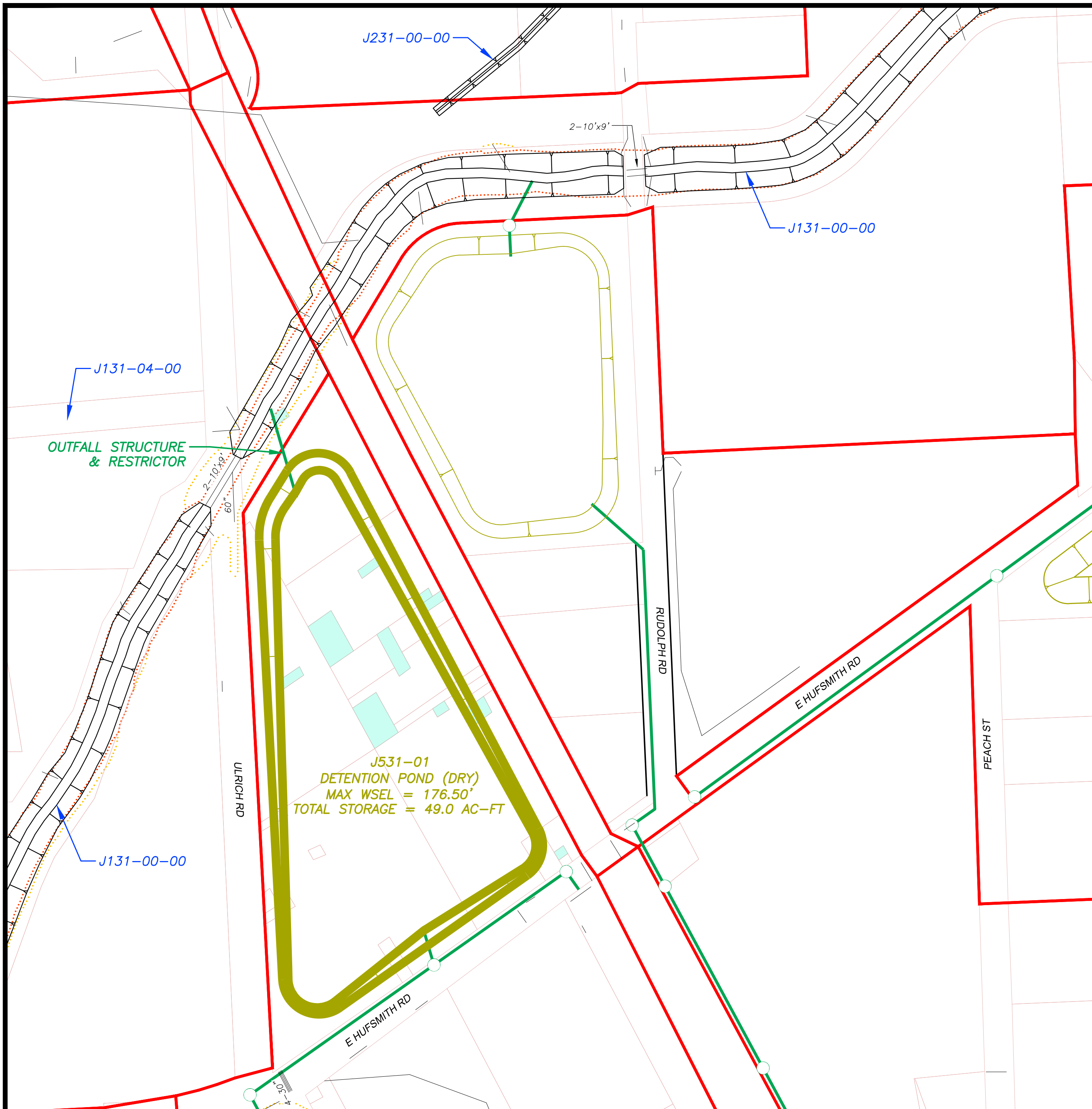
APPENDIX C – J131

CIP PACKETS



DESIGN CRITERIA

1. DESIGN STORM EVENT: 100-YEAR
2. HYDROLOGY - PEAK FLOWS DETERMINED FROM RATIONAL METHOD BASED ON EXISTING AND FUTURE LAND USE MAPS
3. SMALL WATERSHED METHOD USED TO ESTIMATE DETENTION VOLUME FOR INCREASED FLOWS (MINIMUM VOLUME = SWM + 20%)
   - 3.1. STORAGE VOLUME REQUIRED FOR J131_A5 SUBBASIN = 22.8 AC-FT
   - 3.2. STORAGE VOLUME REQUIRED FOR J131_B1_S1 SUBBASIN = 13.1 AC-FT
   - 3.3. STORAGE VOLUME REQUIRED FOR HUFSMITH RD = 2.8 AC-FT (1,5500 LF OF 80' ROW @ 1 AC-FT/AC)
   - 3.4. TOTAL STORAGE VOLUME REQUIRED = 38.7 AC-FT
4. TOTAL LAND ACQUISITION = 20, 623 SF

0 150 300 600

(IN FEET)

1 INCH = 300 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: A5

SCALE: 1" = 1" = 300'	March 2025
EXHIBIT NO. 1	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**1**	Phase	
Project Name	J531-01 Detention Pond Improvements				
Project Category					

Project Description

Acruire remaining parcel within City-owned triangular tract between Hufsmith Road, Ulrich Road and BNSF Railroad. Construction sub-regional dry detention pond on City owned property. Acquisition effots for remaining parcels are not included in cost estimate.

Project Justification

Mitigate increased flows for future storm sewer additions along Cherry Street, Commerce Street and Hufmsith Road. Relieve flooding for Old Town.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*J531-01 DETENTION POND*	*49*	*AC-FT*	*$ 40,000*	*$ 1,960,000*
2	*OUTFALL STRUCTURE*	*1*	*EA*	*$ 25,000*	*$ 25,000*
				SUBTOTAL	*$ 1,985,000*
		CONTINGENCY		*30%*	*$ 595,500*
		CONSULTANT		*25%*	*$ 496,250*
3	*LAND ACQUISITION (FEE)*	*0.54*	*AC*	*$ 435,600*	*$ 234,000*
				SUBTOTAL	*$ 234,000*
		CONTINGENCY		*10%*	*$ 23,400*
				ESTIMATED PROJECT TOTAL COST:	**$ 3,334,150**

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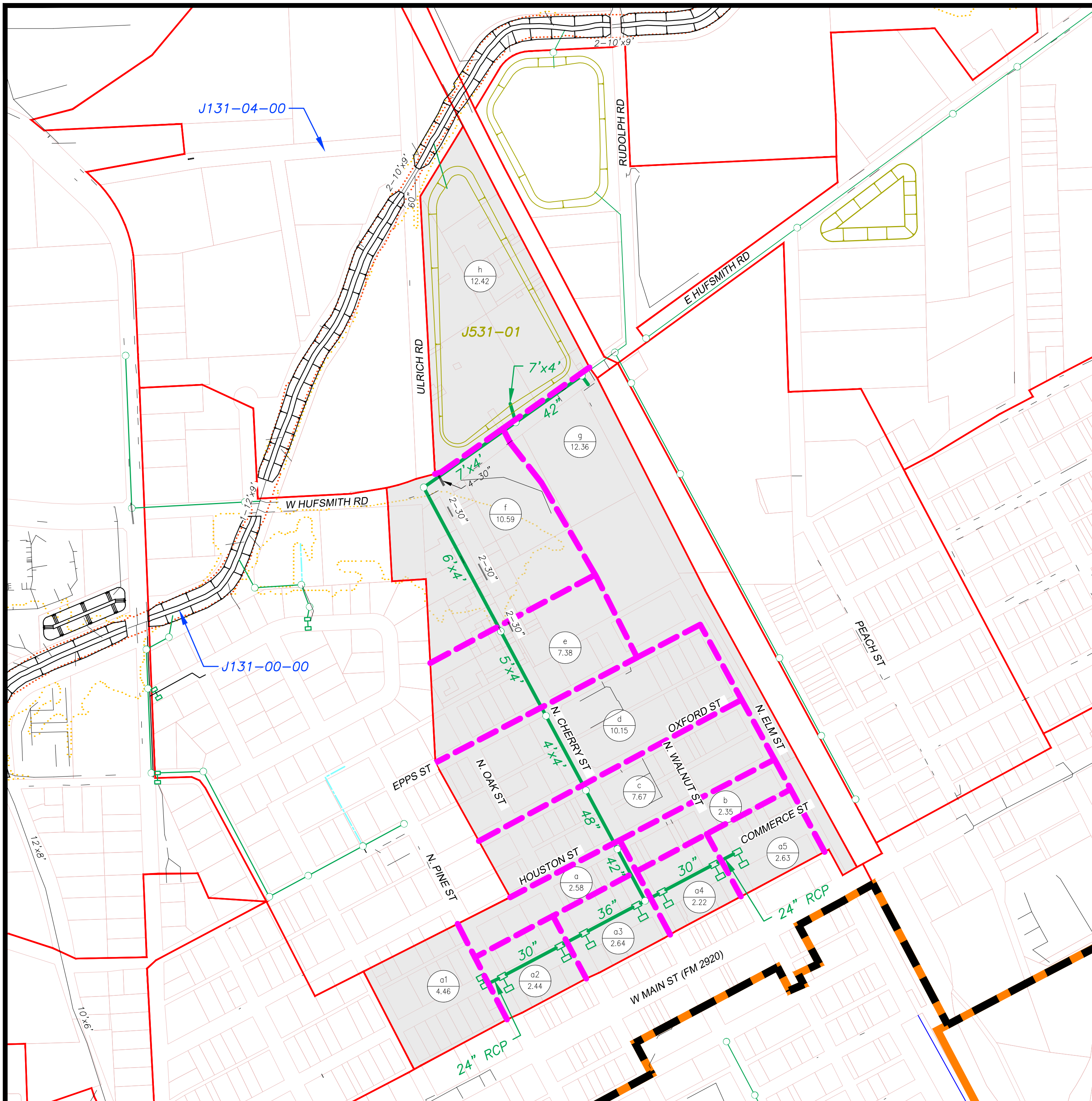
Pricing excludes reloaction of pipelines and abandonment of wells.



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. MITIGATION PROVIDED IN J531-01

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: A5

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 2 & 3	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**2**	Phase	
Project Name		N. Cherry Street Storm Sewer Improvements (From Commerce Street to Hufsmith Rd)			
Project Category					

Project Description

Construct storm sewer and roadside ditch interceptors along N. Cherry Street to J531-01. Cost assumes improvements will be installed without roadway reconstruction.

Project Justification

Provide local flood relief for Old Town by adding conveyance capacity.

Potential Funding Opportunities

Partnership with Harris County Precinct 3 during roadway reconstruction.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*42" RCP*	*570*	*LF*	*$ 300*	*$ 171,000*
2	*48" RCP*	*270*	*LF*	*$ 380*	*$ 102,600*
3	*4'x4' RCB*	*350*	*LF*	*$ 500*	*$ 175,000*
4	*5'x4' RCB*	*390*	*LF*	*$ 480*	*$ 187,200*
5	*6'x4' RCB*	*660*	*LF*	*$ 810*	*$ 534,600*
6	*7'x4' RCB*	*525*	*LF*	*$ 900*	*$ 472,500*
7	*STM MH (SM)*	*1*	*EA*	*$ 6,000*	*$ 6,000*
8	*STM MH (MED)*	*1*	*EA*	*$ 7,500*	*$ 7,500*
9	*STM JB (SM)*	*1*	*EA*	*$ 8,000*	*$ 8,000*
10	*STM JB (MED)*	*2*	*EA*	*$ 12,000*	*$ 24,000*
11	*STM JB (LG)*	*2*	*EA*	*$ 23,500*	*$ 47,000*
12	*DITCH INTERCEPTOR*	*18*	*EA*	*$ 9,100*	*$ 163,800*
13	*PAVEMENT REPAIR - ASP*	*2765*	*LF*	*$ 140*	*$ 387,100*
				SUBTOTAL	*$ 2,286,300*
		CONTINGENCY		*30%*	*$ 685,890*
		CONSULTANT		*25%*	*$ 571,575*
				ESTIMATED PROJECT TOTAL COST:	**$ 3,543,765**

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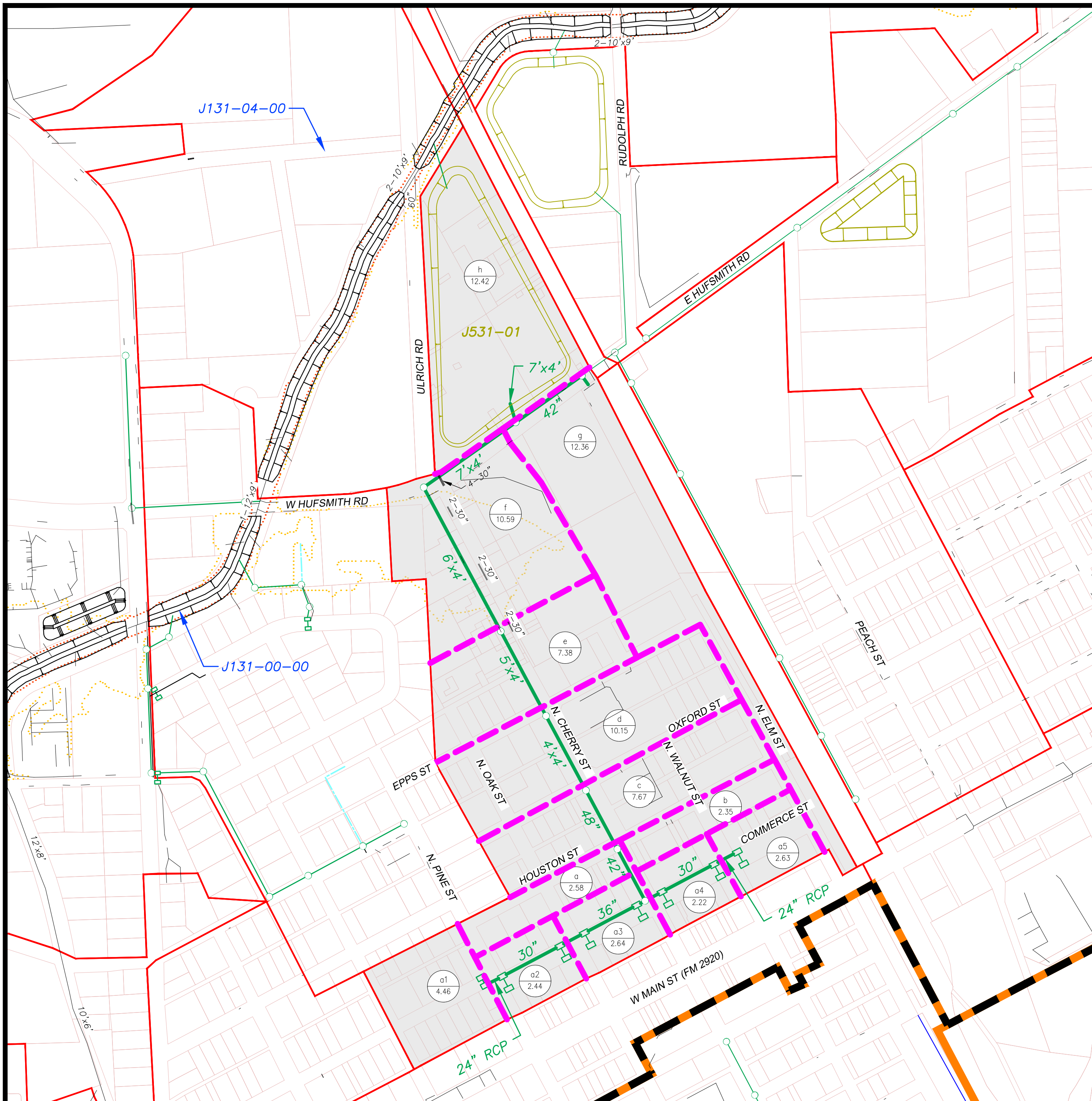
All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. MITIGATION PROVIDED IN J531-01

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: A5

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 2 & 3	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**3**	Phase	
Project Name	Commerce Street Storm Sewer Improvements				
Project Category					

Project Description

Construct storm sewer improvements along Commerce Street from Pine Street to Elm Street.

Project Justification

Provide local flood relief for Old Town by adding inlet conveyance capacity.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*24" RCP*	*150*	*LF*	*$ 130*	*$ 19,500*
2	*30" RCP*	*600*	*LF*	*$ 185*	*$ 111,000*
3	*36" RCP*	*240*	*LF*	*$ 200*	*$ 48,000*
4	*CURB INLET*	*16*	*EA*	*$ 8,600*	*$ 137,600*
5	*STM MH (MED)*	*1*	*EA*	*$ 7,500*	*$ 7,500*
6	*PAVEMENT REPAIR - ASP*	*1260*	*LF*	*$ 140*	*$ 176,400*
				SUBTOTAL	*$ 500,000*
		CONTINGENCY		*30%*	*$ 150,000*
		CONSULTANT		*25%*	*$ 125,000*
				ESTIMATED PROJECT TOTAL COST:	**$ 775,000**

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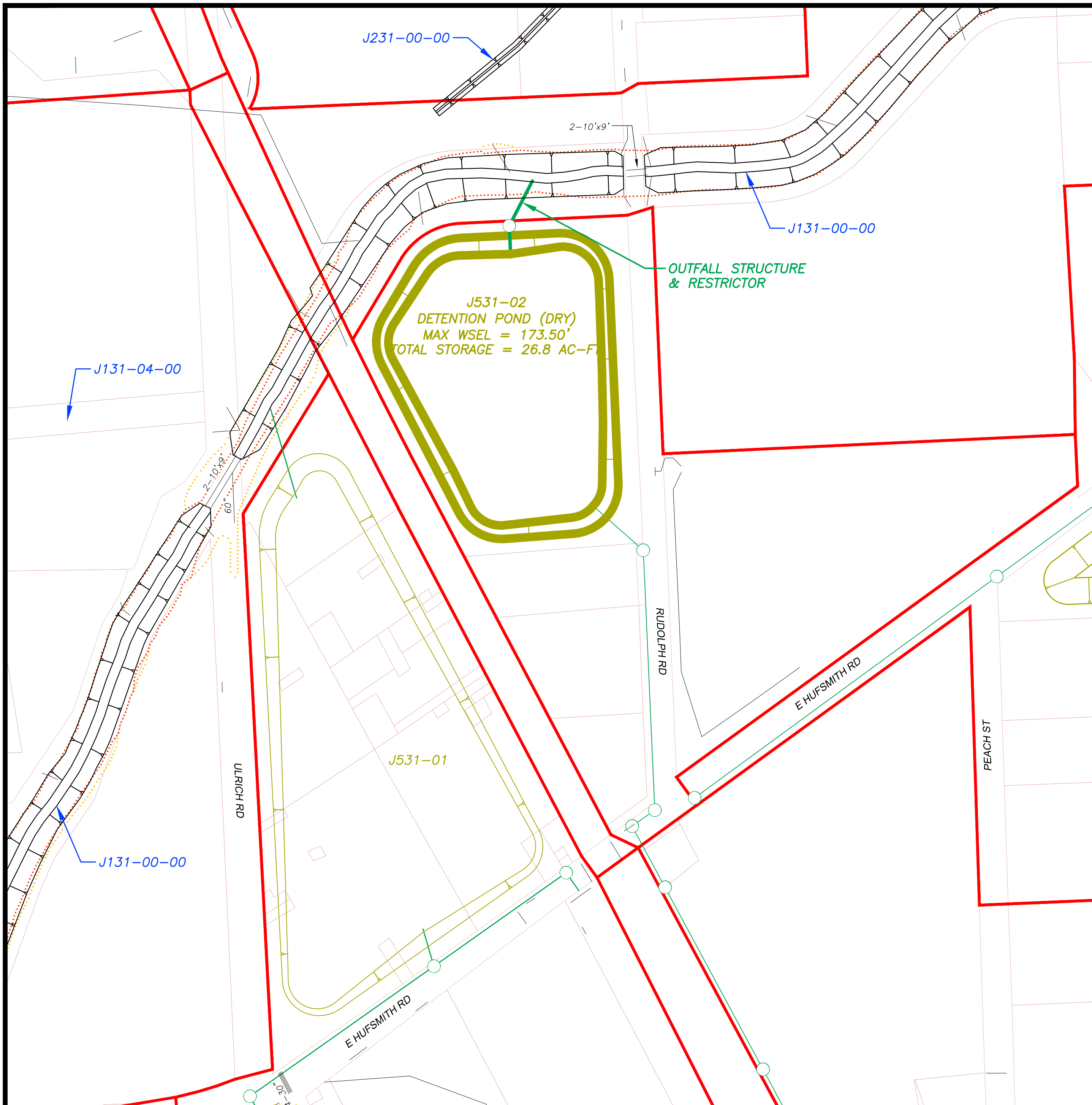
All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT: 100-YEAR
2. HYDROLOGY - PEAK FLOWS DETERMINED FROM RATIONAL METHOD BASED ON EXISTING AND FUTURE LAND USE MAPS
3. SMALL WATERSHED METHOD USED TO ESTIMATE DETENTION VOLUME FOR INCREASED FLOWS (MINIMUM VOLUME = SWM + 20%)
   - 3.1. STORAGE VOLUME REQUIRED FOR J131_B1_S1 = 13.1 AC-FT
   - 3.2. STORAGE VOLUME REQUIRED FOR J132_B1_S2 = 5.6 AC-FT
   - 3.3. TOTAL STORAGE VOLUME REQUIRED = 18.7 AC-FT

0 150 300 600

(IN FEET)

1 INCH = 300 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: B1_S1 & B1_S2

SCALE: 1" = 1" = 300'	March 2025
EXHIBIT NO. 4	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**4**	Phase	
Project Name	J531-02 Detention Pond Improvements				
Project Category					

Project Description

Construction of dry-bottom stormwater detention pond on City-owned tract.

Project Justification

Alternative drainage solution to serve future Hufsmith Road roadway reconstruction and North Sycamore Street storm sewer improvements.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*J531-02 DETENTION POND*	*26.8*	*AC-FT*	*$ 40,000*	*$ 1,072,000*
2	*OUTFALL STRUCTURE*	*1*	*EA*	*$ 25,000*	*$ 25,000*
				SUBTOTAL	*$ 1,097,000*
		CONTINGENCY		*30%*	*$ 329,100*
		CONSULTANT		*25%*	*$ 274,250*
				ESTIMATED PROJECT TOTAL COST:	**$ 1,700,350**

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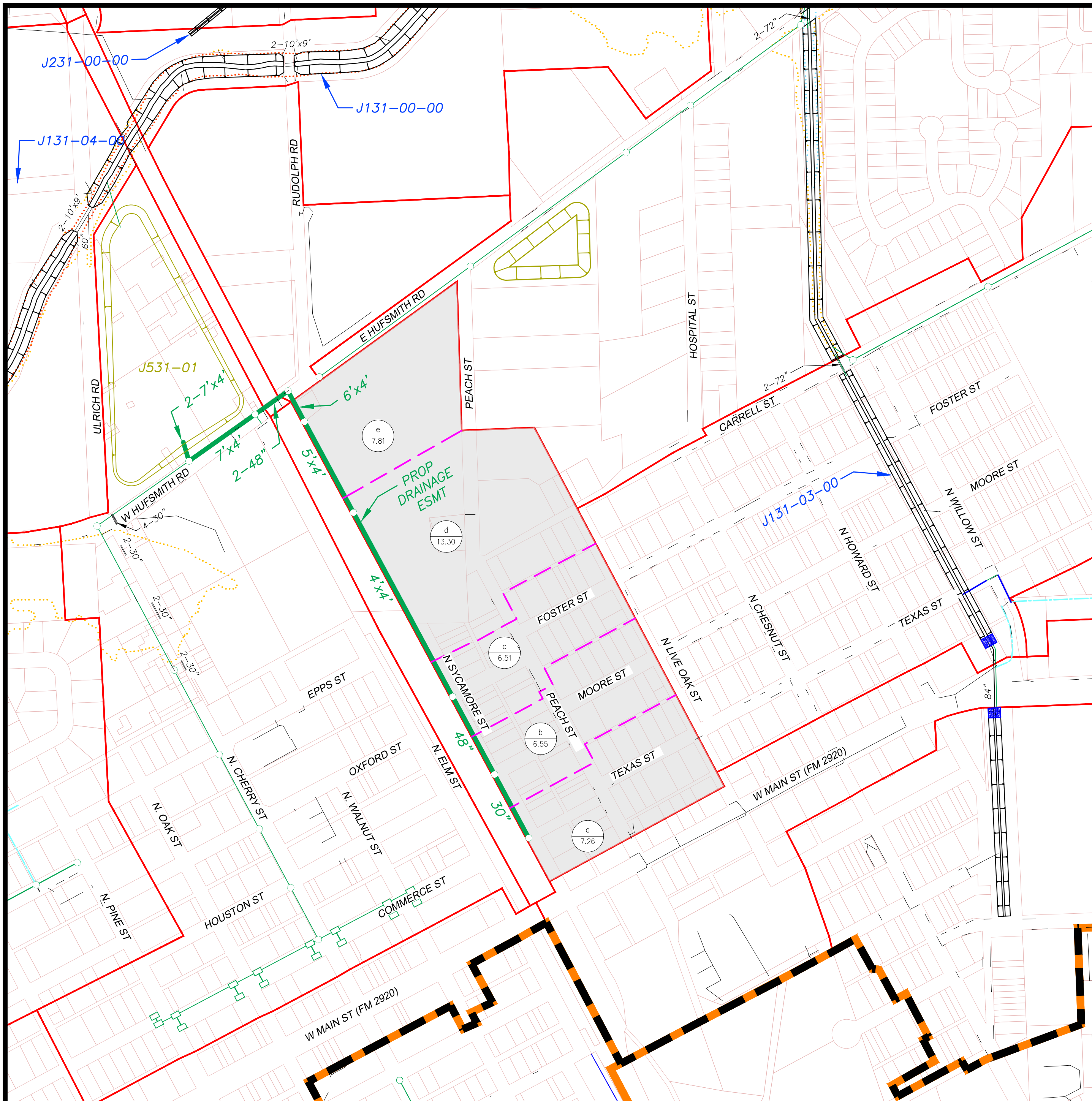
Pricing excludes reloaction of pipelines and abandonment of wells.

All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. MITIGATION PROVIDED IN J531-01
7. LAND ACQUISITION (ESMT) = 20,720 SF

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID
50.0 — DRAINAGE AREA IN ACRES

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: B1_S1

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 5A	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**5A**	Phase	
Project Name	N. Sycamore Storm Sewer Alternate 1				
Project Category					
Project Description					
Construct storm sewer along N. Sycamore Street to J531-01 detention pond.					
Project Justification					
Relieve local flooding due to limited conveyance capacity to J131-00-00. Provide outfall depth for future development and future roadway improvements.					
Potential Funding Opportunities					
Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*30" RCP*	*300*	*LF*	*$ 185*	*$ 55,500*
2	*48" RCP*	*360*	*LF*	*$ 380*	*$ 136,800*
3	*48" RCP (railroad)*	*150*	*LF*	*$ 760*	*$ 114,000*
4	*4'x4' RCB*	*840*	*LF*	*$ 500*	*$ 420,000*
5	*5'x4' RCB*	*420*	*LF*	*$ 480*	*$ 201,600*
6	*6'x4' RCB*	*120*	*LF*	*$ 810*	*$ 97,200*
7	*7'x4' RCB*	*450*	*LF*	*$ 900*	*$ 405,000*
8	*STM MH (SM)*	*2*	*EA*	*$ 6,000*	*$ 12,000*
9	*STM JB (SM)*	*2*	*EA*	*$ 8,000*	*$ 16,000*
10	*STM JB (MED)*	*2*	*EA*	*$ 12,000*	*$ 24,000*
11	*STM JB (LG)*	*2*	*EA*	*$ 23,500*	*$ 47,000*
12	*DITCH INTERCEPTOR*	*8*	*EA*	*$ 9,100*	*$ 72,800*
13	*PAVEMENT REPAIR - ASP*	*1000*	*LF*	*$ 140*	*$ 140,000*
				SUBTOTAL	*$ 1,741,900*
		CONTINGENCY		*30%*	*$ 522,570*
		CONSULTANT		*25%*	*$ 435,475*
14	*LAND ACQUISITION (ESMT)*	*0.48*	*AC*	*$ 130,680*	*$ 62,157*
				SUBTOTAL	*$ 62,157*
		CONTINGENCY		*10%*	*$ 6,216*
				ESTIMATED PROJECT TOTAL COST:	**$ 2,768,318**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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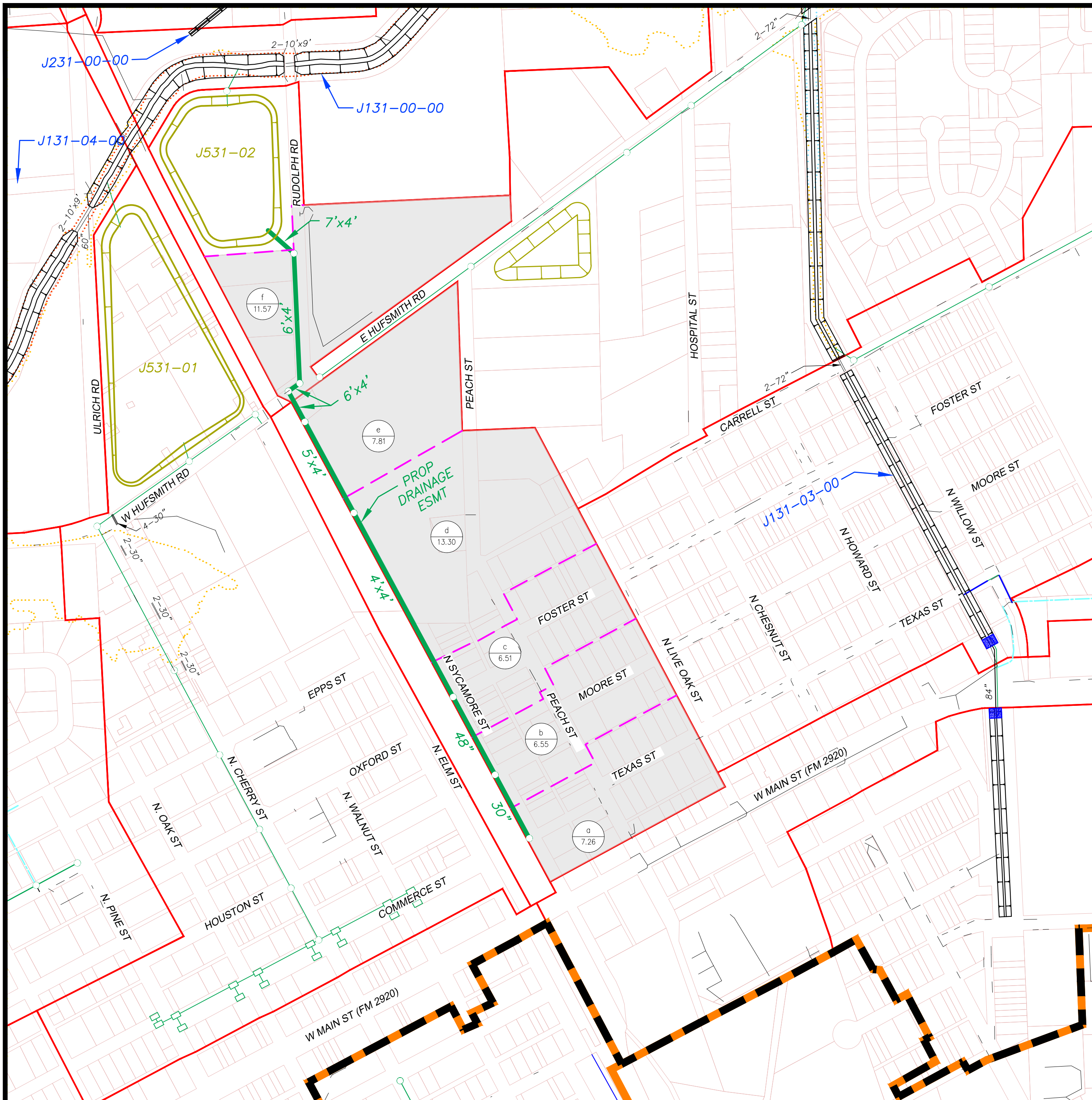

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. MITIGATION PROVIDED IN J531-02
7. LAND ACQUISITION (ESMT) = 20,720 SF

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A / 50.0 — DRAINAGE AREA ID / DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: B1_S1 & B1_S2

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 5B	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**5B**	Phase	
Project Name	N. Sycamore Storm Sewer Alternate 2				
Project Category					

Project Description

Construct storm sewer along N. Sycamore Street to J531-01 detention pond.

Project Justification

Alternative solution to relieve local flooding due to limited conveyance capacity to J131-00-00. Provide outfall depth for future development and future roadway improvements.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*30" RCP*	*300*	*LF*	*$ 185*	*$ 55,500*
2	*48" RCP*	*360*	*LF*	*$ 380*	*$ 136,800*
3	*4'x4' RCB*	*840*	*LF*	*$ 500*	*$ 420,000*
4	*5'x4' RCB*	*420*	*LF*	*$ 480*	*$ 201,600*
5	*6'x4' RCB*	*690*	*LF*	*$ 810*	*$ 558,900*
6	*7'x4' RCB*	*120*	*LF*	*$ 900*	*$ 108,000*
7	*STM MH (SM)*	*1*	*EA*	*$ 6,000*	*$ 6,000*
8	*STM MH (MED)*	*1*	*EA*	*$ 7,500*	*$ 7,500*
9	*STM JB (SM)*	*2*	*EA*	*$ 8,000*	*$ 16,000*
10	*STM JB (MED)*	*3*	*EA*	*$ 12,000*	*$ 36,000*
11	*STM JB (LG)*	*1*	*EA*	*$ 23,500*	*$ 23,500*
12	*DITCH INTERCEPTOR*	*6*	*EA*	*$ 9,100*	*$ 54,600*
13	*PAVEMENT REPAIR - ASP*	*1000*	*LF*	*$ 140*	*$ 140,000*
				SUBTOTAL	*$ 1,764,400*
		CONTINGENCY		*30%*	*$ 529,320*
		CONSULTANT		*25%*	*$ 441,100*
14	*LAND ACQUISITION (ESMT)*	*0.48*	*AC*	*$ 130,680*	*$ 62,157*
				SUBTOTAL	*$ 62,157*
		CONTINGENCY		*10%*	*$ 6,216*
				ESTIMATED PROJECT TOTAL COST:	**$ 2,803,193**

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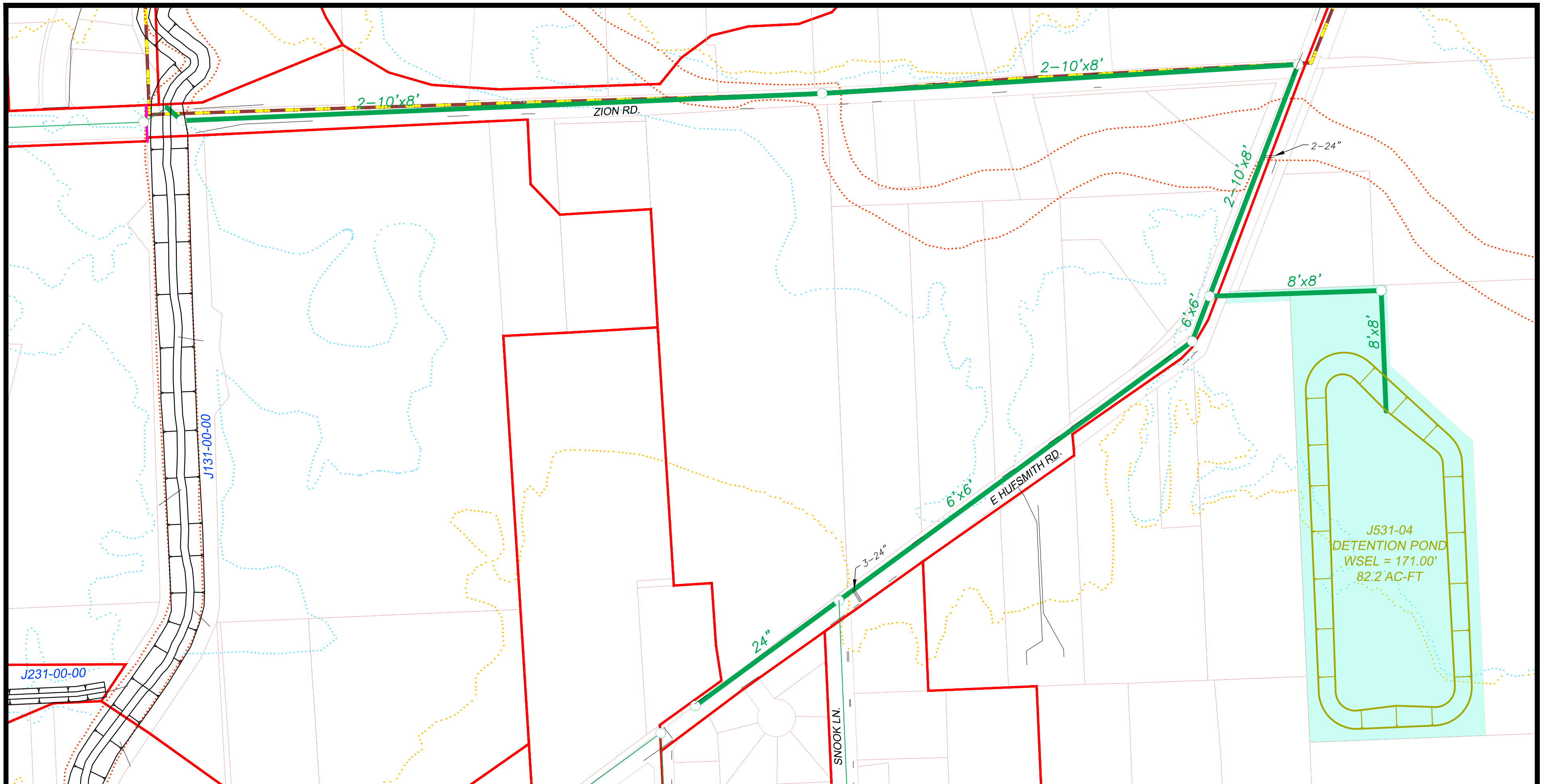

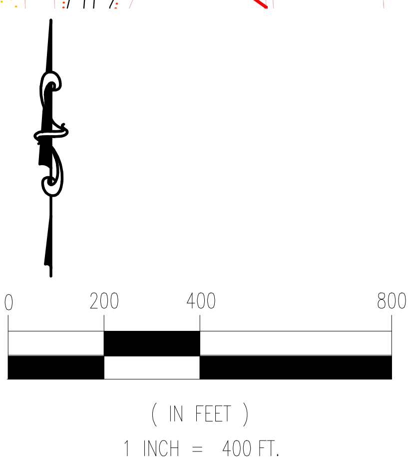

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 484,993 SF

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A / 50.0 — DRAINAGE AREA ID / DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL DMP
CIP DETAIL LAYOUTS

BASIN: J131-00-00
SUBBASIN:

SCALE: 1" = 400'	March 2025
EXHIBIT NO. 6A	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**6A**	Phase	
Project Name		J131-01 Alternate 1			
Project Category					

Project Description

Construct storm sewer along Hufsmith Rd and Zion Road. Construct J531-04 detention and mitigation pond. Improvements assumed to be in correlation with Harris County Precinct 3 roadway improvements for Hufsmith and Zion.

Project Justification

Relieve flooding, mitigate J131-01 floodplain, and provide outfall depth for future development.

Potential Funding Opportunities

HCFCD and/or Harris County Precinct 3 joint venture

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	440	LF	$ 130	$ 57,200
2	6'x6' RCB	1240	LF	$ 820	$ 1,016,800
3	8'x8' RCB	740	LF	$ 1,250	$ 925,000
4	10'x8' RCB	7040	LF	$ 1,560	$ 10,982,400
5	STM MH (SM)	1	EA	$ 6,000	$ 6,000
6	STM JB (MED)	2	EA	$ 12,000	$ 24,000
7	STM JB (LG)	9	EA	$ 23,500	$ 211,500
8	CURB INLET	28	EA	$ 8,600	$ 240,800
10	J531-04	82.2	AC-FT	$ 40,000	$ 3,288,000
				SUBTOTAL	$ 16,751,700
		CONTINGENCY		30%	$ 5,025,510
		CONSULTANT		25%	$ 4,187,925
11	LAND ACQUISITION (J531-04)	11.02	AC	$ 217,800	$ 2,400,458
12	LAND ACQUISITION (ESMT)	0.11	AC	$ 130,680	$ 14,704
				SUBTOTAL	$ 2,415,162
		CONTINGENCY		10%	$ 241,516
				ESTIMATED PROJECT TOTAL COST:	**$ 28,621,813**

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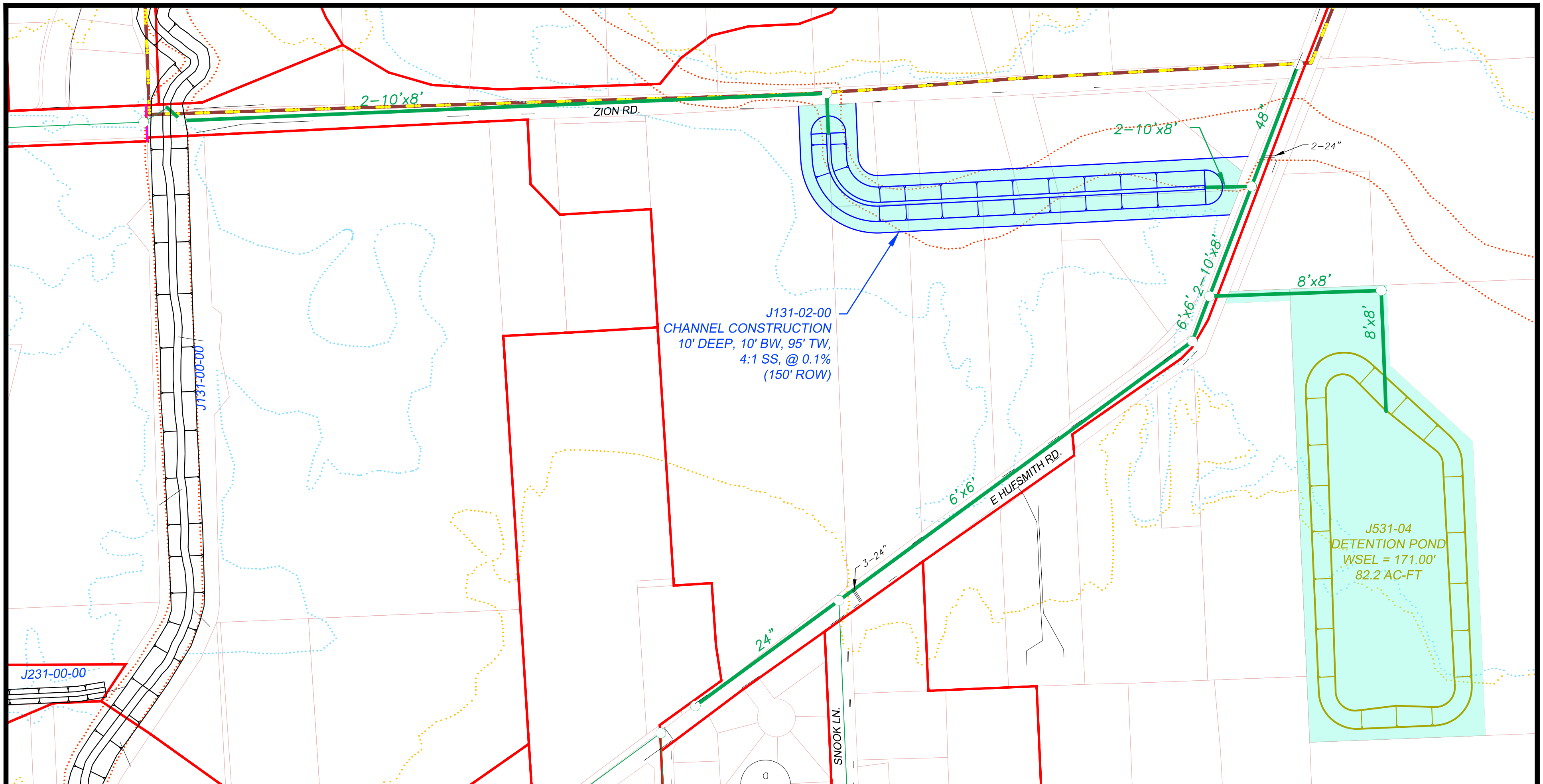

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 675,388 SF

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID
50.0 — DRAINAGE AREA IN ACRES

0 200 400 800

(IN FEET)

1 INCH = 400 FT.

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL DMP
CIP DETAIL LAYOUTS

BASIN: J131-00-00
SUBBASIN:

SCALE: 1" = 400'	March 2025
EXHIBIT NO. 6B	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**6B**	Phase	
Project Name	J131-01 Alternate 2				
Project Category					

Project Description

Construct storm sewer along Hufsmith Rd and Zion Road. Construct J531-04 detention and mitigation pond. Construct J131-02 between Zion and Hufsmith. Improvements assumed to be in correlation with Harris County Precinct 3 roadway improvements for Hufsmith and Zion.

Project Justification

Relieve flooding, mitigate J131-01 floodplain, and provide outfall depth for future development.

Potential Funding Opportunities

HCFCD and/or Harris County Precinct 3 joint venture

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	440	LF	$ 130	$ 57,200
2	48" RCP	320	LF	$ 380	$ 121,600
2	6'x6' RCB	1240	LF	$ 820	$ 1,016,800
3	8'x8' RCB	740	LF	$ 1,250	$ 925,000
4	10'x8' RCB	4160	LF	$ 1,560	$ 6,489,600
5	STM MH (SM)	1	EA	$ 6,000	$ 6,000
6	STM MH (MED)	1	EA	$ 7,500	$ 7,500
7	STM JB (MED)	2	EA	$ 12,000	$ 24,000
8	STM JB (LG)	9	EA	$ 23,500	$ 211,500
9	CURB INLET	26	EA	$ 8,600	$ 223,600
11	J131-02-00	1640	LF	$ 410	$ 672,400
12	J531-04	82.2	AC-FT	$ 40,000	$ 3,288,000
				SUBTOTAL	$ 13,043,200
		CONTINGENCY		30%	$ 3,912,960
		CONSULTANT		25%	$ 3,260,800
13	LAND ACQUISITION (J531-04)	11.02	AC	$ 217,800	$ 2,400,458
14	LAND ACQUISITION (ESMT)	0.11	AC	$ 130,680	$ 14,704
15	LAND ACQUISITION (J131-02-00)	4.37	AC	$ 217,800	$ 951,978
				SUBTOTAL	$ 3,367,140
		CONTINGENCY		10%	$ 336,714
				ESTIMATED PROJECT TOTAL COST:	**$ 23,920,814**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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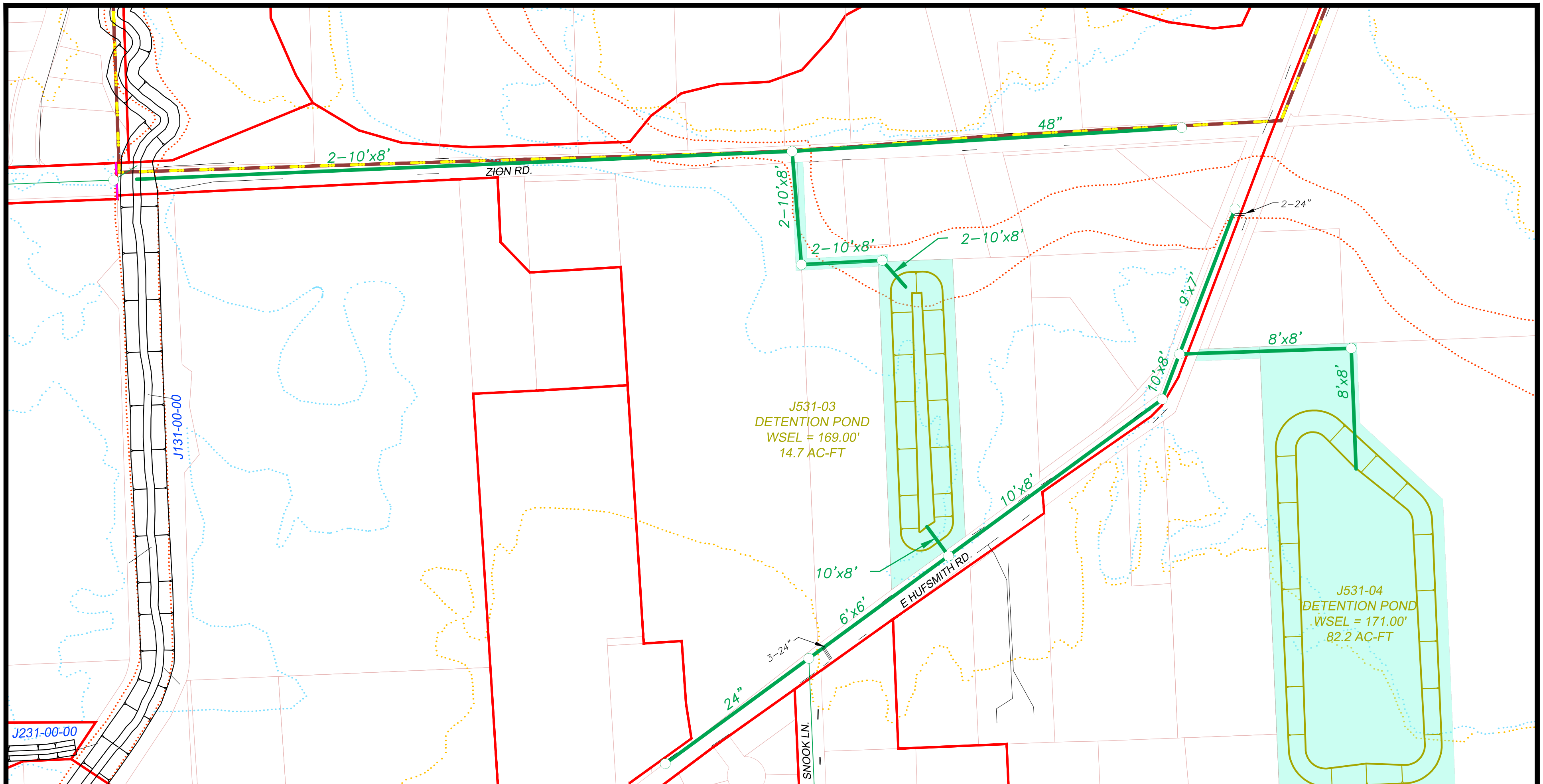


0 200 400 800

(IN FEET)

1 INCH = 400 FT.

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 655,005 SF

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID
50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL DMP
CIP DETAIL LAYOUTS

BASIN: J131-00-00
SUBBASIN:

SCALE: 1" = 400'	March 2025
EXHIBIT NO. 6C	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**6C**	Phase	
Project Name	J131-01 Alternate 3				
Project Category					

Project Description

Construct storm sewer along Hufsmith Rd and Zion Road. Construct J531-03 and J531-04 detention and mitigation ponds. Improvements assumed to be in correlation with Harris County Precinct 3 roadway improvements for Hufsmith and Zion.

Project Justification

Relieve flooding, mitigate J131-01 floodplain, and provide outfall depth for future development.

Potential Funding Opportunities

HCFCD and/or Harris County Precinct 3 joint venture

Opinion of Probable Construction Cost

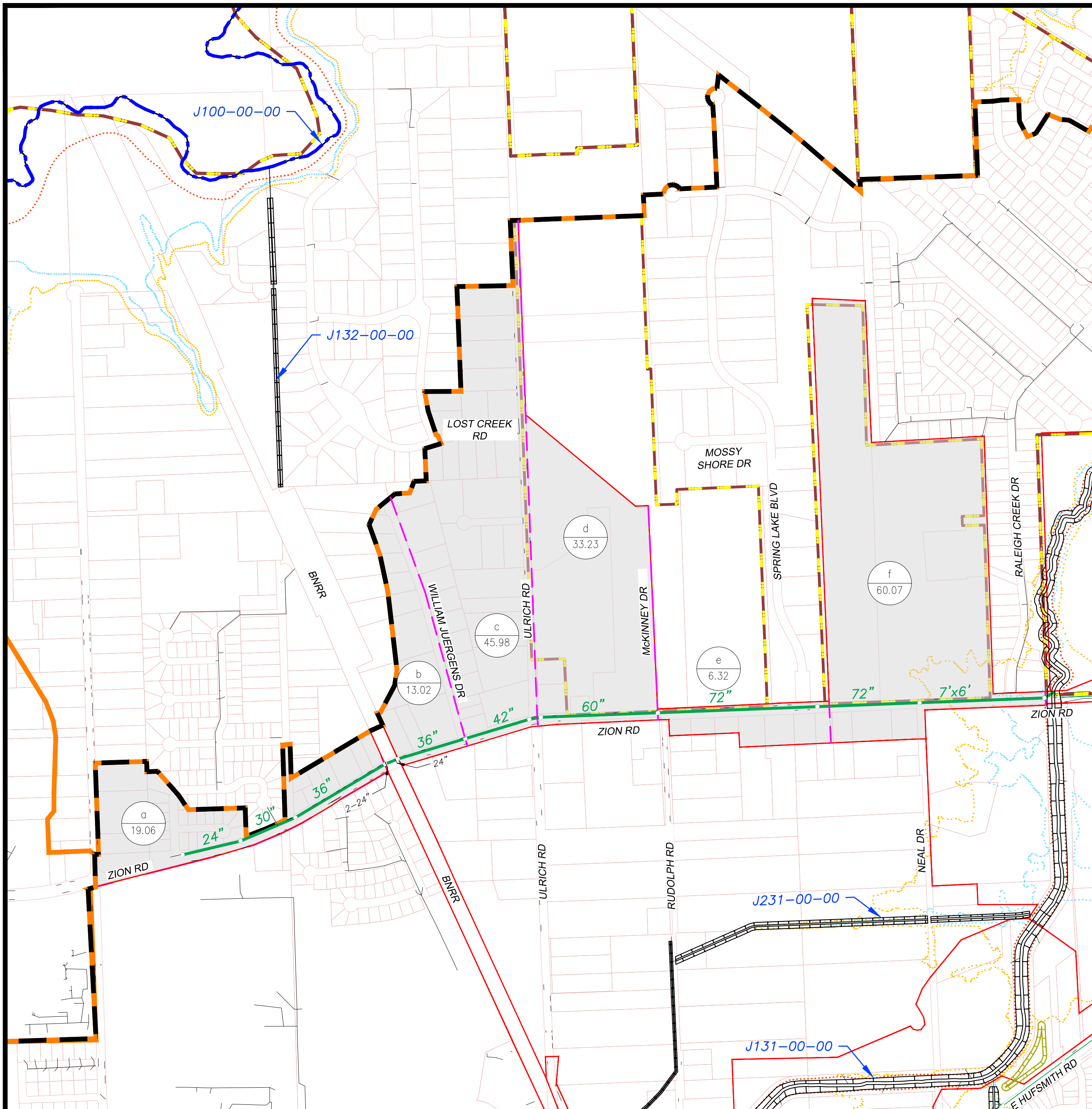
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	440	LF	$ 130	$ 57,200
2	48" RCP	1000	LF	$ 380	$ 380,000
3	6'x6' RCB	440	LF	$ 820	$ 360,800
4	8'x8' RCB	740	LF	$ 1,250	$ 925,000
5	9'x7' RCB	400	LF	$ 1,420	$ 568,000
6	10'x8' RCB	4960	LF	$ 1,560	$ 7,737,600
7	STM MH (SM)	1	EA	$ 6,000	$ 6,000
8	STM MH (LG)	1	EA	$ 9,000	$ 9,000
9	STM JB (MED)	1	EA	$ 12,000	$ 12,000
10	STM JB (LG)	11	EA	$ 23,500	$ 258,500
11	CURB INLET	33	EA	$ 8,600	$ 283,800
13	J531-03	14.7	AC-FT	$ 40,000	$ 588,000
14	J531-04	82.2	AC-FT	$ 40,000	$ 3,288,000
				SUBTOTAL	$ 14,473,900
		CONTINGENCY		30%	$ 4,342,170
		CONSULTANT		25%	$ 3,618,475
15	LAND ACQUISITION (J531-04)	11.02	AC	$ 217,800	$ 2,400,458
16	LAND ACQUISITION (ESMT)	0.45	AC	$ 130,680	$ 58,162
17	LAND ACQUISITION (J531-03)	3.57	AC	$ 217,800	$ 777,638
				SUBTOTAL	$ 3,236,259
		CONTINGENCY		10%	$ 323,626
				ESTIMATED PROJECT TOTAL COST:	**$ 25,994,429**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

Land acquisition is based on parcel data received from the City and is a preliminary estimation. CSE has not evaluated, researched, or appraised property for rights-of-way and easements necessary for the construction and maintenance of the proposed improvements.

Pricing excludes reloaction of pipelines and abandonment of wells.

All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 500 1000 2000

(IN FEET)

1 INCH = 1000 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID
50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: A5

SCALE: 1" = 1" = 1000'	March 2025
EXHIBIT NO. 7	J131 BASIN

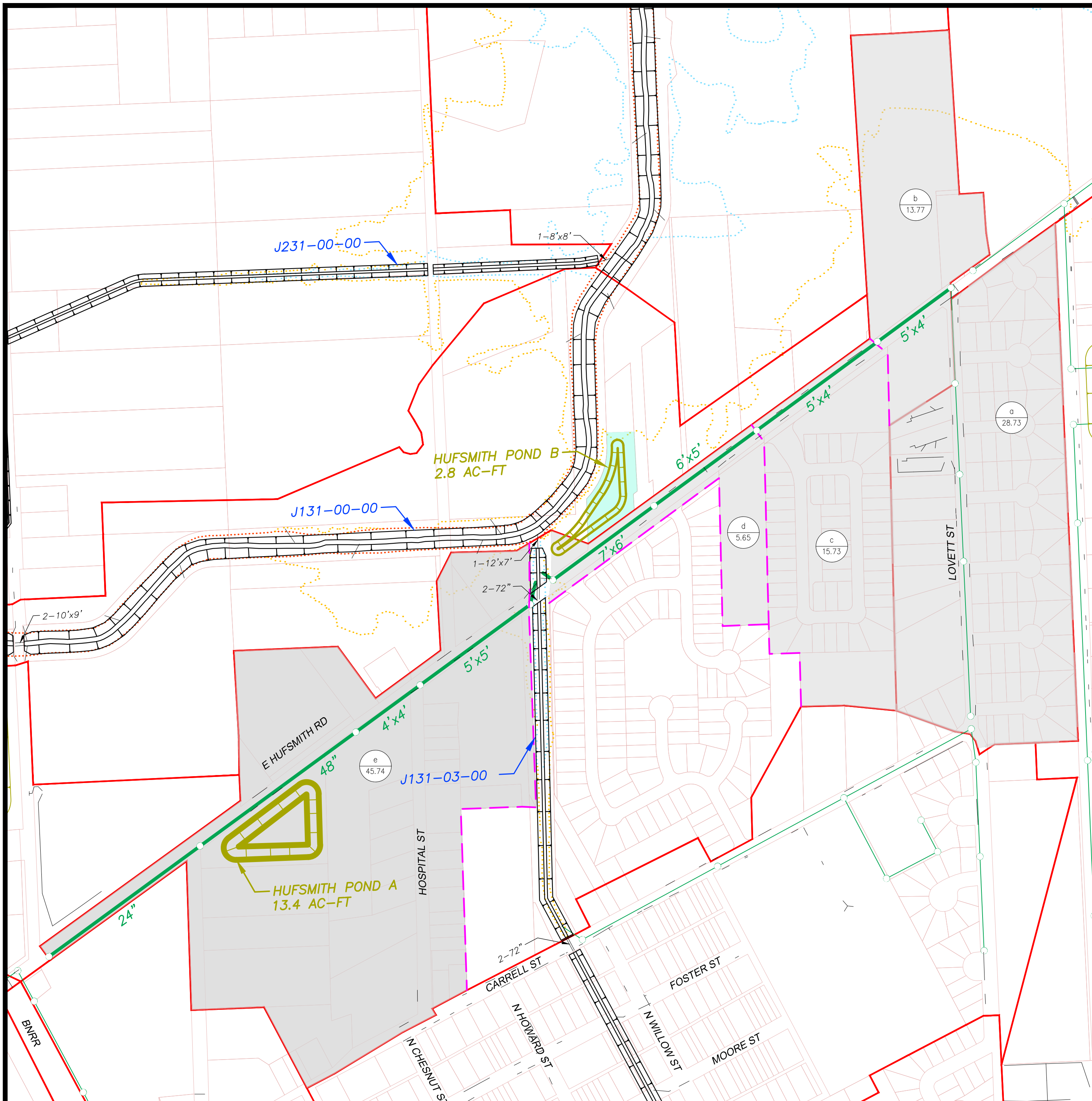
Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**7**	Phase	
Project Name		Zion Road Storm Sewer Improvements			
Project Category					
Project Description					
Construct storm sewer along Zion Road. Improvements assumed to be part of roadway reconstruction.					
Project Justification					
Provide increased conveyance and relieve local flooding.					
Potential Funding Opportunities					
Harris County Precinct 3					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*24" RCP*	*400*	*LF*	*$ 130*	*$ 52,000*
2	*30" RCP*	*400*	*LF*	*$ 185*	*$ 74,000*
3	*36" RCP*	*1150*	*LF*	*$ 200*	*$ 230,000*
4	*36" RCP (railroad)*	*100*	*LF*	*$ 400*	*$ 40,000*
5	*42" RCP*	*500*	*LF*	*$ 300*	*$ 150,000*
6	*60" RCP*	*800*	*LF*	*$ 400*	*$ 320,000*
7	*72" RCP*	*1800*	*LF*	*$ 650*	*$ 1,170,000*
8	*7'x6' RCB*	*950*	*LF*	*$ 1,020*	*$ 969,000*
9	*STM MH (SM)*	*5*	*EA*	*$ 6,000*	*$ 30,000*
10	*STM MH (MED)*	*2*	*EA*	*$ 7,500*	*$ 15,000*
11	*STM MH (LG)*	*3*	*EA*	*$ 9,000*	*$ 27,000*
12	*STM JB (LG)*	*2*	*EA*	*$ 23,500*	*$ 47,000*
13	*CURB INLET*	*20*	*EA*	*$ 8,600*	*$ 172,000*
				SUBTOTAL	*$ 3,296,000*
		CONTINGENCY		*30%*	*$ 988,800*
		CONSULTANT		*25%*	*$ 824,000*
				ESTIMATED PROJECT TOTAL COST:	**$ 5,108,800**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

Land acquisition is based on parcel data received from the City and is a preliminary estimation. CSE has not evaluated, researched, or appraised property for rights-of-way and easements necessary for the construction and maintenance of the proposed improvements.

All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 59,941 SF

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131 (J131-03-00)
SUBBASIN: E1 & E2

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 8	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.		**8**	Phase
Project Name	Hufsmith Road Storm Sewer Improvements				
Project Category					

Project Description

Construct storm sewer down Hufsmith Road between BNSF Railroad and Lovett Street. Improvements assumed to be incorparated as part of roadway reconstruction.

Project Justification

Provice increased conveyance and relieve local flooding.

Potential Funding Opportunities

Harris County Precinct 3

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	750	LF	$ 130	$ 97,500
2	48" RCP	780	LF	$ 380	$ 296,400
3	4'x4' RCB	300	LF	$ 500	$ 150,000
4	5'x4' RCB	960	LF	$ 480	$ 460,800
5	5'x5' RCB	600	LF	$ 670	$ 402,000
6	6'x5' RCB	510	LF	$ 750	$ 382,500
7	7'x6' RCB	540	LF	$ 1,020	$ 550,800
8	STM MH (SM)	1	EA	$ 6,000	$ 6,000
9	STM MH (LG)	1	EA	$ 9,000	$ 9,000
10	STM JB (SM)	5	EA	$ 8,000	$ 40,000
11	STM JB (MED)	1	EA	$ 12,000	$ 12,000
12	STM JB (LG)	2	EA	$ 23,500	$ 47,000
13	CURB INLET	22	EA	$ 8,600	$ 189,200
14	HUFSMITH POND A	13.4	AC-FT	$ 40,000	$ 536,000
15	HUFSMITH POND B	2.8	AC-FT	$ 40,000	$ 112,000
16	OUTFALL STRUCTURE	2	EA	$ 25,000	$ 50,000
				SUBTOTAL	$ 3,341,200
		CONTINGENCY		30%	$ 1,002,360
		CONSULTANT		25%	$ 835,300
18	LAND ACQUISITION (FEE)	1.38	AC	$ 217,800	$ 299,702
				SUBTOTAL	$ 299,702
		CONTINGENCY		10%	$ 29,970
				ESTIMATED PROJECT TOTAL COST:	**$ 5,508,533**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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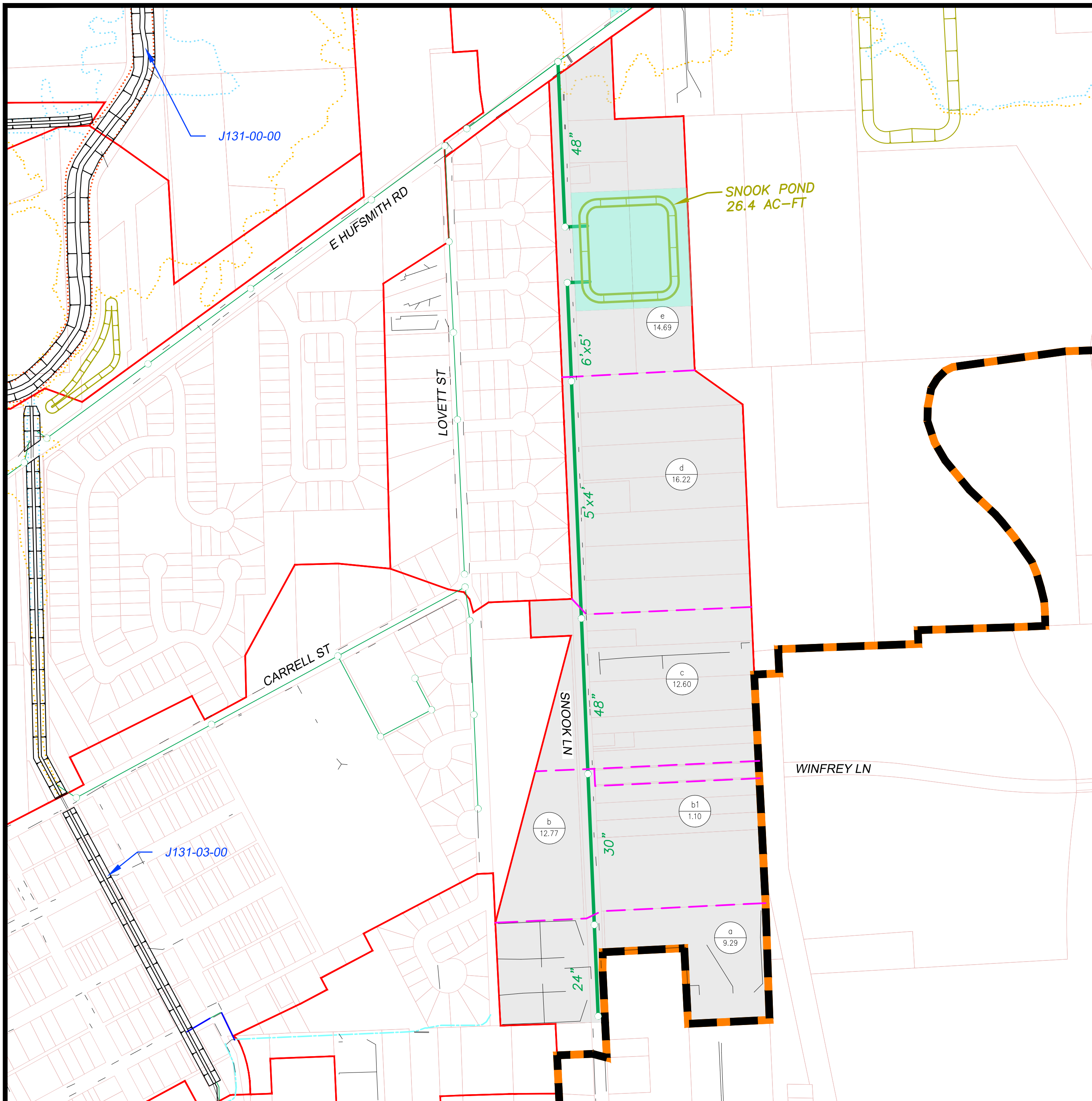
All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT POND OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. DETENTION PROVIDED IN SNOOK DETENTION POND FOR WATERSHED DIVERSION
7. LAND ACQUISITION (ESMT) = 231,028 SF

0 300 600 1,200

(IN FEET)

1 INCH = 600 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-01-00
SUBBASIN: A

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 9	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**9**	Phase	
Project Name	Snook Lane Storm Sewer Improvements				
Project Category					
Project Description					
Construct storm sewer improvements along Snook Lane. Construct detention pond near Hufsmith Road. Improvements assumed to be installed as part of roadway reconstruction and require improvements to Hufsmith Road for outfall depth.					
Project Justification					
Watershed diversion from M116 to J131 due to issues along FM 2920 and lack of outfall depth for future improvements. Stormwater detention pond to offset runoff impacts for watershed diversion and roadway improvements.					
Potential Funding Opportunities					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*24" RCP*	*360*	*LF*	*$ 130*	*$ 46,800*
2	*30" RCP*	*600*	*LF*	*$ 185*	*$ 111,000*
3	*48" RCP*	*1350*	*LF*	*$ 380*	*$ 513,000*
4	*5'x4' RCB*	*960*	*LF*	*$ 480*	*$ 460,800*
5	*6'x5' RCB*	*450*	*LF*	*$ 750*	*$ 337,500*
6	*STM MH (SM)*	*3*	*EA*	*$ 6,000*	*$ 18,000*
7	*STM MH (LG)*	*2*	*EA*	*$ 9,000*	*$ 18,000*
8	*STM JB (MED)*	*3*	*EA*	*$ 12,000*	*$ 36,000*
9	*CURB INLET*	*22*	*EA*	*$ 8,600*	*$ 189,200*
10	*SNOOK DETENTION POND*	*27*	*AC-FT*	*$ 40,000*	*$ 1,080,000*
11	*OUTFALL STRUCTURE*	*2*	*EA*	*$ 150*	*$ 300*
				SUBTOTAL	*$ 1,730,300*
		CONTINGENCY		*30%*	*$ 519,090*
		CONSULTANT		*25%*	*$ 432,575*
12	*LAND ACQUISITION (FEE)*	*5.30*	*AC*	*$ 217,800*	*$ 1,155,140*
				SUBTOTAL	*$ 1,155,140*
		CONTINGENCY		*10%*	*$ 115,514*
				ESTIMATED PROJECT TOTAL COST:	**$ 3,952,619**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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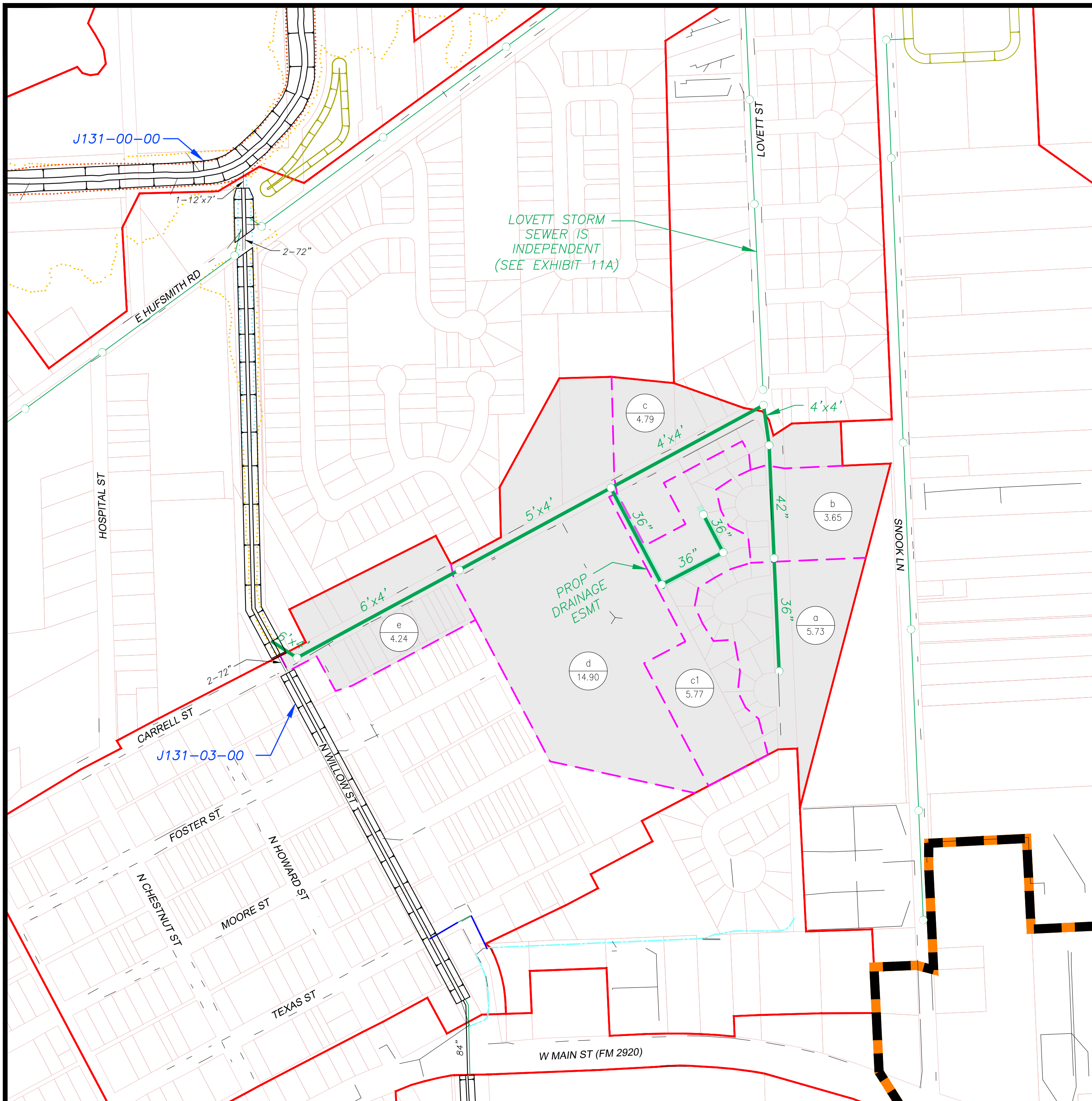

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
7. LAND ACQUISITION (ESMT) = 15,316 SF

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		

ZONE AE/FLOODWAY

ZONE AE (100-YR)

ZONE X (500-YR)

3A ← DRAINAGE AREA ID

50.0 ← DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131 (J131-03-00)
SUBBASIN: D

SCALE: 1" = 1" = 500'	March 2025
EXHIBIT NO. 10A	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**10A**	Phase	
Project Name	Carrell Street Storm Sewer Improvements				
Project Category					

Project Description

Construct storm sewer along Carrell Street and southern segments of Lovett Street to J131-03-00. Construct storm sewer to around Carrell Street Baptist Church.

Project Justification

Relieve local flooding and provide conveyance capacity. Construct storm sewer to decrease ongoing maintance cost at Carrell Street Baptist Church.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	36" RCP	1050	LF	$ 200	$ 210,000
2	42" RCP	375	LF	$ 300	$ 112,500
3	4'x4' RCB	650	LF	$ 500	$ 325,000
4	5'x4' RCB	550	LF	$ 480	$ 264,000
5	6'x4' RCB	750	LF	$ 810	$ 607,500
6	STM MH (SM)	5	EA	$ 6,000	$ 30,000
7	STM JB (SM)	2	EA	$ 8,000	$ 16,000
8	STM JB (MED)	5	EA	$ 12,000	$ 60,000
9	DITCH INTERCEPTOR	18	EA	$ 9,100	$ 163,800
10	PAVEMENT REPAIR - ASP	2850	LF	$ 140	$ 399,000
				SUBTOTAL	$ 2,187,800
		CONTINGENCY		30%	$ 656,340
		CONSULTANT		25%	$ 546,950
11	LAND ACQUISITION (ESMT)	0.35	AC	$ 130,680	$ 45,948
				SUBTOTAL	$ 45,948
		CONTINGENCY		10%	$ 4,595
				ESTIMATED PROJECT TOTAL COST:	**$ 3,441,633**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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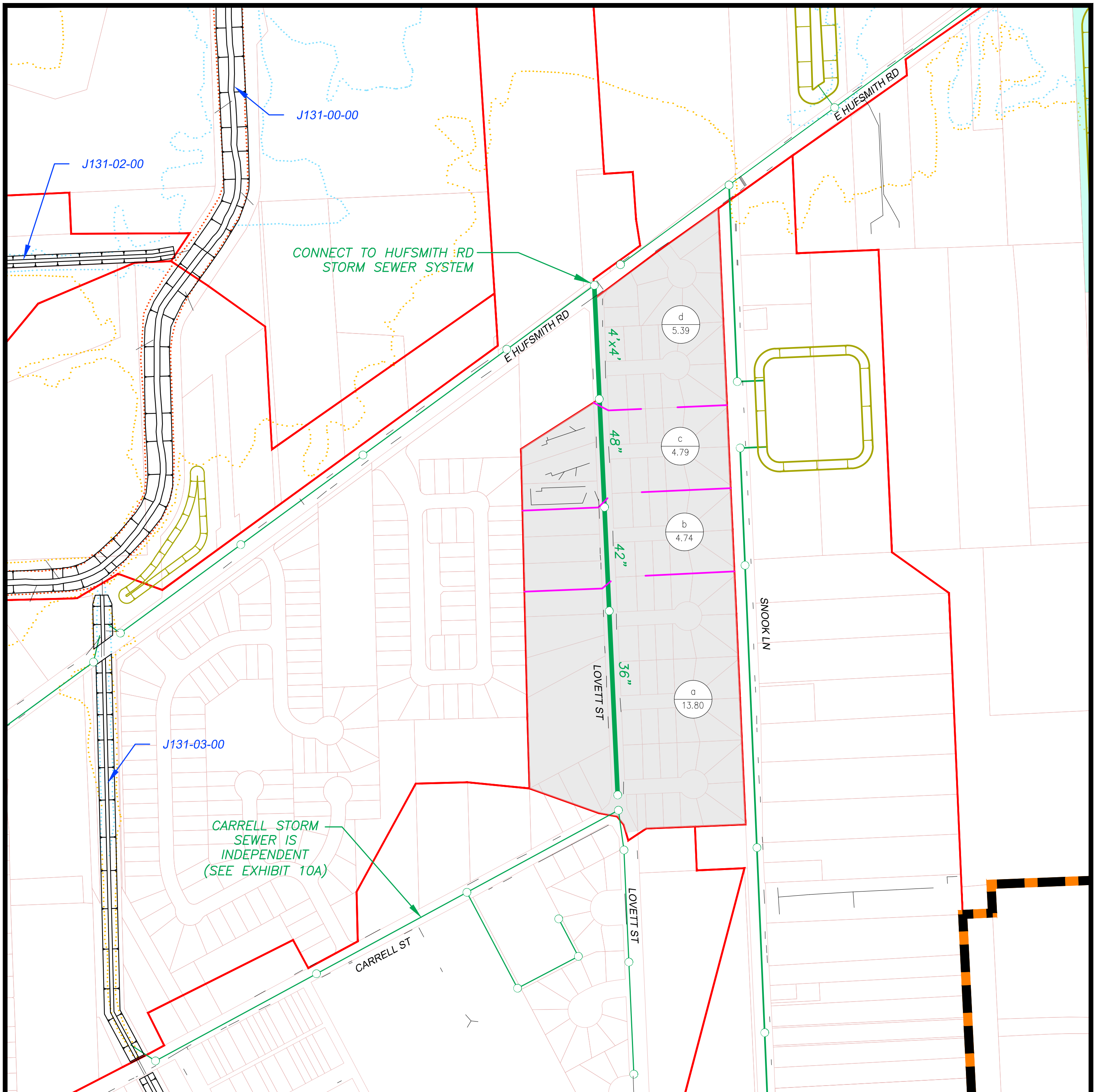


DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
5. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
6. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A ← DRAINAGE AREA ID

50.0 ← DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131 (J131-03-00)
SUBBASIN: E1

SCALE: 1" = 1" = 500'	March 2025
EXHIBIT NO. 11A	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**11A**	Phase	
Project Name		Lovett Street Storm Sewer Improvements			
Project Category					

Project Description

Construct storm sewer along Lovett Street to Hufsmith Road.

Project Justification

Provide local flooding relief and conveyance capacity.

Potential Funding Opportunities

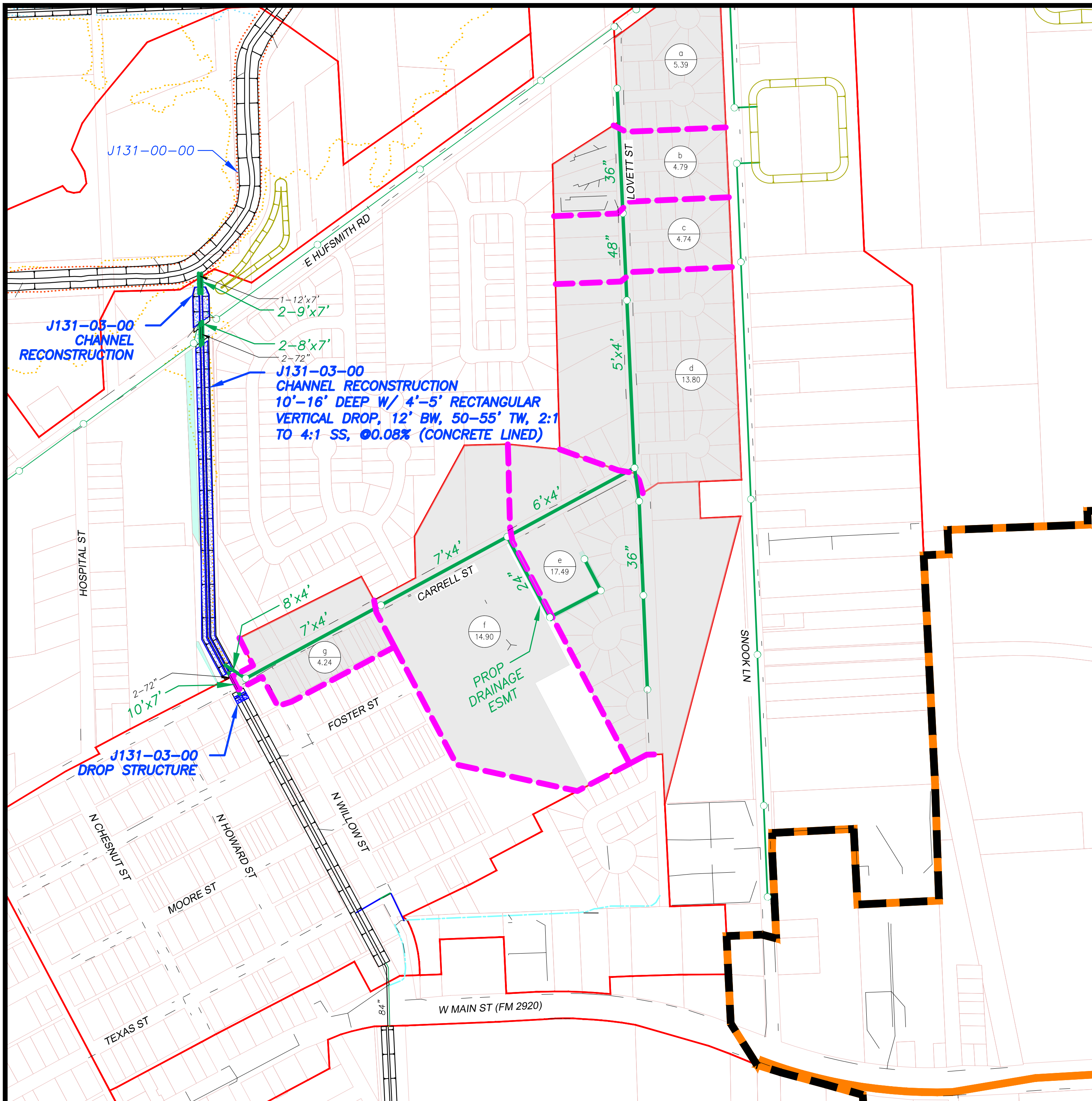
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	36" RCP	650	LF	$ 200	$ 130,000
2	42" RCP	350	LF	$ 300	$ 105,000
3	48" RCP	375	LF	$ 380	$ 142,500
4	4'x4' RCB	400	LF	$ 500	$ 200,000
5	STM MH (SM)	2	EA	$ 6,000	$ 12,000
6	STM MH (MED)	1	EA	$ 7,500	$ 7,500
7	STM JB (SM)	2	EA	$ 8,000	$ 16,000
8	DITCH INTERCEPTOR	10	EA	$ 9,100	$ 91,000
9	PAVEMENT REPAIR - ASP	1800	LF	$ 140	$ 252,000
				SUBTOTAL	$ 956,000
		CONTINGENCY		30%	$ 286,800
		CONSULTANT		25%	$ 239,000
				ESTIMATED PROJECT TOTAL COST:	**$ 1,481,800**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

Land acquisition is based on parcel data received from the City and is a preliminary estimation. CSE has not evaluated, researched, or appraised property for rights-of-way and easements necessary for the construction and maintenance of the proposed improvements.

All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.



DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
5. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
6. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
7. LAND ACQUISITION (ESMT) = 15,316 SF
8. LAND ACQUISITION (FEE) = 23,872 SF

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131 (J131-03-00)
SUBBASIN: D

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 10B & 11B	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**10B-11B**	Phase	
Project Name	Carrell Street / Lovett Street / J131-03 Channel Improvements				
Project Category					

Project Description

Construct storm sewer along Carrell Street and Lovett Street to J131-03-00 independent of Hufsmith roadway reconstruction. Construct storm sewer to around Carrell Street Baptist Church. Reconstruct J131-03 to a concrete-lined channel with a vertical drop of 5 feet.

Project Justification

Relieve local flooding and provide conveyance capacity. Construct storm sewer to decrease ongoing maintance cost at Carrell Street Baptist Church.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	640	LF	$ 130	$ 83,200
2	36" RCP	1200	LF	$ 200	$ 240,000
3	48" RCP	400	LF	$ 380	$ 152,000
4	5'x4' RCB	580	LF	$ 480	$ 278,400
5	6'x4' RCB	490	LF	$ 810	$ 396,900
6	7'x4' RCB	1020	LF	$ 900	$ 918,000
7	8'x4' RCB	80	LF	$ 950	$ 76,000
8	8'x7' RCB	240	LF	$ 1,150	$ 276,000
9	9'x7' RCB	150	LF	$ 1,420	$ 213,000
10	10'x7' RCB	100	LF	$ 1,525	$ 152,500
11	STM JB (LG)	3	EA	$ 23,500	$ 70,500
12	INLET - TYPE E	3	EA	$ 5,000	$ 15,000
13	DITCH INTERCEPTOR	26	EA	$ 9,100	$ 236,600
14	PAVEMENT REPAIR - ASP	1300	LF	$ 140	$ 182,000
15	J131-03	1500	LF	$ 1,470	$ 2,205,000
				SUBTOTAL	$ 5,495,100
		CONTINGENCY		30%	$ 1,648,530
		CONSULTANT		25%	$ 1,373,775
16	LAND ACQUISITION (ESMT)	0.35	AC	$ 130,680	$ 45,948
17	LAND ACQUISITION (J131-03)	0.55	AC	$ 217,800	$ 119,358
				SUBTOTAL	$ 165,306
		CONTINGENCY		10%	$ 16,531
				ESTIMATED PROJECT TOTAL COST:	**$ 8,699,242**

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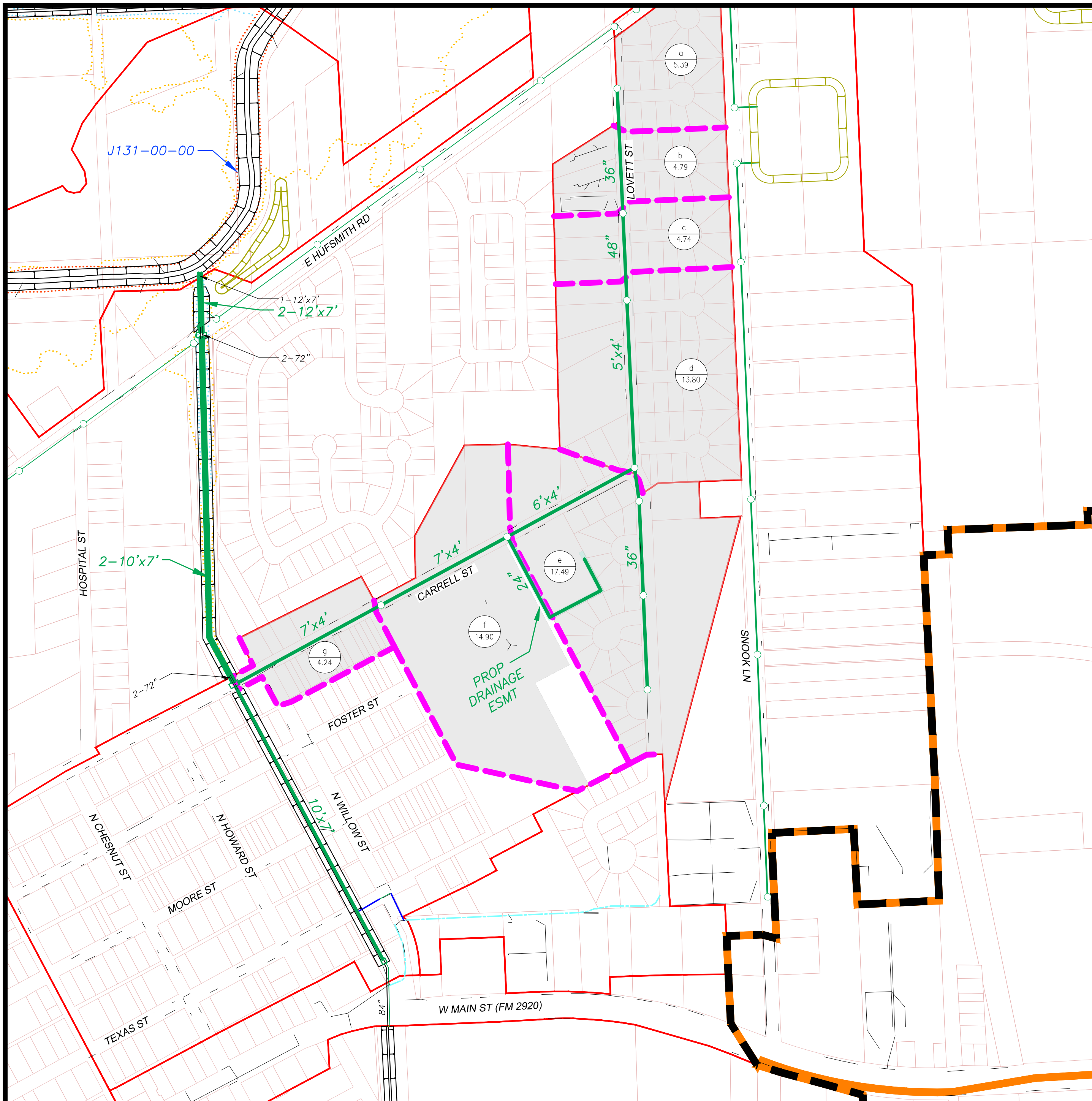

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
5. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
6. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131 (J131-03-00)
SUBBASIN: D

SCALE: 1" = 1"=600'	March 2025
EXHIBIT NO. 10C & 11C	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**10C-11C**	Phase	
Project Name	Carrell Street / Lovett Street / J131-03 Channel Enclosure Improvements				
Project Category					

Project Description

Construct storm sewer along Carrell Street and Lovett Street to J131-03-00 independent of Hufsmith roadway reconstruction. Construct storm sewer to around Carrell Street Baptist Church. Enclose J131-03 with storm sewer.

Project Justification

Relieve local flooding and provide conveyance capacity. Construct storm sewer to decrease ongoing maintance cost at Carrell Street Baptist Church.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	640	LF	$ 130	$ 83,200
2	36" RCP	1200	LF	$ 200	$ 240,000
3	48" RCP	400	LF	$ 380	$ 152,000
4	5'x4' RCB	580	LF	$ 480	$ 278,400
5	6'x4' RCB	490	LF	$ 810	$ 396,900
6	7'x4' RCB	1020	LF	$ 900	$ 918,000
7	8'x4' RCB	80	LF	$ 950	$ 76,000
8	8'x7' RCB	240	LF	$ 1,150	$ 276,000
9	10'x7' RCB	3560	LF	$ 1,525	$ 5,429,000
10	12'x7' RCB	400	LF	$ 1,800	$ 720,000
11	STM JB (LG)	3	EA	$ 23,500	$ 70,500
12	STM JB (EX LG)	3	EA	$ 60,000	$ 180,000
13	INLET - TYPE E	3	EA	$ 5,000	$ 15,000
14	DITCH INTERCEPTOR	26	EA	$ 9,100	$ 236,600
15	PAVEMENT REPAIR - ASP	1300	LF	$ 140	$ 182,000
				SUBTOTAL	$ 9,253,600
		CONTINGENCY		30%	$ 2,776,080
		CONSULTANT		25%	$ 2,313,400
16	LAND ACQUISITION (ESMT)	0.35	AC	$ 130,680	$ 45,948
				SUBTOTAL	$ 45,948
		CONTINGENCY		10%	$ 4,595
				ESTIMATED PROJECT TOTAL COST:	**$ 14,393,623**

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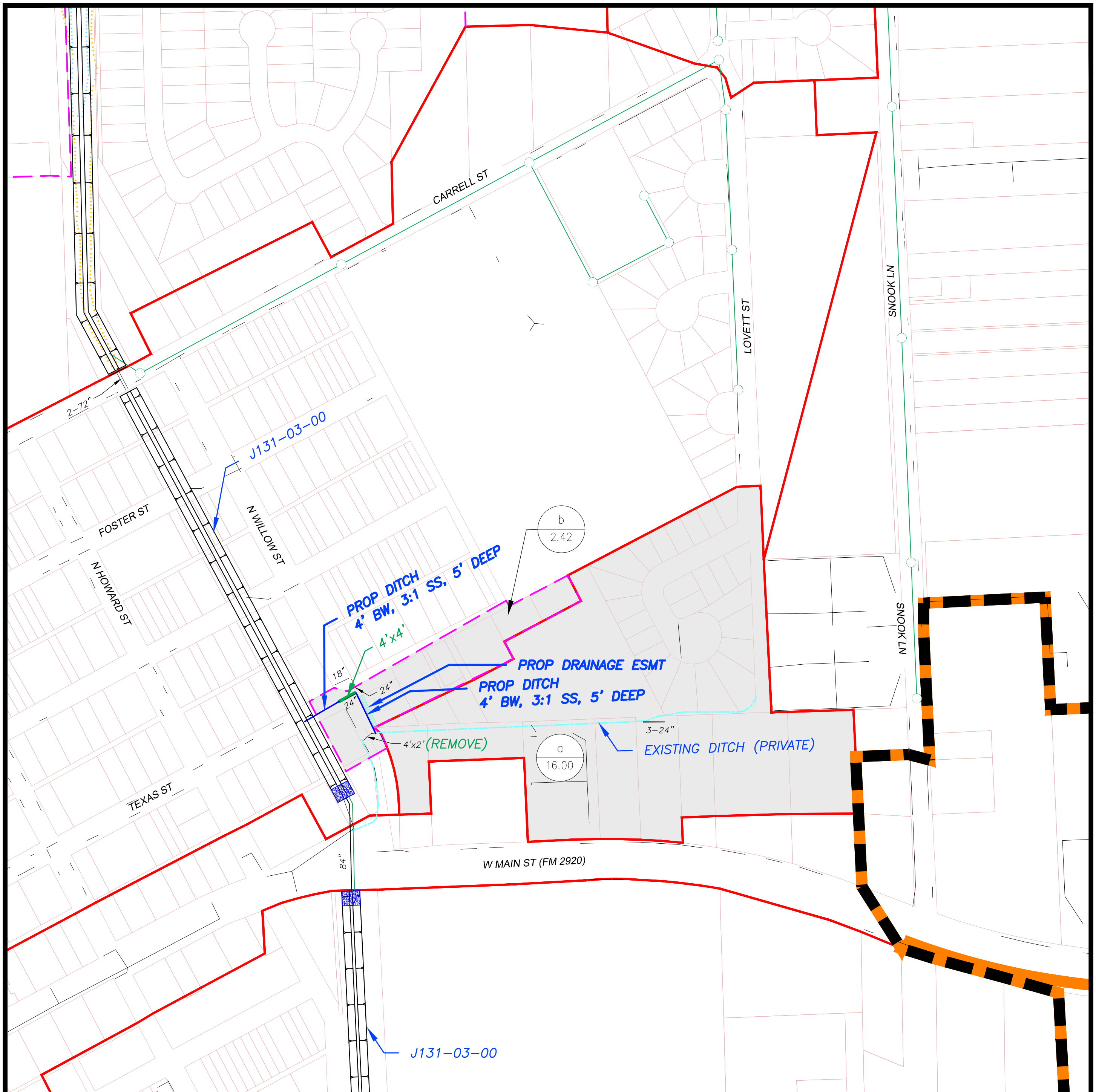

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 967 SF

0 200 400 800

(IN FEET)

1 INCH = 400 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131 (J131-03-00)
SUBBASIN: D

SCALE: 1" = 1" = 400'	March 2025
EXHIBIT NO. 12	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**12**	Phase	
Project Name	Willow Street Ditch Regrade and Culvert Crossing to J131-03-00				
Project Category					
Project Description					
Regrade roadside ditch allow Willow to new culvert crossing at Texas Street unimproved right-of-way to J131-03-00.					
Project Justification					
Increase conveyance capacity, repair erosive storm sewer conditions, and relieve flooding at adjacent residential structures.					
Potential Funding Opportunities					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*REMOVE EX. 4'x2' RCB*	*75*	*LF*	*$ 30*	*$ 2,250*
2	*4'x4' RCB*	*60*	*LF*	*$ 500*	*$ 30,000*
3	*PROPOSED DITCH*	*280*	*LF*	*$ 100*	*$ 28,000*
4	*STM HW*	*2*	*EA*	*$ 10,000*	*$ 20,000*
5	*PAVEMENT REPAIR - ASP*	*60*	*LF*	*$ 140*	*$ 8,400*
				SUBTOTAL	*$ 88,650*
		CONTINGENCY		*30%*	*$ 26,595*
		CONSULTANT		*25%*	*$ 22,163*
6	*LAND ACQUISITION*	*0.02*	*AC*	*$ -*	*$ -*
				SUBTOTAL	*$ -*
		CONTINGENCY		*10%*	*$ -*
				ESTIMATED PROJECT TOTAL COST:	**$ 137,408**

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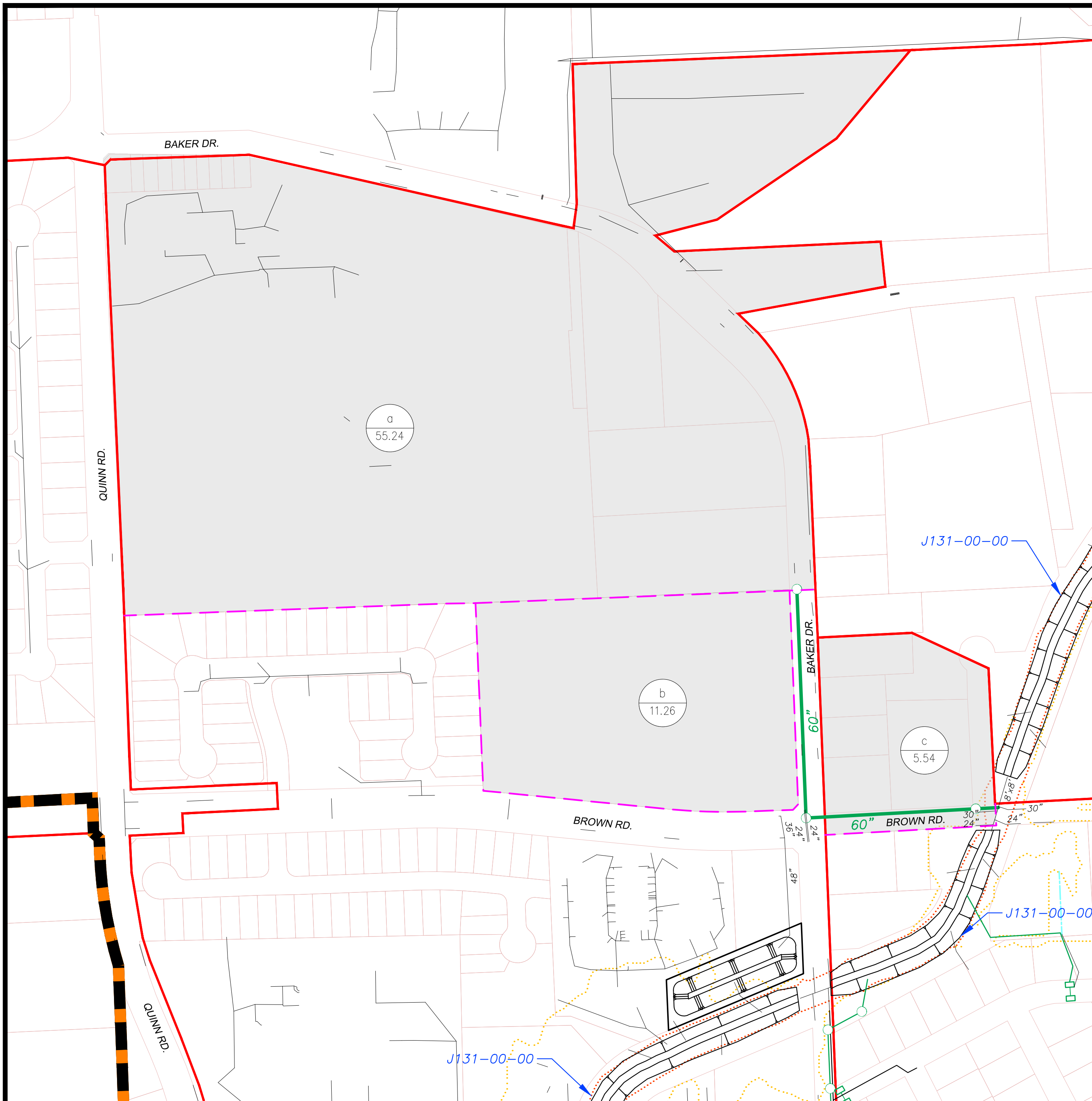

DESIGN CRITERIA
1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
5. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
6. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 200 400 800

(IN FEET)

1 INCH = 400 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131 (J131-00-00)
SUBBASIN: D

SCALE: 1" = 1" = 400'	March 2025
EXHIBIT NO. 13	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.		**13**	Phase	
Project Name		Baker Drive & Brown Road Storm Sewer to J131-00-00			
Project Category					
Project Description					
Construct storm sewer along Baker Drive and Brown Road to J131-00-00. Improvements are assumed to be indepentent of roadway reconstruction.					
Project Justification					
Relieve local flooding and provide outfall depth for TISD Transportation Facility and increase conveyance.					
Potential Funding Opportunities					

Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*60" RCP*	*1100*	*LF*	*$ 400*	*$ 440,000*
2	*STM MH (LG)*	*3*	*EA*	*$ 9,000*	*$ 27,000*
3	*DITCH INTERCEPTOR*	*8*	*EA*	*$ 9,100*	*$ 72,800*
4	*OUTFALL TIE-IN*	*1*	*EA*	*$ 10,000*	*$ 10,000*
5	*PAVEMENT REPAIR - ASP*	*1210*	*LF*	*$ 140*	*$ 169,400*
				SUBTOTAL	*$ 719,200*
		CONTINGENCY		*30%*	*$ 215,760*
		CONSULTANT		*25%*	*$ 179,800*
				ESTIMATED PROJECT TOTAL COST:	**$ 1,114,760**

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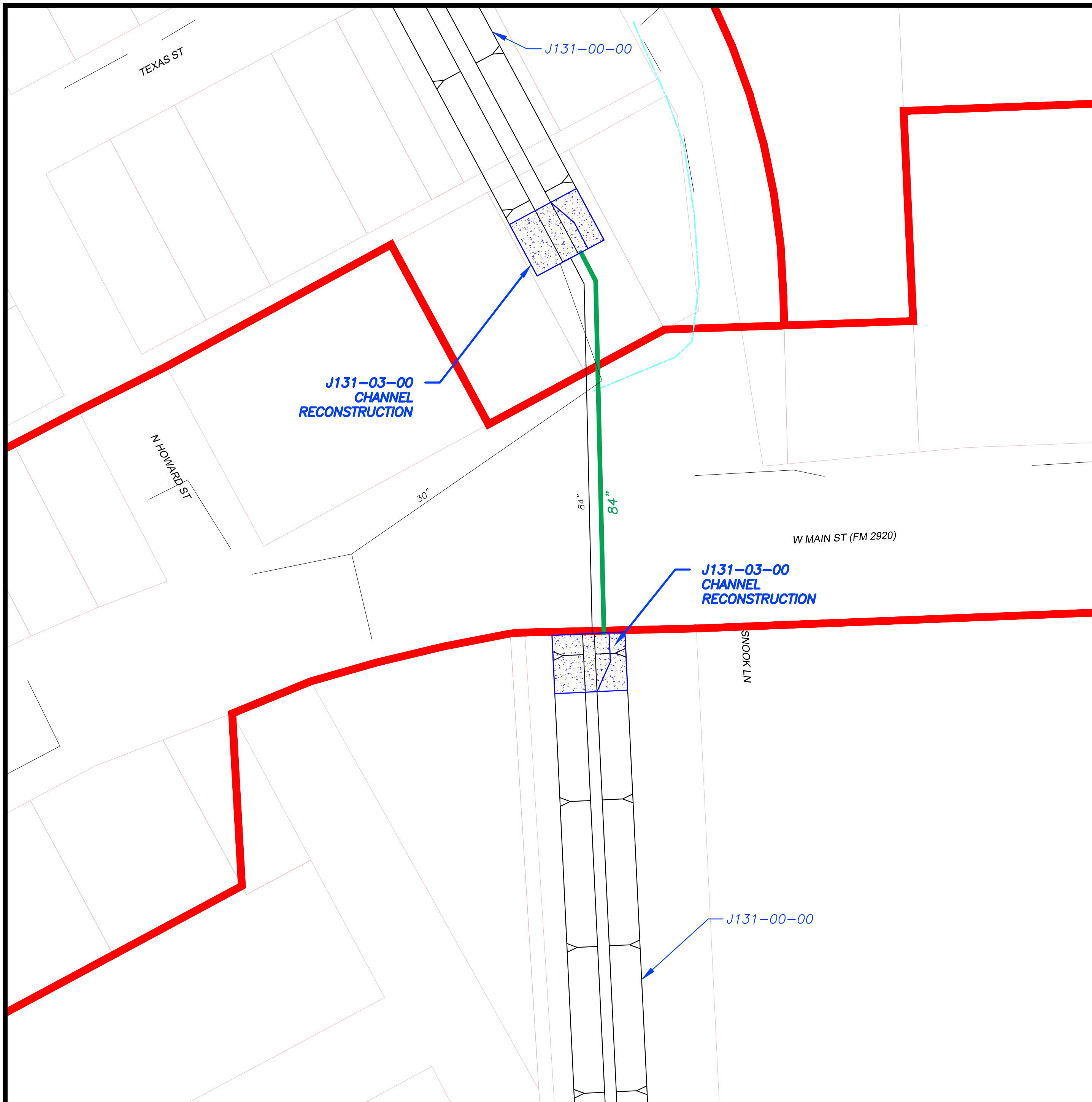

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. DESIGN STORM EVENT (CHANNEL): 100-YR
3. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
4. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
5. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
6. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 50 100 200

(IN FEET)

1 INCH = 100 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131 (J131-00-00)
SUBBASIN: D

SCALE: 1" = 1" = 100'	March 2025
EXHIBIT NO. 10A	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**14**	Phase	
Project Name	FM 2920 (Main Street) Culvert Crossing Reconstruction				
Project Category					

Project Description

Construct parallel culvert crossing along J131-03-00 under FM 2920.

Project Justification

Increase conveyance capacity.

Potential Funding Opportunities

TxDOT

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	*84" RCP*	*255*	*LF*	*$ 1,500*	*$ 382,500*
2	*J131-03-00 CHANNEL LINING*	*2*	*EA*	*$ 32,000*	*$ 74,400*
				SUBTOTAL	*$ 456,900*
		CONTINGENCY		*30%*	*$ 137,070*
		CONSULTANT		*25%*	*$ 114,225*
				ESTIMATED PROJECT TOTAL COST:	**$ 708,195**

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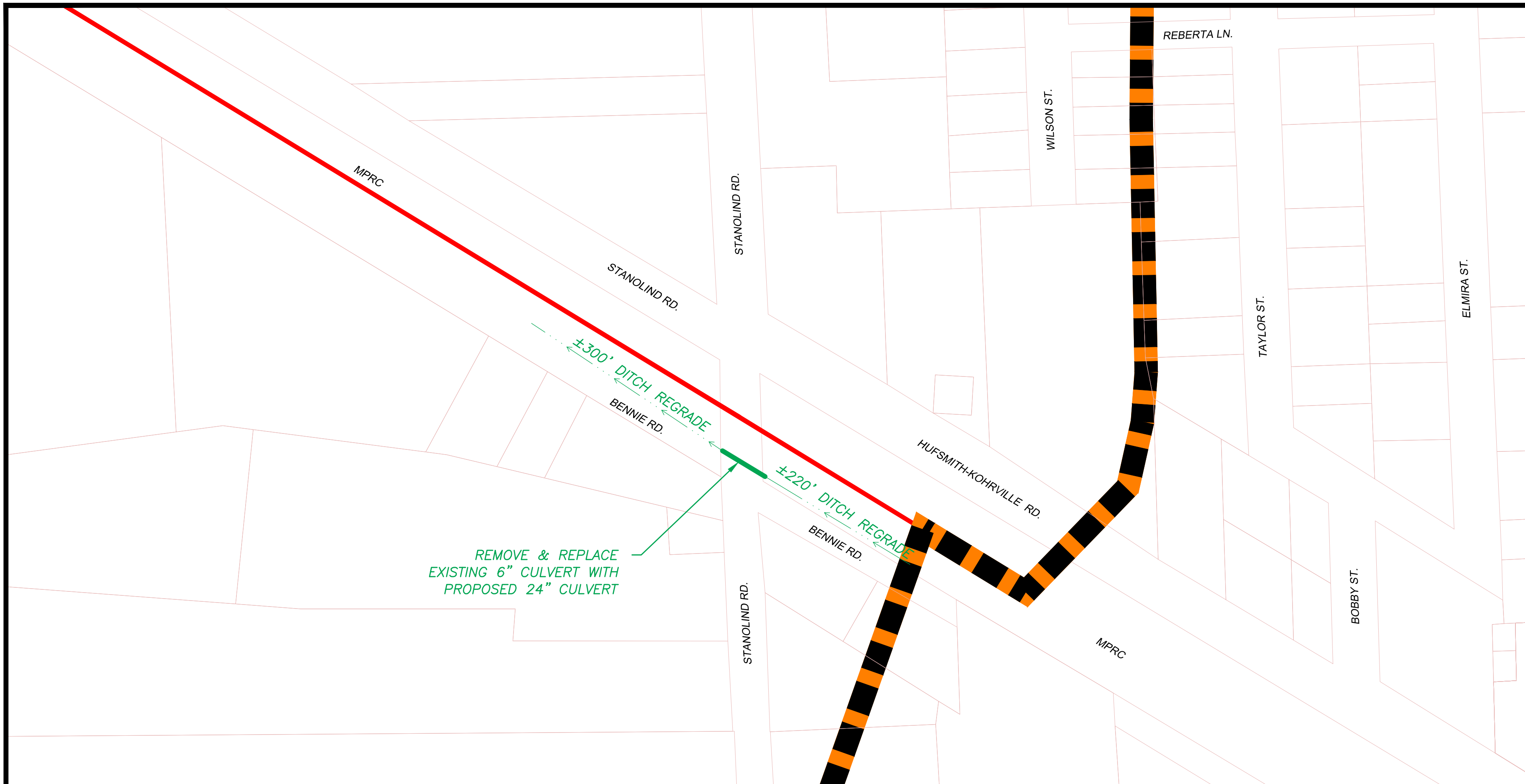

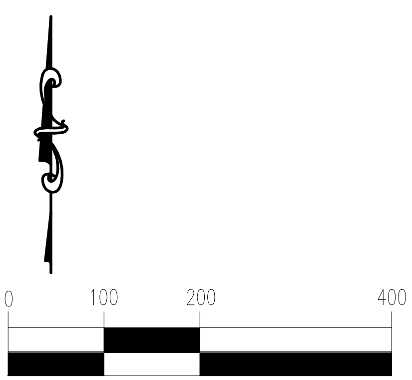

(IN FEET)

1 INCH = 200 FT.

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS ★ FOUNDED 1907 ★

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL DMP
CIP DETAIL LAYOUTS

BASIN: J131-00-00
SUBBASIN: C2_E

SCALE: 1:200_XREF	March 2025
EXHIBIT NO. 15	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**15**	Phase	
Project Name		Stanolind Road Culvert Crossing			
Project Category					
Project Description					
Replace existing culvert crossing.					
Project Justification					
Provide positive drainage and relieve localize ponding.					
Potential Funding Opportunities					
Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*REMOVE STRUCTURE (PIPE)*	*60*	*LF*	*$ 120*	*$ 7,200*
2	*24" RCP*	*60*	*LF*	*$ 130*	*$ 7,800*
2	*ROADSIDE DITCH*	*500*	*LF*	*$ 40*	*$ 20,000*
3	*24" SET*	*2*	*EA*	*$ 5,000*	*$ 10,000*
4	*PAVEMENT REPAIR - ASP*	*25*	*LF*	*$ 140*	*$ 3,500*
				SUBTOTAL	*$ 48,500*
		CONTINGENCY		*30%*	*$ 14,550*
		CONSULTANT		*25%*	*$ 12,125*
				ESTIMATED PROJECT TOTAL COST:	**$ 75,175**

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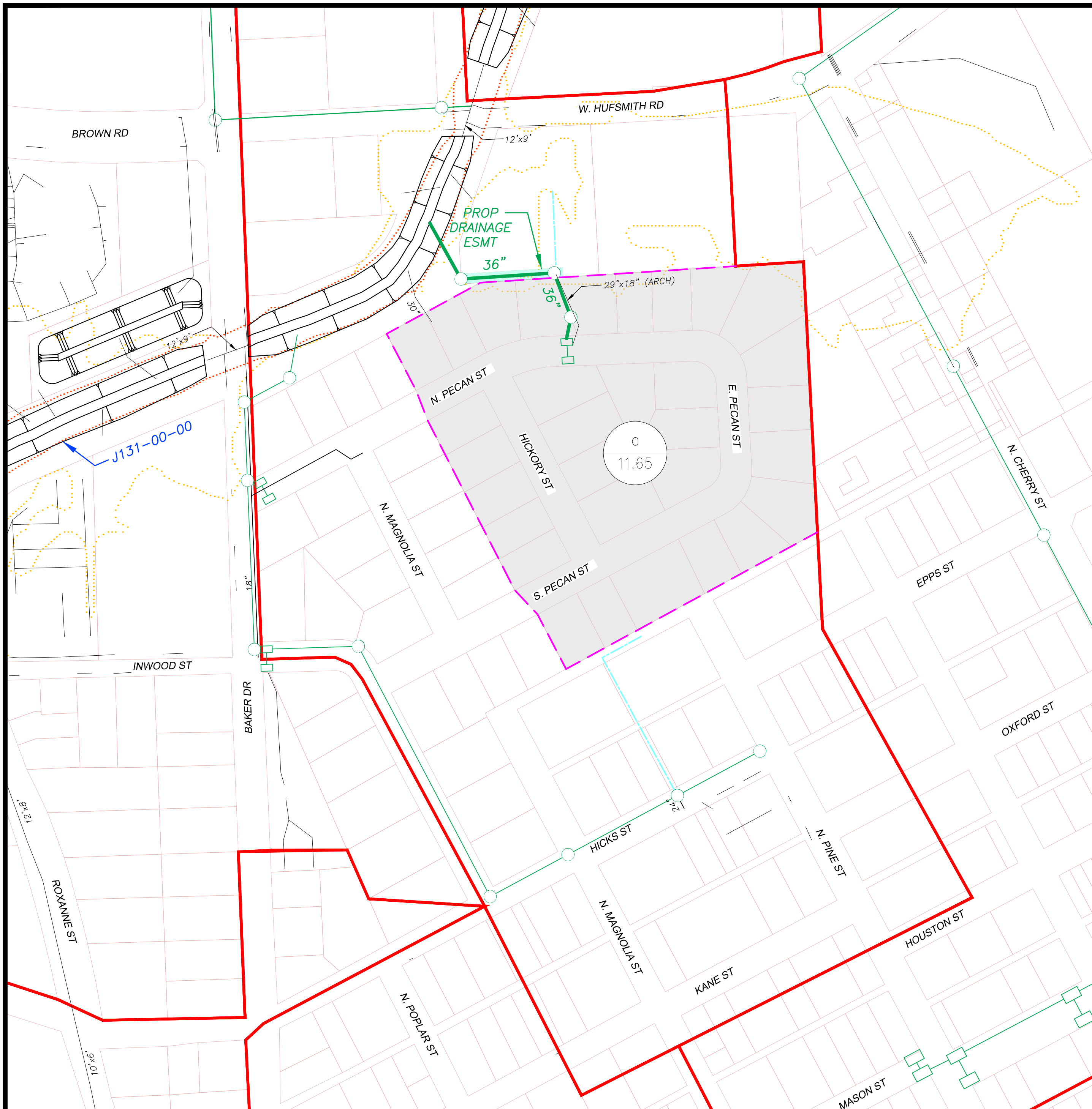

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. LAND ACQUISITION (ESMT) = 4,202 SF

0 150 300 600

(IN FEET)

1 INCH = 300 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS — FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: A4S

SCALE: 1" = 1" = 300'	March 2025
EXHIBIT NO. 16	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.	**16**	Phase	
Project Name	Tomball Terrace Outfall to J131-00-00 Reconstruction (Pecan Street)				
Project Category					

Project Description

Reconstruct outfall from N. Pecan Street to J131-00-00.

Project Justification

Relieve flooding along N. Pecan Street.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	REMOVE EX. 29" x 18" Arch	155	LF	$ 30	$ 4,650
2	36" RCP	380	LF	$ 200	$ 76,000
3	42" CMP	135	LF	$ 140	$ 18,900
4	STM MH (SM)	3	LF	$ 6,000	$ 18,000
5	CURB INLET	2	EA	$ 8,600	$ 17,200
6	PAVEMENT REPAIR - CONC	26	LF	$ 140	$ 3,640
				SUBTOTAL	$ 138,390
		CONTINGENCY		30%	$ 41,517
		CONSULTANT		25%	$ 34,598
7	LAND ACQUISITION	0.10	AC	$ 130,680	$ 12,606
				SUBTOTAL	$ 12,606
		CONTINGENCY		10%	$ 1,261
				ESTIMATED PROJECT TOTAL COST:	**$ 228,371**

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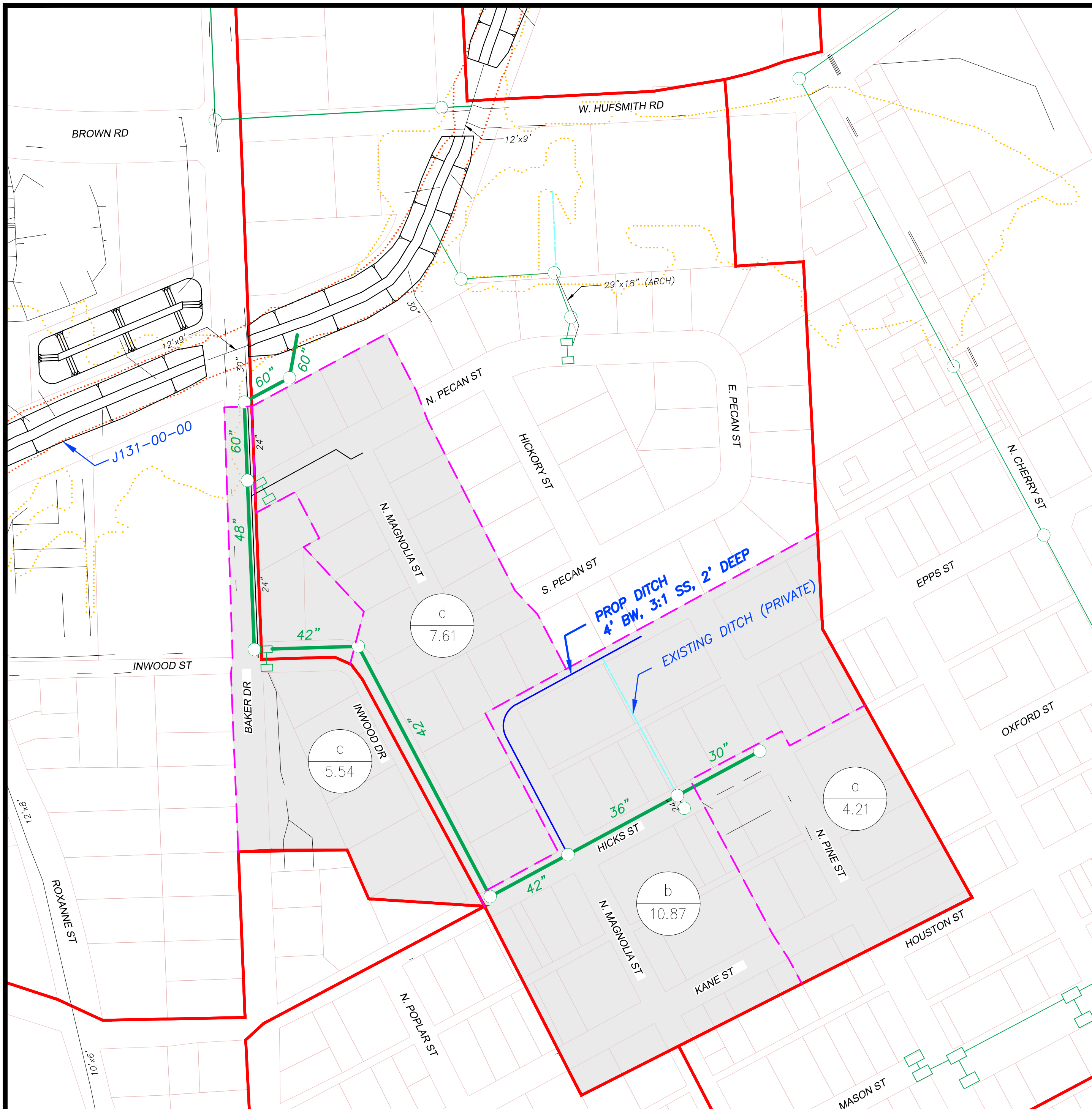

DESIGN CRITERIA

1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS
3. STORM SEWER 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT CHANNEL OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS

0 150 300 600

(IN FEET)

1 INCH = 300 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J131-00-00
SUBBASIN: A4S

SCALE: 1" = 1" = 300'	March 2025
EXHIBIT NO. 17	J131 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J131**	CIP Project No.		**17**	Phase
Project Name	Hicks Street and Inwood Drive Storm Sewer				
Project Category					

Project Description

Construct storm sewer

Project Justification

Redirect runoff from south of Tomball Terrace Subdivision to J131-00-00 along Hicks Street and Inwood Drive.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
2	24" RCP	78	LF	$ 130	$ 10,140
2	30" RCP	195	LF	$ 185	$ 36,075
2	36" RCP	255	LF	$ 200	$ 51,000
2	42" RCP	980	LF	$ 300	$ 294,000
2	48" RCP	350	LF	$ 380	$ 133,000
3	60" RCP	265	LF	$ 400	$ 106,000
3	60" CMP	100	LF	$ 200	$ 20,000
4	STM MH (SM)	1	LF	$ 6,000	$ 6,000
4	STM MH (MED)	3	LF	$ 7,500	$ 22,500
4	STM MH (LG)	4	LF	$ 9,000	$ 36,000
5	CURB INLET	4	EA	$ 8,600	$ 34,400
5	DITCH INTERCEPTOR	2	EA	$ 9,100	$ 18,200
3	PROPOSED DITCH	650	LF	$ 50	$ 32,500
6	PAVEMENT REPAIR - CONC	78	LF	$ 140	$ 10,920
				SUBTOTAL	$ 800,595
		CONTINGENCY		30%	$ 240,179
		CONSULTANT		25%	$ 200,149
				ESTIMATED PROJECT TOTAL COST:	**$ 1,240,922**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

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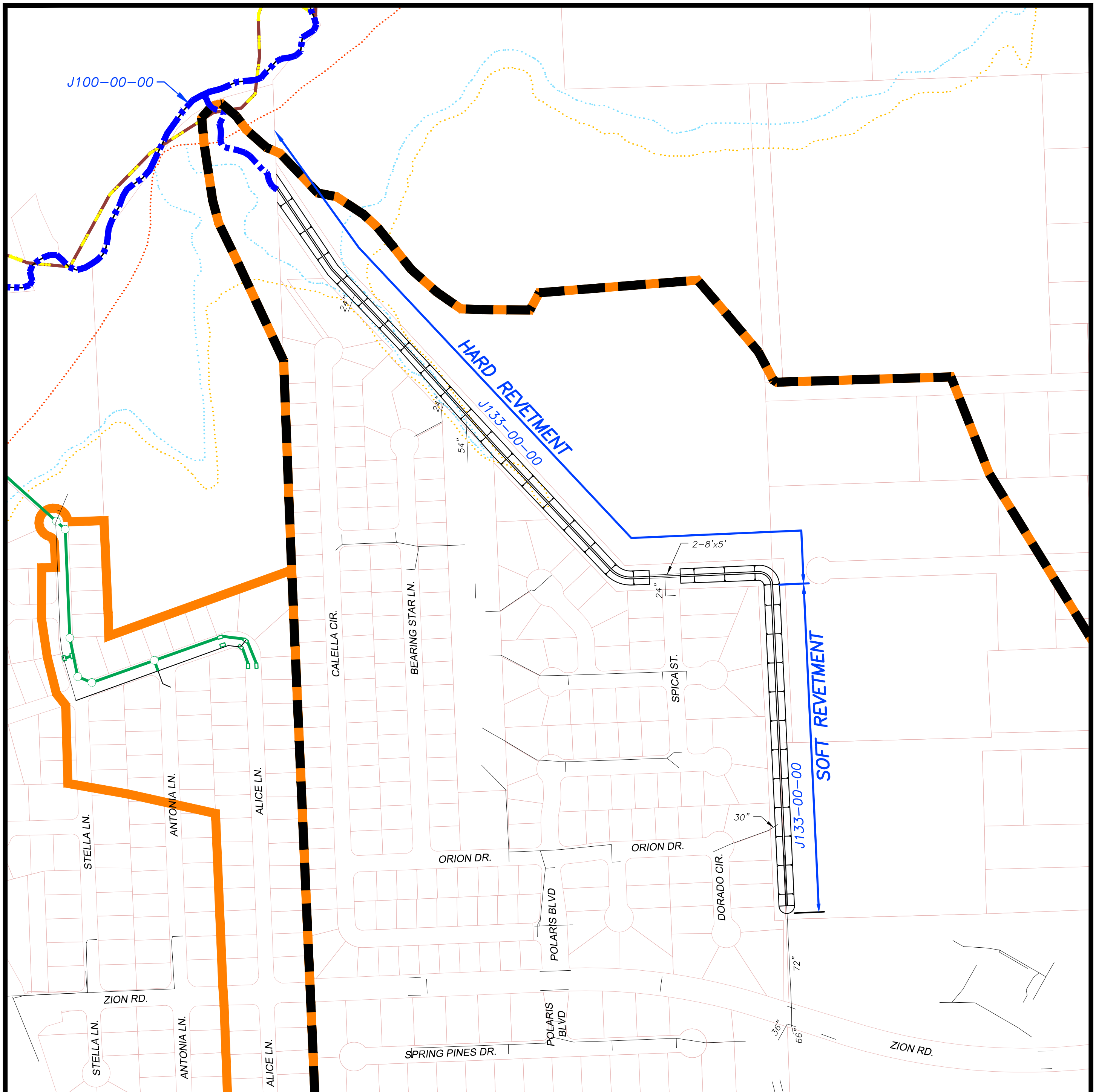
All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.

APPENDIX C – J133

CIP PACKETS



DESIGN CRITERIA

1. DESIGN STORM EVENT (CHANNEL): 100-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON EXISTING LAND USE MAPS

0 250 500 1000

(IN FEET)

1 INCH = 500 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID

50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J133 (J133-00-00)
SUBBASIN:

SCALE: 1" = 1" = 500'	March 2025
EXHIBIT NO. 1	J133 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J133**	CIP Project No.	**1**	Phase	
Project Name	J133-00-00 Channel Rehabilitation				
Project Category					
Project Description					
Channel rehabilitation from Zion Road to Spring Creek.					
Project Justification					
Existing dispervie soils cause frequent erosion and bank failure near North Star Estates Subdivision.					
Potential Funding Opportunities					
Opinion of Probable Construction Cost					
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
1	*SOFT REVETMENT*	*1100*	*LF*	*$ 300*	*$ 330,000*
2	*HARD REVETMENT*	*2400*	*LF*	*$ 500*	*$ 1,200,000*
				SUBTOTAL	*$ 1,530,000*
		CONTINGENCY		*30%*	*$ 459,000*
		CONSULTANT		*25%*	*$ 382,500*
				ESTIMATED PROJECT TOTAL COST:	**$ 2,371,500**

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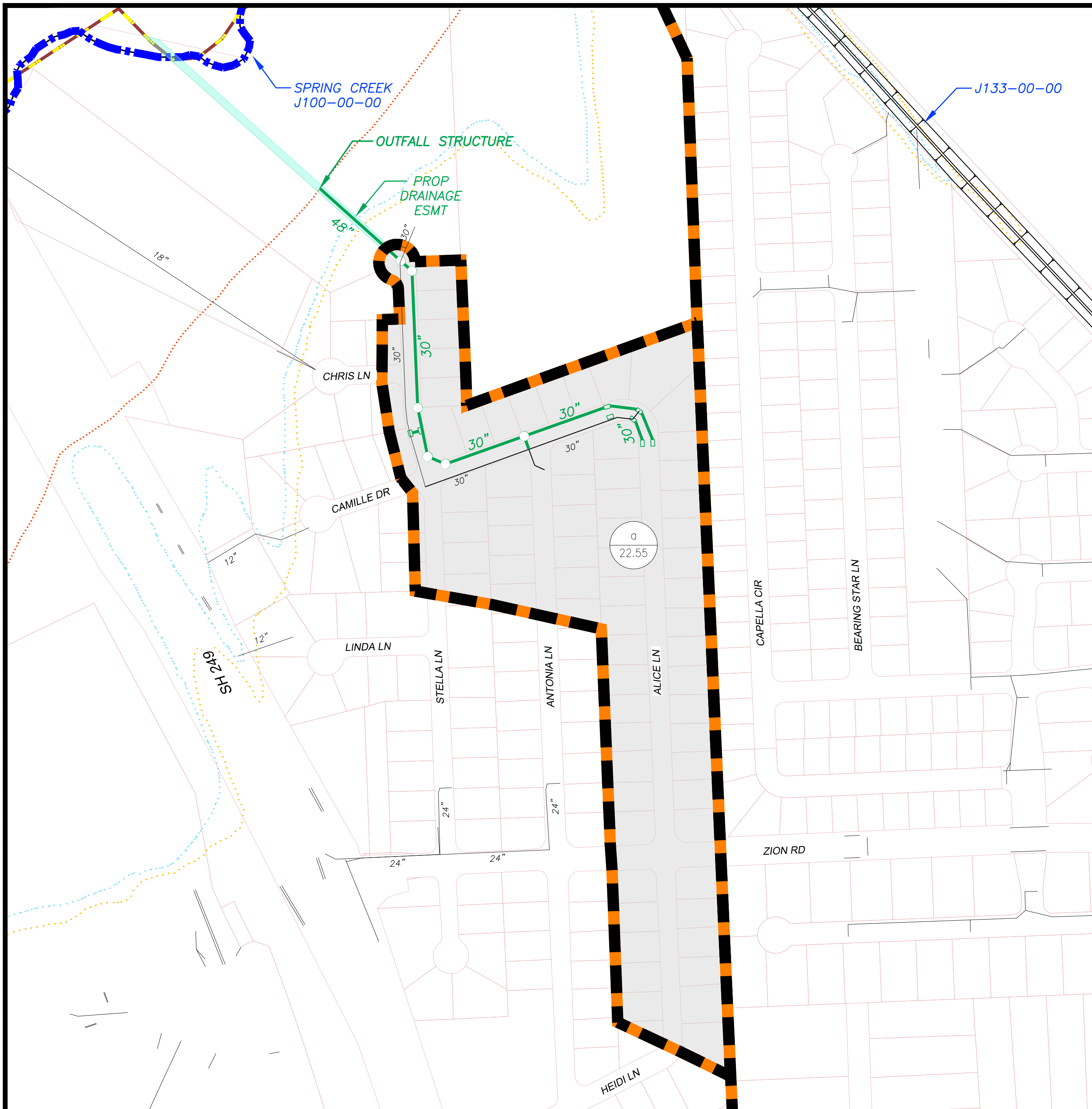
Land acquisition is based on parcel data received from the City and is a preliminary estimation. CSE has not evaluated, researched, or appraised property for rights-of-way and easements necessary for the construction and maintenance of the proposed improvements.

All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.

APPENDIX C – J100

CIP PACKETS



DESIGN CRITERIA
1. DESIGN STORM EVENT (STORM SEWER): 25-YEAR
2. HYDROLOGY - RATIONAL METHOD BASED ON FUTURE LAND USE MAPS
3. 25-YEAR HGL 1 FOOT BELOW GUTTER
4. STARTING HYDRAULIC GRADE LINE - TOP OF PIPE AT OUTFALL
5. ACTUAL PIPE VELOCITIES LESS THAN 7 FPS
6. TOTAL LAND ACQUISITION = 17,920 SF

0 200 400 800

(IN FEET)

1 INCH = 400 FT.

LEGEND

DESCRIPTION	EXISTING	PROPOSED
STORM SEWER		
STORM INLET		
STORM MANHOLE		
DITCH		
CHANNEL		
DETENTION POND		
BASIN BNDY		
SUBBASIN BNDY		
STM SWR SERVICE AREA		
DRAINAGE AREA BNDY		
LAND ACQUISITION		
ZONE AE/FLOODWAY		
ZONE AE (100-YR)		
ZONE X (500-YR)		

3A — DRAINAGE AREA ID
50.0 — DRAINAGE AREA IN ACRES

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

BASIN: J100-00-00
SUBBASIN: TOMBALL HILLS

SCALE: 1" = 400'	March 2025
EXHIBIT NO. 1	J100 BASIN

Drainage CIP - Opinion of Probable Construction Cost					
Basin	**J100**	CIP Project No.	**1**	Phase	
Project Name	Tomball Hills Subdivision				
Project Category					

Project Description

Construct new sag inlets and flanking inlets at Camille Drive and Alice Lane kunckle. Construct parallel storm sewer along Camille Drive and Stella Lane with new outfall to J100-00-00.

Project Justification

Prevent structural flooding and relieve street ponding at Camille Drive and Alice Lane knuckle.

Potential Funding Opportunities

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" RCP	100	LF	$ 130	$ 13,000
2	30" RCP	1260	LF	$ 185	$ 233,100
3	48" RCP	300	LF	$ 380	$ 114,000
4	STM MH (SM)	5	EA	$ 6,000	$ 30,000
4	STM MH (MED)	1	EA	$ 7,500	$ 7,500
6	CURB INLET	8	EA	$ 8,600	$ 68,800
7	OUTFALL STRUCTURE	1	EA	$ 10,000	$ 10,000
8	PAVEMENT REPAIR - CONC	230	LF	$ 140	$ 32,200
				SUBTOTAL	$ 508,600
		CONTINGENCY		30%	$ 152,580
		CONSULTANT		25%	$ 127,150
9	LAND ACQUISITION	0.40	AC	$ 130,680	$ 51,868
				SUBTOTAL	$ 51,868
		CONTINGENCY		10%	$ 5,187
				ESTIMATED PROJECT TOTAL COST:	**$ 845,385**

CSE's opinion of probable construction cost provided is based on the best available information at the time of preparation and standard cost estimating practices. It is understood that this is a conceptual cost estimate and the Engineers shall not be liable to the Owner or a third party for the accuracy of the project or any part thereof. Final engineering and design shall be performed to accurately reflect ground and project conditions.

Land acquisition is based on parcel data received from the City and is a preliminary estimation. CSE has not evaluated, researched, or appraised property for rights-of-way and easements necessary for the construction and maintenance of the proposed improvements.

All values are in 2024 dollars. An inflation rate of 4% should be allocated to each year until formal project funding.

APPENDIX D

CIP COST SUMMARY

DMP CIP COST SUMMARY TABLE						
BASIN	CIP NO.	CIP YEAR	DESCRIPTION	CONSTRUCTION COST	LAND COST	TOTAL COST
M116	1A	LR	M116-00-00 DIVERSION	$ 1,112,125	$ 1,456,161	$ 2,568,286
	1B	LR	MAHAFFEY ROAD STORM SEWER	$ 5,015,645	$ -	$ 5,015,645
	2	10-YR	FM 2920 / HUFSMITH-KOHVILLE RD ROADSIDE DITCH REGRADE	$ 231,338	$ -	$ 231,338
			M116 TOTAL	**$ 6,359,108**	**$ 1,456,161**	**$ 7,815,269**
M118	1	5-YR	M518-01 DETENTION BASIN	$ 2,790,000	$ -	$ 2,790,000
	2	10-YR	M118-00-00 CHANNEL EXTENSION TO MEDICAL COMPLEX BLVD	$ 1,684,075	$ 2,099,268	$ 3,783,343
	3	10-YR	MEDICAL COMPLEX BLVD STORM SEWER EXTENSION TO M118-00-00	$ 723,850	$ -	$ 723,850
	4	10-YR	M118-01-00 (S. PERSIMMON) STORM SEWER EXTENSION TO LIZZIE LANE	$ 7,638,555	$ -	$ 7,638,555
	5	5-YR	M118-01-01 CHANNEL IMPROVEMENTS (PHASE 1)	$ 1,604,715	$ -	$ 1,604,715
	6	LR	S. PITCHFORD STORM SEWER EXTENSION	$ 9,621,315	$ -	$ 9,621,315
	7	#N/A	M118-00-00 UNDERGROUND ALTERNATE	$ 11,663,750	$ 250,919	$ 11,914,669
	8A	#N/A	M518-02 DETENTION POND	$ 1,901,695	$ 531,787	$ 2,433,482
	8B	10-YR	M118-01-01 CHANNEL IMPROVEMENTS (PHASE 2) AND M518-02 DETENTION POND	$ 1,513,420	$ 2,507,359	$ 4,020,779
			M118 TOTAL	**$ 25,575,930**	**$ 4,606,627**	**$ 30,182,557**
M121	1	10-YR	M500-01 DETENTION POND EXCAVATION (ULTIMATE CONDITION)	$ 8,067,750	$ -	$ 8,067,750
	2	5-YR	M121-01-00 (M121 WEST) CHANNEL RECONSTRUCTION FROM MEDICAL COMPLEX TO HARDIN STREET	$ 491,040	$ -	$ 491,040
	3	5-YR	M121-01-01 (HARDIN STREET EAST) CHANNEL CONSTRUCTION TO CHERRY STREET	$ 1,478,700	$ -	$ 1,478,700
	4	5-YR	CHERRY LAUREL STORM SEWER IMPROVEMENTS	$ 117,025	$ -	$ 117,025
	5	5-YR	HAMPTON PLACE STORM SEWER IMPROVEMENTS	$ 859,708	$ 33,135	$ 892,843
	6	5-YR	S. CHERRY STREET STORM SEWER IMPROVEMENTS (FROM FANNIN STREET TO HARDIN STREET)	$ 4,080,995	$ -	$ 4,080,995
	7	5-YR	S. MAGNOLIA STREET STORM SEWER IMPROVEMENTS	$ 2,168,605	$ -	$ 2,168,605
	8	5-YR	M121-01-02 (HARDIN STREET WEST) CHANNEL CONSTRUCTION TO SCHOOL STREET	$ 822,430	$ -	$ 822,430
	9	LR	THESIS LANE STORM SEWER RECONSTRUCTION	$ 3,483,470	$ -	$ 3,483,470
	10	LR	M521-01 DETENTION POND	$ 20,653,750	$ 10,370,727	$ 31,024,477
	11	LR	M121-02-00 (M121 EAST) CHANNEL EXTENSION TO AGG ROAD	$ 5,440,500	$ 3,660,828	$ 9,101,328
	12	LR	S. CHERRY STREET & AGG ROAD (FROM ANNA STREET TO M121-02-00) STORM SEWER	$ 5,393,225	$ 84,853	$ 5,478,078
	13	LR	MULBERRY STREET STORM SEWER	$ 1,760,490	$ -	$ 1,760,490
	14	LR	S. CHERRY STREET (FROM AGG ROAD TO CHERRYWOOD ESTATES) STORM SEWER TO M121-02-00	$ 5,393,225	$ 84,853	$ 5,478,078
	15	LR	MEDICAL COMPLEX DRIVE STORM SEWER RECONSTRUCTION	$ 546,724	$ -	$ 546,724
	16	10-YR	MICHEL ROAD STORM SEWER RECONSTRUCTION	$ 1,048,885	$ -	$ 1,048,885
	17	LR	M521-02 DETENTION POND	$ 14,329,750	$ 20,901,625	$ 35,231,375
	18	10-YR	S. PINE STREET STORM SEWER IMPROVEMENTS	$ 1,636,335	$ -	$ 1,636,335
			M121 TOTAL	**$ 77,772,606**	**$ 35,136,023**	**$ 112,908,629**
M124	1	LR	M124-00-00-E002 (HCFCD)	$ -	$ -	$ -
	2	LR	TOMBALL CEMETARY RD & TREICHEL STORM SEWER TO M124-00-00	$ 13,705,488	$ -	$ 13,705,488
	3	10-YR	M124-00-00 CHANNEL EXTENSION TO BAKER DRIVE	$ 2,315,700	$ 1,522,008	$ 3,837,708
			M124 TOTAL	**$ 16,021,188**	**$ 1,522,008**	**$ 17,543,196**
M125	1	10-YR	MICHEL ROAD AND LAWRENCE STREET STORM SEWER RECONSTRUCTION	$ 945,252	$ 7,458	$ 952,710
			M125 TOTAL	**$ 945,252**	**$ 7,458**	**$ 952,710**
J100	1	10-YR	TOMBALL HILLS SUBDIVISION STORM SEWER IMPROVEMENTS	$ 788,330	$ 57,055	$ 845,385
			J100 TOTAL	**$ 788,330**	**$ 57,055**	**$ 845,385**
J131	1	5-YR	J531-01 DETENTION POND IMPROVEMENTS	$ 3,076,750	$ 257,400	$ 3,334,150
	2	5-YR	N. CHERRY STREET STORM SEWER IMPROVEMENTS (FROM COMMERCE ST TO HUFSMITH RD)	$ 3,543,765	$ -	$ 3,543,765
	3	5-YR	COMMERCE STREET STORM SEWER IMPROVEMENTS	$ 775,000	$ -	$ 775,000
	4	#N/A	J531-02 DETENTION POND	$ 1,700,350	$ -	$ 1,700,350
	5A	10-YR	N. SYCAMORE STORM SEWER ALT 1	$ 2,699,945	$ 68,373	$ 2,768,318
	5B	#N/A	N. SYCAMORE STORM SEWER ALT 2	$ 2,734,820	$ 68,373	$ 2,803,193
	6A	LR	J131-01 ALTERNATE 1	$ 25,965,135	$ 2,656,678	$ 28,621,813
	6B	#N/A	J131-01 ALTERNATE 2	$ 20,216,960	$ 3,703,854	$ 23,920,814
	6C	#N/A	J131-01 ALTERNATE 3	$ 22,434,545	$ 3,559,884	$ 25,994,429
	7	LR	ZION ROAD STORM SEWER	$ 5,108,800	$ -	$ 5,108,800
	8	LR	HUFMISTH ROAD STORM SEWER	$ 5,178,860	$ 329,673	$ 5,508,533
	9	LR	SNOOK LANE STORM SEWER	$ 2,681,965	$ 1,270,654	$ 3,952,619
	10A	#N/A	CARRELL STREET STORM SEWER IMPROVEMENTS	$ 3,391,090	$ 50,543	$ 3,441,633
	11A	#N/A	LOVETT STREET STORM SEWER IMPROVEMENTS	$ 1,481,800	$ -	$ 1,481,800
	10B-11B	5-YR	CARRELL STREET / LOVETT STREET/ J131-03 CHANNEL IMPROVEMENTS	$ 8,517,405	$ 181,837	$ 8,699,242
	10C-11C	#N/A	CARRELL STREET / LOVETT STREET/ J131-03 CHANNEL ENCLOSURE IMPROVEMENTS	$ 14,343,080	$ 50,543	$ 14,393,623
	12	5-YR	WILLOW STREET DITCH REGRADE AND CULVERT CROSSING TO J131-03-00	$ 137,408	$ -	$ 137,408
	13	10-YR	BAKER DR & BROWN RD STORM SEWER TO J131-00-00	$ 1,114,760	$ -	$ 1,114,760
	14	LR	FM 2920 CULVERT CROSSING RECONSTRUCTION	$ 708,195	$ -	$ 708,195
	15	10-YR	STANOLIND RD CULVERT CROSSING	$ 75,175	$ -	$ 75,175
	16	5-YR	PECAN STREET STORM SEWER IMPROVEMENTS	$ 214,505	$ 13,867	$ 228,371
	17	LR	INWOOD & HICKS STREET STORM SEWER IMPROVEMENTS	$ 1,240,922	$ -	$ 1,240,922
			J131 TOTAL	**$ 61,038,589**	**$ 4,778,481**	**$ 65,817,070**
J132						
J133	1	10-YR	J133-00-00 CHANNEL REHABILITATION	$ 2,371,500	$ -	$ 2,371,500
			J133 TOTAL	**$ 2,371,500**	**$ -**	**$ 2,371,500**
			CIP TOTAL	**$ 190,872,503**	**$ 47,563,813**	**$ 238,436,316**

ALTERNATIVE SCENARIO OPTION IN GRAY ARE NOT INCLUDED IN TOTAL COST

DMP CIP PRIORITZATION AND FORECAST WORKBOOK

BASIN	CIP NO.	CIP CATEGORY	2024 CIP COST	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
J131	*1*	*5-YR*	*$ 3,334,150*	*$ 3,600,882*	*$ 3,888,953*	*$ 4,200,069*	*$ 4,536,074*	*$ 4,898,960*	*$ 5,290,877*	*$ 5,714,147*	*$ 6,171,279*	*$ 6,664,981*	*$ 7,198,180*
J131	*2*	*5-YR*	*$ 3,543,765*	*$ 3,827,266*	*$ 4,133,447*	*$ 4,464,123*	*$ 4,821,253*	*$ 5,206,953*	*$ 5,623,510*	*$ 6,073,390*	*$ 6,559,262*	*$ 7,084,003*	*$ 7,650,723*
J131	*3*	*5-YR*	*$ 775,000*	*$ 837,000*	*$ 903,960*	*$ 976,277*	*$ 1,054,379*	*$ 1,138,729*	*$ 1,229,828*	*$ 1,328,214*	*$ 1,434,471*	*$ 1,549,229*	*$ 1,673,167*
J131	*10B-11B*	*5-YR*	*$ 8,699,242*	*$ 9,395,181*	*$ 10,146,796*	*$ 10,958,539*	*$ 11,835,223*	*$ 12,782,040*	*$ 13,804,604*	*$ 14,908,972*	*$ 16,101,690*	*$ 17,389,825*	*$ 18,781,011*
J131	*12*	*5-YR*	*$ 137,408*	*$ 148,400*	*$ 160,272*	*$ 173,094*	*$ 186,941*	*$ 201,897*	*$ 218,048*	*$ 235,492*	*$ 254,332*	*$ 274,678*	*$ 296,652*
J131	*16*	*5-YR*	*$ 228,371*	*$ 246,641*	*$ 266,372*	*$ 287,682*	*$ 310,696*	*$ 335,552*	*$ 362,396*	*$ 391,388*	*$ 422,699*	*$ 456,515*	*$ 493,036*
M118	*1*	*5-YR*	*$ 2,790,000*	*$ 3,013,200*	*$ 3,254,256*	*$ 3,514,596*	*$ 3,795,764*	*$ 4,099,425*	*$ 4,427,379*	*$ 4,781,570*	*$ 5,164,095*	*$ 5,577,223*	*$ 6,023,401*
M118	*5*	*5-YR*	*$ 1,604,715*	*$ 1,733,092*	*$ 1,871,740*	*$ 2,021,479*	*$ 2,183,197*	*$ 2,357,853*	*$ 2,546,481*	*$ 2,750,200*	*$ 2,970,215*	*$ 3,207,833*	*$ 3,464,459*
M121	*2*	*5-YR*	*$ 491,040*	*$ 530,323*	*$ 572,749*	*$ 618,569*	*$ 668,054*	*$ 721,499*	*$ 779,219*	*$ 841,556*	*$ 908,881*	*$ 981,591*	*$ 1,060,119*
M121	*3*	*5-YR*	*$ 1,478,700*	*$ 1,596,996*	*$ 1,724,756*	*$ 1,862,736*	*$ 2,011,755*	*$ 2,172,695*	*$ 2,346,511*	*$ 2,534,232*	*$ 2,736,971*	*$ 2,955,928*	*$ 3,192,402*
M121	*4*	*5-YR*	*$ 117,025*	*$ 126,387*	*$ 136,498*	*$ 147,418*	*$ 159,211*	*$ 171,948*	*$ 185,704*	*$ 200,560*	*$ 216,605*	*$ 233,934*	*$ 252,648*
M121	*5*	*5-YR*	*$ 892,843*	*$ 964,270*	*$ 1,041,412*	*$ 1,124,725*	*$ 1,214,703*	*$ 1,311,879*	*$ 1,416,829*	*$ 1,530,176*	*$ 1,652,590*	*$ 1,784,797*	*$ 1,927,581*
M121	*6*	*5-YR*	*$ 4,080,995*	*$ 4,407,475*	*$ 4,760,073*	*$ 5,140,878*	*$ 5,552,149*	*$ 5,996,321*	*$ 6,476,026*	*$ 6,994,108*	*$ 7,553,637*	*$ 8,157,928*	*$ 8,810,562*
M121	*7*	*5-YR*	*$ 2,168,605*	*$ 2,342,093*	*$ 2,529,461*	*$ 2,731,818*	*$ 2,950,363*	*$ 3,186,392*	*$ 3,441,304*	*$ 3,716,608*	*$ 4,013,937*	*$ 4,335,051*	*$ 4,681,856*
M121	*8*	*5-YR*	*$ 822,430*	*$ 888,224*	*$ 959,282*	*$ 1,036,025*	*$ 1,118,907*	*$ 1,208,419*	*$ 1,305,093*	*$ 1,409,500*	*$ 1,522,261*	*$ 1,644,041*	*$ 1,775,565*
		5-YR	***$ 31,164,288***	***$ 33,657,431***	***$ 36,350,026***	***$ 39,258,028***	***$ 42,398,670***	***$ 45,790,564***	***$ 49,453,809***	***$ 53,410,114***	***$ 57,682,923***	***$ 62,297,556***	***$ 67,281,361***
M116	*2*	*10-YR*	*$ 231,338*	*$ 249,845*	*$ 269,832*	*$ 291,419*	*$ 314,732*	*$ 339,911*	*$ 367,104*	*$ 396,472*	*$ 428,190*	*$ 462,445*	*$ 499,440*
M118	*2*	*10-YR*	*$ 3,783,343*	*$ 4,086,010*	*$ 4,412,891*	*$ 4,765,923*	*$ 5,147,196*	*$ 5,558,972*	*$ 6,003,690*	*$ 6,483,985*	*$ 7,002,704*	*$ 7,562,920*	*$ 8,167,954*
M118	*3*	*10-YR*	*$ 723,850*	*$ 781,758*	*$ 844,299*	*$ 911,843*	*$ 984,790*	*$ 1,063,573*	*$ 1,148,659*	*$ 1,240,552*	*$ 1,339,796*	*$ 1,446,979*	*$ 1,562,738*
M118	*4*	*10-YR*	*$ 7,638,555*	*$ 8,249,639*	*$ 8,909,611*	*$ 9,622,379*	*$ 10,392,170*	*$ 11,223,543*	*$ 12,121,427*	*$ 13,091,141*	*$ 14,138,432*	*$ 15,269,507*	*$ 16,491,067*
M118	*8B*	*10-YR*	*$ 4,020,779*	*$ 4,342,441*	*$ 4,689,836*	*$ 5,065,023*	*$ 5,470,225*	*$ 5,907,843*	*$ 6,380,471*	*$ 6,890,908*	*$ 7,442,181*	*$ 8,037,555*	*$ 8,680,560*
M121	*1*	*10-YR*	*$ 8,067,750*	*$ 8,713,170*	*$ 9,410,224*	*$ 10,163,041*	*$ 10,976,085*	*$ 11,854,172*	*$ 12,802,505*	*$ 13,826,706*	*$ 14,932,842*	*$ 16,127,470*	*$ 17,417,667*
M121	*16*	*10-YR*	*$ 1,048,885*	*$ 1,132,796*	*$ 1,223,419*	*$ 1,321,293*	*$ 1,426,996*	*$ 1,541,156*	*$ 1,664,449*	*$ 1,797,605*	*$ 1,941,413*	*$ 2,096,726*	*$ 2,264,464*
M121	*18*	*10-YR*	*$ 1,636,335*	*$ 1,767,242*	*$ 1,908,621*	*$ 2,061,311*	*$ 2,226,216*	*$ 2,404,313*	*$ 2,596,658*	*$ 2,804,391*	*$ 3,028,742*	*$ 3,271,041*	*$ 3,532,725*
M124	*3*	*10-YR*	*$ 3,837,708*	*$ 4,144,725*	*$ 4,476,303*	*$ 4,834,407*	*$ 5,221,160*	*$ 5,638,852*	*$ 6,089,960*	*$ 6,577,157*	*$ 7,103,330*	*$ 7,671,596*	*$ 8,285,324*
M125	*1*	*10-YR*	*$ 952,710*	*$ 1,028,927*	*$ 1,111,241*	*$ 1,200,140*	*$ 1,296,151*	*$ 1,399,844*	*$ 1,511,831*	*$ 1,632,778*	*$ 1,763,400*	*$ 1,904,472*	*$ 2,056,829*
J100	*1*	*10-YR*	*$ 845,385*	*$ 913,016*	*$ 986,057*	*$ 1,064,942*	*$ 1,150,137*	*$ 1,242,148*	*$ 1,341,520*	*$ 1,448,842*	*$ 1,564,749*	*$ 1,689,929*	*$ 1,825,123*
J131	*5A*	*10-YR*	*$ 2,768,318*	*$ 2,989,783*	*$ 3,228,966*	*$ 3,487,283*	*$ 3,766,266*	*$ 4,067,567*	*$ 4,392,972*	*$ 4,744,410*	*$ 5,123,963*	*$ 5,533,880*	*$ 5,976,590*
J131	*13*	*10-YR*	*$ 1,114,760*	*$ 1,203,941*	*$ 1,300,256*	*$ 1,404,277*	*$ 1,516,619*	*$ 1,637,948*	*$ 1,768,984*	*$ 1,910,503*	*$ 2,063,343*	*$ 2,228,410*	*$ 2,406,683*
J131	*15*	*10-YR*	*$ 75,175*	*$ 81,189*	*$ 87,684*	*$ 94,699*	*$ 102,275*	*$ 110,457*	*$ 119,293*	*$ 128,837*	*$ 139,144*	*$ 150,275*	*$ 162,297*
J133	*1*	*10-YR*	*$ 2,371,500*	*$ 2,561,220*	*$ 2,766,118*	*$ 2,987,407*	*$ 3,226,400*	*$ 3,484,512*	*$ 3,763,272*	*$ 4,064,334*	*$ 4,389,481*	*$ 4,740,639*	*$ 5,119,891*
		10-YR	***$ 39,116,390***	***$ 42,245,702***	***$ 45,625,358***	***$ 49,275,386***	***$ 53,217,417***	***$ 57,474,811***	***$ 62,072,796***	***$ 67,038,619***	***$ 72,401,709***	***$ 78,193,846***	***$ 84,449,353***
M116	*1A*	*LR*	*$ 2,568,286*	*$ 2,773,749*	*$ 2,995,649*	*$ 3,235,301*	*$ 3,494,125*	*$ 3,773,655*	*$ 4,075,548*	*$ 4,401,592*	*$ 4,753,719*	*$ 5,134,016*	*$ 5,544,738*
M116	*1B*	*LR*	*$ 5,015,645*	*$ 5,416,897*	*$ 5,850,248*	*$ 6,318,268*	*$ 6,823,730*	*$ 7,369,628*	*$ 7,959,198*	*$ 8,595,934*	*$ 9,283,609*	*$ 10,026,298*	*$ 10,828,401*
M118	*6*	*LR*	*$ 9,621,315*	*$ 10,391,020*	*$ 11,222,302*	*$ 12,120,086*	*$ 13,089,693*	*$ 14,136,868*	*$ 15,267,818*	*$ 16,489,243*	*$ 17,808,383*	*$ 19,233,053*	*$ 20,771,697*
M121	*9*	*LR*	*$ 3,483,470*	*$ 3,762,148*	*$ 4,063,119*	*$ 4,388,169*	*$ 4,739,222*	*$ 5,118,360*	*$ 5,527,829*	*$ 5,970,055*	*$ 6,447,660*	*$ 6,963,473*	*$ 7,520,550*
M121	*10*	*LR*	*$ 31,024,477*	*$ 33,506,436*	*$ 36,186,950*	*$ 39,081,906*	*$ 42,208,459*	*$ 45,585,136*	*$ 49,231,946*	*$ 53,170,502*	*$ 57,424,142*	*$ 62,018,074*	*$ 66,979,520*
M121	*11*	*LR*	*$ 9,101,328*	*$ 9,829,434*	*$ 10,615,788*	*$ 11,465,051*	*$ 12,382,256*	*$ 13,372,836*	*$ 14,442,663*	*$ 15,598,076*	*$ 16,845,922*	*$ 18,193,596*	*$ 19,649,083*
M121	*12*	*LR*	*$ 5,478,078*	*$ 5,916,325*	*$ 6,389,631*	*$ 6,900,801*	*$ 7,452,865*	*$ 8,049,095*	*$ 8,693,022*	*$ 9,388,464*	*$ 10,139,541*	*$ 10,950,704*	*$ 11,826,761*
M121	*13*	*LR*	*$ 1,760,490*	*$ 1,901,329*	*$ 2,053,436*	*$ 2,217,710*	*$ 2,395,127*	*$ 2,586,737*	*$ 2,793,676*	*$ 3,017,170*	*$ 3,258,544*	*$ 3,519,228*	*$ 3,800,766*
M121	*14*	*LR*	*$ 5,478,078*	*$ 5,916,325*	*$ 6,389,631*	*$ 6,900,801*	*$ 7,452,865*	*$ 8,049,095*	*$ 8,693,022*	*$ 9,388,464*	*$ 10,139,541*	*$ 10,950,704*	*$ 11,826,761*
M121	*15*	*LR*	*$ 546,724*	*$ 590,462*	*$ 637,699*	*$ 688,714*	*$ 743,812*	*$ 803,317*	*$ 867,582*	*$ 936,988*	*$ 1,011,948*	*$ 1,092,903*	*$ 1,180,336*
M121	*17*	*LR*	*$ 35,231,375*	*$ 38,049,885*	*$ 41,093,876*	*$ 44,381,386*	*$ 47,931,897*	*$ 51,766,449*	*$ 55,907,765*	*$ 60,380,386*	*$ 65,210,817*	*$ 70,427,682*	*$ 76,061,897*
M124	*1*	*LR*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*
M124	*2*	*LR*	*$ 13,705,488*	*$ 14,801,927*	*$ 15,986,081*	*$ 17,264,967*	*$ 18,646,164*	*$ 20,137,858*	*$ 21,748,886*	*$ 23,488,797*	*$ 25,367,901*	*$ 27,397,333*	*$ 29,589,120*
J131	*6A*	*LR*	*$ 28,621,813*	*$ 30,911,558*	*$ 33,384,483*	*$ 36,055,241*	*$ 38,939,661*	*$ 42,054,833*	*$ 45,419,220*	*$ 49,052,758*	*$ 52,976,978*	*$ 57,215,137*	*$ 61,792,348*
J131	*7*	*LR*	*$ 5,108,800*	*$ 5,517,504*	*$ 5,958,904*	*$ 6,435,617*	*$ 6,950,466*	*$ 7,506,503*	*$ 8,107,024*	*$ 8,755,585*	*$ 9,456,032*	*$ 10,212,515*	*$ 11,029,516*
J131	*8*	*LR*	*$ 5,508,533*	*$ 5,949,215*	*$ 6,425,153*	*$ 6,939,165*	*$ 7,494,298*	*$ 8,093,842*	*$ 8,741,349*	*$ 9,440,657*	*$ 10,195,910*	*$ 11,011,582*	*$ 11,892,509*
J131	*9*	*LR*	*$ 3,952,619*	*$ 4,268,829*	*$ 4,610,335*	*$ 4,979,162*	*$ 5,377,495*	*$ 5,807,695*	*$ 6,272,310*	*$ 6,774,095*	*$ 7,316,022*	*$ 7,901,304*	*$ 8,533,409*
J131	*14*	*LR*	*$ 708,195*	*$ 764,851*	*$ 826,039*	*$ 892,122*	*$ 963,491*	*$ 1,040,571*	*$ 1,123,816*	*$ 1,213,722*	*$ 1,310,820*	*$ 1,415,685*	*$ 1,528,940*
J131	*17*	*LR*	*$ 1,240,922*	*$ 1,340,196*	*$ 1,447,412*	*$ 1,563,205*	*$ 1,688,261*	*$ 1,823,322*	*$ 1,969,188*	*$ 2,126,723*	*$ 2,296,860*	*$ 2,480,609*	*$ 2,679,058*
		LR	***$ 168,155,637***	***$ 181,608,088***	***$ 196,136,735***	***$ 211,827,674***	***$ 228,773,888***	***$ 247,075,799***	***$ 266,841,863***	***$ 288,189,212***	***$ 311,244,349***	***$ 336,143,897***	***$ 363,035,409***

Notes:

1. Cost assumes no change from existing conditions from time of cost preparation.

2. Assumes design and construction occur in a single fiscal year.

3. Annual rate of 8% was used for inflation and escalation.

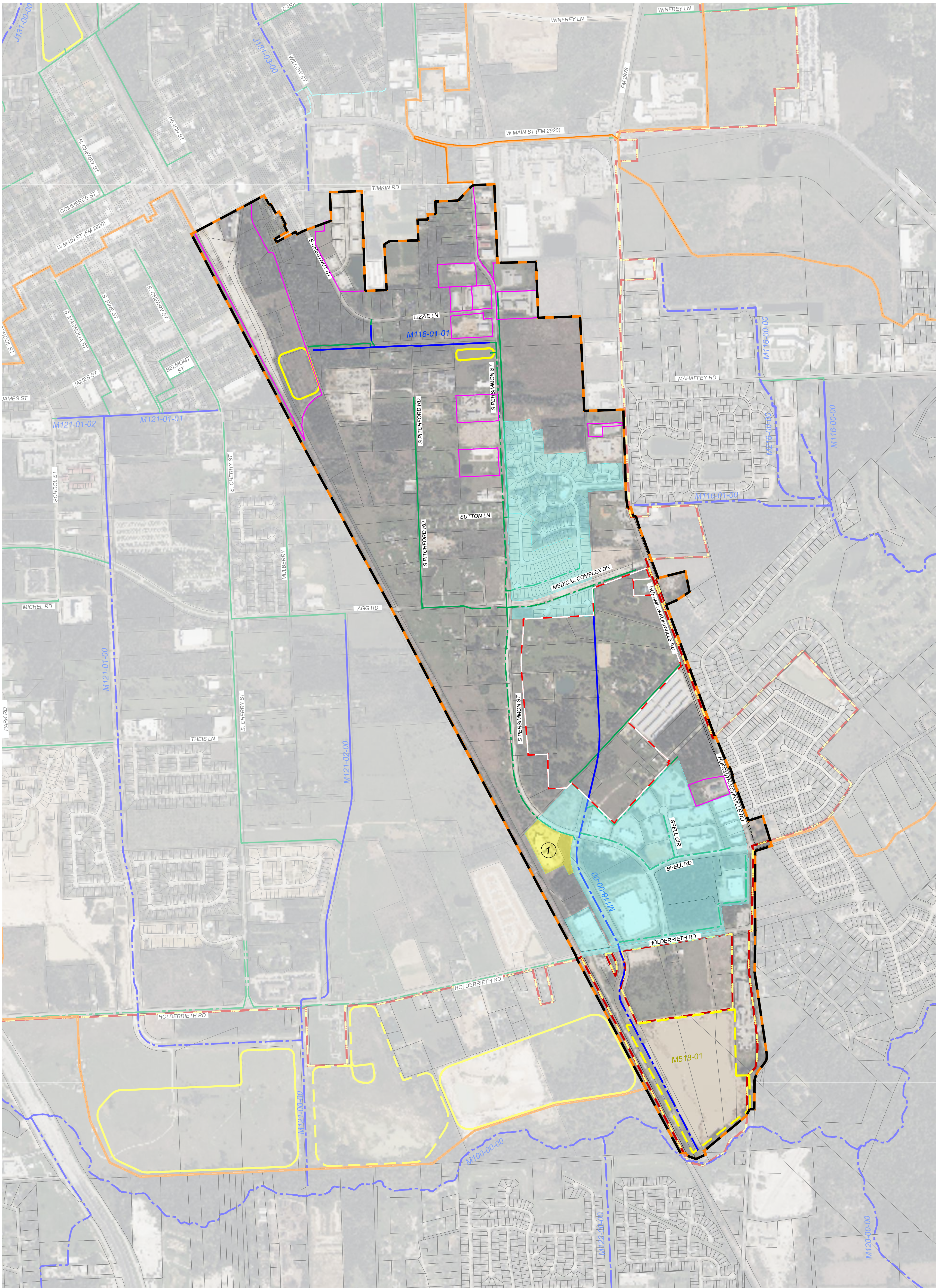
LAND ACQUISITION SUMMARY TABLE								
BASIN	CIP PROJECT	ACQUSITION TYPE	HCAD NO	OWNER	TRACT AREA	PROPOSED ACQUISITION AREA (SF)	COST ($/SF)	TOTAL CIP LAND COST
J100	1	ESMT	1129570000029	EWING GREGORY A & KATHRYN A	454,766	17,289	$ 3	$ 51,868
J131	1	FEE	0352970030026	ALI SYED	1,200	1,200	$ 10	$ 234,000
		FEE	0352970010077	ALI SYED	600	600	$ 10	
		FEE	0352970050159	GORDON CLYDE ESTATE	600	600	$ 10	
		FEE	0352970050160	ALI SYED	600	600	$ 10	
		FEE	0352970050006	ALI SYED	2,400	2,400	$ 10	
		FEE	0352970020002	ALI SYED	1,200	1,200	$ 10	
		FEE	0352970030151	TANDEM ENERGY CORPORATION	6,000	6,000	$ 10	
		FEE	0352970030105	ALI SYED	3,000	3,000	$ 10	
		FEE	0352970030109	BOYKIN MADELYN JOHNSON ET AL	1,200	1,200	$ 10	
		FEE	0352970030099	AMERITRUST SAN ANTONIO	600	600	$ 10	
		FEE	0352970030057	ALI SYED	6,000	6,000	$ 10	
J131	5A	ESMT	0430490000004	DISTRICT & URBAN TX INC	569,267	18,954	$ 3	$ 62,157
		ESMT	0430490000003	LOPEZ LUCRETIA	8,877	1,765	$ 3	
J131	5B	ESMT	0430490000004	DISTRICT & URBAN TX INC	569,267	18,954	$ 3	$ 62,157
		ESMT	0430490000003	LOPEZ LUCRETIA	8,877	1,765	$ 3	
J131	6A	FEE	0450340010214	RMDMG LTD	480,092	480,092	$ 5	$ 2,415,162
		ESMT	0450340010060	STOKLEY MELVIN LEE	4,901	4,901	$ 3	
J131	6B	FEE	0450340010214	RMDMG LTD	480,092	480,092	$ 5	$ 3,367,140
		ESMT	0450340010060	STOKLEY MELVIN LEE	4,901	4,901	$ 3	
		FEE	1450450010002	GALZA INDUSTRIAL	40,256	40,256	$ 5	
		FEE	1452520010002	LEAL SERGIO	29,553	29,553	$ 5	
		FEE	0450340010165	CENTERPOINT ENERGY HOU ELE	8,481	8,481	$ 5	
		FEE	0450340010050	LANGDON TROY W & BARBARA	13,619	13,619	$ 5	
		FEE	0450340010185	BURCHFIELD MICHAEL D & LYETTE J	49,328	49,328	$ 5	
		FEE	0450340010096	BURCHFIELD MICHAEL D & LYNETTE J	3,827	3,827	$ 5	
		FEE	0450340010040	BREAUX RICHARD A & CHRISTINA A	12,901	12,901	$ 5	
		FEE	0352820000171	RODANO DANIEL G	18,688	18,688	$ 5	
		FEE	0450340010223	OLE SPEC LTD	13,742	13,742	$ 5	
J131	6C	FEE	0450340010214	RMDMG LTD	480,092	480,092	$ 5	$ 3,236,259
		ESMT	0450340010060	STOKLEY MELVIN LEE	4,901	4,901	$ 3	
		FEE	0450340010223	OLE SPEC LTD	155,528	155,528	$ 5	
		ESMT	0450340010185	BURCHFIELD MICHAEL D & LYETTE J	7,555	7,555	$ 3	
		ESMT	0352820000178	RODANO DANIEL G	4,229	4,229	$ 3	
		ESMT	0450340010040	BREAUX RICHARD A & CHRISTINA A	2,702	2,702	$ 3	
J131	8	FEE	1409120010003	HARVEY DARRIN & ROXANE	59,940	59,940	$ 5	$ 299,702
J131	9	FEE	0450340010070	OLE SPEC LTD	116,330	116,330	$ 5	$ 1,155,140
		FEE	0450340010065	OLE SPEC LTD	114,698	114,698	$ 5	
J131	10A	ESMT	0352830000102	IGLESIA BAUTISTA FUENTE DE VIDA ETERNA	8,121	8,121	$ 3	$ 45,948
		ESMT	1270990000001	PROTESTANT EPISCOPAL CHURCH COUNCIL OF TOMBALL	7,196	7,196	$ 3	
J131	10B	ESMT	0352830000102	IGLESIA BAUTISTA FUENTE DE VIDA ETERNA	8,121	8,121	$ 3	$ 165,306
		ESMT	1270990000001	PROTESTANT EPISCOPAL CHURCH COUNCIL OF TOMBALL	7,196	7,196	$ 3	
		FEE	0352830000271	TOMBALL TIMBER TRAILS LLC	1,893	1,893	$ 5	
		FEE	0352830000092	VALADEZ AMADEO JR & MARINELA	21,978	21,978	$ 5	
J131	10C	ESMT	0352830000102	IGLESIA BAUTISTA FUENTE DE VIDA ETERNA	8,121	8,121	$ 3	$ 45,948
		ESMT	1270990000001	PROTESTANT EPISCOPAL CHURCH COUNCIL OF T	7,196	7,196	$ 3	
J131	12	ESMT	0352830000106	CITY OF TOMBALL	13,280	967	$ -	$ -
J131	16	ESMT	0402700010061	SPECIALIZED PAINT & BODY LLC	77,319	4,202	$ 3	$ 12,606
M116	1A	FEE	0440550010074, 0440550010209	OBANNION KAREN & RAYMOND	1,252,461	216,729	$ 5	$ 1,083,643
		FEE	0440550010208	MCCOWN JOSEPH B OBANNION MOLLY S	86,711	40,927	$ 5	$ 204,637
		FEE	0440550010088	ESTATES OF WILLOW CREEK HOA	7,101	7,101	$ 5	$ 35,503
M118	2	FEE	0352920000521	WILKERSON MELODY	49,521	49,521	$ 5	$ 1,908,425
		FEE	0352920000529	GRAPPE JAMES R & CAROLYN	2,704	2,704	$ 5	
		FEE	0352920000530	RANDALL JOHN W JR & TRACY A	173,398	173,398	$ 5	
		FEE	0352920000528	DIXON WENDY L & RONALD O JR	26,335	26,335	$ 5	
		FEE	0352920000538	MLADENKA PAUL	38,723	38,723	$ 5	
		FEE	0352920000390	PASSAFUMA PHILLIP	48,854	48,854	$ 5	
		FEE	0352920000389	PASSAFUMA ROBERTA	42,150	42,150	$ 5	
M118	7	ESMT	0352920000530	RANDALL JOHN W JR & TRACY A	68,965	68,965	$ 3	$ 228,108
		ESMT	1342060000003	RALCO HOUSTON LTD	7,071	7,071	$ 3	
M118	8A	FEE	0352880000413	JOHNSON ROY E	96,688	96,688	$ 5	$ 483,442
M118	8B	FEE	0352880000252	CENTERPOINT ENERGY HOU ELE	75,197	75,197	$ 5	
		FEE	0430370000001	TANDEM ENERGY CORPORATION	17,233	17,233	$ 5	
M118	8B	FEE	1277310020004	MARTIN MARIETTA MATERIALS SOUTHWEST INC	25,169	25,169	$ 5	
		FEE	1277310020005	MARTIN MARIETTA MATERIALS SOUTHWEST INC	338,284	338,284	$ 5	$ 2,279,417

LAND ACQUISITION SUMMARY TABLE								
BASIN	CIP PROJECT	ACQUSITION TYPE	HCAD NO	OWNER	TRACT AREA	PROPOSED ACQUISITION AREA (SF)	COST ($/SF)	TOTAL CIP LAND COST
M121	5	ESMT	1156610010014	KEYSTONE TOWNHOMES LLC	13,211	6,418	$ 3	$ 30,123
		ESMT	1156610010013	TAMIROWOOD TOMBALL LLC	13,227	523	$ 3	
		ESMT	1400140010001	TAMIROWOOD TOMBALL LLC	68,489	3,100	$ 3	
M121	7	ESMT	0352840000123	CITY OF TOMBALL	187,657	17,661	$ -	$ -
M121	10	FEE	0440580000080	MUELLER ALLEN H	2,213,742	2,213,742	$ 2	$ 9,427,934
		FEE	0440580000085	MY FAMILY LLC	3,112,274	2,500,225	$ 2	
M121	11	FEE	1287800010004	HOLDERRIETH ROAD LAND HOLDINGS LP	46,653	13,053	$ 5	$ 3,328,025
		FEE	0440580000190	TURRUBIARTES JOSE	1,643,996	86,119	$ 5	
		FEE	0440580000108	WALL JANICE F	1,171,657	102,558	$ 5	
		FEE	0352860000418	NGUYEN LONG	490,651	77,565	$ 5	
		FEE	0352860000233	WALL JANICE F	703,789	59,152	$ 5	
		FEE	0352860000277	NGUYEN JAMES HOAI & TIFFANY	485,807	76,987	$ 5	
		FEE	0352860000228	NWAIWU JUDE	812,653	30,824	$ 5	
		FEE	0352860000226	SPOTTSWOOD SONJA	43,560	12,620	$ 5	
		FEE	0352860000227	KISHLA KISHELLE MYERS	139,514	21,787	$ 5	
		FEE	0352860000223	NWAIWU JUDE	435,265	67,816	$ 5	
		FEE	0352860000224	MCNEILL JAMES T JR	218,991	13,904	$ 5	
		FEE	0352860000221	AGG ROAD ASSOCIATES LP	217,771	33,789	$ 5	
		FEE	0352860000220	AGG ROAD ASSOCIATES LP	434,245	35,778	$ 5	
		FEE	0352860000219	AGG ROAD ASSOCIATES LP	217,717	33,653	$ 5	
M121	14	ESMT	0440580000108	WALL JANICE F	1,129,075	25,713	$ 3	$ 77,140
M121	17	FEE	0440580000195	LANG CAROLYN	1,313,703	1,313,703	$ 5	$ 19,001,478
		FEE	0440580000040	MIDKIFF JAMES J	1,641,123	1,064,984	$ 5	
		FEE	0440580000185	MICHEL FAMILY IRREVOCABLE TRUST	3,902,762	1,421,609	$ 5	
M124	3	FEE	1308830010001	HAFFNER RONALD & AMY N	337,813	81,821	$ 5	$ 1,383,644
		FEE	0402700030008	TOMBALL UNITED METHODIST CHURCH	29,728	9,847	$ 5	
		FEE	0402700030007	TOMBALL UNITED METHODIST CHURCH	61,127	61,127	$ 5	
		FEE	0402700030006	TOMBALL UNITED METHODIST CHURCH	58,282	27,653	$ 5	
		FEE	0402700010039	TOMBALL UNITED METHODIST CHURCH	431,640	96,281	$ 5	
M125	1	ESMT	1048040000001	MANDVIWALA MUSTAFA	55,757	2,260	$ 3	$ 6,780
							TOTAL	**$ 50,631,693**

**Land acqusition costs is based on parcel data received from the City and is a preliminary estimate. CSE has not evaluated, researched, or appraised property for rights-of-way and easements necessary for the construction and maintenance of the proposed improvements.*

APPENDIX E

IMPACT FEE EXHIBITS



CHANNEL DESIGN CRITERIA

1. DESIGN STORM EVENT: 100-YEAR
2. MITIGATION WITHIN M518-01 ULTIMATE BASIN

IMPACT FEE NOTES (1)

1. PARTIAL IMPACT FEE PAID

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

IMPACT LEGEND

- COLLECTED FEES
- IMPACT FEE (SEE NOTES)

LEGEND

- EXISTING STORM SEWER
- EXISTING CHANNEL
- EXISTING DETENTION
- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- TRIBUTARY DIVIDES
- PROPOSED STORM SEWER
- PROPOSED CHANNEL
- PROPOSED DETENTION
- CITY LIMITS

M121 / 34 / 50.0 — BASIN ID, SUBBASIN ID, DRAINAGE AREA IN ACRES

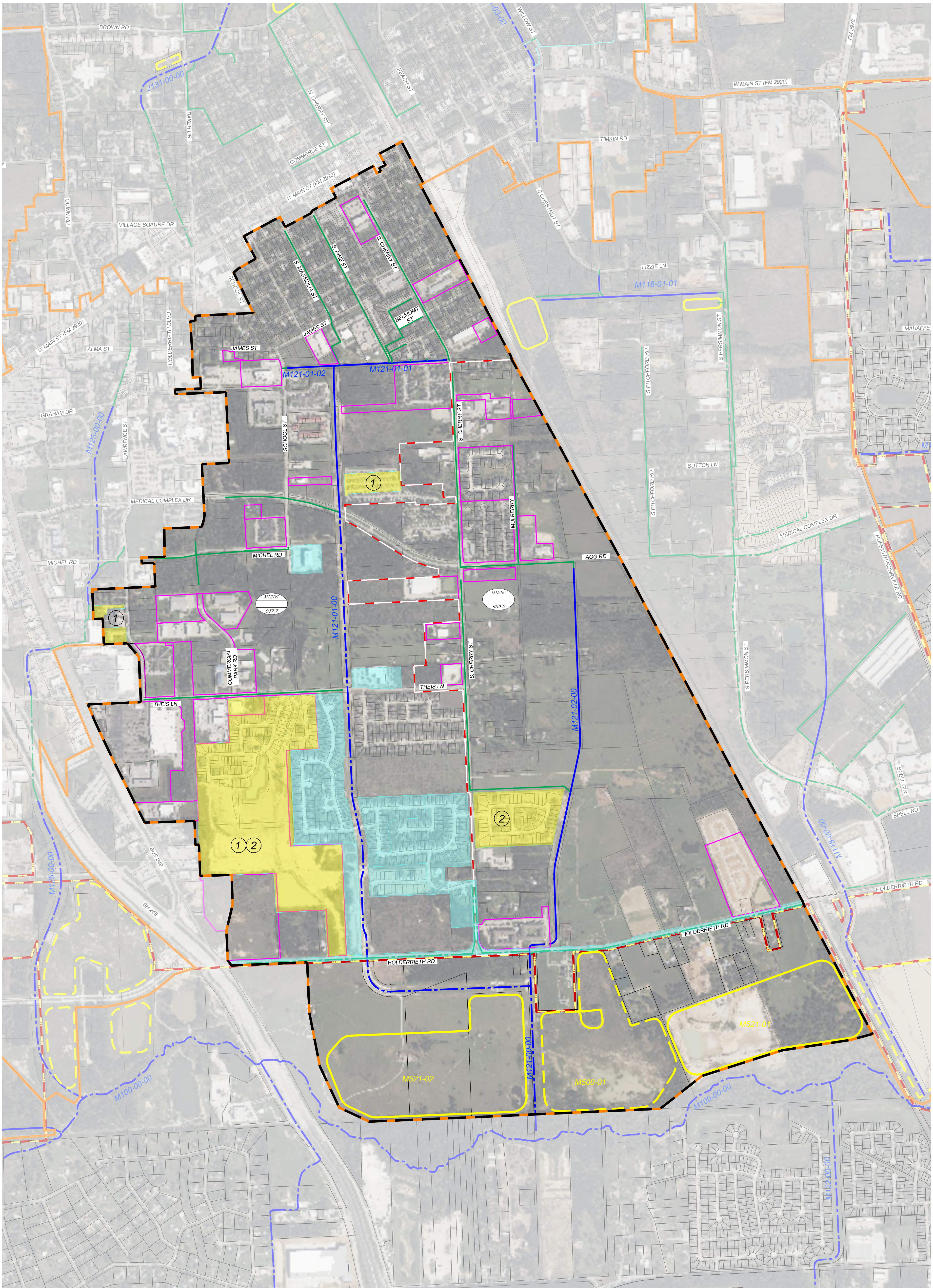
CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

M118 DRAINAGE IMPACT FEE AND CHANNEL DELINEATION

SCALE: 1" = 0.25 mi	March 2025
EXHIBIT NO. 14	M118 BASIN

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG



CHANNEL DESIGN CRITERIA

1. DESIGN STORM EVENT: 100-YEAR
2. MITIGATION WITHIN M500 BASINS

IMPACT FEE NOTES 1

1. PARTIAL IMPACT FEE PAID
2. IMPACT FEE SWAP BETWEEN M121-01-00 AND M121-02-00

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

IMPACT LEGEND

- COLLECTED FEES
- IMPACT FEE (SEE NOTES)

LEGEND

- EXISTING STORM SEWER
- EXISTING CHANNEL
- EXISTING DETENTION
- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- TRIBUTARY DIVIDES
- PROPOSED STORM SEWER
- PROPOSED CHANNEL
- PROPOSED DETENTION
- CITY LIMITS

M121 / 3A / 50.0
- BASIN ID
- SUBBASIN ID
- DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL, TEXAS ★ FOUNDED 1907 ★

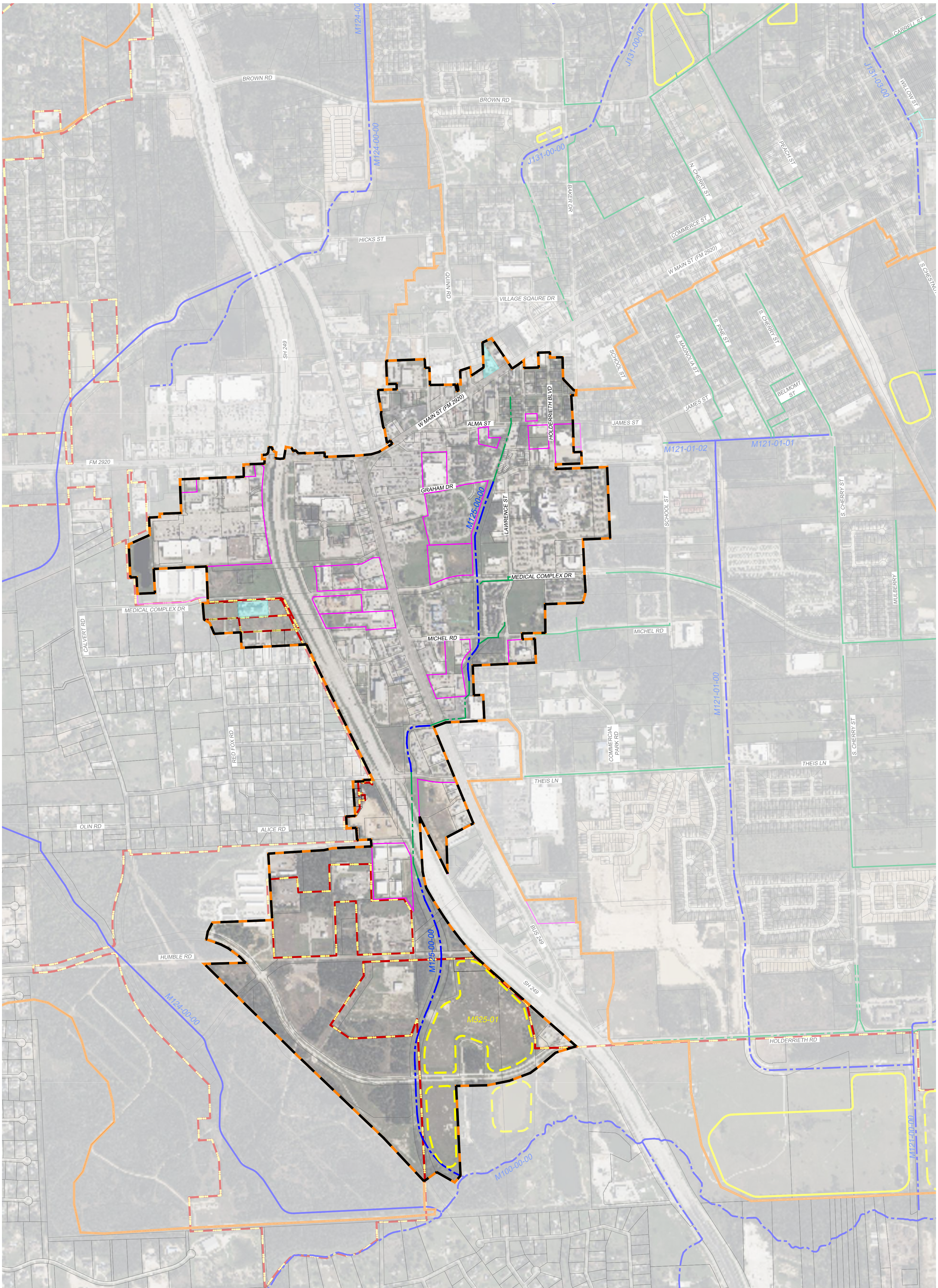
CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL
DRAINAGE MASTER PLAN

M121 IMPACT FEE AND CHANNEL DELINEATION

SCALE: 1" = 0.25 mi	March 2025
EXHIBIT NO. 15	M121 BASIN

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG



CHANNEL DESIGN CRITERIA
1. DESIGN STORM EVENT: 100-YEAR
2. MITIGATION WITHIN M525-01 BASIN

0.125mi 0 0.125mi 0.25mi

SCALE H: 1" = 0.25 mi

IMPACT LEGEND

- COLLECTED FEES
- IMPACT FEE (SEE NOTES)

LEGEND

- EXISTING STORM SEWER
- EXISTING CHANNEL
- EXISTING DETENTION
- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- TRIBUTARY DIVIDES
- PROPOSED STORM SEWER
- PROPOSED CHANNEL
- PROPOSED DETENTION
- CITY LIMITS

M121 — BASIN ID
34 — SUBBASIN ID
50.0 — DRAINAGE AREA IN ACRES

THE CITY OF TOMBALL TEXAS
FOUNDED 1907

CSE Civil Systems Engineering, Inc.

CITY OF TOMBALL DRAINAGE MASTER PLAN

M125 IMPACT FEE AND CHANNEL DELINEATION

SCALE: 1" = 0.25 mi	March 2025
EXHIBIT NO. 16	M125 BASIN

DWG INFO: P:\532301_TOMBALL_MDP\CAD\532301_SUBBASIN AND PONDS.DWG